Indian and
Northern Affairs

Affaires indiennes
et du Nord

GRANULAR MATERIALS INVENTORY

Tuktoyaktuk, Northwest Territories

Sources 160 and 161

MARCH 1980

PREPARED BY

HARDY ASSOCIATES (1978) LTD.
CONSULTING ENGINEERS & PROFESSIONAL SERVICES

HARDY ASSOCIATES (1978) LTD.

CONSULTING ENGINEERING & PROFESSIONAL SERVICES

File No. B4821

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1980, March 6

Mr. I. G. Petrie, Head
Land Use Section, Land Management Division,
Northern Water, Lands and Forests Branch,
Department of Indian Affairs &
Northern Development
Les Terrasses de la Chaudiere,
Hull, P. Q.
K1A OH4

Dear Sir:

Re: Granular Materials Inventory,
Sources 160 and 161,
Tuktoyaktuk, N. W. T.,
DSS File 01SU.C7111-9-0332

We are pleased to submit our report, in fifty copies, dealing with the evaluation of granular materials resources on the east shore of Tuktoyaktuk Harbour.

In submitting the report, we wish to acknowledge cooperation received during the study from members of the Tuktoyaktuk community, the Department of Indian Affairs and Northern Development, and Supply and Services Canada.

We would like to express our appreciation for the opportunity to undertake this study, and we assure you of our willingness to answer any questions that may arise.

Yours truly,

HARDY ASSOCIATES (1978) LTD.

Per:

N. Hernadi, P.Eng.
Project Manager

NH/tls

cc: Dr. L. G. Shaw

GRANULAR MATERIALS INVENTORY
TUKTOYAKTUK, NORTHWEST TERRITORIES
SOURCES 160 AND 161

Prepared For

DEPARTMENT OF INDIAN AFFAIRS AND NORTHERN DEVELOPMENT

By

HARDY ASSOCIATES (1978) LTD.
CALGARY ALBERTA

MARCH 1980

PROJECT B4821

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1.0 SUMMARY

This report summarizes the results of a detailed investigation of potential granular materials sources in the upland areas on the east shores of Tuktoyaktuk Harbour in the Northwest Territories.

A total of 746 000 m^3 of good to fair quality granular materials was identified as potentially extractable from six borrow areas. These materials are predominantly sands, with the extractable volume of gravel estimated at 128 500 m^3.

The occurrence of massive ice at shallow depths was identified as widespread in the potential borrow areas. Therefore, extraction of granular materials will result in thawing of massive ice in all development areas, and the creation of thaw ponds in abandoned pits was considered environmentally acceptable for the purpose of this study.

Minimum development costs have been estimated to be in the order of $15.00 to $16.00 per m^3 for summer or winter operations. Winter operations are preferable, provided ripping of frozen overburden and/or frozen granular materials proves feasible.

The results, interpretations, conclusions and recommendations given in this report are those of the author and not necessarily those of the Minister.

2.0 INTRODUCTION

Historically, the sources of granular materials for Tuktoyaktuk, including surfacing aggregate, have been the shoreline features near the community. Although extractable materials are still available from these sources, the demand for granular materials has increased in recent years, and further extraction of materials from shoreline features has become undesirable from an environmental standpoint. Furthermore, the beach materials tend to perform poorly as surfacing due to a lack of cohesive fine-grained component in their grain size distribution.

During 1977, the Government of Canada, through the office of the Department of Indian Affairs and Northern Development (DIAND), commissioned R. M. Hardy & Associates Ltd. of Calgary to carry out an assessment of granular material sources in the vicinity of Tuktoyaktuk, N.W.T., to meet the increasing demand by the community and industry. The principal objective of the initial phase of the study was to locate at least 7 600 000 m^3 of sand and gravel, with an emphasis on finding major deposits or stockpiling sites with year-round access to Tuktoyaktuk. This phase of the work encompassed a 48 km radius study area around Tuktoyaktuk, N.W.T., and included an investigation of granular deposits on land, near-shore and offshore. The report on the first phase of the study identified 22 potential sources of granular materials, and was completed in August 1977. This report identified the sediments in Tuktoyaktuk Harbour (Deposit 162), and the glaciofluvial outwash plain east of Tuktoyaktuk Harbour (Deposits 159, 160 and 161) as primary potential sources of granular materials. Further investigations were recommended to define quality and quantity of available materials.

The next phase of the Tuktoyaktuk granular inventory involved a detailed investigation of the harbour bottom sediments (Deposit 162), which included a geophysical survey, followed by a drilling program. This study, carried out by Hardy Associates (1978) Ltd., was completed in April 1979, and identified four potential borrow sources containing a total 630 000 m^3 unfrozen, dredgeable granular materials. The materials identified were predominantly fine to medium sands with variable gravel and silt content. These materials were considered suitable for general backfill, granular subbase and pads for light loading conditions.

During a gravel management workshop held at Tuktoyaktuk in July 1979, requirements were identified for up to 1 340 000 m^3 of granular materials for specific projects over the next five years. Much of this requirement could be met with general fill, such as the dredgeable materials identified in the harbour bottom. However, approximately ten percent of the identified requirement represents better quality surfacing material.

To meet the identified granular materials requirement at least partially from onshore sources, and particularly to locate sources of material suitable for surfacing aggregate, the Department of Indian Affairs and Northern Development initiated a detailed investigation of portions of the previously identified potential granular materials sources on the east shore of Tuktoyaktuk Harbour. The area selected for the investigation falls south of Fresh Water Creek, and represents portions of Deposits 160 and 161. This report presents the results of a field drilling program within the selected study area, and provides recommendations regarding the development of the granular materials resources identified.

Authorization to proceed with this investigation was received from Supply and Services Canada, under Contract Serial Number OSU79-00237, dated November 29, 1979.

3.0 SCOPE

The objectives of this study were to:

a) Undertake a field drilling program at sites selected by DIAND, to determine subsurface stratigraphy within areas previously identified as potential granular materials sources and to obtain granular materials samples for laboratory analyses,

b) Describe the setting and geomorphology of the potential aggregate sources, and determine the feasibility of developing portions of the study area as a source of granular materials for Tuktoyaktuk,

c) Delineate the distribution, volumes and quality of granular materials, including in-place and recoverable volumes, and assess the processing requirements to produce aggregate for various end uses,

d) Identify location and distribution of overburden and ground ice,

e) Discuss costs of development, ease of access, and problems involved in the extraction of the materials according to season, and

f) Suggest an optimum strategy to develop and restore each potential borrow source.

4.0 PERSONNEL

Mr. N. Hernadi, P.Eng., of Hardy Associates (1978) Ltd., as Project Manager and Project Engineer, was responsible for management of the project team, administration of the contract, cost control, planning and supervision of field work, co-ordinating input from sub-contractors and specialists, and preparation of the final report.

Mr. G. Daw, P.Eng., of Hardy Associates (1978) Ltd., as Field Engineer, was directly responsible for field operation during the survey and drilling phases. Following completion of field work, Mr. Daw co-ordinated and supervised the laboratory testing program and the preparation of test hole logs.

Mr. A. Costin, of Hardy Associates (1978) Ltd., surveyed the test hole locations and supervised night shift drilling operations.

Mr. T. J. Fujino, P.Eng. of Hardy Associates (1978) Ltd., as Project Leader, provided assistance in administration of the contract, and was specialist consultant on matters dealing with the development of potential borrow sources.

5.0 INVESTIGATIONAL PROCEDURE

5.1 Field Work

5.1.1 Planning

The Department of Indian Affairs and Northern Development selected 46 test hole locations, including six optional test holes, within the study area located to the east of Tuktoyaktuk Harbour.

The drill rig selected to undertake the drilling program was a fully winterized rotary drill, located in Inuvik, N.W.T. It was planned to commence drilling on

January 13, 1980. As timing for drill rig mobilization neared, it became obvious that the ice road to Tuktoyaktuk required to transport the drill rig would be unusually late to open, and alternate possibilities were investigated to undertake the field work within the scheduled time frame.

An auger drill rig under contract to Imperial Oil Limited in Tuktoyaktuk was located. This drill was not enclosed for winter operation, but it was considered capable of meeting the project requirements, although operations would be more susceptible to downtime due to adverse weather.

Authorization to modify our field work plan was obtained verbally on January 3, 1980 from Mr. I. Petrie, the Scientific Authority, and was confirmed by letter dated January 9, 1980. Imperial Oil Limited released the drill rig for the duration of this drilling program, and the Land Use Permit for our field operations was issued on January 7, 1980. Thus the date for field mobilization was finalized for January 14, 1980.

5.1.2 Survey of Test Hole Locations

Survey of test hole locations was carried out between January 15 and 20, 1980, by a two-man Hardy Associates survey crew, assisted by a local resident who acted as driver and helper.

The survey of test hole locations was carried out using a micro triangulation method, with an existing access road along the east shore of Mayogiak Inlet serving as reference line. The reference line was established by a stadia traverse with the northwest corner of the existing Imperial Oil Limited airstrip serving as a benchmark, and the magnetic declination of the airstrip as a reference bearing.

The surveyed test hole locations are shown on site photo mosaic and the topographic plan (Maps 1 and 2).

5.1.3 Field Drilling

The field drilling program was conducted between January 21 and 27, 1980. Drilling was carried out on a 24 hour basis utilizing two shifts. Approximately three shifts were lost due to adverse weather conditions.

Each drill crew consisted of the Hardy Associates field engineer or field technician, the driller and drill helper. The drilling contractor was Roberts Rathole Drilling Limited of Edmonton, Alberta, and the drill personnel were mobilized from Inuvik, N.W.T.

The drill was a Texoma 600 auger rig mounted on a Nodwell FN210. Support equipment used during the field program was a 966C loader for plowing access roads, and a Bombadier and/or 4x4 trucks for transport of personnel and fuel.

The drilling procedure involved augering of all test holes. Hole diameters were 356 or 406 mm, and the depths of holes ranged between 1.8 and 9.5 m. Most holes were in the order of 8.0 to 9.0 m deep. A total of 42 test holes were drilled and all holes were backfilled immediately upon completion of drilling.

The subsurface stratigraphy was logged by examining the cuttings obtained from the flights of the auger, which was withdrawn from the hole at approximately 0.3 m intervals.

Samples were obtained from each test hole to provide adequate materials for a comprehensive laboratory testing program to delineate granular materials qualities within the study area.

All samples obtained from the auger were logged, labelled, packaged and maintained in a frozen state. Due to the nature of the sampling methods all samples were disturbed, consequently, the classifications of visual ice content and soil structure are approximate.

5.1.4 Logistics Support

Travel and freight shipments between Calgary and Inuvik were by PWA scheduled flights, and Inuvik based charter services were utilized for transportation between Inuvik and Tuktoyaktuk. Equipment, supplies and services obtained locally were from E. Gruben Transport Ltd., J and J Services, and the Hamlet of Tuktoyaktuk.

5.2 Laboratory Testing

The testing program on samples returned to our laboratory included the following procedures:

a) Mechanical grain size analyses
b) Moisture content determinations

c) Colour test for organic impurities in the aggregate

d) Petrographic analyses of coarse aggregate

All test were performed in accordance with the applicable current ASTM (American Society for Testing and Materials) or CSA (Canadian Standards Association) test procedures.

The results of the laboratory testing program are included in Appendix A.

The laboratory testing program was aimed at obtaining test data on granular materials quality over the entire study area. Selection of specific samples for testing followed a preliminary evaluation of field logs. This resulted in a concentrated laboratory testing effort for samples obtained from areas which appeared promising with respect to development potential.

6.0 GEOLOGIC SETTING OF THE STUDY AREA

The study area is located on the Tuktoyaktuk Peninsula which is within the Arctic Coastal Plain physiographic region of Bostock and the Pleistocene Coastlands division of

Mackay (Bostock, 1970; Mackay, 1963). Terrain is flat to gently rolling and relief is usually less than 15 m. Numerous lakes cover the surface and organic deposits fill low lying areas in the glaciofluvial, lacustrine, and marine deposits which make up Sources 160 and 161 and adjacent areas. The distribution of surficial deposits within the study area is shown on the airphoto mosaic (Map 1).

Permafrost is found to depths of 365 m throughout the study area. The average thickness of the active layer is 0.7 m, and is up to 1 m in coarse grained materials that are bare of vegetation. Massive segregated ice bodies, and sediments containing an abundance of excess ice are common. Excess ice is found in the form of ice lenses, vein ice and pore ice, and ice wedge ice. Former abundant ground ice is represented by patterned ground and thermokarst depressions (Rampton and Bouchard, 1975).

Glaciofluvial terrace deposits are the most common constituent of Sources 160 and 161. These deposits originated as flat outwash fans and valley trains. The present rolling to hummocky nature of the surface of the glaciofluvial deposits probably resulted from ice melting out and leaving depressions. Material in glaciofluvial terrace deposits includes clean to dirty gravel with stratification, some

includes clean to dirty gravel with stratification, some

silt and clay, and glaciofluvial sand. Where gravel is present at the surface it ranges from 0.5 to 2.5 m in thickness. When sand is at the surface, gravel beds generally occur within the upper 3 m. Gravel is generally free of excess ice, although some of it contains up to 20 percent excess ice by volume. The glaciofluvial materials are frequently underlain by massive segregated ice bodies at relatively shallow depths.

Most of the glaciofluvial sand is medium to coarse grained, cross bedded, and contains pockets and lenses of coal and driftwood and a few silty and gravelly beds. The sand generally contains 5 to 20 percent excess ice by volume, but in places excess ice is absent. A thin layer of fine material, lacustrine in origin, locally overlies glaciofluvial material.

Thicker lacustrine deposits occupy basins developed by thermokarst subsidence. Coarse grained lacustrine deposits are common where glaciofluvial deposits are prominent. Some fine grained lacustrine deposits are also present, particularly along the northeast shore of Mayogiak Inlet.

The ice content of coarse lacustrine deposits resembles the ice content of glaciofluvial deposits, although the occasional silt bed may include ice lenses. Beaches in these areas are better sorted than in dry areas because of the nature of the parent material.

Finer grained lacustrine deposits contain 10 to 20 percent excess ice by volume, but commonly they contain up to 80 percent in the upper metre and negligible amounts at depth. Massive segregated ice is rare under lacustrine deposits. The vegetation on some abandoned lacustrine basins indicates that they were drained within the last 200 years.

Fine grained intertidal marine deposits are found along Mayogiak Inlet and an embayment southeast of Kiktoreak Point which are protected from intense wave action. These deposits are generally high in organic content and nearshore facies contain sand, gravel lenses, isolated stones, and fragments of driftwood. Fine grained marine deposits contain much ground ice and are generally less than 1.5 m thick. Erosion and deposition occurs annually on these intertidal marine deposits. Some smaller coarse grained marine beach deposits also occur along the bay that is southeast of Kiktoreak Point.

Organic deposits occur on lacustrine and pond deposits and in small poorly drained portions of glaciofluvial deposits. Most organic deposits are 1 to 2 m thick and the base of the organics grades into the underlying material. Boundaries of organic areas are generally sharp, but sometimes peat less than 1 m thick is found outside of mapped organic areas. This usually occurs in intertidal and lacustrine areas. Organic deposits generally have a surface pattern of either high-centre or low-centre peat polygons. Peat has ice contents that range from 200 to 500 percent of the dry weight of the peat, but occasionally exceed 2000 percent.

7.0 ASSESSMENT OF DATA

Detailed soil profile logs for all test holes, and the results of the laboratory tests are included in Appendix A. An explanation of symbols and terminology used on the test hole logs is given in Appendix B.

7.1 Distribution and Nature of Overburden

Overburden, defined as all material overlying granular materials was encountered to variable depths at 31 of the 42 test holes. At 11 test hole locations granular materials, usually sand, was found immediately below existing ground surface.

The overburden thickness is categorized as "thin" at 12 test hole locations where less than 0.3 m of overburden was encountered. At these locations the overburden is peat, 0.2 to 0.3 m in thickness, and was classified as containing 20 to 30 percent excess ice randomly or irregularly oriented in layers less than 25 mm in thickness.

At 19 test hole locations the overburden is categorized as "thick". At these locations, the overburden thickness is generally 1 m or greater, and is usually comprised of a peat layer overlying ice-rich silt. Ice contents in the silt range from non-visible to ice-plus layers.

7.2 Occurrence of Ground Ice

The test hole data indicate that massive segregated bodies of ice are prevalent at relatively shallow depths within the study area. At the 23 test hole locations where overburden was categorized as thin, and therefore representative of areas potentially suitable for development as borrow sources, massive segregated ice was encountered at 16 locations. Of these, 14 test holes were terminated in ice.

The depth to massive ice, where encountered at "thin" overburden test hole locations ranged between 1.4 and 6.3 m, averaging 3.5 m. The total thickness of massive ice was not determined at the test hole locations. However, massive ice is known to exist to thickness of 10 to 40 m in the Tuktoyaktuk area (Rampton and Walcott, 1974).

7.3 Granular Materials

The occurrence of granular materials is widespread within the study area. However, the variability in overburden thickness and the frequent presence of massive ice underlying the granular materials at shallow depths result in relatively thin zones of extractable granular materials.

The field and laboratory data indicate that considerable variability exists in the grain size distribution of granular materials samples obtained from test holes drilled within any given area. Therefore, the discussion of granular materials quality and suitability for various uses is given on a site specific basis for each potential borrow area identified.

7.3.1 Potential Borrow Areas

Areas considered suitable for development as potential borrow sources were defined as follows:

- Upland areas where at least two test hole locations indicated overburden to be thin (i.e. less than 0.3 m), and
- Where the presence of gravel has been identified in at least two test holes.

Using the above criteria, six areas, designated as Potential Borrow Areas A to F have been identified, as shown on the topographic map of the study area (Map 2). It should be noted that granular materials covered by thin overburden were identified at a number of test hole locations falling outside of the delineated borrow areas. However, the drilling data indicate that these occurrences are isolated, consequently such locations were not considered for potential borrow areas.

7.3.1.1 Potential Borrow Area "A"

Potential Borrow Area "A" covers approximately 10 ha (24.7 acres), and is bounded by the 10 m contour of a large well for moderately well drained flat terrace feature, located to the north of the inlet channel of Mayogiak Inlet.

Four test holes were drilled within this area yielding the following data:

Thickness of overburden - 0 to 1.0 m,
Average - 0.35 m

Depth to massive ice - 2.5 to 5.8 m
Average - 4.0 m

Thickness of granular materials - 2.3 to 5.6 m
Average - 3.7 m

The best quality granular material was identified at Test Hole 4 near the eastern tip of the designated area. At this location 0.2 m of peat overlies a 5.6 m stratum of gravel and sand, having a relatively low fines content. Moisture contents of the granular material range between 9.1 and 23.4%, and up to 10% excess ice was noted in the gravel.

The granular material at the remaining three test hole locations was identified predominantly as fine to medium sand containing minor silt and gravel components. Ice contents of the sand range between non-visible to 20% excess ice, mostly falling in the 10% excess ice category.

The total extractable volume of granular materials within this deposit was estimated based on an average deposit thickness of 3 m above massive ice within the outlined boundary. This yields a potential extractable volume of 300 000 m^3 of granular material. Based on data from Test Hole 4, 25% of the estimated extractable volume, or 75 000 m^3, is assumed to be gravel, which will be found predominantly in the northeast portion of the outlined area. The remainder of the borrow area will yield mostly sand.

The gravel is rated as good to fair quality granular material, suitable for base courses without need for further processing. The fines content of the gravel is at the lower limit desirable for surface course use. The organic colour number of 3+ indicates that some processing, such as washing of the sand fraction may be desirable prior to its use in concrete.

The sand from this source is predominantly fine to medium grained. Both silt and gravel contents are low, and the material is classified as fair, suitable for use as granular subbase, general backfill and pads for light loading conditions.

7.3.1.2 Potential Borrow Area "B"

Potential Borrow Area "B" covers approximately 4.6 ha (11.4 acres), and is located to the northeast of Mayogiak Inlet. This source is location on a well drained north to south trending ridge, approximately 70 m wide and 550 m long, which is part of the glaciofluvial terrace feature containing all granular material in the study area. The boundary of the source generally follows the 10 m contour. The surface of the ridge is essentially flat, and its slopes are gentle to moderate.

Three test holes were drilled within this area, yielding the following data:

Thickness of overburden - 0.2 to 2.5 m
Average - 0.9 m

Depth of massive ice - 3 m to 4.8 m
(no massive ice encountered to 8.5 m at Test Hole 7)

Thickness of granular materials - 2.7 to 6.0 m
Average - 4.5 m

The subsurface stratigraphy is variable in this area with respect to overburden thickness and depth to massive ice. At Test Holes 7 and 8 the sands have a significant gravel and silt content, and distinct gravel layers were identified. The sand at Test Hole 6 is less silty, however, the gravel content is also lower. Visible excess ice and moisture contents are mostly in the 10 to 20%, and 15 to 25% range, respectively, although some higher excess ice contents, and correspondingly higher moisture contents were also noted.

The total extractable volume of granular materials within this deposit was estimated based on an average deposit thickness of 3 m within the outlined area. This yields a potential extractable granular materials volume of 138 000 m^3. The test hole data indicate that gravel layers are probably thin and discontinuous within this source. Therefore, it was estimated that only approximately 15% of the extractable volume, or about 20 000 m^3 will be gravel. It should be noted, however, that the sands at Test Hole 7 and 8 contain significant quantities of gravel sized particles.

The granular materials from this source are generally rated as good to fair, suitable for use as granular subbase, general fill and pads for light loading conditions. The fines content of the gravel is in the range suitable for surfacing material, however, the discontinuous nature of the gravel beds will make their selective extraction difficult. Processing of the aggregate (i.e. washing) would be required to make the material suitable for use in concrete.

7.3.1.3 Potential Borrow Area "C"

Potential Borrow Area "C" covers approximately 2.6 ha (6.4 acres) and is located to the southeast of Sources "B". The area is bounded by the 8 m contour of a relatively flat, moderately well drained glaciofluvial terrace.

Three test holes fall within the outlined area, and the subsurface stratigraphy was identified as follows:

Thickness of overburden - nil

Depth to massive ice - 2.0 to 4.5 m
Average 3.5 m

Thickness of granular materials - 2.0 to 4.5 m
Average - 3.5 m

The granular materials at all three test holes are fine to coarse grained sands, containing a significant gravel component. Fines content is generally low. The moisture content of the sand ranges between 11.6 and 22.4%, and no visible excess ice content was observed. The upper portions of the stratigraphies were logged as poorly bonded or friable at all test holes.

The total extractable volume of granular materials in this deposit was estimated based on an average extractable thickness of 3.5 m within the outlined area. This yields a potential extractable granular materials volume of 92 000 m^3. Although a significant gravel component is contained within this source, the deposit is categorized predominantly as sand.

The material is classified as fair to good. It is considered suitable for granular base and subbase, and pads for light loading conditions. As well, high gravel content sand, such as that identified at Test Hole 19 is suitable for surfacing aggregate.

7.3.1.4 Potential Borrow Area "D"

Potential Borrow Area "D", located to the east of Source "B", covers approximately 3.6 ha (8.9 acres). It is bounded mostly by the 10 m contour on a relatively flat, moderately to well drained glaciofluvial terrace with gentle to moderate slopes.

Three test holes were drilled within this area, yielding the following data:

Thickness of overburden - 0 to 1.6 m
Average - 0.5 m

Depth to massive ice - 2.2 to 3.7 m
Average 3.2 m

Thickness of granular materials - 2.0 to 3.7 m
Average 2.6 m

The granular materials at Test Holes 9 and 11 are predominantly fine to medium sands containing significant amounts of gravel and silt. Visible ice contents are low and the granular material is bare of overburden. At Test Hole 10, the overburden is 1.6 m thick, overlying a 2 m stratum of sand and gravel.

The total extractable volume of granular materials within this deposit was estimated based on an average extractable thickness of 2.5 m within the outlined boundary. This yields a potential extractable granular materials volume of 90 000 m^3. Gravel was only encountered as a relatively thin layer at Test Hole 10, therefore, it is estimated that approximately 15%, or 13 500 m^3, of the total extractable volume will be gravel. It should be noted, however, that the sands in this deposit contain a significant gravel component.

Based on petrographic analysis, the gravel fraction of the sand at Test Hole 9 was classified as fair for use in concrete. In the sand fraction, the fines content and the organic impurities content are high. Therefore, washing of the aggregate would be required prior to its use in concrete.

Generally, the granular materials from this source are classified as good to fair, although the small quantity of gravel, if extracted selectively would be suitable for surfacing material.

7.3.1.5 Potential Borrow Area "E"

Potential Borrow Area "E" covers approximately 2.5 ha (6.2 acres) and is located on a relatively flat, moderately well drained glaciofluvial terrace to the southeast of Source "C". The outlined area is generally bounded by the 8 m contour. A lake with an estimated water surface elevation of 5 m is located immediately north of the outlined area.

The three test holes drilled within this area yielded the following data:

Thickness of overburden - 0 to 0.2 m
Average 0.1 m

Depth of massive ice - 3.6 to 6.2 m
(Test Hole 22 was terminated in sand at a depth of 4.0 m)

Thickness of granular materials - 3.4 to 6.2 m
Average 4.5 m

The granular materials at Test Hole 20 and 21 are comprised of stratified sands with discontinuous gravel layers. Medium grained sand containing a minor gravel component was encountered at Test Hole 22. Moisture and visible ice contents are generally low, and the upper part of the stratigraphies were generally logged as poorly bonded or friable.

The total extractable volume was estimated based on an average thickness of 3.0 m granular materials within the outlined area located at an elevation above the water level in the small lake to the north of the deposit. This yields a potential extractable granular materials volume of 75 000 m^3. Of this amount, it was estimated that 20%, or 15 000 m^3 is gravel, present in discontinuous layers in the area of Test Holes 20 and 21.

The granular materials from this source are rated as good to fair, and are suitable for base and subbase construction without need for further processing. The fines content of the gravel is below the limit desirable for surfacing materials, however, if some siltier materials are blended into the gravel, a good surfacing mixture will result. If the low fines content gravel can be extracted selectively, an aggregate having a gradation suitable for use in concrete would be obtained.

7.3.1.6 Potential Borrow Area "F"

Potential Borrow Area "F" covers 1.7 ha (4.2 acres), and is the smallest of the sources identified. This source occupies a relatively narrow, well drained moderately sloping ridge, on a larger glaciofluvial terrace. The outlined area generally follows the 8 m contour.

Two test holes are located within this area, yielding the following data:

Thickness of overburden - 0 to 0.2 m

Depth to massive ice - ice layers below 5.8 m at Test Hole 25, Test Hole 24 terminated in sand at 3.5 m

Thickness of granular materials - greater than 3.3 m

The granular materials in this source are predominantly stratified sands with a variable gravel content. Thin gravel layers which are probably discontinuous were encountered near ground surface at both test holes. No visible ice was noted within the upper part of the stratigraphies and moisture contents ranged between 13.3 and 24.9%. The granular materials were logged as poorly bonded or friable at Test Hole 25.

The total extractable volume of granular materials was calculated based on an assumed average extraction depth of 3 m within the outlined area. This yields a potential extractable granular materials volume of 51 000 m^3. It is estimated that only 10% of this amount, about 5 000 m^3, is gravel. It should be noted, however, that significant qualities of gravel are contained in the fine to coarse sand of this source.

The granular materials from this source are rated as good to fair, and are suitable for base and subbase construction. A petrographic analysis of the coarse aggregate resulted in an unsuitable rating of this material for concrete use, due to its high chert content. However, the organic impurities content of the sand fraction is within acceptable limits for concrete.

8.0 DEVELOPMENT OF SOURCES 160 AND 161

8.1 Feasibility of Development

All sites identified as potential borrow areas are underlain by massive ice at shallow depth. Therefore, major development in any of the areas delineated, although technically feasible, will result in melting of massive ice and the creation of thaw ponds in worked areas. Due to the shallow and probably variable depths to massive ice, it is not considered feasible to extract granular materials from these deposits without initiating thaw of massive ice. Thus it is assumed in the following discussions that thawing of massive ice will occur, and will be acceptable, as a result of extracting granular materials from within the study area.

8.2 Recommended Priority for Development

With the exception of minor differences in materials quality the six potential development areas identified are relatively similar with respect to geologic setting, the presence of massive ice at shallow depth, and the thickness of overburden. Therefore, the methods of extraction and the environmental consequences will be similar for each of the deposits identified, and development priority should be based primarily on ease of access, proximity and potentially extractable volumes within the delineated deposits. Using these criteria, the recommended priority for development is as follows:

Priority	Potential Borrow Area	Estimated Volumes (m^3)	
		Total	Gravel
1	A	300 000	75 000
2	B	138 000	20 000
3a	C	92 000	-
3b	D	90 000	13 500
3c	E	75 000	15 000
3d	F	51 000	5 000

Potential Borrow Area "A" contains the largest estimated volume of extractable granular materials, it is the source closest to the community, and it is the only source directly accessible from Tuktoyaktuk Harbour. The remaining sources, which are all accessible through Mayogiak Inlet, contain significantly smaller quantities of potentially extractable material and are located at increasing distances to the community.

8.3 Potential Development Methods

Development of the potential borrow areas could be undertaken as winter or summer projects. Equipment requirements, logistics and reclamation procedures for a winter operation are less complex, and net recovered volumes of granular materials may be greater during winter. Therefore a winter operation would be the preferred mode of development.

8.3.1 Winter Operation

A winter operation would involve ripping the overburden where encountered, pushing the overburden to the edges of the area to be developed, ripping the granular material, pushing the ripped material into temporary stockpiles, loading and trucking the granular material to stockpile sites at the community, and upon completion of extraction, spreading the stockpiled overburden on the slopes of the completed excavation and/or other disturbed areas such as access roads. The stockpiled frozen granular material would then be available for community use during the following summer as thawing of the stockpile progressed.

This procedure is considered feasible during the period while the harbour ice can support the trucks, loaders and dozers required for the winter operation.

Access to all potential borrow areas would be available predominantly across ice, together with short snow roads from shore to the development sites.

The major problem anticipated with a winter operation will be the rippability of the materials encountered, and a relatively low level of productivity should be anticipated in this regard. The subsurface conditions identified range from poorly bonded friable granular materials devoid of overburden, to high excess ice content silt overburden. The former would be easily rippable while the latter may not be rippable. A thin organic cover above granular materials should not present major ripping problems.

Moisture contents of the granular materials fell mostly in the 10 to 20% range, and the stratigraphies were often logged as well bonded, or as containing small percentages of visible excess ice. This indicates that ripping of frozen granular materials will generally be a slow, difficult and costly procedure.

Following extraction of granular materials, thaw of underlying massive ice will likely be initiated. Therefore, the size of the pit area should be minimized during an extraction season. As well, mining should be carried to the full depth of extraction, since unextracted granular materials may become submerged in thaw ponds as the underlying massive ice thaws.

8.3.2 Summer Operation

Due to a lack of all weather road access to any of the potential borrow areas, summer operations will require barging of excavation equipment between Tuktoyaktuk and the borrow areas. The extracted material could be returned to the community by barging during summer, or alternately, the extracted material could be stockpiled at the borrow site, and recovered by trucking across the ice during the following winter season.

The summer recovery operation would consist of stripping, windrowing and recovering the thawed material in cycles, as the thaw front progressed. As for winter operations, the area of extraction should be minimized during an extraction season, and recovery of materials should be to the full depth intended within the same season, since subsequent thawing of massive ice may preclude the possibility of future extraction from a previously worked area.

Summer operations would require a temporary docking facility for barges as well as short temporary access roads to the pit areas, and these facilities will require considerable quantities of granular materials. Thus the recoverable quantities of granular materials from these relatively small potential borrow areas would be reduced significantly. As well, maintenance of drainage could be of major concern during summer operations. Thus summer operations, although technically feasible, appear to be less attractive than winter operations for these small potential borrow areas, provided ripping of the frozen materials proves to be feasible during winter.

8.4 Abandonment and Reclamation of Depleted Borrow Sources and Associated Facilities

Since thaw of massive ice is anticipated following extraction of granular materials, thaw ponds can be expected in all worked areas. Ponds and small lakes are common in the general area, thus the formation of additional ponds is considered an environmentally acceptable end result. The perimeters of the worked areas will be unstable initially if underlain by massive ice, however, these areas can be expected to stabilize naturally over a few years, without excessive regression. The time to stabilize and the amount of regression likely to occur along the boundaries of depleted

of regression likely to occur along the boundaries of depleted

borrow areas will be dependent on soil type, ice content, vegetation cover and depth to massive ice.

In preparation for abandonment, the area should be cleaned of all debris, and topographic irregularities associated with pit operations, such as ridges and mounds, should be removed.

No significant terrestrial disturbances are anticipated during winter operations for areas outside the pit limits. However, access roads and stockpile sites utilized for summer operations will require reclamation prior to pit abandonments. Disturbed areas which are not expected to become flooded should be smoothly graded, and previously stockpiled overburden should be mixed into the abandoned surfaces in preparation for establishing a seeded plant cover.

Prior to seeding, the site should be deeply ripped with a caterpillar mounted ripping tool. This will serve to mix some native soil high in organic content with the layer of coarse material remaining on the surface after cleanup, thereby improving fertility and moisture holding capacity of the surface materials. This operation would be most successful when done in late fall after frost has penetrated 100 to 150 mm

when done in late fall after frost has penetrated 100 to 150 mm

into the surface but before the entire active layer is frozen. Clods of soil generated by ripping at this time would provide a roughened surface that would reduce the potential of wind erosion and provide protected microsites for the establishment of seeded and native species.

Seed and fertilizer should be applied by broadcast in late fall, immediately following ripping. The recommended seed mixture includes Boreal creeping red fescue, Nugget Kentucky bluegrass, Fairway crested wheatgrass and Engmo timothy in a 2:2:1:1 ratio, by weight, applied at 56 kg/ha (50 lb/ac). Fertilization should be with a 14-28-14 mix of N, P_2O_5 and K_20, applied at 440 kg/ha (400 lb/ac) at the time of seeding, and again at the beginning of the second growing season. Annual monitoring of re-vegetation success for the first two years is recommended. Although the seed mix includes species that are winter hardy (Younkin, 1976) and species with moderate tolerance to saline soil conditions, harsh climatic and site conditions may require that portions of the site be reseeded or that fertilization be continued for more than two years.

8.5 Estimated Cost of Development

Current estimated minimum costs for stockpiled granular materials in place at the community is in the order of \$15.00 to \$16.00 per m^3 for a winter operation. This estimate assumes a production rate of about 40 m^3 per hour, using two D-8 dozers, two 966C loaders and four dump trucks. If difficulties are experienced in ripping frozen overburden and/or frozen granular materials, the above cost estimate could increase significantly.

The costs for summer operations in the pit area would likely be lower, however, the requirement for barging would increase transportation costs above those estimated for winter work. Thus the overall costs for summer work will probably be in the same range as the minimum estimated winter operation costs. Additional costs associated with summer operations not included above are construction of temporary access roads and barge docking facilities, and reclamation costs.

8.6 Recommended Development Strategy

Development of the delineated borrow sources should commence with Potential Borrow Area "A". This source

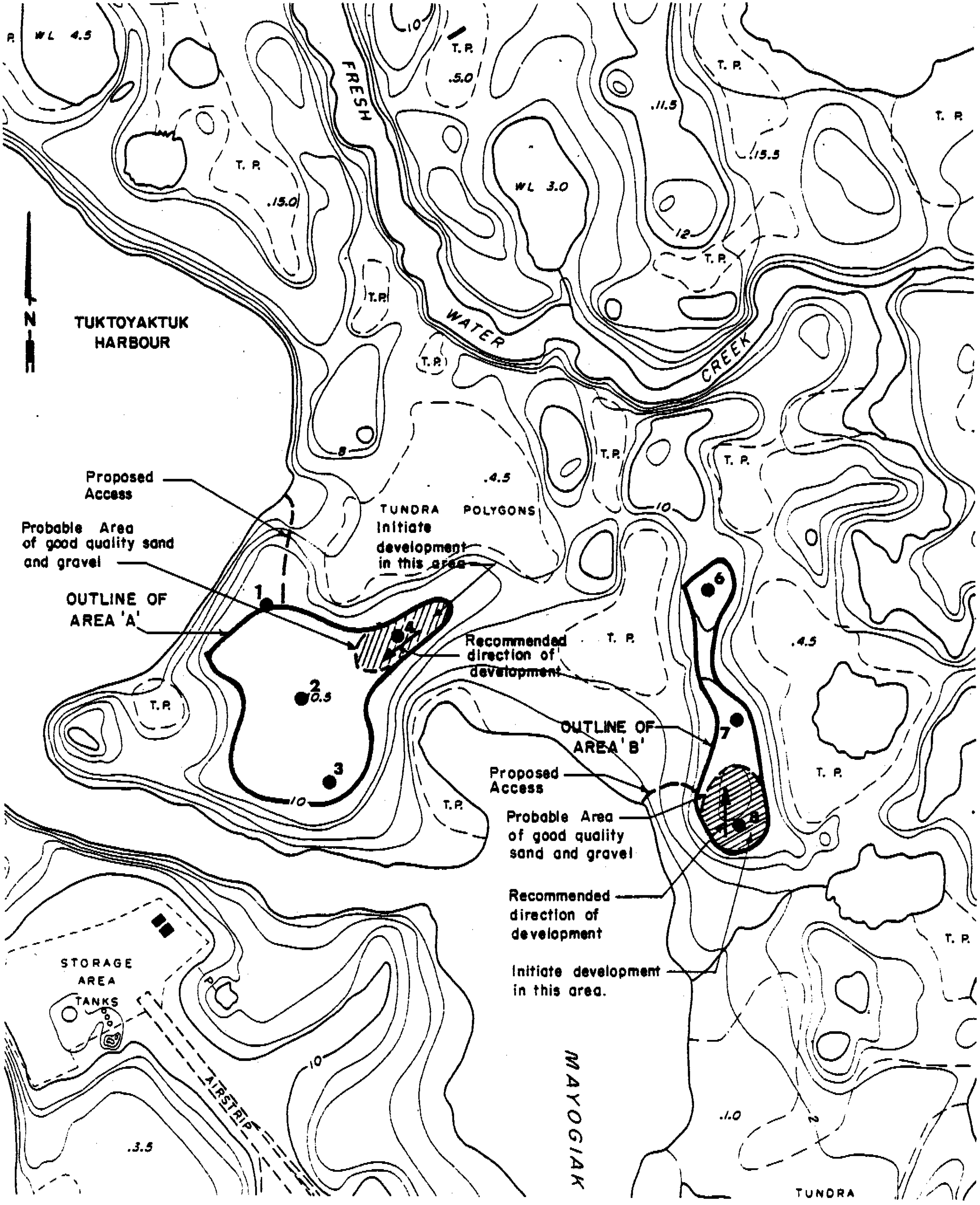
should commence with Potential Borrow Area "A". This source

contains the largest volume of extractable material and is located closest to the community.

At Test Hole 4, in the northeast portion of Area "A", a 5.6 m stratum of good quality sand and gravel was identified under thin overburden cover. Therefore, it is recommended that development of Area "A" be initiated in the northeast corner of the outlined area, and extraction should proceed in a southwesterly direction. A sketch of the proposed development scheme is shown on Figure 8.1. The active pit area should be kept as small as possible, and extraction should proceed to the full depth of granular materials above the massive ice.

A winter operation is recommended as the preferred method of development. Should ripping of the frozen overburden and/or frozen granular material prove to be too costly, summer extraction would have to be considered as an alternative.

Development of the remaining potential borrow areas should not commence until Area "A" has been depleted and abandoned. At that time, Area "B" should be scheduled for development. Extraction from Area "B" should commence from the southern tip of the outlined area, where the best quality granular materials were identified in this source



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RECOMMENDED DEVELOPMENT STRATEGIES
POTENTIAL BORROW AREAS 'A' AND 'B'

SCALE 1:10000

FIGURE 8-1

HT09 - 79/05

(i.e. Test Hole 8). A sketch of the proposed development scheme is shown on Figure 8.1.

Potential Borrow Areas "C" to "F" are considerably smaller than Areas "A" and "B", and should be considered as low priority areas for development.

9.0 CONCLUSIONS

A field drilling program was carried out in the upland areas on the east shore of Tuktoyaktuk Harbour to delineate areas containing potentially extractable granular materials. Laboratory and office studies followed the drilling program to establish suitability of granular materials for various uses, to quantify potentially extractable volumes, to recommend development plans, and to estimate development costs.

The study area contains a large quantity of granular materials. However, excessive overburden in lower lying areas, and the presence of massive ground ice at shallow depths in the upland areas result in relatively small quantities of extractable granular materials. The total volume of extractable granular materials was estimated at 746 000 m^3

contained in six potential borrow areas. The total volume of extractable gravel was estimated at 128 500 m^3. The remaining 617 500 m^3 of extractable granular material is classified as fine to medium sand with variable fines and gravel content.

Using the DIAND criteria for classifying granular materials quality, the identified deposits are rated as "good" to "fair" for construction purposes. The gravels are generally suitable for road surfacing aggregate. Some sand and gravel from these sources would also be suitable for use in concrete with little or no processing.

Due to the widespread occurrence of massive ice at shallow depths, development of any potential borrow sources in the study area will result in thawing of massive ice and creation of thaw ponds in pit areas. Since ponds and small lakes are prevalent in the study area, it has been assumed for the purpose of this study that thaw ponds resulting from pit development will be an environmentally acceptable end result.

Development of the potential borrow areas could be carried out as winter or summer operations. Equipment requirement, logistics and reclamation procedures for a winter operation are less complex, and net recovered volumes of

APPENDIX "A"

TEST HOLE LOGS AND LABORATORY TEST DATA

TEST HOLE LOG

DEPTH (M)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	MATERIAL DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %	SAMPLE TYPE AND NUMBER	SAMPLE CONDITION	DEPTH (M)	OTHER INFORMATION
	SM		SAND little silt, fine to medium grained, brown		Vx 10%				
1						A_1	☒	1.0 1.5	
			--- trace gravel to 1 cm size			A_2	☒	1.5 1.7	
2	SP		SAND little gravel to 4 cm size, trace silt						
3					Vc 5%	A_3	☒	3.0 3.3	
	I+		ICE+ trace gravel, trace silty sand		I+ 95%				
4									
5									
6									
7						A_4	☒	7.0 8.0	
8									
9			Bottom of Hole at 9.0 m depth						
10									

DATE: 80.01.21

LOGGED BY: G.D.

DRWN BY: C.G.

CHKD BY: N.H.

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TEST HOLE NO.
1

TEST HOLE LOG

DEPTH (M)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	MATERIAL DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %	SAMPLE TYPE AND NUMBER	SAMPLE CONDITION	DEPTH (M)	OTHER INFORMATION
	Pt		PEAT		Vr 40%				
	I+		ICE+ trace silt		I+ 90%				
1	SM		SAND little silt, fine grained, brown		Vx 10%	A_1	☒	1.0 1.3	
2	SP		SAND fine grained, trace silt, trace coarse sand to 0.5 cm size			A_2	☒	2.0 2.3	
3					Nbe				
4						A_3	☒	4.0 4.3	
	I+		ICE+ trace sand		I+ 90%				
5									
6									
7									
8	SP		SAND fine to medium grained, light brown		Vc- Vx 30%	A_4	☒	8.5	
9			Bottom of Hole at 9.0 m depth						
10									

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TEST HOLE NO.
2

TEST HOLE LOG

DEPTH (M)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	MATERIAL DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %	SAMPLE TYPE AND NUMBER	SAMPLE CONDITION	DEPTH (M)	OTHER INFORMATION
	Pt		PEAT		Vr 30%				
1 2	SM		SAND little silt, fine grained, brown		Vx 20%	A_1	☒	1.4 1.6	
3 4 5	I+		ICE+ trace sand		I+ 90%				
6	SP		SAND fine to medium grained, occasional coarse sand sizes		Vx 15%	A_2	☒	5.5 6.0	
7	I+		ICE+ little sand		I+ 80%	A_3	☒	7.2 7.4	
8	SP		SAND fine to medium grained, occasional coarse sand sizes		Vx 40%	A_4	☒	8.2 8.6	
	I		ICE		I				
9 10			Bottom of Hole at 9.0 m depth						

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TEST HOLE NO.
3

TEST HOLE LOG

DEPTH (M)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	MATERIAL DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %	SAMPLE TYPE AND NUMBER	SAMPLE CONDITION	DEPTH (M)	OTHER INFORMATION
	Pt		PEAT		Vr 30%				
	GP		GRAVEL and fine to coarse sand, trace silt, rounded to subrounded, to 4 cm size, poorly graded, brown		Vx 10%	A_1	☒	0.3 0.6	Grain Size (A-43) w = 10.9%
1	SP		SAND and rounded to subrounded gravel to 4 cm size, trace silt, fine to coarse grained, poorly graded, brown			A_2	☒	1.5 2.0	Grain Size (A-44) w = 15.8%
2			--- trace gravel to 4 cm size			A_3	☒	2.5 2.8	Organic Colour: #3+ Grain Size (A-45) w = 23.4%
3			___trace gravel to 3 cm size			A_4	☒	3.2 3.4	w = 21.0%
4	GP		GRAVEL some fine to coarse sand, trace silt, to 10 cm cobble size, rounded, poorly graded		Nbn	A_5	☒	3.8 4.0	Grain Size (A-46) w = 9.1%
5						A_6	☒	4.7 5.0	w = 15.4%
6	I+		ICE+ trace silty sand		I+ 90%				
7									
8			Bottom of Hole at 8.0 m depth						
9									
10									

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CHKD BY: N.H.

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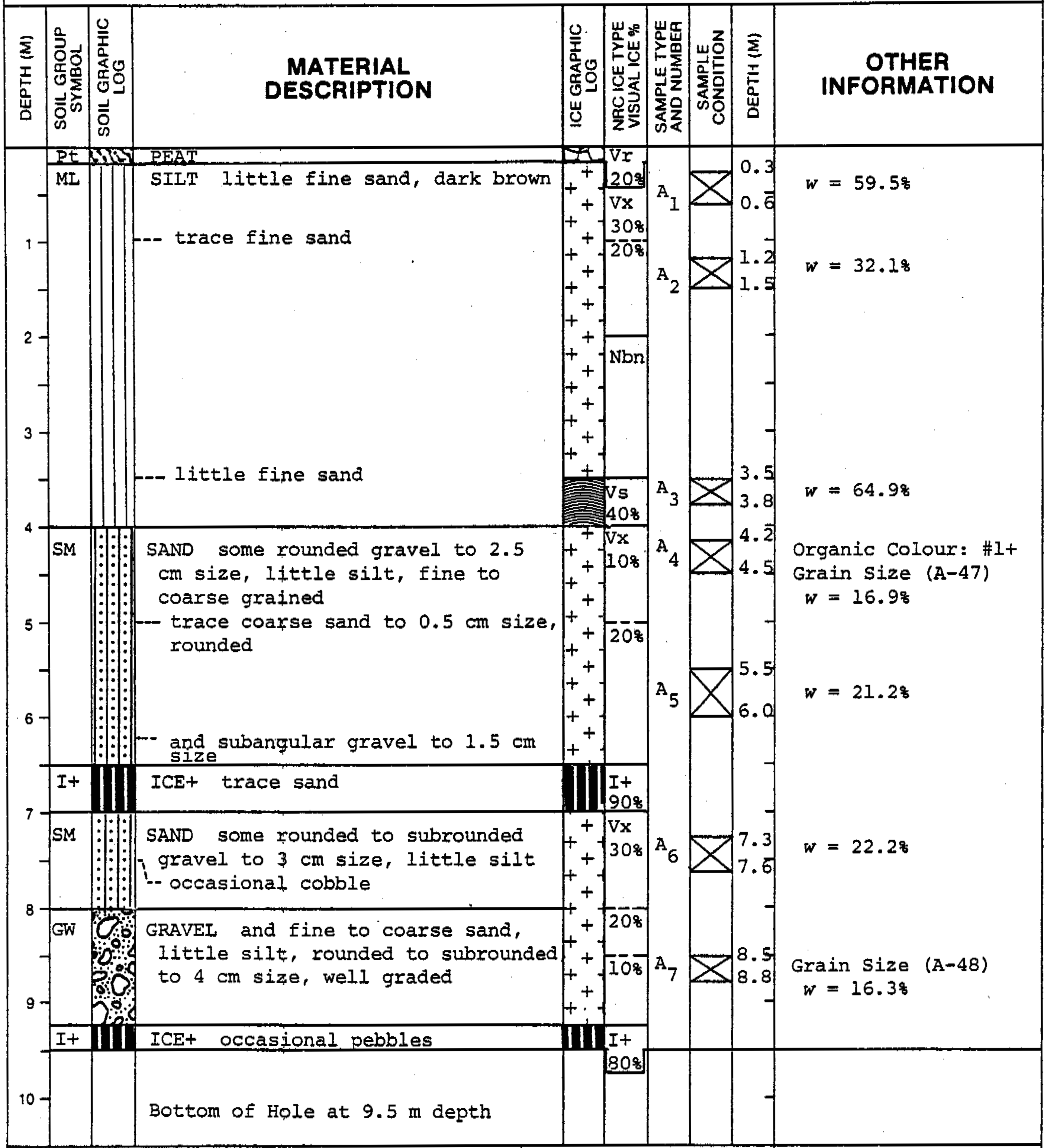
TEST HOLE NO.
4

TEST HOLE LOG



DEPTH (M)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	MATERIAL DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %	SAMPLE TYPE AND NUMBER	SAMPLE CONDITION	DEPTH (M)	OTHER INFORMATION
	Pt		PEAT		Vr				
	ML		SILT little fine sand, dark brown		20%	A_1	☒	0.3 0.6	w = 59.5%
1			-- trace fine sand		Vx 30%				
					20%	A_2	☒	1.2 1.5	w = 32.1%
2					Nbn				
3			--- little fine sand		Vs 40%	A_3	☒	3.5 3.8	w = 64.9%
4	SM		SAND some rounded gravel to 2.5 cm size, little silt, fine to coarse grained		Vx 10%	A_4	☒	4.2 4.5	Organic Colour: #1+ Grain Size (A-47) w = 16.9%
5			-- trace coarse sand to 0.5 cm size, rounded		20%				
6			-- and subangular gravel to 1.5 cm size			A_5	☒	5.5 6.0	w = 21.2%
	I+		ICE+ trace sand		I+ 90%				
7	SM		SAND some rounded to subrounded gravel to 3 cm size, little silt -- occasional cobble		Vx 30%	A_6	☒	7.3 7.6	w = 22.2%
8	GW		GRAVEL and fine to coarse sand, little silt, rounded to subrounded to 4 cm size, well graded		20% 10%	A_7	☒	8.5 8.8	Grain Size (A-48) w = 16.3%
9	I+		ICE+ occasional pebbles		I+ 80%				
10			Bottom of Hole at 9.5 m depth						

DATE: 80.01.22

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DRWN BY: C.G.

CHKD BY: N.H.

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TEST HOLE NO.
5

TEST HOLE LOG

DEPTH (M)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	MATERIAL DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %	SAMPLE TYPE AND NUMBER	SAMPLE CONDITION	DEPTH (M)	OTHER INFORMATION
	Pt		PEAT		Vr 30%				
	SP		SAND trace gravel to 1 cm size, fine to medium grained		Vx 20%	A_1	☒	0.3 0.6	w = 23.4%
2	SW		SAND some subrounded gravel to 4 cm size, little silt, fine to coarse grained, well graded		10%	A_2	☒	2.2 2.6	Grain Size (A-49) w = 18.1%
			--- no gravel		Vs 50%				
3	I+		ICE+ trace silt		I+ 99%	A_3	☒	3.5 3.8	
5						A_4	☒	5.0 5.3	
9						A_5	☒	9.0 9.2	
10			Bottom of Hole at 9.5 m depth						

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TEST HOLE NO.
6

TEST HOLE LOG

SOIL GROUP SYMBOL	MATERIAL DESCRIPTION	NRC ICE TYPE VISUAL ICE %	SAMPLE TYPE AND NUMBER	SAMPLE CONDITION	DEPTH (M)	OTHER INFORMATION
Pt	PEAT	Vr 30%				
ML	SILT little fine sand, occasional pebbles to 1 cm size, dark brown	Vx 30%	A_1	☒	0.3 0.6	w = 76.6%
		50%				
	-- no pebbles	20%	A_2	☒	1.5 1.8	Grain Size (A-50) w = 33.1%
SM	SAND little silt, fine to medium grained -- little gravel, rounded to sub-rounded, to 4 cm size	10%	A_3	☒	3.0 3.3	Grain Size (A-51) w = 21.2%
SP	SAND some gravel to 4 cm size, trace silt, fine to coarse grained poorly graded		A_4	☒	4.5 4.8	Organic Colour: #1+ Grain Size (A-52) w = 15.8%
	-- medium to coarse grained sand, no gravel	50%	A_5	☒	5.5 5.8	w = 22.8%
	-- and gravel, occasional cobbles	10%	A_6	☒	6.4 6.7	w = 13.2%
GM	GRAVEL some sand, little silt, frequent cobbles	5%	A_7	☒	7.5 7.8	Grain Size (A-53) w = 10.7%
	Bottom of Hole at 8.5 m depth					

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TEST HOLE NO.
7

TEST HOLE LOG

DEPTH (M)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	MATERIAL DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %	SAMPLE TYPE AND NUMBER	SAMPLE CONDITION	DEPTH (M)	OTHER INFORMATION
1	SM		SAND little silt, trace gravel to 2 cm size, fine to medium grained		Vx 5%				
2	GM		GRAVEL some silt, some sand, rounded, to 6 cm size			A_1	☒	1.2 1.5	Organic Colour: #5+ Grain Size (A-54) w = 42.0%
	SM		SAND some gravel to 4 cm size, little silt		Nbn	A_2	☒	2.0 2.3	Grain Size (A-55) w = 15.1%
			-- and silt, little gravel to 4 cm size, fine to coarse grained			A_3	☒	2.5 2.8	w = 17.5%
3						A_4	☒	3.0 3.3	Grain Size (A-56) w = 27.6%
4			--- 0.2 m thick layer, trace gravel to 2 cm size						
			ice layers to 10 cm thickness		Vs 50%	A_5	☒	4.5 4.7	w = 24.9%
5 6 7 8	I+		ICE+ little sand, trace gravel		I+ 80%				
9	SP		SAND trace gravel, fine to medium grained		Vs 40%	A_6	☒	8.5 8.7	
10			Bottom of Hole at 9.0 m depth						

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TEST HOLE NO.
8

TEST HOLE LOG

DEPTH (M)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	MATERIAL DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %	SAMPLE TYPE AND NUMBER	SAMPLE CONDITION	DEPTH (M)	OTHER INFORMATION
	SM		SAND little silt, fine to medium grained, brown		Vx 5%				
1						A_1	☒	0.7 1.0	w = 28.6%
2			and rounded to subrounded gravel to 5 cm size		Nbn	A_2	☒	2.4 2.7	Organic Colour: #5+ Grain Size (A-57) Petrographics (A-81) w = 13.6%
3						A_3	☒	3.2 3.5	w = 27.5%
			ice layers to 5 cm thickness		Vs 50%				
4	I+		ICE+ little sand, trace gravel		I+ 80%				
5									
6									
7									
8									
9			Bottom of Hole at 9.0 m depth						
10									

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TEST HOLE NO.
9

TEST HOLE LOG

DEPTH (M)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	MATERIAL DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %	SAMPLE TYPE AND NUMBER	SAMPLE CONDITION	DEPTH (M)	OTHER INFORMATION
	Pt		PEAT		Vr 20%				
	ML		SILT trace sand, non plastic, brown		Nbe	A1	☒	1.2 1.5	w = 29.3%
	SW		SAND little rounded gravel to 4 cm size, trace silt, fine to coarse grained		Nbn	A2	☒	1.8 2.1	w = 20.9%
	GP-GM		GRAVEL some fine to medium grained sand, little silt, rounded to subrounded, to 7.5 cm size ice layers to 10 cm thickness		Vs 50%	A3	☒	2.5 2.8	Grain Size (A-58) w = 9.1%
	I+		ICE+ trace sand		I+ 90%				
			some sand, fine to medium grained		60%	A4	☒	5.5 5.6	
	SP		SAND trace gravel to 1 cm size, fine to medium grained		Vc 30%	A5	☒	6.3 6.6	
					Nbe	A6	☒	8.7	
			Bottom of Hole at 9.0 m depth						

DATE: 80.01.22	LOGGED BY: G.D.	DRWN BY: C.G.	CHKD BY: N.H.

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TEST HOLE NO.
10

TEST HOLE LOG

DEPTH (M)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	MATERIAL DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %	SAMPLE TYPE AND NUMBER	SAMPLE CONDITION	DEPTH (M)	OTHER INFORMATION
	SM	⁙	SAND little silt, occasional pebble to 1 cm size, brown	⁙	Nbn	A_1	☒	0.5 0.7	
1		⁙		⁙					
2		⁙	--- little gravel to 1 cm size	⁙		A_2	☒	1.8 2.1	
	I+	▮	ICE+ trace sand	▮	I+ 90%				
3		▮		▮					
4		▮	--- little medium grained sand	▮	80%	A_3	☒	4.5 4.8	
5		▮	--- trace sand	▮	95%				
6		▮		▮					
7		▮		▮					
8		▮		▮					
9			Bottom of Hole at 9.0 m depth						
10									

DATE: 80.01.22	LOGGED BY: G.D.	DRWN BY: C.G.	CHKD BY: N.H.

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TEST HOLE NO.
11

TEST HOLE LOG

DEPTH (M)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	MATERIAL DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %	SAMPLE TYPE AND NUMBER	SAMPLE CONDITION	DEPTH (M)	OTHER INFORMATION
	Pt		PEAT		Vr 30%				
1	ML		SILT trace fine sand, non plastic, brown		Nbe	A_1	☒	0.8 1.0	
2	SP		SAND trace silt, fine to medium grained, occasional coarse grained sand sizes to 0.5 cm		Vx 30%	A_2	☒	2.0 2.2	
					Vs 60%				
3 4 5	I+		ICE+ trace fine silty sand		I+ 95%	A_3	☒	4.0 4.2	
6 7 8 9					90%	A_4	☒	7.0 7.3	
10			Bottom of Hole at 9.4 m depth						

DATE: 80.01.23
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TEST HOLE NO.
12

TEST HOLE LOG

DEPTH (M)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	MATERIAL DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %	SAMPLE TYPE AND NUMBER	SAMPLE CONDITION	DEPTH (M)	OTHER INFORMATION
	Pt		PEAT		Vr				
	ML		SILT trace fine sand, brown		30%				
	I+		ICE+ trace sandy silt		Nbe I+ 90%	A_1	☒	0.5 0.8	
1 2	ML		SILT little fine sand, occasional coarse sand sizes to 0.5 cm - frequent pebbles to 1 cm size, occasional pebbles to 7 cm size		Vx 20% Nbn	A_2	☒	2.0 2.2	
	SP		SAND trace silt, medium to coarse grained		Vx 10%				
3 4 5 6	SM		SAND little silt, occasional coarse sand sizes to 0.5 cm, fine to medium grained		30% Vc 20%	A_3 A_4	☒ ☒	3.2 3.5 5.5 5.8	
7 8	SP		SAND trace silt, occasional coarse sand sizes to 0.5 cm, fine to medium grained		Vs 40%	A_5	☒	7.2 7.5	
9 10			Bottom of Hole at 9.0 m depth						

DATE: 80.01.23	LOGGED BY: G.D.	DRWN BY: C.G.	CHKD BY: N.H.

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TEST HOLE NO.
13

TEST HOLE LOG

DEPTH (M)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	MATERIAL DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %	SAMPLE TYPE AND NUMBER	SAMPLE CONDITION	DEPTH (M)	OTHER INFORMATION
	Pt		PEAT		Vr 30%				
	ML		SILT little fine sand, occasional pebbles to 1.5 cm size, brown		Vx 20%				
1						A1	☒	1.2 1.4	
2	SP		SAND trace silt, occasional pebbles to 1.0 cm size, fine to medium grained						
						A2	☒	2.5 2.8	
3					Vs- Vx 40%				
4	I+		ICE+ trace silty sand		I+ 95%	A3	☒	4.5 4.8	
5	SP		SAND fine to medium grained, occasional coarse sand sizes		Vx 30%				
6					Vc 20%	A4	☒	6.0 6.3	
7									
8						A5	☒	8.0 8.5	
	I+		ICE trace sand		I+ 95%				
9	SP		SAND fine to medium grained		Vc 20%				
			Bottom of Hole at 9.4 m depth						
10									

DATE: 80.01.23

LOGGED BY: A.C.

DRWN BY: C.G.

CHKD BY: N.H.

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TEST HOLE NO. 14

TEST HOLE LOG

DEPTH (M)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	MATERIAL DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %	SAMPLE TYPE AND NUMBER	SAMPLE CONDITION	DEPTH (M)	OTHER INFORMATION
	Pt		PEAT		Vr 30%	A_1	☒	0.4 0.6	w = 83.1%
	ML		SILT sandy, occasional pebbles to 1.5 cm size, occasional boulders		Vx 40%				
1			-- sandy, gravelly, frequent rounded cobbles, occasional boulders		20%	A_2	☒	1.5 1.8	w = 22.5%
2									
	SP		SAND trace silt, occasional pebbles to 1 cm size, fine to medium grained		10%				
3	I+		ICE+ trace sand		I+ 90%				
4						A_3	☒	3.8 4.0	
5			--- little silty sand		80%	A_4	☒	5.5 5.8	
6									
7			---and fine to medium sand		50%	A_5	☒	6.8 7.0	
8						A_6	☒	8.2 8.6	
9			Bottom of Hole at 8.8 m depth						
10									

DATE: 80.01.23
LOGGED BY: A.C.
DRWN BY: C.G.
CHKD BY: N.H.

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TEST HOLE NO. 15

DATE: LOGGED BY: DRWN BY: CHKD BY:

TEST HOLE LOG

DEPTH (M)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	MATERIAL DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %	SAMPLE TYPE AND NUMBER	SAMPLE CONDITION	DEPTH (M)	OTHER INFORMATION
	SM		SAND some rounded gravel to 6 cm size, little silt, brown - and silt, little gravel to 2.5 cm size		Nbn	A_1	☒	0.7 1.0	Grain Size (A-59) w = 17.9%
1	SP		SAND trace silt, fine to medium grained			A_2	☒	1.5 1.8	
2						A_3	☒	2.8 3.0	
3									
4						A_4	☒	4.8 5.0	
5									
6									
7						A_5	☒	7.3 7.5	
8						A_6	☒	8.7	
9			Bottom of Hole at 9.0 m depth						
10									

DATE: 80.01.23

LOGGED BY: G.D.

DRWN BY: C.G.

CHKD BY: N.H.

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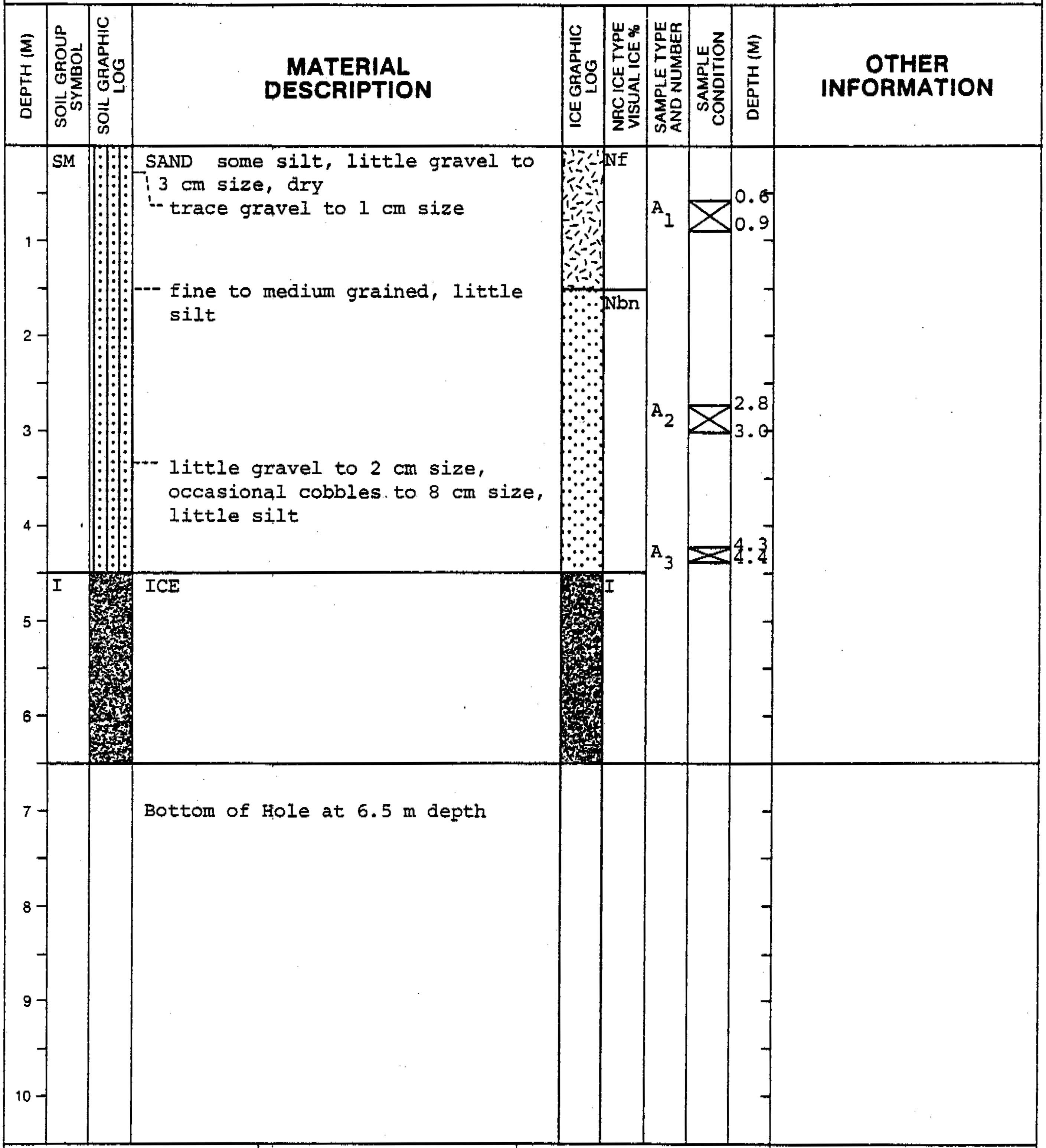
TEST HOLE NO.
16

TEST HOLE LOG



DEPTH (M)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	MATERIAL DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %	SAMPLE TYPE AND NUMBER	SAMPLE CONDITION	DEPTH (M)	OTHER INFORMATION
	SM		SAND some silt, little gravel to 3 cm size, dry trace gravel to 1 cm size		Nf	A_1	☒	0.6 0.9	
			fine to medium grained, little silt		Nbn				
						A_2	☒	2.8 3.0	
			little gravel to 2 cm size, occasional cobbles to 8 cm size, little silt						
						A_3	☒	4.3 4.4	
	I		ICE		I				
			Bottom of Hole at 6.5 m depth						

DATE: 80.01.26

LOGGED BY: G.D.

DRWN BY: C.G.

CHKD BY: N.H.

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TEST HOLE NO.
17

TEST HOLE LOG

DEPTH (M)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	MATERIAL DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %	SAMPLE TYPE AND NUMBER	SAMPLE CONDITION	DEPTH (M)	OTHER INFORMATION
1 2	SP	░	SAND trace silt, occasional pebbles to 1 cm size, fine to medium grained --- trace gravel to 6 cm size, rounded --- no gravel	▨	Nf	A_1	☒	0.8 0.9	
3 4	I+	▮	ICE+	▮	I+ 95%				
5 6 7 8 9 10			Bottom of Hole at 4.0 m depth						

DATE: 80.01.26	LOGGED BY: G.D.	DRWN BY: C.G.	CHKD BY: N.H.

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TEST HOLE NO. 18

TEST HOLE LOG

DEPTH (M)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	MATERIAL DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %	SAMPLE TYPE AND NUMBER	SAMPLE CONDITION	DEPTH (M)	OTHER INFORMATION
	SP		SAND and rounded gravel to 3 cm size, little silt, fine to coarse grained, poorly graded, dry to 1.0 m depth		Nf	A_1	☒	0.6 0.8	Organic Colour: #5+ Grain Size (A-60) w = 14.1%
			- trace silt		Nbn	A_2	☒	1.6 1.8	Grain Size (A-61) w = 14.4%
	SM		SAND little gravel to 5 cm size, little silt			A_3	☒	2.8 3.0	Grain Size (A-62) w = 22.4%
			--- some gravel to 3 cm size			A_4	☒	3.5 3.6	w = 11.6%
4	I+		ICE+ trace sand		I+ 95%				
6			Bottom of Hole at 6.0 m depth						

DATE: 80.01.26
LOGGED BY: G.D.
DRWN BY: C.G.
CHKD BY: N.H.

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TEST HOLE NO.
19

TEST HOLE LOG

DEPTH (M)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	MATERIAL DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %	SAMPLE TYPE AND NUMBER	SAMPLE CONDITION	DEPTH (M)	OTHER INFORMATION
	Pt		PEAT		Vr				
1	SP		SAND and rounded to subrounded gravel to 3 cm size, fine to coarse grained, poorly graded, dry --- some gravel, frequent cobbles and boulders		20% Nf	A_1	☒	0.3 0.6	Organic Colour: #5+ Grain Size (A-63) w = 5.3%
2	SM		SAND some rounded gravel to cobble size, little silt in pockets, fine to medium grained		Vx 10%	A_2	☒	1.8 2.0	
3	GW		GRAVEL and fine to coarse sand, trace silt, rounded, well graded			A_3	☒	3.0 3.2	Grain Size (A-64) w = 11.5%
	SP		SAND little silt in pockets, trace gravel, fine to medium grained		15%				
4 5 6	I+		ICE+ trace silt, trace fine sand ---little sand		I+ 95% 80%	A_4 A_5	☒ ☒	3.9 4.2 6.1 6.3	
7 8 9 10			Bottom of Hole at 6.5 m depth						

DATE: 80.01.25	LOGGED BY: A.C.	DRWN BY: C.G.	CHKD BY: N.H.

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TEST HOLE NO.
20

TEST HOLE LOG

DEPTH (M)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	MATERIAL DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %	SAMPLE TYPE AND NUMBER	SAMPLE CONDITION	DEPTH (M)	OTHER INFORMATION
	SM	▥	SAND trace gravel to 2 cm size, trace silt, dry, gravel to 7 cm size to 0.5 m depth	▨	Nf	A_1	☒	0.6 0.9	Grain Size (A-65) w = 23.9%
1	GP	○	GRAVEL some fine to medium sand, trace silt, rounded to subangular, to 4 cm size, dry			A_2	☒	1.2 1.4	
2			--- to 2 cm size			A_3	☒	2.0 2.2	
						A_4	☒	2.5 2.6	
3	SP	▒	SAND trace gravel to 1 cm size, trace silt, fine to coarse grained	○	Vc 5%				
4						A_5	☒	3.9 4.0	
			--- and gravel to 4 cm size			A_6	☒	4.4 4.5	Grain Size (A-66) w = 14.7%
5			--- trace gravel to 1 cm size		10%	A_7	☒	5.5 5.7	
6						A_8	☒	6.0 6.2	
	I	▓	ICE	▓	I				
7			Bottom of Hole at 6.5 m depth						
8									
9									
10									

DATE: 80.01.25 LOGGED BY: G.D. DRWN BY: C.G. CHKD BY: N.H.

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TEST HOLE NO.
21

TEST HOLE LOG

DEPTH (M)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	MATERIAL DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %	SAMPLE TYPE AND NUMBER	SAMPLE CONDITION	DEPTH (M)	OTHER INFORMATION
	SM		SAND little angular gravel to 6 cm size, little silt, medium grained, dry		Nf	A_1	☒	0.6 0.9	
1			-- trace gravel to 1 cm size						
2						A_2	☒	1.6 1.9	
3						A_3	☒	2.6 2.9	
4						A_4	☒	3.7	
			Bottom of Hole at 4.0 m depth						
5									
6									
7									
8									
9									
10									

DATE: 80.01.25

LOGGED BY: G.D.

DRWN BY: C.G.

CHKD BY: N.H.

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TEST HOLE NO.
22

TEST HOLE LOG

DEPTH (M)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	MATERIAL DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %	SAMPLE TYPE AND NUMBER	SAMPLE CONDITION	DEPTH (M)	OTHER INFORMATION
	ML		SILT little sand, trace angular gravel		Vx 5%	A_1	☒	1.2 1.4	w = 17.8%
	SM		SAND and rounded to subangular gravel, little silt, fine to coarse grained		2%	A_2	☒	1.6 1.8	Grain Size (A-67) w = 14.3%
	I+		ICE+ trace sand --- some sand		I+ 90% 70%	A_3	☒	4.3 4.4	
	SP		SAND trace gravel to 1 cm size, fine to medium grained		Vc 40%				
	I		ICE		I				

Bottom of Hole at 4.6 m depth

DATE: 80.01.25

LOGGED BY: G.D.

DRWN BY: C.G.

CHKD BY: N.H.

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TEST HOLE NO.
23

TEST HOLE LOG

DEPTH (M)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	MATERIAL DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %	SAMPLE TYPE AND NUMBER	SAMPLE CONDITION	DEPTH (M)	OTHER INFORMATION
	Pt		PEAT		Vr				
	GM		GRAVEL and sand, little silt, to 10 cm cobble size, rounded		30%	A_1	☒	0.4 0.7	Grain Size (A-68) w = 13.3%
1	SW		SAND some rounded gravel to 3 cm size, trace silt, rounded - trace gravel to 2 cm size		Nbn				
2	SM		SAND little silt, occasional pebble to 2 cm size, dark brown			A_2	☒	1.8 2.0	
3						A_3	☒	3.3	
4			Bottom of Hole at 3.5 m depth						
5									
6									
7									
8									
9									
10									

DATE: 80.01.25	LOGGED BY: G.D.	DRWN BY: C.G.	CHKD BY: N.H.

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TEST HOLE NO.
24

TEST HOLE LOG

DEPTH (M)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	MATERIAL DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %	SAMPLE TYPE AND NUMBER	SAMPLE CONDITION	DEPTH (M)	OTHER INFORMATION
	GP		GRAVEL and sand, trace silt, to 8 cm size, rounded		Nf				
1	SP		SAND some rounded gravel to 5 cm size, trace silt, fine to coarse grained, poorly graded - some rounded gravel to 3 cm size			A_1	☒	0.8 1.0	Grain Size (A-69) w = 15.0%
2						A_2	☒	2.2 2.4	w = 24.9%
3						A_3	☒	3.0 3.2	Organic Colour: #3- Grain Size (A-70) Petrographics (A-82) w = 18.1%
4	SW-SM		SAND little gravel to 2 cm size, little silt, fine to coarse grained, well graded			A_4	☒	4.5 4.7	Grain Size (A-71) w = 19.7%
5			-- some gravel to 3 cm size			A_5	☒	5.1 5.3	Grain Size (A-72) w = 17.7%
			ice layers to 10 cm thickness---		Vs 30%				
6	SW		SAND trace gravel to 1 cm size, trace silt, fine to coarse grained		Nbe	A_6	☒	6.2 6.4	
7	I		ICE		I				
	SW		SAND trace gravel to 1 cm size, trace silt, fine to coarse grained		Vs 5%				
8						A_7	☒	7.9 8.0	
9			Bottom of Hole at 9.0 m depth						
10									

DATE: 80.01.25	LOGGED BY: G.D.	DRWN BY: C.G.	CHKD BY: N.H.

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TEST HOLE NO.
25

TEST HOLE LOG

DEPTH (M)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	MATERIAL DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %	SAMPLE TYPE AND NUMBER	SAMPLE CONDITION	DEPTH (M)	OTHER INFORMATION
	Pt		PEAT		Vr 20%				
1	GP		GRAVEL and fine to coarse sand, trace silt, numerous cobbles to 5 cm size, poorly graded		Nbn	A_1	☒	0.5 0.7	Organic Color #5+ Grain Size (A-73) w = 17.2%
2	SM		SAND and gravel to 5 cm size, silty, fine to medium grained little gravel to 5 cm size		Vc 5%	A_2	☒	2.0 2.2	w = 24.1%
3	GP		GRAVEL and medium to coarse sand, occasional cobbles, rounded, to 4 cm size		Vx 5% 20%	A_3	☒	3.1 3.3	Grain Size (A-74) w = 10.7%
4 5	I+		ICE+ trace fine sand		I+ 95%	A_4	☒	3.8 4.0	
6 7 8 9 10			Bottom of Hole at 6.0 m depth						

DATE: 80.01.25

LOGGED BY: A.C.

DRWN BY: C.G.

CHKD BY: N.H.

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TEST HOLE NO. 26

TEST HOLE LOG

DEPTH (M)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	MATERIAL DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %	SAMPLE TYPE AND NUMBER	SAMPLE CONDITION	DEPTH (M)	OTHER INFORMATION
	Pt		PEAT		Vr 25%				
	ML		SILT trace fine sand, occasional cobbles to 10 cm size	+ +	Vx 20%	A_1	☒	0.6 0.8	
1				+ +					
			--- frequent large boulders	+ +					
2			Bottom of Hole at 1.8 m depth						
3									
4									
5									
6									
7									
8									
9									
10									

DATE: 80.01.25	LOGGED BY: A.C.	DRWN BY: C.G.	CHKD BY: N.H.

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TEST HOLE NO.
26a

TEST HOLE LOG

DEPTH (M)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	MATERIAL DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %	SAMPLE TYPE AND NUMBER	SAMPLE CONDITION	DEPTH (M)	OTHER INFORMATION
	Pt		PEAT		Vr 10%				
	GW		GRAVEL some fine to coarse sand, trace silt, occasional boulders, rounded, to 5 cm size		Nbn	A_1	☒	0.4 0.6	Grain Size (A-75) w = 4.8%
1									
	SP		SAND and gravel						
2			--medium grained, little gravel to 3 cm size, silty pockets		Vx 2%	A_2	☒	2.1 2.3	w = 23.2%
3			--- medium grained, clean		Nbn				
						A_3	☒	3.5 3.8	
4									
5									
			--- trace silt, occasional coarse sand sizes to 0.5 cm						
6						A_4	☒	6.0 6.3	
7					Vx 20%				
8						A_5	☒	7.8 8.1	
9			Bottom of Hole at 8.5 m depth						
10									

DATE: 80.01.25	LOGGED BY: A.C.	DRWN BY: C.G.	CHKD BY: N.H.

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TEST HOLE NO.
27

TEST HOLE LOG

DEPTH (M)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	MATERIAL DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %	SAMPLE TYPE AND NUMBER	SAMPLE CONDITION	DEPTH (M)	OTHER INFORMATION
	Pt		PEAT		Vr 20%				
	ML		SILT and fine sand, occasional pebbles to 1 cm size, brown trace sand		Vx 40%	A_1	☒	0.6 0.8	
1					30%				
2						A_2	☒	2.1	
3			Bottom of Hole at 2.3 m depth						
4									
5									
6									
7									
8									
9									
10									

DATE: 80.01.25

LOGGED BY: A.C.

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CHKD BY: N.H.

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TEST HOLE NO.
28

TEST HOLE LOG

DEPTH (M)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	MATERIAL DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %	SAMPLE TYPE AND NUMBER	SAMPLE CONDITION	DEPTH (M)	OTHER INFORMATION
	Pt		PEAT		Vr 20%				
	SP		SAND and rounded gravel to 3 cm size, fine to coarse grained, poorly graded, dry		Nf	A_1	☒	0.4 0.7	Grain Size (A-76) *w* = 5.4%
1									
2			little rounded gravel		Nbn	A_2	☒	2.0 2.3	*w* = 17.0%
3			occasional rounded pebbles to 5 cm size			A_3	☒	3.2 3.5	
4					Vx 10%				
5			occasional pebbles to 1 cm size						
6						A_4	☒	6.0 6.3	
			trace silt		20%				
7									
8			Bottom of Hole at 8.0 m depth						
9									
10									

DATE: 80.01.25

LOGGED BY: A.C.

DRWN BY: C.G.

CHKD BY: N.H.

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TEST HOLE NO.
28a

TEST HOLE LOG

DEPTH (M)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	MATERIAL DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %	SAMPLE TYPE AND NUMBER	SAMPLE CONDITION	DEPTH (M)	OTHER INFORMATION
	Pt		PEAT		Vr				
1	SP		SAND trace silt, fine grained, occasional coarse sand sizes to 0.5 cm		30% Nf	A_1	☒	0.4 0.6	
						A_2	☒	1.6 1.8	
2			-- fine to medium grained, trace silt	+	Vx 5%				
3 4	I+		ICE+ trace silty sand		I+ 95%	A_3	☒	2.5 2.8	
5	SM		SAND silty, fine to medium grained ice layers to 3 cm thickness		Vs- Vx 50%	A_4	☒	4.5 4.7	
6			Bottom of Hole at 5.5 m depth						
7									
8									
9									
10									

DATE: 80.01.27	LOGGED BY: A.C.	DRWN BY: C.G.	CHKD BY: N.H.

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TEST HOLE NO.
29

TEST HOLE LOG

DEPTH (M)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	MATERIAL DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %	SAMPLE TYPE AND NUMBER	SAMPLE CONDITION	DEPTH (M)	OTHER INFORMATION
	Pt		PEAT		Vr 30%				
	ML		SILT some fine sand		Vx 20%	A_1	☒	0.4 0.6	*w* = 10.7%
1 2	SM		SAND and rounded gravel to 3 cm size, little silt, fine to coarse grained		Vx- Vc 15%	A_2	☒	1.6 1.8	Grain Size (A-77) *w* = 13.4%
	SP		SAND trace gravel		Vs- Vx 40%				
3	I+		ICE+ trace sand		I+ 95%				
4	SP		SAND trace silt, fine to medium grained, occasional coarse sand sizes to 0.5 cm		Nbn	A_3	☒	4.0 4.2	
5 6	SM		SAND silty inclusions			A_4	☒	6.0 6.3	
	I+		ICE+ trace silty sand		I+ 95%				
7	SM		SAND little silt, fine to medium grained		Nbn				
8 9 10			Bottom of Hole at 7.5 m depth						

DATE: 80.01.27	LOGGED BY: A.C.	DRWN BY: C.G.	CHKD BY: N.H.

GOVERNMENT OF CANADA
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TEST HOLE NO.
30

TEST HOLE LOG

DEPTH (M)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	MATERIAL DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %	SAMPLE TYPE AND NUMBER	SAMPLE CONDITION	DEPTH (M)	OTHER INFORMATION
	Pt		PEAT		Vr				
	SM		SAND little silt, fine to medium grained		30% Nbn	A_1	☒	0.4 0.6	
	I+		ICE+ trace silty sand		I+ 90%	A_2	☒	2.0 2.2	
			--- little silty sand		80%	A_3	☒	4.0 4.2	
			Bottom of Hole at 5.5 m depth						

DATE: 80.01.27

LOGGED BY: A.C.

DRWN BY: C.G.

CHKD BY: N.H.

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TEST HOLE NO. 31

TEST HOLE LOG

DEPTH (M)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	MATERIAL DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %	SAMPLE TYPE AND NUMBER	SAMPLE CONDITION	DEPTH (M)	OTHER INFORMATION
	Pt		PEAT		Vr				
	SM		SAND silty, trace gravel, fine to medium grained		30% Nf	A_1	☒	0.4 0.6	
1									
			--- silty, fine grained, occasional coarse sand sizes to 0.5 cm		Vc 5%				
2						A_2	☒	2.0 2.3	
			--- little silt						
3									
						A_3	☒	3.6 4.0	
4									
5									
						A_4	☒	5.8	
6									
			Bottom of Hole at 6.0 m depth						
7									
8									
9									
10									

DATE: 80.01.26

LOGGED BY: A.C.

DRWN BY: C.G.

CHKD BY: N.H.

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TEST HOLE NO.
32

TEST HOLE LOG

DEPTH (M)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	MATERIAL DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %	SAMPLE TYPE AND NUMBER	SAMPLE CONDITION	DEPTH (M)	OTHER INFORMATION
	Pt		PEAT		Vr				
	ML		SILT fine sandy		30% Vx	A_1	☒	0.4 0.6	w = 84.5%
1			--- frequent thin sand layers, trace gravel		20% Vs 25% Vx 5%	A_2	☒	1.6 1.9	w = 43.6%
2	GM		GRAVEL and fine to coarse sand, some silt, to 5 cm size, occasional cobbles		10%	A_3	☒	2.2 2.5	Grain Size (A-78) w = 12.2%
3	ML		SILT some sand, occasional coarse sand sizes to 0.5 cm		20%				
	I+		ICE+ trace silty sand		I+ 95%	A_4	☒	3.5 3.8	
4									
5									
6			Bottom of Hole at 5.8 m depth						
7									
8									
9									
10									

DATE: 80.01.26
LOGGED BY: A.C.
DRWN BY: C.G.
CHKD BY: N.H.

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NORTHERN DEVELOPMENT

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TEST HOLE NO.
33

TEST HOLE LOG

DEPTH (M)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	MATERIAL DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %	SAMPLE TYPE AND NUMBER	SAMPLE CONDITION	DEPTH (M)	OTHER INFORMATION
	Pt		PEAT		Vr				
1	SP		SAND little gravel to 1 cm size, fine to medium grained		30% Nf	A_1	☒	0.4 0.6	
2	SM		SAND large silty pockets, occasional pebbles to 1 cm size, fine to medium grained		Vx Vc 10%	A_2	☒	1.5 1.8	
3 4 5	I+		ICE+ trace silty sand		I+ 95%	A_3	☒	3.0 3.3	
6 7 8 9 10			Bottom of Hole at 5.5 m depth						

DATE: 80.01.26	LOGGED BY: A.C.	DRWN BY: C.G.	CHKD BY: N.H.

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AND
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TEST HOLE NO. 34

TEST HOLE LOG

DEPTH (M)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	MATERIAL DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %	SAMPLE TYPE AND NUMBER	SAMPLE CONDITION	DEPTH (M)	OTHER INFORMATION
	Pt		PEAT		Vr				
	ML		SILT little sand	+ +	40%				
	I+		ICE+ trace silt, clear		Vx 30%	A_1	☒	0.6 0.8	
1					I+ 95%				
	SM		SAND little gravel, silty	+ + + +	Vx 15%	A_2	☒	1.8 2.0	
2			-- occasional cobbles, boulders	+ + + +					
3	I+		ICE+ trace sand in layers, clear		I+ 95%				
4						A_3	☒	4.0 4.2	
5									
6			Bottom of Hole at 6.0 m depth						
7									
8									
9									
10									

DATE: 80.01.26	LOGGED BY: A.C.	DRWN BY: C.G.	CHKD BY: N.H.

GOVERNMENT OF CANADA DEPARTMENT OF INDIAN AFFAIRS AND NORTHERN DEVELOPMENT	HARDY ASSOCIATES (1978) LTD. CONSULTING ENGINEERING & PROFESSIONAL SERVICES	TEST HOLE NO. 35

TEST HOLE LOG

DEPTH (M)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	MATERIAL DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %	SAMPLE TYPE AND NUMBER	SAMPLE CONDITION	DEPTH (M)	OTHER INFORMATION
	Pt		PEAT		Vx 40%				
	ML		SILT trace sand		Vs 40%	A_1	☒	0.4 0.6	
	I+		ICE+ little silt		I+ 80%				
1	ML		SILT some fine to medium sand		Vx 20%				
2	GM		GRAVEL and sand, silty, rounded to subrounded, to 4 cm size		10%	A_2	☒	1.6 2.0	
	SP		SAND little gravel						
3 4 5	ML		SILT and sand, trace gravel		30%	A_3	☒	3.0 3.2	
6	I		ICE		I	A_4	☒	5.5 5.7	
7	SM		SAND little gravel, silty --- boulder		Vx 20%				
8			--- and silt, occasional rounded pebbles		Vc-Vx 20%	A_5	☒	7.3 7.5	
9	I+		ICE+ little sandy silt		I+ 80%				
10			Bottom of Hole at 9.0 m depth						

DATE: 80.01.26

LOGGED BY: A.C.

DRWN BY: C.G.

CHKD BY: N.H.

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NORTHERN DEVELOPMENT

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TEST HOLE NO.
36

TEST HOLE LOG

DEPTH (M)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	MATERIAL DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %	SAMPLE TYPE AND NUMBER	SAMPLE CONDITION	DEPTH (M)	OTHER INFORMATION
	Pt		PEAT		Vr				
1	ML		SILT some fine sand		30% Vx 20%	A_1	☒	0.4 0.6	
2			--- little gravel, trace fine sand, frequent rounded cobbles		Vx-Vc 15%	A_2	☒	2.0 2.3	
3 4	SM		SAND little silt, fine to medium grained		Vx 10%	A_3	☒	3.2 3.5	
5	I+		ICE+ trace silty sand		I+ 95%	A_4	☒	5.0 5.2	
6 7 8 9 10			Bottom of Hole at 6.0 m depth						

DATE: 80.01.27

LOGGED BY: A.C.

DRWN BY: C.G.

CHKD BY: N.H.

GOVERNMENT OF CANADA
DEPARTMENT OF INDIAN AFFAIRS
AND
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TEST HOLE NO. 37

TEST HOLE LOG

DEPTH (M)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	MATERIAL DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %	SAMPLE TYPE AND NUMBER	SAMPLE CONDITION	DEPTH (M)	OTHER INFORMATION
	Pt		PEAT		Vr				
1	ML		SILT some sand		25% Vc-Vx 20%	A_1	☒	0.4 0.6	w = 72.4%
2			-- little fine sand, occasional coarse sand sizes to 0.5 cm		Vx 20%	A_2	☒	1.6 1.8	w = 26.8%
	GM		GRAVEL some fine to coarse sand, some silt, rounded to subrounded, to 5 cm size, occasional large cobbles		Nbn	A_3	☒	2.5 2.8	Grain Size (A-79) w = 9.1%
3 4	SM		SAND little silt, occasional pebble, fine to medium grained		Vx 20% 15%	A_4	☒	3.8 4.0	
5			-- and silt			A_5	☒	5.0 5.3	
	I+		ICE+ trace sand		I+ 95%				
6	ML		SILT little sand, occasional coarse sand sizes to 0.5 cm		Vx 20%				
			Bottom of Hole at 6.0 m depth						
7									
8									
9									
10									

DATE: 80.01.26 LOGGED BY: A.C. DRWN BY: C.G. CHKD BY: N.H.

GOVERNMENT OF CANADA
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NORTHERN DEVELOPMENT

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TEST HOLE NO.
38

TEST HOLE LOG

DEPTH (M)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	MATERIAL DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %	SAMPLE TYPE AND NUMBER	SAMPLE CONDITION	DEPTH (M)	OTHER INFORMATION
	Pt		PEAT		Vr 30%				
1	I+		ICE+ some silt, trace fine sand		I+ 70%	A_1	☒	0.7 0.9	w = 171.1%
2	SM		SAND some angular to rounded gravel to 2.5 cm size, little silt fine to coarse grained		Nbn	A_2	☒	2.0 2.2	Grain Size (A-80) w = 19.6%
3	SW		SAND occasional pebbles to 1.5 cm size, fine to coarse grained		Nf	A_3	☒	2.8 3.0	
4 5	I+		ICE+ some sand -- trace sand		I+ 70% 95%				
6 7 8 9 10			Bottom of Hole at 5.5 m depth						

DATE: 80.01.26

LOGGED BY: G.D.

DRWN BY: C.G.

CHKD BY: N.H.

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TEST HOLE NO. 39

TEST HOLE LOG

DEPTH (M)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	MATERIAL DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %	SAMPLE TYPE AND NUMBER	SAMPLE CONDITION	DEPTH (M)	OTHER INFORMATION
	Pt		PEAT		Vr 30%				
	I+		ICE+ some silt, trace sand		I+ 70%	A_1	☒	0.7 0.9	
1	ML		SILT some sand, occasional pebbles, non plastic -- little rounded gravel to 5 cm size		Nbn				
2			-- little fine to medium sand, occasional pebble -- some fine to medium sand			A_2	☒	2.0 2.2	
3						A_3	☒	3.0 3.2	
4			-- cobble			A_4	☒	4.0	
			Bottom of Hole at 4.2 m depth						
5									
6									
7									
8									
9									
10									

DATE: 80.01.26

LOGGED BY: G.D.

DRWN BY: C.G.

CHKD BY: N.H.

GOVERNMENT OF CANADA
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NORTHERN DEVELOPMENT

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TEST HOLE NO.
40

GRAIN SIZE ANALYSIS

GOVERNMENT OF CANADA
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AND
NORTHERN DEVELOPMENT

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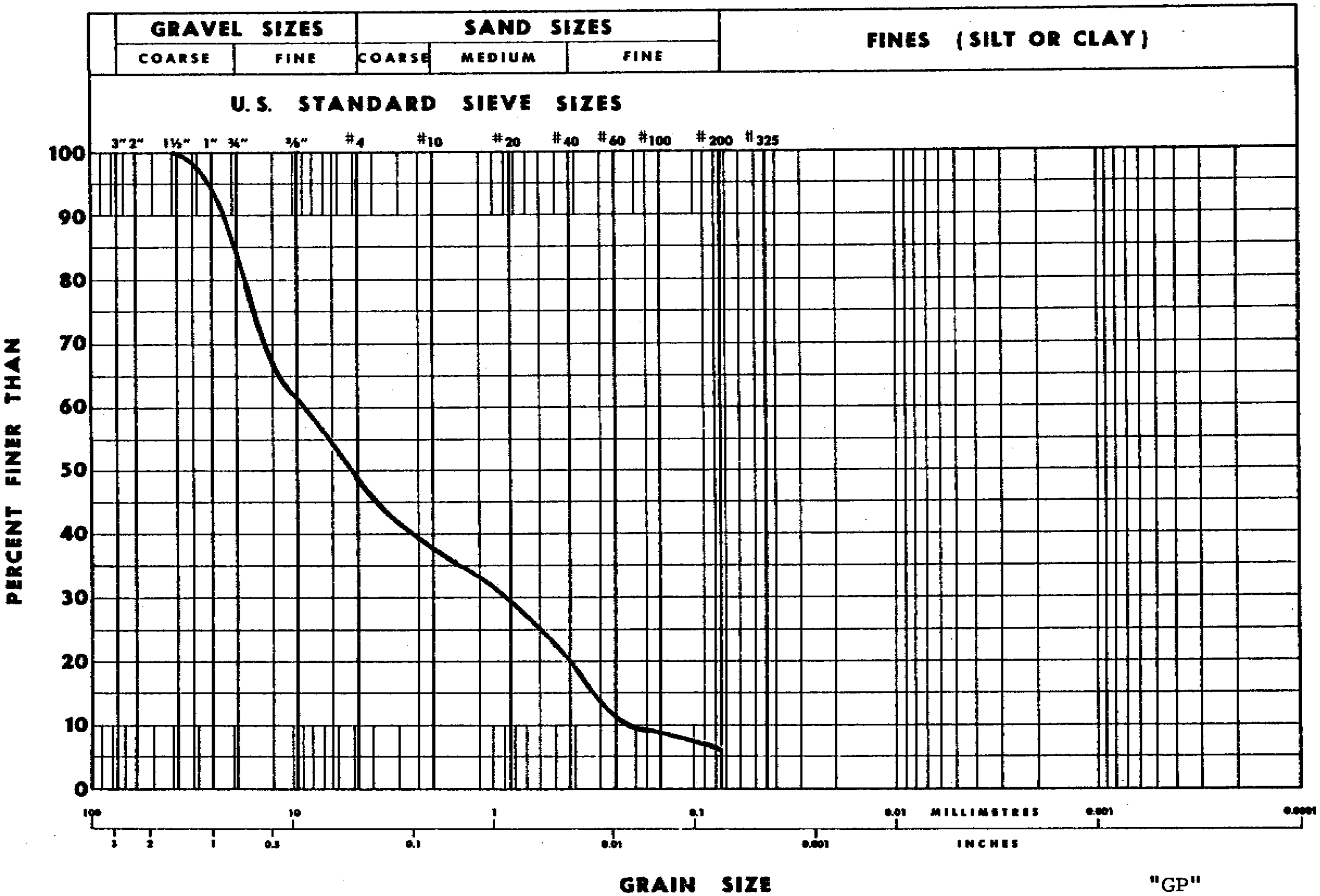
TEST HOLE NO. 4



REMARKS: Sample A1, 0.3 - 0.6 m

Gravel	51.5%
Sand	41.6%
Fines	6.9%

"GP"

D_{10}= 0.2 MM.
D_{30}= 0.8 MM.
D_{60}= 8.5 MM.
C_U 42.5
C_C 0.38

NOTE: UNIFIED SOIL CLASSIFICATION SYSTEM

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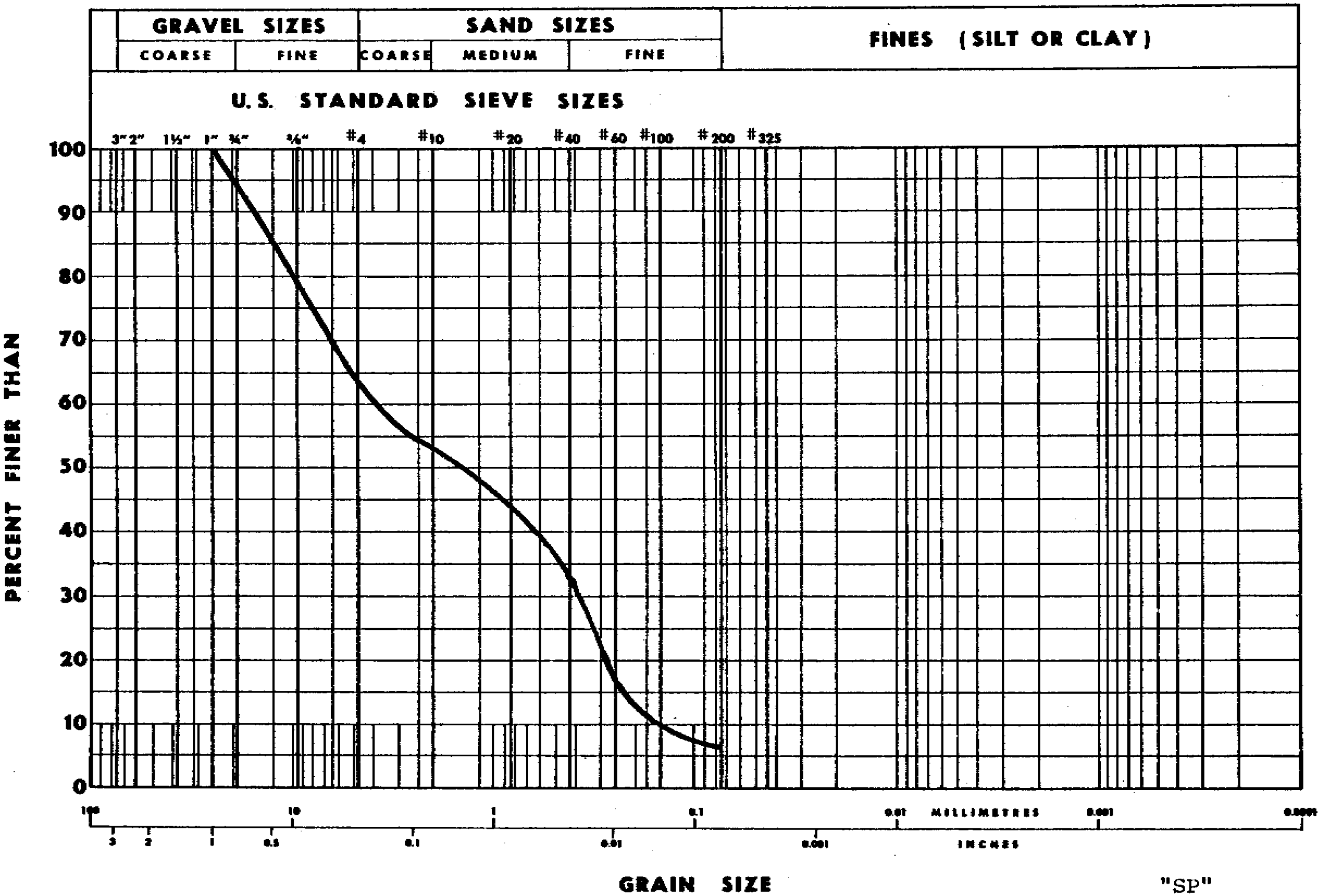
TEST HOLE NO. 4

GRAIN SIZE ANALYSIS



REMARKS: Sample A2, 1.5 - 2.0 m

Gravel 38.2%

Sand 55.0%

Fines 6.8%

NOTE: UNIFIED SOIL CLASSIFICATION SYSTEM

"SP"

D_{10} = 0.17 MM.
D_{30} = 0.38 MM.
D_{60} = 4.0 MM.
C_U 23.5
C_C 0.21

GRAIN SIZE ANALYSIS

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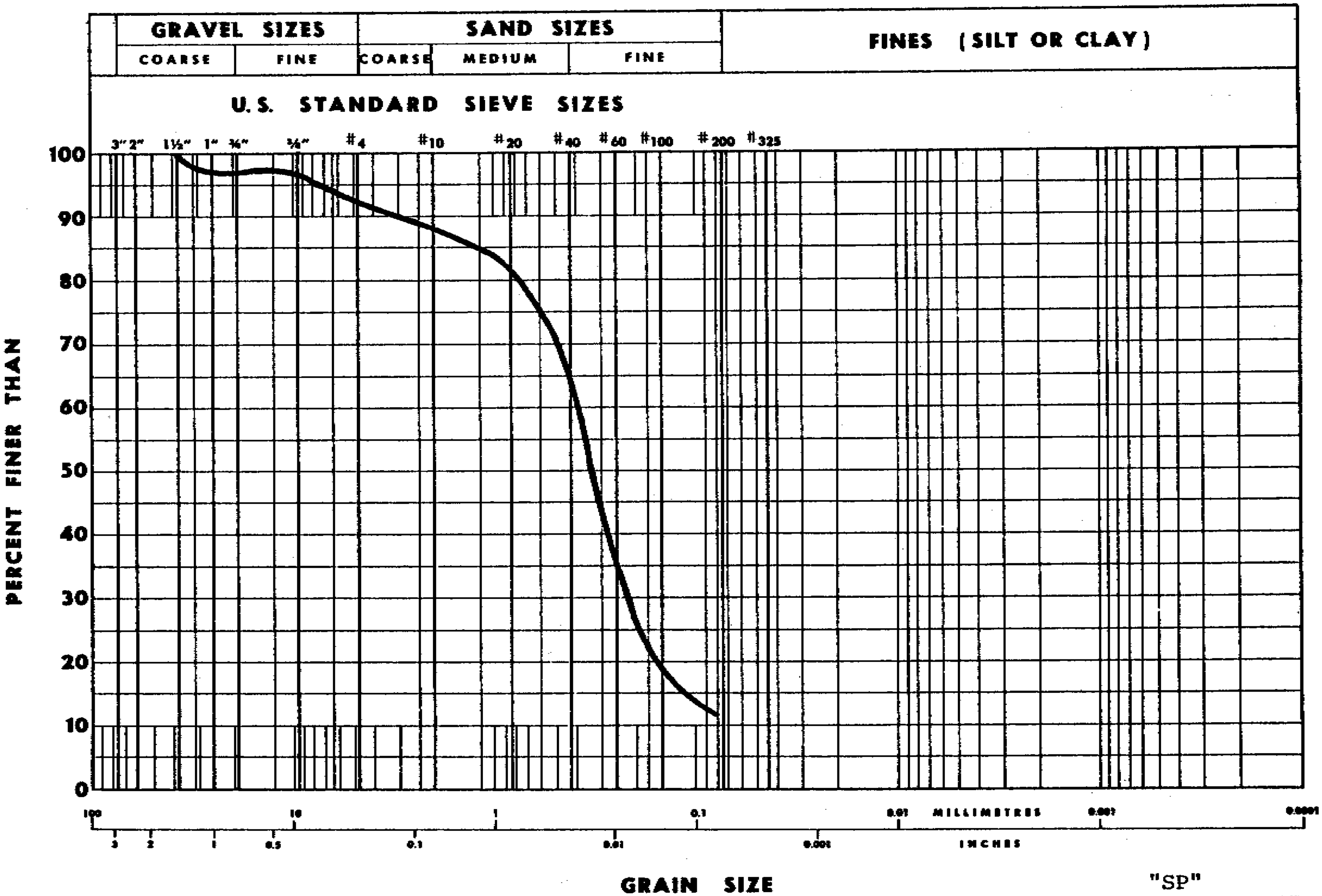
TEST HOLE NO. 4



REMARKS: Sample A3, 2.5 - 2.8 m

Gravel 8.0%

Sand 80.3%

Fines 11.7%

"SP"

D_{10} = 0.03 MM.
D_{30} = 0.22 MM.
D_{60} = 0.4 MM.
C_U 13.3
C_C 4.03

NOTE: UNIFIED SOIL CLASSIFICATION SYSTEM

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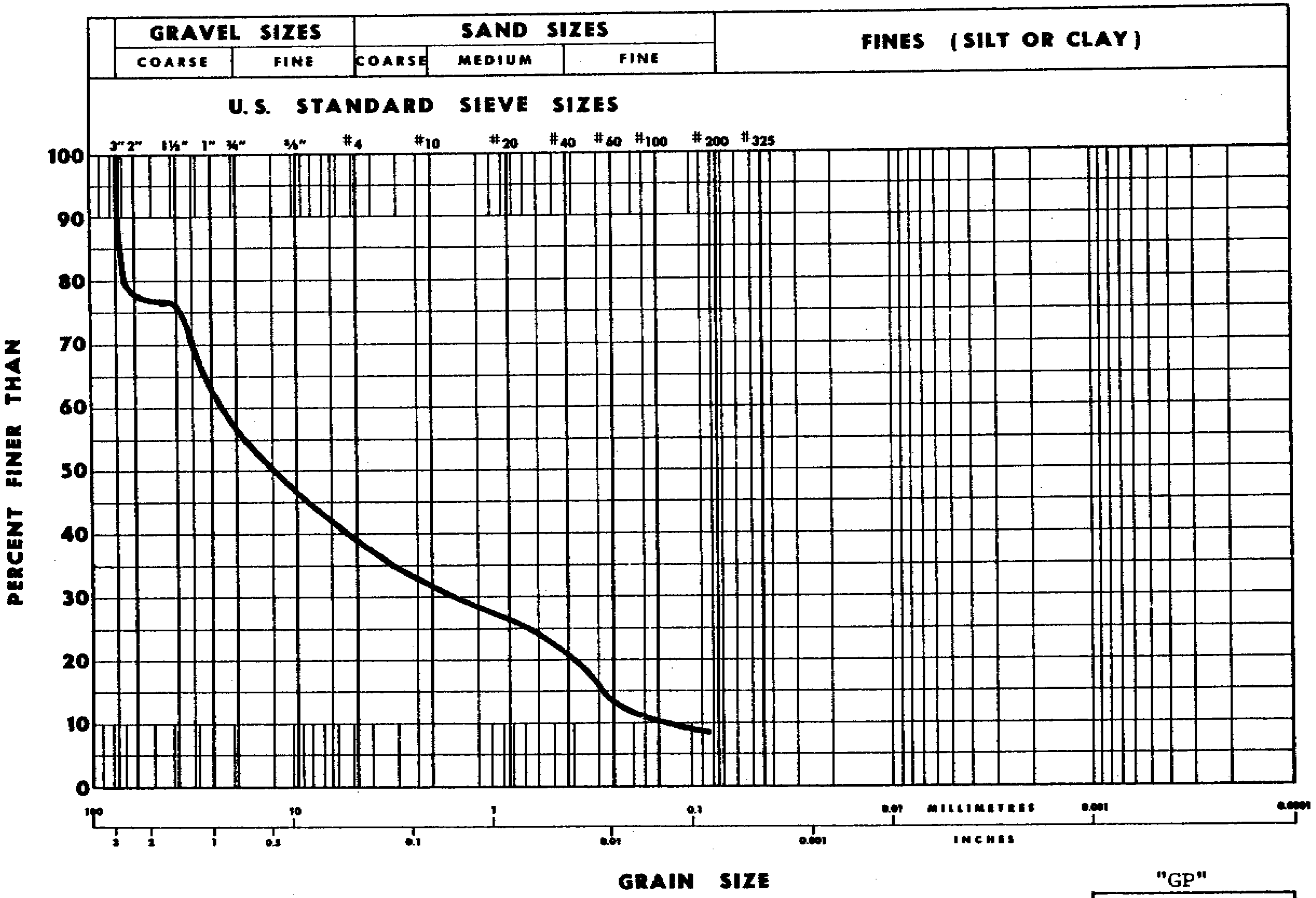
TEST HOLE NO. 4

GRAIN SIZE ANALYSIS



REMARKS: Sample A5, 3.8 - 4.0 m

Gravel 61.0%

Sand 30.8%

Fines 8.2%

NOTE: UNIFIED SOIL CLASSIFICATION SYSTEM

"GP"

D_{10} = 0.15 MM.
D_{30} = 1.3 MM.
D_{60} = 24 MM.
C_U 160
C_C 0.47

GRAIN SIZE ANALYSIS

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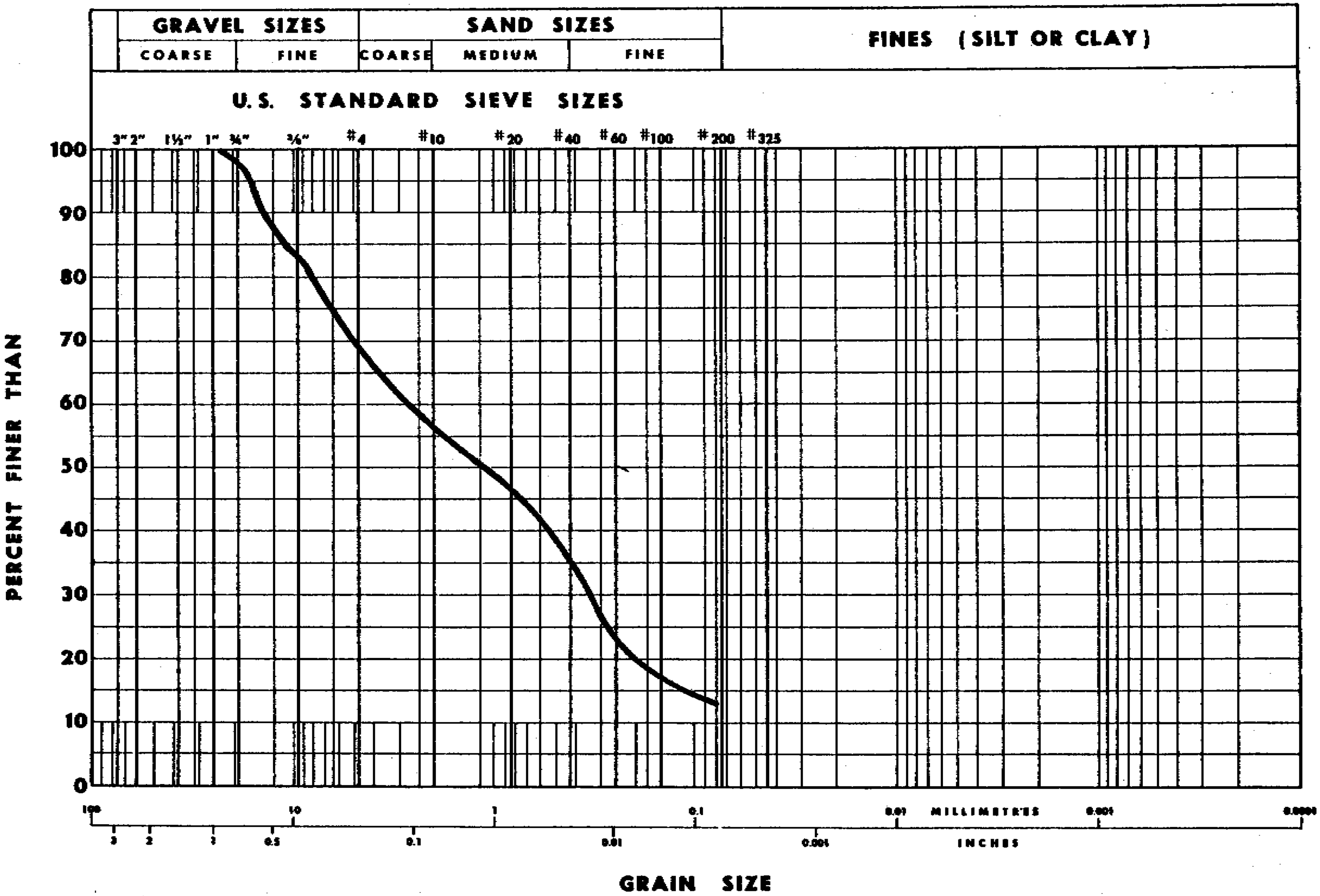
TEST HOLE NO. 5



REMARKS: Sample A4, 4.2 - 4.5 m

Gravel 31.1%

Sand 55.1%

Fines 13.8%

NOTE: UNIFIED SOIL CLASSIFICATION SYSTEM

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

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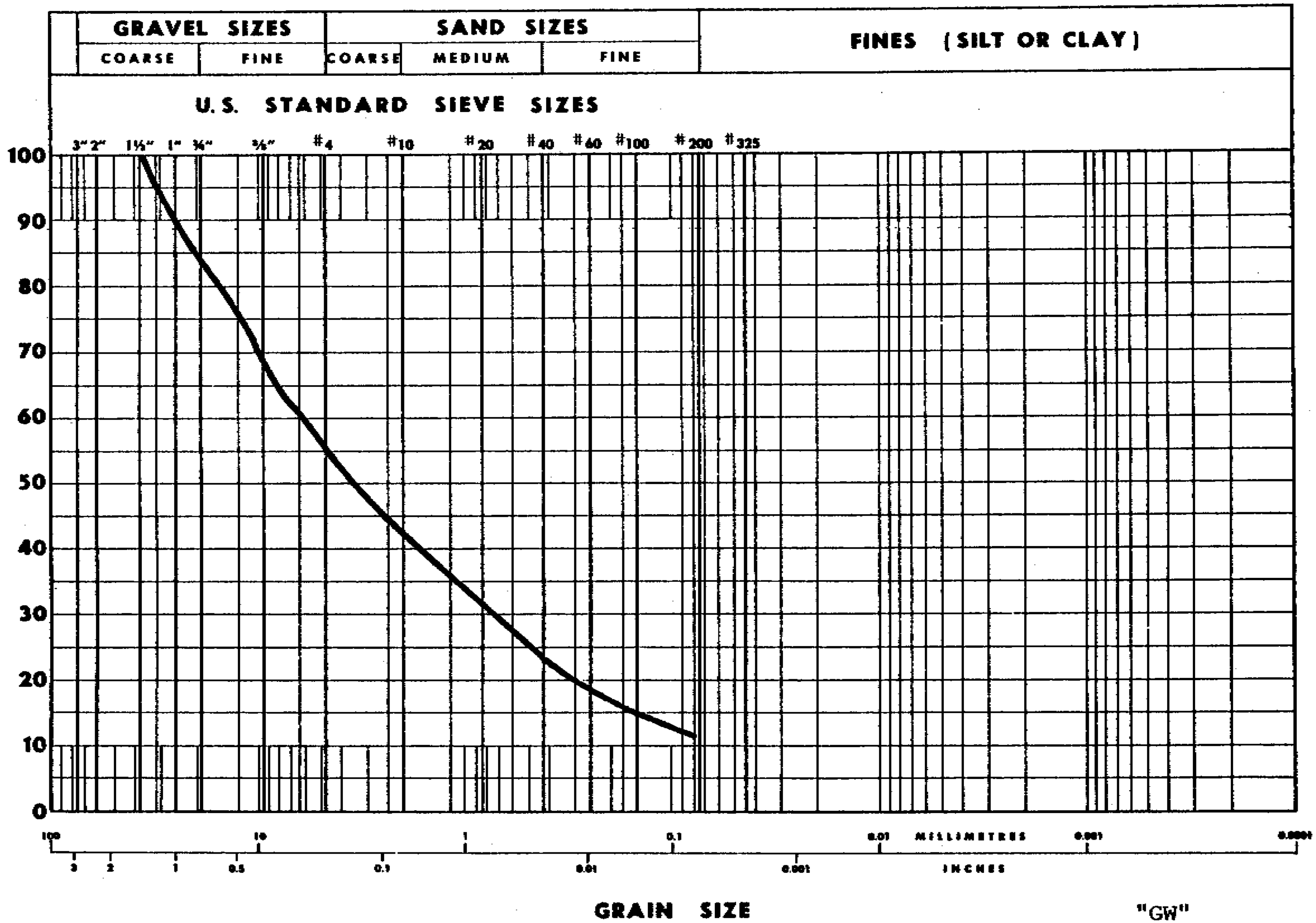
TEST HOLE NO. 5

GRAIN SIZE ANALYSIS



REMARKS: Sample A7, 8.5 - 8.8 m

Gravel 45.3%

Sand 43.6%

Fines 11.1%

NOTE: UNIFIED SOIL CLASSIFICATION SYSTEM

"GW"

D_{10}= 0.06 MM.
D_{30}= 0.8 MM.
D_{60}= 5.0 MM.
C_U 83.3
C_C 2.13

GRAIN SIZE ANALYSIS

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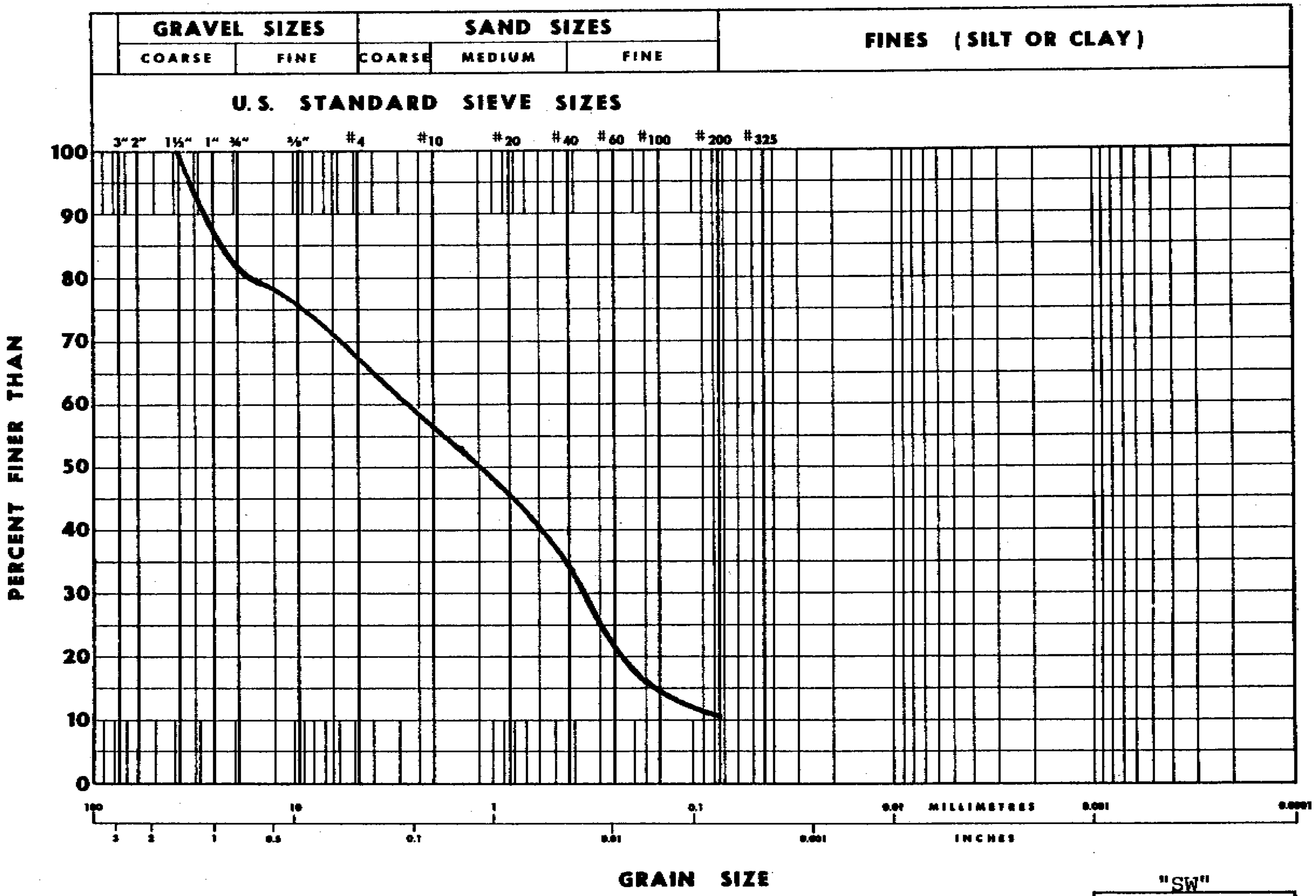
TEST HOLE NO.
6



REMARKS: Sample A2, 2.2 - 2.6 m

Gravel 33.4%

Sand 55.8%

Fines 10.8%

NOTE: UNIFIED SOIL CLASSIFICATION SYSTEM

"SW"

D_{10} = 0.04 MM.
D_{30} = 0.35 MM.
D_{60} = 3.0 MM.
C_U 75
C_C 1.02

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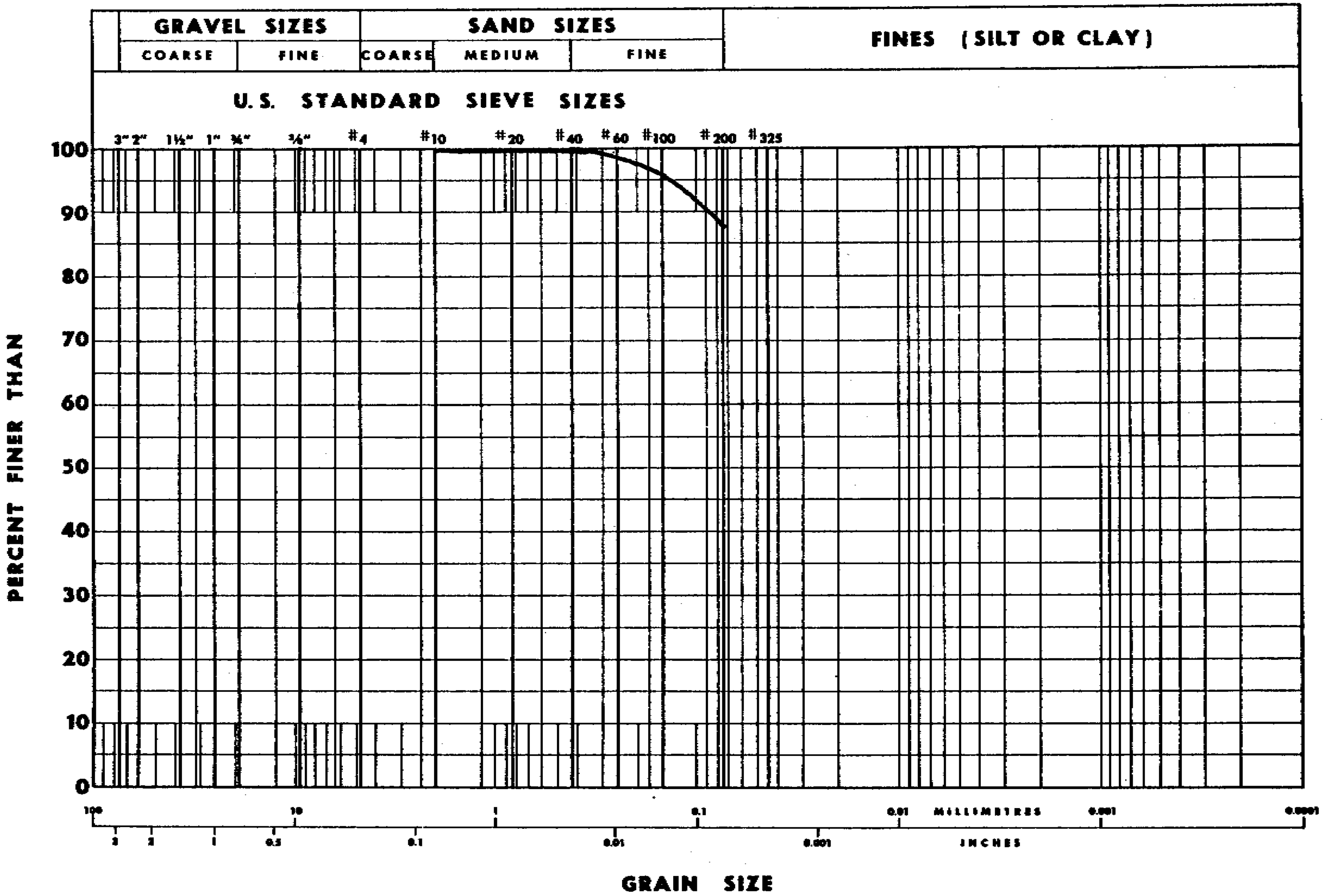
TEST HOLE NO. 7

GRAIN SIZE ANALYSIS



REMARKS: Sample A2, 1.4 - 1.8 m

Gravel 0%

Sand 12.5%

Fines 87.5%

NOTE: UNIFIED SOIL CLASSIFICATION SYSTEM

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

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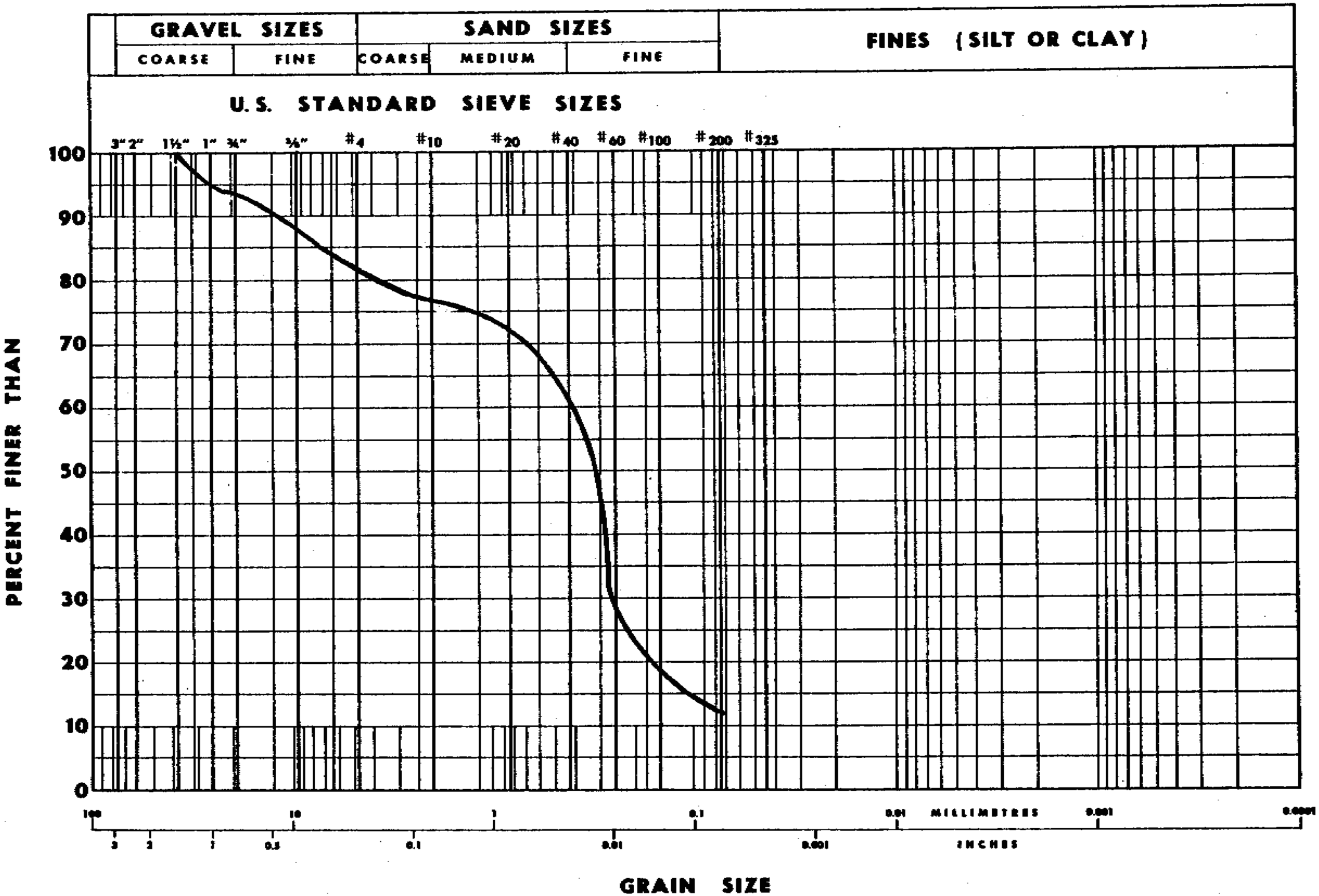
TEST HOLE NO. 7

GRAIN SIZE ANALYSIS



REMARKS: Sample A3, 3.0 - 3.3 m

Gravel 18.4%

Sand 68.8%

Fines 12.8%

NOTE: UNIFIED SOIL CLASSIFICATION SYSTEM

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

GRAIN SIZE ANALYSIS

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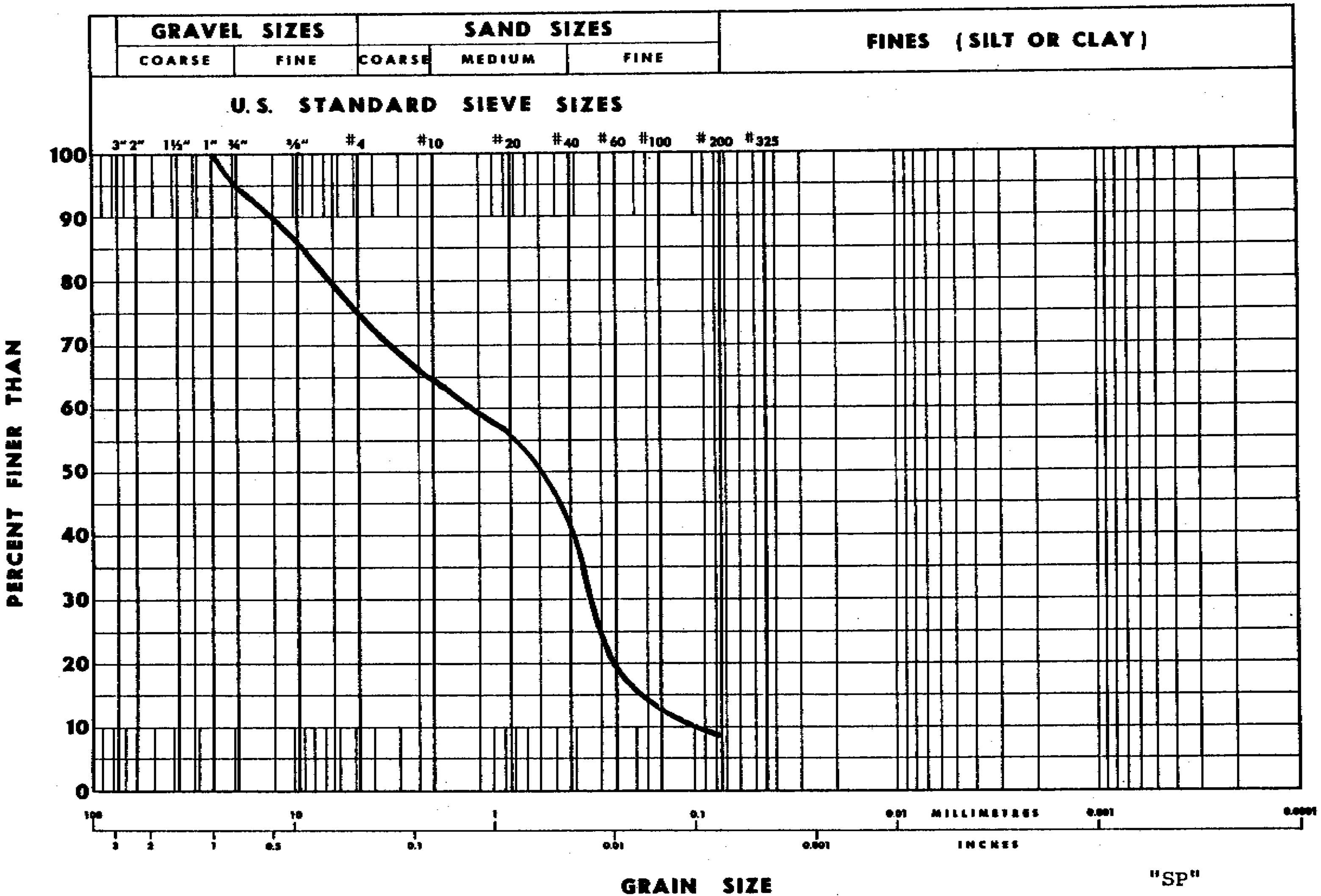
TEST HOLE NO. 7



"SP"

REMARKS: Sample A4, 4.5 - 4.8 m

Gravel 25.8%

Sand 64.6%

Fines 9.6%

NOTE: UNIFIED SOIL CLASSIFICATION SYSTEM

D_{10}= 0.1 MM.
D_{30}= 0.33 MM.
D_{60}= 1.2 MM.
C_u 12.0
C_c 0.91

GRAIN SIZE ANALYSIS

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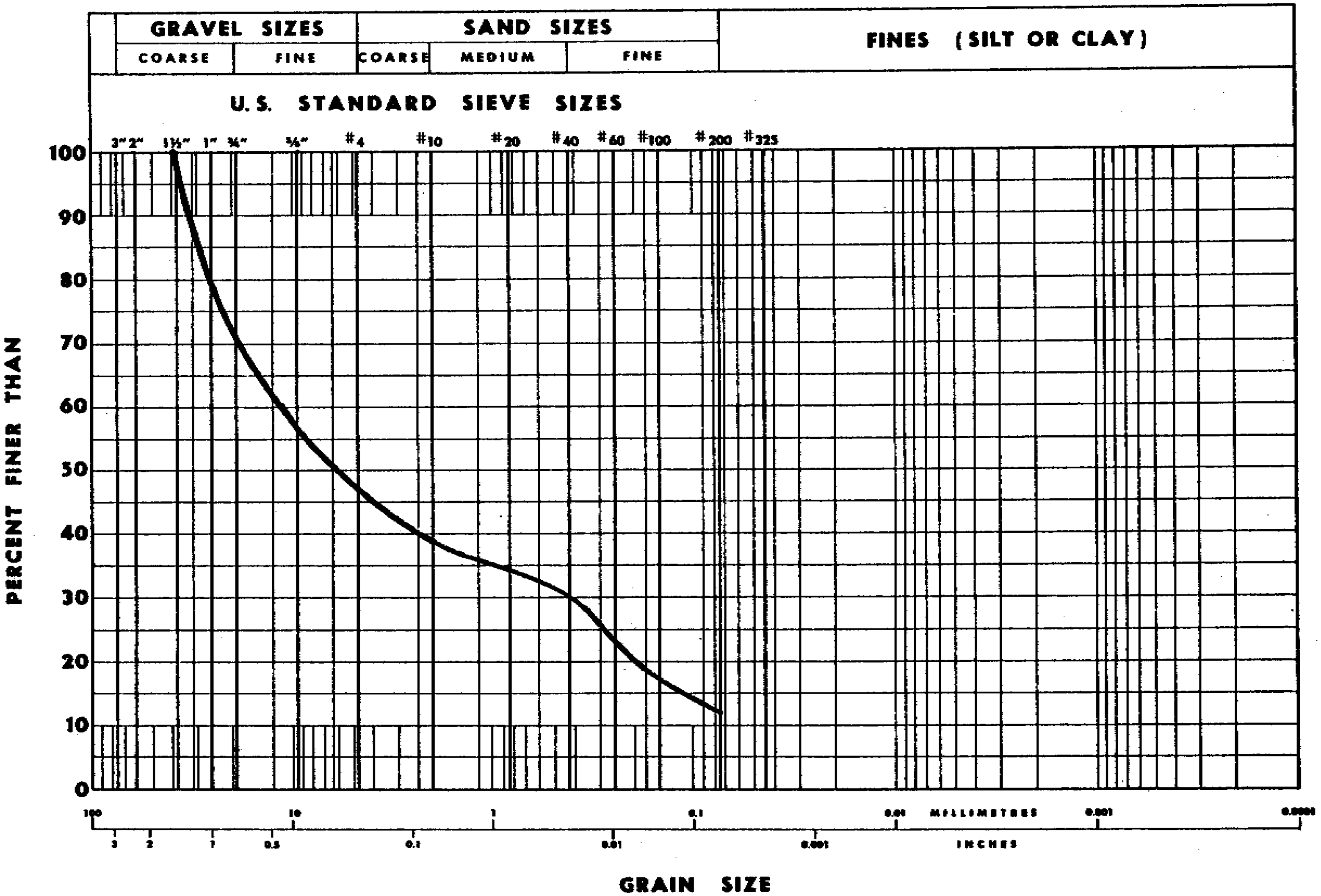

REMARKS: Sample A7, 7.5 - 7.8 m

Gravel 53.0%

Sand 33.8%

Fines 13.2%

NOTE: UNIFIED SOIL CLASSIFICATION SYSTEM

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

TEST HOLE NO. 7

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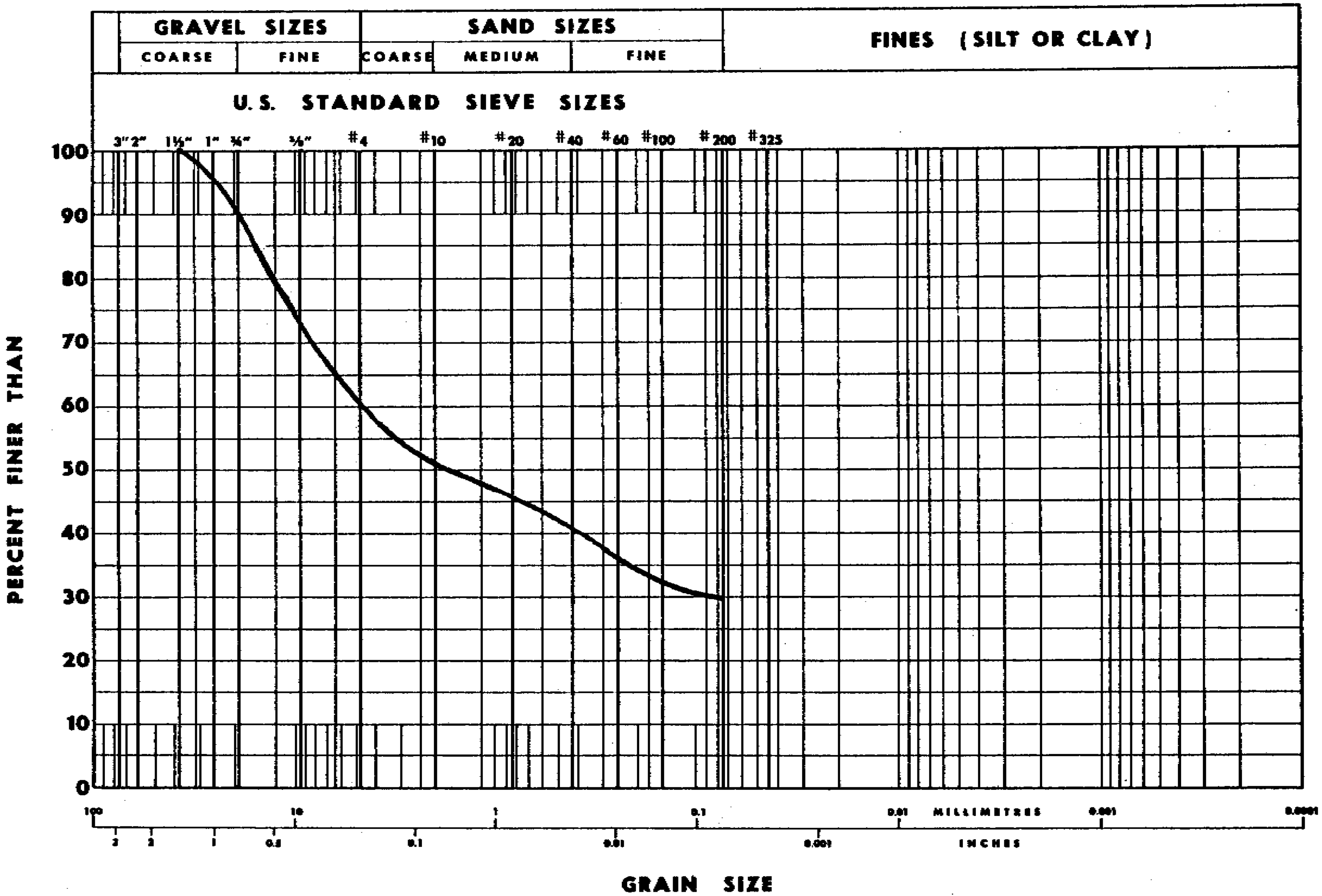
TEST HOLE NO. 8

GRAIN SIZE ANALYSIS



REMARKS: Sample A1, 1.2 - 1.5 m
Gravel 40.1%
Sand 29.6%
Fines 30.3%

NOTE: UNIFIED SOIL CLASSIFICATION SYSTEM

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

GRAIN SIZE ANALYSIS

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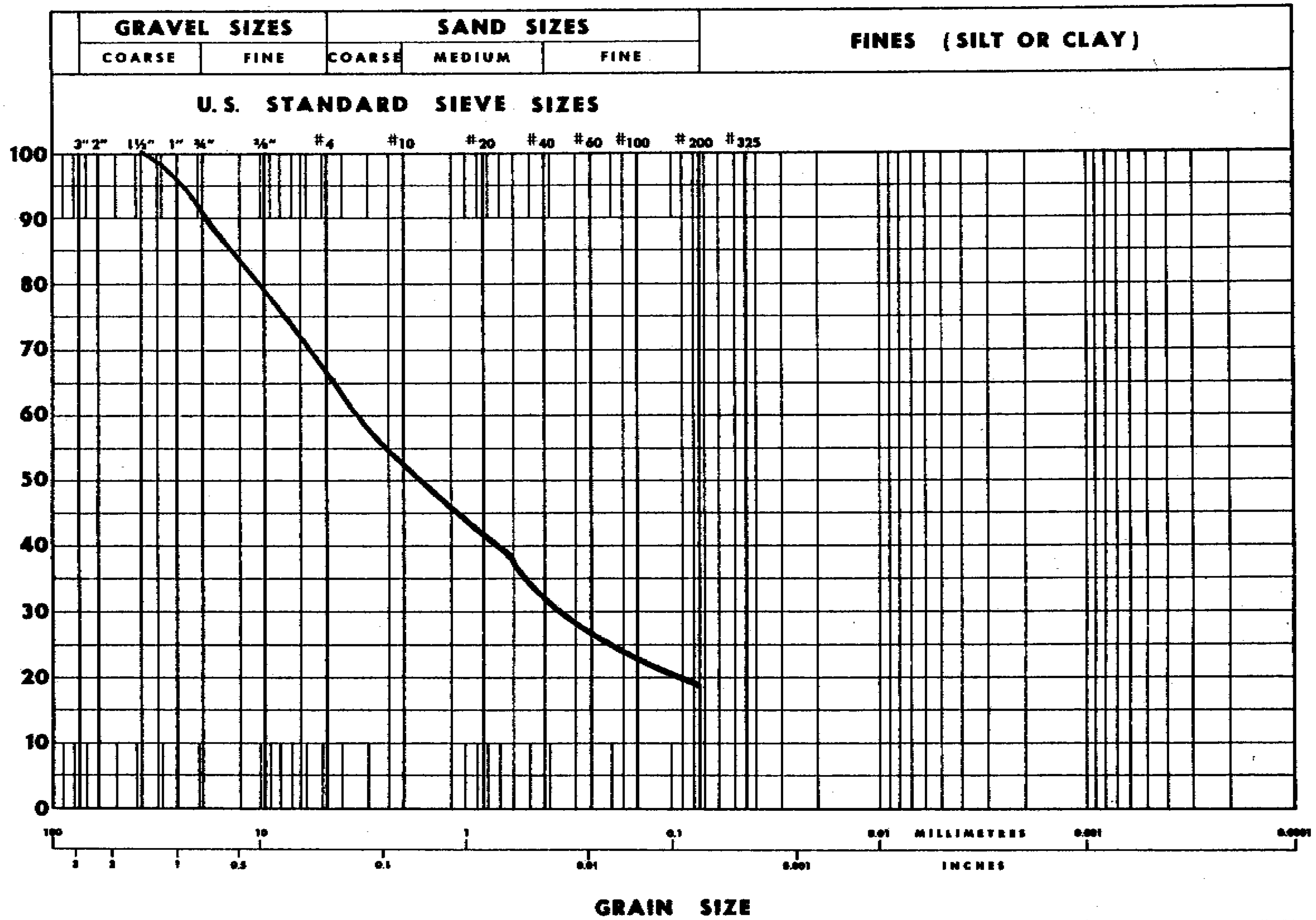
TEST HOLE NO. 8



REMARKS: Sample A2, 2.0 - 2.3 m

Gravel 33.5%

Sand 46.6%

Fines 19.9%

NOTE: UNIFIED SOIL CLASSIFICATION SYSTEM

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

GRAIN SIZE ANALYSIS

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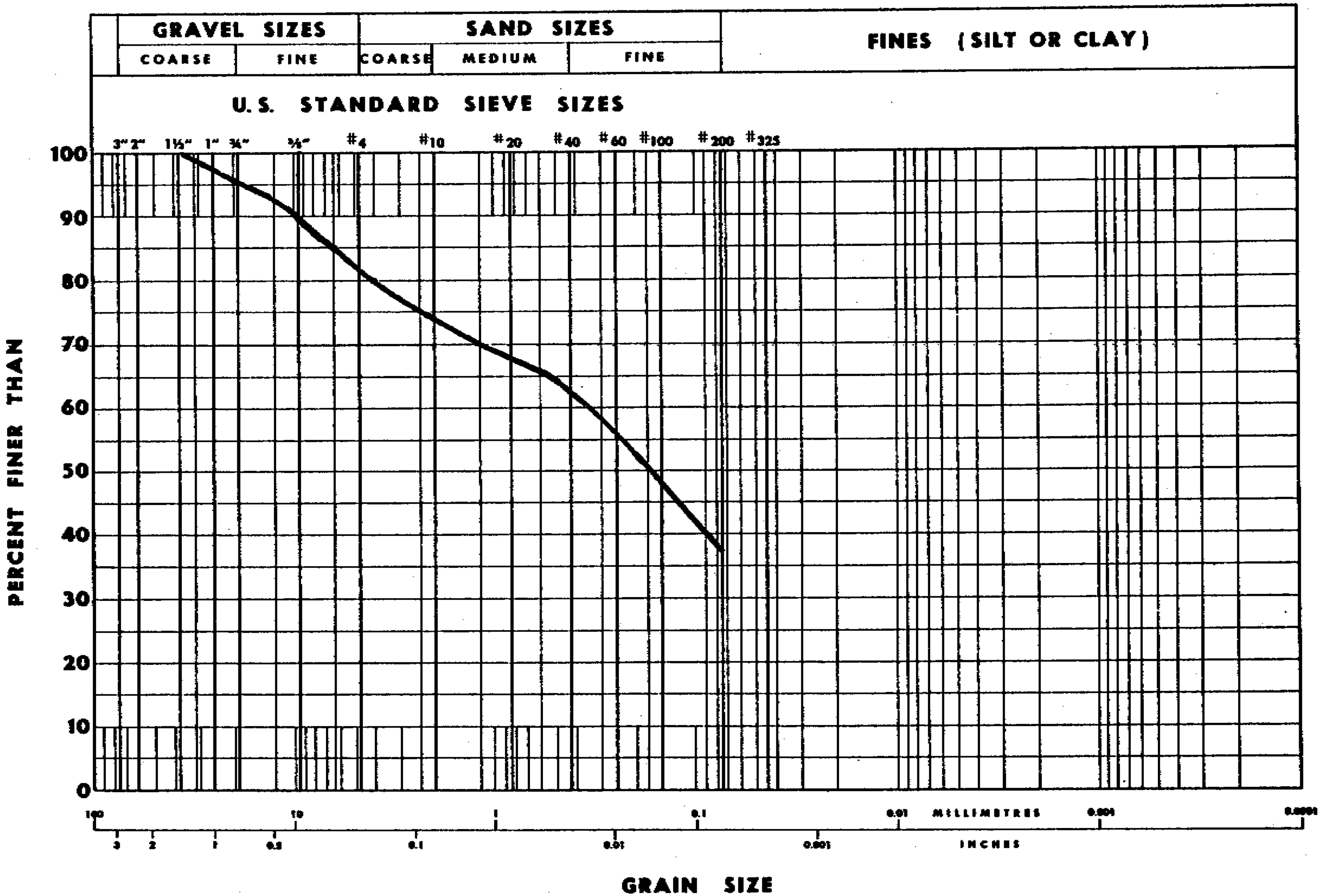
TEST HOLE NO. 8



REMARKS: Sample A4, 3.0 - 3.3 m

Gravel	18.2%
Sand	44.1%
Fines	37.7%

NOTE: UNIFIED SOIL CLASSIFICATION SYSTEM

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

GRAIN SIZE ANALYSIS

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AND
NORTHERN DEVELOPMENT

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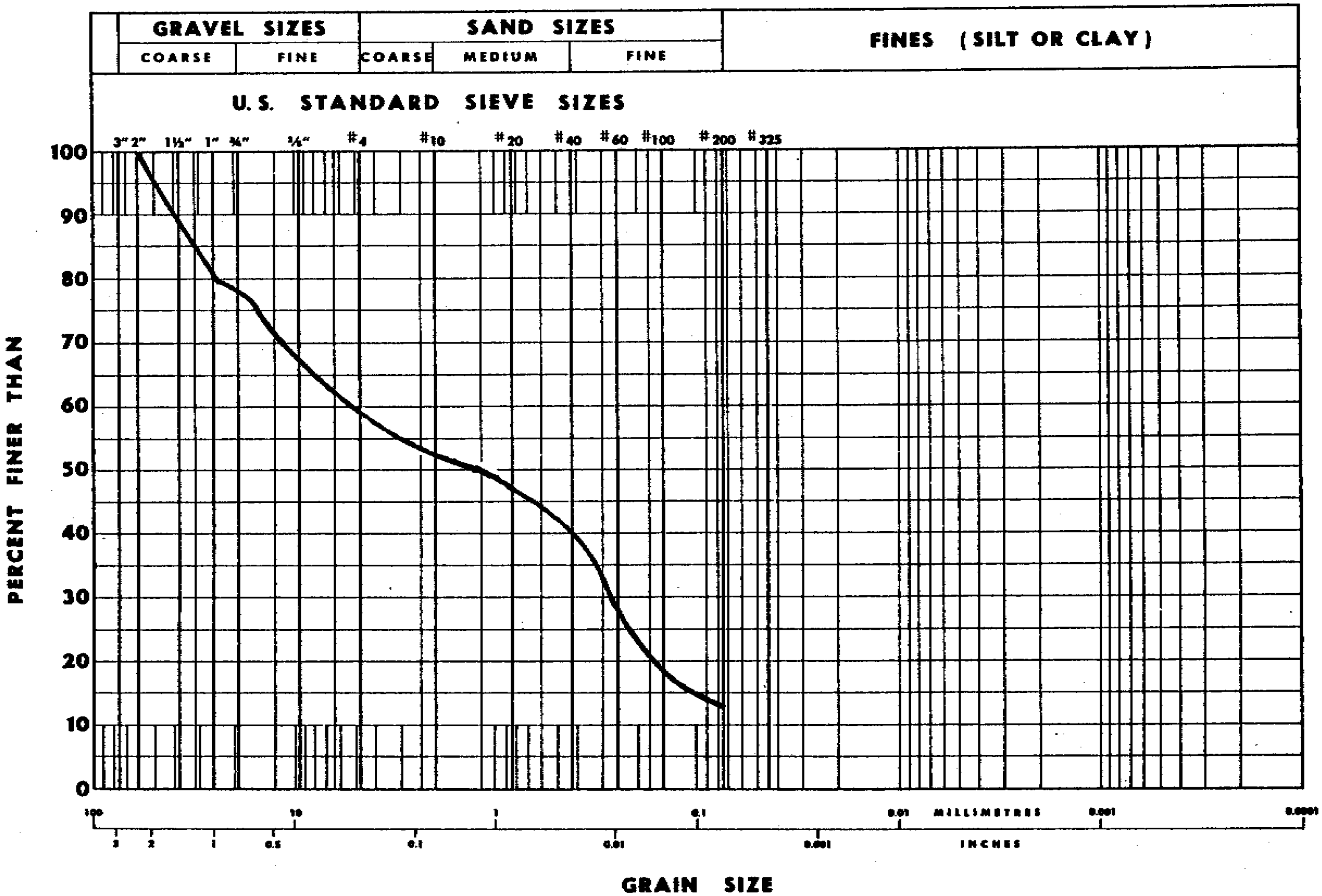
TEST HOLE NO.
9



REMARKS: Sample A2, 2.4 - 2.7 m

Gravel 41.1%

Sand 45.2%

Fines 13.7%

NOTE: UNIFIED SOIL CLASSIFICATION SYSTEM

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

GOVERNMENT OF CANADA
DEPARTMENT OF INDIAN AFFAIRS
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NORTHERN DEVELOPMENT

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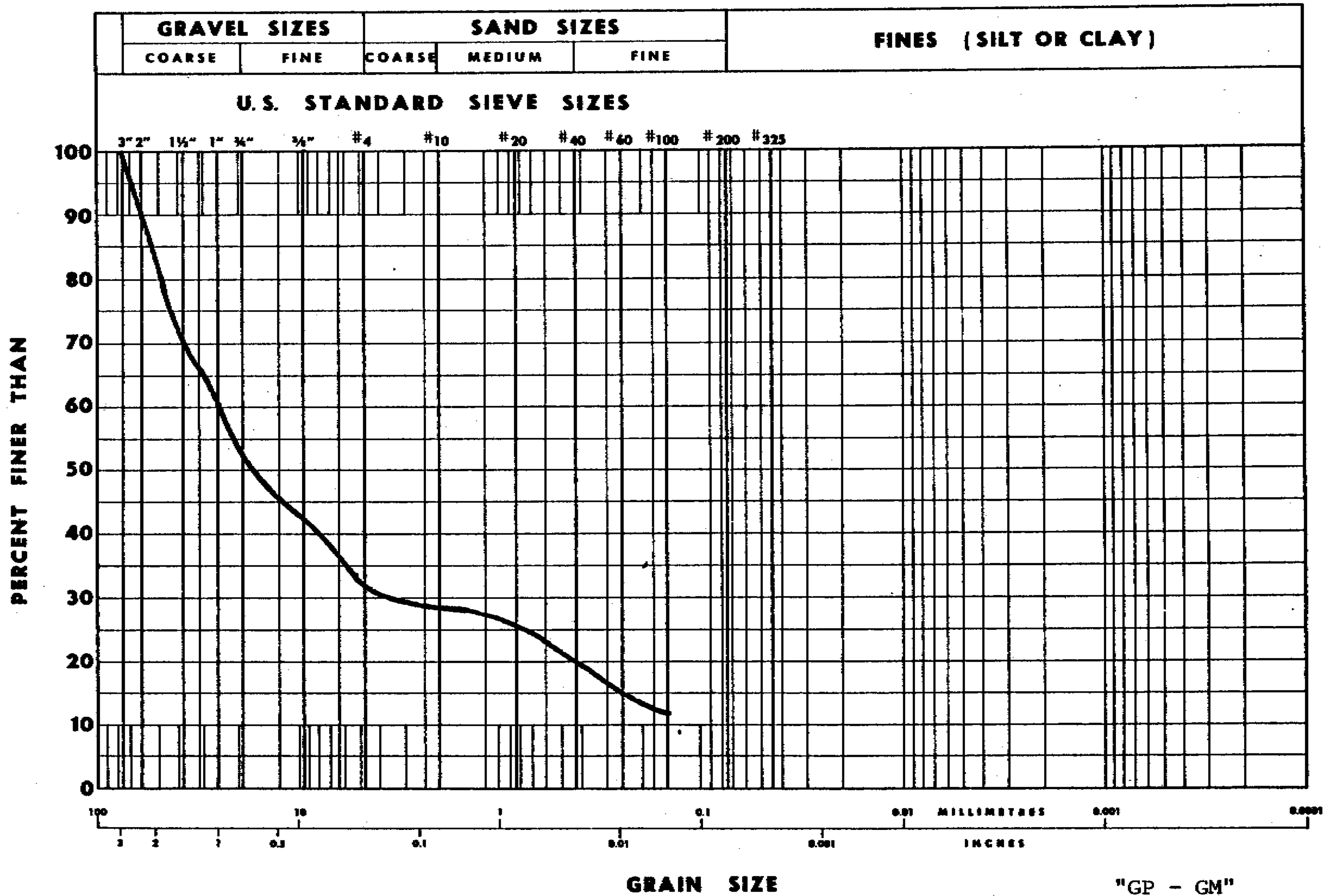
TEST HOLE NO. 10

GRAIN SIZE ANALYSIS



REMARKS: Sample A3, 2.5 - 2.8 m

Gravel	67.8%
Sand	20.2%
Fines	12.0%

NOTE: UNIFIED SOIL CLASSIFICATION SYSTEM

"GP - GM"

D_{10} = 0.06 MM.
D_{30} = 3.8 MM.
D_{60} = 27 MM.
C_U 450
C_C 8.9

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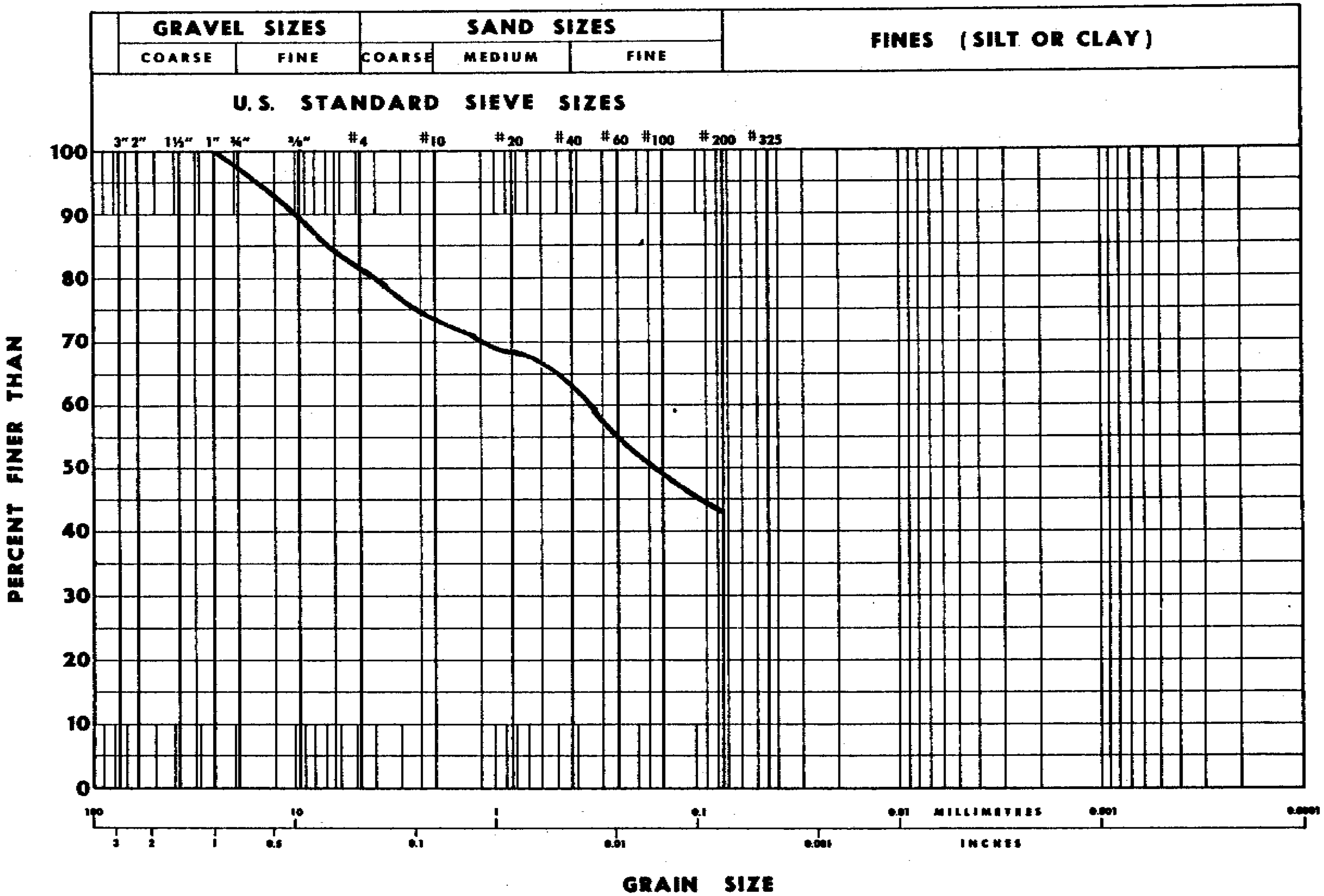
TEST HOLE NO.
16

GRAIN SIZE ANALYSIS



REMARKS: Sample A1, 0.7 - 1.0 m

Gravel 18.6%

Sand 37.5%

Fines 43.9%

NOTE: UNIFIED SOIL CLASSIFICATION SYSTEM

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

GRAIN SIZE ANALYSIS

GOVERNMENT OF CANADA
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NORTHERN DEVELOPMENT

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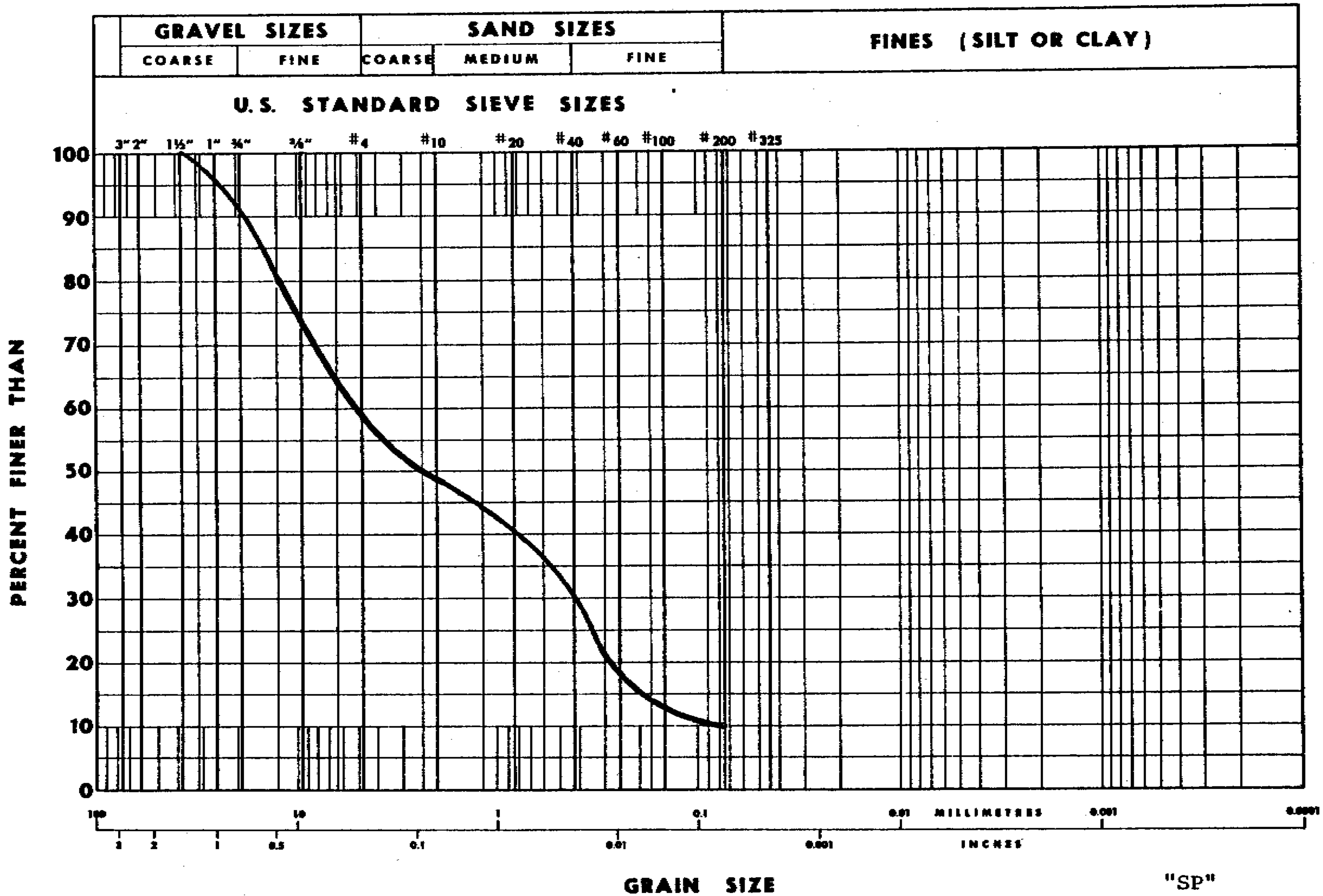
TEST HOLE NO.
19

A-60



REMARKS: Sample Al, 0.6 - 0.8 m

Gravel 42.1%

Sand 47.8%

Fines 10.1%

NOTE: UNIFIED SOIL CLASSIFICATION SYSTEM

"SP"

D_{10} = 0.08 MM.
D_{30} = 0.4 MM.
D_{60} = 5.5 MM.
C_U 68.8
C_C 0.36

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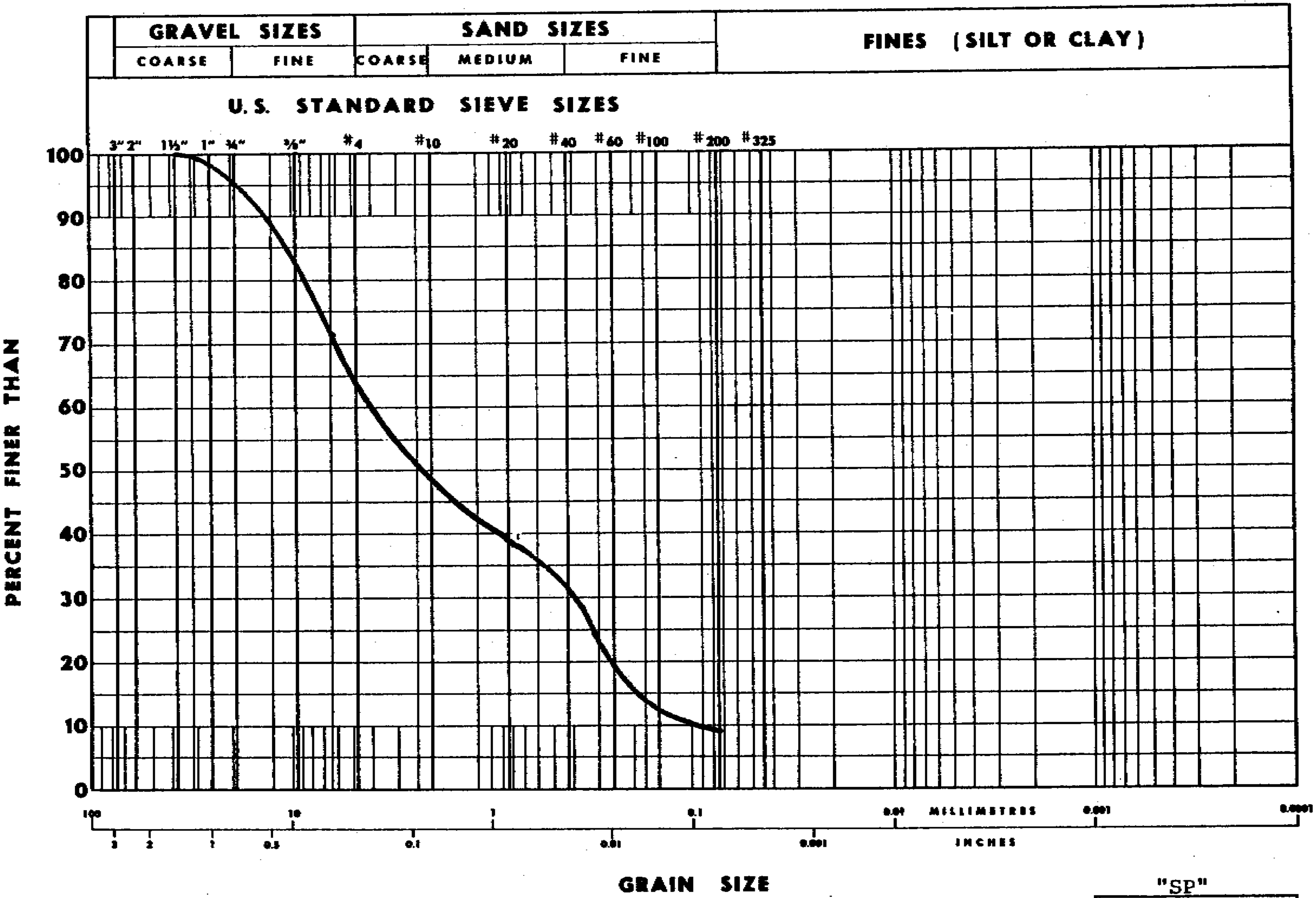
TEST HOLE NO. 19

GRAIN SIZE ANALYSIS



"SP"

REMARKS: Sample A2, 1.6 - 1.8 m

Gravel 37.3%

Sand 53.4%

Fines 9.3%

NOTE: UNIFIED SOIL CLASSIFICATION SYSTEM

D_{10} = 0.09 MM.
D_{30} = 0.4 MM.
D_{60} = 4.2 MM.
C_U 46.7
C_C 0.42

GRAIN SIZE ANALYSIS

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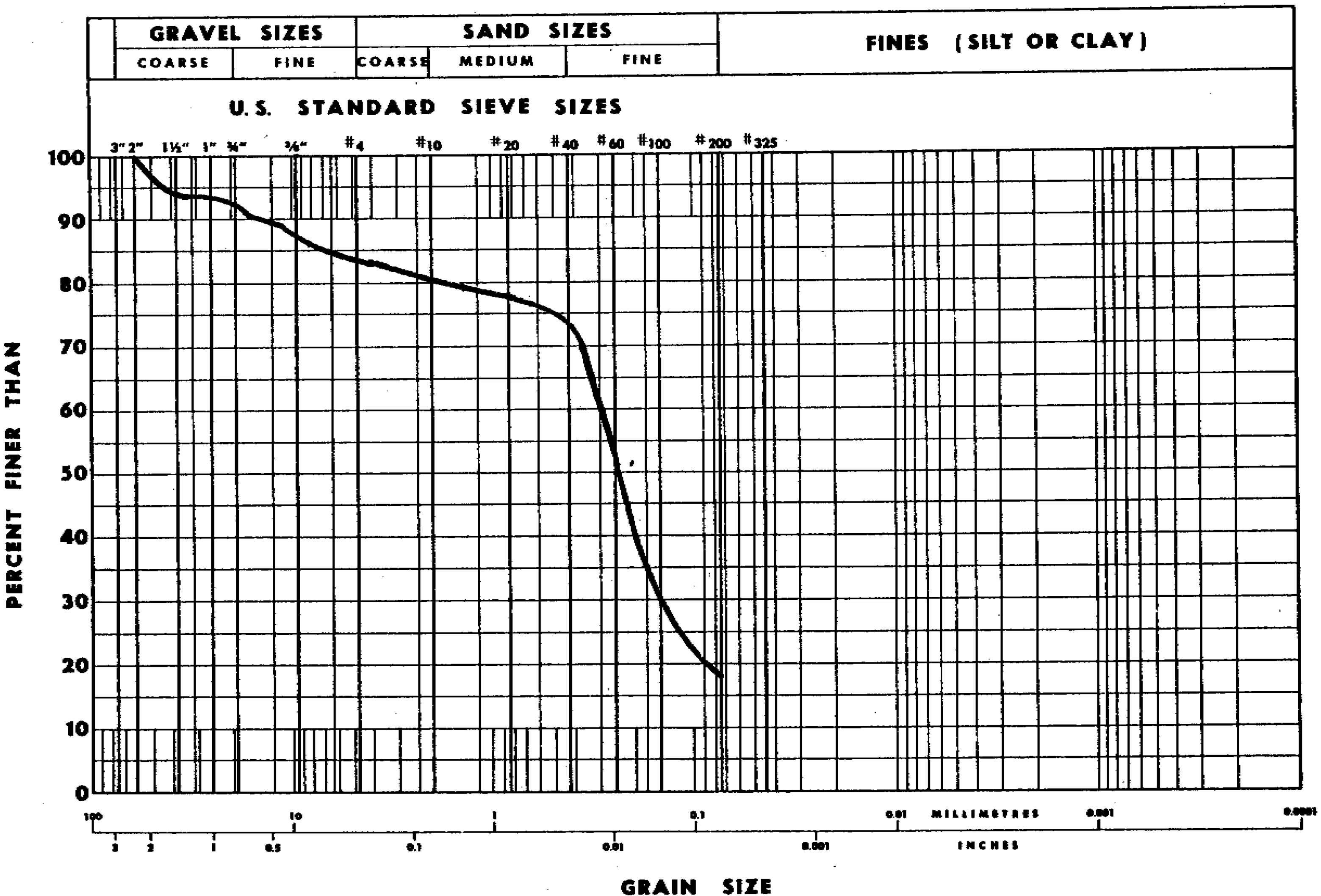
TEST HOLE NO. 19



REMARKS: Sample A3, 2.8 - 3.0 m

Gravel 16.6%

Sand 64.4%

Fines 19.0%

NOTE: UNIFIED SOIL CLASSIFICATION SYSTEM

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

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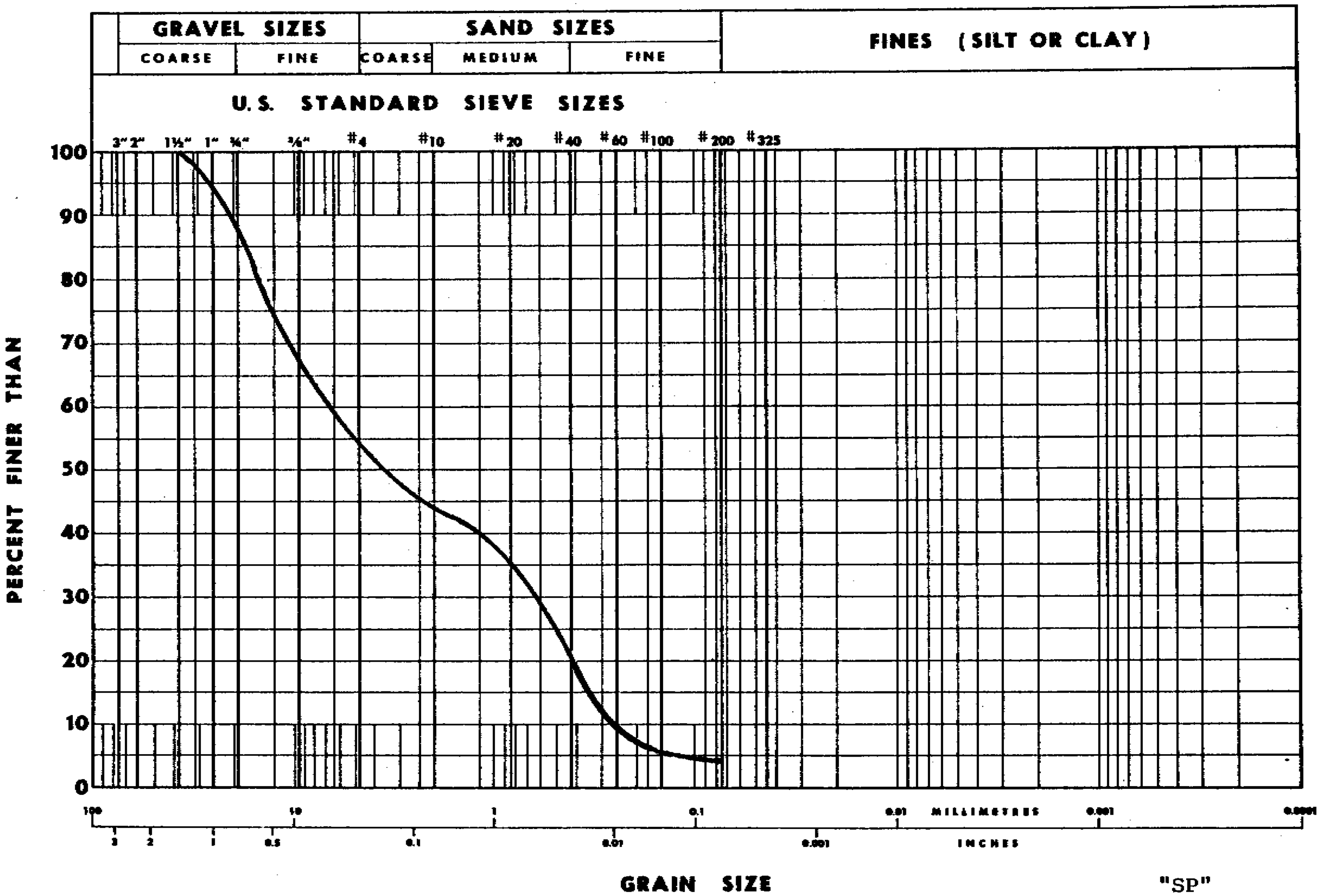
TEST HOLE NO.
20

GRAIN SIZE ANALYSIS



"SP"

D_{10}=	0.28	MM.
D_{30}=	0.4	MM.
D_{60}=	6.1	MM.
C_U	21.8	
C_C	0.09	

REMARKS: Sample Al, 0.3 - 0.6 m

Gravel 45.3%

Sand 50.3%

Fines 4.4%

NOTE: UNIFIED SOIL CLASSIFICATION SYSTEM

GRAIN SIZE ANALYSIS

GOVERNMENT OF CANADA
DEPARTMENT OF INDIAN AFFAIRS
AND
NORTHERN DEVELOPMENT

HARDY ASSOCIATES (1978) LTD.
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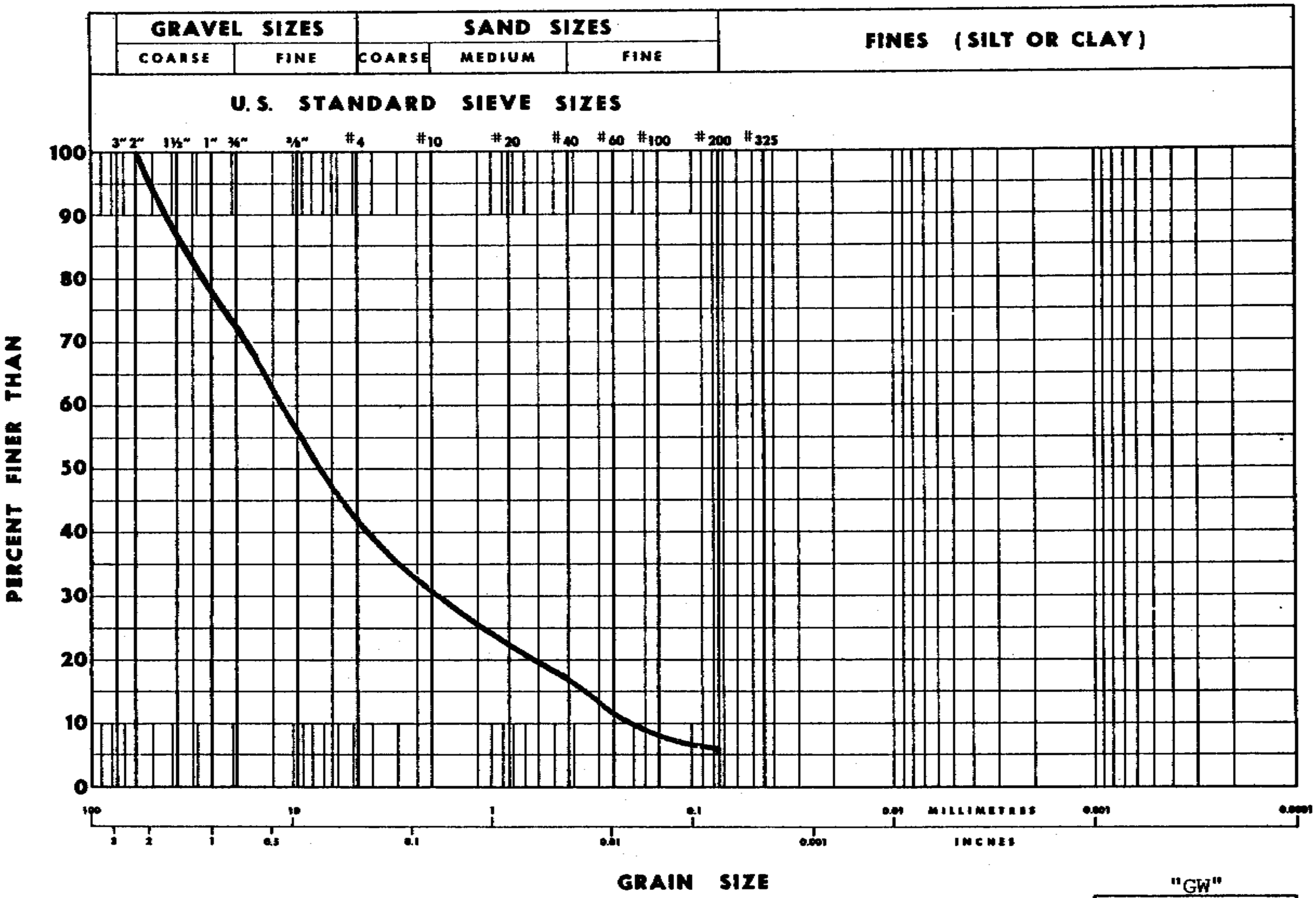
TEST HOLE NO. 20



REMARKS: Sample A3, 3.0 - 3.2 m

Gravel 57.3%

Sand 35.9%

Fines 6.8%

NOTE: UNIFIED SOIL CLASSIFICATION SYSTEM

"GW"

D_{10}= 0.2 MM.
D_{30}= 2.0 MM.
D_{60}= 12.0 MM.
C_U 60
C_C 1.67

GRAIN SIZE ANALYSIS

GOVERNMENT OF CANADA
DEPARTMENT OF INDIAN AFFAIRS
AND
NORTHERN DEVELOPMENT

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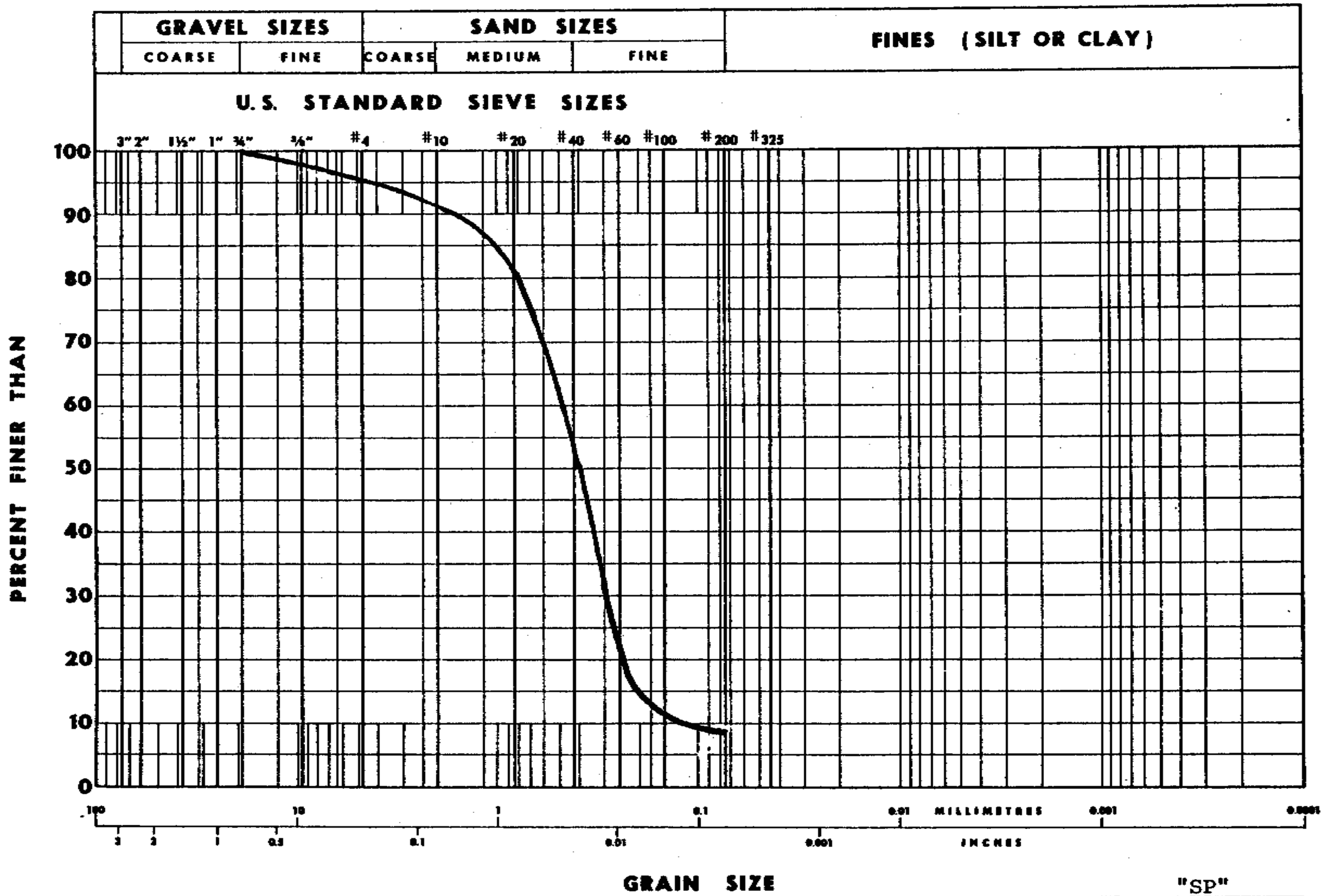
TEST HOLE NO. 21



REMARKS: Sample A1, 0.6 - 0.9 m

Gravel 4.4%

Sand 87.1%

Fines 8.5%

NOTE: UNIFIED SOIL CLASSIFICATION SYSTEM

"SP"

D_{10} = 0.12 MM.

D_{30} = 0.3 MM.

D_{60} = 0.5 MM.

C_U 4.2

C_C 1.5

GRAIN SIZE ANALYSIS

GOVERNMENT OF CANADA
DEPARTMENT OF INDIAN AFFAIRS
AND
NORTHERN DEVELOPMENT

HARDY ASSOCIATES (1978) LTD.
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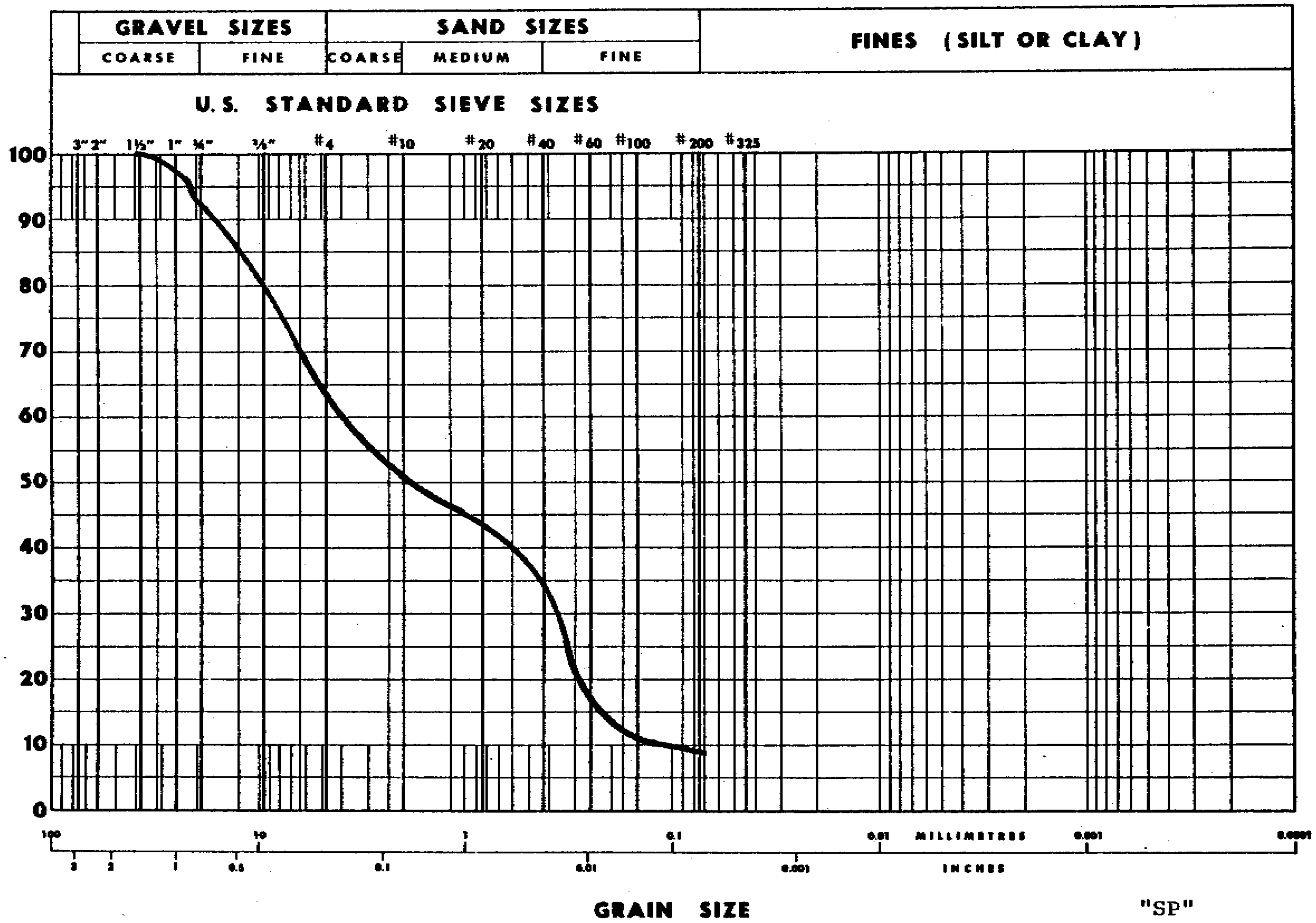
TEST HOLE NO. 21



REMARKS: Sample A6, 4.4 - 4.5 m

Gravel	36.5%
Sand	54.8%
Fines	8.7%

NOTE: UNIFIED SOIL CLASSIFICATION SYSTEM

"SP"

D_{10} = 0.1 MM.
D_{30} = 0.37 MM.
D_{60} = 4.0 MM.
C_U 40
C_C 0.34

GRAIN SIZE ANALYSIS

GOVERNMENT OF CANADA
DEPARTMENT OF INDIAN AFFAIRS
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NORTHERN DEVELOPMENT

HARDY ASSOCIATES (1978) LTD.
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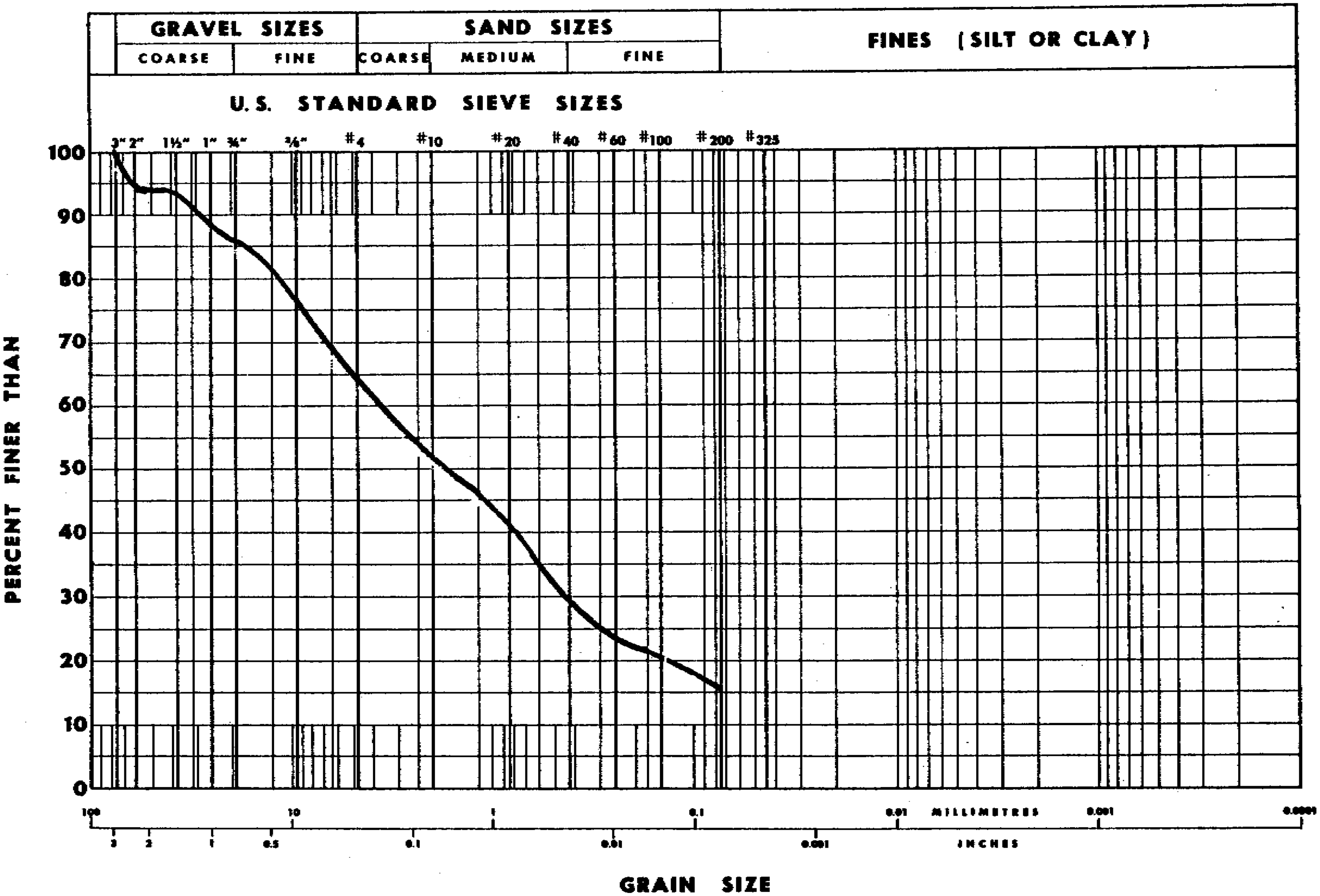
TEST HOLE NO. 23



REMARKS: Sample A2, 1.6 - 1.8 m

Gravel 36.0%

Sand 47.3%

Fines 16.7%

NOTE: UNIFIED SOIL CLASSIFICATION SYSTEM

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

GRAIN SIZE ANALYSIS

GOVERNMENT OF CANADA
DEPARTMENT OF INDIAN AFFAIRS
AND
NORTHERN DEVELOPMENT

HARDY ASSOCIATES (1978) LTD.
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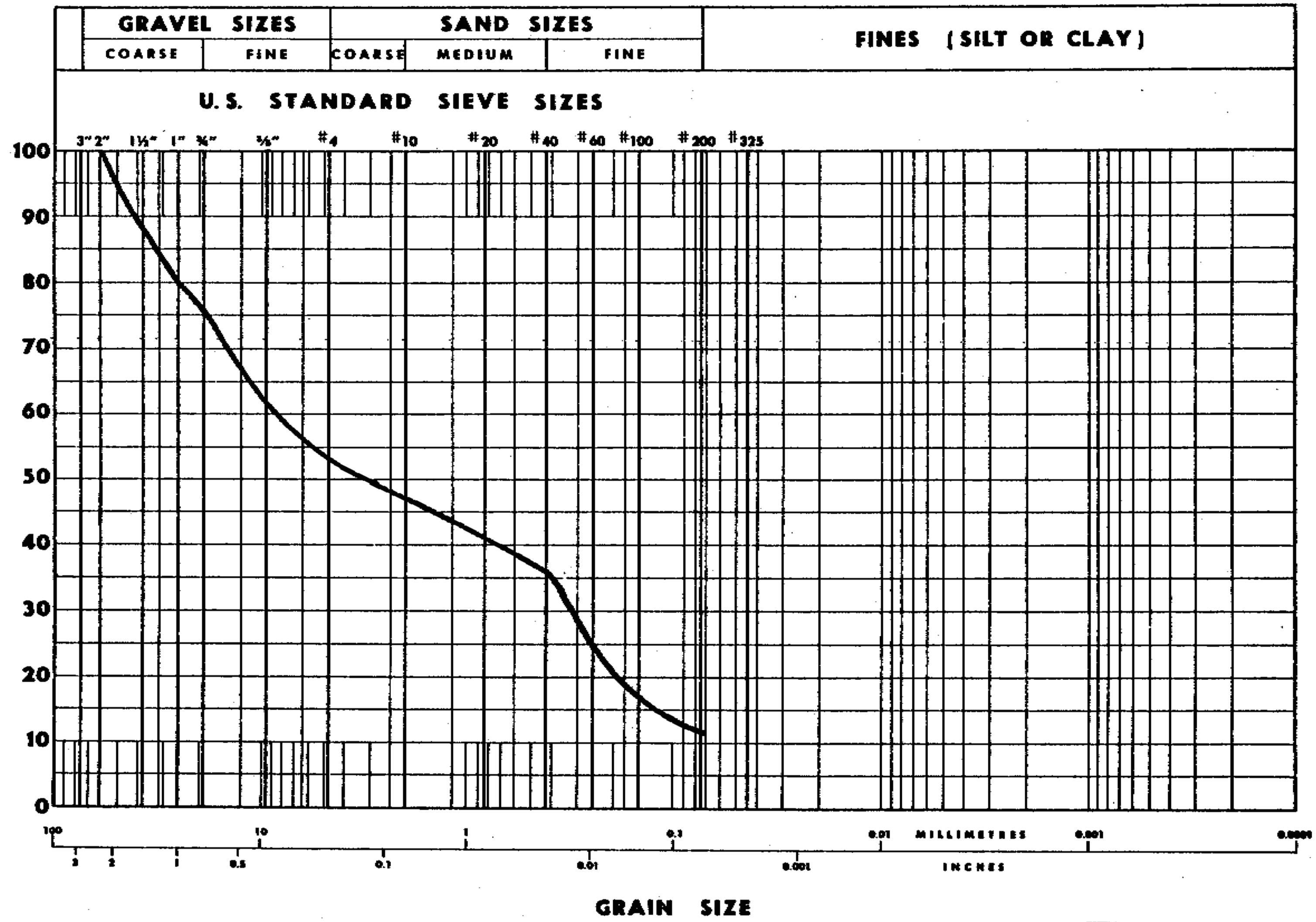
TEST HOLE NO.
24



REMARKS: Sample A1, 0.4 - 0.7 m

Gravel 46.5%

Sand 40.6%

Fines 12.9%

NOTE: UNIFIED SOIL CLASSIFICATION SYSTEM

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

GOVERNMENT OF CANADA
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AND
NORTHERN DEVELOPMENT

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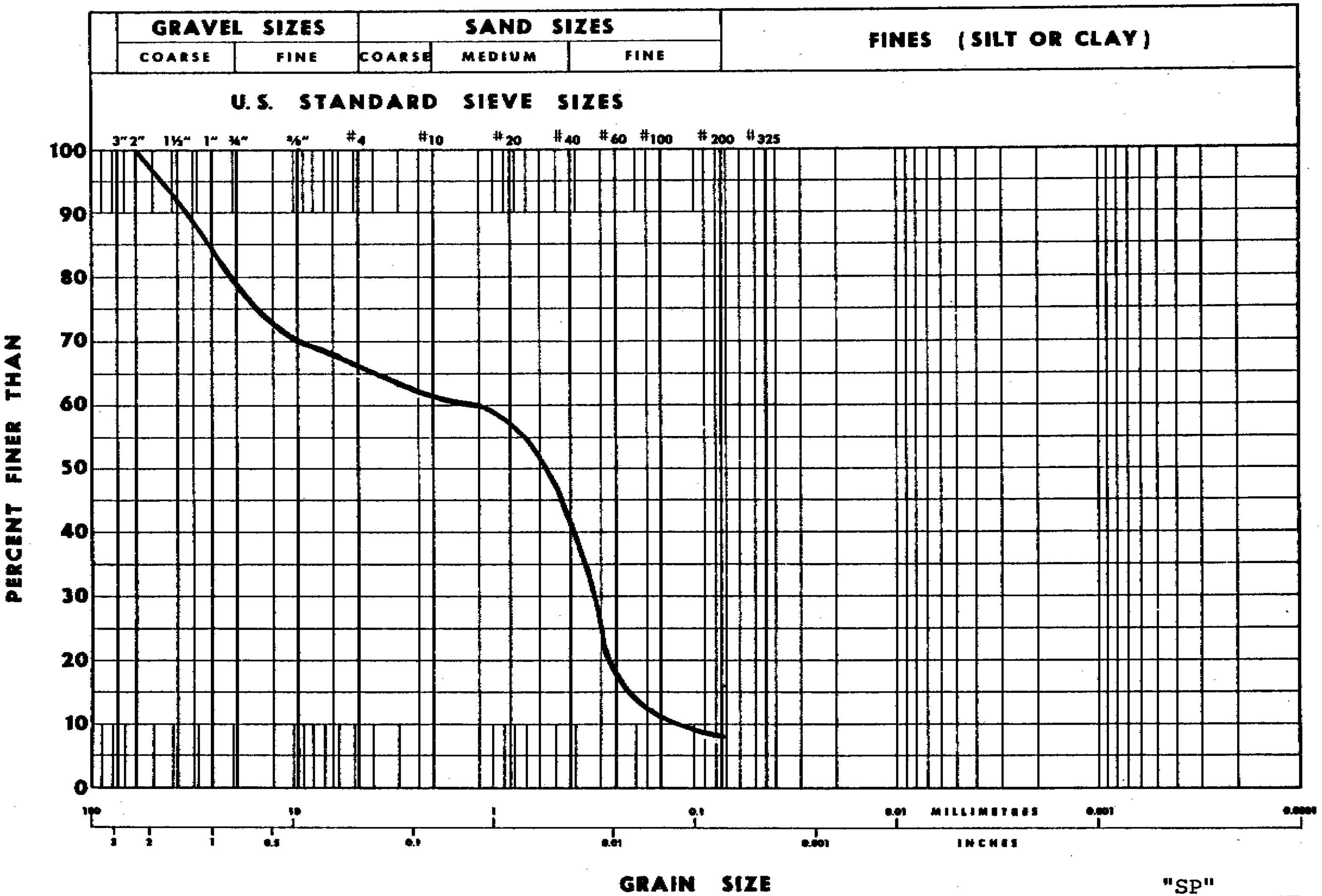
TEST HOLE NO. 25

GRAIN SIZE ANALYSIS



REMARKS: Sample A, 0.8 - 1.0 m

Gravel 34.3%

Sand 57.2%

Fines 8.5%

NOTE: UNIFIED SOIL CLASSIFICATION SYSTEM

"SP"

D_{10} = 0.1 MM.
D_{30} = 0.33 MM.
D_{60} = 1.2 MM.
C_U 12
C_C 0.91

GRAIN SIZE ANALYSIS

GOVERNMENT OF CANADA
DEPARTMENT OF INDIAN AFFAIRS
AND
NORTHERN DEVELOPMENT

HARDY ASSOCIATES (1978) LTD.
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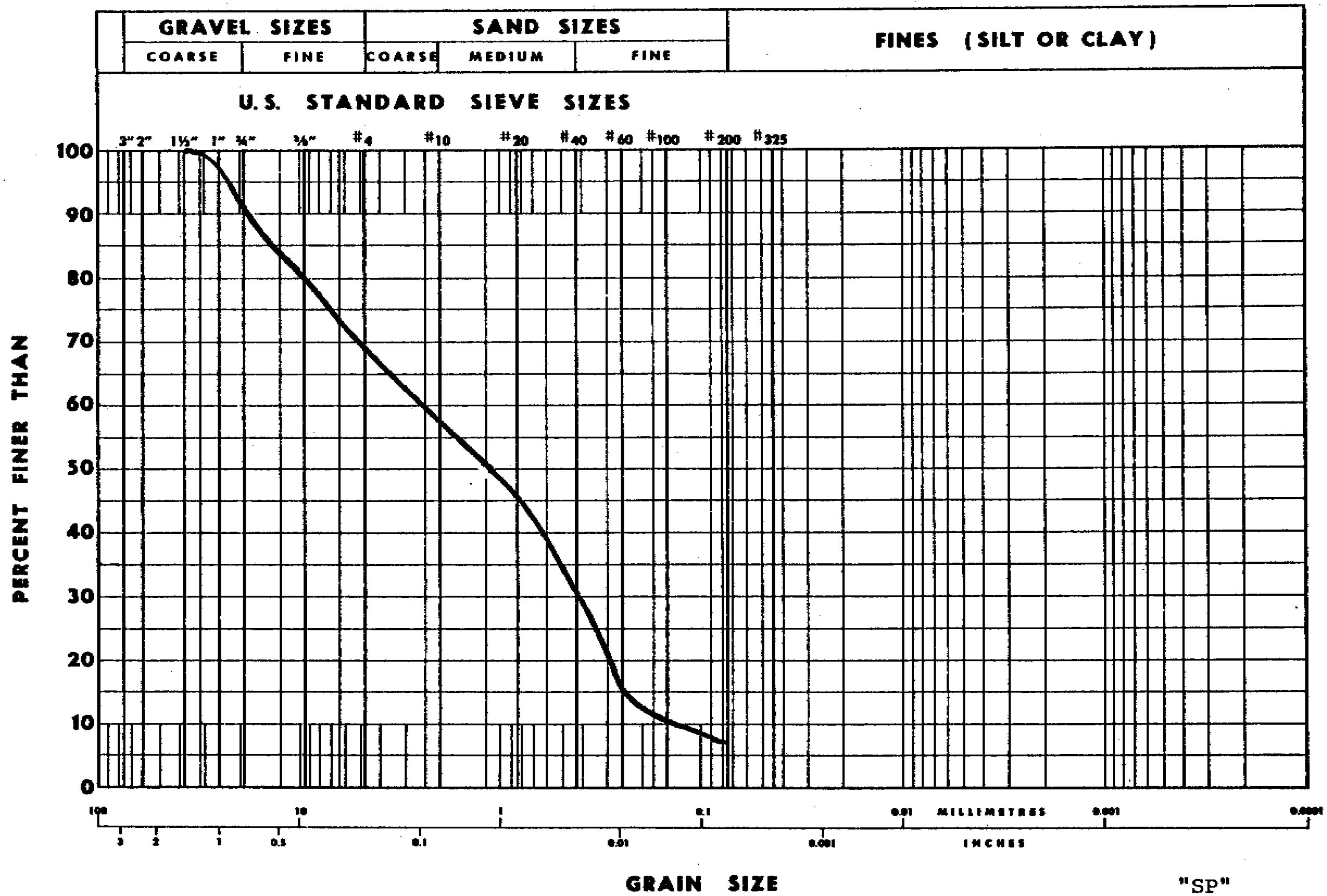
TEST HOLE NO. 25



"SP"

D$_{10}$= 0.14 MM.
D$_{30}$= 0.4 MM.
D$_{60}$= 2.5 MM.
C$_U$ 17.9
C$_C$ 0.46

REMARKS: Sample A3, 3.0 - 3.2 m

Gravel 30.9%

Sand 61.6%

Fines 7.5%

NOTE: UNIFIED SOIL CLASSIFICATION SYSTEM

GRAIN SIZE ANALYSIS

GOVERNMENT OF CANADA
DEPARTMENT OF INDIAN AFFAIRS
AND
NORTHERN DEVELOPMENT

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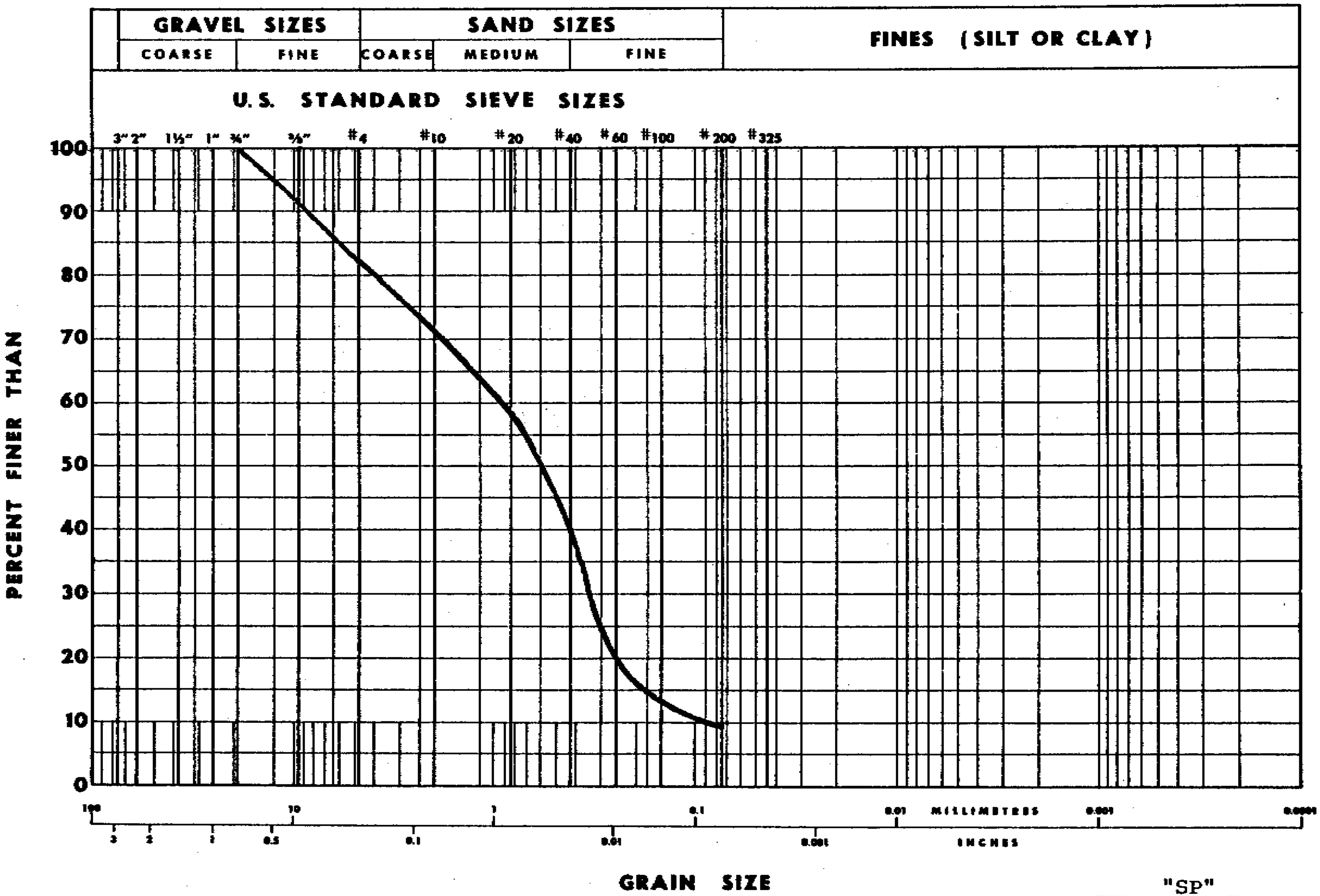

REMARKS: Sample A4, 4.5 - 4.7 m

Gravel 16.8%

Sand 72.7%

Fines 10.5%

NOTE: UNIFIED SOIL CLASSIFICATION SYSTEM

"SP"

D_{10}= 0.08 MM.
D_{30}= 0.33 MM.
D_{60}= 0.9 MM.
C_U 11.25
C_C 1.5

TEST HOLE NO. 25

GRAIN SIZE ANALYSIS

GOVERNMENT OF CANADA
DEPARTMENT OF INDIAN AFFAIRS
AND
NORTHERN DEVELOPMENT

HARDY ASSOCIATES (1978) LTD.
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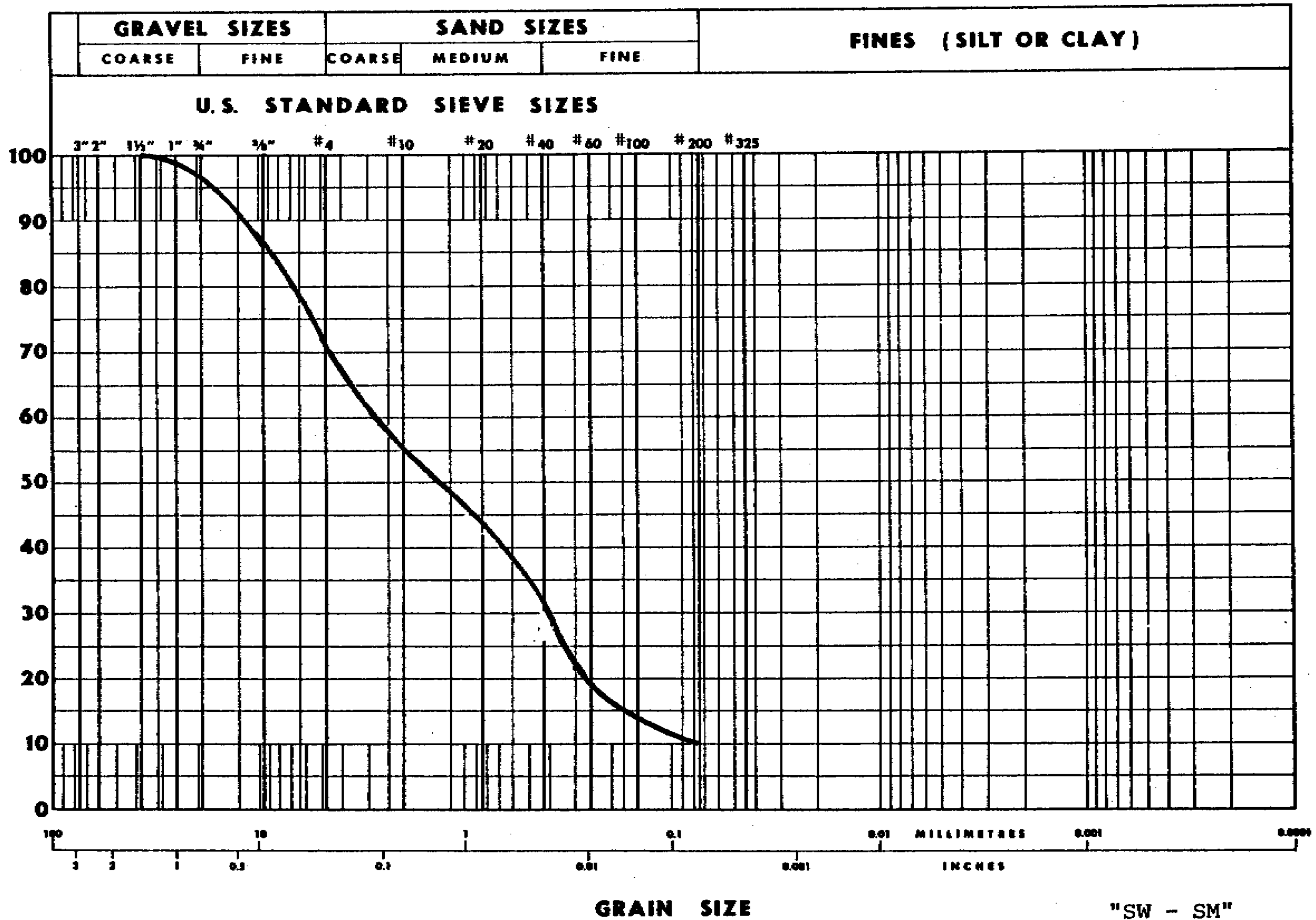
TEST HOLE NO. 25



REMARKS: Sample A5, 5-1 - 5.3 m

Gravel 29.5%

Sand 58.6%

Fines 11.9%

NOTE: UNIFIED SOIL CLASSIFICATION SYSTEM

"SW - SM"

D_{10} = 0.04 MM.

D_{30} = 0.4 MM.

D_{60} = 3 MM.

C_U 25

C_C 1.33

GOVERNMENT OF CANADA
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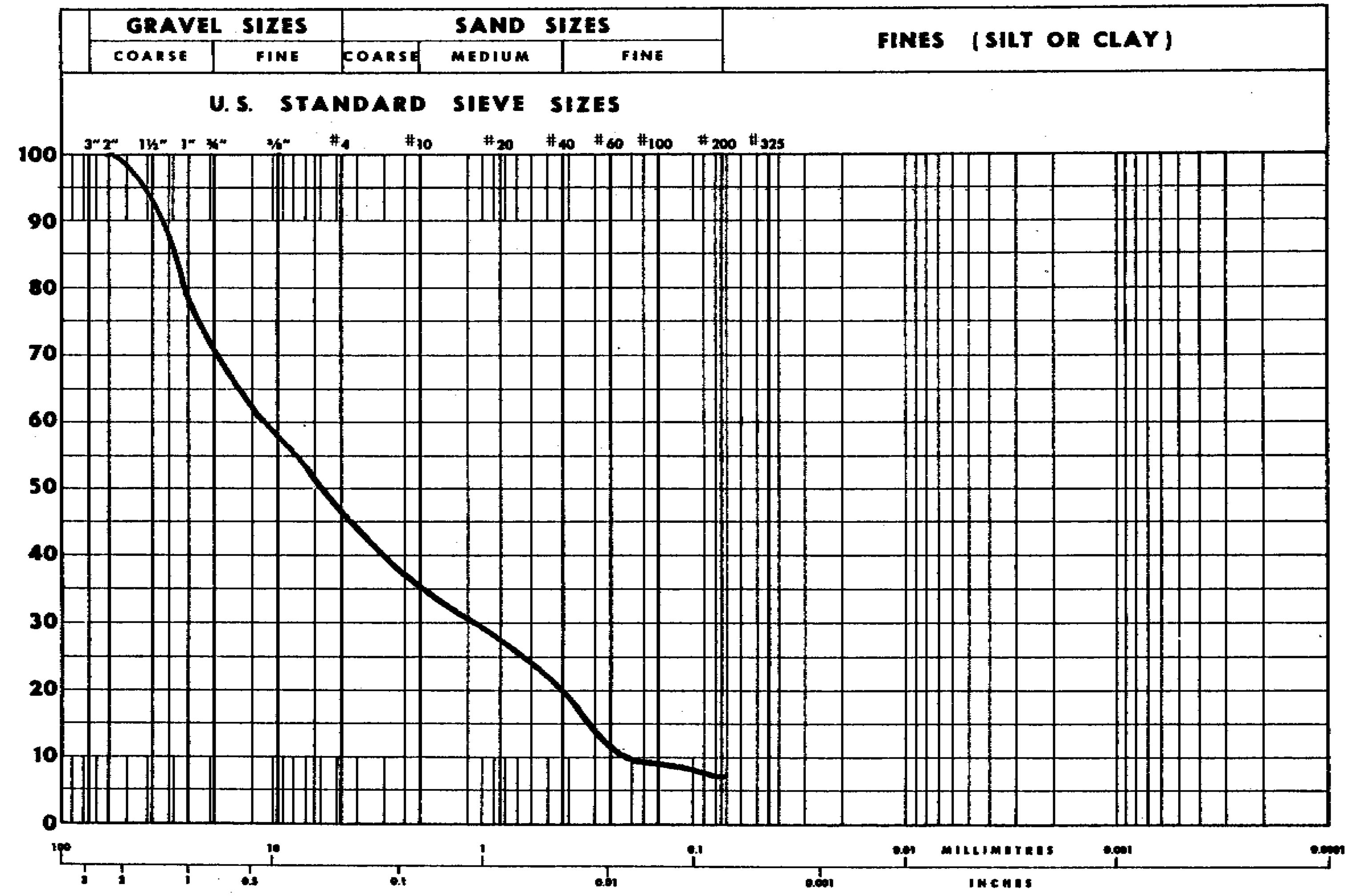
TEST HOLE NO.
26

GRAIN SIZE ANALYSIS



GRAIN SIZE

"GP"

D_{10}=	0.22 MM.
D_{30}=	1.0 MM.
D_{60}=	11 MM.
C_U	50
C_C	0.41

REMARKS: Sample A1, 0.5 - 0.7 m

Gravel 54.1%

Sand 38.9%

Fines 7.0%

NOTE: UNIFIED SOIL CLASSIFICATION SYSTEM

GOVERNMENT OF CANADA
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NORTHERN DEVELOPMENT

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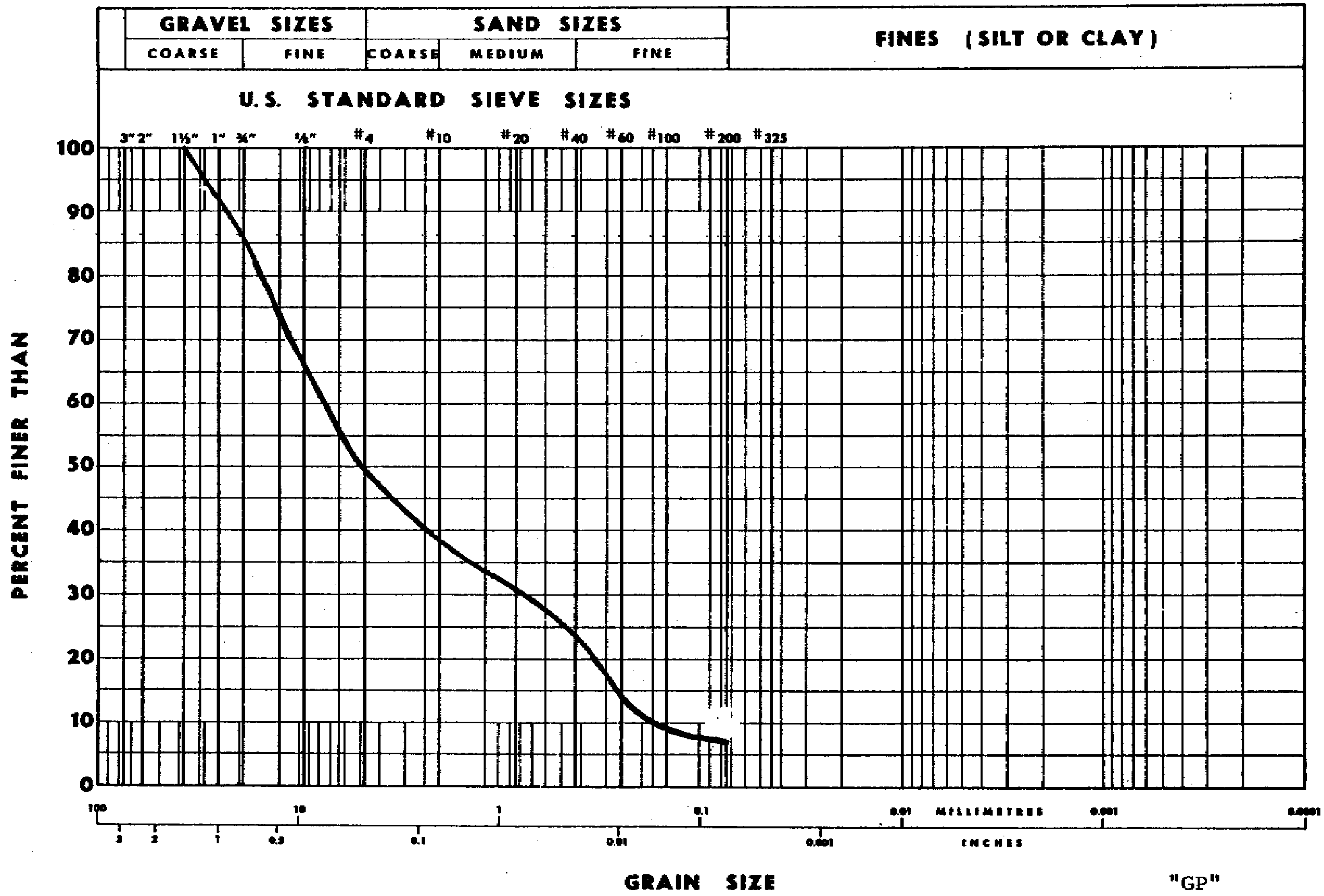
TEST HOLE NO.
26

GRAIN SIZE ANALYSIS



"GP"

REMARKS: Sample A3, 3.1 - 3.3 m

Gravel 51.1%

Sand 41.5%

Fines 7.4%

NOTE: UNIFIED SOIL CLASSIFICATION SYSTEM

D_{10} = 0.17 MM.
D_{30} = 0.8 MM.
D_{60} = 8.4 MM.
C_U 49.4
C_C 0.45

GRAIN SIZE ANALYSIS

GOVERNMENT OF CANADA
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NORTHERN DEVELOPMENT

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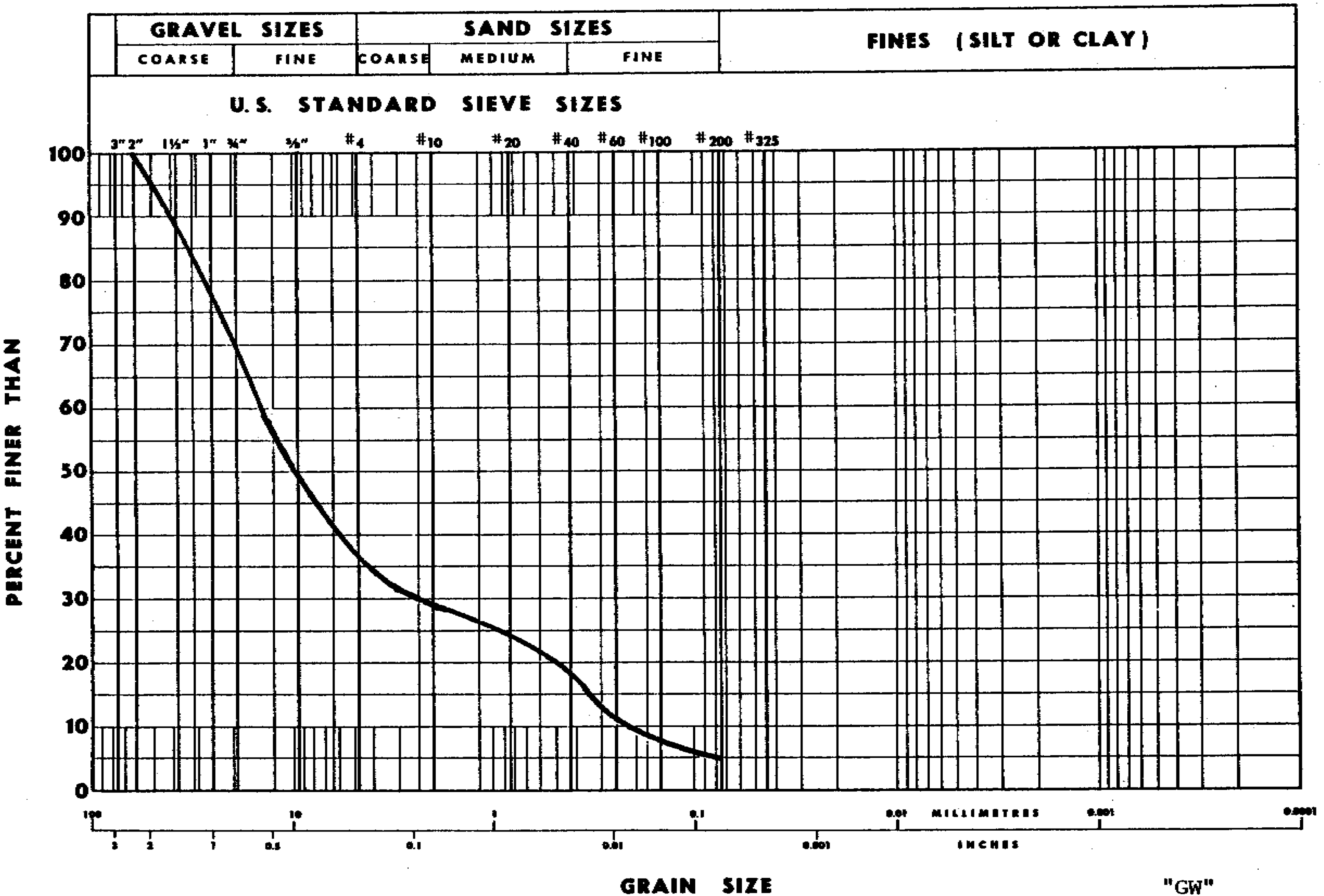
TEST HOLE NO. 27



REMARKS: Sample Al, 0.4 - 0.6 m

Gravel 62.4%

Sand 31.7%

Fines 5.9%

NOTE: UNIFIED SOIL CLASSIFICATION SYSTEM

"GW"

D_{10}= 0.2 MM.
D_{30}= 2.3 MM.
D_{60}= 14 MM.
C_U 70
C_c 1.9

GRAIN SIZE ANALYSIS

GOVERNMENT OF CANADA
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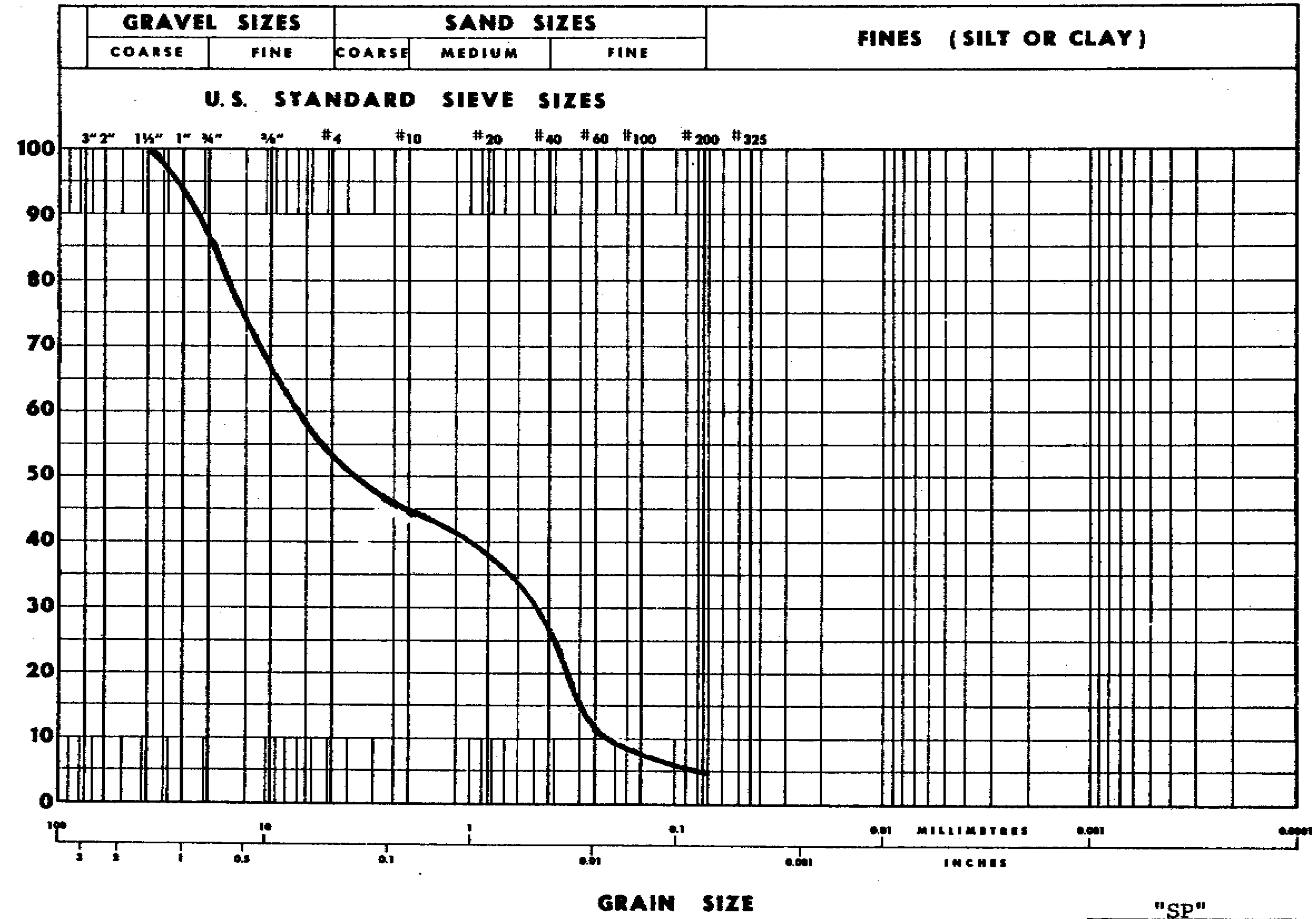
TEST HOLE NO.
28a



REMARKS: Sample A1, 0.4 - 0.7 m

Gravel 47.0%

Sand 47.6%

Fines 5.4%

NOTE: UNIFIED SOIL CLASSIFICATION SYSTEM

"SP"

D_{10}= 0.27 MM.
D_{30}= 0.47 MM.
D_{60}= 7 MM.
C_U 25.9
C_C 0.12

GOVERNMENT OF CANADA
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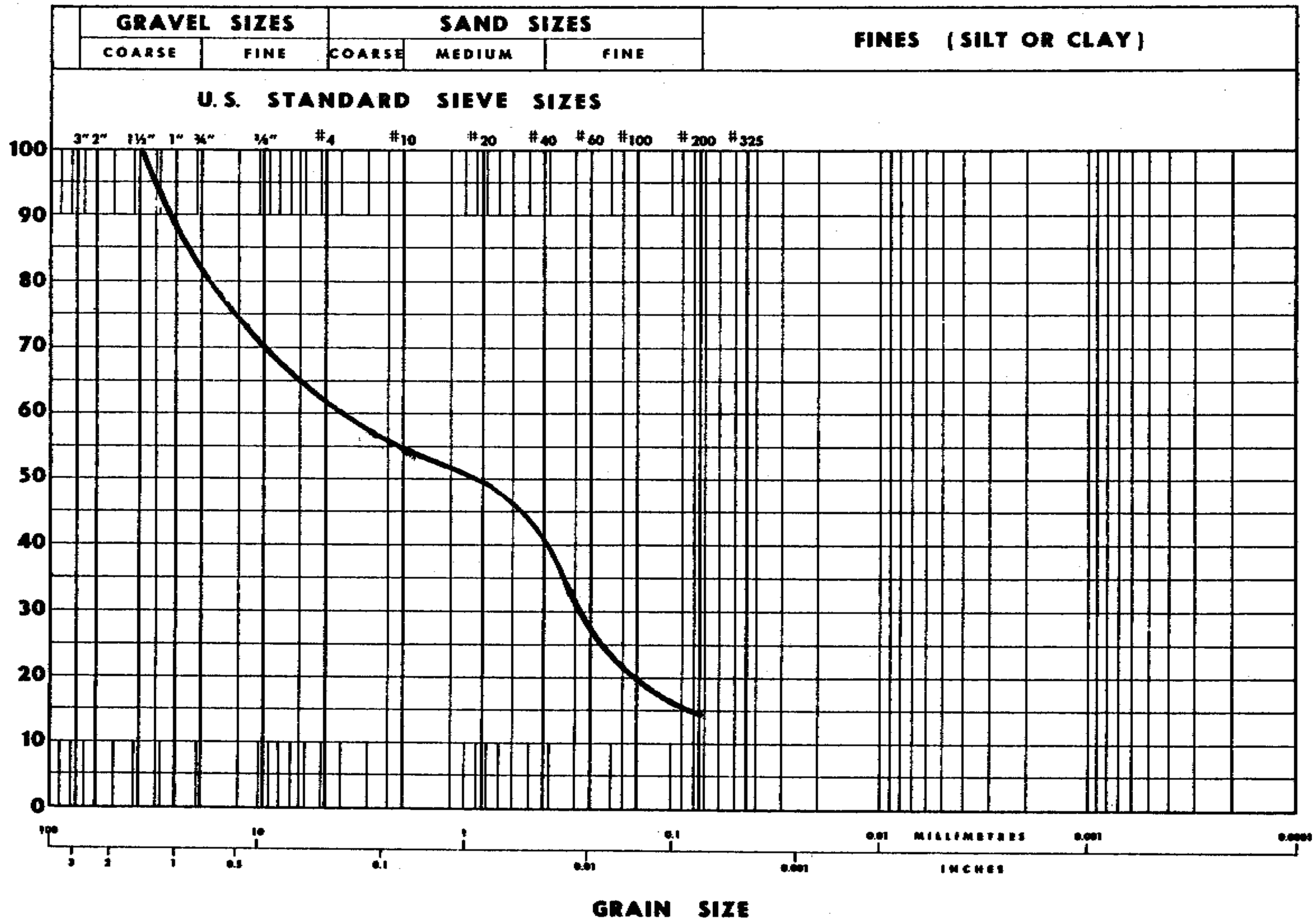
TEST HOLE NO.
30

GRAIN SIZE ANALYSIS



REMARKS: Sample A2, 1.6 - 1.8 m

Gravel 38.0%

Sand 46.9%

Fines 15.1%

NOTE: UNIFIED SOIL CLASSIFICATION SYSTEM

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

GRAIN SIZE ANALYSIS

GOVERNMENT OF CANADA
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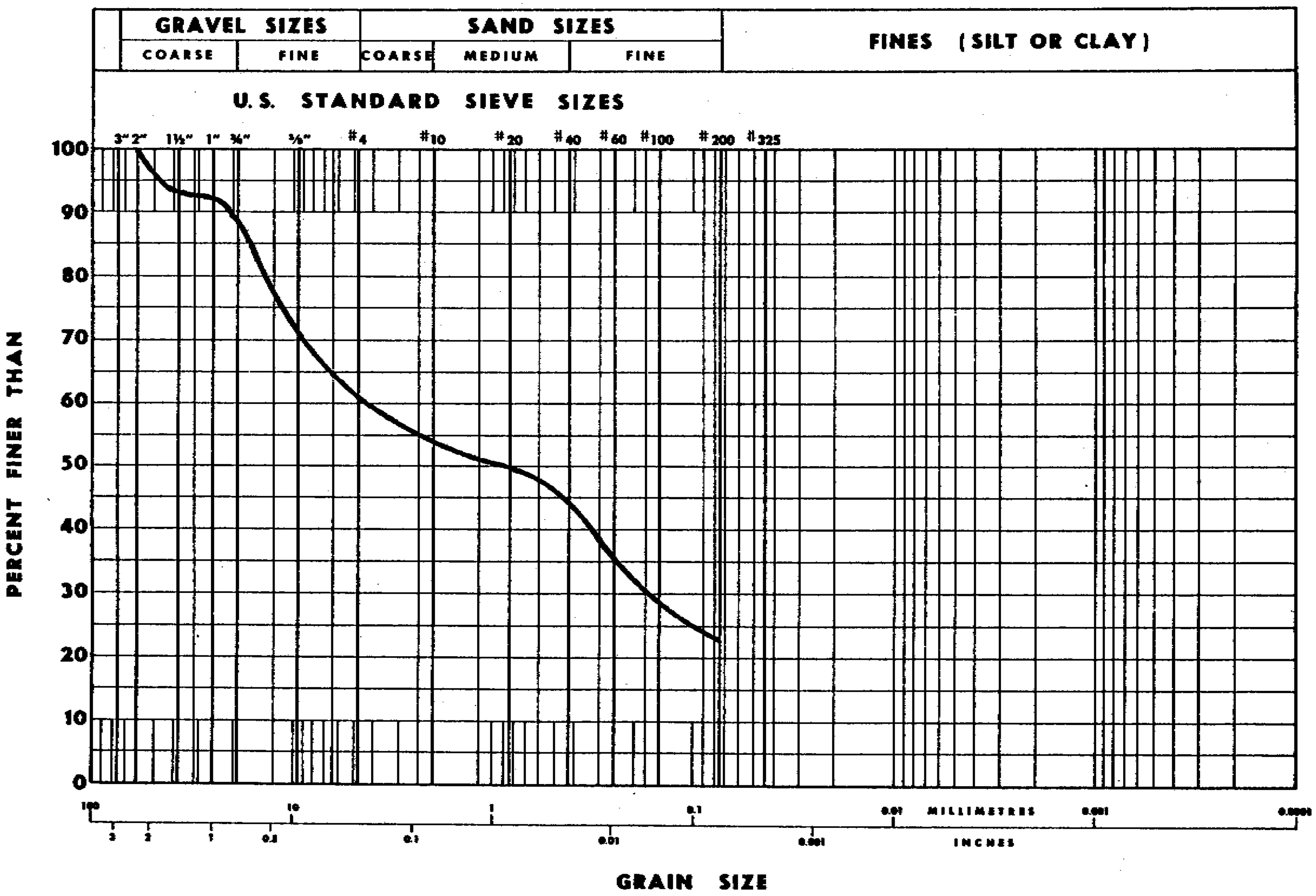
TEST HOLE NO. 33



REMARKS: Sample A3, 2.2 - 2.5 m

Gravel 39.2%

Sand 37.1%

Fines 23.7%

NOTE: UNIFIED SOIL CLASSIFICATION SYSTEM

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

GRAIN SIZE ANALYSIS

GOVERNMENT OF CANADA
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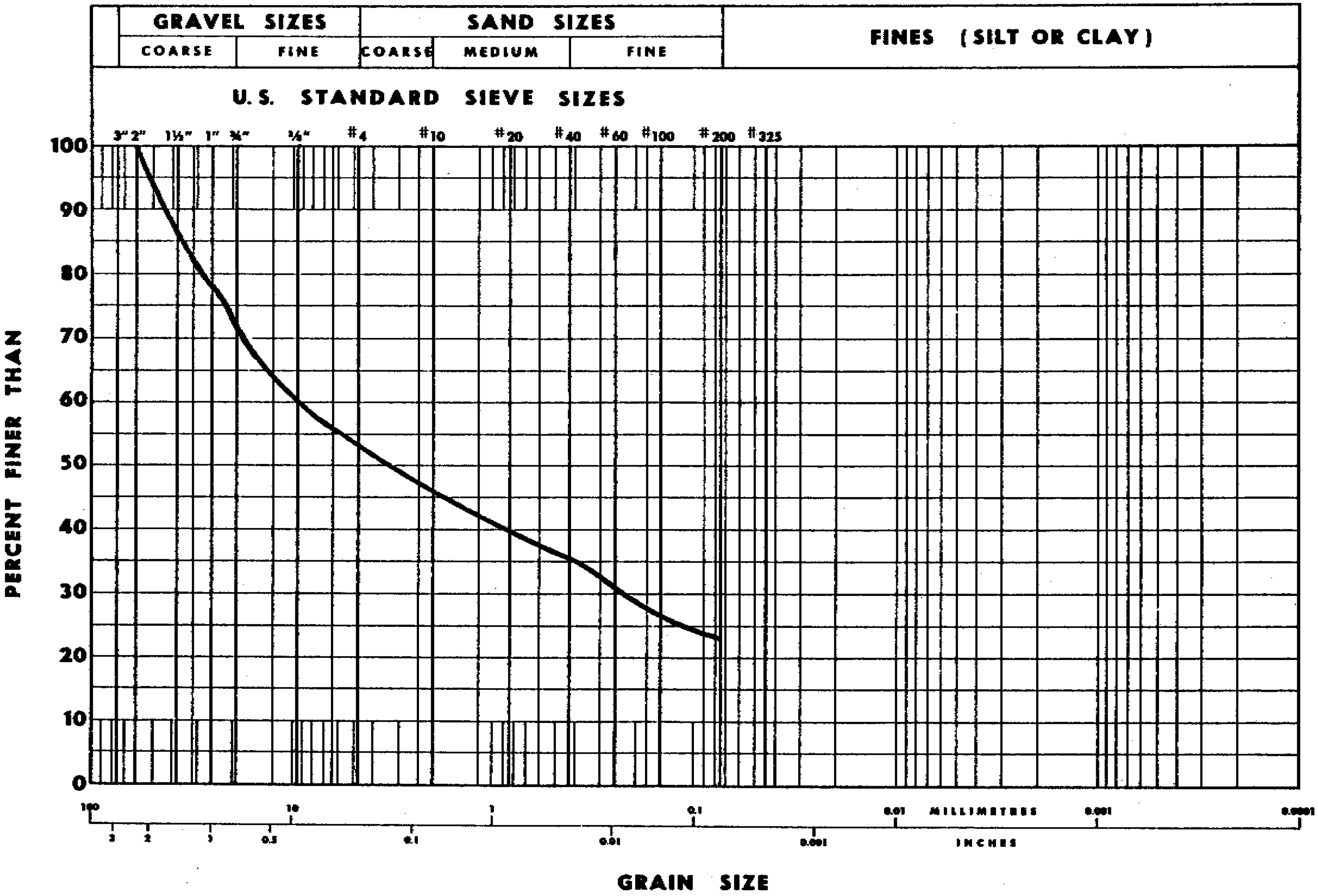
TEST HOLE NO.
38



REMARKS: Sample A3, 2.5 - 2.8 m

Gravel 46.5%

Sand 30.4%

Fines 23.1%

NOTE: UNIFIED SOIL CLASSIFICATION SYSTEM

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

GRAIN SIZE ANALYSIS

GOVERNMENT OF CANADA
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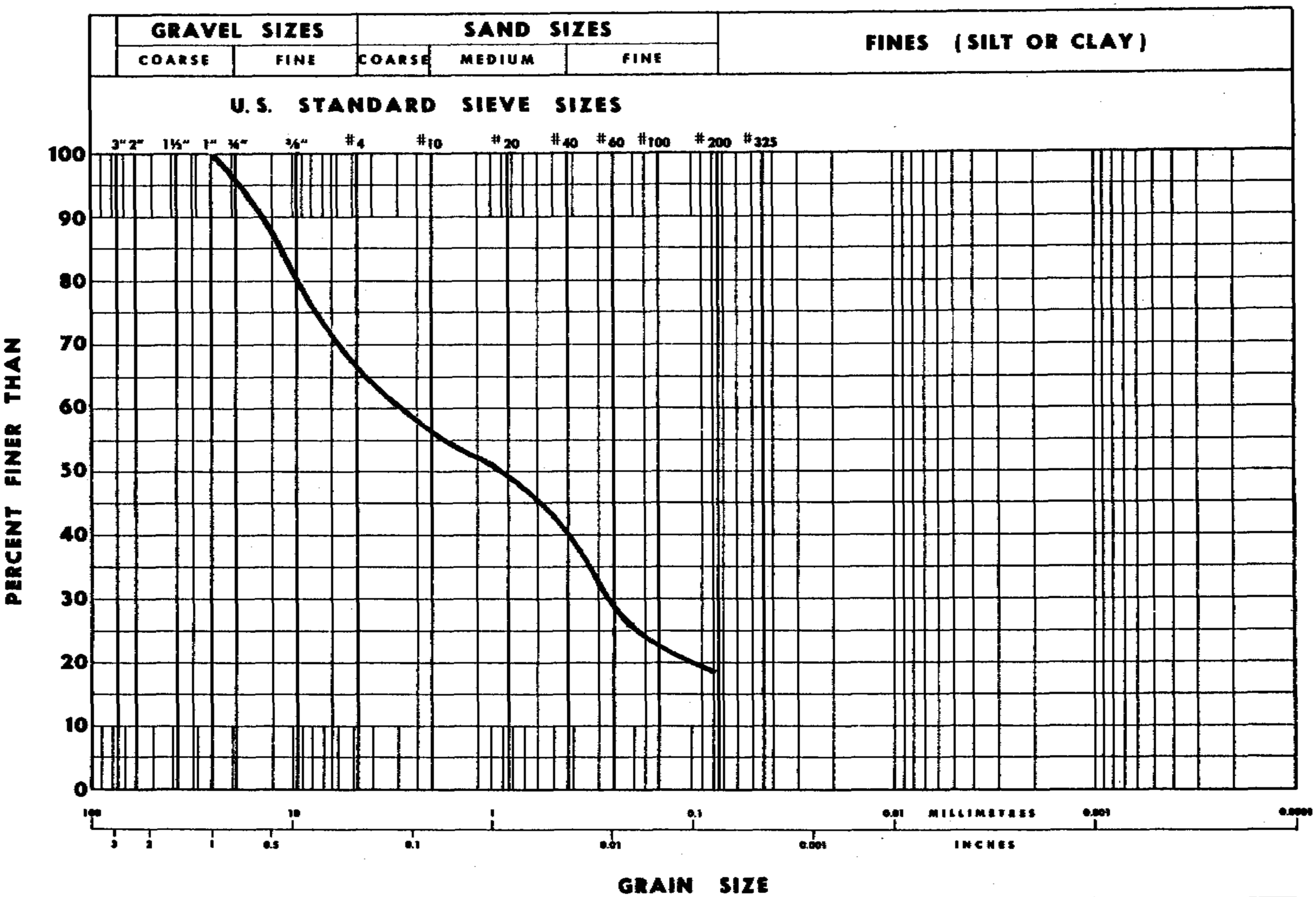
TEST HOLE NO. 39



REMARKS: Sample A2, 2.0 - 2.2 m

Gravel 32.8%

Sand 48.0%

Fines 19.2%

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

NOTE: UNIFIED SOIL CLASSIFICATION SYSTEM

PETROGRAPHIC ANALYSIS OF COARSE AGGREGATE

Test Hole 9, Sample A2

The coarse aggregate accounts for 41.1% of the total sample. The predominant component is a very strong quartzite which represents over 60 percent of the analysed sample. Subordinate components include medium strong sandstone/siltstone and medium strong granite. Potentially deleterious, deleterious and friable components represent over 12 percent of the analyzed sample.

Over 80 percent of the pebbles are subangular to angular with the rest being subrounded to rounded. Approximately 50 percent of the pebbles are isometric in shape with the remaining pebbles being either flat and/or rod-like. As the grain size decreases, the pebbles tend to become more isometric. The pebble surfaces are generally clean, however a trace of carbonate coating was observed occassionally.

The normalized PN for this sample was calculated to be 135.6. From a petrographic standpoint, this represents a fair quality aggregate for use in concrete.

SUMMARY OF ROCK TYPES

Rock Type	Classifications	Total Weighted Composition %
Quartzite	Very strong - Good	26.1
Granite	Medium strong - Good	0.75
Sandstone/Siltstone	Medium strong - Good	9.2
Chert	Potentially Deleterious - Fair	4.2
Friable Sandstone	Friable, weak - Poor	0.35
Ironstone	Weak, soft - Deleterious	0.5
TOTAL		41.1

PETROGRAPHIC ANALYSIS OF COARSE AGGREGATE

Test Hole 25, Sample A3

The analyzed coarse aggregate represents 30.9 percent of the total sample. The major components include a medium strong sandstone/siltstone (37.3%), a potentially deleterious chert (27.2%) and a very strong quartzite (24.3%). Minor components are a medium strong granite and a deleterious ironstone. Potentially deleterious and deleterious components account for just under 30 percent of the analyzed sample.

Approximately 55 percent of the pebbles are subangular to angular, however, the coarser fractions (i.e. > 1/2") tend to have more rounded to subrounded pebbles. An average of 63 percent of the pebbles are isometric in shape with close to 75 percent being isometric in the 1/2", 3/8" and #4 fractions. The pebble surfaces are clean and contain only a trace of calcareous film. None of the rock types exhibit a tendency to split or to flake.

The normalized PN for this sample was calculated to 171.8. From a petrographic point of view, this represents an unsuitable quality of aggregate for use in concrete, mainly as a result of the high percentage of potentially deleterious chert in the sample. The above rating may be upgraded if chemical tests show that the chert is not reactive.

SUMMARY OF ROCK TYPES

Rock Type	Classifications	Total Weighted Composition %
Quartzite	Very strong - Good	7.5
Granite	Medium strong - Good	2.85
Sandstone/Siltstone	Medium strong - Good	11.55
Chert	Potentially Deleterious - Fair	8.4
Ironstone	Weak - Deleterious	0.6
TOTAL		30.9

APPENDIX "B"

EXPLANATION OF TERMS AND SYMBOLS

APPENDIX "B"

EXPLANATION OF TERMS AND SYMBOLS

1.0 GENERAL

The terms and symbols used on the test hole logs to summarize the results of the field investigation and of subsequent laboratory testing are described in detail below and are illustrated on the appended exhibit test hole log (Figure 1).

General information, such as test hole number, date of drilling and inspector, is noted in the lower portion of the test hole log. Detailed subsurface information observed at each test hole location and laboratory test data are presented in columnar form on the test hole log. Each column used is described in detail below using the reference numbers shown on the appended blank test hole log (Figure 2).

It should be noted that the soil type, stratigraphic boundaries, and in situ conditions have been established only at the test hole location and that they are not necessarily representative of subsurface conditions elsewhere across the site.

Column 1:	Depth: The depth of test hole below existing ground surface is shown in this column.
Column 2:	Soil Group Symbol: A soil classification symbol in accordance with a modification of the Unified Soil Classification System (1) is noted in this column. A definition of each Group Symbol is given on Figure 3 "Modified Unified Classification System for Soils". Where ice with or without soil inclusions is encountered in the stratigraphy, the ground ice classification symbol (see Column 6) is used in this column.
Column 3:	Soil Graphic Log: Soil strata are depicted graphically in accordance with the Graphic Symbol shown on Figure 3. The Ice Graphic Symbol (see Column 5) is used where ice is the predominant component of the stratigraphic segment.

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(1) References are listed on Pages B-24 and 25.

(1) References are listed on Pages B-24 and 25.

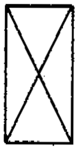
Column 4: Soil Description: A detailed engineering description of each soil stratum encountered is noted in this column. This description is given in accordance with the criteria outlined in Section 2.1 "Soil Description". The interface between soil strata is shown noted as a single continuous line with the depth to the interface above the line. A short broken line indicates a change in soil type descriptors, the soil type remaining the same.

Column 5: Ice Graphic Log: The various types of ground ice are depicted graphically according to Figure 4 "Ground Ice Classification".

Column 6: NRC Ice Type: (Visual Ice %): Abbreviated symbols for the forms of ground ice are noted in this column. A description of the NRC classification is contained in Section 2.2 "NRC Ice Type", and on Figure 4 "Ground Ice Classification". The volume of ground ice is estimated visually and expressed as a percentage of the total volume of soil and ice.

Column 7:	Sample Type and Number: The type and reference number of each sample is recorded in this column at the appropriate depth. All samples taken in conjunction with this drilling program were taken from the flights of the auger, and are designated by the prefix "A" as Auger Samples.
Column 8:	Sample Condition: The condition of each sample, and whether it was recovered or lost, is recorded against depth in this column with the following symbols:

undisturbed



disturbed

not recovered

Undisturbed samples refer to core samples which have been recovered in a state relatively unchanged by sampling. Disturbed samples are any other samples recovered from the hole. 'Not recovered' refers to samples lost down the hole.

Column 9: Depth: The depths of samples retained are noted in this column.

Column 10: Other Information: Test data and field observations not incorporated into the previous columns are presented here. Information for grain size and petrographic analyses are included on separate forms following the test hole logs.

Moisture content of a sample, as percent of dry weight is shown in this column. The moisture content percentage is indicated by the symbol "w".

The organic impurities in sand for concrete is indicated in this column by a number ranging between 1 and 5. The interpretation for the Organic Color Numbers is as follows;

Organic Color	Interpretation
1 to 1+	Sand suitable for use in high grade concrete.
2 to 2+	Sand which may be used in unimportant concrete work.
3 to 3+	Sand which should not be used in concrete without processing.
4 to 5+	Sand with high organic content that should not be used in concrete.

2.0 DESCRIPTION DETAILS

The various terms, symbols, and abbreviations are discussed in detail to facilitate interpretation and understanding of the data presented on the test hole logs.

2.1 Soil Description (Column 4)

Soils are classified and described according to their engineering properties and behaviour.

2.1.1 Soil Description System

The following properties are described for a comprehensive soil classification system:

> Grain size distribution or plasticity, colour, moisture, sensitivity, structure, foreign materials, and consistency or strength.

The soil in each stratum is described on the test hole logs using the Unified Soil Classification System modified slightly so that an inorganic clay of "medium plasticity" is recognized. Selected adjectives are used to define the actual or estimated percentage range by weight of the various components.

The identification of soil components and fractions is defined by the Modified Unified Soil Classification System which classifies soils into three major divisions:

Coarse-grained soils - gravel and sand
Fine-grained soils - silt and clay
Highly organic soils - peat

Classification of soils is based on the grain size distribution of that portion of the soil smaller than the 76.2 mm (3 inch) U.S. Standard sieve size.

Soils with 50 percent or more of the components coarser than the No. 200 U.S. Standard sieve size (0.074 mm) are described as COARSE-GRAINED (or granular) soils. Coarse-grained soils (gravel and sand) are classified by grain size distribution and are subdivided into coarse and fine gravel, and coarse, medium, and fine sand.

Soils with 50 percent or more of the components finer than No. 200 sieve size are described as FINE-GRAINED soils. These may be cohesive or non-cohesive. Note that for visual classification the No. 200 sieve size is about the smallest size of particle that can be distinguished individually by the unaided eye.

Fine-grained soils (silt and clay) are classified by behaviour on the basis of the liquid limit and plasticity index of the fraction finer than the No. 40 U.S. Standard sieve size. The boundaries defining the fine-grained soil groups are shown on the Plasticity Chart on Figure 3. The Plasticity Chart is also used to determine the behaviour of the fines content of coarse-grained soils.

Particle size and shape are usually described for coarse-grained soils, and plasticity is usually described for fine-grained soils. An exception to this rule applies when describing glacial till. Then plasticity, particle size, and shape are all included in the description.

The principal component of the fraction of the soil passing the 76.2 mm (3 inch) U.S. Standard sieve size is shown capitalized on the test hole logs. Where ice has been identified as the principal component within a segment of the stratigraphy, it is indicated capitalized in this column.

The proportions by weight of the minor components are defined according to the following descriptors:

Descriptor	Proportion
"and"	50 to 36 percent
"some"	35 to 21 percent
"little"	20 to 11 percent
"trace"	10 to 1 percent

The descriptors used must not contradict the classification by the Modified Unified Soil Classification System.

The terms given above are used to define proportions by weight of granular components, but they may also be used to define the proportion of minor components of fine-grained material, according to the subdivisions of the Plasticity Chart shown on Figure 3. The adjectives are not used to subdivide a principal fine-grained component. The modifier "y" or "ey" (i.e., SILT - clayey) is used when the liquid limit and plasticity index plot close to the "A-line" on the Plasticity Chart.

Peat and other highly organic soils are classified under the group symbol "Pt". Peat may be categorized and described using the Radforth Classification System.

The soil is described first by identifying the principal component, followed by the minor components in order of decreasing proportion by weight. This is followed by other significant identifying features such as plasticity, colour, moisture, structure, and strength.

2.1.2 Typical Example of a Complete Soil Description

"Clay, silty, little medium sand, trace coarse gravel, medium plasticity, yellow-brown", describes a yellow-brown fine-grained silty clay soil containing 50 percent or more of components finer than the No. 200 U.S. Standard sieve size with minor components of sand and gravel. The fraction passing the No. 40 U.S. Standard sieve size plots above, and close to the "A-line" on the Plasticity Chart. The soil contains between 10 percent and 20 percent of sand particles generally in the size range No. 10 to No. 40 (i.e., finer than the No. 10 Standard sieve size and larger than the No. 40 Standard sieve size) and between 1 percent and 10 percent of gravel in the size range 19 to 76.2 mm. The identifying feature "medium plasticity" indicates that the liquid limit plots between 30 and 50 on the Plasticity Chart. Such a soil is classified as CI by the Modified Unified Soil Classification System.

2.1.3 Typical Examples of the Use of Modifiers and Descriptors

(a) Coarse-grained soil with minor fine-grained components:

"Gravel fine, some silty clay", describes a coarse-grained soil with a minor component of fines, which has a liquid limit and plasticity index that plot above and close to the "A-line" on the plasticity chart. Such a soil is classified as GC by the Unified Soil Classification System.

"Sand some silt", is correct in that "silt" in this case is a minor component of non-plastic fines which plot below the A-line on the Plasticity Chart.

(b) Fine-grained soil with a minor coarse-grained component:

"Clay silty, some fine sand", describes a fine-grained soil having a fines content in excess of 50 percent.

2.2 NRC Ice Type and Estimated Visual Ice (Column 6)

Ground ice is divided by the NRC system on the basis of examination by the unaided eye into the three major categories shown below. A complete description of this system is contained in the NRC "Guide to a Field Description of Permafrost for Engineering Purposes".

2.2.1 Ground Ice Classification Categories

Non-visible ice	N
Visible ice less than 25.4 mm thick	V
Visible ice greater than 25.4 mm thick	ICE or ICE + soil type

Figure 4 "Ground Ice Classification" shows the various types of ground ice recognized by the NRC classification system. Graphic symbols for ground ice have been devised to complement the graphic soil log.

Frozen soils in the N group may, on close examination, indicate presence of ice within the voids of the material by crystalline reflections or by a sheen on fractured or trimmed surfaces. The impression received by the unaided eye, however, is that the ice does not occupy space in excess of the original voids in the soil. Excess ice in the N group can be identified by use of a hand magnifying lens, or by placing some frozen soil in a small jar, allowing it to melt and observing the supernatant water. To the unaided eye, ice in frozen soils in the V group appears to occupy space in excess of the original voids in the soils.

The volume of ground ice can be described quantitatively in two ways. "Excess ice" is the volume of supernatant water expressed as a percentage of the total volume of the thawed soil and water. This quantity is often referred to as "excess moisture". "Visual ice" is the estimated volume of segregated ice discernible by eye in the frozen sample and is expressed as a percentage of the total volume of the frozen soil. By these definitions the quantity "excess ice" and "visual ice" are not necessarily the same for a given frozen soil. Care is taken when estimating the volume of ice coatings on granular material (Vc). The ice is usually obvious, giving the impression of "excess ice", which may not necessarily be the case.

2.2.2 Ice Description Terminology

The following terminology has been generally taken from Table II of the NRC Guide.

"Ice Coatings on Particles" are discernible layers of ice found on or below the larger soil particles in a frozen soil mass. They are associated sometimes with hoarfrost crystals that have grown into voids produced by the freezing action.

"Ice Crystal" is a very small individual ice particle visible in the face of a soil mass. Crystals may be present alone or in combination with other ice formations.

"Clear Ice" is transparent and contains only a moderate number of air bubbles.

"Cloudy Ice" is relatively opaque due to entrained air bubbles or other reasons, but is essentially sound and non-pervious.

"Porous Ice" contains numerous voids, usually interconnected, and generally results from melting at air bubbles or along crystal interfaces, from presence of salt or other materials in the water, or from the freezing of saturated snow; though porous, the mass retains its structural unity.

"Candled Ice" is ice that has rotted or otherwise formed into long columnar crystals very loosely bonded together.

"Granular Ice" is composed of coarse, more or less equidimensional ice crystals weakly bonded together.

"Ice Lenses" are lenticular ice formations in soil occurring essentially parallel to each other, generally normal to the direction of heat loss and commonly in repeated layers.

"Ice Segregation" is the growth of ice as distinct lenses, layers, veins, and masses in soils, commonly but not always oriented normally to direction of heat loss.

"Well-bonded" signifies that the soil particles are strongly held together by the ice and that the frozen soil possesses relatively high resistance to chipping or breaking.

"Poorly-bonded" signifies that the soil particles are weakly held together by the ice and that the frozen soil possesses poor resistance to chipping or breaking.

"Friable" denotes extremely weak bonds between soil particles. The material is easily broken up.

The symbols "UF" or "F" may be used in Column 6. "UF" is added to indicate unfrozen zones in areas of generally frozen ground and also to avoid possible errors of omission.

"F" is used in certain cases along with the corresponding graphic representation for "Undifferentiated" permafrost or frozen active layer soils. It may be used where the soil is known to be frozen but, due to circumstances beyond field control, the ice type cannot be determined because of grinding or temporary thawing of the material by the drilling operation.

2.4 Petrographic Analysis

The petrographic analysis was conducted in accordance with ASTM specification C245 entitled "Petrographic Examination of Aggregates for Concrete" and CSA specification A23.2, 30-1973 entitled "Procedure for the Petrographic Analysis of Coarse Aggregate."

The analysis employs factors ranging from 1 to 10 depending upon the various rock types identified and their classification in terms of concrete suitability ranging from good to deleterious. The sum of the products of the percentage of each rock type multiplied by the appropriate factor yields a petrographic number (or PN).

The standards referred to above do not specify acceptance levels for concrete aggregate based on PN values.

acceptance levels for concrete aggregate based on PN values

However, various organizations across Canada have adopted their own classification charts including the one below by Ontario Hydro, which we have used in our analysis:

100 - 110	Excellent
110 - 125	Good
125 - 140	Fair
140 - 155	Poor
> 155	Unsuitable

2.4 Classification of Construction Materials

Table B-1 is a classification of materials based on the potential construction usage of the granular material. This classification system for Granular Materials are provided by DIAND.

2.5 Soil Drainage Classes

The Soil Drainage Classes were used in describing drainage of the areas investigated. The following set of definitions was used to determine the drainage of each site.

TABLE B1

CLASSIFICATION OF GRANULAR MATERIALS

Source Quality Description	General Description of Material	Minimum Technical Identification Parameters	Suggested Uses of Material
(1) Excellent	Well graded sand and gravel suitable for use as aggregates with a minimum of processing	Petrographic Number - 160 max. Los Angeles Abrasion Loss - 35% max. Soundness Loss (Magnesium Sulphate) - 12% max. and meeting other requirements of CSA A23.1 - 1973	Portland cement concrete, asphaltic concrete, masonry sand, concrete block, surface treatment and roofing aggregate
(2) Good	Graded sand and gravel with varying quantities of silt	Petrographic Number - 200 max. Los Angeles Abrasion Loss - 60% max. Fines greater than 10% passing the 200 sieve can be removed with minimum of processing	Granular base and sub-base, winter sand backfill for trenches and slabs, pads for structure
(3) Fair	Poorly graded sand and gravel with or without substantial silt content	Petrographic Number - 250 max. Can be processed to meet local frost susceptibility criteria	Granular sub-base, general backfill material, pads for equipment
(4) Poor	Poorly graded granular soils of high silt content, possibility containing very weak particles and deleterious materials	Nil	General non-structural fill

The following is extracted from pages 215 and 216 of National Soil Survey Committee, 1970 "The System of Soil Classification for Canada", Canada Department of Agriculture, Ottawa. The system, although devised primarily for agricultural purposes is suitable for engineering purposes and was employed when describing soil drainage at the deposit locations. The soil drainage classes are defined in terms of:

(i) actual moisture in excess of field moisture capacity, and

(ii) the extent of the period during which such excess water is present in the plant-root zone.

Permeability, groundwater levels and seepage affect the moisture status but these are not easily observed in the field and therefore cannot generally be used as criteria for moisture status. The recommended definitions are as follows:

(1) Rapidly drained - The soil moisture content seldom exceeds field capacity in any horizon except immediately after water conditions.

(2) Well drained - The soil moisture content does not normally exceed field capacity in any horizon for a significant part of the year. ("significant -as used in the definitions is considered in relation to plant growth).

(3) Moderately well drained - The soil moisture in excess of field capacity remains for a small but significant period of the year.

(4) Imperfectly drained - The soil moisture in excess of field capacity remains in subsurface horizons for moderately long periods during the year.

(5) Poorly drained - The soil moisture in excess of field capacity remains in all horizons for a large part of the year.

(6) Very poorly drained - Free water remains at or within 12 inches of the surface most of the year.

2.5 Topography

The topography of each site was described using the following table of terms:

Single Slopes	Complex Slopes	Slope (%)	Slope (Angle °)
flat	flat depressional	0- 2	0- 1
gently sloping	undulating, smoothly rounded	2- 5	1- 3
moderately sloping	rolling ridgy, choppy	5-15	3- 8
steeply sloping	kettled, knobby	15-60	8-31
precipitous	precipitous	>60	>31

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2. National Research Council, Canada, 1963. "Guide to a Field Description of Permafrost for Engineering Purposes", prepared by Pihlainen, J.A. and Johnston, G.H., Technical Memorandum 79, NRC 7576, Ottawa.

3. American Society for Testing and Materials, 1964. Procedures for Testing Soils, "Suggested Methods of Testing for Identification of Soils", Fourth Ed. pp 221-233, December 1964.

4. National Research Council, Canada, 1958. "Guide to a Field Description of Muskeg", (Based on the Radforth Classification System) compiled by MacFàrlane, I.C., Technical Memorandum 44 (Revised Edition) NRC 4214, Ottawa.

5. American Society for Testing and Materials, 1979. "Annual Book of Standards", (Part 19), Philadelphia, Pa., U.S.A.

TEST HOLE LOG

DEPTH (M)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	MATERIAL DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %	SAMPLE TYPE AND NUMBER	SAMPLE CONDITION	DEPTH (M)	OTHER INFORMATION
	Pt		PEAT		Vr 30%				
1	SP		SAND trace gravel to 1 cm size, fine to medium grained		Vx 20%	A_1	☒	0.3 0.6	w = 23.4%
2	SW		SAND some subrounded gravel to 4 cm size, little silt, fine to coarse grained, well graded --- no gravel		10%	A_2	☒	2.2 2.6	Grain Size (A-49) w = 18.1%
3 4	I+		ICE+ trace silt		Vs 50% I+ 99%	A_3	☒	3.5 3.8	
5 6 7 8						A_4	☒	5.0 5.3	
9						A_5	☒	9.0 9.2	
10			Bottom of Hole at 9.5 m depth						

EXHIBIT
LOG

DATE: 80.01.22	LOGGED BY: A.C.	DRWN BY: C.G.	CHKD BY: N.H.

GOVERNMENT OF CANADA
DEPARTMENT OF INDIAN AFFAIRS
AND
NORTHERN DEVELOPMENT

HARDY ASSOCIATES (1978) LTD.
CONSULTING ENGINEERING & PROFESSIONAL SERVICES

TEST HOLE NO.
6

FIGURE 1

TEST HOLE LOG

DEPTH (M)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	MATERIAL DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %	SAMPLE TYPE AND NUMBER	SAMPLE CONDITION	DEPTH (M)	OTHER INFORMATION
1									
2									
3									
①	②	③	④	⑤	⑥	⑦	⑧	⑨	⑩
4									
5									
6									
7									
8									
9									
10									

DATE:	LOGGED BY:	DRWN BY:	CHKD BY:

GOVERNMENT OF CANADA DEPARTMENT OF INDIAN AFFAIRS AND NORTHERN DEVELOPMENT	**HARDY ASSOCIATES (1978) LTD.** CONSULTING ENGINEERING & PROFESSIONAL SERVICES	TEST HOLE NO.

FIGURE 2

DATE: LOGGED BY: DRWN BY: CHKD BY:

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	$C_U = \frac{D_{60}}{D_{10}} > 4 \quad C_C = \frac{(D_{30})^2}{D_{10} \times D_{60}} = 1 \text{ to } 3$	
			GP	▒	RED	POORLY GRADED GRAVELS, AND GRAVEL-SAND MIXTURES, LITTLE OR NO FINES	NOT MEETING ABOVE REQUIREMENTS	
		DIRTY GRAVELS (WITH SOME FINES)	GM	▥	YELLOW	SILTY GRAVELS, GRAVEL-SAND-SILT MIXTURES	CONTENT OF FINES EXCEEDS 12%	ATTERBERG LIMITS BELOW "A" LINE 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	$C_U = \frac{D_{60}}{D_{10}} > 6 \quad C_C = \frac{(D_{30})^2}{D_{10} \times D_{60}} = 1 \text{ to } 3$	
			SP	▒	RED	POORLY GRADED SANDS, LITTLE OR NO FINES	NOT MEETING ABOVE REQUIREMENTS	
		DIRTY SANDS (WITH SOME FINES)	SM	▥	YELLOW	SILTY SANDS, SAND-SILT MIXTURES	CONTENT OF FINES EXCEEDS 12%	ATTERBERG LIMITS BELOW "A" LINE P.I. LESS THAN 4
			SC	▨	YELLOW	CLAYEY SANDS, SAND-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

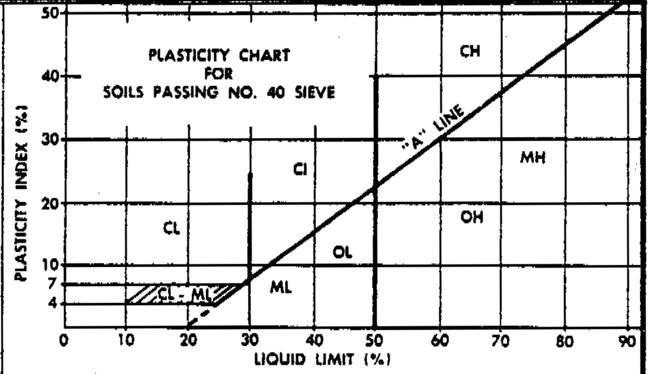
▦	BEDROCK (Undifferentiated)
▒	VOLCANIC ASH

SOIL COMPONENTS

FRACTION	U S STANDARD SIEVE SIZE		DEFINING RANGES OF PERCENTAGE BY WEIGHT OF MINOR COMPONENTS	
	PASSING	RETAINED	PERCENT	DESCRIPTOR
GRAVEL				
coarse	76 mm	19 mm	50 - 35	and
fine	19 mm	No 4	35 - 20	some
SAND				
coarse	No 4	No 10	20 - 10	little
medium	No 10	No 40	10 - 1	trace
fine	No 40	No 200		
SILT (non plastic) or CLAY (plastic)	No 200			

OVERSIZE MATERIAL

Rounded or subrounded	Not rounded
COBBLES 76 mm to 203 mm	ROCK FRAGMENTS > 76 mm
BOULDERS > 203 mm	ROCKS > 0·76 cubic metre in volume



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 3

GRADED GRAVEL SAND MIXTURE WITH CLAY BINDER BETWEEN 5% AND

GROUND ICE CLASSIFICATIONS

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

NOTE: 1. UF signifies unfrozen ground.

2. F/UF signifies that it was not possible to determine whether the ground was frozen, or unfrozen during drilling.

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FIGURE 4

APPENDIX "C"

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