BEAUFORT GAS PROJECT

IMPERIAL OIL LIMITED

TAGLU, N.W.T.

1976 GEOTECHNICAL SURVEY

PREPARED FOR

FLUOR CANADA LTD.

CALGARY, ALBERTA

R.M.HARDY & ASSOCIATES LTD.

CONSULTING ENGINEERING & PROFESSIONAL SERVICES

GEOTECHNICAL DIVISION

1976 GEOTECHNICAL SURVEY
FIELD STUDIES

TAGLU, N.W.T.

R. M. HARDY & ASSOCIATES LTD.
CALGARY ALBERTA

REPORT ON

1976 GEOTECHNICAL SURVEY
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FOR

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JUNE, 1976
CS 3161

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1.0 INTRODUCTION

1.1 General

Imperial Oil Limited is currently planning a gas gathering and processing facility at Taglu in the Mackenzie Delta, N.W.T. Geotechnical recommendations and design criteria for the foundations and earth structures associated with the plant facilities are being established by R. M. Hardy and Associates Ltd. for Fluor Canada Ltd., the design engineers.

In order to verify and finalize this initial phase of the geotechnical studies, it was decided to carry out a field program in the winter of 1975/76. The areas delineated for further work within the present study program are outlined in the following paragraphs.

1.2 Scope of Work

The scope of work for the 1976 Geotechnical survey was outlined by Mr. W. L. Smith, Project Director, Fluor Canada Ltd., in a letter dated November 20, 1975, and later confirmed in a telex dated December 11, 1975 from Messrs. R. Foster and J. Miecik. The scope of work was laid out as follows:

1.2.1 Field Drilling Program

R. M. Hardy and Associates were requested to provide technical personnel to log and sample boreholes, and to participate in selecting borehole locations based on aerial photograph interpretation and the day-to-day findings of the drilling program. The drilling program included the following items:

(a) Plant site

Borings were to be made in the ice-wedge terrain at the plant site to define the likely maximum depth of ice wedges at the site. As ice-wedges are extremely prevalent at the site, it was considered quite likely that some holes augered for the installation of piles at the site will encounter pure ice to a depth equal to the depth of the ice-wedges. As the embedded length of the pile was a direct function of the amount of pure ice encountered, it was important to assess the maximum embedded depth of piling likely to be required.

(b) Dock site

Additional borings would be made at the dock site, in order to obtain the necessary geotechnical data to

finalize barge dock design criteria. The dock location was selected by Fluor Canada Ltd. and drilling was concentrated in this area. Other borings would also be made to the East of the selected location in the event that unforeseen circumstances dictated that the barge dock be located elsewhere in this area.

It was estimated that about 30 holes would be required at the docksite and plantsite to obtain the necessary information for planning and design purposes.

(c) Potential Alternate Borrow Source

Additional borings would be made at possible new borrow sources a few miles southwest of the plantsite. Based on the terrain information currently available for the area, and two borings (PB-3 and PB-4 of the E.B.A. Engineering Consultants report) that apparently encountered granular material, it was possible that significant deposits of sand or sandy gravel were present in this area.

It was proposed to examine the terrain information and aerial photographs currently available for the area, and to assess the more promising areas in which drilling would take place. One or more sites were to be selected for

exploratory drilling and sampling to obtain the quantity and quality of the potential borrow materials. One potential borrow site was located on the edge of a small lake 3 miles (5 km) southwest of the plantsite. The possibility of obtaining suitable granular material from this lake would be investigated, the extent depending on the results of preliminary test holes drilled at the beginning of the field program.

(d) Big Horn Channel

Depending on the results obtained earlier, additional borings would be made in Harry channel at Big Horn Point in order to verify properties and quantities of sand indicated in previous investigations.

(e) Big Horn Bluff

Additional borings in the Big Horn Bluff would be made to obtain back-up information on quantities and properties of sand deposits in this area.

It was estimated that about 20 holes approximately 30 feet (9 m) in depth would be required in the river channel and the adjacent bluff to obtain the necessary information.

1.2.2 Laboratory Testing Program

During the course of the drilling program, soil samples would be collected for laboratory testing.

No samples were to be collected for testing during drilling of the ice-wedge terrain at the plant site, as the primary purpose of this part of the program was to determine the maximum extent of the ice in the wedges.

Samples would be collected from the dock site, borrow source, and Big Horn Point drilling programs, to augment the field logging and testing. Moisture content, grain size analysis, consistency limits and visual description would be carried out on disturbed samples collected at regular intervals from each hole. Strength tests would be carried out on samples of unfrozen, undisturbed river bed material at the docksite.

1.3 Authorization

Authorization to proceed with the 1976 Geotechnical Survey was received from Messrs. R. Foster and J. Miecik of Fluor Canada Ltd. in a telex dated December 11, 1975.

Details of the contract between Fluor Canada Ltd. and R. M. Hardy & Associates Ltd. are outlined in Amendments Number 2 and 3 of Contract Number 65040 C-9-0001.

1.4 Personnel

The work described in this report was carried out by a project team, with Dr. J. F. Nixon, P.Eng. as Project Director. The supervision of the field program and the compilation of field results was carried out by Mr. R. S. Tenove, P.Eng. The surficial geological work was carried out by Mr. D. Hora, P.Geol. Mr. S. Munn and Mr. D. Vincent were field engineers on the project. Laboratory testing was supervised by Mr. R. Cooper, and drafting of the report was carried out by Mr. Y. Kunimoto and Mr. L. Bell.

Field logistical support was provided by Imperial Oil Limited, Field Services Branch, under the direction of Mr. G. Turnock, Operations Superintendent of Field Support.

Program co-ordination and technical liaison was provided by Mr. J. C. McDougall of the Beaufort Gas Group, Imperial Oil Limited, who also arranged for field surveys to be carried out by Canadian Engineering Surveys Company Limited of Edmonton.

Field engineering support was provided by Mr. A. Gebraad of Fluor Canada Ltd.

2.0 SITE DESCRIPTION AND SURFICIAL GEOLOGY

2.1 Study Area - Physiography and General Geology

An overview of the general surficial geology of the area has been presented in a previous report (E.B.A. Engineering Consultants, 1975). The following discussion is designed to augment prior work in this area, by concentrating on the particular areas of interest covered by this report. The study area extends along the boundary of two Physiographic Regions (MacKay, 1963):

(i) Alluvial Islands of Mackenzie Delta and

(ii) Tununuk Low Hills

The division between the two physiographic regions forms the boundary between the low alluvial deposits of the modern delta and the higher area with the Pleistocene deposits of fluvial and deltaic origin with glacial drift. Several detached portions of Pleistocene deposits scattered in the delta alluvium (Kendall, Pelly, Rae, Hooper islands, etc.) are also considered as part of the Tununuk Low Hills Region.

The elevation of the Tununuk Low Hills Region is, in general, from 100 to 200 feet (30 to 60 m) above sea level (a.s.l.), while the elevation of the Alluvial Islands of the Mackenzie Delta, excluding pingos, does not exceed 10 feet (3 m) a.s.l.

Geologically, the Tununuk Low Hills Region is an old Pre-Wisconsin Pleistocene delta whose surface relief has been greatly modified by:

(1) glacier ice
(2) deposits of glacio-fluvial origin
(3) collapse of kettlehole ice (glacier ice) and long-continued thermokarst development
(4) Ice-rafted sediments, both of glacial and nonglacial (ocean ice, Mackenzie River ice) origin.

As the glacier retreated, the isostatic rebound lifted the land and exposed these deposits to erosion. Due to the raised surface, the Mackenzie River system cut into the older deposits and is building the modern delta over the underlain lower parts of the Pleistocene sediments and around the outliers. In the channels of the present outer delta, 650-700 feet (200-220 m) of Quaternary sediments are

reported. Of these deposits, a maximum of 200 feet (60 m) is attributed to post-glacial deltaic deposits (Kerfoot, 1975).

The irregularities in deposition of any deltaic sediments is a typical phenomena for the Mackenzie Delta as well.

Seasonal variations in current velocities and volumes of discharge, together with the changing amount of suspended material result in different rates of bank erosion, channel shifting, scouring-and-filling and a changing rate of gravitational sorting of transported particles. Abandoned parts of channel system are subject of siltation in a similar way as the thermokarst lakes. Therefore, sudden changes in the grain size both in vertical and horizontal sense are basic characteristics for deltaic deposits.

The mean grain size of delta surface sediments appears to decrease from fine and very fine sand in the southern portion of the delta to silt in the middle and outer delta. Although minor textural differences have been recorded between deltaic sub-environments, most sediments

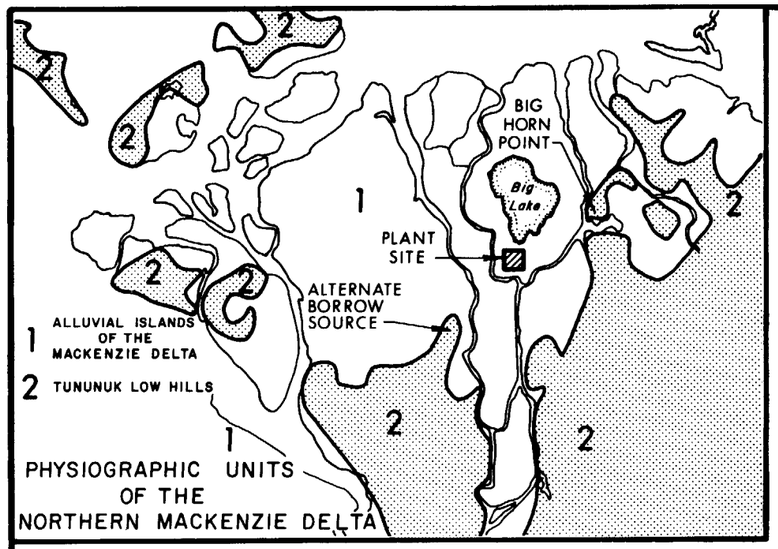
are finer than 0.125 mm and appear to be predominantly composed of silt with a clay fraction. Very little material in the upper 100 feet (30 m) of the delta, even in the channel bottoms, is coarser than fine sand (0.25 mm). No sources of coarser aggregate have been reported from the modern delta (Kerfoot, 1975).

The sedimentation process during the Pleistocene period was not different enough to expect coarse aggregate deposits in the old deltaic sediments. The only exception may be glacial outwash, found locally as irregular blankets overlying the moraine deposits or old deltaic sediments.

A summary of the surficial geology of the study area has been prepared as shown on Figure 2.1. Geological units have been grouped into four main categories comprising: alluvium of the modern delta, lacustrine deposits, glacial outwash and deltaic glacial till deposits.

2.2 Plant site and Dock

This area is entirely within the deposits of the modern delta, (see Figure 2.1). The surface pattern observed on air-photos indicates irregular deposition of material,



492000m.E. 495 500 505 510000m.E.

7699000m.N. 695 690 7688000m.N.

BIG HORN POINT

PLANT SITE

ALTERNATE BORROW SOURCE

LEGEND

- ALLUVIUM OF MODERN DELTA MAINLY SILT, WITH CLAY AND SAND LAYERS
- LACUSTRINE DEPOSITS MAINLY CLAY, SOME SILT AND ORGANIC DEPOSITS
- GLACIAL OUTWASH MAINLY SAND, SOME SILT AND GRAVEL
- TILL, LOCAL PATCHES OF PLEISTOCENE DELTAIC DEPOSITS. MAINLY SILT AND CLAY, SOME SAND
- PINGO

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Figure 2.1

SURFICIAL GEOLOGY TAGLU GAS PLANT AREA

SCALE: 1:50,000

typical for deltaic sediments. Old channel scars are distributed at random over the area. This corresponds with Mackay's (1963) observations of a wandering type of channel shifting within the Mackenzie River delta. Very well developed ice-wedge patterned ground on both sides of the Kuluarpak Channel is an indication that no significant channel shifting has occured there for at least several hundreds of years. According to Mackay (1963), development of the ice-wedge pattern requires several hundreds to thousands of years. The area does not exhibit well developed and/or widely distributed thermokarst features.

The deltaic deposits are composed mainly of silt and clay size particles with less important lenticular bodies of fine sand.

2.3 Big Horn Point (Channel and Bluff)

This area extends along the boundary of modern delta and Pleistocene deposits of Tununuk Low Hills Physiographic Region, as shown on Figure 2.1. The deposits of the modern delta exhibit a very similar pattern of deposition to those described at the plant site. Patterned ground, old channel scars and a general absence of thermokarst features are also typical for these recent alluvial deposits.

Big Horn Bluff, and adjacent areas to the east, is a completely different type of landform. The surface exhibits widespread and well developed thermokarst depressions. Some of these depressions have been infilled with lacustrine sediments, while most of the others are lake basins with either internal drainage or integrated by irregular channels into the Mackenzie River Delta system. The surface and near-surface soils are mainly sand on highs and level plateaus, and silt and clay in lows, with occasional thick surficial organic (peat) layers in the hollows. Glacial till and Pleistocene deltaic deposits are the main geological units in the Big Horn Bluff area. Since the deltaic deposits are the main source of local till and the length of the transport by advancing glacier in this area has not been over long distances, it is sometimes very difficult to distinguish till from deposits of the Pleistocene delta.

Clayey and silty sediments with peat layers have accumulated in thermokarst depressions and locally overlie the deposits of till and Pleistocene delta. The pingo is a typical feature which develops in these lacustrine sediments.

Larger accumulations of fine sand in irregular lenses extend along the recent river channel, and are interbedded with subordinate silt and minor clay. While the sand covers the surface of a large part of Big Horn Bluff, only minor sand lenses were intersected during the drilling program.

2.4 Potential Alternate Borrow Source

The potential alternate borrow source area (in common with the Big Horn area) extends along the boundary of the modern delta and Pleistocene complex of glacial drift and deltaic sediments, overlain locally in depresssions by lacustrine deposits. The area delineated for study is shown on Figure 2.1.

The surface of the modern delta exhibits a wide-spread, well developed ice-wedge pattern. Old channel scars are less well developed compared with the previous two study areas. There are indications that the thickness of modern alluvial deposits is rather limited and the Pleistocene deposits are present near ground surface. (Test Holes H76-G2, G5, G6, G15).

The complex of Pleistocene deposits in this area consists of mainly glacial outwash with subordinate lacustrine deposits in thermokarst basins and till, with sediments of the Pleistocene delta. The glacial outwash covers a large proportion of the tills and deltaic sediments of this area. The composition of this outwash is classified on the surficial geology map (Rampton, 1972) as mainly sand with occasional layers of gravel.

The drilling in this area intersected sand in layers more than 20 feet (60 m) thick only on elevated areas of outwash and in one test hole drilled on the 'West Lake' (see Figure 5.21), immediately adjacent to the outwash area.

The rest of test holes in this area intersected deltaic deposits with only minor or subordinate amount of sand layers.

3.0 FIELD PROGRAM

3.1 Scope

The scope of the field drilling program may be divided into three areas as follows.

3.1.1 Alternate Borrow Area

To delineate subsoil conditions in a one mile (1.6 km) square area approximately three miles (5 km) southwest of the Taglu Plant Site (see Figure 5.13) for the purpose of evaluating potential granular borrow sources. Airphoto studies of the area suggested granular deltaic or outwash deposits may be present. This area was outlined by Mr. J. C. McDougall, of Imperial Oil Limited, as an area of general interest.

3.1.2 Plant Site

To evaluate subsoil conditions and location of the permafrost boundary along the channel at the plant site for the purpose of locating and designing a barge dock, a field program of 15 test holes was set out within the channel. Test holes were drilled in the unfrozen sediments to a depth sufficient to delineate permafrost, and soil samples were retained. Five additional holes were spaced at 25 foot (8 m) intervals at the preferred dock location and Dynamic Cone Penetration tests were conducted to assess the soil consistency and delineate the permafrost boundary. In addition, penetration tests were conducted at all test holes

drilled over water, to determine soil consistency, scour depth and the position of permafrost boundary.

In addition to test holes at the barge dock location, two test holes were drilled along the realigned airstrip and several shallow test holes were drilled at three locations to determine ice thickness at predetermined possible ice wedge locations near the plant site. The possible ice wedge locations were flagged by Mr. J. C. McDougall during site reconnaissance in the summer of 1975.

3.1.3 Big Horn Point

Visual inspections of soil exposures on Big Horn Point Bluff suggested granular soils may be encountered on the bluff. A series of six holes were drilled at an approximate spacing of 400 feet (120 m).

To further delineate sand deposits within Harry Channel at Big Horn Point, ten test holes were drilled and sampled. A single test hole was drilled on a mid channel island.

3.2 Drilling Equipment

The Field Services Division of Imperial Oil Limited retained Big Indian Drilling, a Division of Kenting Petrolia Drilling, to provide a drill rig. The drilling equipment selected was a sleigh mounted Heli-Drill 500 (see Figure 3.1). This drill rig is equipped with a separately housed air compressor and pump and is capable of wet or dry drilling techniques to a depth of approximately 100 feet (30 m). Both units are fully enclosed to shield equipment and personnel from the elements.

The drill rig assembly was skidded with a D7 caterpillar tractor. A laboratory trailer was attached to the end of the drill string to provide for storage and preparation of the soil samples, maintenance of equipment and shelter.

A self-contained sleigh-mounted trailer camp was also provided by Imperial Oil Limited, and was set up in each of the three study areas.

3.3 Sampling Equipment and Methods

Samples of frozen and unfrozen soil in both an undisturbed and disturbed state were required to properly

assess the engineering properties of the soils encountered together with soil classification and index tests.

3.3.1 Frozen Soils

Frozen soils were sampled using a CRREL (Cold Regions Research & Engineering Laboratories) core barrel equipped with carbide tipped insert teeth. Using the dry drilling method, the core barrel acts as an auger and can cut a 3 inch (75 mm) diameter core 2.5 feet (0.8 m) in length which is retained in the barrel. The core was hydraulically extruded, labelled, photographed, wrapped and packaged in an insulated crate for shipment (see Figure 3.2). Where the sample was to be used for moisture content determination or soil classification, the soil was packaged and sealed but no attempt was made to prevent thawing.

3.3.2 Unfrozen Soils

Unfrozen soils were sampled using 2 and 3 inch (50 and 75 mm) diameter split spoon samplers which are driven into the soil (see Figure 3.1). A driving method employing 350 foot pounds (475 N-m) was used. The number of blows required to advance the sampler is recorded and the

PHOTOGRAPH No. 1
Drill Rig String on River Channel

PHOTOGRAPH No. 2
Typical Split-Spoon Sample (from Dock Site H76-D15)

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PHOTOS OF DRILLING EQUIPMENT AND SPLIT-SPOON SAMPLE

FIGURE 3.1

PHOTOGRAPH No. 3
CRREL Core Showing Frozen Sediments (from Dock Site H76–D6)

PHOTOGRAPH No. 4
CRREL Core Showing Stratified Ice (from Big Horn Bluff H76–BB2)

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PHOTOS OF SOIL SAMPLES

FIGURE 3.2

relative density and/or consistency of the soil strata can be determined (ASTM D1586-64T, Standard Penetration Test). Disturbed samples were obtained and packaged for soil classification and index tests.

Relatively undisturbed samples of unfrozen ground were obtained by hydraulically pushing a 3 inch (75 mm), diameter Shelby tube into undisturbed soils. The cohesionless nature of most channel deposits made retention of these samples difficult. A piston sampler was used with some success to obtain several undisturbed samples of the more sandy soils. These samples were retained and tested to evaluate the soil shear strength for the unfrozen sediments at the proposed barge dock site.

3.3.3 Insitu Testing

At the dock site and in Harry Channel at Big Horn Point, Dynamic Cone Penetration tests were conducted to assess the insitu relative density and/or consistency of the unfrozen sediments encountered. Standard Penetration Tests were conducted where a soil sample was also desired. A continuous profile of relative density with depth was obtained using the Dynamic Cone Penetration test. A driving effort

of 350 ft pounds was also used. The tip of the driving rod is a solid 2 inch (50 mm) diameter cone tapered to an angle of 60 degrees at the apex.

All samples were transported to BAR C and shipped to Edmonton by Imperial Oil Limited aircraft where they were trucked to the Calgary laboratory of R. M. Hardy & Associates Ltd. Frozen samples were stored in a freezer until laboratory testing was conducted.

3.4 Surveying

All test holes were flagged and staked at the completion of drilling. Test hole locations were mapped and recorded on airphotos.

Canadian Engineering Surveys Company Limited of Edmonton was retained by Imperial Oil Limited to conduct a survey of all test holes and to provide locations relative to the UTM coordinate system. Time delays resulted in postponement of the field survey until early March. Location of test hole stakes was sometimes difficult at that time and a few stakes could not be located. Survey data was transmitted to R. M. Hardy & Associates Ltd. between March 17 and

22nd, 1976. Interpretation of survey data was closely referenced to initial test hole positioning using air-photos. Co-ordinates submitted by Canadian Engineering Survey, Company Limited are tabulated at the beinning of each Appendix, together with additional co-ordinates based on field measurements at the docksite at the time of drilling.

4.0 LABORATORY TESTING

4.1 Test Description

The majority of soil samples retained from the field program were visually identified and tests such as Atterberg Limits and particle size analysis were conducted to aid in soil classification. The Modified Unified Classification System for Soils was used and is shown on Figure F.1 in Appendix F. The NRC Ground Ice Classification System was used to describe the ice types present in frozen soil samples, and is shown on Figure F.2 in Appendix F.

Additional laboratory tests were conducted to determine the index properties of the soil types encountered relative to foundation design. These tests include moisture

content, unconfined compressive strength, unit weight, drained triaxial, frozen bulk density and thaw settlement. Strength tests were conducted only on unfrozen, relatively undisturbed soil samples.

Where applicable, tests were carried out using current ASTM (American Society for Testing and Materials) Standards. The ASTM Designation and definition of these tests are as follows:

4.1.1 Moisture Content (ASTM D2216-71)

The moisture content of a soil is the ratio, expressed as a percentage, of the weight of water in a given mass of soil to the weight of solid particles.

4.1.2 Atterberg Limits

4.1.2.1 Liquid Limit (D423-66)

The liquid limit of a soil is the moisture content, expressed as a percentage of the weight of oven-dried soil, at the boundary between liquid and plastic states.

4.1.2.2 Plastic Limit (D424-59)

The plastic limit of a soil is the moisture content, expressed as a percentage of the mass of oven-dried soil, at the boundary between the plastic and semi-solid states.

4.1.3 Grainsize Distribution or Particle Size Analysis (D422-63)

The grainsize analysis is the quantitative determination of the distribution of particle sizes in soils. The distribution of particle sizes larger than 75 μm (retained on No. 200 sieve) is determined by sieving whereas the distribution of smaller particle sizes is determined by a sedimentation process using a hydrometer.

4.1.4 Unit Weight (D2937-71)

The unit weight or density of a soil sample obtained by hydraulically pushing a 3 inch (75 mm) thin-walled Shelby tube into undisturbed soil is determined without extruding the soil sample from the tube.

4.1.5 Unconfined Compressive Strength of Cohesive Soil (D2166-66)

The unconfined compressive strength is the load per unit area at failure (20 percent axial strain) of an unconfined cylindrical specimen of soil. The test is carried out using strain-controlled application of the test load.

4.2 Test Results

Laboratory tests were conducted on soil samples as an aid to soil classification and to determine the index or engineering properties of the soil. All test results are shown on the test hole logs or, in the case of grain size distribution, the figure number on which the test results are presented is given. In addition, a summary of all laboratory tests, excluding moisture content, is given at the end of each appendix.

Moisture contents recorded in the unfrozen sediments below the bottom of lakes and river channels often reflect the normal saturated state of the soil.

In frozen soils where large discrete ice bodies were present the soil layer between the ground ice was

sampled; thus the moisture content will be that of the soil layer only. Visual ice contents are given on the logs and indicate the percent of ice by volume in excess of that normally present in the soil type in an unfrozen state.

Shear strength tests (drained triaxial and unconfined compression) were conducted on selected undisturbed samples of the unfrozen sediments at the barge dock site. Also, a profile of soil consistency with depth was obtained by conducting dynamic cone and standard split spoon penetration tests from which approximate soil shear strengths may be derived empirically.

Frozen bulk density and two thaw settlement tests were conducted on frozen cores obtained at the dock site. These tests provide the settlement characteristics of a frozen soil. Two samples were placed in consolidation test devices, and thawed under a small nominal loading, and the strain recorded. Subsequent load increments were then placed on the samples to determine the compression characteristics of the thawed soil. The thaw strain was evaluated using the method proposed by Watson, Slusarchuk and Rowley (1973), as shown on Figure B.55, and the thaw strain and compressibility values so obtained are valid for the

stress range of 0.3 to 0.8 t.s.f. (32 to 86 kPa). These test results are included in Appendix B, and are also shown on the test summary sheets at the end of Appendix B.

5.0 RESULTS OF FIELD PROGRAM AND DISCUSSION OF SUBSOIL CONDITIONS

5.1 Plant site

The subsurface investigation at the plant site area was limited to two considerations; (a) to obtain further information on the depth and lateral extent of ice-wedges at the site, and (b) to drill two holes at the revised airstrip location.

5.1.1 Ice Wedges

During the summer of 1975, the locations of some possible ice wedges on the plant-site were flagged by Mr. J. C. McDougall of Imperial Oil Limited. Six holes were drilled at one of these locations (H76 W1), and the maximum depth of ice was 2.8 feet (0.85 m). Three holes were drilled at a second location, H76-W2, about 22 feet (7 m) away, and the maximum depth of ice recorded was 8.5 feet (2.6 m).

Another hole H76-W3 was drilled at a third location, but no ice was found. The positions of these holes are shown on Figure 5.1, and the drilling logs and test results are given on Figures A-1 through A-7 in Appendix A.

The maximum depth of ice encountered during this phase of the study was 8.5 feet (2.6 m). This is not felt to be representative of the depth of wedges at the site. The limited time available for this part of the field program did not permit sufficient holes to be located and drilled to obtain representative drill-hole data on the depth of ice-wedges in the Taglu area.

In the context of pile foundations, and the depth of ice that may be encountered at the site, the following discussion reviews the available drill-hole information, provides some estimates of the depth and extent of wedges at the site, and outlines the surface distribution of ice wedges based on aerial photographs.

Parts of Richards Island are underlain by massive tabular blocks of underground ice (Rampton and Mackay, 1971); however, the low lying nature of the Taglu site and the well-developed ice-wedge polygon system suggest that the only abundant ice type is wedge ice.

The available borehole logs record the presence or absence of ice, but it is difficult to ascertain the genesis of the ice (i.e., whether wedge ice or not). However, the infrequent occurrence of ice in the drilling logs indicates laterally discontinuous ice, and in addition, the polygonal pattern on air-photos suggest the presence of wedge ice. It should also be noted that drill-hole records probably do not give maximum ice depths, as ice-wedges taper downwards and drill holes may pass through the side of a wedge.

The following drill-holes display abundant ice: A-6, B-7, F-2, G-11 and O-6 (E.B.A. Engineering Consultants, 1975), and H76-W2 drilled during this program. The hole A-6 may indicate the presence of a buried ice-wedge, as it records ice from 14-24 feet (4.5-7.5 m). Although there is no published information specifically for the Taglu site, there is evidence of a thaw unconformity in the vicinity (Mackay, 1975) at a depth of 9-12 feet (3-4 m). If this extends beneath the Taglu area, there may be relic wedges at depth with no surface expression. If such wedges are present, they are unlikely to exceed a depth of 10 feet (3 m) below such an unconformity. The E.B.A. borehole A-6 probably indicates a buried wedge, otherwise a vertical borehole would intercept a vertical wedge above 14 feet (4.3 m).

METRES

500 0 500 1000

1000 500 0 1000 2000 3000

FEET

(E.B.A.)
× AS-9

AS-8
×

REVISED AIRSTRIP ℄
FROM FLUOR DRAWING
650406-SK-4-0050

H76A2
⊙
× AS-7

H76 W3
⊙

H76 A1
⊙
× AS-6

(E.B.A.)
× A-6

H 76 W1 & W2
⊙ (Holes are about 22 ft. apart)

× AS-5

× AS-4

D-43

AS-3
×

AS-2
×

× AS-1

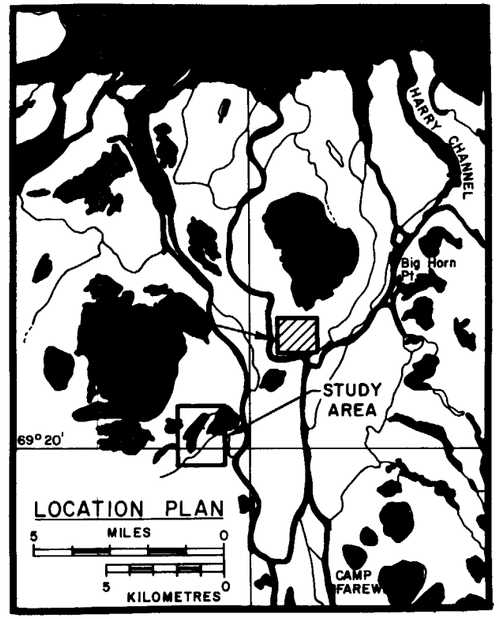
7 695 000

501 000 m. E

502 000 m. E

503 000 m. E

LB



LEGEND

⊙ 1976 R.M. HARDY & ASSOCIATES LTD.

× E.B.A. FIELD PROGRAM

NOTE

1976 BOREHOLE LOCATIONS AND RIVERBANK BASED ON CANADIAN ENGINEERING SURVEYS DRAWING NO. 8363-M-1A.

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BOREHOLE LOCATIONS AT PLANTSITE

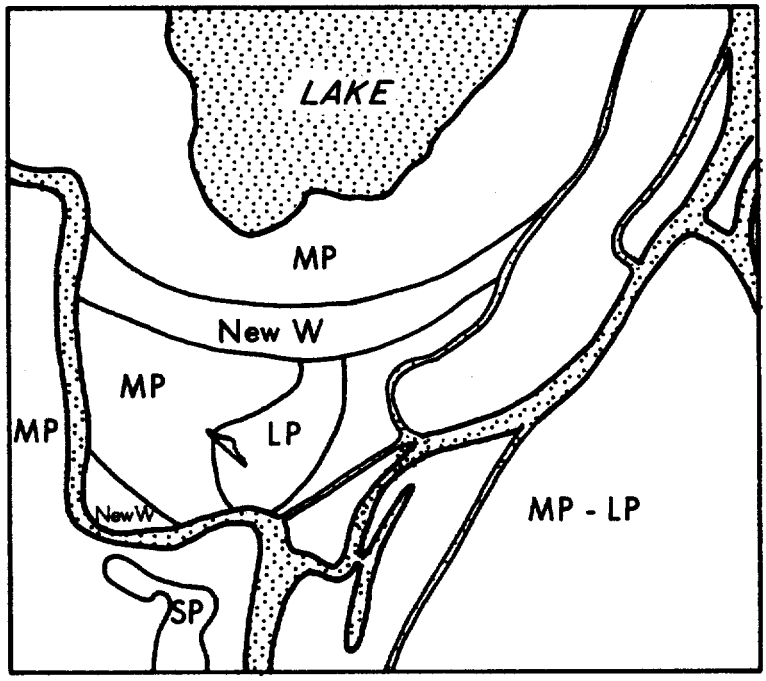
Figure 5.1

Further evidence of ice-wedge depths in the general area is obtained from test hole log H76-G6, where 17 feet (5.2 m) of ice was logged during drilling of the alternate borrow source south of the plant site.

Comparison of drill-hole positions with ice-wedge distribution is difficult due to the scale of the airphotographs, but holes with records of abundant ice are close to wedges shown on photographs. Aerial photographs display polygons up to 75 feet (23 m) across, thus wedges with surface expression may comprise a limited proportion of the terrain, but individual wedges may be several feet across. Depths of wedges have not been reported in the literature, but wedges 4-6 feet (1-2 m) across at the top may penetrate to 15-18 feet (5-6 m). Where wedges have grown syngenetically with active sedimentation, multiple tiered wedges may occur, and surface expression may not represent the volume of ice at depth. However, the width of wedges is minimal below about 12 feet (4 m). For the Taglu site, therefore, it should be assumed that ice-wedges are 4-6 feet (1-2 m) across at the top, and that holes drilled for pile foundations at the site may remain predominantly in ice for depths of up to 20 feet (6 m).

An attempt has been made to map ice-wedge polygon distribution at the Taglu site, in terms of the presence or absence of wedges, polygon size, and associated wedge size. The map is based on airphoto interpretation, and is shown on Figure 5.2. The map displays a zone of large polygons which probably comprises the largest wedges. Medium polygons comprise large and medium wedges, while small polygons have the greatest range of wedge size, and the greatest density. Large polygons are usually low-centred, whereas the smaller polygons tend to have high centres. Low-centred polygons have ridges adjacent to the wedges, whereas in high-centred polygons the ridges have broadened and the central hollows have become infilled with peaty material. Frequently this peat has a high ice content. At Taglu, most polygons are low-centred, as readily observed on the shore of Big Lake, where centres are water-filled. In addition, zones of possible new wedges are outlined. These are where an old channel has been abandoned, and point bars have developed. No polygons are evident, but thermal contraction cracking may occur.

From a terrain sensitivity and construction viewpoint, the following distinctions may be made between the two types:



SCALE 0 500 1000 METRES

LP = LARGE POLYGONS, PROBABLY WITH LARGEST WEDGES, BUT LOW DENSITY OF WEDGES.

MP = MEDIUM POLYGONS, PROBABLY FORMED BY SUBDIVISION OF LARGE POLYGONS. LARGE AND MEDIUM WEDGES.

SP = SMALL POLYGONS. RANGE OF SIZES HIGHEST DENSITY.

New W = NEW WEDGES. NO EXPRESSION OF WEDGES; THERMAL CONTRACTION CRACKS OCCUR.

LB

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Figure 5.2
ICE WEDGE DISTRIBUTION

1. Low-centred polygons may have ponds in their centres.
2. Low-centred polygons may have ice lenses in the ridges; in addition high-centred polygons tend to have high ice contents in their peaty centres.
3. High-centred polygons have thinner active layers in their centres.
4. High-centred polygons have more ice, both ice wedge ice and ice in the peaty centre.

5.1.2 Airstrip

Subsequent to the preliminary geotechnical evaluation carried out by E.B.A. Engineering Consultants Ltd., the location of the STOL airstrip was altered to a more northerly alignment. The revised location was taken from the most recent plot plan of the site available (Fluor Drawing No. 650406-SK4-0050) and is shown on Figure 5.1. The original airstrip alignment is clearly seen from the location of the nine E.B.A. drill-holes, AS-1 to AS-9.

The preliminary geotechnical evaluation has concluded that the subsurface conditions were relatively uniform and typical of conditions over the rest of the site. Ice-rich silts overlie denser silts or silty sands at depth.

In order to confirm that subsurface conditions would not be greatly different under the revised airstrip location, two drill-holes (H76-A1 and H76-A2) were drilled. The test hole logs for these two holes are shown in Appendix A. Sandy silts were found in both holes to a depth of 25 feet (8 m). Excess ice contents varied from 60 percent in the top 10 feet (3 m) to little or no excess ice below 20 feet (6 m). In the depth range 10-20 feet (3-6 m), moisture contents lay between 20 and 40% by dry weight.

These results are similar to those determined in the preliminary geotechnical evaluation, (Test Holes AS-1 to AS-9). The high excess ice contents in the near-surface layers provide further evidence for the requirement to maintain the permafrost beneath the airstrip pad in the frozen condition, thereby preventing thaw-settlement in the underlying soils.

5.2 Barge Dock

5.2.1 General

Prior to the present geotechnical survey, subsurface information on the dock site area included four profiles of the channel bathymetry reported by Slaney (1976),

and six test hole logs described in the preliminary geotechnical survey (E.B.A. Engineering Consultants, 1975). Of these six holes drilled in the river channel, five were located in a relatively shallow area of the river where a dock might have to extend up to 200 feet (60 m) from the shoreline in order to attain the required draught for barges. The remaining test hole was drilled closer to the existing gravel pad at the river bank, the area now favoured for a barge dock location (see Figure 5.3).

In order to augment the subsurface information in the area of the preferred dock site location, some twenty holes were drilled during the present program. The locations of these holes are shown on Figure 5.3. The borehole logs, laboratory test summary sheets and grain size distribution curves are included in Figures B-1 through B-57 of Appendix B. The field and laboratory logging and testing programs were designed to provide information on the water depth, depth of scour, permafrost depth, and the consistency or strength of the unfrozen sediments above the permafrost table.

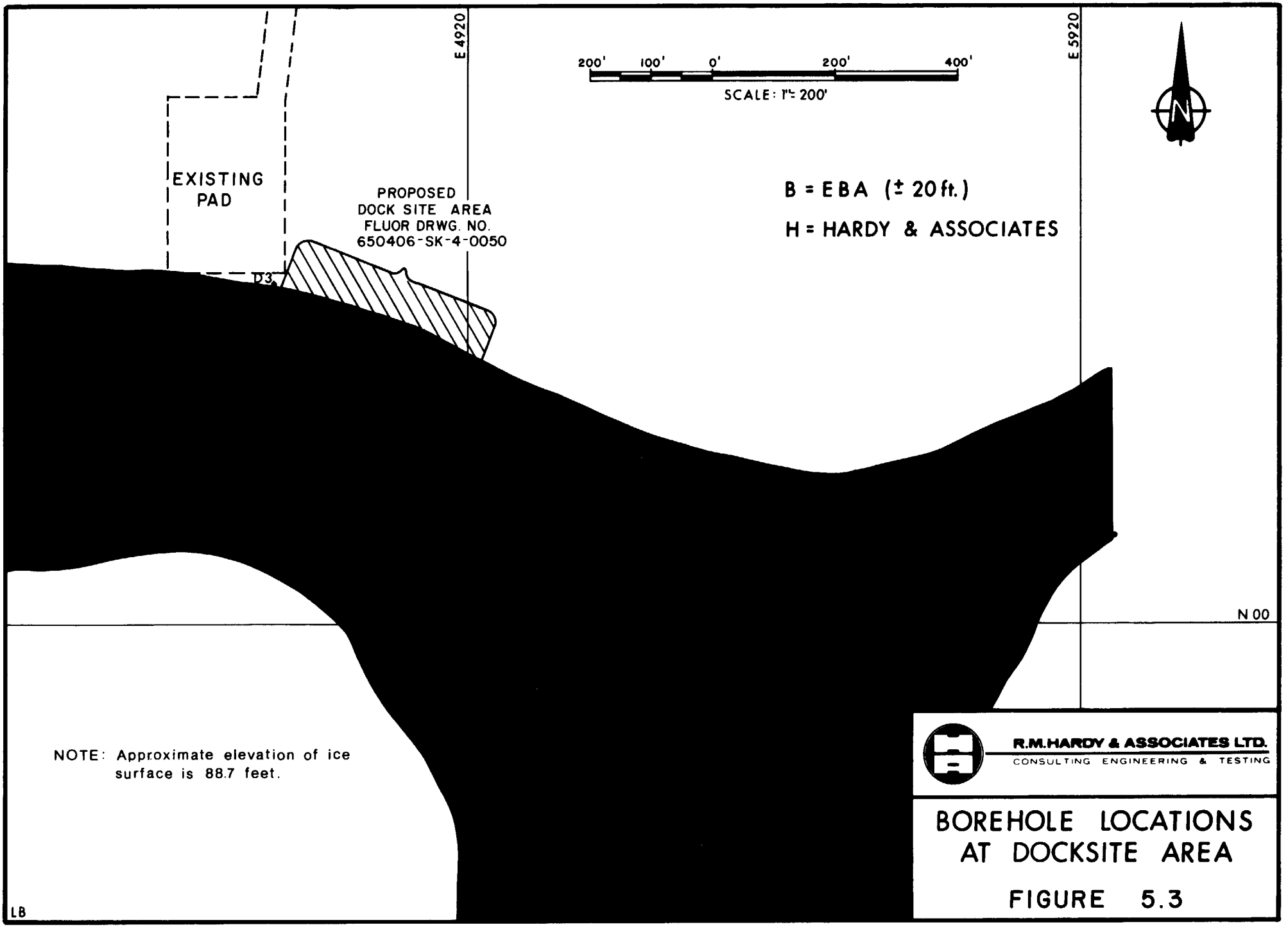
The permafrost table was delineated by either (a) retrieval of a soil sample containing ice or (b) noting the

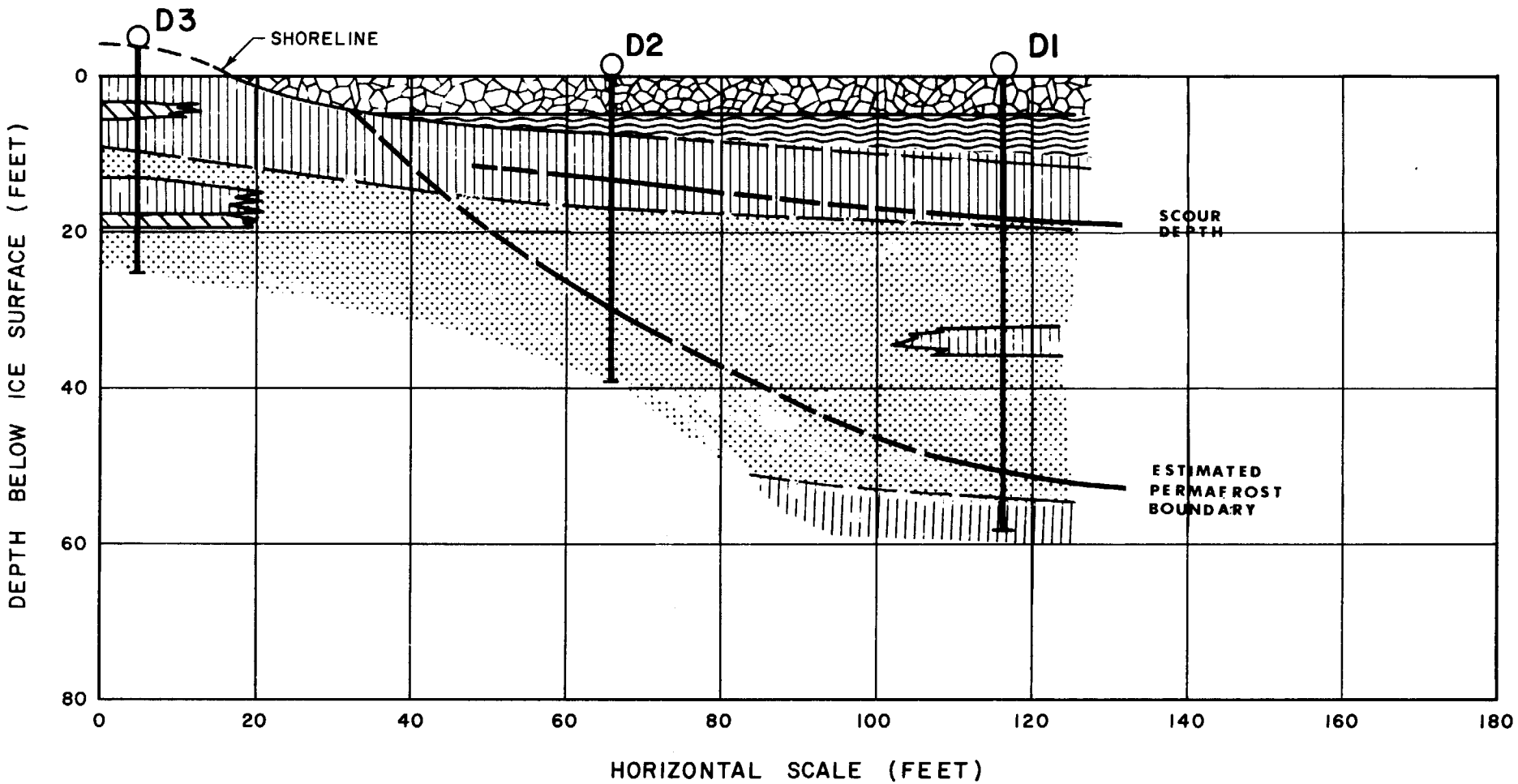
depth at which the resistance to penetration of the dynamic cone showed a sudden increase in excess of 45 blows/foot.

The "depth of scour" was defined on an empirical basis as that depth above which the dynamic cone penetration resistance was less than 5 blows/foot. This definition may not correspond exactly to the possible scour depth, but certainly indicates a surficial zone of very soft soil, that may have been reworked and whose strength should not be relied upon in the dock design.

5.2.2 Subsurface Conditions at the Docksite

Based on the drill-hole information and the field determinations of "scour" depth and permafrost table, cross-sections A-A through G-G were drawn running in a North-South direction as shown on Figure 5.3. The sections themselves are shown on Figures 5.4 through 5.11. In general, the water (plus ice) depths vary between zero at the river bank and 15 feet (5 m) within 100 feet (30 m) of the river bank. Some of the cross-sections, however, indicate a pronounced reduction in water depth between 80 and 120 feet (25 and 40 m) from shore. This reduced depth appears to be greater than about 7 feet (2 m). This same feature is reported by Slaney


E 4920
E 5920
200' 100' 0' 200' 400'
SCALE: 1"= 200'
N
EXISTING PAD
PROPOSED DOCK SITE AREA FLUOR DRWG. NO. 650406-SK-4-0050
D3
B = EBA (± 20 ft.)
H = HARDY & ASSOCIATES
N 00
NOTE: Approximate elevation of ice surface is 88.7 feet.
LB
R.M. HARDY & ASSOCIATES LTD.
CONSULTING ENGINEERING & TESTING
BOREHOLE LOCATIONS AT DOCKSITE AREA
FIGURE 5.3



LEGEND

- ICE
- WATER
- SAND
- SILT
- CLAY
- NOT DELINEATED

NOTE: Data concerning the various strata have been obtained at the borehole locations only. The soil stratigraphy between boreholes has been inferred from geological evidence and so may vary from that shown.

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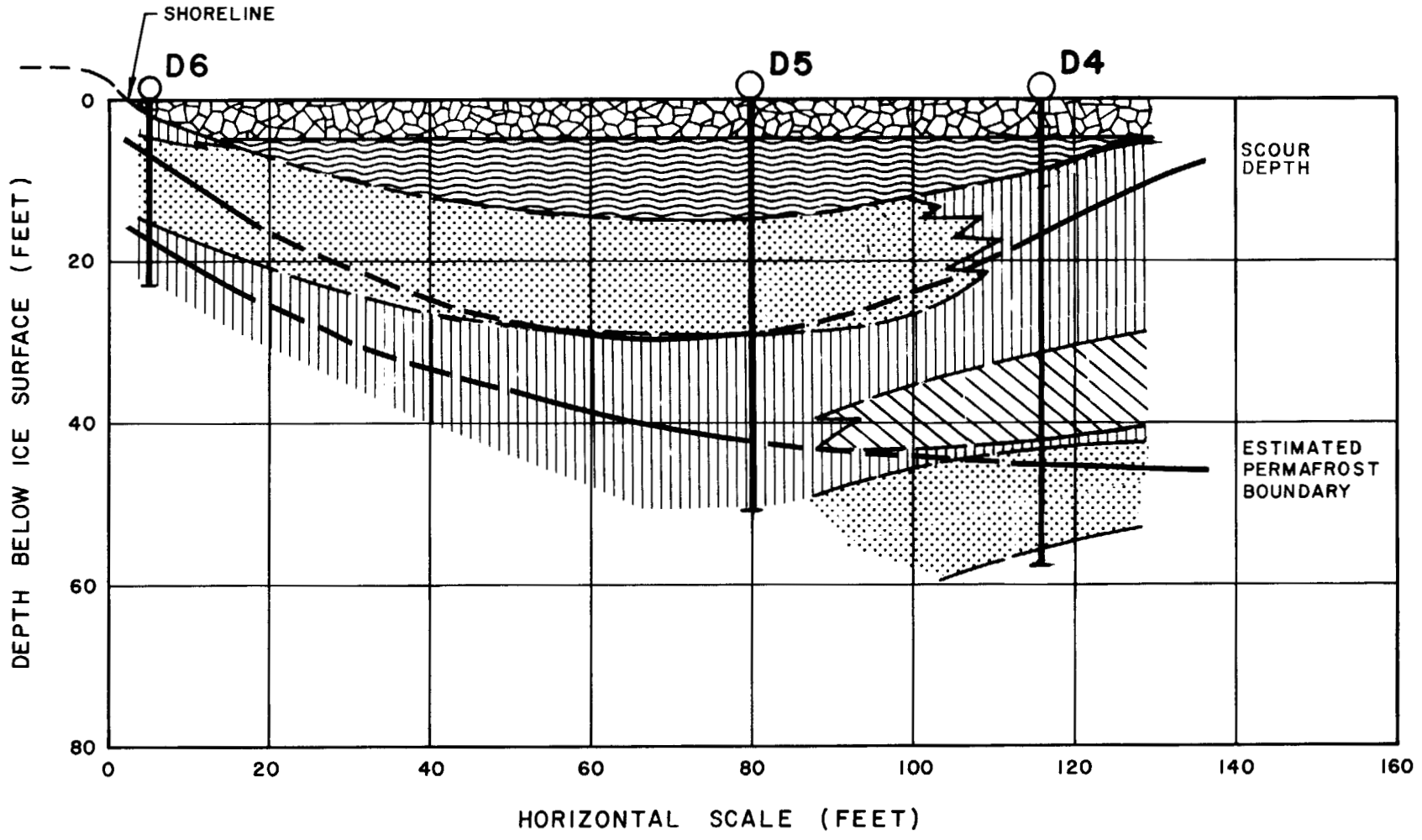
DOCKSITE AREA SECTION A-A
(LOOKING EAST)

Figure 5.4

LB



LEGEND

ICE
WATER
SAND
SILT
CLAY
NOT DELINEATED

NOTE: Data concerning the various strata have been obtained at the borehole locations only. The soil stratigraphy between boreholes has been inferred from geological evidence and so may vary from that shown.

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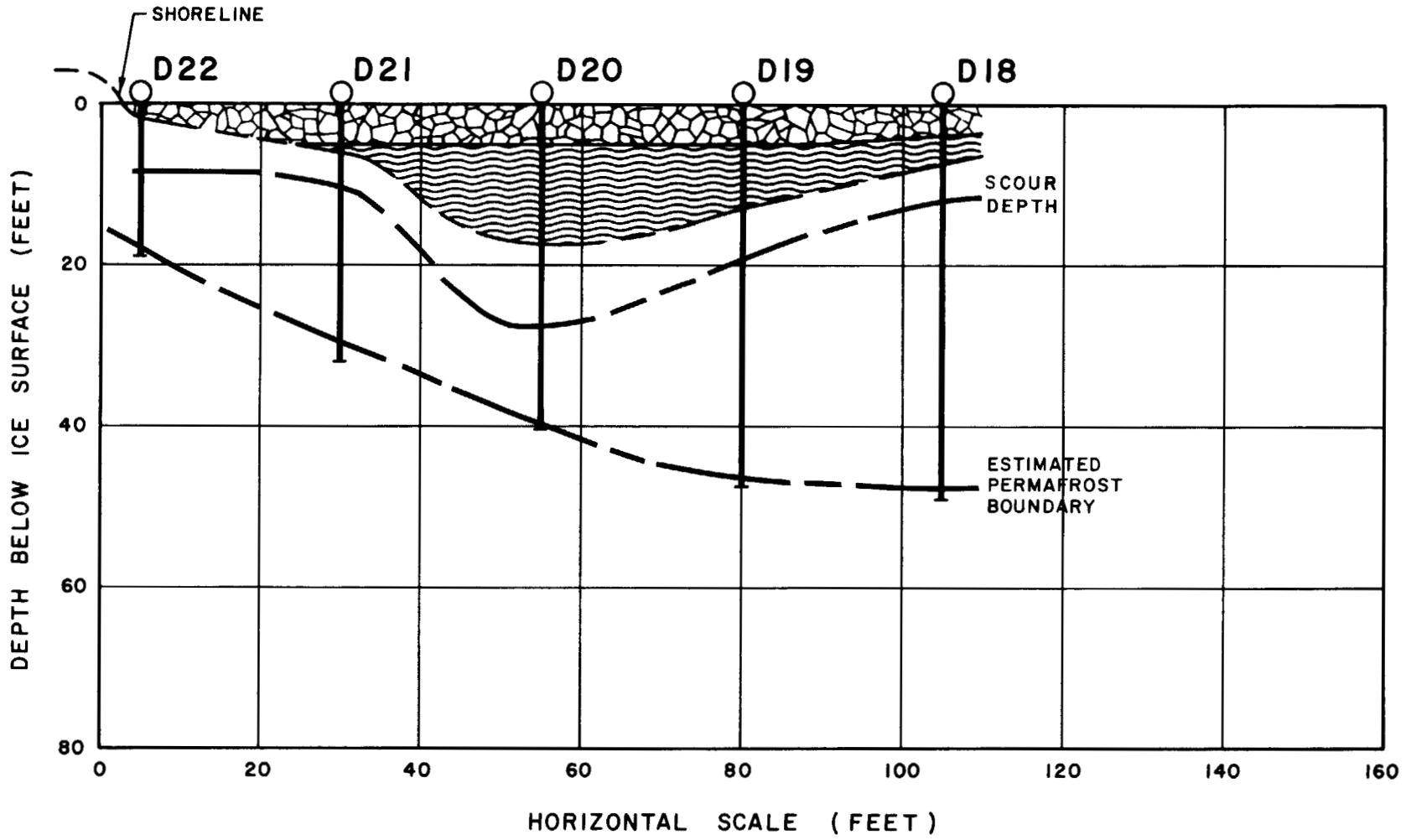
DOCKSITE AREA SECTION B-B
(LOOKING EAST)

Figure 5.5

LB



LEGEND

ICE
WATER
SAND
SILT
CLAY
NOT DELINEATED

NOTE: Data concerning the various strata have been obtained at the borehole locations only. The soil stratigraphy between boreholes has been inferred from geological evidence and so may vary from that shown.

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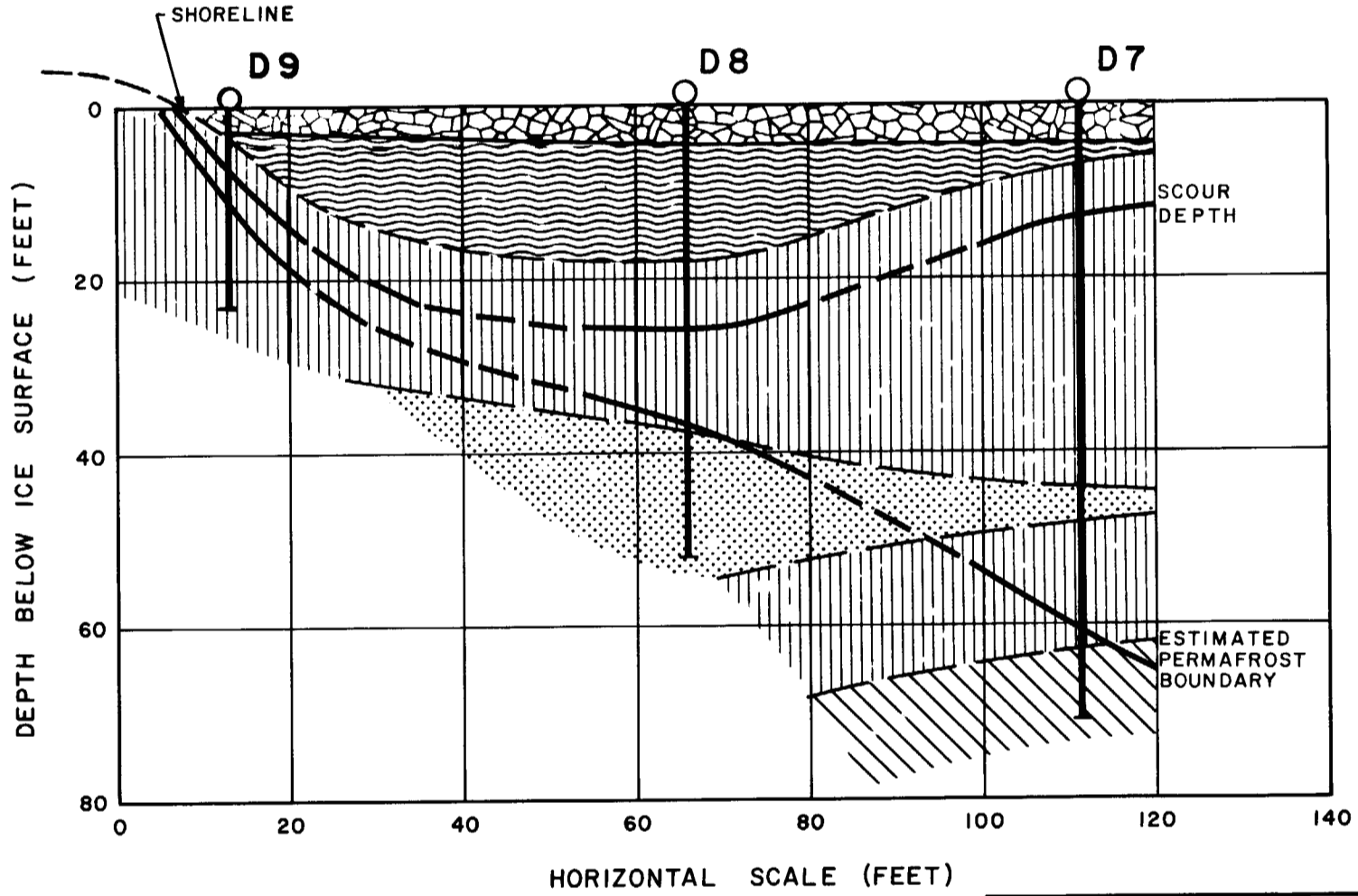
DOCKSITE AREA SECTION C-C
(LOOKING EAST)

Figure 5.6

LB



LEGEND

ICE
WATER
SAND
SILT
CLAY
NOT DELINEATED

NOTE: Data concerning the various strata have been obtained at the borehole locations only. The soil stratigraphy between boreholes has been inferred from geological evidence and so may vary from that shown.

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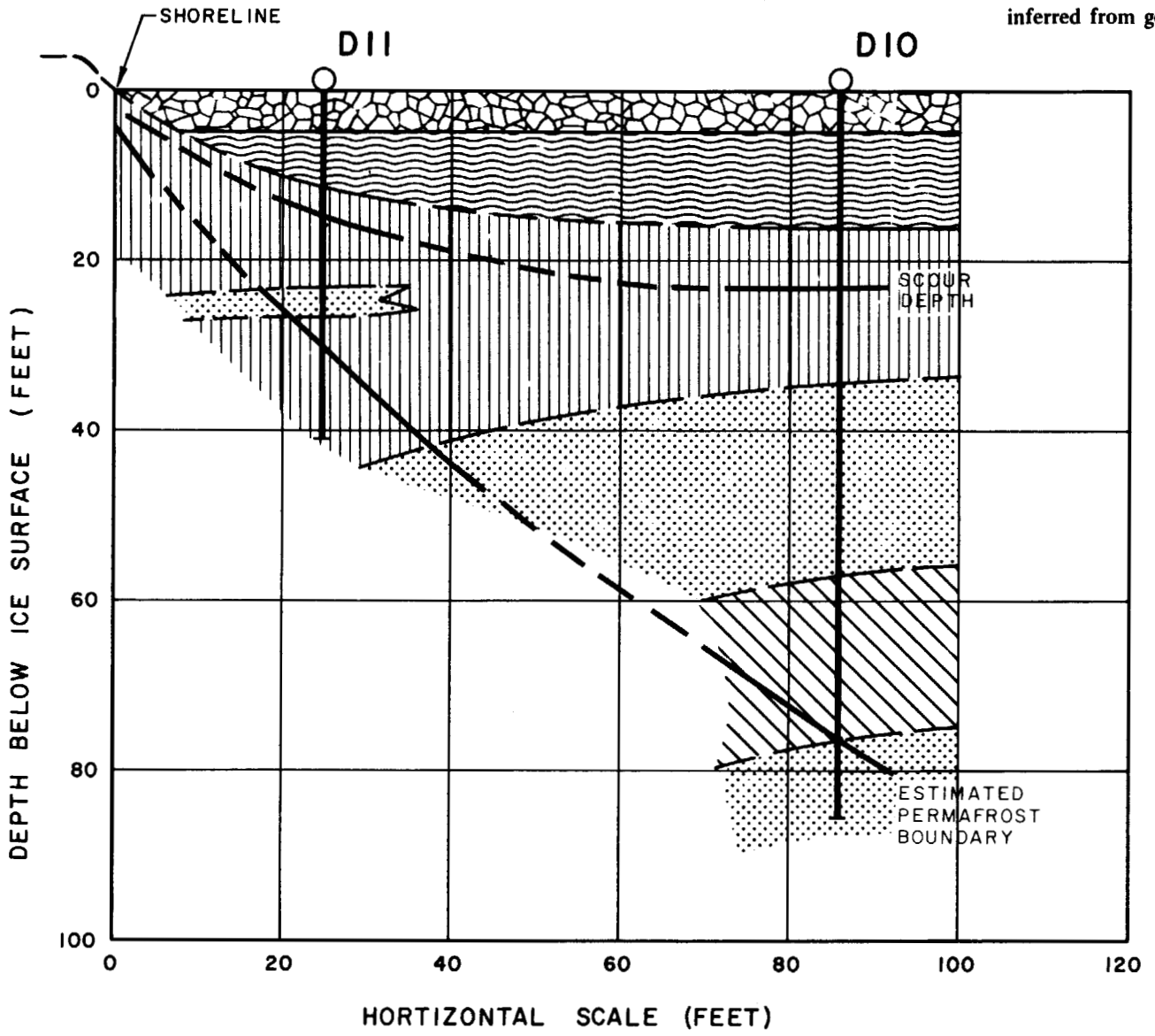
DOCKSITE AREA
SECTION D-D
(LOOKING EAST)

Figure 5.7

LB

NOTE: Data concerning the various strata have been obtained at the borehole locations only. The soil stratigraphy between boreholes has been inferred from geological evidence and so may vary from that shown.



LEGEND

- ICE
- WATER
- SAND
- SILT
- CLAY
- NOT DELINEATED

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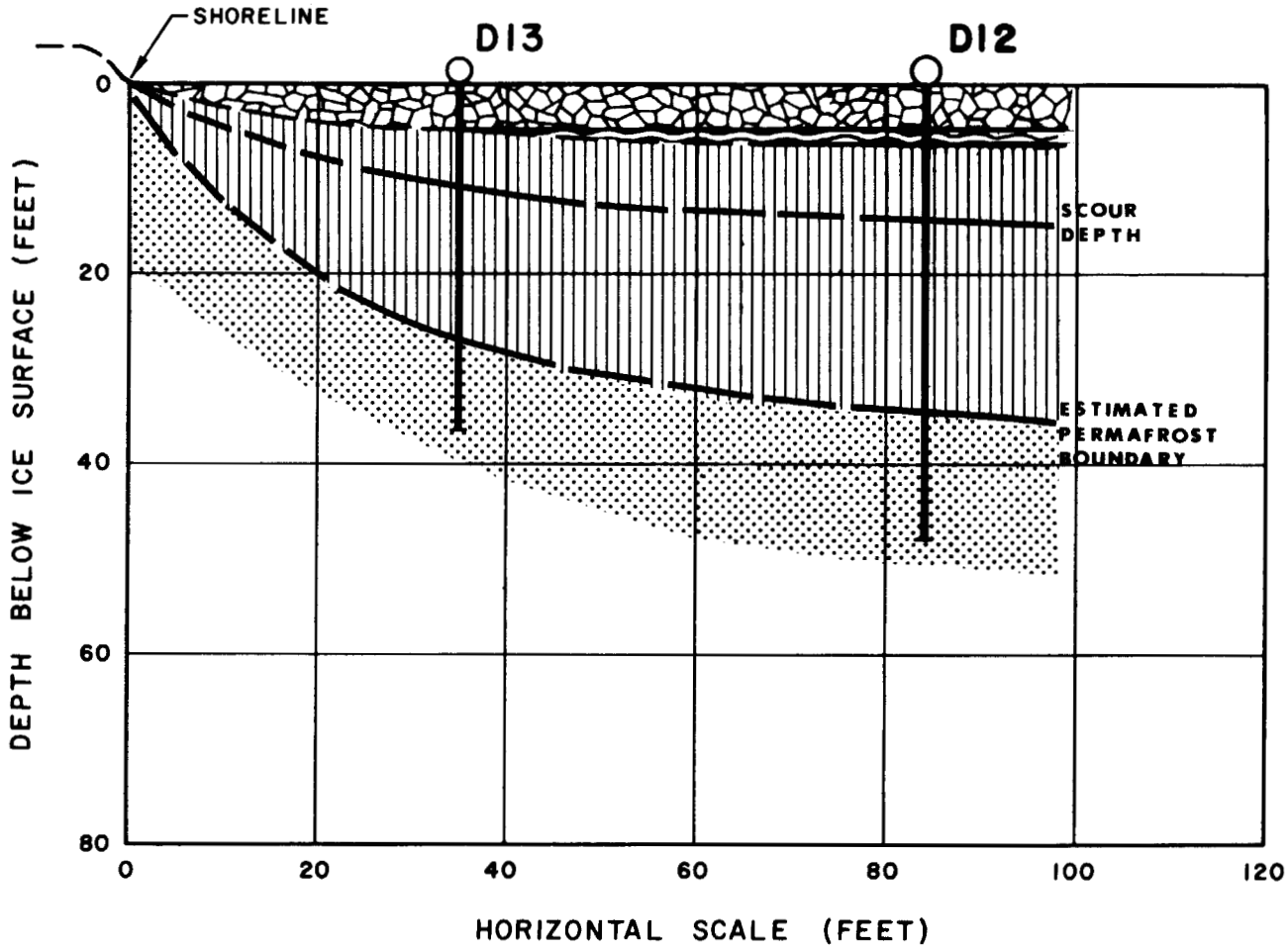
DOCKSITE AREA SECTION E-E
(LOOKING EAST)

Figure 5.8

LB



LEGEND

ICE
WATER
SAND
SILT
CLAY
NOT DELINEATED

NOTE: Data concerning the various strata have been obtained at the borehole locations only. The soil stratigraphy between boreholes has been inferred from geological evidence and so may vary from that shown.

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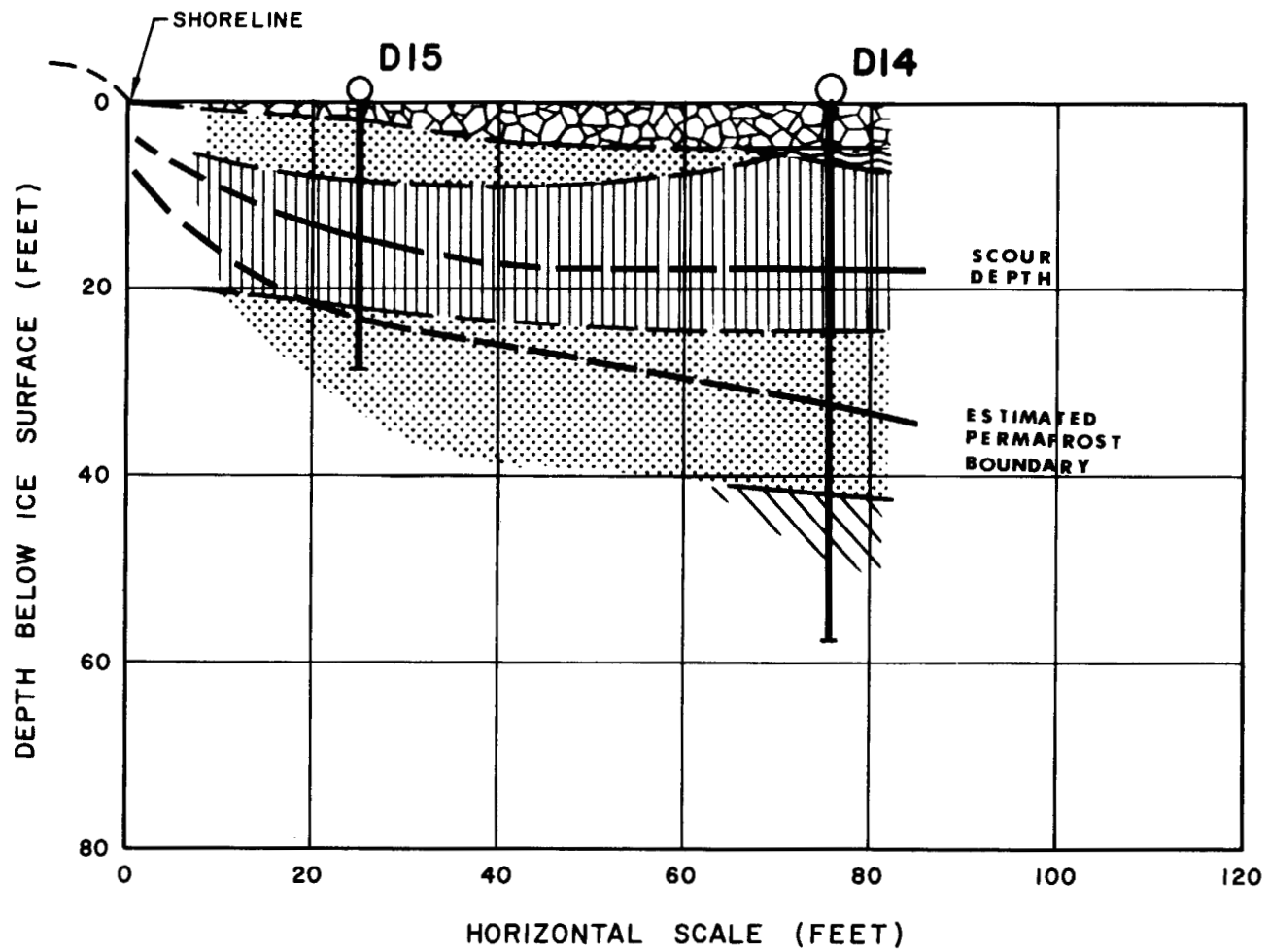
DOCKSITE AREA SECTION F-F
(LOOKING EAST)

Figure 5.9

LB



LEGEND

ICE
WATER
SAND
SILT
CLAY
NOT DELINEATED

NOTE: Data concerning the various strata have been obtained at the borehole locations only. The soil stratigraphy between boreholes has been inferred from geological evidence and so may vary from that shown.

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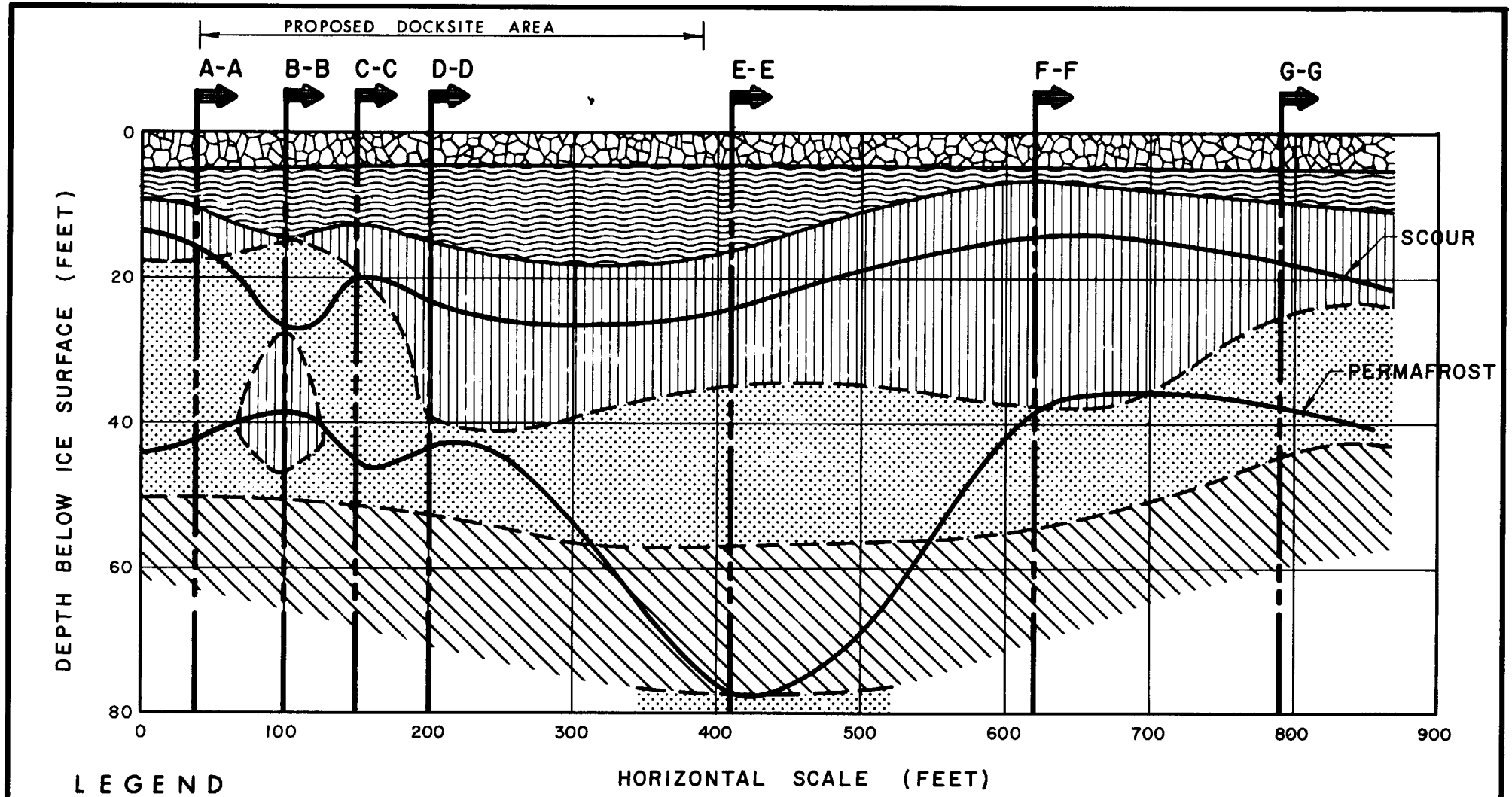
DOCKSITE AREA
SECTION G-G
(LOOKING EAST)

Figure 5.10

LB



NOTE: Data concerning the various strata have been obtained at the borehole locations only. The soil stratigraphy between boreholes has been inferred from geological evidence and so may vary from that shown.

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DOCKSITE AREA SECTION H-H
(LOOKING NORTH)

PARALLEL TO AND 80 ft. FROM SHORE

FIGURE 5.11

(1976). In general, 5 to 15 feet (1.5 to 5 m) of silt or sandy silt overlies silty sand. Some of the test holes indicate the presence of silts or clays beneath the sand at greater depths.

The position of the permafrost table beneath the river is a typical feature of the thermal regime beneath an Arctic river at these latitudes. The depth to permafrost varies from zero at the shoreline to depths of 50-70 feet (15 to 20 m) a distance of 100 feet (30 m) from shore. The actual position of the permafrost table may vary a few feet from that shown, due to the difficulties in logging the first occurrence of permafrost in the field. No "islands" of permafrost were delineated during the subsurface investigation, and although it is unlikely that such islands are present, the possibility of encountering them over 200-300 feet (60-90 m) of dock installation certainly exists. A summary of the depths to permafrost below river bed level is shown on Figure 5.12.

The depth of scour as defined above varies generally between 5 and 10 feet (1.5 and 3 m) at most locations investigated. Sections B-B and C-C show an increased scour depth about 60 feet (18 m) from shore. The maximum scour

depth below river bed level here was 14.5 feet (4.4 m), and coincides with an area of deeper water. A summary of the information on scour depth is presented on Figure 5.13. A discussion of scour depth in the context of riverbed morphology is included in section 5.2.3.

The consistency or in-situ strength characteristics of the unfrozen soils at the docksite has been evaluated using dynamic cone and standard penetration tests. In addition, laboratory strength tests were carried out on selected samples of the unfrozen soils to assess soil strength for design purposes. Plates B-1 through B-37 contain the dynamic cone penetration results for test holes at the dock site. A summary of the dynamic cone penetration data recorded for all boreholes is shown on Figure 5.14. Penetration data are included for sands, silts and clays, together with data for frozen soils. Considerable scatter is evident in the data, but a general trend of increasing strength with depth is observed. No clear distinction can be made with regard to different soil types. Almost all of the data points for frozen materials are greater than 45 blows/foot, and this fact was used to assist in defining the position of the permafrost table in test holes that were advanced using the dynamic penetration device alone.

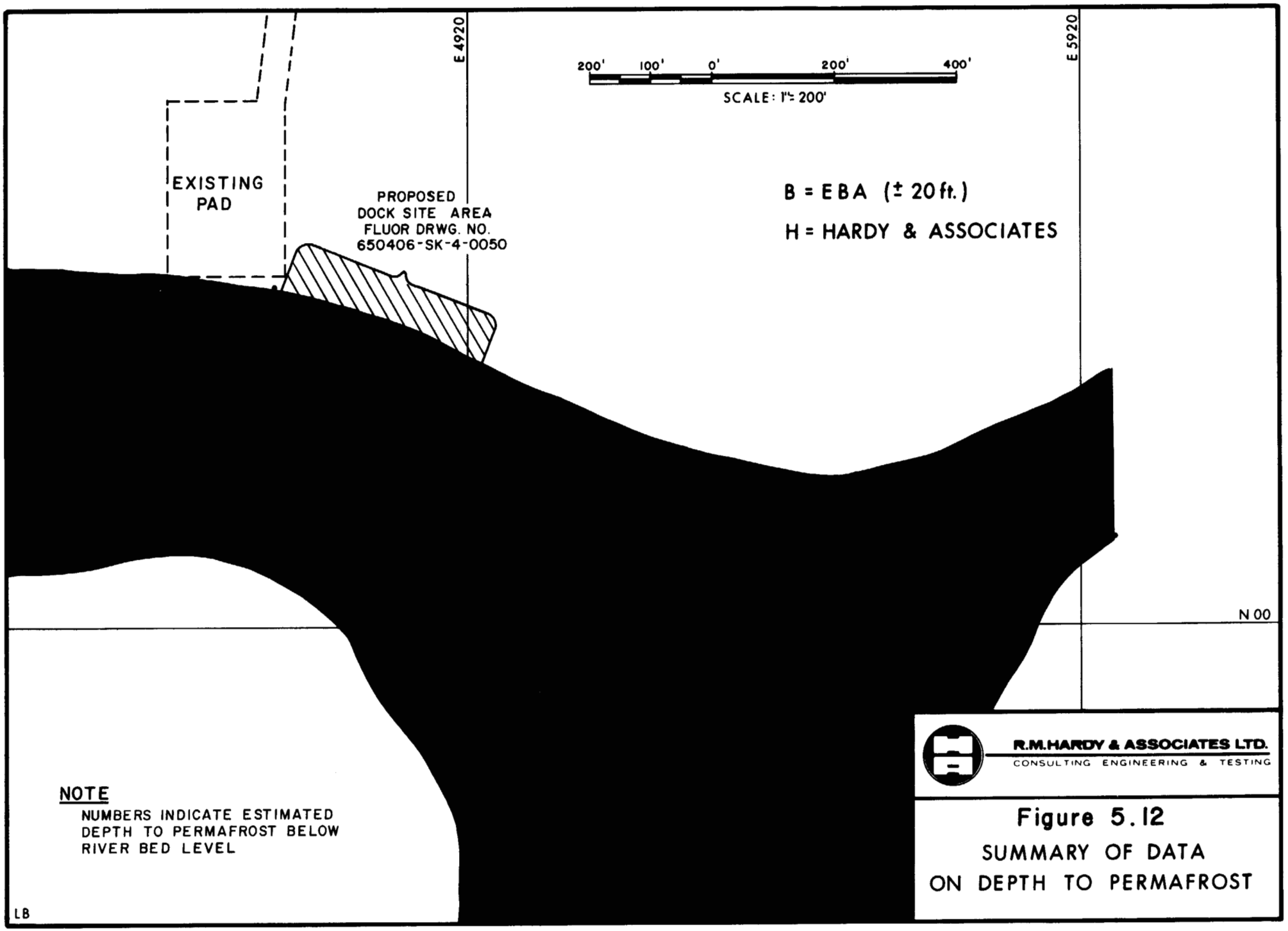

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Figure 5.12
SUMMARY OF DATA
ON DEPTH TO PERMAFROST

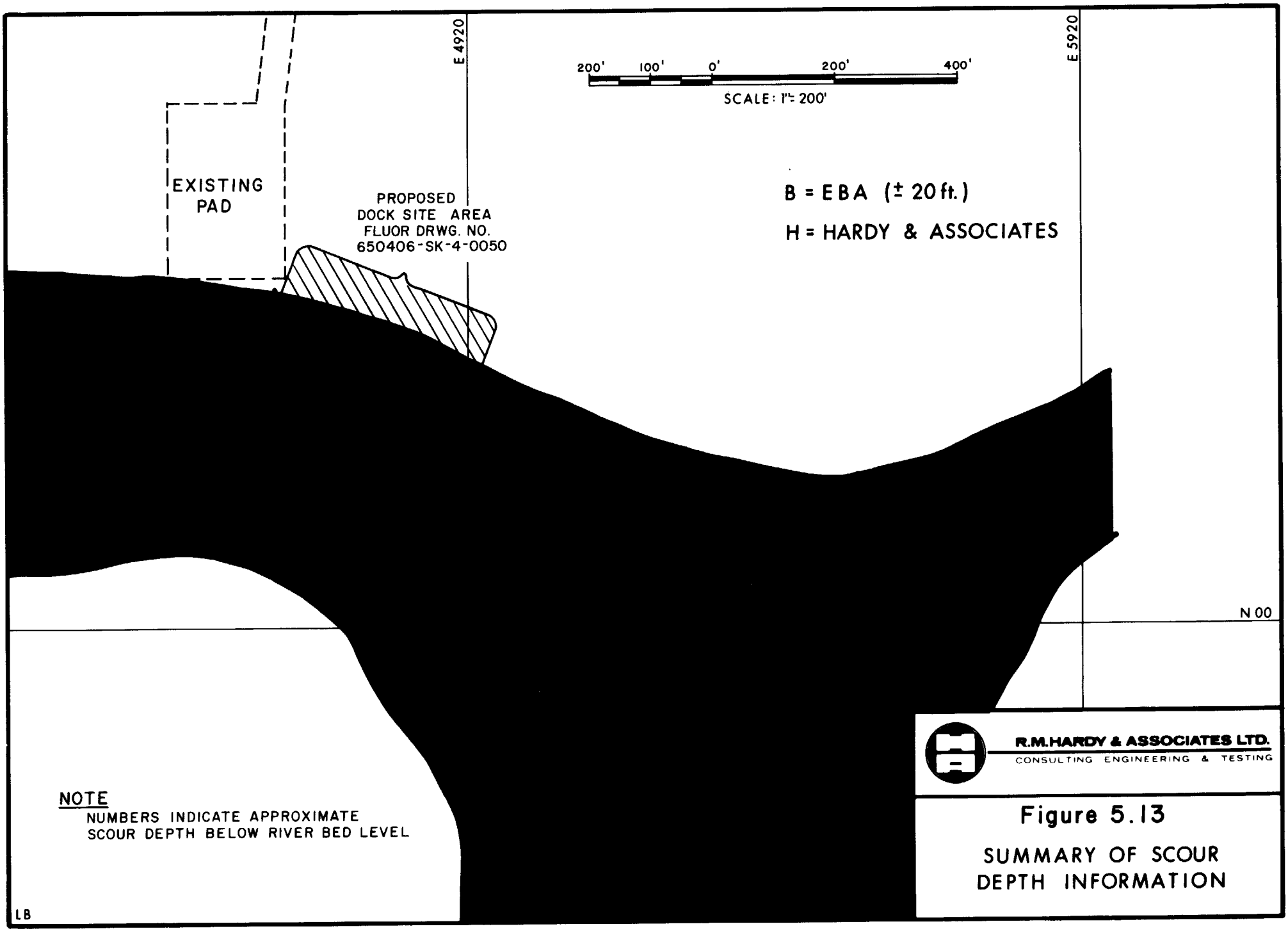

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Figure 5.13

SUMMARY OF SCOUR DEPTH INFORMATION

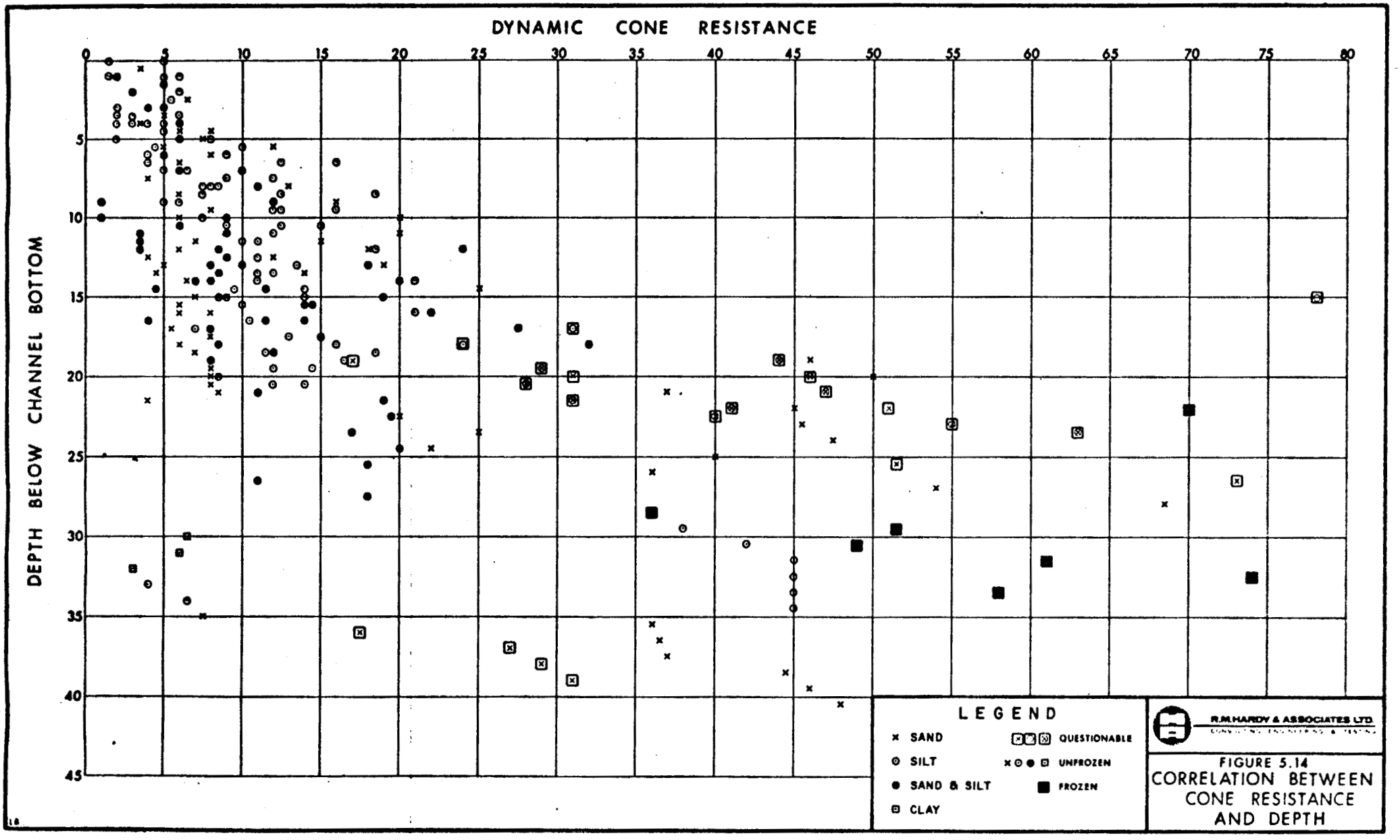


FIGURE 5.14
CORRELATION BETWEEN CONE RESISTANCE AND DEPTH

Based on established relationships between dynamic penetration tests and the relative density or consistency of soils, the following assessment of the unfrozen sediments at the dock-site can be made.

Depth below river bed level (feet)	Lower bound of Dynamic Cone Resistance (Blows/foot)	Relative Density
0-Scour (approx. 8 ft)	2	Very Loose
Scour-20	6	Loose
20-30	18	Medium
30-permafrost	36	Dense

In the depth range greater than 30 feet (9 m), some of the cone penetration data indicate layers of low density soils at depth. These are generally confined to layers of soft clay or organic silt and are probably not representative of typical conditions at depth at the site.

An unconfined compression test on a sample of sandy silt from 14 feet (4.3 m) below river bed level gave an unconfined compressive strength of 920 p.s.f. (44 kPa). This low compressive strength reflects the sandy non-plastic

nature of this stratum. Two drained trixial tests on samples of sandy silt from 8 and 18 feet (2.5 and 5.5 m) below river bed level provided effective strength parameters as follows:

Sample	Depth below River bed level (feet)	Dry Density (p.c.f.)	Effective Strength Parameters	
			cohesion	friction angle
H76-D4 (U2)	8.0	81	C'=0;	Ø'=35°
H76-D4 (U6)	18.0	93	C'=0;	Ø'=38°

These friction angles are probably representative of the stronger, more intact samples that could be retained in the sample tubes, and looser, weaker soils could not be retained during the sampling operations, and therefore could not be tested. Consequently, these values represent the higher strength parameters that might be anticipated for the sandy silts at this location.

Some limited testing of the permafrost underlying the unfrozen sediments was carried out to determine the likely thaw settlement of the permafrost, should long-term deepening of the permafrost table occur near the outer limit

of the proposed dock. The frozen bulk densities of the permafrost lie between 118 and 120 p.s.f. (about 1.9 Mg/m^3). Based on thaw strain tests and these bulk density values, a strain of 2 to 4 percent may be anticipated where deepening of the permafrost table occurs.

The compressibility of the unfrozen sediments beneath the dock pad can be estimated from the consolidation behaviour of similar frozen soils after they have been thawed in the laboratory. Based on such laboratory tests, the value for the coefficient of compressibility, m_v, of the unfrozen sandy silts is estimated to be 0.02 to 0.04 ft^2/ton.

The application of this parameter in estimating dock pad settlement following construction is discussed later in section 5.2.4.

5.2.3 Riverbank Migration and Channel Scour

Several factors will govern the precise location and final design the dock. Channel bank migration and potential scour depth are two of the more important factors and are discussed in the following paragraphs. It is important to recognize that the design of the structure and the

two phenomena discussed herein are interdependent so that the potential for migration and scour should be assessed at each design stage.

5.2.3.1 Channel Bank Migration

The area of interest encompasses the Kuluarpak Channel of the Mackenzie River Delta from where it deviates from the Harry Channel to a point approximately 1 3/4 miles (2.8 km) downstream.

The section of concern within the Kuluarpak Channel is "S" shaped, 400 to 600 feet (120 to 180 m) wide and 25 to 50 feet (8 to 15 m) deep. The banks and the bottom have a shallow slope angle (10° to 20°) with no apparent river bank erosion. Slow slumping due to the thermal niching is manifested above the normal high water line at about elevation 89.5 feet (27.3 m). The normal fluctuations of the water level in the Kuluarpak Channel are in the order of 2 feet (0.6 m) with peak levels due to the spring break-up and summer storm surges up to a possible elevation of 97.0 feet (29.6 m).

Comparitive aerial photography techniques have been used to assess potential river bank migration. Two different air-photo coverages were employed for this purpose.

The low quality of the older 1:40,000 scale air photos eliminated the possibility of establishing the water elevations in relationship to the banks and surrounding ground and made the determination of the changes in the river channel difficult. Therefore, a correlation between the more recent 1:10,000 scale set and the blow-up of 1:40,000 air photos into the 1:10,000 scale was chosen as the best approach to establish any possible shifting of the river channel. First, the shoreline from the 1:10,000 scale photo was traced under the stereoplotter on a transparent sheet. Subsequently the shoreline from the enlarged 1:40,000 scale air photo was plotted on the same sheet as shown on Figure 5.15.

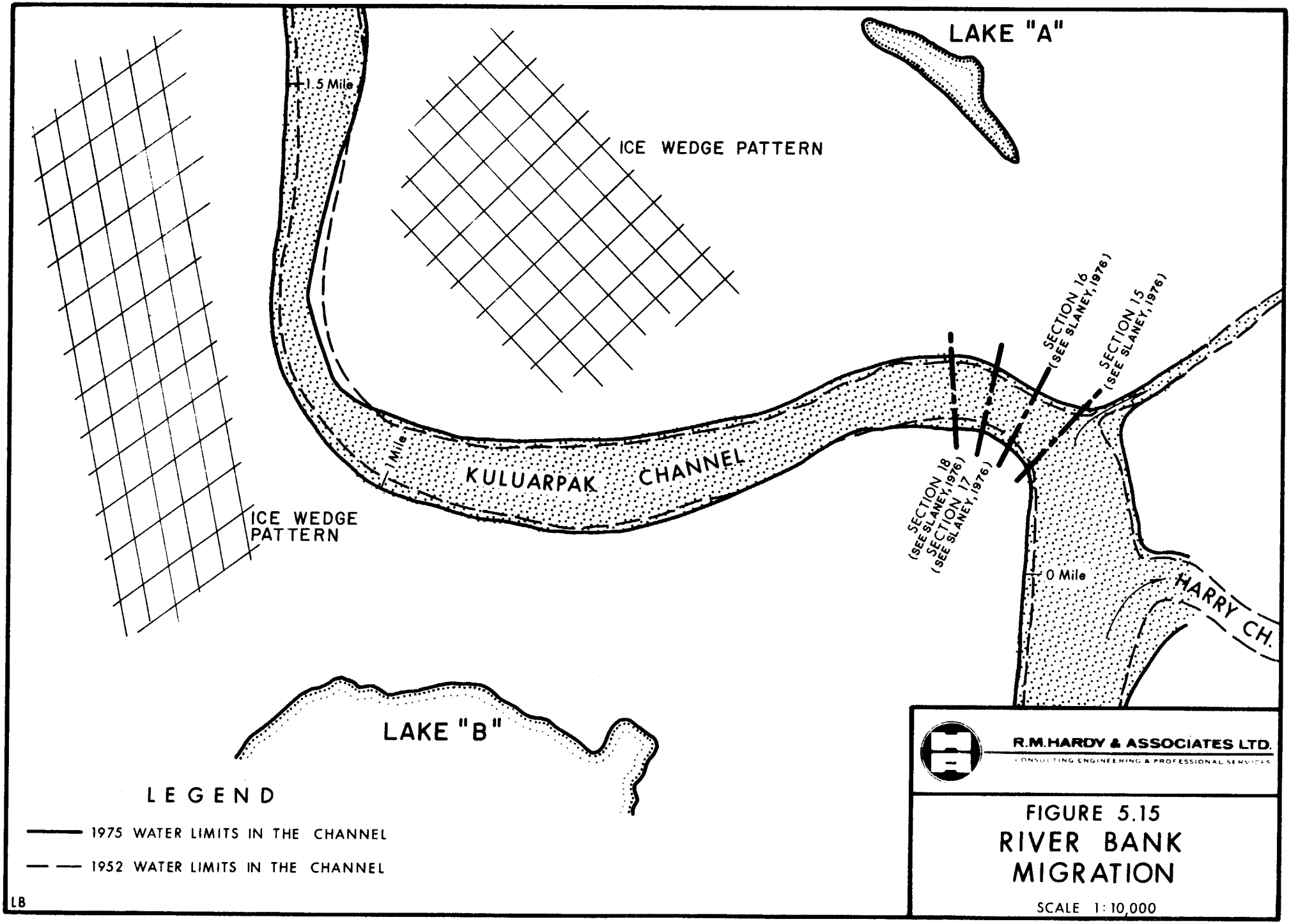
A well developed net of ice-wedge polygons on both sides of the river channel together with two small lakes (Lake "A" and Lake "B") made it possible to match the air photo and blow-up, thereby minimizing the influence of the optical distortion. The following observations were made comparing the two shorelines as delineated on each set of air photos:

For the first mile from the place where the Kuluarpak Channel splits from the Harry Channel the 1975 channel contours closely follow the channel contours of 1950. The only difference is that the recent air photos show that the shoreline receded on each side some 33 to 50 feet (10 to 15 m) compared to its position in 1950.

The next 0.5 miles (0.8 km) of the channel indicate a positive shifting of the channel to the west. The western shoreline remains the same distance from the shoreline 25 years ago, while the eastern shoreline was moved some 100 feet (30 m) to the west.

For the last 1,300 feet (400 m) both shorelines on the recent air photos are once again outside the 1950 channel limits with 50 feet (15 m) overlap on the western side and up to 16 feet (5 m) on the eastern side.

These observations lead to the conclusion that the channel widened over the past 25 years some 15 to 50 feet (5 to 15 m) along the northern and eastern bank and some 30 to 50 feet (9 to 15 m) along the southern and western bank with the exception of a 0.5 mile (0.8 km) section where the channel shifted 100 feet (30 m) to the west. This would indicate a rate of widening of approximately 1.2 feet per year (0.36 m/year).


LAKE "A"
1.5 Mile
ICE WEDGE PATTERN
SECTION 16 (SEE SLANEY, 1976)
SECTION 15 (SEE SLANEY, 1976)
1 Mile
KULUARPAK CHANNEL
SECTION 18 (SEE SLANEY, 1976)
SECTION 17 (SEE SLANEY, 1976)
ICE WEDGE PATTERN
0 Mile
HARRY CH.
LAKE "B"
LEGEND
1975 WATER LIMITS IN THE CHANNEL
1952 WATER LIMITS IN THE CHANNEL
LB
R.M. HARDY & ASSOCIATES LTD.
CONSULTING ENGINEERING & PROFESSIONAL SERVICES
FIGURE 5.15
RIVER BANK MIGRATION
SCALE 1:10,000

However, there are indications that the 1975 air photos represent the shoreline at the high water mark while the 1950 air photos represent the channel at the low water level. Under such circumstances, the actual channel widening would be considerably smaller than indicated by the above established differences in the shoreline position. It is our opinion that the only significant change is represented by the westward shifting or narrowing of the channel, within its segment 1.0 to 1.5 miles (1.5 to 2.5 km) from the point where the Kuluarpak Channel deviates from the Harry Channel.

These estimates of river bank migration confirm independent field observations by R. M. Hardy & Associates Ltd. personnel in the summer of 1975 that an average regression at the dock site of 0.3 to 1.0 feet per year (0.1 to 0.3 m/year) might be expected. The central position of the channel thalweg, low energy gradient combined with the short duration of high water coinciding with the thawed bank probably help to explain the comparatively low rate of migration. The construction of the dock structure will very likely further reduce the erosion along the north bank both upstream and downstream of the site. Thus we believe that bank migration will not be of great concern at the proposed site.

5.2.3.2 Potential Scour Depth

The bed level at any given time and location will vary with

- general aggradation
- movement of bed forms
- local scour due to channel bends, structures, etc.

Given the general nature of the delta, the low channel slopes, and fine grained bed materials; bed level changes due to aggradation and movement of bed forms at the proposed dock site will be relatively minor. The depths to which the river bed materials are re-worked on a regular basis to the present time have been estimated during this program using in-situ testing techniques. The results of these investigations have been summarized on Figure 5.13. On the other hand there will be local scour caused by the structure itself. Depending upon its final shape and extent it will likely have much the same effect as a spur projecting into the channel.

Kuluarpak channel has been analysed for local scour at the proposed dock site. The analysis is based on a section which is equivalent to station 15 of the Slaney

(1976) report. Depths are related to the June 10, 1975 water level which may be taken as the bankfull condition. The corresponding flow in Kuluarpak channel on 10 June 1975 was 28,600 cfs (810 $m^3/s.$). Assuming that the dock projects approximately 90 feet (27 m) into the channel (i.e., to station 3+60) at which point the depth is 10 feet (3 m) below high water, it is estimated that the local scour effect could result in a scour depth of 50 feet (15 m) below bankfull stage. Depending on the depth of water at this time, this suggests potential scour depths of 30-35 feet (9-10.5 m) below present channel bed depth, for the example cited above (i.e., dock projecting 90 feet into channel). The present maximum channel depth varies from 40 to 50 feet (12 to 15 m) without any imposed structure, and it is possible that this low point may migrate in time towards the North bank of the channel, in view of the fact that the dock structure constricts channel flow, and imposes a rigid outside wall in lieu of an erodible bank. This method of calculating the maximum scour depth is based on the design approaches outlined for example by Blench (1957 and 1969) and Neill (1973). Although the permafrost table may offer temporary resistance to such potential scour, recession of the permafrost table after partial removal of the unfrozen sediments may occur. Some design measures are available which can help to reduce the potential scour. These include

the alignment of the dock face into the flow at an angle of 10 degrees or less, feathering the dock into the bank and placement of gravel or larger size stone around the base of the structure.

If a design approach is adopted where piling for dock structure is driven to refusal, then the shift of the thalweg can be monitored annually, and should it become a cause for concern, an erosion control method (e.g., "Fabriform" type apron) can be employed to control further scour.

5.2.4 Soil Parameters for Barge Dock Design

5.2.4.1 Dock Pad Settlement

An estimate of the consolidation settlement of the dock pad surface following construction may be obtained from the following equation:

$$S = m_v . H . \Delta P \qquad (5.1)$$

where S is settlement in feet

H is the thickness of the unfrozen soil above the permafrost table (feet)

ΔP is the increase in vertical effective stress due to pad construction (tons/ft^2)

and m_v is the coefficient of soil compressibility (ft^2/ton)

Two tests were carried out on undisturbed permafrost cores in which the samples were thawed and subsequently consolidated. The compression characteristics of these two samples are likely to be representative of the behavior of the overlying unfrozen sediments. Over the stress range likely to be experienced by the unfrozen soils beneath the barge dock pad, the tests provided the following results.

Sample	Soil Type	Moisture Content (%)	Frozen Density (p.c.f.)	Compressibility, m_v (ft^2/ton)	Thaw Strain (%)
H76D5-C1	silt	26.9	118.3	0.038	2.4
H76D8-C1	sand	26.4	119.9	0.014	1.6

In view of the fact that silts predominate beneath the dock locations, a value of

$$m_v = 0.04 \text{ ft}^2/\text{ton}$$

should be used to provide an estimate of total pad settlement following construction.

The stress increase, ΔP, following construction can be estimated from the following equation:

$$\Delta P \text{ (in t.s.f.)} = (\gamma H_1 + \gamma' H_2)/2000 \qquad (5.2)$$

where γ is the total unit weight of fill above the low water level ($\gamma \doteqdot 125$ p.c.f.)

γ' is the submerged unit weight of gravel ($\gamma' \doteqdot 65$ p.c.f.)

H_1 is the height of fill above low water level (feet)

H_2 is the height of fill below water level (feet)

The total pad settlement following construction can therefore be calculated readily. The method of calculating the rate at which such settlements will develop has not been presented, but it is likely that up to a year may elapse before most of the consolidation settlement has been experienced.

The above estimate of total settlement does not include the consolidation or possible lateral displacement of the very soft near surface sediments that may occur during fill pad placement. Settlements arising from this source will likely take place during construction, and will require placement of additional fill material to offset these effects. In view of these initial settlements and possible lateral soil displacements, it would be advisable to place the dock pad prior to installation of the dock structure. If the dock pad is placed subsequent to the dock

pad structure, larger settlements of the bed material should be accounted for in design.

Should deepening of the permafrost table occur beneath the dock structure adjacent to the river, the thaw strains measured above indicate that the settlements resulting from deepening of the permafrost table by a few feet will be small in comparison with the pad settlements resulting from consolidation of the existing unfrozen sediments.

5.2.4.2 Soil Properties for Design of Dock Structure

Based on the results of laboratory triaxial tests and the field dynamic penetration test results, (see Figure 5.14 and section 5.1) the following strength parameters are recommended for use in barge dock design where sands and silts are present:

Depth Range below river bed level (feet)	Submerged Density (p.c.f.)	Strength Properties		Earth Pressure Coefficients	
		C'	Ø'	Active, K_a	Passive, K_p
0-scour (approx. 8')	50	0	0	1.0	1.0
Scour-20	55	0	28	0.36	3.5
20-permafrost	60	0	32	0.3	4.5

Should the dock structure be located on an area where the subsurface investigation delineated significant clay layers, then the density and strength properties for the clay layer should be as follows:

For clays, Submerged density γ' = 55 p.c.f.

Strength C'=0; ϕ'=28°

Active Earth Pressure Coefficient K_a = 0.36

Passive Earth Pressure Coefficient K_p = 3.5

For sand or gravel fill placed to form the dock structure, the following soil properties should be assumed:

C' = 0

ϕ' = 32°

γ_{total} = 125 p.c.f.

γ'(submerged) = 62 p.c.f.

Active Earth Pressure Coefficients:

for end-dumped or lightly compacted fill, K_a = 0.4

for compacted fill, K_a = 0.7

Surcharge loadings due to stockpiles, vehicles or off-loading equipment should be accounted for in design of dock structures. Methods of estimating the lateral pressures on the dock structures from such loads are outlined, for example, in the Navfac DM-7 Design Manual (1971).

5.2.5 Other Geotechnical Considerations

5.2.5.1 Ice Forces

The various forces that ice may exert on the dock structure may be listed as follows:

(i) Impact from floating ice masses. These forces would normally be experienced at break-up, and would depend on the thickness of the ice sheet, the consistency of the ice and the river velocity. Observations carried out by Slaney (1976) provide information on this design aspect.

(ii) Uplift or downdrag forces caused by ice adhering to the dock structure. Fluctuations in river level during the winter period may cause tangential forces to be transmitted to the dock structure. Such forces will depend on the rate of fluctuation, and the strength, temperature and thickness of the ice sheet.

(iii) Static lateral pressures imposed by the river ice sheet. Little information is available on the likely magnitude of such forces, but experience gained by Imperial Oil Limited and other agencies with similar structures in this area should pro-

vide assistance in this regard. A number of publications dealing with lateral ice pressures on structures might be consulted, including Kivisild (1966), Assur (1966) and Drouin (1966).

5.2.5.2 Frost Action

The near-surface soils at the dock location are presently in an unfrozen condition, due to the presence of the river. Placement of the dock pad will change the thermal regime of the soil surface beneath the dock pad. The ground surface thermal conditions will then approach those experienced by the adjacent tundra surface, which is underlain by permafrost. It should therefore be anticipated that permafrost will aggrade slowly back into the unfrozen soils beneath the dock pad.

Assuming that about 10 feet (3 m) of granular fill overlies the river bed materials, it is estimated that frost will penetrate through the fill pad within 2 to 3 years. Subsequently, the frost line will likely continue to descend into the unfrozen material beneath. Considering the silty nature of the river-bed materials, there is at least the potential for ice lensing and some frost heaving to occur. Although the relatively large surcharge pressures imposed by

the dock pad will greatly restrain the amount of frost heaving, it should be anticipated that some heaving will occur once the frost line penetrates the subsoils. A rigorous estimate of the amount of heaving has not been carried out, but prior analyses for soils of similar grain size distribution have indicated heave rates up to several inches per year may occur. These rates will decrease with time as the frost line penetrates deeper, and the overburden pressure on the frost line increases.

Deep-seated frost action will likely not affect the performance of the dock structure itself, as its proximity to the river will ensure that freezing and consequent heaving in the unfrozen silts immediately adjacent to the dock structure will not occur.

Piping, water intake facilities and other permanent structures founded on the dock pad should therefore be designed to accomodate differential movements resulting from frost heaving.

5.3 Big Horn Channel

5.3.1 General

Consideration of alternative borrow sources may provide economic benefits in the general Taglu area, in view of the high cost of granular material. The presence of sandy deposits on the riverbank near Big Horn Point, together with the surficial geological mapping, led Imperial Oil Limited to drill exploratory holes in the river bed in Harry Channel in the winter of 1974/75. The results of the preliminary evaluation of the river bed material is reported by E.B.A. Engineering Consultants (1975). Large deposits of silty sand overlain by silt overburden were delineated and it was concluded that a potentially exploitable borrow resource existed in Harry Channel near Big Horn Point. The suitability of the material was evaluated in terms of its acceptability for dredging, handling and placement, but not in terms of acceptability for heaving capacity, compaction or frost susceptibility in place.

In order to confirm the quantities of available material, and augment the existing information on the quality of the deposit, the present field program included the drilling of eleven test holes in the areas of Harry Channel that seemed most promising in terms of material quality and quantity.

5.3.2 Subsurface Conditions

The location of the study area in Harry Channel is about 3 miles (5 km) North-East of the plant site, and is shown on Figure 5.16. Eleven test holes were drilled at the locations on this figure, five along the centre of Harry Channel (section A-A), three parallel to section A-A along the East bank of the channel (section C-C), two along an East-West tributary (section B-B) and one hole on an island in the channel.

The test hole logs are shown on Figures C-1 through C-21 in Appendix C, together with laboratory moisture content data. Grain size distribution curves were determined in the laboratory for selected soil samples to assist in delineating the overburden and assessing the quality of the sand deposits. The grain size curves are presented on Figure C-22 through C-43 of Appendix C. A summary of the laboratory tests carried out is included at the end of this Appendix.

In general, the channel deposits consist of a variable thickness of silt (0-20 feet (6 m)) overlying a silty sand. The thickness of silt becomes greater than 20

feet (6 m) at the extremeties of the study area. The sand is generally a fine uniform deposit that varies between 10% and 50% silt content. Using the test hole data obtained from the previous (E.B.A.) study and the present program, section A-A, B-B and C-C have been prepared as shown on Figures 5.17, 5.18 and 5.19.

5.3.3 Borrow Evaluation

In order to evaluate the quality and quantity of the borrow from a dredging and handling viewpoint, the following criteria were established following discussion with Fluor Canada Ltd. and Imperial Oil Limited.

(a) The depth of excavation below river bed level would not exceed 50 feet (5 m), and depths of 25, 35 and 50 feet (7.6, 10.7 and 15.2 m) were to be considered for calculation purposes.

(b) The limits of the area suitable for borrow recovery was to be limited to the segments of the river channel where the depth of silt overburden was generally less than 20 feet (6 m).

(c) The borrow excavation would be assumed to have side slopes of 3:1.

505 000 m. E.

507 000 m. E.

7 699 000 m. N.

7 698 000 m. N.

7 697 000 m. N.

BB 5

BB 3

BB 4

BB 6

BB 2

BB 1

HARRY CHANNEL

BLUFF AREA

B

BH 3

BH 9

C'

B'

A'

× 20

BOREHOLE PLAN

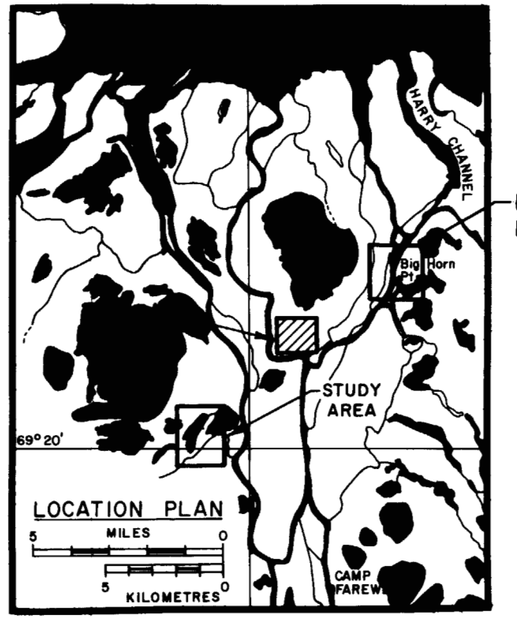
500 0 500

METRES

FEET

1000 0 1000 2000

SCALE: 1 : 10 000



BOREHOLE LEGEND

⊙ R.M. HARDY, 1976

× EBA, 1975 (approx.)

NOTE

1976 BOREHOLE LOCATION AND RIVER BANKS BASED ON CANADIAN ENGINEERING SURVEY DWG. Nº 8363-M-2 FOR IMPERIAL OIL LIMITED.

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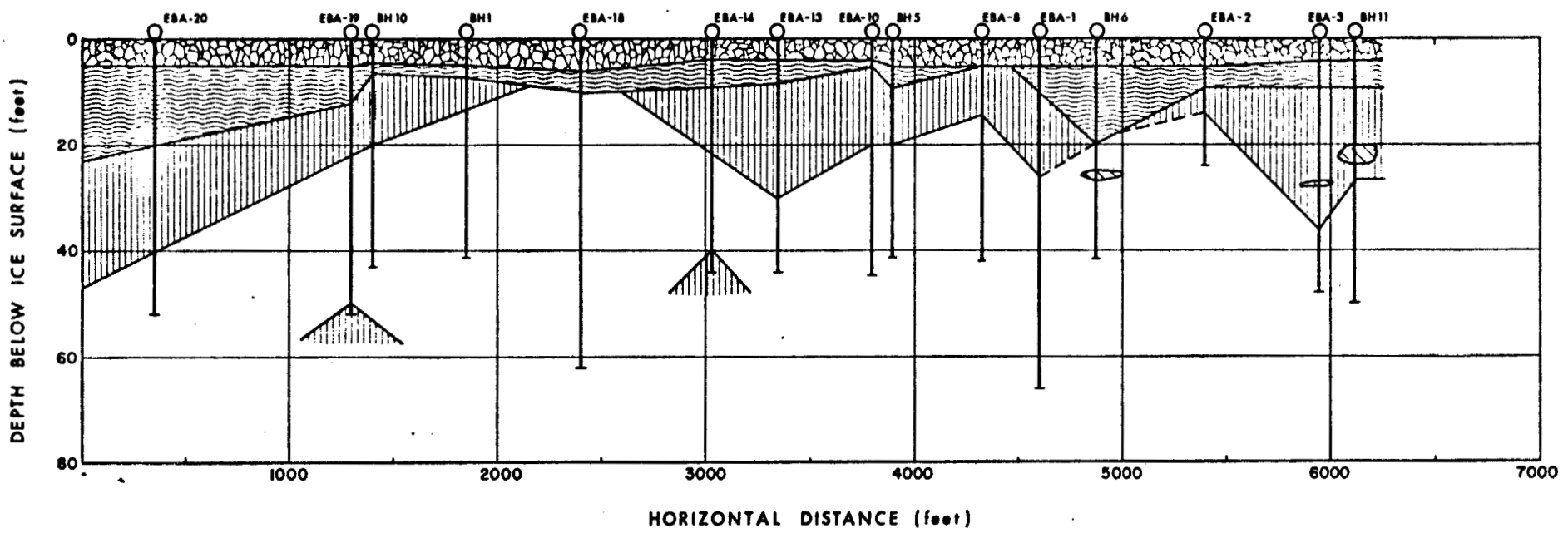
BOREHOLE LOCATION PLAN BIG HORN POINT AREA

FIGURE 5.16

LB



LEGEND

- ICE
- WATER
- SILT
- SAND

NOTE: Data concerning the various strata have been obtained at the borehole locations only. The soil stratigraphy between boreholes has been inferred from geological evidence and so may vary from that shown.

NOTE

PREFIX EBA DENOTES EBA 1975 DRILLING PROGRAM

PREFIX BH DENOTES R.M. HARDY & ASSOCIATES LTD. 1976 DRILLING PROGRAM

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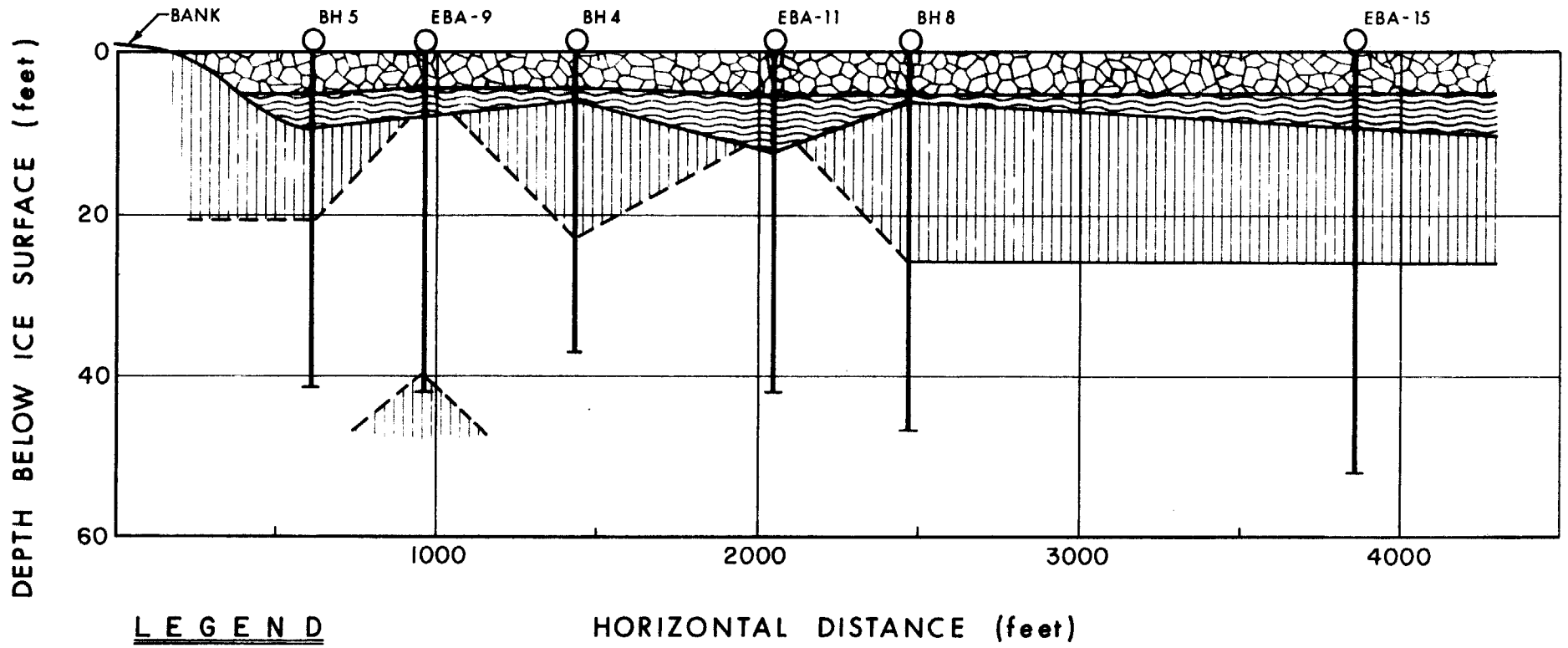
Figure 5.17
BIG HORN POINT
CHANNEL BORROW
SECTION A-A

LB



LEGEND

- ICE
- WATER
- SILT (OVERBURDEN)
- SAND (SUITABLE FOR PROCESSING)

NOTE

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NOTE: Data concerning the various strata have been obtained at the borehole locations only. The soil stratigraphy between boreholes has been inferred from geological evidence and so may vary from that shown.

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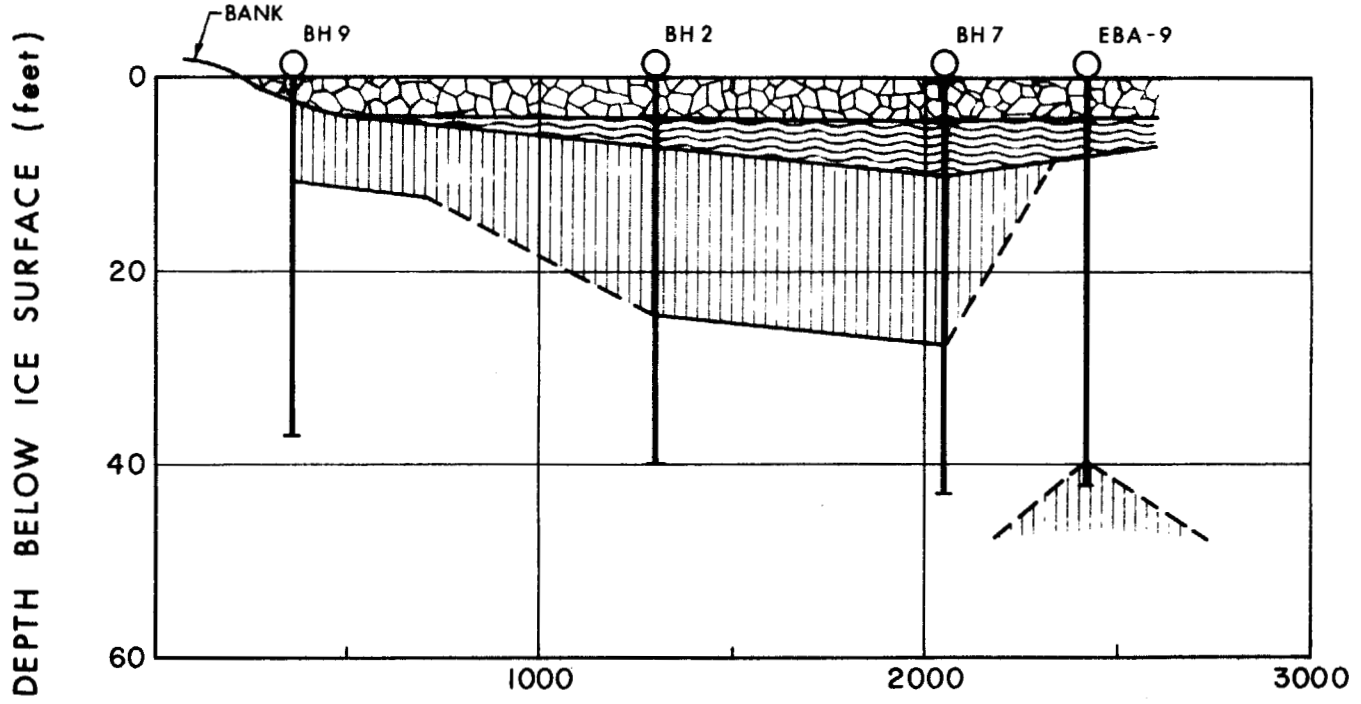
Figure 5.18
BIG HORN POINT
CHANNEL BORROW
SECTION B - B



LEGEND

- ICE
- WATER
- SILT (OVERBURDEN)
- SAND (SUITABLE FOR PROCESSING)

NOTE. Data concerning the various strata have been obtained at the borehole locations only. The soil stratigraphy between boreholes has been inferred from geological evidence and so may vary from that shown.

NOTE

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Figure 5.19
BIG HORN POINT
CHANNEL BORROW
SECTION C - C

LB

(d) The "volume of material suitable for processing" was defined as that material having greater than 50% sand sizes (i.e., less than 50% passing the #200 sieve).

(e) The "volume of processed fill" was defined as the volume remaining after a separation method was used to reduce the silt fraction to a maximum of 10%.

Fill material would be lost during dredging and subsequent separation, but these loss factors have not been estimated or introduced into the following calculations for borrow volumes, as these will vary with the dredging, handling and separation techniques adapted. The cross-sections shown on Figures 5.17, 5.18 and 5.19, together with the grain size data included in Appendix C were used to calculate the potentially exploitable volumes of borrow.

The total volumes of waste, material suitable for processing, processed material and overburden ratios are summarized in Table 5.1 for sections A-A and B-B, and are plotted on Figure 5.20.

The volume of processed fill increases with the depth of excavation (1.4 x 10^6 cu. yds at 25 feet to 2.9 x 10^6 cu. yds at 50 feet). The volume of overburden remains constant however, and when combined with the material wasted during separation, provides an overburden ratio that decreases (improves) with increases in the depth of excavation (see Figure 5.20). Assuming a 35 foot (10.7 m) excavation, a volume of processed material of 2.2 million cubic yards (1.7 x 10^6 m^3) has been calculated. Assuming, for example, that a further 30% of this material is lost during dredging handling and separation, approximately 1.5 million yards (1.1 x 10^6 m^3) of processed material is available.

The quality of the in-place sand deposit and the amount of overburden vary considerably with location along the river channel. Table C-2 in Appendix C shows the detailed borrow calculations, and this table may be used to evaluate volumes for different locations in the river channel. The largest volumes and most favourable overburden ratios appear to be between Test Holes 14 and BH1 on section A-A (see Figure 5.16).

This 1200 foot (370 m) segment of the channel would yield about 514,000 cubic yards (393,000 m^3) of processed

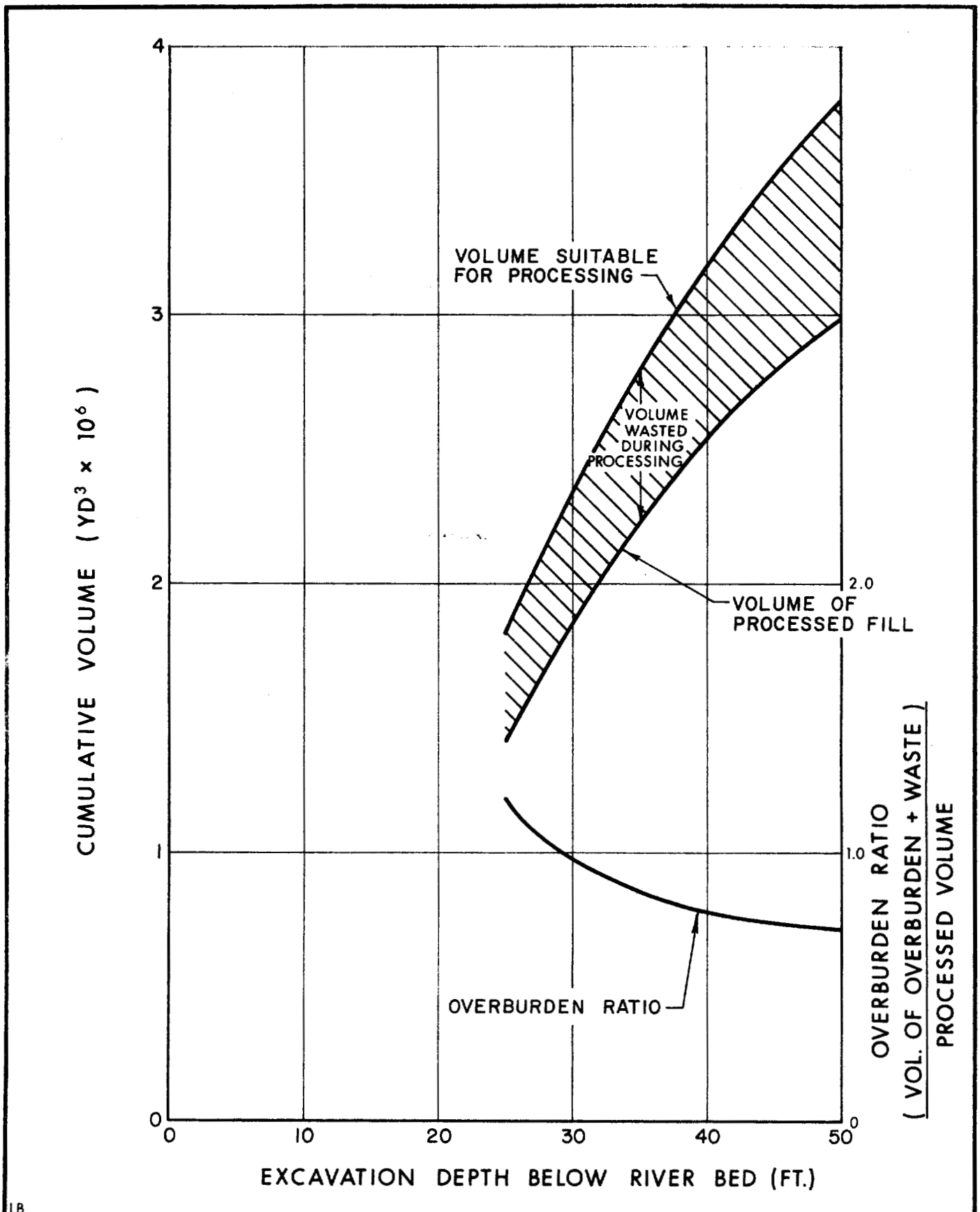

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Figure 5.20
BIG HORN POINT
FINE SAND FILL

Table 5.1 Summary of Borrow Calculations

Excavation Depth ft.	Overburden (yd^3)	Volume of Material Suitable for Processing	Cumulative Total Waste yd^3 without overburden	Volume of Processed Fill yd^3	Total Waste + Overburden $(yds)^3$	Average Overburden Ratio
25	1,330,229	1,807,827	387,722	1,420,105	1,717,951	1.21
35	1,330,229	2,795,494	565,902	2,229,592	1,896,131	0.85
50	1,330,229	3,804,160	814,389	2,989,771	2,144,751	0.72

(No loss factor assumed for handling, processing etc.)

These results are plotted on Figure 5.20.

material from a 35 foot (10.7 m) excavation, with 103,000 cubic yards (78.000 m^3) of waste and 73,000 cubic yards (56,000 m^3) of overburden. The ratio of overburden and waste to processed material at this location is therefore 0.34.

The feasibility of the separation process, and the geotechnical qualities of the material when placed have not been considered within the scope of the present work, and these factors must be considered before this source of borrow is designated for use as a core material in pads and roads for this project.

5.4 Big Horn Point Bluff

A total of six test holes were drilled at different locations on the bluff at Big Horn Point. The locations of those holes are shown on Figure 5.16. The logs for the test holes are included in Figures D-1 to D-6 of Appendix D.

The logs indicate that the bluff is comprised of variable thicknesses of sand, silt and clay. Sand does not constitute a large proportion of the soil types delineated in this area. Considerable thicknesses of ground ice were logged in these test holes, and are indicative of a high intensity of ice wedges and other ice forms at this site.

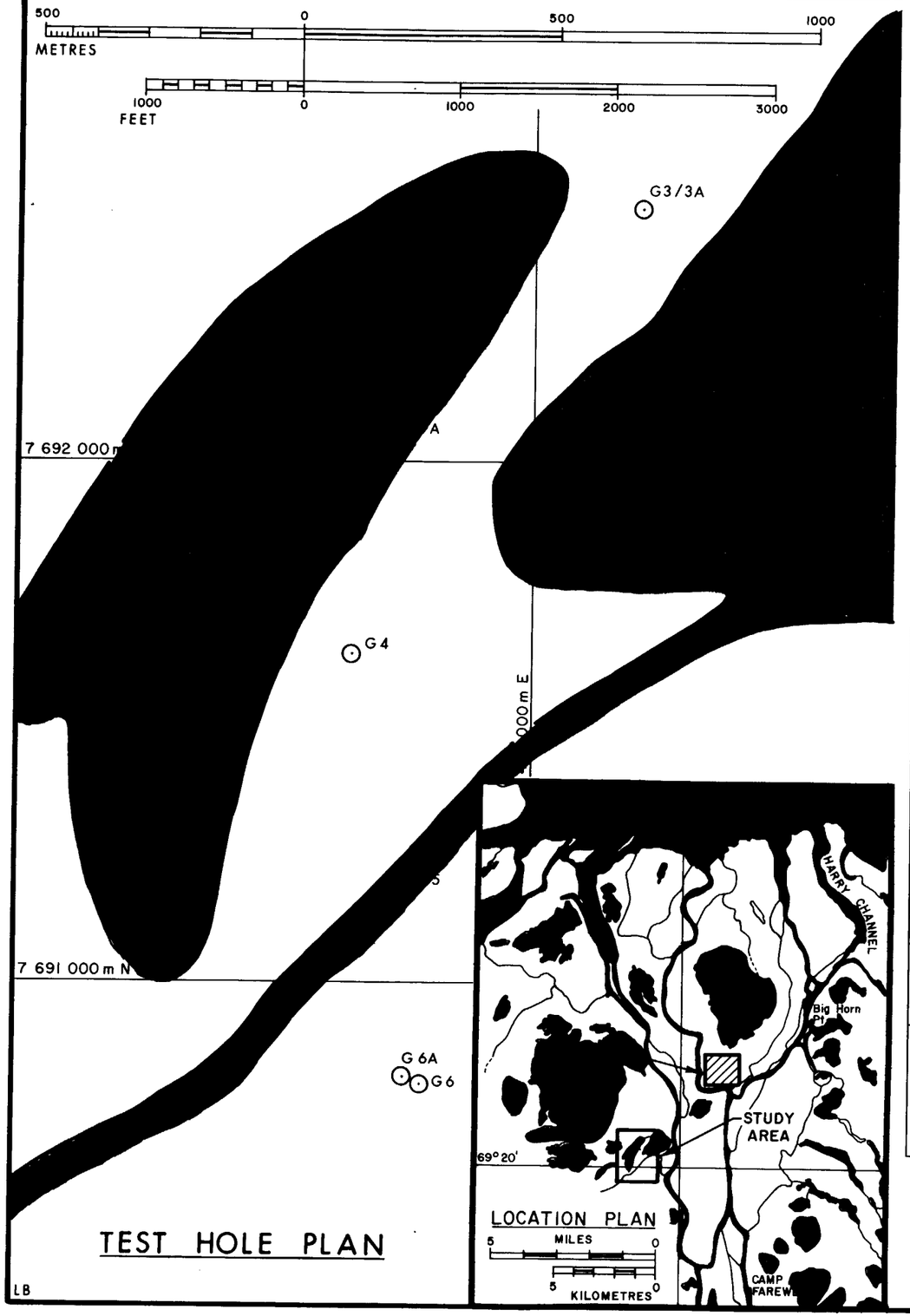
The sand observed on the slopes of the bluff and on the adjacent beach are likely colluvial deposits derived from the relatively minor deposits of sand intersected during the drilling program.

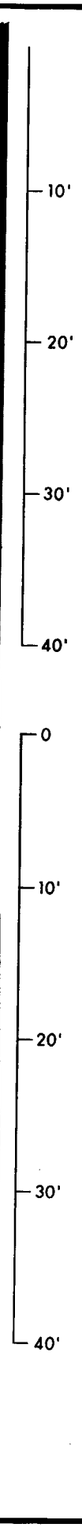
No attempt has been made to draw cross-sections of the soil profile at this location, because of the high variability of the subsoils over relatively short distances.

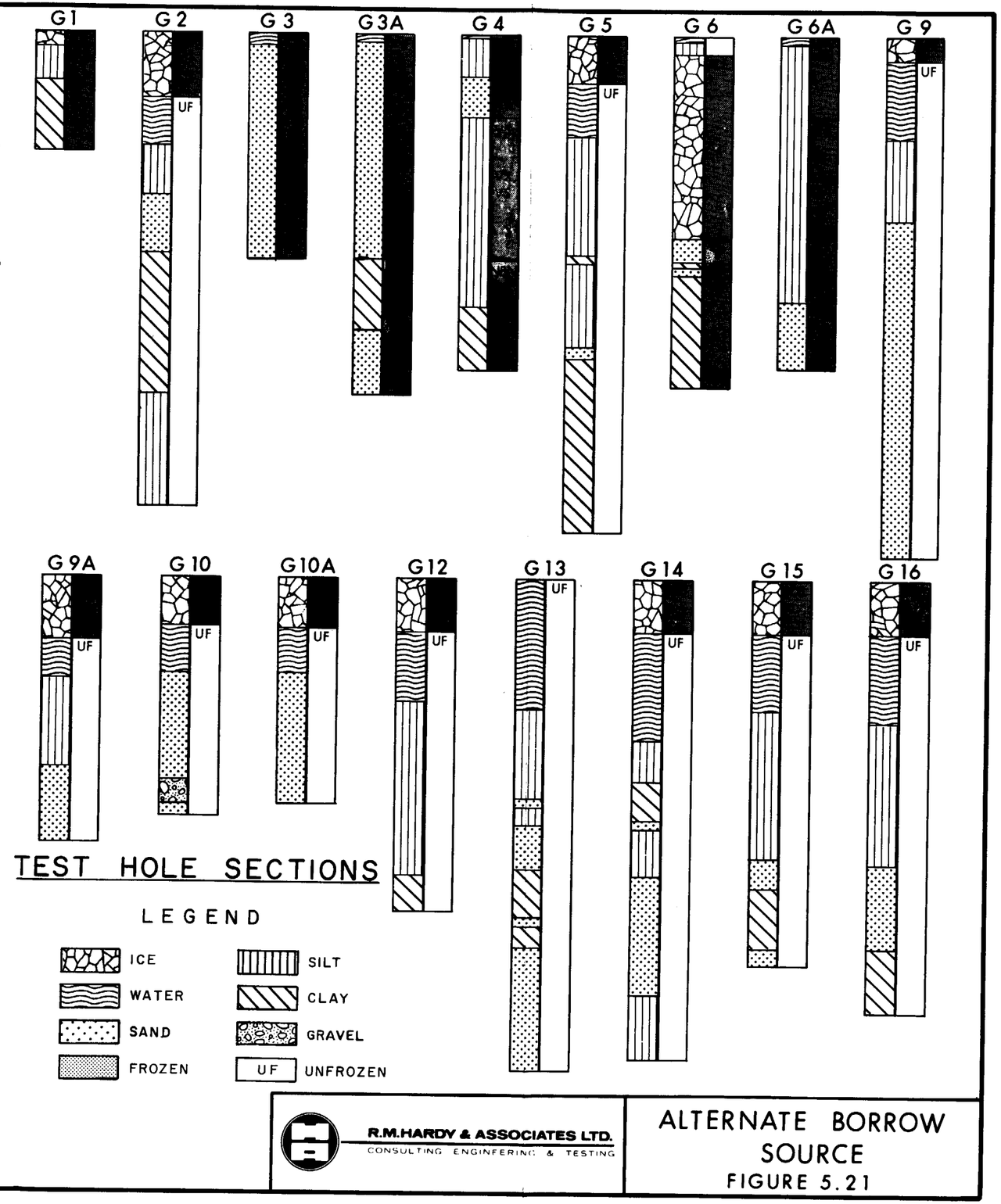
Based on the soil types encountered during this part of the drilling program, and the large quantities of ice apparently present in the sub-soils, this site is not recommended for further consideration as a potential borrow source. A thaw-strip type of operation would be difficult to carry out and would produce large quantities of melt-water, and the material so derived would not be suitable for use as a non-frost-susceptible fill material.

5.5 Potential Alternate Borrow Source

The area outlined for study is about 3 miles (5 km) South-West of the plant site, and is shown on Figure 5.21. A total of seventeen holes were drilled in the locations shown on Figure 5.21. The detailed test hole logs are given







TEST HOLE SECTIONS

LEGEND

ICE	SILT
WATER	CLAY
SAND	GRAVEL
FROZEN	UF UNFROZEN

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ALTERNATE BORROW SOURCE

FIGURE 5.21

on Figures E.1 through E.23 in Appendix E, together with the laboratory test summary sheets and grain size curves on Figures E.24 through E.64.

A simplified soil type and ice description is given for each test hole on Figure 5.21, to assist in the interpretation of subsurface data. Test holes G3, G3A and G4 were drilled on the higher ground between the two lakes shown on Figure 5.21. Test holes G1 and G2 were drilled in the "East" lake, and G9, G9A, G10, G10A, G12, G13, G14, G15 and G16 were drilled in the "West" lake. A further test hole, G5, was drilled in the narrow delta channel to the south.

The test holes in the East lake and the delta channel indicated up to 40 feet (12 m) of silts or silty clays, with minor amounts of sands. The two holes G3 and G3A, indicated primarily fine sand to 30 feet, with some silt. This sand deposit is similar in grain size characteristics to the Big Horn Channel deposit. Test holes G9, G9A and G13, drilled on the Eastern edge of the "West" lake also indicated the presence of significant quantities of fine sand overlain by 8-10 feet (2.5-3 m) of silt.

Occasional coarse sand and gravel layers were also intersected in this area, and some grain size distributions are presented for samples of these layers. Test holes G-10 and G-10A were predominantly very fine sand and silt, with a 2 foot (0.6 m) gravel layer at 17 feet (5.2 m) in G-10.

The remaining holes drilled in the "West" lake generally contained only minor quantities of fine sand, and silt comprising the dominant soil type.

Two test holes G-6 and G-6A at the southern edge of the study area also indicated silt or silty fine sand.

The subsurface investigation at this site covered a wide area, in an effort to indicate whether potentially exploitable deposits of suitable borrow material exists. Because of the large area covered and the widely spaced boreholes, it is not possible to provide quantitative estimates of the amounts of various materials present. The original objective of this phase of the drilling program was to drill a series of preliminary holes at widely spaced locations. Should any of these holes indicate promising results, the remainder of the program was to be devoted to proving out the quality and quantities of such granular

resources. Although significant depths of fine sand were encountered in some holes, no test holes indicated large quantities of material of superior quality to, for example, the Big Horn Point channel deposit. Consequently, no area was selected for further subsurface investigation on a more intensive basis.

In summary, it appears that although potentially exploitable quantities of fine sand may be present in one section of the study area, the geotechnical properties of the material for construction pruposes would not be any more acceptable than the sand deposit present in the channel at Big Horn Point. In view of the geological history of these deposits, the gravel or coarse sand layers encountered during the drilling program are likely to be limited in depth and discontinuous in lateral extent. Such layers would, therefore, be difficult to delineate accurately, and would be costly to obtain.

6.0 SUMMARY AND CONCLUSIONS

In order to finalize the geotechnical parameters for design of the barge dock, and to augment the subsurface information at the Taglu plant site and potential borrow

source areas, a geotechnical survey has been carried out by R. M. Hardy and Associates Ltd.

Soil conditions have been investigated at the revised airstrip location, and found to be similar to conditions elsewhere at the plant site. Data on the magnitude and frequency of occurrence of ice wedges have been summarized for the plant site area.

Test holes drilled at the barge dock site have provided information on soil stratigraphy, water depth, scour depth and depth to the permafrost table. Recommendations for soil properties to be used for design purposes have been presented.

The quantities of a sand deposit in the river channel at Big Horn Point have been confirmed. Estimates indicate that a volume of silty sand in excess of 2 million cubic yards (1.5×10^6 m^3) is suitable for processing at this location, and that about one-quarter of this volume would be wasted during processing, in order to obtain a material that has greater than 90% sand-sized particles. This deposit is overlain by an estimated 1.3 million cubic yards (1×10^6 m^3) of silt overburden. The suitability of

this as a fill material for pad construction has not as yet been determined, and its compaction characteristics, bearing capacity and frost susceptibility will have to be assessed before final recommendations can be established.

A limited drilling program on the bluff at Big Horn Point revealed that this area is underlain by materials that are not suitable for fill construction.

Subsurface investigation at an area about 3 miles (5 km) south of the plant site indicated that some parts of the study area are underlain by significant deposits of silty sand, with occasional coarse sand or gravel layers. The prime objective of this phase of the program was to determine if potentially exploitable quantities of coarse sand or gravel were present, and such quantities do not appear to exist in this area. Based on the limited program carried out, it is not possible to establish the likely quantities of the silty sand. It is clear, however, that the engineering properties of the silty sand delineated in

this area would not, on average, be superior to the properties of the sand deposit in the channel at Big Horn Point.

Respectfully Submitted,

R. M. HARDY & ASSOCIATES LTD.

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June 28, 1976.
CS3161

REFERENCES

Assur, A. (1966) Ice forces on sloping structures. Proc. of Ice Pressure Conf., Laval Univ., Nov. 1966.

Blench, T. (1957) Regime behavior of canals and rivers. Publ. by Butterworth.

Blench, T. (1969) Mobile Bed Fluviology. Univ. of Alberta Press.

Christie, R. L. et al. (1972) The Canadian Arctic Islands and the Mackenzie Region. XXIV Int. Geot. Congress, Excursion A66 Guidebook.

Drouin, M. (1966) Static ice force on extended structures. Proc. Ice Pressure Conf., Laval Univ. Nov. 1966.

E.B.A. Engineering Consultants Ltd. (1975) Preliminary Geotechnical Evaluation, Beaufort Gas Project. Report submitted to Imperial Oil Ltd.

Kerfoot, H. (1975) Mackenzie Delta - A Summary Report of Surface Conditions. Unpublished report, GSC 179 p.

Kivisild, H. (1966) Influence of ice forces on the strength and stability of piers, dolphins and offshore structures. Proc. of Ice Pressure Conf., Laval Univ., Nov. 1966.

Mackay, J. R. (1963) The Mackenzie Delta Area, N.W.T. Dept. of Mines and Techn. Surveys, Geogr. Branch, Memoir 8. 202 p.

Mackay, J. R. (1975) Relict Ice Wedges, Pelly Island, N.W.T. (107 C/12). GSC Paper 75-1, Part A, pp. 469-470.

Navfac DM-7 Design Manual (1971) U.S. Dept. of the Navy; Soil Mechanics, Foundations and Earth Structures.

Neill, C. R. (1973) Guide to Bridge Hydraulics. Univ of Toronto Press.

Rampton, V. N. (1972) Surficial Geology and Landforms, Mackenzie Delta. Open file map 96, GSC.

Rampton, V. N., M. Bouchard (1975) Surficial Geology of Tuktoyaktuk, district of Mackenzie, Paper 74-53, GSC.

Rampton, V. and Mackay, J. (1971) Throughout the Tuktoyaktuk Pennisula, Richards Island, and Nearby Areas, District of Mackenzie. GSC Paper 71-21, 16 p.

Slaney, F. F. and Company Ltd. (1976) 1975 Hydrology Survey, Taglu, N.W.T. Report submitted to Imperial Oil Limited.

Watson, G., Slusarchuk, W. and Rowley, R. (1973) Determination of some frozen and thawed properties of permafrost soils. Can. Geotech. J.10, p. 592.

APPENDIX A

PLANT SITE AREA
BOREHOLE AND LABORATORY DATA

TABLE A-1 TEST HOLE CO-ORDINATES FOR PLANTSITE AREA

(U.T.M. Zone 8)

Test Hole	N (Metres)	E
H76 A1	7695890	501335
A2	7696065	501250
H76 W1/W2	7695895	502260
W3	7696020	502210

TEST HOLE LOG

R.M.HARDY & ASSOCIATES LTD.
CONSULTING ENGINEERING & TESTING

PROJECT: TAGLU GAS PLANT

TEST HOLE NO. H76-A1

LOGGED BY SGM	DRAWN BY BT	CHECKED RST	DATE February, 1976
RIG Heli Drill	METHOD	START January 12, 1976	FINISH
PROJECT NO. CS 3161	ELEVATION	AIR TEMPERATURE	

W_P-⊡ W-⊙ W_L-△ MOISTURE CONTENT 20 40 60	DEPTH (feet)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %	LABORATORY TEST DATA	SAMPLE TYPE AND NUMBER	SAMPLE CONDITION	CORE RUN AND % RECOVERY	CORE CONDITION	REMARKS
		ML		grass cover under 6-8" snow SILT medium grey, uniform		Vx, Vs (60%)						
				--- trace of fine sand, high ice content				C1		90%	I	
	5			--- layered, brown to grey --- very fine ice laminae --- little fine sand, brown		Vs (50%)		C2		100 %	I	
	10			--- little fine sand		Nbn, Vx (5%)		C3		100 %	I	
	15			--- organic lense 1" thick --- trace of fine sand, very fine ice laminae, cross-bedding and horizontal layering		Nbn		C5		90%	II	
	20			--- no sand, finely laminated, stratified, trace of organics				C6		100 %	II	
	25			--- laminated silt, trace of fine sand				C7		100 %	II	
				Bottom of Hole at 25.0 Feet.								

PLATE A-1

TEST HOLE LOG

R.M.HARDY & ASSOCIATES LTD.
CONSULTING ENGINEERING & TESTING

PROJECT: TAGLU GAS PLANT

TEST HOLE NO. H76-A2

LOGGED BY SGM	DRAWN BY BT	CHECKED RST	DATE February, 1976
RIG Heli Drill	METHOD 3" CRREL	START January 12, 1976	FINISH Janaury 13, 1976
PROJECT NO. cs 3161	ELEVATION	AIR TEMPERATURE	

MOISTURE CONTENT (W_P-□ W-⊙ W_L-△) 20 40 60	DEPTH (feet)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %	LABORATORY TEST DATA	SAMPLE TYPE AND NUMBER	SAMPLE CONDITION CORE RUN AND % RECOVERY	CORE CONDITION	REMARKS
				grass cover, 1" ice		Vx, Vs (60%)					
		ML		SILT very ice rich, trace of clay				C1	40%	I	
	5										
				--- trace of fine sand, very fine ice laminae, non plastic, layered, medium brown		(25%)	Gr. Size Plate A-6	C2	100 %	II	
	10							C3	100 %	II	
						Vr (20%)					
	15			--- trace of fine sand, layered				C4	100 %	I	
						Nbn					
				--- trace of fine sand, medium to light brown				C5	100 %	II	
	20										
⊙								C6	100 %	II	
	25			Bottom of Hole at 25.0 Feet.							

PLATE A-2

R.M.HARDY & ASSOCIATES LTD.
CONSULTING ENGINEERING & TESTING

TEST HOLE LOG

PROJECT: TAGLU GAS PLANT

TEST HOLE NO. H76-W1

LOGGED BY	DRAWN BY	CHECKED	DATE
MR	BT	RST	February, 1976

RIG	METHOD	START	FINISH
Heli Drill			

PROJECT NO.	ELEVATION	AIR TEMPERATURE
cs 3161		-20° F

W_P-□ W-○ W_L-△ MOISTURE CONTENT 20 40 60	DEPTH (feet)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %	LABORATORY TEST DATA	SAMPLE TYPE AND NUMBER	SAMPLE CONDITION	CORE RUN AND % RECOVERY	CORE CONDITION	REMARKS
				ICE		ICE						
	5	SM		SILT sandy, fine grained, brown, thin layering and cross-bedding		Vbn						
	10											
	15											
	20			Bottom of Hole at 17.0 Feet. Five additional holes drilled in immediate vicinity-maximum ice depth 2.8 Feet.								

PLATE A-3

R.M.HARDY & ASSOCIATES LTD.
CONSULTING ENGINEERING & TESTING

TEST HOLE LOG

PROJECT: TAGLU GAS PLANT

TEST HOLE NO. H76-W2

LOGGED BY	DRAWN BY	CHECKED	DATE
MR	YK	RST	February, 1976

RIG	METHOD	START	FINISH
Heli Drill			

PROJECT NO.	ELEVATION	AIR TEMPERATURE
cs 3161		

W_P-□ W-○ W_L-△ MOISTURE CONTENT 20 40 60	DEPTH (feet)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %	LABORATORY TEST DATA	SAMPLE TYPE AND NUMBER	SAMPLE CONDITION	CORE RUN AND % RECOVERY	CORE CONDITION	REMARKS
				MUSKEG								
	5			ICE - silty layers near surface		ICE						
	10	ML		SILT sandy, fine grained, brown, occasional thin lenses of clay, occasional lenses of ice to 1/8" thick		Vs (10%)						
				Bottom of Hole at 10.5 Feet. Two additional holes were drilled and the maximum ice depth encountered was 4.5 feet.								

PLATE A-4

R.M.HARDY & ASSOCIATES LTD.
CONSULTING ENGINEERING & TESTING

TEST HOLE LOG

PROJECT: TAGLU GAS PLANT

TEST HOLE NO. H76-W3

LOGGED BY	DRAWN BY BT	CHECKED RST	DATE February, 1976
RIG Héli Drill	METHOD	START	FINISH
PROJECT NO. cs 3161	ELEVATION	AIR TEMPERATURE	

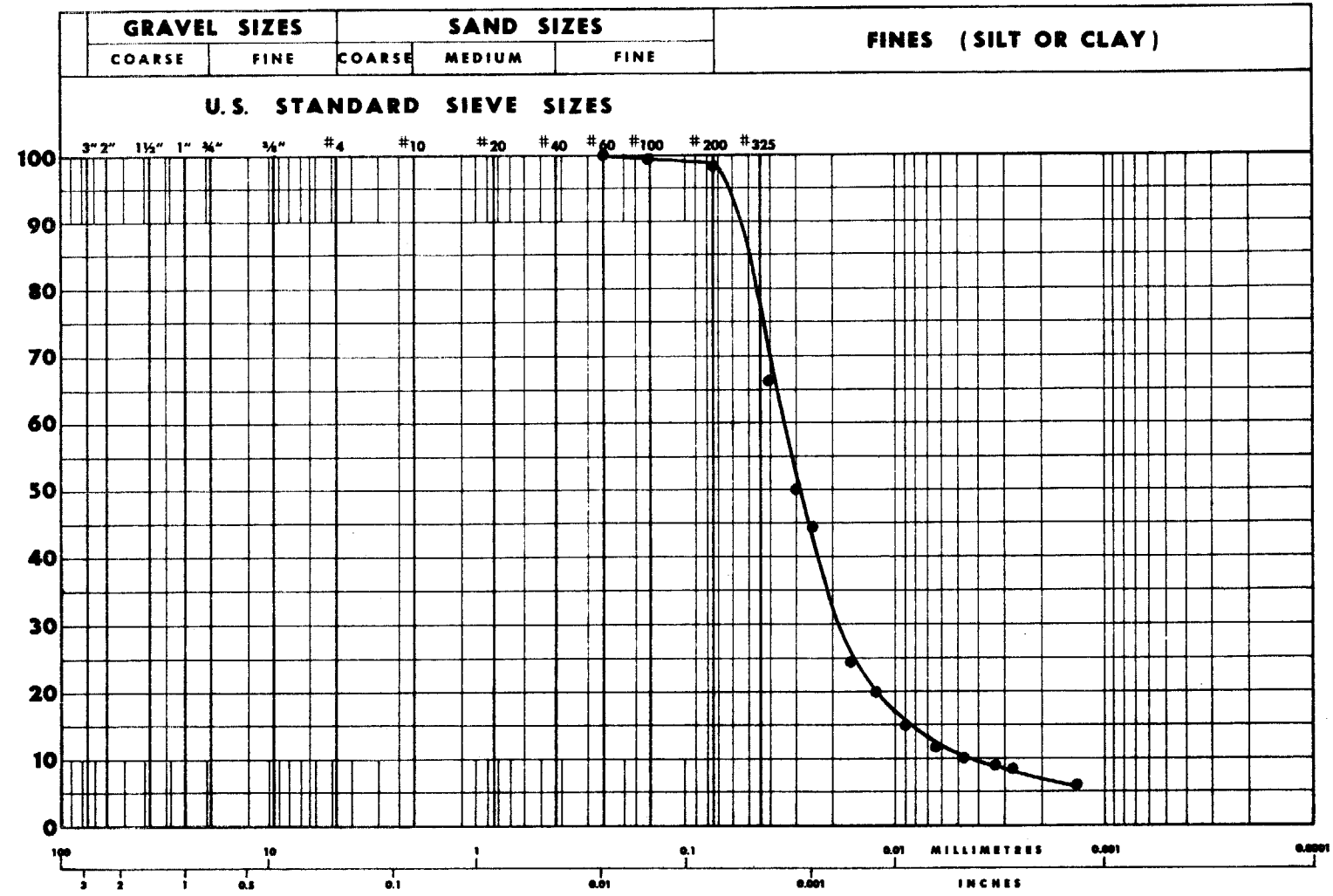
W_P-⊡ W-⊙ W_L-△ MOISTURE CONTENT 20 40 60	DEPTH (feet)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %	LABORATORY TEST DATA	SAMPLE TYPE AND NUMBER	SAMPLE CONDITION	CORE RUN AND % RECOVERY	CORE CONDITION	REMARKS
	5	SM		SILT sandy, fine grained, brown, layered								
	10			Bottom of Hole at 8.0 Feet. No massive ice encountered.								

PLATE A-5

R.M. HARDY & ASSOCIATES LTD.
CONSULTING ENGINEERING & TESTING

GRAIN SIZE CURVE

LAB ORDER NO. cs 3161
CLIENT Taglu Gas Plant
SAMPLE C 2
SOURCE
HOLE H76-A2 at 7'-8'
TECHNICIAN MS DATE TESTED Feb/76



D_{10} = _____ MM.
D_{30} = _____ MM.
D_{60} = _____ MM.
C_U = _____
C_C = _____

REMARKS: _____

NOTE: UNIFIED SOIL CLASSIFICATION SYSTEM

PLATE A-6

R.M. HARDY & ASSOCIATES LTD.
CONSULTING ENGINEERING & PROFESSIONAL SERVICES

SUMMARY OF LABORATORY TESTING

PROJECT: Taglu Gas Plant
LOCATION: Plate Site
DATE: January, 1976
JOB NO.: CS3161

SAMPLE DATA					CLASSIFICATION TESTS						OTHER TESTS			
					ATTERBERG LIMITS			TEXTURE (%)						
TEST HOLE	DEPTH (ft)	SAMPLE NO	CLASSIFICATION	SOIL DESCRIPTION	LIQUID	PLASTIC	PLASTICITY INDEX	SAND	SILT	CLAY	WET DENSITY (PCF)	DRY DENSITY (PCF)	MOISTURE CONTENT (%)	
H76-A2	7-8	C2	ML	SILT, trace of clay, trace of fine sand, layered, non plastic, brown					81	7				

PLATE A-7

APPENDIX B

BARGE DOCK SITE
BOREHOLE AND LABORATORY TEST DATA

TABLE B-1 TEST HOLE CO-ORDINATES FOR DOCKSITE AREA

(U.T.M. Zone 8)

Test Hole	R. M. Hardy N (metres)	E	C.E.S. N (metres)	E
D1	7,695,137	501,905	7,695,120	501,900
2	7,695,152	501,905	7,695,145	501,905
3	7,695,168	501,915	7,695,165	501,910
4	7,695,128	501,927	7,695,115	501,925
5	7,695,138	501,927	7,695,135	501,925
6	7,695,158	501,927	7,695,155	501,930
7	7,695,118	501,957	7,695,110	501,955
8	7,695,133	501,957	7,695,125	501,955
9	7,695,148	501,957	7,695,145	501,960
10	7,695,098	502,017	7,695,080	502,015
11	7,695,115	502,017	7,695,100	502,015
12	7,695,076	502,077	7,695,065	502,075
13	7,695,091	502,077	7,695,075	502,080
14	7,695,060	502,130	7,695,035	502,125
15	7,695,075	502,130	7,695,045	502,130
18	7,695,123	501,944		
19	7,695,132	501,944	7,695,115	501,945
20	7,695,138	501,944	7,695,135	501,940
21	7,695,146	501,944		
22	7,695,153	501,944	7,695,145	501,945

R.M. HARDY & ASSOCIATES LTD.
CONSULTING ENGINEERING & TESTING

TEST HOLE LOG

PROJECT: TAGLU GAS PLANT

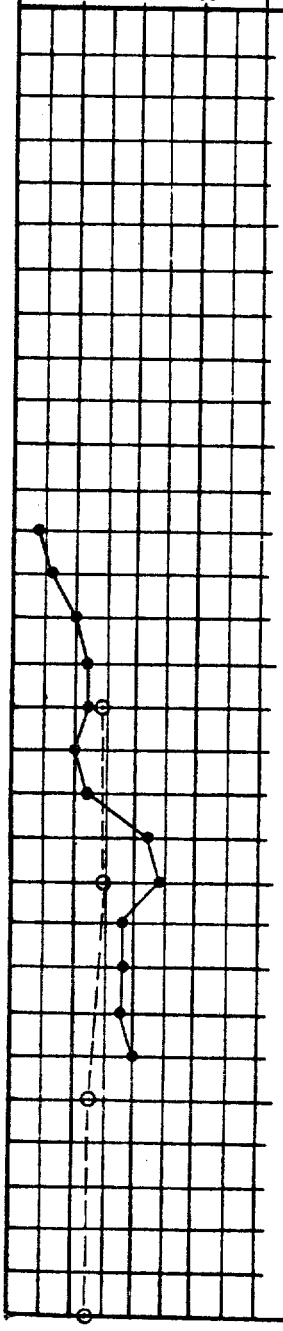
TEST HOLE NO. H76-D1

LOGGED BY SGM	DRAWN BY BT	CHECKED RST	DATE February, 1976
RIG Heli Drill	METHOD Split Spoon, Shelby Tube	START January 8, 1976	FINISH January 9, 1976
PROJECT NO. CS 3161	ELEVATION	AIR TEMPERATURE	

W_P - ⊡ W - ⊙ W_L - △

● Dynamic Cone Penetration (Blows/Foot) 5 10 15

MOISTURE CONTENT 20 40 60



DEPTH (feet)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %	LABORATORY TEST DATA	SAMPLE TYPE AND NUMBER	SAMPLE CONDITION	CORE RUN AND % RECOVERY	CORE CONDITION	REMARKS
0			ICE		ICE						
5			5.0								
			WATER		UF						
10			11.2								
	ML		SILT sandy, non plastic, fine-grained, dark grey, wet, layered			Gr. Size Plate B-38	S1		100 %		
15											
	SM		SAND fine grained, silty				S2 (SPT)		100 %		N=3 blows/foot
20			— — thin layers of organic matter, medium fibrous								
							S3		100 %		
25	SP		SAND silty, fine-grained, medium grey								
			— — — lense of medium-grained sand				S4		100 %		PLATE B-1
30											

TEST HOLE LOG

R.M.HARDY & ASSOCIATES LTD.
CONSULTING ENGINEERING & TESTING

PROJECT: TAGLU GAS PLANT

TEST HOLE NO. H76-D1 (Cont.)

LOGGED BY SGM	DRAWN BY BT	CHECKED RST	DATE February, 1976
RIG Heli Drill	METHOD Split Spoon / Shelby Tube	START January 8, 1976	FINISH January 9, 1976
PROJECT NO. cs 3161	ELEVATION	AIR TEMPERATURE	

MOISTURE CONTENT (W_P-□ W-○ W_L-△) 20 40 60	DEPTH (feet)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %	LABORATORY TEST DATA	SAMPLE TYPE AND NUMBER	SAMPLE CONDITION	CORE RUN AND % RECOVERY	CORE CONDITION	REMARKS
		SP		SAND silty, fine-grained, medium grey		UF		S4	X			
				32.2								
		ML		SILT sandy layers, medium brown								
	35			--fine organic laminations, traces of wood and fine sand				S5 (SPT)	X	100 %		N=7 blows/foot
				35.5								
		SP		SAND fine-grained, traces of organic material								
				--- layers of fine to medium sand sizes				S6 (SPT)	X	100 %		N=16 blows/foot
	40											
				--- medium sand sizes				S7 (SPT)	X	100 %		N=21 blows/foot
	45			---gravel sizes								
				--- clean, medium grey		Nbn		S8 (SPT)	X	100 %		N=64 blows/foot
	50			--- silty layers								
				53.5								
		ML		SILT clayey, traces of gravel and sand, brown to grey thick layering		Vr (10%)						
	55							C9	◢	100 %	II	
				58.0								
				Bottom of Hole at 58.0 Feet.								

PLATE B-2

R.M.HARDY & ASSOCIATES LTD.
CONSULTING ENGINEERING & TESTING

TEST HOLE LOG

PROJECT: TAGLU GAS PLANT

TEST HOLE NO.: H76-D2

LOGGED BY SGM	DRAWN BY BT	CHECKED RST	DATE February, 1976
RIG Heli Drill	METHOD Split Spoon / Shelby Tube	START January 6, 1976	FINISH January 7, 1976
PROJECT NO. CS 3161	ELEVATION	AIR TEMPERATURE	

W_P - ⊡ W - ⊙ W_L - △
● - Dynamic Cone Penetration (Blows/Foot)
MOISTURE CONTENT (%) 20 40 60 — 10 20 30

DEPTH (feet)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %	LABORATORY TEST DATA	SAMPLE TYPE AND NUMBER	SAMPLE CONDITION	CORE RUN AND % RECOVERY	CORE CONDITION	REMARKS
			ICE		ICE						
5			5.0								
			WATER		UF						
			7.6								
	ML		SILT trace of clay, trace of sand, non plastic, dark grey, sensitive to shaking, wet				S1		0%		
10							S2		100 %		
			----little coarse sand, dark grey, coarse gravel sizes			γ_w=142.2pcf γ_d=113.1pcf	U1		0%		
15			----stratified, fine layers of organic, medium grey			γ_w=103.0pcf γ_d=80.2pcf	U2		80%		
17.0							U3		80%		Gr. Size Plate B-39
	SM		SAND trace of silt, fine-grained, non plastic, dark grey, very sensitive to shaking (rapid dilatancy)			γ_w=106.9pcf γ_d=78.8pcf	U4		100 %		
			--- wet				U5		80%		
20							U6		0%		
							U7		0%		
25			----numerous gravel sizes to 1/4"			γ_w=132.2pcf γ_d=104.6pcf	U8		80%		
			----finely laminated with dark silty layers, very silty								
			---frozen		Nbn		C1		80%	III	γ_w = 110.6 pcf γ_d = 80.7 pcf
30			---- isolated cobble								

(for 6")

PLATE B-3

R.M.HARDY & ASSOCIATES LTD.
CONSULTING ENGINEERING & TESTING

TEST HOLE LOG

PROJECT: TAGLU GAS PLANT

TEST HOLE NO. H76-D2(Cont.)

LOGGED BY SGM	DRAWN BY BT	CHECKED RST	DATE February,1976
RIG Heli Drill	METHOD Split Spoon / Shelby Tube	START January 6,1976	FINISH January 7,1976
PROJECT NO. CS3161	ELEVATION	AIR TEMPERATURE	

W_P-□ W-○ W_L-△ MOISTURE CONTENT 20 40 60	DEPTH (feet)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %	LABORATORY TEST DATA	SAMPLE TYPE AND NUMBER	SAMPLE CONDITION	CORE RUN AND % RECOVERY	CORE CONDITION	REMARKS
		SM		SAND very silty, fine-grained, non plastic, dark grey, wet		Nbn						
	35	ML		SILT sandy, wet								
				---slightly clayey, fine-grained, finely laminated				C2	X	60%	IV	
	39.0			Bottom of Hole at 39.0 Feet.								
	40											

PLATE B-4

R.M.HARDY & ASSOCIATES LTD.
CONSULTING ENGINEERING & TESTING

TEST HOLE LOG

PROJECT: TAGLU GAS PLANT

TEST HOLE NO. HZ6-D3

LOGGED BY SGM	DRAWN BY BT	CHECKED RST	DATE February, 1976
RIG Heli Drill	METHOD 3" Creel	START Januaru 11, 1976	FINISH January 12, 1976
PROJECT NO. cs 3161	ELEVATION	AIR TEMPERATURE	

W_P-□ W-○ W_L-△ MOISTURE CONTENT 20 40 60	DEPTH (feet)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %	LABORATORY TEST DATA	SAMPLE TYPE AND NUMBER	SAMPLE CONDITION	CORE RUN AND % RECOVERY	CORE CONDITION	REMARKS
				GRAVEL (FILL)		F						
		ML		SILT trace of organic material		Nbn						
		CL		CLAY silty, low plastic, grey			γ_w=95.9pcf γ_d=62.2pcf	C1	X	58%	IV	
	5	ML		SILT trace of fine sand, trace of clay, low to non plastic,		Vr 50%		C2	X	80%	IV	
	10	SP		SAND finely stratified, thin laminae of sandy silt		Vr 5-10%		C3	■	50%	III	
	15	ML		SILT trace of sand, non plastic		Vr 20%		C4	X	20%	IV	
		CL		CLAY silty, low plastic		Nbn						
	20	SP		SAND silty, fine-grained, non plastic, dark grey			γ_w=116.9 pcf γ_d= 88.4 pcf	C5	■	60%	II	
								C6	■	100%	II	
				--- laminated with organic material crossbedded, stratified			γ_w=113.1 pcf γ_d= 77.1 pcf γ_w=106.1 pcf γ_d= 74.4 pcf	C7	■	80%	I	
	25			Bottom of Hole at 25.0 Feet.								

PLATE B-5

TEST HOLE LOG

R.M.HARDY & ASSOCIATES LTD.
CONSULTING ENGINEERING & TESTING

PROJECT: TAGLU GAS PLANT

TEST HOLE NO. H76-D4

LOGGED BY SGM	DRAWN BY BT	CHECKED RST	DATE February, 1976
RIG Heli Drill	METHOD Shelby Tube	START January 7, 1976	FINISH January 7, 1976
PROJECT NO. cs 3161	ELEVATION	AIR TEMPERATURE	

W_P - ⊡ W - ⊙ W_L - △

● Dynamic Cone Penetration (Blows/Foot)

MOISTURE CONTENT: 10 20 30 / 20 40 60

DEPTH (feet)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %	LABORATORY TEST DATA	SAMPLE TYPE AND NUMBER	SAMPLE CONDITION	CORE RUN AND % RECOVERY	CORE CONDITION	REMARKS
0			ICE		ICE						
5.0											
5			WATER		UF						
9.0											
10	ML		SILT sandy, very sensitive to shaking								
15			---very sandy, non plastic, dark grey, stratified			γ_w=114.4pcf γ_d=81.3pcf	U1		0%		
							U2		100 %		Drained Triaxial c'=0 ϕ'=35° Plate B-47
20							U3		0%		
							U4		0%		
							U5		0%		
25			--- very sandy, fine-grained, non plastic dark grey, sensitive to shaking, moist			γ_w=116.0pcf γ_d=93.0pcf	U6		100 %		Drained Triaxial c'=0, ϕ'=38° Plate B-48
30											

PLATE B-6

TEST HOLE LOG

R.M.HARDY & ASSOCIATES LTD.
CONSULTING ENGINEERING & TESTING

PROJECT: TAGLU GAS PLANT

TEST HOLE NO. H76-D4 (Cont)

LOGGED BY SGM	DRAWN BY BT	CHECKED RST	DATE February, 1976
RIG Heli Drill	METHOD Shelby Tube	START Januaru7, 1976	FINISH January 7, 1976
PROJECT NO. cs 3161	ELEVATION	AIR TEMPERATURE	

W_P-⊡ W-⊙ W_L-△

● Dynamic Cone Penetration (Blows/Foot)

MOISTURE CONTENT 10 20 30 — 20 40 60

DEPTH (feet)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %	LABORATORY TEST DATA	SAMPLE TYPE AND NUMBER	SAMPLE CONDITION	CORE RUN AND % RECOVERY	CORE CONDITION	REMARKS
	ML		SILT sandy, non plastic, dark grey, stratified, very sensitive to shaking, wet			γ_w=112.5pcf γ_d=86.7pcf	U8		100 %		
32											
	CL		CLAY silty, low to medium plastic, medium grey, stratified, traces of organics, moist			γ_w=114.7pcf γ_d=86.4pcf	U9		100 %		
35											
			---fine-grained sand, lense, non plastic, dark grey			γ_w=118.0pcf γ_d=94.4pcf	U10		100 %		
40											
42.0											
	ML		SILT trace of clay, low plastic, dark grey, wet			γ_w=122.1pcf γ_d=98.8pcf	U11		100 %		
	SM		SAND trace of silt, non plastic, fine-grained, dark grey, pockets of coarse-grained sand, saturated			γ_w=122.3pcf γ_d=101.3pcf	U12		100 %		
45											
50											
55											
	SP		--- fine to coarse grained, possible slough								
56.0				+ + + + + + + +	Vx (2%)		C1		100%	IV	
	CI		CLAY silty, trace of sand, soft, grey-brown, gravel sizes to 1", wet, occasional ice crystals and coal particles.								
			Bottom of Hole at 58.0 Feet.								

PLATE B-7

R.M.HARDY & ASSOCIATES LTD.
CONSULTING ENGINEERING & TESTING

TEST HOLE LOG

PROJECT: TAGLU GAS PLANT

TEST HOLE NO. H76-D5

LOGGED BY SGM	DRAWN BY BT	CHECKED RST	DATE February, 1976
RIG Heli Drill	METHOD	START January 9, 1976	FINISH
PROJECT NO. cs 3161	ELEVATION	AIR TEMPERATURE	

W_P-□ W-○ W_L-△
● Dynamic Cone Penetration (Blows/Foot)
20 40 60
MOISTURE CONTENT
20 40 60

DEPTH (feet)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %	LABORATORY TEST DATA	SAMPLE TYPE AND NUMBER	SAMPLE CONDITION	CORE RUN AND % RECOVERY	CORE CONDITION	REMARKS
			ICE		ICE						
5			WATER								
10					UF						
15	SP		SAND silty, fine-grained, finely laminated								
20											
25			--- uniform, fine-grained				S1	X	60%		
30	ML		SILT sandy, non plastic, grey			Gr. Size Plate B-40	S2	X			PLATE B-8

R.M.HARDY & ASSOCIATES LTD.
CONSULTING ENGINEERING & TESTING

TEST HOLE LOG

PROJECT: TAGLU GAS PLANT

TEST HOLE NO. H76-D5 (Cont.)

LOGGED BY SGM	DRAWN BY BT	CHECKED RST	DATE February, 1976
RIG Heli Drill	METHOD	START January 9, 1976	FINISH
PROJECT NO. cs 3161	ELEVATION		AIR TEMPERATURE

W_P - ⊡ W - ⊙ W_L - △

● Dynamic Cone Penetration (Blows/Foot)

MOISTURE CONTENT 20 40 60

DEPTH (feet)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %	LABORATORY TEST DATA	SAMPLE TYPE AND NUMBER	SAMPLE CONDITION	CORE RUN AND % RECOVERY	CORE CONDITION	REMARKS
	ML		SILT sandy, non plastic, grey		UF		S2				
35			-- silt layer interbedded, trace of organics, finely laminated, medium grey				S3				
40			-- frozen		Nbn		S4 (SPT)		100 %		N=45 blows/foot
45						Thaw Strain Figure 49 γ_w=118.3 pcf γ_d= 93.2 pcf	∈I		100% II		Thaw Strain = 2.4 % M_v = 0.038 ft^2/ton
50			Bottom of Hole at 51.0 Feet.								

PLATE B-9

R.M.HARDY & ASSOCIATES LTD.
CONSULTING ENGINEERING & TESTING

TEST HOLE LOG

PROJECT: TAGLU GAS PLANT

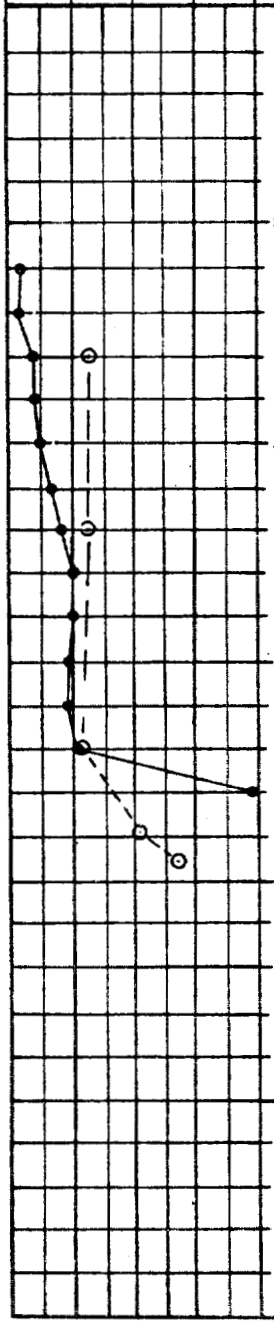
TEST HOLE NO. HZ6-D6

LOGGED BY SGM	DRAWN BY BT	CHECKED RST	DATE February, 1976
RIG Heli Drill	METHOD Splitspoon, 3" Shelby Tube, 3"CRREL	START January 8, 1976	FINISH
PROJECT NO. cs 3161	ELEVATION	AIR TEMPERATURE	

W_P-⊡ W-⊙ W_L-△

● DYNAMIC CONE PENETRATION blows/ft. 20 40 60

MOISTURE CONTENT 20 40 60



DEPTH (feet)	SOIL GROUP SYMBOL	DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %	LABORATORY TEST DATA	SAMPLE TYPE AND NUMBER	SAMPLE CONDITION	CORE RUN AND % RECOVERY	CORE CONDITION	REMARKS
		ICE		ICE						
	ML	SILT sandy, fine-grained		Vx						
				UF						
	SP	SAND fine grained, silty, brownish grey, loose, wet				S1		20%		
		--- fine grained, minor silt laminations, medium grey				S2		60%		
					q_u = 923 psf γ_w=114.3 pcf γ_d= 92.4 pcf Gr. Size Plate B-41					Hole sloughing
	ML	SILT grey, non plastic, trace of sand				U3		100 %		
		--- fine grained, cross-bedded, with laminae of darker silt		NHn		C1		100%	I	
		--- laminae of silt and organic matter crossbedded			γ_w=113.6 pcf γ_d= 80.5 pcf γ_w=100.9 pcf γ_d= 65,3 pcf	C2		100 %	I	
										Refusal
		Bottom of Hole at 23.0 Feet.								

PLATE B-10

R.M.HARDY & ASSOCIATES LTD.
CONSULTING ENGINEERING & TESTING

TEST HOLE LOG

PROJECT: TAGLU GAS PLANT

TEST HOLE NO. H76-D7

LOGGED BY MR	DRAWN BY BT	CHECKED RST	DATE February, 1976
RIG Heli Drill	METHOD	START January 8, 1976	FINISH
PROJECT NO. cs 3161	ELEVATION		AIR TEMPERATURE

W_P - ⊡ W - ⊙ W_L - △

● DYNAMIC CONE PENETRATION blows/ft. 20 40 60

MOISTURE CONTENT 20 40 60

DEPTH (feet)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %	LABORATORY TEST DATA	SAMPLE TYPE AND NUMBER	SAMPLE CONDITION	CORE RUN AND % RECOVERY	CORE CONDITION	REMARKS
			ICE		TCE						
5			WATER		UF						
			⌐ bottom of channel								
	ML		SILT fine sandy, brown, non plastic, occasional layers to 3/8" of organics, wet			Gr. Size Plate B-42	S1	X	67%		
10											
15							S2	X	67%		
20											
	SM		SAND silty, non plastic			γ_w=110.6 pcf γ_d= 76.7 pcf	U1		100 %		
25	ML		SILT little sand, brown, non plastic, soft				S3 (SPT)	X	100 %		N = 5 blows/foot
30											

PLATE B-11

R.M.HARDY & ASSOCIATES LTD.
CONSULTING ENGINEERING & TESTING

TEST HOLE LOG

PROJECT: TAGLU GAS PLANT

TEST HOLE NO. H76-07 (cont.)

LOGGED BY MR	DRAWN BY BT	CHECKED RST	DATE February, 1976
RIG Heli Drill	METHOD	START January, 1976	FINISH
PROJECT NO. cs 3161	ELEVATION	AIR TEMPERATURE	

W_P - ⊡ W - ⊙ W_L - △

● DYNAMIC CONE PENETRATION blows/ft. 20 40 60

MOISTURE CONTENT 20 40 60

DEPTH (feet)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %	LABORATORY TEST DATA	SAMPLE TYPE AND NUMBER	SAMPLE CONDITION	CORE RUN AND % RECOVERY	CORE CONDITION	REMARKS
	ML		SILT fine sandy, brown, non plastic, medium dense, wet		UF						
							S4 (SPT)	X	100 %		N = 12 blows/foot
35			--- sand lenses interbedded, fine grained				S5	X	100 %		
40						Gr. Size Plate B-43	S6 (SPT)	X	100 %		N = 26 blows/foot
45	SP		SAND fine grained, very silty, brown, wet								
	ML		SILT fine sandy, brown, faintly laminated, dilatant, one 3/8" layer containing organics, wet				S7	X	100 %		
50			--- stratified layers of silt, sand, soft, wet				S8	X	100 %		
55											
60			probable start of permafrost								

PLATE B-12

R.M.HARDY & ASSOCIATES LTD.
CONSULTING ENGINEERING & TESTING

TEST HOLE LOG

PROJECT: TAGLU GAS PLANT

TEST HOLE NO. H76-07 (cont.)

LOGGED BY	DRAWN BY	CHECKED	DATE
MR	BT	RST	Februaru, 1976

RIG	METHOD	START	FINISH
Heli Drill		Januaru 8, 1976	

PROJECT NO.	ELEVATION	AIR TEMPERATURE
cs 3161		

MOISTURE CONTENT (W_P-⊡ W-⊙ W_L-△) 20 40 60	DEPTH (feet)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %	LABORATORY TEST DATA	SAMPLE TYPE AND NUMBER	SAMPLE CONDITION	CORE RUN AND % RECOVERY	CORE CONDITION	REMARKS
		ML		SILT fine sandy, brown, wet, (cont.)		s, x <5%						
		CI		CLAY silty, trace of sand, dark grey, medium plastic, frozen			γ_w=103.1 pcf γ_d= 69.8 pcf					
	65			inclusions to 3/4" of fine sand, brown, occasional organics to 1/8", occasional ice crustals to 1/8"			γ_w=110.4 pcf γ_d= 81.0 pcf γ_w=106.2 pcf γ_d= 77.2 pcf	C1		80%	II	
	70			possible gravel or cobbles								
				Bottom of Hole at 71.0 Feet.								
	75											

PLATE B-13

R.M.HARDY & ASSOCIATES LTD.
CONSULTING ENGINEERING & TESTING

TEST HOLE LOG

PROJECT: TAGLU GAS PLANT

TEST HOLE NO. H76-D8

LOGGED BY MR	DRAWN BY BT	CHECKED RST	DATE February, 1976
RIG Heli Drill	METHOD	START January 7, 1976	FINISH
PROJECT NO. cs 3161	ELEVATION	AIR TEMPERATURE	-25° C

W_P - ⊡ W - ⊙ W_L - △

● DYNAMIC CONE PENETRATION blows/ft.

MOISTURE CONTENT 20 40 60

DEPTH (feet)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %	LABORATORY TEST DATA	SAMPLE TYPE AND NUMBER	SAMPLE CONDITION	CORE RUN AND % RECOVERY	CORE CONDITION	REMARKS
			ICE		ICE						
5			WATER		UF						
10											
15			bottom of channel								
20	ML		SILT fine sandy, brown, non plastic, occasional fine organics, highly dilatant, wet				S1	X	33%		
25						γ_w=115.6 pcf γ_d= 89.3 pcf.	U1		100 %		
30											

PLATE B-14

R.M.HARDY & ASSOCIATES LTD.
CONSULTING ENGINEERING & TESTING

TEST HOLE LOG

PROJECT: TAGLU GAS PLANT

TEST HOLE NO. H76-D8 (cont.)

LOGGED BY MR	DRAWN BY BT	CHECKED RST	DATE February, 1976
RIG Heli Drill	METHOD	START January 7, 1976	FINISH
PROJECT NO. cs 3161	ELEVATION	AIR TEMPERATURE -25° C	

W_P - ⊡ W - ⊙ W_L - △

● DYNAMIC CONE PENETRATION blows/ft.

MOISTURE CONTENT 20 40 60

DEPTH (feet)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %	LABORATORY TEST DATA	SAMPLE TYPE AND NUMBER	SAMPLE CONDITION	CORE RUN AND % RECOVERY	CORE CONDITION	REMARKS
35	ML		SILT fine sandy, brown, non plastic, quick, wet (cont.)		UF		S2	X	80%		N = 6 blows/foot
			--- 2" sand lense, medium grained				U2	X	53%		
40	SM		SAND silty, fine grained, less coal and shell fragments, possible ice crystals, silty layers	+ + + + + + + + + + + + + + +	Vx		S3	X	67%		N = 33 blows/foot
			--- fine grained, silty, brown, frozen, occasional small shell fragments		Nbn	Thaw Strain Figure 50 γ_w=119.9 pcf γ_d= 94.9 pcf	C1	X	100 %	I	Thaw Strain = 1.6% M_v = 0.016 ft^2/ton
45											
50			Bottom of Hole at 52.0 Feet.								
55											

PLATE B-15

R.M.HARDY & ASSOCIATES LTD.
CONSULTING ENGINEERING & TESTING

TEST HOLE LOG

PROJECT: TAGLU GAS PLANT

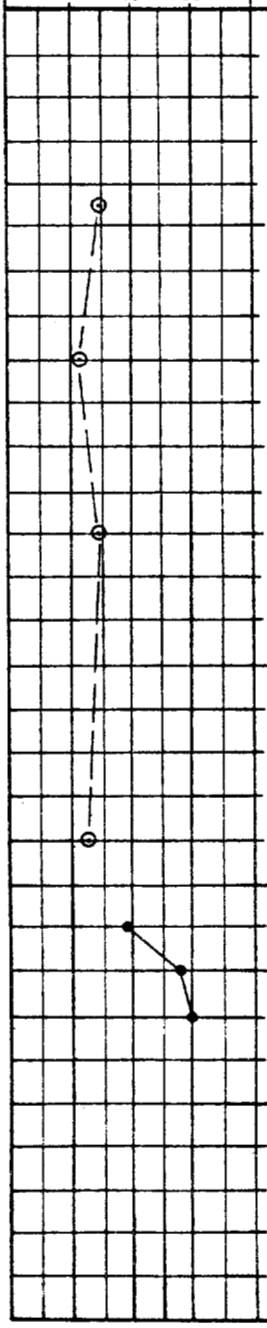
TEST HOLE NO. H76-D9

LOGGED BY MR	DRAWN BY BT	CHECKED RST	DATE February, 1976
RIG Heli Drill	METHOD	START January 10, 1976	FINISH
PROJECT NO. cs 3161	ELEVATION	AIR TEMPERATURE -30° C	

W_P-⊡ W-⊙ W_L-△

● DYNAMIC CONE PENETRATION blows/ft. 20 40 60

MOISTURE CONTENT 20 40 60



DEPTH (feet)	SOIL GROUP SYMBOL	DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %	LABORATORY TEST DATA	SAMPLE TYPE AND NUMBER	SAMPLE CONDITION	CORE RUN AND % RECOVERY	CORE CONDITION	REMARKS
		ICE		ICE						
	ML	SILT fine sandy, brown, frozen		Vx 10%						
		--- soft to firm, ice crystals to 1/4"				U1	X	40%		
		--- fine sandy, brown, soft, moderate dilatancy, wet		UF		S1	X	67%		
		--- slightly sandier				S2	X	67%		
	ML to SM	--- fine sand, brown, non plastic, moist to wet				S3 (SPT)	X	100 %		N = 10 blows/foot
		Hole drilled to 20.0 Feet.								
		Hole completed to 23.0 Feet by means of Dynamic Cone Penetration.								

PLATE B-16

TEST HOLE LOG

R.M.HARDY & ASSOCIATES LTD.
CONSULTING ENGINEERING & TESTING

PROJECT: TAGLU GAS PLANT

TEST HOLE NO. H76-D10

LOGGED BY MR	DRAWN BY BT	CHECKED RST	DATE February, 1976
RIG Heli Drill	METHOD	START January 9, 1976	FINISH January 9, 1976
PROJECT NO. cs 3161	ELEVATION	AIR TEMPERATURE -30° F	

W_P - ⊡ W - ⊙ W_L - △

● DYNAMIC CONE PENETRATION blows/ft.

MOISTURE CONTENT 20 40 60

DEPTH (feet)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %	LABORATORY TEST DATA	SAMPLE TYPE AND NUMBER	SAMPLE CONDITION	CORE RUN AND % RECOVERY	CORE CONDITION	REMARKS
			ICE		ICE						
5			WATER		UF						
10											
15			bottom of channel								
	ML		SILT soft, brown								
20											
25			--- brown, non plastic, numerous thin laminations of organics, wet				S1	X	67%		
			--- sandy layers, brown, non plastic								
30							U1		100 %		PLATE B-17

R.M.HARDY & ASSOCIATES LTD.
CONSULTING ENGINEERING & TESTING

TEST HOLE LOG

PROJECT: TAGLU GAS PLANT

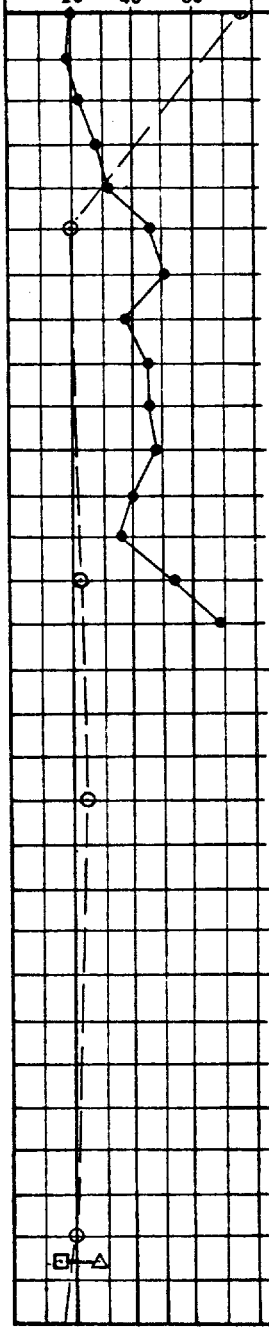
TEST HOLE NO. H76-D10 (cont.)

LOGGED BY MR	DRAWN BY BT	CHECKED RST	DATE February, 1976
RIG Heli Drill	METHOD	START January 9, 1976	FINISH January 9, 1976
PROJECT NO. cs 3161	ELEVATION	AIR TEMPERATURE -30° F	

W_P-⊡ W-⊙ W_L-△

● DYNAMIC CONE PENETRATION blows/ft. 20 40 60

MOISTURE CONTENT 20 40 60



DEPTH (feet)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %	LABORATORY TEST DATA	SAMPLE TYPE AND NUMBER	SAMPLE CONDITION	CORE RUN AND % RECOVERY	CORE CONDITION	REMARKS
	ML		SILT sandy, brown, non plastic, numerous thin laminations of organics, wet		UF	γ_w= 87.6 pcf γ_d= 49.5 pcf	U1				
35	SP		SAND fine grained, silty, brown, non plastic, moderate dilatancy, wet				U2		100 %		
			--- fine grained, silty, brown, non plastic, moist to wet, moderate dilatancy				S2 (SPT)		80%		N = 43 blows/ft.
45			--- lenses and distorted layers to 1/2" of silt, fine sandy, brown				C1		100 %	II	
50											
55	CL		CLAY silty, little sand, low plastic, soft to firm, occasional gravel sizes --- stiff, frequent coarse sand and coal particles (till-like)				C2		100 %	IV II	
60											PLATE B-18

R.M. HARDY & ASSOCIATES LTD.
CONSULTING ENGINEERING & TESTING

TEST HOLE LOG

PROJECT: TAGLU GAS PLANT

TEST HOLE NO. H76-D10 (cont.)

LOGGED BY MR	DRAWN BY BT	CHECKED RST	DATE February, 1976
RIG Heli Drill	METHOD	START January 9, 1976	FINISH January 9, 1976
PROJECT NO. cs 3161	ELEVATION	AIR TEMPERATURE -30° F	

W_P-□ W-○ W_L-△ MOISTURE CONTENT 20 40 60	DEPTH (feet)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %	LABORATORY TEST DATA	SAMPLE TYPE AND NUMBER	SAMPLE CONDITION	CORE RUN AND % RECOVERY	CORE CONDITION	REMARKS
		CL		CLAY (till-like) silty, little sand, brownish-grey, stiff, low to medium plastic		UF						
				--- occasional particles of gravel to 1" diameter				C3		100 %	IV / II	
	65											
	70											
	75			estimated interface								
		SP		SAND fine grained, silty, damp, grey to medium brown, distorted layering	+ + +	Vx (10%)		C4		80%	II	
				thin layer of clayey silt and fine sand, trace of fine gravel	+ + +							
	80				+ + +							
				--- thin clay lense interbedded	+ + +			C5		60%	III	
	85			Bottom of Hole at 85.5 Feet.								

PLATE B-19

TEST HOLE LOG

R.M.HARDY & ASSOCIATES LTD.
CONSULTING ENGINEERING & TESTING

PROJECT: TAGLU GAS PLANT

TEST HOLE NO. H76-D11

LOGGED BY SGM	DRAWN BY BT	CHECKED RST	DATE February, 1976
RIG Heli Drill	METHOD Splitspoon, 3" Shelby Tube	START January 7, 1976	FINISH
PROJECT NO. cs 3161	ELEVATION	AIR TEMPERATURE	

W_P - □ W - ○ W_L - △

● DYNAMIC CONE PENETRATION blows/ft. 10 20 30

MOISTURE CONTENT 20 40 60

DEPTH (feet)	SOIL GROUP SYMBOL	DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %	LABORATORY TEST DATA	SAMPLE TYPE AND NUMBER	SAMPLE CONDITION	CORE RUN AND % RECOVERY	CORE CONDITION	REMARKS
		ICE		ICE						
5		WATER		UF						
10	ML	SILT some fine sand, brownish grey, very soft			Gr. Size Plate B-44	S1		5%		
15		--- sandy, laminated, sensitive to shaking				S2		5%		
	OL	SILT very sandy, fine-grained sand sizes, numerous organic lenses to 1/8", saturated				S3		60%		
20	ML	SILT fine sand sizes								
	SP	SAND fine grained, trace to little silt			γ_w=108.2 pcf γ_d= 74.6 pcf	U4		80%		
25										
170 for 10"	ML	SILT fine sand, trace of organic material, saturated		Nbr		S5		50%		
30		--- sandy layers, finely laminated								

PLATE B-20

R.M.HARDY & ASSOCIATES LTD.
CONSULTING ENGINEERING & TESTING

TEST HOLE LOG

PROJECT: TAGLU GAS PLANT

TEST HOLE NO. H76-D11 (cont.)

LOGGED BY SGM	DRAWN BY BT	CHECKED RST	DATE February, 1976
RIG Heli Drill	METHOD Splitspoon, 3" Shelby Tube	START January 7, 1976	FINISH
PROJECT NO. cs 3161	ELEVATION	AIR TEMPERATURE	

W_P-⊡ W-⊙ W_L-△ MOISTURE CONTENT 20 40 60	DEPTH (feet)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %	LABORATORY TEST DATA	SAMPLE TYPE AND NUMBER	SAMPLE CONDITION	CORE RUN AND % RECOVERY	CORE CONDITION	REMARKS
		ML		SILT sandy, finely laminated, crossbedded, poorly graded (cont)		Vbn	γ_w=108.1 pcf γ_d= 78.8 pcf γ_w=111.8 pcf γ_d= 81.4 pcf γ_w=107.1 pcf γ_d =80.5 pcf	C1		100 %	I	
	35			--- brown to grey bedding, sand layers								
	40			--- occasional thin organic lenses				C2		80%	III	
				Bottom of Hole at 41.0 Feet.								
	45											

PLATE B-21

R.M.HARDY & ASSOCIATES LTD.
CONSULTING ENGINEERING & TESTING

TEST HOLE LOG

PROJECT: TAGLU GAS PLANT

TEST HOLE NO. H76-D12

LOGGED BY SGM	DRAWN BY BT	CHECKED RST	DATE February, 1976
RIG Heli Drill	METHOD Splitspoon, 3"Shelbu Tube, 3" ID CRREL	START January 10, 1976	FINISH January 10, 1976
PROJECT NO. cs 3161	ELEVATION	AIR TEMPERATURE	

W_P - ⊡ W - ⊙ W_L - △

• DYNAMIC CONE PENETRATION blows/ft. 20 40 60

MOISTURE CONTENT 20 40 60

DEPTH (feet)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %	LABORATORY TEST DATA	SAMPLE TYPE AND NUMBER	SAMPLE CONDITION	CORE RUN AND % RECOVERY	CORE CONDITION	REMARKS
			ICE		ICE						
5			WATER		UF						
	ML		SILT some fine sand, soft				S1	X	80%		
10											
15											
	OL		ORGANIC SILT spongey, wood, leaves, roots				S2	X	80%		
20											
25							S3	X	80%		
	ML		SILT sandy, non to low plastic, stratified								
30							S4	X	80%		PLATE B-22

R.M.HARDY & ASSOCIATES LTD.
CONSULTING ENGINEERING & TESTING

TEST HOLE LOG

PROJECT: TAGLU GAS PLANT

TEST HOLE NO. H76-D12 (cont.)

LOGGED BY SGM	DRAWN BY BT	CHECKED RST	DATE February, 1976
RIG Heli Drill	METHOD Splitspoon, 3"Shelby Tube, 3" ID CRREL	START January 10, 1976	FINISH January 10, 1976
PROJECT NO. cs 3161	ELEVATION	AIR TEMPERATURE	

W_P-□ W-⊙ W_L-△

● DYNAMIC CONE PENETRATION blows/ft. 20 40 60

MOISTURE CONTENT 20 40 60

DEPTH (feet)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %	LABORATORY TEST DATA	SAMPLE TYPE AND NUMBER	SAMPLE CONDITION	CORE RUN AND % RECOVERY	CORE CONDITION	REMARKS
	ML		SILT sandy, non to low plastic, stratified		UF	γ_w=107.4 pcf γ_d= 76.3 pcf Gr. Size Plate B-45	SS (SPT)				N=1 blow/foot
							U5		100 %		
35	SP		SAND fine grained, silty, dense, medium brown		Nbn	γ_w=111.5 pcf γ_d= 81.7 pcf	C6		100%	I	
									0%	V	
40											
45											
50			Bottom of Hole at 48.0 Feet.								

PLATE B-23

TEST HOLE LOG

R.M.HARDY & ASSOCIATES LTD.
CONSULTING ENGINEERING & TESTING

PROJECT: TAGLU GAS PLANT

TEST HOLE NO. H76-D13

LOGGED BY MR	DRAWN BY BT	CHECKED RST	DATE February, 1976
RIG Heli Drill	METHOD	START January 10, 1976	FINISH January 10, 1976
PROJECT NO. CS 3161	ELEVATION	AIR TEMPERATURE -25° F.	

W_P-□ W-○ W_L-△

● Dynamic Cone Penetration (Blows/Foot)

MOISTURE CONTENT 20 40 60

DEPTH (feet)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %	LABORATORY TEST DATA	SAMPLE TYPE AND NUMBER	SAMPLE CONDITION	CORE RUN AND % RECOVERY	CORE CONDITION	REMARKS
			ICE		ICE						
5	ML		SILT sandy, non plastic, brown, occasional layer of organic material, moderate dilatancy, wet		UF						
10											
15			---clayey, low plastic, dark grey, wet				S1 (SPT)	X	80%		N=4 blows/foot
							S2 (SPT)	X	67%		N=3 blows/foot
20			---thin laminations, more organics				S3	X	53%		
			---low to non plastic								
25	SM		SAND silty, fine, non plastic, hard, brown, numerous thin laminations containing organics, frozen		Nbn		S4 (SPT)	X	100%		N=45 blows/foot
30											

PLATE B-24

R.M.HARDY & ASSOCIATES LTD.
CONSULTING ENGINEERING & TESTING

TEST HOLE LOG

PROJECT: TAGLU GAS PLANT

TEST HOLE NO. H76-D13 (Cont.)

LOGGED BY MR	DRAWN BY BT	CHECKED RST	DATE February,1976
RIG Heli Drill	METHOD	START January 10,1976	FINISH January 10,1976
PROJECT NO. cs 3161	ELEVATION	AIR TEMPERATURE -25° F	

W_P-⊡ W-⊙ W_L-△ MOISTURE CONTENT 20 40 60	DEPTH (feet)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %	LABORATORY TEST DATA	SAMPLE TYPE AND NUMBER	SAMPLE CONDITION	CORE RUN AND % RECOVERY	CORE CONDITION	REMARKS
	35	SM		SAND silty,fine, non plastic, brown, numerous thin laminations containing organics, frozen		Nbn	γ_w=104.5 pcf γ_d= 69.9 pcf γ_w=113.0 pcf γ_d= 82.5 pcf γ_w=113.0 pcf γ_d= 82.7 pcf					
					+ + +	Vx 2%	γ_w=110.4 pcf γ_d= 81.4 pcf	C1		100%	I	
	40			Bottom of Hole at 36.5 Feet.								

PLATE B-25

R.M.HARDY & ASSOCIATES LTD.
CONSULTING ENGINEERING & TESTING

TEST HOLE LOG

PROJECT: TAGLU GAS PLANT

TEST HOLE NO. H76-D14

LOGGED BY SGM	DRAWN BY BT	CHECKED RST	DATE February, 1976
RIG Heli Drill	METHOD	START January 10, 1976	FINISH January 10, 1976
PROJECT NO. cs 3161	ELEVATION	AIR TEMPERATURE	

W_P-⊡ W-⊙ W_L-△

● DYNAMIC CONE PENETRATION blows/ft.

MOISTURE CONTENT 20 40 60

DEPTH (feet)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %	LABORATORY TEST DATA	SAMPLE TYPE AND NUMBER	SAMPLE CONDITION	CORE RUN AND % RECOVERY	CORE CONDITION	REMARKS
			ICE		ICE						
5			WATER		UF						
	ML		SILT some fine sand, brownish grey								
10											
15											
			---silt, stratified, grey, trace of organics				S1	X	80%		
20											
							S2	X	80%		
25	SP		SAND fine grained, stratified								
			--- trace of organics, grey								
			--- trace to little silt				S3	X	80%		
30											

PLATE B-26

R.M.HARDY & ASSOCIATES LTD.
CONSULTING ENGINEERING & TESTING

TEST HOLE LOG

PROJECT: TAGLU GAS PLANT

TEST HOLE NO. H76-D14 (cont.)

LOGGED BY SGM	DRAWN BY BT	CHECKED RST	DATE February, 1976
RIG Heli Drill	METHOD	START January 10, 1976	FINISH January 10, 1976
PROJECT NO. cs 3161	ELEVATION	AIR TEMPERATURE	

W_P - ⊡ W - ⊙ W_L - ▲
● DYNAMIC CONE PENETRATION blows/ft. 20 40 60
MOISTURE CONTENT 20 40 60

DEPTH (feet)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %	LABORATORY TEST DATA	SAMPLE TYPE AND NUMBER	SAMPLE CONDITION	CORE RUN AND % RECOVERY	CORE CONDITION	REMARKS
	SP		SAND fine grained, stratified (cont.)								
			--- fine grained				U4		60%		
35			--- occasional silt lense		Nhn	γ_w=111.4 pcf γ_d= 81.4 pcf γ_w=112.1 pcf γ_d= 84.1 pcf γ_w=115.1 pcf γ_d= 85.3 pcf	C5		100 %	II	
40			--- gravel sizes								
	CI		CLAY (Till-like) silty, little sand, occasional coarse and fine gravel sizes				S6		50%		
45			Bottom of Hole at 43.5 Feet.								

PLATE B-27

TEST HOLE LOG

R.M.HARDY & ASSOCIATES LTD.
CONSULTING ENGINEERING & TESTING

PROJECT: TAGLU GAS PLANT

TEST HOLE NO. H76-H15

LOGGED BY SGM	DRAWN BY BT	CHECKED RST	DATE February, 1976
RIG Heli Drill	METHOD Splitspoon	START January 9, 1976	FINISH January 10, 1976
PROJECT NO. cs 3161	ELEVATION	AIR TEMPERATURE	

W_P - ⊡ W - ○ W_L - △
● DYNAMIC CONE PENETRATION blows/ft. 10 20 30
MOISTURE CONTENT 20 40 60

DEPTH (feet)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %	LABORATORY TEST DATA	SAMPLE TYPE AND NUMBER	SAMPLE CONDITION	CORE RUN AND % RECOVERY	CORE CONDITION	REMARKS
			ICE		ICE						
5	SP		SAND fine, silty, medium brown-grey		Vr						
					UF						
10	ML		SILT sandy, grey, laminated fine grained sand sizes								
15			--- little fine sand; medium grey-brown, non plastic, wet			Gr. Size Plate B-46	S1		100 %		
20							S2		30%		
	SP		SAND fine grained, stratified, trace of organics, medium grey to brown		Nbn		S3 (SPT)		80%		N = 18 blows/ft.
(for 6") 25							S4		60%		
30			Bottom of Hole at 28.5 Feet.								

PLATE B-28

TEST HOLE LOG

R.M.HARDY & ASSOCIATES LTD.
CONSULTING ENGINEERING & TESTING

PROJECT: TAGLU GAS PLANT

TEST HOLE NO. H76-D18

LOGGED BY: SGM	DRAWN BY: BT	CHECKED: RST	DATE: February, 1976
RIG: Heli Drill	METHOD: Dynamic Cone Penetration Test	START: January 11, 1976	FINISH: January 11, 1976
PROJECT NO.: cs 3161	ELEVATION:	AIR TEMPERATURE:	

W_P-□ W-○ W_L-△

● DYNAMIC CONE PENETRATION blows/ft.

MOISTURE CONTENT

20 40 60

DEPTH (feet)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %	LABORATORY TEST DATA	SAMPLE TYPE AND NUMBER	SAMPLE CONDITION	CORE RUN AND % RECOVERY	CORE CONDITION	REMARKS
0			ICE		ICE						
5			WATER		UF						
			bottom of channel								
10											
15											
20											
25											
30											

PLATE B-29

R.M.HARDY & ASSOCIATES LTD.
CONSULTING ENGINEERING & TESTING

TEST HOLE LOG

PROJECT: TAGLU GAS PLANT

TEST HOLE NO. H76-D19 (cont.)

LOGGED BY SGM	DRAWN BY BT	CHECKED RST	DATE February, 1976
RIG Heli Drill	METHOD Dynamic Cone Penetration Test	START January 11,1976	FINISH January 11, 1976
PROJECT NO. cs 3161	ELEVATION	AIR TEMPERATURE	

W_P - ⊡ W - ⊙ W_L - △

● DYNAMIC CONE PENETRATION blows/ft.

MOISTURE CONTENT 20 40 60

DEPTH (feet)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %	LABORATORY TEST DATA	SAMPLE TYPE AND NUMBER	SAMPLE CONDITION	CORE RUN AND % RECOVERY	CORE CONDITION	REMARKS
					UF						
			possible permafrost interface								
35											
40											
45											
			permafrost								
50			Bottom of Hole at 49.0 Feet.								

PLATE B-30

R.M.HARDY & ASSOCIATES LTD.
CONSULTING ENGINEERING & TESTING

TEST HOLE LOG

PROJECT: TAGLU GAS PLANT

TEST HOLE NO. H76-D19

LOGGED BY	DRAWN BY	CHECKED	DATE
SGM	BT	RST	February, 1976

RIG	METHOD	START	FINISH
Heli Drill	Dynamic Cone Penetration Test	January 11, 1976	January 11, 1976

PROJECT NO.	ELEVATION	AIR TEMPERATURE
cs 3161		

W_P - ⊡ W - ⊙ W_L - △

● DYNAMIC CONE PENETRATION blows/ft. 20 40 60

MOISTURE CONTENT 20 40 60

DEPTH (feet)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %	LABORATORY TEST DATA	SAMPLE TYPE AND NUMBER	SAMPLE CONDITION	CORE RUN AND % RECOVERY	CORE CONDITION	REMARKS
0			ICE		ICE						
5			WATER		UF						
10			r bottom of channel								
15											
20											
25											
30											

PLATE B-31

R.M.HARDY & ASSOCIATES LTD.
CONSULTING ENGINEERING & TESTING

TEST HOLE LOG

PROJECT: TAGLU GAS PLANT

TEST HOLE NO. H76-D19 (cont.)

LOGGED BY: SGM	DRAWN BY: BT	CHECKED: RST	DATE: February, 1976
RIG: Heli Drill	METHOD: Dynamic Cone Penetration Test	START: January 11, 1976	FINISH: January 11, 1976
PROJECT NO.: cs 3161	ELEVATION:	AIR TEMPERATURE:	

W_P-□ W-○ W_L-△

● DYNAMIC CONE PENETRATION blows/ft.

MOISTURE CONTENT 20 40 60

DEPTH (feet)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %	LABORATORY TEST DATA	SAMPLE TYPE AND NUMBER	SAMPLE CONDITION	CORE RUN AND % RECOVERY	CORE CONDITION	REMARKS
35					UF						
40											
45											
83 %			--- permafrost interface								
			Bottom of Hole at 47.5 Feet.								
50											

PLATE B-32

R.M.HARDY & ASSOCIATES LTD.
CONSULTING ENGINEERING & TESTING

TEST HOLE LOG

PROJECT: TAGLU GAS PLANT

TEST HOLE NO. HZ6-D20

LOGGED BY SGM	DRAWN BY ET	CHECKED RST	DATE February, 1976
RIG Heli Drill	METHOD Dynamic Cone Penetration Test	START January 11, 1976	FINISH January 11, 1976
PROJECT NO. cs 3161	ELEVATION	AIR TEMPERATURE	

W_P - ⊡ W - ⊙ W_L - △

● DYNAMIC CONE PENETRATION blows/ft. 20 40 60

MOISTURE CONTENT 20 40 60

DEPTH (feet)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %	LABORATORY TEST DATA	SAMPLE TYPE AND NUMBER	SAMPLE CONDITION	CORE RUN AND % RECOVERY	CORE CONDITION	REMARKS
0			ICE		ICE						
5			WATER		UF						
10											
15			⌐ bottom of channel								
20											
25											
30											

PLATE B-33

R.M.HARDY & ASSOCIATES LTD.
CONSULTING ENGINEERING & TESTING

TEST HOLE LOG

PROJECT: TAGLU GAS PLANT

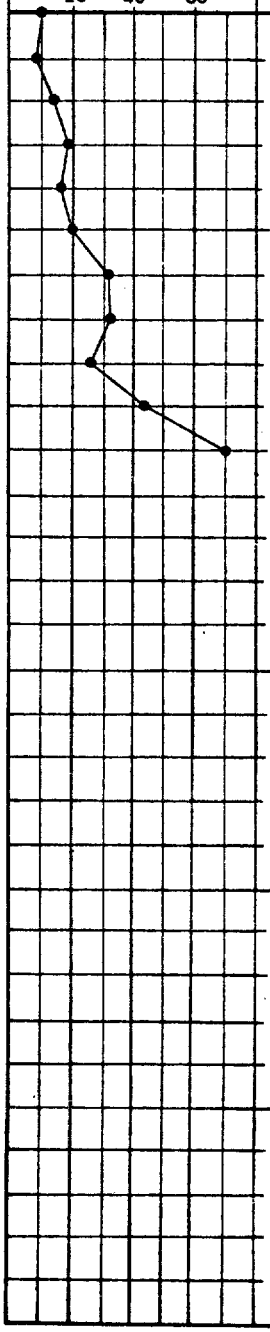
TEST HOLE NO. H76-D20 (cont.)

LOGGED BY: SGM	DRAWN BY: BT	CHECKED: RST	DATE: Februaru, 1976
RIG: Heli Drill	METHOD: Dynamic Cone Penetration Test	START: January 11, 1976	FINISH: January 11, 1976
PROJECT NO.: cs 3161	ELEVATION:	AIR TEMPERATURE:	

W_P-□ W-○ W_L-△

● DYNAMIC CONE PENETRATION blows/ft. 20 40 60

MOISTURE CONTENT 20 40 60



DEPTH (feet)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %	LABORATORY TEST DATA	SAMPLE TYPE AND NUMBER	SAMPLE CONDITION	CORE RUN AND % RECOVERY	CORE CONDITION	REMARKS
40			--- permafrost								
			Bottom of Hole at 40.5 Feet.								

PLATE B-34

R.M.HARDY & ASSOCIATES LTD.
CONSULTING ENGINEERING & TESTING

TEST HOLE LOG

PROJECT: TAGLU GAS PLANT

TEST HOLE NO. H76-D21

LOGGED BY	DRAWN BY	CHECKED	DATE
SGM	BT	RST	February, 1976

RIG	METHOD	START	FINISH
		January 11, 1976	

PROJECT NO.	ELEVATION	AIR TEMPERATURE
CS 3161		

W_P - ⊡ W - ⊙ W_L - △

● DYNAMIC CONE PENETRATION blows/ft.

MOISTURE CONTENT 20 40 60

DEPTH (feet)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %	LABORATORY TEST DATA	SAMPLE TYPE AND NUMBER	SAMPLE CONDITION	CORE RUN AND % RECOVERY	CORE CONDITION	REMARKS
0			ICE		ICE						
5			WATER Bottom of channel		UF						
10											
15											
20											
25											
30			--- possible permafrost interface								

PLATE B-35

R.M.HARDY & ASSOCIATES LTD.
CONSULTING ENGINEERING & TESTING

TEST HOLE LOG

PROJECT: TAGLU GAS PLANT

TEST HOLE NO. H76-D21 (cont.)

LOGGED BY SGM	DRAWN BY BT	CHECKED RST	DATE Februaru, 1976
RIG	METHOD	START Januaru 11, 1976	FINISH
PROJECT NO. cs 3161	ELEVATION	AIR TEMPERATURE	

W_P-⊡ W-⊙ W_L-△

● DYNAMIC CONE PENETRATION blows/ft.

MOISTURE CONTENT 20 40 60

DEPTH (feet)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %	LABORATORY TEST DATA	SAMPLE TYPE AND NUMBER	SAMPLE CONDITION	CORE RUN AND % RECOVERY	CORE CONDITION	REMARKS
			permafrost		UF						
35			Bottom of Hole at 32.0 Feet.								

PLATE B-36

R.M.HARDY & ASSOCIATES LTD.
CONSULTING ENGINEERING & TESTING

TEST HOLE LOG

PROJECT
TAGLU GAS PLANT

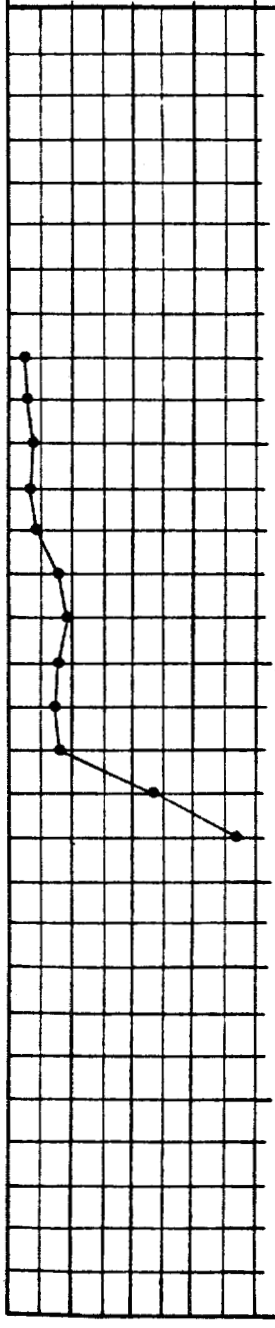
TEST HOLE NO. H76-D22

LOGGED BY SGM	DRAWN BY BT	CHECKED RST	DATE February, 1976
RIG Heli Drill	METHOD Dynamic Cone Penetration Test	START January 10, 1976	FINISH January 10, 1976
PROJECT NO. cs 3161	ELEVATION	AIR TEMPERATURE	

W_P - ⊡ W - ⊙ W_L - △

● DYNAMIC CONE PENETRATION blows/ft.

MOISTURE CONTENT 20 40 60



DEPTH (feet)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %	LABORATORY TEST DATA	SAMPLE TYPE AND NUMBER	SAMPLE CONDITION	CORE RUN AND % RECOVERY	CORE CONDITION	REMARKS
			ICE		ICE						
	ML		SILT some fine sand		Vr						
5											
					UF						
10											
15			permafrost								
20			Bottom of Hole at 19.0 Feet.								

PLATE B-37

R.M.HARDY & ASSOCIATES LTD.
CONSULTING ENGINEERING & TESTING

GRAIN SIZE CURVE

LAB ORDER NO.	CS3161
CLIENT	Taglu Gas Plant
SAMPLE	S1
SOURCE	
HOLE	H76-D1 @ 15-16.5'
TECHNICIAN	M.S. DATE TESTED Feb./76

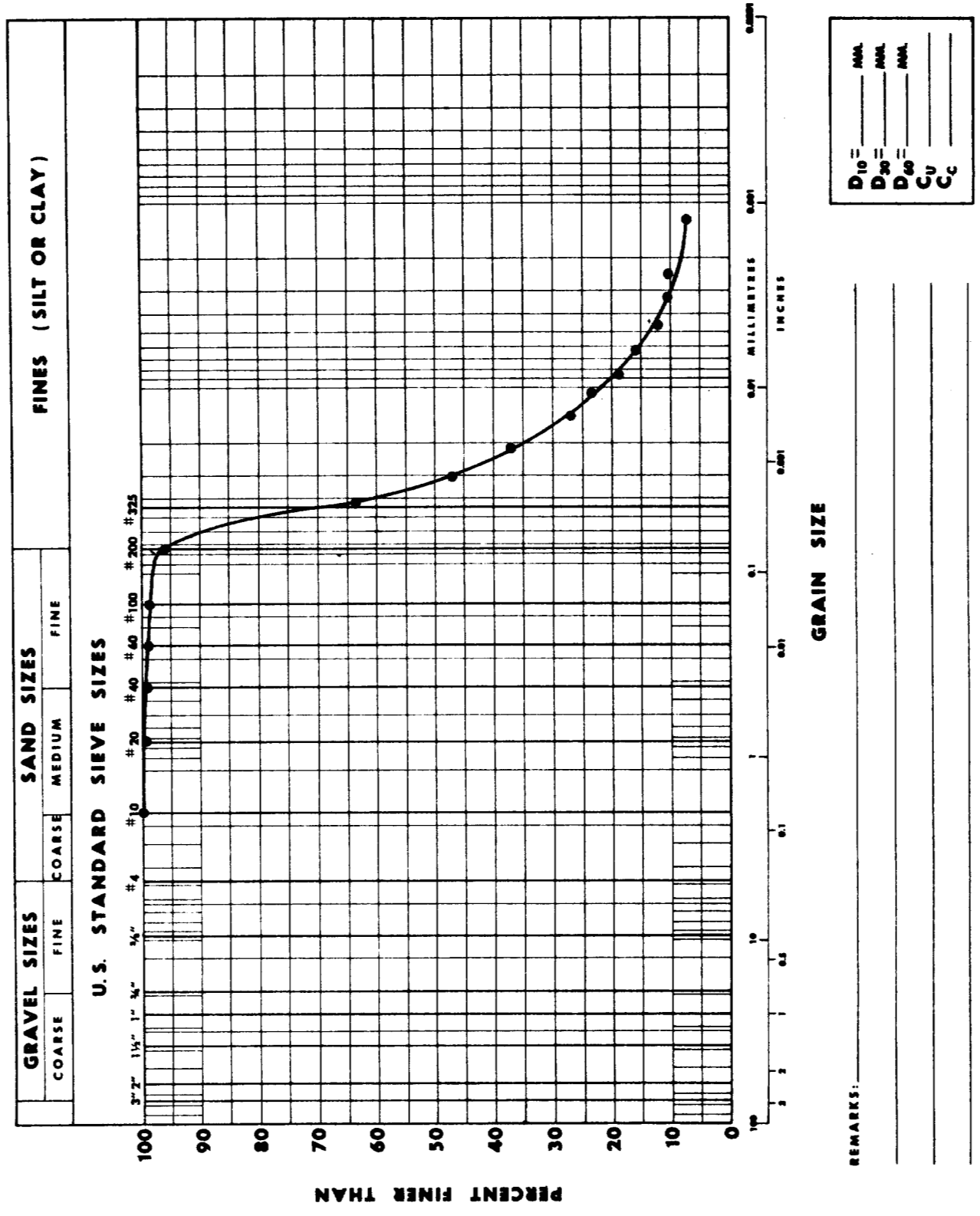


PLATE B-38

R.M.HARDY & ASSOCIATES LTD.
CONSULTING ENGINEERING & TESTING

GRAIN SIZE CURVE

LAB ORDER NO.	CS 3161
CLIENT	Taglu Gas Plant
SAMPLE	U3
SOURCE	
HOLE	H76-D2 @ 16-17' DATE REC'D.
TECHNICIAN	MS DATE TESTED Feb/76

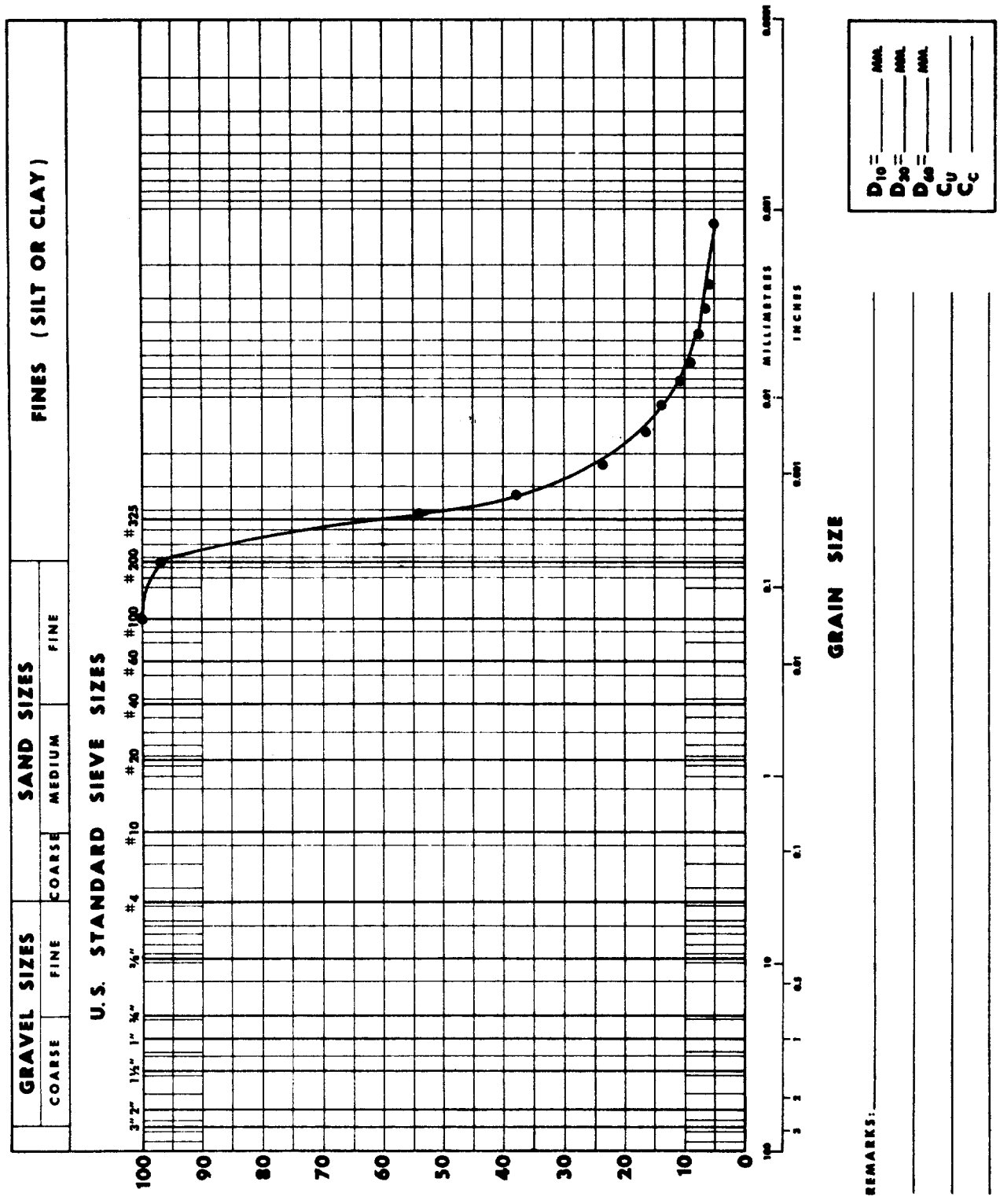


PLATE B-39

R.M.HARDY & ASSOCIATES LTD.
CONSULTING ENGINEERING & TESTING

GRAIN SIZE CURVE

LAB ORDER NO.	CS3161
CLIENT	Taglu Gas Plant
SAMPLE	S2
SOURCE	
HOLE	H76-D5 @ 29-30.5'
TECHNICIAN	M.S.
DATE TESTED	Feb./76

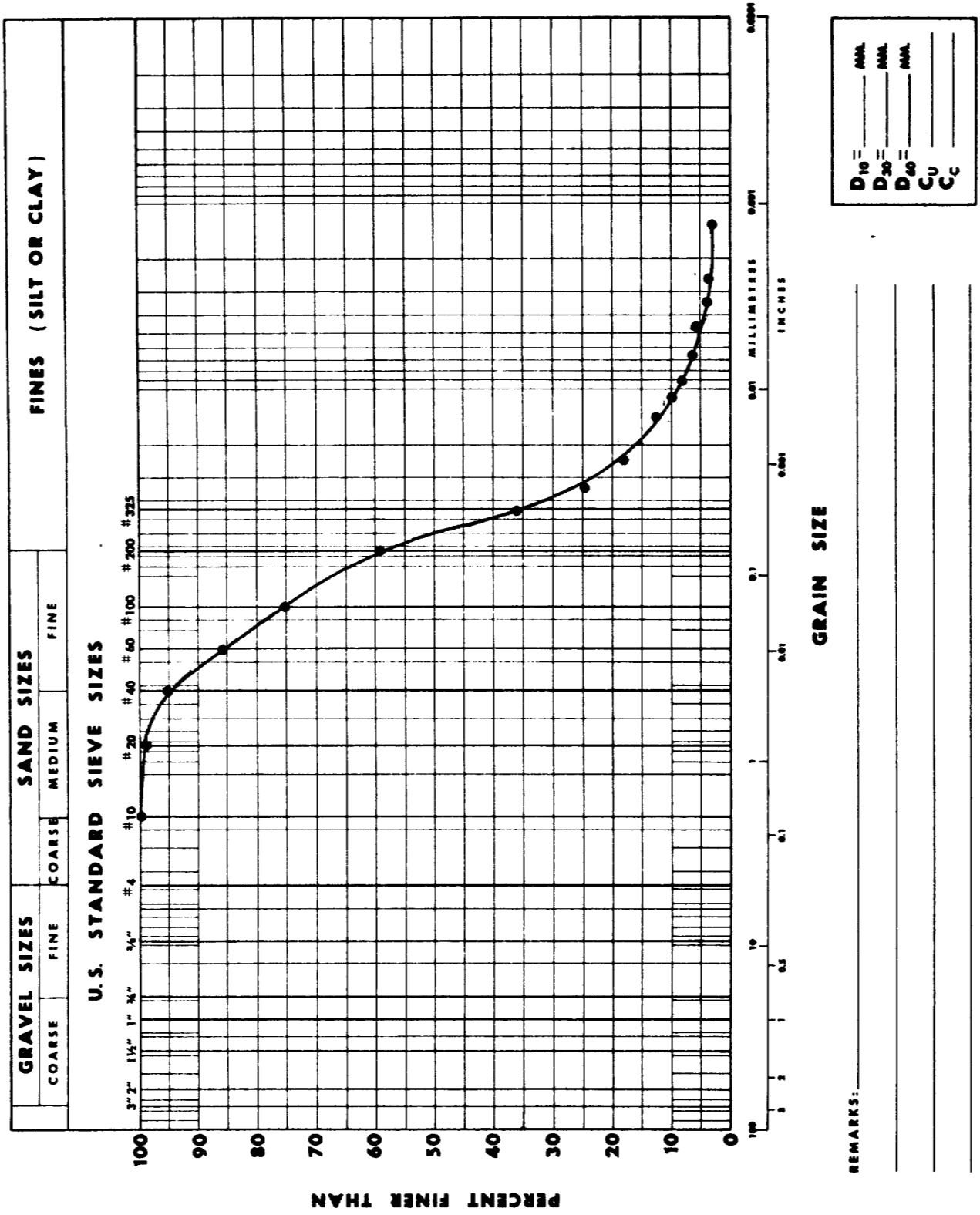


PLATE B-40

R.M.HARDY & ASSOCIATES LTD.
CONSULTING ENGINEERING & TESTING

GRAIN SIZE CURVE

LAB ORDER NO.	CS3161
CLIENT	Taglu Gas Plant
SAMPLE	U3
SOURCE	
HOLE	H76-D6 @ 15.5-17' DATE REC'D.
TECHNICIAN	M.S. DATE TESTED Feb./76

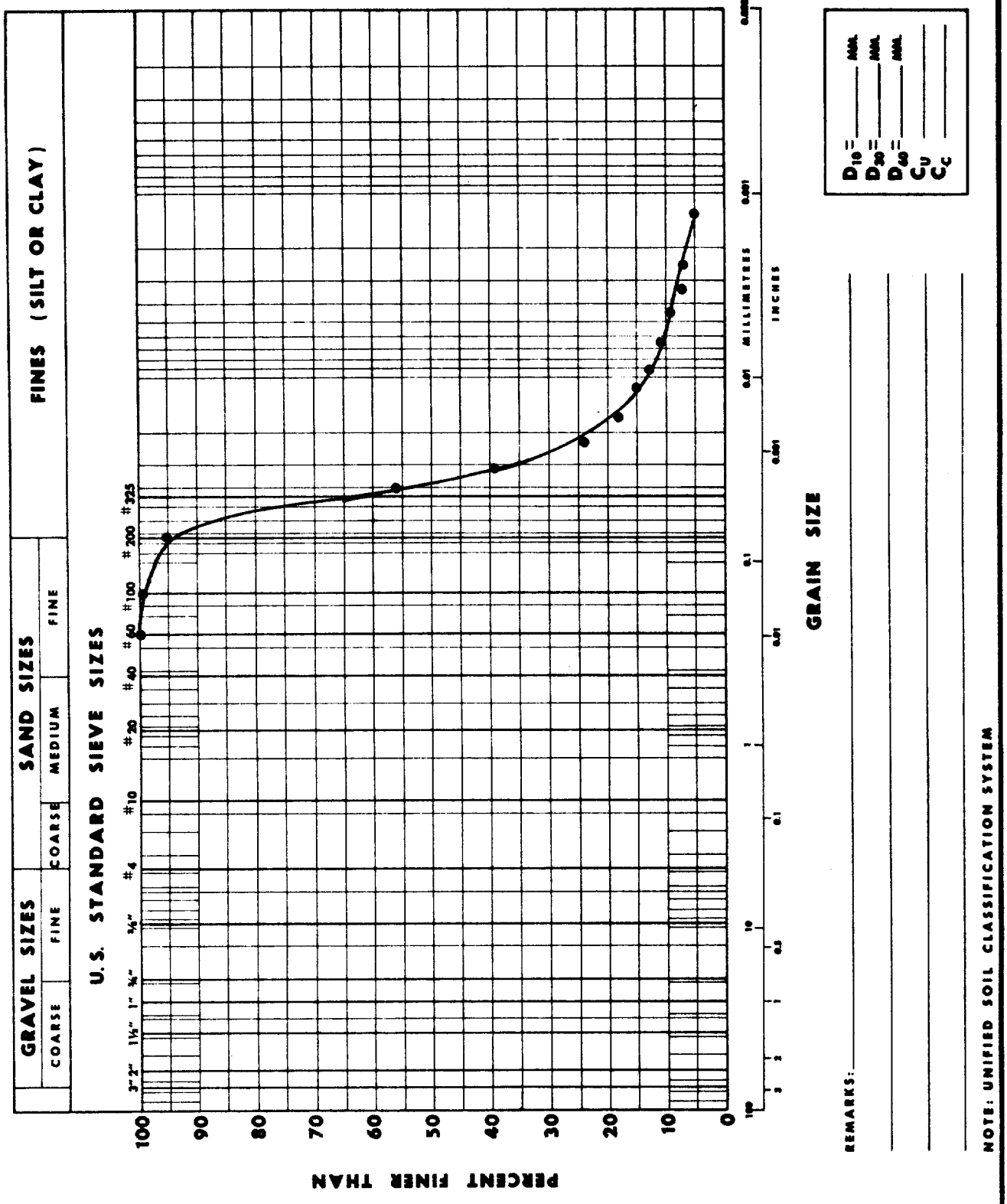


PLATE B-41

R.M.HARDY & ASSOCIATES LTD.
CONSULTING ENGINEERING & TESTING

GRAIN SIZE CURVE

LAB ORDER NO.	CS 3161
CLIENT	Taglu Gas Plant
SAMPLE	S1
SOURCE	
HOLE	H76-D7 @ 12-13½' DATE REC'D.
TECHNICIAN	M.S. DATE TESTED Feb/76

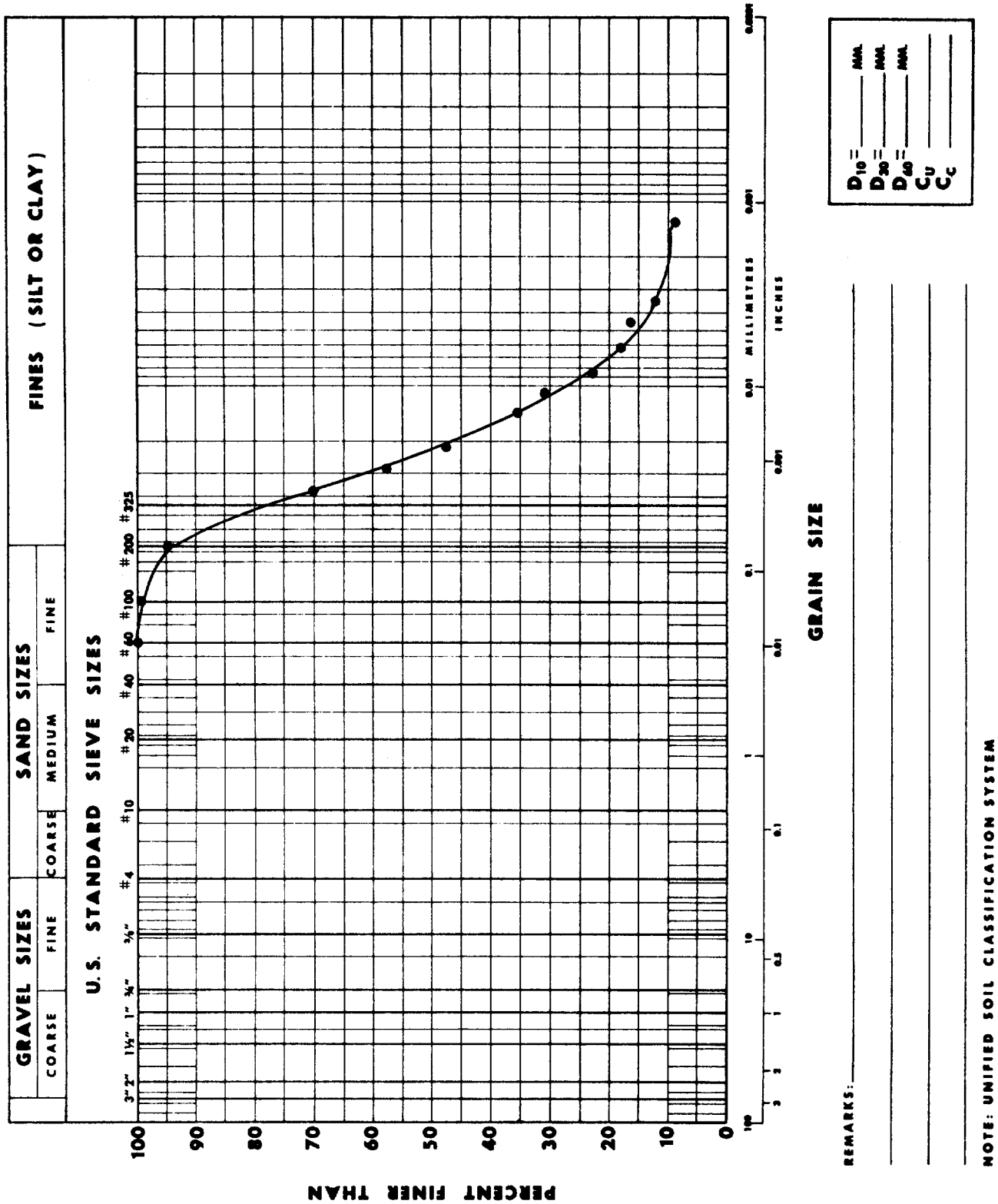
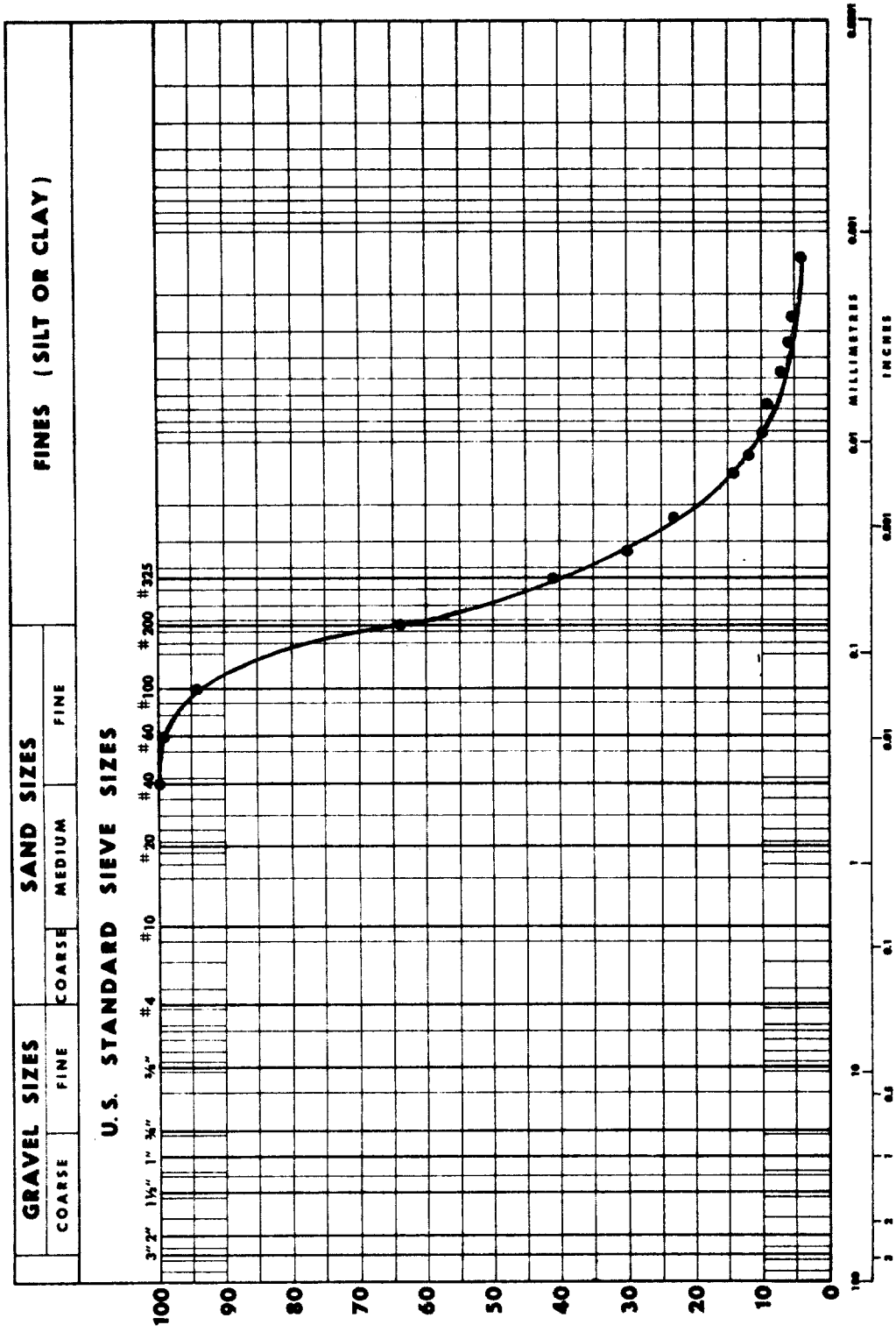


PLATE B-42

R.M.HARDY & ASSOCIATES LTD.
CONSULTING ENGINEERING & TESTING

GRAIN SIZE CURVE

LAB ORDER NO.	CS3161
CLIENT	Taglu Gas Plant
SAMPLE	S6
SOURCE	
HOLE	H76-D7 @ 42-43.5'
TECHNICIAN	M.S. DATE TESTED Feb./76



REMARKS:

NOTE: UNIFIED SOIL CLASSIFICATION SYSTEM

PLATE B-43

R.M.HARDY & ASSOCIATES LTD.
CONSULTING ENGINEERING & TESTING

GRAIN SIZE CURVE

LAB ORDER NO.	CS3161
CLIENT	Taglu Gas Plant
SAMPLE	S2
SOURCE	
HOLE	H76-D11 @ 13-14.5' DATE REC'D.
TECHNICIAN	M.S. DATE TESTED Feb./76

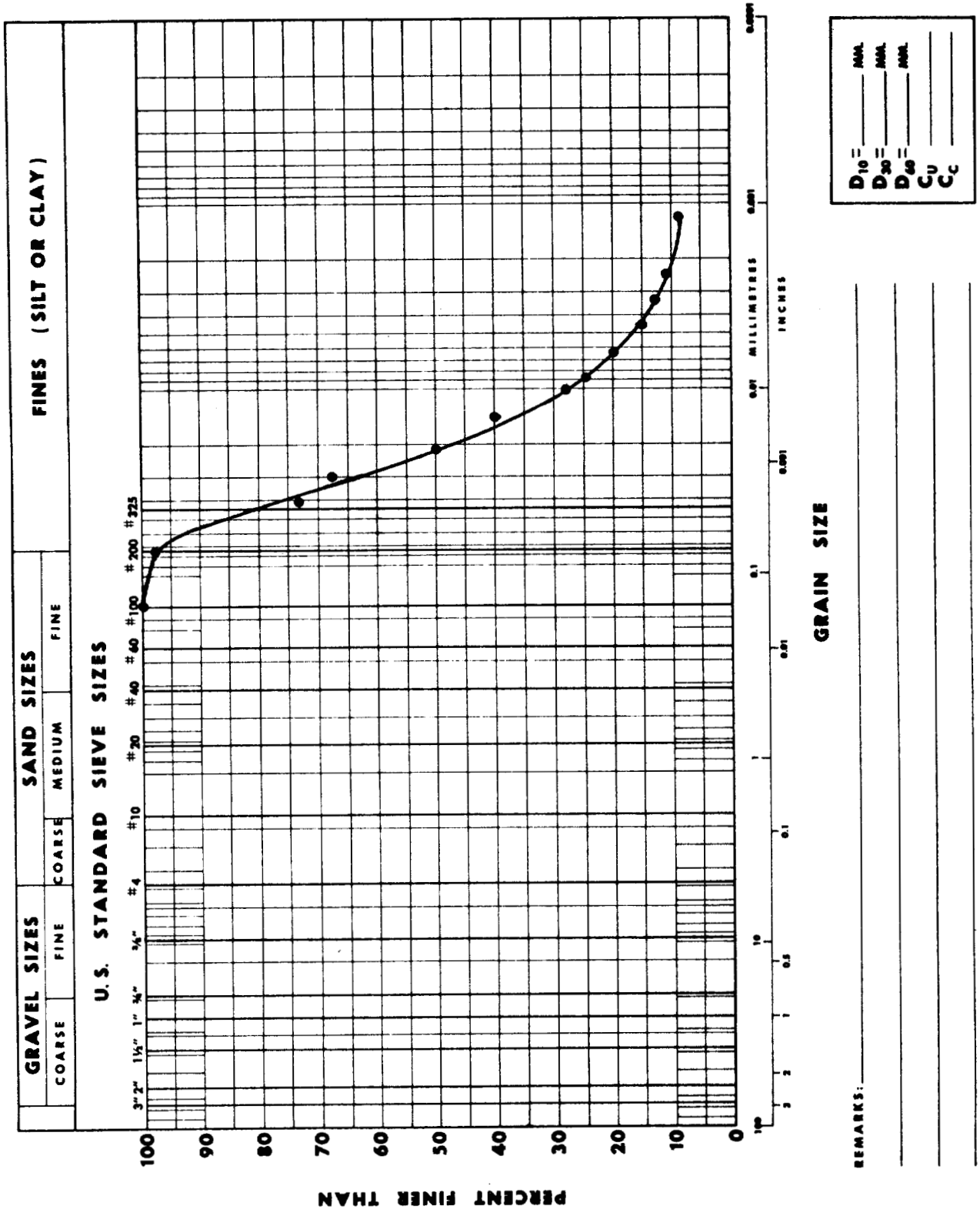


PLATE B-44

R.M. HARDY & ASSOCIATES LTD.
CONSULTING ENGINEERING & TESTING

GRAIN SIZE CURVE

LAB ORDER NO.	CS3161
CLIENT	Taglu Gas Plant
SAMPLE	U5
SOURCE	
HOLE	H76-D12 @ 31-32.5'
TECHNICIAN	M.S.
DATE TESTED	Feb./76

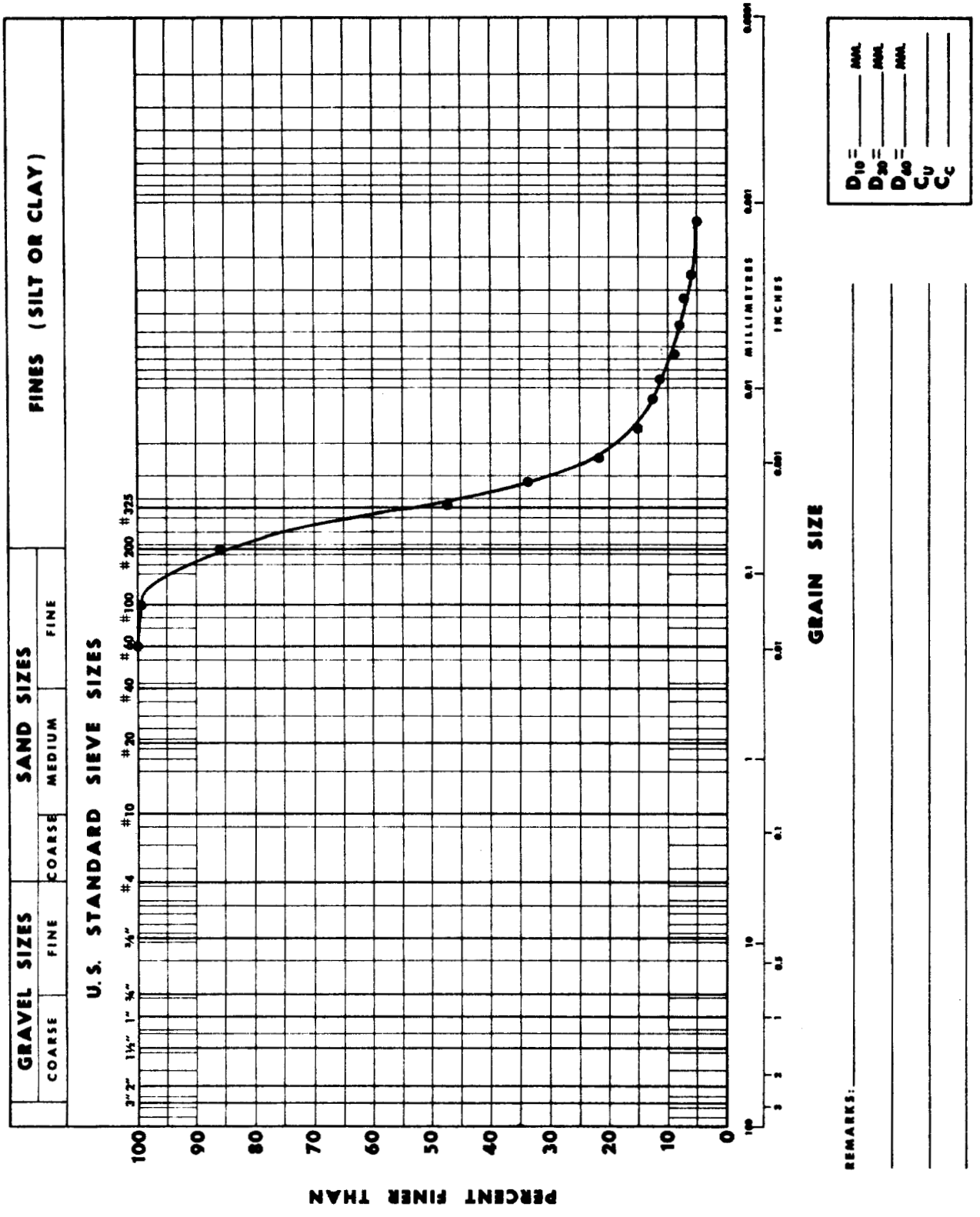


PLATE B-45

R.M.HARDY & ASSOCIATES LTD.
CONSULTING ENGINEERING & TESTING

GRAIN SIZE CURVE

LAB ORDER NO.	CS3161
CLIENT	Taglu Gas Plant
SAMPLE	S1
SOURCE	
HOLE	H76-D15 @ 15-16.5'
TECHNICIAN	M.S. DATE TESTED Feb./76

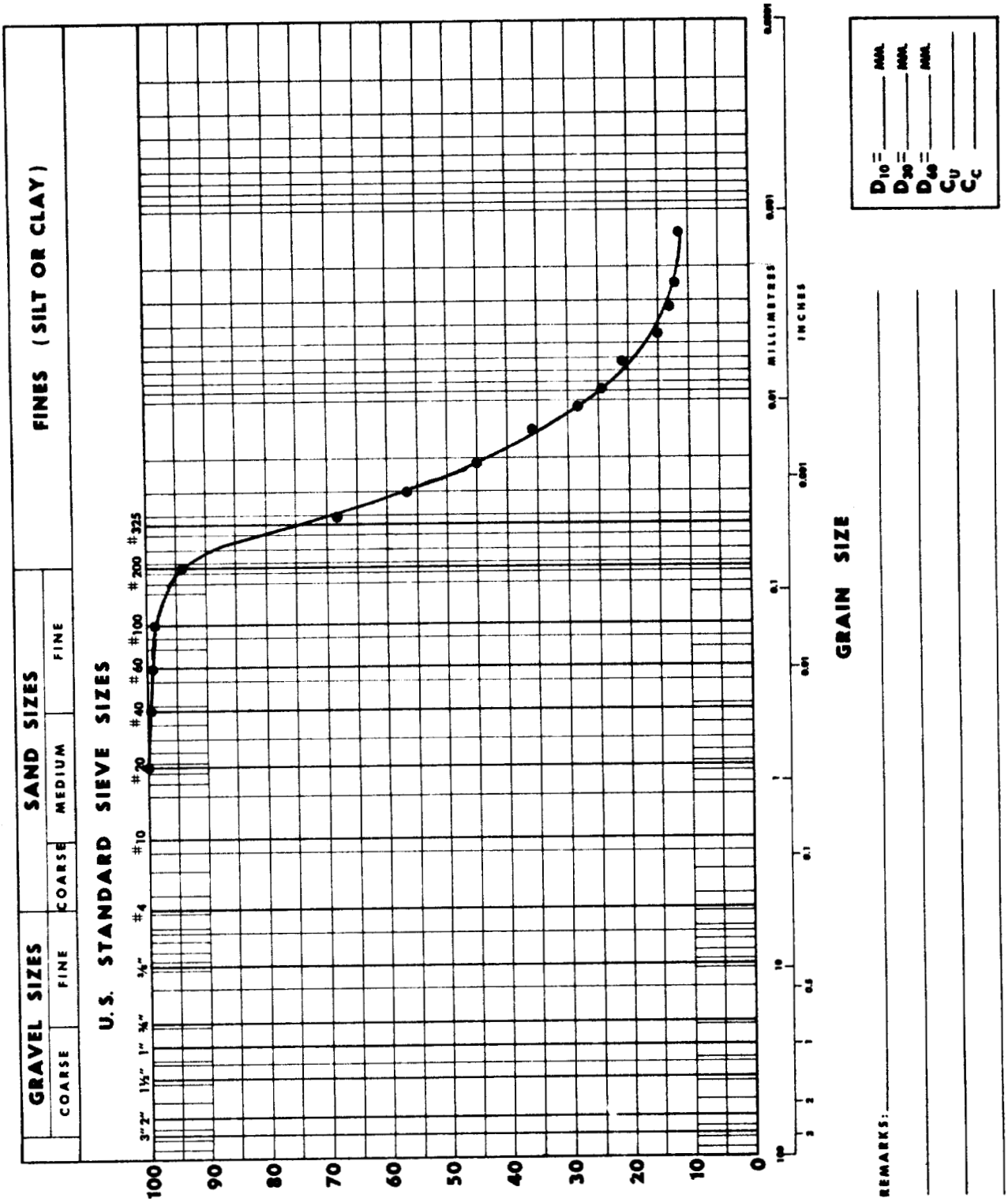
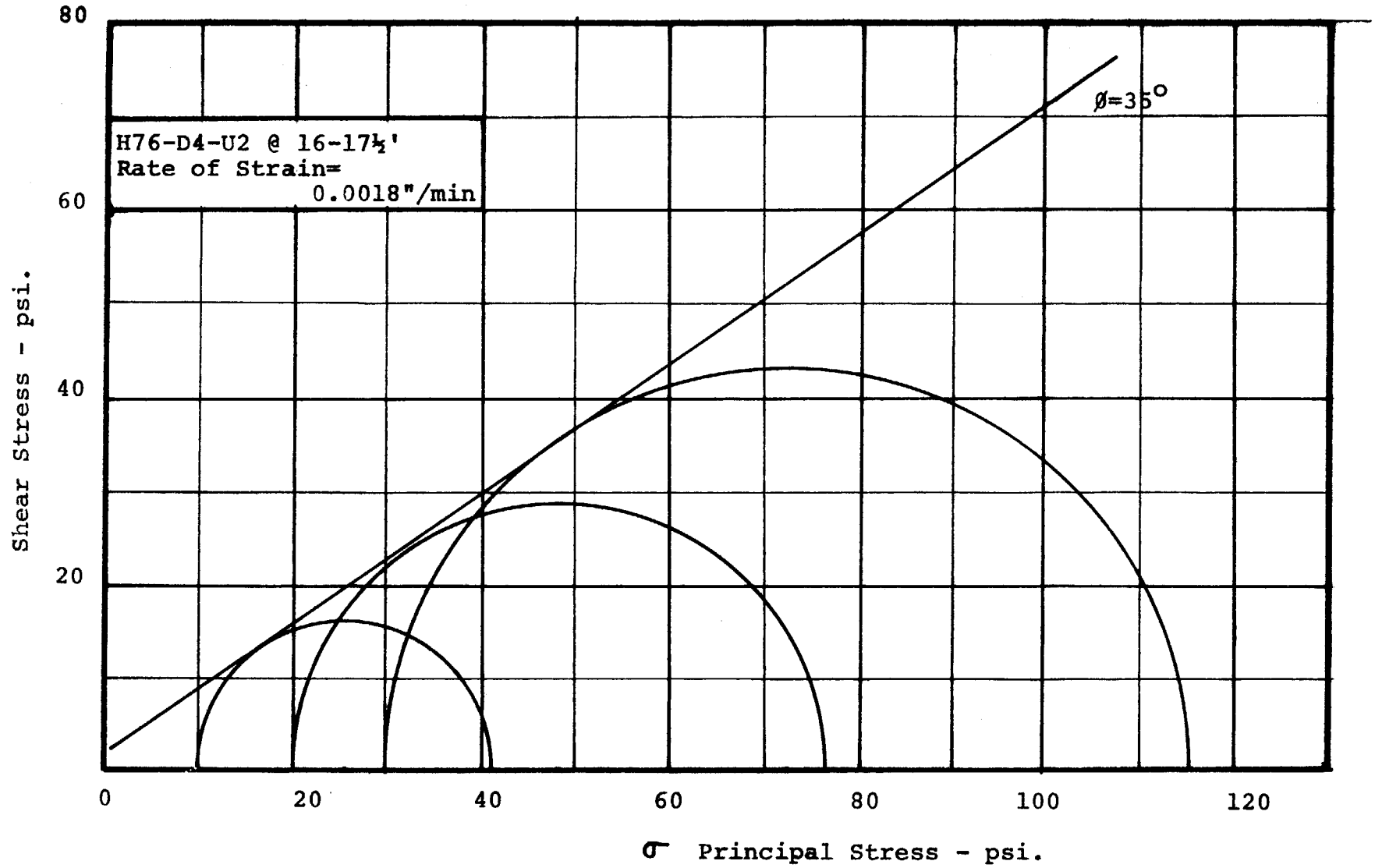


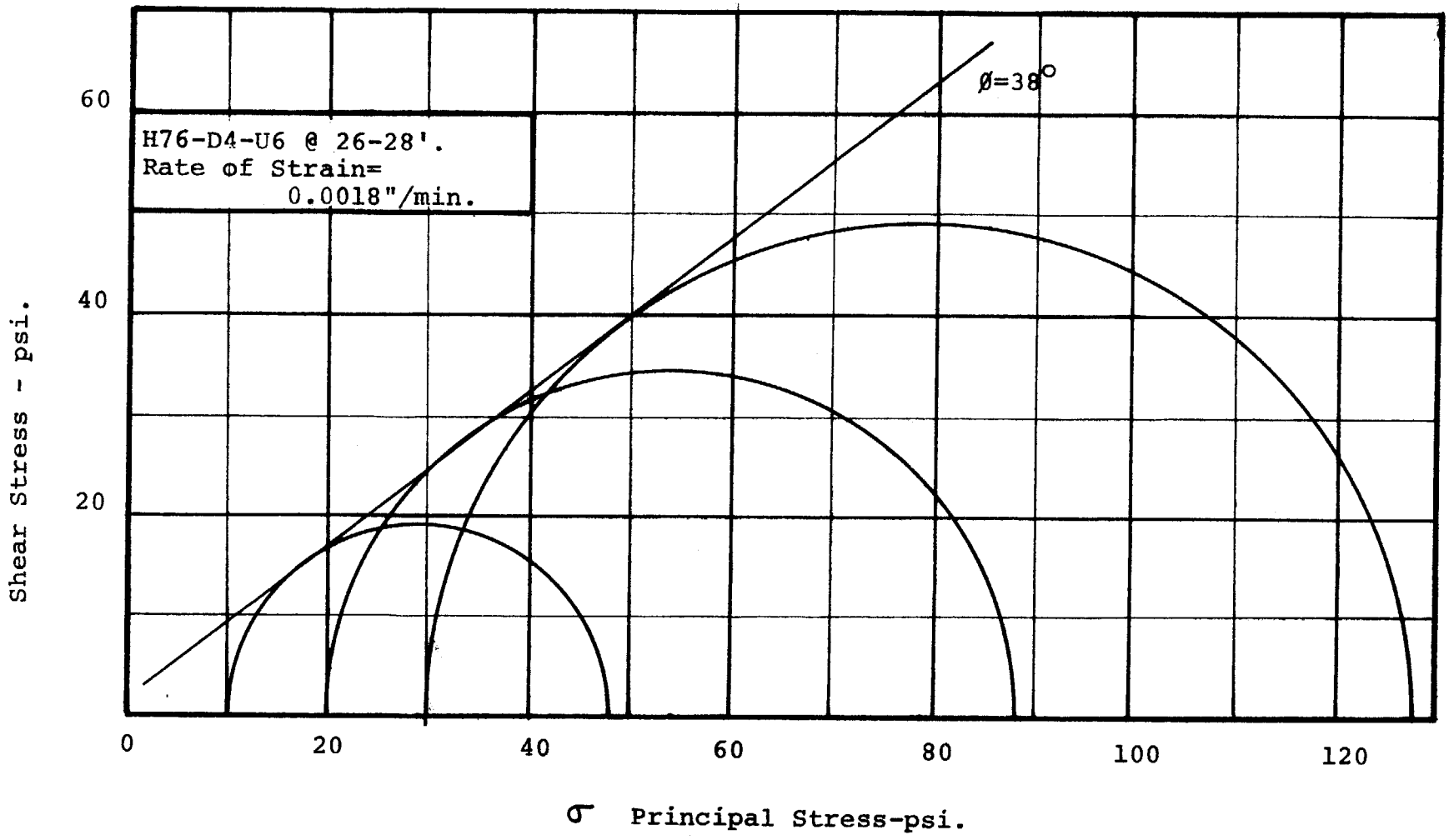
PLATE B-46



R.M.HARDY & ASSOCIATES LTD.
CONSULTING ENGINEERING & TESTING

TAGLU GAS PLANT
MOHR CIRCLES OF TOTAL AND
EFFECTIVE STRESSES
DRAINED TRIAXIAL TEST RESULTS

SCALE	DATE	MADE	CHKD.	JOB:	PLATE
		YK	RST	CS3161	B47



R.M. HARDY & ASSOCIATES LTD.
CONSULTING ENGINEERING & TESTING

TAGLU GAS PLANT
MOHR CIRCLES OF TOTAL AND
EFFECTIVE STRESSES
DRAINED TRIAXIAL TEST RESULTS

SCALE _____ DATE APR. 76 MADE YK CHKD RST JOB: CS3161 PLATE B48

MTL-4

R.M.HARDY & ASSOCIATES LTD.
CONSULTING ENGINEERING & TESTING

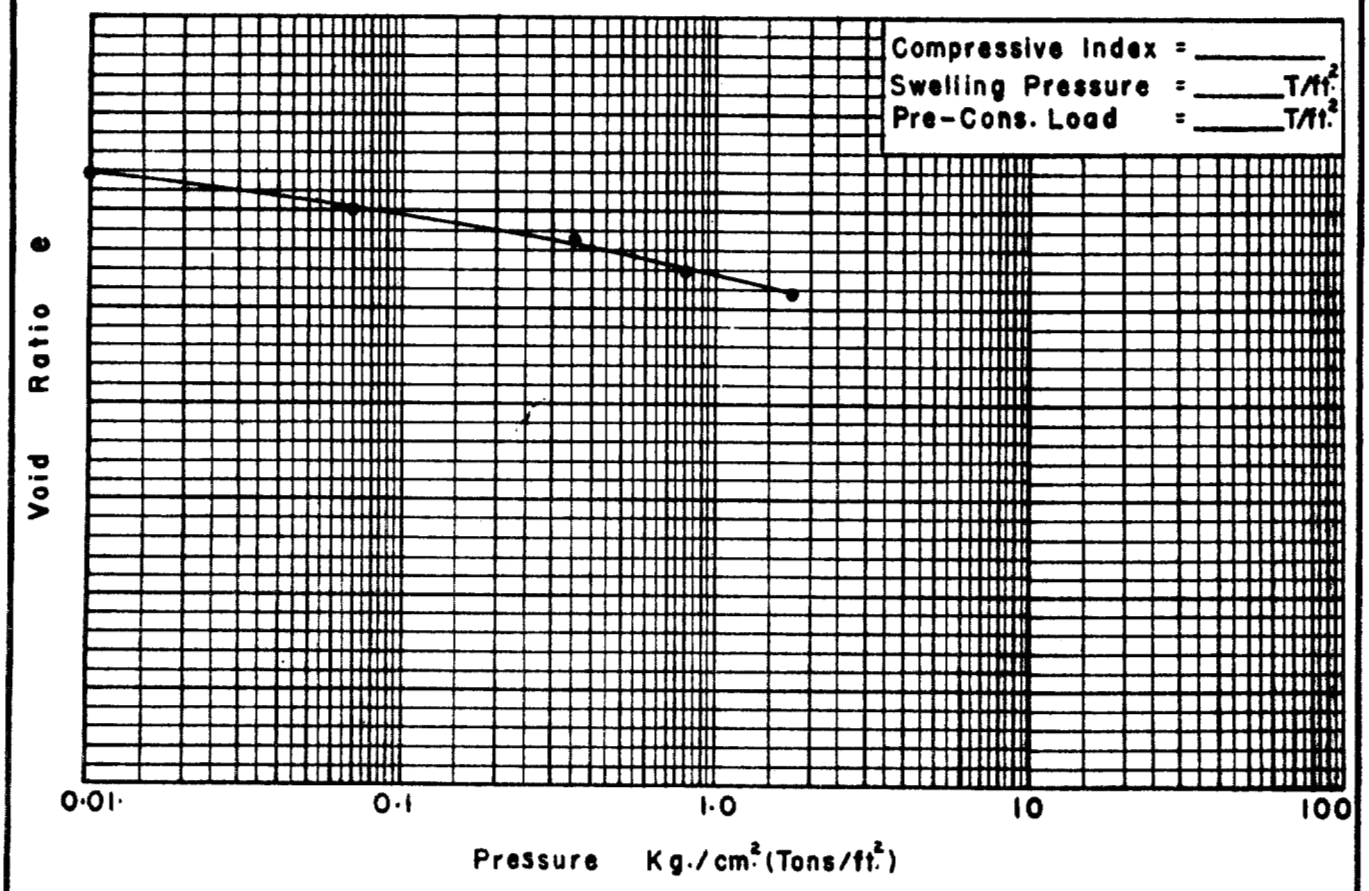
PROJECT	Taglu Gas Plant
LAB. ORDER	CS3161
SAMPLE	C1
LOCATION	Barge Dock Site
HOLE H76-D5	DEPTH 47-47.3'
TECHNICIAN RC	DATE April 197(

Specific Gravity of Soil Solids G_s = 2.70 (est Height of Soil Solids H_s = .913 ins.
Void Ratio e (End) = _____
Void Ratio e(Start) = _____
Void Ratio e (Start Dimensions) = .769

e(End) = W%(End) x G_s $\quad H_s = \left(\frac{\text{Wt. Soil}}{G_s \times \text{Area} \times 2.54}\right)$ ins. $\quad e = \text{previous } e \pm \frac{\text{Def'l.}}{H_s}$

Time Interval	Load on Pan (gms)	Corr. Dial Reading (ins.)	Deflection (ins.)	Deflection / H_s	Void Ratio e	Pressure Kg/cm² = T/ft²
		1.487	0	0	.769	
	.96 psi	1.470	.017	.019	.750	.07
	5.0 psi	1.456	.014	.015	.735	.36
	11.3 psi	1.441	.015	.016	.719	.81
	24.9 psi	1.432	.009	.010	.709	1.79

	Core Sample	Test Sample
Bulk Density (pcf.)	118.3	120.0
Dry Density (pcf)	93.2	96.5
Moisture Content (%)	26.9	24.3
Moisture Content (after test) (%)		25.8



MTL-4

R.M.HARDY & ASSOCIATES LTD.
CONSULTING ENGINEERING & TESTING

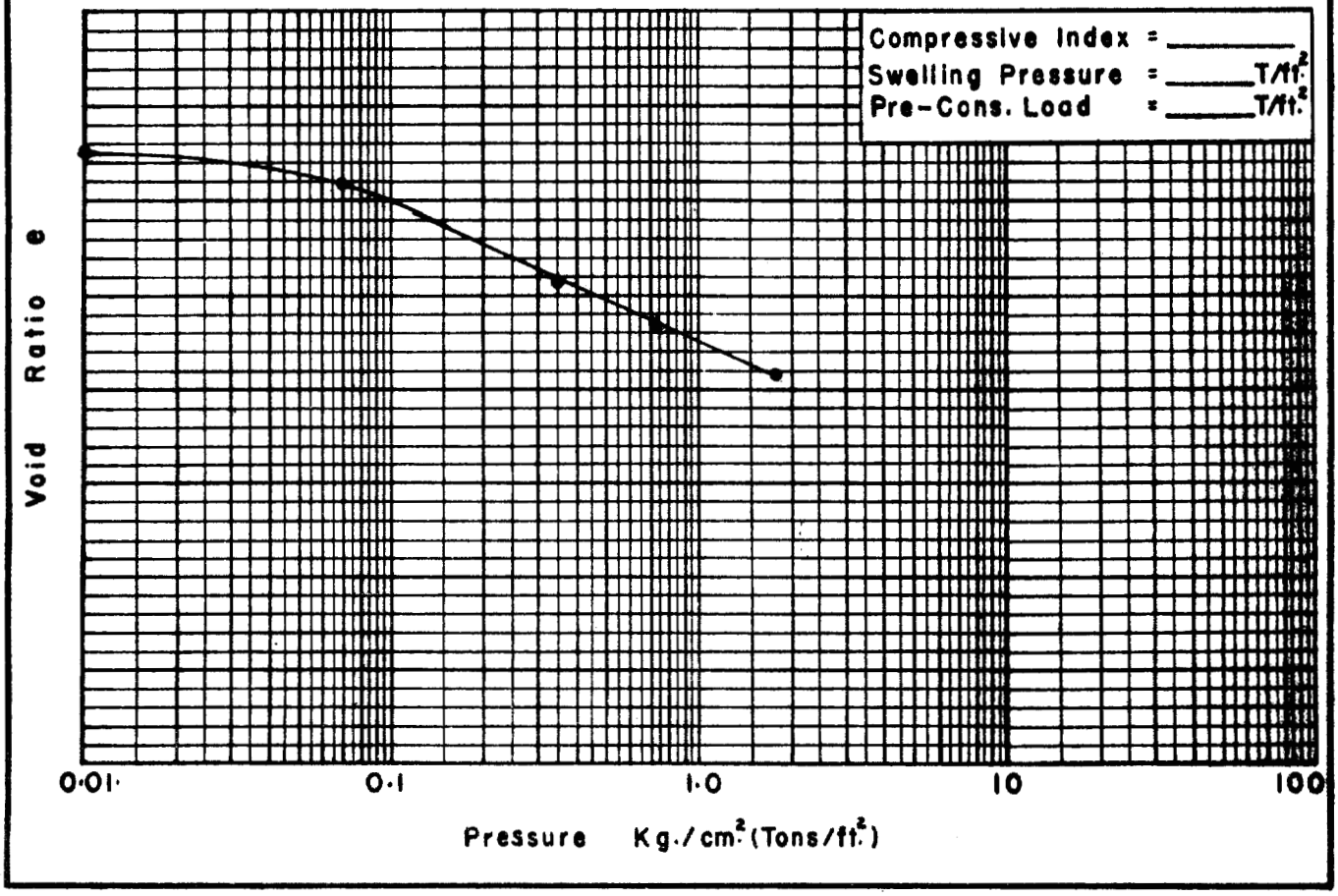
PROJECT	Taglu Gas Plant
LAB. ORDER	CS3161
SAMPLE	C1
LOCATION	Barge Dock Site
HOLE H76-D8	DEPTH 42-43.5'
TECHNICIAN RC	DATE April/76

Specific Gravity of Soil Solids G_s = 2.70 (est) Height of Soil Solids H_s = .897 ins.
Void Ratio e (End) = _____
Void Ratio e(Start) = _____
Void Ratio e (Start Dimensions) = .775

$e(End) = W\%(End) \times G_s$ $\quad H_s = \left(\frac{\text{Wt. Soil}}{G_s \times \text{Area} \times 2.54}\right)$ ins. $\quad e = \text{previous } e \pm \frac{\text{Def'l.}}{H_s}$

Time Interval	Load on Pan (gms)	Corr. Dial Reading (ins.)	Deflection (ins.)	Deflection / H_s	Void Ratio e	Pressure Kg/cm² = T/ft²
	0	1.552	0	0	.775	0
	.92 psi	1.537	.015	.017	.758	.07
	4.88 psi	1.499	.038	.042	.706	.35
	10.2 psi	1.487	.012	.013	.683	.73
	25.3 psi	1.465	.022	.025	.658	1.82

	Core Sample	Test Sample
Bulk Density (pcf)	119.9	118.2
Dry Density (pcf)	94.9	94.2
Moisture Content (%)	26.4	25.5
Moisture Content (after test) (%)		25.5



R.M. HARDY & ASSOCIATES LTD.
CONSULTING ENGINEERING & PROFESSIONAL SERVICES

SUMMARY OF LABORATORY TESTING

PROJECT Taglu Gas Plant
LOCATION Barge Dock Site
DATE January, 1976
JOB NO. CS3161

SAMPLE DATA					CLASSIFICATION TESTS						OTHER TESTS			
					ATTERBERG LIMITS			TEXTURE (%)						
TEST HOLE	DEPTH (ft)	SAMPLE NO	CLASSIFICATION	SOIL DESCRIPTION	LIQUID	PLASTIC	PLASTICITY INDEX	SAND	SILT	CLAY	WET DENSITY (PCF)	DRY DENSITY (PCF)	MOISTURE CONTENT (%)	
H76-D1	15-16.5	S1	ML	SILT, sandy, fine grained, non plastic, dark grey, layered, wet				4	88	8				
H76-D2	15-16	U2	ML	SILT, sandy, trace clay, occ. gravel sizes, non plastic, layered, occ. organic stringers, grey							142.2	113.1	25.7	
H76-D2	16-17	U3	ML	SILT, sandy, trace clay, occ. gravel sizes, non plastic, layered, occ. organic stringers, grey				3	91	6	103.0	80.2	28.4	
H76-D2	17-18	U4	SM	SAND, fine grained, silty, non plastic, grey, wet							106.9	78.8	34.7	
H76-D2	24-24.5	U8	SM	SAND, fine grained, silty, non plastic, grey, wet, numerous gravel sizes to ¼" diameter							132.2	104.6	26.4	
H76-D2	28-29	C1	SM	SAND, silty, fine grained, non plastic, dark grey, frozen							110.6	80.7	31.7	frozen sample
H76-D3	4-5	C1	CL	CLAY, silty, low plastic, grey							95.9	62.2	54.0	
H76-D3	19.5-20.5	C6	SP	SAND, silty, fine grained, non plastic, dark grey							116.9	88.4	32.2	frozen sample
H76-D3	24-24.8	C7	SP	SAND, silty, fine grained, non plastic, dark grey, laminated with organic material, stratified							113.1	77.1	46.6	frozen sample
H76-D3	24.8-25	C7	SP	SAND, silty, fine grained, non plastic, dark grey, laminated with organic material, stratified							106.1	74.4	42.6	frozen sample
H76-D4	16-17.5	U2	ML	SILT, sandy, non plastic, dark grey, stratified							114.4	81.3	40.7	Drained triaxial c'=0, ϕ'=35°
H76-D4	26-28	U6	ML	SILT, very sandy, fine grained non plastic, dark grey							116.0	93.0	24.7	Drained triaxial c'=0, ϕ'=35°
H76-D4	30-32	U8	ML	SILT, very sandy, fine grained, non plastic, dark grey							112.5	86.7	29.8	
H76-D4	32-33.4	U9	CL	CLAY, silty, low to medium plastic stratified, grey, trace of organics							114.7	86.4	32.8	
H76-D4	37.5-38.5	U10	CL	CLAY, silty, low to medium plastic stratified, grey, trace of organics, occ. fine grained sand							118.0	94.4	25.0	

PLATE B-51

R.M. HARDY & ASSOCIATES LTD.
CONSULTING ENGINEERING & PROFESSIONAL SERVICES

SUMMARY OF LABORATORY TESTING

PROJECT Taglu Gas Plant
LOCATION Barge Dock Site
DATE January, 1976
JOB NO. CS3161

SAMPLE DATA					CLASSIFICATION TESTS						OTHER TESTS			
					ATTERBERG LIMITS			TEXTURE (%)						
TEST HOLE	DEPTH (ft)	SAMPLE NO	CLASSIFICATION	SOIL DESCRIPTION	LIQUID	PLASTIC	PLASTICITY INDEX	SAND	SILT	CLAY	WET DENSITY (PCF)	DRY DENSITY (PCF)	MOISTURE CONTENT (%)	
H76-D4	42-43.4	U11	ML	SILT, trace clay, low plastic, dark grey, wet							122.1	98.6	23.6	
H76-D4	43.5-45	U12	SM	SAND, fine grained, trace silt, non plastic, dark grey, saturated							122.3	101.3	20.7	
H76-D5	29-30.5	S2	ML	SILT, trace sand, non plastic, grey				41	56	3				
H76-D5	47-47.3	C1	ML	SILT, sandy, non plastic, grey, frozen							120.0	96.5	24.3	Thaw Strain =2.4% M_v =0.038 $ft.^2/ton$
H76-D6	15.5-17	U3	ML	SILT, trace sand, non plastic, grey				6	87	7	114.3	92.4	23.7	
H76-D6	18.5-19.3	C2	ML	SILT, trace sand, non plastic, grey, cross-bedded							113.6	80.5	41.1	frozen sample
H76-D6	19.3-20	C2	ML	SILT, trace sand, non plastic, grey, cross-bedded, laminae of silt and organic matter							100.9	65.3	54.4	frozen sample
H76-D7	12-13.5	S1	ML	SILT, sandy, fine grained, non plastic				22	60	4				
H76-D7	22-23.5	U1	SM	SAND, silty, non plastic							110.6	76.7	44.2	
H76-D7	42-43.5	S6	ML	SILT, sandy, fine grained, non plastic, brown, wet				36	60	4				
H76-D7	62-62.6	C1	CI	CLAY, silty, trace of sand, dark grey, med. plastic, fine sand incl. to 3/4", brown, occ. organic sand and ice crystals							103.1	69.8	47.8	frozen sample
H76-D7	62.6-63.1	C1	CI	CLAY, silty, trace of sand, dark grey, med. plastic, fine sand incl. to 3/4", brown, occ. organic sand and ice crystals							110.4	81.0	36.3	frozen sample
H76-D7	63.1-63.8	C1	CI	CLAY, silty, trace of sand, dark grey, med. plastic, fine sand incl. to 3/4", brown, occ. organic sand and ice crystals							106.2	77.2	37.6	frozen sample
H76-D8	25-26.5	U1	ML	SILT, sandy, fine grained, non plastic, occasional organics, wet							115.6	89.3	29.5	
H76-D8	42-43.5	C1	SM	SAND, silty, fine grained, occ. coal and shale fragments, brown frozen							118.2	94.2	25.5	Thaw Strain =1.6% M_v = 0.014 $ft.^2/ton$

R.M. HARDY & ASSOCIATES LTD.
CONSULTING ENGINEERING & PROFESSIONAL SERVICES

SUMMARY OF LABORATORY TESTING

PROJECT Taglu Gas Plant
LOCATION Barge Dock Site
DATE January, 1976
JOB NO. CS3161

SAMPLE DATA					CLASSIFICATION TESTS						OTHER TESTS			
					ATTERBERG LIMITS			TEXTURE (%)						
TEST HOLE	DEPTH (ft)	SAMPLE NO	CLASSIFICATION	SOIL DESCRIPTION	LIQUID	PLASTIC	PLASTICITY INDEX	SAND	SILT	CLAY	WET DENSITY (PCF)	DRY DENSITY (PCF)	MOISTURE CONTENT (%)	
H76-D10	29-30.5	U1	ML	SILT,non plastic,brown,laminated occasional organics, wet							87.6	49.5	77.0	
H76-D10	52-59	C2	CL	CLAY, silty,sandy,low plastic occasional gravel sizes	27	14	13							
H76-D11	13-14.5	S2	ML	SILT,sandy, fine grained,grey-brown				2	88	10				
H76-D11	22-24	U4	SP	SAND, fine grained,trace silt							108.2	74.6	45.0	
H76-D11	31-31.8	C1	ML	SILT,sandy,finely laminated,cross bedded,poorly graded							108.1	78.8	37.1	frozen sample
H76-D11	31.8-32.4	C1	ML	SILT,sandy, finely laminated cross-bedded,poorly graded							111.1	81.4	37.4	frozen sample
H76-D11	32.4-33	C1	ML	SILT,sandy,finely laminated, cross-bedded, poorly graded,brown to grey bedding, sand layers							107.1	80.5	33.1	frozen sample
H76-D12	31.5-32.5	U5	ML	SILT,sandy, non to low plastic stratified				14	81	5	107.4	76.3	40.8	
H76-D12	35-35.7	C6	SP	SAND, fine grained,silty,dense medium brown							111.5	81.7	36.4	frozen sample
H76-D13	35-35.5	C1	SM	SAND, silty,fine grained,non plastic,brown,occ.organics, frozen							104.5	69.9	49.5	frozen sample
H76-D13	35.5-35.8	C1	SM	SAND, silty,fine grained, non plastic,brown, occasional organics,frozen							113.0	82.5	39.6	frozen sample
H76-D13	35.8-36.1	C1	SM	SAND, silty, fine grained,non plastic,brown,occasional organics frozen							113.0	82.7	36.7	frozen sample
H76-D13	36.1-36.5	C1	SM	SAND, silty,fine grained,non plastic,brown, occasional organics,frozen							110.4	81.4	35.6	
H76-D14	34.3-34.8	C5	SP	SAND, fine grained,stratified occasional silt lense							111.4	81.4	36.8	frozen sample
H76-D14	34.8-35.3	C5	SP	SAND, fine grained, stratified occasional silt lense							112.1	84.1	33.3	frozen sample

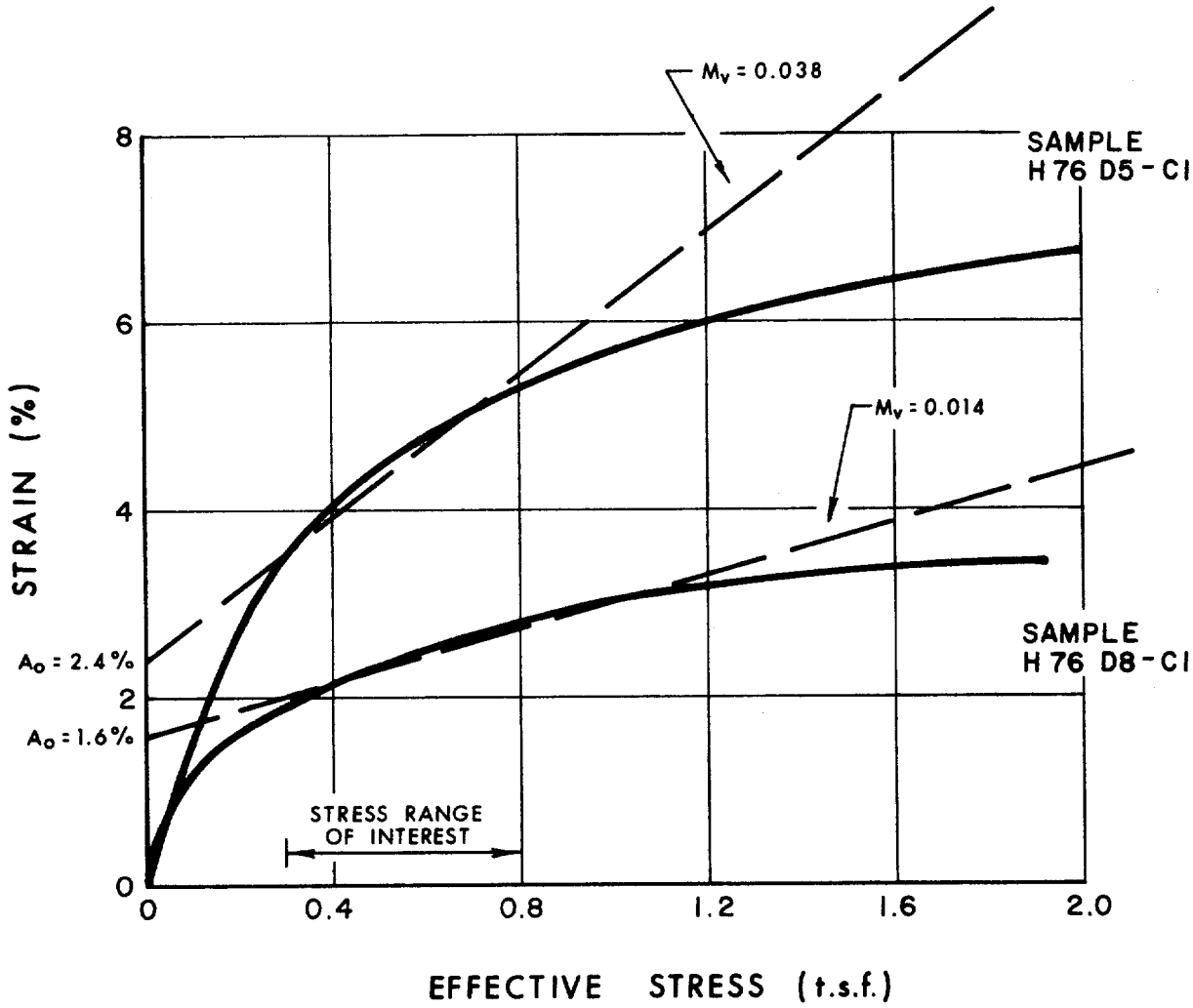
R.M.HARDY & ASSOCIATES LTD.
CONSULTING ENGINEERING & PROFESSIONAL SERVICES

SUMMARY OF LABORATORY TESTING

PROJECT: Taglu Gas Plant
LOCATION: Barge Dock Site
DATE: January, 1976
JOB NO. CS3161

SAMPLE DATA				SOIL DESCRIPTION	CLASSIFICATION TESTS						OTHER TESTS			
					ATTERBERG LIMITS			TEXTURE (%)						
TEST HOLE	DEPTH (ft)	SAMPLE NO	CLASSIFICATION		LIQUID	PLASTIC	PLASTICITY INDEX	SAND	SILT	CLAY	WET DENSITY (PCF)	DRY DENSITY (PCF)	MOISTURE CONTENT (%)	
H76-D14	35.3 -36	C5	SP	SAND, fine grained, stratified occasional silt lense							115.1	85.3	34.9	frozen sample
H76-D15	15- 16.5	S1	ML	SILT, sandy, fine grained laminated, grey				6	82	12				

PLATE B-54



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R.M. HARDY & ASSOCIATES LTD.
CONSULTING ENGINEERING & TESTING

PLATE B 55

EVALUATION OF THAW STRAIN AND SOIL COMPRESSIBILITY

APPENDIX C

BIGHORN CHANNEL BORROW AREA
BOREHOLE AND LABORATORY TEST DATA

TABLE C-1 TEST HOLE CO-ORDINATES;
BIG HORN CHANNEL AREA

(U.T.M. Zone 8)

Test Hole	N (metres)	E
H76 BH1	7,697,680	505,580
2	7,697,890	505,850
3	7,697,985	506,005
4	7,698,170	506,090
5	7,698,220	505,850
6	7,698,515	505,865
7	7,698,110	505,915
8	7,697,880	506,140
9	7,697,630	505,715
10	7,697,560	505,515
11	7,698,890	505,805

TEST HOLE LOG

R.M.HARDY & ASSOCIATES LTD.
CONSULTING ENGINEERING & TESTING

PROJECT: TAGLU GAS PLANT

TEST HOLE NO. H76-BH1

LOGGED BY SGM	DRAWN BY BT	CHECKED RST	DATE February, 1976
RIG Heli Drill	METHOD	START January 13, 1976	FINISH
PROJECT NO. cs 3161	ELEVATION	AIR TEMPERATURE	

W_P-⊡ W-⊙ W_L-△ MOISTURE CONTENT 20 40 60	DEPTH (feet)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %	LABORATORY TEST DATA	SAMPLE TYPE AND NUMBER	SAMPLE CONDITION	CORE RUN AND % RECOVERY	CORE CONDITION	REMARKS
				ICE		ICE						
	5			WATER		UF						
		ML		SILT little fine sand, saturated, rapid dilatancy								
	10			--- trace fine sand			Gr. Size Plate C-22	S1	X	100 %		
		SM		SAND fine, silty, trace to little medium sand, layered, wet				S2	X	20%		
	15			--- fine to medium grained, little silt, dark grey, very silty layer, wet			Gr. Size Plate C-23	S3	X	100 %		
								S4	X	100 %		
	20							S5	X	100 %		
	25			--- trace of silt, non plastic, occasional gravel sizes				S6	X	100 %		
	30							S7	X	40%		PLATE C-1

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TEST HOLE LOG

PROJECT: TAGLU GAS PLANT

TEST HOLE NO. H76-BH1 (cont.)

LOGGED BY	DRAWN BY	CHECKED	DATE
SGM	BT	RST	February, 1976

RIG	METHOD	START	FINISH
Heli Drill		January 13, 1976	

PROJECT NO.	ELEVATION	AIR TEMPERATURE
CS 3161		

W_P-⊡ W-⊙ W_L-△ MOISTURE CONTENT 20 40 60	DEPTH (feet)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %	LABORATORY TEST DATA	SAMPLE TYPE AND NUMBER	SAMPLE CONDITION	CORE RUN AND % RECOVERY	CORE CONDITION	REMARKS
		SM		SAND trace of silt, medium brown, fine grained sand sizes		UF Nbn						
				--- occasional gravel sizes				U1		80%		
	35							U2		100 %		
				--- medium grained				C1		30%	IV	
								C2		100 %	IV	
	40			--- medium grained				S8		50%		
				Bottom of Hole at 41.5 Feet.								
	45											

PLATE C-2

TEST HOLE LOG

R.M.HARDY & ASSOCIATES LTD.
CONSULTING ENGINEERING & TESTING

PROJECT: TAGLU GAS PLANT

TEST HOLE NO. H76-BH2

LOGGED BY: SGM	DRAWN BY: BT	CHECKED: RST	DATE: February, 1976
RIG: Heli Drill	METHOD: Splitspoon, Shelby Tube	START: January 13, 1976	FINISH:
PROJECT NO.: cs 3161	ELEVATION:	AIR TEMPERATURE: -30° C	

W_P-⊡ W-⊙ W_L-△ MOISTURE CONTENT 20 40 60	DEPTH (feet)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %	LABORATORY TEST DATA	SAMPLE TYPE AND NUMBER	SAMPLE CONDITION	CORE RUN AND % RECOVERY	CORE CONDITION	REMARKS
				ICE		ICE						
	5			*WATER*		UF						
		ML		*SILT low plastic, grey, wet*								
	10			--- *sandy, dark grey, low to medium plastic, layered, wet*			*Gr. Size Plate C-24*	S1	X	30%		
	15	CL		*CLAY silty, trace of sand, low to medium plastic, brown to grey, soft to firm*				S2	X	80%		
	20			--- *medium plastic, silty, trace of medium sand, soft to firm*				S3	X	90%		
	25	SM		*SAND fine grained, silty, grey to brown*								
				--- *some silt, layered, brown*			*Gr. Size Plate C-25*	S4	X			
				--- *1" rounded pebble*				S5	X			
				--- *medium to fine grained*		Nbn		C1	■			
	30											PLATE C-3

R.M.HARDY & ASSOCIATES LTD.
CONSULTING ENGINEERING & TESTING

TEST HOLE LOG

PROJECT: TAGLU GAS PLANT

TEST HOLE NO. H76-BH2 (cont.)

LOGGED BY SGM	DRAWN BY BT	CHECKED RST	DATE February, 1976
RIG Heli Drill	METHOD Splitspoon, Shelby Tube	START January 13, 1976	FINISH
PROJECT NO. cs 3161	ELEVATION	AIR TEMPERATURE -30° C	

W_P-⊡ W-⊙ W_L-△ MOISTURE CONTENT 20 40 60	DEPTH (feet)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %	LABORATORY TEST DATA	SAMPLE TYPE AND NUMBER	SAMPLE CONDITION	CORE RUN AND % RECOVERY	CORE CONDITION	REMARKS
		SM		SAND medium to fine grained, medium grey, non plastic, wet		Nbn		C2		0%	V	
				---occasional clay pocket and pebbles to 1/2" dia.				C3		75%	II	
				--- thin organic laminae								
				--- uniform, medium grained				C4		0%	V	
	35			--- fine grained, silty layers, brown, frozen								
								C5		100 %	II	
	40			**Bottom of Hole at 40.0 Feet.**								

PLATE C-4

R.M.HARDY & ASSOCIATES LTD.
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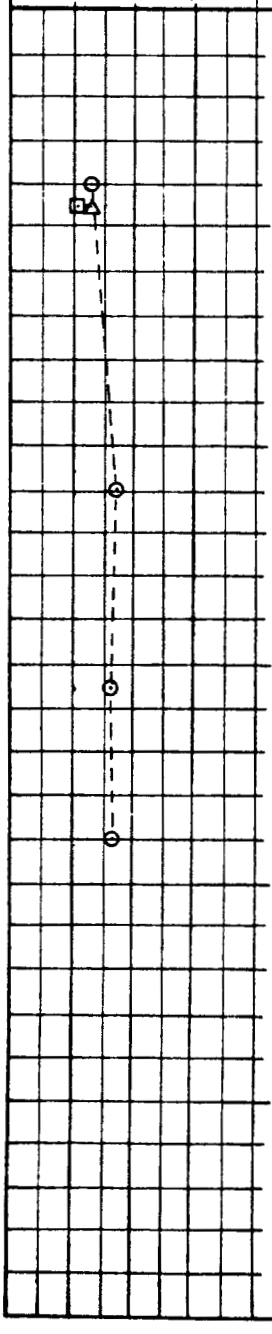
TEST HOLE LOG

PROJECT: TAGLU GAS PLANT

TEST HOLE NO. HZ6-BH3

LOGGED BY DV	DRAWN BY BT	CHECKED RST	DATE February, 1976
RIG Heli Drill	METHOD CRREL	START Januaru 12, 1976	FINISH
PROJECT NO. cs 3161	ELEVATION	AIR TEMPERATURE -30° C	



DEPTH (feet)	SOIL GROUP SYMBOL	DESCRIPTION	ICE GRAPHIC LOG / NRC ICE TYPE VISUAL ICE %	LABORATORY TEST DATA	SAMPLE TYPE AND NUMBER	SAMPLE CONDITION	CORE RUN AND % RECOVERY	CORE CONDITION	REMARKS
	ML	grass cover SILT low plastic, grey, trace of fine sand	Nbn						
5		--- sandier --- clay lense			W1		50%		
	CL to CI	CLAY silty, brown, low to medium plastic , layered			C1		100 %	I	
10		--- ice crystals to 1/8" diameter, thin ice lenses	Vs, Vx		C2		53%	IV	
15		--- particles of organics to 1/2", very silty	<5%	Gr. Size Plate C-26	C3		100 %	II	
		--- silty, dark grey, medium to high plastic, occasional ice lenses to 1/8"	Vx, Vs		C4		53%	IV	
20		--- silty, low to medium plastic occasional gravel sizes to 1 1/2" dia., brown			C5				
		Bottom of Hole at 22.0 Feet.							
25									

PLATE C-5

R.M.HARDY & ASSOCIATES LTD.
CONSULTING ENGINEERING & TESTING

TEST HOLE LOG

PROJECT: TAGLU GAS PLANT

TEST HOLE NO. H76-BH4

LOGGED BY MR	DRAWN BY BT	CHECKED RST	DATE February, 1976
RIG Heli Drill	METHOD	START January 13, 1976	FINISH
PROJECT NO cs 3161	ELEVATION	AIR TEMPERATURE	

W_P-⊡ W-⊙ W_L-△ MOISTURE CONTENT 20 40 60

DEPTH (feet)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %	LABORATORY TEST DATA	SAMPLE TYPE AND NUMBER	SAMPLE CONDITION	CORE RUN AND % RECOVERY	CORE CONDITION	REMARKS
			ICE		ICE						
5			WATER		UF						
	Pt		PEAT amorphous granular, silty, non woody								
10	ML to SM		SILT and sand, grey brown, non plastic, fine grained sand sizes, layered				S1	X	67%		
15			--- greyish brown, non plastic, soft to firm, wet, sandy			Gr. Size Plate C-27	S2	X	80%		
20	CL		CLAY silty, little sand, brown, low plastic, soft				S3	X	33%		
	SM		SAND fine to medium grained, trace to little silt, brown, moderate dialtancy, wet			Gr. Size Plate C-28	S4	X	100 %		
25							S5	X	53%		
30											

PLATE C-6

R.M.HARDY & ASSOCIATES LTD.
CONSULTING ENGINEERING & TESTING

TEST HOLE LOG

PROJECT: TAGLU GAS PLANT

TEST HOLE NO. H76-BH4 (cont.)

LOGGED BY	MR	DRAWN BY	BT	CHECKED	RST	DATE	February, 1976
RIG	Heli Drill	METHOD		START	Januaru 13, 1976	FINISH	
PROJECT NO.	cs 3161	ELEVATION		AIR TEMPERATURE			

W_P-□ W-○ W_L-△ MOISTURE CONTENT 20 40 60	DEPTH (feet)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %	LABORATORY TEST DATA	SAMPLE TYPE AND NUMBER	SAMPLE CONDITION	CORE RUN AND % RECOVERY	CORE CONDITION	REMARKS
		SM		SAND fine to medium grained, trace to little silt, brown, moderate dilatancy, wet (cont.)		UF		S6		NR		
								S7		100 %		
	35			--- occasional gravel sizes to 2" diameter				S8		75%		
				Bottom of Hole at 37.0 Feet.								
	40											

PLATE C-7

TEST HOLE LOG

R.M.HARDY & ASSOCIATES LTD.
CONSULTING ENGINEERING & TESTING

PROJECT: TAGLU GAS PLANT

TEST HOLE NO. H76-BH5

LOGGED BY SGH	DRAWN BY BT	CHECKED RST	DATE February, 1976
RIG Heli Drill	METHOD	START January 14, 1976	FINISH January 14, 1976
PROJECT NO. cs 3161	ELEVATION	AIR TEMPERATURE -40°C	

MOISTURE CONTENT (W_P-□ W-○ W_L-△) 20 40 60	DEPTH (feet)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %	LABORATORY TEST DATA	SAMPLE TYPE AND NUMBER	SAMPLE CONDITION	CORE RUN AND % RECOVERY	CORE CONDITION	REMARKS
				ICE		ICE						
	5			WATER		UF						
	10	ML		SILT and medium to fine sand, trace of clay, grey								
				--- clayey			Gr. Size Plate C-29	S1	X	100 %		
	15			--- clayey				S2	X	100 %		
		SP		SAND fine to medium grained, trace of silt								
	20	ML		SILT some fine to medium grained sand, trace of clay				S3	X	100 %		
		SM		SAND silty, fine grained, grey, trace of clay, occasional gravel sizes to 1" dia., layered								
	25			--- medium to fine grained			Gr. Size Plate C-30	S4	X	50%		
		SP		--- trace of silt, fine to medium grained				S5	X	50%		
	30											PLATE C-8

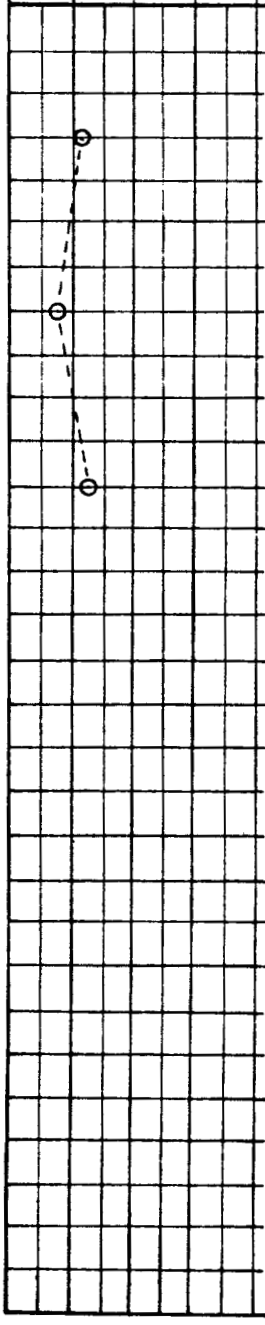
R.M.HARDY & ASSOCIATES LTD.
CONSULTING ENGINEERING & TESTING

TEST HOLE LOG

PROJECT: TAGLU GAS PLANT

TEST HOLE NO. H76-BH5 (cont.)

LOGGED BY SGM	DRAWN BY BT	CHECKED RST	DATE February, 1976
RIG Heli Drill	METHOD	START January 14, 1976	FINISH January 14, 1976
PROJECT NO. cs 3161	ELEVATION	AIR TEMPERATURE -40° C	



DEPTH (feet)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %	LABORATORY TEST DATA	SAMPLE TYPE AND NUMBER	SAMPLE CONDITION	CORE RUN AND % RECOVERY	CORE CONDITION	REMARKS
	SP		SAND fine to medium grained, trace of silt		UF						
							S6	X	50%		
35			--- fine, light brown, poorly graded, clean			Gr. Size Plate C-31	S7	X	100 %		
40							S8	X	100 %		Hole sloughed in some 10 feet.
			Bottom of Hole at 41.5 Feet.								
45											

PLATE C-9

TEST HOLE LOG

R.M.HARDY & ASSOCIATES LTD.
CONSULTING ENGINEERING & TESTING

PROJECT: TAGLU GAS PLANT

TEST HOLE NO. H76-BH6

LOGGED BY MR	DRAWN BY BT	CHECKED RST	DATE February, 1976
RIG Heli Drill	METHOD	START January 14, 1976	FINISH January 14, 1976
PROJECT NO. cs 3161	ELEVATION	AIR TEMPERATURE -40° C	

W_P-□ W-○ W_L-△ MOISTURE CONTENT 20 40 60	DEPTH (feet)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %	LABORATORY TEST DATA	SAMPLE TYPE AND NUMBER	SAMPLE CONDITION CORE RUN AND % RECOVERY	CORE CONDITION	REMARKS
				ICE		ICE					
	5			WATER		UF					
	10										
	15										
	20			bottom of channel							
		SM		SAND fine to coarse grained, brown, occasional particles of rounded gravel to 1/2" dia., wet				S2	67%		
				--- some gravel to 1 1/2" dia.			Gr. Size Plate C-32	S3	67%		
	25	CL		CLAY silty, little sand, occasional gravel sizes				S1	33%		
		SM		SAND silty, medium to coarse grained, occasional gravel sizes				S4	100 %		
				-- very silty							
	30							S5	50%		PLATE C-10

R.M.HARDY & ASSOCIATES LTD.
CONSULTING ENGINEERING & TESTING

TEST HOLE LOG

PROJECT: TAGLU GAS PLANT

TEST HOLE NO. H76-BH6 (cont.)

LOGGED BY MR	DRAWN BY BT	CHECKED RST	DATE February, 1976
RIG Heli Drill	METHOD	START January 14, 1976	FINISH January 14, 1976
PROJECT NO. cs 3161	ELEVATION	AIR TEMPERATURE -40° C	

MOISTURE CONTENT (W_P - ▣ W - ⊙ W_L - △) 20 40 60	DEPTH (feet)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %	LABORATORY TEST DATA	SAMPLE TYPE AND NUMBER	SAMPLE CONDITION	CORE RUN AND % RECOVERY	CORE CONDITION	REMARKS
		SM		SAND fine to medium grained, grey		UF		S5	X	50%		
				--- fine grained, silty, brown			Gr. Size Plate C-33	S6	X	25%		
	35											
		SP		--- fine to medium grained, brown, wet, some gravel sizes			Gr. Size Plate C-34	S7		0%		Hole sloughing in 7 feet.
	40							S8	X	67%		
				Bottom of Hole at 41.5 Feet.								
	45											

PLATE C-11

TEST HOLE LOG

R.M.HARDY & ASSOCIATES LTD.
CONSULTING ENGINEERING & TESTING

PROJECT: TAGLU GAS PLANT

TEST HOLE NO. HZ6-BH7

LOGGED BY MR	DRAWN BY BT	CHECKED RST	DATE February, 1976
RIG Heli Drill	METHOD	START January 14, 1976	FINISH January 14, 1976
PROJECT NO. cs 3161	ELEVATION	AIR TEMPERATURE -40° C	

MOISTURE CONTENT (W_P-⊡ W-⊙ W_L-△) 20 40 60	DEPTH (feet)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %	LABORATORY TEST DATA	SAMPLE TYPE AND NUMBER	SAMPLE CONDITION	CORE RUN AND % RECOVERY	CORE CONDITION	REMARKS
				ICE		ICE						
	5			*WATER*		UF						
	10	ML		*SILT sandy, brown, non plastic, layered , wet to saturated, trace of organics*				S1		50%		
	15	CI to CH		*CLAY silty, brown, mottled, dark grey, medium to high plastic, firm to stiff, occasional inclusions to 1/4" of organics*				S2		87%		
	20	CI		*CLAY (till-like) silty, brown to dark grey, medium plastic, firm to stiff, occasional particles to 1/4" of coal, fine sand layers*				S3		100 %		
	25							S4		67%		
	30	SP		*SAND fine grained, grey brown, trace of silt, rapid dilatancy, non plastic*		Nbn		S5		67%		
								S6		0%		PLATE C-12

R.M.HARDY & ASSOCIATES LTD.
CONSULTING ENGINEERING & TESTING

TEST HOLE LOG

PROJECT: TAGLU GAS PLANT

TEST HOLE NO. H76-BH7 (cont.)

LOGGED BY MR	DRAWN BY BT	CHECKED RST	DATE February, 1976
RIG Heli Drill	METHOD	START January 14, 1976	FINISH January 14, 1976
PROJECT NO. cs 3161	ELEVATION	AIR TEMPERATURE -40° C	

W_P - ⊡ W - ⊙ W_L - △

MOISTURE CONTENT 20 40 60

DEPTH (feet)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %	LABORATORY TEST DATA	SAMPLE TYPE AND NUMBER	SAMPLE CONDITION	CORE RUN AND % RECOVERY	CORE CONDITION	REMARKS
35	SP		SAND fine grained, non plastic, layered, wet, trace of silt		Nbn		C1		80%	III	VTM core barrel
							C2		40%	III	
40							C3		50%	III	
			--- occasional gravel sizes to 1/2"				S4		50%		
45			Bottom of Hole at 43.0 Feet.								

PLATE C-13

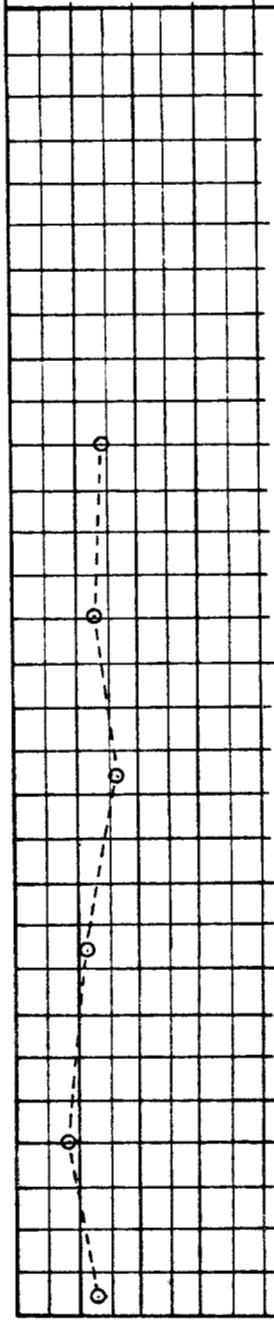
TEST HOLE LOG

R.M.HARDY & ASSOCIATES LTD.
CONSULTING ENGINEERING & TESTING

PROJECT: TAGLU GAS PLANT

TEST HOLE NO. H76-BH8

LOGGED BY: SGM	DRAWN BY: BT	CHECKED: RST	DATE: February, 1976
RIG: Heli Drill	METHOD:	START: January 15, 1976	FINISH: January 16, 1976
PROJECT NO.: cs 3161	ELEVATION:	AIR TEMPERATURE:	



DEPTH (feet)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %	LABORATORY TEST DATA	SAMPLE TYPE AND NUMBER	SAMPLE CONDITION	CORE RUN AND % RECOVERY	CORE CONDITION	REMARKS
			ICE		ICE						
5			WATER		UF						
	ML		SILT trace of fine sand, dark grey, clayey								
10							S1				
			--- dry, stiff, trace of fine sand, layered								
15			--- little organics, medium brown, peat layers to 1/2" thick			Gr. Size Plate C-35	S2		100 %		
	CI to CL		CLAY silty, low to medium plastic, dark grey, layered				S3		100 %		
20			--- trace of medium sand, soft, silty, medium plastic				S4		50%		
25	SM		SAND fine to medium grained, trace of silt, layered				S5		90%		
30			--- some silt, trace of organics				S6		80%		PLATE C-14

R.M.HARDY & ASSOCIATES LTD.
CONSULTING ENGINEERING & TESTING

TEST HOLE LOG

PROJECT: TAGLU GAS PLANT

TEST HOLE NO. H76-BH8 (cont.)

LOGGED BY SGM	DRAWN BY BT	CHECKED RST	DATE February, 1976
RIG Heli Drill	METHOD	START January 15, 1976	FINISH January 16, 1976
PROJECT NO. cs 3161	ELEVATION	AIR TEMPERATURE	

W_P-⊡ W-⊙ W_L-△ MOISTURE CONTENT 20 40 60	DEPTH (feet)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %	LABORATORY TEST DATA	SAMPLE TYPE AND NUMBER	SAMPLE CONDITION	CORE RUN AND % RECOVERY	CORE CONDITION	REMARKS
		SM		SAND fine to medium grained, trace of silt, layered		UF		S6	X	80%		
				--- 3" clay layer interbedded				S7	X	100 %		
	35			--- organic clay lumps in fine sand matrix, silty				S8	X	100 %		
						Nbn						
	40			--- organic clay layer interbedded								
				--- silty, trace of fine and coarse gravel at interface				S9	X	100 %		
	45			--- occasional OH lumps to 1/8"								
				--- trace of fine and coarse gravel				S10	X	50%		
				Bottom of Hole at 46.5 Feet.								
	50											

PLATE C-15

R.M.HARDY & ASSOCIATES LTD.
CONSULTING ENGINEERING & TESTING

TEST HOLE LOG

PROJECT: TAGLU GAS PLANT

TEST HOLE NO. H76-BH9

LOGGED BY SGM	DRAWN BY BT	CHECKED RST	DATE February, 1976
RIG Heli Drill	METHOD	START January 15, 1976	FINISH January 15, 1976
PROJECT NO. cs 3161	ELEVATION	AIR TEMPERATURE	

W_P-⊡ W-⊙ W_L-△ MOISTURE CONTENT 20 40 60	DEPTH (feet)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %	LABORATORY TEST DATA	SAMPLE TYPE AND NUMBER	SAMPLE CONDITION	CORE RUN AND % RECOVERY	CORE CONDITION	REMARKS
				ICE		ICE						
		ML		SILT medium brown, trace of fine sand		Vx, Vr						
	5			--- clayey, trace of sand, wet		UF Nbn	Gr. Size Plate C-36	S1	X	60%		
	10	SM		SAND fine to medium grained, trace of silt, coal and gravel sizes to 1/2" dia.								
				--- very silty			Gr. Size Plate C-37	A1	X	50%		
	15			--- medium to fine grained, pebbles to 1/4" dia.				A2	X	50%		
				--- gravel sizes								
	20			--- more silty				A3	X	50%		
	25			--- trace of fine gravel, silty				A4	X	50%		
				--- trace of silt, wet				A5	X	50%		
	30											PLATE C-16

R.M.HARDY & ASSOCIATES LTD.
CONSULTING ENGINEERING & TESTING

TEST HOLE LOG

PROJECT: TAGLU GAS PLANT

TEST HOLE NO. H76-BH9 (cont.)

LOGGED BY SGM	DRAWN BY BT	CHECKED RST	DATE February, 1976
RIG Heli Drill	METHOD	START January 15, 1976	FINISH January 15, 1976
PROJECT NO. cs 3161	ELEVATION	AIR TEMPERATURE	

MOISTURE CONTENT (W_P-□ W-○ W_L-△) 20 40 60	DEPTH (feet)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %	LABORATORY TEST DATA	SAMPLE TYPE AND NUMBER	SAMPLE CONDITION	CORE RUN AND % RECOVERY	CORE CONDITION	REMARKS
		SM		SAND fine to medium grained, trace of silt		Nbn						
○				--- medium to fine grained				A6	X	50%		
	35											
○								A7	X	50%		
				Bottom of Hole at 37.0 Feet.								
	40											

PLATE C-17

R.M.HARDY & ASSOCIATES LTD.
CONSULTING ENGINEERING & TESTING

TEST HOLE LOG

PROJECT: TAGLU GAS PLANT

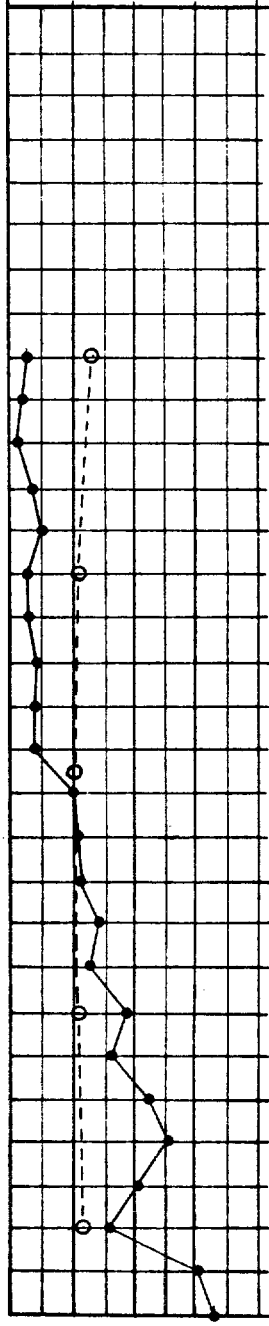
TEST HOLE NO. H76-BH10

LOGGED BY SGH & MR	DRAWN BY BT	CHECKED RST	DATE February, 1976
RIG HELI DRILL	METHOD	START JANUARY 15, 1976	FINISH
PROJECT NO. cs 3161	ELEVATION	AIR TEMPERATURE - 40° C	

W_P - ⊡ W - ⊙ W_L - △

● Dynamic Cone Penetration Blows/Ft. 20 40 60

MOISTURE CONTENT 20 40 60



DEPTH (feet)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %	LABORATORY TEST DATA	SAMPLE TYPE AND NUMBER	SAMPLE CONDITION	CORE RUN AND % RECOVERY	CORE CONDITION	REMARKS
			ICE		ICE						
			WATER		UF						
5	ML		SILT little fine sand, trace of clay, low to non plastic, wet			Gr. Size Plate C-38	S1	X	100 %		
10			--- grey to brown, layered				S2	X	100 %		
15			--- sandy				S3	X	100 %		
20	SM		SAND fine grained, trace of silt, wet			Gr. Size Plate C-39	S4	X	100 %		
25			--- fine grained, brown, wet				S5	X	100 %		
30											PLATE C-18

R.M.HARDY & ASSOCIATES LTD.
CONSULTING ENGINEERING & TESTING

TEST HOLE LOG

PROJECT: TAGLU GAS PLANT

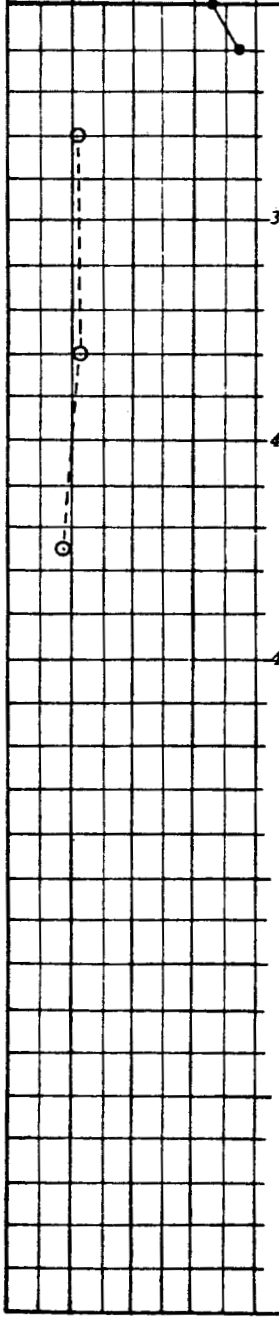
TEST HOLE NO. H76-BH10 (cont.)

LOGGED BY SGM & MR	DRAWN BY BT	CHECKED RST	DATE February, 1976
RIG Heli Drill	METHOD	START January 15, 1976	FINISH
PROJECT NO. cs 3161	ELEVATION	AIR TEMPERATURE -40° C	

W_P-⊡ W-⊙ W_L-△

●Dynamic Cone Penetration Blows/Ft. 20 40 60

MOISTURE CONTENT 20 40 60



DEPTH (feet)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %	LABORATORY TEST DATA	SAMPLE TYPE AND NUMBER	SAMPLE CONDITION	CORE RUN AND % RECOVERY	CORE CONDITION	REMARKS
	SM		SAND fine grained, brown, wet		UF						
							S6	X	67%		
35			--- fine grained, brown, wet			Gr. Size Plate C-40	S7	X	53%		
40			--- layer of clay, medium plastic								
			~ possibly permafrost interface				S8	X	50%		
45			Bottom of Hole at 43.2 Feet.								

PLATE C-19

TEST HOLE LOG

R.M.HARDY & ASSOCIATES LTD.
CONSULTING ENGINEERING & TESTING

PROJECT: TAGLU GAS PLANT

TEST HOLE NO. H76-BH11

LOGGED BY MR	DRAWN BY BT	CHECKED RST	DATE February, 1976
RIG HELI DRILL	METHOD	START JANUARY 15, 1976	FINISH
PROJECT NO. cs 3161	ELEVATION		AIR TEMPERATURE

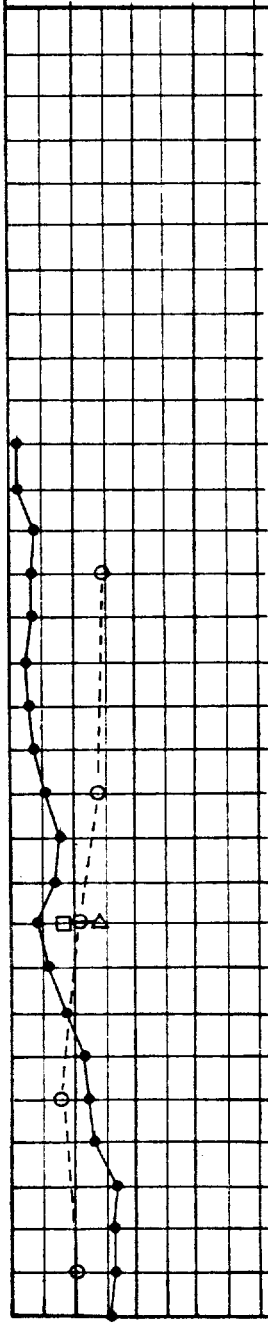
W_P - ⊡ W - ⊙ W_L - △

● DYNAMIC CONE PENETRATION TEST blows/ft.

20 40 60

MOISTURE CONTENT

20 40 60



DEPTH (feet)	SOIL GROUP SYMBOL	DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %	LABORATORY TEST DATA	SAMPLE TYPE AND NUMBER	SAMPLE CONDITION	CORE RUN AND % RECOVERY	CORE CONDITION	REMARKS
		ICE		ICE						
		WATER		UF						
		bottom of channel								
	ML	SILT fine, sandy, brown, occasional layers of fine sand, trace of clay, wet								
		--- trace of sand			GRAIN SIZE PLATE C-41	S1	X	100 %		
		--- fine sandy, brown, wet				S2	X	47 %		
		--- gravel to 1" dia., possible boulder sizes								
	CL	CLAY silty, trace of sand, brown grey mottling, low plastic, firm, occasional inclusions of organics				S3	X	75 %		Redrilled hole to get past boulder sizes
	ML	SILT, little sand, dark grey to brown, low plastic, firm, spongey				S4	X	100 %		
	SM	SAND, trace of silt, rust, fine grained, layered			Grain Size Plate C-42	S5	X	50%		
		--- very silty, dark grey to brown								

PLATE C-20

R.M.HARDY & ASSOCIATES LTD.
CONSULTING ENGINEERING & TESTING

TEST HOLE LOG

PROJECT: TAGLU GAS PLANT

TEST HOLE NO. H76-BH11 (con't)

LOGGED BY MR	DRAWN BY BT	CHECKED RST	DATE February, 1976
RIG HELI DRILL	METHOD	START JANUARY 15, 1976	FINISH
PROJECT NO. CS 3161	ELEVATION	AIR TEMPERATURE	

W_P - ⊡ W - ⊙ W_L - △

● DYNAMIC CONE PENETRATION TEST blows/ft.

MOISTURE CONTENT 20 40 60

DEPTH (feet)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %	LABORATORY TEST DATA	SAMPLE TYPE AND NUMBER	SAMPLE CONDITION	CORE RUN AND % RECOVERY	CORE CONDITION	REMARKS
35	SM		SAND fine grained, silty, layered, brown and dark grey, wet		VF	Gr. Size Plate C-43	S6	X	50%		
40											
45											
50			Bottom of Hole at 50.0 Feet.								

PLATE C-21

R.M.HARDY & ASSOCIATES LTD.
CONSULTING ENGINEERING & TESTING

GRAIN SIZE CURVE

LAB ORDER NO.	CS 3161
CLIENT	TAGLU GAS PLANT
SAMPLE	S1
SOURCE	
HOLE	H76-BH1 @ 10' - 111/2'
TECHNICIAN	DATE TESTED FEB./76

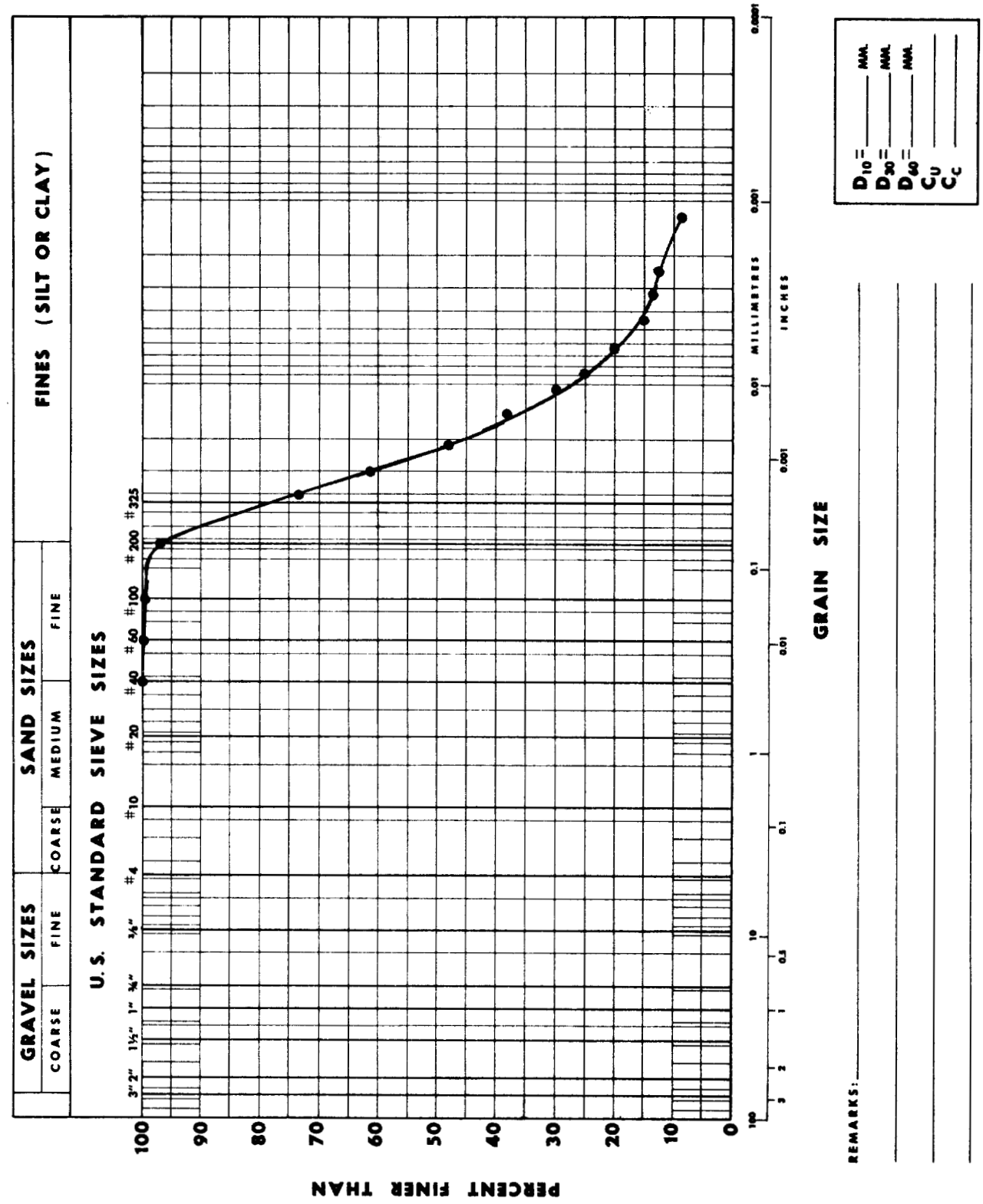
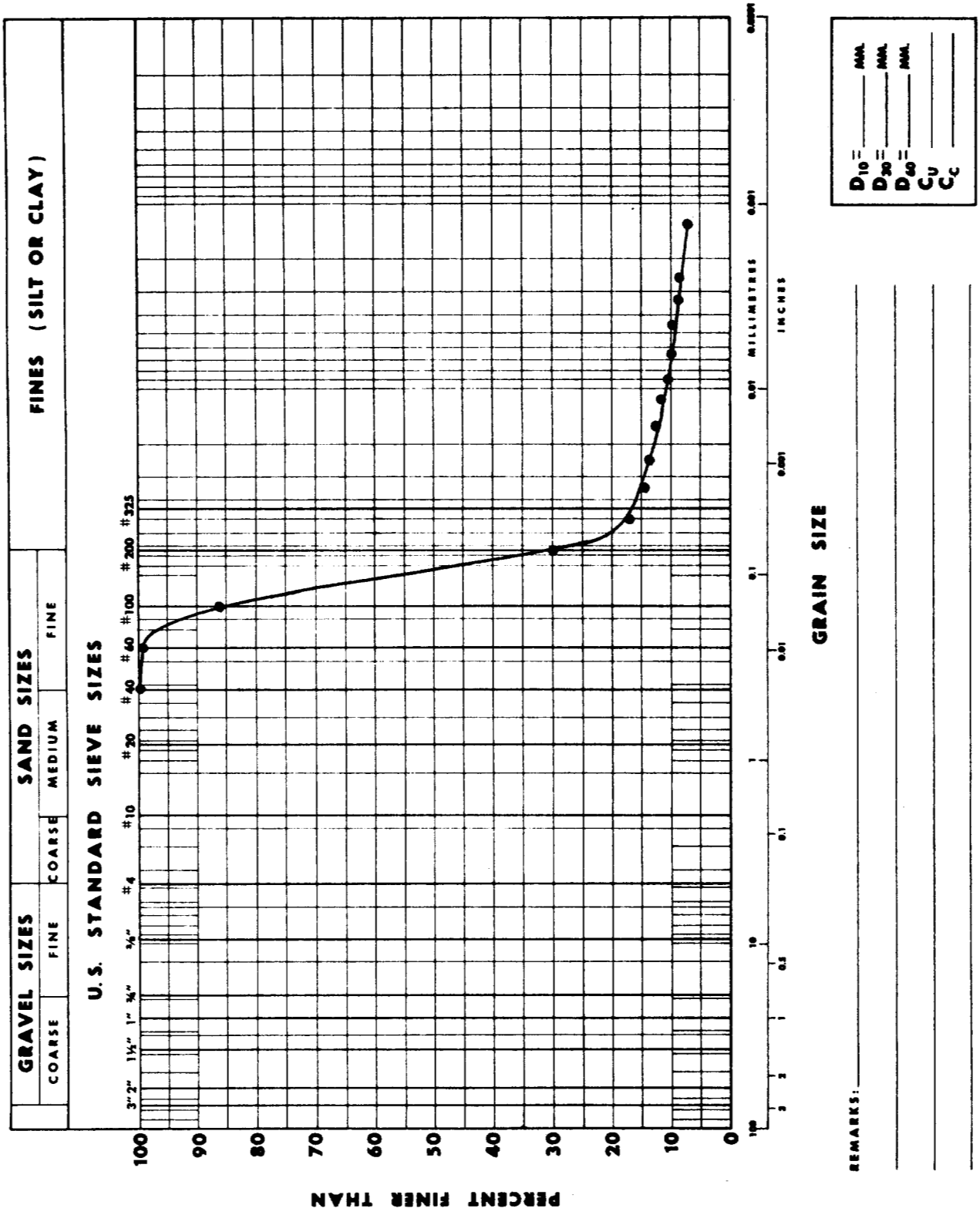


PLATE C-22

R.M.HARDY & ASSOCIATES LTD.
CONSULTING ENGINEERING & TESTING

GRAIN SIZE CURVE

LAB ORDER NO.	CS3161
CLIENT	Taglu Gas Plant
SAMPLE	S 3
SOURCE	
HOLE	H76-BH1 @ 19-20.5'
TECHNICIAN	M.S.
DATE TESTED	Feb./76



REMARKS:

NOTE: UNIFIED SOIL CLASSIFICATION SYSTEM

PLATE C-23

R.M.HARDY & ASSOCIATES LTD.
CONSULTING ENGINEERING & TESTING

GRAIN SIZE CURVE

LAB ORDER NO.	CS 3161
CLIENT	Taglu Gas Plant
SAMPLE	S 1
SOURCE	
HOLE	H76-BH2 at 10'-11.5'
TECHNICIAN	MS DATE TESTED Feb/76

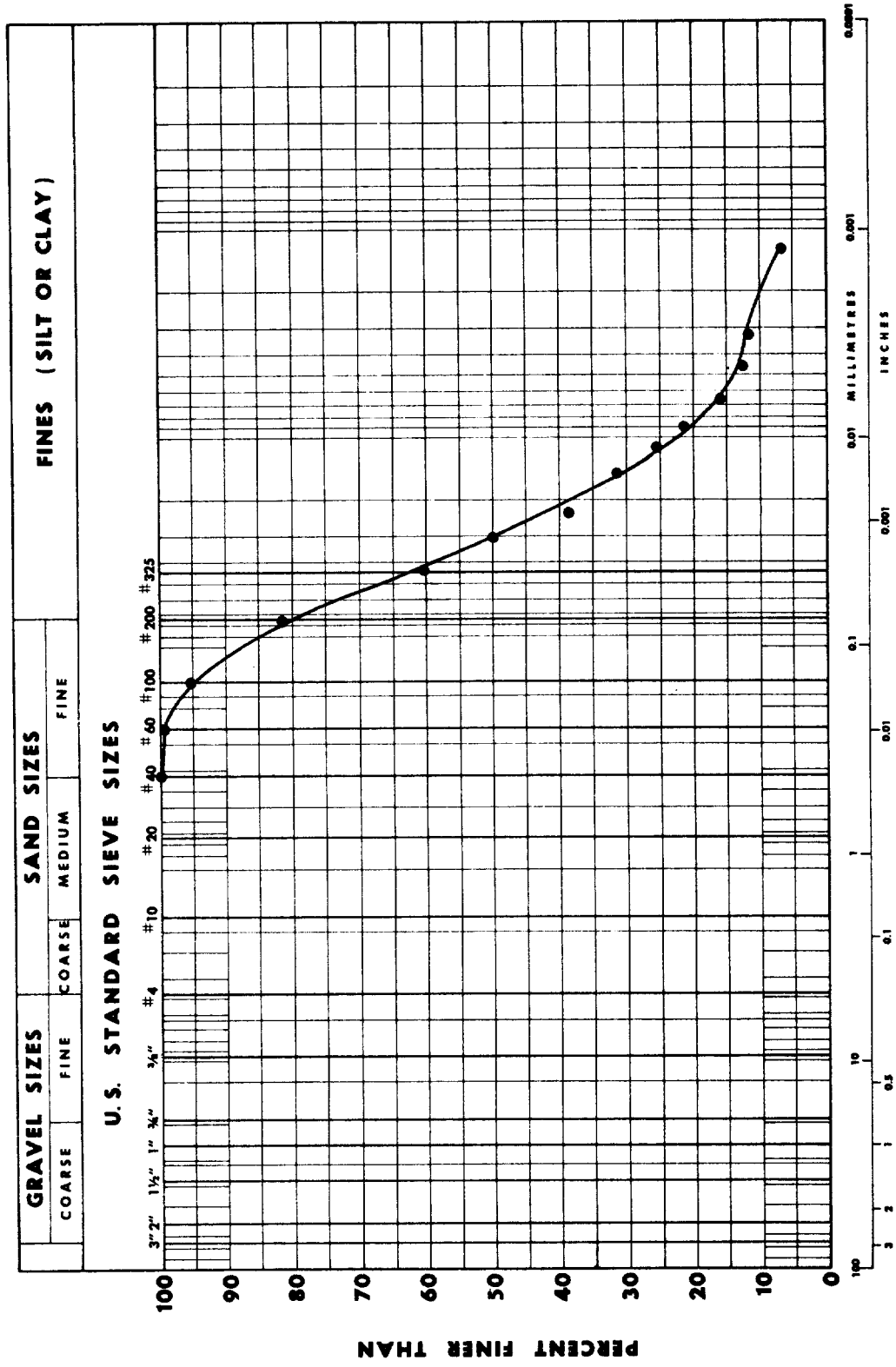


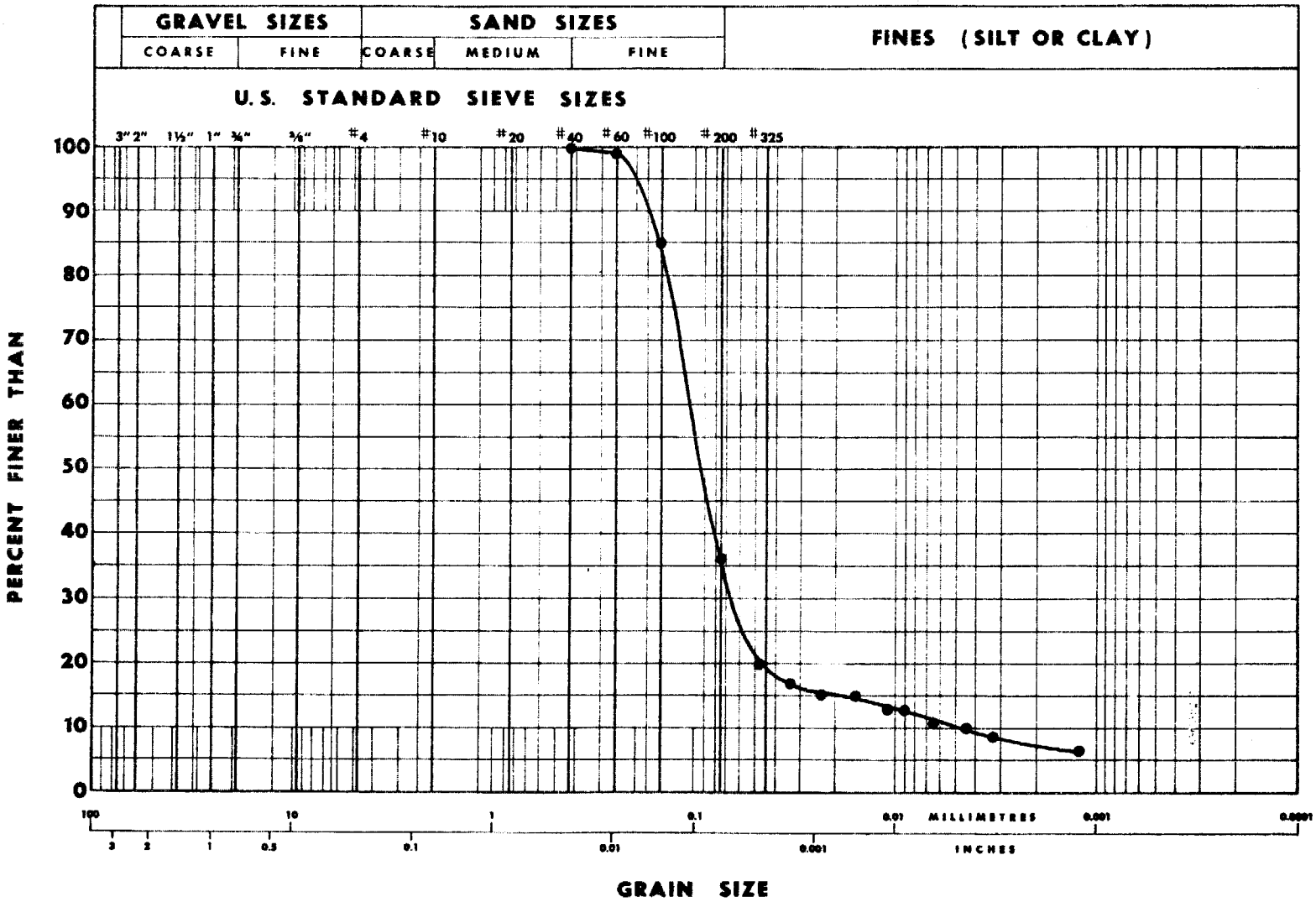
PLATE C-24

GU202-0373

R.M. HARDY & ASSOCIATES LTD.
CONSULTING ENGINEERING & TESTING

GRAIN SIZE CURVE

LAB ORDER NO. CS3161
CLIENT Taglu Gas Plant
SAMPLE S4
SOURCE
HOLE H76-BH2 @ 26' - 27.5'
TECHNICIAN M.S. DATE TESTED Feb./76



D_{10} = ____ MM.
D_{30} = ____ MM.
D_{60} = ____ MM.
C_U = ____
C_C = ____

REMARKS: _____

NOTE: UNIFIED SOIL CLASSIFICATION SYSTEM

PLATE C-25

R.M.HARDY & ASSOCIATES LTD.
CONSULTING ENGINEERING & TESTING

GRAIN SIZE CURVE

LAB ORDER NO.	CS 3161
CLIENT	Taglu Gas Plant
SAMPLE	C3
SOURCE	
HOLE	H76-BH3 @ 15.0-16.5'
TECHNICIAN	CS DATE TESTED Mar. 76

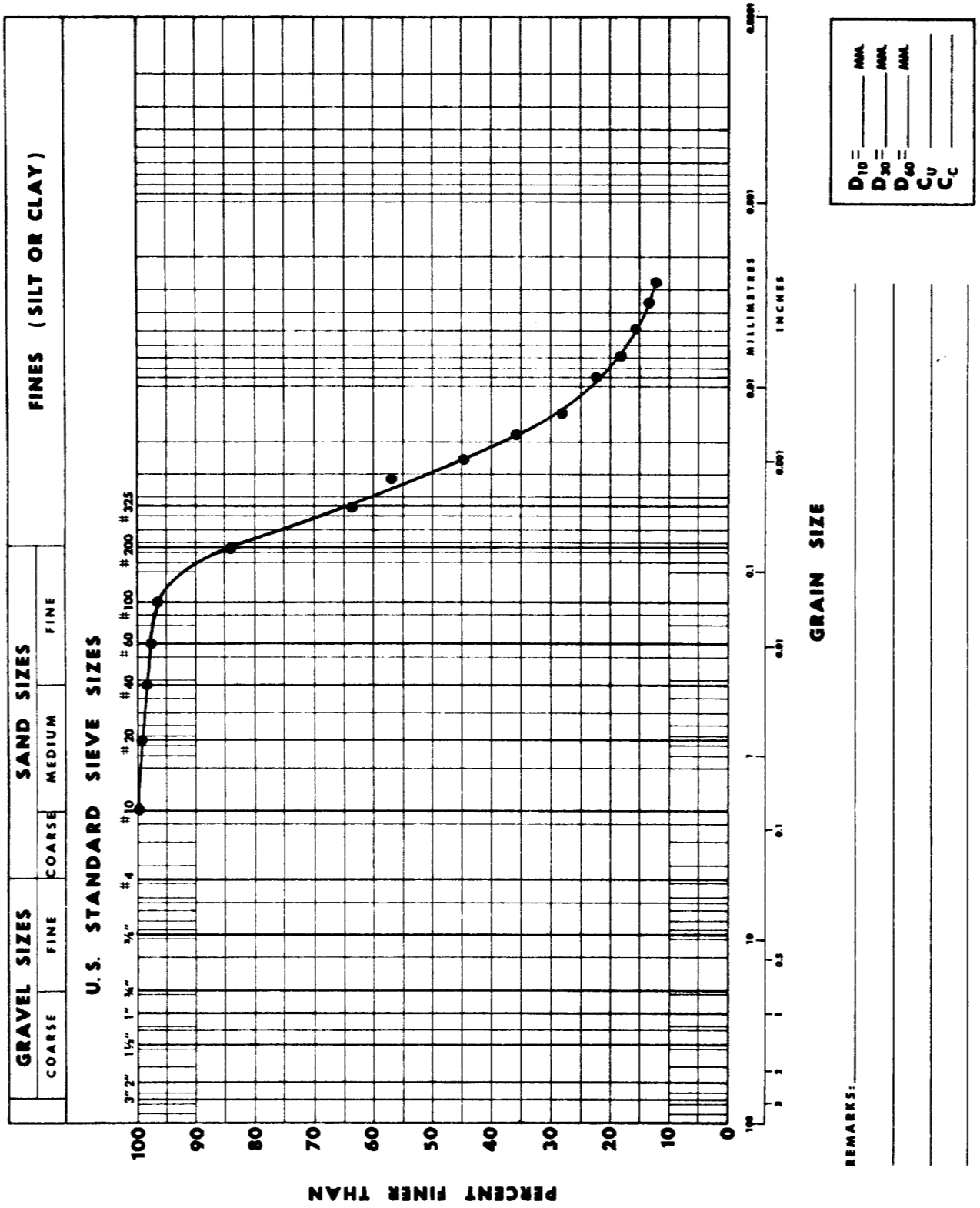


PLATE C-26

R.M. HARDY & ASSOCIATES LTD.
CONSULTING ENGINEERING & TESTING

GRAIN SIZE CURVE

LAB ORDER NO.	CS 3161
CLIENT	Taglu Gas Plant
SAMPLE	S2
SOURCE	
HOLE	H76-BH4 at 15' - 16.5'
TECHNICIAN	MS DATE TESTED Feb/76

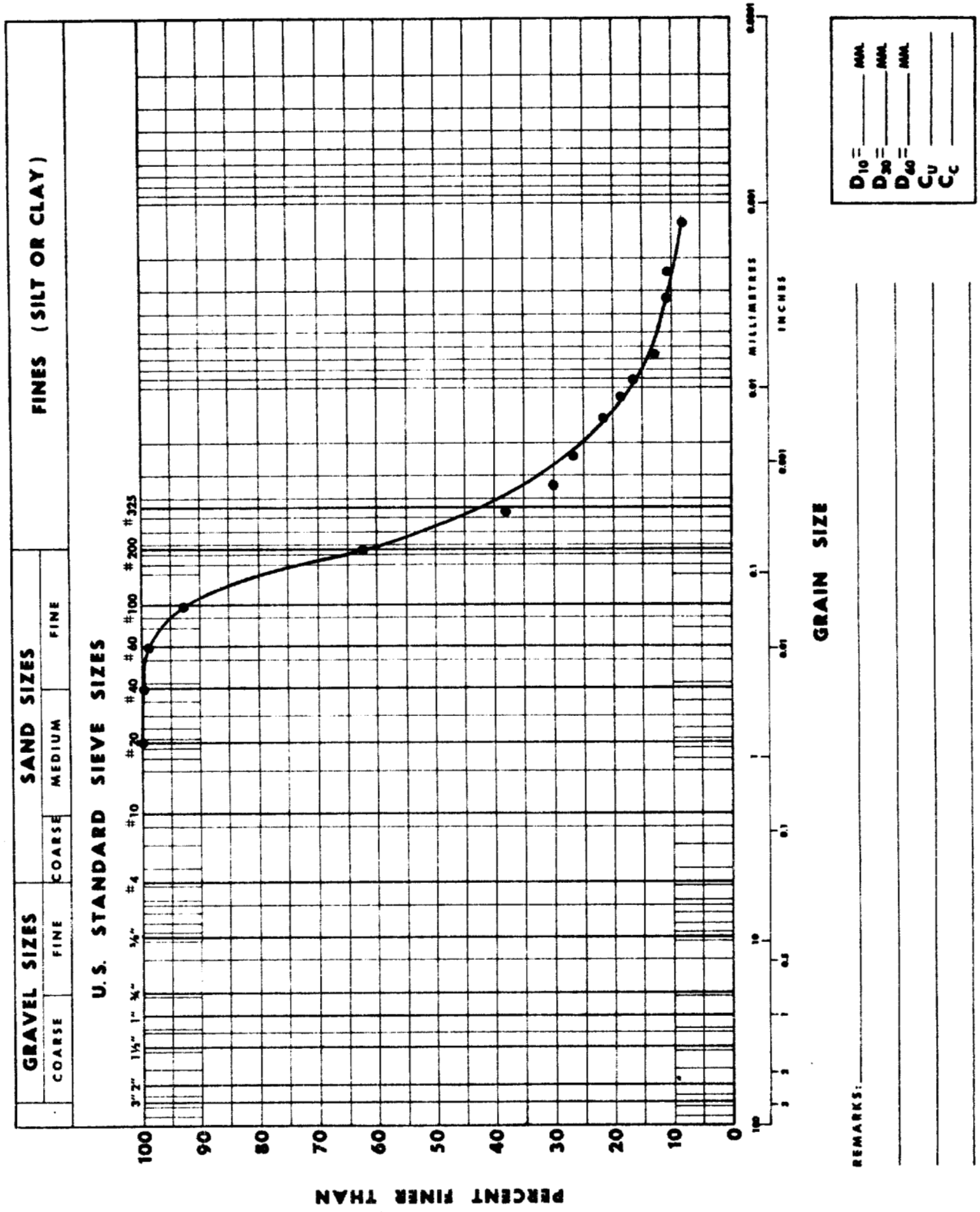


PLATE C-27

R.M.HARDY & ASSOCIATES LTD.
CONSULTING ENGINEERING & TESTING

GRAIN SIZE CURVE

LAB ORDER NO.	CS 3161
CLIENT	TAGLU GAS PLANT
SAMPLE	S4
SOURCE	
HOLE	H76-BH4 at 23 - 24.5'
TECHNICIAN	DATE TESTED FEB./76

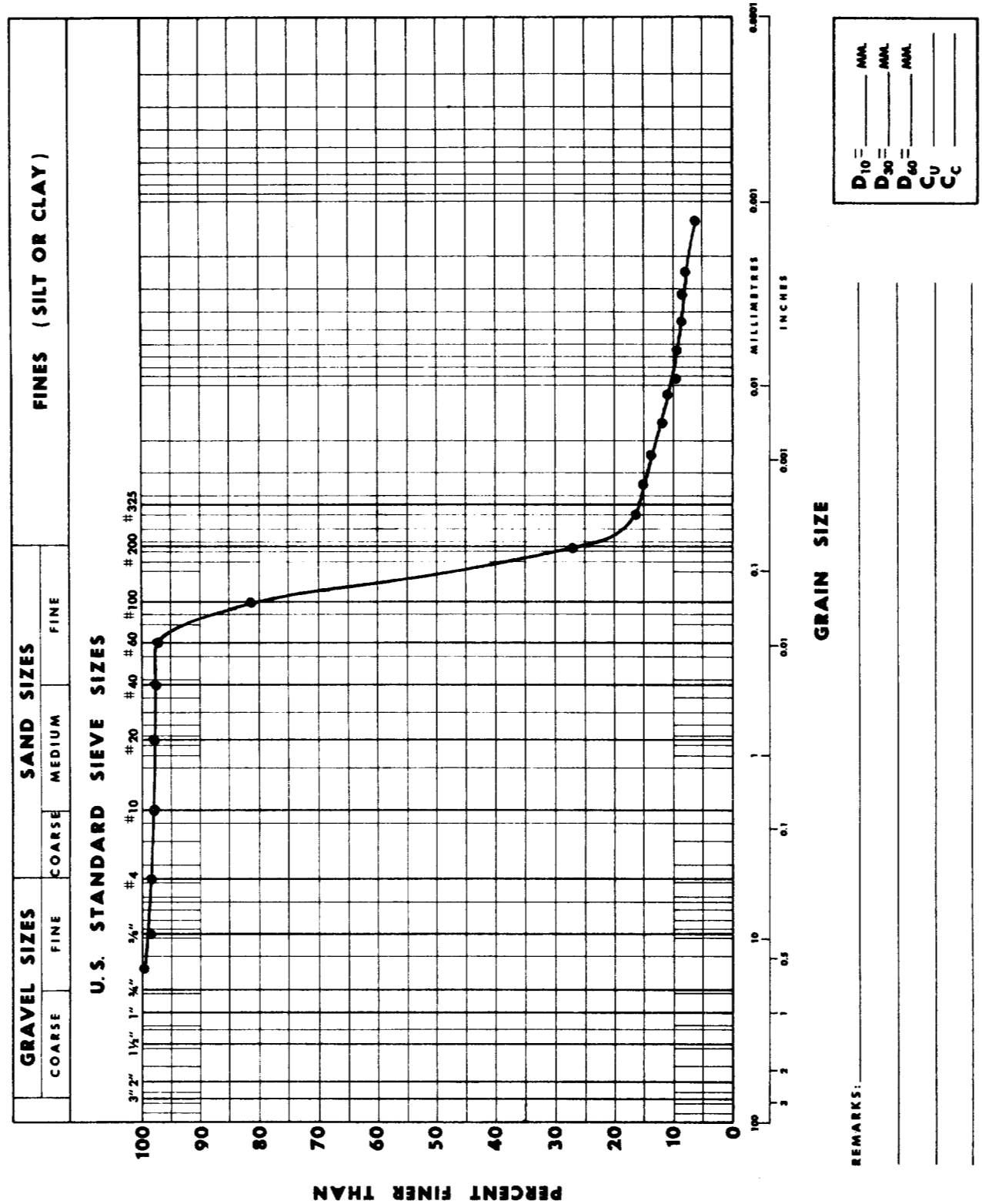


PLATE C-28

R.M.HARDY & ASSOCIATES LTD.
CONSULTING ENGINEERING & TESTING

GRAIN SIZE CURVE

LAB ORDER NO.	CS3161
CLIENT	Taglu Gas Plant
SAMPLE	S1
SOURCE	
HOLE	H76-BH5 @ 12.0'- 13.5'
TECHNICIAN	MS. DATE TESTED 2/76

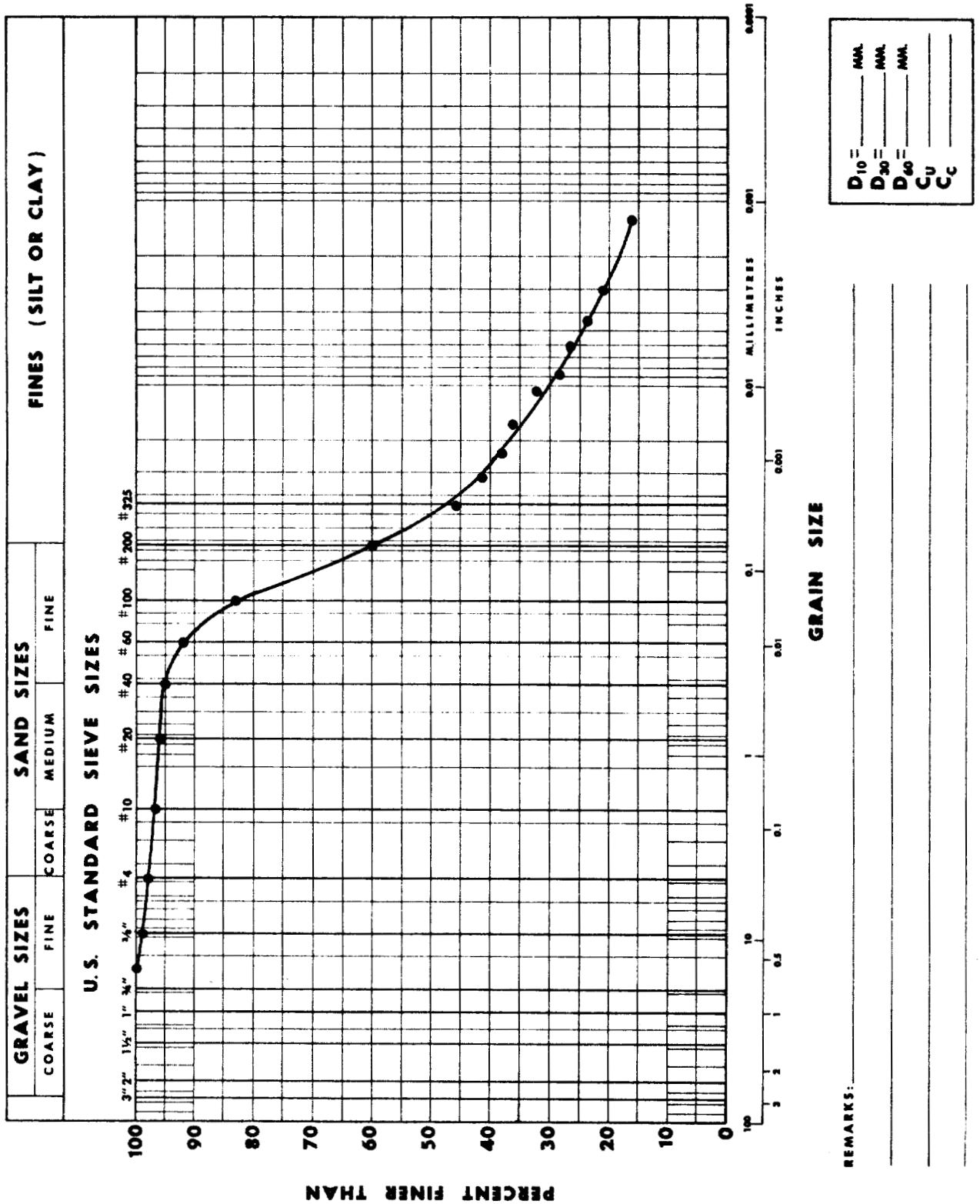


PLATE C-29

R.M. HARDY & ASSOCIATES LTD.
CONSULTING ENGINEERING & TESTING

GRAIN SIZE CURVE

LAB ORDER NO.	CS3161
CLIENT	Taglu Gas Plant
SAMPLE	S4
SOURCE	
HOLE	H76-BH5 @ 24-25.5'
TECHNICIAN	M.S. DATE TESTED 2/76

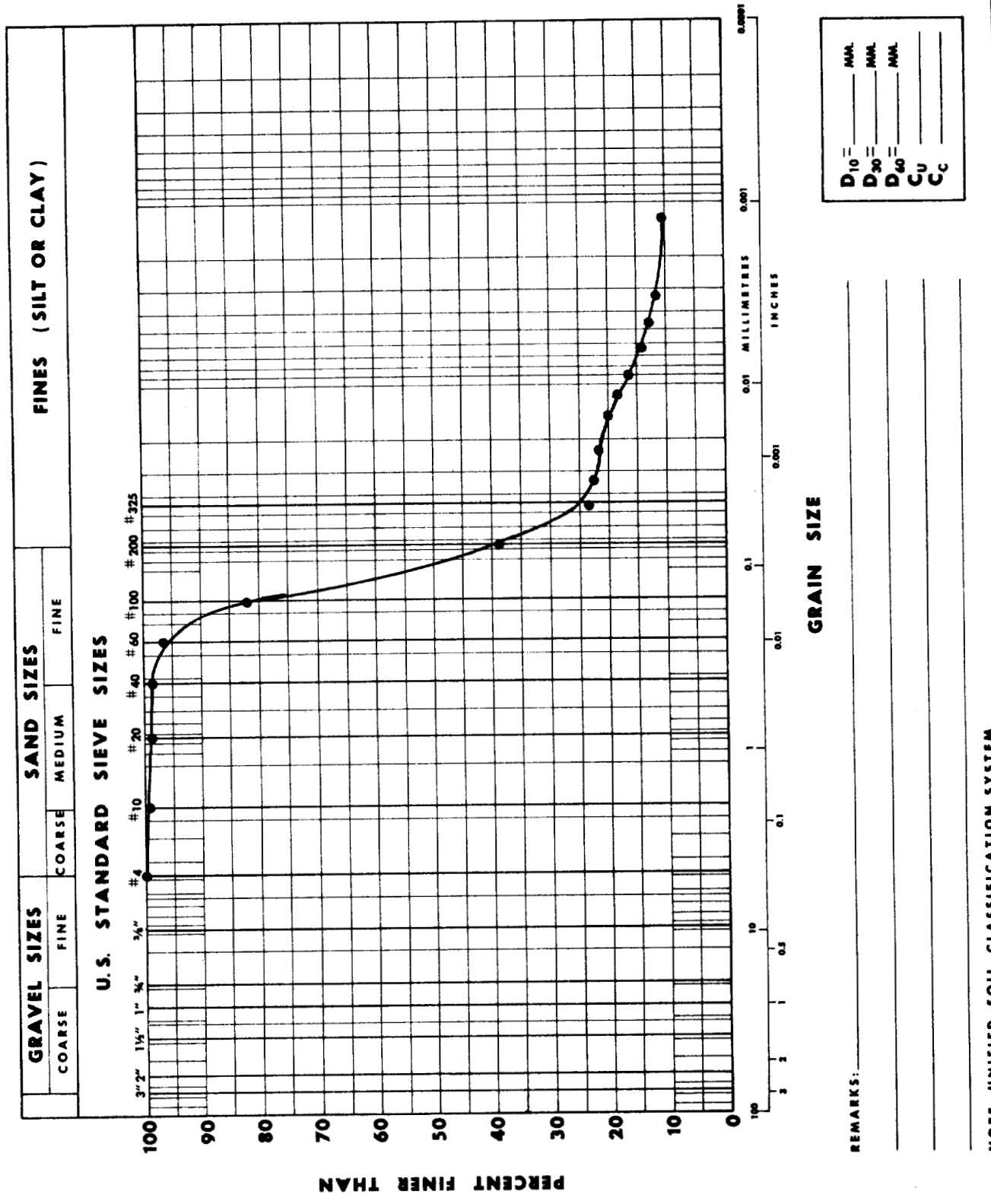


PLATE C-30

R.M.HARDY & ASSOCIATES LTD.
CONSULTING ENGINEERING & TESTING

GRAIN SIZE CURVE

LAB ORDER NO.	CS3161
CLIENT	Taglu Gas Plant
SAMPLE	S7
SOURCE	
HOLE	H76-BH5 @ 36.0-37.5'
TECHNICIAN	CS
DATE TESTED	Mar.76

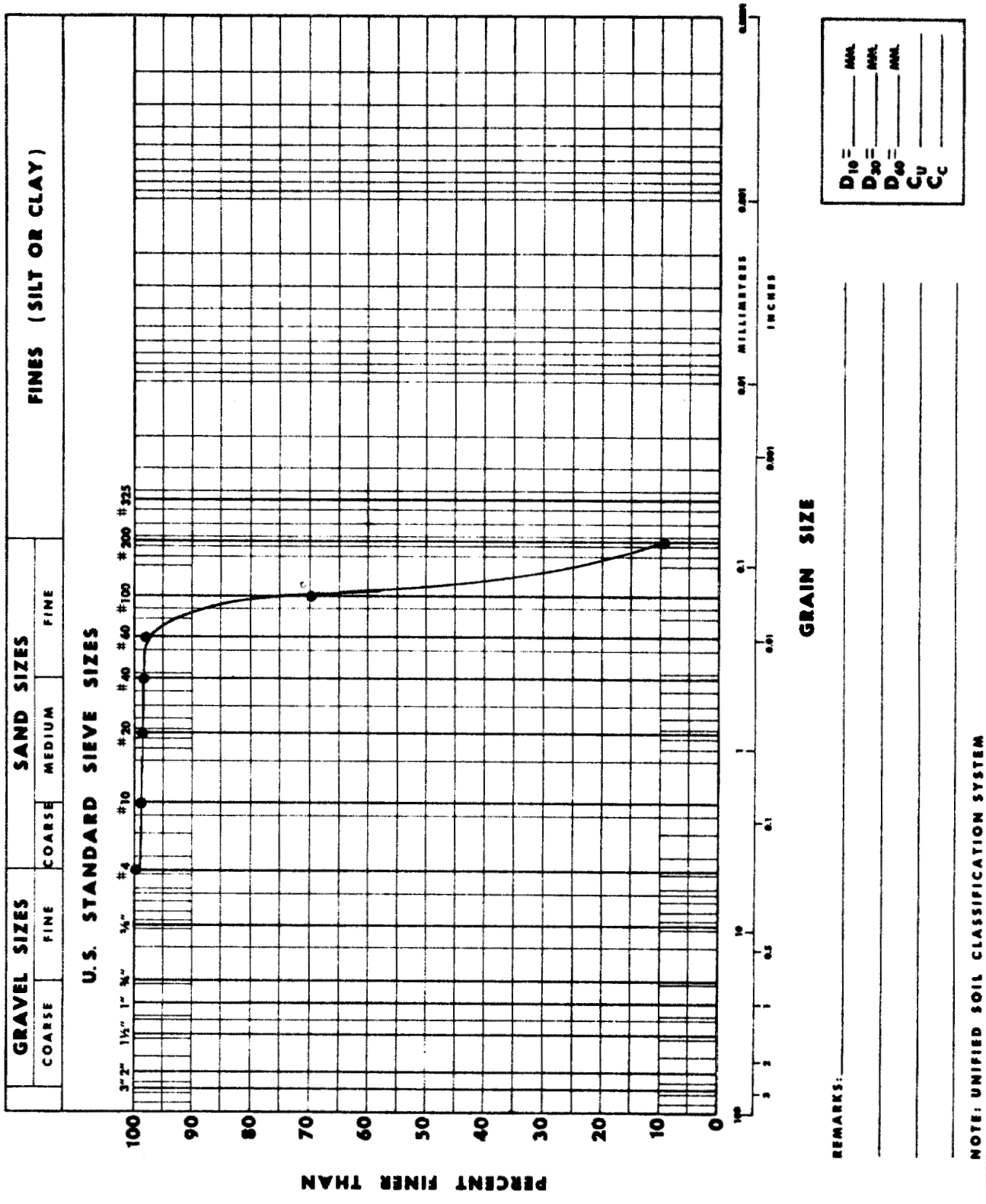


PLATE C-31

R.M.HARDY & ASSOCIATES LTD.
CONSULTING ENGINEERING & TESTING

GRAIN SIZE CURVE

LAB ORDER NO.	CS 3161
CLIENT	TAGLU GAS PLANT-
SAMPLE -	S3
SOURCE	
HOLE	H76-BH6 at 22 - 24'
TECHNICIAN	DATE TESTED FEB/76

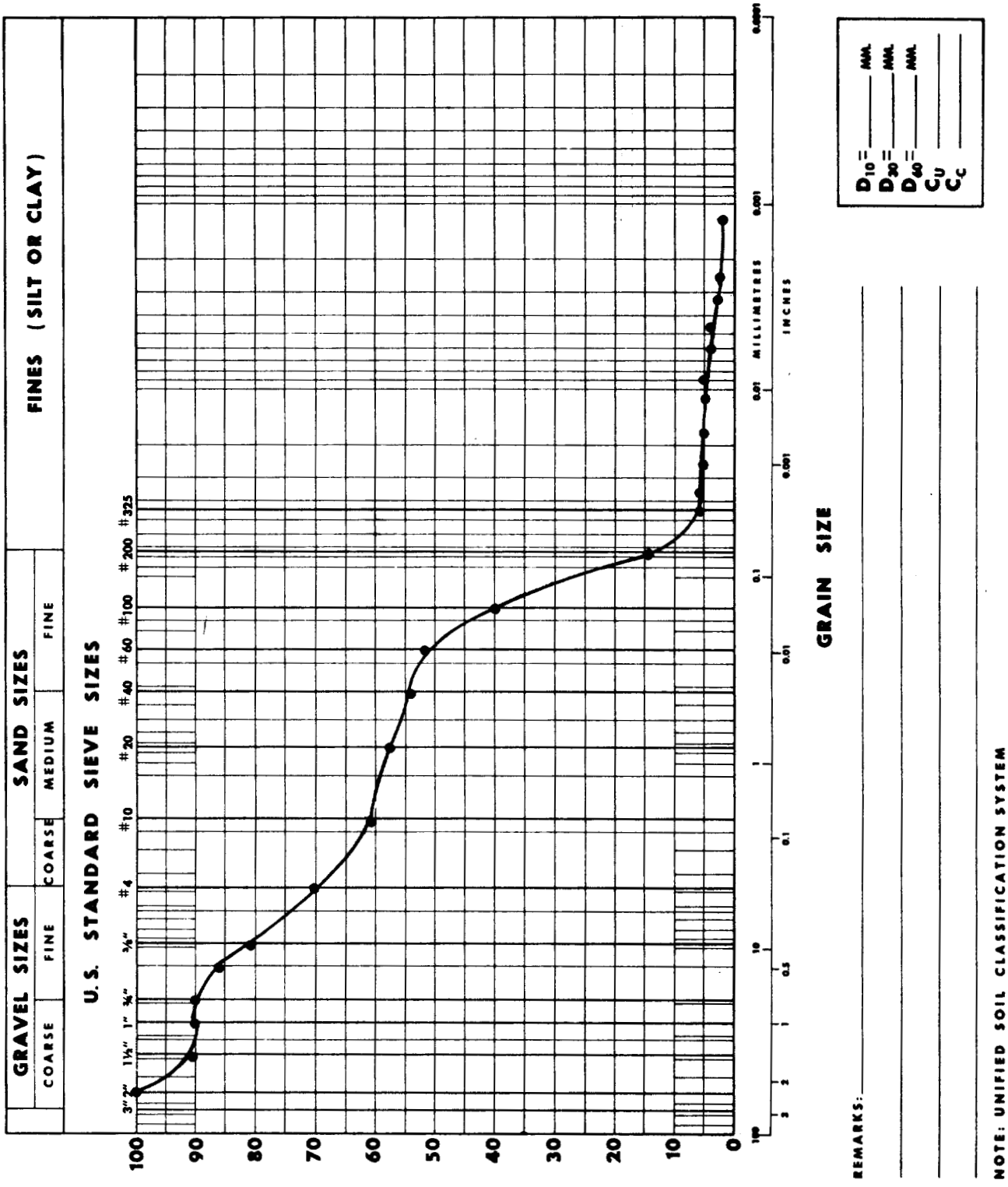


PLATE C-32

R.M. HARDY & ASSOCIATES LTD.
CONSULTING ENGINEERING & TESTING

GRAIN SIZE CURVE

LAB ORDER NO.	CS3161
CLIENT	Taglu Gas Plant
SAMPLE	S6
SOURCE	
HOLE	H76-BH6 @ 33-35'
TECHNICIAN	CS
DATE TESTED	Mar. 76

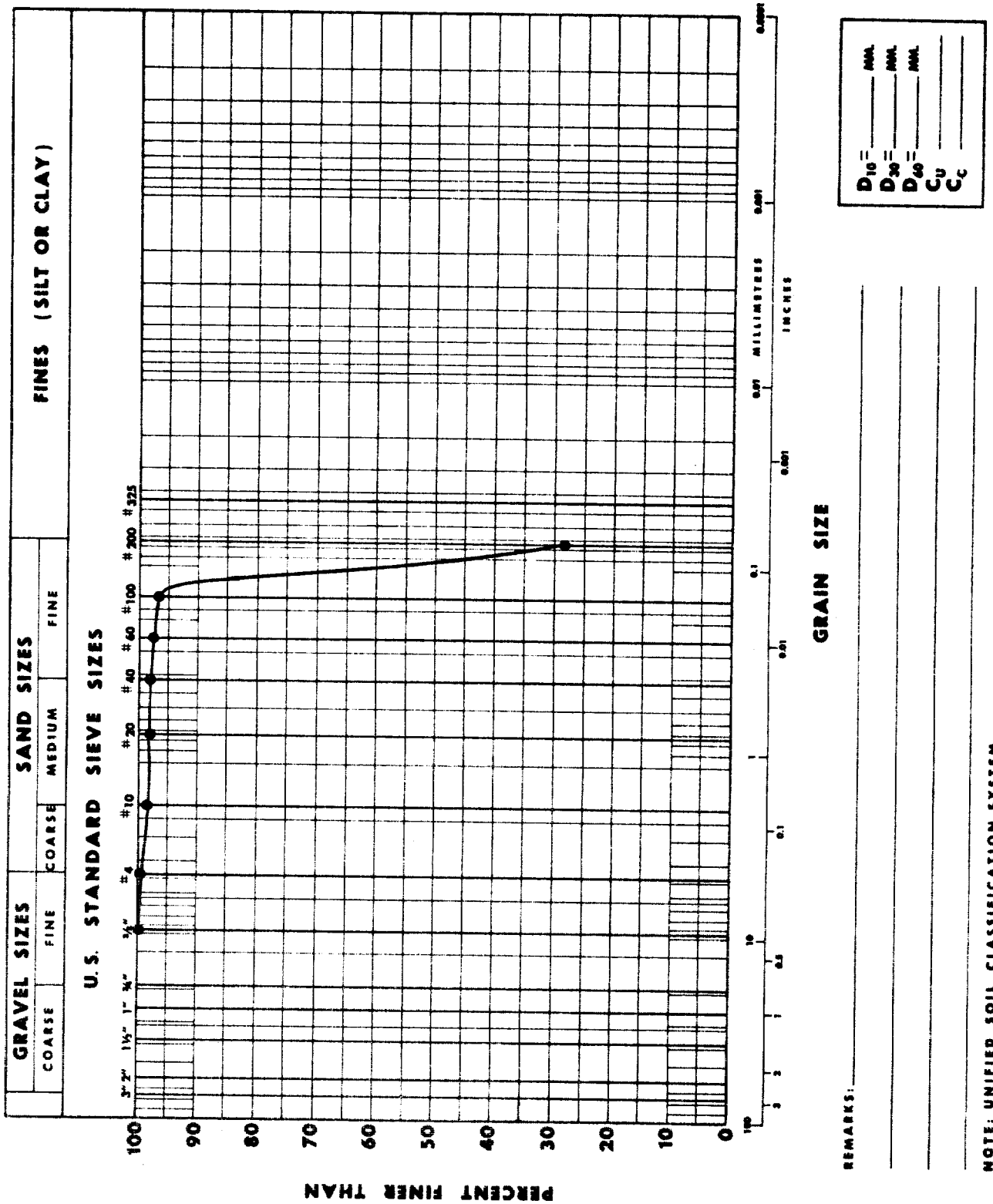


PLATE C-33

R.M.HARDY & ASSOCIATES LTD.
CONSULTING ENGINEERING & TESTING

GRAIN SIZE CURVE

LAB ORDER NO.	CS3161
CLIENT	Taglu Gas Plant
SAMPLE	S8
SOURCE	
HOLE	H76-BH6 @ 40-41.5'
TECHNICIAN	CW
DATE TESTED	Mar.76

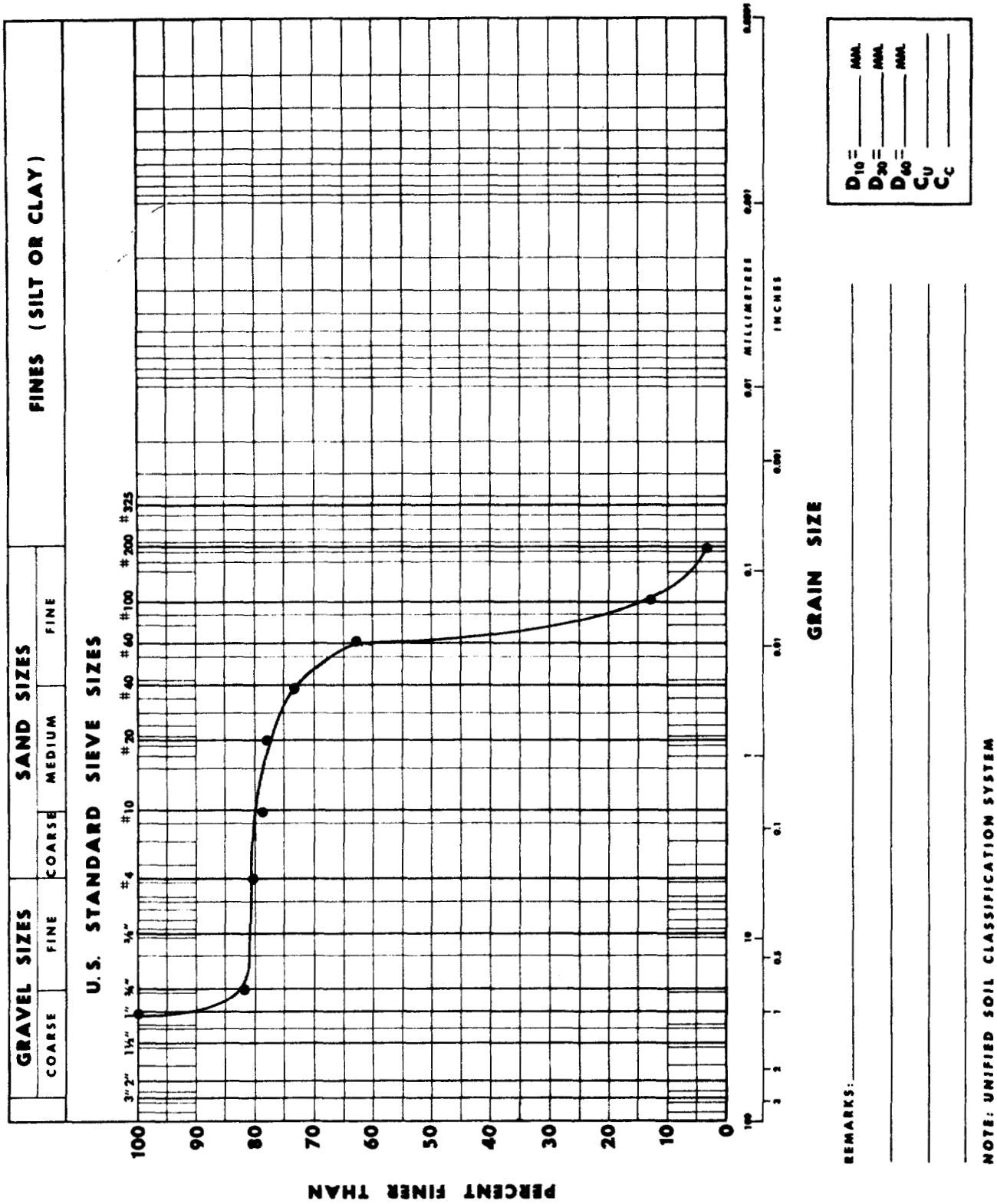


PLATE C-34

R.M.HARDY & ASSOCIATES LTD.
CONSULTING ENGINEERING & TESTING

GRAIN SIZE CURVE

LAB ORDER NO.	CS 3161
CLIENT	TAGLU GAS PLANT
SAMPLE	S2
SOURCE	
HOLE	H76-BH8 @ 13-14.5'
TECHNICIAN	DATE TESTED FEB./76

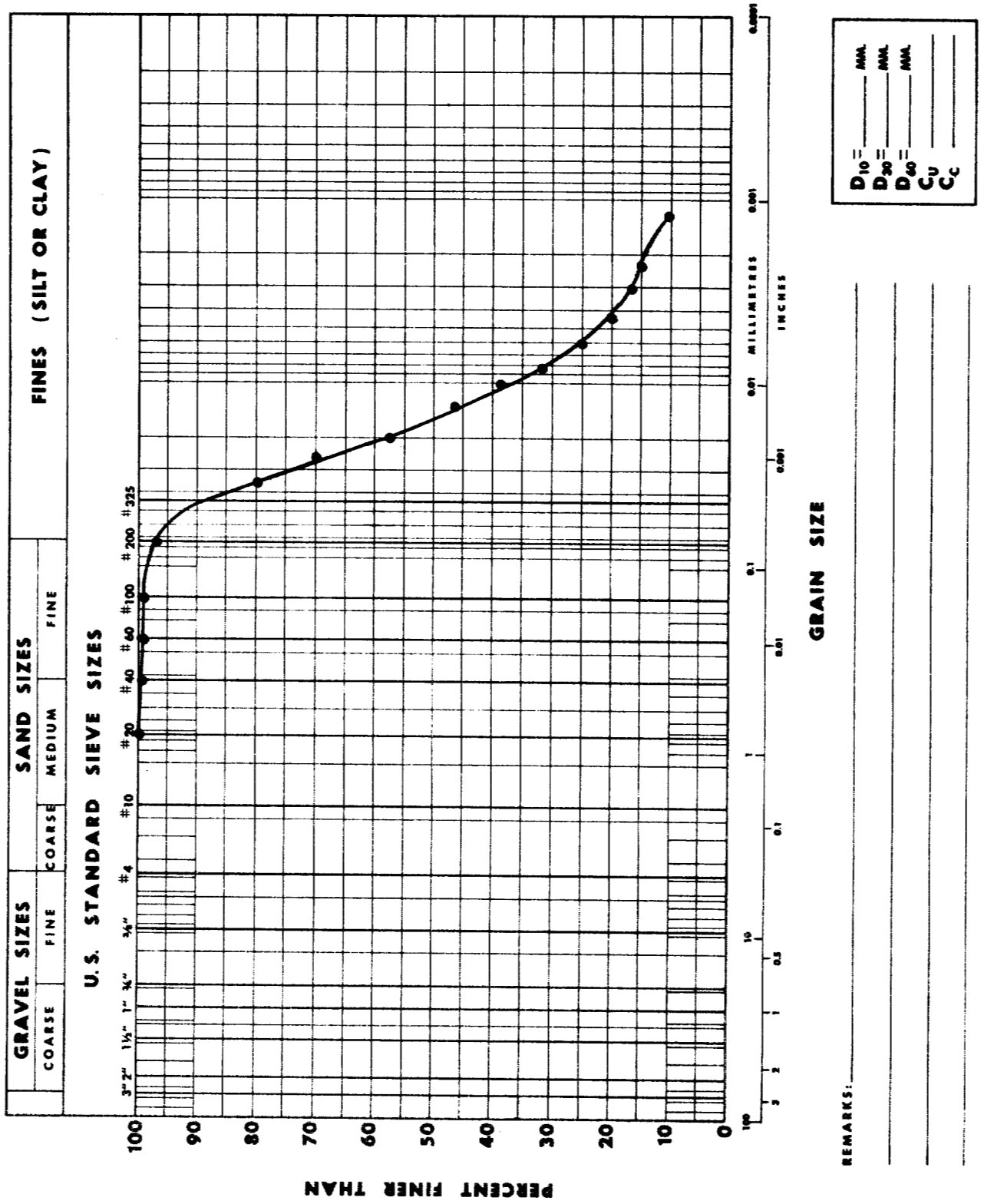


PLATE C-35

GU202-0373

R.M.HARDY & ASSOCIATES LTD.
CONSULTING ENGINEERING & TESTING

GRAIN SIZE CURVE

LAB ORDER NO.	CS3161
CLIENT	Taglu Gas Plant
SAMPLE	S1
SOURCE	
HOLE	H76-BH9 @ 6-7½'
TECHNICIAN	M.S. DATE TESTED 2/76

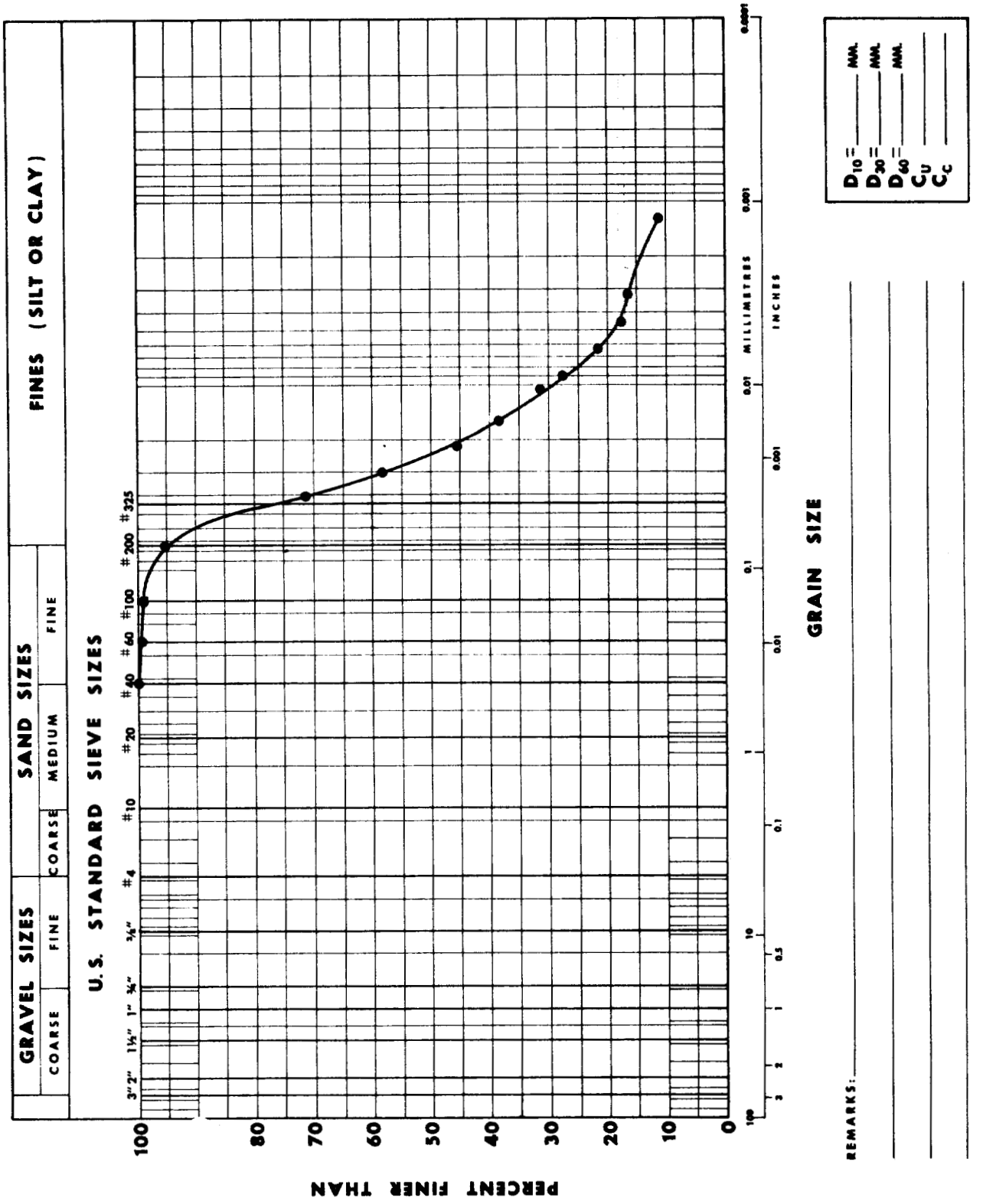


PLATE C-36

R.M.HARDY & ASSOCIATES LTD.
CONSULTING ENGINEERING & TESTING

GRAIN SIZE CURVE

LAB ORDER NO.	CS 3161
CLIENT	TAGLU GAS PLANT
SAMPLE	A1
SOURCE	
HOLE	H76-BH9 at 13 - 14'
TECHNICIAN	DATE TESTED FEB/76

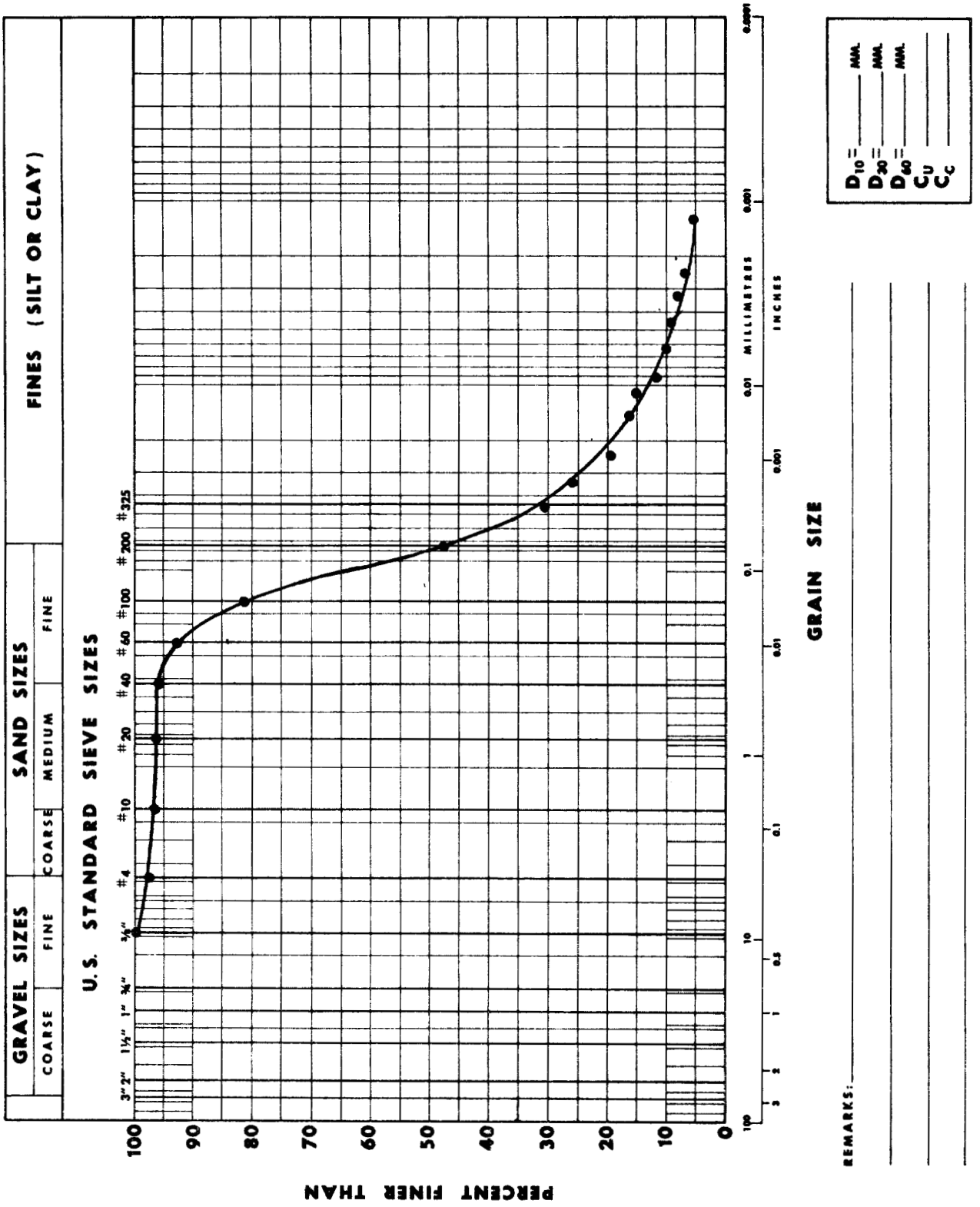


PLATE C-37

R.M.HARDY & ASSOCIATES LTD.
CONSULTING ENGINEERING & TESTING

GRAIN SIZE CURVE

LAB ORDER NO.	CS 3161
CLIENT	TAGLU GAS PLANT
SAMPLE	S1
SOURCE	
HOLE	H76-BH10 @ 7 - 8.5'
TECHNICIAN	DATE TESTED FEB/76

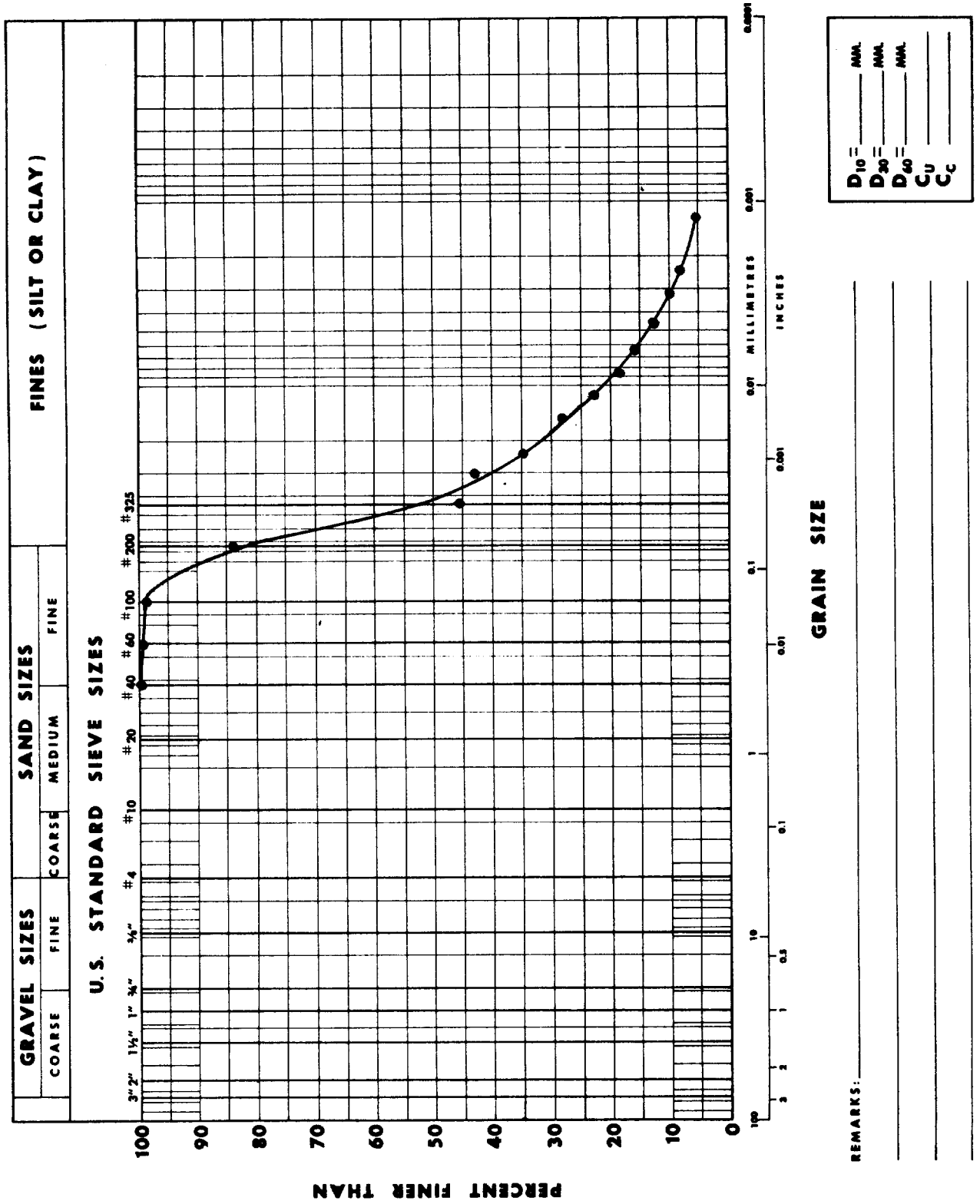


PLATE C-38

R.M.HARDY & ASSOCIATES LTD.
CONSULTING ENGINEERING & TESTING

GRAIN SIZE CURVE

LAB ORDER NO.	CS3161
CLIENT	Taglu Gas Plant
SAMPLE	S4
SOURCE	
HOLE	H76-BH10 @ 22-23.5
TECHNICIAN	M.S. DATE TESTED 2/76

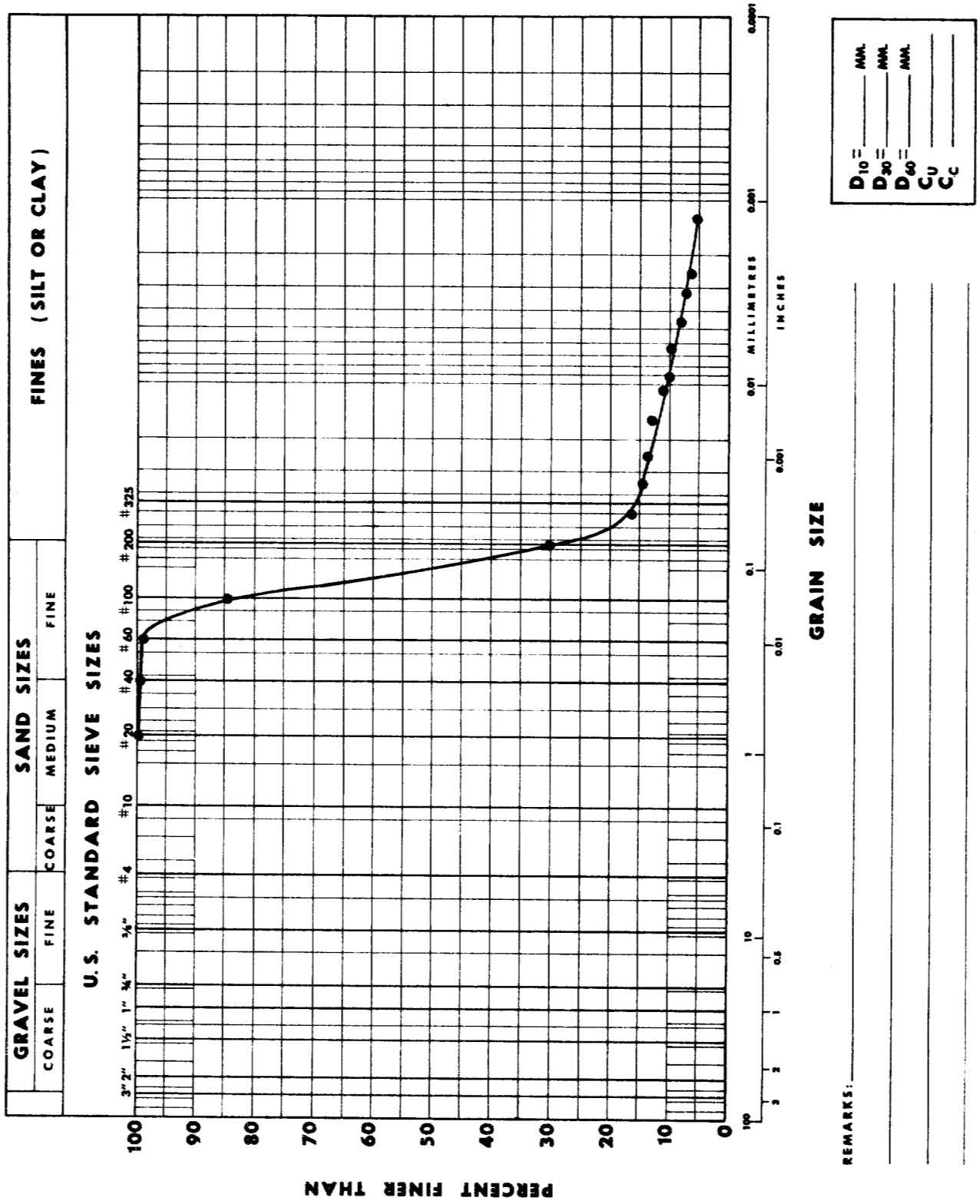


PLATE C-39

R.M.HARDY & ASSOCIATES LTD.
CONSULTING ENGINEERING & TESTING

GRAIN SIZE CURVE

LAB ORDER NO.	CS3161
CLIENT	Taglu Gas Plant
SAMPLE	S7
SOURCE	
HOLE	H76-BH10 @ 37-38.5'
TECHNICIAN	CW
DATE TESTED	Mar.76

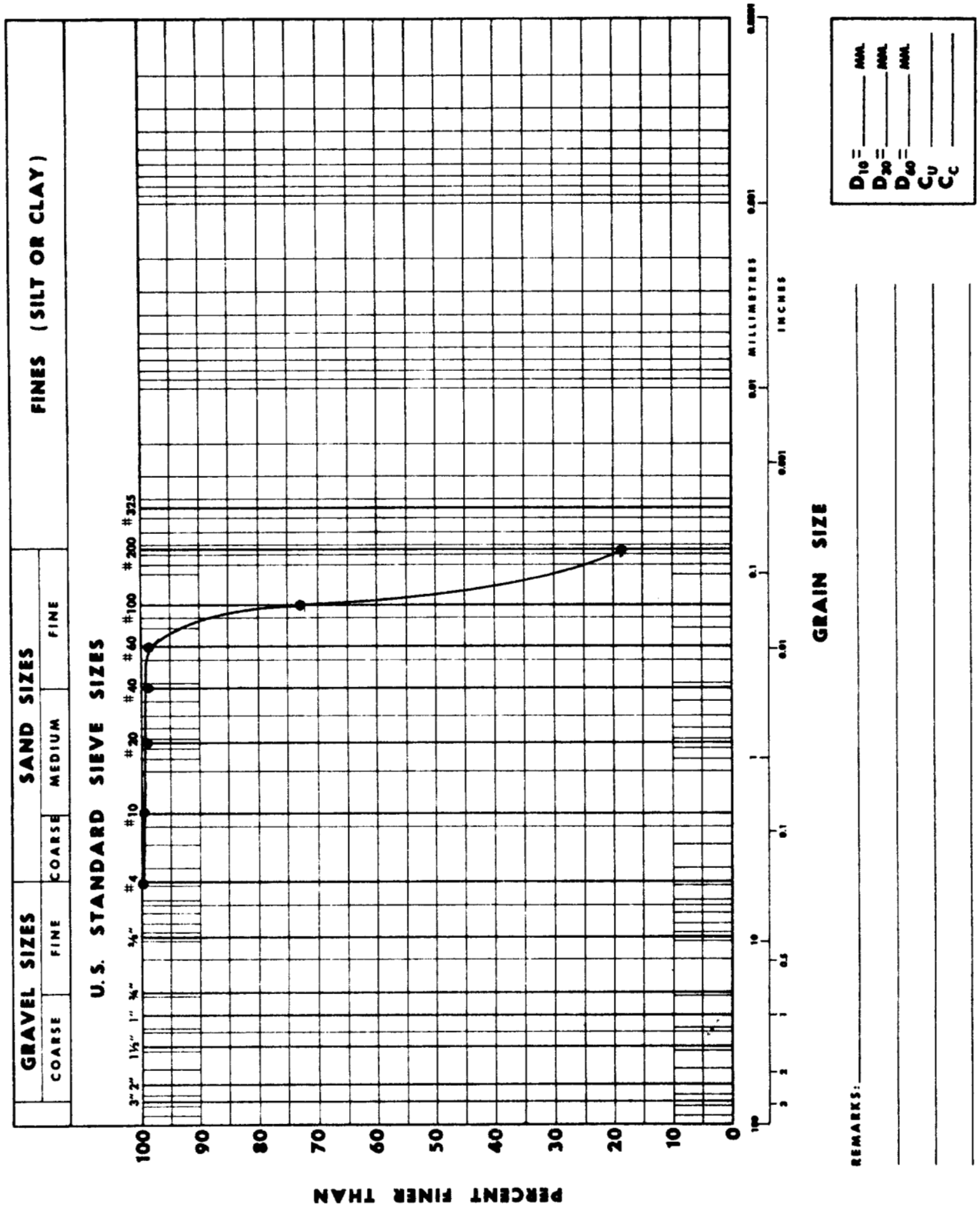


PLATE C-40

R.M.HARDY & ASSOCIATES LTD.
CONSULTING ENGINEERING & TESTING

GRAIN SIZE CURVE

LAB ORDER NO.	CS 3161
CLIENT	TAGLU GAS PLANT
SAMPLE	S1
SOURCE	
HOLE	H76-BH11 @ 12 - 13.5'
TECHNICIAN	DATE TESTED FEB./76

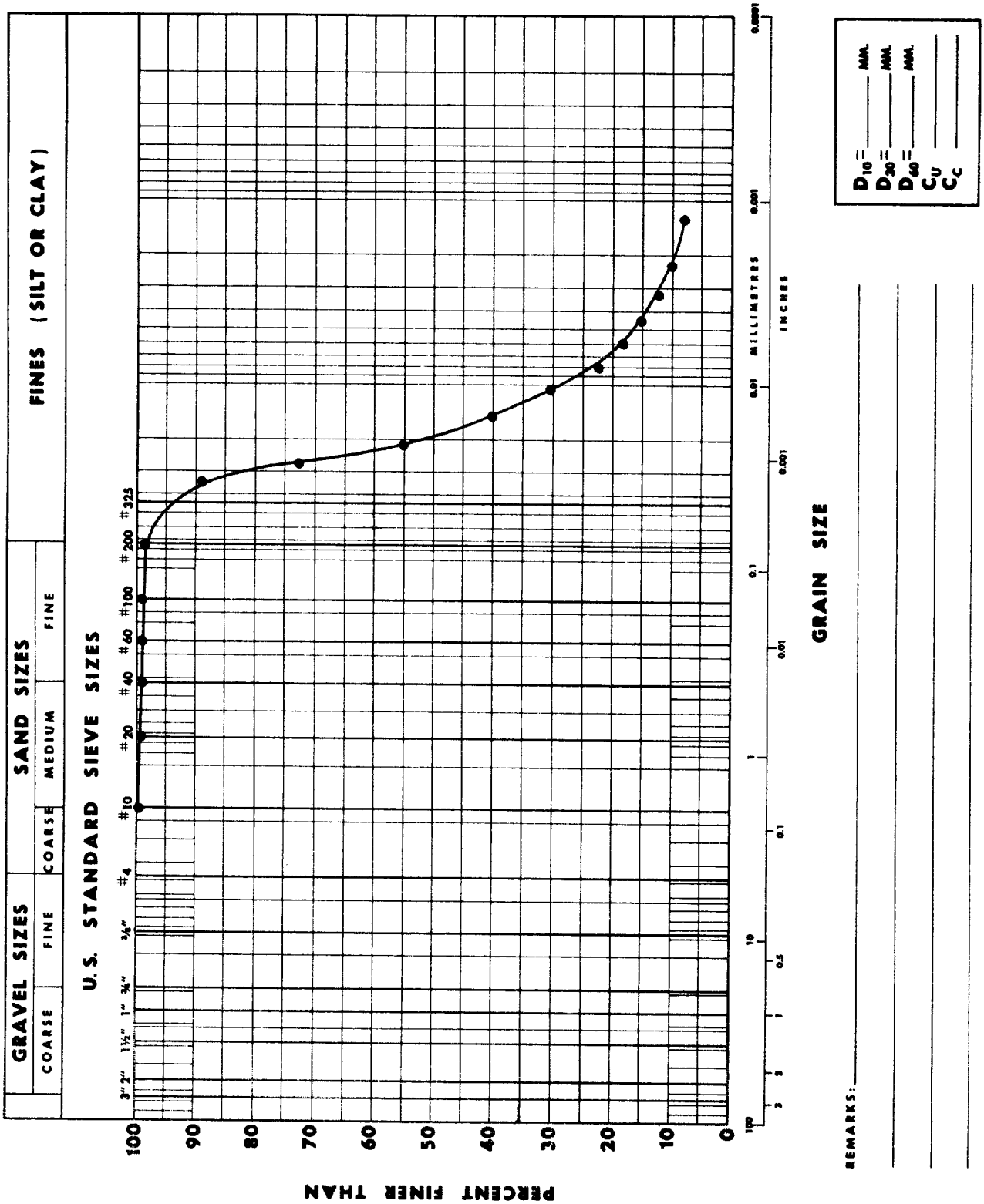


PLATE C-41

R.M.HARDY & ASSOCIATES LTD.
CONSULTING ENGINEERING & TESTING

GRAIN SIZE CURVE

LAB ORDER NO.	CS3161
CLIENT	Taglu Gas Plant
SAMPLE	S5
SOURCE	
HOLE	H76-BH11 @ 28.5-30.0'
TECHNICIAN	CS
DATE TESTED	Mar.76

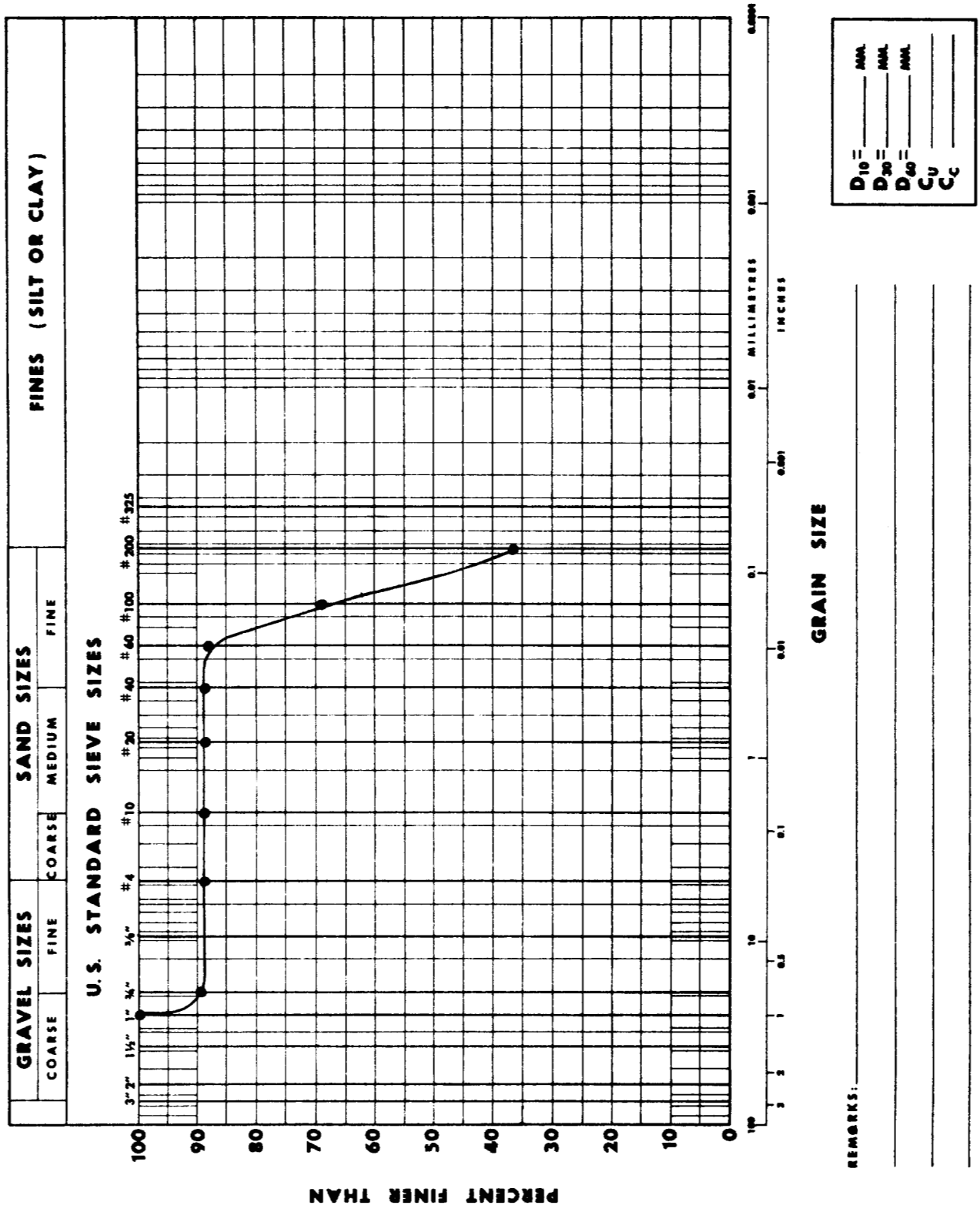


PLATE C-42

R.M. HARDY & ASSOCIATES LTD.
CONSULTING ENGINEERING & TESTING

GRAIN SIZE CURVE

LAB ORDER NO.	CS3161
CLIENT	Taglu Gas Plant
SAMPLE	S6
SOURCE	
HOLE	H76-BH11 @ 38.0' - 39.5'
TECHNICIAN	CW DATE TESTED Mar.76

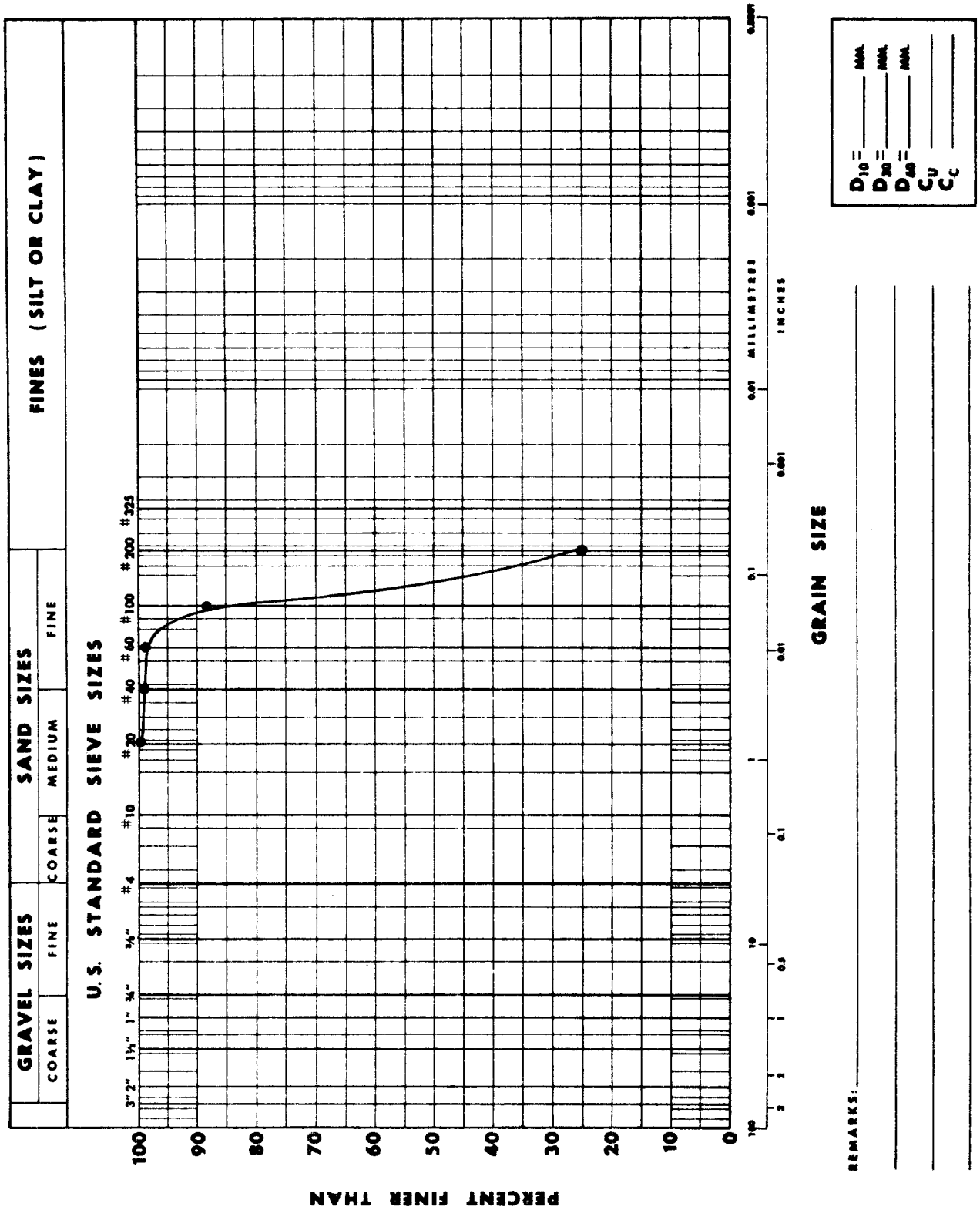


PLATE C-43

R.M. HARDY & ASSOCIATES LTD.
CONSULTING ENGINEERING & PROFESSIONAL SERVICES

SUMMARY OF LABORATORY TESTING

PROJECT: Taglu Gas Plant
LOCATION: Big Horn Point-Channe.
DATE: January, 1976
JOB NO.: CS3161

SAMPLE DATA					CLASSIFICATION TESTS						OTHER TESTS			
					ATTERBERG LIMITS			TEXTURE (%)						
TEST HOLE	DEPTH (ft)	SAMPLE NO	CLASSIFICATION	SOIL DESCRIPTION	LIQUID	PLASTIC	PLASTICITY INDEX	SAND	SILT	CLAY	WET DENSITY (PCF)	DRY DENSITY (PCF)	MOISTURE CONTENT (%)	
H76-BH1	10-11.5	S1	ML	SILT, little fine sand,saturated				3	85	12				
H76-BH1	19-20.5	S3	SM	SAND, fine to medium grained, silty,layered, wet				70	22	8				
H76-BH2	10-11.5	S1	ML	SILT, sandy, low plastic,dark grey, layered				18	72	10				
H76-BH2	21-22.5	S3	CI	CLAY, silty,trace sand, low to medium plastic,brown to grey, soft to firm	27	14	13							
H76-BH2	26-27.5	S4	SM	SAND, fine grained, silty,grey to brown, layered				64	29	7				
H76-BH3	4-5	W1	ML	SILT, trace sand, low plastic, grey	26	22	4							
H76-BH3	15-16.5	C3	CL to CI	CLAY, very silty,low to medium plastic,brown, layered,trace organics				16	72	12				
H76-BH4	15-16.5	S2	ML to SM	SILT, very sandy,fine grained, non plastic,layered				37	54	9				
H76-BH4	22-24.5	S4	SM	SAND, fine to medium grained, silty,brown,wet				73	20	7				
H76-BH5	12-13.5	S1	ML	SILT, very sandy,fine to medium grained, trace to little clay, grey				40	42	18				
H76-BH5	24-25.5	S4	SM	SAND, fine grained, silty, trace clay, occasional gravel sizes, layered, grey				61	28	11				
H76-BH5	36-37.5	S7	SP	SAND, fine grained, silty				91	9					
H76-BH6	22-24	S3	SM	SAND, fine to coarse grained, gravel sizes to 2" diameter, silty,brown,wet				86	12	2				
H76-BH6	33-35	S6	SM	SAND, fine grained, silty,brown				72	28					
H76-BH6	40-41.5	S8	SP	SAND, fine grained, silty,brown some gravel sizes				97	3					

PLATE C-44

R.M. HARDY & ASSOCIATES LTD.
CONSULTING ENGINEERING & PROFESSIONAL SERVICES

SUMMARY OF LABORATORY TESTING

PROJECT: Taglu Gas Plant
LOCATION: Big Horn Point-Channel
DATE: January, 1976
JOB NO. CS3161

SAMPLE DATA					CLASSIFICATION TESTS						OTHER TESTS			
					ATTERBERG LIMITS			TEXTURE (%)						
TEST HOLE	DEPTH (ft)	SAMPLE NO	CLASSIFICATION	SOIL DESCRIPTION	LIQUID	PLASTIC	PLASTICITY INDEX	SAND	SILT	CLAY	WET DENSITY (PCF)	DRY DENSITY (PCF)	MOISTURE CONTENT (%)	
H76-BH7	18-19.5	S3	CI	CLAY, silty, fine sand layers, medium plastic, grey to brown, stiff, coal particles	30	17	13							
H76-BH8	13-14.5	S2	ML	SILT, sandy, fine grained, layered, organics				3	82	15				
H76-BH9	6-7.5	S1	ML	SILT, clayey, trace sand, brown, wet				3	81	14				
H76-BH9	13-14	A1	SM	SAND, fine to medium grained, trace silt, occasional gravel sizes				52	42	6				
H76-BH10	7-8.5	S1	ML	SILT, sandy, clayey, low to non plastic, wet				16	77	7				
H76-BH10	22-23.5	S4	SM	SAND, fine grained, silty, wet				70	24	6				
H76-BH10	37-38.5	S7	SM	SAND, fine grained, silty, wet				82	18					
H76-BH11	12-13.5	S1	ML	SILT, sandy, fine grained, trace				2	88	10				
H76-BH11	20-22	S3	CL	CLAY, silty, trace sand, low plastic, occasional organics,	27	17	10							
H76-BH11	28.5 30	S5	SM	SAND, fine grained, silty, layered				63	37					
H76-BH11	38-39.5	S6	SM	SAND, fine grained, silty, layered				75	25					

PLATE C-45

TABLE C-2. BORROW CALCULATIONS FOR BIG HORN POINT CHANNEL

Section		Volume of O/B yd^3 O-X	Base of overburden 25'		25'-35'		35'-50	
			Processed Volume yd^3	Vol. of Waste yd^3	Processed Volume yd^3	Vol. of Waste yd^3	Processed Volume yd^3	Vol. of Waste yd^3
	9-BH4	83,844	184,527	55,119	91,031	19,310	95,762	49,332
B-B	BH4-11	73,889	114,400	45,600	57,933	12,289	66,275	14,058
	11-BH8	59,496	88,721	18,820	47,363	3,896	52,995	7,227
	2-2	100,837	74,875	5,205	50,336	6,864	53,554	15,996
	2-BH6	14,963	131,022	9,108	37,482	5,111	35,521	7,535
	BH6-1	30,707	57,165	7,795	27,378	0	24,255	5,145
	1-8	92,250	35,640	18,360	29,040	18,960	33,413	27,337
	8-BH5	98,963	86,973	44,805	59,091	17,650	75,802	22,642
	BH5-10	38,080	22,511	8,973	23,548	0	23,669	7,070
A-A	10-13	223,243	38,214	24,950	85,758	11,694	91,408	36,436
	13-16	129,956	37,453	16,591	40,363	20,792	0	0
	14-18	52,080	200,459	36,211	75,075	15,925	45,680	9,690
	10-BH1	21,837	178,189	37,798	60,836	12,905	72,348	15,346
	BH1-BH10	74,667	71,803	21,447	40,975	8,692	40,605	12,128
	BH10-19	19,556	12,952	4,622	9,044	1,919	3,996	1,515
	19-20	215,861	85,201	32,318	74,234	22,173	44,896	17,030
Totals		1,330,229	1,420,105	387,722	809,487	178,180	760,179	248,487

For 50' excavation:

Total Volume of Processed Material	2,989,771
Total Volume of Waste	814,389
Total Volume of Material Suitable for Processing	3,804,160

APPENDIX D

BIGHORN BLUFF AREA
BOREHOLE AND LABORATORY TEST DATA

TABLE D-1 TEST HOLE CO-ORDINATES FOR BIG HORN BLUFF AREA

(U.T.M. Zone 8)

Test Hole	N (metres)	E
H76 BB1	7,698,550	505,470
2	7,698,713	506,185
3	7,699,030	506,230
4	7,698,995	506,440
5	7,699,125	506,365
6	7,698,820	506,115

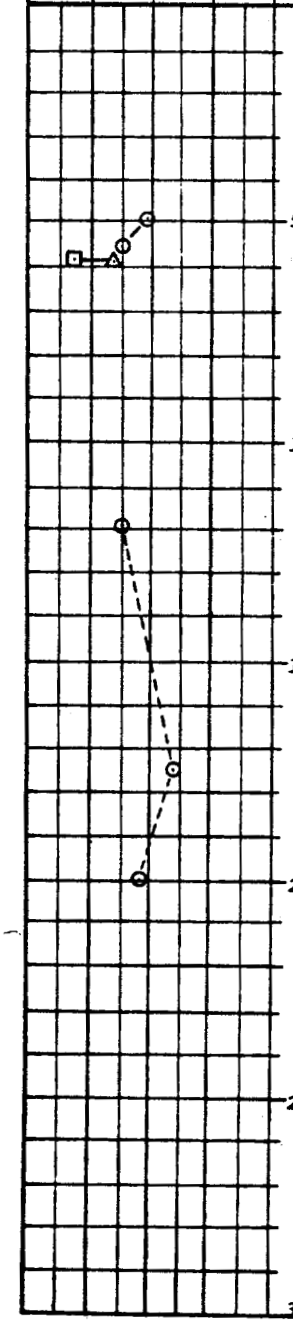
R.M.HARDY & ASSOCIATES LTD.
CONSULTING ENGINEERING & TESTING

TEST HOLE LOG

PROJECT: TAGLU GAS PLANT

TEST HOLE NO. H76-RBH

LOGGED BY DV	DRAWN BY BT	CHECKED RST	DATE February, 1976
RIG Heli Drill	METHOD CRREL and Air Wash	START January 16, 1976	FINISH
PROJECT NO. cs 3161	ELEVATION	AIR TEMPERATURE -40° C	



DEPTH (feet)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %	LABORATORY TEST DATA	SAMPLE TYPE AND NUMBER	SAMPLE CONDITION	CORE RUN AND % RECOVERY	CORE CONDITION	REMARKS
	SM		SAND and silty, fine, medium brown, low plastic, low moisture		Nbn		C1		100 %	IV	
			ICE massive, vertical stringers (silt < 5%)		ICE (95+%)						
5	ML		SILT some medium to fine sand clayey, low plastic, pebbles		Nbe 20%		C2		100 %	III	
							C3		100 %	III	
			ICE		ICE	Gr. Size Plate D-7					
10	ML		SILT sandy, fine grained, trace of coarse sand, brown, low plastic		ICE+ 60%						
	CL		CLAY (Till) silty, sandy, medium plastic, brown, occasional gravel sizes, some fine to coarse sand		Vx 20%		C4		100 %	II	
15			ice content decreasing - - -		Nbe						
							W1				
20							W2				
			Bottom of Hole at 21.0 Feet.								
25											
30											

PLATE D-1

R.M.HARDY & ASSOCIATES LTD.
CONSULTING ENGINEERING & TESTING

TEST HOLE LOG

PROJECT: TAGLU GAS PLANT

TEST HOLE NO. H76-BH2

LOGGED BY DV	DRAWN BY BT	CHECKED RST	DATE February, 1976
RIG Heli Drill	METHOD 3" CRREL	START January 16, 1976	FINISH
PROJECT NO. cs 3161	ELEVATION	AIR TEMPERATURE -40° C	

DEPTH (feet)	SOIL GROUP SYMBOL	DESCRIPTION	ICE GRAPHIC LOG / NRC ICE TYPE VISUAL ICE %	LABORATORY TEST DATA	SAMPLE TYPE AND NUMBER	SAMPLE CONDITION	CORE RUN AND % RECOVERY	CORE CONDITION	REMARKS
	ML	SILT sandy, trace clay, brown, layered	Vx (10-20%)		C1		100 %	II	
		ICE 20% soil---	ICE+		C2		100%	II	
					C3		100%	III	
	ML	SILT little sand, trace clay, brown, layered	Vs 30%		C4		100%	IV	
5			50%		C5		100%	II	
			Vs 10%		C6		100%	II	
					C7		100%	II	
			Vr 15%		C8		100%	II	
10		--- grey brown, layered	Vx 20% 40%	at 11.5'	C9		100%	I	
					C10		100%	II	
					C11		0%	V	
		ICE silt layers, 30-40% soil	ICE+		C12		100%	I	
15					C13		100%	III	
	ML	SILT clayey, trace of sand, fine occasional coarse sand, trace o organics, dark grey.	75% Vs, Vx		C14		80%	III	
		--- medium brown, little sand, fi							
		ICE silt inclusions (ML)	ICE+						
25									
	CI	CLAY medium plastic, trace of medium sand, trace of coal, grey brown	Vx 10%		C15		100%	II	
30		Bottom of Hole at 28.5 Feet.							PLATE D-2

W_P-⊡ W-⊙ W_L-△
MOISTURE CONTENT
20 40 60

R.M.HARDY & ASSOCIATES LTD.
CONSULTING ENGINEERING & TESTING

TEST HOLE LOG

PROJECT: TAGLU GAS PLANT

TEST HOLE NO. H76-BB3

LOGGED BY DV	DRAWN BY BT	CHECKED RST	DATE February, 1976
RIG Heli Drill	METHOD CRREL/AIR	START January 16, 1976	FINISH
PROJECT NO. cs 3161	ELEVATION	AIR TEMPERATURE -40° C	

MOISTURE CONTENT (W_P-⊡ W-⊙ W_L-△) 20 40 60	DEPTH (feet)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %	LABORATORY TEST DATA	SAMPLE TYPE AND NUMBER	SAMPLE CONDITION	CORE RUN AND % RECOVERY	CORE CONDITION	REMARKS
	0	ML		MOSS grass cover		Vx, Vr 10%						
				SILT								
		Pt		PEAT silty, black				A1	X	80%		
		ML		SILT clayey, sandy, trace of organics, low plastic								
	5			--- trace of organics, occasional gravel sizes to 1/2" dia.				A2	X			
								C1		100%	III	
		CI		CLAY silty, trace of fine sand, low plastic, gravel sizes to 1/4" dia., brown to grey		Vx 30%		W1	X	100%		
	10			--- gravel sizes								
				--- (till-like)				C2		100%	III	
				--- brown to grey, low to medium plastic, silty, sand, occasional gravel sizes		40%						
	15							C3		100%	I	
				ICE clay soil inclusions		ICE+ 90%						
				ICE clay, trace of sand		ICE+ 70%						
	20	SP		SAND fine grained, light brown, clean, non plastic		Nbn						
				--- brown-grey, fine grained, silty				W3	X	100%		
				--- increasing grey color, more silty				W4	X	100%		
	25							W5	X	100%		
		CI		CLAY silty, snady, low plastic, grey to brown				W6	X	100%		
		SC		SAND clayey, silty, dark grey				W7	X	100%		
	30			Bottom of Hole at 27.0 Feet.								

PLATE D-3

TEST HOLE LOG

R.M.HARDY & ASSOCIATES LTD.
CONSULTING ENGINEERING & TESTING

PROJECT: TAGLU GAS PLANT

TEST HOLE NO. H76-B4

LOGGED BY SGM	DRAWN BY YK	CHECKED RST	DATE February, 1976
RIG Heli Drill	METHOD 3 3/8, Air Flush	START January 17, 1976	FINISH Janaury 17, 1976
PROJECT NO. cs 3161	ELEVATION	AIR TEMPERATURE -50° C	

W_P-□ W-○ W_L-△ MOISTURE CONTENT 20 40 60	DEPTH (feet)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %	LABORATORY TEST DATA	SAMPLE TYPE AND NUMBER	SAMPLE CONDITION	CORE RUN AND % RECOVERY	CORE CONDITION	REMARKS
		Pt		PEAT		Vx 40%						
		ML		SILT little fine to medium sand, clayey, occasional gravel sizes brown								
				zones of ice rich soil ---			Gr. Size Plate D-8	A1				
	5			--- trace of clay		20%		A2				
				--- low to medium plastic clay layers				A3				
	10					35%						
		CL		CLAY (till-like) silty, little fine to medium sand, occasional gravel sizes to 1/2" dia., dark grey, low to medium plastic		40%		A4				
	15					35%		A5				
								A6				
	20			--- high ice content								
				--- sandy				A7				
				--- very sandy		40%		A8				
	25											
				--- some fine to coarse sand		25%		A9				
	30					20%		A10				

PLATE D-4

Bottom of Hole at 30.5 Feet.

R.M.HARDY & ASSOCIATES LTD.
CONSULTING ENGINEERING & TESTING

TEST HOLE LOG

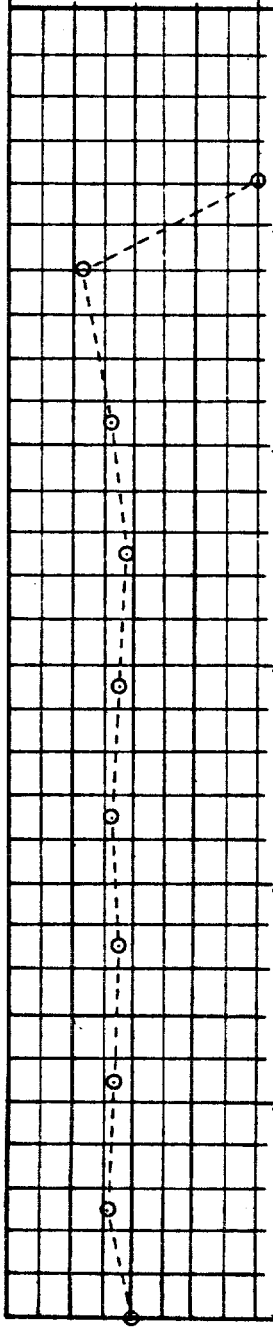
PROJECT: TAGLU GAS PLANT

TEST HOLE NO. H76-BB5

LOGGED BY	DRAWN BY	CHECKED	DATE
SGM	YK	RST	February, 1976

RIG	METHOD	START	FINISH
Heli Drill	Air-Flush	January 16, 1976	January 16, 1976

PROJECT NO. cs 3161 | ELEVATION | AIR TEMPERATURE



DEPTH (feet)	SOIL GROUP SYMBOL	DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %	LABORATORY TEST DATA	SAMPLE TYPE AND NUMBER	SAMPLE CONDITION	CORE RUN AND % RECOVERY	CORE CONDITION	REMARKS
	Pt	PEAT fine fibrous, dark brown, high ice content		Vr 50% to 60%		C1		100%	II	
		--- isolated cobble				A1				
5	ML to CL	SILT very sandy, clayey, medium to low plastic, medium brown, high ice content		Vx, Vs 40%	Gr. Size Plate D-9	A2				
		--- isolated cobble				C2		100%	II	
		--- high ice content								
		--- trace of medium sand				A3				
10										
		--- trace of medium coarse sand, high ice content				A4				
				70%		C3		100%	II	
15						A5				
						C4		100%	I	
		--- very clayey, trace of sand, low plastic, dark grey, wet, occasional coarse sand sizes		60%	Gr. Size Plate D-10	A6				
		--- clayey, less sand								
20						A7				
		--- clayey, low to medium plastic, dark grey, wet, occasional coarse sand particle				C5		0%		
						A8				
25						A9				
				20%		C6		100%	III	
30						A10				

PLATE D-5

Bottom of Hole at 30.5 Feet.

TEST HOLE LOG

R.M.HARDY & ASSOCIATES LTD.
CONSULTING ENGINEERING & TESTING

PROJECT: TAGLU GAS PLANT

TEST HOLE NO. H76-BB6

LOGGED BY DV	DRAWN BY BT	CHECKED RST	DATE February, 1976
RIG Heli Drill	METHOD CRREL and Air Wash	START January 16, 1976	FINISH
PROJECT NO. cs 3161	ELEVATION	AIR TEMPERATURE -40° C	

MOISTURE CONTENT (W_P-□ W-○ W_L-△) 20 40 60	DEPTH (feet)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %	LABORATORY TEST DATA	SAMPLE TYPE AND NUMBER	SAMPLE CONDITION	CORE RUN AND % RECOVERY	CORE CONDITION	REMARKS
	0	SP		SAND silty, trace of organics, fine to medium grained, light brown		Nbn						
		ML		SILT sandy, clayey, medium brown, low plastic, trace of coarse snad, gravel to 2"-3"dia		Vs 30%		C1		100%	III	
				gravel to 1" dia.		ICE+ 70%		C2		100%	IV	
		CL		CLAY (till-like) sandy, silty, low plastic, gravel sizes		Vs, Vr 40%						
	5			gravel encountered, low plastic								
				3"-4" dia. rock								
				silty, sandy, occasional gravel sizes								
	10											
				dark brown to dark grey low to medium plastic, grey, silty, trace of fine sand, occasional gravel sizes to 1/2" dia.		30%		W1		80%		
	15											
				grey								
	20			little fine sand				W4		80%		
				3" thick gravel layer								
	25											
	30			Bottom of Hole at 27.0 Feet.								

PLATE D-6

R.M.HARDY & ASSOCIATES LTD.
CONSULTING ENGINEERING & TESTING

GRAIN SIZE CURVE

LAB ORDER NO.	cs 3161
CLIENT	Taglu Gas Plant
SAMPLE	C 3
SOURCE	Big Horn Bluff
HOLE	H76-BB1 at 5.2'-6.0'
TECHNICIAN	MS DATE TESTED Feb/76

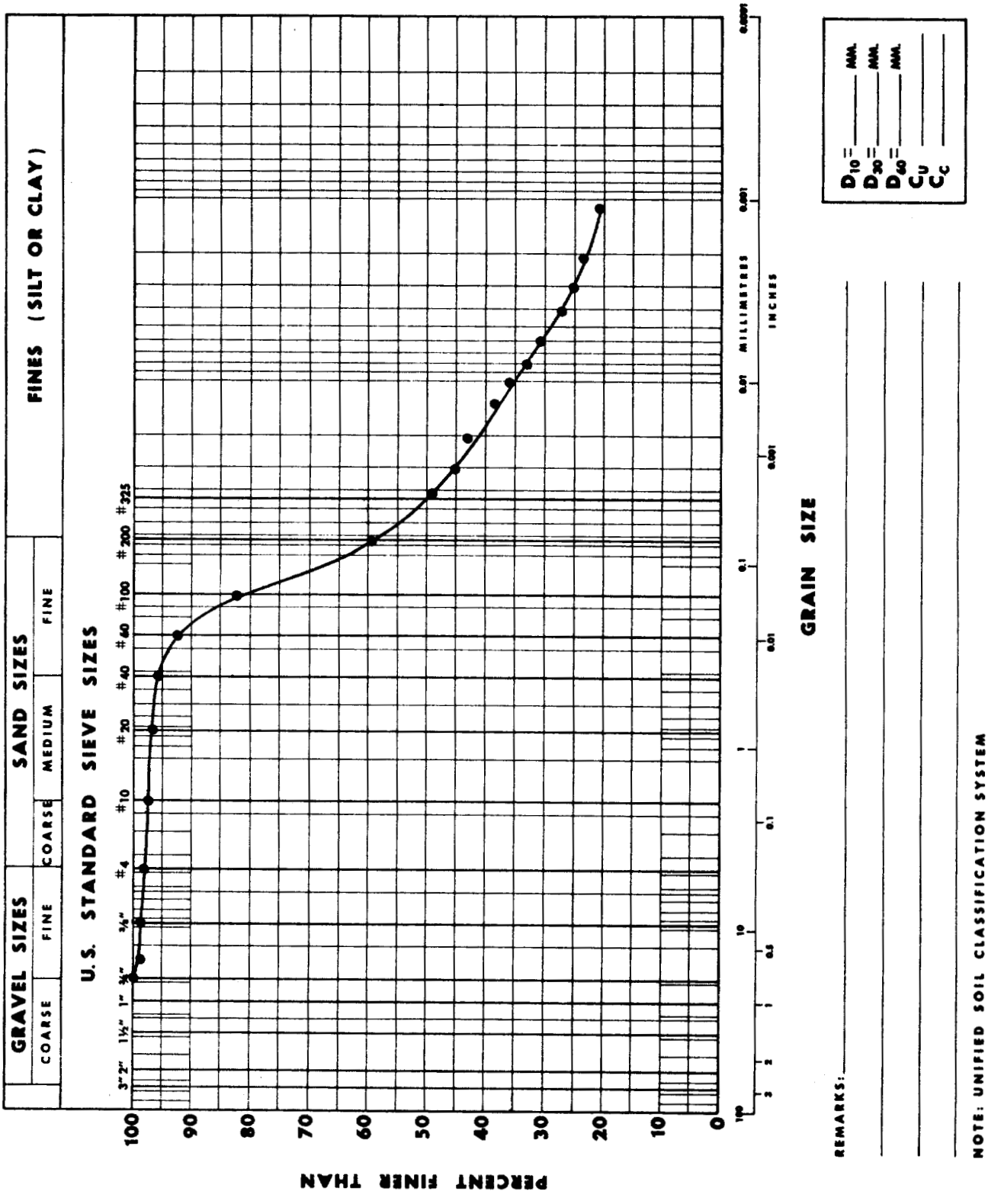


PLATE D-7

R.M.HARDY & ASSOCIATES LTD.
CONSULTING ENGINEERING & TESTING

GRAIN SIZE CURVE

LAB ORDER NO.	CS3161
CLIENT	Taglu Gas Plant
SAMPLE	A1
SOURCE	
HOLE	H76-BB4 @ 3.0'-3.5'
TECHNICIAN	M.S. DATE TESTED 2/76

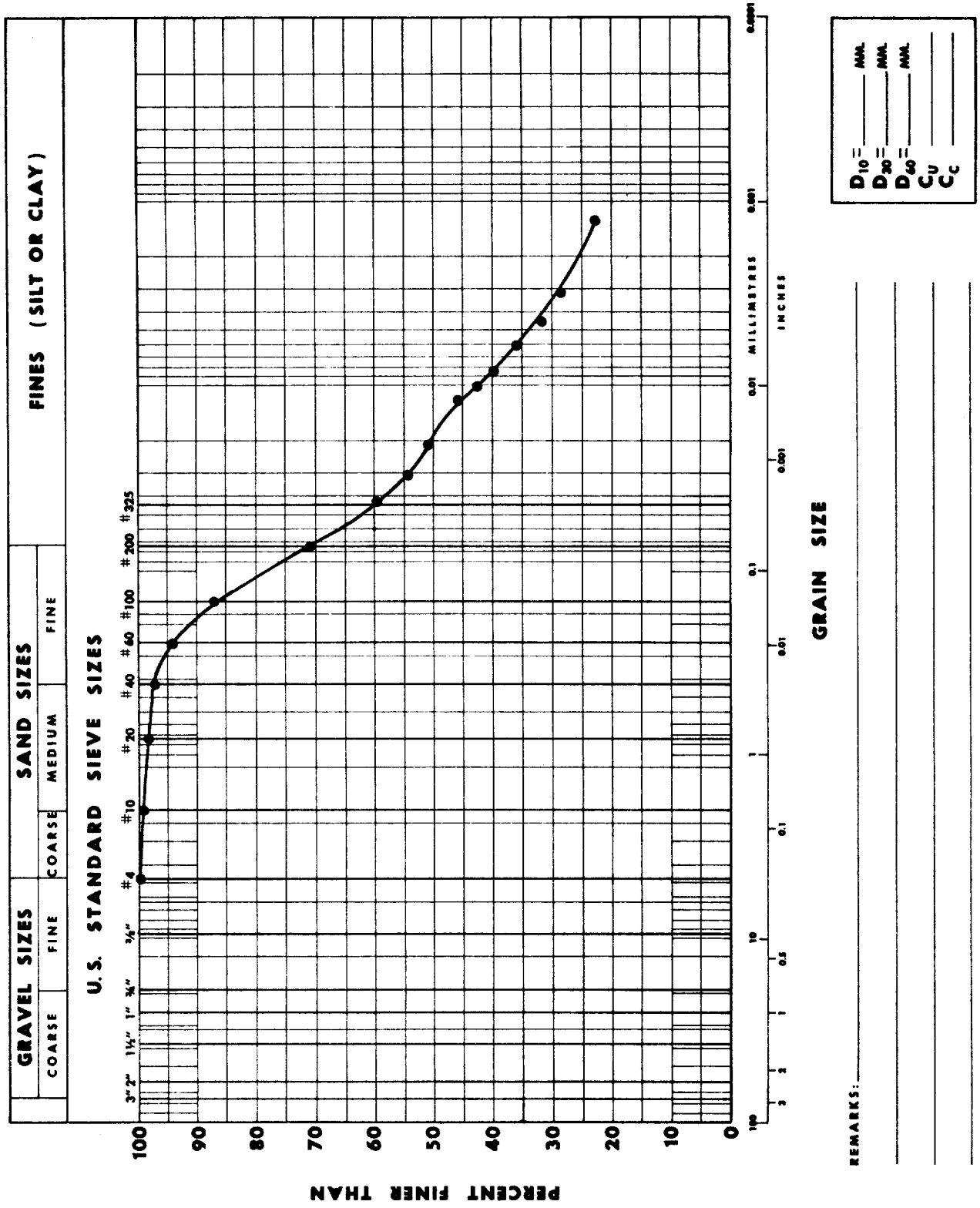


PLATE D-8

GU202-0373

R.M.HARDY & ASSOCIATES LTD.
CONSULTING ENGINEERING & TESTING

GRAIN SIZE CURVE

LAB ORDER NO.	CS 3161
CLIENT	Taglu Gas Plant
SAMPLE	A 2
SOURCE	
HOLE	H76-BB5 at 6.0'-6.5'
TECHNICIAN	MS DATE TESTED Feb/76

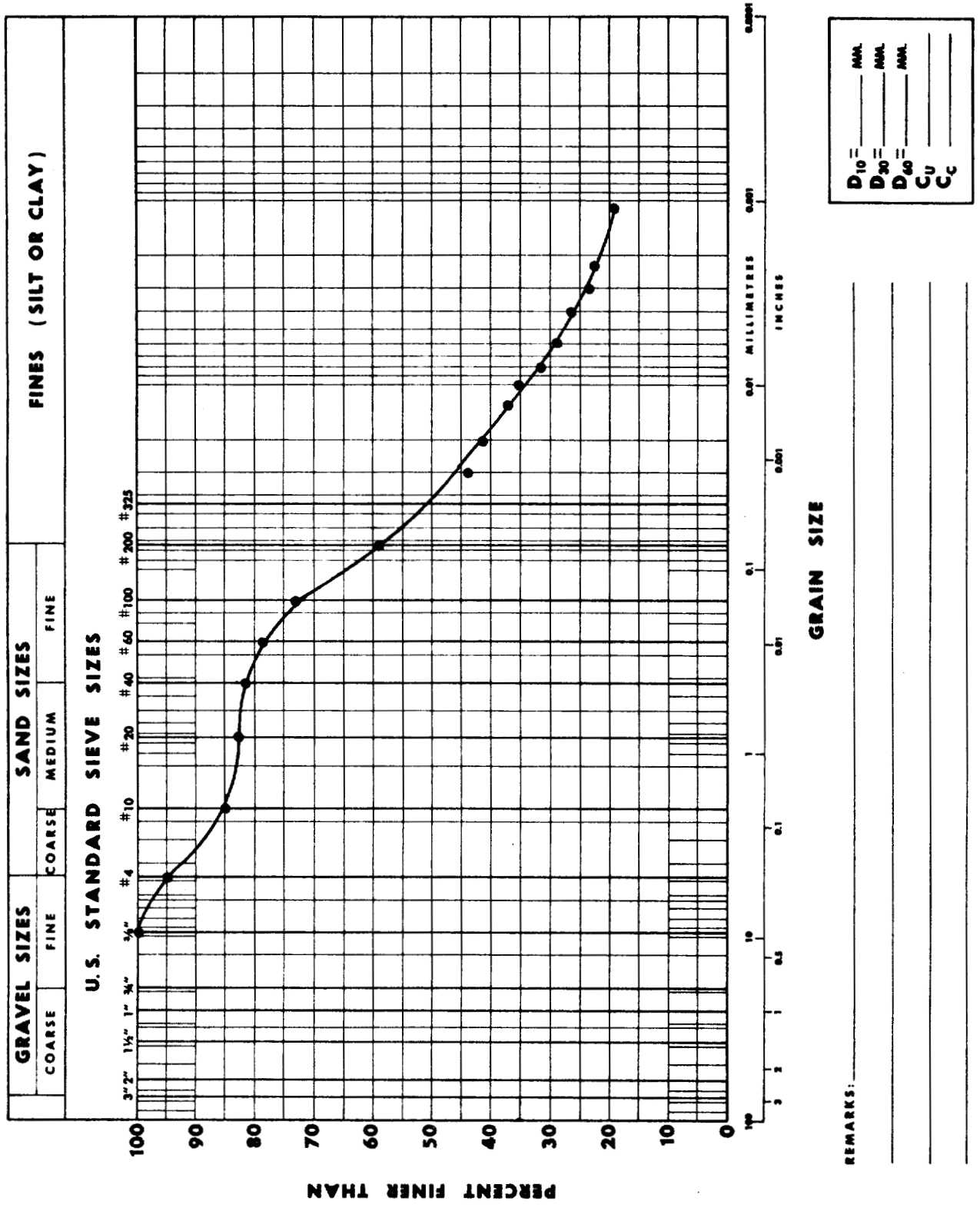


PLATE D-9

R.M.HARDY & ASSOCIATES LTD.
CONSULTING ENGINEERING & TESTING

GRAIN SIZE CURVE

LAB ORDER NO.	CS 3161
CLIENT	Taglu GAs Plant
SAMPLE	A 6
SOURCE	
HOLE	H76-BB5 at 18' - 18.5'
TECHNICIAN	MS
DATE TESTED	Feb/76

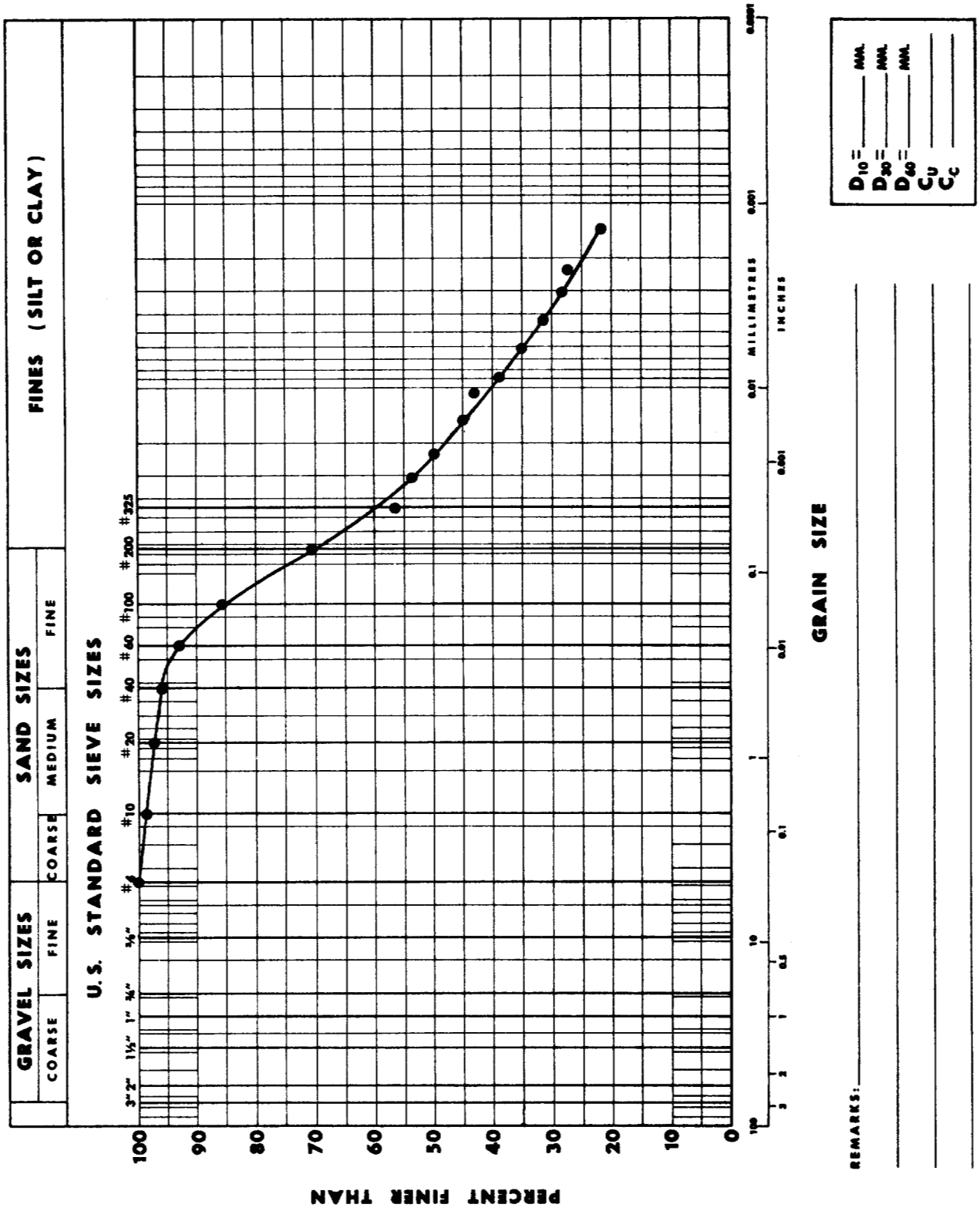


PLATE D-10

R.M. HARDY & ASSOCIATES LTD.
CONSULTING ENGINEERING & PROFESSIONAL SERVICES

SUMMARY OF LABORATORY TESTING

PROJECT Taglu Gas Plant
LOCATION Big Horn Point - Channe
DATE January, 1976
JOB NO. CW3161

SAMPLE DATA					CLASSIFICATION TESTS						OTHER TESTS			
					ATTERBERG LIMITS			TEXTURE (%)						
TEST HOLE	DEPTH (ft)	SAMPLE NO	CLASSIFICATION	SOIL DESCRIPTION	LIQUID	PLASTIC	PLASTICITY INDEX	SAND	SILT	CLAY	WET DENSITY (PCF)	DRY DENSITY (PCF)	MOISTURE CONTENT (%)	
H76-BB1	5.2-6.0	C3	ML	SILT, sandy, fine to medium grained, occasional gravel sizes, low plastic, clayey	27	13	14	41	36	23				
H76-BB4	3-4.5	A1	ML	SILT, sandy, fine to medium grained, clayey, occasional gravel sizes				28	48	26				
H76-BB4	8	A3	ML	SILT, sandy, fine to medium grained clayey, occasional gravel sizes, more clayey	32	15	17							
H76-BB5	6-6.5	A2	ML to CL	SILT, very sandy, clayey, low to medium plastic, brown				41	37	22				
H76-BB5	18-18.5	A6	ML to CL	SILT, less sandy, clayey, low to medium plastic, brown				29	46	25				
H76-BB6	2.5-4	C2	CL	CLAY, sandy, silty, low plastic, occasional gravel sizes	25	14	11							

PLATE D-11

APPENDIX E

POTENTIAL ALTERNATE BORROW SOURCE BOREHOLE AND LABORATORY TEST DATA

TABLE E-1 TEST HOLE CO-ORDINATES;
POTENTIAL ALTERNATE BORROW SOURCE

(U.T.M. Zone 8)

Test Hole	N (metres)	E
H76 G-1	7,642,240	498,360
2	7,692,460	498,450
3/3A	7,692,490	498,210
4	7,691,630	497,650
5	7,691,170	497,765
6	7,690,805	497,790
6A	7,690,820	497,755
9/9A	7,692,040	497,690
12	7,692,300	497,660
13	7,691,850	497,630
13A	7,691,960	497,580
14	7,691,280	497,280
15	7,691,860	497,300
16	7,692,060	497,360

R.M.HARDY & ASSOCIATES LTD.
CONSULTING ENGINEERING & TESTING

TEST HOLE LOG

PROJECT: TAGLU GAS PLANT

TEST HOLE NO. M76-G1

LOGGED BY *SGM & DV*	DRAWN BY *BT*	CHECKED *RST*	DATE *February, 1976*
RIG *Heli Drill*	METHOD *4" ID CRREL, WALMAC*	START *December 19, 1975*	FINISH *December 19, 1975*
PROJECT NO. *cs 3161*	ELEVATION	AIR TEMPERATURE *-30° C*	

W_P-⊡ W-⊙ W_L-△ MOISTURE CONTENT 20 40 60	DEPTH (feet)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %	LABORATORY TEST DATA	SAMPLE TYPE AND NUMBER	SAMPLE CONDITION	CORE RUN AND % RECOVERY	CORE CONDITION	REMARKS
	1			*ICE*		ICE						
	2	ML		*SILT clayey, trace to little fine sand, medium grey, occasional lense of fine sand to 1" thick*		Vs 10-20%		C1		100 %	I	*Cuttings freezing above bit-problem with compressor*
								C2		100 %	III	
	4	CL		*CLAY silty, low plastic, trace of fine sand, grey*								
	5											
	6											
	7											
	8											
	9											
	10			*Bottom of Hole at 10.0 Feet.*								

PLATE E-1

R.M.HARDY & ASSOCIATES LTD.
CONSULTING ENGINEERING & TESTING

TEST HOLE LOG

PROJECT: TAGLU GAS PLANT

TEST HOLE NO. HZ6-G2

LOGGED BY MR	DRAWN BY BT	CHECKED RST	DATE February, 1976
RIG Heli Drill	METHOD	START January 3, 1976	FINISH
PROJECT NO. cs 3161	ELEVATION	AIR TEMPERATURE -30° C	

W_P-□ W-○ W_L-△ MOISTURE CONTENT 20 40 60	DEPTH (feet)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %	LABORATORY TEST DATA	SAMPLE TYPE AND NUMBER	SAMPLE CONDITION	CORE RUN AND % RECOVERY	CORE CONDITION	REMARKS
	5			ICE		ICE						
				WATER		UF						
	10	ML		SILT clayey, greyish brown, non to very low plastic, very soft				S1	X	87%		
				--- slight dilatancy			Grain Size Plate E-24	S2	X	100 %		
	15	SM		SAND fine grained, silty, brown, non plastic, medium dense, wet								
				--- with thin (to 1/2") layers of silt, brown			Grain Size Plate E-25	S3	X	53%		
□-△	20	CI		CLAY silty, trace to little fine sand, brown grey, medium plastic firm to stiff (till-like)				S4	X	67%		
								S5 (SPT)	X	53%		N = 9 blows/foot
	25			--- as above				S6 (SPT)	X	53%		N = 14 blows/foot
								S7 (SPT)	X	67%		N = 13 blows/foot
	30			--- as above								

PLATE E-2

R.M.HARDY & ASSOCIATES LTD.
CONSULTING ENGINEERING & TESTING

TEST HOLE LOG

PROJECT: TAGLU GAS PLANT

TEST HOLE NO. H76-G2 (cont.)

LOGGED BY	DRAWN BY	CHECKED	DATE
MR	BT	RST	February, 1976

RIG	METHOD	START	FINISH
Heli Drill		January 3, 1976	

PROJECT NO.	ELEVATION	AIR TEMPERATURE
cs 3161		-30° C

W_P-⊡ W-⊙ W_L-△ MOISTURE CONTENT 20 40 60	DEPTH (feet)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %	LABORATORY TEST DATA	SAMPLE TYPE AND NUMBER	SAMPLE CONDITION	CORE RUN AND % RECOVERY	CORE CONDITION	REMARKS
		CI / ML		CLAY silty, trace to little fine sand, brown-grey, medium plastic, firm to stiff (till-like)				S8 (SPT)	X	100 %		N = 8 blows/foot
				SILT very sandy, trace of clay, dark grey, non plastic, clay lenses interbedded, wet				S9 (SPT)	X	53%		N = 8 blows/foot
	35			--- trace of coarse sand				S10 (SPT)	X	67%		N = 8 blows/foot
	40			Bottom of Hole at 40.0 Feet.								

PLATE E-3

TEST HOLE LOG

R.M.HARDY & ASSOCIATES LTD.
CONSULTING ENGINEERING & TESTING

PROJECT: TAGLU GAS PLANT

TEST HOLE NO. H76-G3/G3A

LOGGED BY: SGM	DRAWN BY: BT	CHECKED: RST	DATE: Febrauru, 1976
RIG: Heli Drill	METHOD: 4 3/4 WALMAC, 3" CRREL	START: January 3, 1976	FINISH:
PROJECT NO.: cs 3161	ELEVATION:	AIR TEMPERATURE: -25° C	

DEPTH (feet)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %	LABORATORY TEST DATA	SAMPLE TYPE AND NUMBER	SAMPLE CONDITION	CORE RUN AND % RECOVERY	CORE CONDITION	REMARKS
	PT		PEAT fine fibrous, medium brown, reindeer moss, grass		Vx						
	SM		SAND fine to medium grained, silty, grey, poorly graded, layered		Nbn						
5			--- light grey, silty, fine grained			Grain Size Plate E-26	C1		100 %	II	
									100%	I	
							C2		0%	V	
							C3		100 %	II	
			--- clay lense		Vs		C4		0%	V	
10			--- fine to medium grained, light grey to brown		Nbn		C5		0%	V	
			--- drier, trace of clay, mottled, brown				C6		100 %	IV	
							C7		100%	III	
							C8			IV	
15			--- gravel piece (1" diameter)						100%	I	
							C9		0%	V	
							C10		0%	V	CRREL barrel sheared off when frozen in (hole redrilled — H76-3A)
			Bottom of Hole H76-G3 .								
			--- gravel pieces								
20	CI		CLAY very silty, sandy, medium plastic, occasional gravel sizes to 1/2" diameter		Vx, Vr (30-40%)	Grain Size Plate E-27	C11		100 %	III	
							C12		0%	V	
			--- more ice rich		Vx, Vs (50%)		C13		50%	III	
25			--- grading to fine sand, silty								
	SC		SAND fine grained, clayey, low plastic								
			-- fine grained, silty, trace of clay, dark grey				C14		0%	V	
30			Bottom of Hole at 30.4 Feet.				C15		100%	II	

MOISTURE CONTENT: W_P - ⊡ W - ⊙ W_L - △ (20, 40, 60)

PLATE E-4

R.M.HARDY & ASSOCIATES LTD.
CONSULTING ENGINEERING & TESTING

TEST HOLE LOG

PROJECT: TAGLU GAS PLANT

TEST HOLE NO. H76-G4

LOGGED BY SGM	DRAWN BY BT	CHECKED RST	DATE February, 1976
RIG Heli Drill	METHOD WALMAC / 3" CRREL	START January 4, 1976	FINISH
PROJECT NO. cs 3161	ELEVATION	AIR TEMPERATURE -30° C	

W_P - ⊡ W - ⊙ W_L - △

MOISTURE CONTENT 20 40 60

DEPTH (feet)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %	LABORATORY TEST DATA	SAMPLE TYPE AND NUMBER	SAMPLE CONDITION	CORE RUN AND % RECOVERY	CORE CONDITION	REMARKS
	PT		PEAT								
	ML		SILT little fine sand, trace of small pebbles (fine gravel), medium grey, ice rich		Vx (15%)						
5	SM		SAND silty, non plastic, fine grained sand sizes, brown, trace of organics		Nbn		C1		100 %	IV	
			grading to silt								
	ML		SILT little clay, brown		Vs, 30%)		C2		100 %	III	
10			--- medium grey		Vx, Vs 15-20%						
			--- ice lenses to 1/2"				C3		100 %	IV	
15			--- becoming very clayey, darker grey								
			--- very clayey		Nbn		C4		100 %	II	
20			--- rounded cobble to 1 1/2" dia.				C5			V	
	CI		CLAY silt, trace of sand, brown, medium plastic				C6		100%	III IV	
25			--- vertical ice fissures to 1/8" thick								
			--- silty, trace of sand, brown, gravel sizes to 1" dia.				C7		100 %	II	
30			Bottom of Hole at 28.5 Feet.								

PLATE E-5

R.M.HARDY & ASSOCIATES LTD.
CONSULTING ENGINEERING & TESTING

TEST HOLE LOG

PROJECT: TAGLU GAS PLANT

TEST HOLE NO. H76-G5

LOGGED BY MR	DRAWN BY BT	CHECKED RST	DATE February, 1976
RIG Heli Drill	METHOD	START January 4, 1976	FINISH
PROJECT NO. cs 3161	ELEVATION	AIR TEMPERATURE -20° C	

W_P-□ W-○ W_L-△ MOISTURE CONTENT 20 40 60

DEPTH (feet)	SOIL GROUP SYMBOL	DESCRIPTION	ICE GRAPHIC LOG / NRC ICE TYPE / VISUAL ICE %	LABORATORY TEST DATA	SAMPLE TYPE AND NUMBER	SAMPLE CONDITION	CORE RUN AND % RECOVERY	CORE CONDITION	REMARKS
		ICE	ICE						
5		WATER	UF						
		bottom of channel							
	ML	SILT clayey, fine sand, brown, soft, non to very low plastic, wet			S1	X	100%		
10		--- fine sand, brown, wet, soft, non plastic, medium dilatancy, highly plastic clay layer interbedded		Grain Size Plate E-28	S2	X	100 %		
15									
	CL CH	CLAY silty, medium to high plastic, firm to stiff			S3	X	100 %		
20	OL	SILT organic, black-grey, piece of non-woody peat, soft			S4 (SPT)	X	67%		N = 8 blows/ foot
		--- dark brown, organic, odour, crumbly							
25	SM SC	SAND silty, trace of clay, dark brown, non to very low plastic, spongey, moist			S5 (SPT)	X	67%		N = 12 blows/foot
	CH	CLAY brown, highly plastic, stiff to very stiff							
30	CL	CLAY (till-like) cont.				X			

PLATE E-6

TEST HOLE LOG

R.M.HARDY & ASSOCIATES LTD.
CONSULTING ENGINEERING & TESTING

PROJECT: TAGLU GAS PLANT

TEST HOLE NO. H76-G5 (cont.)

LOGGED BY MR	DRAWN BY BT	CHECKED RST	DATE February, 1976
RIG Heli Drill	METHOD	START January 4, 1976	FINISH
PROJECT NO. cs 3161	ELEVATION	AIR TEMPERATURE -20° C	

W_P-□ W-○ W_L-△ MOISTURE CONTENT 20 40 60	DEPTH (feet)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %	LABORATORY TEST DATA	SAMPLE TYPE AND NUMBER	SAMPLE CONDITION	CORE RUN AND % RECOVERY	CORE CONDITION	REMARKS
		CI		CLAY (till-like) silty, trace of sand, brown, occasional gravel sizes to 3/8" dia., medium plastic, stiff to very stiff			Grain Size Plate E-29	S6 (SPT)	X	67%		N = 19 blows/foot
	35			--- dark greyish brown with occasional layers of wet sand, medium plastic clay lenses, interbedded, trace of organic material				S7 (SPT)	X	80%		N = 22 blows/foot
	40			--- as above								
	45			Bottom of Hole at 42.0 Feet.								

PLATE E-7

TEST HOLE LOG

R.M.HARDY & ASSOCIATES LTD.
CONSULTING ENGINEERING & TESTING

PROJECT: TAGLU GAS PLANT

TEST HOLE NO. H76-G6

LOGGED BY MR	DRAWN BY BT	CHECKED RST	DATE February, 1976
RIG Heli Drill	METHOD	START	FINISH
PROJECT NO. cs 3161	ELEVATION	AIR TEMPERATURE -20° C	

MOISTURE CONTENT (W_P-□ W-⊙ W_L-△) 20 40 60	DEPTH (feet)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %	LABORATORY TEST DATA	SAMPLE TYPE AND NUMBER	SAMPLE CONDITION	CORE RUN AND % RECOVERY	CORE CONDITION	REMARKS
		Pt		PEAT								
		ML		SILT								
				MASSIVE ICE		ICE						
	5							C1	X	67%	IV	
	10											
	15											
		SM		SAND fine grained, silty, brown		Vc		C2		100 %	II	
		CI		CLAY very silty, sandy		Vx	(70%)					
	20	SM		SAND fine grained, siltu, brown, clay inclusions		Vx	(50%)	C3		100 %	II	
		CI		CLAY (till-like) silty, trace of sand, dark brown, medium plastic		Vx (40%)		C4		100 %		
	25			--- occasional rounded particles of gravel to 1" dia., one 3/8" ice lense		Vx 5%	Vs	C5		100 %	II	
	30			Bottom of Hole at 29.8 Feet.								PLATE E-8

R.M.HARDY & ASSOCIATES LTD.
CONSULTING ENGINEERING & TESTING

TEST HOLE LOG

PROJECT: TAGLU GAS PLANT

TEST HOLE NO. H76-G6A

LOGGED BY	DRAWN BY	CHECKED	DATE
SGM	YK	RST	February, 1976
RIG: Heli Drill	METHOD: WALMAC, CRREL	START: January 4, 1976	FINISH
PROJECT NO.: cs 3161	ELEVATION	AIR TEMPERATURE	

DEPTH (feet)	SOIL GROUP SYMBOL	DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %	SAMPLE TYPE AND NUMBER	SAMPLE CONDITION	CORE RUN AND % RECOVERY	CORE CONDITION	REMARKS
		PEAT fibrous		Vx					
	ML	SILT clayey, medium brown, some organic inclusions, fine grained sand sizes, trace organic material, low plastic		Vx (20%)					
5		--- occasional gravel sizes							
				Vs (30-40%)	C1		70%	IV	
					C2		90%	II	
10		--- trace of clay, grey							
				Vs (65%)	C3		40%	IV	
15		--- grey brown, rock fragments		Vx (20%)	C4		90%	II	
		--- dark grey, clayey							
20				Vx, Vs (20%)	C5		80%	IV	
	SP	SAND fine, brown grey, trace of silt and clay		Nbn	C6		0%	V	
25					C7		0%	V	
		--- clayey silt laminations		Vs, Nbn	C8		0%	V	
					C9		70%	II	
30		Bottom of Hole at 28.0 Feet.							

MOISTURE CONTENT: W_P - ⊡ W - ⊙ W_L - △ (20, 40, 60)

PLATE E-9

TEST HOLE LOG

R.M.HARDY & ASSOCIATES LTD.
CONSULTING ENGINEERING & TESTING

PROJECT: TAGLU GAS PLANT

TEST HOLE NO. H76-G9

LOGGED BY SGM	DRAWN BY BT	CHECKED RST	DATE February, 1976
RIG Heli Drill	METHOD Splitspoon	START January 5, 1976	FINISH
PROJECT NO. cs 3161	ELEVATION	AIR TEMPERATURE -30° C	

DEPTH (feet)	SOIL GROUP SYMBOL	DESCRIPTION	ICE GRAPHIC LOG / NRC ICE TYPE VISUAL ICE %	LABORATORY TEST DATA	SAMPLE TYPE AND NUMBER	SAMPLE CONDITION	CORE RUN AND % RECOVERY	CORE CONDITION	REMARKS
		ICE	ICE						
		WATER	UF						
5									
	ML	SILT medium grey, low plastic, uniform, trace of organic matter at top, wet			S1	X	100%		
10									
		--- clayey							
15				Gr. Size Plate E-30	S2	X	100%		
	SM	SAND fine grained, trace to little silt							
	SW	SAND fine to coarse, very silty, gravelly, well graded, dense, wet		Gr. Size Plate E-31	S3	X	100%		
20					S4		0%		
	SM	SAND fine grained, very silty, clayey, poorly graded, dark grey, wet, layered							
		--- rapid dilatancy		Gr. Size Plate E-32	S5	X	100%		
25									
		--- trace of medium sand, clayey							
		--- clayey, silt layers							
		fine sand, clean		Gr. Size Plate E-33	S6	X	100%		
30									PLATE E-10

MOISTURE CONTENT: W_P - ⊡ W - ⊙ W_L - △ (20, 40, 60)

R.M. HARDY & ASSOCIATES LTD.
CONSULTING ENGINEERING & TESTING

TEST HOLE LOG

PROJECT: TAGLU GAS PLANT

TEST HOLE NO. H76-G9 (cont.)

LOGGED BY	DRAWN BY	CHECKED	DATE
SGM	BT	RST	February, 1976

RIG	METHOD	START	FINISH
Heli Drill	Splitspoon	January 5, 1976	

PROJECT NO.	ELEVATION	AIR TEMPERATURE
cs 3161		-30° C

MOISTURE CONTENT (W_p-□ W-○ W_L-△) 20 40 60	DEPTH (feet)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %	LABORATORY TEST DATA	SAMPLE TYPE AND NUMBER	SAMPLE CONDITION	CORE RUN AND % RECOVERY	CORE CONDITION	REMARKS
		SM		SAND medium to fine grained, silty, dark grey, wet		UF						
								S7	X	100 %		
	35			--- some fine gravel, clayey					X	100%		
								S8		0%		
	40			--- fine grained, poorly graded								
		SW		SAND well graded, fine to coarse sizes				S9	X	60%		
		SM		SAND fine, poorly graded, silty								
	45			Bottom of Hole at 44.0 Feet.								

PLATE E-11

R.M.HARDY & ASSOCIATES LTD.
CONSULTING ENGINEERING & TESTING

TEST HOLE LOG

PROJECT: TAGLU GAS PLANT

TEST HOLE NO. H76-G9A

LOGGED BY SGM	DRAWN BY YK	CHECKED RST	DATE February, 1976
RIG Heli Drill	METHOD	START January 5, 1976	FINISH
PROJECT NO. cs 3161	ELEVATION	AIR TEMPERATURE -30° C	

W_P-⊡ W-⊙ W_L-△ MOISTURE CONTENT 20 40 60	DEPTH (feet)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %	LABORATORY TEST DATA	SAMPLE TYPE AND NUMBER	SAMPLE CONDITION	CORE RUN AND % RECOVERY	CORE CONDITION	REMARKS
	5			ICE		ICE						
				WATER		UF						
	10	ML		SILT grey, some sand and clay, wet								
	15			estimated interface								
		SM		SAND fine, silty, medium grey, wet				S1A		0%		
	20			--- 1' layer of gravelly sand, gravel sizes to 3/4" dia.			Gr. Size Plate E-34	S1		75%		
				--- occasional gravel sizes				S1B		0%		
	25			Bottom of Hole at 22.5 Feet.								

PLATE E-12

R.M.HARDY & ASSOCIATES LTD.
CONSULTING ENGINEERING & TESTING

TEST HOLE LOG

PROJECT: TAGLU GAS PLANT

TEST HOLE NO. HZ6-G10

LOGGED BY MR	DRAWN BY BT	CHECKED RST	DATE February, 1976
RIG Heli Drill	METHOD	START	FINISH
PROJECT NO. cs 3161	ELEVATION	AIR TEMPERATURE	

W_P-⊡ W-⊙ W_L-△

MOISTURE CONTENT 20 40 60

DEPTH (feet)	SOIL GROUP SYMBOL	DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %	LABORATORY TEST DATA	SAMPLE TYPE AND NUMBER	SAMPLE CONDITION CORE RUN AND % RECOVERY	CORE CONDITION	REMARKS
		ICE		ICE					
5		WATER - bottom of channel		UF					
	SM	SAND very silty, brown, saturated, fine grained sand sizes				S1	40%		
10						S2	20%		
15	GW	GRAVEL sandy, little silt, dense, wet, gravel sizes to 3/4" dia.			Gr. Size Plate E-35				
	SM	SAND silty, trace of clay, dark brownish grey, soft, spongey, non plastic			Gr. Size Plate E-36	S3	75%		
20		Bottom of Hole at 20.0 Feet.							

PLATE E-13

R.M.HARDY & ASSOCIATES LTD.
CONSULTING ENGINEERING & TESTING

TEST HOLE LOG

PROJECT: TAGLU GAS PLANT

TEST HOLE NO. HZ6-G10A

LOGGED BY MR	DRAWN BY YK	CHECKED RST	DATE February, 1976
RIG Heli Drill	METHOD	START January 5, 1976	FINISH January 5, 1976
PROJECT NO. cs 3161	ELEVATION	AIR TEMPERATURE	

MOISTURE CONTENT (W_P-⊡ W-⊙ W_L-△) 20 40 60	DEPTH (feet)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %	LABORATORY TEST DATA	SAMPLE TYPE AND NUMBER	SAMPLE CONDITION	CORE RUN AND % RECOVERY	CORE CONDITION	REMARKS
				ICE		ICE						
	5			WATER		UF						
	10	SM		SAND very silty, brown, fine grained sand sizes, saturated								
	15	SP		SAND medium to coarse grained, trace of silt, brown, particles of sub-rounded gravel to 1" dia, wet to saturated				S1		50%		
		SM		SAND very silty, fine grained, brown, trace of clay, layered				S2		75%		
	20			Bottom of Hole at 19.0 Feet.								

PLATE E-14

R.M.HARDY & ASSOCIATES LTD.
CONSULTING ENGINEERING & TESTING

TEST HOLE LOG

PROJECT: TAGLU GAS PLANT

TEST HOLE NO. H76-G12

LOGGED BY DV	DRAWN BY BT	CHECKED RST	DATE February, 1976
RIG Heli Drill	METHOD	START January 17, 1976	FINISH
PROJECT NO. cs 3161	ELEVATION	AIR TEMPERATURE -20° C	

MOISTURE CONTENT (W_P-□ W-○ W_L-△) 20 40 60	DEPTH (feet)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %	LABORATORY TEST DATA	SAMPLE TYPE AND NUMBER	SAMPLE CONDITION	CORE RUN AND % RECOVERY	CORE CONDITION	REMARKS
				ICE		ICE						
	5			WATER		UF						
	10	OL		SILT organic								
		ML		SILT trace of sand, non to low plastic, grey, wet			Gr. Size Plate E-37	S1	X	67%		
	15			--- trace of sand, rapid dilatancy grey, low plastic				S2	X	67%		
	20			--- grey, some fine sand, little clay, low plastic				S3	X	80%		
	25	CH		CLAY highly plastic, stiff, grey-blue └ sand lenses interbedded				S4	X	100 %		
								U1	◢	100 %	I	
	30			Bottom of Hole at 28.0 Feet.								

PLATE E-15

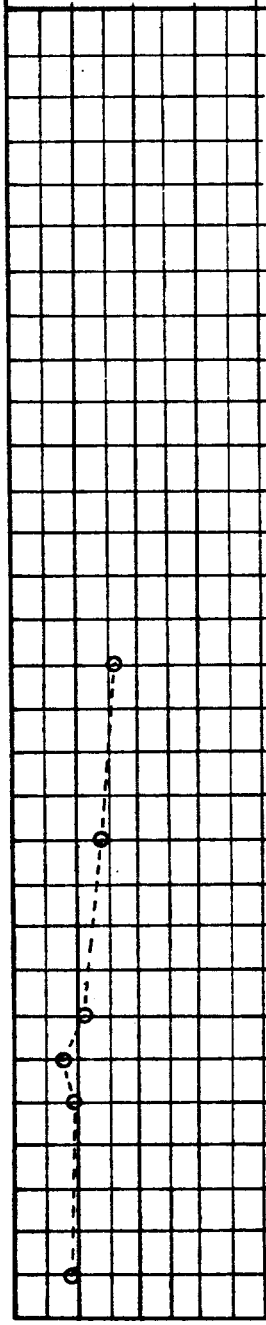
TEST HOLE LOG

R.M.HARDY & ASSOCIATES LTD.
CONSULTING ENGINEERING & TESTING

PROJECT: TAGLU GAS PLANT

TEST HOLE NO. H76-G13

LOGGED BY SGM	DRAWN BY BT	CHECKED RST	DATE February, 1976
RIG Heli Drill	METHOD Splitspoon	START January 17, 1976	FINISH
PROJECT NO. cs 3161	ELEVATION	AIR TEMPERATURE -20° C	



SOIL GROUP SYMBOL	DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %	LABORATORY TEST DATA	SAMPLE TYPE AND NUMBER	SAMPLE CONDITION	CORE RUN AND % RECOVERY	CORE CONDITION	REMARKS
	WATER		UF						
	estimated lake bottom								
ML	SILT trace of organics, stratified, medium grey, trace of sand			Gr. Size Plate E-38	S1	X	60%		
SM	SAND fine, silty, 1/2" layer of medium sand sizes				S2	X	70%		
ML	SILT medium grey								
SM	SAND fine, medium grey, silty --- silt lense --- trace of fine gravel			Gr. Size Plate E-39	S3	X	40%		
CI	CLAY medium - to low plastic, trace of fine sand, medium grey, stratified, sandy lenses to 1/2" thick, soft				S4	X	40%		
SM	SAND fine grained, silty				S5	X	60%		
CI	CLAY little fine sand (cont.)								

PLATE E-16

R.M.HARDY & ASSOCIATES LTD.
CONSULTING ENGINEERING & TESTING

TEST HOLE LOG

PROJECT: TAGLU GAS PLANT

TEST HOLE NO. H76-G13 (cont.)

LOGGED BY SGM	DRAWN BY BT	CHECKED RST	DATE February, 1976
RIG Heli Drill	METHOD Splitspoon	START January 17, 1976	FINISH
PROJECT NO. cs 3161	ELEVATION	AIR TEMPERATURE -20° C	

MOISTURE CONTENT (W_P-□ W-○ W_L-△) 20 40 60	DEPTH (feet)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %	LABORATORY TEST DATA	SAMPLE TYPE AND NUMBER	SAMPLE CONDITION	CORE RUN AND % RECOVERY	CORE CONDITION	REMARKS
		CI		CLAY little fine sand, medium plastic (cont.)		UF						
		SP		SAND fine to medium grained, trace of silt, grey								
	35							S6	X	50%		
								S7	X	50%		
	40			--- fine, grained, grey				S8	X	50%		
				Bottom of Hole at 41.5 Feet.								
	45											

PLATE E-17

TEST HOLE LOG

R.M.HARDY & ASSOCIATES LTD.
CONSULTING ENGINEERING & TESTING

PROJECT: TAGLU GAS PLANT

TEST HOLE NO. H76-G14

LOGGED BY DV	DRAWN BY BT	CHECKED RST	DATE February, 1976
RIG Heli Drill	METHOD	START January 18, 1976	FINISH
PROJECT NO. cs 3161	ELEVATION	AIR TEMPERATURE	

W_P-⊡ W-⊙ W_L-△ MOISTURE CONTENT 20 40 60	DEPTH (feet)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %	LABORATORY TEST DATA	SAMPLE TYPE AND NUMBER	SAMPLE CONDITION	CORE RUN AND % RECOVERY	CORE CONDITION	REMARKS
				ICE		ICE						
	5			WATER		UF						
	10											
	15	ML		SILT non plastic, trace of sand								
		CI		CLAY silty, medium plastic, medium grey				S1		100 %		
								U2		100 %		Piston samples
	20							U3		70%		Shelby tube
		SP		SAND medium grained, dark brown, little gravel to 3/4" dia., subrounded				S4		70%		
		ML		SILT sandy, grey, low plastic, trace of clay								
	25	SM		SAND some gravel, sub-angular to sub-rounded, light brown, fine to medium grained, silty			Gr. Size Plate E-40	S5		20%	IV	
	30											

PLATE E-18

R.M.HARDY & ASSOCIATES LTD.
CONSULTING ENGINEERING & TESTING

TEST HOLE LOG

PROJECT: TAGLU GAS PLANT

TEST HOLE NO. HZ6-G14 (cont.)

LOGGED BY	DRAWN BY	CHECKED	DATE
DV	BT	RST	February, 1976

RIG	METHOD	START	FINISH
Heli Drill		January 19, 1976	

PROJECT NO.	ELEVATION	AIR TEMPERATURE
cs 3161		

W_P-□ W-○ W_L-△ MOISTURE CONTENT 20 40 60	DEPTH (feet)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %	LABORATORY TEST DATA	SAMPLE TYPE AND NUMBER	SAMPLE CONDITION	CORE RUN AND % RECOVERY	CORE CONDITION	REMARKS
		SM		SAND (cont.)		UF						
				--- fine to medium, little gravel to 3/4" dia., trace of silt, brown				S6	X	67%		
	35	ML		SILT grey brown, some fine sand, slightly sensitive to shaking				S7	X	50%		
				--- sandy, little clay, layered				S8	X	100 %		
	40			Bottom of Hole at 40.5 Feet.								

PLATE E-19

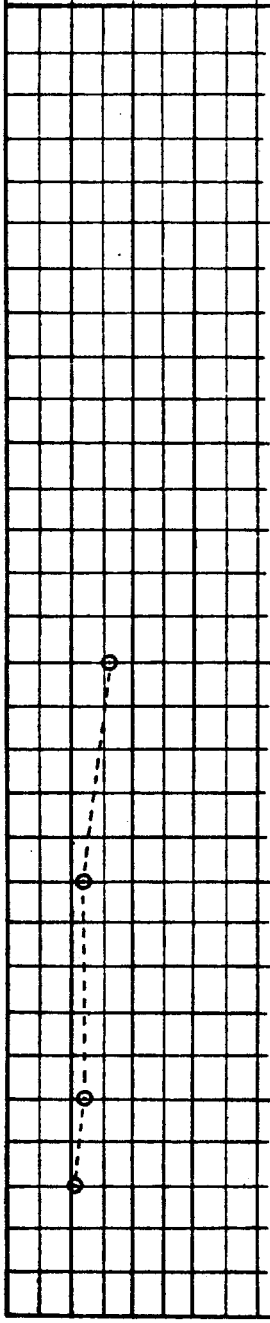
R.M.HARDY & ASSOCIATES LTD.
CONSULTING ENGINEERING & TESTING

TEST HOLE LOG

PROJECT: TAGLU GAS PLANT

TEST HOLE NO. HZ6-G15

LOGGED BY SGM	DRAWN BY BT	CHECKED RST	DATE February, 1976
RIG Heli Drill	METHOD Splitspoon	START January 18, 1976	FINISH
PROJECT NO. cs 3161	ELEVATION	AIR TEMPERATURE -25° C	



DEPTH (feet)	SOIL GROUP SYMBOL	DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %	LABORATORY TEST DATA	SAMPLE TYPE AND NUMBER	SAMPLE CONDITION	CORE RUN AND % RECOVERY	CORE CONDITION	REMARKS
		ICE		ICE						
5		WATER		UF						
10	OL	SILT organic, dense, grey, saturated								
15	ML	SILT trace of organics, medium brown, non plastic, wet				S1		100 %		
20		--- sandy, fine grained			Gr. Size Plate E-41	S2		100 %		
25	SM	SAND fine, grained, silty - gravel pieces				S3		60%		
30	CI	CLAY (till-like) trace of sand, occasional gravel sizes, stiff, medium plastic				S4		100 %		

PLATE E-20

R.M.HARDY & ASSOCIATES LTD.
CONSULTING ENGINEERING & TESTING

TEST HOLE LOG

PROJECT: TAGLU GAS PLANT

TEST HOLE NO. H76-G15 (cont.)

LOGGED BY SGM	DRAWN BY BT	CHECKED RST	DATE February, 1976
RIG Heli Drill	METHOD Splitspoon	START January 19, 1976	FINISH
PROJECT NO. cs 3161	ELEVATION	AIR TEMPERATURE -25° C	

W_P-⊡ W-⊙ W_L-△ MOISTURE CONTENT 20 40 60	DEPTH (feet)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %	LABORATORY TEST DATA	SAMPLE TYPE AND NUMBER	SAMPLE CONDITION	CORE RUN AND % RECOVERY	CORE CONDITION	REMARKS
⊖		CI		CLAY (till-like) medium-plastic, stiff, occasional gravel sizes		VF						
		SC		SAND fine-grained, clayey, dark grey				S5	X	50%		
	35			Bottom of Hole at 32.5 Feet.								

PLATE E-21

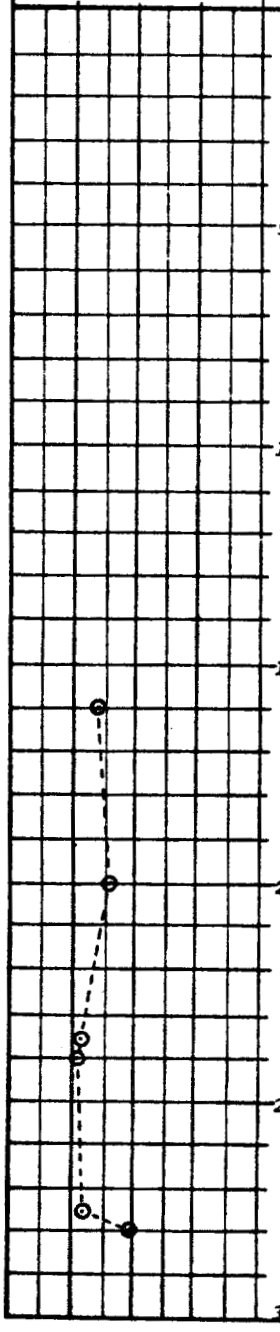
R.M.HARDY & ASSOCIATES LTD.
CONSULTING ENGINEERING & TESTING

TEST HOLE LOG

PROJECT: TAGLU GAS PLANT

TEST HOLE NO. H76-G16

LOGGED BY SGM	DRAWN BY BT	CHECKED RST	DATE February, 1976
RIG Heli Drill	METHOD	START January 18, 1976	FINISH
PROJECT NO. cs 3161	ELEVATION	AIR TEMPERATURE	



DEPTH (feet)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %	LABORATORY TEST DATA	SAMPLE TYPE AND NUMBER	SAMPLE CONDITION	CORE RUN AND % RECOVERY	CORE CONDITION	REMARKS
			ICE		ICE						
5			WATER		UF						
10											
	ML		SILT medium grey, slightly brownish, some clay, layered				S1		100 %		
15			--- layering inclined (55°), organic layers to 1/2" thick, stratified				S2		100 %		
20			--- sandy				S3		70%		
	SM		SAND fine grained, silty, grey				S4		30%		
25			--- occasional gravel sizes			Grain Size Plate E-42	S4A		100%		
30											

PLATE E-22

R.M.HARDY & ASSOCIATES LTD.
CONSULTING ENGINEERING & TESTING

TEST HOLE LOG

PROJECT: TAGLU GAS PLANT

TEST HOLE NO. H76-G16 (cont.)

LOGGED BY SGM	DRAWN BY BT	CHECKED RST	DATE February, 1976
RIG Heli Drill	METHOD	START January 18, 1976	FINISH
PROJECT NO. cs 3161	ELEVATION	AIR TEMPERATURE	

W_P-⊡ W-○ W_L-△ MOISTURE CONTENT 20 40 60	DEPTH (feet)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %	LABORATORY TEST DATA	SAMPLE TYPE AND NUMBER	SAMPLE CONDITION	CORE RUN AND % RECOVERY	CORE CONDITION	REMARKS
		SP		SAND fine grained, occasional gravel size (cont.)		UF						
		CI CH		CLAY medium to high plastic, dark grey, silty, layered				S5	X	100 %		
⊙	35			--- high to medium plastic, dark grey				S6	X	50%		
				Bottom of Hole at 36.5 Feet.								
	40											

PLATE E-23

R.M. HARDY & ASSOCIATES LTD.
CONSULTING ENGINEERING & TESTING

GRAIN SIZE CURVE

LAB ORDER NO.	CS3161
CLIENT	Taglu Gas Plant
SAMPLE	S2
SOURCE	Hole H76-G-2 @ 12.5-14.0'
TECHNICIAN	CS
DATE TESTED	Apr.76

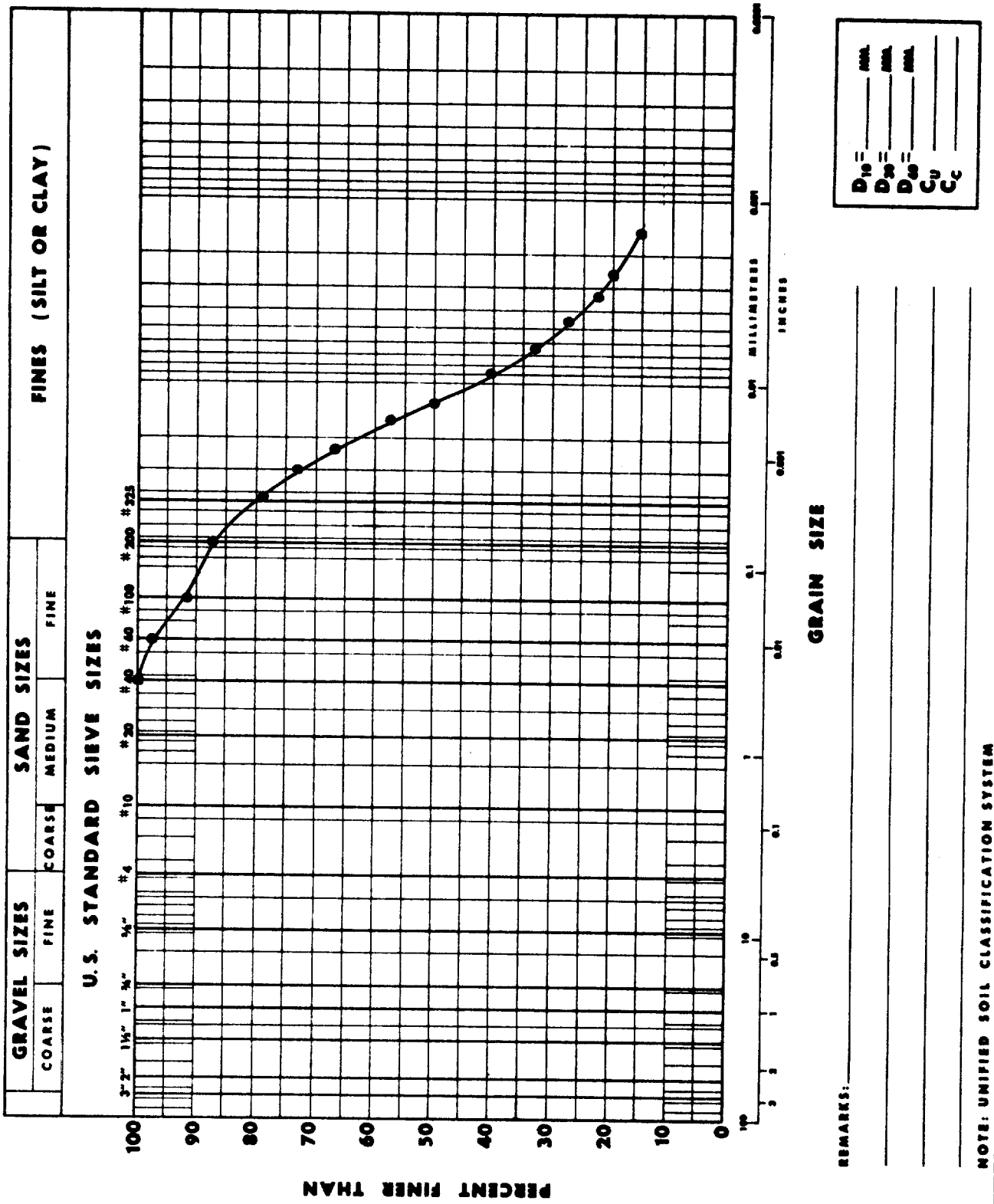
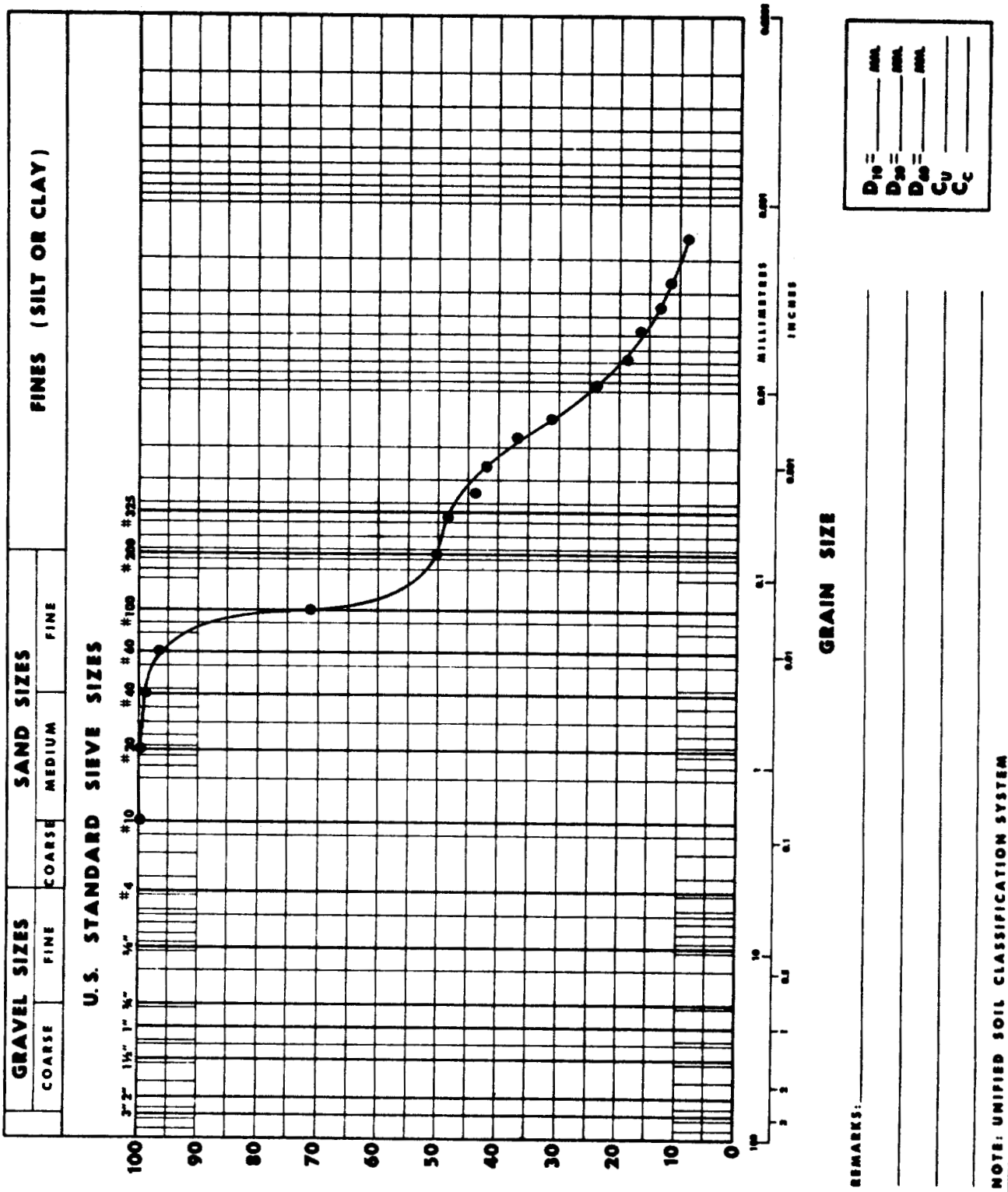


PLATE E-24

R.M. HARDY & ASSOCIATES LTD.
CONSULTING ENGINEERING & TESTING

GRAIN SIZE CURVE

LAB ORDER NO.	CS3161
CLIENT	Taglu Gas Plant
SAMPLE	S3
SOURCE	
	Hole H76 G2 @15.5-17.0'
TECHNICIAN	CS
DATE TESTED	Apr.76



REMARKS:

NOTE: UNIFIED SOIL CLASSIFICATION SYSTEM

PLATE E-25

R.M.HARDY & ASSOCIATES LTD.
CONSULTING ENGINEERING & TESTING

GRAIN SIZE CURVE

LAB ORDER NO.	CS3161
CLIENT	Taglu Gas Plant
SAMPLE	C1
SOURCE	
HOLE	H76 G3 @ 4-5'
TECHNICIAN	CS
DATE TESTED	Apr.76

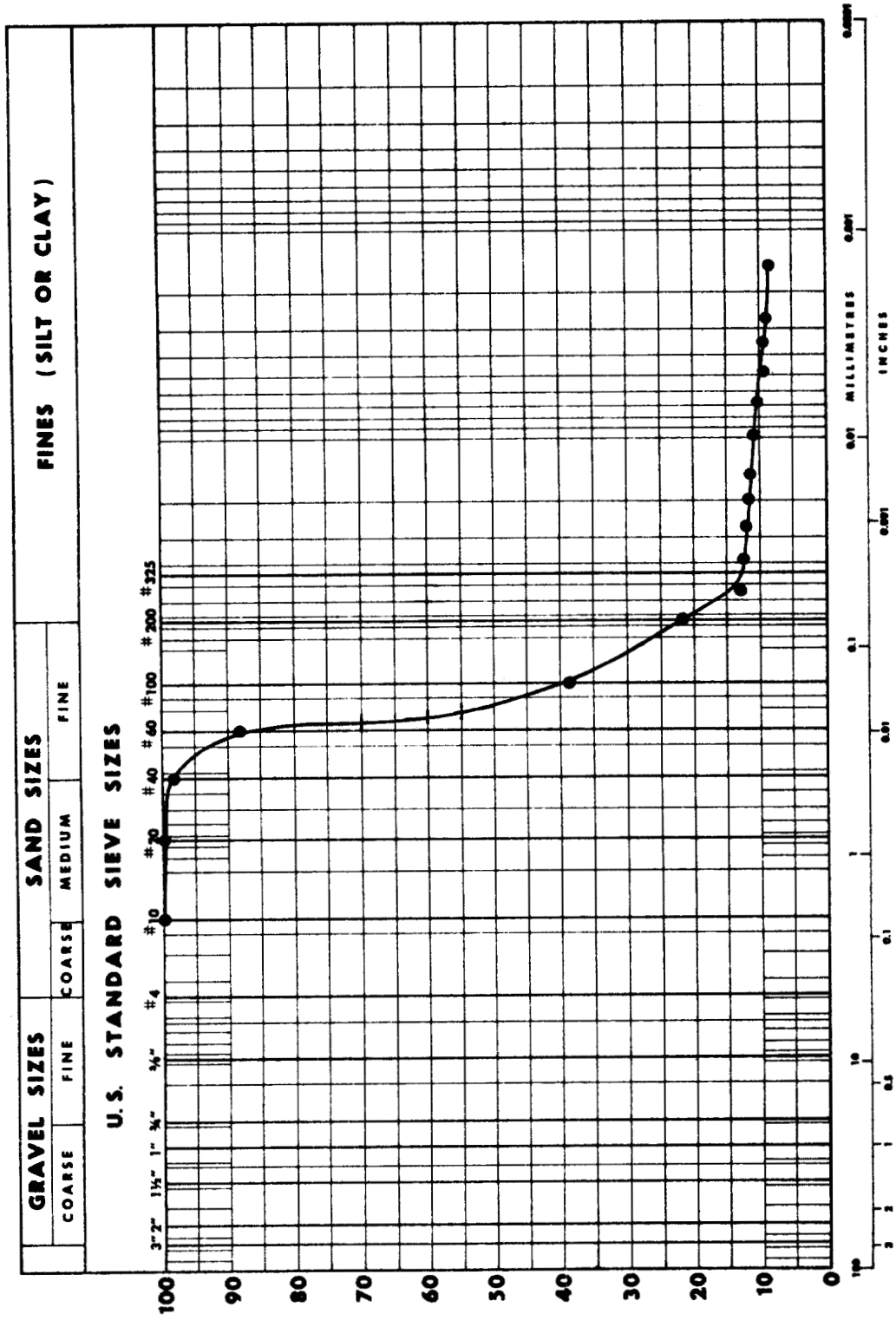


PLATE E-26

R.M. HARDY & ASSOCIATES LTD.
CONSULTING ENGINEERING & TESTING

GRAIN SIZE CURVE

LAB ORDER NO.	CS3161
CLIENT	Taglu Gas Plant
SAMPLE	C11
SOURCE	Hole H76G-3A @ 19-20'
TECHNICIAN	CS
DATE TESTED	Apr.76

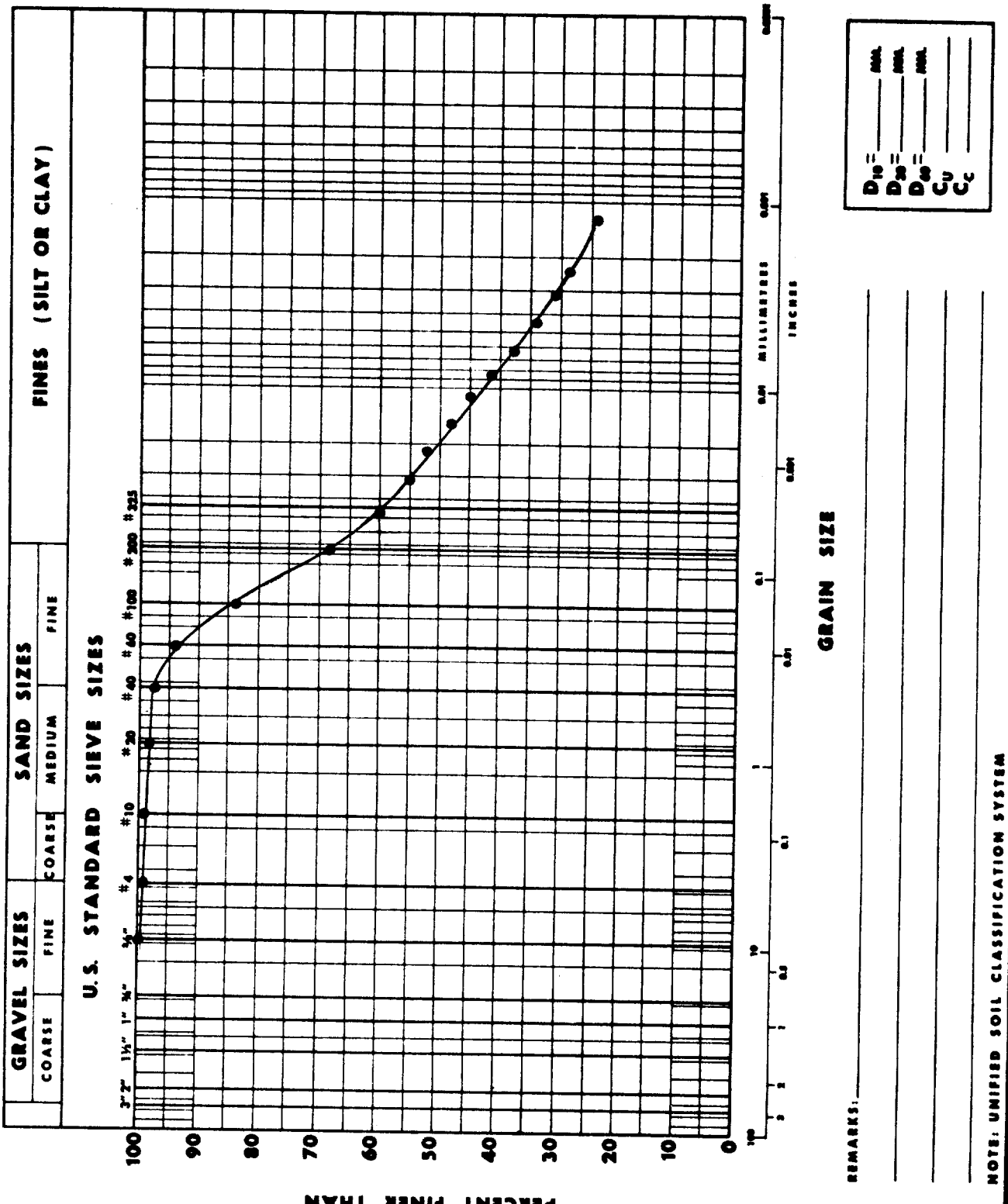


PLATE E-27

R.M.HARDY & ASSOCIATES LTD.
CONSULTING ENGINEERING & TESTING

GRAIN SIZE CURVE

LAB ORDER NO.	CS3161
CLIENT	Taglu Gas Plant
SAMPLE	S2
SOURCE	
	Hole H76-G5 @ 13.5-15.0'
TECHNICIAN CS	DATE TESTED Apr.76

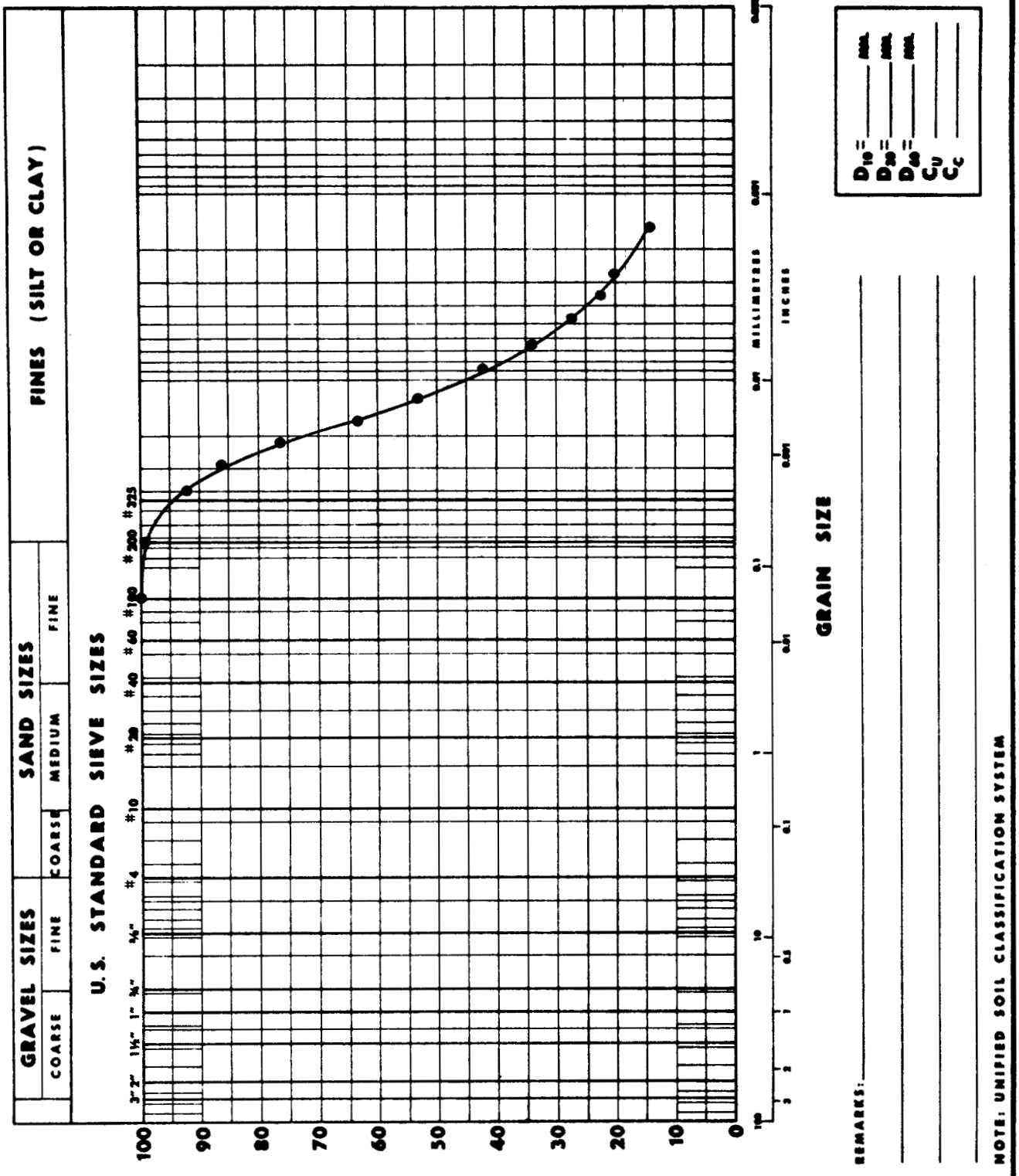


PLATE E-28

R.M.HARDY & ASSOCIATES LTD.
CONSULTING ENGINEERING & TESTING

GRAIN SIZE CURVE

LAB ORDER NO.	CS3161
CLIENT	Taglu Gas Plant
SAMPLE	S6
SOURCE	
	Hole H76-G5 @ 29.5-31.0'
TECHNICIAN CS	DATE TESTED Apr.76

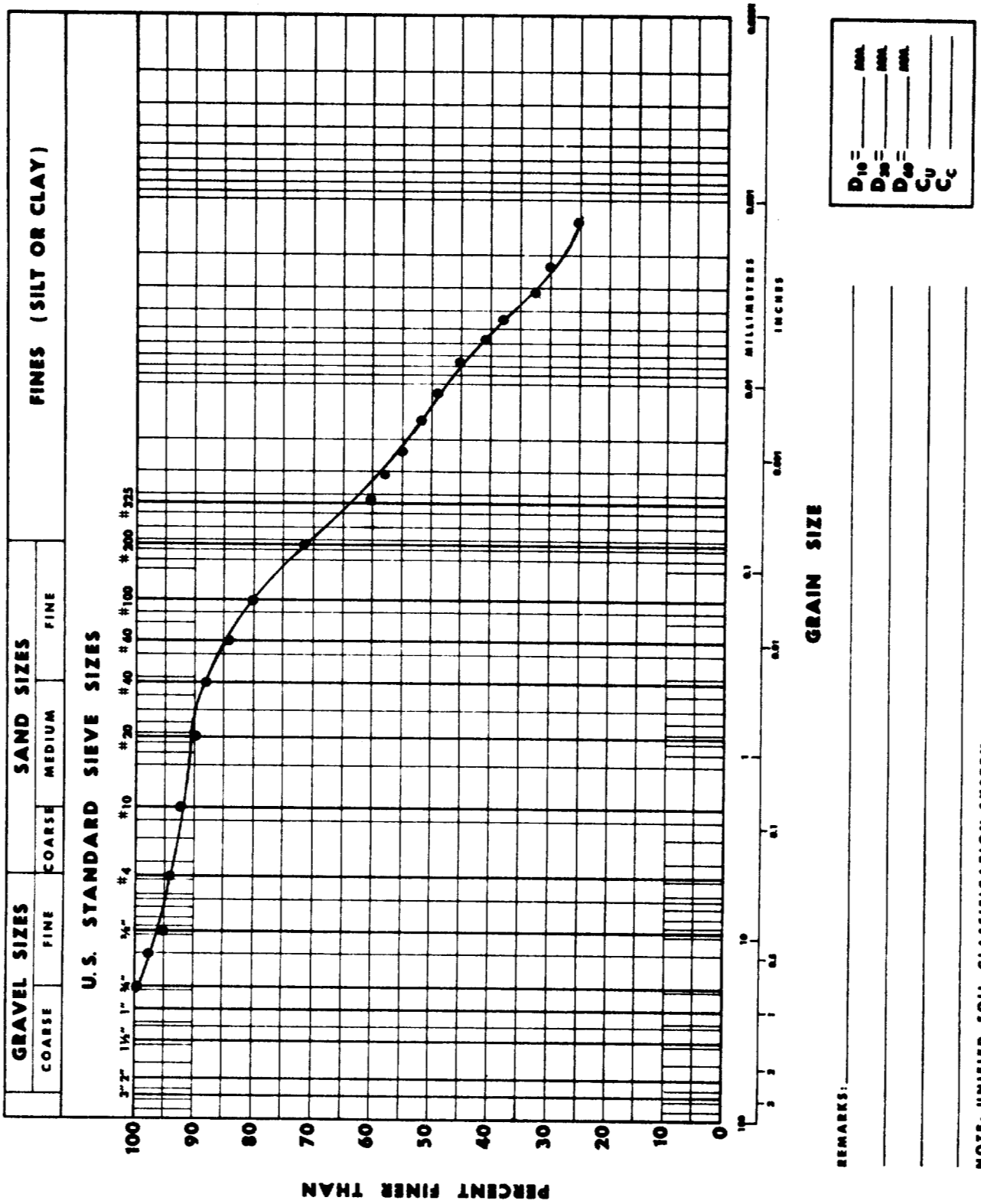


PLATE E-29

R.M.HARDY & ASSOCIATES LTD.
CONSULTING ENGINEERING & TESTING

GRAIN SIZE CURVE

LAB ORDER NO.	CS 3161
CLIENT	Taglu Gas Plant
SAMPLE	S 2
SOURCE	
HOLE	H76-G9 @ 15-16'
DATE REC'D.	
TECHNICIAN	
DATE TESTED	Jan/76

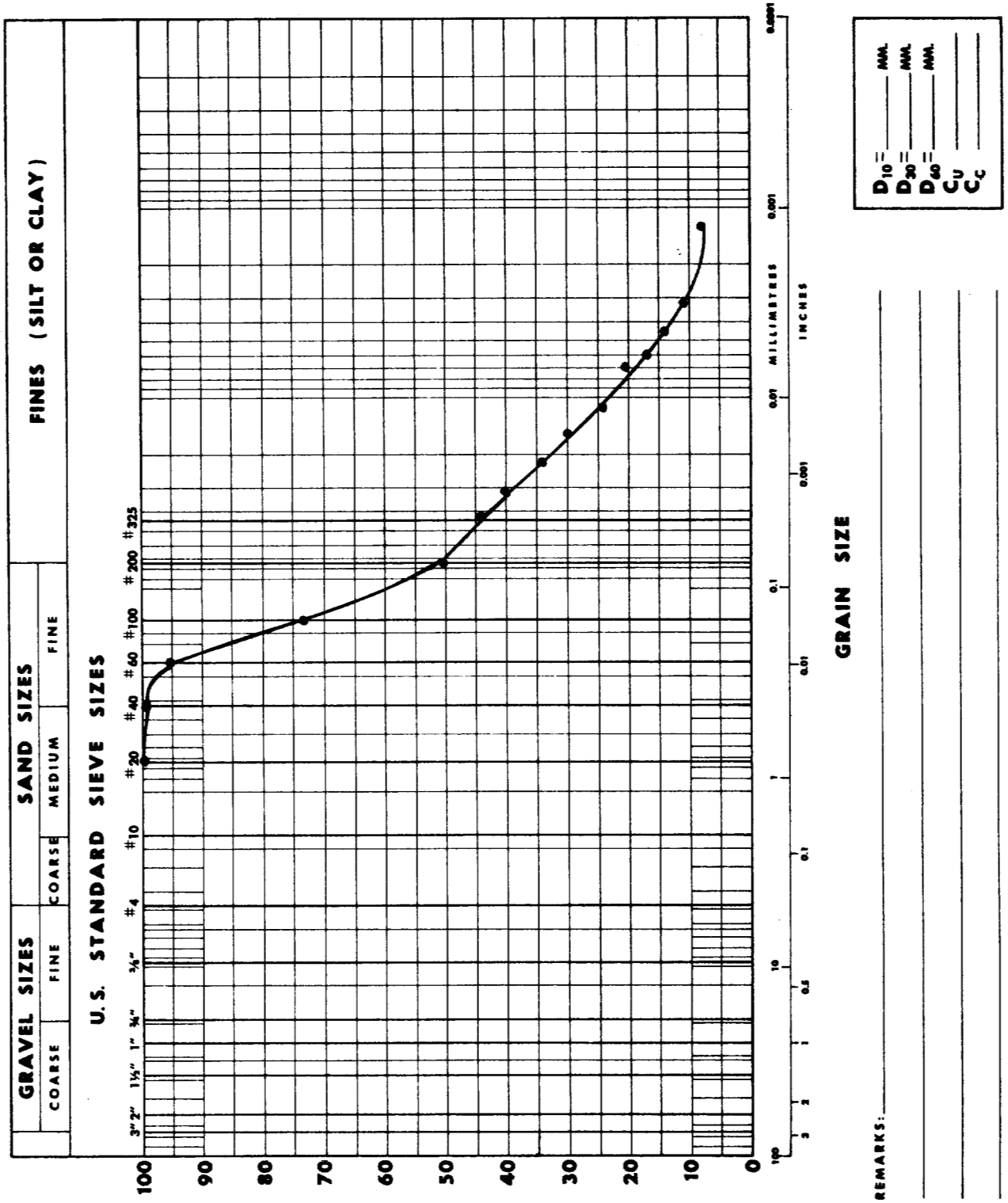


PLATE E-30

R.M.HARDY & ASSOCIATES LTD.
CONSULTING ENGINEERING & TESTING

GRAIN SIZE CURVE

LAB ORDER NO.	CS 3161
CLIENT	Taglu Gas Plant
SAMPLE	S 3
SOURCE	
HOLE	H76-G9 @ 19-20' DATE REC'D.
TECHNICIAN	DATE TESTED Jan/76

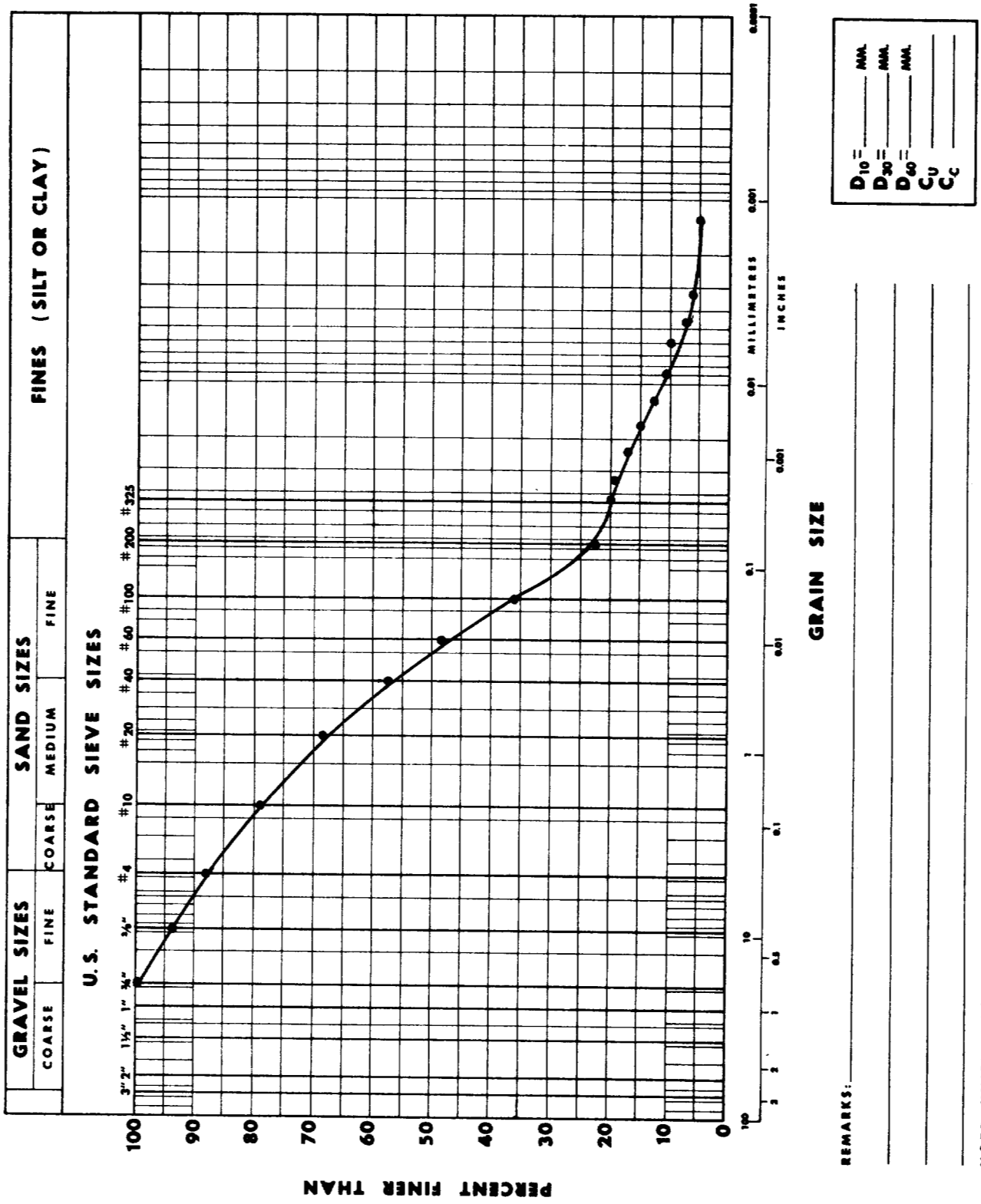


PLATE E-31

R.M.HARDY & ASSOCIATES LTD.
CONSULTING ENGINEERING & TESTING

GRAIN SIZE CURVE

LAB ORDER NO.	CS 3161
CLIENT	Taglu Gas Plant
SAMPLE	S 5
SOURCE	
HOLE	H76-G9 @ 22-25' DATE REC'D.
TECHNICIAN	DATE TESTED

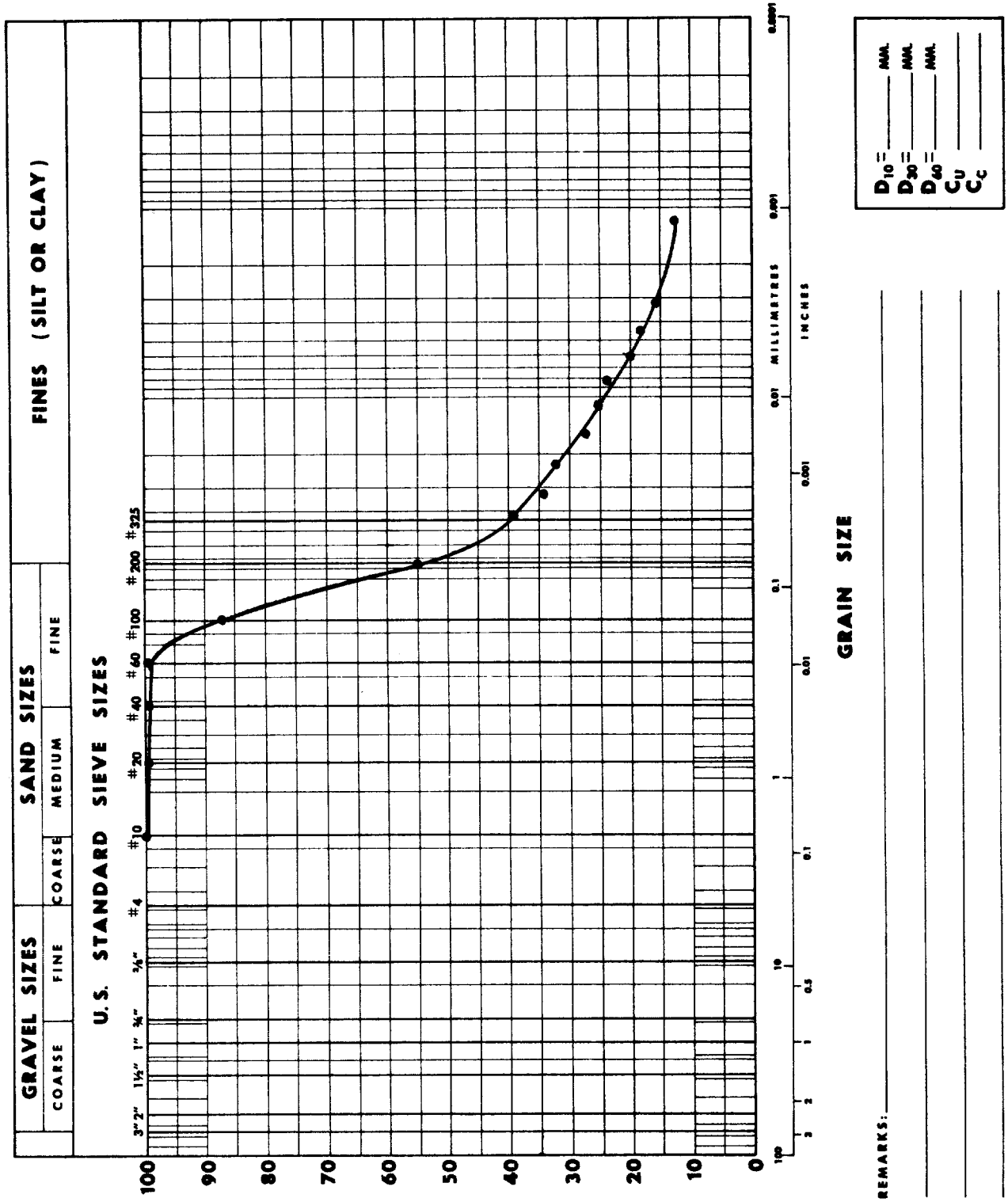


PLATE E-32

R.M.HARDY & ASSOCIATES LTD.
CONSULTING ENGINEERING & TESTING

GRAIN SIZE CURVE

LAB ORDER NO.	CS 3161
CLIENT	Taglu Gas Plant
SAMPLE	S 6
SOURCE	
HOLE	H76-G9 @ 28-30' DATE REC'D.
TECHNICIAN	DATE TESTED Jan/76

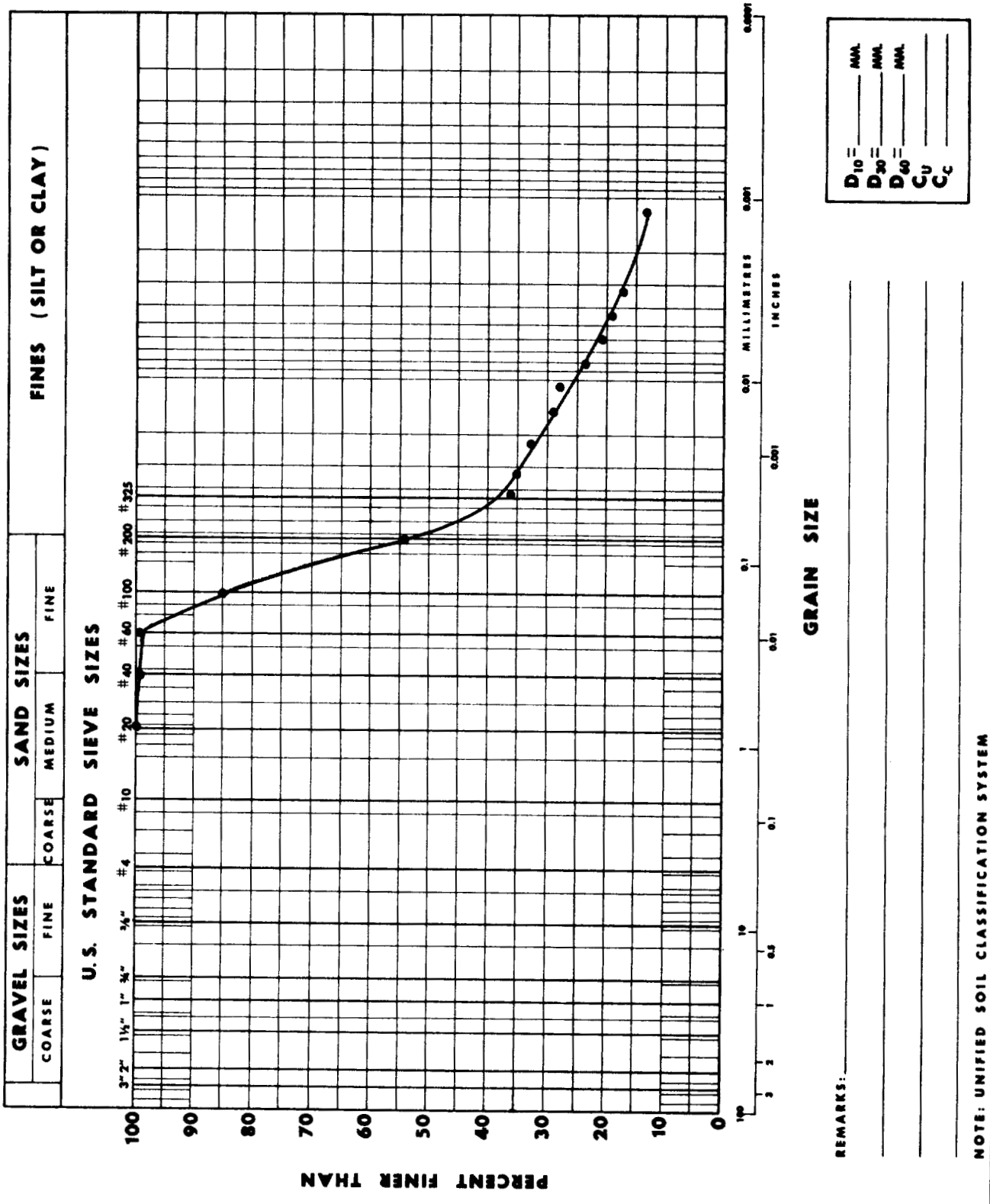


PLATE E-33

R.M.HARDY & ASSOCIATES LTD.
CONSULTING ENGINEERING & TESTING

GRAIN SIZE CURVE

LAB ORDER NO.	CS 3161
CLIENT	Taglu Gas Plant
SAMPLE	S 1
SOURCE	
HOLE	H76-G9A @ 19-19.9'
TECHNICIAN	DATE TESTED Jan/76

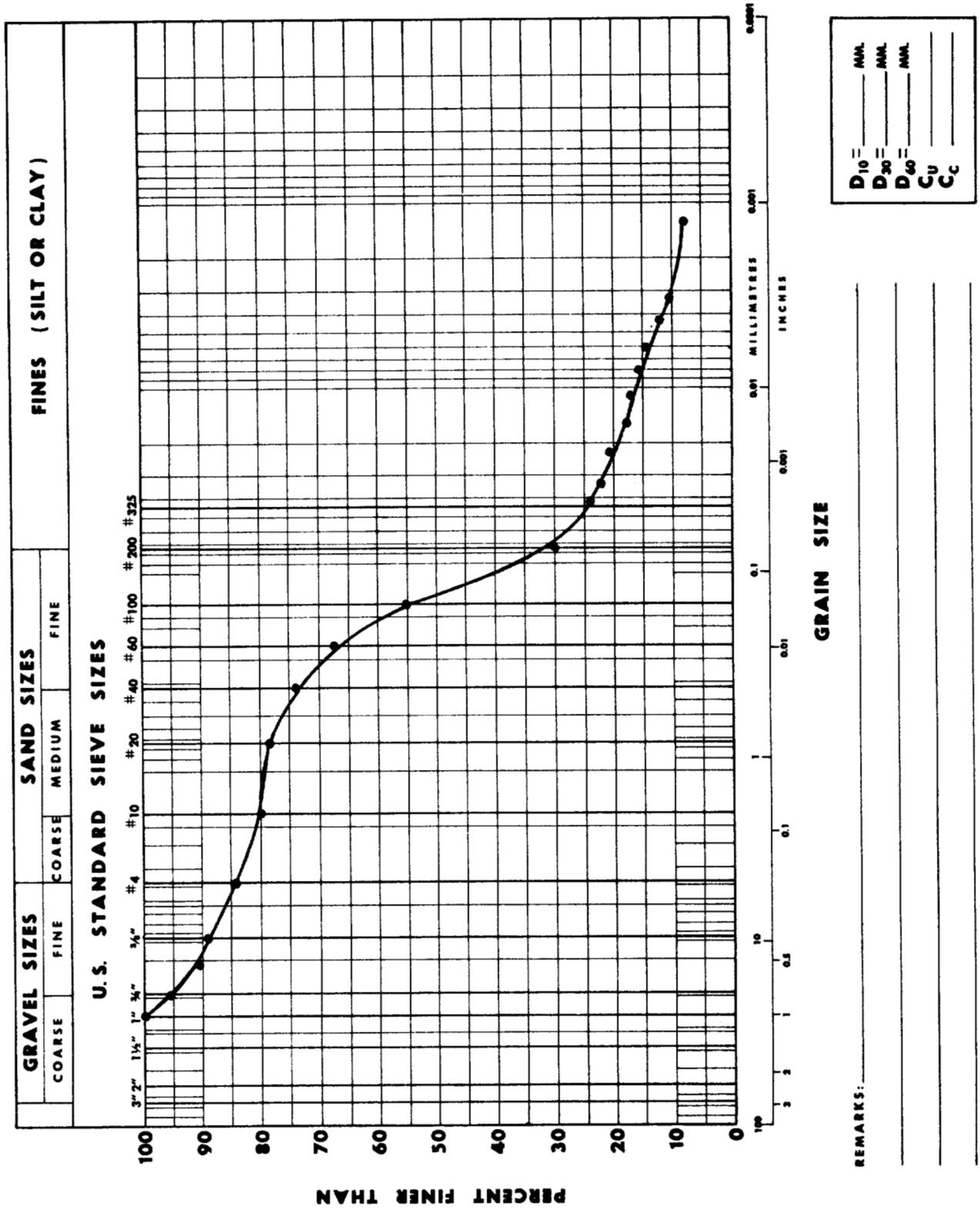
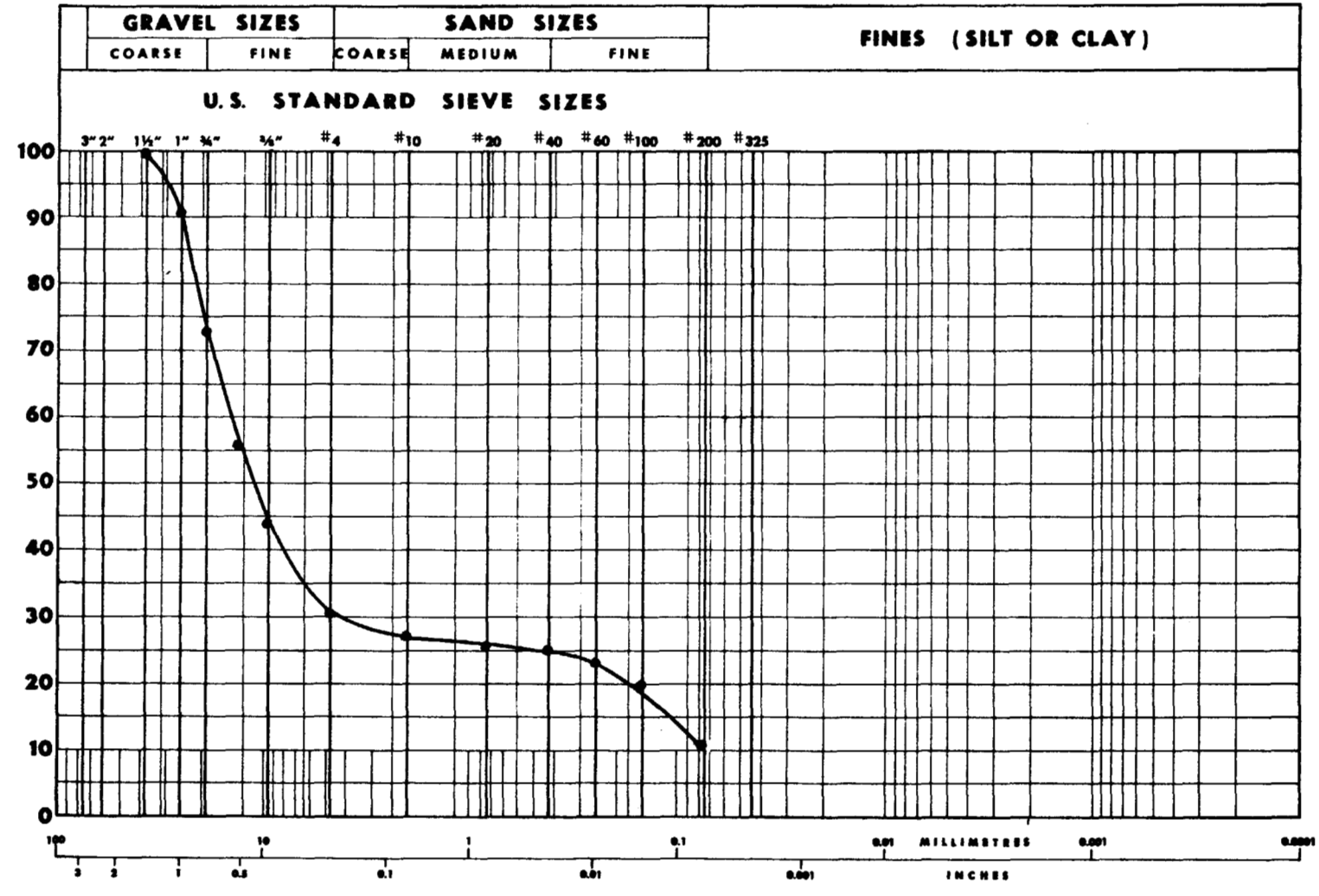


PLATE E-34

R.M.HARDY & ASSOCIATES LTD.
CONSULTING ENGINEERING & TESTING

GRAIN SIZE CURVE

LAB ORDER NO. CS 3161
CLIENT Taglu Gas Plant
SAMPLE S3 Top
SOURCE H76G-10
HOLE 10 DEPTH 18-20' DATE REC'D.
TECHNICIAN DATE TESTED



REMARKS: _____

D_{10} = _____ MM.
D_{30} = _____ MM.
D_{60} = _____ MM.
C_U = _____
C_C = _____

NOTE: UNIFIED SOIL CLASSIFICATION SYSTEM

PLATE E-35

R.M.HARDY & ASSOCIATES LTD.
CONSULTING ENGINEERING & TESTING

GRAIN SIZE CURVE

LAB ORDER NO.	CS 3161
CLIENT	Taglu Gas Plant
SAMPLE	S3
SOURCE	H76G-10
HOLE 10	DEPTH 19-20' DATE REC'D.
TECHNICIAN	DATE TESTED

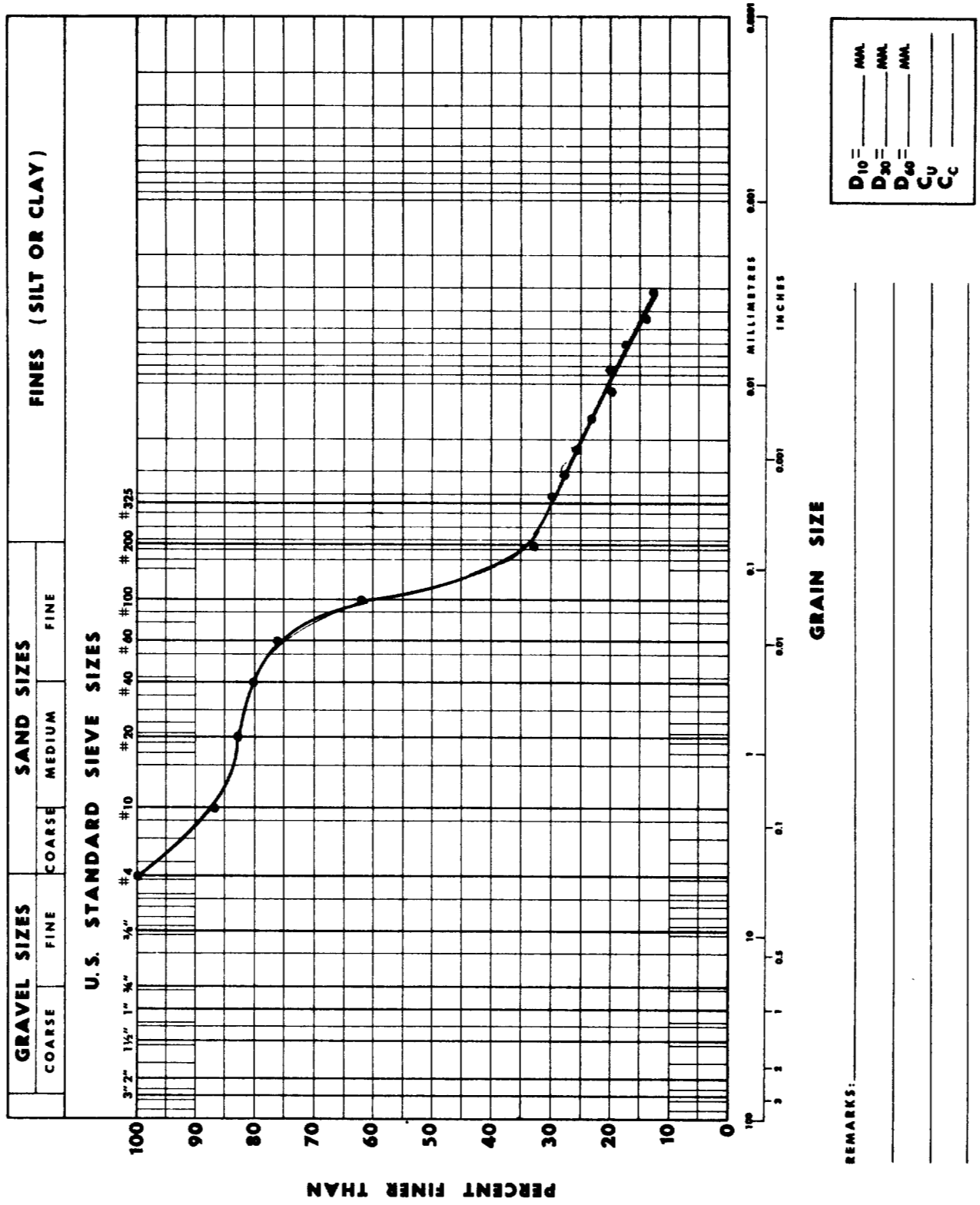


PLATE E-36

R.M.HARDY & ASSOCIATES LTD.
CONSULTING ENGINEERING & TESTING

GRAIN SIZE CURVE

LAB ORDER NO.	CS 3161
CLIENT	Taqlu Gas Plant
SAMPLE	S 1
SOURCE	
HOLE	H76-G-12 at 13'-14.5'
TECHNICIAN	MS
DATE TESTED	Feb/76

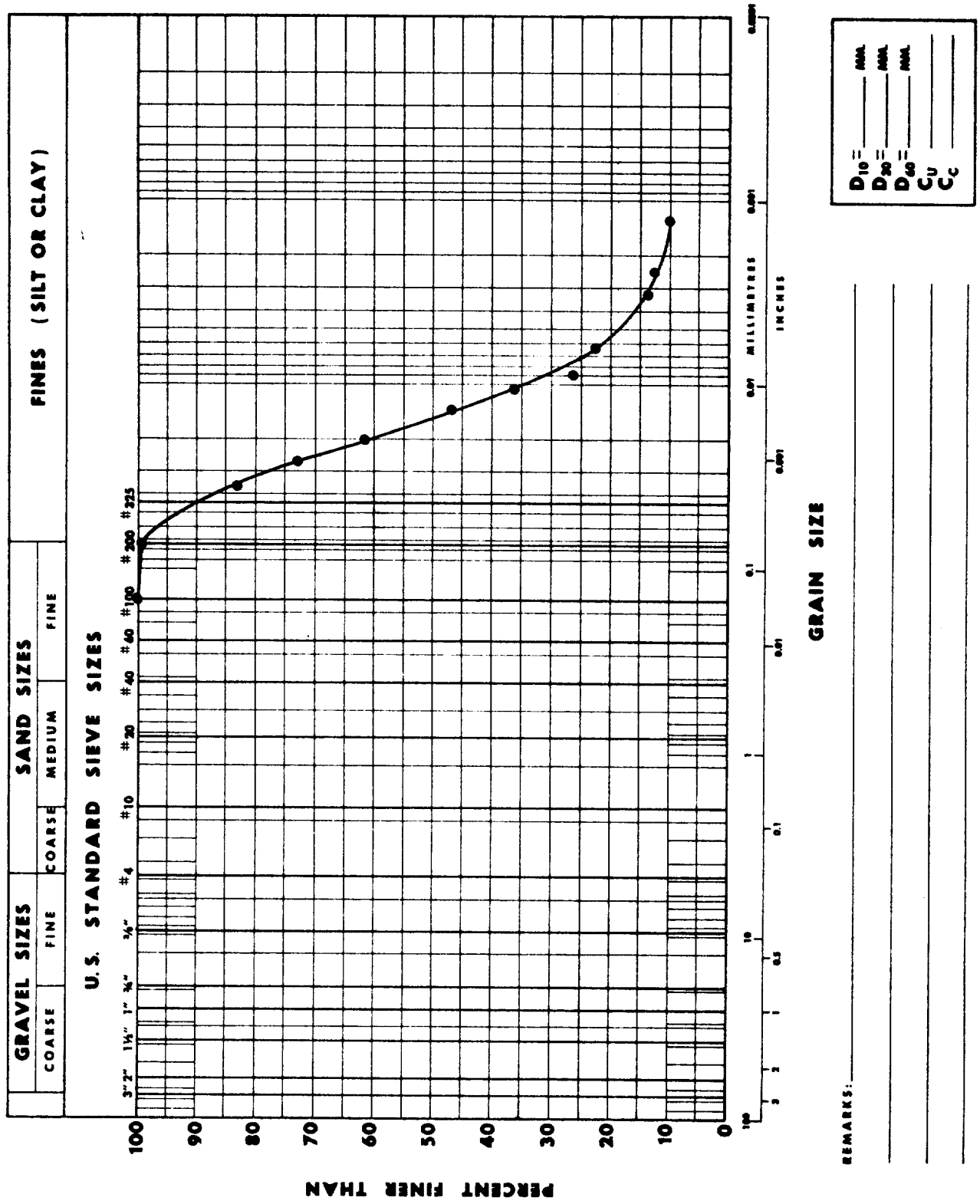


PLATE E-37

R.M.HARDY & ASSOCIATES LTD.
CONSULTING ENGINEERING & TESTING

GRAIN SIZE CURVE

LAB ORDER NO.	CS 3161
CLIENT	Taglu Gas Plant
SAMPLE	S 1
SOURCE	
HOLE	H76-G-13 at 14'-14.5'
TECHNICIAN	MS DATE TESTED Feb/76

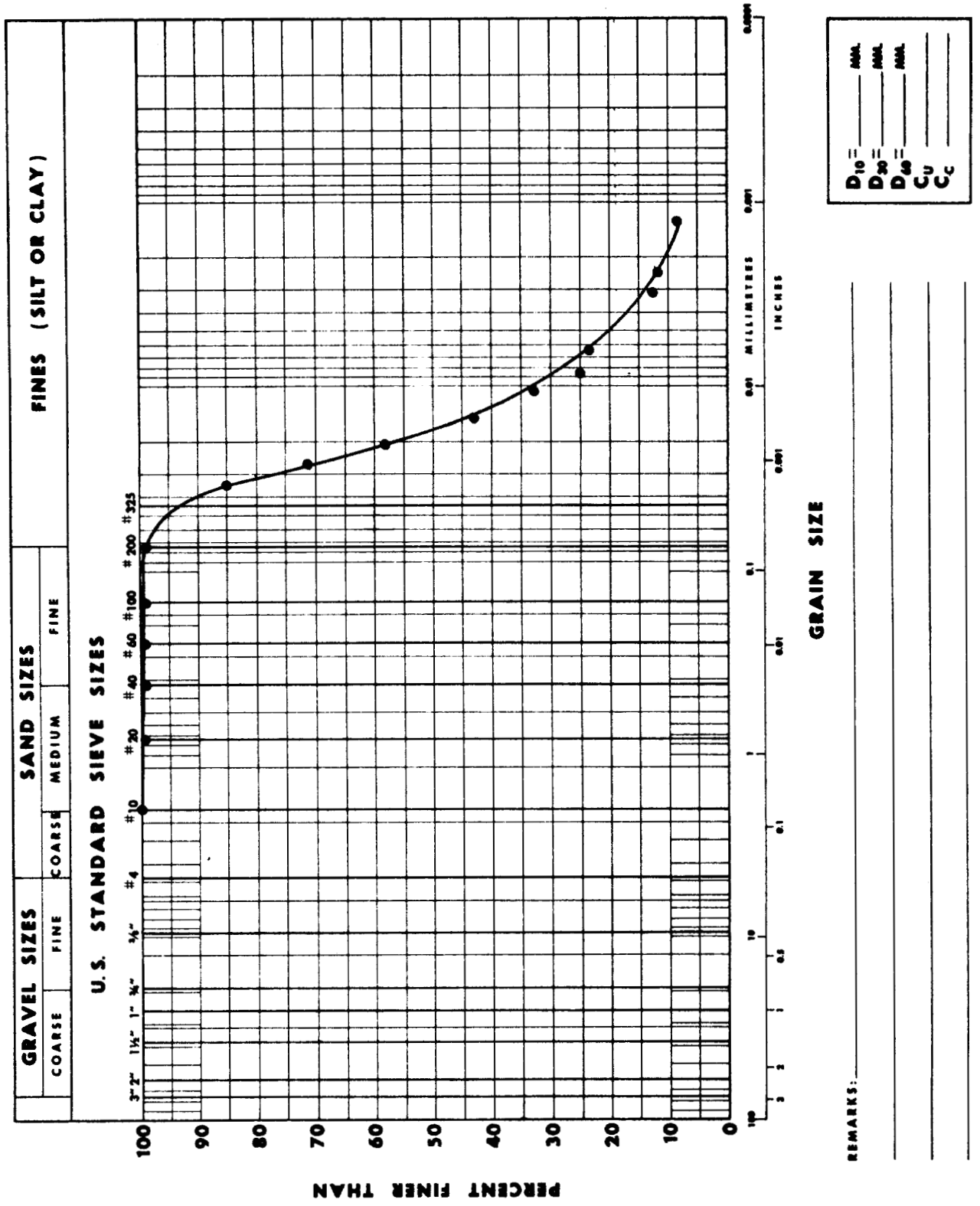


PLATE E-38

R.M.HARDY & ASSOCIATES LTD.
CONSULTING ENGINEERING & TESTING

GRAIN SIZE CURVE

LAB ORDER NO.	CS 3161
CLIENT	Taglu Gas Plant
SAMPLE	S 3
SOURCE	
HOLE	H76-G-13 at 22'-23.5'
TECHNICIAN	MS
DATE TESTED	Feb/76

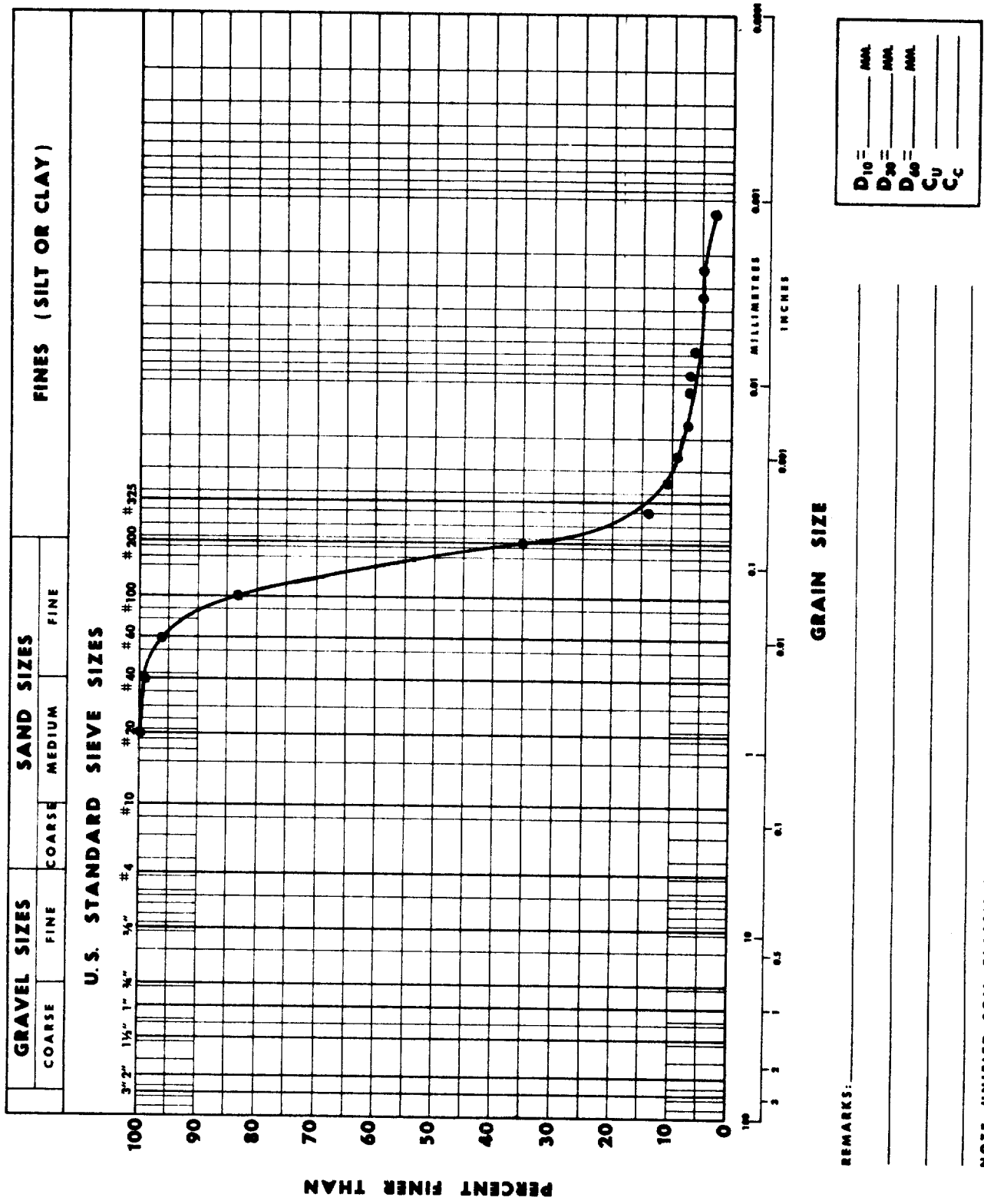


PLATE E-39

R.M.HARDY & ASSOCIATES LTD.
CONSULTING ENGINEERING & TESTING

GRAIN SIZE CURVE

LAB ORDER NO.	CS 3161
CLIENT	Taglu Gas Plant
SAMPLE	S 5
SOURCE	
HOLE	H76 - G 14 at 25'-26.5'
TECHNICIAN	MS DATE TESTED Feb/76

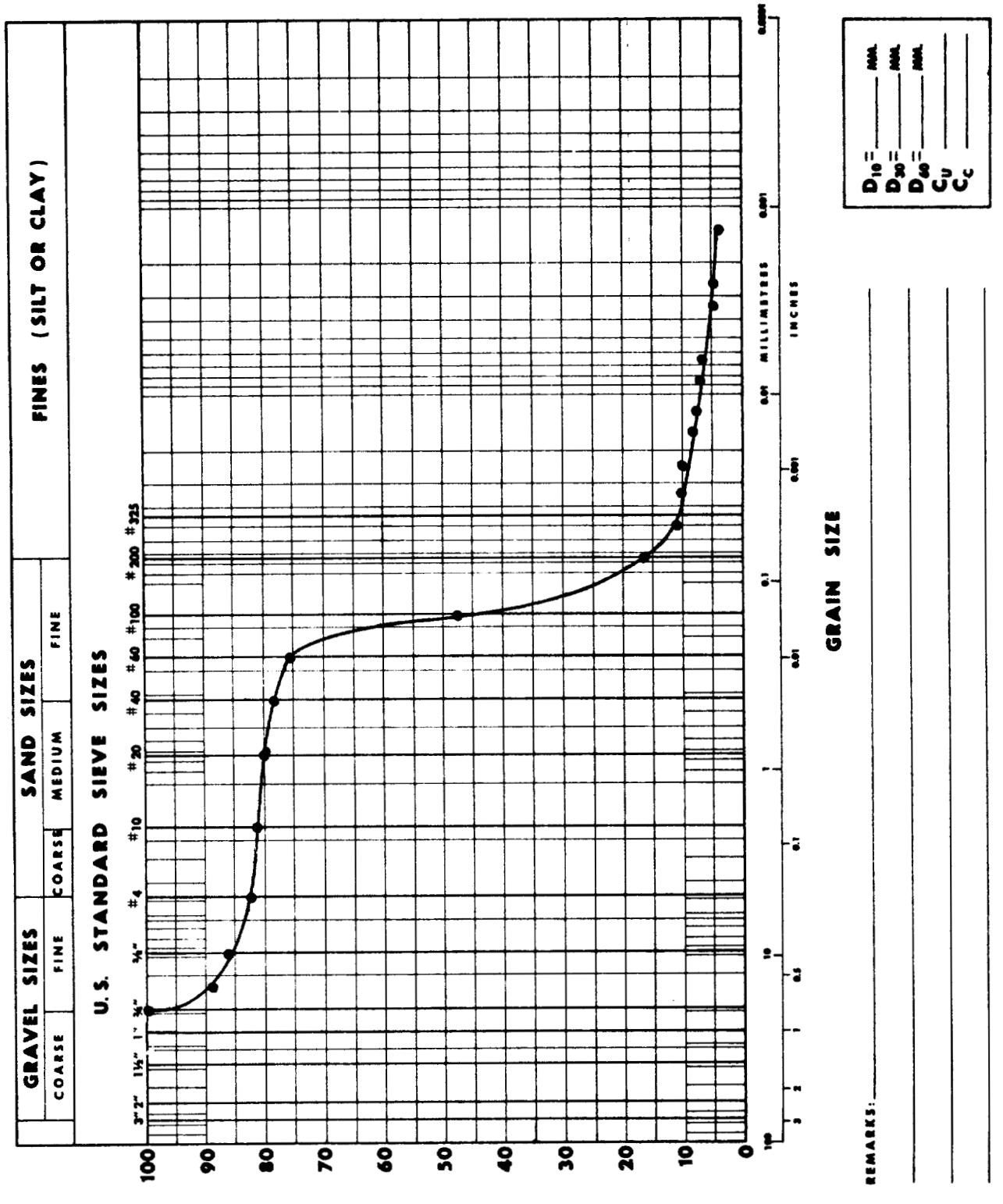
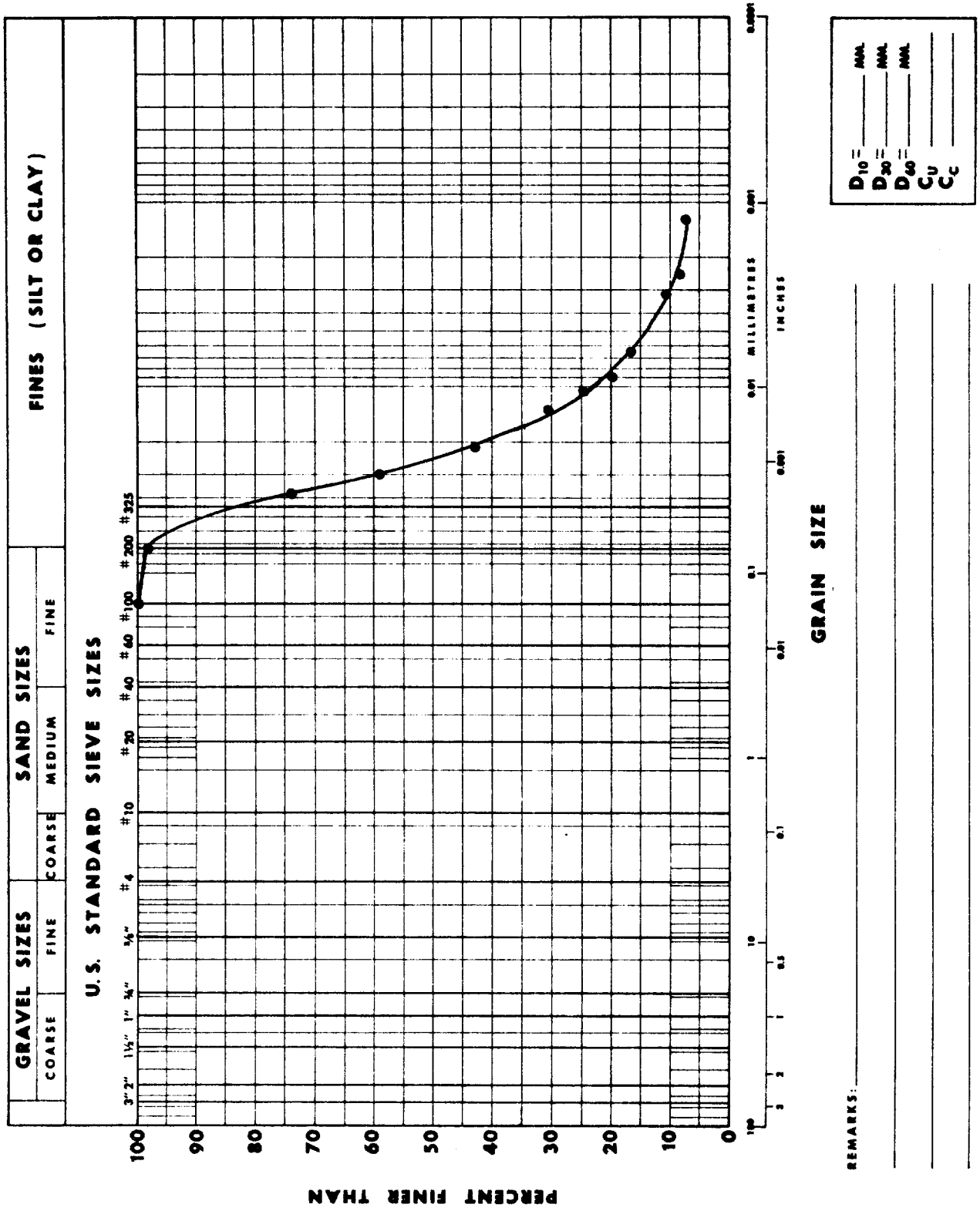


PLATE E-40

R.M.HARDY & ASSOCIATES LTD.
CONSULTING ENGINEERING & TESTING

GRAIN SIZE CURVE

LAB ORDER NO.	CS 3161
CLIENT	Taglu Gas Plant
SAMPLE	S 2
SOURCE	
HOLE	H76-G-15 at 19'-20.5'
TECHNICIAN	MS DATE TESTED Feb/76



REMARKS:

NOTE: UNIFIED SOIL CLASSIFICATION SYSTEM

PLATE E-41

R.M.HARDY & ASSOCIATES LTD.
CONSULTING ENGINEERING & TESTING

GRAIN SIZE CURVE

LAB ORDER NO.	CS 3161
CLIENT	Taglu Gas Plant
SAMPLE	S 4A
SOURCE	
HOLE	H76-G 16. at 28'-30.0'
TECHNICIAN	MS DATE TESTED Feb/76

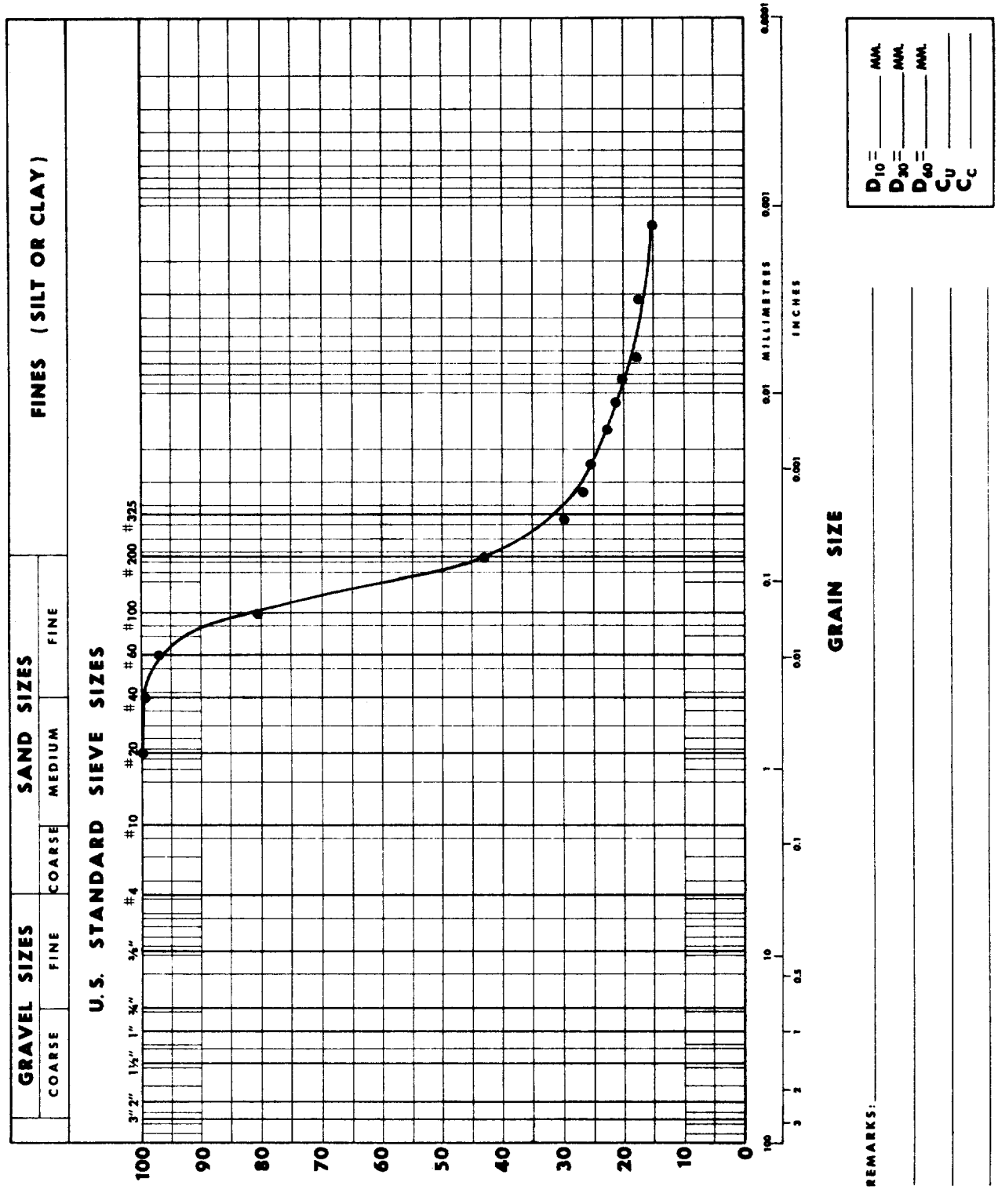


PLATE E-42

R.M. HARDY & ASSOCIATES LTD.
CONSULTING ENGINEERING & PROFESSIONAL SERVICES

SUMMARY OF LABORATORY TESTING

PROJECT Taglu Gas Plant
LOCATION Alternate Borrow Area
DATE January, 1976
JOB NO. CS3161

SAMPLE DATA					CLASSIFICATION TESTS						OTHER TESTS			
					ATTERBERG LIMITS			TEXTURE (%)						
TEST HOLE	DEPTH (ft)	SAMPLE NO	CLASSIFICATION	SOIL DESCRIPTION	LIQUID	PLASTIC	PLASTICITY INDEX	SAND	SILT	CLAY	WET DENSITY (PCF)	DRY DENSITY (PCF)	MOISTURE CONTENT (%)	
H76-G2	12.5 14	S2	ML	SILT,clayey,greyish brown, non to very low plastic,very soft, slight dilatancy				13	69	18				
H76-G2	15.5 17	S3	SM	SAND,fine grained, silty,brown, non plastic,medium dense,wet				50	40	10				
H76-G3	4-5	C1	SM	SAND, fine grained, silty,light grey				78	14	8				
H76-G3A	19-20	C11	CI	CLAY , silty, sandy layer,medium plastic,occasional gravel sizes to ¼" diameter				32	41	27				
H76-G5	13.5 15.0	S2	ML	SILT,fine sand, brown,soft,non plastic,highly plastic clay layer interbedded,wet				2	81	17				
H76-G5	29.5 31	S6	CI	CLAY(till-like),silty,trace of sand,brown,occasional gravel sizes to 3/8" Ø,med.plastic,stiff to very stiff				28	44	28				
H76-G9	15-16	S2	SM	SAND,fine grained, silty,grey				50	42	8				
H76-G9	19-20	S3	SW	SAND, fine to coarse, very silty,				77	18	5				
H76-G9	22-25	S5	SM	SAND,fine grained,very silty, clayey, layered				45	42	13				
H76-G9	28-30	S6	SM	SAND, fine grained, very silty, clayey, layered				46	39	15				
H76-G9A	19-19.9	S1	SM	SAND, fine grained, silty,wet occasional gravel sizes to 1" diameter				70	22	8				
H76-10	18-19	S3	GW	GRAVEL, well graded, sandy, little silt,gravel sizes to 1½" diameter				89	11					70% Gravel sizes 19% Sand 11% Silt
H76-G10	19-20	S3	SM	SAND, fine to coarse,silty, clayey				67	20	13				
H76-G12	13-14.5	S1	ML	SILT,clayey,trace sand,layered				1	87	11				
H76-G13	14-14.5	S1	ML	SILT,clayey,trace sand,layered				2	87	11				

PLATE E-43

R.M. HARDY & ASSOCIATES LTD.
CONSULTING ENGINEERING & PROFESSIONAL SERVICES

SUMMARY OF LABORATORY TESTING

PROJECT: Taglu Gas Plant
LOCATION: Alternate Borrow Area
DATE: January, 1976
JOB NO.: CS3161

SAMPLE DATA					CLASSIFICATION TESTS						OTHER TESTS			
					ATTERBERG LIMITS			TEXTURE (%)						
TEST HOLE	DEPTH (ft)	SAMPLE NO	CLASSIFICATION	SOIL DESCRIPTION	LIQUID	PLASTIC	PLASTICITY INDEX	SAND	SILT	CLAY	WET DENSITY (PCF)	DRY DENSITY (PCF)	MOISTURE CONTENT (%)	
H76-G13	22-23.5	S3	SM	SAND, fine grained, very silty, layered				65	31	4				
H76-G14	25-26.5	S5	SM	SAND, fine grained, gravelly, silty gravel sizes to 3/4" diameter				83	13	4				
H76-G15	19-20.5	S2	ML	SILT, clayey, trace sand				2	90	8				
H76-G16	28-30	S4A	SM	SAND, fine grained, silty, clayey grey				57	27	16				

PLATE E-44

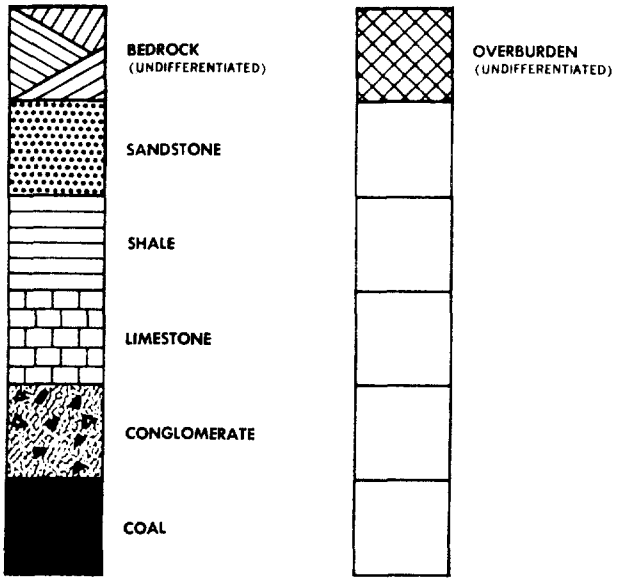
APPENDIX F

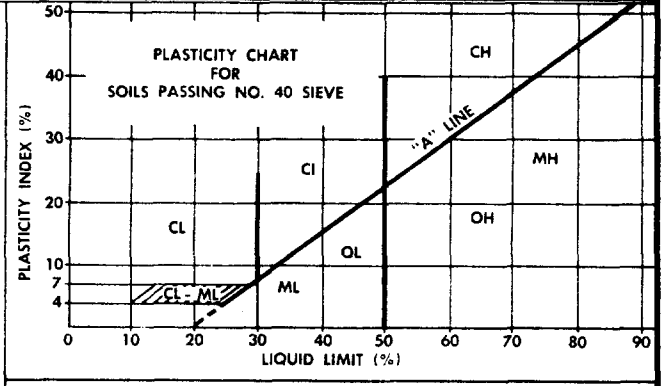
SOIL AND ICE CLASSIFICATION SYSTEMS

MODIFIED UNIFIED CLASSIFICATION SYSTEM FOR SOILS

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

SPECIAL SYMBOLS





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

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Figure F.1

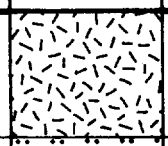
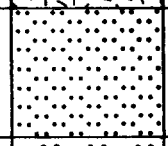
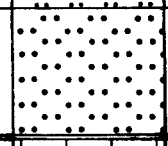
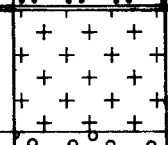
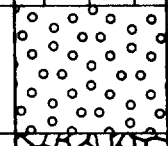
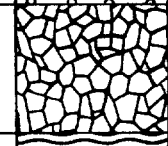
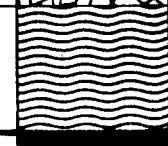
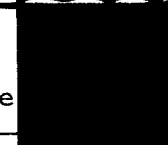
CATEGORY	GROUP SYMBOL	SUBGROUP SYMBOL	GRAPHIC SYMBOL	DESCRIPTION
		F		Undifferentiated
Non-visible ice	N	Nf		Poorly bonded or friable frozen soil
		Nbn		Well bonded frozen soil with no excess ice
		Nbe		Well bonded frozen soil with excess ice. Free water present when sample thawed
Visible Ice less than one inch thick	V	Vx		Individual ice crystals or inclusions
		Vc		Ice coatings on particles
		Vr		Random or irregularly oriented ice formations
		Vs		Stratified or distinctly oriented ice formations
Visible Ice greater than one inch thick	ICE	ICE + soil type		Ice greater than one inch thick with soil inclusions
		ICE		Ice greater than one inch thick without soil inclusions

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Figure F.2

GROUND ICE CLASSIFICATION