GRANULAR MATERIALS EVALUATION

DEPOSITS 168 & 211

TUKTOYAKTUK AREA, N.W.T.

MAY 1983

Prepared by

BBT GEOTECHNICAL CONSULTANTS LTD.
GVM GEOLOGICAL CONSULTANTS LTD.
and
TERRAIN ANALYSIS AND MAPPING SERVICES LTD.

A-1

GRANULAR MATERIALS EVALUATION
DEPOSITS 168 & 211
TUKTOYAKTUK AREA, N.W.T.

Prepared for

GOVERNMENT OF CANADA

DEPARTMENT OF INDIAN AFFAIRS AND NORTHERN DEVELOPMENT

Prepared by

BBT GEOTECHNICAL CONSULTANTS LTD.

GVM GEOLOGICAL CONSULTANTS LTD.

AND

TERRAIN ANALYSIS AND MAPPING SERVICES LTD.

PROJECT NO. A83-613

MAY 1983

BBT Geotechnical Consultants Ltd.
BBT GEOTECHNICAL CONSULTANTS LTD.

May 30, 1983

6423 A Burbank Road S.E.
Calgary, Alberta T2H 2E1
Telephone (403) 252-1106

File No. A83-613

Government of Canada
Department of Indian Affairs and Northern Development
Land Management Division
6th Floor Les Terrasses de la Chaudiere
10 Wellington Street
Hull, P.Q.
K1A 0H4

Attention: Mr. C. Cuddy, Manager
Project Co-ordination Inventories & Regulations

Dear Sir:

Subject: Granular Materials Evaluation
Deposits 168 & 211
Tuktoyaktuk Area, N.W.T.

Enclosed, herein, please find a copy of our report on the above captioned project.

At this time we would like to acknowledge the assistance and cooperation received from both, the Land Management Division and the Inuvik District Office of the Department of Indian Affairs and Northern Development, during the course of this study.

We thank you for this opportunity to be of service.

Yours very truly,

BBT GEOTECHNICAL CONSULTANTS LTD.

L.J. Korchinski, P.Eng.

LJK:pk

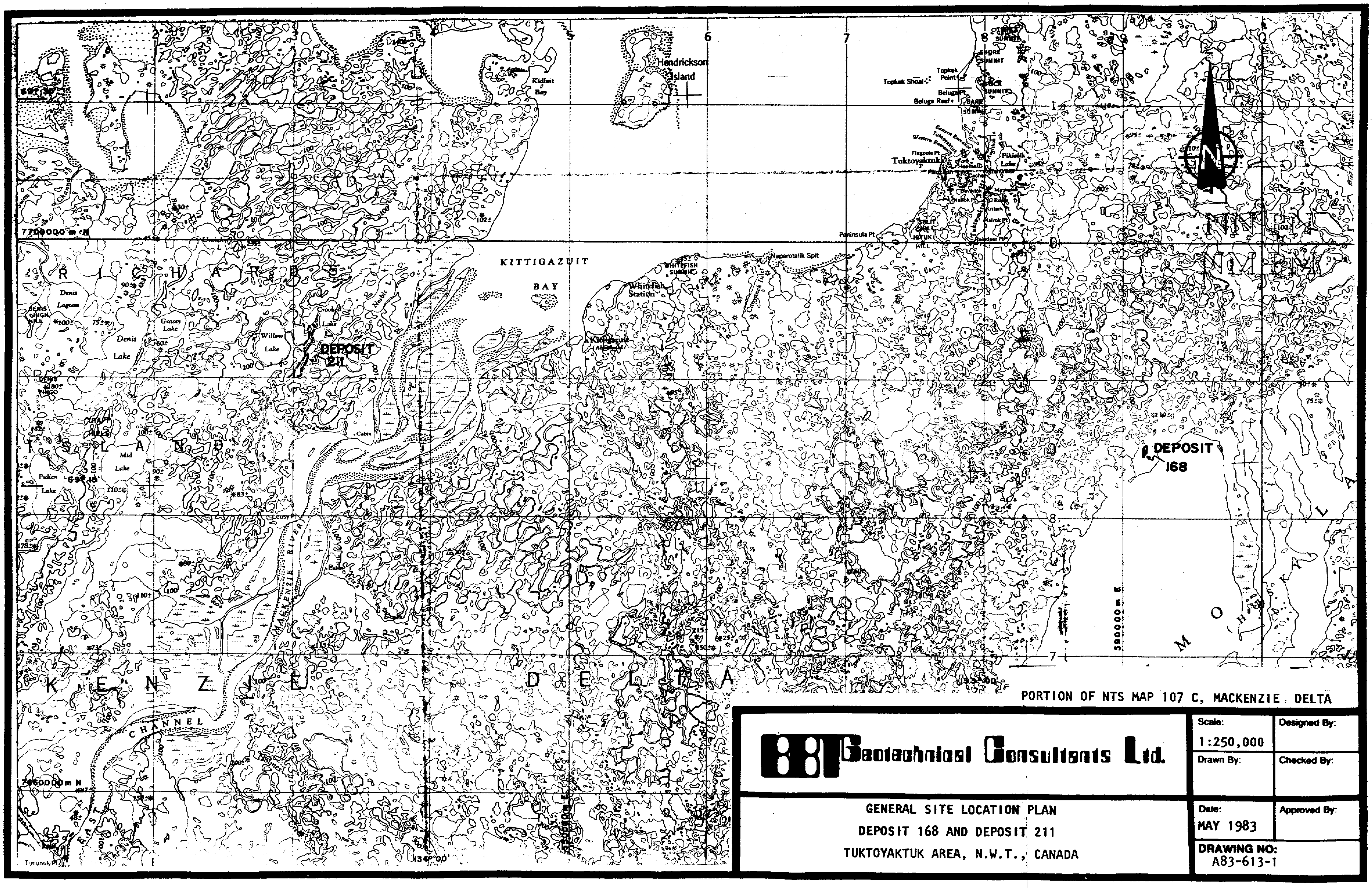
TABLE OF CONTENTS

TABLE OF CONTENTS

1.0 SUMMARY

This report presents the results of a geotechnical evaluation of two potential sources of granular material in the area of Tuktoyaktuk, N.W.T. identified as Deposit 168 and Deposit 211. Deposit 168 is located near the shore of Eskimo Lakes, approximately 25 km southeast of the Hamlet of Tuktoyaktuk. Deposit 211 is located adjacent to Willow Lake on Richards Island in the Mackenzie River delta, approximately 50 km west-southwest of the Hamlet of Tuktoyaktuk. A total of seventeen test holes were drilled and sampled at the two deposits during March of 1983. The field and laboratory data were used in estimating the areal extent, thickness, and quality of the granular materials.

It appears that a total of 600,000 m^3 of good quality gravel exists in Deposit 168. That portion of Deposit 211 presently under evaluation contains in the order of 500,000 m^3 of material which is predominantly composed of sand with a minor gravel component. The results of the laboratory tests suggest that the material in Deposit 168 could potentially be suitable for use in the manufacture of concrete aggregate. Additional testing will be required to determine if certain deleterious components within the aggregate are reactive with cement. The material in Deposit 211 is suitable for use as general fill.



PORTION OF NTS MAP 107 C, MACKENZIE DELTA

Geotechnical Consultants Ltd.

GENERAL SITE LOCATION PLAN
DEPOSIT 168 AND DEPOSIT 211
TUKTOYAKTUK AREA, N.W.T., CANADA

Scale: 1:250,000	Designed By:
Drawn By:	Checked By:
Date: MAY 1983	Approved By:
DRAWING NO: A83-613-1	

2.0 INTRODUCTION

In mid-March of 1983, the Government of Canada, through the offices of the Department of Indian Affairs and Northern Development (DIAND), commissioned BBT Geotechnical Consultants Ltd., GVM Geological Consultants Ltd. and Terrain Analysis and Mapping Services Ltd. to evaluate, in detail, three potential sources of granular material for the hamlet of Tuktoyaktuk, N.W.T. The three sources, identified as Deposits 167, 168 and 211, had been visited previously by the Geological Survey of Canada and others. Based on the preliminary data obtained, it was felt that the three deposits warranted further investigation, to determine if they could meet possible future requirements for granular material.

Deposits 167 and 168 are located approximately 25 km southeast of the Hamlet of Tuktoyaktuk, near the shore of Eskimo Lakes. The portion of Deposit 211, which is presently of interest, forms the northern part of the ridged feature to the east of Willow Lake on Richards Island in the Mackenzie River Delta. This site is approximately 40 km northeast of Tununuk Point on the Mackenzie River and approximately 50 km west-southwest of the Hamlet of Tuktoyaktuk.

Although initially, all three sources were to be evaluated, Deposit 167 was deleted from this study, due to difficulty of access.

3.0 SCOPE OF WORK

The scope of work for this project was defined by the Department of Indian Affairs and Northern Development in the Terms of Reference sent to Terrain Analysis and Mapping Ltd. on February 18, 1983. The project was to include:

1. A review of all geological and geotechnical data collected during previous studies at each of the sites.

2. The undertaking of a field drilling and testing program at the three deposits previously identified as potential sources of granular material. The program would attempt to determine the subsurface stratigraphy within the deposits and obtain samples of granular materials for laboratory analysis.

3. The delineation of the distribution and extent of the various materials within the deposits and the estimation of the total and recoverable volumes, and quality of these materials.

4. The preparation of a pit development strategy for each deposit.

5. The assembly of data on potential extraction costs taking into account overburden, moisture content, drainage and restoration.

All of the above data was to be summarized in a formal report prepared in the format requested by DIAND.

4.0 METHODOLOGY

4.1 Planning

Authorization to proceed with this program was received on March 11, 1983. Prior to this time, all available Government of Canada airphoto coverage of the deposits was obtained through the offices of Terrain Analysis and Mapping Services Ltd. For the most part, the aerial photography taken in July and August of 1972, at a scale of 1:54,000, was used, as it showed the best coverage and detail of the sites.

Other information available consisted of the summaries of the results of preliminary studies done previously by others. The summaries for Deposits 167 and 168 were obtained from Terrain Analysis and Mapping Services Ltd., while that for Deposit 211 was forwarded by the Yellowknife office of DIAND.

The features and terrain shown on the airphotos, combined with the experience of Dr. V.N. Rampton, who had visited all of the deposits previously, formed the basis of our belief that the required work could be completed effectively using truck-mounted drilling equipment supported by a crawler tractor and a 4-wheel-drive vehicle for the daily transport of the crew.

4.2. Field Work

4.2.1 General

The field work commenced with the arrival of the BBT Geotechnical Consultants Ltd. crew in Inuvik on March 16, 1983. The drill rig arrived in Inuvik on the afternoon of March 17, 1983, as scheduled. It was felt that the one and a half day time lag would be required to enable the BBT field personnel to reconnoitre the sites with the local DIAND Land-Use officer and clear the snow from one of the access routes.

The site reconnaissance was completed on March 16, 1983, using a helicopter supplied by DIAND. During the initial site reconnaissance, a concern over the potential environmental damage which might occur during the construction of access routes was expressed by the local land-use officer. As a result, the preparation of site access trails was not started as planned, and further field work temporarily suspended. After review by DIAND, it was decided that a representative of the local office should accompany the field party to ensure that damage to the terrain would be kept to a minimum.

The field party was finally staged into the Tuktoyaktuk area on the morning of March 18, 1983.

4.2.2 Personnel and Logistical Support

During most of the program, the field crew consisted of six people. These were the two-man BBT Geotechnical Consultants Ltd. field crew, the two-man crew required to operate the drill rig, the tractor operator, and the Land-Use officer from the Inuvik office.

Accommodation and meals, during the course of the project, were supplied by Beau-Tuk Marine Services Ltd. in their camp at Tuktoyaktuk. Beau-Tuk Marine also supplied any incidental expediting services required. Fuel was purchased in bulk in Inuvik and trucked to Tuktoyaktuk a day before the program was to commence.

4.2.3 Equipment

The rig used to drill and sample all of the test holes was a Becker-type diesel hammer drill owned and operated by Beck Construction Ltd. of Calgary. The rig, two-man crew, and support truck were mobilized via the Dempster Highway.

The rig employed uses a diesel hammer to advance a 17-cm outside diameter double walled casing into the soil. Cuttings are lifted to the surface through the 11.5-cm diameter centre of the casing by compressed air forced down the annular space between the casing walls.

The Becker hammer drill is most effective in penetrating granular soils, especially soils of the type suspected to form the bulk of these deposits, and in providing representative samples from the various strata encountered. The quantity of material larger than the inside diameter of the drill pipe is estimated from the type of cuttings returned and the rate of penetration. The rig was mobilized to the field with approximately 12.0 m of drill stem, as it was suspected that in some areas it would be necessary to drill beyond the 8.0 m suggested in the original terms of reference.

The drill was supported by a Caterpillar D-6 tractor and a fuel sled obtained locally from Beau-Tuk Marine Services Ltd. of Tuktoyaktuk, N.W.T. The tractor was used to plough snow from the access trails, assist the rig up any steep grades and over rough terrain, and drag the fuel sled to the next site. In addition, Caterpillar 966 front-end loaders from Beau-Tuk Marine Services Ltd. and Tuk Enterprises Ltd. were employed on a casual basis. These pieces of equipment were used to clear snow along major ice crossings or pull a snow packing apparatus known as a "drag" during the construction of one of the overland access routes.

Daily transport to and from the deposits was with a 4-wheel-drive Ford Bronco rented in Inuvik. During the latter stages of the program, a power toboggan was brought in by the DIAND Land-Use officer and used in scouting the best possible access route.

4.2.4 Site Location and Access Preparation

4.2.4.1 Access to Deposits 167 and 168

Since Deposit 168 was the most remote of the two deposits to the southeast of Tuktoyaktuk, it was the first to be investigated. The winter road already constructed by Imperial Oil Ltd. to their rig located approximately 24 km to the southeast of Tuktoyaktuk, was used as part of the access trail. From that point, a series of lakes were connected with short land crossings to a major inlet off the north shore of Eskimo Lakes. Both, Deposits 167 and 168, were readily accessible from that point.

A total of 10.5 km of new trail, of which 3.5 km was across land, had to be constructed to gain access to Deposit 168.

As the access trail had not been cleared in advance, the rate of progress across the land connections became a much more time consuming procedure than initially anticipated. The rate was now dictated by the Caterpillar D-6 tractor, which first had to clear snow, then double back to pull the rig through the hollows still filled with loose snow, and then return a second time to move the fuel sled forward. As a result, it took two long working days to position the rig on Deposit 168 and drill the first hole.

The fact that, on occasion, the 4-wheel-drive truck got stuck in the loose snow raised a concern about the ability of this vehicle to transport the crew to and from the sites. A "drag" was employed in an attempt to better compact the snow. Once the snow was allowed to harden overnight, the Bronco passed over it with ease. The time required to access the site each day from Tuktoyaktuk by way of the Imperial Oil snow road and the new trail, was approximately one hour. In demobilizing from Deposit 168, the rig was able to pass over the hardened snow virtually unassisted. Demobilization took less than five hours.

The general snow cover in the area was relatively light this year. However, the concentrations of snow at the lake edges and through the low areas between the lakes, made it difficult to select a good access route without first clearing the snow. Often potential access points had to be manually probed in advance to confirm the shape of the bank and depth of snow cover.

The segmented nature of Deposit 167 made it necessary to construct access trails up several slopes. The local land-use officer felt that an unacceptable amount of damage to the terrain might occur while clearing the snow from these trails. Therefore, we were asked to delete this deposit from the program.

4.2.4.2 Access to Deposit 211

Except for one short, very difficult section, which resulted in a half day delay, preparing the access trail to Deposit 211 was close to what had been anticipated. Preliminary studies suggested that potential routes from the ice road on the Mackenzie River to the deposit existed from the south, via Cabin Creek and from the northeast, through an interconnection of Nesbit Lake and Crooked Lake. However, it became apparent during the initial site reconnaissance, that the Cabin Creek route contained too much rough terrain for the wheeled vehicles to cross, while the slopes adjacent to Nesbit Lake were too steep. The route finally selected, left the ice of the Mackenzie River at the mouth of a small creek due east of the most southerly arm of Crooked Lake. The route followed the high ground to three small lakes adjacent to the northeasterly end of Crooked Lake. It then crossed these lakes to Crooked Lake and followed it to the draw at the north end of Deposit 211. With the exception of the considerable amount of snow plowing required at the point where the trail left the Mackenzie River and where it entered Crooked Lake, very little snow removal was required. The Caterpillar D-6 simply backbladed the thin snow cover into the hollows, and the trucks could pass over the ground with relative ease. It took a little more than a day and a half to prepare the 13 km of access trail to this site. Daily travel time to Deposit 211 from Tuktoyaktuk via this route was approximately one hour and fifteen minutes.

4.2.5 Drilling and Sampling Procedure

A total of eight test holes were drilled and sampled on Deposit 168 on March 19 and 20, 1983. As the granular material was thicker than originally expected, most of the holes were extended to approximately 9 m.

Once Deposit 167 was dropped from the program, the scope of work at Deposit 211 was changed to include more test holes. However, a major mechanical failure of the rig's transmission prevented this from being completed. A total of nine test holes were drilled and sampled on Deposit 211 on March 23 and 24, 1983. The holes ranged in depth from 6 m to 12 m. The mechanical failure experienced meant that no test holes could be drilled on the southernmost ridge under evaluation during this program.

The very cold temperatures encountered required that the main engines of the truck and tractor be run continually. However, delays were still experienced each morning in warming the drill rig's hydraulic systems and the diesel hammer. Once the rig was operational, the test holes could be drilled and sampled relatively quickly. An 8 m to 9 m deep hole in gravel took from forty-five minutes to one hour to complete from set-up to rig-down. Photo 3 in Appendix C shows the drill rig in operation on Deposit 211.

All material within the drill pipe was cleared with each 0.3 m of penetration. This ensured that the material sampled was most representative of the stratum being penetrated. Where good quality granular material was encountered, samples were usually retained at each change in soil type, or at approximately 1.5 m intervals, whichever was less. As the samples taken were large, most had to be split in the field prior to packaging in order to minimize the volume of material. Samples retained for in situ water content determinations were double bagged as quickly as possible in order to minimize desiccation. Most were then sealed into one or more 4-litre plastic pails to prevent the bags from being torn during transport. In total, over 500 kg of sample was packaged and shipped to Calgary by truck at the end of the program.

The soil classsification system used in preparing the test hole logs is a modified form of the Unified Soil Classification System and is defined in the "Explanation of Terms and Symbols used on Test Hole Logs" contained in Appendix D. The ice contained in the soil was described according to the methods laid out in the NRC Technical Memorandum 79 entitled "Guide to a Field Description of Permafrost for Engineering Purposes". Visible ice content was estimated from the actual cuttings returned. Excess ice contents were determined in the laboratory in Calgary after the samples had been allowed to thaw.

4.2.6 Survey Procedures

All test holes were referenced to physical features of various parts of each deposit and to each other, using rudimentary survey techniques. The relatively small size of Deposit 168 made it possible to measure most distances with a survey chain. On Deposit 211, all extensive horizontal distances were measured using the odometer of the power toboggan.

The bearing from true North of the lines between test holes, and from test holes to identifiable terrain features such as edges of adjacent lakes, points of land, etc. were obtained with a compass.

The elevation of the highest points of the deposits relative to adjacent flat lying terrain and nearby lake surfaces was obtained using a hand level. In addition, the relative elevation between some of the test holes was also measured. The above information was used to assist in the photogrametric production of detailed topographic maps of both deposits. These maps are presented as Drawing Nos. A83-613-A1 and A83-613-B1 in Appendices A and B, respectively.

4.3 Laboratory Analysis

After the samples were reviewed in the Calgary laboratory, each sample was visually classified to confirm and supplement the field classifications. An estimate of the excess ice content of any ice-rich material was made once the samples thawed in the laboratory. The moisture content of all representative samples was also determined. In addition, the following tests were performed on select samples of granular material:

1. Sieve Analysis Tests (ASTM C-136).
2. Specific Gravity and Absorption of Fine Aggregate (ASTM C-128) and Coarse Aggregate (ASTM C-127).
3. Organic Impurities in Sands for Concrete (ASTM C-40).
4. Coal Content Determinations.
5. Soundness of Aggregates (ASTM C-88) using Magnesium Sulphate.
6. Los Angeles Abrasion (ASTM C-131).

Because of the limited size of some of the samples, samples from the same test hole, or two or more test holes with similar material, were combined to complete some of the tests.

A petrographic analysis of the gravel-sized material was performed by GVM Geological Consultants Ltd. on a combination of samples from several test holes on Deposit 168. The composition of the sand sized fraction was estimated visually.

4.4 Presentation of Data

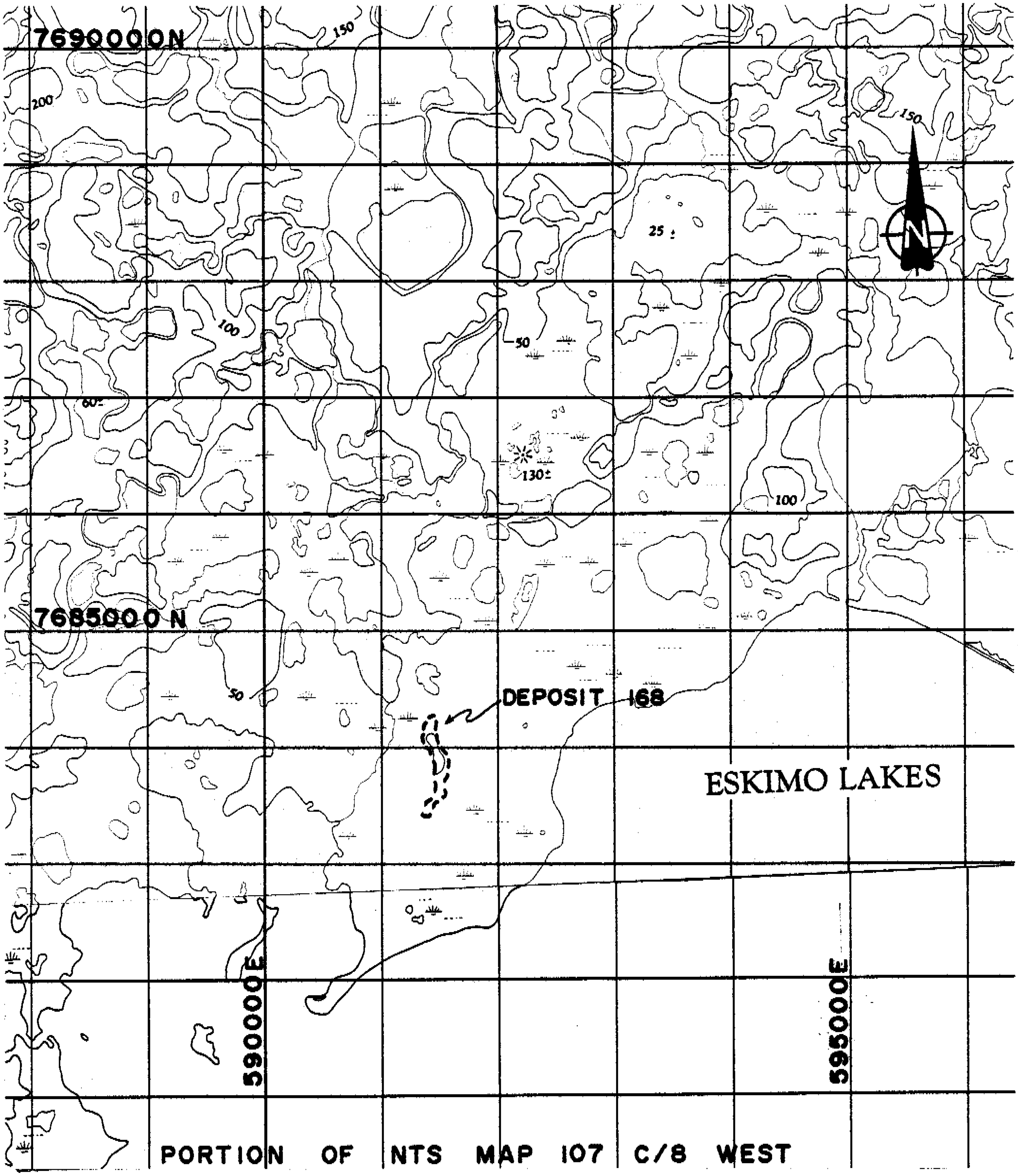
All of the field and laboratory data gathered during this evaluation has been grouped by deposit. The results are presented either in Tabular form in the text or as drawings within Appendix A for Deposit 168 and Appendix B for Deposit 211.

A detailed site plan showing topography and the location of all test holes drilled during this and other programs is presented as the first drawing in each appendix. The approximate areal extent of the granular materials encountered and the limits of any cross section drawings are also shown on the site plans. Cross section drawings appear immediately following the site plan.

The complete logs of all test holes drilled form the next series of drawings in each appendix. These logs contain the detailed soil and ice descriptions, the location of the samples, and the results of any water content determinations or soil classification tests performed. The terms and symbols appearing on the logs are defined in Appendix D.

The results of the mechanical analysis tests form the last series of drawings in Appendices A and B.

The results of all other tests performed and the petrographic analysis have been summarized on Tables which appear in the text.



PORTION OF NTS MAP 107 C/8 WEST

Geotechnical Consultants Ltd.

Scale:	1:50,000
Date:	MAY 1983
Drawn By:	
DRAWING NO:	A83-613-2

GENERAL SITE LOCATION PLAN
DEPOSIT 168, NEAR ESKIMO LAKES
TUKTOYAKTUK AREA, N.W.T., CANADA

5.0 ESKIMO LAKES SITE - DEPOSIT 168

5.1 Location and Geological Setting

The deposit is located approximately 1 km from the shores of Eskimo Lakes, at a point approximately 25 km southeast of Tuktoyaktuk, N.W.T. The general location of the deposit is shown on Drawing Nos. A83-613-1 and 2. Topographic details on the area immediately around the deposit, the test hole locations, and the approximate areal extent of the granular deposit is presented on Drawing No. A83-613-A1 in Appendix A.

Site 168 consists of a sand and gravel glaciofluvial esker-kame deposit which is part of a larger glaciofluvial complex adjacent to Eskimo Lakes(Rampton, 1974). The fine grained greyish sands beneath the stratified medium to coarse sand and gravel of the esker ridge probably represent sandy outwash which was deposited in proglacial lakes as the most recent ice sheet advanced. The clays at approximately the same depth as the greyish sands represent the glaciolacustrine phase of deposition within the proglacial lake.

As the ice sheet retreated, layers of esker gravels and sands were then plastered on the proglacial sands and clays in a river channel formed beneath the retreating ice sheet. Silt and clay (approximately 1.5 m thick) which cap the stratified esker sands and gravels, represent lacustrine or pond deposits which formed locally over glaciofluvial material as the ice sheet retreated (Rampton and Bouchard, 1975).

The main body of the deposit is the esker ridge which is approximately 100 m long and varies from 80 to 140 m in width at its base. Its highest point is in the order of 9 m above the surrounding flat lying terrain. This is somewhat lower than had been suggested by studies done previously. The southern one-third of the deposit is at a lower elevation relative to the rest of the ridge, typically rising to only 4 m to 5 m above the surrounding terrain.

What little vegetation exists on the higher portions of the deposit consists of low shrubby tundra supported by an organic cover less than 50 mm thick. Several portions of the tops of the ridges were observed to be bare. No extensive analysis of the overburden thickness along the flanks of the deposit could be done at this time because of the snow cover. Studies done by others suggest that it is a maximum of 1 m thick.

Previous studies have also identified what is believed to be a series of small kames located approximately 500 m to the north of the main ridge. Test holes were not drilled on these features, because they are small and because granular material is suspected to be thin. A 1 m deep test pit excavated previously on the most easterly, and highest kame ridge, confirmed that a gravelly sand cover exists to at least this depth.

Photo 1 in Appendix C presents an oblique aerial view of the deposit.

5.2 Nature of the Subsurface Materials

5.2.1 General

Gravel and very gravelly sand were encountered in all portions of the main ridge to depths ranging from 4.5 m at Test Hole 168-6 to in excess of 10.5 m at Test Hole 168-4. At most test hole locations, the granular material was still present at elevations which were several metres below that of the surrounding terrain. In fact, in the southernmost quarter of the deposit, where the relief is lowest, the granular material extended to at least 4 m below the surrounding terrain. Typically, the base elevation of these types of deposits would be expected to be relatively flat lying. The anomaly at this deposit, however, could be the result of pre-depositional erosion and subsequent infilling with granular material, or post-depositional thawing of massive ice or very ice-rich clay at depth. The fact that this portion of the deposit is at a lower elevation than the rest, suggests the latter possibility is most likely.

It is believed that the bottom of the esker was penetrated at the location of Test Hole 168-2 and 168-6, where medium plastic, ice-rich clay containing pebbles, was encountered. In addition, Test Hole 168-7 also may have reached the bottom of the deposit at the 7.3 m depth, where a medium to fine-grained, ice-rich sand, stratified with silt and a trace of fine gravel was encountered.

The estimated vertical extent of the granular material within the main body of this deposit and the stratigraphy inferred from the test hole data is presented on Drawing No. A83-613-A2 in Appendix A. The logs of the most recent test holes drilled at this site are shown on Drawing Nos. A83-613-A3 thru A83-613-A10. The results of the mechanical analyses performed on samples from Deposit 168 are presented on Drawing Nos. A83-613-A11 thru A83-613-A48. All of the remaining test results not summarized on the test hole logs are presented on Table 1 and Table 2.

5.2.2 Gradation and Composition of the Granular Materials

Approximately 75 to 80 percent of the material within this deposit appears to consist of well graded sandy gravel; the maximum size of which is typically less than 75 mm. The gravel contains only a trace of cobble size material. The sand content ranges from 12 percent to as high as 46 percent. An average sand content probably would lie in the 30 to 35 percent range.

The gravelly sand, which comprises the remaining 20 to 25 percent of the material, has a gravel content in the range of 40 to 45 percent and is often poorly graded.

Both granular materials appear to be fairly clean, with a silt content typically in the range of 1 to 2 percent, or less. Actual silt layers appear to be thin, discontinuous, and relatively few in number. The

TABLE 1

SUMMARY OF LABORATORY TEST RESULTS - SITE 168

HOLE NO	DEPTH (m)	GRAIN SIZE (% by weight)			ORGANIC IMPURITIES COLOR PLATE	COAL CONTENT OF SAND COMPONENT (% by weight)	SOUNDNESS OF AGG. TEST	LOS ANGELES ABRASION		SPECIFIC GRAVITY				PETROGRAPHIC ANALYSIS
										COARSE		FINES		
		Gravel	Sand	Fines				GRADE	% WEAR	BULK (SSD) (gm/cc)	PERCENT ABSORPTION	BULK (SSD) (gm/cc)	PERCENT ABSORPTION	
168-1	0-1.8	48.5	40.7	0.8			Yes							One analysis performed on combined samples TH 168-1 3.0m - 3.7m 5.2m - 5.5m TH 168-4 0.6m - 0.8m 2.1m - 2.6m 4.2m - 4.5m 5.0m - 5.3m 6.1m - 6.4m TH 168-7 1.5m - 1.8m TH 168-8 0.6m - 0.9m 2.1m - 2.4m
	3.0-3.7	57.4	41.7	0.9	# 5									
	5.2-5.5	77.4	21.5	1.1										
168-2	0-0.9	68.4	31.2	0.4										
	1.8-2.2	32.7	67.1	0.2	# 4									
	3.2-3.5	67.0	31.4	1.6										
	5.5-6.4	51.7	47.0	1.3										
Comb.	0-1.0,3.2-3.5,5.5-6.4							B	15.8					
Comb.	0-1.0,1.5-1.8 3.2-3.5,5.5-6.4							C	9.1					
168-3	1.5-1.8	39.5	59.3	1.2										
	1.8-2.4	70.0	29.4	0.6	# 4	0.24								
	3.5-3.8	46.7	50.9	2.4										
	4.3-5.5	43.0	55.3	1.7										
	7.2-7.5	66.2	31.8	2.0										
168-4	0.6-0.8	59.5	39.1	1.4										
	2.1-2.6	52.8	37.9	1.4	# 4									
	3.3-3.6	64.8	32.9	2.3		0.30				2.608	0.66	2.646	0.89	
	5.0-5.3	69.7	29.2	1.1										
	6.1-6.4				# 2									
	7.4-7.7	50.4	31.6	2.7										
	8.5-8.8	37.9	60.6	1.5										

TABLE 1

SUMMARY OF LABORATORY TEST RESULTS SITE 168 (con't)

HOLE NO	DEPTH (m)	GRAIN SIZE (% by weight)			ORGANIC IMPURITIES COLOR PLATE	COAL CONTENT OF SAND COMPONENT (% by weight)	SOUNDNESS OF AGG. TEST	LOS ANGELES ABRASION		SPECIFIC GRAVITY			
										COARSE		FINES	
		Gravel	Sand	Fines				GRADE	% WEAR	BULK (SSD) (gm/cc)	PERCENT ABSORPTION	BULK (SSD) (gm/cc)	PERCENT ABSORPTION
168-5	1.4-1.7	67.4	42.1	0.5									
	2.3-2.5	65.2	33.6	1.2	# 3								
	4.3-4.6	80.7	18.2	1.1									
	5.5-5.8	86.4	12.7	0.9									
	6.3-6.6	71.4	26.7	1.9									
	8.7-9.0	68.1	30.8	1.1									
Comb.	2.2-2.5, 4.3-4.6 5.4-5.7									2.620	0.86	2.619	1.24
168-6	1.5-1.8	56.6	43.0	0.4									
	2.2-2.5	33.7	65.6	0.7									
	4.2-4.5	58.8	40.1	1.1		0.45							
168-7	0.3-0.7	60.3	38.1	1.6	# 5								
	0.9-1.5	48.0	51.7	0.3									
	3.0-3.3	69.6	27.9	2.5	# 4								
	4.0-4.3	77.5	20.0	2.5									
	6.4-6.7	37.2	58.5	4.3									
168-8	0.6-0.9	63.1	35.7	1.2	# 4	0.20	Yes						
	2.4-2.7	88.7	10.3	1.0									
	3.3-3.7	82.2	16.5	1.3									
	4.8-5.1	80.1	18.4	1.5									
	6.4-6.8	73.9	25.1	1.0									
	7.9-8.3	77.1	22.1	0.8									
Comb.	0.6-0.9, 3.3-3.6 & 4.8-5.1				# 3			A	18.9	2.622	0.74	2.616	1.58

TABLE 2

SUMMARY OF SOUNDNESS OF AGGREGATE TEST BY MAGNESIUM SULPHATE SITE 168

SIEVE SIZE (mm)	168-1 - ALL SAMPLES COMBINED % LOSS	168-8 - ALL SAMPLES COMBINED % LOSS
80 - 40	8.5	1.94
40 - 20	0.70	0.9
20 - 10	1.82	0.3
10 - 5	3.57	2.5
5 - 2.5	7.4	9.6
2.5 - 1.25	10.1	11.9
1.25- 0.630	11.2	15.1
0.630- 0.315	4.6	3.0

only significant silt stratum appears to be the 1.5 m thick cap in the area of Test Hole 168-3. No coal or organics were noted in any of the granular material.

The results of a petrographic analysis of the gravel sizes is presented on Table 3. From this analysis, it appears that the gravel contains approximately 38 percent Sandstone, 24 percent Quartzite, 13 percent Siltstone, 13 percent Chert and 12 percent other minor constituents. The composition of a representative sample of sand sized material also was visually estimated. The sand fraction appears to be composed of materials similar to those found in the gravel. It was observed to contain approximately 35 percent Quartz, 20 percent Siltstone, 15 percent Sandstone, 10 percent Chert, 10 percent Quartzite and 10 percent of other minor constituents.

5.2.3 Ice Content

The uppermost 1.8 m to 2 m of this deposit appears to be dry. The fact that little or no vegetative cover is present on its uppermost surfaces would allow the active layer to extend to approximately that depth. The relief would also present ample opportunity for drainage.

The visible ice content of the material immediately below the active layer was in the order of 5 percent. In some areas, it increased to as high as 20 percent at depth. Although much of this material was wet

TABLE 3

PETROGRAPHIC ANALYSIS OF GRAVEL CONTENT - COMBINED SAMPLES FROM SITE 168

Composition of Fractions Retained on Sieves — SIEVE SIZE RANGE | Weighted Percentages of Constituents in Each Sieve Size Range — SIEVE SIZE RANGE

CONSTITUENTS	38 mm - 76 mm		19 mm - 38 mm		4.75 mm - 19 mm		38 mm - 76 mm	19 mm - 38 mm	4.75 mm - 19 mm	WEIGHTED COMPOSITION OF SAMPLE
	# Particles	%	# Particles	%	# Particles	%				
SANDSTONE	19	38.0	267	52.5	107	32.1	7.6	13.2	17.6	38.4
QUARTZITE	19	38.0	78	15.3	75	22.5	7.6	3.8	12.3	23.7
SILTSTONE	3	6.0	69	13.5	50	15.0	1.2	3.4	8.2	12.8
GRANITE	5	10.0					2.0			2.0
CHERT	2	4.0	33	6.5	65	19.5	0.8	1.6	10.7	13.1
VEIN QUARTZ			17	3.3	15	4.5		0.8	2.5	3.3
IGNEOUS PLUTONIC			29	5.7	9	2.7		1.4	1.5	2.9
IGNEOUS VOLCANIC			9	1.8	6	1.8		0.4	1.0	1.4
CLAYSTONE			1	0.2	3	0.9		0.1	0.5	0.6
LIMESTONE	1	2.0	1	0.2	1	0.3	0.4	0.1	0.2	0.7
DOLOMITE					1	0.3			0.2	0.2
FERRUGINOUS SILTSTONE					1	0.3			0.2	0.2
FERRUGINOUS DOLOMITE	1	2.0					0.4			0.4
IRONSTONE			1	0.2				0.1		0.1
JASPER			4	0.8				0.2		0.2
TOTALS	50	100.0	509	100.0	333	100.0	20.0	25.1	54.9	100.0

Petrographic Analysis Conducted On
A Combination of the Following Samples:

TH 168 - 1	TH 168 - 4	TH 168 - 7	TH 168 - 8
3.0m - 3.7m	0.6m - 0.8m	1.5m - 1.8m	0.6m - 0.9m
5.2m - 5.5m	2.1m - 2.6m		2.1m - 2.4m
	4.2m - 4.5m		
	5.0m - 5.3m		
	6.1m - 6.4m		

upon thawing, no water in excess of the saturated state was noted in any of the samples tested. Although localized ice-rich zones were noted in some of the test holes, no massive ice was encountered. Massive ice, however, may exist in the clay at depth.

5.3 Potential Uses of the Granular Material

The gravel, and gravelly sand, which comprise the bulk of this deposit are of relatively good quality. Once thawed and drained, this material would perform well in any application calling for granular fill. It would be easy to work with and relatively easy to compact because the material is well graded, and lacks cobbles and boulders. The shortage of fines would allow it to drain relatively freely.

A review of the test results obtained also suggest that the gravel and sand from this deposit may be a good source of material for the production of normal weight concrete.

The series of grain size analyses performed confirm that, generally, the material is well graded and contains few fines. Silt and clay layers of any significant thickness were not noted during the drilling and sampling and, therefore, should not affect the quality of the material significantly. We would expect that once the material has been crushed and separated into the rock and sand fractions, very little additional processing will be required to meet the limits for content of material finer than 80 microns as set out in Canadian Standards Association CAN3-A23.1-M77 "Concrete Materials and Methods of Concrete Construction".

The results of the sulphate soundness test indicated losses ranging from 0.3 percent to 8.5 percent for the coarse aggregate, and from 3 percent to 15.1 percent for the fine aggregate. All of these values fall below the maximum set out in CAN3-A23.1-M77 of 12 percent and 16 percent for coarse and fine aggregate, respectively. The Los Angeles Abrasion Test results showed losses of 9.1 percent to 18.9 percent, which are well below the 35 percent maximum specified by CAN3-A23.1-M77 for aggregate used in concrete paving or concrete surfaces subjected to significant wear. Therefore, it would appear that the aggregate in this source is sufficiently durable for use in the production of concrete.

The organic impurities content as shown by the results of the color plate test appear to range from moderate to high. The coal content determinations, and the fact that no other organic material was noted during either the field or the laboratory classification, suggest that the discoloration may be primarily due to the presence of fine coal particles or lignite. The coal contents performed all fell below the 0.5 percent maximum allowable. However, as some of the values were close to this limit, removal of this deleterious material from some of the gravel and sand may be necessary prior to using it in the manufacture of concrete.

The results of the Petrographic Analysis performed on a combination of samples from Deposit 168 indicate that some potentially deleterious components are present within the granular material. Of these, only Chert is present in any significant quantity. This potentially deleterious material appears to form approximately 13 percent of the aggregate, with the bulk of it being in the finer particle sizes. Although some types of cherts are known to react with alkalies in the cement and cause an excessive expansion in the concrete, it is not known whether the type of chert present in this deposit would be reactive. In order to confirm whether or not the granular material can be used as concrete aggregate, additional testing will have to be done on actual trial batches of concrete manufactured with aggregates from this source. The concrete would be tested for its resistance to cement-aggregate reactivity and also for its resistance to freeze-thaw cycles. If these tests have a minimal detrimental effect on the samples, then the granular materials from this source can be used in the production of concrete aggregate.

5.4 Access and Methods of Extraction

Due to the relatively small size of Deposit 168, it would appear that construction of a gravel access road required for summer exploitation may not be justified. Barging the material to Tuktoyaktuk also may not be economical due to the distances involved. It appears that the most effective access can be gained by constructing a winter road to the deposit and hauling the material out by truck to a suitable stockpile site in the area of intended use.

The dry nature of the uppermost 1.5 m of material and the lack of appreciable overburden would make its removal relatively simple. The material could easily be loosened with a ripper attachment, prior to loading it onto trucks.

The hard, well-bonded frozen material below the 1.5 m to 2.0 m depth would be considerably more difficult to extract. Even if a large crawler tractor, such as a Caterpillar D8 or D9, equipped with a single tooth ripper were used, it may not be possible to efficiently loosen more than a 1.0 m to 1.5 m thick layer of this material in any one season. It would be necessary to allow an additional layer of material to thaw and drain through at least one summer season before further attempts to mine it were made.

During the initial extraction process, the natural relief of the deposit would be adequate to permit drainage to take place. The natural tendency to drain upon thawing would diminish as more material was removed. Some form of drainage path, possibly directed to the south, may have to be constructed, once the elevation of the terrain immediately surrounding the deposit has been reached. At this point, it may not be practicable to continue the mining operation beyond removing the material which can be extracted during one more winter season.

Reclamation of the site could consist of spreading what little organic material could be salvaged during the gravel mining procedure and seeding the area if necessary. If the excavation was extended to an elevation below that of the surrounding terrain, then the bulk of it would simply form another lake in the area.

5.5 Estimate of Quantities

It appears, from the data collected, that with the exception of a few small areas, such as the clay cap noted in Test Hole 168-3, all of the material within the main esker of Deposit 168 is good quality granular borrow.

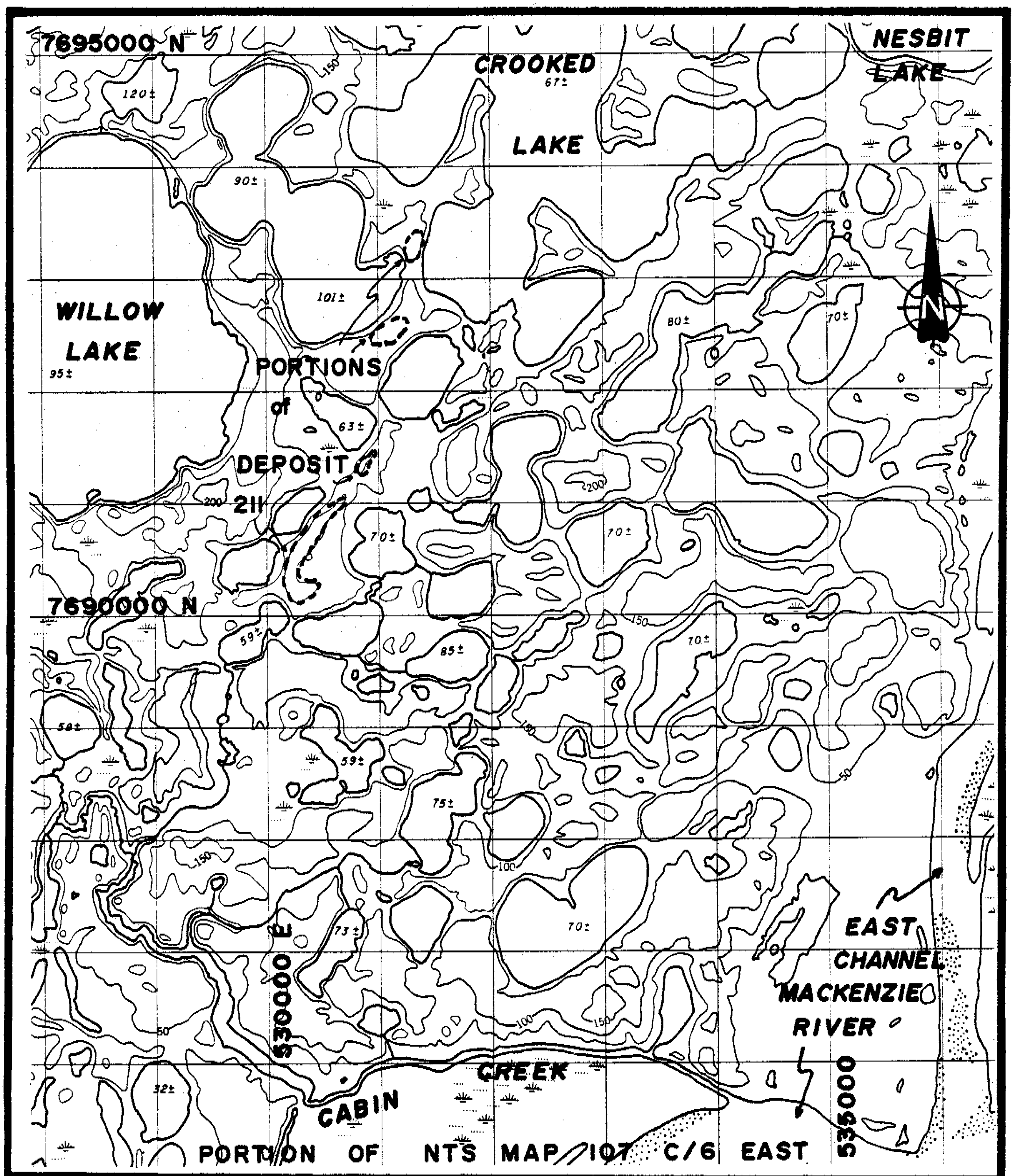
The volume of material has been calculated by the "average end area method" between the contour intervals shown on the topographic site plan, Drawing No. A83-613-A1. For estimation purposes, it has been assumed that gravel exists only within the areal extent of the deposit shown on this drawing. This limit was drawn somewhat inside of the actual deposit boundary to compensate for the fact that up to 1 m of overburden is suspected to exist on the flanks.

It is estimated that in total, the main ridge of the deposit contains 540,000 m^3 of granular material. If the kame deposits to the north are also to be considered for development and mined to the 2 m depth, approximately an additional 60,000 m^3 would be available. The estimate of total volumes assumes that, within the portion of the main esker north of Test Hole 168-7, the granular material extends to a relative elevation of 5.0 m, while at the southern tip, it extends to at least elevation 0.0 (See Drawing No. A83-613-A2 in Appendix A).

It is realized that the recovery of this gravel is largely limited by the quantity which can be effectively thawed and drained, and/or excavated in the frozen state. It is our estimation that the limit of excavation throughout the northern end of the deposit would be to approximately relative elevation 7.5 m, while at the southern tip the materials could be mined to a relative elevation of 5.5 m. If the deposit is only exploited to these limits, the total amount of material readily available from the main ridge would be in the order of 290,000 m^3. The addition of the material recoverable from the kames would raise this estimate to 350,000 m^3. Each additional metre of material which could be extracted from the main ridge in excess of the above depths would add approximately 90,000 m^3 to the volume.

5.6 Potential Costs of Extraction and Development

In order to gain information on the costs which could be associated with developing this pit, we contacted a local contractor familiar with extracting granular material from sources in the Tuktoyaktuk area. From our discussions with Gruben Transport Ltd., it would appear that constructing and maintaining a winter haul road to this deposit would be an appreciable factor in the unit cost of the material if the quantity removed at one time was relatively small. With the seasonal extractions of larger volumes of material, say in the order of 150,000 m^3 or more, the winter road construction and maintenance costs would form a considerably smaller portion of the unit cost of extracting a cubic metre of granular material. On-site factors, such as having to rip hard frozen gravel at depth as compared to just using the dry frozen uppermost 1.5 m would also have an effect on the overall development cost. The many variables which presently exist, make it difficult to accurately predict what the actual cost of development would be. However, in the opinion of Gruben Transport Ltd., if reasonable quantities of material are removed in one construction season, and the excavation of the material is largely limited to the better drained material, the unit cost of extracting and transporting the granular material to the Tuktoyaktuk area would presently lie in the range of \$25 to \$30 per cubic metre.



Geotechnical Consultants Ltd.

Scale:	1:50,000
Date:	MAY 1983
Drawn By:	
DRAWING NO:	A83-613-3

GENERAL SITE LOCATION PLAN
DEPOSIT 211, NEAR WILLOW LAKE ON RICHARDS ISLAND
TUKTOYAKTUK AREA, N.W.T., CANADA

6.0 WILLOW LAKE SITE - DEPOSIT 211

6.1 Location and Geological Setting

Deposit 211, which follows along the southern and eastern shores of Willow Lake, is located approximately 40 km northeast of Tununuk Point on the Mackenzie River and approximately 50 km west-southwest of the Hamlet of Tuktoyaktuk, N.W.T. Only that portion of the deposit to the east of Willow Lake was to be evaluated under the present scope of work. The general location of the site is shown on Drawing Nos. A83-613-1 and A83-613-3. Topographic details of the area immediately around the deposit, the test hole locations, and the approximate areal extent of the granular materials are presented on Drawing No. A83-613-B1 in Apprendix B.

Site 211 consists of a thin sandy esker ridge which was deposited during ice retreat on previously deposited glaciofluvial sands and minor gravel. The earlier glaciofluvial sands have a hummocky surface expression which has probably resulted from thermokarst subsidence. Thermokarst lakes are common in areas adjacent to the esker ridge. The glaciofluvial outwash deposits, which predate the overlying esker materials, are pre-"classical" Wisconsin in age (Rampton, 1974). The esker materials, composed mostly of sand, with a minor gravel content, were deposited on the earlier glaciofluvial deposits by rivers flowing beneath a retreating ice sheet. These sands are about 4 m thick. Ice-rich layers are found at the contact between the esker materials and the underlying outwash deposits.

During the course of this investigation, it was confirmed that the esker materials were more discontinuous than had been previously suspected. The esker materials appear to be restricted to the uppermost 4 m of the 18 m high ridges which form the main surface features in the area. If the base of the esker deposit is assumed to be flat lying, then it ranges in width from 30 m to 175 m.

Much of the deposit surface is bare of any vegetation, while the remainder is covered with a thin veneer of moss and dwarf shrubs.

6.2 Nature of the Subsurface Materials

In all, four areas have been identified as remnants of the esker deposit. These are shown on Drawing No. A83-613-B1 as Areas A thru D.

Gravel size material exists all along the exposed surface of the esker deposit. However, a few centimeters below the surface, the material rapidly grades into a poorly graded, coarse to fine sand containing a minor amount of fine gravel. The granular appearance of the surface material is likely the result of wind erosion removing the finer sand and silt material.

In Area D, esker sand containing minor quantities of gravel, extends to approximately the 4.6 m depth. It is suspected that the knoll just to the north of Test Hole 211-1 is also composed of similar materials.

The uppermost 1.5 m is relatively dry and loose. The sand below the 1.5 m depth had an appreciable ice content which increased with depth. Outwash sand, which was ice-rich and had a layered structure, was encountered below the 4.6 m depth. Massive ice and very ice-rich sand were encountered below 7.0 m.

The esker materials in Area C appear to extend to approximately the 37 m contour interval and have a maximum thickness of just over 3 m near Test Hole RKL-211-2. Again, the uppermost 1.5 m to 2.0 m are relatively loose and dry. Fine glaciofluvial sands with a layered structure and an appreciable organic and coal content were noted below the 2 m depth at the location of Test Hole 211-5. No massive ice was encountered in this hole until the 8.5 m depth.

Subsurface material in the area of Test Hole 211-3 appears to be fine-grained layered glaciofluvial sand with a high silt content. Layers of gravelly sand and good quality, well graded gravel, suspected to be from an earlier depositional period than that of the esker, were noted between the 2.7 m and 7.0 m depths. However, these materials overlie massive ice which extends from approximately the 5 m depth to beyond the 12 m depth.

Subsurface materials, in the area of Test Holes 211-4, 211-6 and 211-7 do not appear to be related to the esker deposit. Most of the subsurface material consists of fine-grained sand, silt and very ice-rich clay, which all appear to be layered. Massive ice is prevalent throughout this portion of the ridge.

The segmented ridge identified as Area B appears to contain esker materials with the highest observed gravel content. Sand, with fine gravel, extends to approximately 1.8 m and 5.5 m at the north and south end of the deposit, respectively. Layered fine-grained glaciofluvial sands underlie the esker materials. No massive ice was encountered to the depth of drilling.

The only information available on subsurface soil conditions at the extreme south end of the portion of Deposit 211 presently under study and defined by the boundary of Area A, was obtained in 1973 by Ripley, Klohn and Leonoff International Ltd. The exact locations of these previous test holes was uncertain, so it is difficult to estimate the extent of the esker deposit. For the purpose of this analysis, the deposit has been conservatively estimated to approximately follow the 40 m contour intervals as shown on Drawing No. A83-613-B1.

The detailed description of the soils encountered and the results of the tests performed are presented on the Test Hole Logs in Appendix B and on Table 4. The logs have been used to prepare a series of cross sections depicting the inferred subsurface soil stratigraphy and our estimation of the limit of esker materials. These cross sections also appear in Appendix B.

6.3 Potential Uses of Material

Virtually all of the esker material would be suitable for use as general fill. However, its engineering properties would be more like those of a sand rather than a gravel because only small portions of the part of the esker analysed at this time contain any appreciable amounts of gravel size material. For the most part, the gravel size material is in the fine range.

The fact that the deposit is segmented and contains very little gravel size material would, in our opinion, make it relatively undesirable for development until sources containing similar materials much closer to Tuktoyaktuk have been depleted. Another major restriction to development would be the presence of massive ice beneath portions of the deposit. The thawing of this ice in areas of high relief would cause considerable environmental damage. It would appear that a much more extensive drilling program than that presently commissioned, would be required to confirm that areas selected for development are not underlain by massive ice.

TABLE 4 SUMMARY OF LABORATORY TEST RESULTS - SITE 211

HOLE NO.	DEPTH (m)	GRAIN SIZE(% by weight) GRAVEL	SAND	FINES	ORGANIC IMPURITIES COLOR PLATE	COAL CONTENT OF SAND COMPONENT (% by weight)
211-1	0.9-1.2	1.2	89.6	9.2		
	2.9-3.2	2.9	73.0	24.1		
	6.0-6.3	0.2	95.7	4.1		
211-2	1.5-1.8		85.8	14.2		
	5.0-5.3		71.1	28.9		
211-3	2.4-2.7	0.1	89.4	10.5		
	2.7-3.3	44.6	54.4	1.0		
	4.1-4.4	66.0	33.3	0.7		
	4.9-5.5	45.7	53.4	0.9		
211-5	0-1.5	27.1	71.5	1.4		
	1.5-2.1	31.5	66.8	1.7	# 5	
	3.7-4.0				# 5	
	5.7-6.0		93.0	7.0		
	8.2-8.5					1.59
211-6	0.6-0.9	0.8	78.8	20.4		
211-8	0-1.5	17.9	79.9	2.2	# 5	1.91
	4.3-4.7	0.4	95.9	3.7	# 5	
Combined	4.3-4.6 & 5.5-5.8 7.9-8.2	29.2	67.0	3.8		9.89
211-9	0.9-1.2	4.8	93.7	1.5	# 4	
	2.9-3.2	1.7	97.4	0.9		
	4.9-5.2	26.6	71.1	2.3		
	5.6-5.9		94.9	5.1		

A Petrographic Analysis performed by others suggests that the granular component contains a high percentage of chert. Other deleterious materials such as silt, clay and coal are also present in quantities in excess of that normally considered to be acceptable. If this material were to be used in the manufacture of concrete quality aggregate, it would have to undergo considerable processing. Also, significant quantities of material would have to be handled in order to obtain a relatively small amount of suitable aggregate. For the above reasons, we do not believe that the portion of the deposit evaluated at this time, is a good source of granular material suitable for use in the manufacture of concrete.

Should consideration be given to developing the site, it would appear that the gravel content of the granular material is greater in the southern portions of the esker than in the north. In addition, previous studies also suggest that a portion of the deposit immediately south of Willow Lake, which did not form part of the present scope of work, may contain materials with a higher gravel content. If development of this deposit were to take place, it should probably begin at the south end.

6.4 Site Access and Methods of Extraction

It would appear that the deposit is accessible by winter snow road from the East Channel of the Mackenzie River. However, the steep slopes adjacent to the Mackenzie River restrict initial access to the mouth of one of the drainage courses which enter the Mackenzie River from the west. An access route similar to the one used during this investigation could be constructed. However, the grades along this route would be fairly steep. A route with more acceptable grade would probably follow Cabin Creek to the south end of the deposit.

The material would have to be excavated during the winter months and either trucked along snow and ice roads, directly to the area of proposed use, or stockpiled near the Mackenzie River for transport by barge during the summer. Conventional excavation equipment, such as bulldozers equipped with ripper attachments, front-end loaders, and trucks could be used to remove the material from this source. The uppermost 1.5 m to 2.0 m of well drained material would be relatively easy to rip and excavate. Beyond this depth, the sand is well bonded with non visible ice. From the difficulty experienced in penetrating these materials with the drill, it is anticipated that the excavation of the frozen material would be very difficult. In all likelihood, it would first have to be allowed to thaw and drain during one or more summer seasons before the deposit could be developed beyond the 2 m depth. It should be noted that much of the material suitable for granular borrow does not extend much beyond the 2 m depth.

Most of the area designated for potential development is bare of any vegetation. Any topsoil encountered should be removed and stockpiled for later use. If areas which are known to be underlain by massive ice are to be developed, the excavations should terminate at least 2 m above the ice surface. It appears that where massive ice and ice- rich soils are present in potential borrow areas, they exist at a depth in excess of 4 m below grade. Site rehabilitation could consist largely of grading all embankments to a stable slope and grading the general area to a relatively flat contour. What little organic material was stripped and stockpiled during the excavation procedure could then be replaced and the area reseeded.

6.5 Estimate of Quantities

It must be realized that relatively few test holes could be drilled during this investigation on what is a reasonably extensive deposit. Airphoto interpretation is being relied upon heavily, to determine what material exists between test holes. The estimates which we have prepared are based on the assumption that the materials are continuous over considerable distances. Additional test pits or drill holes will be required prior to development to verify that these estimates are reasonably accurate.

The quantity of granular material available was estimated using the "average end area method" between the contour intervals shown on Drawing No. A83-613-B1 in Appendix B. It was assumed that the useable material extends to the contour interval at the perimeter of each area delineated on this drawing. As the uppermost 1.5 m of material is most easily recoverable, its volume has been calculated separately.

TABLE 5 - ESTIMATE OF QUANTITY SITE 211

AREA	ESTIMATE OF TOTAL VOLUME AVAILABLE	ESTIMATE OF VOLUME TO 1.5 m BELOW GRADE
A	200,000 m^3	150,000 m^3
B	70,000 m^3	40,000 m^3
C	80,000 m^3	60,000 m^3
D	150,000 m^3	115,000 m^3
TOTAL	500,000 m^3	365,000 m^3

6.6 Potential Costs of Extraction

The potential cost of extracting the material within this deposit and trucking it to Tuktoyaktuk, was discussed with Gruben Transport Ltd. If the main ice road along the East Channel of the Mackenzie River was constructed and maintained for purposes other than accessing this deposit, the cost of constructing and maintaining the short snow road road from the East Channel to the deposit would not add significantly to the unit cost of extracting the granular material. However, this cannot be assumed to always be the case. Without the main ice road, the cost of removing this material would be only slightly less than that presently being paid for granular material extracted from the Ya-Ya esker to the south. It is anticipated that the cost of extraction likely would be in the order of $27 to $30 per cubic metre.

7.0 CONCLUSIONS

The results of this geotechnical evaluation showed that reasonably good quality gravel and very gravelly sand is present throughout the main portion of Deposit 168. In total, this deposit contains approximately 600,000 m^3 of material, of which approximately 350,000 m^3 could be extracted with relative ease. The total quantity present is less than had been previously suspected. The gravel and very gravelly sand are certainly all useable in applications calling for granular fill. In addition, the deposit would appear to be a good source of concrete quality aggregate. However, the reactivity of certain potentially deleterious components with the alkalies in cement would have to be known before it could be confirmed that the material could be used in the manufacture of concrete.

The results of this geotechnical evaluation also confirmed that significant quantities of fair quality granular material are present in Deposit 211. In total, the portion of the deposit evaluated at this time is suspected to contain approximately 500,000 m^3 of material. Of this, approximately 365,000 m^3 would be relatively easy to extract. However, the granular material in this deposit consists almost entirely of a sand with a minor gravel component. Significant quantities of silt and other deleterious material are also present. Without undergoing a considerable amount of processing, it would only be useable as general granular fill. Until sources of better quality material in the Tuktoyaktuk area are depleted, it would not appear that Deposit 211 warrants development.

Respectfully submitted,

BBT GEOTECHNICAL CONSULTANTS LTD.

Steve C. Musulak, P.Eng.

GVM GEOLOGICAL CONSULTANTS LTD.

G.V. Minning, P.Geol.

SCM:pk

THE ASSOCIATION OF
PROFESSIONAL ENGINEERS
OF ALBERTA
PERMIT NUMBER
P 2060
BBT GEOTECHNICAL
CONSULTANTS LTD.

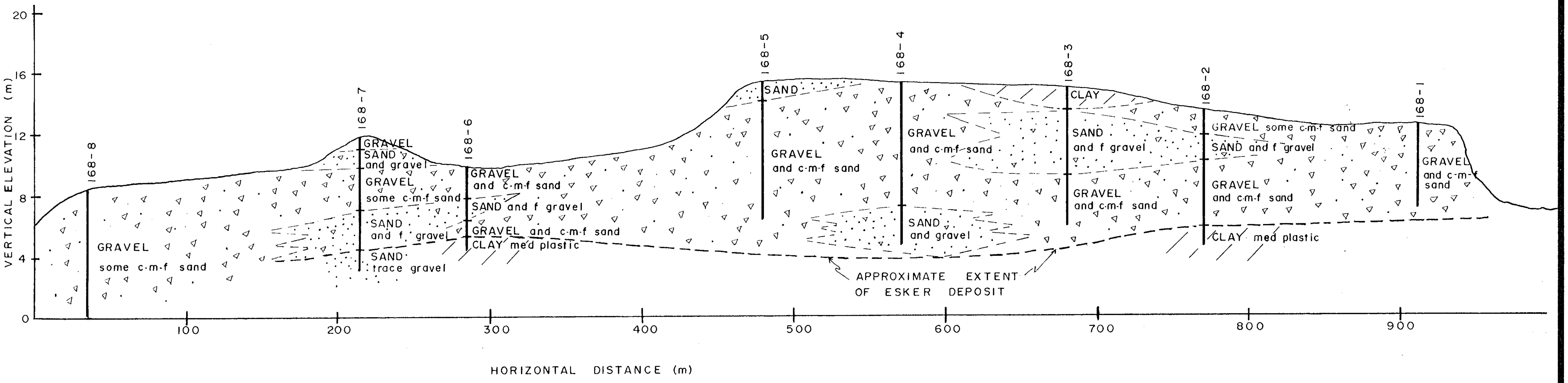
THE ASSOCIATION OF
PROFESSIONAL ENGINEERS,
GEOLOGISTS and GEOPHYSICISTS
OF ALBERTA
PERMIT NUMBER
P 3184
GVM Geological
Consultants Ltd.

NOTE: - - APPROX. AREAL EXTENT OF ESKER DEPOSITS
⌖ LOCATION OF BBT TEST HOLE
⊙ LOCATION OF TEST HOLE BY OTHERS
CONTOURS GIVEN IN 1m INTERVALS

BBT Geotechnical Consultants Ltd.
BBT GEOTECHNICAL CONSULTANTS LTD.

SITE PLAN SHOWING TOPOGRAPHY AND
LOCATION OF TEST HOLES
DEPOSIT 211, NEAR WILLOW LAKE ON RICHARDS ISLAND
TUKTOYAKTUK AREA N.W.T.

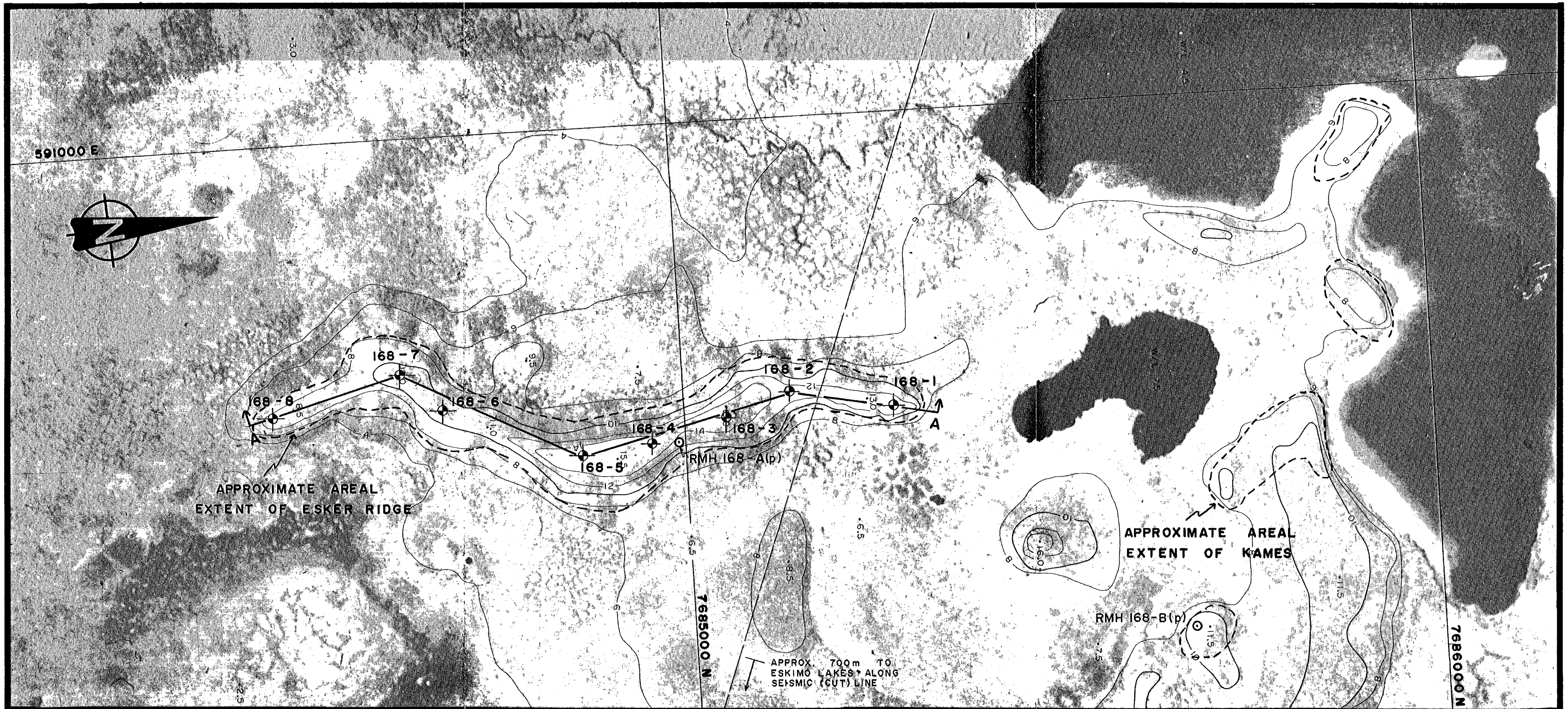
Date: MAY 1983
Scale: 1:5000
DRAWING NO: A83 - 613 - B1



BBT Geotechnical Consultants Ltd.
BBT GEOTECHNICAL CONSULTANTS LTD.

CROSS SECTION A—A
DEPOSIT 168, NEAR ESKIMO LAKES
TUKTOYAKTUK AREA NWT

Scale: AS SHOWN	Designed By:
Drawn By:	Checked By:
Date: MAY 1983	Approved By:
DRAWING NO: A83-613- A2	



NOTE:
✛ LOCATION OF BBT TEST HOLE
⊙ LOCATION OF TEST HOLE BY OTHERS
CONTOUR INTERVAL IS 2 m
PORTION OF E.M.R. AIR PHOTO A12902 - 74

BBT Geotechnical Consultants Ltd.
BBT GEOTECHNICAL CONSULTANTS LTD.

SITE PLAN SHOWING TOPOGRAPHY AND
LOCATION OF TEST HOLES
DEPOSIT 168, NEAR ESKIMO LAKES
TUKTOYAKTUK AREA N.W.T.

Date: MAY 1983
Scale: 1: 4000
DRAWING NO: A83 - 613 - A1

BBT Geotechnical Consultants Ltd.
BBT GEOTECHNICAL CONSULTANTS LTD.

LOG OF TEST HOLE 168 - 1

PROJECT: GRANULAR MATERIAL STUDY

CLIENT: GOVERNMENT OF CANADA

LOCATION: TUKTOYAKTUK, N.W.T.

DEPT. OF INDIAN AFFAIRS & NORTHERN DEVELOPMENT

THIS SUMMARY APPLIES ONLY AT THE LOCATION OF THIS TEST HOLE AND AT THE TIME OF DRILLING.

NRC Ice	N_B	γ_D	$\frac{U}{pp}$	P_w	L_w	w%		DEPTH (m)	SYM.	USC	SOIL DESCRIPTION	OTHER TESTS
N_f											50 mm, Organic cover	
										GW	GRAVEL, well graded, dry, brown, and c-m-f sand, trace silt, occasional cobble, loose to 2.4 m, frozen below	
						3		1				MA
								2			2.0 m - thin layers of medium sand below 2.0 m	
V <5%												
								3			3.0 m - becomes coarser below 3.0 m	MA
						6						
								4				
								5				
						6						MA
											5.7 m - End of Hole	
								6				
								7				
								8				

DRILL RIG:	DATE DRILLED:	SCALE:	DRAWING NUMBER:
Becker Diesel Hammer	March 19, 1983	1:50	A83-613-A3

BBT Geotechnical Consultants Ltd.
BBT GEOTECHNICAL CONSULTANTS LTD.

LOG OF TEST HOLE 168 - 2

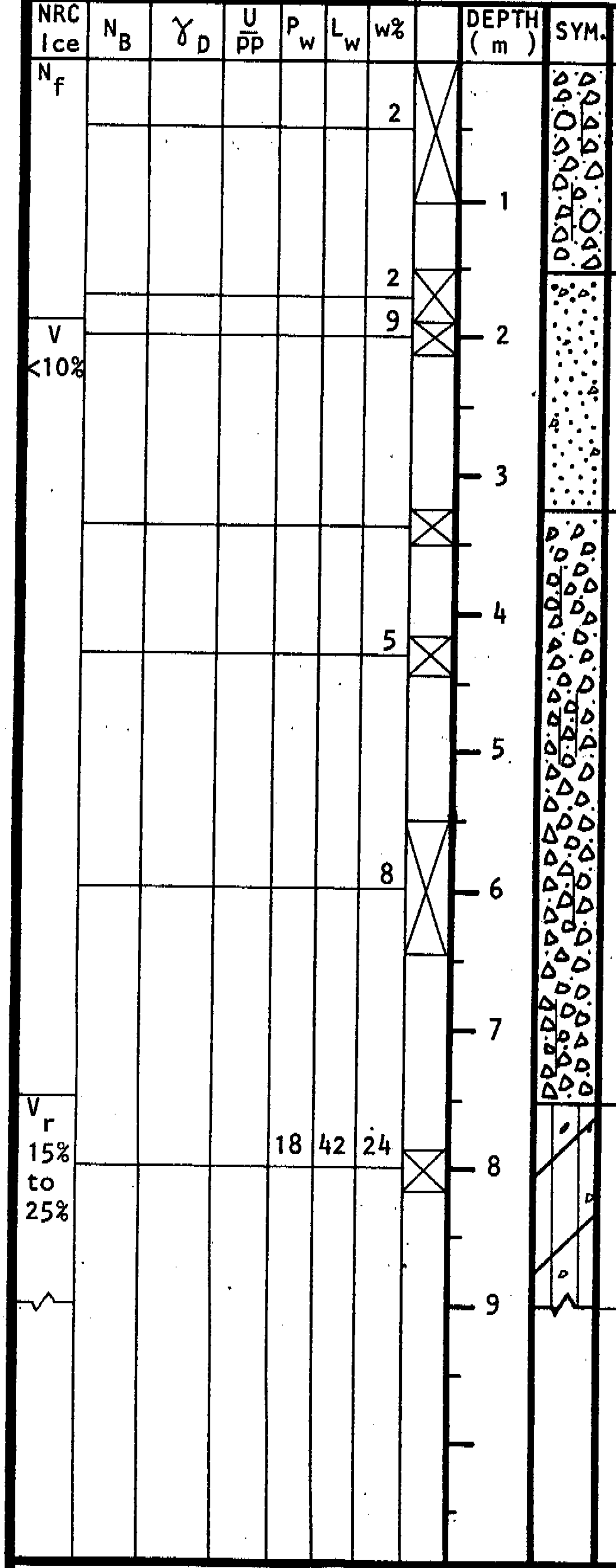
PROJECT: GRANULAR MATERIAL STUDY

CLIENT: GOVERNMENT OF CANADA

LOCATION: TUKTOYAKTUK, N.W.T.

DEPT. OF INDIAN AFFAIRS & NORTHERN DEVELOPMENT

THIS SUMMARY APPLIES ONLY AT THE LOCATION OF THIS TEST HOLE AND AT THE TIME OF DRILLING.



USC	SOIL DESCRIPTION	OTHER TESTS
GW	GRAVEL, well graded, dry, brown, some c-m-f sand (35%), trace silt, occasional cobble, loose 1.5 m	MA
SP	SAND, poorly graded, brown, some fine gravel (35%), loose to 2.4 m, frozen below, wet upon thawing 3.0 m - 0.15 m thick fine sand layer 3.2 m	MA
GP	GRAVEL, poorly graded, and c-m-f sand (35% to 45%), trace silt, wet upon thawing 7.5 m	MA MA
CI	CLAY, medium plastic, silty, grey, occasional pebble, ice layers to 15 mm thick 9.0 m End of Hole	

DRILL RIG: Becker Diesel Hammer

DATE DRILLED: March 19, 1983

SCALE: 1:50

DRAWING NUMBER: A83-613-A4

BBT Geotechnical Consultants Ltd.
BBT GEOTECHNICAL CONSULTANTS LTD.

LOG OF TEST HOLE 168-3

PROJECT: GRANULAR MATERIAL STUDY

CLIENT: GOVERNMENT OF CANADA

LOCATION: TUKTOYAKTUK, N.W.T.

DEPT. OF INDIAN AFFAIRS & NORTHERN DEVELOPMENT

THIS SUMMARY APPLIES ONLY AT THE LOCATION OF THIS TEST HOLE AND AT THE TIME OF DRILLING.

NRC Ice	N_B	γ_D	$\frac{U}{pp}$	P_w	L_w	w%		DEPTH (m)	SYM.	USC	SOIL DESCRIPTION	OTHER TESTS
V_s <5%										CL	50 mm Peat cover CLAY, low plastic, grey-brown, frozen, ice rich below 1 m (50% to 60% excess upon thawing)	
V_s >25%				17	27	52	☒	1			1.5 m	
V <5%						4	☒ ☒	2		SP	SAND, poorly graded, m-c <u>and</u> fine gravel (35% to 45%), wet upon thawing, trace silt, contains layers of SW and GW at 2.0 m and 4.0 m depth	MA MA
V 10% to 15%						8	☒	3 4			Note: Deposit appears to have layered structure of gravels and sands	MA
						8	☒	5			5.8 m	MA
V >15%								6		GW	GRAVEL, well graded, wet when thawed, <u>and</u> c-m-f sand (35%), brownish-grey, contains layers of coarse gravel, layers of well graded sand < 0.15 m thick	
						7	☒	7 8				MA
								9			9.0 m End of Hole	

DRILL RIG: Becker Diesel Hammer

DATE DRILLED: March 20, 1983

SCALE: 1:50

DRAWING NUMBER: A83-613-A5

BBT Geotechnical Consultants Ltd.
BBT GEOTECHNICAL CONSULTANTS LTD.

LOG OF TEST HOLE 168-4

PROJECT: GRANULAR MATERIAL STUDY

CLIENT: GOVERNMENT OF CANADA
DEPT. OF INDIAN AFFAIRS & NORTHERN DEVELOPMENT

LOCATION: TUKTOYAKTUK, N.W.T.

THIS SUMMARY APPLIES ONLY AT THE LOCATION OF THIS TEST HOLE AND AT THE TIME OF DRILLING.

NRC Ice	N_B	γ_D	$\frac{U}{pp}$	P_w	L_w	w%		DEPTH (m)	USC	SOIL DESCRIPTION	OTHER TESTS
N									GW	GRAVEL, well graded, damp, brown, and c-m-f sand(30% to 40%), trace silt, occasional cobble, loose to 1.8 m, frozen below	
						3	☒				MA
								1			
										1.5 m - 0.15 m sand layer	
								2			
V <5% to 10%						5	☒				MA
										2.5 m - very sandy zone	
										Note: Deposit probably has layered structure of gravel and sand	
								3			
						7	☒				MA
								4			
						3	☒				
										4.5 m - ice rich layers below 4.5 m	
						5	☒	5			MA
						7	☒	6			
								7			
						7	☒				MA
										8.0 m	
V 15%								8	SP	SAND, skip-graded, medium to fine, and gravel(35%), grey, saturated upon thawing, contains trace silt and clay	
						14	☒				MA
								9			
								10			
										10.5 m End of Hole	

DRILL RIG: Becker Diesel Hammer

DATE DRILLED: March 20, 1983

SCALE: 1:50

DRAWING NUMBER: A83-613-A6

BBT Geotechnical Consultants Ltd.
BBT GEOTECHNICAL CONSULTANTS LTD.

LOG OF TEST HOLE 168-5

PROJECT: GRANULAR MATERIAL STUDY	**CLIENT:** GOVERNMENT OF CANADA
LOCATION: TUKTOYAKTUK, N.W.T.	DEPT. OF INDIAN AFFAIRS & NORTHERN DEVELOPMENT

THIS SUMMARY APPLIES ONLY AT THE LOCATION OF THIS TEST HOLE AND AT THE TIME OF DRILLING.

NRC Ice	N_B	γ_D	U pp	P_w	L_w	w%		DEPTH (m)	SYM.	USC	SOIL DESCRIPTION	OTHER TESTS
N_f						7	☒	1		SP	SAND, poorly graded, m-f, brown, moist when thawed, trace roots near surface 1.2 m	
V <5%						4 6 14	☒ ☒ ☒	2 3		GW	GRAVEL, well graded, moist, brown, and c-m-f sand(35% to 40%), trace silt, occasional cobble 2.8 m - 0.15 m thick layer of ML 3.0 m - 0.5 m thick layer of fine GP 3.5 m	MA MA
V 15% to 20%						 13	☒ ☒	4 5		GW	GRAVEL, well graded, wet when thawed, grey-brown, little to some c-m-f sand(15% to 20%), occasional cobble 6.0 m	MA MA
						10 9	☒ ☒ ☒	6 7 8 9		GW	GRAVEL, well graded, wet when thawed, grey-brown, some c-m-f sand (30% to 35%), trace silt, occasional cobble 9.0 m End of Hole	MA MA
								10				

DRILL RIG:	DATE DRILLED:	SCALE:	DRAWING NUMBER:
Becker Diesel Hammer	March 20, 1983	1:50	A83-613-A7

BBT Geotechnical Consultants Ltd.
BBT GEOTECHNICAL CONSULTANTS LTD.

LOG OF TEST HOLE 168-6

PROJECT: GRANULAR MATERIAL STUDY

CLIENT: GOVERNMENT OF CANADA

LOCATION: TUKTOYAKTUK, N.W.T.

DEPT. OF INDIAN AFFAIRS & NORTHERN DEVELOPMENT

THIS SUMMARY APPLIES ONLY AT THE LOCATION OF THIS TEST HOLE AND AT THE TIME OF DRILLING.

NRC Ice	N_B	γ_D	U_{pp}	P_w	L_w	w%		DEPTH (m)	SYM.	USC	SOIL DESCRIPTION	OTHER TESTS
N_f						2	☒	0 – 2.0		GW	GRAVEL, well graded, damp, brown <u>and</u> coarse to fine sand(45%), occasional cobble, loose to 2.0 m, frozen below, wet upon thawing 2.0 m	MA
V <5%						8	☒	2.0 – 3.5		SP	SAND, poorly graded, medium to fine, <u>and</u> fine gravel, contains 0.15 m thick layers of clean uniform sand 3.5 m	MA
V 15%						12	☒					
						8	☒	3.5 – 4.5		GW	GRAVEL, well graded, saturated upon thawing, brown, <u>and</u> coarse to fine sand(45%) 4.5 m	MA
V_r 15% to 20%								4.5 – 5.4		CI	CLAY, medium plastic, grey, ice rich, contains pebbles 5.4 m — End of Hole	

DRILL RIG:	DATE DRILLED:	SCALE:	DRAWING NUMBER:
Becker Diesel Hammer	March 20, 1983	1:50	A83-613-A8

BBT Geotechnical Consultants Ltd.
BBT GEOTECHNICAL CONSULTANTS LTD.

LOG OF TEST HOLE 168-7

PROJECT: GRANULAR MATERIAL STUDY

CLIENT: GOVERNMENT OF CANADA

LOCATION: TUKTOYAKTUK, N.W.T.

DEPT. OF INDIAN AFFAIRS & NORTHERN DEVELOPMENT

THIS SUMMARY APPLIES ONLY AT THE LOCATION OF THIS TEST HOLE AND AT THE TIME OF DRILLING.

NRC Ice	N_B	γ_D	U pp	P_w	L_w	w%		DEPTH (m)	USC	SOIL DESCRIPTION	OTHER TESTS
N_f						4	☒		Pt GW	50 mm Peat cover GRAVEL, well graded, silty near surface, and c-m-f sand, brown, moist, occasional cobble 0.8 m	MA
						4	☒	1	SP	SAND, poorly graded, loose, brown, moist when thawed, and c-f gravel, thin layer of clayey silt at 1.0 m 2.0 m	MA
V >5%						5	☒	2	GP- GW	GRAVEL, fairly well graded, grey-brown, wet when thawed (>5% excess), some c-m-f sand (25% to 30%), trace silt, occasional cobble, very ice rich layer at 3.0 m	
V >10%						8	☒	3			MA
						8	☒	4		4.8 m	MA
V >15%						13	☒	5	SW	SAND, well graded, grey, and fine gravel, trace coarse gravel to 75 mm, trace cobbles, contains layers of silt and clay, wet upon thawing (>5% excess)	
								6			
						11	☒				MA
								7		7.3 m	
V 15% to 20%						22	☒	8	SP	SAND, poorly graded, m-f, grey-brown, trace gravel sizes, layered structure with silt, coal specks, very hard to penetrate, ice rich layers 8.8 m End of Hole	

DRILL RIG:	DATE DRILLED:	SCALE:	DRAWING NUMBER:
Becker Diesel Hammer	March 20, 1983	1:50	A83-613-A9

BBT Geotechnical Consultants Ltd.
BBT GEOTECHNICAL CONSULTANTS LTD.

LOG OF TEST HOLE 168-8

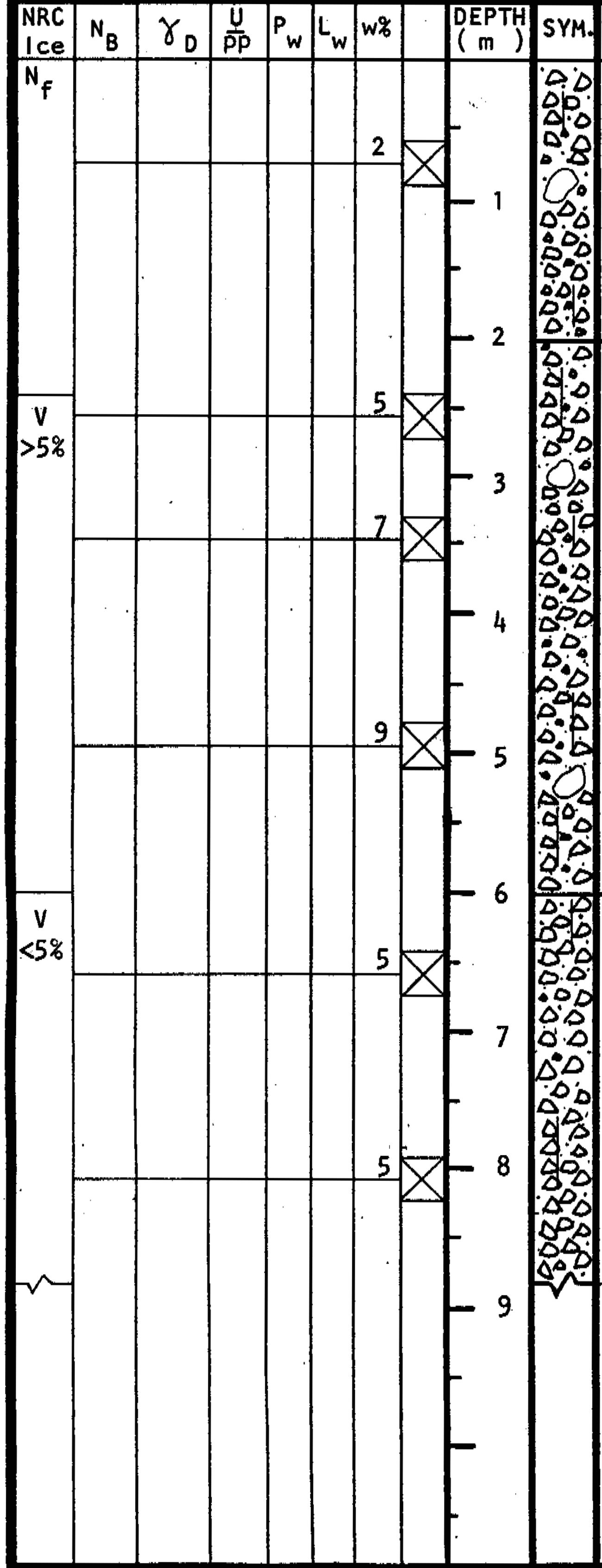
PROJECT: GRANULAR MATERIAL STUDY

CLIENT: GOVERNMENT OF CANADA

LOCATION: TUKTOYAKTUK, N.W.T.

DEPT. OF INDIAN AFFAIRS & NORTHERN DEVELOPMENT

THIS SUMMARY APPLIES ONLY AT THE LOCATION OF THIS TEST HOLE AND AT THE TIME OF DRILLING.



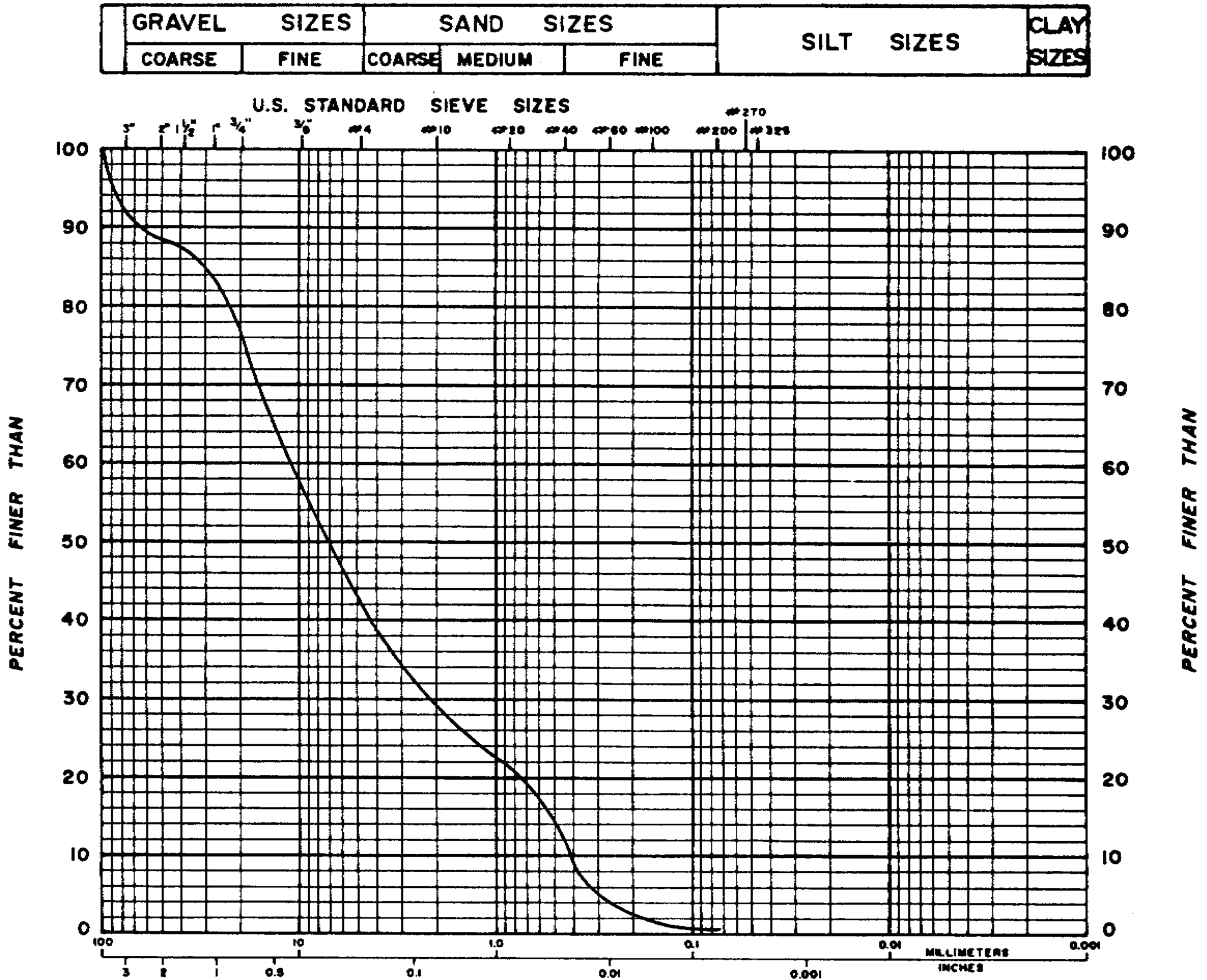
USC	SOIL DESCRIPTION	OTHER TESTS
GW	GRAVEL, well graded, max. size 75 mm, and c-m-f sand(35%), trace to no silt, loose, brown, occasional cobble 2.0 m	MA
GW	GRAVEL, well graded, grey, loose to 2.4 m, frozen below, little to some c-m-f sand (15% to 20%), trace cobbles to 200 mm size, trace silt 4.2 m — 0.3 m thick ice rich layer 6.0 m	MA MA MA
GW-GP	GRAVEL, fairly well graded, grey, some c-m-f sand(25%), trace silt, wet upon thawing, low visible ice content except for ice rich layer at 7.1 m 8.8 m — End of Hole	MA MA

DRILL RIG: Becker Diesel Hammer

DATE DRILLED: March 20, 1983

SCALE: 1:50

DRAWING NUMBER: A83-613-A10



D_{10} 0.38mm

D_{30} 2.2 mm

D_{60} 12.0 mm

C_u 31.6

C_c 1.1

Geotechnical Consultants Ltd.

GRAIN SIZE DISTRIBUTION

DRAWING NO: A83-613-A11

REMARKS:

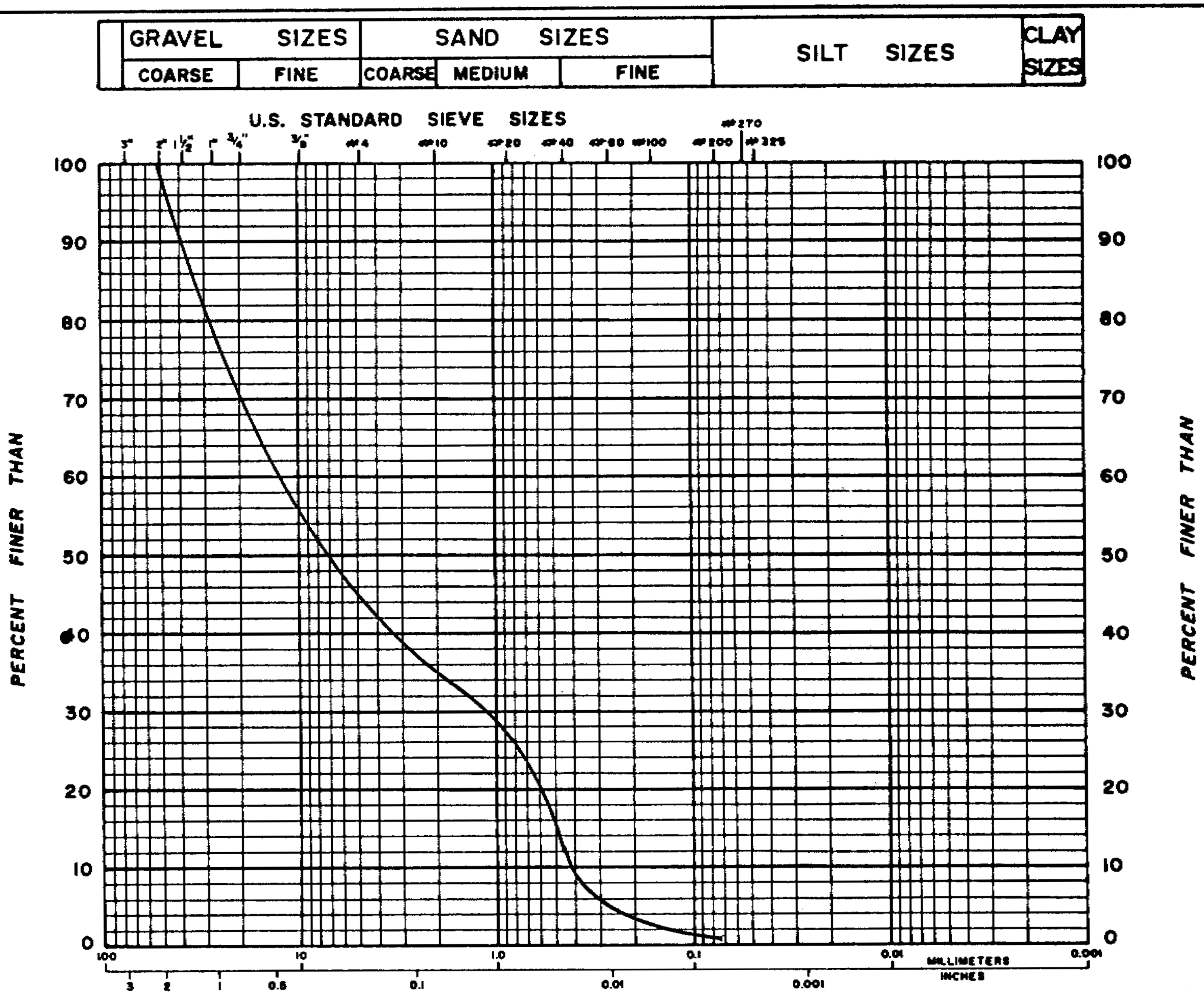
CLIENT: GOVERNMENT OF CANADA, DIAND

PROJECT: GRANULAR MATERIAL EVALUATION

LOCATION: TUKTOYAKTUK AREA, NWT

TEST HOLE NO: 168-1

DEPTH: 0-1.8m



D_{10} 0.42mm

D_{30} 1.2 mm

D_{60} 13.0 mm

C_u 31.0

C_c 0.26

Geotechnical Consultants Ltd.

GRAIN SIZE DISTRIBUTION

DRAWING NO: A83-613-A12

REMARKS:

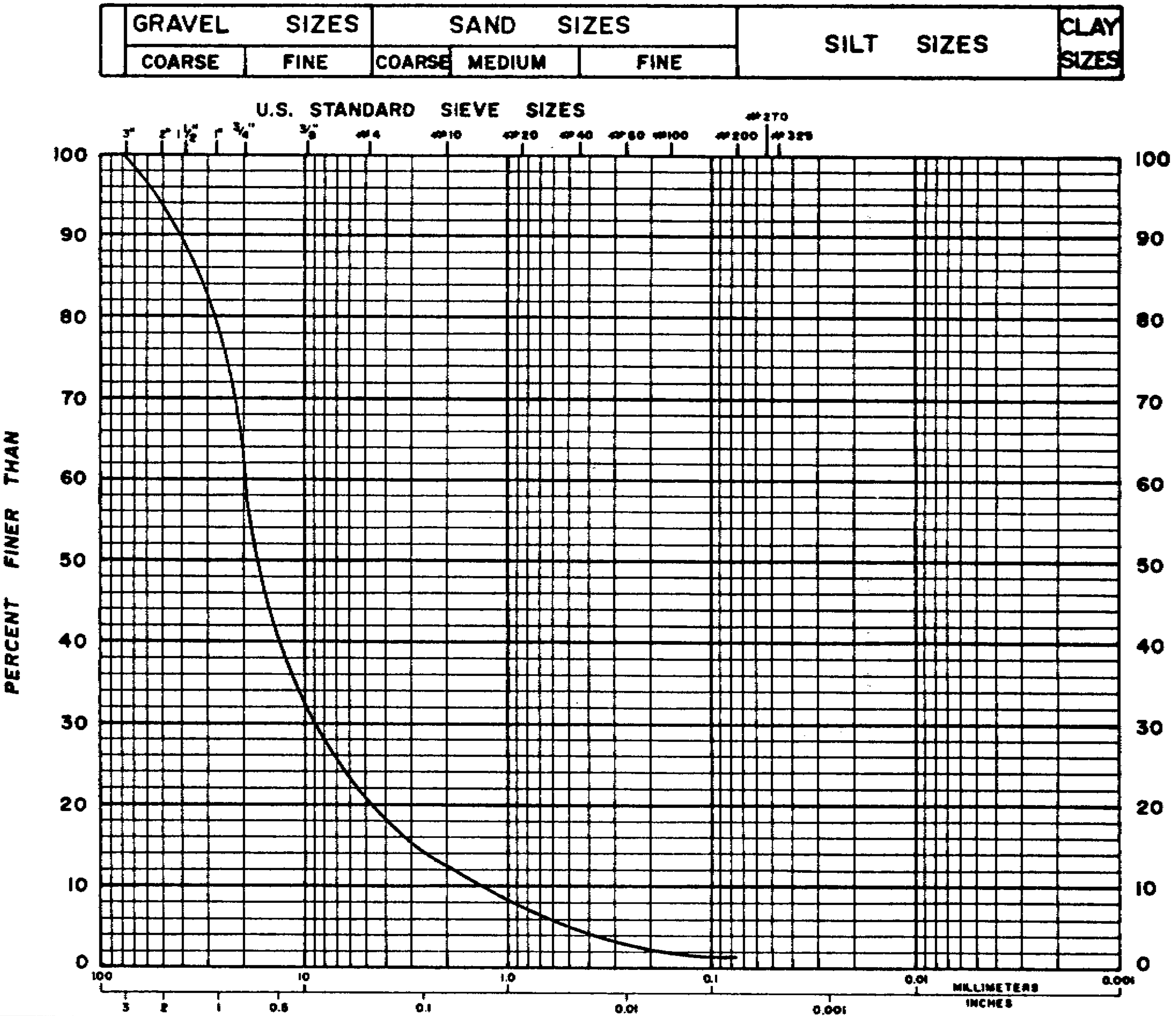
CLIENT: GOVERNMENT OF CANADA, DIAND

PROJECT: GRANULAR MATERIAL EVALUATION

LOCATION: TUKTOYAKTUK AREA, NWT

TEST HOLE NO: 168-1

DEPTH: 3.0m-3.7m



D_{10}	1.4mm
D_{30}	9.0mm
D_{60}	20.0mm
C_u	14.3
C_c	2.9

Geotechnical Consultants Ltd.

GRAIN SIZE DISTRIBUTION

DRAWING NO: A83-613-A13

REMARKS:

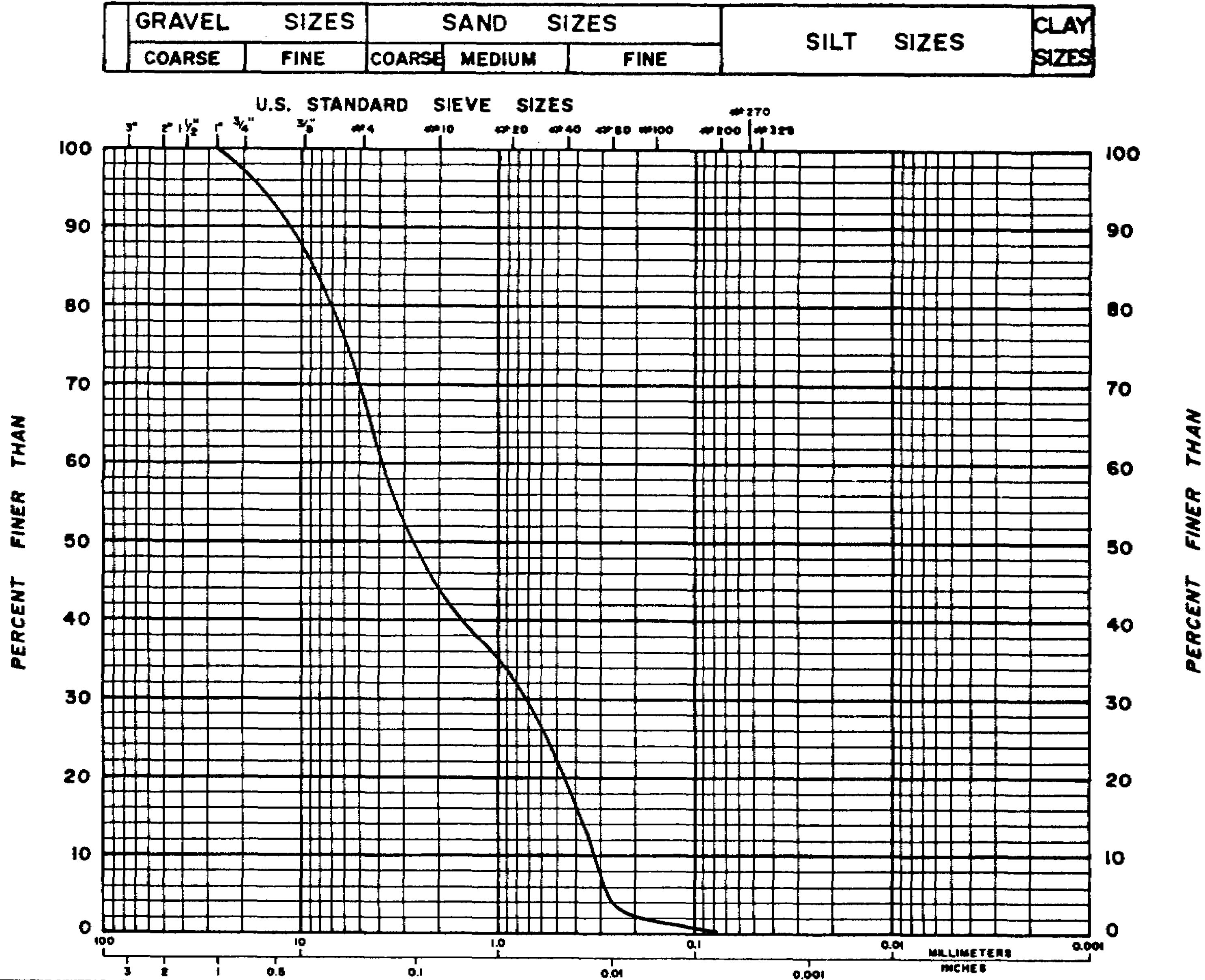
CLIENT: GOVERNMENT OF CANADA, DIAND

PROJECT: GRANULAR MATERIAL EVALUATION

LOCATION: TUKTOYAKTUK AREA, NWT

TEST HOLE NO: 168-1

DEPTH 5.2-5.5m



D_{10} 0.33mm

D_{30} 0.71mm

D_{60} 4.0 mm

C_u 12.1

C_c 0.4

Geotechnical Consultants Ltd.

GRAIN SIZE DISTRIBUTION

DRAWING NO: A83-613-A15

REMARKS:

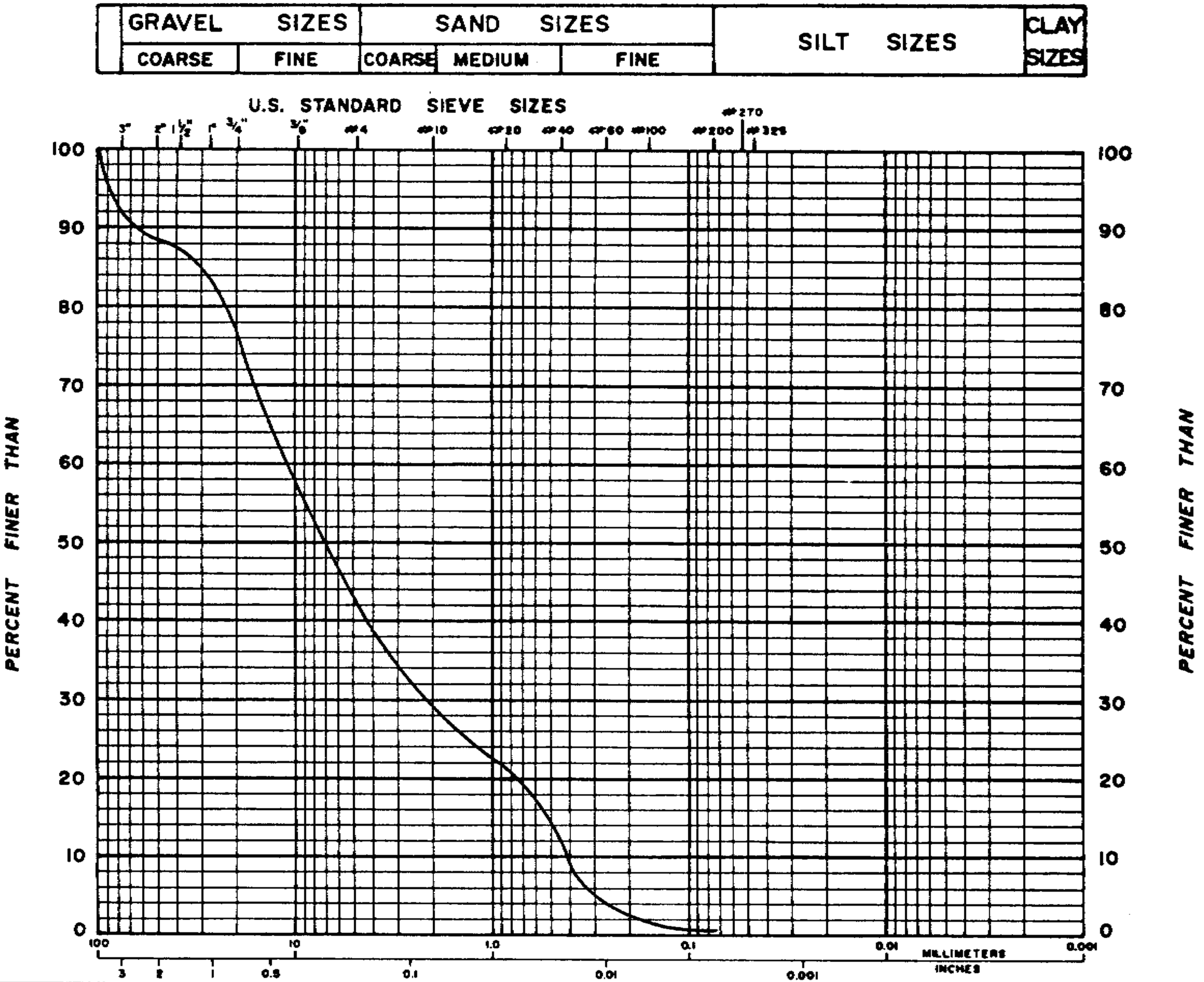
CLIENT: GOVERNMENT OF CANADA, DIAND

PROJECT: GRANULAR MATERIAL EVALUATION

LOCATION: TUKTOYAKTUK AREA, NWT

TEST HOLE NO: 168-2

DEPTH: 1.8m-2.3m



D_{10} 0.38mm

D_{30} 2.2 mm

D_{60} 12.0 mm

C_u 31.6

C_c 1.1

Geotechnical Consultants Ltd.

GRAIN SIZE DISTRIBUTION

DRAWING NO: A83-613-A11

REMARKS:

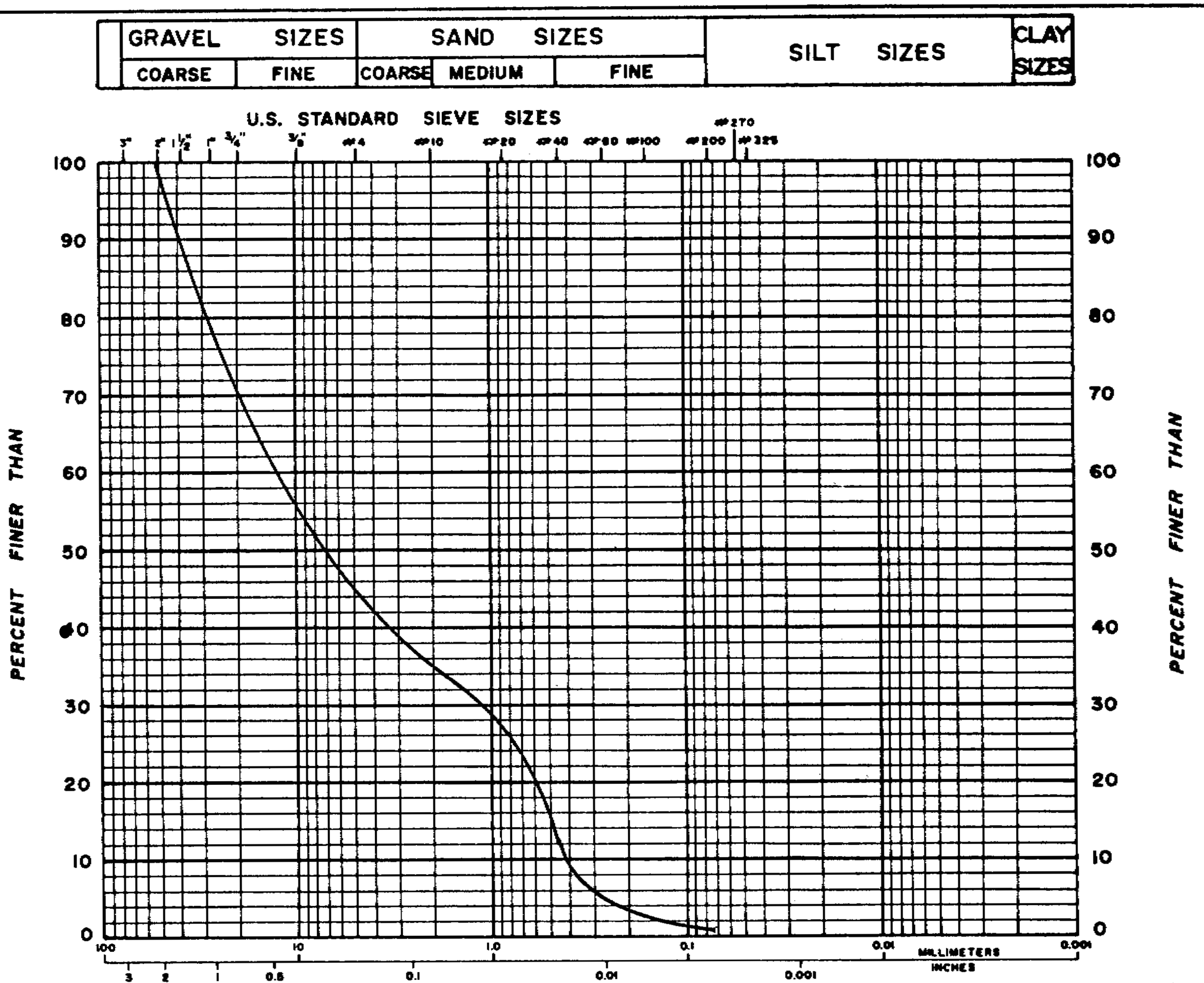
CLIENT: GOVERNMENT OF CANADA, DIAND

PROJECT: GRANULAR MATERIAL EVALUATION

LOCATION: TUKTOYAKTUK AREA, NWT

TEST HOLE NO: 168-1

DEPTH: 0-1.8m



D_{10} 0.42mm

D_{30} 1.2 mm

D_{60} 13.0 mm

C_u 31.0

C_c 0.26

88 Geotechnical Consultants Ltd.

GRAIN SIZE DISTRIBUTION

DRAWING NO: A83-613-A12

REMARKS:

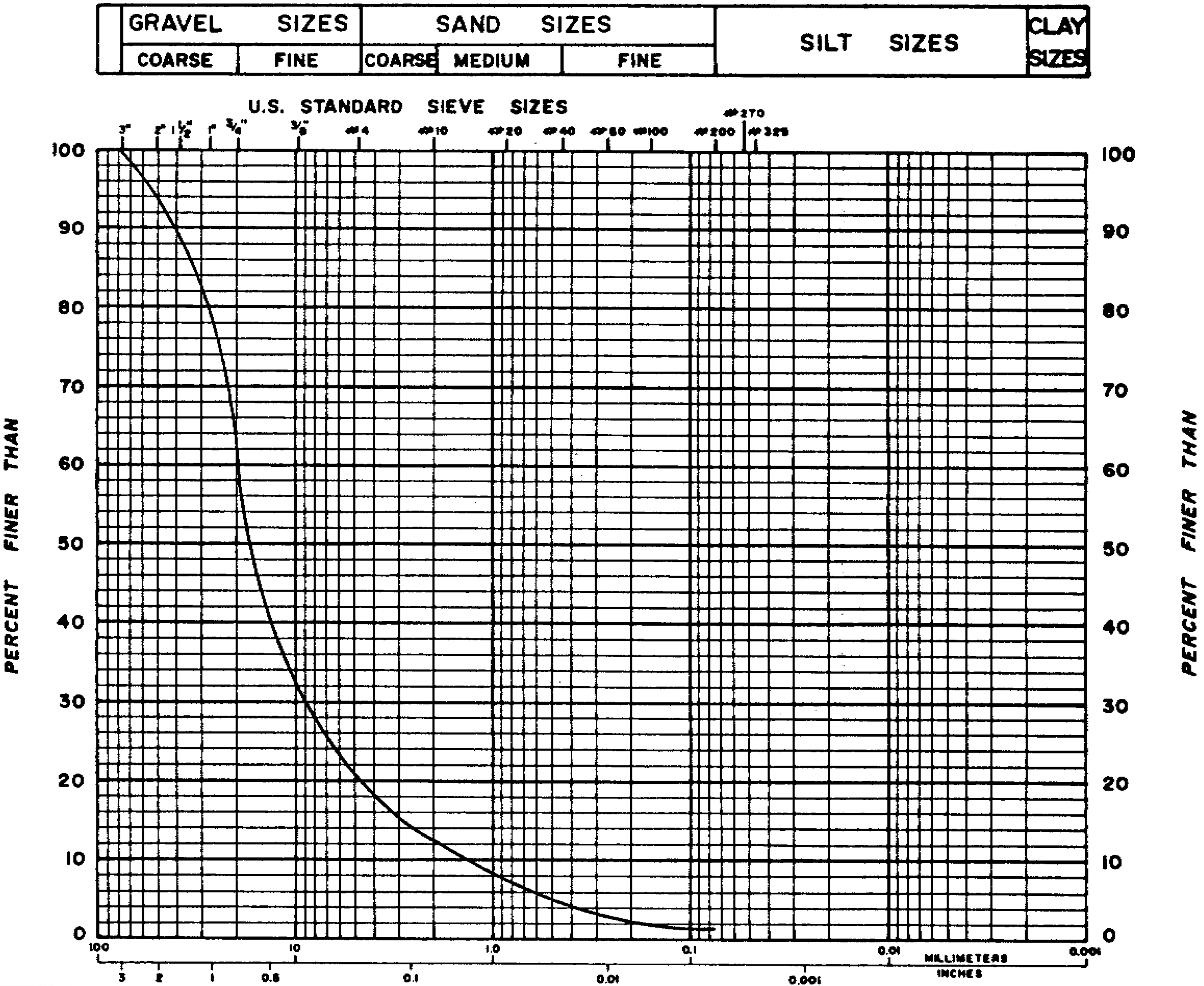
CLIENT: GOVERNMENT OF CANADA, DIAND

PROJECT: GRANULAR MATERIAL EVALUATION

LOCATION: TUKTOYAKTUK AREA, NWT

TEST HOLE NO: 168-1

DEPTH: 3.0m-3.7m



D_{10}	1.4mm
D_{30}	9.0mm
D_{60}	20.0mm
C_u	14.3
C_c	2.9

Geotechnical Consultants Ltd.

GRAIN SIZE DISTRIBUTION

DRAWING NO: A83-613-A13

REMARKS:

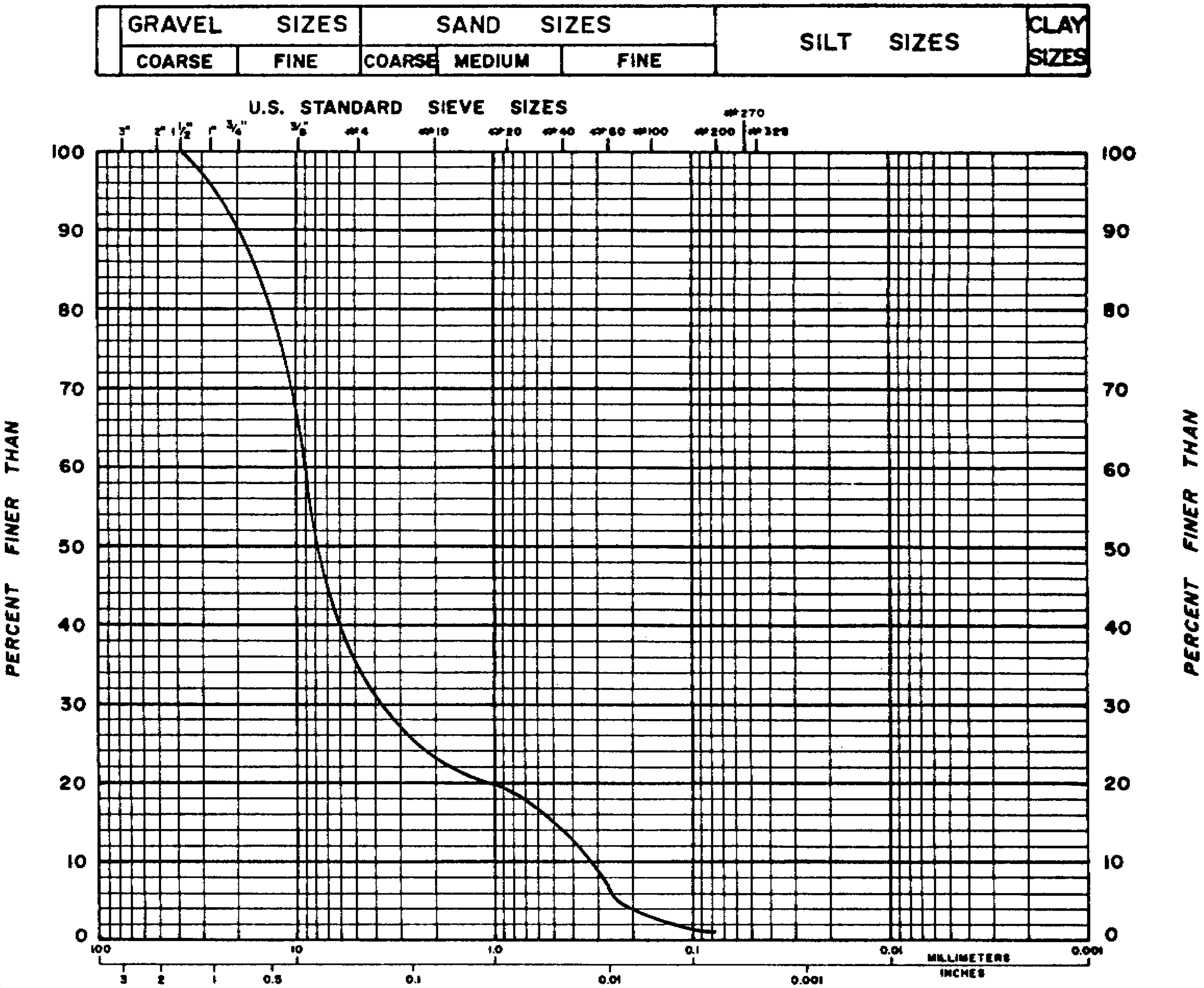
CLIENT: GOVERNMENT OF CANADA, DIAND

PROJECT: GRANULAR MATERIAL EVALUATION

LOCATION: TUKTOYAKTUK AREA, NWT

TEST HOLE NO: 168-1

DEPTH 5.2-5.5m



D_{10} 0.33mm

D_{30} 3.8 mm

D_{60} 9.0 mm

C_u 27.3

C_c 4.9

EBA Geotechnical Consultants Ltd.

GRAIN SIZE DISTRIBUTION

DRAWING NO: A83-613-A16

REMARKS:

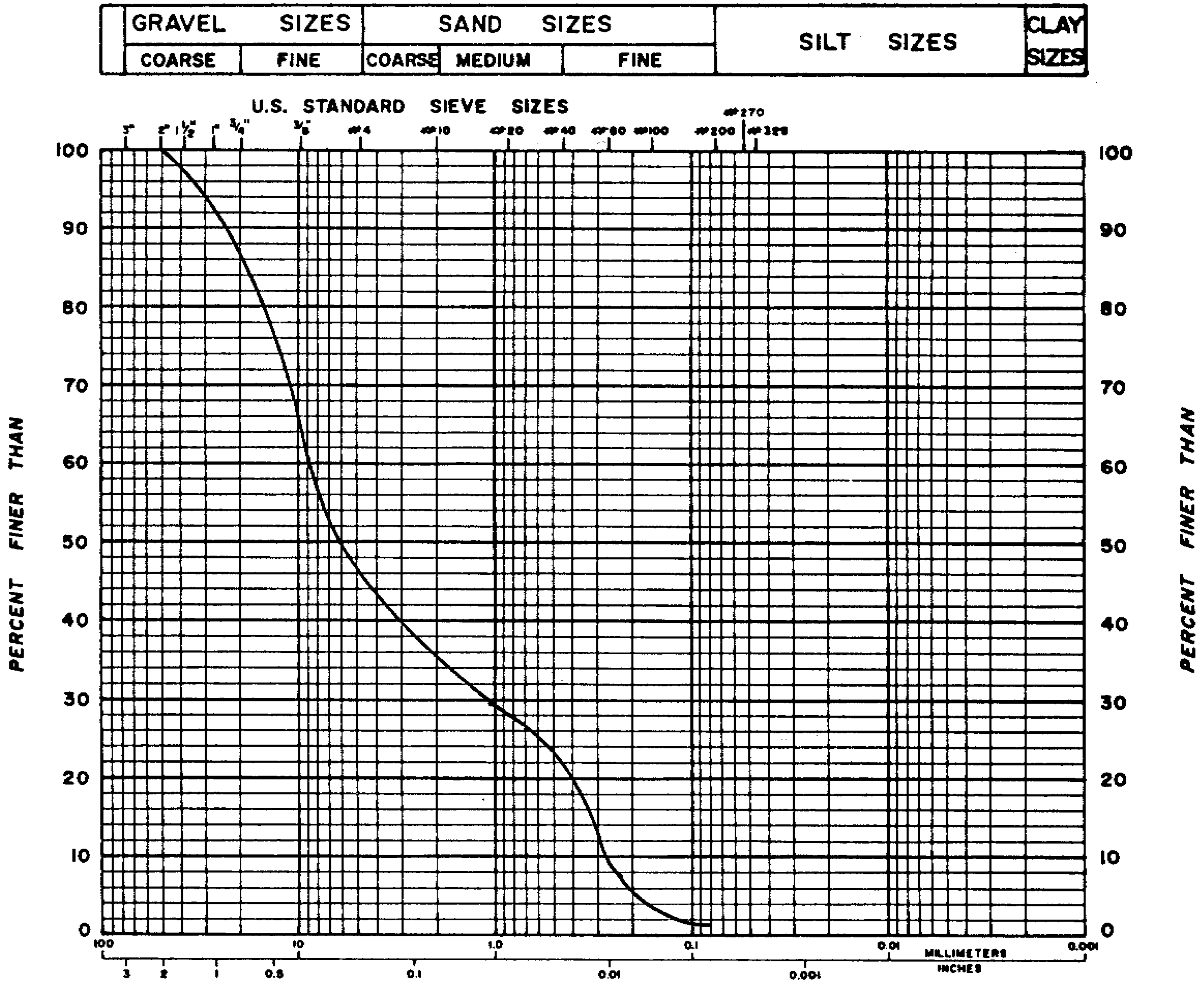
CLIENT: GOVERNMENT OF CANADA, DIAND

PROJECT: GRANULAR MATERIAL EVALUATION

LOCATION: TUKTOYAKTUK AREA, NWT

TEST HOLE NO: 168-2

DEPTH: 3.2m-3.7m



D_{10} 0.28mm

D_{30} 1.0 mm

D_{60} 9.0 mm

C_u 32.1

C_c 0.4

BBT Geotechnical Consultants Ltd.

GRAIN SIZE DISTRIBUTION

DRAWING NO: A83-613-A17

REMARKS:

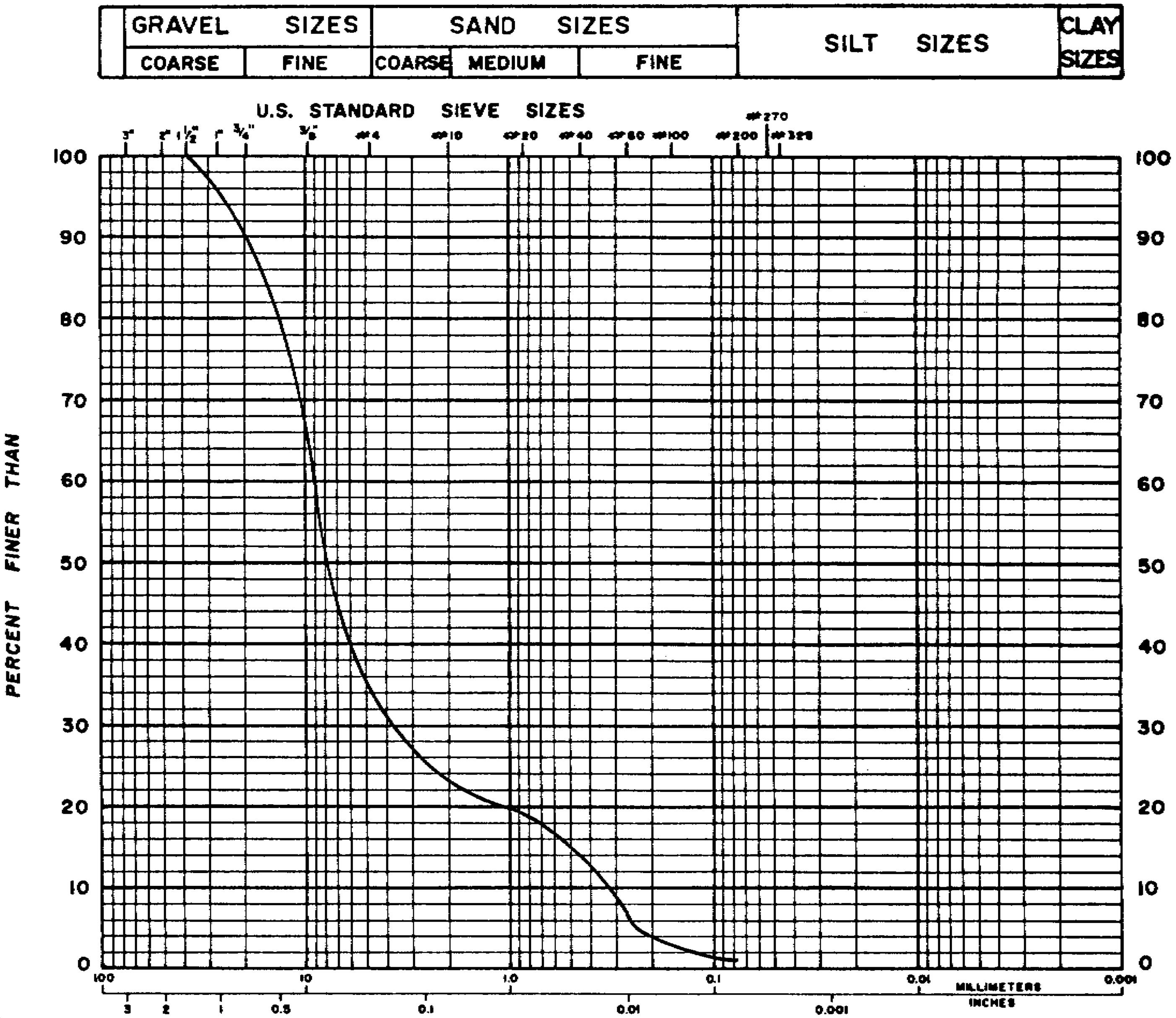
CLIENT: GOVERNMENT OF CANADA, DIAND

PROJECT: GRANULAR MATERIAL EVALUATION

LOCATION: TUKTOYAKTUK AREA, NWT

TEST HOLE NO: 168-2

DEPTH 5.5m-6.4m



D_{10}	0.33mm
D_{30}	3.8 mm
D_{60}	9.0 mm
C_u	27.3
C_c	4.9

Geotechnical Consultants Ltd.

GRAIN SIZE DISTRIBUTION

DRAWING NO: A83-613-A16

REMARKS:

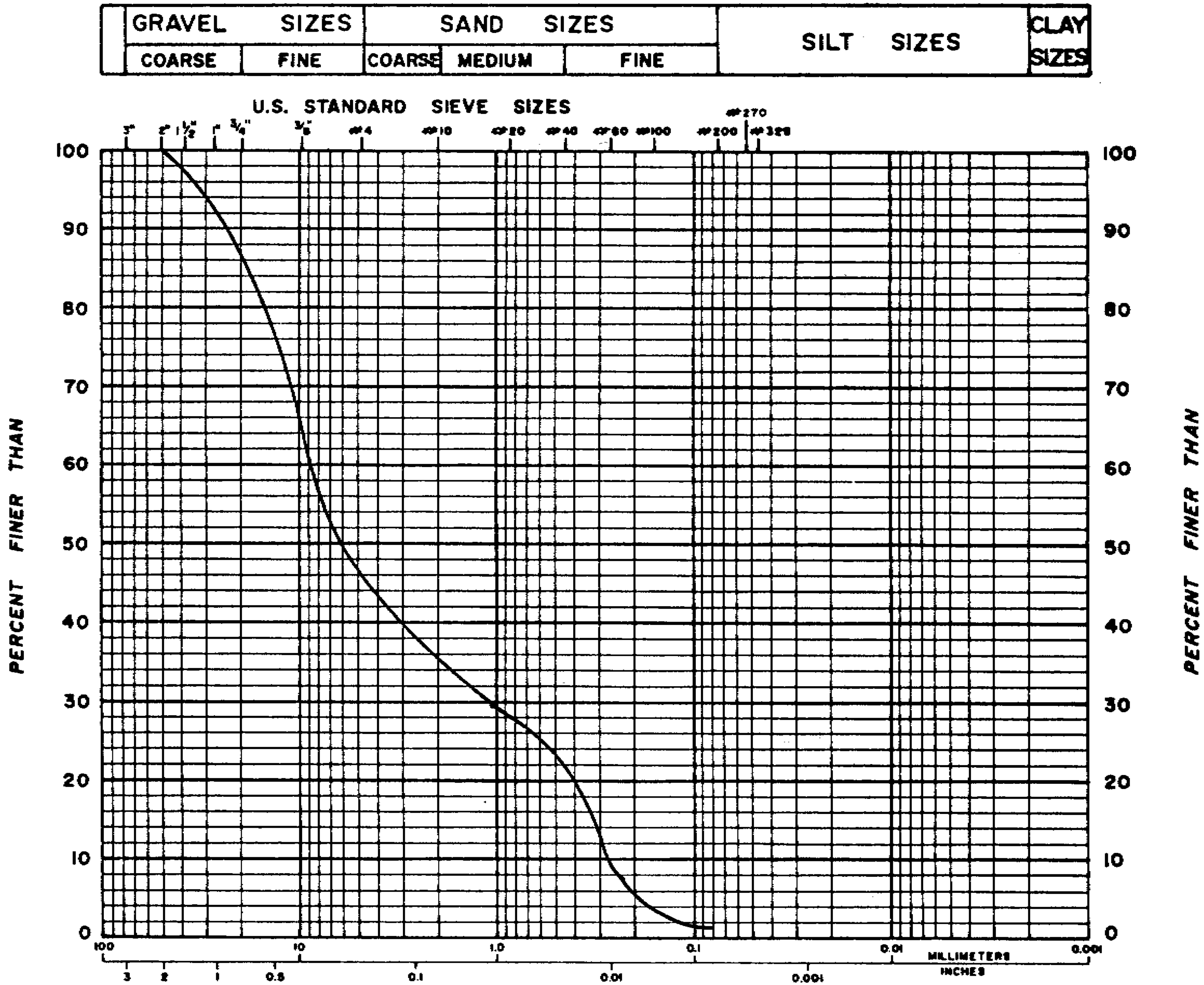
CLIENT: GOVERNMENT OF CANADA, DIAND

PROJECT: GRANULAR MATERIAL EVALUATION

LOCATION: TUKTOYAKTUK AREA, NWT

TEST HOLE NO: 168-2

DEPTH: 3.2m-3.7m



D_{10} 0.28mm

D_{30} 1.0 mm

D_{60} 9.0 mm

C_u 32.1

C_c 0.4

Geotechnical Consultants Ltd.

GRAIN SIZE DISTRIBUTION

DRAWING NO: A83-613-A17

REMARKS:

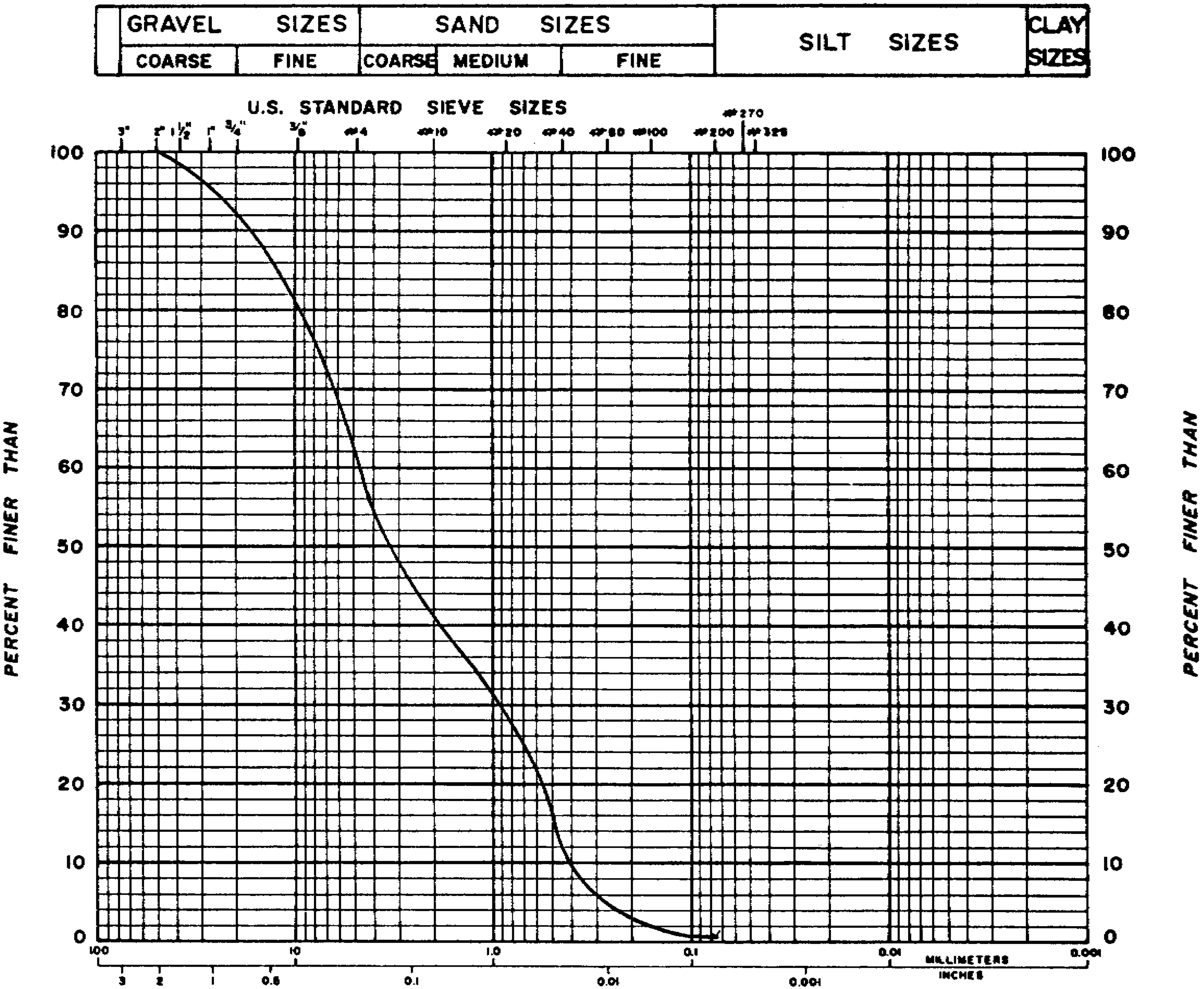
CLIENT: GOVERNMENT OF CANADA, DIAND

PROJECT: GRANULAR MATERIAL EVALUATION

LOCATION: TUKTOYAKTUK AREA, NWT

TEST HOLE NO: 168-2

DEPTH 5.5m-6.4m



D_{10} 0.42mm

D_{30} 0.90mm

D_{60} 4.7 mm

C_u 11.2

C_c 0.4

Geotechnical Consultants Ltd.

GRAIN SIZE DISTRIBUTION

DRAWING NO: A83-613-A18

REMARKS:

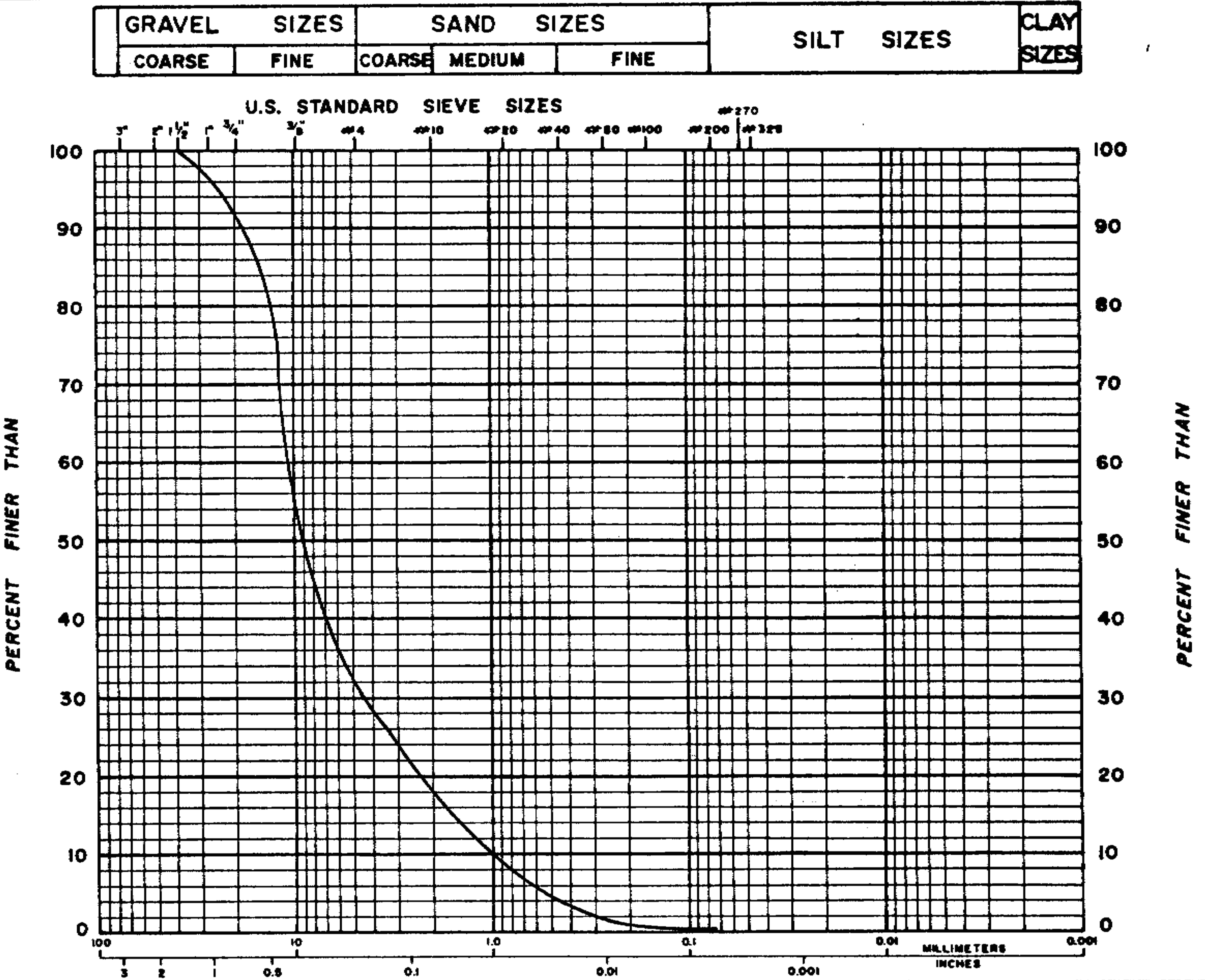
CLIENT: GOVERNMENT OF CANADA, DIAND

PROJECT: GRANULAR MATERIAL EVALUATION

LOCATION: TUKTOYAKTUK AREA, NWT

TEST HOLE NO: 168-3

DEPTH: 1.5m



D_{10}	1.0mm
D_{30}	4.5mm
D_{60}	11.0mm
C_u	11.0
C_c	1.8

Geotechnical Consultants Ltd.

GRAIN SIZE DISTRIBUTION

DRAWING NO: A83-613-A14

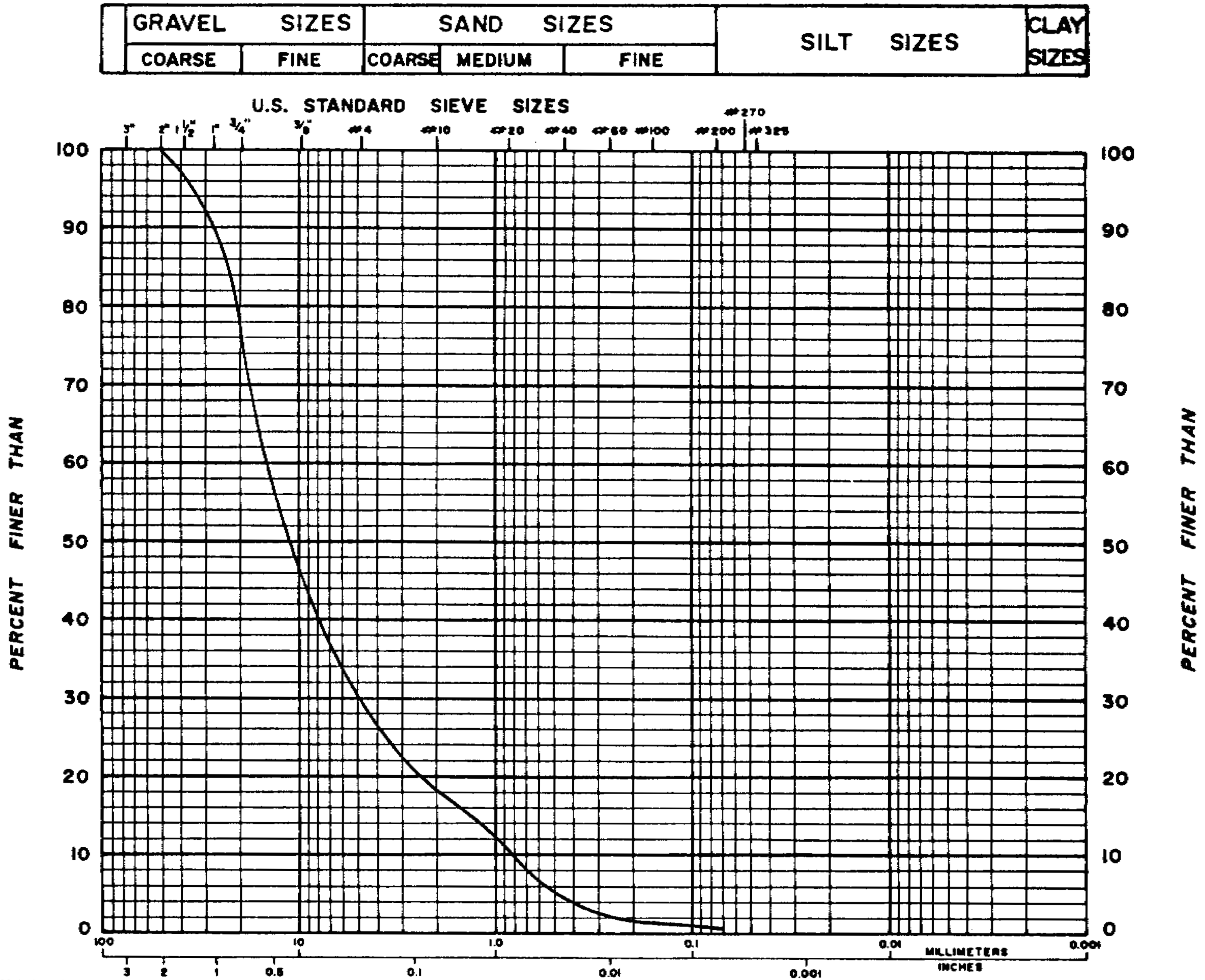
REMARKS:

CLIENT: GOVERNMENT OF CANADA, DIAND

PROJECT: GRANULAR MATERIAL EVALUATION

LOCATION: TUKTOYAKTUK AREA, NWT

TEST HOLE NO: 168-2 **DEPTH:** 0-0.9m



D_{10} 0.85mm

D_{30} 4.9 mm

D_{60} 16.0 mm

C_u 18.8

C_c 1.8

BBT Geotechnical Consultants Ltd.

GRAIN SIZE DISTRIBUTION

DRAWING NO: A83-613-A19

REMARKS:

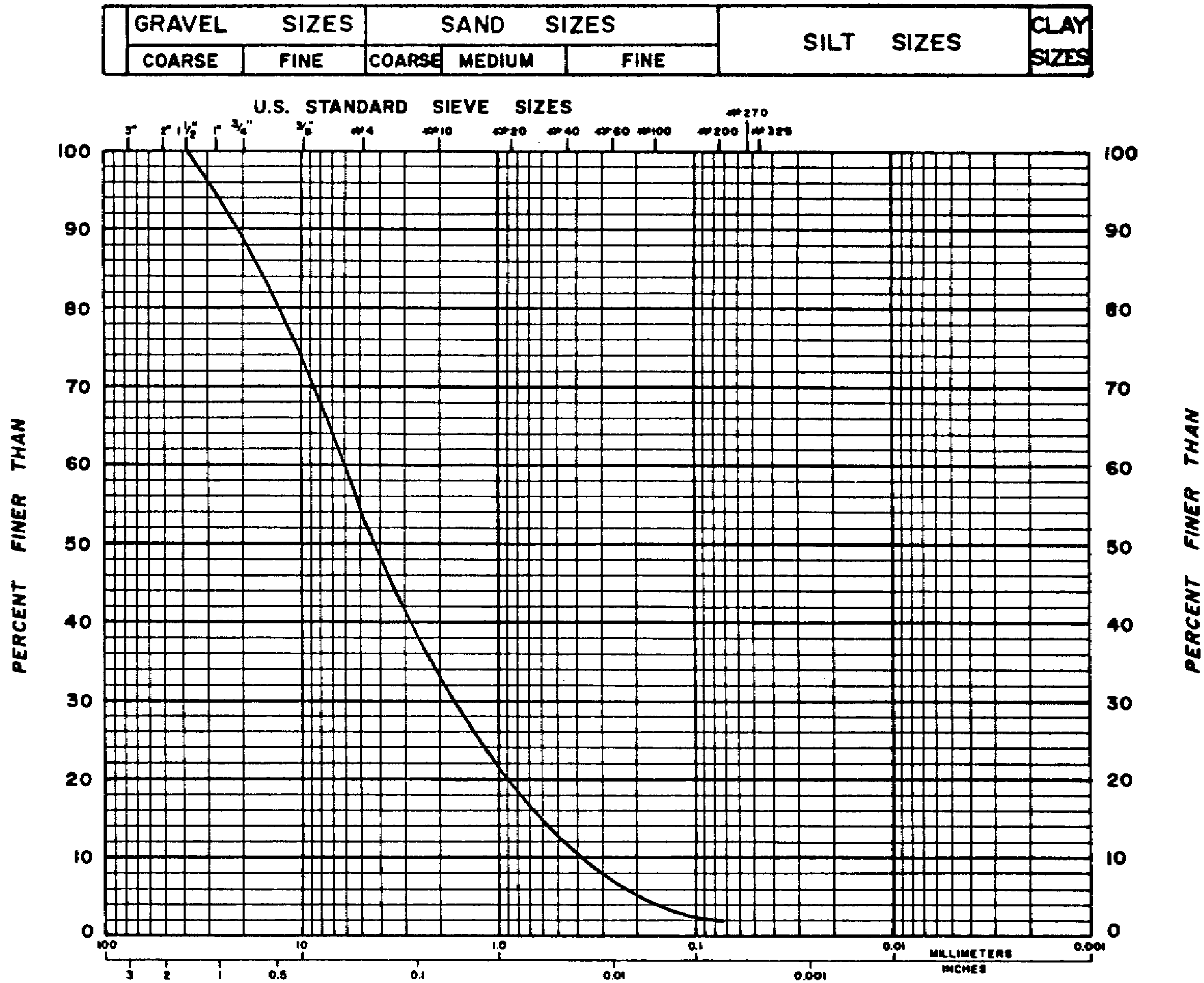
CLIENT: GOVERNMENT OF CANADA, DIAND

PROJECT: GRANULAR MATERIAL EVALUATION

LOCATION: TUKTOYAKTUK AREA, NWT

TEST HOLE NO: 168-3

DEPTH: 1.8m-2.4m



D_{10} 0.38mm

D_{30} 1.8 mm

D_{60} 6.0 mm

C_u 15.8

C_c 1.4

Geotechnical Consultants Ltd.

GRAIN SIZE DISTRIBUTION

DRAWING NO: A83-613-A20

REMARKS:

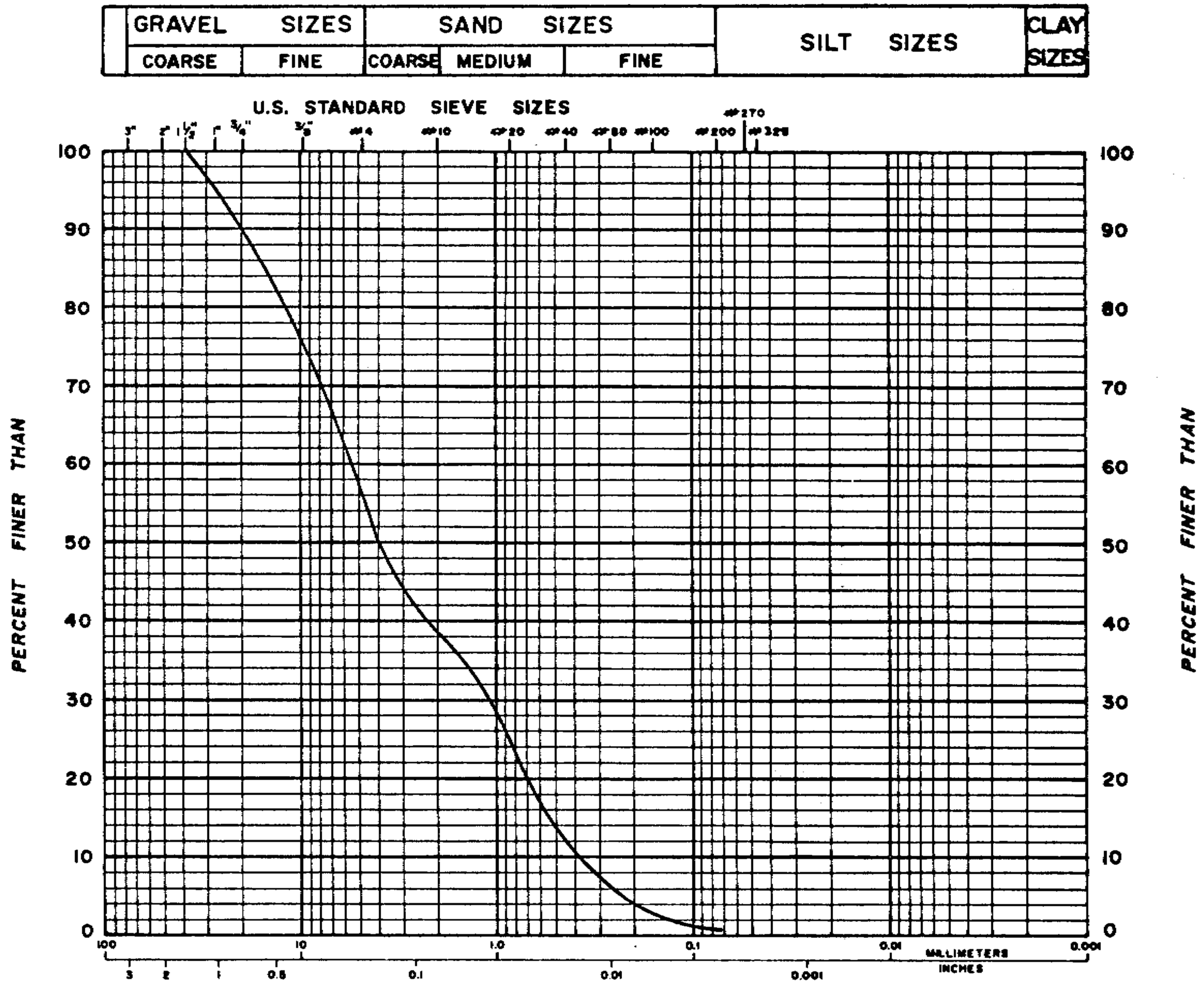
CLIENT: GOVERNMENT OF CANADA, DIAND

PROJECT: GRANULAR MATERIAL EVALUATION

LOCATION: TUKTOYAKTUK AREA, NWT

TEST HOLE NO: 168-3

DEPTH: 3.7m



D_{10} 0.38mm

D_{30} 1.2 mm

D_{60} 5.5 mm

C_u 14.5

C_c 0.7

BBT Geotechnical Consultants Ltd.

GRAIN SIZE DISTRIBUTION

DRAWING NO: A83-613-A21

REMARKS:

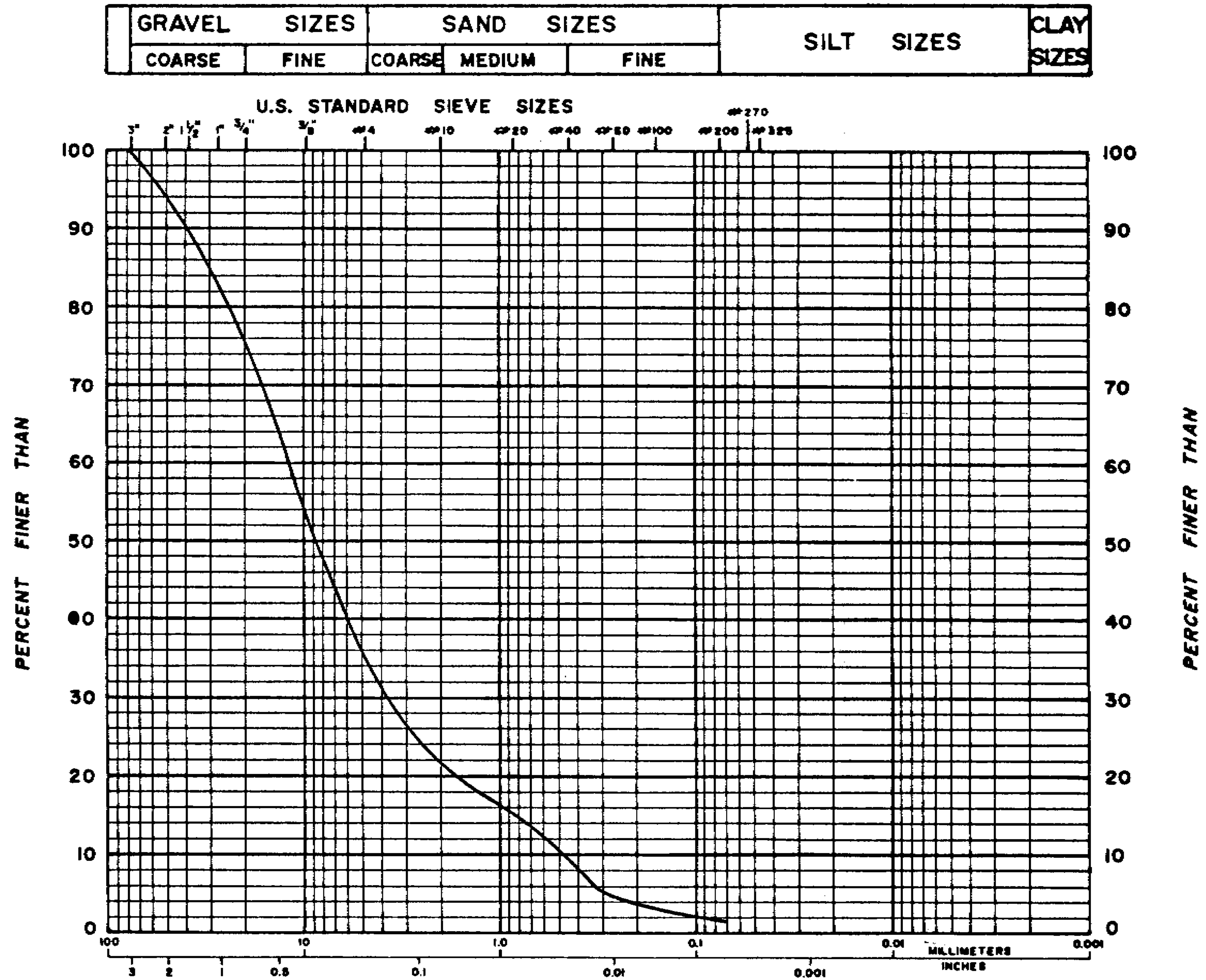
CLIENT: GOVERNMENT OF CANADA, DIAND

PROJECT: GRANULAR MATERIAL EVALUATION

LOCATION: TUKTOYAKTUK AREA, NWT

TEST HOLE NO: 168-3

DEPTH: 4.3m-5.5m



D_{10}	0.46mm
D_{30}	3.7 mm
D_{60}	13.0 mm
C_u	28.3
C_c	2.3

Geotechnical Consultants Ltd.

GRAIN SIZE DISTRIBUTION

DRAWING NO: A83-613-A22

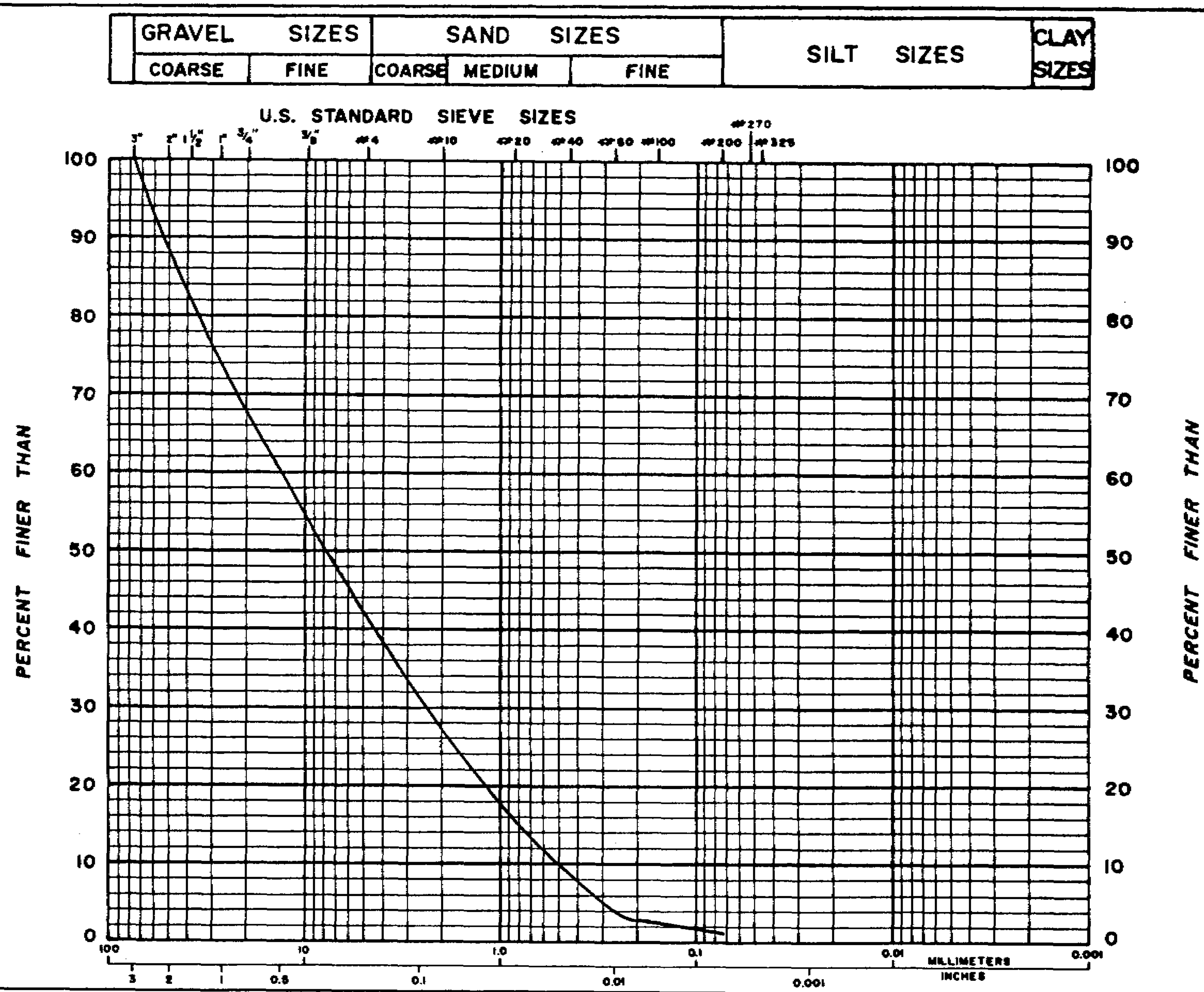
REMARKS:

CLIENT: GOVERNMENT OF CANADA, DIAND

PROJECT: GRANULAR MATERIAL EVALUATION

LOCATION: TUKTOYAKTUK AREA, NWT

TEST HOLE NO: 168-3 **DEPTH:** 7.3m



D_{10}	0.5mm
D_{30}	2.4mm
D_{60}	13.0mm
C_u	26.0
C_c	0.89

Geotechnical Consultants Ltd.

GRAIN SIZE DISTRIBUTION

DRAWING NO: A83-613-A23

REMARKS:

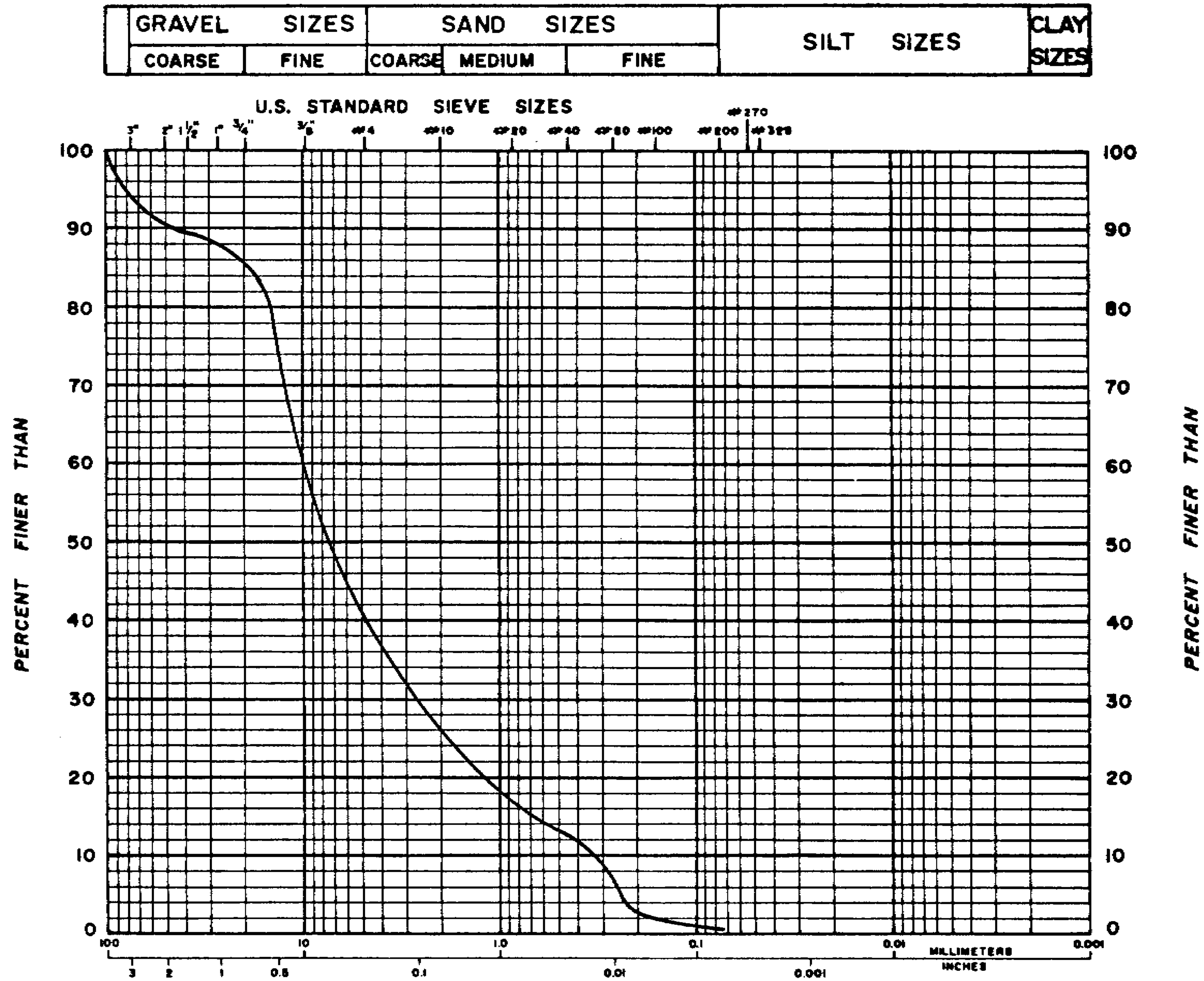
CLIENT: GOVERNMENT OF CANADA, DIAND

PROJECT: GRANULAR MATERIAL EVALUATION

LOCATION: TUKTOYAKTUK AREA, NWT

TEST HOLE NO: 168-4

DEPTH: 0.6m



D_{10} 0.32mm

D_{30} 2.7 mm

D_{60} 10.0 mm

C_u 31.3

C_c 2.3

Geotechnical Consultants Ltd.

GRAIN SIZE DISTRIBUTION

DRAWING NO: A83-613-A24

REMARKS:

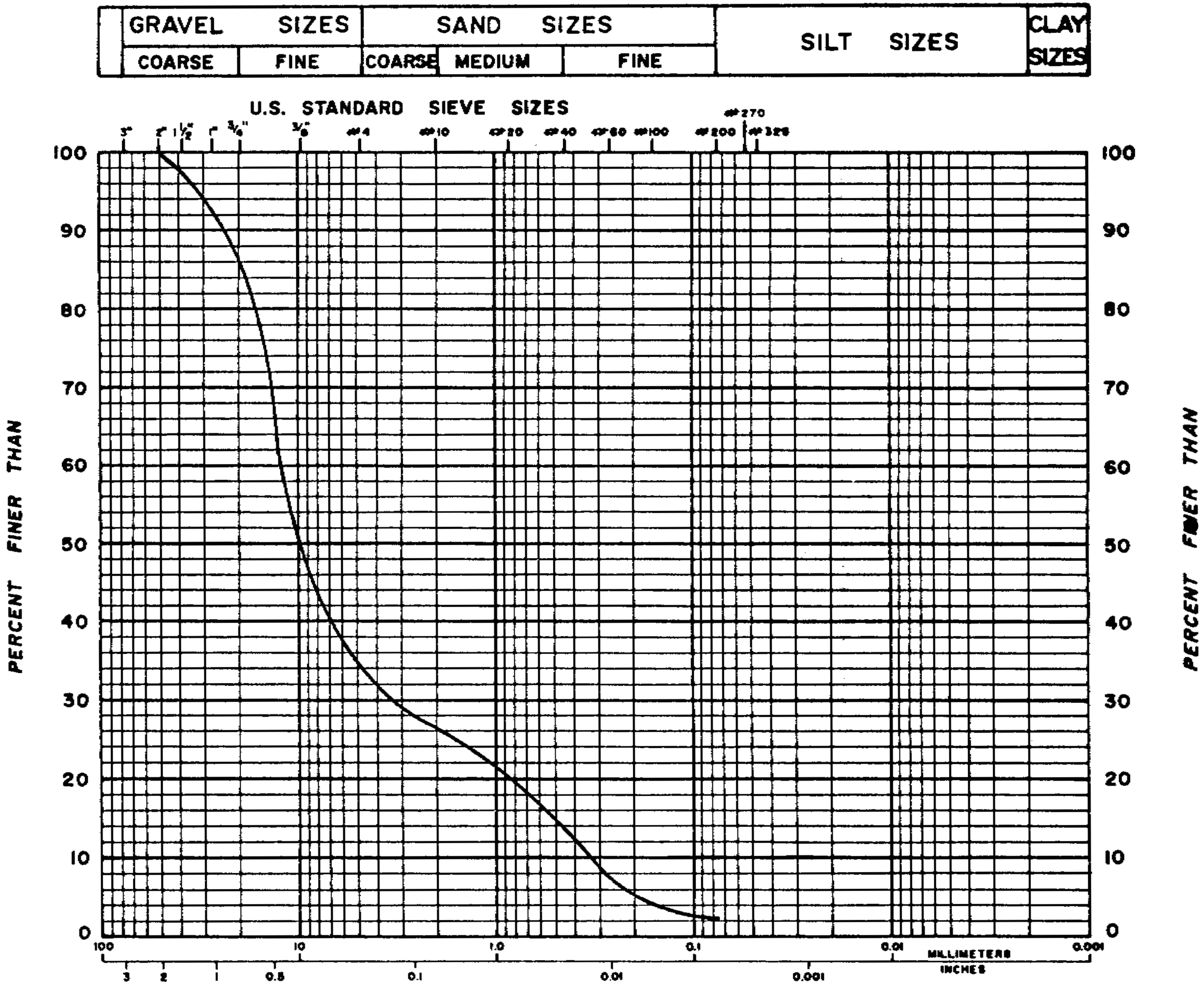
CLIENT: GOVERNMENT OF CANADA, DIAND

PROJECT: GRANULAR MATERIAL EVALUATION

LOCATION: TUKTOYAKTUK AREA, NWT

TEST HOLE NO: 168-4

DEPTH: 2.1m-2.6m



D_{10}	0.32mm
D_{30}	3.3 mm
D_{60}	12.0 mm
C_u	37.5
C_c	2.8

Geotechnical Consultants Ltd.

GRAIN SIZE DISTRIBUTION

DRAWING NO: A83-613-A25

REMARKS:

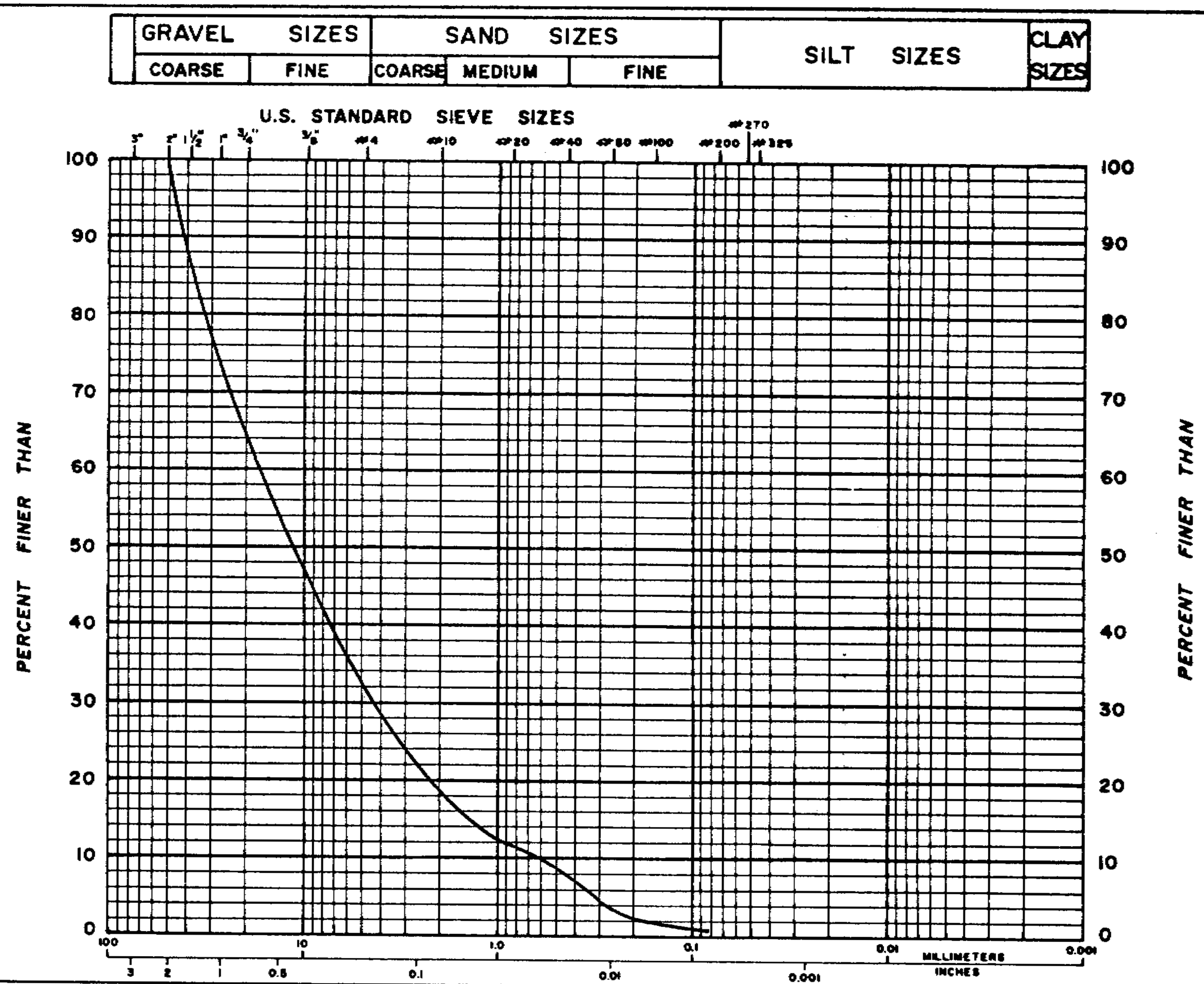
CLIENT: GOVERNMENT OF CANADA, DIAND

PROJECT: GRANULAR MATERIAL EVALUATION

LOCATION: TUKTOYAKTUK AREA, NWT

TEST HOLE NO: 168-4

DEPTH: 3.4m



D_{10}	0.6mm
D_{30}	4.3mm
D_{60}	17.0mm
C_u	28.3
C_c	1.8

Geotechnical Consultants Ltd.

GRAIN SIZE DISTRIBUTION

DRAWING NO: A83-613-A26

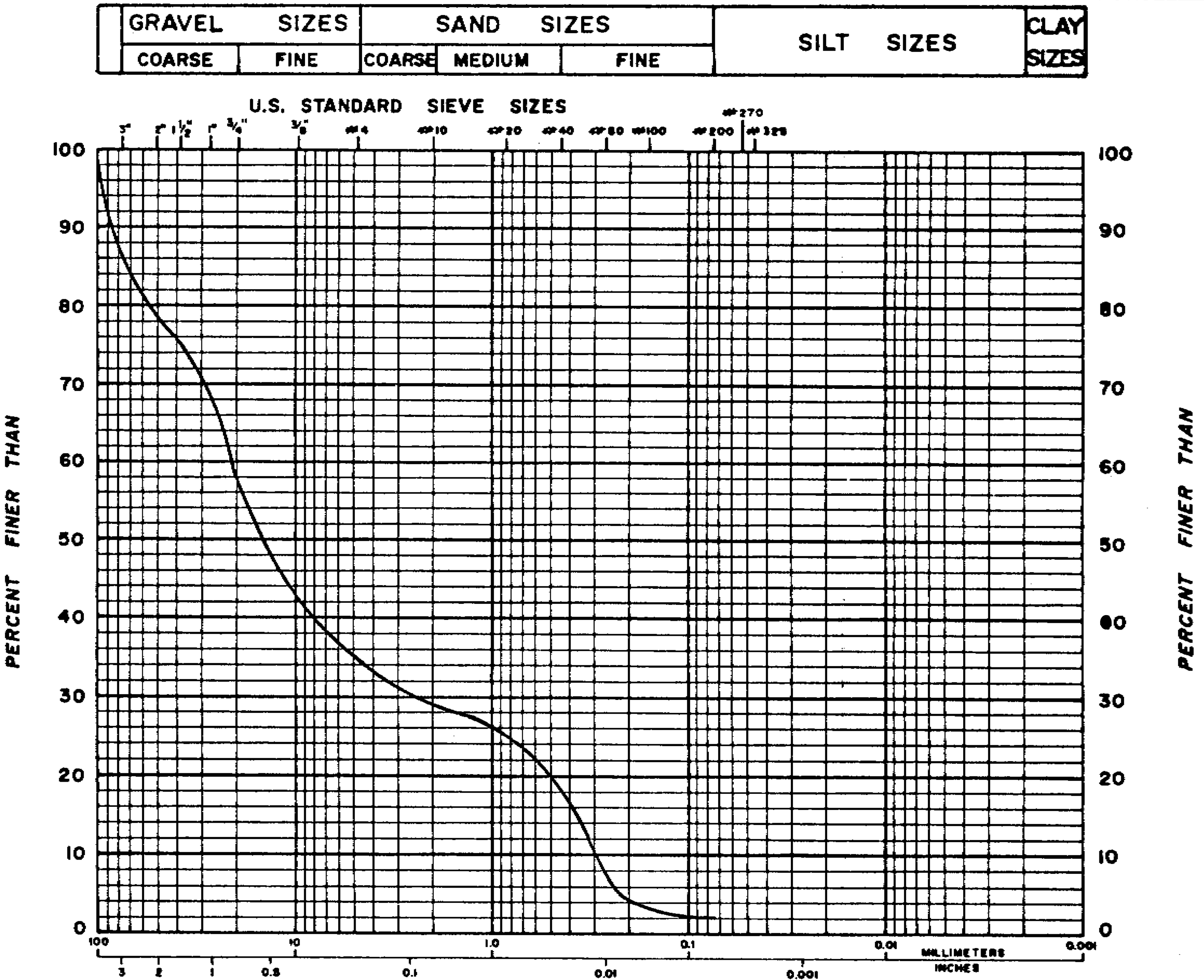
REMARKS:

CLIENT: GOVERNMENT OF CANADA, DIAND

PROJECT: GRANULAR MATERIAL EVALUATION

LOCATION: TUKTOYAKTUK AREA, NWT

TEST HOLE NO: 168-4 **DEPTH:** 5.2m



D$_{10}$ 0.3mm
D$_{30}$ 2.4mm
D$_{60}$ 21.0mm
C$_{u}$ 70.0
C$_{c}$ 0.9

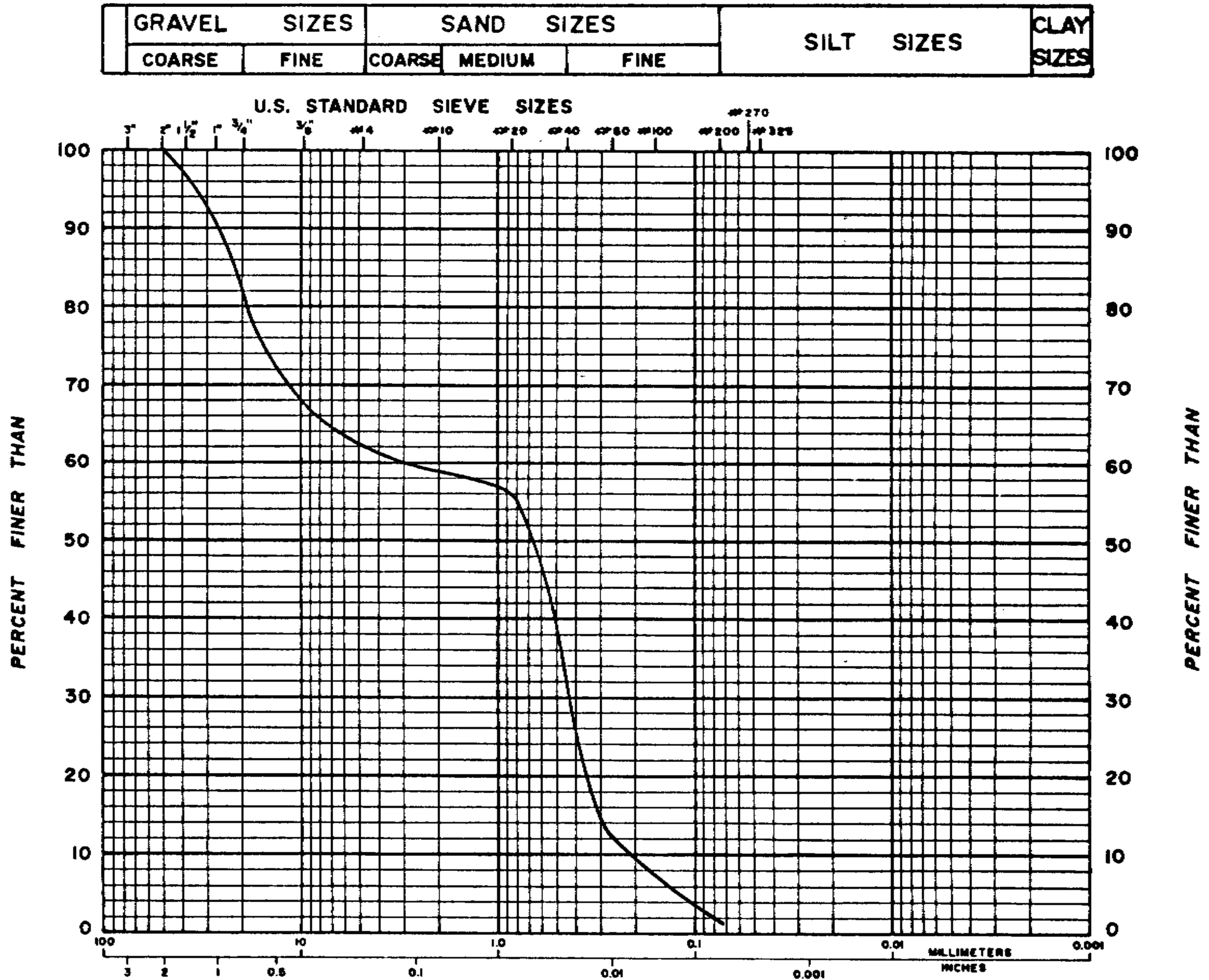
GBT Geotechnical Consultants Ltd.

GRAIN SIZE DISTRIBUTION

DRAWING NO:	A83-613-A27

REMARKS:

CLIENT:	GOVERNMENT OF CANADA, DIAND
PROJECT:	GRANULAR MATERIAL EVALUATION
LOCATION:	TUKTOYAKTUK AREA, NWT
TEST HOLE NO:	168-4
DEPTH:	7.5m-7.8m



D_{10} 0.2 mm

D_{30} 0.43mm

D_{60} 3.0 mm

C_u 15.0

C_c 0.3

Geotechnical Consultants Ltd.

GRAIN SIZE DISTRIBUTION

DRAWING NO: A83-613-A28

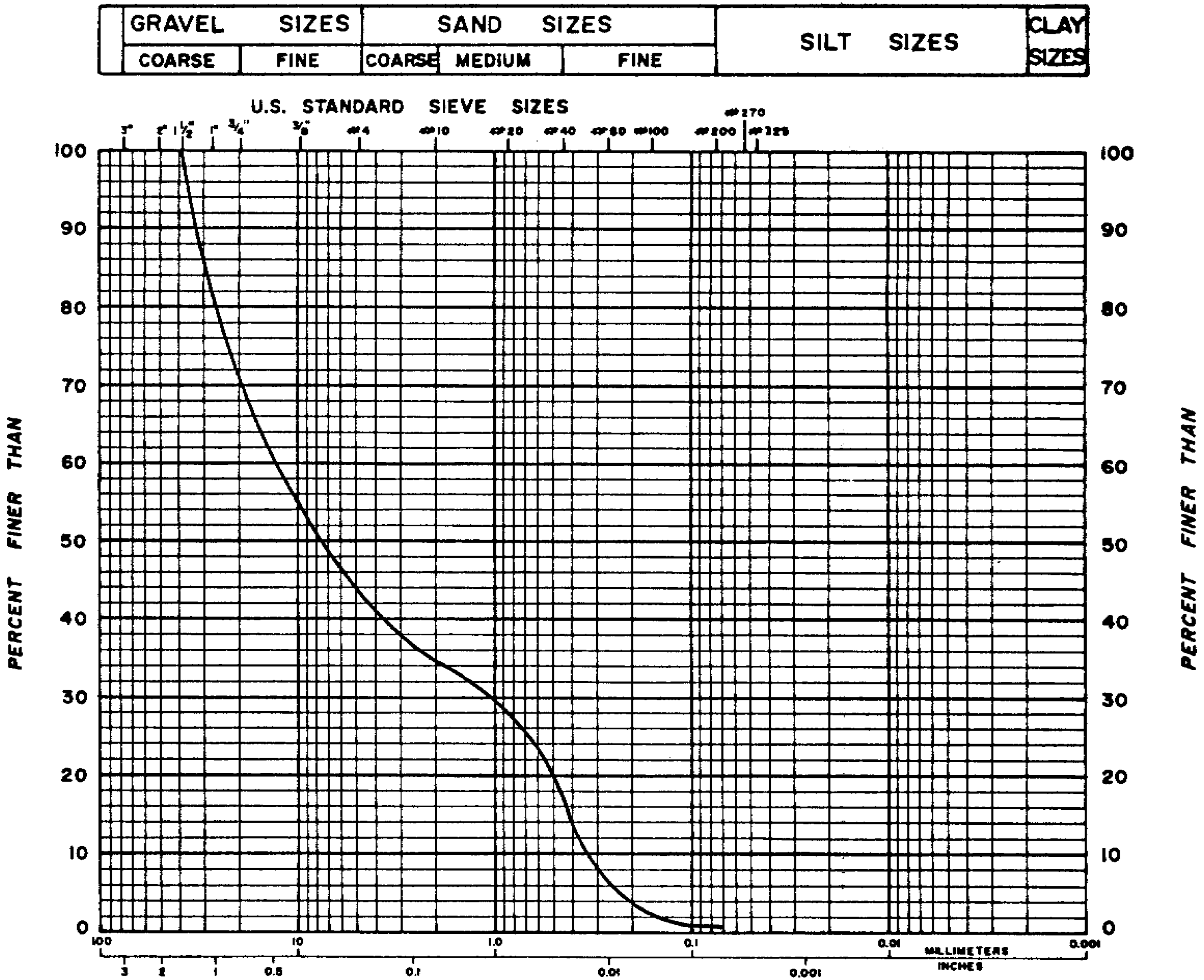
REMARKS:

CLIENT: GOVERNMENT OF CANADA, DIAND

PROJECT: GRANULAR MATERIAL EVALUATION

LOCATION: TUKTOYAKTUK AREA, NWT

TEST HOLE NO: 168-4 **DEPTH** 8.2m-8.5m



D_{10} 0.34mm

D_{30} 1.0 mm

D_{60} 12.0 mm

C_u 35.3

C_c 0.2

Geotechnical Consultants Ltd.

GRAIN SIZE DISTRIBUTION

DRAWING NO: A83-613-A29

REMARKS:

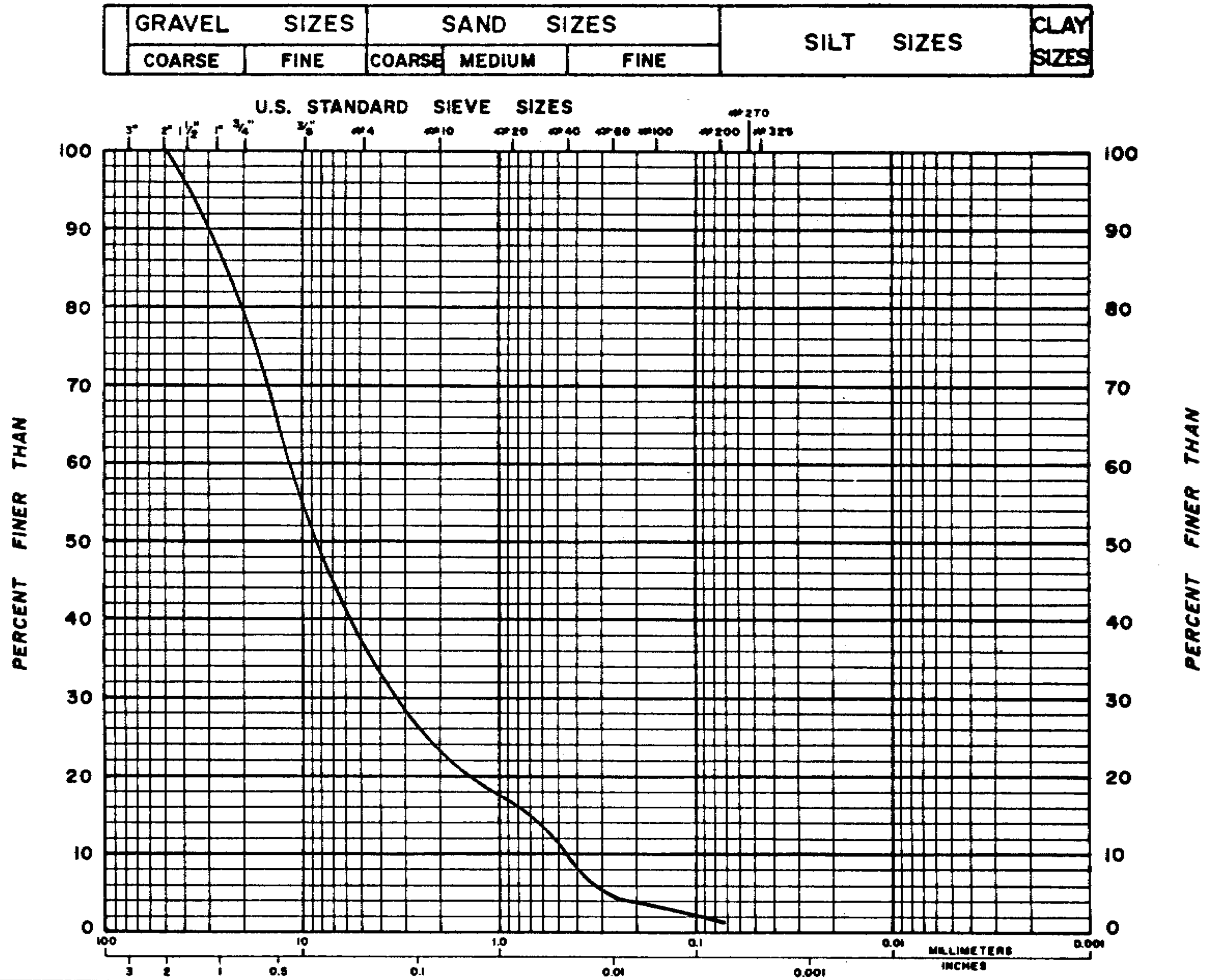
CLIENT: GOVERNMENT OF CANADA, DIAND

PROJECT: GRANULAR MATERIAL EVALUATION

LOCATION: TUKTOYAKTUK AREA, NWT

TEST HOLE NO: 168-5

DEPTH: 1.5m



D_{10}	0.45mm
D_{30}	3.2 mm
D_{60}	11.0 mm
C_u	24.4
C_c	2.1

Geotechnical Consultants Ltd.

GRAIN SIZE DISTRIBUTION

DRAWING NO: A83-613-A30

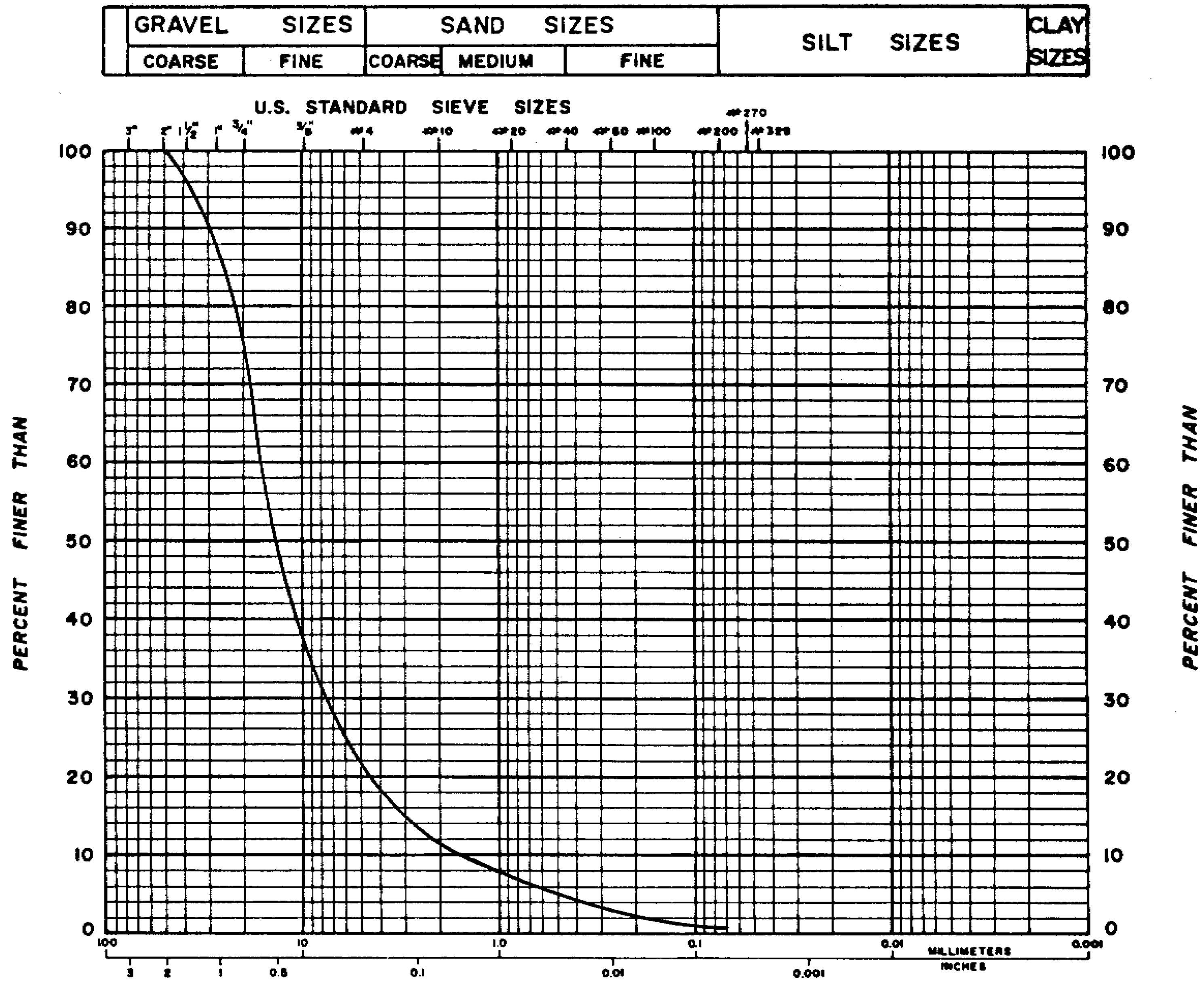
REMARKS:

CLIENT: GOVERNMENT OF CANADA, DIAND

PROJECT: GRANULAR MATERIAL EVALUATION

LOCATION: TUKTOYAKTUK AREA, NWT

TEST HOLE NO: 168-5 **DEPTH:** 2.4m



D_{10}	1.6mm
D_{30}	7.5mm
D_{60}	16.0mm
C_u	10.0
C_c	2.2

Geotechnical Consultants Ltd.

GRAIN SIZE DISTRIBUTION

DRAWING NO: A83-613-A31

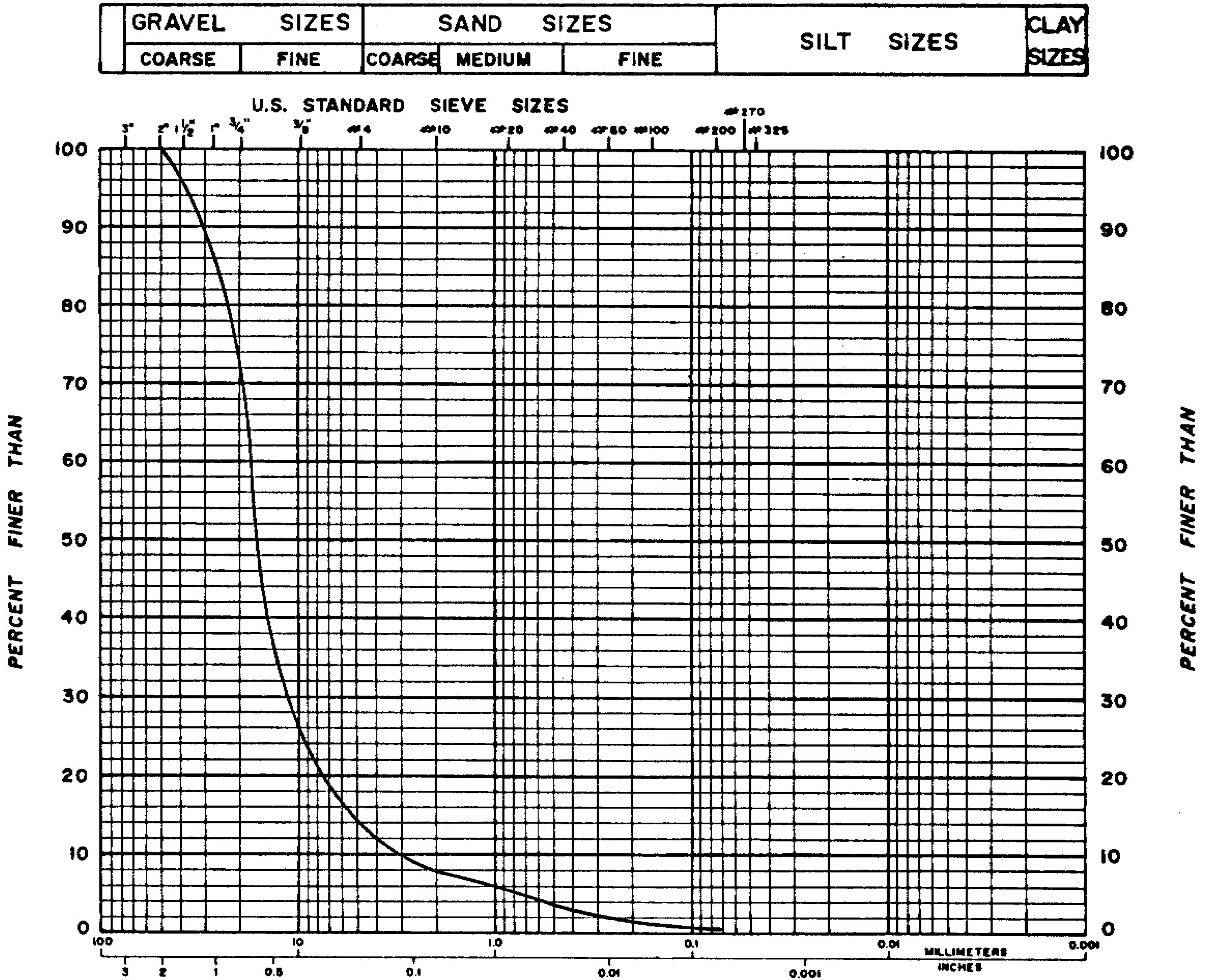
REMARKS:

CLIENT: GOVERNMENT OF CANADA, DIAND

PROJECT: GRANULAR MATERIAL EVALUATION

LOCATION: TUKTOYAKTUK AREA, NWT

TEST HOLE NO: 168-5 **DEPTH:** 4.3m-4.6m



D_{10} 3.0mm

D_{30} 11.0mm

D_{60} 17.0

C_u 5.7

C_c 2.4

Geotechnical Consultants Ltd.

GRAIN SIZE DISTRIBUTION

DRAWING NO: A83-613-A32

REMARKS:

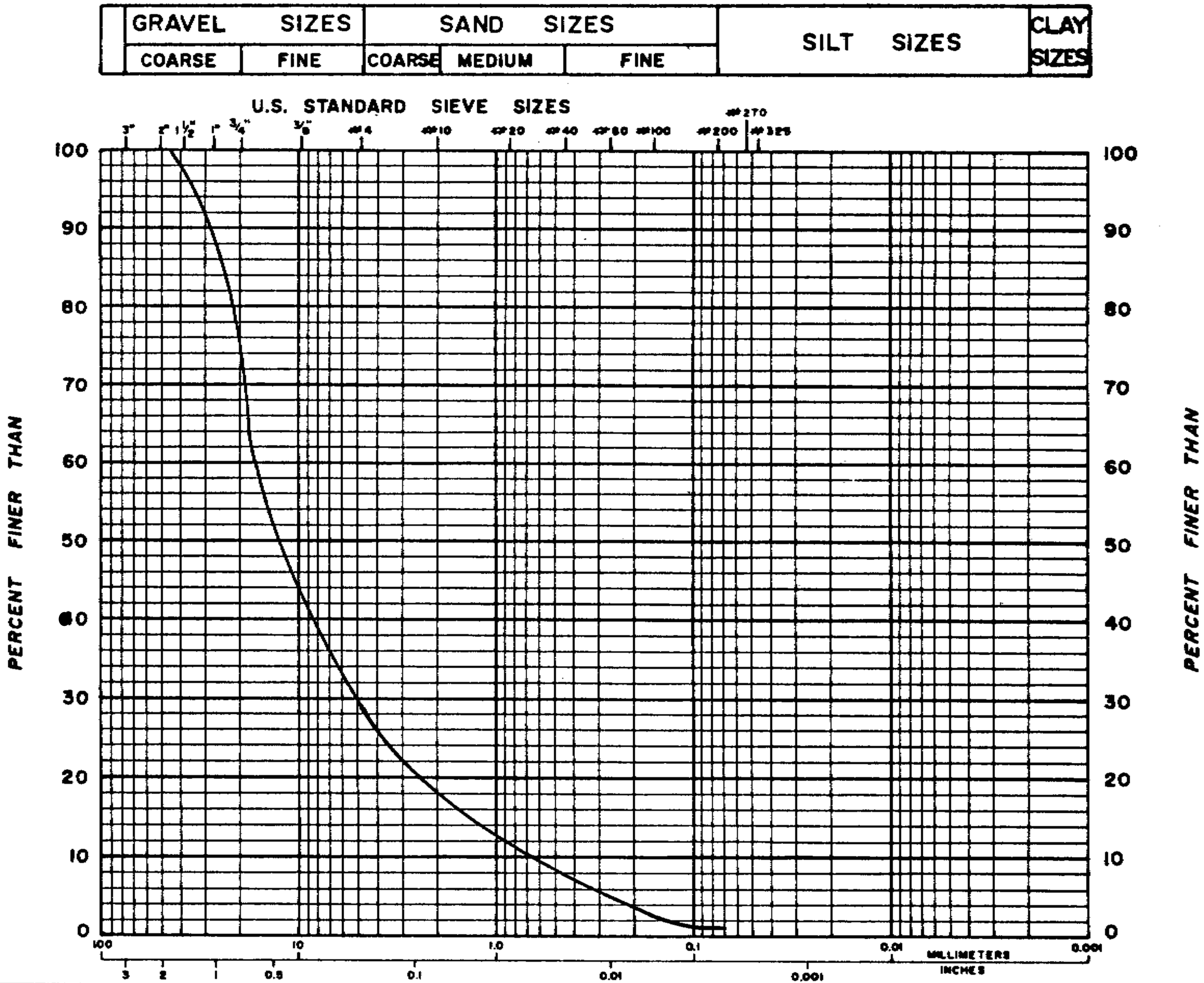
CLIENT: GOVERNMENT OF CANADA, DIAND

PROJECT: GRANULAR MATERIAL EVALUATION

LOCATION: TUKTOYAKTUK AREA, NWT

TEST HOLE NO: 168-5

DEPTH: 5.5m



D_{10} 0.65mm
D_{30} 5.0 mm
D_{60} 17.0 mm
C_u 26.2
C_c 2.3

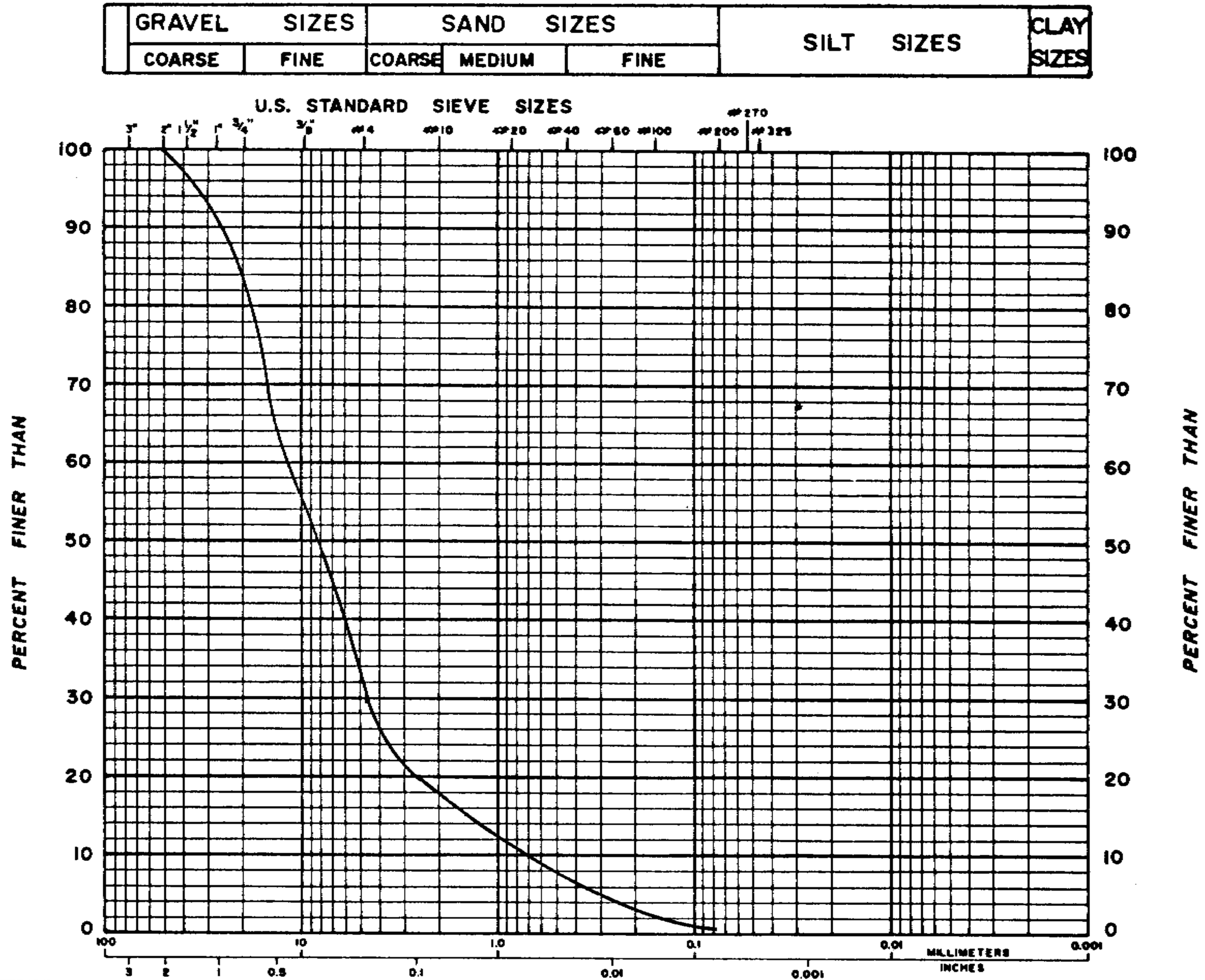
Geotechnical Consultants Ltd.

GRAIN SIZE DISTRIBUTION

DRAWING NO: A83-613-A33

REMARKS:

CLIENT: GOVERNMENT OF CANADA, DIAND
PROJECT: GRANULAR MATERIAL EVALUATION
LOCATION: TUKTOYAKTUK AREA, NWT
TEST HOLE NO: 168-5 **DEPTH:** 6.4m



D_{10} 0.7mm

D_{30} 4.5mm

D_{60} 12.0mm

C_u 17.0

C_c 2.4

EBA Geotechnical Consultants Ltd.

GRAIN SIZE DISTRIBUTION

DRAWING NO: A83-613-A34

REMARKS:

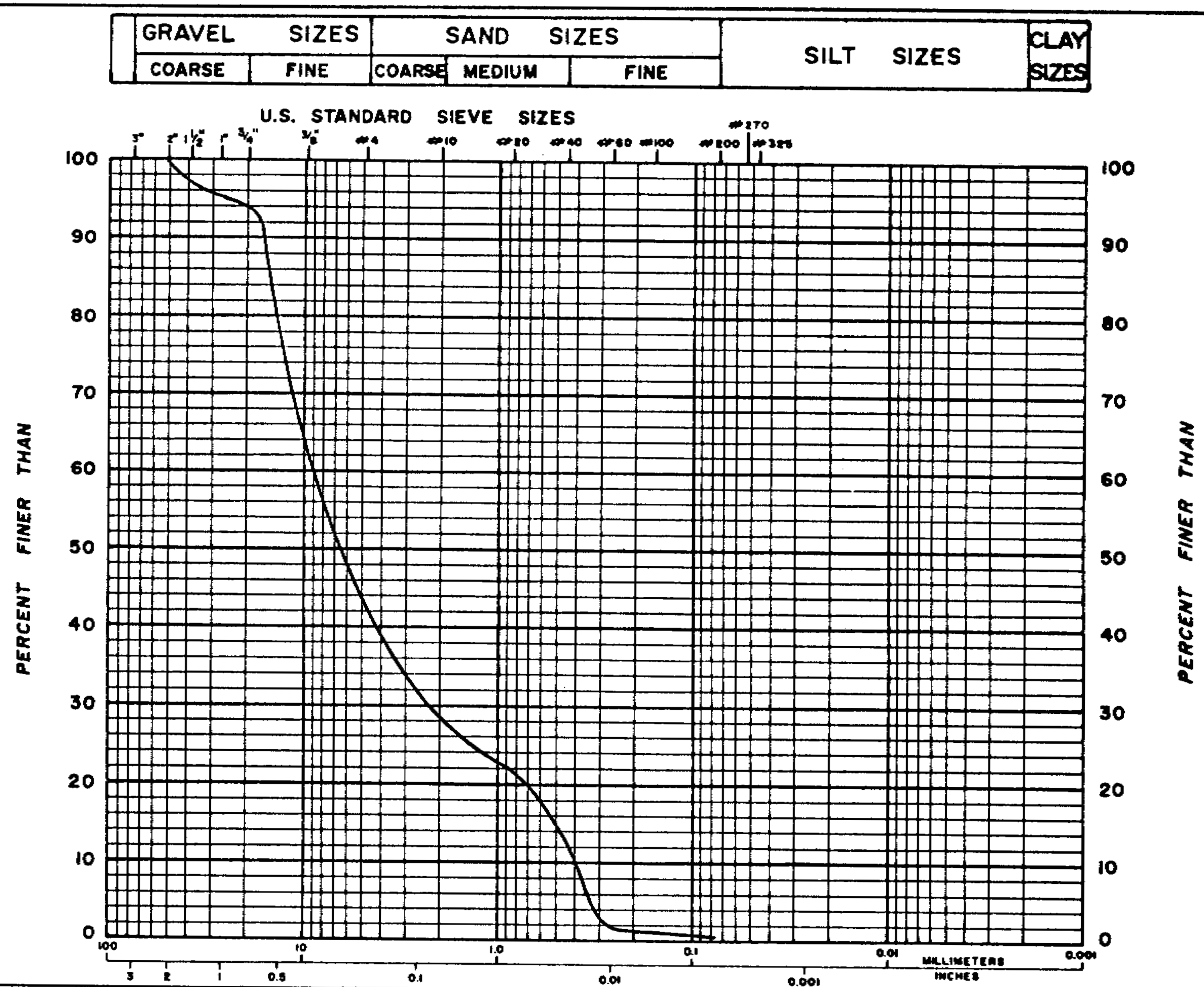
CLIENT: GOVERNMENT OF CANADA, DIAND

PROJECT: GRANULAR MATERIAL EVALUATION

LOCATION: TUKTOYAKTUK AREA, NWT

TEST HOLE NO: 168-5

DEPTH: 8.2m-8.5m



D_{10} 0.45mm

D_{30} 2.2 mm

D_{60} 9.0 mm

C_u 20.0

C_c 1.2

Geotechnical Consultants Ltd.

GRAIN SIZE DISTRIBUTION

DRAWING NO: A83-613-A35

REMARKS:

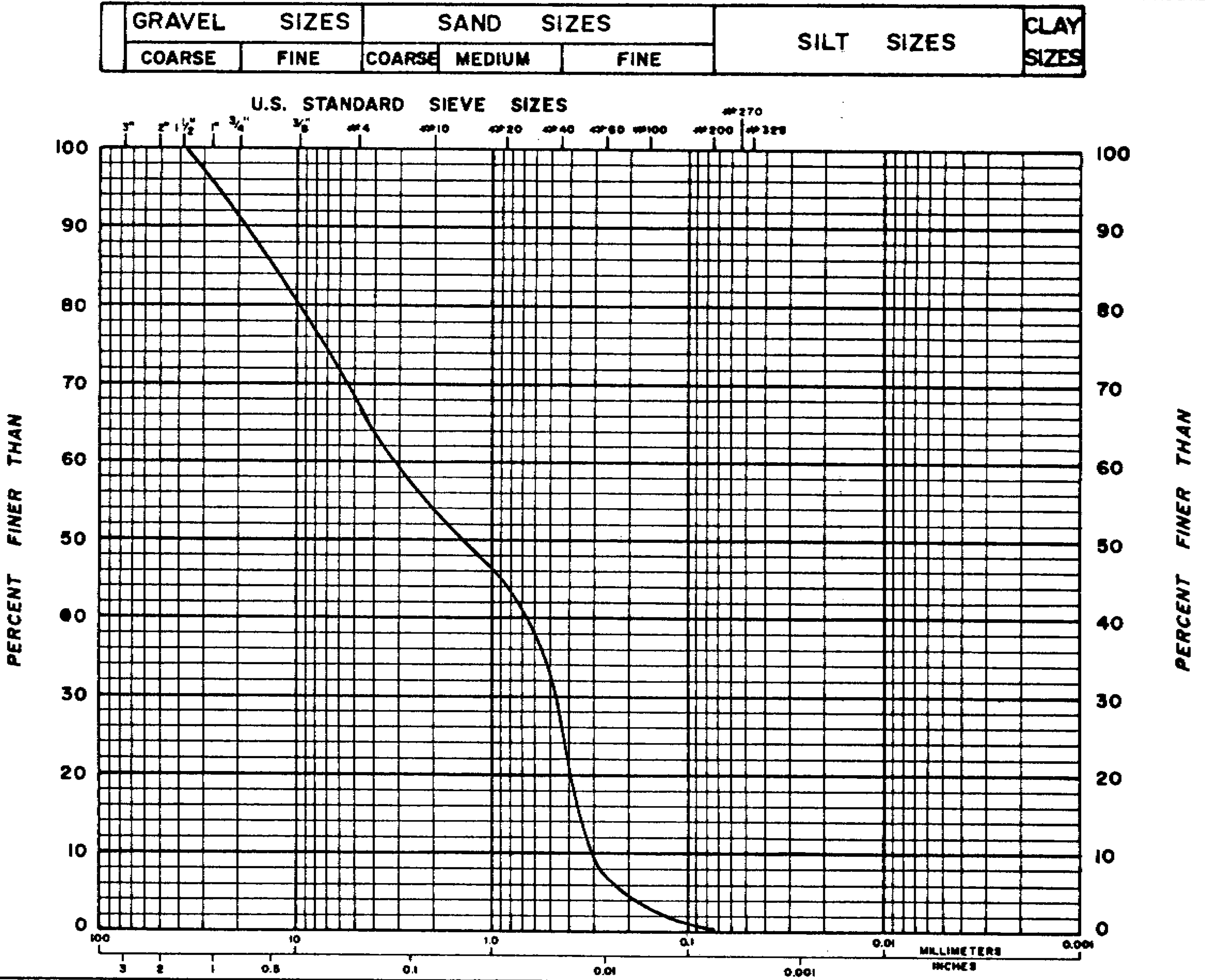
CLIENT: GOVERNMENT OF CANADA, DIAND

PROJECT: GRANULAR MATERIAL EVALUATION

LOCATION: TUKTOYAKTUK AREA, NWT

TEST HOLE NO: 168-6

DEPTH: 1.5m-1.8m



D_{10} 0.3 mm

D_{30} 0.48mm

D_{60} 3.1 mm

C_u 10.3

C_c 0.2

Geotechnical Consultants Ltd.

GRAIN SIZE DISTRIBUTION

DRAWING NO: A83-613-A36

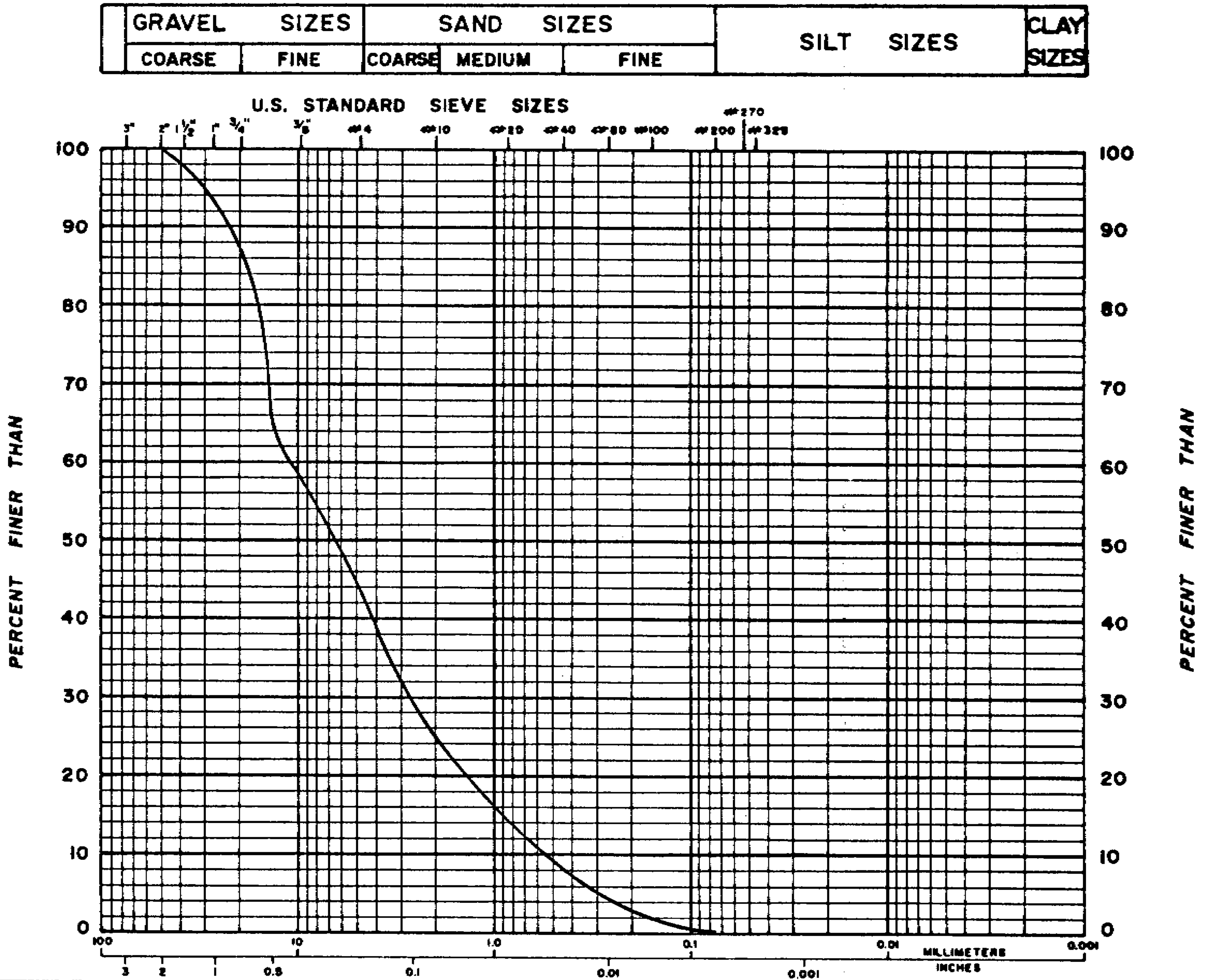
REMARKS:

CLIENT: GOVERNMENT OF CANADA, DIAND

PROJECT: GRANULAR MATERIAL EVALUATION

LOCATION: TUKTOYAKTUK AREA, NWT

TEST HOLE NO: 168-6 **DEPTH:** 2.1m



D_{10} 0.55mm

D_{30} 2.7 mm

D_{60} 11.0 mm

C_u 20.0

C_c 1.2

Geotechnical Consultants Ltd.

GRAIN SIZE DISTRIBUTION

DRAWING NO: A83-613-A37

REMARKS:

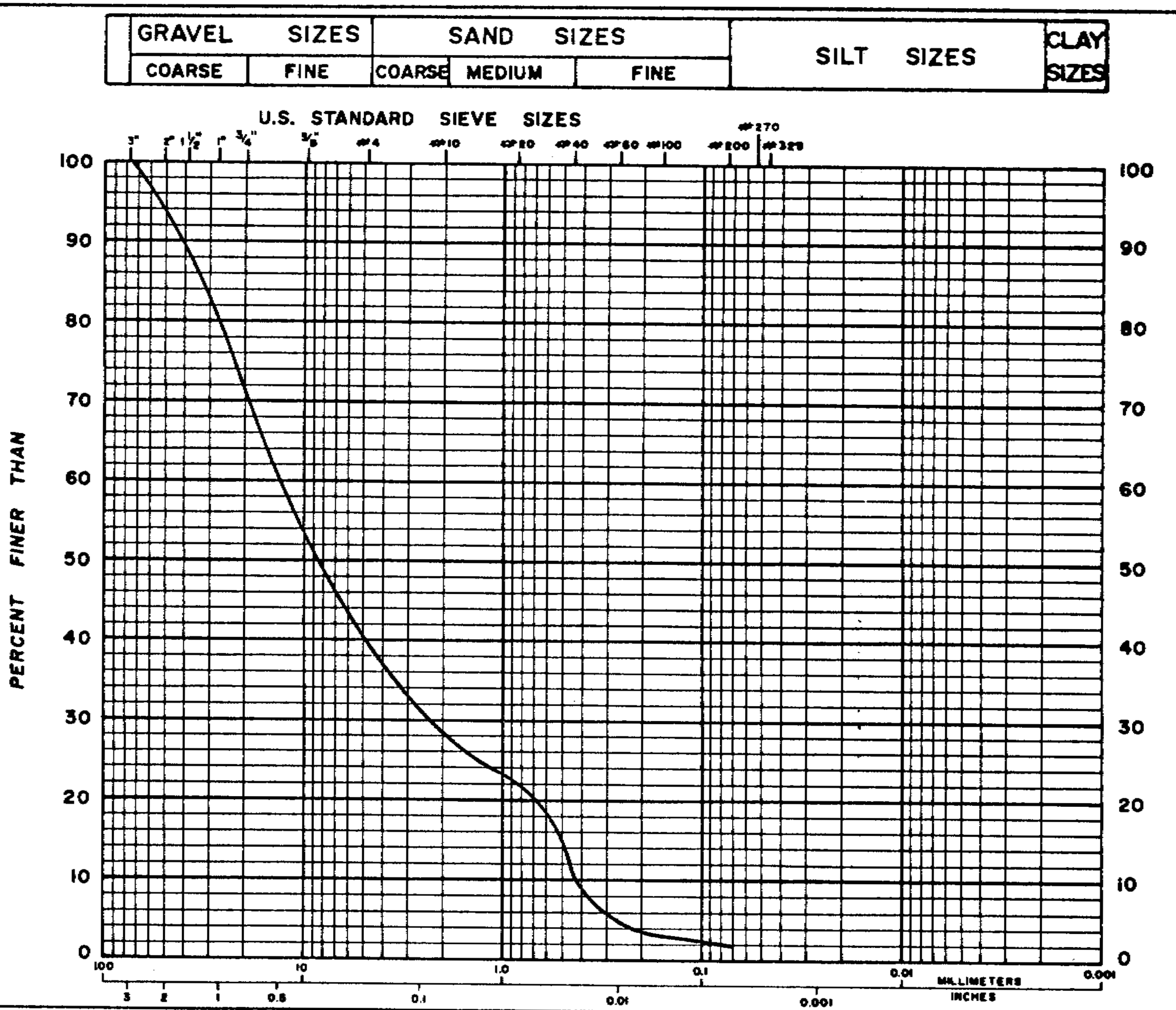
CLIENT: GOVERNMENT OF CANADA, DIAND

PROJECT: GRANULAR MATERIAL EVALUATION

LOCATION: TUKTOYAKTUK AREA, NWT

TEST HOLE NO: 168-6

DEPTH: 4.3m



D_{10} 0.4mm

D_{30} 2.2mm

D_{60} 12.0mm

C_u 30.0

C_c 1.0

Geotechnical Consultants Ltd.

GRAIN SIZE DISTRIBUTION

DRAWING NO: A83-613-A38

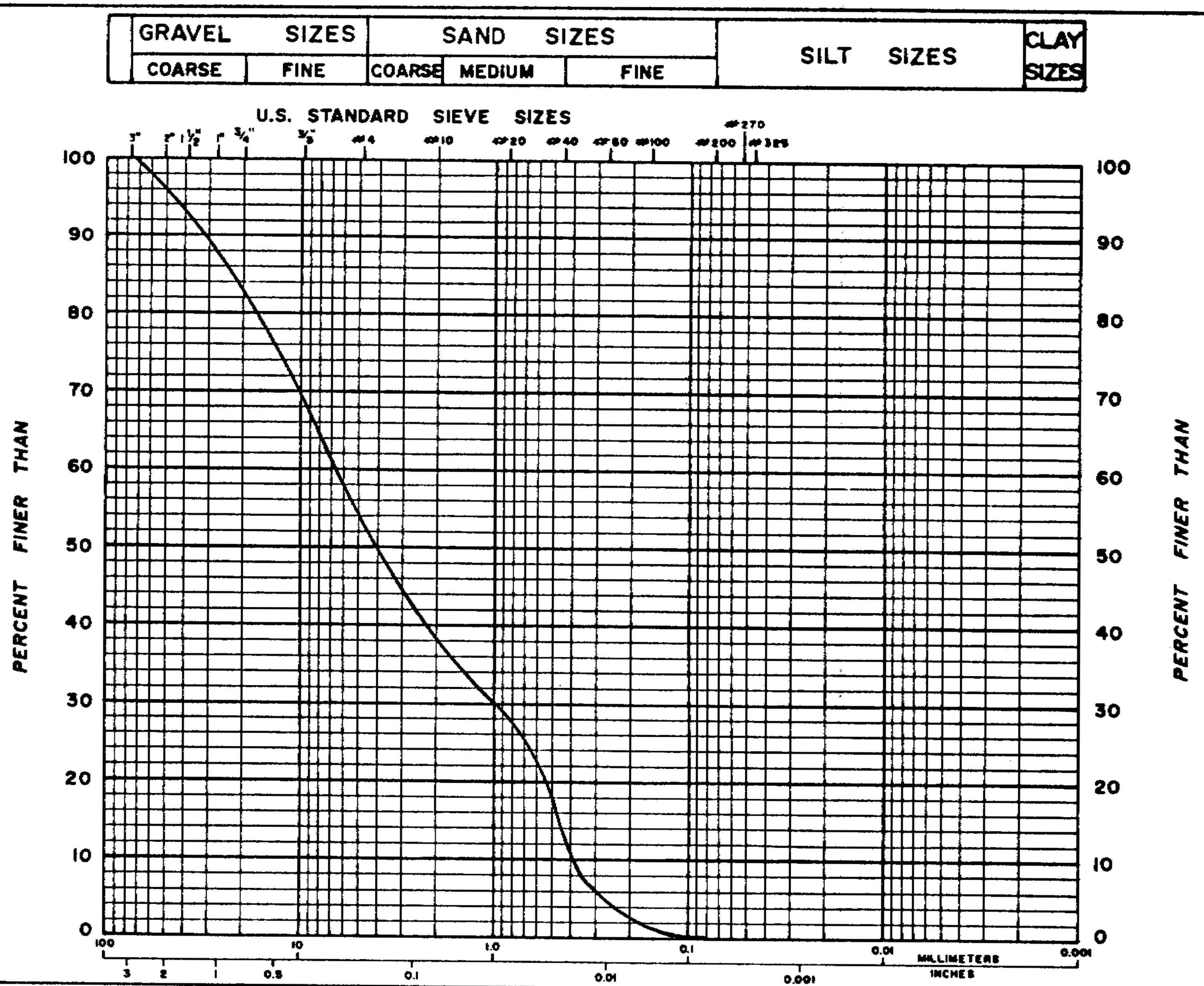
REMARKS:

CLIENT: GOVERNMENT OF CANADA, DIAND

PROJECT: GRANULAR MATERIAL EVALUATION

LOCATION: TUKTOYAKTUK AREA, NWT

TEST HOLE NO: 168-7 **DEPTH:** 0.6m



D_{10}	0.4mm
D_{30}	1.0mm
D_{60}	6.8mm
C_u	17.0
C_c	0.4

Geotechnical Consultants Ltd.

GRAIN SIZE DISTRIBUTION

DRAWING NO: A83-613-A39

REMARKS:

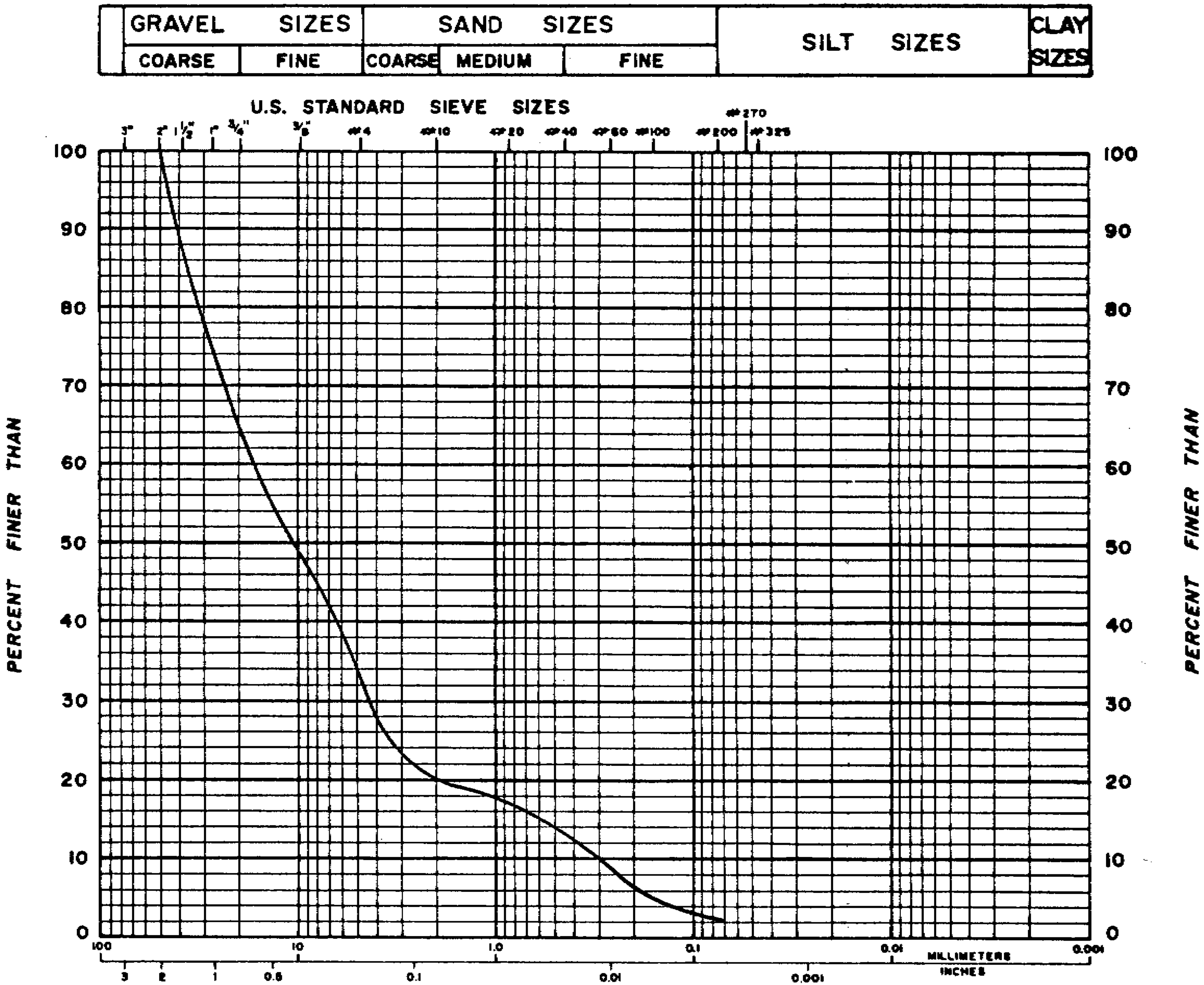
CLIENT: GOVERNMENT OF CANADA, DIAND

PROJECT: GRANULAR MATERIAL EVALUATION

LOCATION: TUKTOYAKTUK AREA, NWT

TEST HOLE NO: 168-7

DEPTH:0.9m-1.5m



D_{10} 0.3mm

D_{30} 4.3mm

D_{60} 16.0mm

C_u 53.3

C_c 3.9

Geotechnical Consultants Ltd.

GRAIN SIZE DISTRIBUTION

DRAWING NO: A83-613-A40

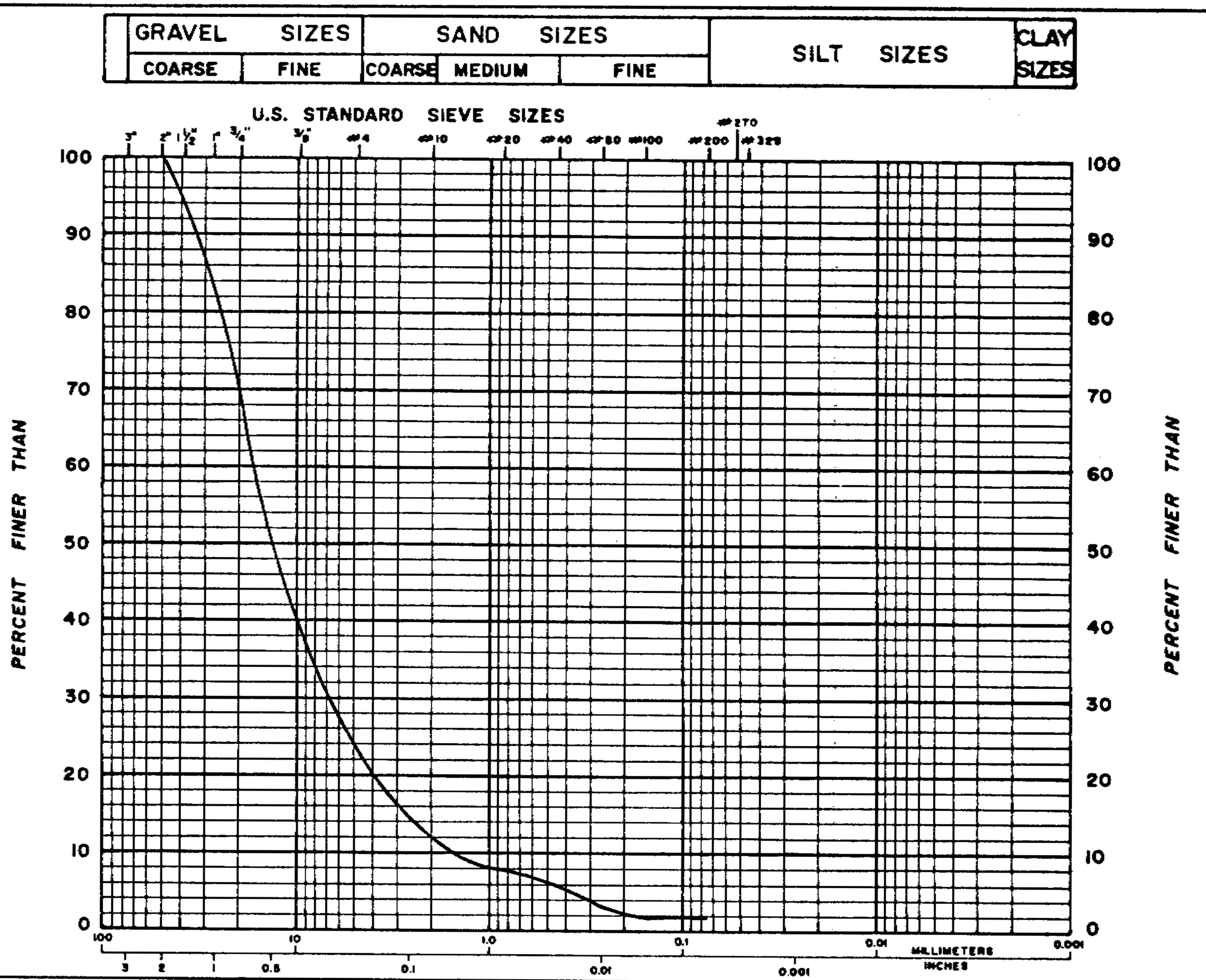
REMARKS:

CLIENT: GOVERNMENT OF CANADA, DIAND

PROJECT: GRANULAR MATERIAL EVALUATION

LOCATION: TUKTOYAKTUK AREA, NWT

TEST HOLE NO: 168-7 **DEPTH:** 3.0m-3.3m



D_{10}	1.5mm
D_{30}	7.0mm
D_{60}	17.0mm
C_u	11.3
C_c	1.9

Geotechnical Consultants Ltd.

GRAIN SIZE DISTRIBUTION

DRAWING NO: A83-613-A41

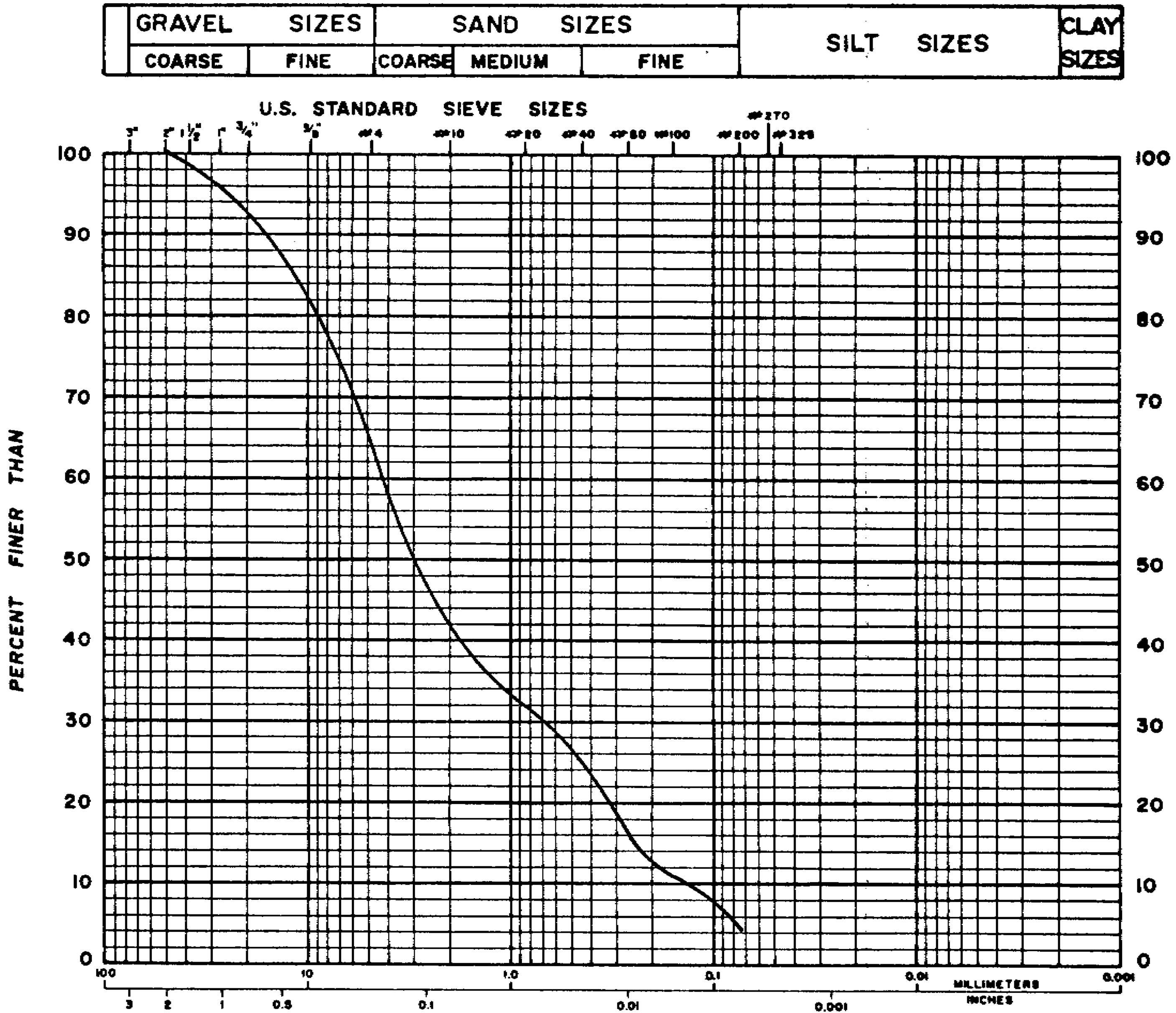
REMARKS:

CLIENT: GOVERNMENT OF CANADA, DIAND

PROJECT: GRANULAR MATERIAL EVALUATION

LOCATION: TUKTOYAKTUK AREA, NWT

TEST HOLE NO: 168-7 **DEPTH:** 4.0m-4.3m



D_{10} 0.14mm
D_{30} 0.7 mm
D_{60} 4.2 mm
C_u 30.0
C_c 0.8

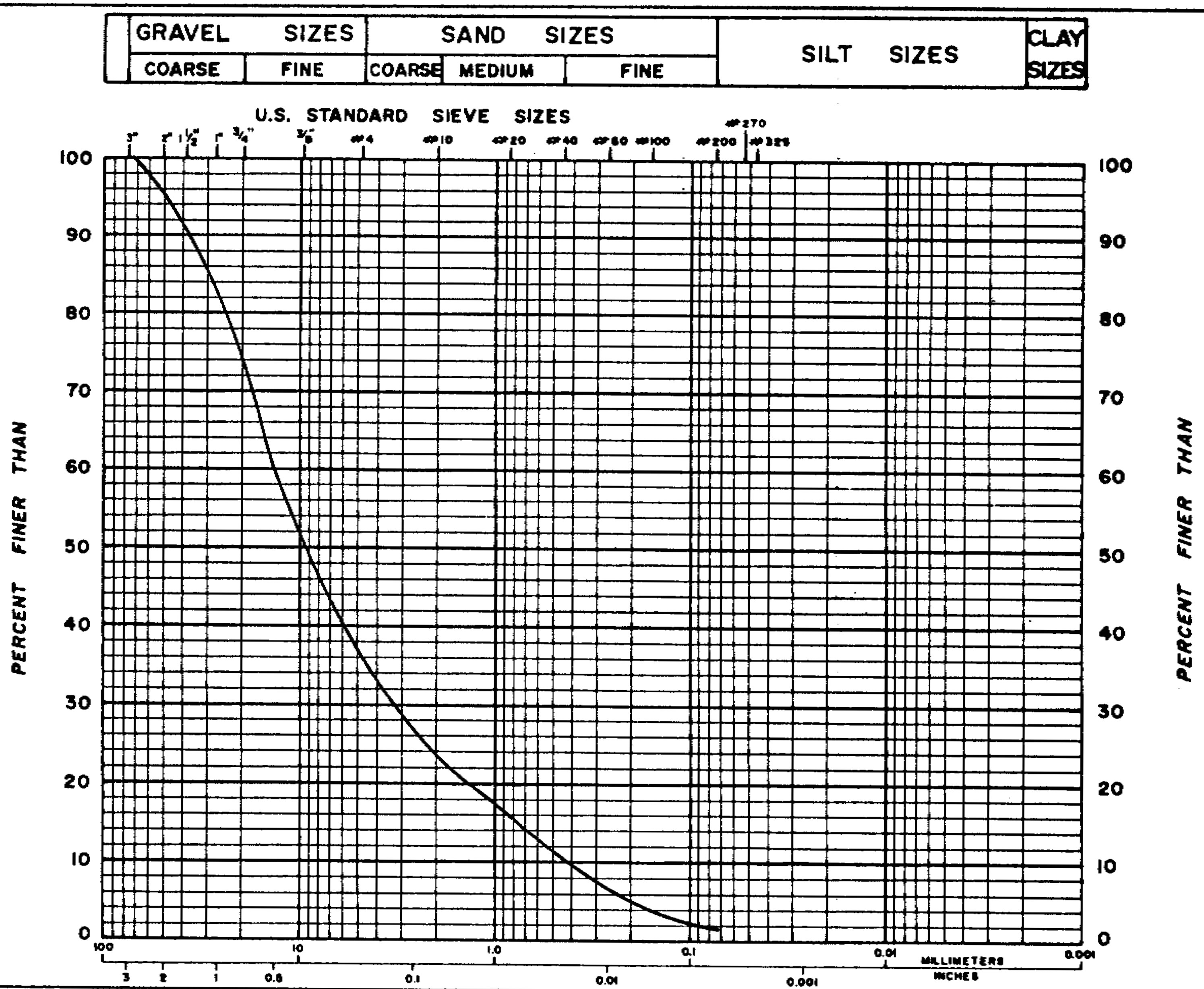
Geotechnical Consultants Ltd.

GRAIN SIZE DISTRIBUTION

DRAWING NO: A83-613-A42

REMARKS:

CLIENT: GOVERNMENT OF CANADA, DIAND
PROJECT: GRANULAR MATERIAL EVALUATION
LOCATION: TUKTOYAKTUK AREA, NWT
TEST HOLE NO: 168-7 **DEPTH:** 6.4m-6.7m



D_{10}	0.4mm
D_{30}	3.2mm
D_{60}	13.0mm
C_u	32.5
C_c	2.0

GBT Geotechnical Consultants Ltd.

GRAIN SIZE DISTRIBUTION

DRAWING NO: A83-613-A43

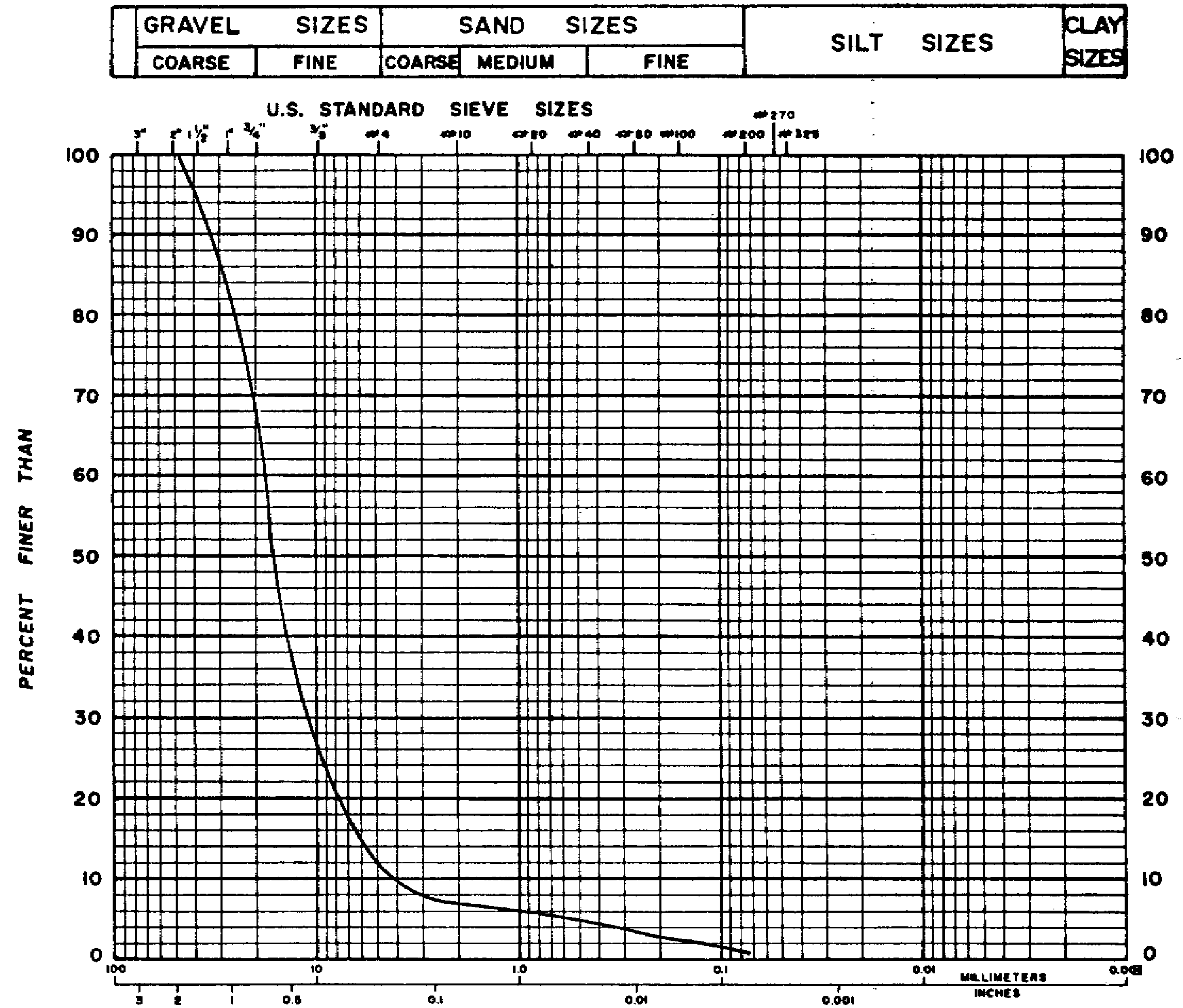
REMARKS:

CLIENT: GOVERNMENT OF CANADA, DIAND

PROJECT: GRANULAR MATERIAL EVALUATION

LOCATION: TUKTOYAKTUK AREA, NWT

TEST HOLE NO: 168-8 **DEPTH:** 0.9m



D$_{10}$ 4.0mm

D$_{30}$ 11.0mm

D$_{60}$ 18.0mm

C$_u$ 4.5

C$_c$ 1.7

BBT Geotechnical Consultants Ltd.

GRAIN SIZE DISTRIBUTION

DRAWING NO: A83-613-A44

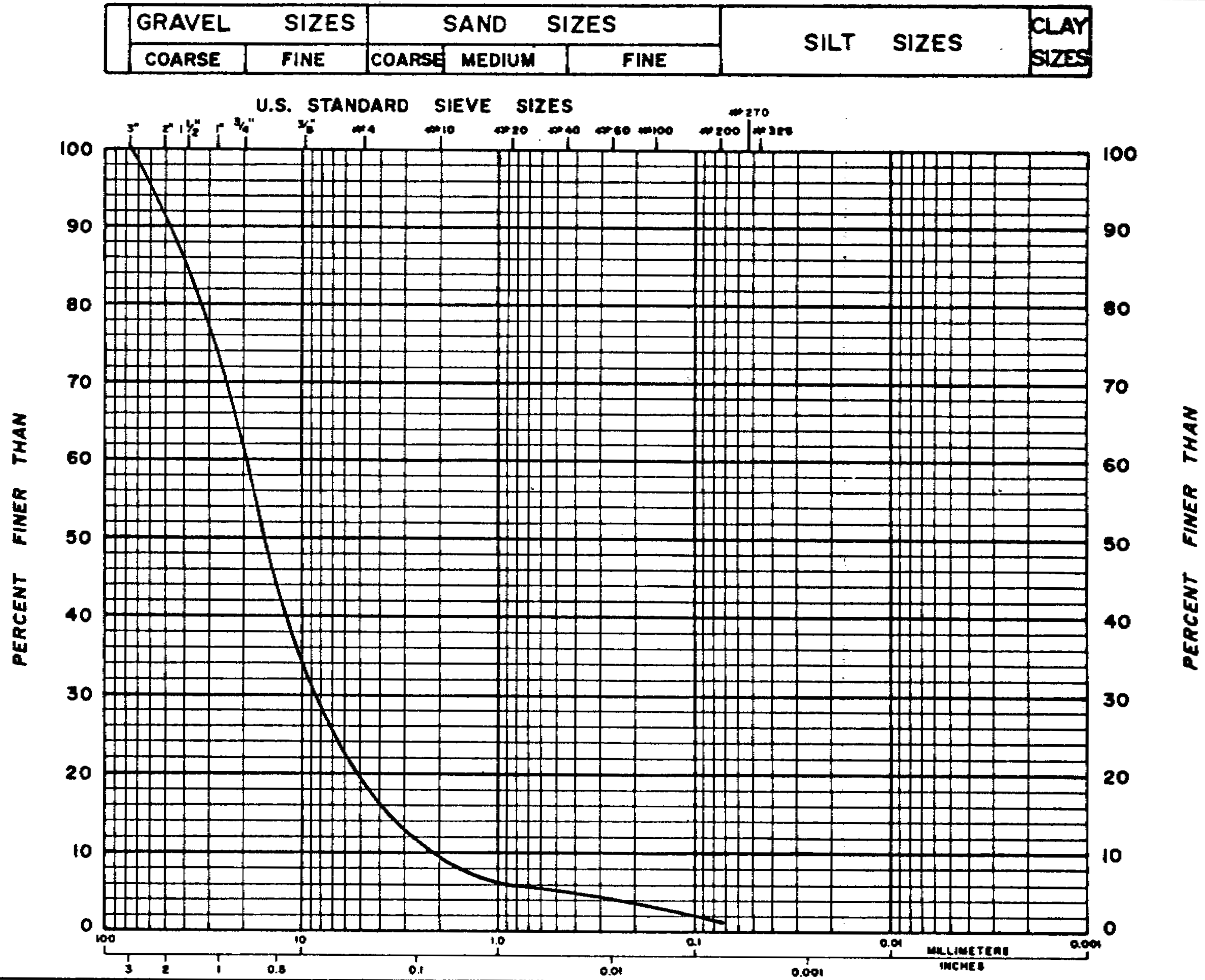
REMARKS:

CLIENT: GOVERNMENT OF CANADA, DIAND

PROJECT: GRANULAR MATERIAL EVALUATION

LOCATION: TUKTOYAKTUK AREA, NWT

TEST HOLE NO: 168-8 **DEPTH:** 2.4m



D_{10}	2.0mm
D_{30}	8.5mm
D_{60}	20.0mm
C_u	10.0
C_c	1.8

BBT Geotechnical Consultants Ltd.

GRAIN SIZE DISTRIBUTION

DRAWING NO: A83-613-A45

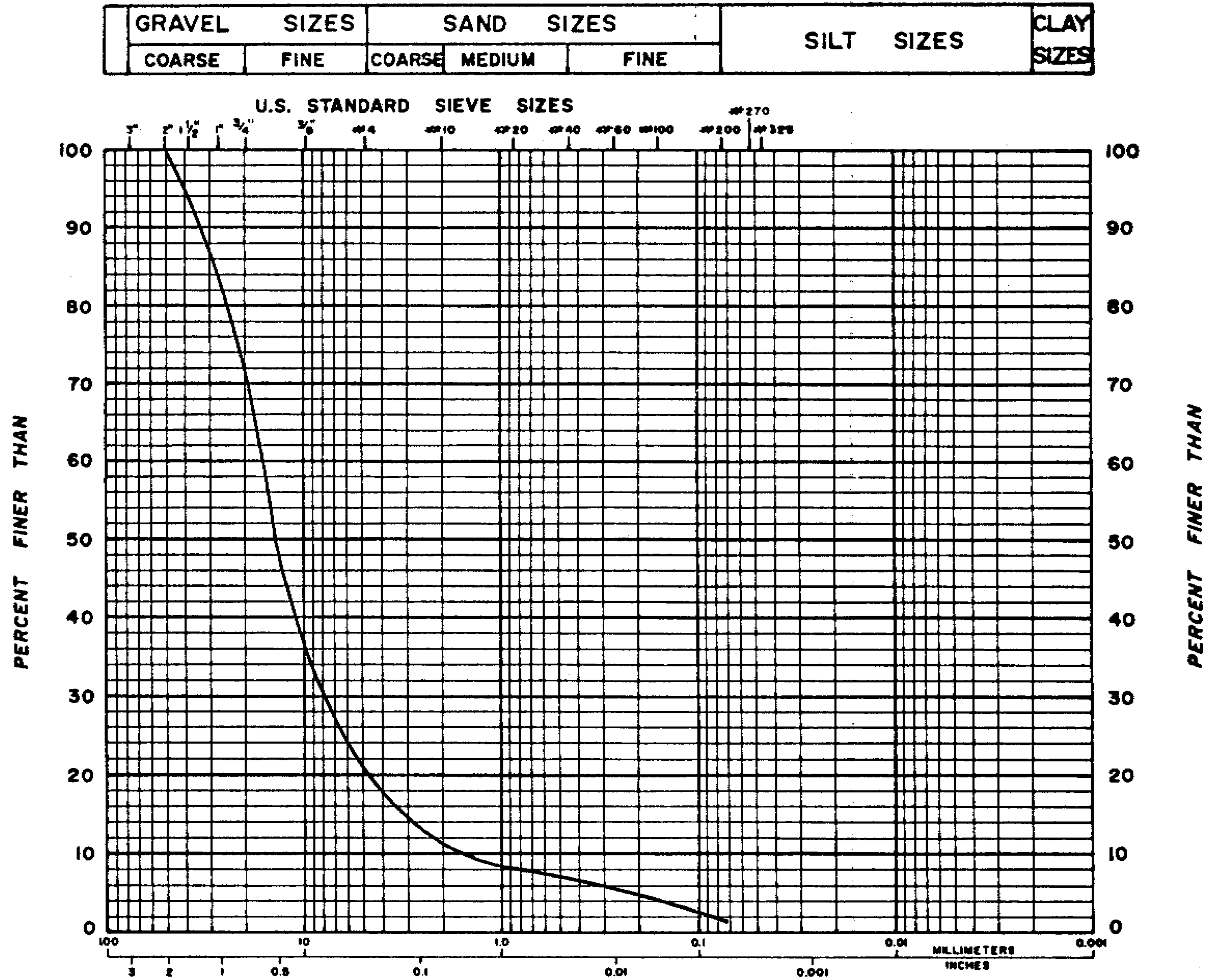
REMARKS:

CLIENT: GOVERNMENT OF CANADA, DIAND

PROJECT: GRANULAR MATERIAL EVALUATION

LOCATION: TUKTOYAKTUK AREA, NWT

TEST HOLE NO: 168-8 **DEPTH:** 3.7m



D_{10} 1.5mm

D_{30} 8.0mm

D_{60} 17.0mm

C_u 11.3

C_c 2.5

EBA Geotechnical Consultants Ltd.

GRAIN SIZE DISTRIBUTION

DRAWING NO: A83-613-A46

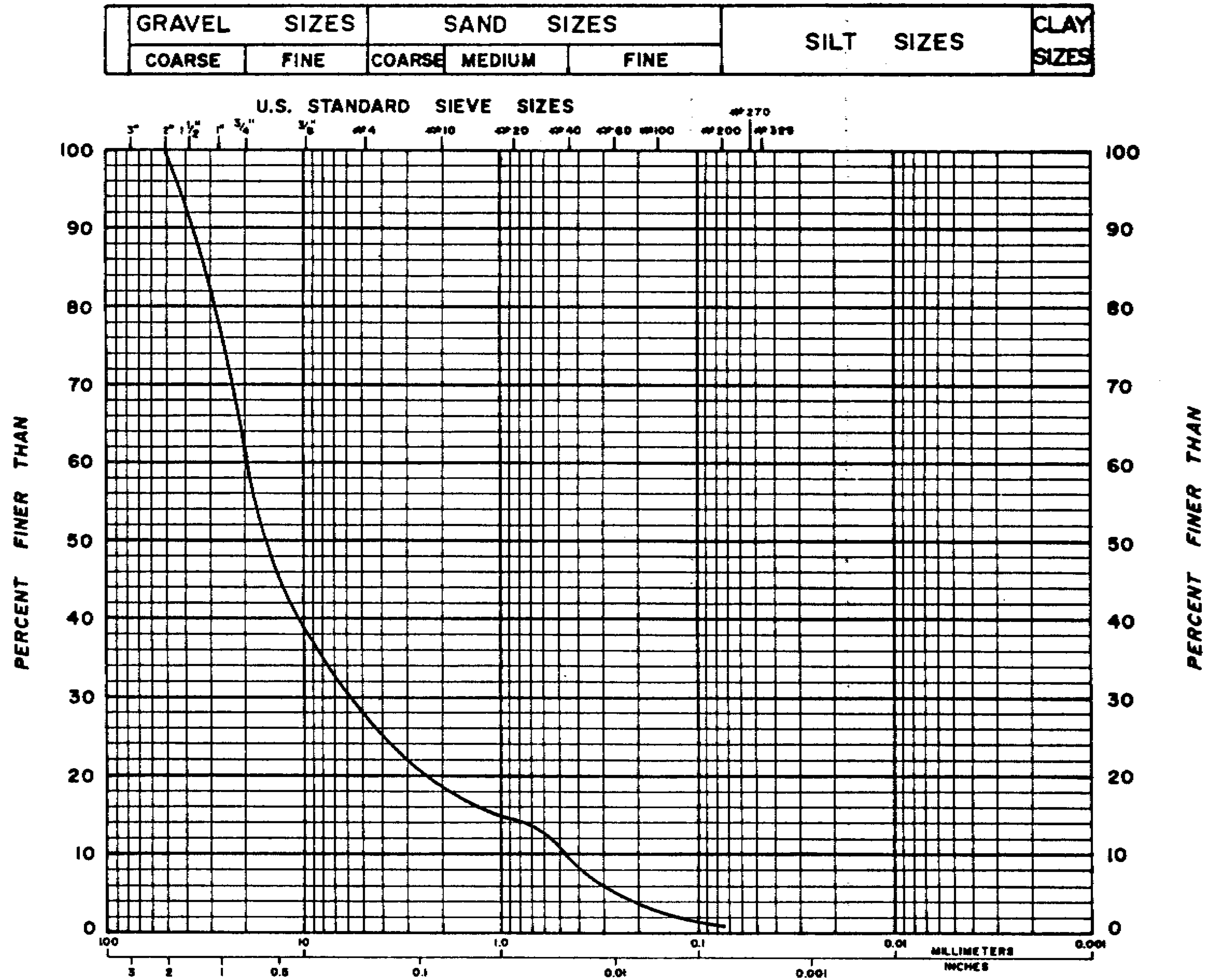
REMARKS:

CLIENT: GOVERNMENT OF CANADA, DIAND

PROJECT: GRANULAR MATERIAL EVALUATION

LOCATION: TUKTOYAKTUK AREA, NWT

TEST HOLE NO: 168-8 **DEPTH:** 4.9m



D_{10} 0.48mm

D_{30} 6.0mm

D_{60} 20.0mm

C_u 41.6

C_c 3.8

Geotechnical Consultants Ltd.

GRAIN SIZE DISTRIBUTION

DRAWING NO: A83-613-A47

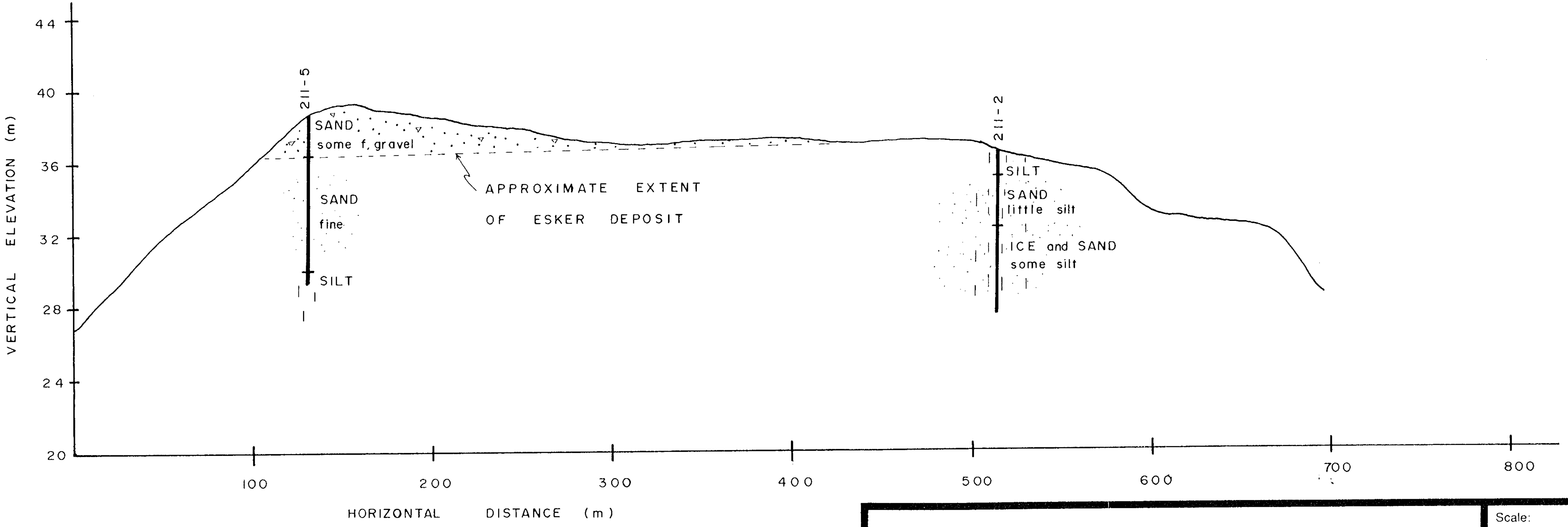
REMARKS:

CLIENT: GOVERNMENT OF CANADA, DIAND

PROJECT: GRANULAR MATERIAL EVALUATION

LOCATION: TUKTOYAKTUK AREA, NWT

TEST HOLE NO: 168-8 **DEPTH:** 6.4m



BBT Geotechnical Consultants Ltd.

BBT GEOTECHNICAL CONSULTANTS LTD.

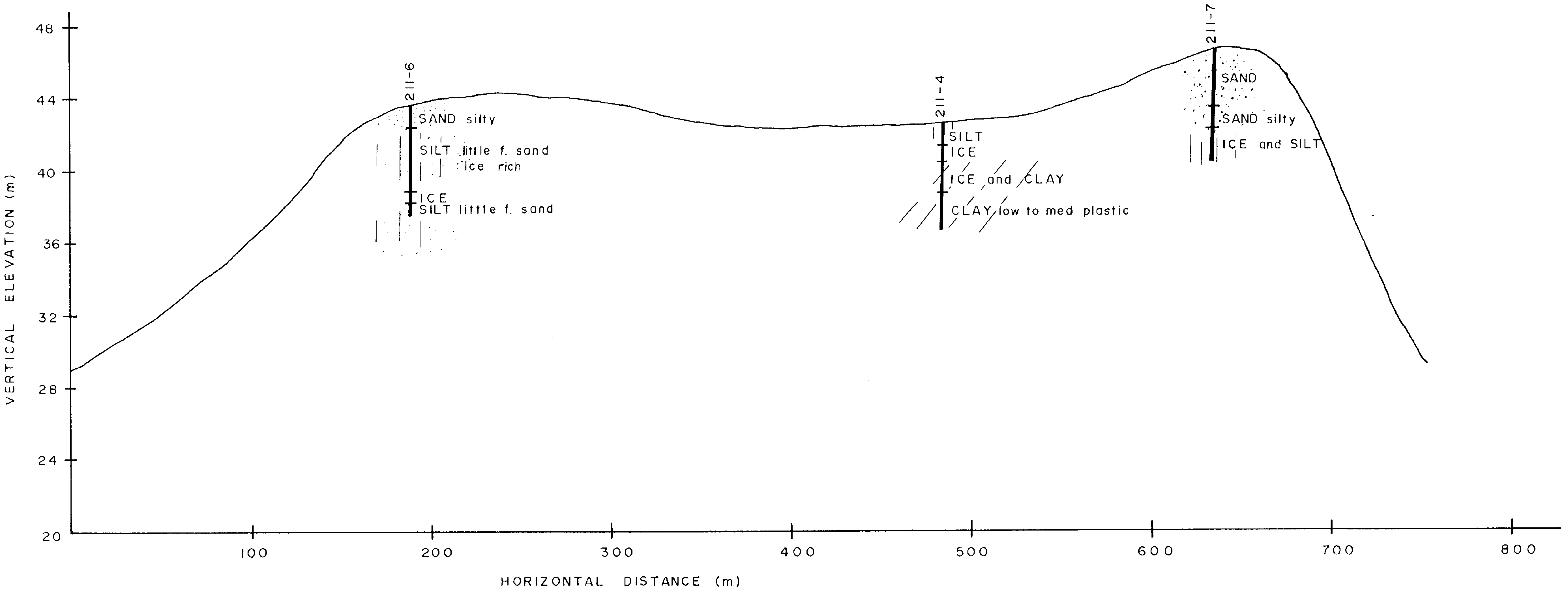
CROSS SECTION A - A

DEPOSIT 211, NEAR WILLOW LAKE ON RICHARDS ISLAND

TUKTOYAKTUK AREA N.W.T.

Scale: AS SHOWN	Designed By:
Drawn By:	Checked By:
Date: MAY 1983	Approved By:

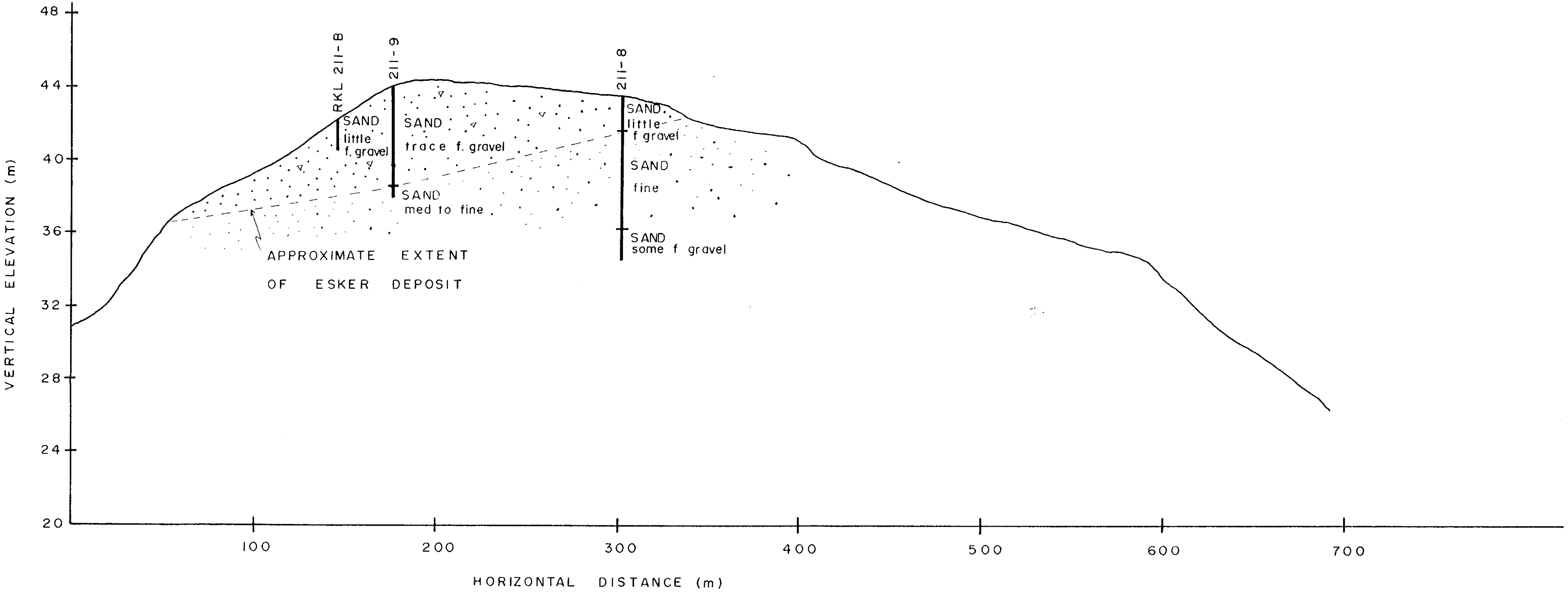
DRAWING NO:
A83-613-B2



BBT Geotechnical Consultants Ltd.
BBT GEOTECHNICAL CONSULTANTS LTD.

CROSS SECTION B-B
DEPOSIT 211, NEAR WILLOW LAKE ON RICHARDS ISLAND
TUKTOYAKTUK AREA N.W.T.

Scale: AS SHOWN	Designed By:
Drawn By:	Checked By:
Date: MAY 1983	Approved By:
DRAWING NO: A83-613-B3	



BBT Geotechnical Consultants Ltd.

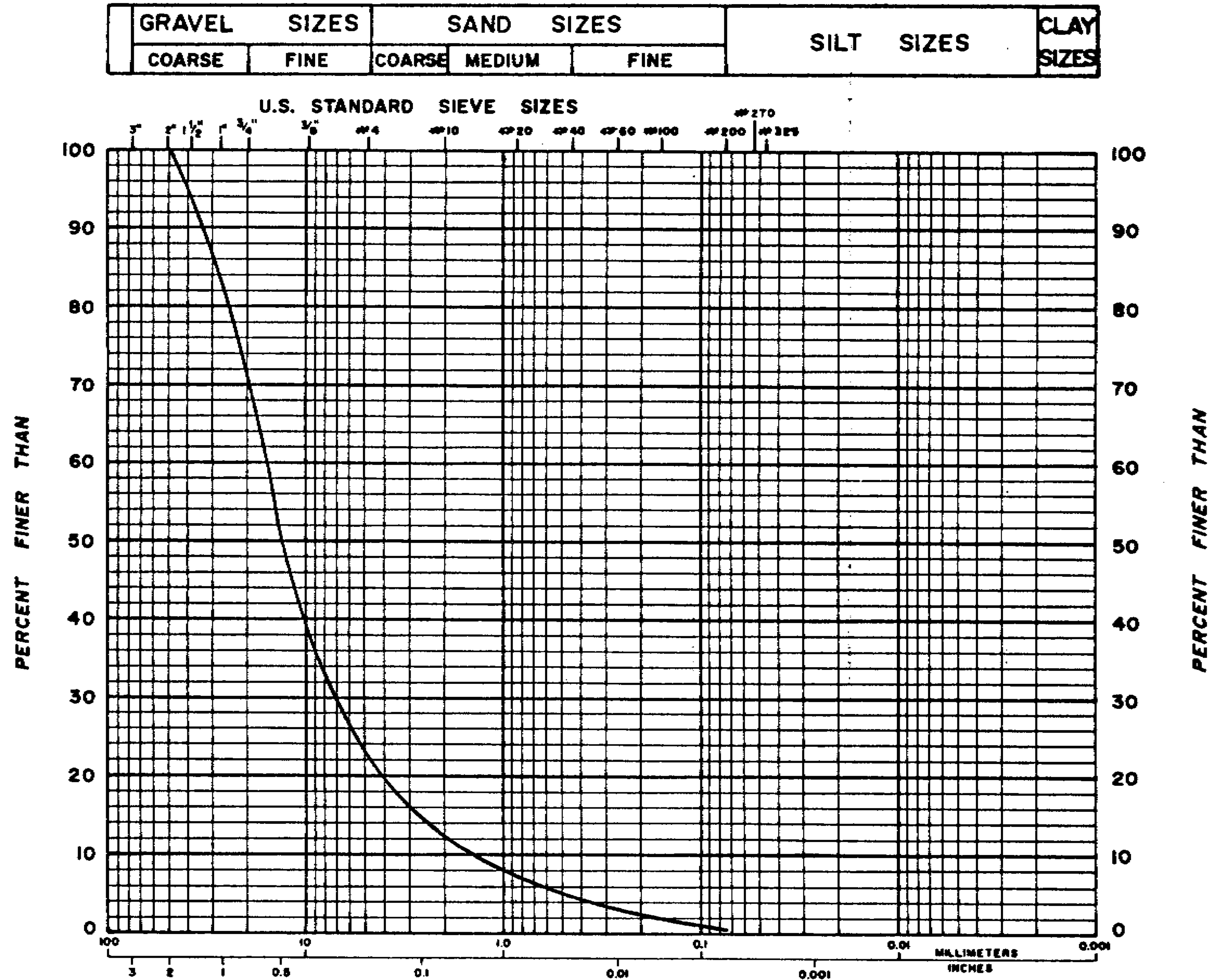
BBT GEOTECHNICAL CONSULTANTS LTD.

Scale: AS SHOWN	Designed By:
Drawn By:	Checked By:
Date: MAY 1983	Approved By:
DRAWING NO: A83- 613- B4	

CROSS SECTION C – C

DEPOSIT 211, NEAR WILLOW LAKE ON RICHARDS ISLAND

TUKTOYAKTUK AREA N.W.T.



D_{10} 1.4mm

D_{30} 7.0mm

D_{60} 16.0mm

C_u 11.4

C_c 2.2

Geotechnical Consultants Ltd.

GRAIN SIZE DISTRIBUTION

DRAWING NO: A83-613-A48

REMARKS:

CLIENT: GOVERNMENT OF CANADA, DIAND

PROJECT: GRANULAR MATERIAL EVALUATION

LOCATION: TUKTOYAKTUK AREA, NWT

TEST HOLE NO: 168-8

DEPTH: 7.9m

BBT Geotechnical Consultants Ltd.
BBT GEOTECHNICAL CONSULTANTS LTD.

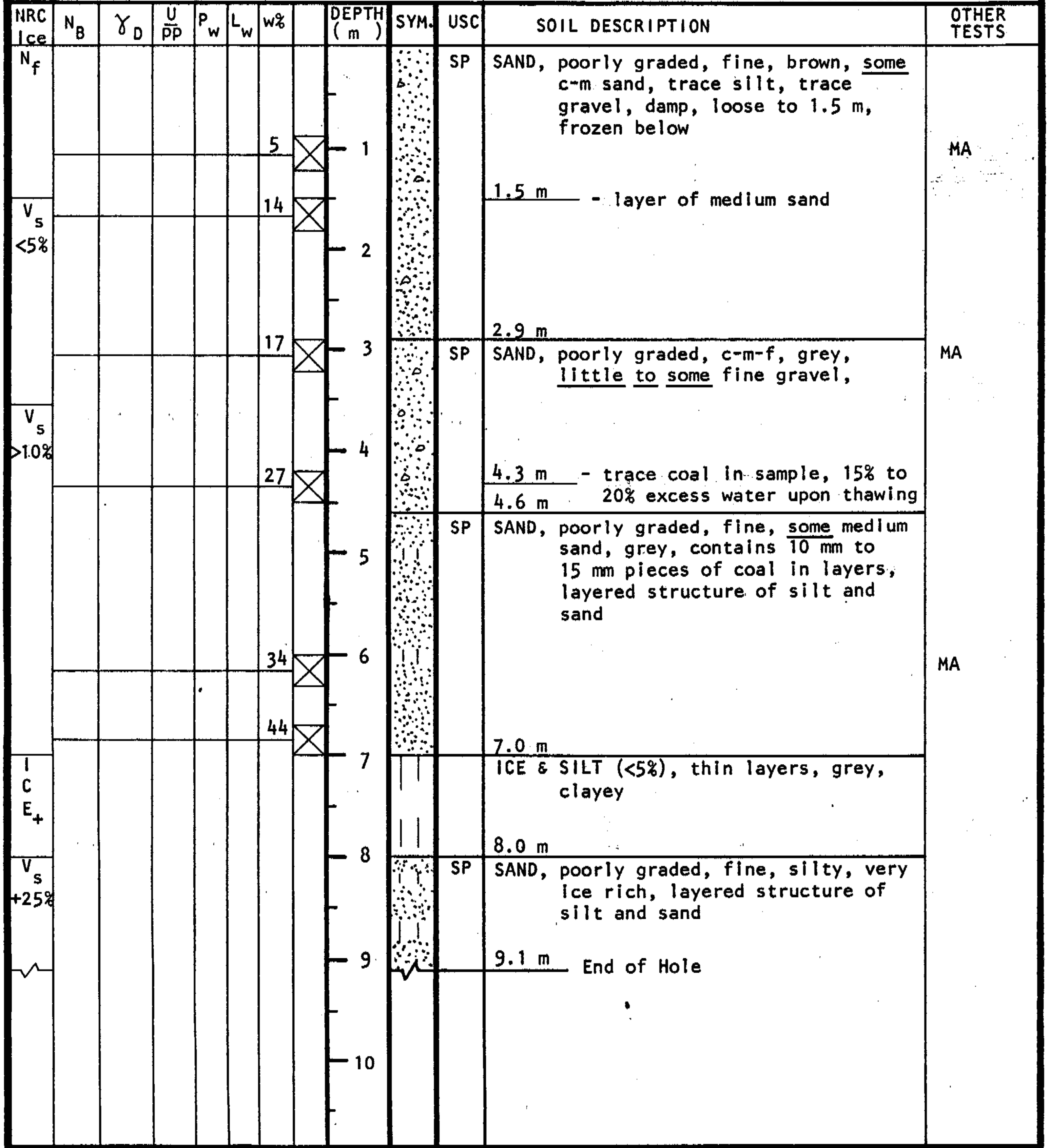
LOG OF TEST HOLE 211-1

PROJECT: GRANULAR MATERIAL STUDY

CLIENT: GOVERNMENT OF CANADA
DEPT. OF INDIAN AFFAIRS & NORTHERN DEVELOPMENT

LOCATION: TUKTOYAKTUK, N.W.T.

THIS SUMMARY APPLIES ONLY AT THE LOCATION OF THIS TEST HOLE AND AT THE TIME OF DRILLING.



SAND, poorly graded, fine, brown, some c-m sand, trace silt, trace gravel, damp, loose to 1.5 m, frozen below

1.5 m - layer of medium sand

2.9 m

SAND, poorly graded, c-m-f, grey, little to some fine gravel,

4.3 m - trace coal in sample, 15% to 20% excess water upon thawing

4.6 m

SAND, poorly graded, fine, some medium sand, grey, contains 10 mm to 15 mm pieces of coal in layers, layered structure of silt and sand

7.0 m

ICE & SILT (<5%), thin layers, grey, clayey

8.0 m

SAND, poorly graded, fine, silty, very ice rich, layered structure of silt and sand

9.1 m End of Hole

DRILL RIG: Becker Diesel Hammer

DATE DRILLED: March 23, 1983

SCALE: 1:50

DRAWING NUMBER: A83-613-B5

BBT Geotechnical Consultants Ltd.
BBT GEOTECHNICAL CONSULTANTS LTD.

LOG OF TEST HOLE 211-2

PROJECT: GRANULAR MATERIAL STUDY

CLIENT: GOVERNMENT OF CANADA
DEPT. OF INDIAN AFFAIRS & NORTHERN DEVELOPMENT

LOCATION: TUKTOYAKTUK, N.W.T.

THIS SUMMARY APPLIES ONLY AT THE LOCATION OF THIS TEST HOLE AND AT THE TIME OF DRILLING.

NRC Ice	N_B	γ_D	$\frac{U}{pp}$	P_w	L_w	w%		DEPTH (m)	SYM.	USC	SOIL DESCRIPTION	OTHER TESTS
V_s 30% to 40%						42	☒	1		ML	SILT, and fine sand, ice rich, brown, layered, thin organic cover 1.3 m	
N_{be} to V <5%						26 23	☒ ☒	2 3 4		SM	SAND, fine, brown, little silt, possible layered structure, 5% excess water upon thawing 4.1 m	MA
ICE											ICE 5.0 m	
ICE+						39 55 56	☒ ☒ ☒	5 6 7 8 9			ICE & SAND, fine, some low plastic silt, brown, layered structure, pieces of coal, twigs in soil layers, 50% to 75% excess water upon thawing 8.0 m - becomes very silty, with organics 9.0 m End of Hole	MA
								10				

DRILL RIG: Becker Diesel Hammer

DATE DRILLED: March 24, 1983

SCALE: 1:50

DRAWING NUMBER: A83-613-B6

BBT Geotechnical Consultants Ltd.
BBT GEOTECHNICAL CONSULTANTS LTD.

LOG OF TEST HOLE 211-3

PROJECT: GRANULAR MATERIAL STUDY

CLIENT: GOVERNMENT OF CANADA

LOCATION: TUKTOYAKTUK, N.W.T.

DEPT. OF INDIAN AFFAIRS & NORTHERN DEVELOPMENT

THIS SUMMARY APPLIES ONLY AT THE LOCATION OF THIS TEST HOLE AND AT THE TIME OF DRILLING.

NRC Ice	N_B	γ_D	$\frac{U}{pp}$	P_w	L_w	w%	DEPTH (m)	USC	SOIL DESCRIPTION	OTHER TESTS
N						23		ML	Thin organic cover <25 mm SILT, low plastic, brown, trace gravel to 50 mm, some sand, wet upon thawing 0.9 m	
ICE N_b to V_s <2%						36 27	1 2	SP-SM	SAND, poorly graded, very fine, grey-brown, trace silt, trace coal, contains thin layers of segregated ice, 5% to 10% excess water upon thawing 2.7 m	MA
V <5%						10	3	SP	SAND, poorly graded, c-m, and fine gravel, clean, grey-brown, low ice content, wet upon thawing 4.0 m	MA
						9	4	GW	GRAVEL, well graded, and c-m-f sand, grey-brown, low ice content, wet upon thawing 4.7 m	MA
ICE									ICE & SAND 5.0 m	
V <5%						13	5	SP	SAND, poorly graded, c-m, and fine gravel, clean, grey-brown 5.8 m	MA
I C E_+							6 7 10 11 12		ICE, <2% silt inclusions ICE, cont'd 12.1 m End of Hole	

DRILL RIG: Becker Diesel Hammer

DATE DRILLED: March 24, 1983

SCALE: 1:50

DRAWING NUMBER: A83-613-B7

BBT Geotechnical Consultants Ltd.
BBT GEOTECHNICAL CONSULTANTS LTD.

LOG OF TEST HOLE 211 - 4

PROJECT: GRANULAR MATERIAL STUDY

CLIENT: GOVERNMENT OF CANADA

LOCATION: TUKTOYAKTUK, N.W.T.

DEPT. OF INDIAN AFFAIRS & NORTHERN DEVELOPMENT

THIS SUMMARY APPLIES ONLY AT THE LOCATION OF THIS TEST HOLE AND AT THE TIME OF DRILLING.

NRC Ice	N_B	γ_D	$\frac{U}{pp}$	P_w	L_w	w%		DEPTH (m)	SYM.	USC	SOIL DESCRIPTION	OTHER TESTS
V_s >10%								1		ML	50 mm Organic cover SILT, low plastic, sandy, brown, ice rich 1.2 m	
ICE+								2			ICE, <2% silt inclusions 2.1 m	
								3			ICE & CLAY, low plastic, silty, layered structure, 10% to 20% soil 3.8 m	
V_s >30%								4		CL	CLAY, low to medium plastic, dark grey, layered structure with silt and fine sand, very ice rich in layers	
						44	☒	5				
						50	☒					
								6			6.0 m End of Hole	
								7				
								8				
								9				
								10				

DRILL RIG: Becker Diesel Hammer

DATE DRILLED: March 24, 1983

SCALE: 1:50

DRAWING NUMBER: A83-613-B8

BBT Geotechnical Consultants Ltd.
BBT GEOTECHNICAL CONSULTANTS LTD.

LOG OF TEST HOLE 211-5

PROJECT: GRANULAR MATERIAL STUDY
CLIENT: GOVERNMENT OF CANADA
LOCATION: TUKTOYAKTUK, N.W.T.
DEPT. OF INDIAN AFFAIRS & NORTHERN DEVELOPMENT

THIS SUMMARY APPLIES ONLY AT THE LOCATION OF THIS TEST HOLE AND AT THE TIME OF DRILLING.

NRC Ice	N_B	γ_D	$\frac{U}{pp}$	P_w	L_w	w%		DEPTH (m)	SYM.	USC	SOIL DESCRIPTION	OTHER TESTS
N_f						3		1		SP	SAND, poorly graded, c-m, little fine gravel, brown, loose 1.5 m	MA
						4		2		SP	SAND, poorly graded, c-m-f, some fine gravel, brown, loose to 2.0 m, frozen below 2.1 m	MA
N_b to V_s >5%						25 29		3 4 5 6 7		SP	SAND, poorly graded, fine, grey, layered structure with silt, contains 10 mm to 15 mm layers with coal pieces, layers of roots, twigs, organics, 5% to 10% excess water upon thawing 7.9 m	MA
						20		8		SP	SAND, poorly graded, c-m-f, little fine gravel, grey, 5% excess water upon thawing 8.5 m	
ICE											ICE 8.8 m	
V_r >25%						43		9		ML	SILT, grey, nonplastic, very ice rich 9.2 m End of Hole	
								10				

DRILL RIG: Becker Diesel Hammer
DATE DRILLED: March 24, 1983
SCALE: 1:50
DRAWING NUMBER: A83-613-B9

BBT Geotechnical Consultants Ltd.
BBT GEOTECHNICAL CONSULTANTS LTD.

LOG OF TEST HOLE 211-6

PROJECT: GRANULAR MATERIAL STUDY

CLIENT: GOVERNMENT OF CANADA

LOCATION: TUKTOYAKTUK, N.W.T.

DEPT. OF INDIAN AFFAIRS & NORTHERN DEVELOPMENT

THIS SUMMARY APPLIES ONLY AT THE LOCATION OF THIS TEST HOLE AND AT THE TIME OF DRILLING.

NRC Ice	N_B	γ_D	$\frac{U}{PP}$	P_w	L_w	w%		DEPTH (m)	SYM.	USC	SOIL DESCRIPTION	OTHER TESTS
N_b						26	☒	1		SM	SAND, silty, fine, grey, frozen 1.2 m	MA
V_r, V_s 30% to 40%						26 51 29	☒ ☒ ☒	2 3 4		ML	SILT, low plastic, grey, little fine sand, layered structure, coal pieces, twigs, roots, etc, very ice rich 2.8 m - 0.15 m thick layer of ice at 2.8 m 4.0 m - 75% excess water upon thawing 4.7 m	
ICE								5			ICE, trace silt 5.3 m	
V_s 40%						39	☒	6		ML	SILT, low plastic, grey, little fine sand, layered, ice rich 6.0 m End of Hole	
								7 8 9 10				

DRILL RIG: Becker Diesel Hammer

DATE DRILLED: March 24, 1983

SCALE: 1:50

DRAWING NUMBER: A83-613-B10

BBT Geotechnical Consultants Ltd.
BBT GEOTECHNICAL CONSULTANTS LTD.

LOG OF TEST HOLE 211-7

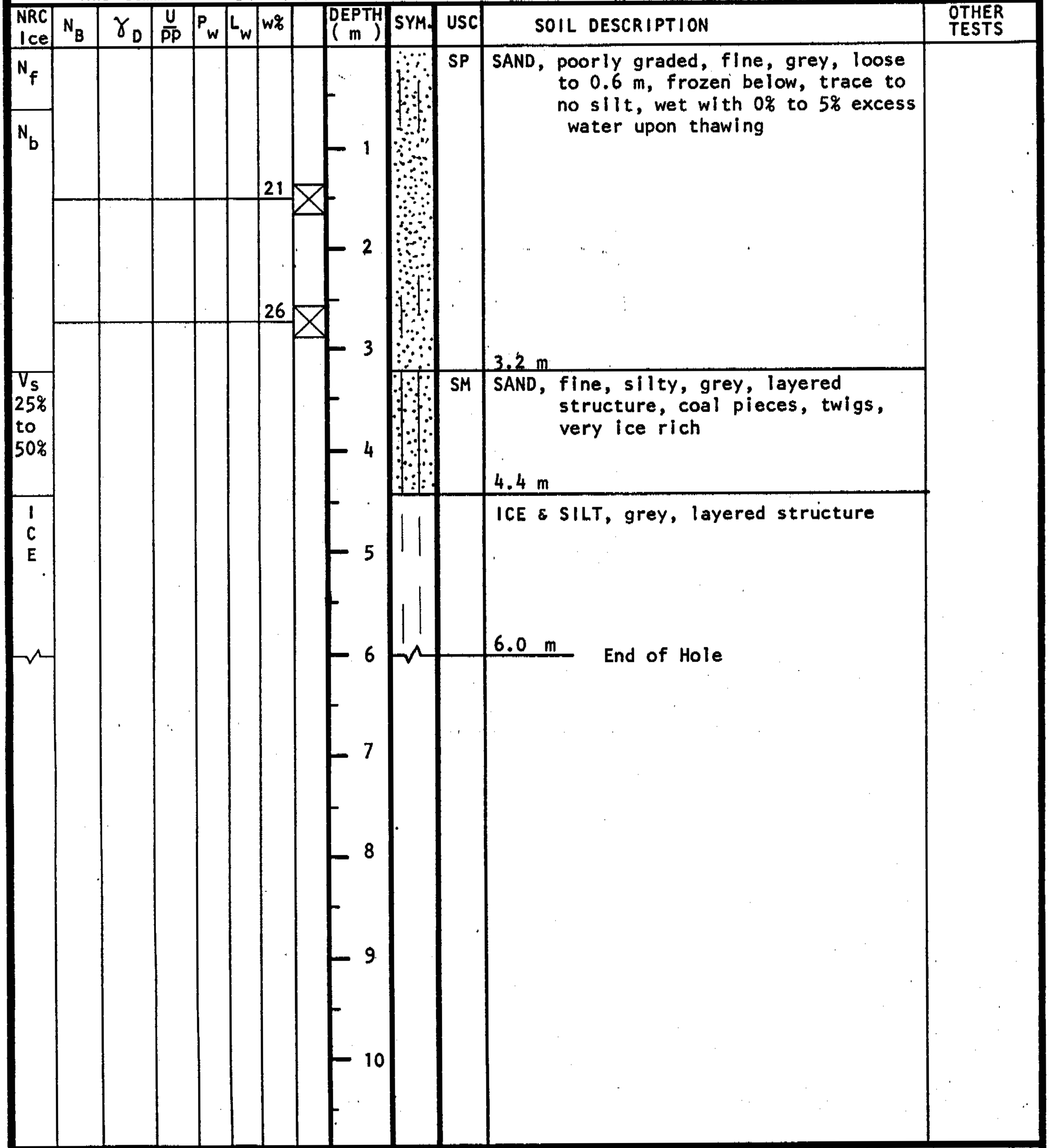
PROJECT: GRANULAR MATERIAL STUDY

CLIENT: GOVERNMENT OF CANADA

LOCATION: TUKTOYAKTUK, N.W.T.

DEPT. OF INDIAN AFFAIRS & NORTHERN DEVELOPMENT

THIS SUMMARY APPLIES ONLY AT THE LOCATION OF THIS TEST HOLE AND AT THE TIME OF DRILLING.



SP — SAND, poorly graded, fine, grey, loose to 0.6 m, frozen below, trace to no silt, wet with 0% to 5% excess water upon thawing

3.2 m

SM — SAND, fine, silty, grey, layered structure, coal pieces, twigs, very ice rich

4.4 m

ICE & SILT, grey, layered structure

6.0 m End of Hole

DRILL RIG: Becker Diesel Hammer

DATE DRILLED: March 24, 1983

SCALE: 1:50

DRAWING NUMBER: A83-613-B11

BBT Geotechnical Consultants Ltd.
BBT GEOTECHNICAL CONSULTANTS LTD.

LOG OF TEST HOLE 211-8

PROJECT: GRANULAR MATERIAL STUDY

CLIENT: GOVERNMENT OF CANADA

LOCATION: TUKTOYAKTUK, N.W.T.

DEPT. OF INDIAN AFFAIRS & NORTHERN DEVELOPMENT

THIS SUMMARY APPLIES ONLY AT THE LOCATION OF THIS TEST HOLE AND AT THE TIME OF DRILLING.

NRC Ice	N_B	γ_D	$\frac{U}{PP}$	P_w	L_w	w%		DEPTH (m)	SYM.	USC	SOIL DESCRIPTION	OTHER TESTS
N_f						3				SW	SAND, well graded, little fine gravel, brown, loose, damp when thawed 1.8 m	MA
V_s 30%						26 31 31 28 30				SP	SAND, poorly graded, fine, grey, wet upon thawing, layered structure, coal pieces, twigs 3.0 m - becomes ice rich below 3.0 m depth, in layers - pieces of coal and wood in layers 7.2 m	MA
V_s <5%						15				SP	SAND, poorly graded, c-m-f, some fine gravel, grey, wet upon thawing, 50 mm max. size 8.8 m End of Hole	MA

DRILL RIG: Becker Diesel Hammer

DATE DRILLED: March 24, 1983

SCALE: 1:50

DRAWING NUMBER: A83-613-B12

BBT Geotechnical Consultants Ltd.
BBT GEOTECHNICAL CONSULTANTS LTD.

LOG OF TEST HOLE 211-9

PROJECT: GRANULAR MATERIAL STUDY

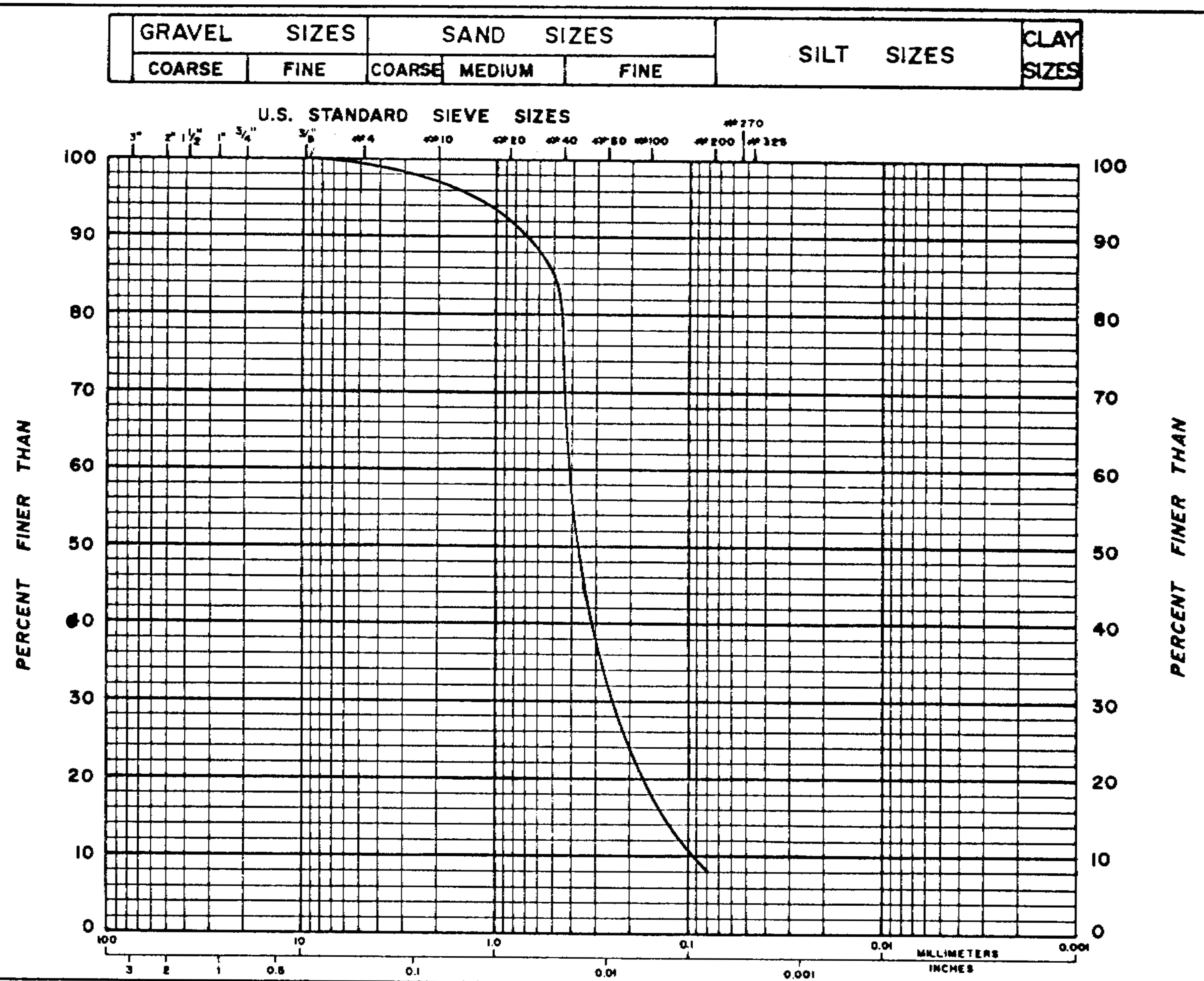
CLIENT: GOVERNMENT OF CANADA
DEPT. OF INDIAN AFFAIRS & NORTHERN DEVELOPMENT

LOCATION: TUKTOYAKTUK, N.W.T.

THIS SUMMARY APPLIES ONLY AT THE LOCATION OF THIS TEST HOLE AND AT THE TIME OF DRILLING.

NRC Ice	N_B	γ_D	$\frac{U}{pp}$	P_w	L_w	w%		DEPTH (m)	SYM.	USC	SOIL DESCRIPTION	OTHER TESTS
N_f										SP	SAND, poorly graded, c-m, trace fine gravel, brown, loose to 1.8 m, frozen and ice rich below, grey below 2.0 m	
						4	☒	1				MA
V_s 10% to 20%								2				
						18	☒	3				MA
						16	☒					
								4			4.2 m	
										SP-SW	SAND, fairly well graded, c-m-f, grey, some fine gravel	
						10	☒	5				MA
											5.5 m	
V_s >5%						26	☒			SP	SAND, poorly graded, m-f, grey, wet upon thawing, layered structure, coal pieces	MA
								6			6.0 m End of Hole	
								7				
								8				
								9				
								10				

DRILL RIG:	DATE DRILLED:	SCALE:	DRAWING NUMBER:
Becker Diesel Hammer	March 24, 1983	1:50	A83-613-B13



D_{10}	0.1 mm
D_{30}	0.24mm
D_{60}	0.41mm
C_u	4.1
C_c	1.4

Geotechnical Consultants Ltd.

GRAIN SIZE DISTRIBUTION

DRAWING NO: A83-613-B14

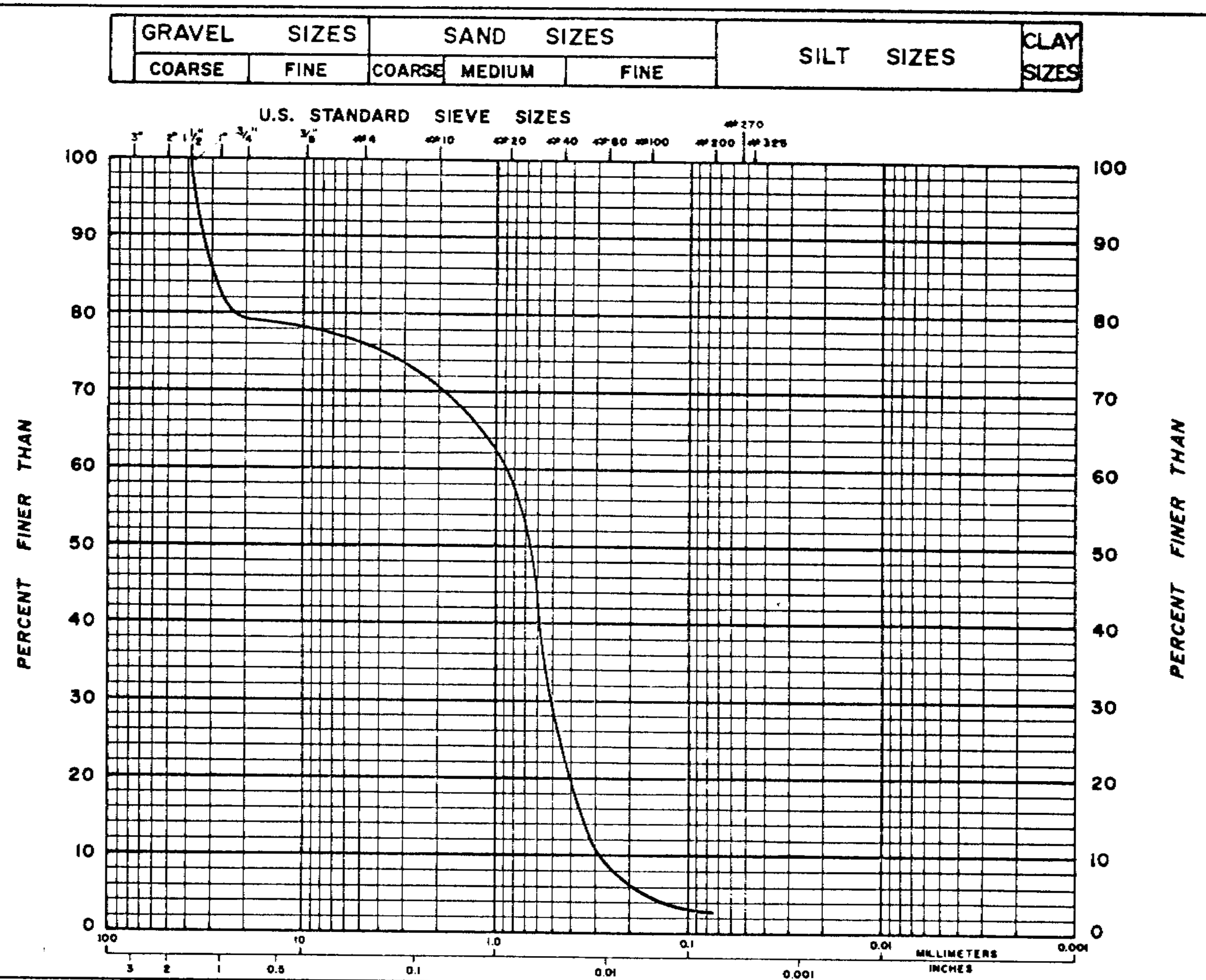
REMARKS:

CLIENT: GOVERNMENT OF CANADA, DIAND

PROJECT: GRANULAR MATERIAL EVALUATION

LOCATION: TUKTOYAKTUK AREA, NWT

TEST HOLE NO: 211-1 **DEPTH:** 0.9m



D_{10}	0.3mm
D_{30}	0.5mm
D_{60}	0.9mm
C_u	3.0
C_c	0.9

Geotechnical Consultants Ltd.

GRAIN SIZE DISTRIBUTION

DRAWING NO: A83-613-B15

REMARKS:

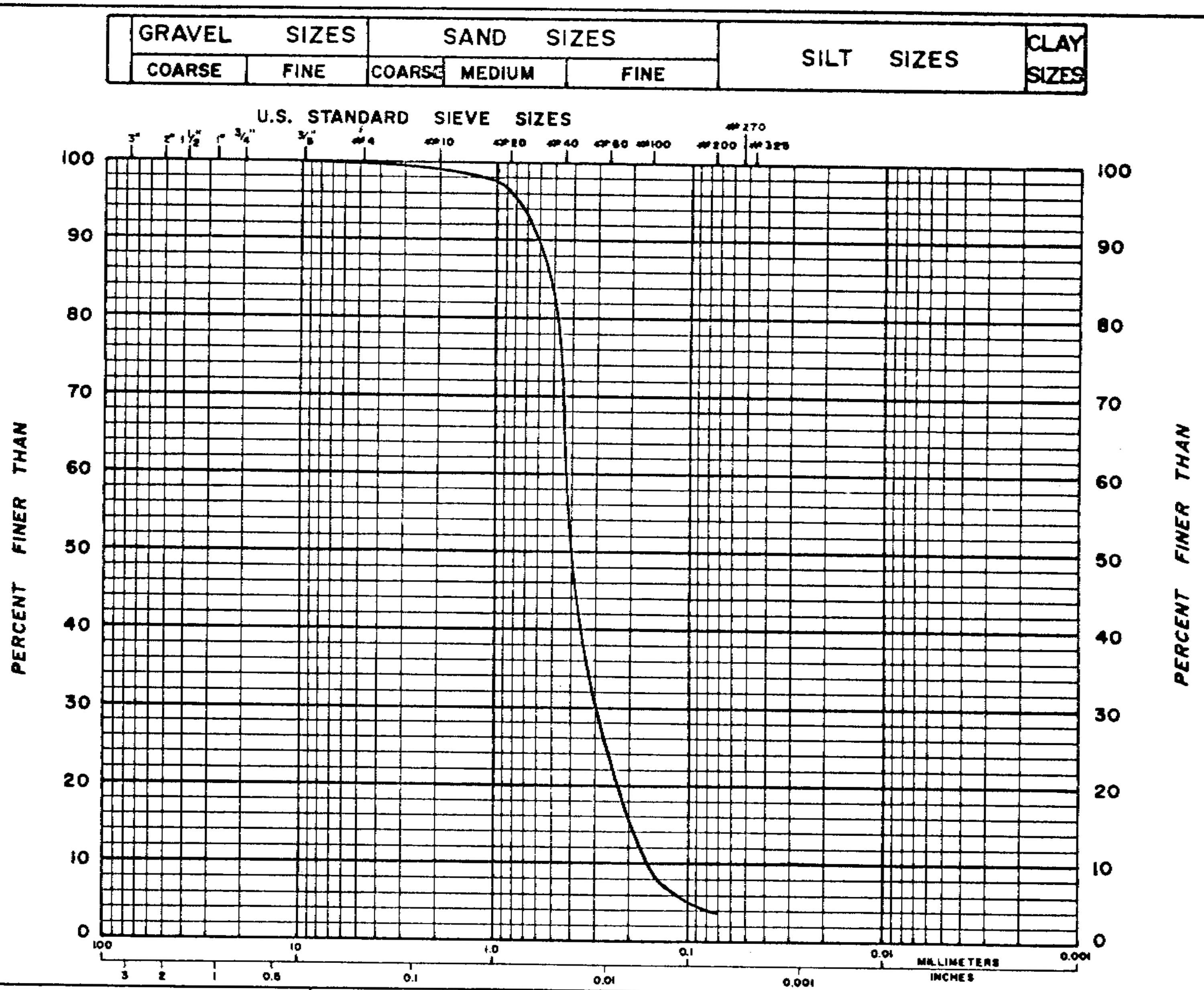
CLIENT: GOVERNMENT OF CANADA, DIAND

PROJECT: GRANULAR MATERIAL EVALUATION

LOCATION: TUKTOYAKTUK AREA, NWT

TEST HOLE NO: 211-1

DEPTH: 2.9m



D_{10}	0.17mm
D_{30}	0.3 mm
D_{60}	0.42mm
C_u	2.5
C_c	1.3

BBT Geotechnical Consultants Ltd.

GRAIN SIZE DISTRIBUTION

DRAWING NO: A83-613-B16

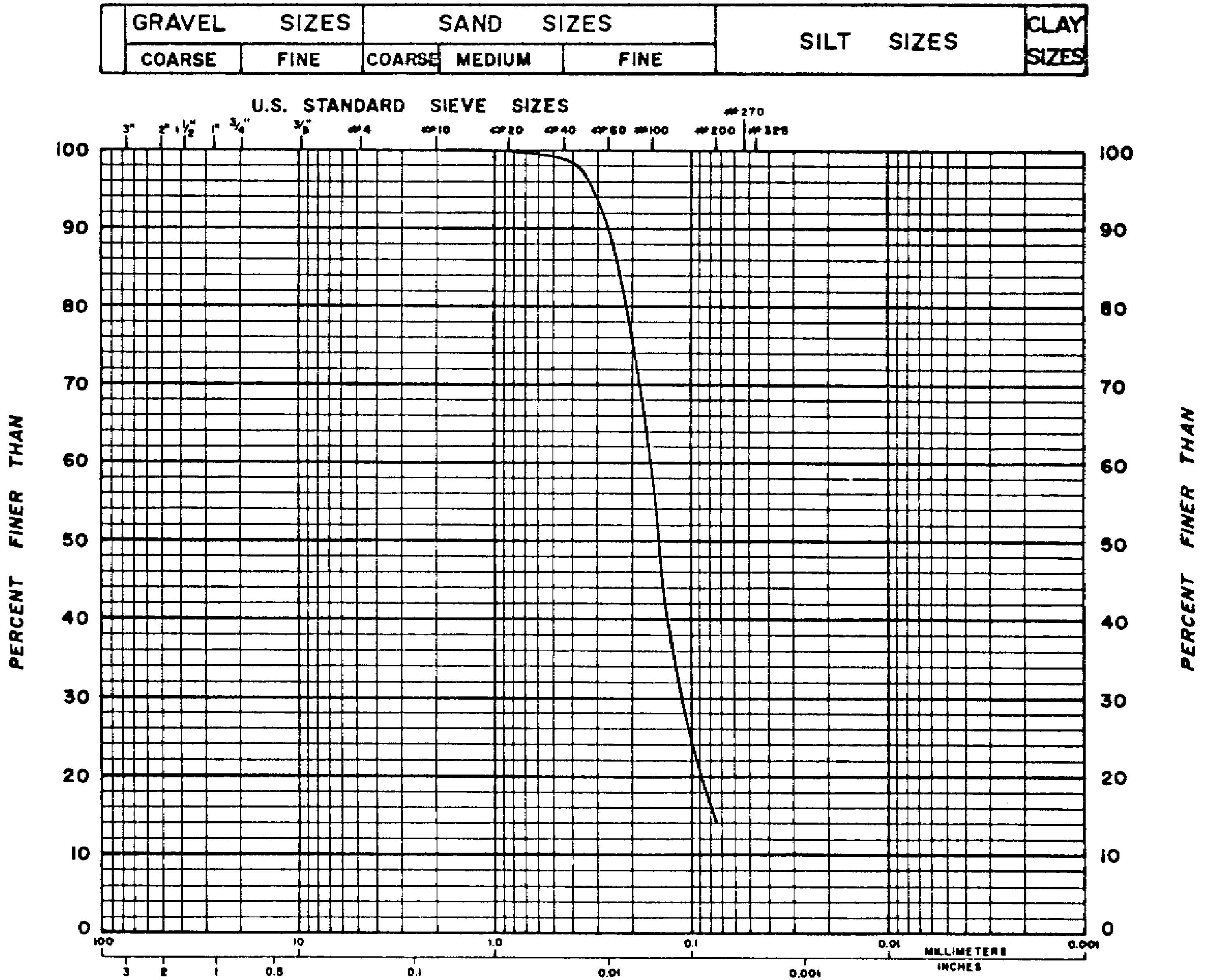
REMARKS:

CLIENT: GOVERNMENT OF CANADA, DIAND

PROJECT: GRANULAR MATERIAL EVALUATION

LOCATION: TUKTOYAKTUK AREA, NWT

TEST HOLE NO: 211-1 **DEPTH:** 6.1m



Geotechnical Consultants Ltd.

GRAIN SIZE DISTRIBUTION

DRAWING NO: A83-613-B17

REMARKS:

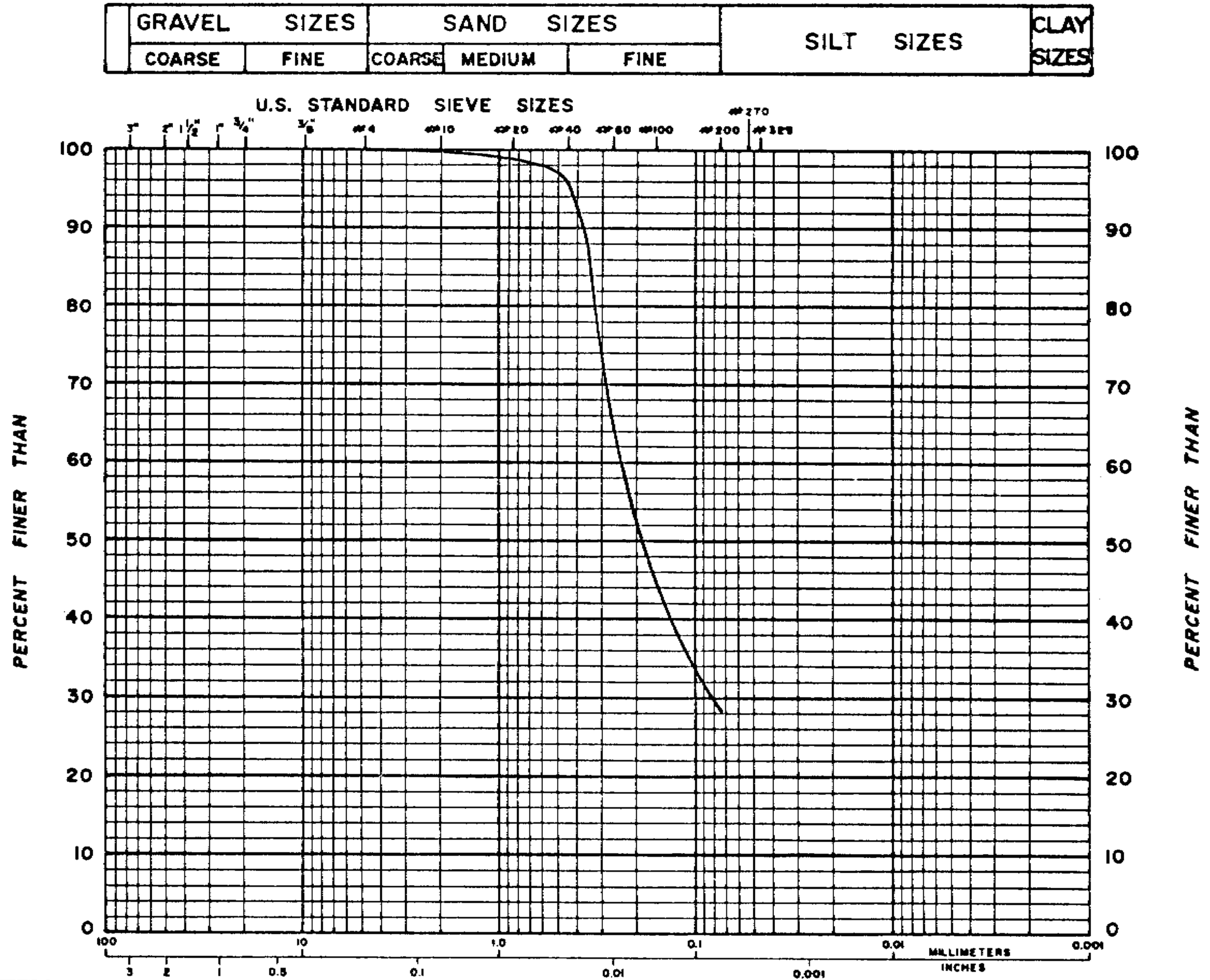
CLIENT: GOVERNMENT OF CANADA, DIAND

PROJECT: GRANULAR MATERIAL EVALUATION

LOCATION: TUKTOYAKTUK AREA, NWT

TEST HOLE NO: 211-2

DEPTH: 1.5m



Geotechnical Consultants Ltd.

GRAIN SIZE DISTRIBUTION

DRAWING NO: A83-613-B18

REMARKS:

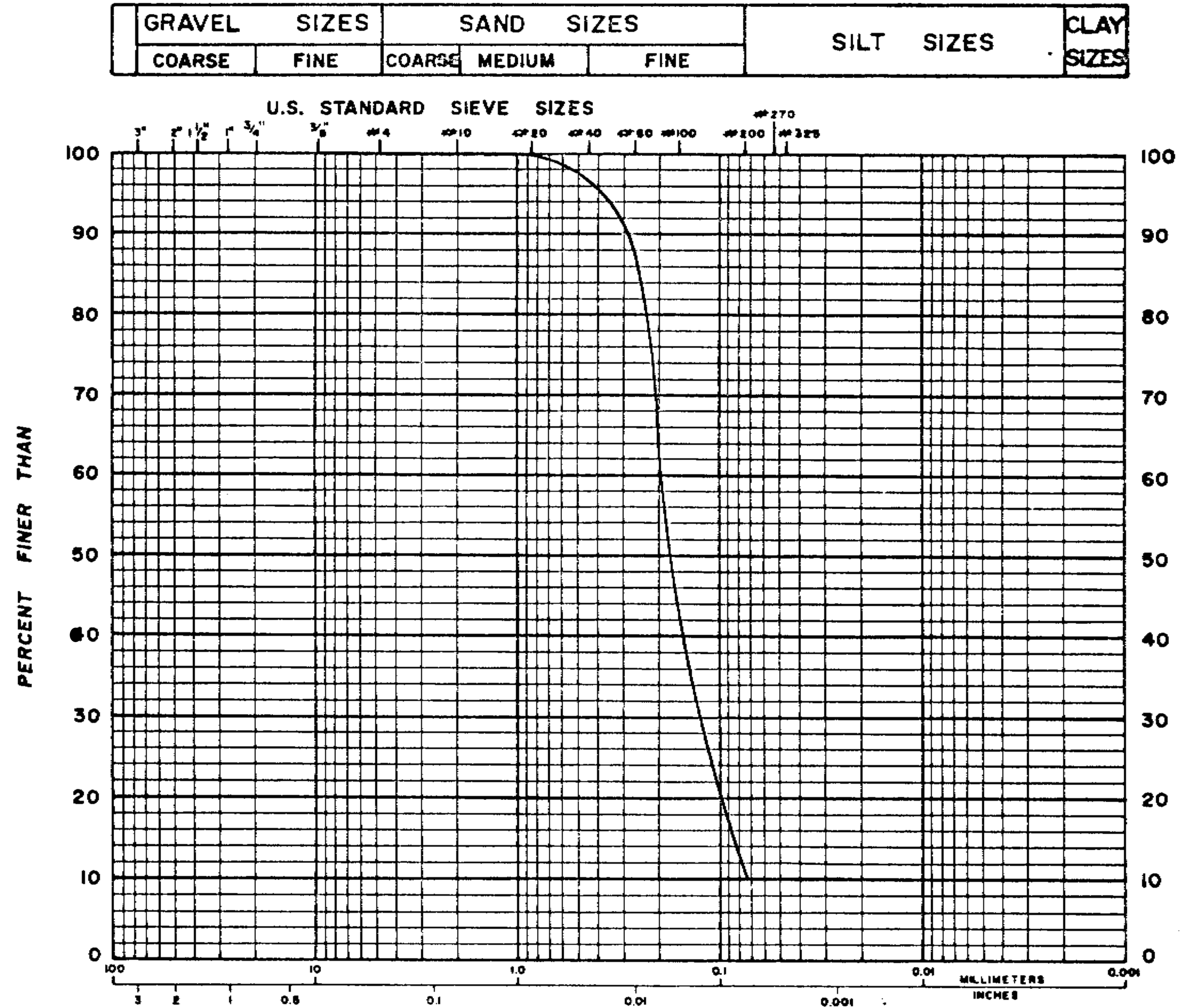
CLIENT: GOVERNMENT OF CANADA, DIAND

PROJECT: GRANULAR MATERIAL EVALUATION

LOCATION: TUKTOYAKTUK AREA, NWT

TEST HOLE NO: 211-2

DEPTH: 5.0m



D_{10} 0.07mm

D_{30} 0.12mm

D_{60} 0.2 mm

C_u 2.9

C_c 1.2

BBT Geotechnical Consultants Ltd.

GRAIN SIZE DISTRIBUTION

DRAWING NO: A83-613-B19

REMARKS:

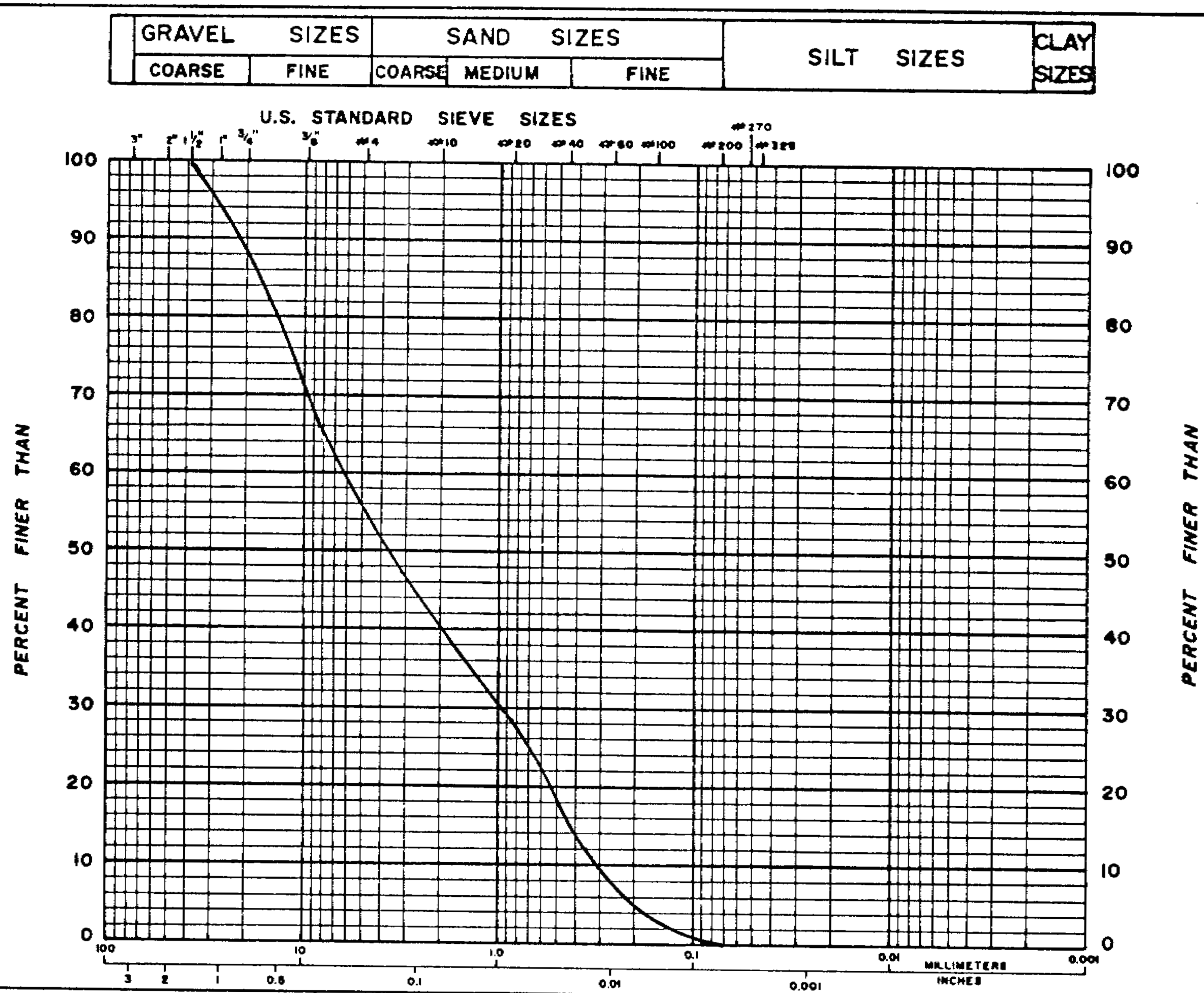
CLIENT: GOVERNMENT OF CANADA, DIAND

PROJECT: GRANULAR MATERIAL EVALUATION

LOCATION: TUKTOYAKTUK AREA, NWT

TEST HOLE NO: 211-3

DEPTH: 2.4



D_{10} 0.3mm
D_{30} 1.0mm
D_{60} 6.0mm
C_u 20.0
C_c 0.6

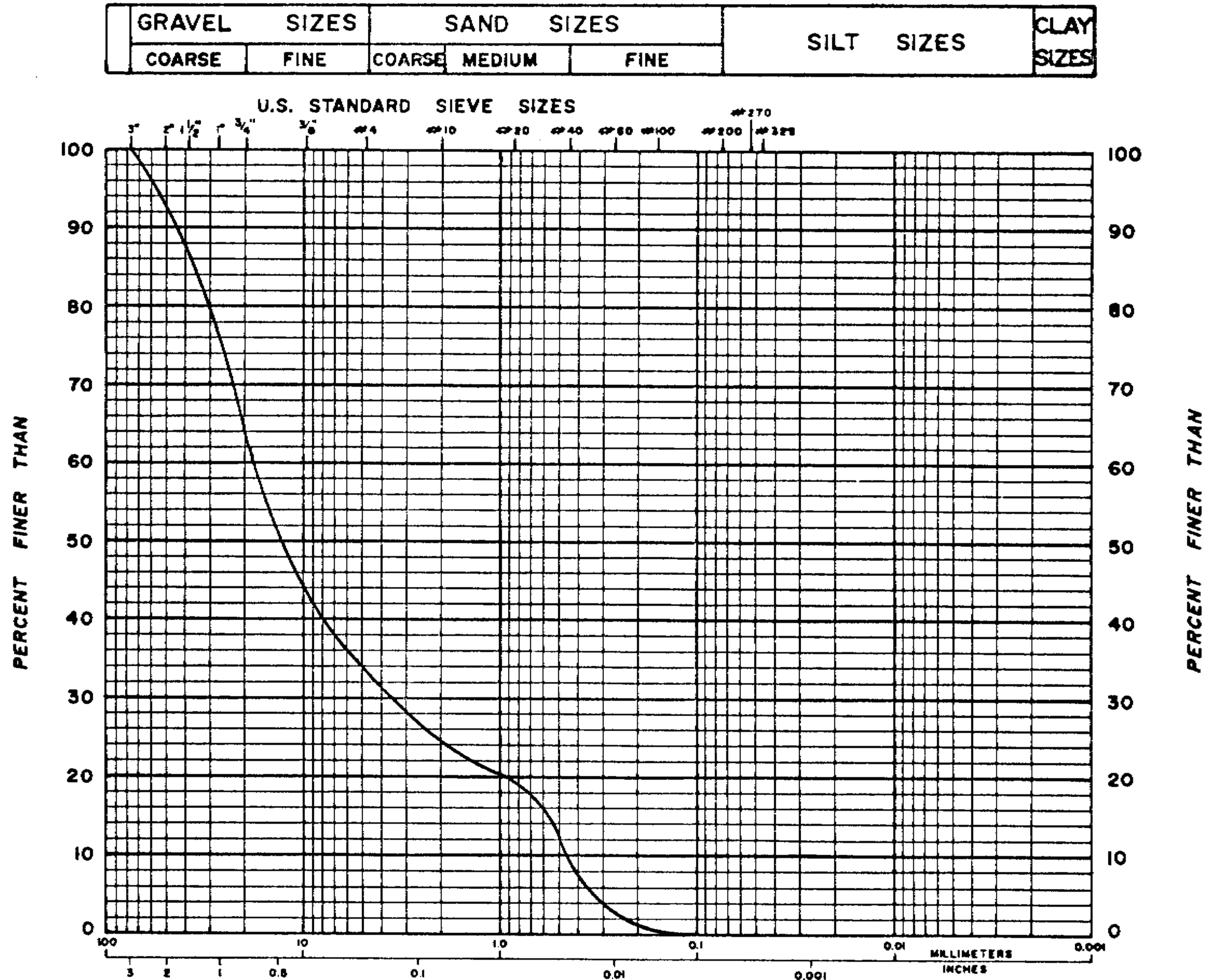
Geotechnical Consultants Ltd.

GRAIN SIZE DISTRIBUTION

DRAWING NO: A83-613-B20

REMARKS:

CLIENT: GOVERNMENT OF CANADA, DIAND
PROJECT: GRANULAR MATERIAL EVALUATION
LOCATION: TUKTOYAKTUK AREA, NWT
TEST HOLE NO: 211-3
DEPTH: 2.7m-3.3m



D_{10} 0.45mm
D_{30} 3.4 mm
D_{60} 18.0 mm
C_u 40.0
C_c 1.4

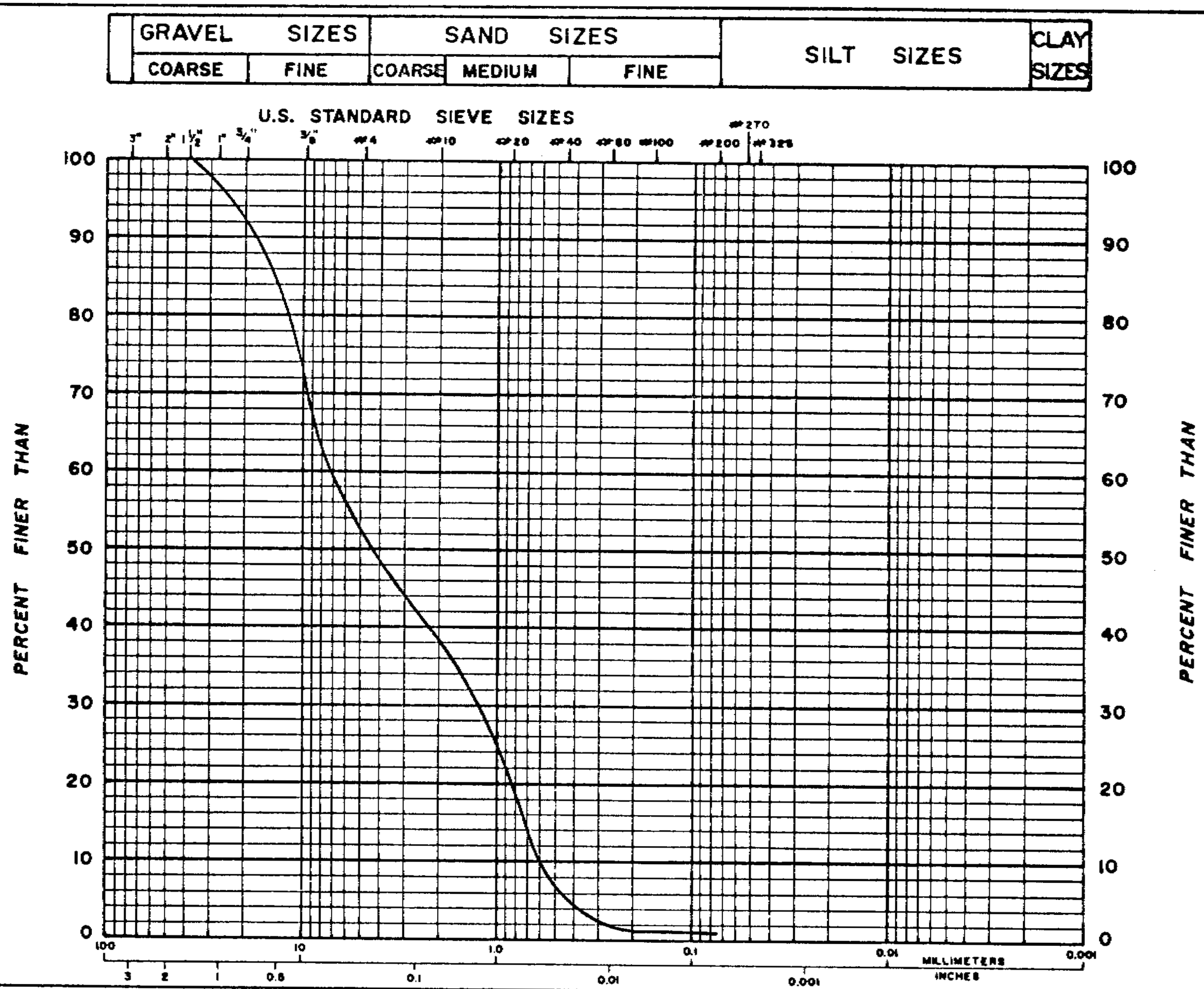
Geotechnical Consultants Ltd.

GRAIN SIZE DISTRIBUTION

DRAWING NO: A83-613-B21

REMARKS:

CLIENT: GOVERNMENT OF CANADA, DIAND
PROJECT: GRANULAR MATERIAL EVALUATION
LOCATION: TUKTOYAKTUK AREA, NWT
TEST HOLE NO: 211-3 **DEPTH:** 4.3M



D_{10}	0.6mm
D_{30}	1.2mm
D_{60}	7.0mm
C_u	11.7
C_c	0.3

Geotechnical Consultants Ltd.

GRAIN SIZE DISTRIBUTION

DRAWING NO: A83-613-B22

REMARKS:

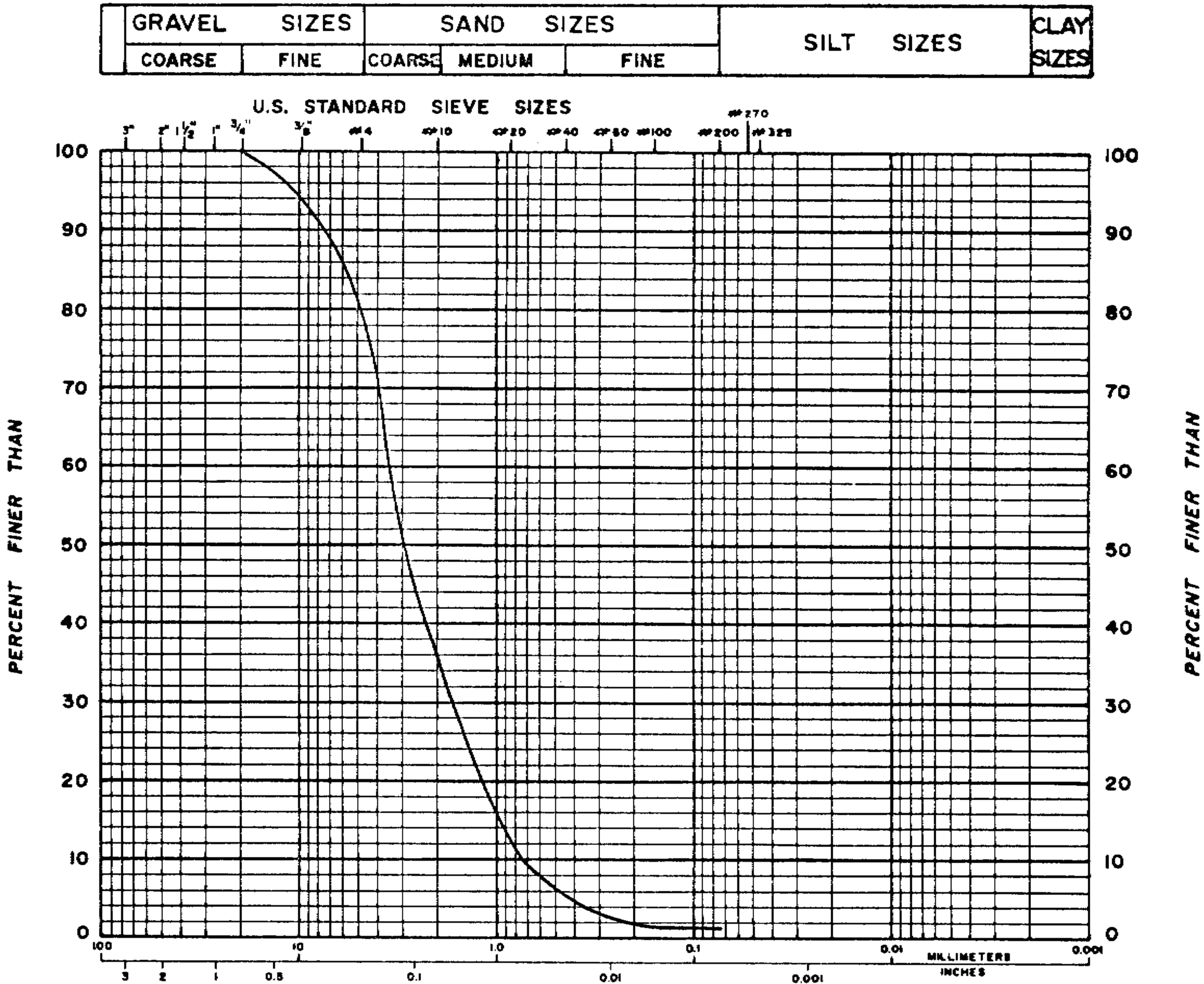
CLIENT: GOVERNMENT OF CANADA, DIAND

PROJECT: GRANULAR MATERIAL EVALUATION

LOCATION: TUKTOYAKTUK AREA, NWT

TEST HOLE NO: 211-3

DEPTH: 4.9m-5.5m



D_{10}	0.75mm
D_{30}	1.7 mm
D_{60}	3.5 mm
C_u	4.7
C_c	1.1

Geotechnical Consultants Ltd.

GRAIN SIZE DISTRIBUTION

DRAWING NO: A83-613-B23

REMARKS:

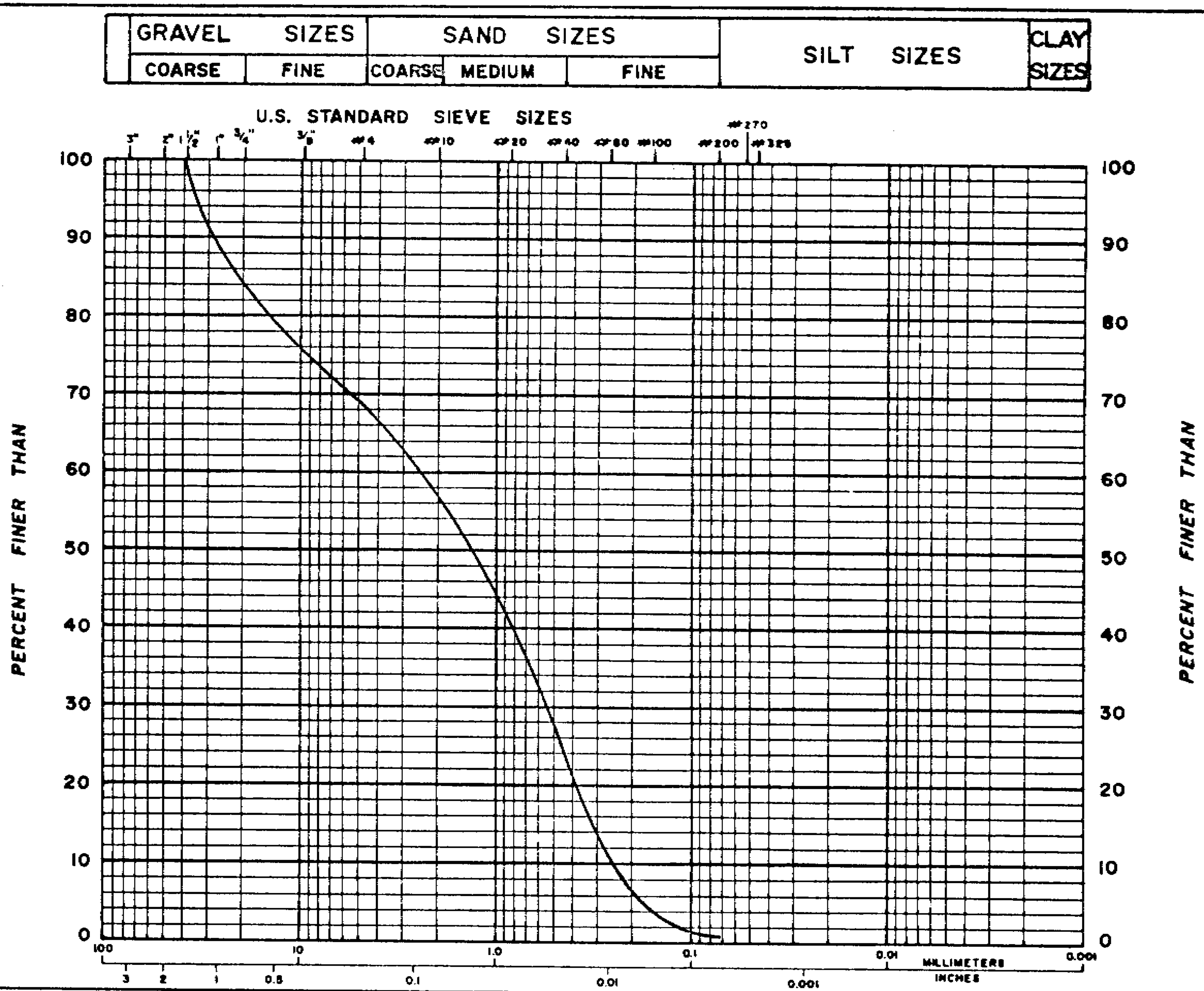
CLIENT: GOVERNMENT OF CANADA, DIAND

PROJECT: GRANULAR MATERIAL EVALUATION

LOCATION: TUKTOYAKTUK AREA, NWT

TEST HOLE NO: 211-5

DEPTH: 0-1.5m



D_{10}	0.25mm
D_{30}	0.54mm
D_{60}	2.4 mm
C_u	9.6
C_c	0.5

Geotechnical Consultants Ltd.

GRAIN SIZE DISTRIBUTION

DRAWING NO: A83-613-B24

REMARKS:

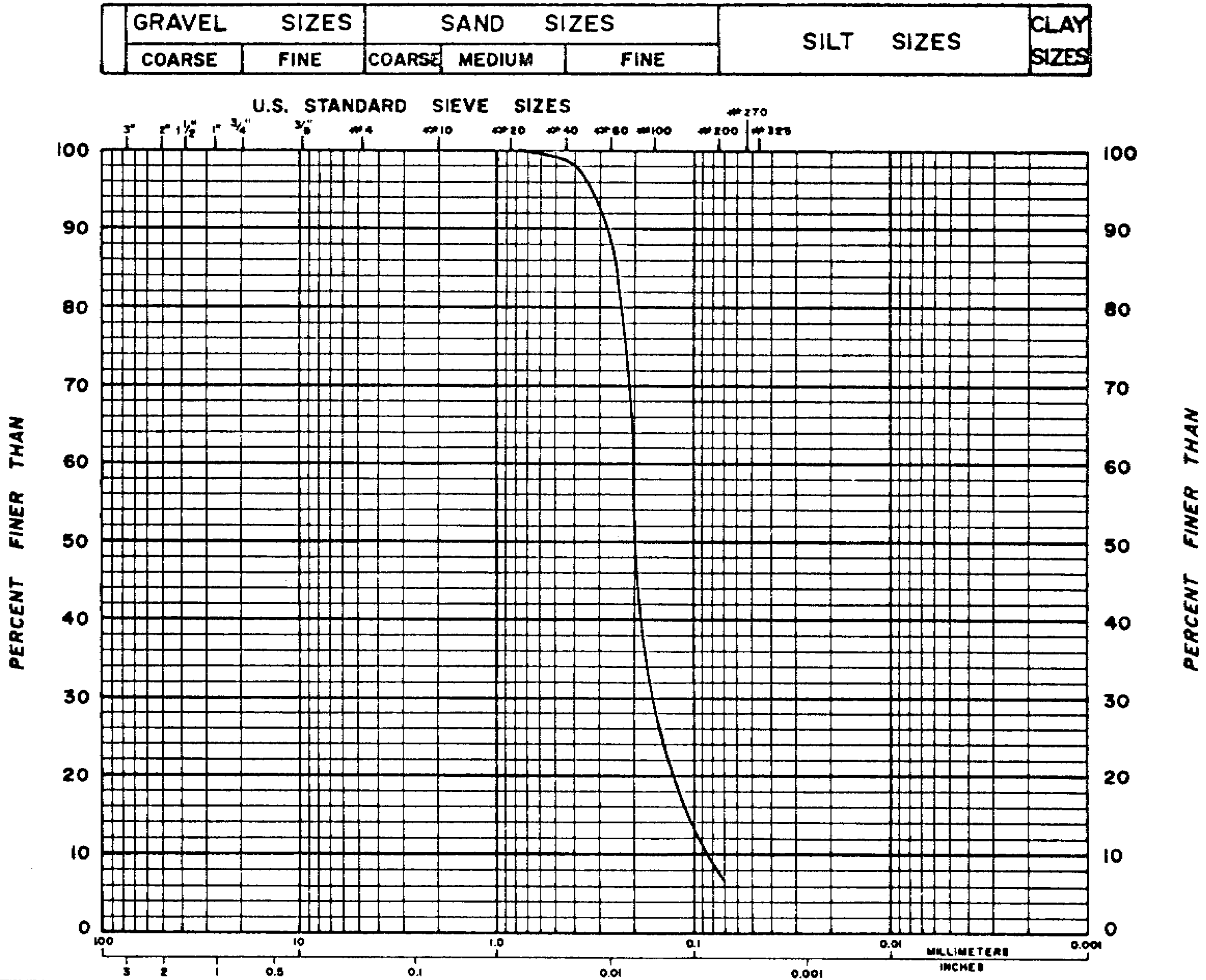
CLIENT: GOVERNMENT OF CANADA, DIAND

PROJECT: GRANULAR MATERIAL EVALUATION

LOCATION: TUKTOYAKTUK AREA, NWT

TEST HOLE NO: 211-5

DEPTH: 1.5m-2.1m



D_{10}	0.085mm
D_{30}	0.17 mm
D_{60}	0.2 mm
C_u	2.4
C_c	1.7

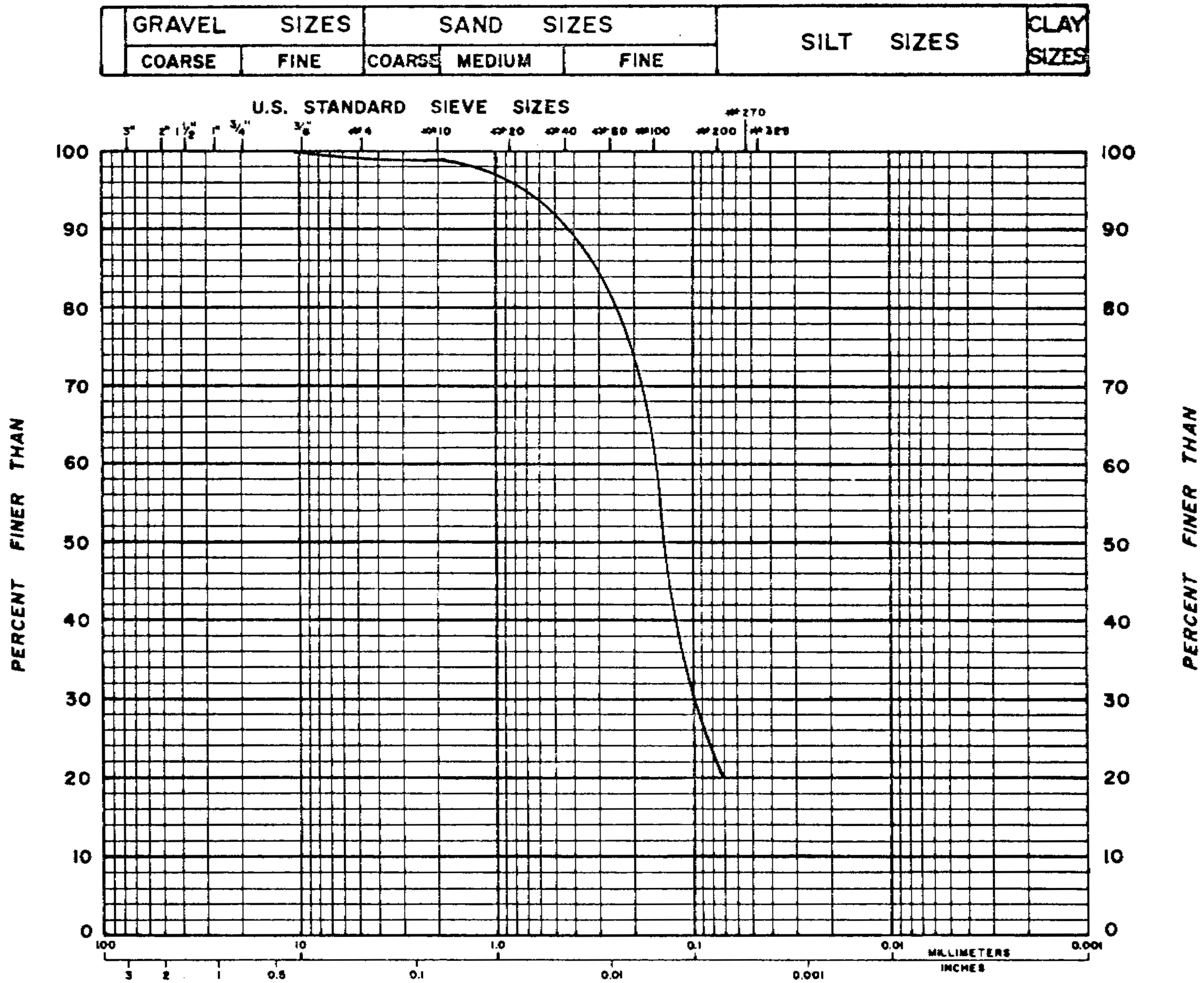
EBA Geotechnical Consultants Ltd.

GRAIN SIZE DISTRIBUTION

DRAWING NO: A83-613-B25

REMARKS:

CLIENT:	GOVERNMENT OF CANADA, DIAND
PROJECT:	GRANULAR MATERIAL EVALUATION
LOCATION:	TUKTOYAKTUK AREA, NWT
TEST HOLE NO:	211-5
DEPTH:	5.8m



EBA Geotechnical Consultants Ltd.

GRAIN SIZE DISTRIBUTION

DRAWING NO: A83-613-B26

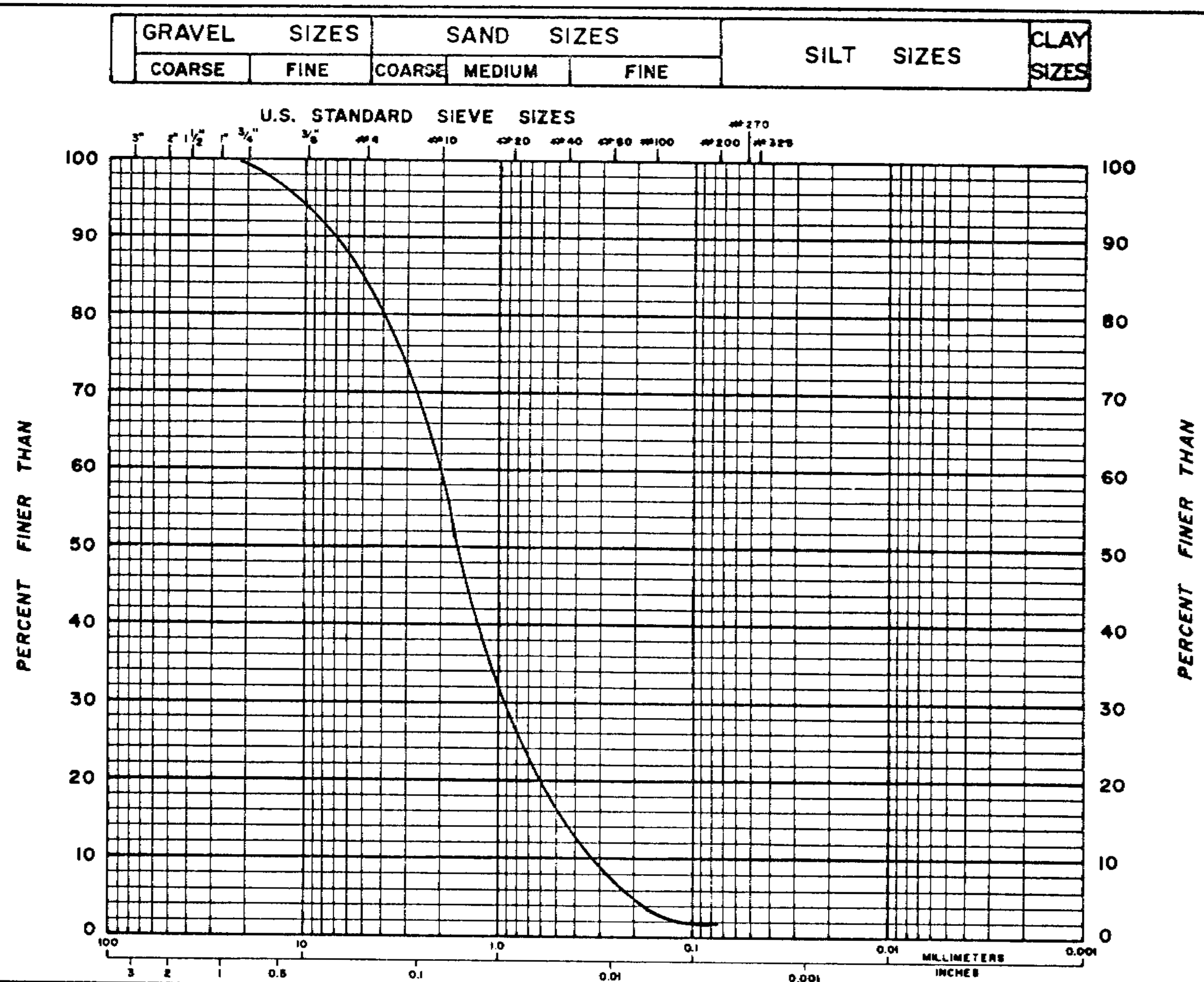
REMARKS:

CLIENT: GOVERNMENT OF CANADA, DIAND

PROJECT: GRANULAR MATERIAL EVALUATION

LOCATION: TUKTOYAKTUK AREA, NWT

TEST HOLE NO: 211-6 **DEPTH:** 0.9m



D_{10}	0.32mm
D_{30}	0.9 mm
D_{60}	2.0 mm
C_u	6.3
C_c	1.3

Geotechnical Consultants Ltd.

GRAIN SIZE DISTRIBUTION

DRAWING NO: A83-613-B27

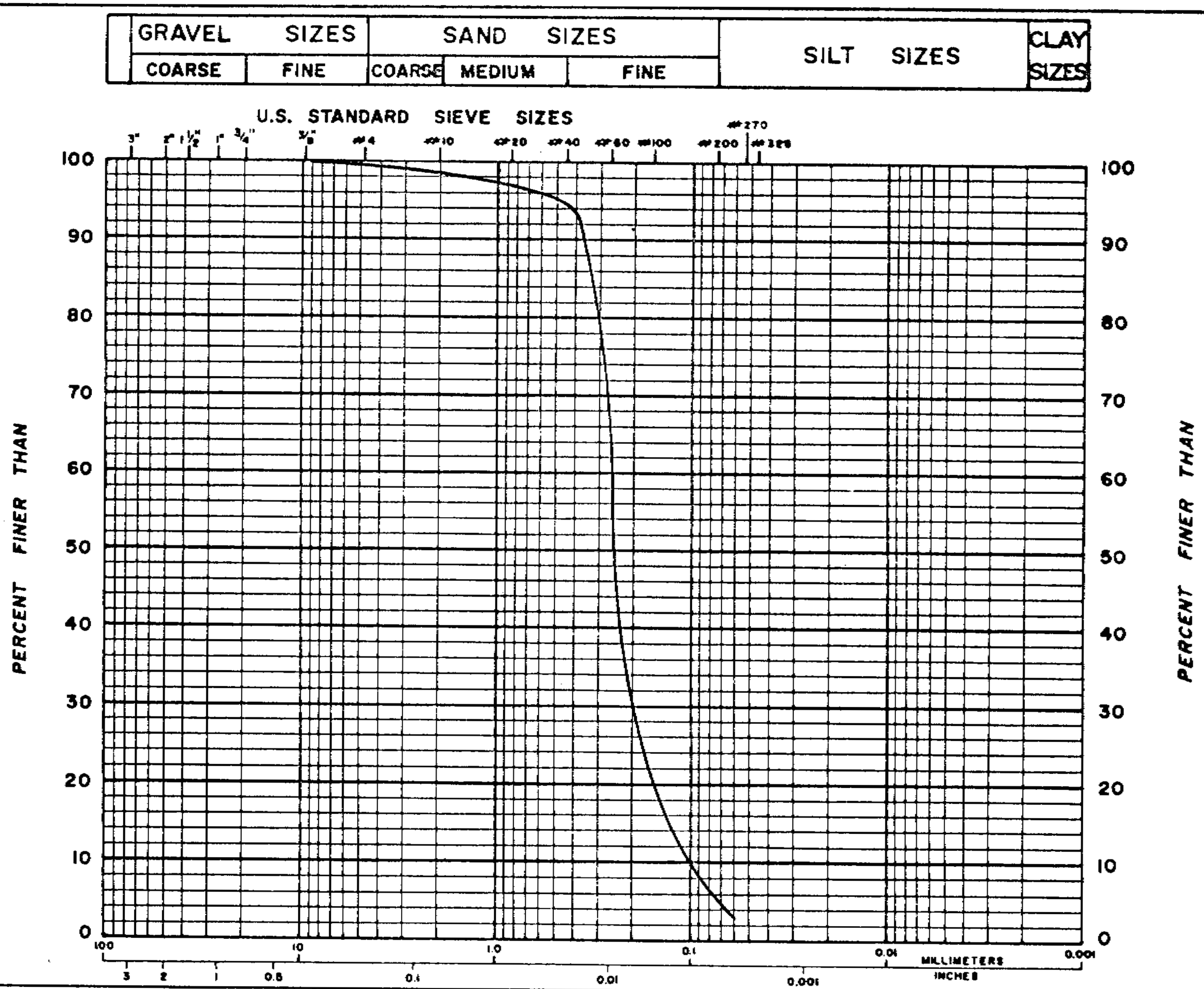
REMARKS:

CLIENT: GOVERNMENT OF CANADA, DIAND

PROJECT: GRANULAR MATERIAL EVALUATION

LOCATION: TUKTOYAKTUK AREA, NWT

TEST HOLE NO: 211-8 **DEPTH:** 0-1.8m



D10 0.1mm

D30 0.2mm

D60 0.25mm

Cu 2.5

Cc 1.6

Geotechnical Consultants Ltd.

GRAIN SIZE DISTRIBUTION

DRAWING NO: A83-613-B28

REMARKS:

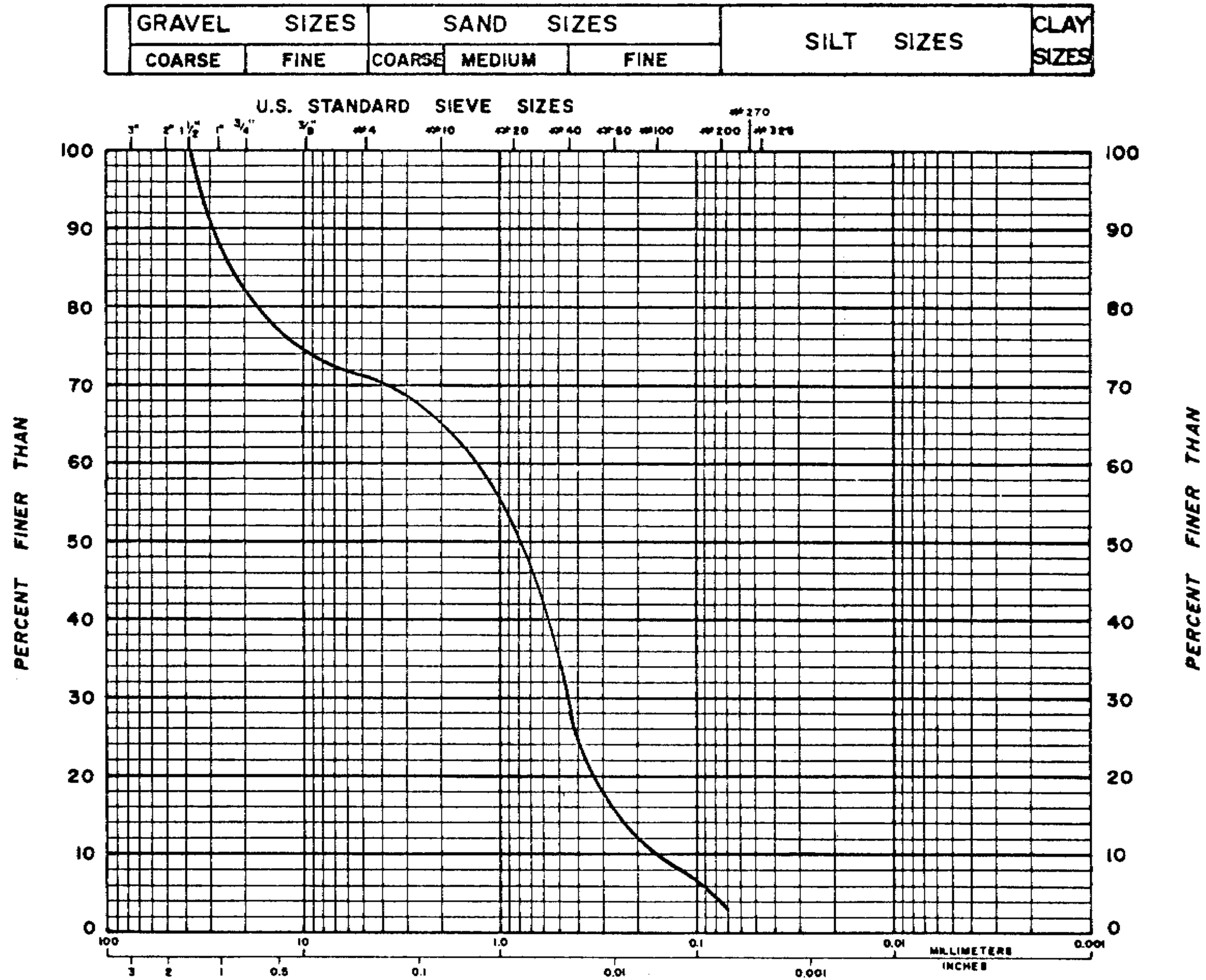
CLIENT: GOVERNMENT OF CANADA, DIAND

PROJECT: GRANULAR MATERIAL EVALUATION

LOCATION: TUKTOYAKTUK AREA, NWT

TEST HOLE NO: 211-8

DEPTH: 4.3m



D_{10} 0.16mm

D_{30} 0.44mm

D_{60} 1.3mm

C_u 8.1

C_c 0.9

Geotechnical Consultants Ltd.

GRAIN SIZE DISTRIBUTION

DRAWING NO: A83-613-B29

REMARKS:

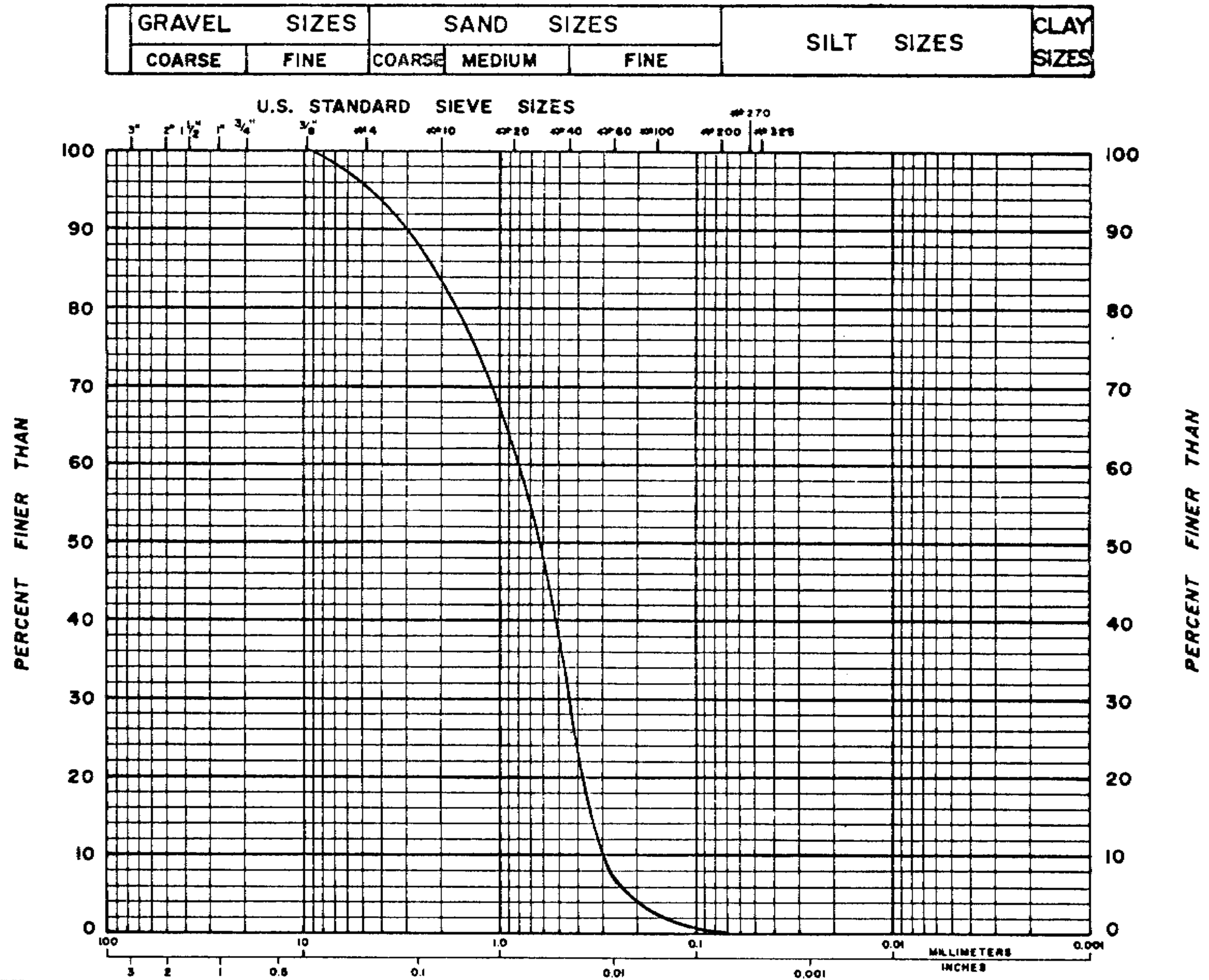
CLIENT: GOVERNMENT OF CANADA, DIAND

PROJECT: GRANULAR MATERIAL EVALUATION

LOCATION: TUKTOYAKTUK AREA, NWT

TEST HOLE NO: 211-8

DEPTH: 7.9m



D_{10}	0.3 mm
D_{30}	0.44mm
D_{60}	0.8mm
C_u	2.7
C_c	0.8

GGC Geotechnical Consultants Ltd.

GRAIN SIZE DISTRIBUTION

DRAWING NO: A83-613-B30

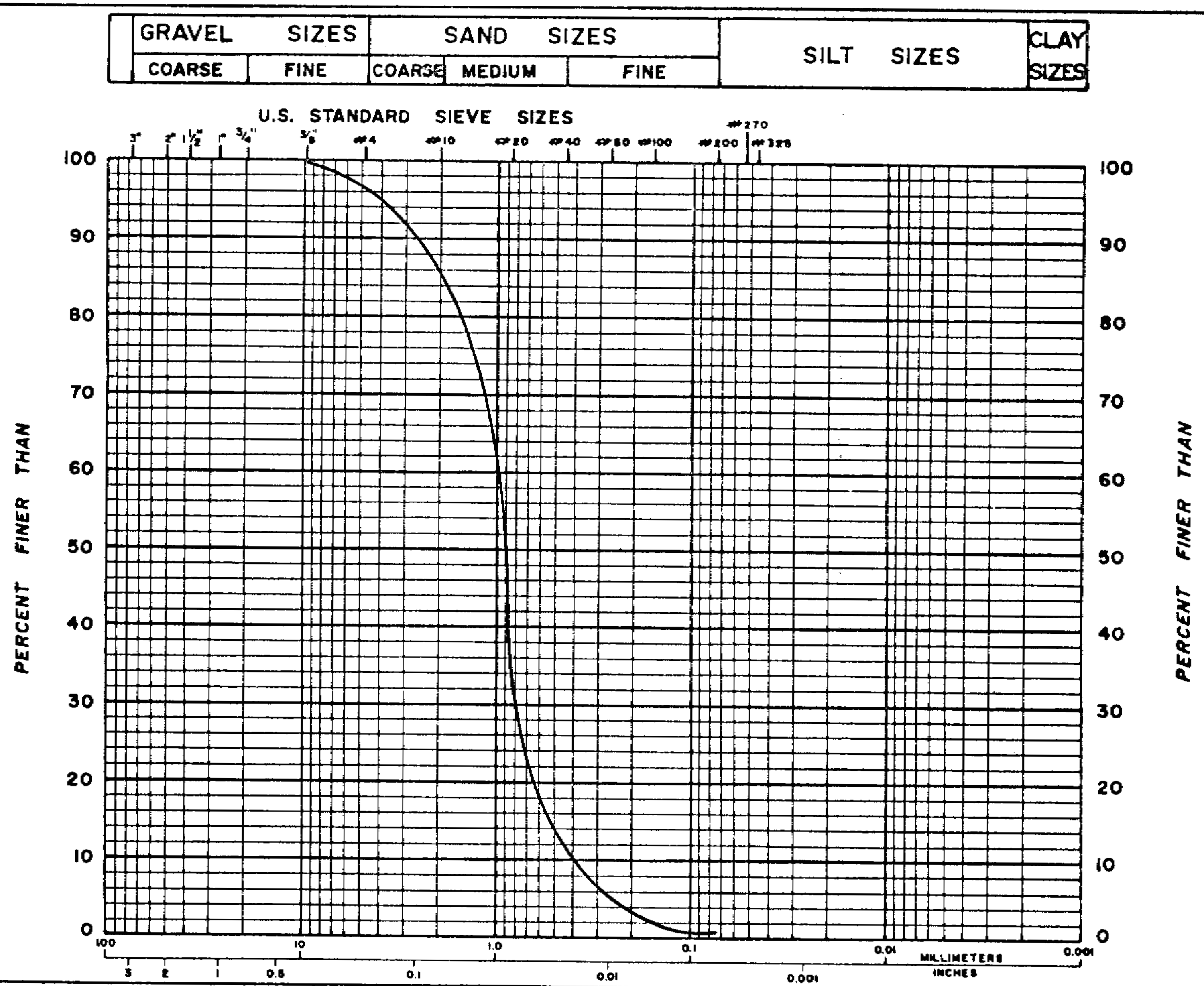
REMARKS:

CLIENT: GOVERNMENT OF CANADA, DIAND

PROJECT: GRANULAR MATERIAL EVALUATION

LOCATION: TUKTOYAKTUK AREA, NWT

TEST HOLE NO: 211-9 **DEPTH:** 0.9m



D_{10}	0.4mm
D_{30}	0.8mm
D_{60}	1.0mm
C_u	2.5
C_c	1.6

Geotechnical Consultants Ltd.

GRAIN SIZE DISTRIBUTION

DRAWING NO: A83-613-B31

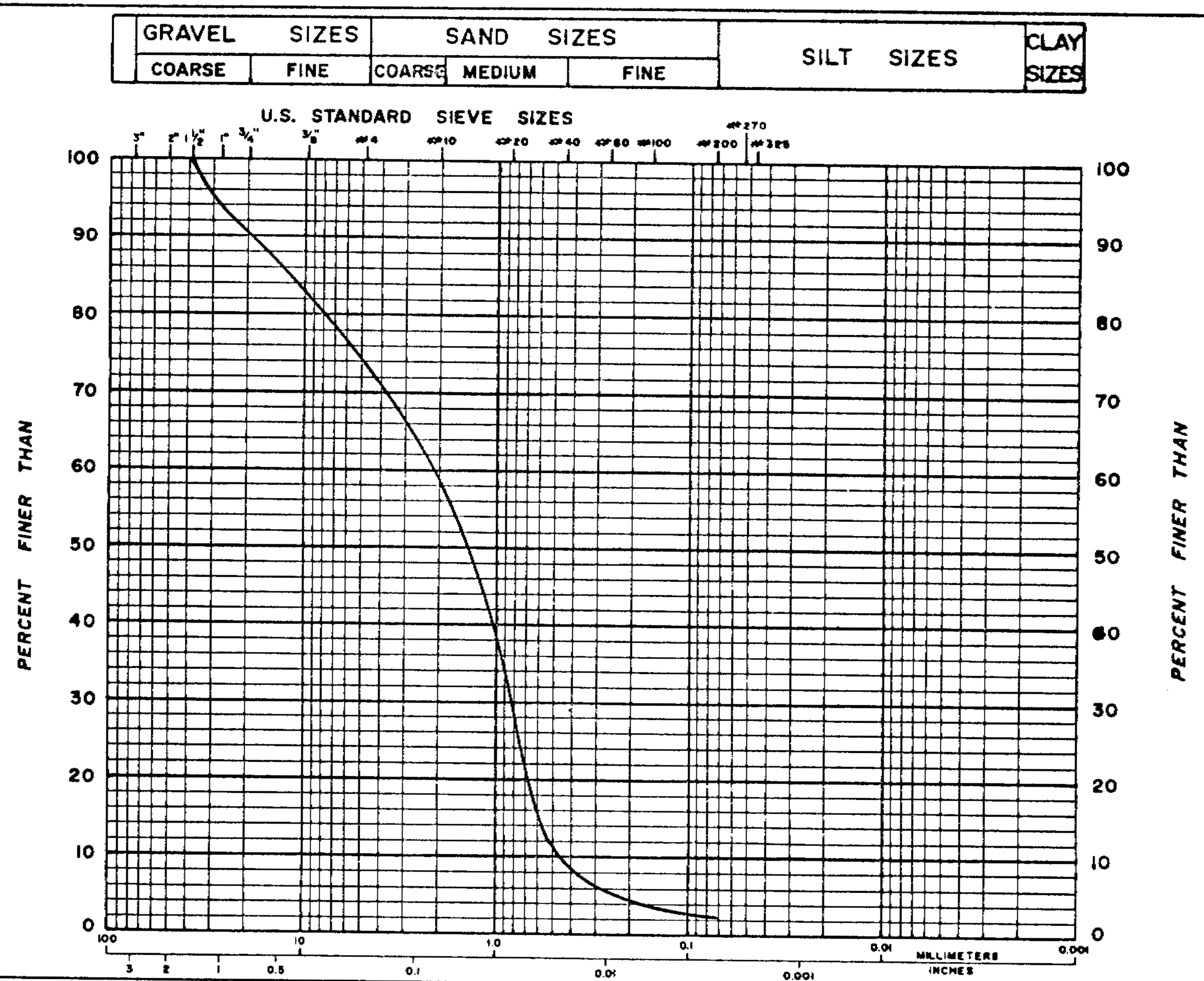
REMARKS:

CLIENT: GOVERNMENT OF CANADA, DIAND

PROJECT: GRANULAR MATERIAL EVALUATION

LOCATION: TUKTOYAKTUK AREA, NWT

TEST HOLE NO: 211-9 **DEPTH:** 2.9m



D_{10}	0.45mm
D_{30}	0.8 mm
D_{60}	2.1 mm
C_u	4.7
C_c	0.7

BBT Geotechnical Consultants Ltd.

GRAIN SIZE DISTRIBUTION

DRAWING NO: A83-613-B32

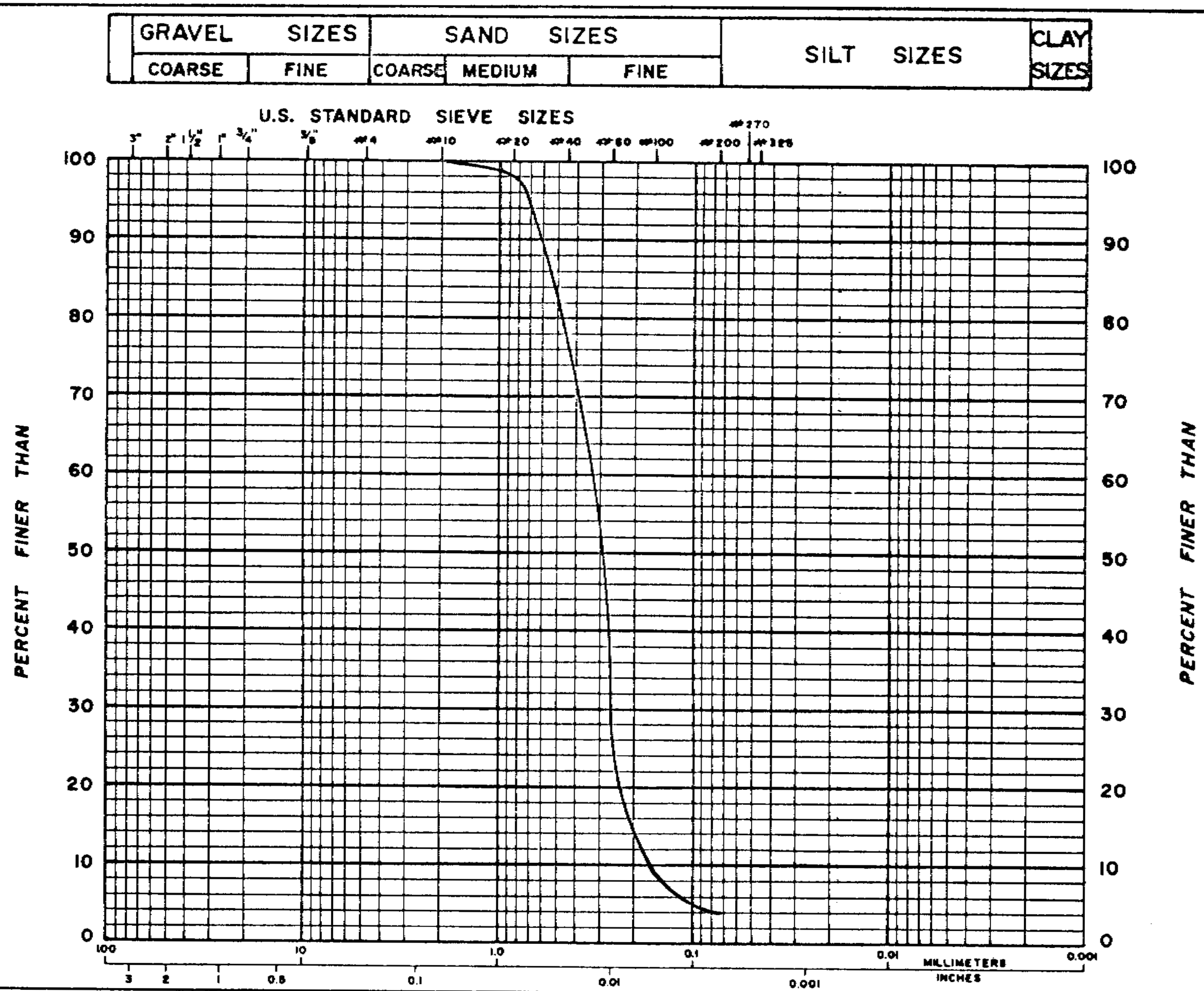
REMARKS:

CLIENT: GOVERNMENT OF CANADA, DIAND

PROJECT: GRANULAR MATERIAL EVALUATION

LOCATION: TUKTOYAKTUK AREA, NWT

TEST HOLE NO: 211-9 **DEPTH:** 4.9m



D_{10}	0.17mm
D_{30}	0.27mm
D_{60}	0.32mm
C_u	1.9
C_c	1.3

EBA Geotechnical Consultants Ltd.

GRAIN SIZE DISTRIBUTION

DRAWING NO: A83-613-B33

REMARKS:

CLIENT: GOVERNMENT OF CANADA, DIAND

PROJECT: GRANULAR MATERIAL EVALUATION

LOCATION: TUKTOYAKTUK AREA, NWT

TEST HOLE NO: 211-9 **DEPTH:** 5.5m

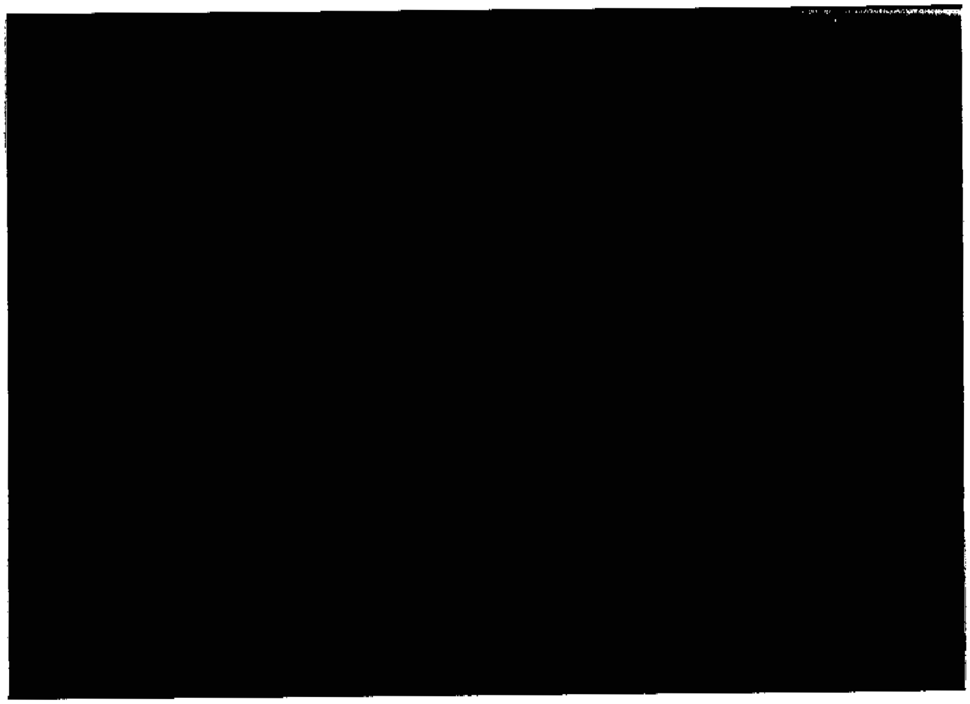


PHOTO 1: Aerial view of the main body of Deposit 168, looking south

PHOTO 2: Rig setting up at location of Test Hole 168-8

PHOTO 3: Drilling and sampling in progress at location of Test Hole 211-3, looking south

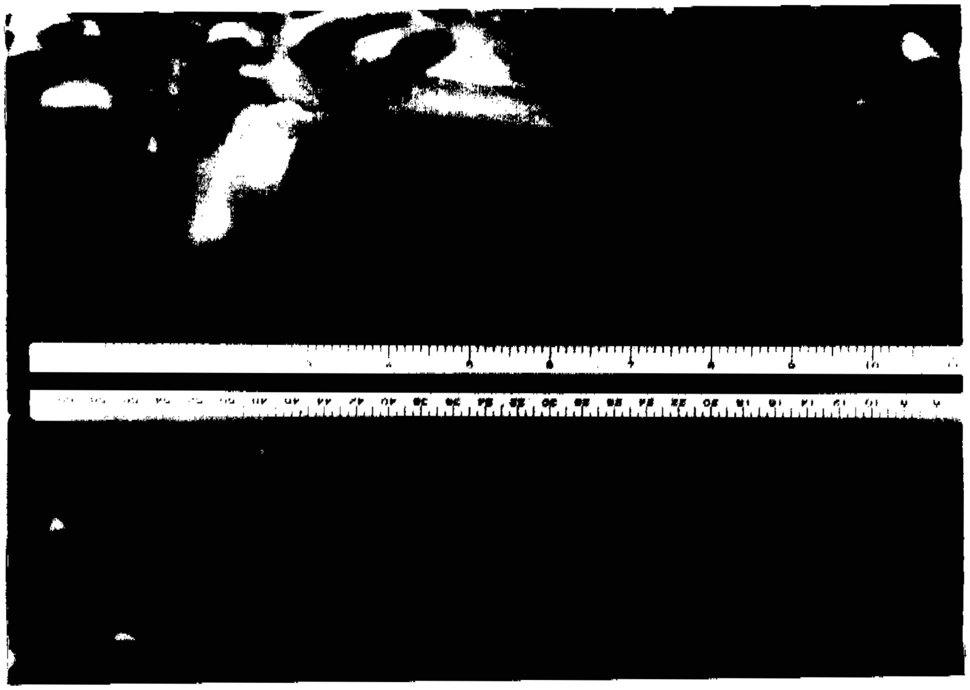


PHOTO 4: Close-up of ground surface in area of Test Hole 211-5

PHOTO 1: Aerial view of the main body of Deposit 168, looking south

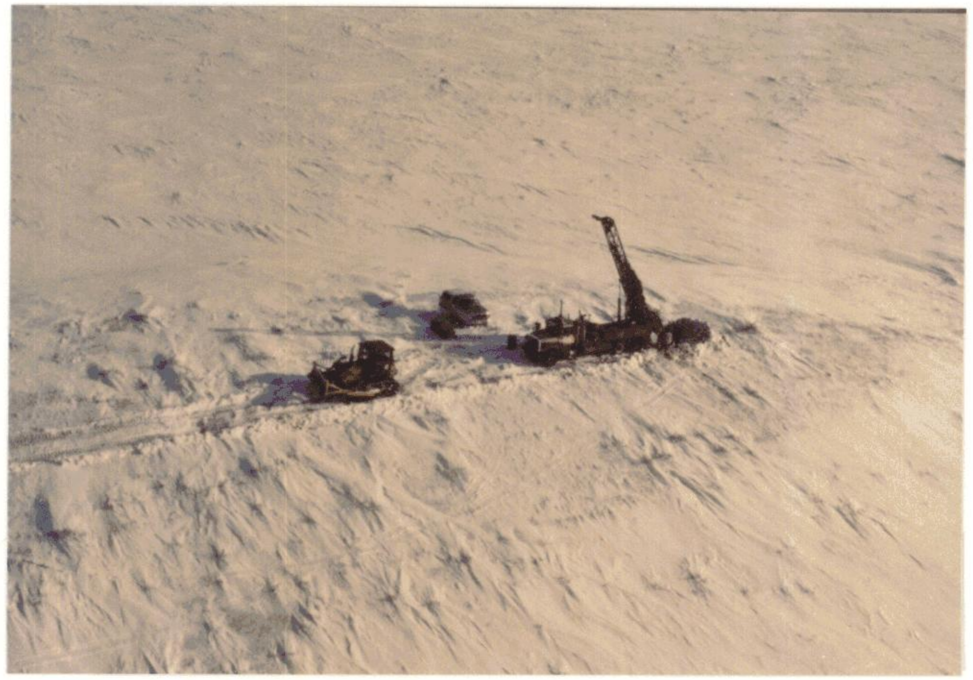


PHOTO 2: Rig setting up at location of Test Hole 168-8

BBT Geotechnical Consultants Ltd.
BBT GEOTECHNICAL CONSULTANTS LTD.

PHOTO 3: Drilling and sampling in progress at location of Test Hole 211-3, looking south

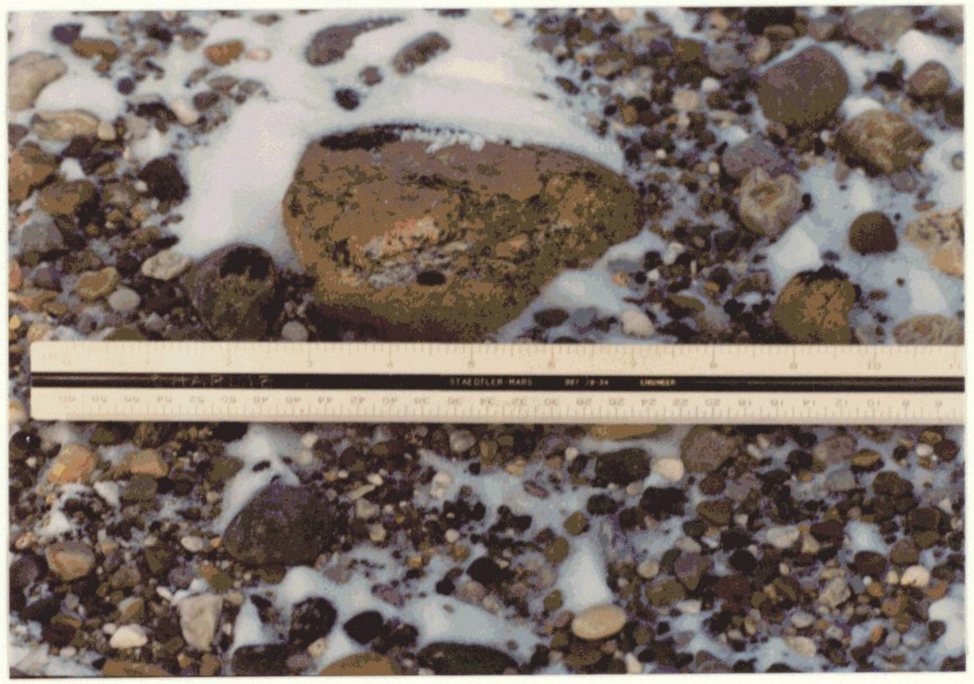


PHOTO 4: Close-up of ground surface in area of Test Hole 211-5

BBT Geotechnical Consultants Ltd.
BBT GEOTECHNICAL CONSULTANTS LTD.

APPENDIX D

EXPLANATION OF TRAFFIC [illegible]

USED ON TEST [illegible]

EXPLANATION OF TERMS AND SYMBOLS USED ON TEST HOLE LOGS

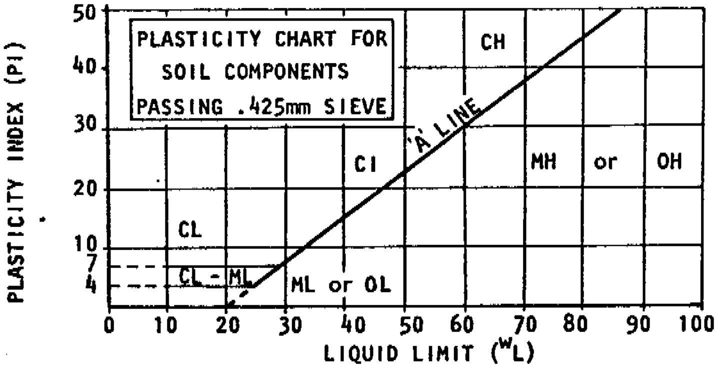
PART I - DEFINITION OF SOIL CLASSIFICATION SYSTEM

The soil classification system used is a modified version of the Unified Soil Classification System ("The Unified Soil Classification System" Technical Memorandum No. 3-357 Vol. 1, 1953, the Waterways and Research Station, USA). The modification is that a clay having a liquid limit between 30% and 50% is recognized separately as a medium plastic clay.

MAJOR DIVISION (Excluding particles > 76 mm)			GROUP SYMBOL	MATERIAL TYPES AND TYPICAL NAMES	LABORATORY CLASSIFICATION CRITERIA	
COARSE-GRAINED SOILS (> 50% BY WEIGHT LARGER THAN 0.074 mm SIEVE)	GRAVELS MORE THAN HALF OF COARSE FRACTION LARGER THAN 4.75 mm SIEVE	CLEAN GRAVELS (NO APPRECIABLE FINES)	GW	Well graded gravels and gravel-sand mixtures. Wide range in grain size and substantial amounts of all intermediate particle sizes	$C_u \frac{D_{60}}{D_{10}} > 4$ $C_c \frac{(D_{30})^2}{D_{10} \times D_{60}}$ 1 to 3	
			GP	Poorly graded gravels and gravel-sand mixtures. Predominately one size or a range of sizes with some intermediate sizes missing	NOT MEETING ABOVE REQUIREMENTS	
		DIRTY GRAVELS (WITH FINES)	GM	Silty gravels, poorly graded gravel-sand-silt mixtures. Non-plastic fines (see below)	CONTENT OF FINES EXCEEDS 12%	ATTERBERG LIMITS BELOW 'A' LINE AND P. I. < 4.
			GC	Clayey gravels, poorly graded gravel-sand-clay mixtures. Plastic fines (see below).		ATTERBERG LIMITS ABOVE 'A' LINE OR P. I. > 7.
	SANDS MORE THAN HALF OF COARSE FRACTION SMALLER THAN 4.75 mm SIEVE	CLEAN SANDS (NO APPRECIABLE FINES)	SW	Well graded sands, gravelly sands. Wide range in grain size and substantial amounts of all intermediate particle sizes.	$C_u \frac{D_{60}}{D_{10}} > 6$ $C_c \frac{(D_{30})^2}{C_{10} \times D_{60}}$ 1 to 3	
			SP	Poorly graded sands, gravelly sands. Predominately one size or a range of sizes with some intermediate sizes missing.	NOT MEETING ABOVE REQUIREMENTS	
		DIRTY SANDS (WITH FINES)	SM	Silty sands, poorly graded sand-silt mixtures. Non-plastic fines (see below)	CONTENT OF FINES EXCEEDS 12%	ATTERBERG LIMITS BELOW 'A' LINE AND P. I. < 4.
			SC	Clayey sands, poorly graded sand-clay mixtures. Plastic fines (see below)		ATTERBERG LIMITS ABOVE 'A' LINE OR P. I. > 7.
FINE-GRAINED SOILS (> 50% BY WEIGHT PASSES 0.074 mm SIEVE)	SILTS, BELOW 'A' LINE, NEGLIGIBLE ORGANIC CONTENT	$W_L < 50$	ML	Inorganic silts and very fine sands. Rock flour, silty sands of slight plasticity.	CLASSIFICATION IS ACCORDING TO PLASTICITY CHART (SEE BELOW)	
		$W_L > 50$	MH	Inorganic silts, micaceous or diatomaceous. Fine, sandy or silty soils. Elastic silts.		
	CLAYS, ABOVE 'A' LINE ON PLASTICITY CHART, NEGLIGIBLE ORGANIC CONTENT	$W_L < 50$	CL	Inorganic clays of low plasticity. Gravelly sandy, or silty clays. Lean clays.		
		$30 < W_L < 50$	CI	Inorganic clays of medium plasticity. Silty clays.		
		$W_L > 50$	CH	Inorganic clays of high plasticity. Fat clays.		
	ORGANIC SILTS & CLAYS, BELOW 'A' LINE ON CHART	$W_L < 50$	OL	Organic silts and organic silty clays of low plasticity.		
		$W_L > 50$	OH	Organic clays of high plasticity.		
HIGHLY ORGANIC			Pt	Peat and other highly organic soils, strong color or odor, and often fibrous texture.		

DEFINITION OF SOIL COMPONENTS

FRACTION		SIEVE SIZE PASSING	SIEVE SIZE RETAINED
GRAVEL	COARSE (c)	76 mm	19 mm
	FINE (f)	19 mm	4.75 mm
SAND	COARSE (c)	4.75 mm	2.00 mm
	MEDIUM (m)	2.00 mm	.425mm
	FINE (f)	.425mm	.074mm
SILT (NON-PLASTIC) CLAY (PLASTIC)		0.074 mm	



BOUNDARY CLASSIFICATIONS POSSESSING CHARACTERISTICS OF TWO GROUPS ARE GIVEN COMBINED GROUP SYMBOLS eg. GW-GC IS A WELL-GRADED GRAVEL SAND MIXTURE WITH CLAY BINDER BETWEEN 5% AND 12%.

BBT Geotechnical Consultants Ltd.
BBT GEOTECHNICAL CONSULTANTS LTD.

PART 2 - DEFINITION OF OTHER TERMS USED ON TEST HOLE LOGS

1. OVERSIZE MATERIAL

Rounded or Subrounded

Cobbles - 76 mm to 200 mm
Boulders - greater than 200 mm

Not Rounded

Rock Fragments - greater than 76 mm
Rocks - greater than 0.75 m^3 in volume

2. DEFINING RANGES OF PERCENTAGE BY WEIGHT OF MINOR COMPONENTS

Percent	Description
50 - 35	and
35 - 20	some
20 - 10	little
10 - 1	trace

3. CONSISTENCY OF FINE-GRAINED SOILS

NO. OF BLOWS (N)	CONSISTENCY	APPROXIMATE UNCONFINED COMPRESSIVE STRENGTH(kPa)
< 2	very soft	< 25
2 to 4	soft	25 to 30
4 to 8	firm	50 to 100
8 to 15	stiff	100 to 200
15 to 30	very stiff	200 to 400
> 30	hard	> 400

4. DENSITY OF COARSE-GRAINED SOILS

NO. OF BLOWS(N)	DESCRIPTIVE TERM
< 4	very loose
4 - 10	loose
10 - 30	medium dense
30 - 50	dense
> 50	very dense

PART 3 - DEFINITION OF SYMBOLS USED ON TEST HOLE LOGS

NRC - ICE - Ground Ice Description - As per Guide to a Field Description of Permafrost for Engineering Purposes, NRC 7576 Technical Memorandum 79 - for brief description, see next page under OTHER TESTS.

N_B - Becker Hammer Blows - The number of blows by a Becker diesel hammer required to drive the casing 0.3 m into the soil.

γ_D - Dry Density - $\frac{\text{Dry Weight}}{\text{Volume}} \left(\frac{kg}{m^3}\right)$

U - Unconfined Compressive Strength (kPa)

PP - Pocket Penetrometer Reading (kPa)

P_W - Plastic Limit (%)

L_W - Liquid Limit (%)

W% - Water Content - $\frac{\text{Weight Water}}{\text{Weight of Dry Soil}}$ X 100

ST - Sample Types - This column depicts the type, and approximate length and depth of each sample attempted.

Disturbed Undisturbed Not Recovered

DEPTH - Distance below ground level

SYM - Graphic symbols used to define soil types

Gravel Sand Silt Clay Organic Bedrock

Combinations of above may be used with predominant soil type in heavy line with modifying soil type in light line.

USC - Unified Soil Classification Symbol

PART 3 - DEFINITION OF SYMBOLS USED ON TEST HOLE LOGS(cont)

OTHER TESTS

MA - Mechanical Grain Size Analysis

GS - Mechanical Grain Size Analysis with Hydrometer

FINES - Fraction washing past 0.074 mm Sieve

SO_4 - Concentration of Soluble Sulphates

GROUND ICE DESCRIPTION

A. ICE - NOT VISIBLE

GROUP	SUBGROUP		
SYMBOL	SYMBOL		DESCRIPTION
N	N_f		Poorly bonded or friable
	N_b	Nbn	Well bonded - no excess ice
		Nbe	Well bonded - excess ice

B. VISIBLE ICE < 25 mm THICK

GROUP	SUBGROUP	
SYMBOL	SYMBOL	DESCRIPTION
V	V_x	Individual ice crystal or inclusions
	V_c	Ice coatings on particles
	V_r	Random or irregularly oriented ice formations
	V_s	Stratified or distinctly oriented ice formations

C. VISIBLE ICE > 25 mm THICK

GROUP	SUBGROUP	
SYMBOL	SYMBOL	DESCRIPTION
ICE	ICE + SOIL TYPE	Ice with soil inclusions (approximate % soil also given)
	ICE	Ice without soil inclusions

REFERENCES

1. Canadian Standards Association (CSA), Section CAN3-A23.1-M77 "Concrete Materials and Methods of Concrete Construction."

2. Rampton V.N., 1974, "Terrain Evaluation with respect to Pipeline Construction, Mackenzie Transportation Corridor Northern Part, lat. 68° N to coast; Environmental-Social Program, Northern Pipelines," Report No. 73-47.

3. Rampton V.N. and Bouchard, M., 1975, "Surficial Geology of Tuktoyaktuk, District of Mackenzie; Geol. Sur. Can.," Paper 74-53.

4. Extract from Ripley, Klohn & Leonoff International Ltd., "Granular Materials Inventory, Zone II", report submitted to Department of Indian Affairs and Northern Development, 1973.

5. Extract from Hardy & Associates Ltd., 1977 Report on preliminary evaluation of granular deposits in the Tuktoyaktuk area, N.W.T.