ELMER W. BROOKER & ASSOCIATES LTD.
SOIL & FOUNDATION CONSULTANTS

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December 23, 1971

Government of Canada
Dept. of Indian Affairs and Northern Development
Technical Services Branch
400 Laurier Avenue West
Ottawa 4, Ontario

Attention: Mr. P. Stumes

Gentlemen:

Subject: Gravel Resource Evaluation - Dawson, Yukon Territory

Laboratory analyses of gravel samples from Dawson, Yukon are complete and the results are enclosed for your review. Samples from the four prospective pits, discussed in our report on the site visit (November, 1971), were shipped to our laboratory by Mr. J. Gould, Department Custodian at Dawson. The test program and subsequent discussion of results was authorized by Mr. P. Stumes, Restoration Engineer (DIAND).

Testing Program

The samples, which arrived in a frozen condition, were immediately dried and the moisture content of the total sample determined. These results are believed to be reasonably representativ of field moisture retention capacities. The grain size distribution of each sample was obtained by sieve analysis. Results of these tests are plotted in Figures 1 to 6 respectively. The fine fraction of samples number 1 to 3 were tested for organic impurities using the ASTM standard colour test (C40-66). Sample description and a summary of the test results obtained are listed in Table 1.

TABLE I

SUMMARY OF TEST RESULTS
DAWSON GRAVEL EVALUATION

Sample No.	Source	Mechanical Analysis % Gravel	% Sand	% Silt (& Clay)	Moisture Content (as received) %	Colour Test	Probable History	Remarks
1	Pit - north end of 5th Avenue	80	20	--	8.8	OK (plate 2)	Colluvium (SS 4.1)*	angular particles contains serpentine
2	Pit - south end of town, cemetery road	65	30	5	5.6	Marginal (plate 3)	Glacial Till (SS 4.2)	sub rounded particles well graded
3	Pit - 'white channel gravel' - Lovett Gulch	53	45	2	6.6	OK (plate 1)	Mine Tailings (SS 4.3)	angular particles friable particles (schist)
4	Yukon River	100	--	--	1.5	--	Tailings (SS 4.4)	washed gravel which is highly variably in gradation (sample may not be representative)
5	Excavation - St. Mary's Hospital	2	73	25	8.3	--	Flood plain deposit, natural soil	silty sand

* Refers to subsection of site visit report (November 1971) where prospective gravel pits are discussed.

Suitability for Gravel Pad Foundations

Recommended materials for gravel pad construction are illustrated in Figure 7. Basements which are currently inundated should be cleaned out and filled with course, Yukon River tailings (approximately 6 inch maximum particle diameter) as discussed in the site visit report. The coarse gravel should be capped with a 6 inch minimum thickness of select tailing material (3 inch maximum). This coarse pad will be relatively simple to place and should remain stable under saturated freezing conditions.

The glacial till (Sample No. 2) is considered most suitable of the soils analysed for above ground pad construction. It contains sufficient fines to act as a 'binder' and gradation is suitable for compaction to a high density. Moreover, the finished surface should be impervious enough to shed surface water.

Material from the north end pit Sample No. 1 is probably also suitable for pad construction although not as desirable as the gravel recommended. The white channel gravel (Sample No. 3) is not considered suitable as this material lacks fines and thus would be very pervious.

Suitability for Concrete Aggregate

Samples 1, 2, and 3 have been studied briefly to determine which is most suitable for concrete aggregates. Figures 8, 9, and 10 illustrate the new grain size distribution curves obtained if each of these samples were split on a No. 4 sieve. Samples 1 and 2 do not meet the ASTM specification for fine aggregates, and would require expensive processing to achieve the required result. The white channel gravel on the other hand does satisfy the gradation criteria for fine concrete aggregate (Figure 10). Moreover, if the coarse fraction is sieved on a 1 inch screen, coarse aggregate with an acceptable gradation is obtained.

White channel gravel would not have to be split on a No. 4 sieve in the field. The pit run material must however be sieved on a 1 inch screen to obtain material of the gradation shown in Figure 10. The new sample would be a mixture of 70% fine aggregate and 30% coarse aggregate. Since an 'average' concrete mix contains 42% fine aggregate and 58% coarse aggregate, additional coarse material would have to be added. For example, to obtain 100 pounds of acceptable mix, 60 pounds of minus 1 inch white channel gravel (42 lbs. fine, 18 lbs. coarse) would have to be combined with an additional 40 pounds of coarse aggregate. The coarse aggregate could readily be processed from Yukon River tailings.

Although gradation of the white channel gravel will result in economical processing of concrete aggregates, mineralogy of the material is not considered ideal. A petrographic analysis was not done, but a cursory inspection indicates that the gravel is composed of metamorphic rock fragments, predominantly quartzite and schist. The schist is a friable material which will be detrimental to strength and durability of the concrete. Laboratory mix designs will have to be carried out in order to assess strength characteristics and precisely determine mixing proportions for the various aggregates. The aggregates are expected, however, to be suitable for production of concrete acceptable for the anticipated re-construction project.

I hope these comments are useful for preliminary design and economic assessment of the proposed project. Additional work will be required to provide a better assessment of mix design, strength and durability of the concrete prior to construction. This work could be incorporated into the proposed spring drilling program if requirements for concrete are better defined at that time.

Yours truly,

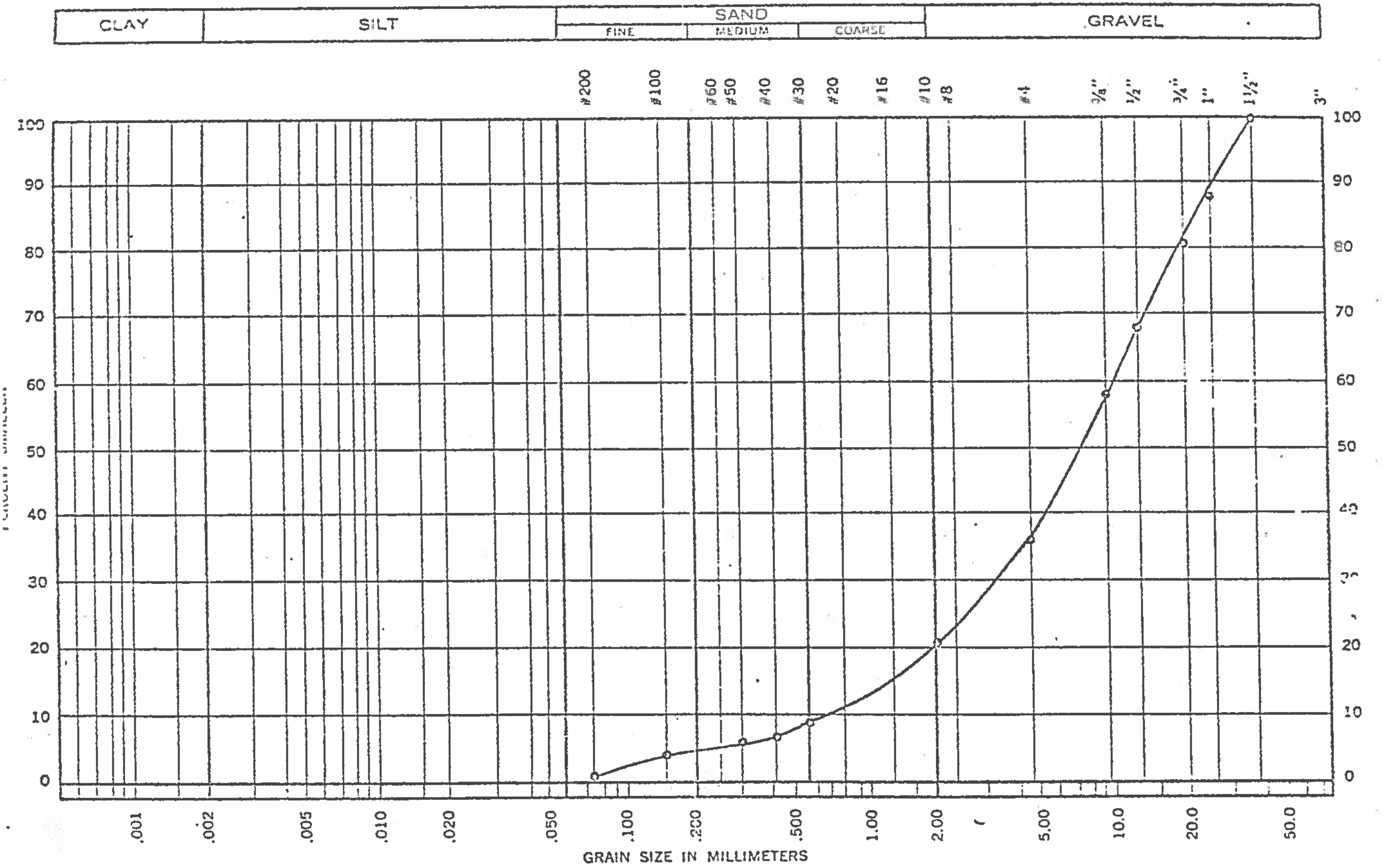
ELMER W. BROOKER & ASSOCIATES LTD.

Don W. Hayley, P. Eng.

DWH:sjw

cc Mr. W. Wells - Calgary

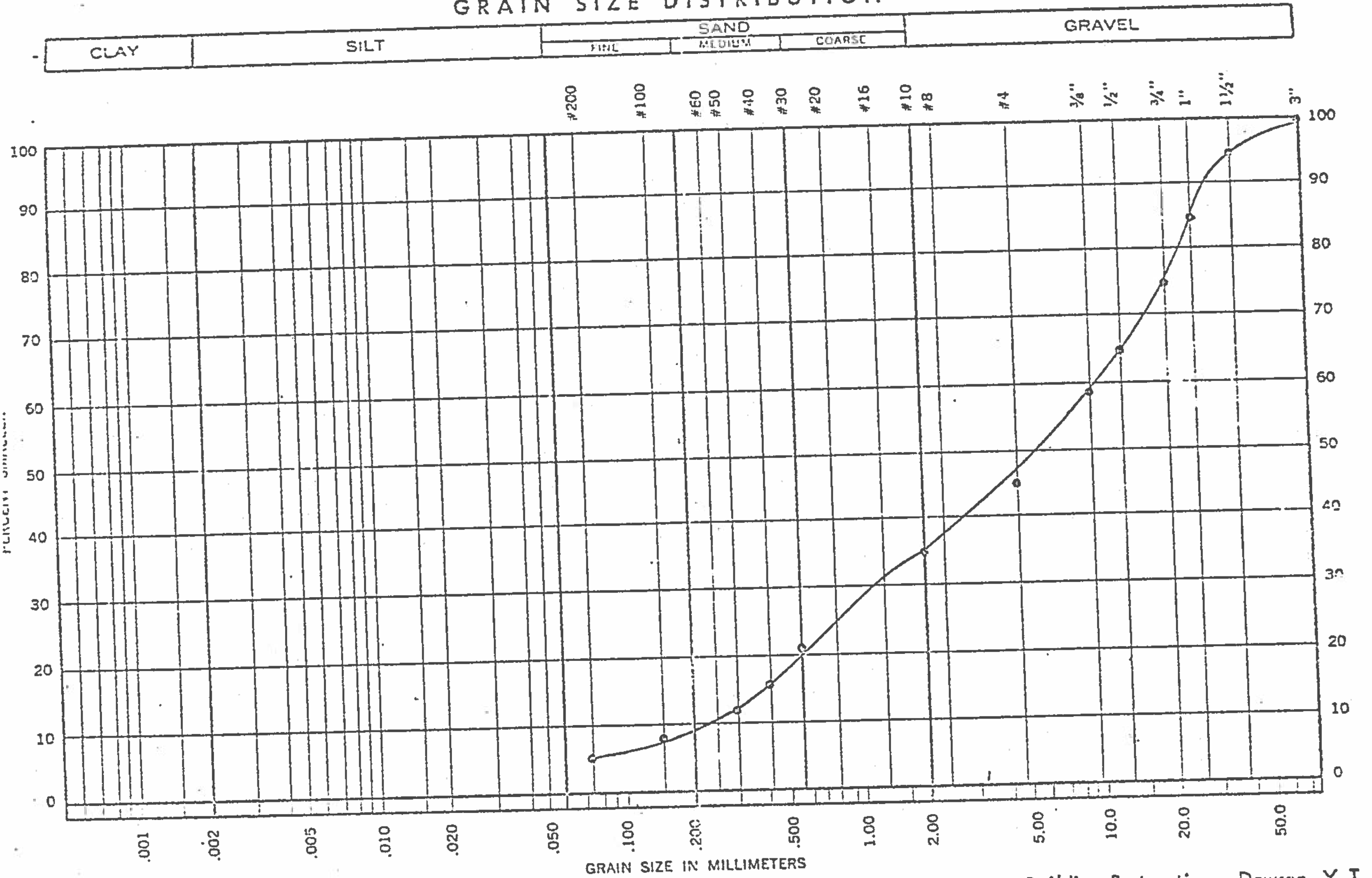
GRAIN SIZE DISTRIBUTION



PROJECT Building Restoration - Dawson Y.T.
JOB No. E - 381 DATE December 3/71
SAMPLE No. 1

SAMPLE DESCRIPTION Gravel

GRAIN SIZE DISTRIBUTION



PROJECT Building Restoration - Dawson Y.T.

JOB No. E - 381 DATE December 3/71

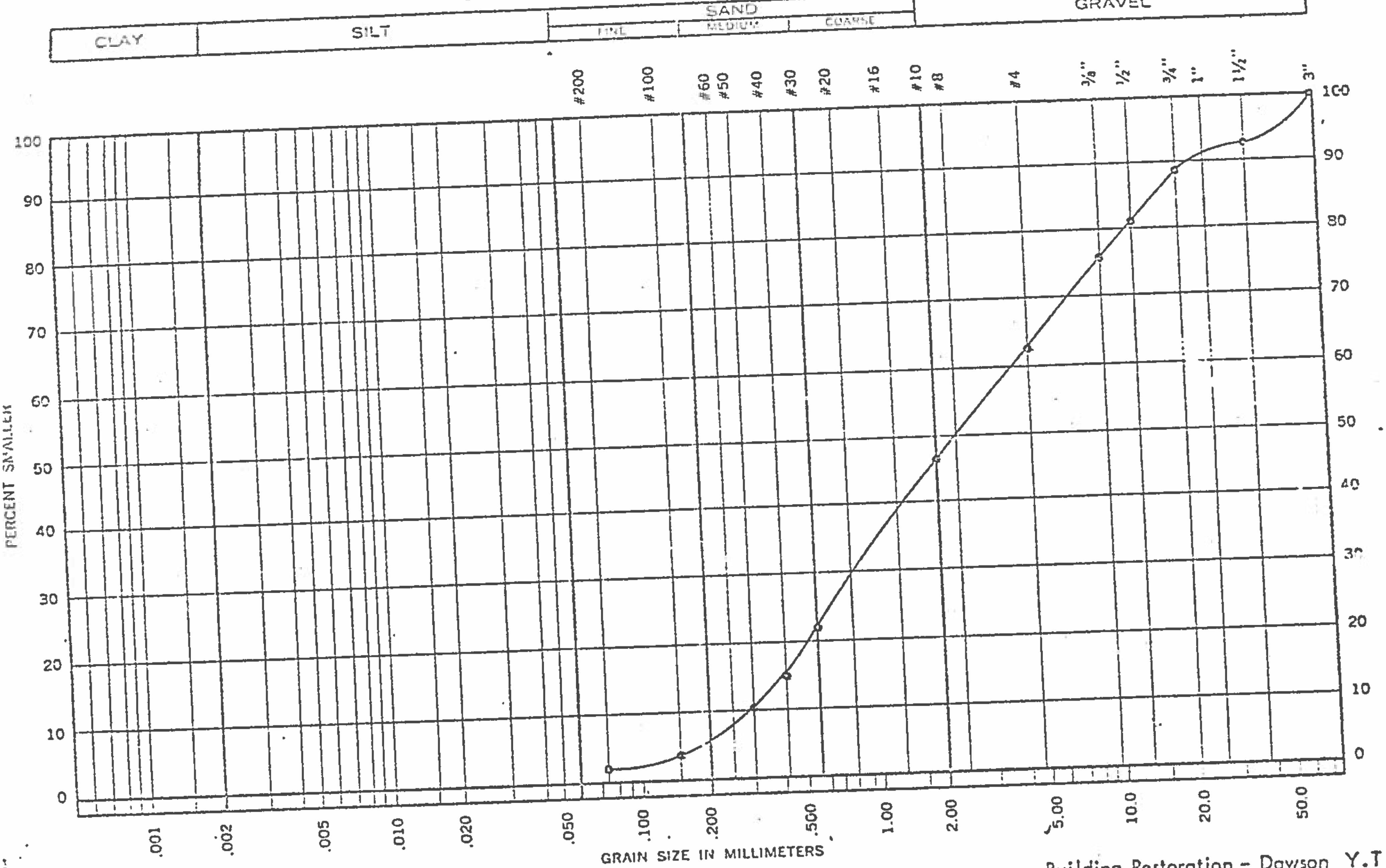
SAMPLE No. 2

DEPTH

SAMPLE DESCRIPTION Sandy Gravel

Pit at south end of town (Glacial Till)

GRAIN SIZE DISTRIBUTION



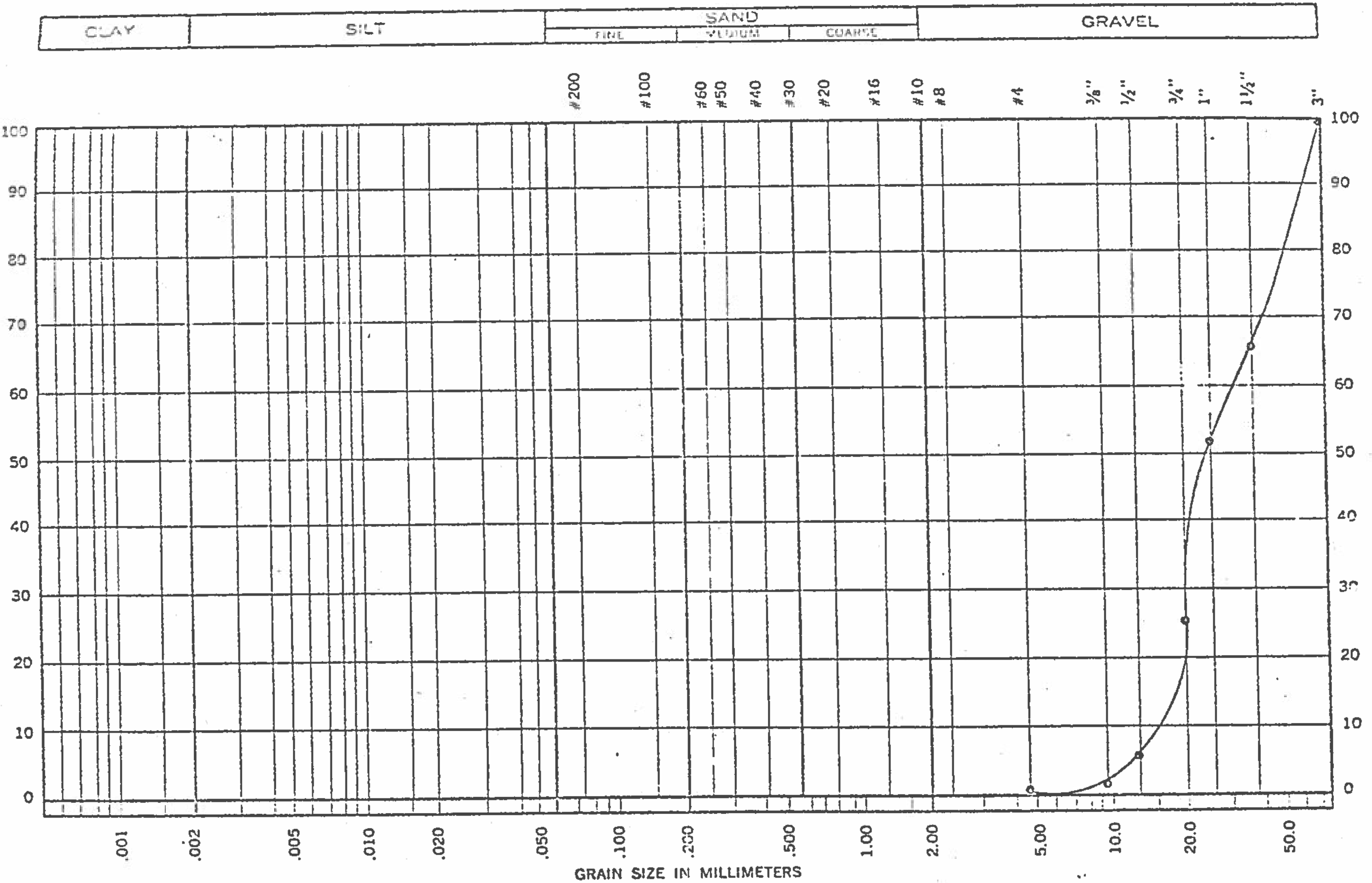
PROJECT Building Restoration - Dawson Y.T

JOB No. E - 381 DATE December 3/71

SAMPLE No. 3

White Channel Gravel

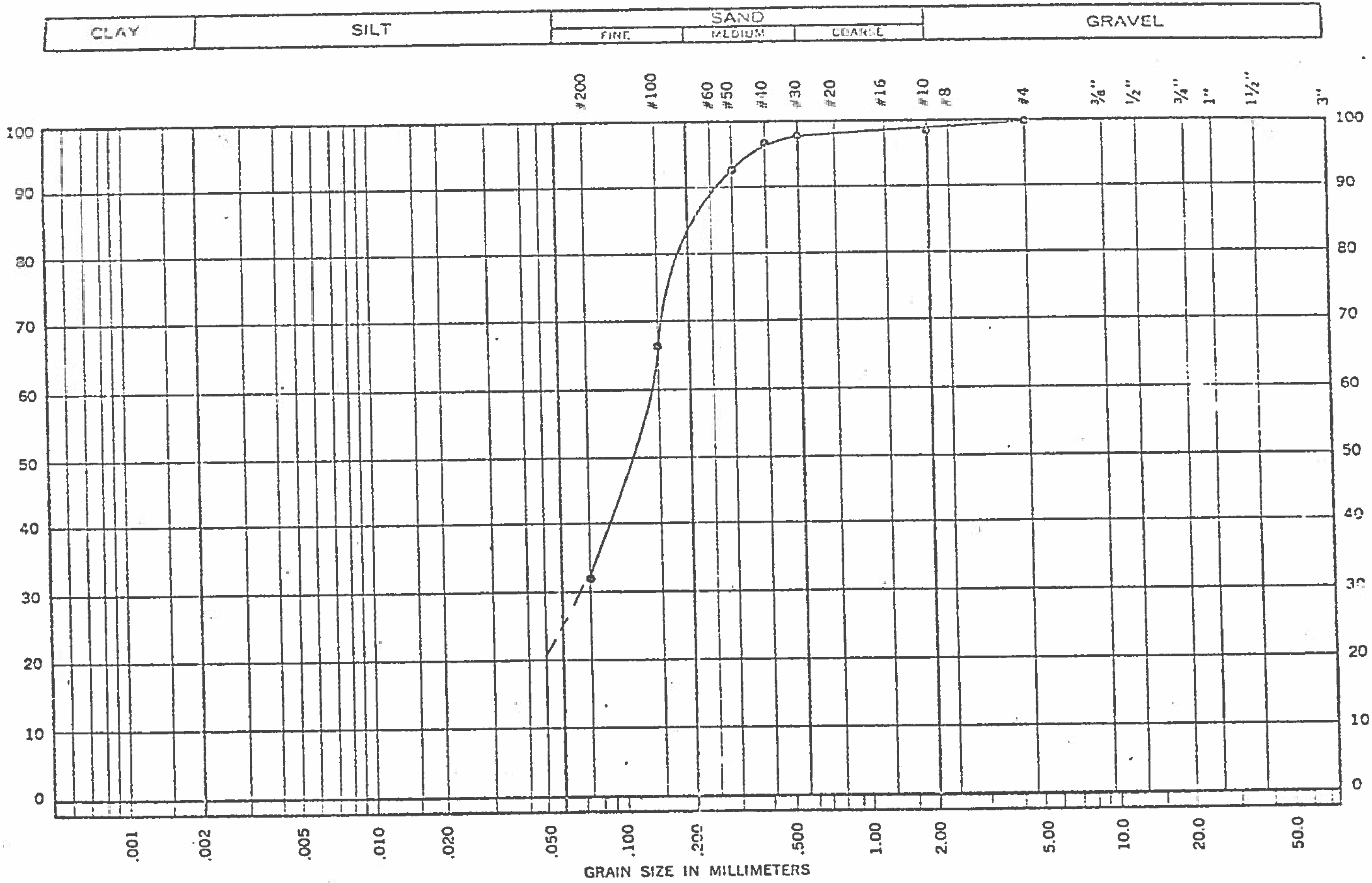
GRAIN SIZE DISTRIBUTION



PROJECT Building Restoration - Dawson Y.T.
JOB No. E - 381 DATE December 3/71
SAMPLE No. 4
DEPTH

SAMPLE DESCRIPTION Gravel
Yukon River Tailings

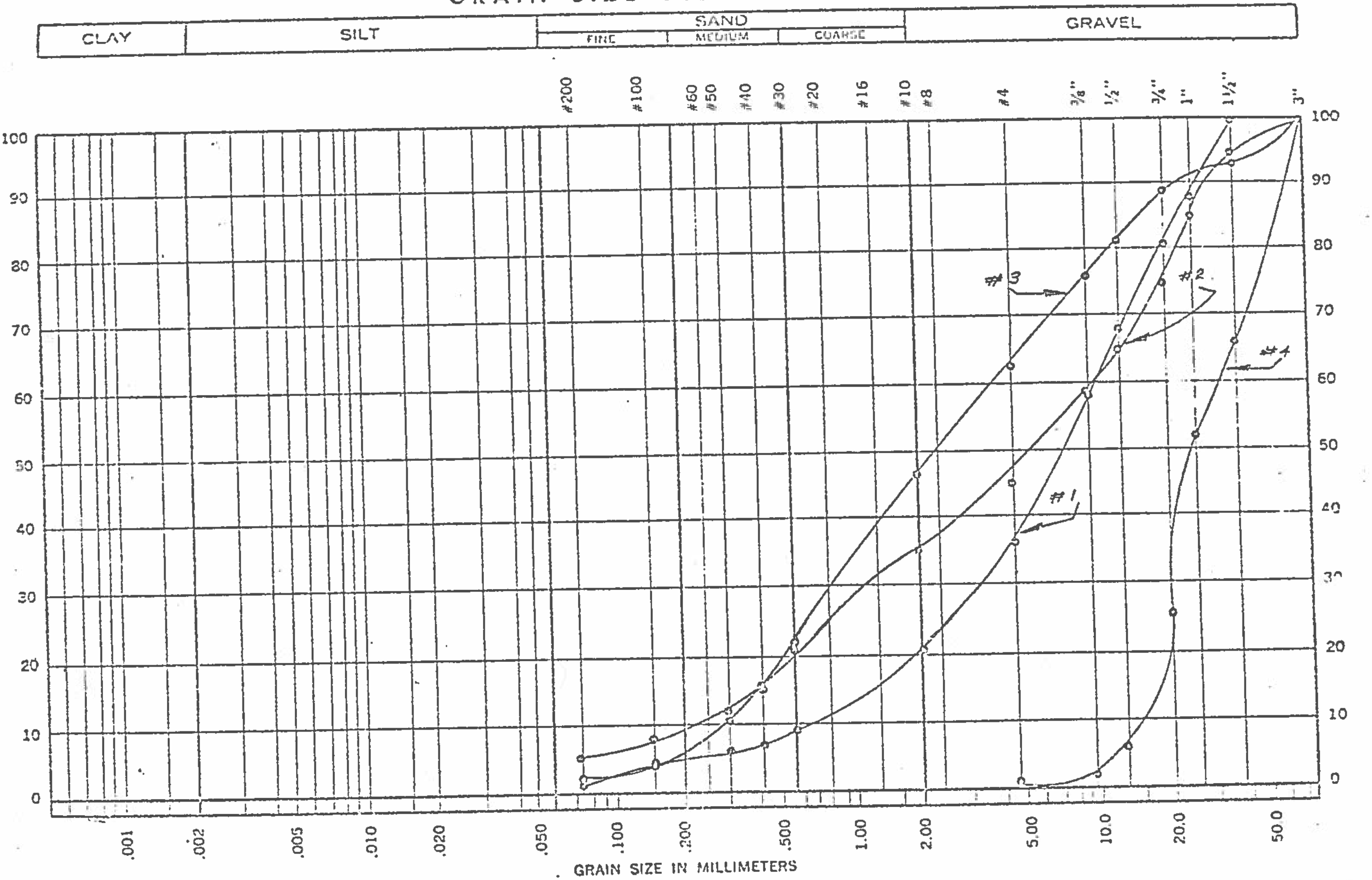
GRAIN SIZE DISTRIBUTION



SAMPLE DESCRIPTION Sand - St. Mary's Hospital

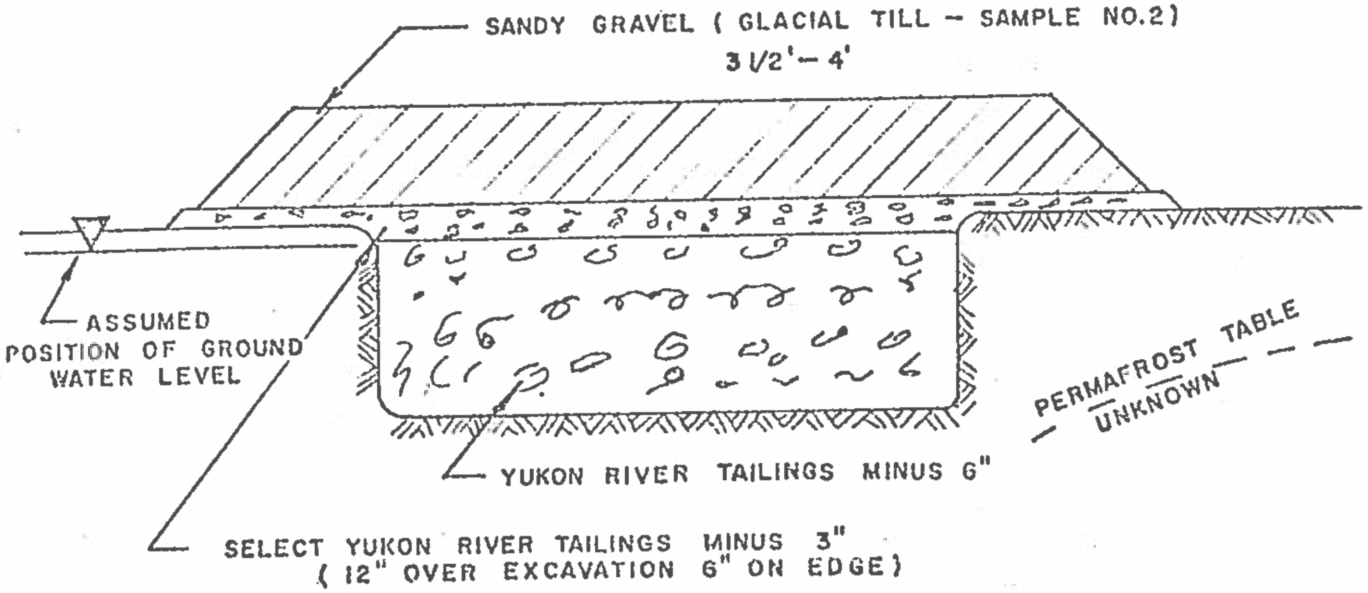
PROJECT Building Restoration - Dawson Y.T.
JOB No. E -381 DATE December 3/71
SAMPLE No. 5
DEPTH

GRAIN SIZE DISTRIBUTION



PROJECT Building Restoration - Dawson Y.T.
JOB No. E - 381 DATE December 3/71
SAMPLE No.

SAMPLE DESCRIPTION Summary Curve Gravel

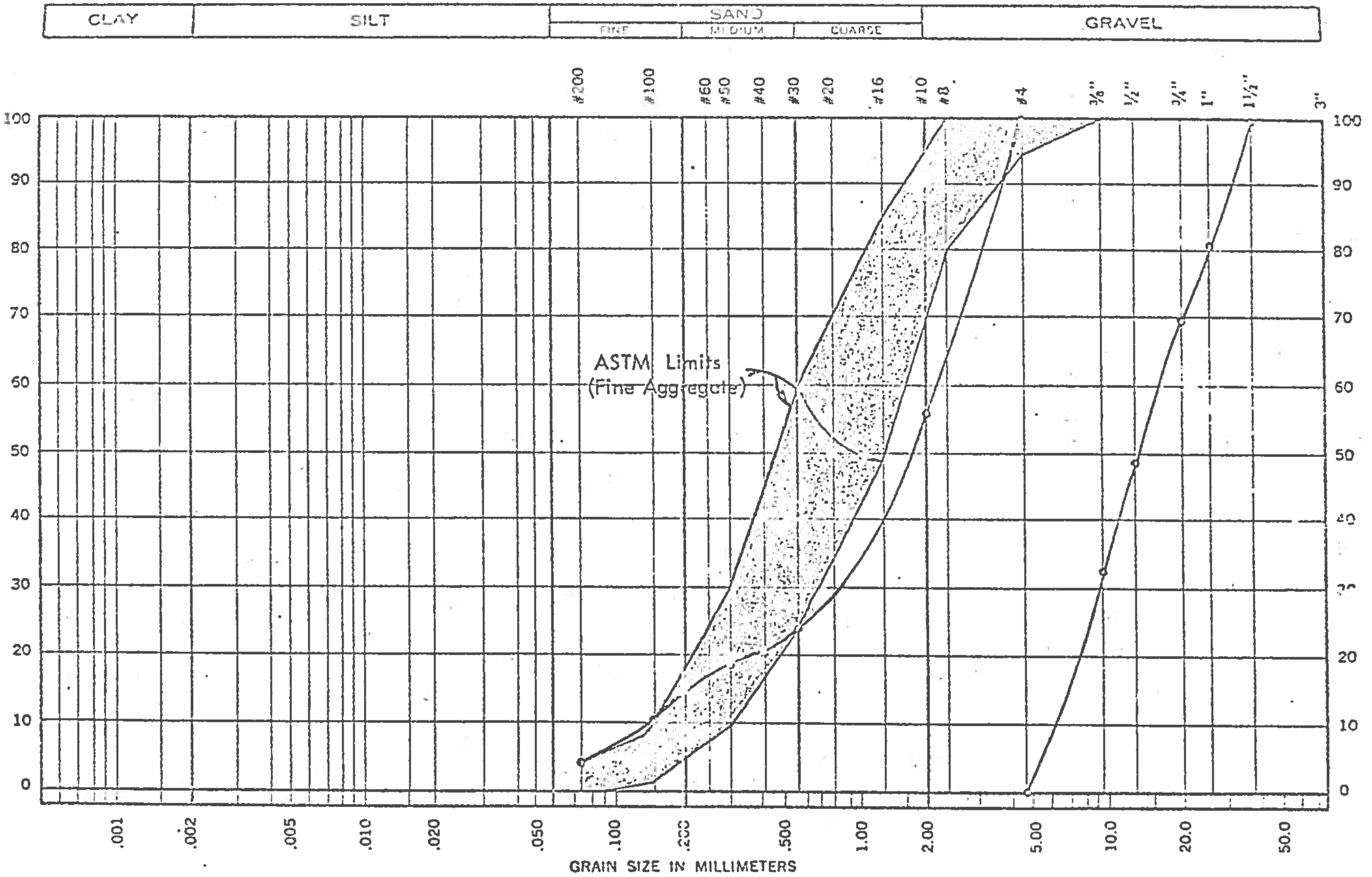


RECOMMENDED TYPICAL SEQUENCE OF GRAVEL PAD MATERIALS

DAWSON, YUKON

DATE: 28/12/71	SCALE: N.T.S.	JOB NO. E–381	DWG. NO. 7

GRAIN SIZE DISTRIBUTION

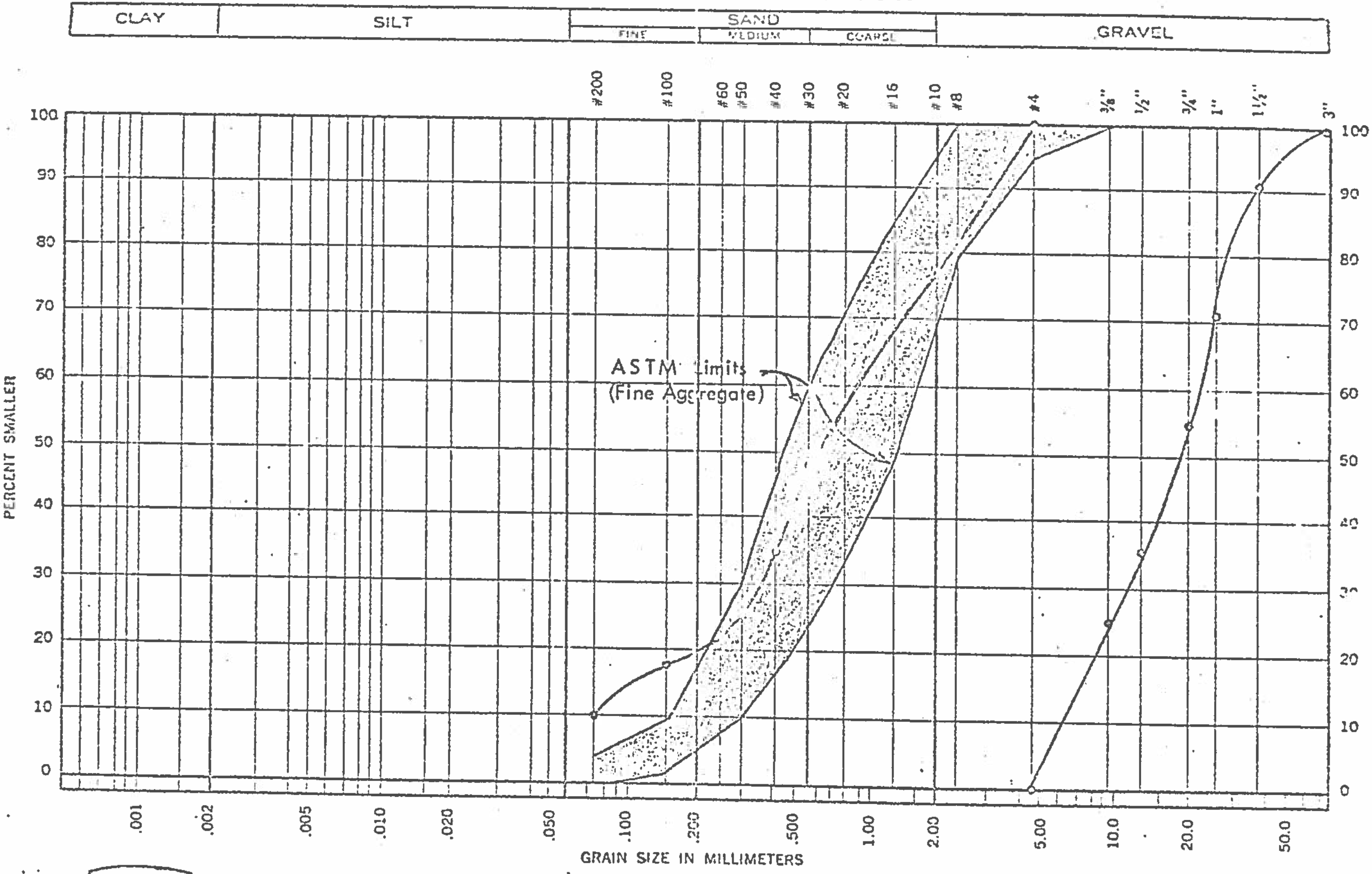


[illegible] ASSOCIATES

SAMPLE DESCRIPTION Concrete Aggregate Evaluation
North Pit Sample No. 1 Split on No. 4 Sieve

PROJECT Building Restoration - Dawson Y.T.
JOB No. E - 381 DATE December 6/71
SAMPLE No. 1
DEPTH

GRAIN SIZE DISTRIBUTION

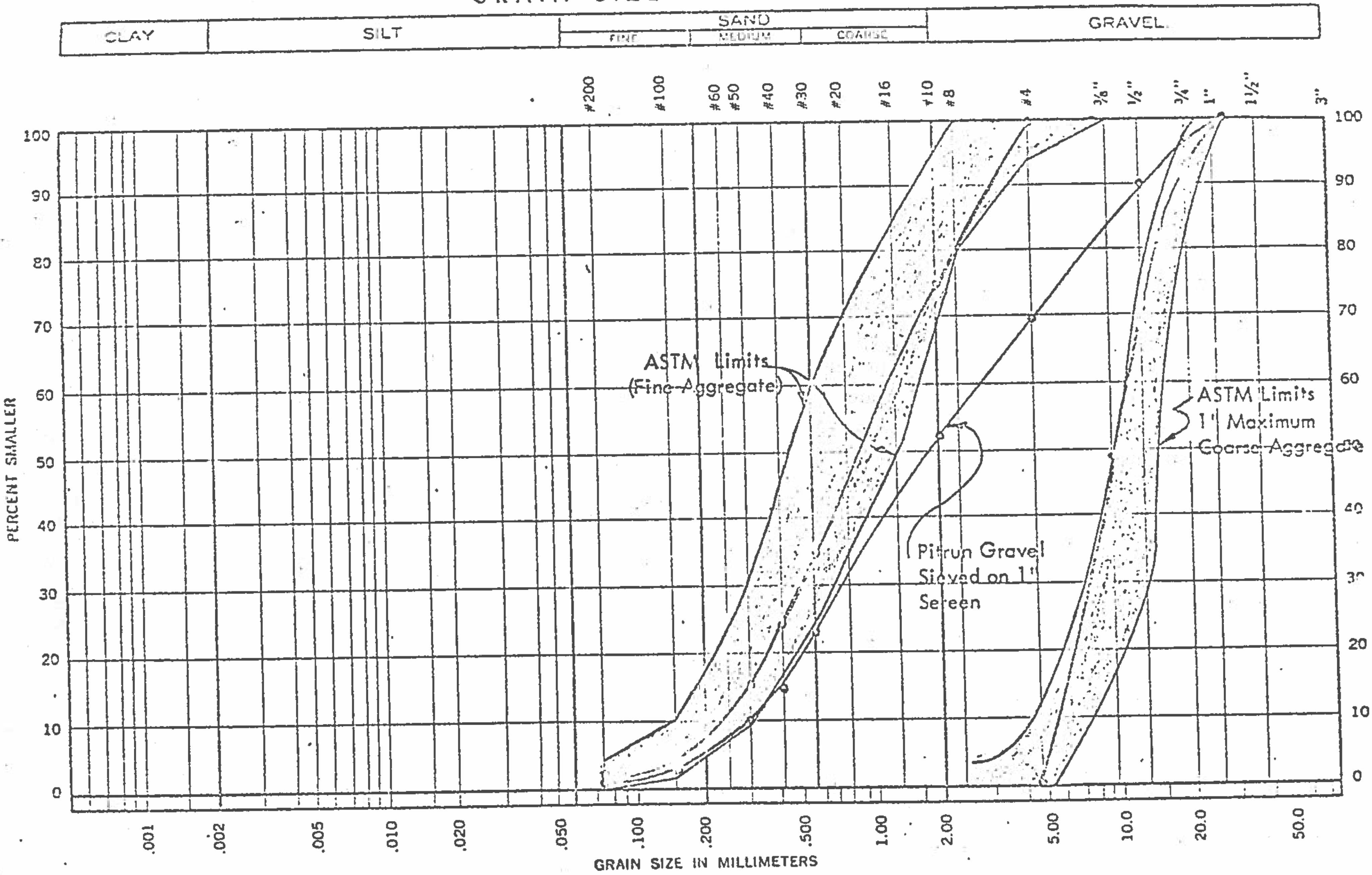


BROOKER & ASSOCIATES

SAMPLE DESCRIPTION Concrete Aggregate Evaluation
South End Pit Sample No. 2 Split on No. 4 Sieve

PROJECT Building Restoration - Dawson Y.T.
JOB No. E - 381 DATE December 6/71
SAMPLE No. 2
DEPTH

GRAIN SIZE DISTRIBUTION



BROOKER & ASSOCIATES

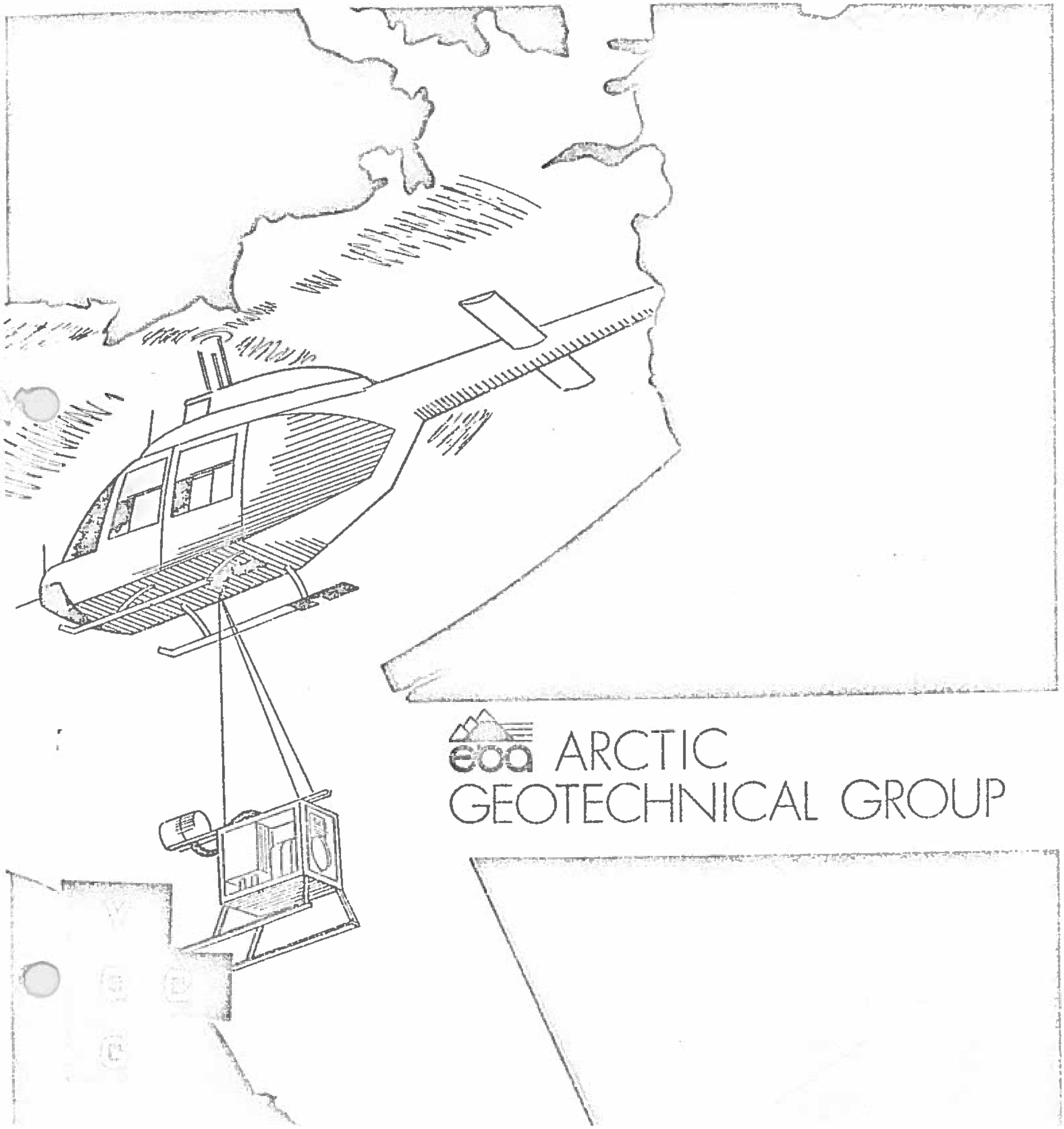
SAMPLE DESCRIPTION Concrete Aggregate Evaluation
White Channel Gravel Screened on 1" and Split on

PROJECT Building Restoration - Dawson Y.T
JOB No. E - 381 DATE December 6/71
SAMPLE No. 3
DEPTH

FIGURE 10

Report On:

SUBSURFACE CONDITIONS
DAWSON , YUKON



EBA ARCTIC
GEOTECHNICAL GROUP

REPORT

ON

SUBSURFACE CONDITIONS

DAWSON , YUKON

Submitted To:

DEPARTMENT OF INDIAN AFFAIRS AND NORTHERN DEVELOPMENT

TECHNICAL SERVICES BRANCH

DECEMBER , 1972

TABLE OF CONTENTS

1. INTRODUCTION

1.1 General

Certain historic buildings at Dawson, Yukon Territory, are under consideration for restoration by the Government of Canada, Department of Indian Affairs and Northern Development (DIAND). Historical signficance of the area dates back to the Klondike gold rush of 1896. Population of the townsite has varied from a high of 9000 to a current low of about 800, depending upon the fortunes of a lucrative gold mining operation.[1] Buildings have been constructed, abandoned, renovated and reoccupied since that time, with little concern for, or knowledge about the problems associated with permafrost terrain. This has led to an interesting history of performance of structures on permafrost evident in today's townsite.

DIAND engineers have recognzied that serious consideration has to be given to foundation conditions, in order to adequately restore the historic structures in the area. Elmer W. Brooker & Associates was retained under authorization of Contract No. 278-71 to investigate subsurface conditions in the townsite and report stating recommendations which will enable re-design of building foundations.

The field drilling program was carried out in April, 1972. In July, 1972, a preliminary report was submitted, which presented results of the boring and testing programs, together with recommendations for foundation reconstruction. This 'final' report, which completes the terms of reference of the study, is essentially a repeat of the preliminary report submitted last summer, with the addition of Appendix D, which describes the Ground Thermal Regime. This supplementary information is based on data collected throughout the summer from three ground temperature sensing installations. Aquisition of this data will continue for approximately 1 more year and will be reported periodically to DIAND as an addendum to this report.

1.2 Scope of Work

Scope of the work involved in this study includes, but is not necessarily limited to the following:

a. Locate and drill testholes from which sufficient data can be obtained to provide a general indication of soil conditions in the townsite.

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b. Locate and drill testholes from which particular foundation re-design recommendations can be formulated at certain historic building sites.

c. Laboratory testing of selected disturbed (thawed) soil samples.

d. Installation of permanent temperature sensing devices in certain boreholes and aquisition of ground temperature data from these.

e. Engineering analysis of the data and preparation of reports.

f. Review of plans and specifications prepared by DIAND at their request.

II. SITE INVESTIGATION

2.1 General

The townsite was initially visited in November, 1971 by Mr. D. Hayley of Brooker & Associates in accompanyment with Mr. P. Stumes and Mr. W. Wells of the Department of Indian Affairs and Northern Development. From this visit, an appreciation of the condition of existing buildings was gained, together with some insight into local experience with foundation construction. Moreover, a preliminary concept of reconstruction on gravel pads was set out, however it was recognized that this concept would require verification by further field exploration work.[1]

The site exploration work decribed in this report was conducted from April 17 to 24, 1972, inclusive. Fifteen boreholes were drilled to depths ranging from 7 to 20 feet. Borehole locations were chosen in the field with assistance from Mr. W. Wells (DIAND Engineer). Choice of borehole locations was predicted on the following considerations.

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[1] 'Report on Site Visit for Foundation Restoration of Certain Historic Buildings - Dawson Yukon', by Brooker & Associates, submitted to DIAND November, 1971.

a. Drill rig access - most sites required snow clearing
b. Buildings under serious consideration for restoration
c. General stratigraphic representation of the townsite.

Two holes were drilled at the site of a proposed arena (at the request of DIAND personnel on site). These holes provided a means of extrapolating subsurface conditions to this part of the townsite. Location of all boreholes is shown in Drawing A-1 and site details are summarized in Table 1.

2.2 Drilling Details

A truck mounted Failing CFDI rig was mobilized from Whitehorse for the project (Appendix B, Plate 1). In addition, an air compressor (300 cubic feet per minute capacity) was rented for flushing cuttings from boreholes where conventional rotary rilling was anticipated. Drilling with air circulation is preferable to more conventional 'wash borings' (drilling with water) for exploration work in permafrost terrain because it facilitates soil identification.

Frozen peat and all soils finer than coarse sand were sampled with a core barrel developed by the U.S. Army, Cold Regions Research and Engineering Laboratory (CRREL) (Appendix B, Plate 2). Excellent cores were obtained (Appendix B, Plate 3) from which the ice distribution in permafrost soils could be readily observed and classified.

The barrel, shown in Plate No. 2, consists of a steel tube with an eight inch pitch double helix welded to the outside. A separate stainless steel cutting shoe with removable carbide tipped inserts is fitted to the bottom. The cutting inserts project slightly below the shoe to provide efficient cutting action without the aid of circulating fluid.

Four boreholes were extended into the gravel which underlies the townsite. A 4-3/4 inch tri-cone bit was used with air as the flushing medium (Appendix B, Plate 4). rilling in the gravel was found to be exceedingly difficult and time consuming.

TABLE I

BOREHOLE SITE DETAILS

Borehole No.	Location	Ground Surface Condition			Estimated Depth To Permafrost Table (ft.)	Average Ground Temp. [1] (°F)	Depth To Gravel (ft)
		Sun Exposure	Snow Cover (In.)	Temperature °F			
1	S.W. Cor. 4th Ave. & King St. 36.5'W Centerline 4th Ave. 36.0'S Centerline King St.	Exposed	Previously Cleared	---	7.0	31.3	11.0
2	Behind Bonanza Hotel 35.5'E. of W. Wall, 15.0' N. of N. Wall	Shaded	18	---	3.5	28.3	13.5
3	North of Vineults Store 31.6' N. of N.W. Cor. Store Along W. Wall line	Partially	20	27.6	---	31.2	15.5
4	Old Post Office 43' W. of S.E. Corner Building 12.5' S. of S. Wall Building	Exposed	18	---	5.0	30.2	12.0
5	Red Feather Saloon 11' S. of S.W. Corner, 7' W. of S.W. Corner	Partially Shaded	22	17.2	5.5	27.8 25.3*	16.6
6	Ruby's Place, 13'S. of S. Wall 27.6' E. of W. Wall	Well Shaded	24	20.2	---	27.1	18.0
7	Proposed Arena, 235'N, 20'E. of N.W. Corner Community Hall	Shaded	Previously Cleared (Gravel)	---	4.0	19.7	13.0
8	Proposed Arena, 45'N, 80'E. of NW Corner Community Hall	Exposed	20	---	---	31.3	7.5
9 & 9A	Commissioners Residence 100'E of N.E. Corner Porch, 25'S. Hole 9A 10.5' E. of No. 9	Exposed	Previously Cleared (grass)	---	NPF[2]	32.8*	13.0
10	St. Andrews Church 35'W. 41'S, of N.W. Corner Tower	Partially Shaded	Previously Cleared	---	NPF	31.8	13.5
11	Old Administration Building (museum) 15.5'S. of S. Wall, 28'E. of W. Wall	Exposed	20	14.8	NPF	32.1	12.2
12	Historic Sites Building 120' E. of N.E. Corner Along N. Wall Line	Exposed	Cleared (gravel pad)	---	NPF ?	29.9	12.5
13	6th Ave. & King St., 66' W. of Centerline 6th Ave., 65'S. of Centerline King St.	Exposed	23	---	---	---	---
14	Second Ave. & Sixth St. 46'N. of Centerline 6th St., 118'E. of Centerline Second Ave.	Exposed	23	30.7	---	30.0	6.2

[1] Average from 5 feet to gravel surface, April 1972.

[2] Non permafrost

* Indicates thermistor cable data

In at least one instance, a new bit was worn out after only two feet of productive drilling. After an hour or two of slow drilling progress, warm air from the compressor would thaw the walls of the borehole, and create a sloughing condition. In at least two instances (Boreholes 4 and 8) a large cavity was created in the gravel with little downward penetration. Under such conditions, undisturbed soil sampling was impossible and the borehole had to be abandoned. The cavities formed were backfilled with dry sand.

The gravel was sampled by retreiving cuttings which were blown out of the borehole (Plate 4). Drive sampling was attempted (SPT split barrel) with little success as the maximum penetration of the sampler was only 2 or 3 inches. Inspite of the above mentioned limitations, however, it is believed that an appreciation of the in-situ conditions of the gravel were obtained from the field boring program.

All boreholes were backfilled after completion. Boreholes on gravel roadways or parking areas were backfilled with sand, whereas others were filled with soil cuttings and core. Any excess soil was removed from around the drill sites.

2.3 Soil and Permafrost Description

Soil and ground ice were described at each boring location based on the, 'Guide to a Field Description of Permafrost for Engineering Purposes', Technical Memorandum No. 79, National Research Council. A pertinent summary of the ice classification system preceeds the borehole logs, Appendix C. Temperature of frozen core was measured immediately after extrusion from the barrel by inserting a 1/8 inch by 1 inch thermistor probe into the core, as illustrated in Plate 5, Appendix B. Throughout the investigation, ambient air temperatures were normally within 10°F of the measured ground temperatures which improved reliability of readings in this manner.

2.4 Thermistor Installation

Three multi-conductor electrical cables on which 8 thermistors are mounted were installed in Boreholes No. 4, 5 and 9. The thermistors are semi-conductor resistance temperature measuring devices which are particularly well adapted for field installation in this manner. The thermistor cables were prefabricated in the Brooker Edmonton laboratory. Spacing of the thermistors on the cable and cable length is variable, however final depth of individual thermistors in the respective boreholes is tabulated in Appendix D, along with readings obtained to date.

The thermistor cable was pushed to the bottom of the borehole with a drilling rod (in some cases 12 to 18 inches of sloughed soil had to be displaced) and held tight in the center of the borehole while backfill was placed. Backfill consisted of clean dry, fine sand mixed with dry drilling mud (bentonite gel). The drilling mud will discourage water infiltration during spring thaw, which could affect ground temperatures.

2.5 Surveying

All boreholes were located by measurement from structures or roadways which are located on the townsite plan provided by DIAND. All borehole locations are shown on the site plan, Drawing A-1. The ground surface elevation at each borehole was determined by level survey. The elevations were determined relative to a system of benchmarks established in the town by the Yukon Territorial Government. The base reference for these benchmarks is understood to be Geodetic Elevation.

2.6 Laboratory Testing

A laboratory testing program, to determine index properties of representative soil samples, was undertaken when the field work was completed. The following soil tests were carried out on selected samples.

a. Natural water content (total moisture content)
b. Atterberg limits
c. Grain size analysis (sieve and hydrometer tests)
d. Organic content determination

Standard soil mechanics testing procedures (ASTM, CSA, etc.) were used for carrying out tests 'a' to 'c' above. The entire sample was used for water content determination. Where free water was present in the bag and obvious leakage had occurred, the water content results were rejected.

The test procedure adopted for determination of organic content in soil samples was patterned after the Alaska Test Method T-6. The sample is heated in an oven to 1300°F and maintained at that temperature for one hour, to oxidize the organic material present. Weight loss is then determined after cooling to room temperature. The organic content quoted is therefore a weight loss due to burning at high temperatures, expressed as a percentage of the weight of mineral residue.

The laboratory test results are incorporated into the borehole logs presented in Appendix C. Furthermore, a summary of laboratory data is presented in the appendix together with grain size distribution curves for the soils tested.

III. SITE CONDITIONS

3.1 General

The townsite of Dawson occupies a recent (but inactive) alluvial floodplain at the point of confluence of the Klondike River with the Yukon River. The area is flat topographically, but is bounded on the east by mountains which rise steeply above the valley floor. A gully, known locally as 'the slough' traverses the south end of town (Drawing A-1). Except for spring runoff, the gully, an abandoned channel of the Klondike River, carries little or no water.

3.2 Soil Types

The details of subsurface conditions encountered at each location drilled are summarized in the borehole logs, Appendix C. The soils encountered can be classified as one of four major types; peat or fill, organic silt, sand, and gravel. These four soil types are discussed separately in this subsection and their distribution throughout the townsite is indicated on two generalized stratigraphic sections, Drawing A-2 .

3.2.1 Peat or Fill

The surficial soil at most boring locations was found to be either fill[1] or peat. The fill is either randomly dumped material or gravel (parking areas). The random fill was easily identified because it usually contained sawdust, bricks, bits of glass and other rubble. Normally, a layer of peat, 6 to 12 inches thick, remains beneath the fill. All fill materials encountered in the townsite were frozen but they did not contain excess ice.[2]

Most building lots in Dawson have been filled to some extent over the past 76 years. Furthermore, subsidence under streets as a result of thermal disturbance to the underlying permafrost soils has necessitated periodic application of gravel surfacing. The

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[1] 'Fill' - the term fill is used to describe any material placed by man.

[2] 'Excess ice' - refers to ice in excess of the fraction that would be retained as water in the soil voids upon thawing.

direct result of this is that current street levels are often above floor elevation of the older structures and unfilled lots have now become enclosed depressed areas. This situation has created serious drainage problems throughout most of the townsite.

Peat thickness varies throughout the townsite. Little or no peat was found at boring locations south of Church Street (Boreholes 9, 10, 11 and 12) whereas a thickness of 6 feet was noted at Borehole No. 7. Peat at this location extended to a depth of 7 feet and an excess ice content of 30 to 35 percent was noted below a depth of 3½ feet.

3.2.2 Organic Silt

The surface covering of peat or fill is directly underalin by a deposit of organic silt. The organic silt is thickest in the northern half of town particularly in the vicinity of Boreholes 2, 3 and 4, where it extends to a maximum depth of 15½ feet. The silt layer thins considerably in the south end of town, (Drawing No. A-2) where sand overlies the alluvial gravel (described below).

The organic silt was found to be grey, non-plastic soil with inclusions of peat and roots, often in the form of interbedding. The organic content determinations ranged from 8 to 15 percent (4 tests) and excess ice contents were normally found to be quite high. Excess ice is generally of the segregated stratified type (Vs) with estimated visible percentages normally ranging from 5 to 25 percent (basis total sample volume). Some non visible excess ice (Nbe) and ice coatings Vc were also apparent in this material. Plate 3 shows a partially thawed core of typical organic silt, exemplifying the volume of soil occupied by ground ice. This soil becomes a slurry when thawed in a plastic bag.

3.2.3 Sand

The organic silt grades into sand towards the south end of town. The boundary between silt and sand is not well defined and in most places the sand contains a large proportion of silt. Inclusions of peat, similar to those reported above for the silt, were also evident in the sand. Where the sand was frozen, permafrost classification was found to be highly variable, ranging from non visible ice in well bonded cores (Nbn) to visible ice coatings (Vc), with most frozen core of the non visible ice type.

3.2.4 Gravel

Alluvial sand and gravel underlies the entire townsite. As mentioned previously, drilling into the gravel was very difficult, primarily because it is composed of hard rock minerals and contains many cobbles and boulders.[1] The gravel is believed to be clean, granular soil, free of excess ice. Thawing of frozen gravel is not expected to pose any problem as it can be considered thaw-stable material.

3.3 Permafrost Distribution

Permafrost is widespread throughout the townsite but it is not continuous. With the exception of Borehole No. 12, unfrozen soil was encountered at depth in all boreholes drilled south of Church Street.

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[1] Observations on Jackson Tailings at the mouth of the Klondike River. Petrographic analysis by DPW shows over 50% Quartz content in these tailings.

In Borehole 12, the sand was frozen to a depth of 12 feet (31.8°F), however, the borehole was drilled in a cleared parking lot thus it is suspected that seasonal frost rather than permafrost was encountered there. It was also noted that large coniferous trees (in excess of 50 feet high) are growing in the townsite only south of Church Street and it is believed that they thrive there as a result of the absence of permafrost in this area.[1]

The absence of permafrost at the south end of the townsite is believed to be associated with lateral shifting of the Klondike River.[2] It is known that permafrost does not exist beneath major rivers and lakes, especially in the discontinuous zone, thus the recent occupation of this area by the Klondike River (probably within the last 200 years) would account for lack of permafrost. Permafrost may exist at depths greater than the field exploration, however, this is not believed to be significant for engineering purposes.

Thickness of the active layer in the part of town underlain by permafrost (Drawing A-1) could not be measured directly because the investigation was carried out in April. At some borehole locations however, position of the permafrost table could be estimated (Table I) indirectly by:

a. Detecting a thin layer of thawed ground beneath seasonal frost (in cases where seasonal frost did not extend to the permafrost table).

b. Observing a zone of major ice segregation which is often found at the permafrost table.[3]

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[1] Any correlation between tree growth and permafrost in the townsite is questionable due to the long natural history of the Area.

[2] Discussion on: Permafrost alternations as a result of lateral shift of the Mackenzie River by C. T. Hwang (Brooker & Associates) and M. W. Smith (Carleton University) Permafrost Seminar Saskatoon, May 1972, Unpublished.

[3] Personal Communication, Dr. J. R. MacKay University of British Columbia, November, 1971.

Thickness of the active layer and average ground temperatures at the time of investigation depend upon the degree of exposure to sunlight the site receives (Table 1). The active layer thickness was observed to vary from about 4 feet in well shaded areas to 7 feet in exposed areas.

Ground temperatures measured on individual soil cores with the hand probe compare quite well with those measured from the permanent thermistor installations at Boreholes No. 4, 5 and 9 (generally within 2°F). Installation of the thermistor cables at Boreholes No. 4 and 5 has confirmed that the gravel is frozen in this area (Appendix D).

3.4 Groundwater

All boreholes except No. 13, were dry at the time of drilling. The standpipe installed in Borehole No. 9A (to 13.5 feet or 0.5 feet into the gravel) was dry after installation. However, on June 4, 1972, groundwater was reported to be 13 inches below ground level, at the same time the Yukon River was at flood stage. Therefore, it appears that the unfrozen gravel underlying the non-permafrost area is continuous to the rivers edge.

An artesian groundwater source was encountered beneath (or within) permafrost soil at a depth of 6 feet in Borehole No. 13. Flow from the 4½ inch borehole, shown in Plate 6, Appendix B, was estimated at 50 gallons per minute. The flow was stopped after about 10 minutes (the flow rate seemed to increase with time) by driving a slightly oversized log into the hole and allowing it to freeze in place. Source of the groundwater is not known, however, it is postulated that a layer of coarse, pervious colluvium (talus) exists under the silt in this area, in as much as it is very close to the base of the mountain (Drawing A-2). If this is the case, recharge would be from the slope above.

The artesian water condition is not sufficiently close to structures under immediate consideration for restoration to pose a problem. However, future expansion of activities into the area of Borehole No. 13 should be viewed with caution. At the time the water was flowing, various persons involved in town maintenance were summoned to view the situation. They were advised at that time that groundwater pressure should be relieved by implementation of a drainage system.

IV. LOCAL FOUNDATION EXPERIENCE

4.1 General

Various methods of foundation design have been utilized in Dawson, but no particular type has been found to perform satisfactorily. Recent foundation construction practice has been limited to timber piles installed in pre-bored holes or ground sills placed on a gravel pad. Observations on performance of some of the old and new buildings in the area can provide a good indication of the problems which must be overcome in order to provide a satisfactory foundation.

4.2 Pile Foundations

Construction on timber piles in the area has produced particularly disappointing results. Piles have been installed only to depths of 10 or 15 feet, where drilling or driving refusal is met at or near the gravel surface. The piles are installed butt end down in the hole, then backfilled with a sand slurry on the supposition that freeze back into the permafrost will occur. At places in the townsite where the ground is only marginally below the freezing point, it is doubtful that freezeback would occur. There is at least one instance of a 16 foot long pile reported to be loose in its hole many years after installation.

This situation is highly undesirable from the point of view of pile stability. Seasonal freezing of the active layer causes heave which is transmitted to the pile by adfreeze bond. Sufficient anchorage is not available below the zone affected by seasonal freezing to resist upward movement of the building, consequently, the buildings heave and settle differentially throughout the various seasons of the year.

An extreme case of pile heave is evident at St. Andrews Church. The building was constructed on driven timber piles in 1901 and was in service until about 1940 (Borehole No. 10 shows this to be a non permafrost area). Since the structure was abandoned, serious heave of the interior piles has taken place (presumeably the building was heated all winter prior to 1940). Differential floor heave, shown in Plate 7, Appendix B, has been estimated at about six feet.

4.3 Gravel Pad Foundations

Gravel pads are commonly used for many new buildings in Dawson. The purpose of a gravel pad on permafrost is to provide a stable insulating layer which will prevent degradation of the permafrost. In a discontinuous permafrost zone, where ground temperatures are often only marginally below freezing, construction on a gravel pad is risky.

The new Father Judge Hospital (East of Borehole No. 11, Drawing A-1) was constructed on ground sills, supported on a gravel pad about 3 feet thick. The building has an 18 inch open (cold) crawl space and insulated floor to prevent heat loss to the ground. Moreover, a thermopile[1] was installed at one end of the building site in an attempt to preserve a frozen ground condition. At the time of the site visit, (November, 1971), a sag of the end walls of about 4 to 6 inches was apparent by sighting along the exterior sheeting.

---

[1] The thermopile is a self contained borehole refrigeration device. No information is known about this particular installation.

The estimated boundary between permafrost and non permafrost has been drawn through the Father Judge Hospital (Drawing A-1). Thus, it is uncertain if in fact permafrost existed beneath the structure at the time of construction. Under these conditions, it seems highly doubtful that the gravel pad serves any function as an insulator and it is possible that the cold crawl space and thermopile installation may have aggravated the stability problems associated with this particular foundation.

4.4 Basements

It was customary in some of the older structures to include basements (ie. Bonanza Hotel, Old Post Office, Commissioners Residence, Administration Building, etc.). Basements in the permafrost area of town are currently full of ice, whereas those in the non permafrost area are generally dry. Ice which has accumulated beneath the Bonanza Hotel and Post Office is believed to be a result of surface runoff, which is trapped in the hole created in the impervious permafrost soils. At the south end of town (non permafrost area), the basements, which have timber cribbed walls and dirt floors, have performed satisfactorily because of the good drainage afforded by the unfrozen sand and gravel which lies below.

V. FOUNDATION RESTORATION RECOMMENDATIONS

5.1 Foundation Type

Three types of foundations have been considered for building restoration; piles, gravel pads and footings. Pile foundations are considered unfeasible for the following reasons.

a. Holes can not be bored into the gravel sufficiently far to provide anchorage against seasonal frost heave.

b. Pile installation under existing buildings is a very difficult and expensive task.

Both gravel pads and footings are considered feasible foundation reconstruction units, subject to the limitations discussed below.

5.2 Gravel Pad Foundations

Reconstruction of building foundations by provision of a gravel pad is considered a satisfactory design north of Church Street (permafrost area) provided some foundation movements can be tolerated. Minor foundation movements can be accomodated if provision is made for releveling of the structure. Individual cribs or posts, supported on the gravel pad are considered a superior design to continuous ground sills. If individual concrete pads are used, they should be buried in the gravel approximately the thickness of the concrete slab (8 or 10 inches anticipated). Design bearing pressure for this type of foundation should not exceed 3000 psf.[1] This type of foundation design is considered suitable for the Bonanza Hotel, Old Post Office, Bank, Ruby's Place and the Red Feather Saloon.

A gravel pad thickness of four feet is suggested, with gravel placed and compacted in layers not exceeding 1 foot in thickness. The materials which are available for pad construction have been assessed previously, (Gravel Resource Evaluation, December 1971). Recommendations concerning gravel selection and placement were stated at that time and this data is included as Appendix E of this report.

---

[1] Based on 3 x 3 foot square footing buried ½ foot into gravel with an internal friction angle of 38 degrees.

All basements should be cleaned and filled (as described in Appendix D) prior to actual pad construction. Stripping or excavation of surficial soils should be kept to an absolute minimum, however it will be unavoidable at some sites in order to prevent an undesirable elevation of the structure. A cold crawl space and insulated floor should be provided under heated structures and any exposed edges of the pad should be landscaped by a covering of peat or topsoil (6 to 12 inches).

5.3 Footing Foundations

An acceptable alternative to the gravel pad design, which is adaptable to both permafrost or non permafrost areas are footing foundations. Individual footing foundations in permafrost areas should be founded at the surface of the underlying gravel. Stipulations pertinent to this design are summarized below (Drawing A-3).

a. The surface of the gravel should be thoroughly cleaned of all loose and unfrozen material.

b. The foundation units can be pre-fabricated, and shipped to the site, which will probably be more economical than a job cast footing. Pre-fabrication of the footing will expedite installation and backfill, which may be a serious concern if construction takes place in the summer.

c. Footing pressure should not exceed 10,000 pounds per square foot and a minimum footing size of 3 feet square is recommended.

d. Footing anchor bolts, steel (or concrete) post and concrete pad should be designed to resist an upward tangential adfreeze force of 4000 psf applied to the perimeter of the embedded portion of the pedestal.

e. If a hollow pipe column is used as a pedestal, it should be filled with concrete on site to prevent corrosion and expedite setting of anchor bolts for above ground structural members.

f. Backfill around the foundation should consist of non frost susceptable granular soil. A well graded sandy gravel with less than 5% passing a No. 200 sieve is recommended. This material is available from pits at the north end of 5th Avenue or at the south end of town on the cementary road

(Appendix E). The gravel should be placed in lifts not exceeding 12 inches in thickness and thoroughly compacted (95 - 98% Standard Proctor Density).

g. The above foundation design is not intended to resist appreciable lateral loads. If non-vertical loading is a design problem, specific details will be provided on request to accommodate this situation.

The use of precast footings will expedite installation and backfill. It is recommended that footing excavations remain open for as short a time as possible so as to minimize degradation of permafrost sideslopes. Excavation sideslopes steeper than 2 vertical to 1 horizontal are not recommended. A thin pad (2 - 4 inches) of clean, well graded sand should be provided over the in-situ frozen gravel to allow adequate leveling of the precast concrete footings.

Footing foundations may also be used in the non permafrost area of town (Drawing A-1). The minimum recommended depth of burial is 8 feet, which will be into the thawed silty sand. The design soil bearing pressure at this depth should not exceed 2000 psf, but footings should not be smaller than 18 inches for strip or 36 inches for square footings, irrespective of bearing pressure considerations. Basements are not recommended under new structures at any location in the townsite.

VI. CONCLUSIONS AND LIMITATIONS

The river flood plain, on which Dawson Yukon is situated, consists of organic silt and silty sand overlying dense bouldery, alluvial gravel. Permafrost was found everywhere north of Church Street, whereas an area to the south end of town was found to be thawed at depth (Drawing A-1).

Piles are not recommended for foundation reconstruction and the use of gravel pads should be limited to the permafrost area. Footing foundations will provide suitable foundation support conditions in either the permafrost on non-permafrost areas and recommendations are provided in the report for design purposes.

The data collection program described herein was designed to develop general recommendations applicable to foundation reconstruction and new construction in Dawson. At the time that redesign of particular building foundations is complete and construction is underway, it would be prudent to verify conditions in the field based on an inspection by a geotechnical engineer.

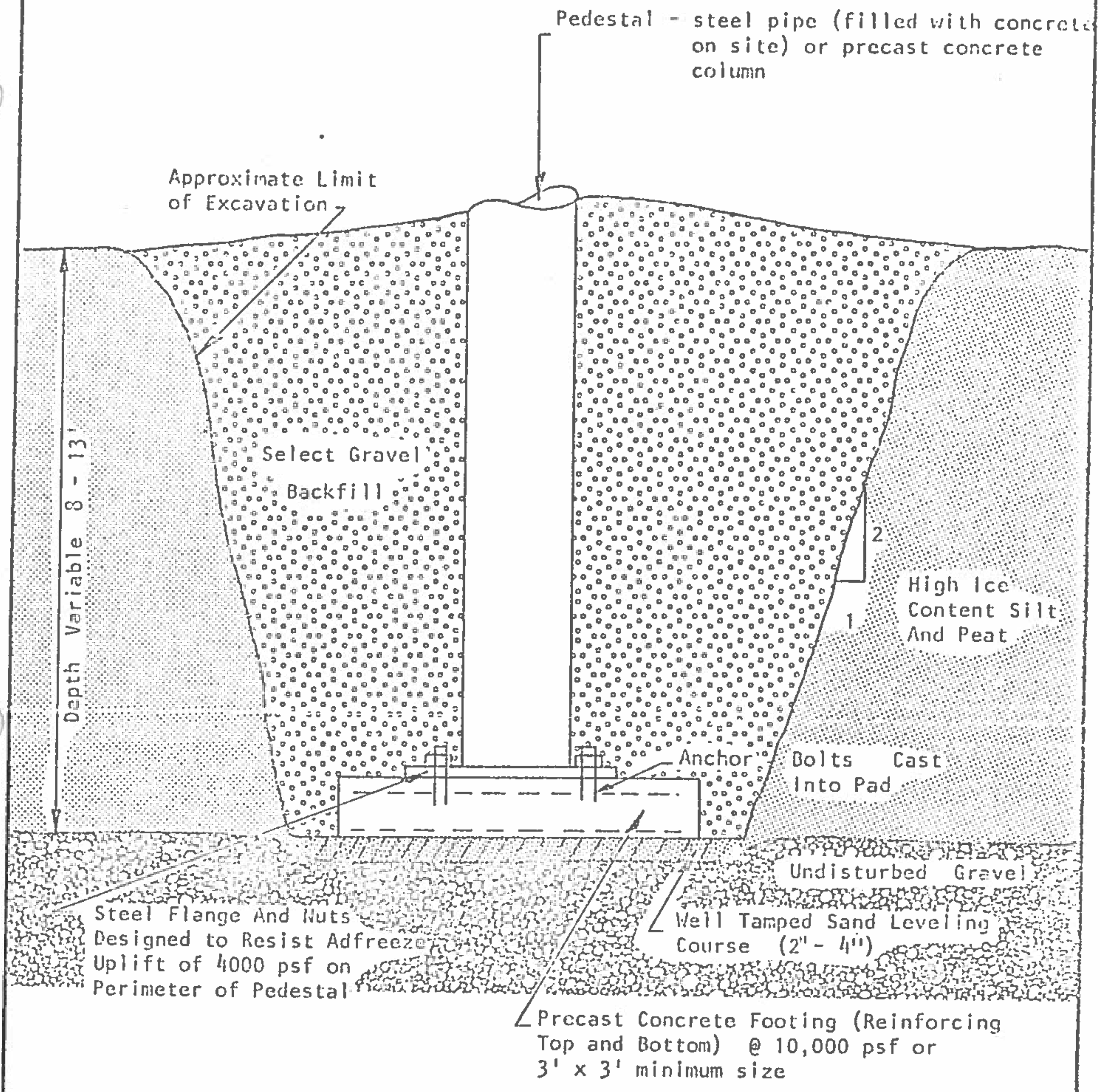
Respectfully Submitted,

ELMER W. BROOKER & ASSOCIATES LTD.

Don W. Hayley, P. Eng.

Garry R. Gilchrist, P. Eng.

DWH:sjw



RECOMMENDED FOOTING FOUNDATION
PERMAFROST AREAS — DAWSON, YUKON

DATE: 10/7/72	SCALE: NTS	JOB NO E-381	DWG. NO. A-3

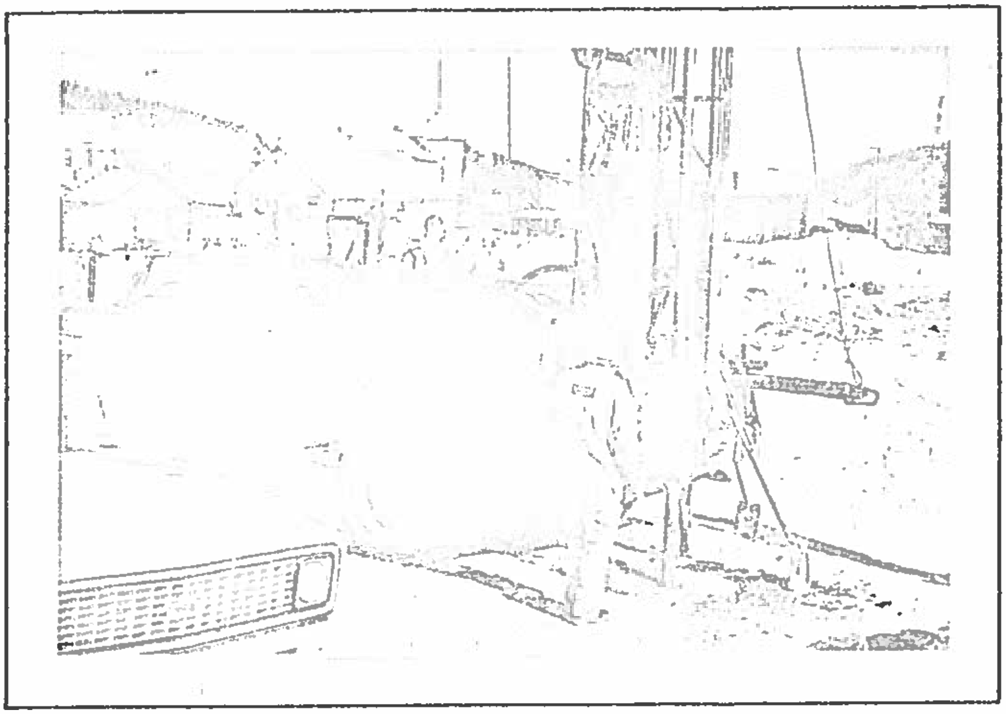


PLATE 1

Falling CFD1 Rig

Borehole No. 7

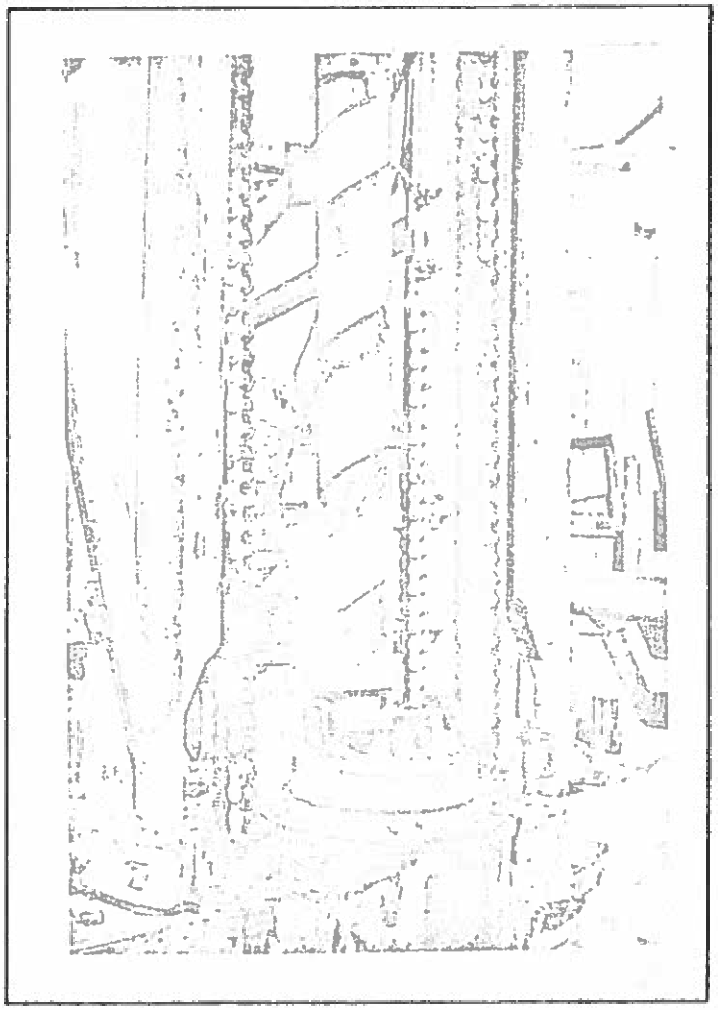


PLATE 2

CRREL Core Barrel

Borehole No. 5

PLATE 3

Partially Thawed Core of Organic Silt Borehole No. 4

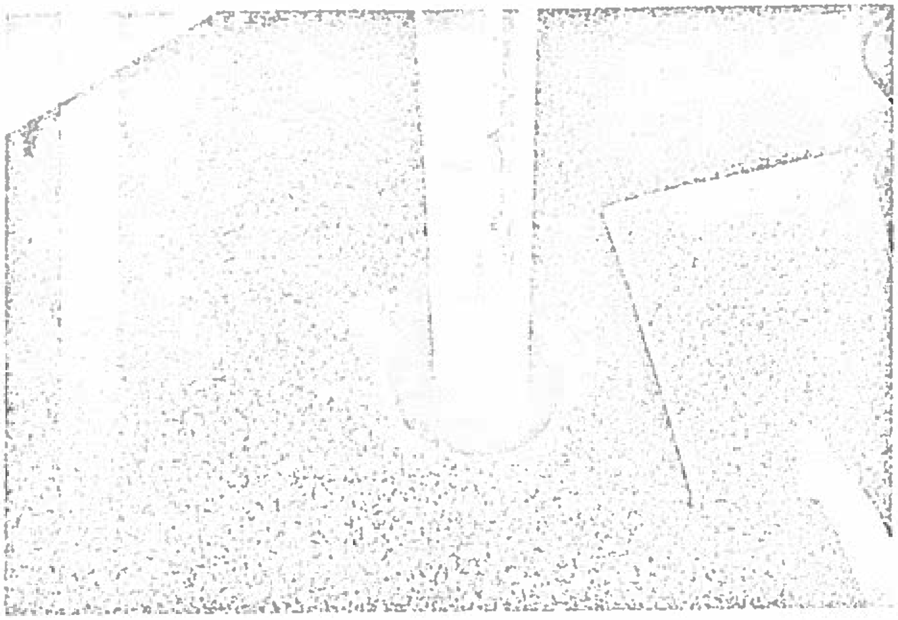


PLATE 4

Drilling Gravel With Air Flush at Borehole No. 9

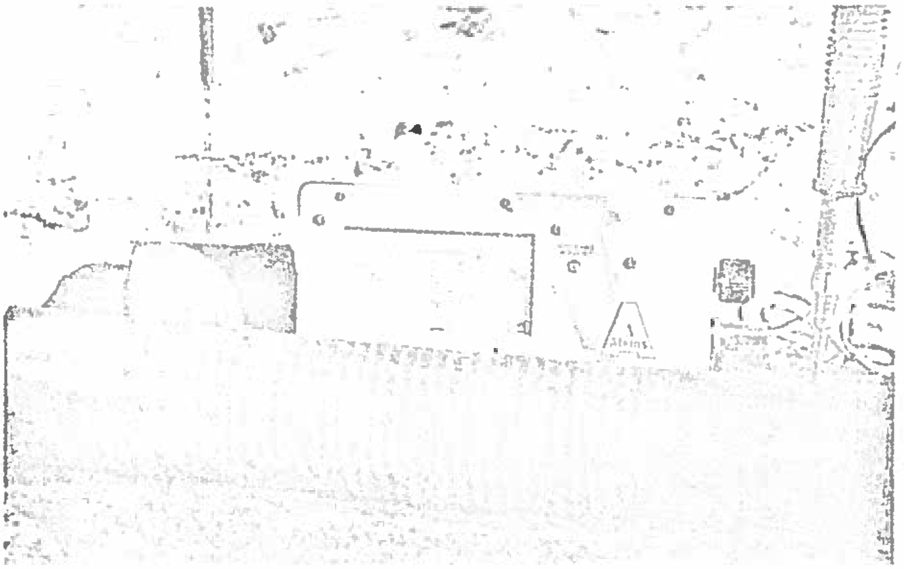


PLATE 5

Core Temperature Measurements Borehole No. 14

PLATE 6

Artesian Groundwater At Borehole No. 13

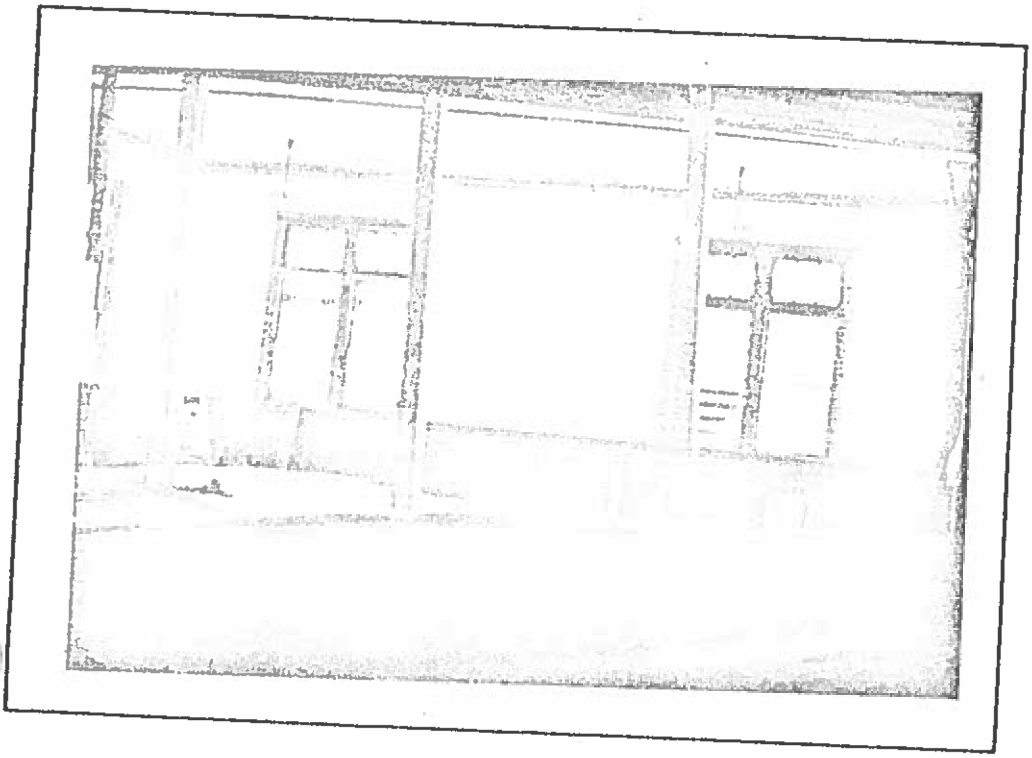


PLATE 7

Differential Floor Heave - St. Andrews Church

SYMBOLS & TERMS USED ON BORING LOGS

I. Soil Description

a) General Basis for Field Description of Soils

Major Divisions	Subdivisions	Field Identification
COARSE-GRAINED SOILS	COBBLES AND BOULDERS	Larger than 3 inches diameter - cobbles 3 to 8 inches - boulders greater than 8 inches
	GRAVEL	Smaller than 3 inches but larger than No. 10 Sieve (2 mm.)
	SAND	Smaller than No. 10 sieve but larger than .06 mm. Smaller particles are not visible to the naked eye.
FINE-GRAINED SOILS	SILT	Exhibits dilatancy (reacts to the shaking test). Powders easily when dry, only slight dry strength. Gritty to the teeth. Dries rapidly. No shine imparted when moist and stroked with knife blade.
	CLAY	Not dilatant. Possesses appreciable dry strength. When moist, sticks to fingers and does not wash off readily. Not gritty to the teeth. When moist a shiny surface is imparted when stroked with a knife blade.
ORGANIC SOILS	PARTLY ORGANIC - organic clay - organic silt etc.	Depending on amount of organic material, these soils usually have some of the characteristics of their inorganic counterparts: usually highly compressible (spongy) usually have characteristic odour.
	ORGANIC MATERIAL - peat	Fibrous structure - usually brown or black when moist. Spongy. Usually has characteristic odour.

(After NRC TM #37 with modifications for MIT Grain Size Scale.)

b) Genetic Terminology

When geologic origin of soils is evident to the field engineer, this terminology is used in conjunction with the general field description.

i.e. Till - soil deposited directly by a glacier. It is generally characterized by its well graded texture (wide range of particle sizes).

II. Ice Description

Non Visible Ice	Nf	Poorly bonded
	Nbn	Well bonded
	Nbe	Excess Ice
Visible Ice Less than 1 inch thick	Vx	Individual ice crystals or inclusions
	Vc	Ice coatings or particles
	Vr	Random or irregularly oriented ice formations
	Vs	Stratified or distinctly oriented ice formations
Visible Ice Greater Than 1 inch thick	ICE +	Ice with soil inclusions
	ICE	Ice without soil inclusions

(After NRC TM #79)

III. Symbols and Abbreviations

Moisture Content ⊖

Note: (1) Moisture content values which plot off scale are handwritten at the extreme right edge of the page.

Atterberg Limits - plastic |——

- liquid ——▷

S.G. Specific Gravity (Soil Solids)

O.C. Organic Content (% of dry soil weight)

Sample Type

☐	Undisturbed Sample	Good core, frozen
◩	Partially Disturbed Sample	Poor core, frozen
☒	Disturbed Sample	Thawed core or auger cuttings

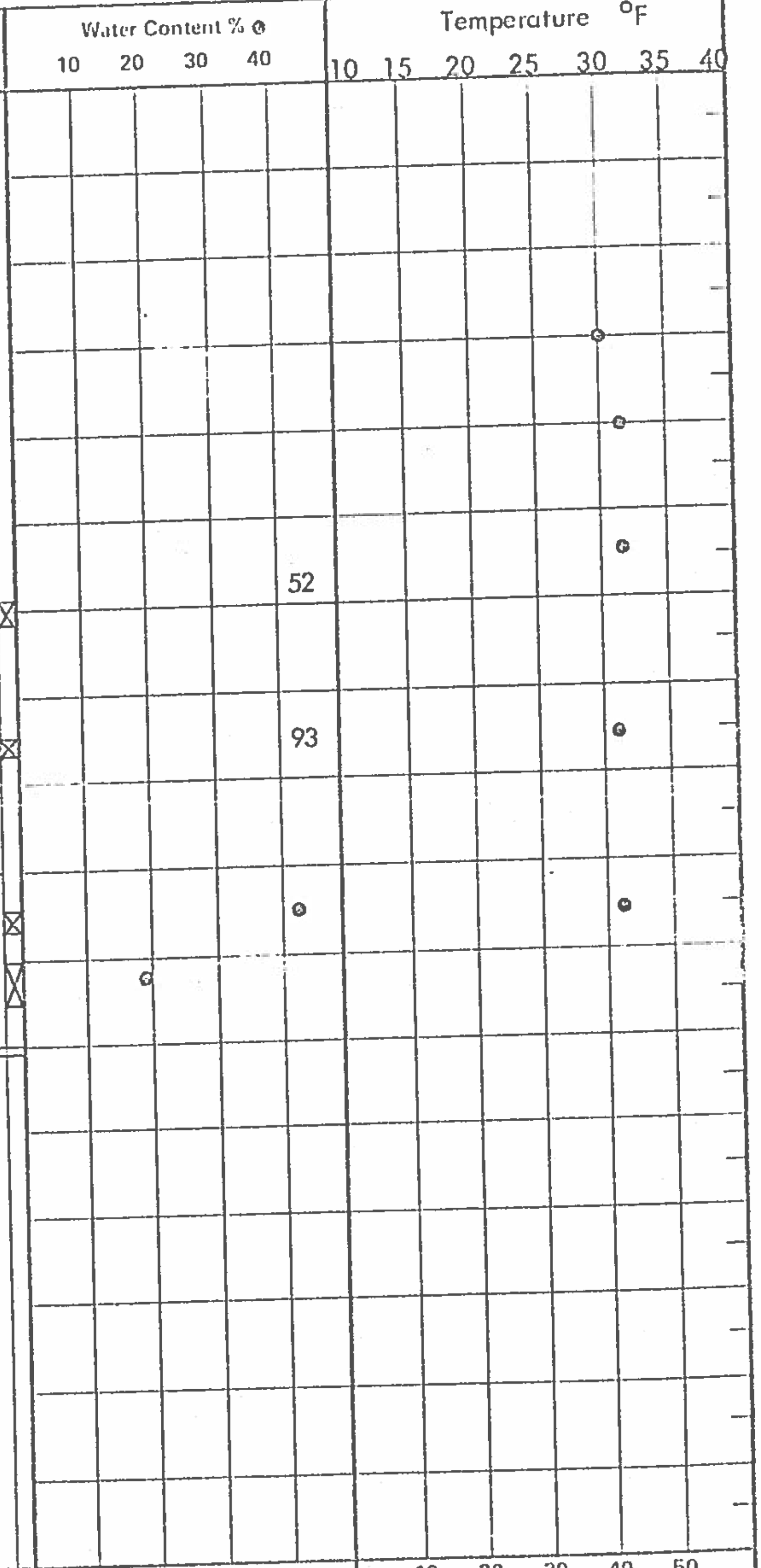
PROJECT Dawson (S.W. Corner 4th Ave. & King St.)

TESTHOLE No. 1

SURFACE ELEVATION 1050.6'

JOB No. E - 381 - C

Depth	Soil Description	Ice Description
1	FILL - clay rubble some gravel	
2	PEAT	
3 4 5 6	SILT - sandy, grey organic - peat & roots - fossil shells	Nbn
		Nbe - Vs 10%
7		Permafrost Nbe - Vs 15 - 20 %
		Nbe - Vs 10%
9 10	SAND - silty, medium brown - cohesive, some gravel	Nbn
11	GRAVEL	



10 20 30 40 50

Penetration Resistance N

Completion Depth 11.0'

Date Apr. 18/72

Depth to Water in Boring Dry

Page 1 of 1

Dwg. No.

BROOKER & ASSOCIATES

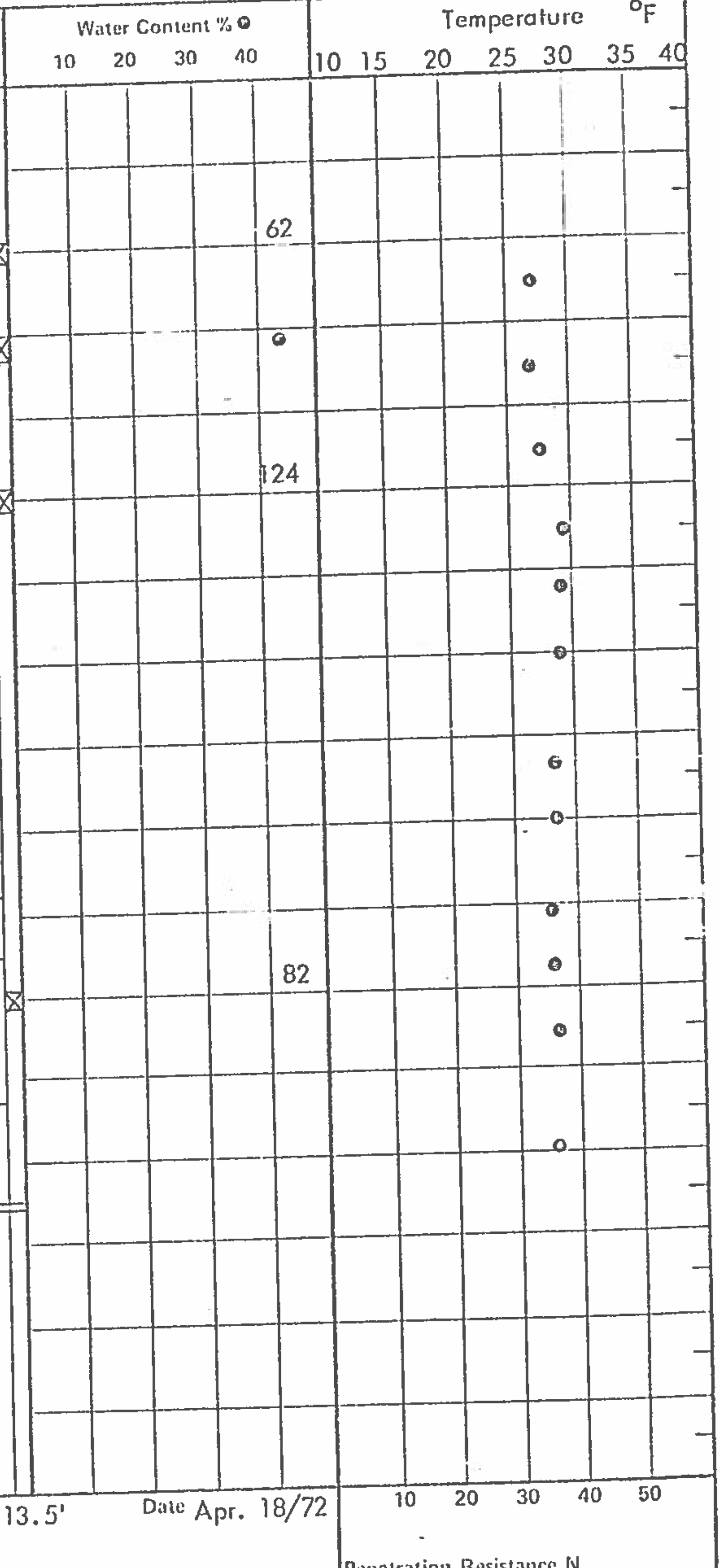
PROJECT Dawson (Old Bonanza Hotel)

SURFACE ELEVATION 1052.1'

TESTHOLE No. 2

JOB No. E - 383 - C

th ft.	Soil Description	Ice Description
0–2	FILL - clay, gravel roots & sawdust	frozen Nbn
2–13.5	SILT - sandy, organic grey - some peat O.C. = 13.9% 25 % sand 70 % silt 5 % clay	Vs 5-10% hairline ice Vs 10 - 15 % Vs 15% Vs 20 - 25 % hairline ice Nbe
13.5	GRAVEL	



Completion Depth 13.5'

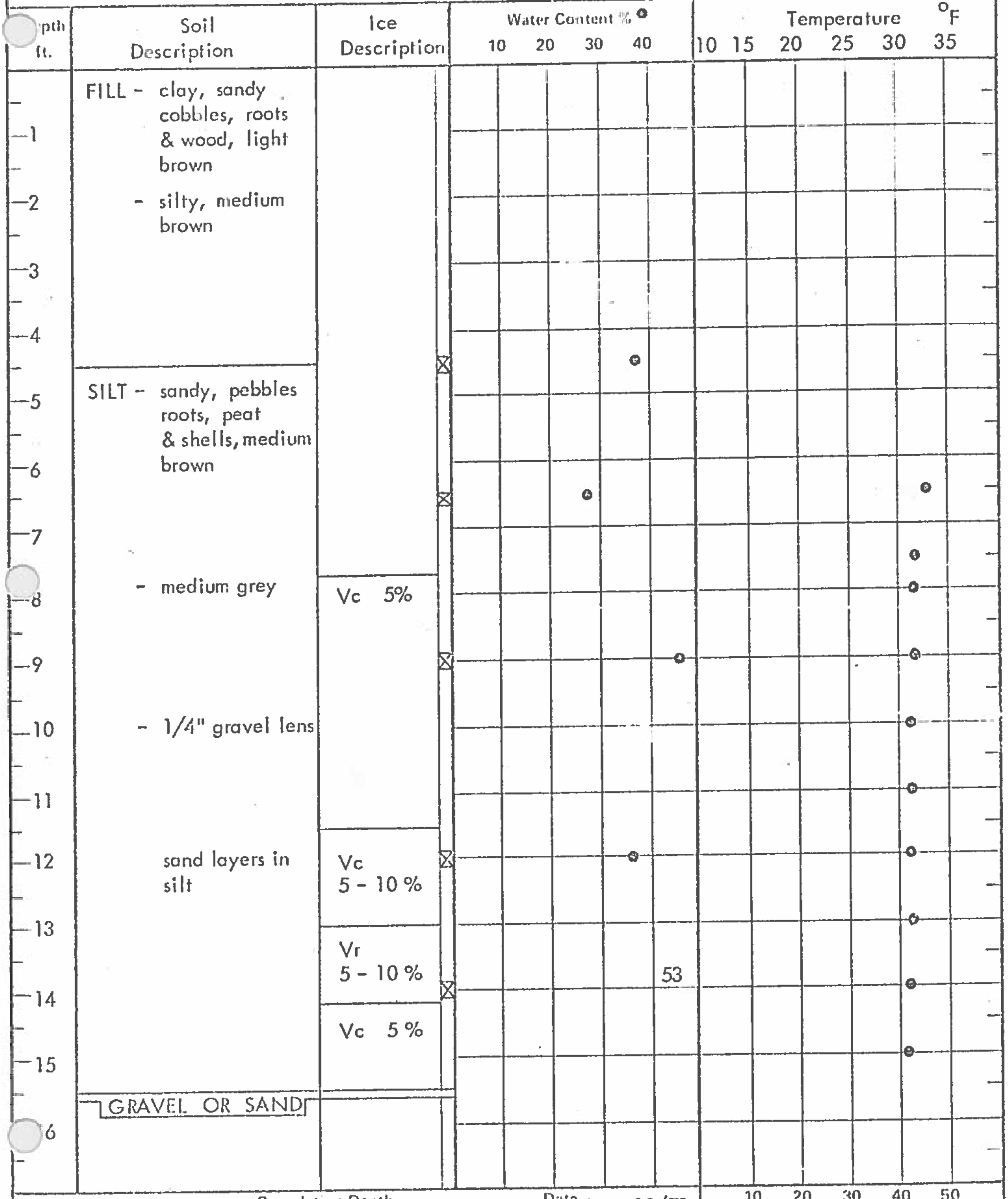
Date Apr. 18/72

Depth to Water in Boring Dry

Page 1 of 1

Dwg. No.

PROJECT	Dawson (Old Winault's Store)	TESTHOLE No.	3
SURFACE ELEVATION	1050.6'	JOB No.	E - 381 - C



Soil Description

FILL – clay, sandy cobbles, roots & wood, light brown

– silty, medium brown

SILT – sandy, pebbles roots, peat & shells, medium brown

– medium grey

– 1/4" gravel lens

sand layers in silt

GRAVEL OR SAND

Ice Description

Vc 5%

Vc 5 - 10 %

Vr 5 - 10 %

Vc 5 %

Completion Depth 15.5'

Date Apr. 19/72

Depth to Water

Page 1 of 1

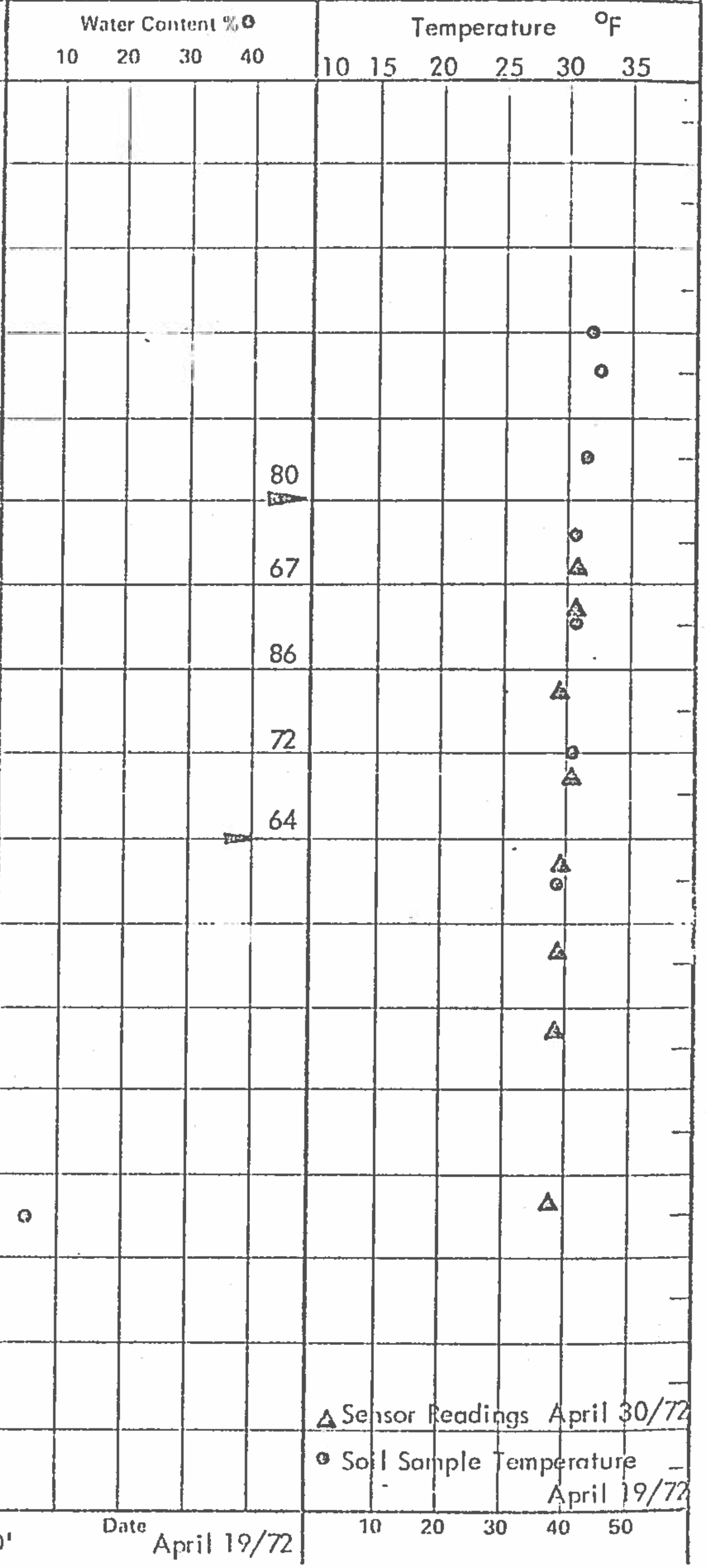
PROJECT Dawson (Old Post Office)

TESTHOLE No. 4

SURFACE ELEVATION 1051.6'

JOB No. E - 381 C

Depth ft.	Soil Description	Ice Description
1	FILL - clay, bricks, roots, wood, pebbles, sawdust medium brown	frozen Nbn (seasonal)
2	PEAT - medium brown	
3	SILT - organic, some peat, medium brown,	
4	nonplastic	thawed
5	OC=15.3% 18% sand 77% silt 5% clay -some fine sand, shells grey	frozen Nbn (permafrost) Vx - Vs 5 - 10 %
6		Vs 25%
7		
8		
9	O.C.=11.1% non plastic	Vs 20% some Vx + Vc
10	no recovery	
11		
12	GRAVEL - sandy, some silt, grey	frozen Nbn
13		
14		
15		
16		
17	(hole sloughed to 12.5')	



Completion Depth 17.0'

Date April 19/72

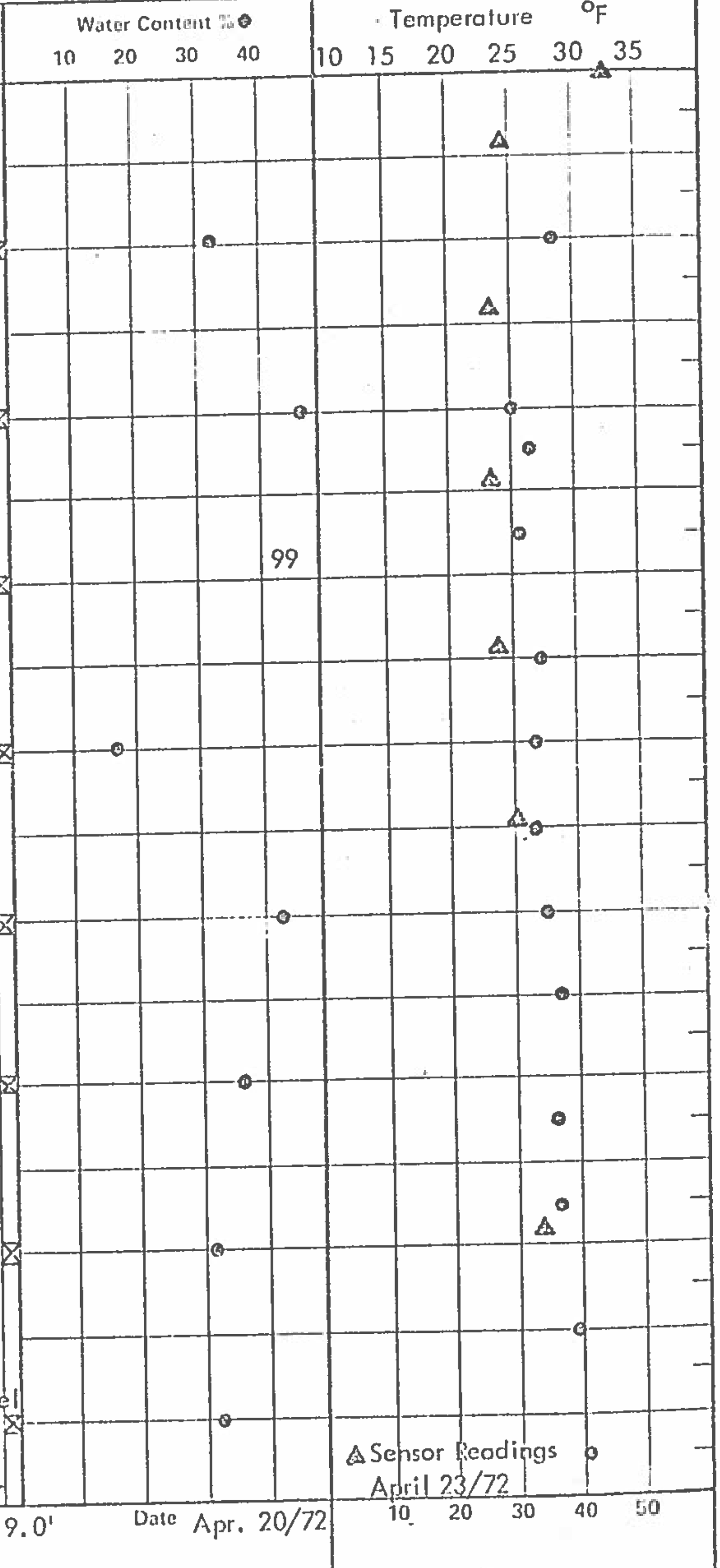
PROJECT Dawson (Red Feather Saloon)

SURFACE ELEVATION 1048.5'

TESTHOLE No. 5

JOB No. E - 381 - C

Depth ft.	Soil Description	Ice Description
0 - 1.5	FILL - clay rubble, wood & steel	frozen
1.5 - 1.9	PEAT - some cobbles & rubble	
1.9 - 4	SILT - organic, grey some peat	Nbn
4 - 6		Vs 5 % 20 %
6 - 7.5		Vs 10 - 15 %
7.5 - 8.3	SAND - silty grey SILT - sandy, grey	Vc 10% some Vx
8.3 - 9.8	SAND - silty, grey - peat & sand lenses	Vx 15%
9.8 - 17	- interbedded peat O.C. = 5.9% 52 % sand 40 % silt 8 % clay - 3" tree root - medium brown some silt - medium brown to grey, fine sand - medium - coarse, medium brown, occ. pebble	Nbn 2 % gravel 98 % sand
17	GRAVEL	



Completion Depth 19.0'

Date Apr. 20/72

Depth to Water

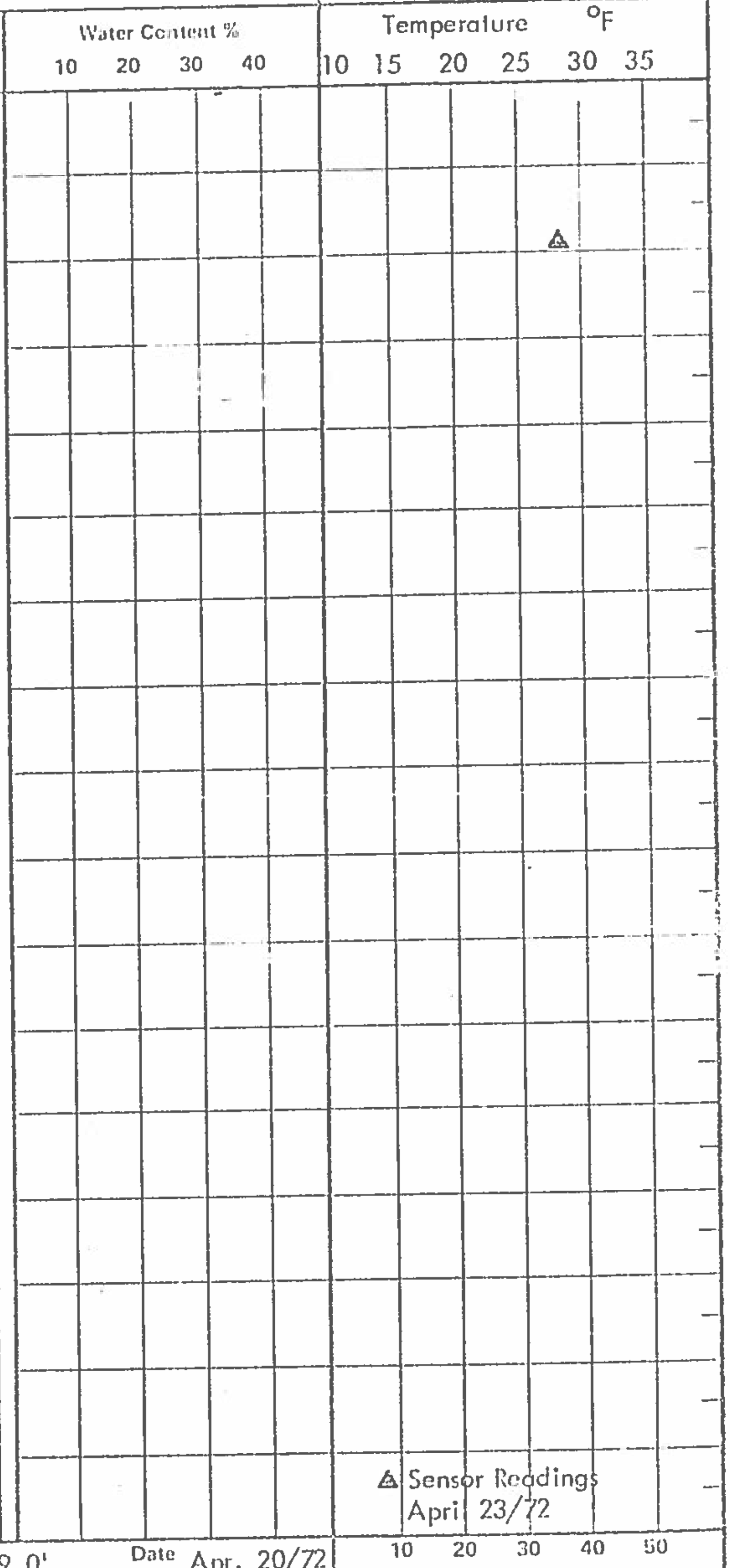
PROJECT Dawson (Red Feather Saloon)

TESTHOLE No. 5

SURFACE ELEVATION 1048.5'

JOB No. E - 381 - C

Depth ft.	Soil Description	Ice Description
18	GRAVEL (no core)	
19	Hole sloughed to 17.0'	



Completion Depth 19.0'

Date Apr. 20/72

Penetration Resistance N

Depth to Water in Boring Dry

Page 2 of 2

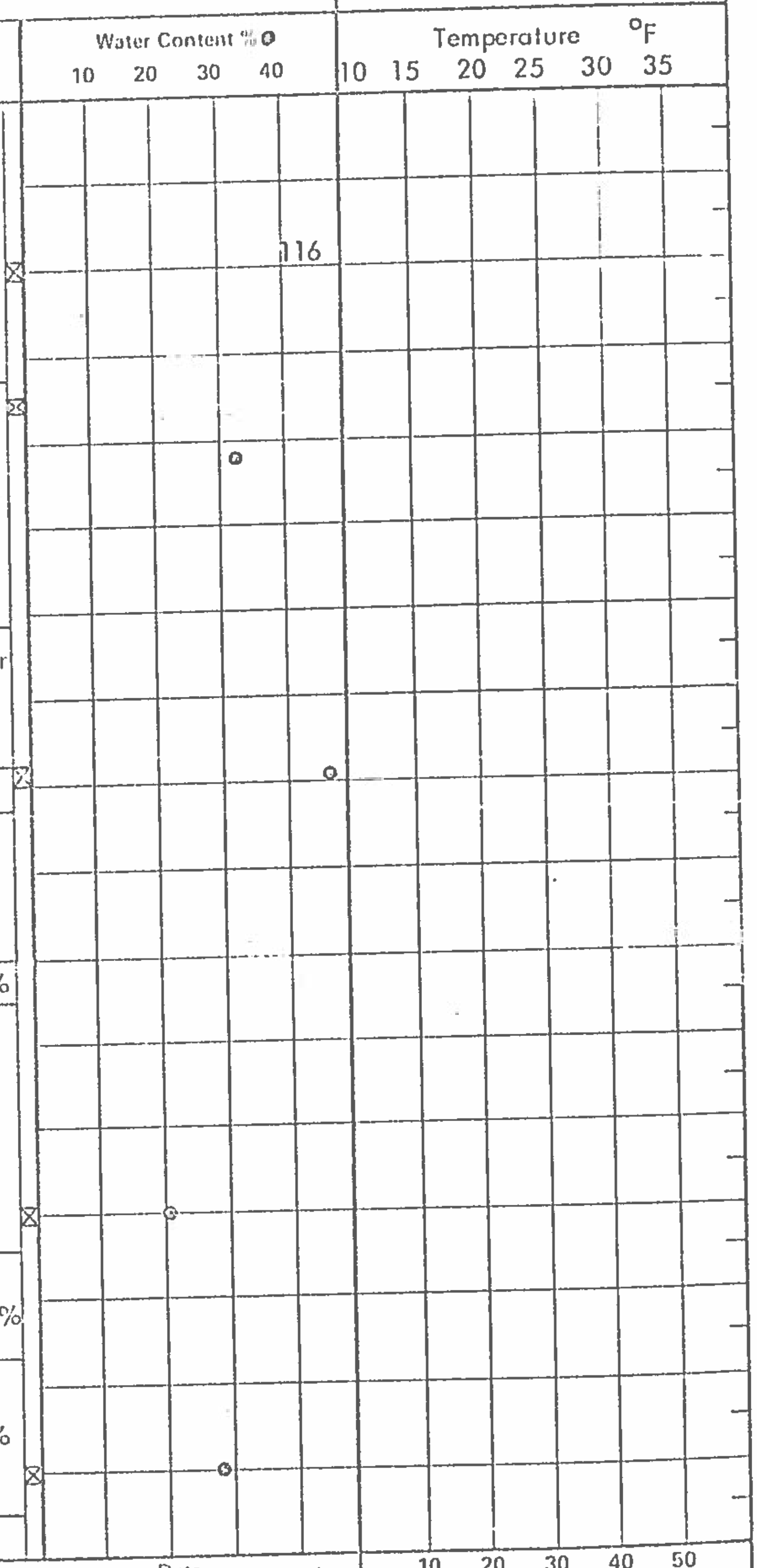
PROJECT Dawson (Ruby's Place)

TESTHOLE No. 6

SURFACE ELEVATION 1049.4'

JOB No. E - 381 - C

Depth ft.	Soil Description	Ice Description
1 2	FILL - clay, rubble, gravel, ashes wood	
	PEAT - dark brown	
3	NO RECOVERY	
4 5 6 7	SILT - sandy, some peat, grey - laminated peat O.C. = 7.7 %	Nbn Nbn to Vr 5 %
8 9	SAND - silty, grey laminated peat - medium brown	Nbn
10	SILT - some sand & peat	Vc 0-5%
11 12	SAND - silty, laminated with peat, grey	Nbn
	GRAVEL	
13 14 15 16 17	SAND - silty, grey, some gravel - tree roots - some pebbles & occ. rock	Vc 10 - 15 % Vc 5 - 10 % Nbn



Completion Depth 18.0'

Date Apr. 20/72

10 20 30 40 50

Penetration Resistance N

Depth to Water in Boring Dry

Page 1 of 2

Dwg. No.

PROJECT	Dawson (Ruby's Place)
TESTHOLE No.	6
JOB No.	E - 381 - C
SURFACE ELEVATION	1049.4'

Depth ft.	Soil Description	Ice Description	Water Content % 10 20 30 40	Temperature °F 10 15 20 25 30 35
	SAND - grey silty some gravel	Nbn		
18	GRAVEL			

Completion Depth 18.0'

Date Apr. 20/72

Depth to Water

Page 2 of 2

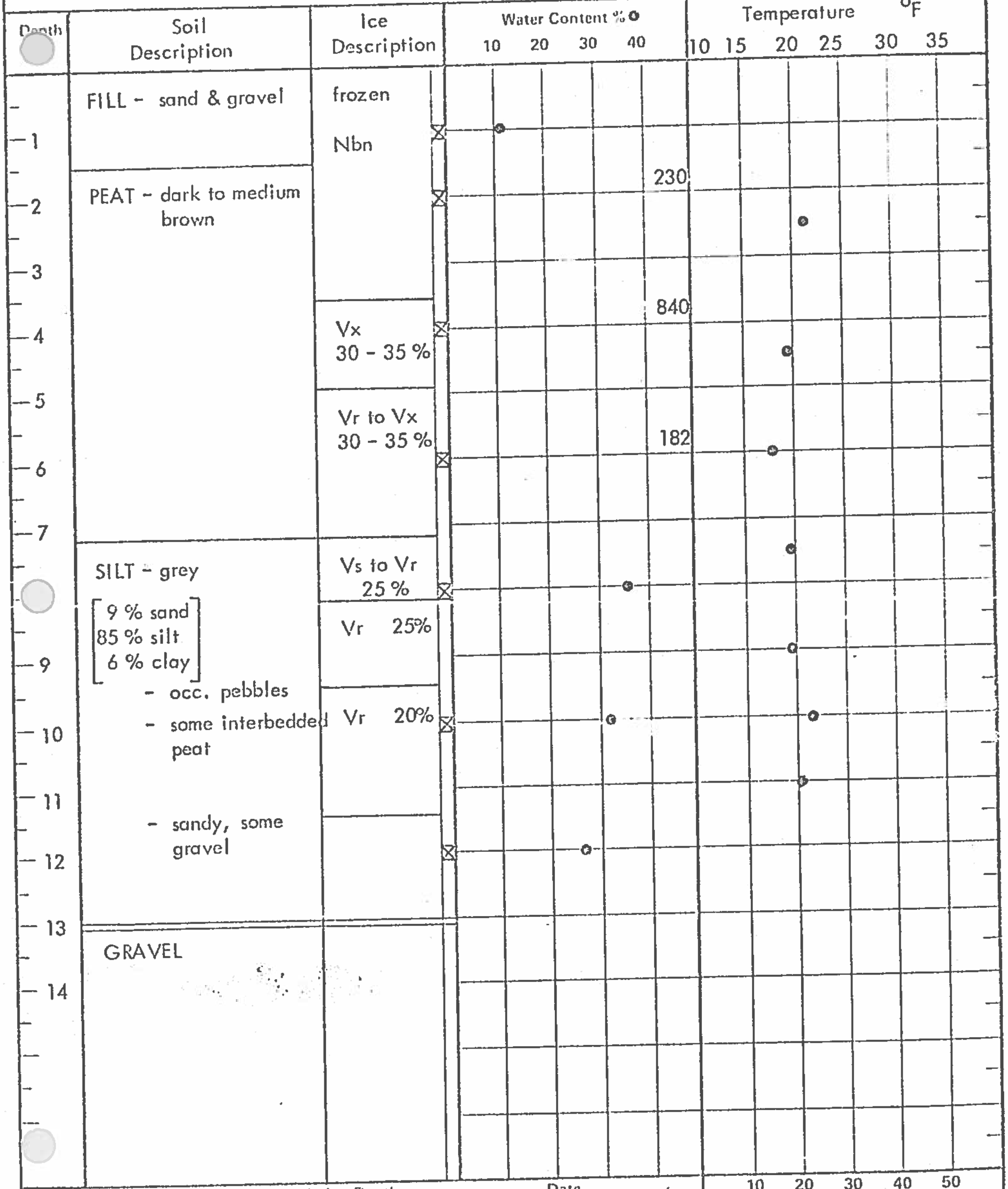
Penetration Resistance N 10 20 30 40 50

PROJECT Dawson (Proposed Arena)

TESTHOLE No. 7

JOB No. E - 381 - C

SURFACE ELEVATION 1052.5'



Soil Description	Ice Description
FILL - sand & gravel	frozen Nbn
PEAT - dark to medium brown	
	Vx 30 - 35 %
	Vr to Vx 30 - 35 %
SILT - grey [9 % sand 85 % silt 6 % clay] - occ. pebbles - some interbedded peat - sandy, some gravel	Vs to Vr 25 %
	Vr 25%
	Vr 20%
GRAVEL	

10 20 30 40 50

Penetration Resistance N

Completion Depth 13' 2"

Date Apr. 20/72

Depth to Water in Boring Dry

Page 1 of 1

Dwg. No.

BROOKER & ASSOCIATES

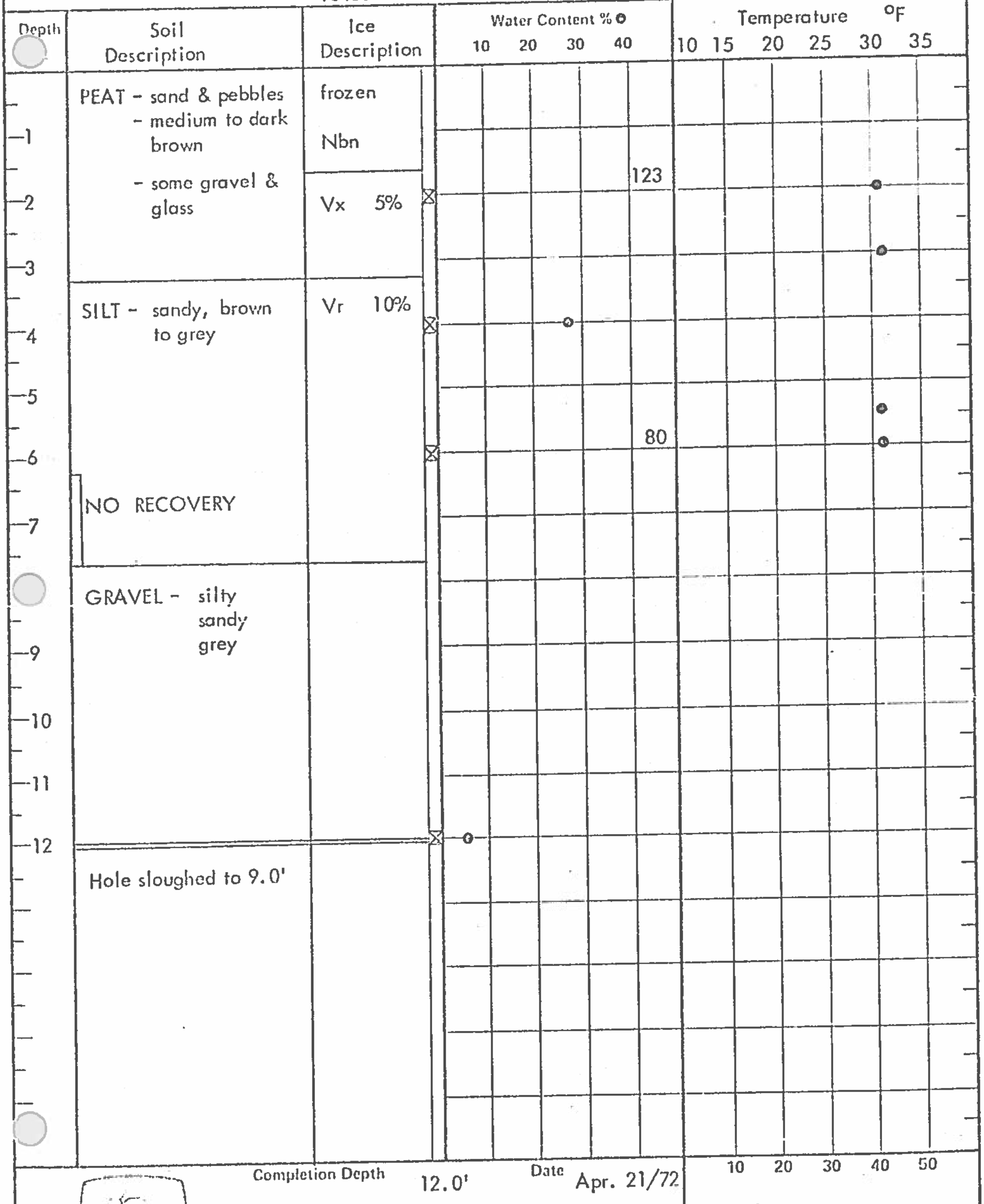
PROJECT Dawson (Proposed Arena).

TESTHOLE No. 8

SURFACE ELEVATION 1048.4'

JOB No. E - 381 - C

Depth	Soil Description	Ice Description
	PEAT - sand & pebbles - medium to dark brown	frozen Nbn
	- some gravel & glass	Vx 5%
	SILT - sandy, brown to grey	Vr 10%
	NO RECOVERY	
	GRAVEL - silty sandy grey	
	Hole sloughed to 9.0'	



Completion Depth 12.0'

Date Apr. 21/72

Depth to Water in Boring Dry

Page 1 of 1

Dwg. No.

BROOKER & ASSOCIATES

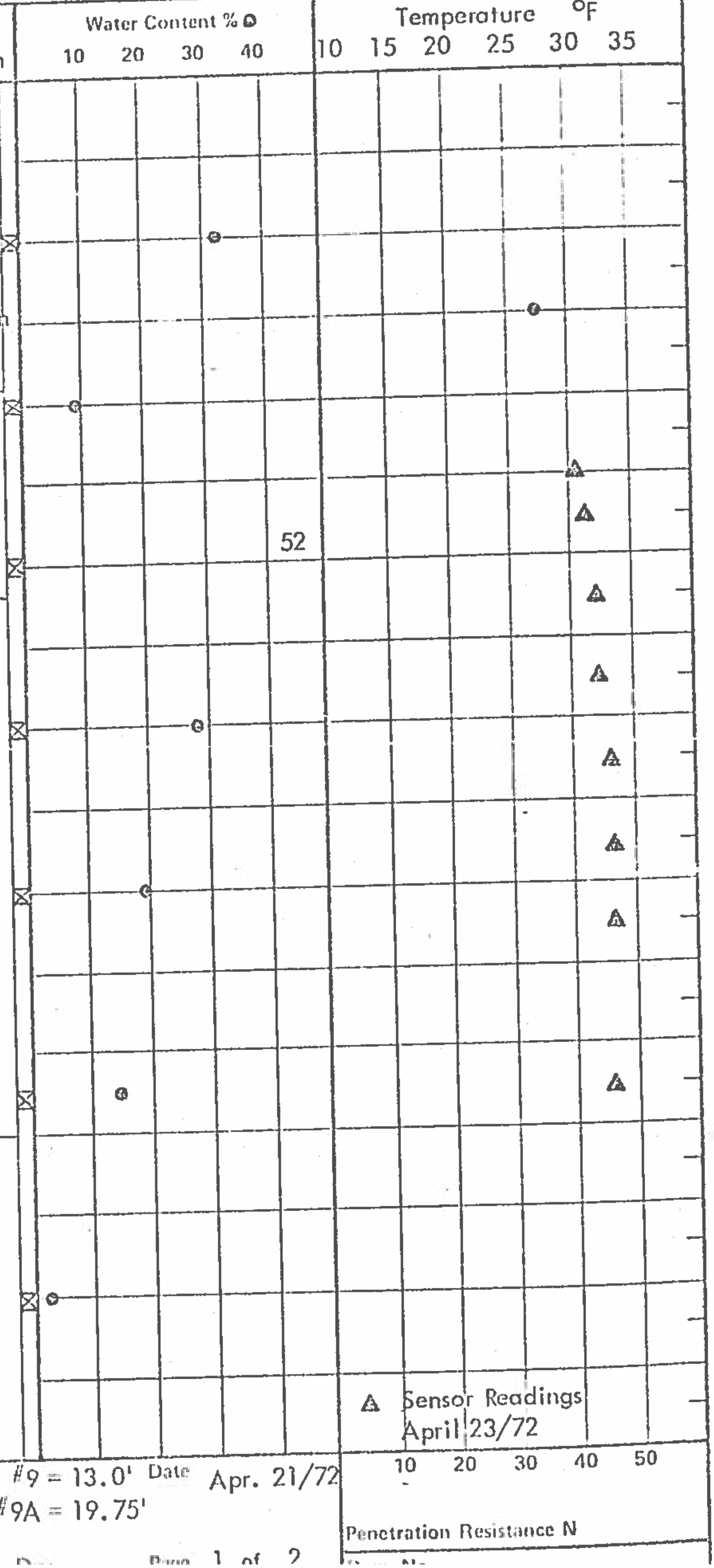
PROJECT Dawson (Commissioner's Residence)

TESTHOLE No. 9 & 9A

SURFACE ELEVATION 1046.7'

JOB No. E - 381 - C

Depth ft.	Soil Description	Ice Description
	SILT - organic, medium brown, roots	frozen Nbn
1		
2	- medium brown to grey, sandy laminated peat	Nbn some ice coatings on peat particles
3		
4	SAND - silty, dry medium brown 62 % sand & gravel 32 % silt 6 % clay	Nf
5		
6	SILT - sandy, grey interbedded peat	
7	SAND - silty, medium brown	unfrozen
8		
9	- some peat	
10		
11	- some gravel	
12		
13	GRAVEL - no penetration TH 9 TH 9A drilled to 19.75' hole sloughed to 12.5'	
14		
15	19 % gravel 67 % sand 14 % silt	
16		
17		



Completion Depth #9 = 13.0' Date Apr. 21/72
#9A = 19.75'

Depth to Water

PROJECT Dawson (Commissioner's Residence)

TESTHOLE No. 9A

SURFACE ELEVATION 1046.7'

JOB No. E - 381 - C

pth ft.	Soil Description	Ice Description	Water Content % 10 20 30 40	Temperature °F 10 15 20 25 30 35
	GRAVEL			
18				
19				
20	END OF HOLE TH 9A Note: Plastic pipe, slotted bottom 18" installed to 13.5'. Backfill with sand filter around slotted portion, 12" of bentonite (drilling mud) seal and random backfill placed above			

Completion Depth 19.75'

Date Apr. 22/72

10 20 30 40 50

Penetration Resistance N

Depth to Water in Boring Dry

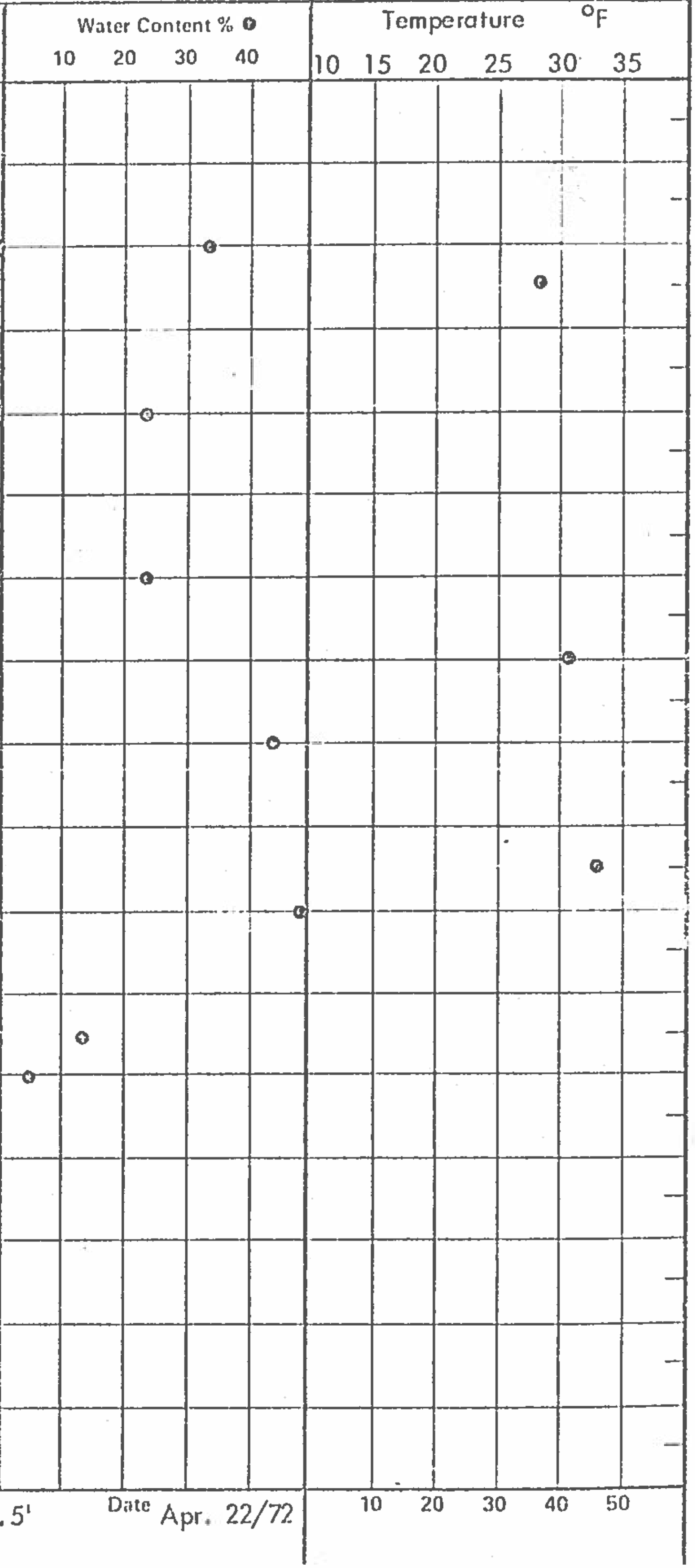
Page 2 of 2

Dwg. No

PROJECT	Dawson (St. Andrews Church)	TESTHOLE No.	10
SURFACE ELEVATION	1048.8'	JOB No.	E - 381 - C

Depth ft.	Soil Description	Ice Description
	FILL - silt, organic sand, gravelly medium brown	
	SILT - med. to dark brown	
	SAND - silty, medium brown, peat laminations - silt laminations	Nf
	SILT - grey, some peat	unfrozen
	SAND - silty, medium brown to grey - medium brown some gravel	
	GRAVEL	

Depth ft.: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14



Completion Depth 13.5'

Date Apr. 22/72

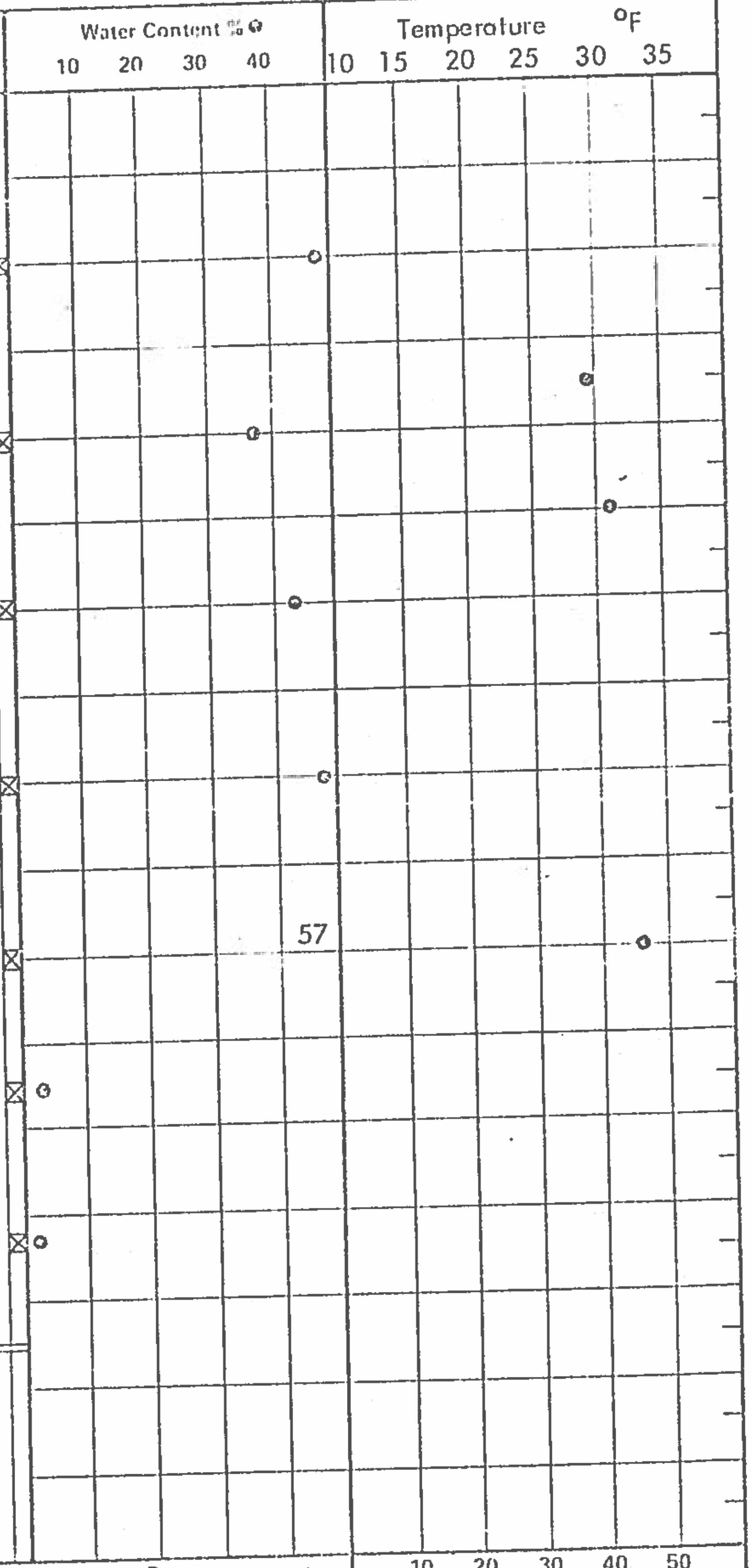
PROJECT Dawson (Old Administration Building)

TESTHOLE No. 11

SURFACE ELEVATION 1047.8'

JOB No. E - 381 - C

th ft.	Soil Description	Ice Description
1	FILL - silt, pebbles wood, roots	
2–3	- silt, sand, peat medium brown	Nf
4–5	- burnt wood, metal	
6	SILT - peat, grey	
6–7	SAND - silty peat medium brown	unfrozen
8–10	- peat & silt laminations 42 % sand 54 % silt 4 % clay O.C. = 16 % - occ. pebble	
11	- dark brown, some gravel	
12–14	GRAVEL - some sand 69 % gravel 31 % sand	
15	Hole sloughed to 12.9'	



Completion Depth 14.5'

Date Apr. 23/72

Depth to Water in Boring Dry

Page 1 of 1

10 20 30 40 50

Penetration Resistance N

Dwg. No.

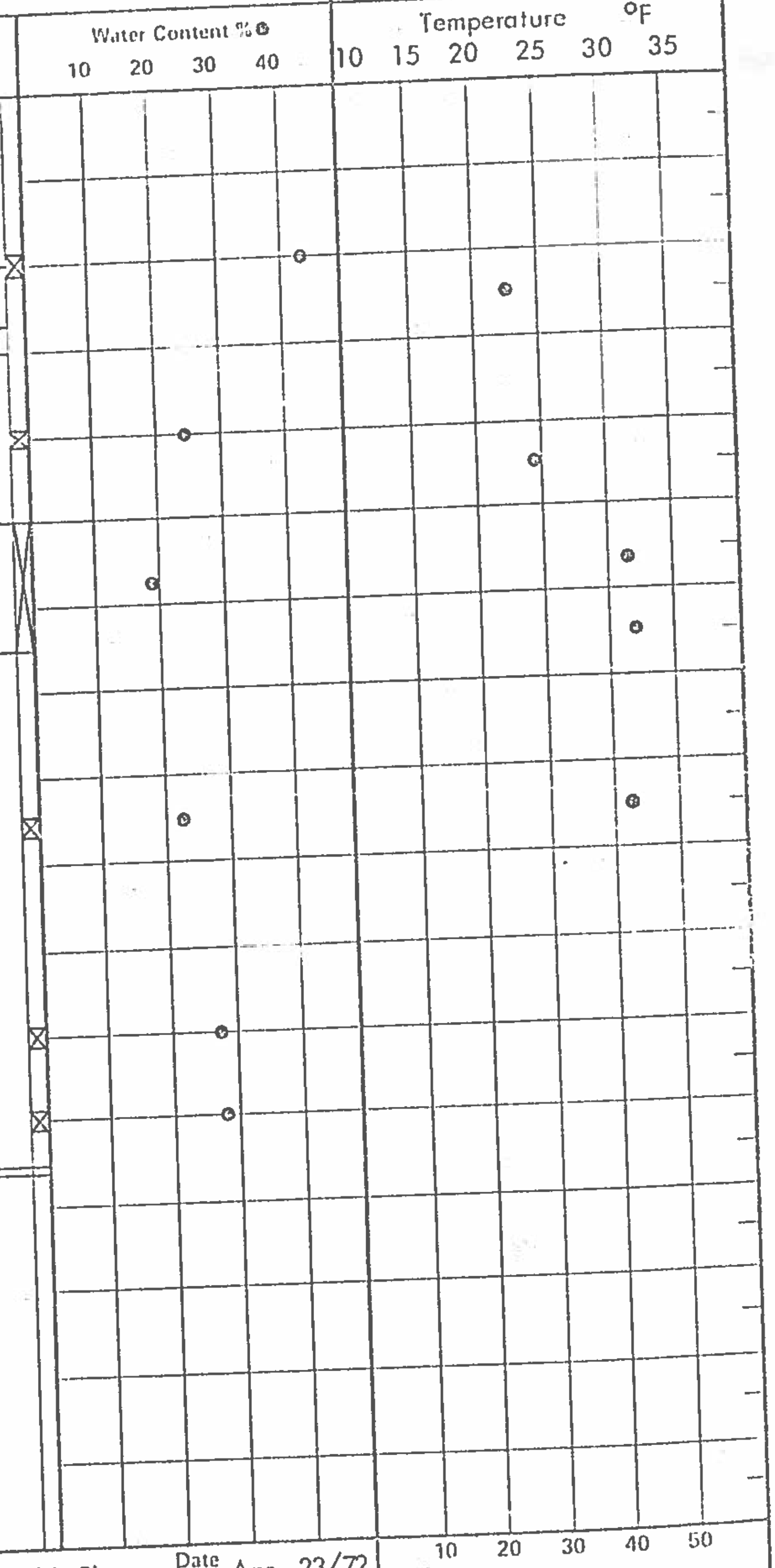
TESTHOLE No. 12

PROJECT Dawson (Historic Sites Building)

JOB No. E - 381 - C

SURFACE ELEVATION 1049.8'

Depth	Soil Description	Ice Description
1	FILL - gravel - silt & gravel mixed, some peat	
2 3 4 5 6	SILT - peat & sand laminations brown to grey - peat laminations 32 % sand 62 % silt 4 % clay	Nbn Ice coating on peat Nf Nbn Ice coating on peat & some Nf Nf
7 8 9 10 11 12	SAND - fine clean - medium - coarse - silty, peat laminations - coarse, silty fine sand laminations - medium to coarse sand	Nbn
13	GRAVEL OR BOULDERS No Penetration	



Completion Depth 12.5'

Date Apr. 23/72

Depth to Water in Boring Dry

Page 1 of 1

Dwg. No.

BROOKER & ASSOCIATES

TESTHOLE No. 13

PROJECT Dawson City

JOB No. E - 381 - C

SURFACE ELEVATION 1052.8'

pth ft.	Soil Description	Ice Description	Water Content % 10 20 30 40	Temperature °F 10 15 20 25 30 35
0–1.5	PEAT - roots & wood dark brown			
1.5–6	SILT - peat mixed - some roots & peat grey - organic, some peat, dark brown	Nbn - ice lens 2-1/2"	57	
6	Note: Artesian water condition encountered at 6 ft. Flow estimated at 50 gpm from 4-1/2" borehole. Auger removed and hole tightly plugged with 5 ft. of log.			

Completion Depth 6.0'

Date Apr. 23/72

Depth to Water Artesian

Page 1 of 1

Penetration Resistance N 10 20 30 40 50

Dwg. No.

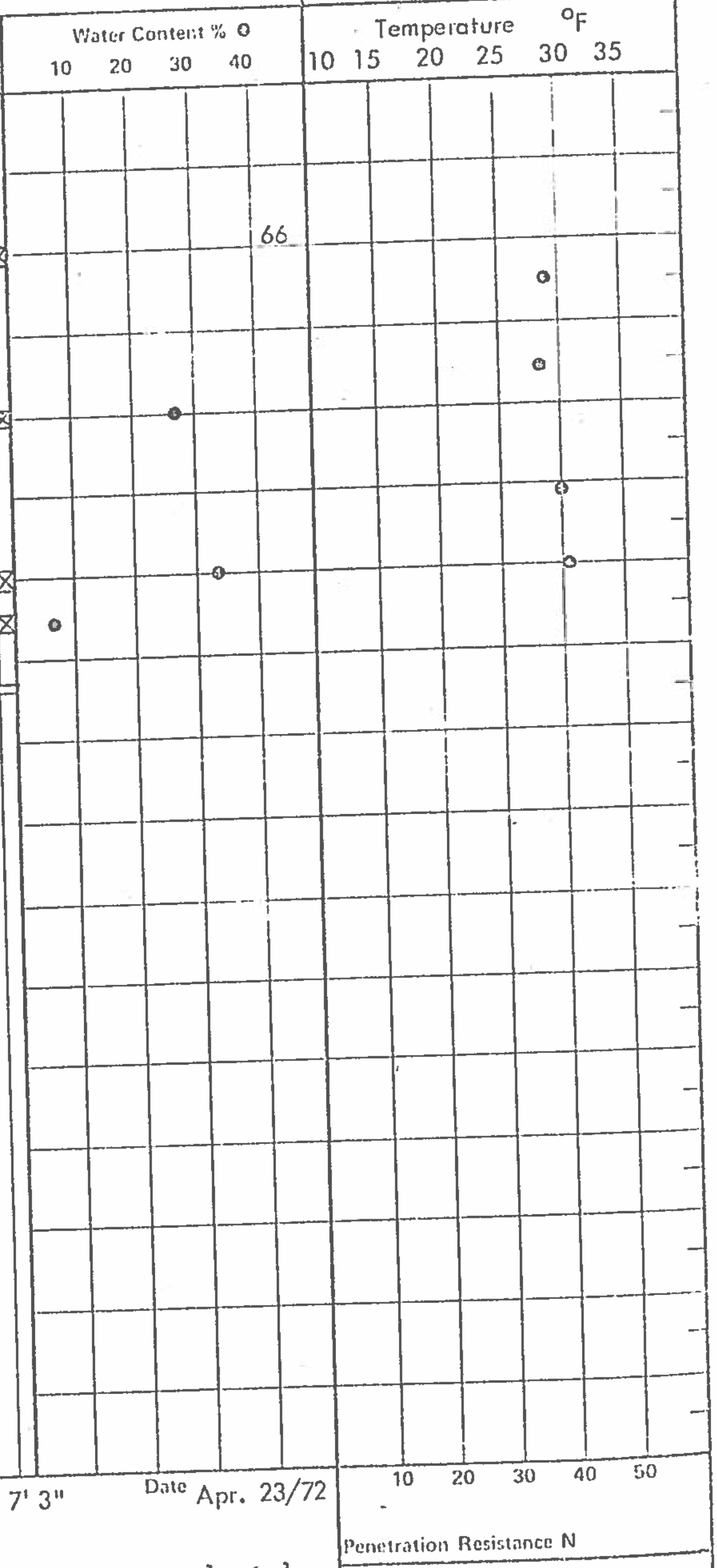
PROJECT Dawson City

SURFACE ELEVATION 1048.2'

TESTHOLE No. 14

JOB No. E - 381 - C

Depth ft.	Soil Description	Ice Description
	FILL - gravel	frozen
1	PEAT - dark brown	
2	SILT - peat laminations brown - light brown to grey, some peat stratified	Vs 5%
3 4		
5 6	- light brown peat laminations	Vs 10 - 15 %
7	GRAVEL - sand & silt	
8	Hole sloughed to 6.5 ft.	



Completion Depth 7' 3"

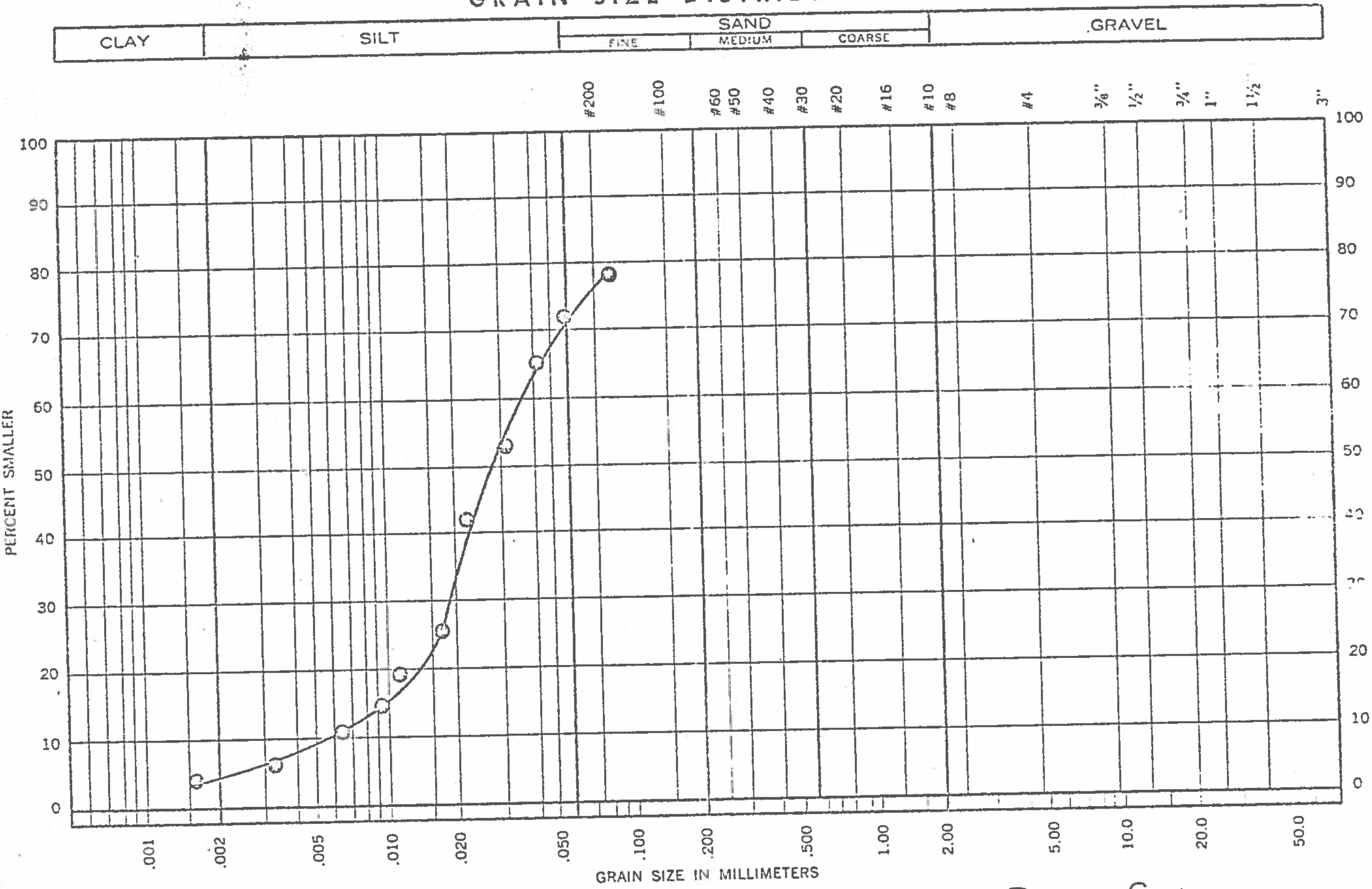
Date Apr. 23/72

Depth to Water in Boring Dry

Page 1 of 1

Dwg. No.

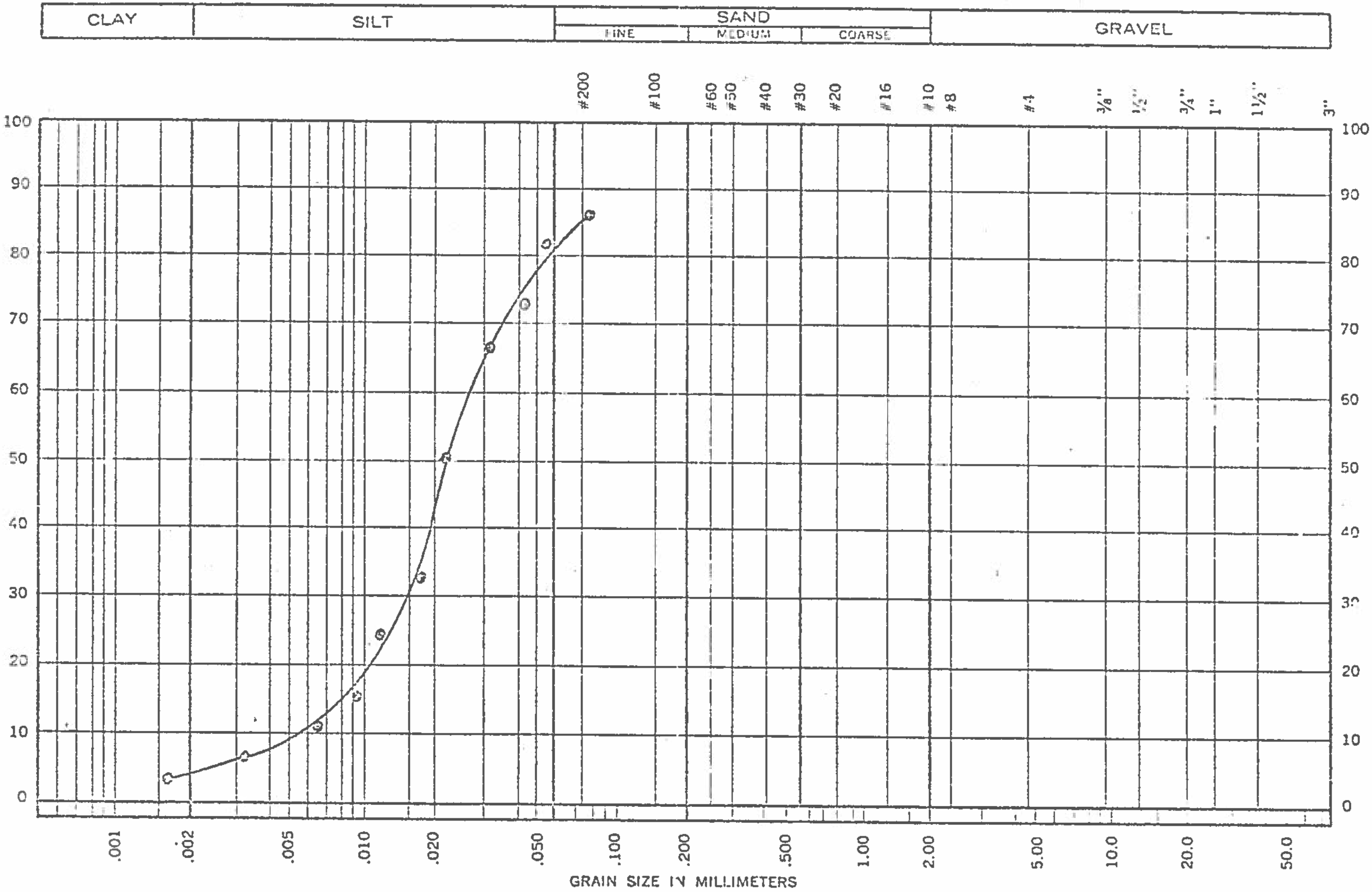
GRAIN SIZE DISTRIBUTION



SAMPLE DESCRIPTION BROWN SILT

PROJECT DAWSON CITY
JOB No. E 391-C DATE MAY 5, 1972
SAMPLE No. T.H. 2
DEPTH 11'

GRAIN SIZE DISTRIBUTION

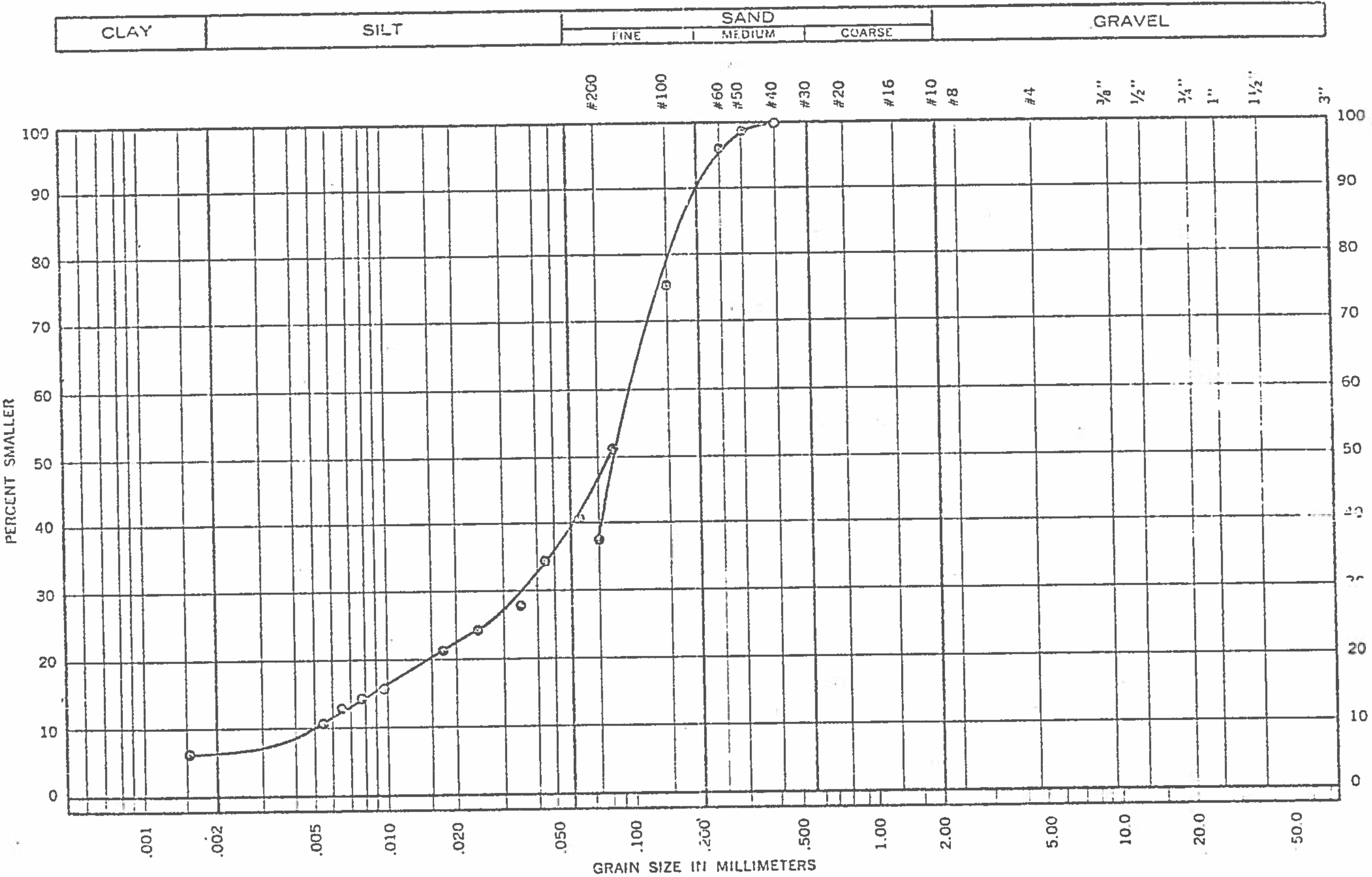


BROOKER & ASSOCIATES

SAMPLE DESCRIPTION BROWN SILT

PROJECT DAWSON CITY
JOB No. E 381-C DATE MAY 5/72
SAMPLE No. T/H4
DEPTH 5'

GRAIN SIZE DISTRIBUTION

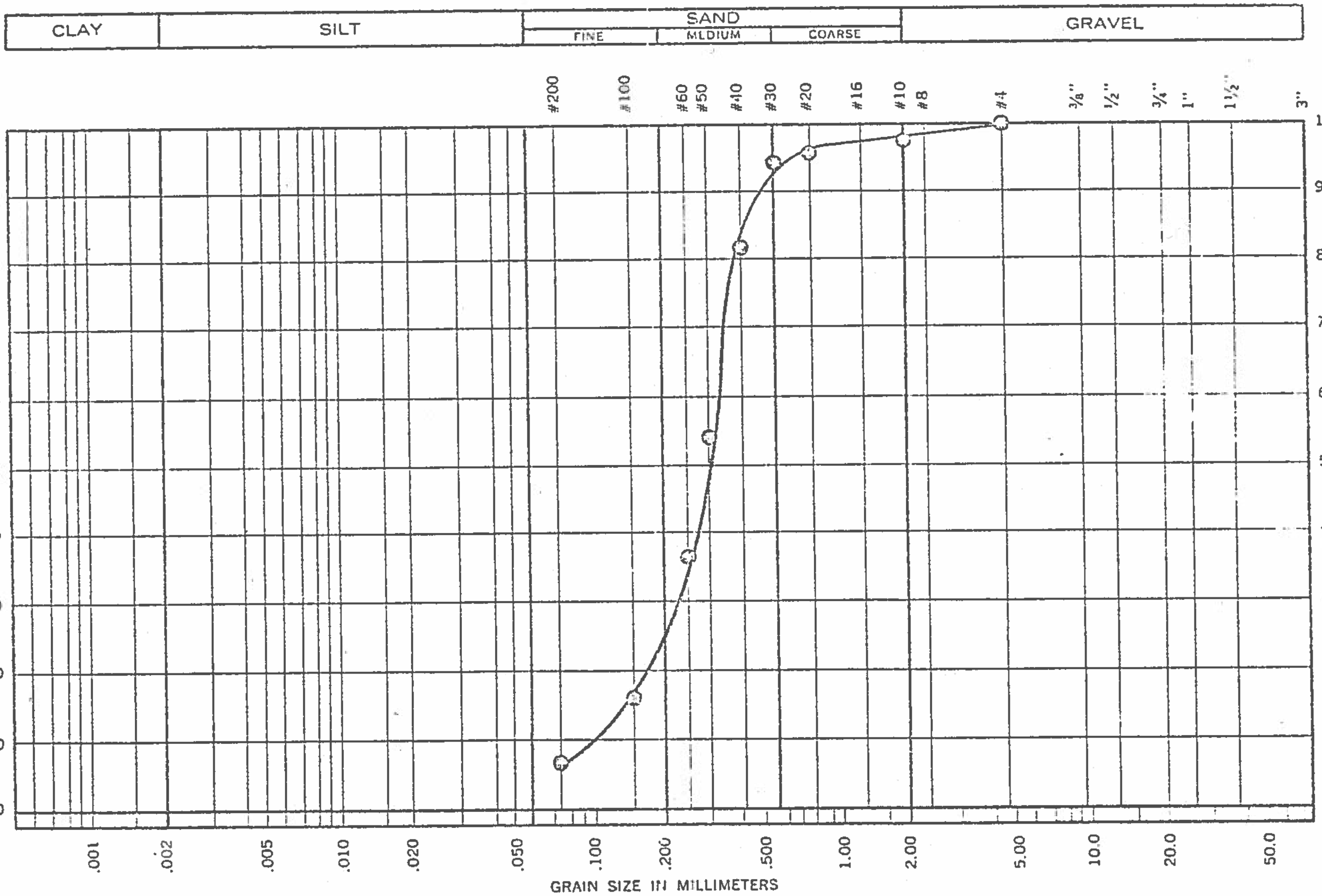


BROOKER & ASSOCIATES

SAMPLE DESCRIPTION SILTY SAND

PROJECT DAWSON CITY
JOB No. E-381-C DATE MAY 8, 1972
SAMPLE No. T.H. #5
DEPTH 10'

GRAIN SIZE DISTRIBUTION

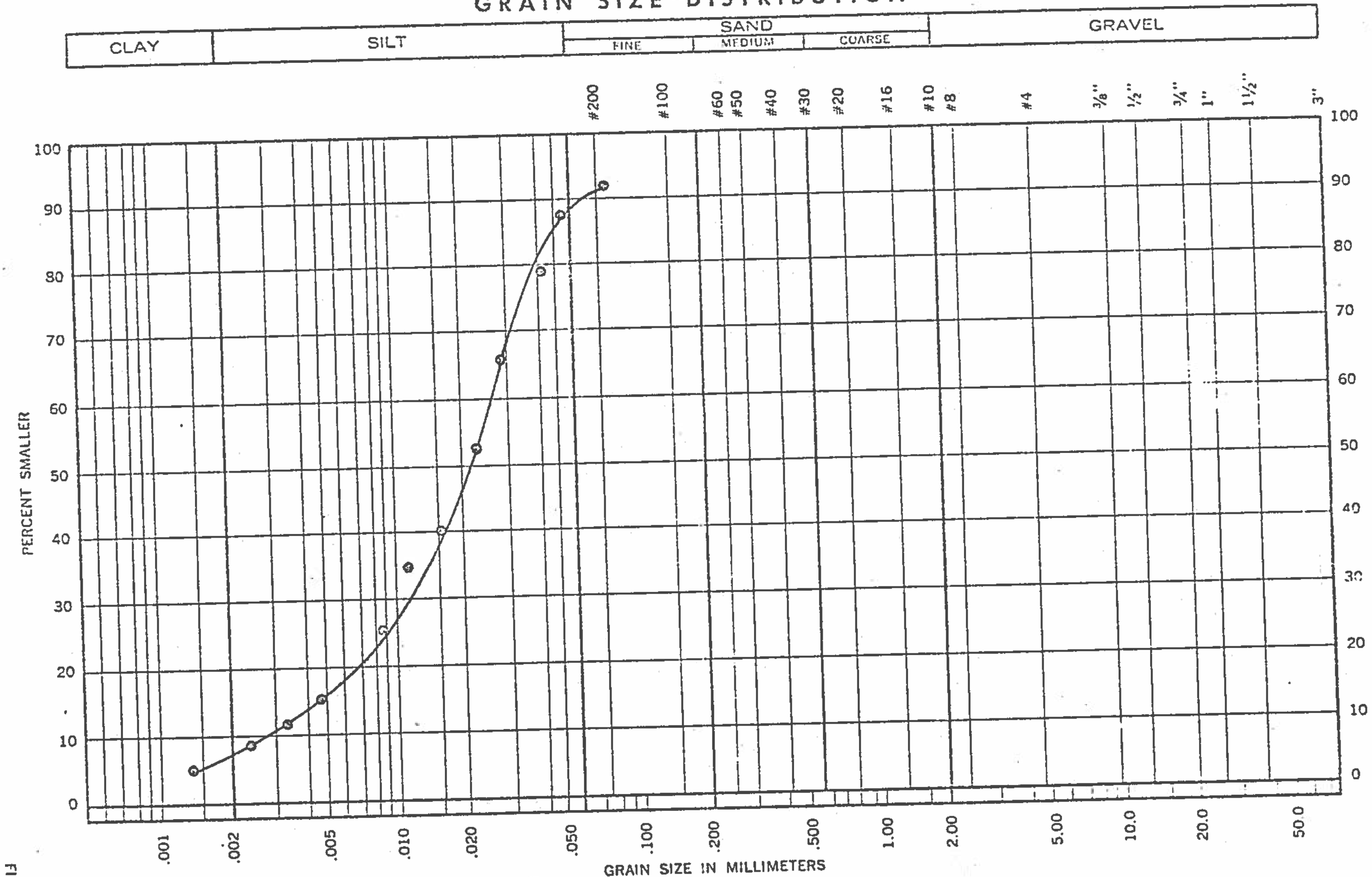


BROOKER & ASSOCIATES

SAMPLE DESCRIPTION SAND

PROJECT DAWSON CITY
JOB No. E381-C DATE MAY 5, 1972
SAMPLE No. TH 5
DEPTH 16'

GRAIN SIZE DISTRIBUTION



FIGURE

BROOKER & ASSOCIATES

SAMPLE DESCRIPTION SILT

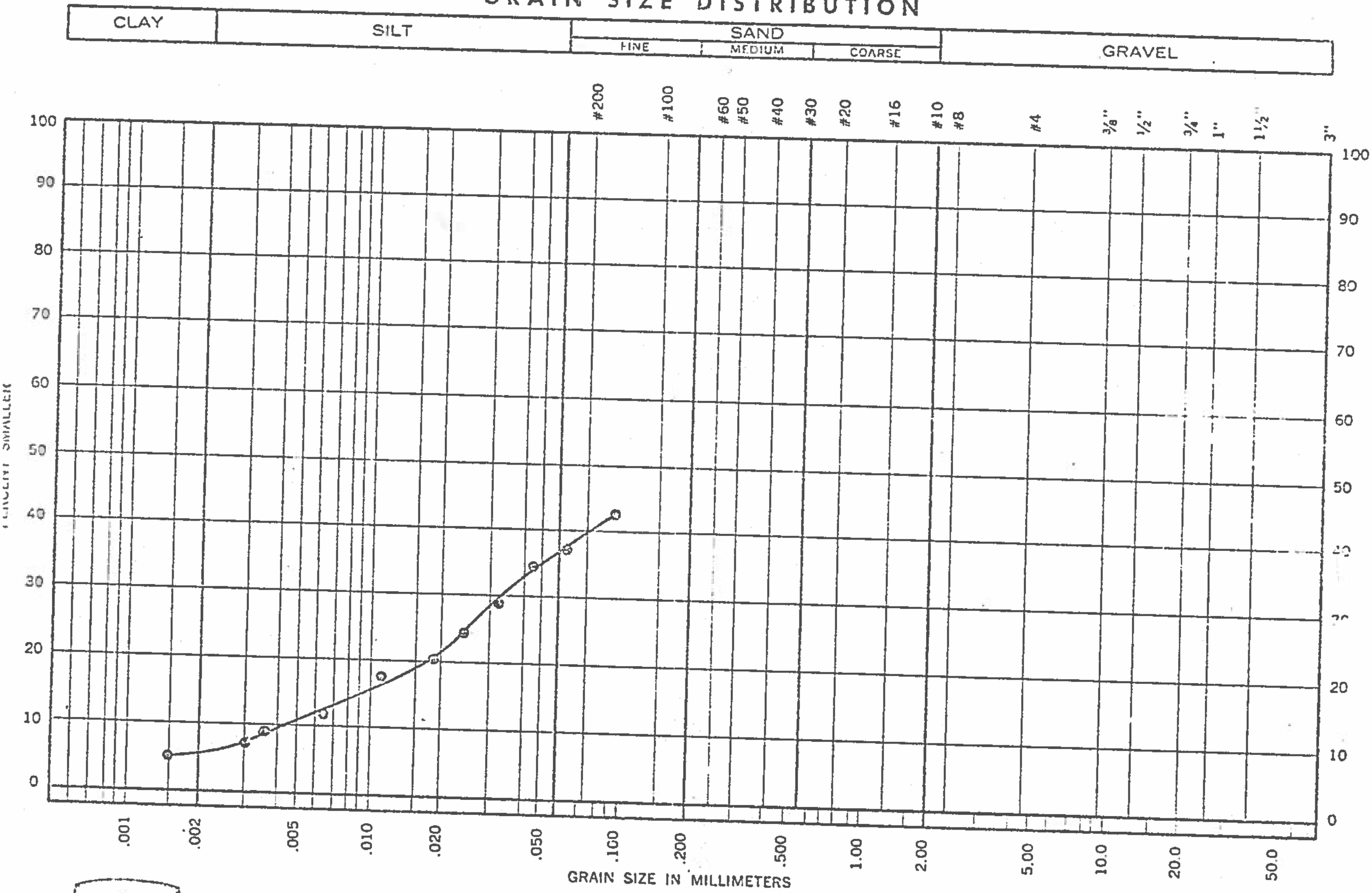
PROJECT DAWSON CITY Y.T.

JOB No. E-381C DATE MAY 24, 1972

SAMPLE No. T.H. #7

DEPTH 8'

GRAIN SIZE DISTRIBUTION

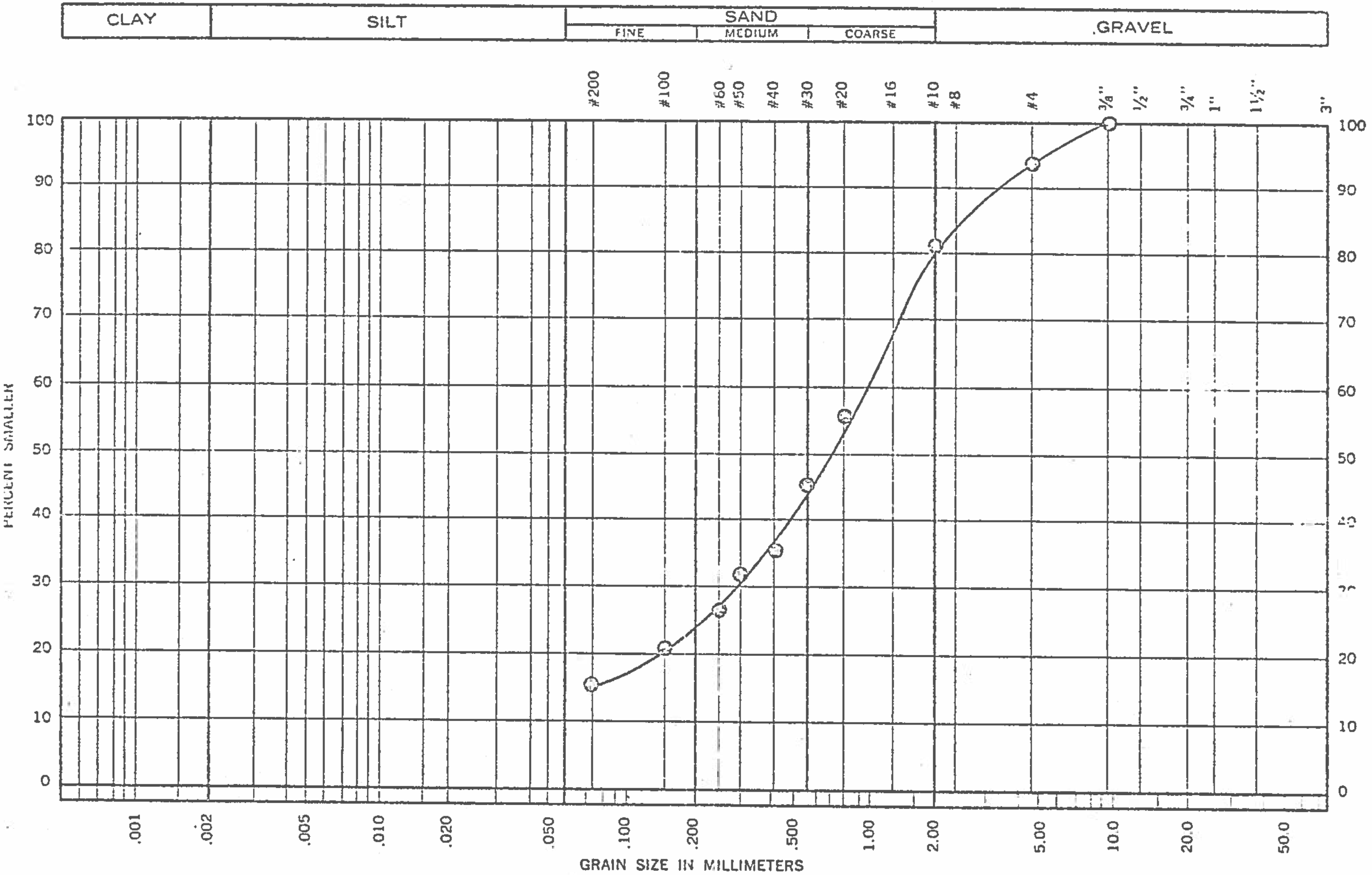


BROOKER & ASSOCIATES

SAMPLE DESCRIPTION BROWN
SILTY SAND

PROJECT DAWSON CITY
JOB No. E-381 c DATE MAY 8, 1972
SAMPLE No. TH # 9
DEPTH 4'

GRAIN SIZE DISTRIBUTION

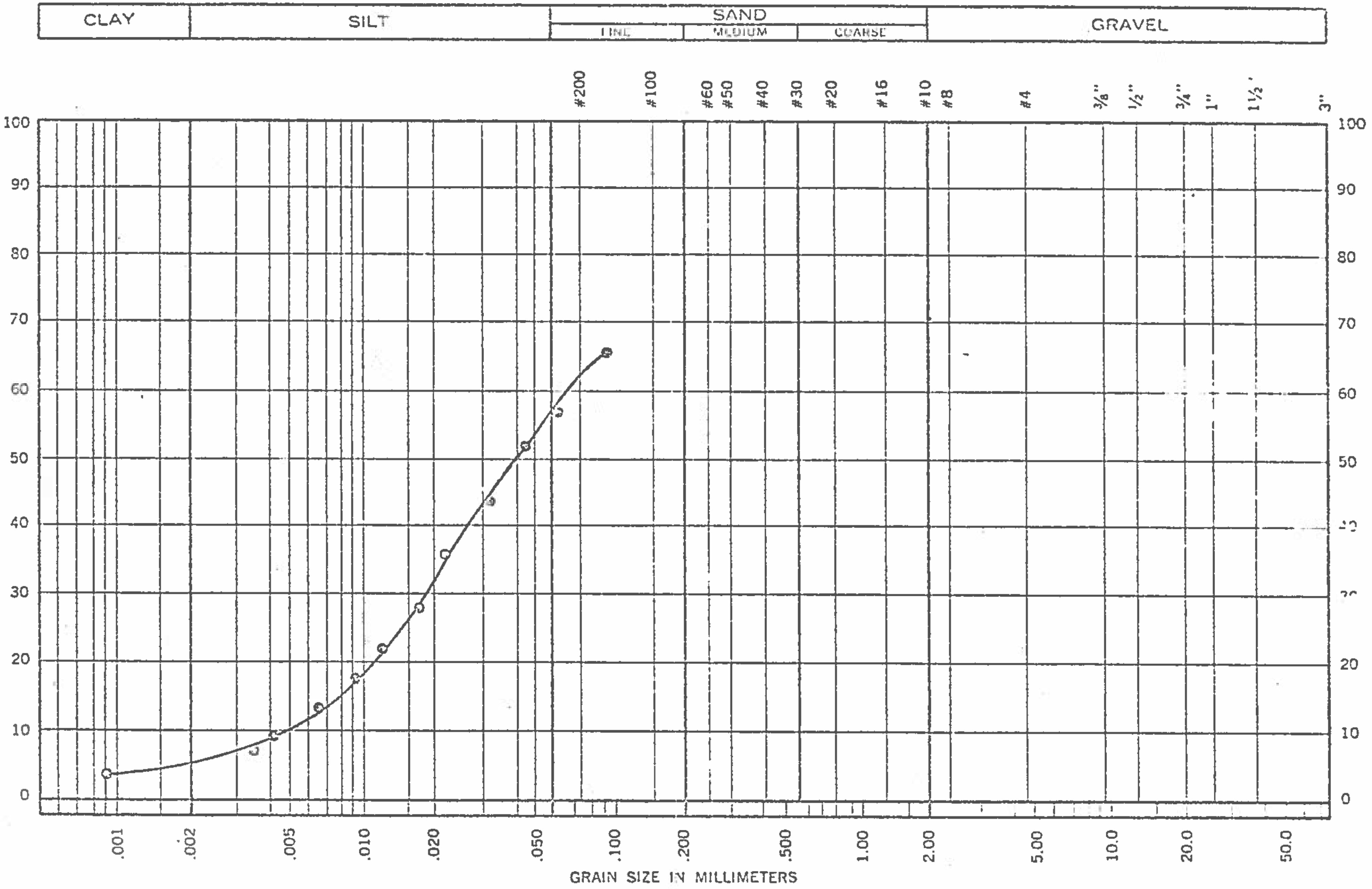


BROOKER & ASSOCIATES

SAMPLE DESCRIPTION Sand

PROJECT Dawson City
JOB No. E 381-C DATE May 4, 1972
SAMPLE No. TH. 9A
DEPTH 15'

GRAIN SIZE DISTRIBUTION

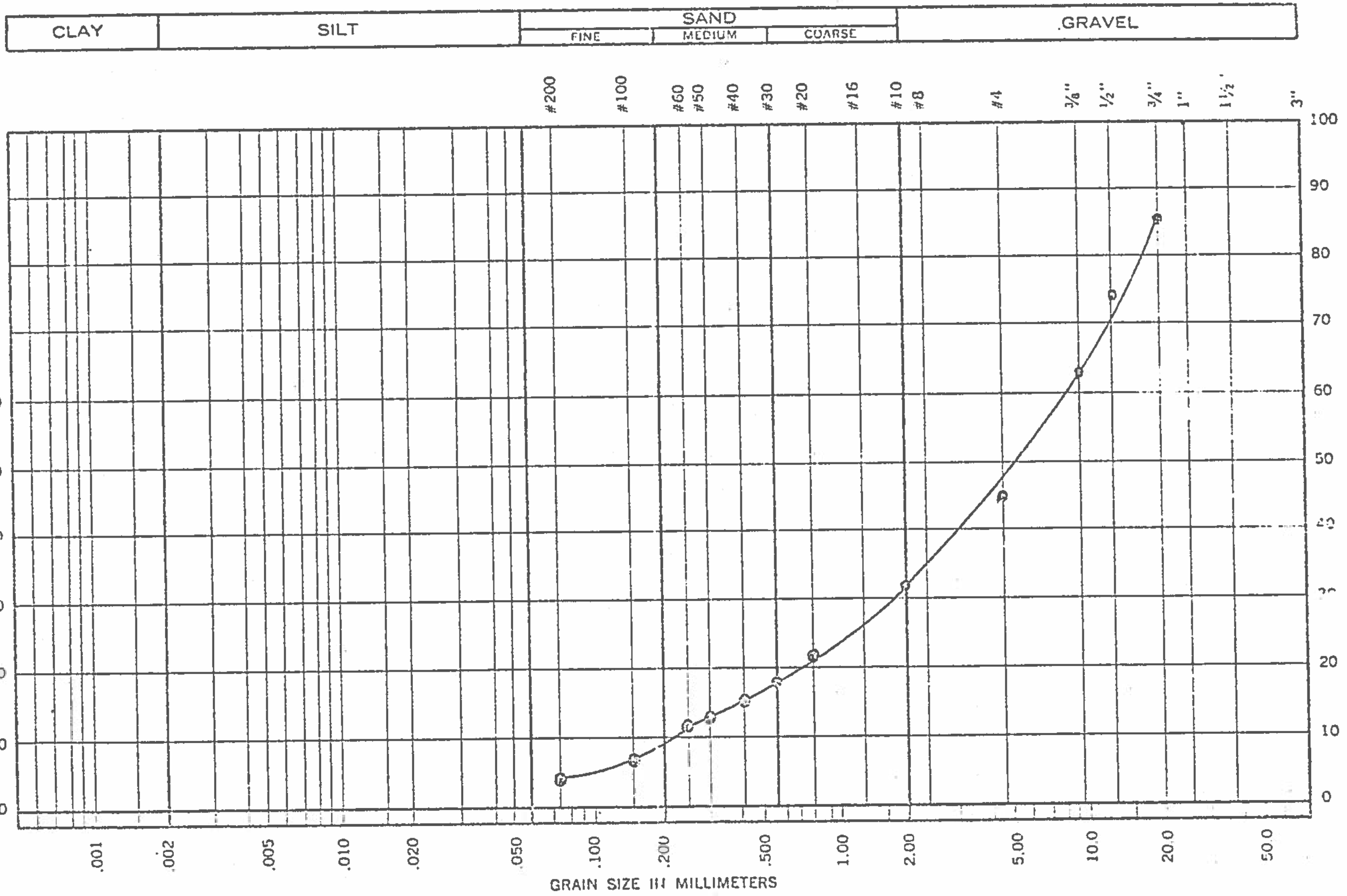


BROCKER & ASSOCIATES

SAMPLE DESCRIPTION GREY SAND AND SILT
ORGANIC

PROJECT DAWSON CITY
JOB No. E-381C DATE MAY 8, 1972
SAMPLE No. T.H. # 11
DEPTH 10'

GRAIN SIZE DISTRIBUTION

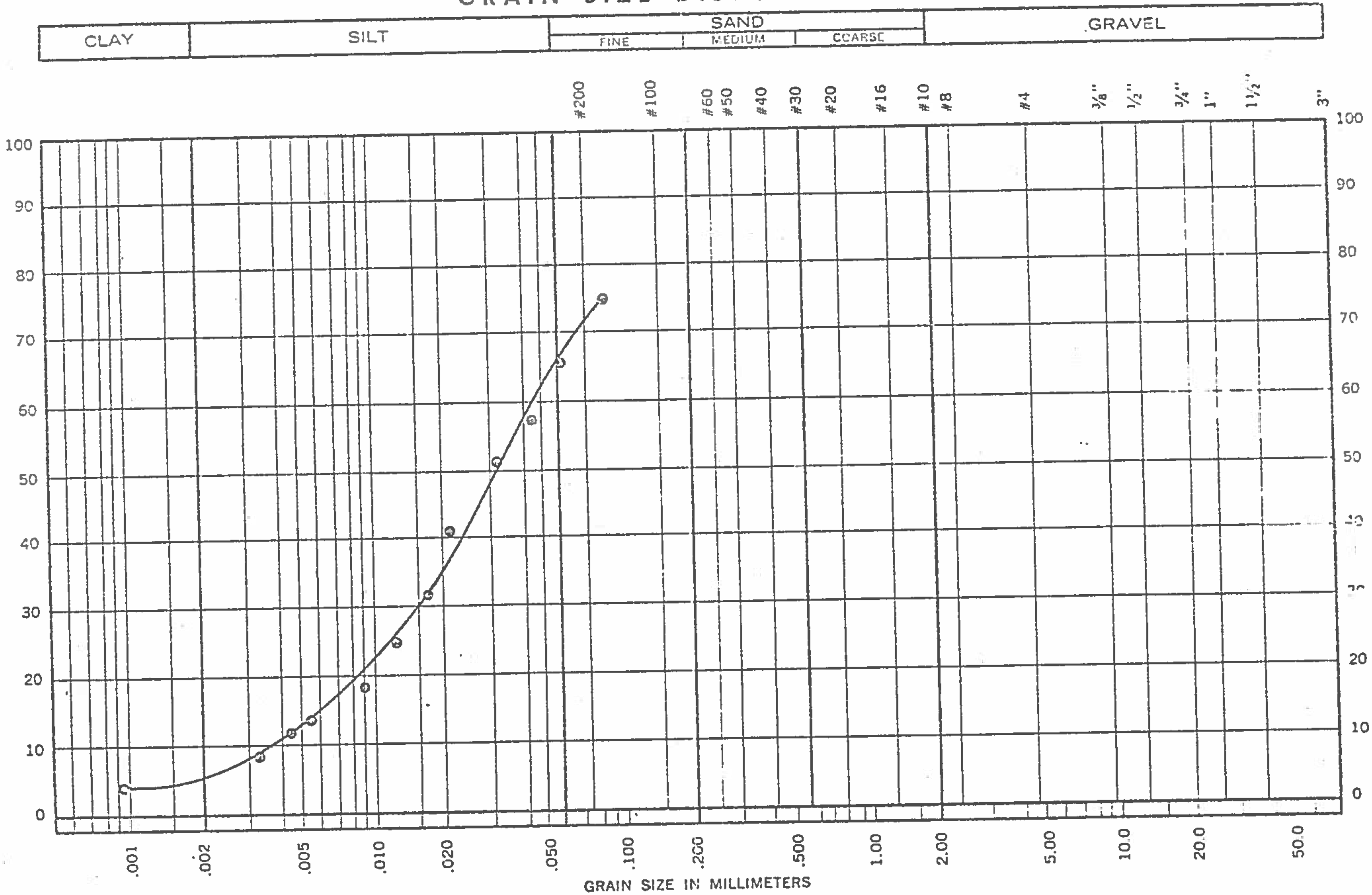


BROOKER & ASSOCIATES

SAMPLE DESCRIPTION MED. BROWN
SANDY GRAVEL

PROJECT DAWSON CITY
JOB No. E381-C DATE MAY 5/72
SAMPLE No. T.H. 11
DEPTH 13'

GRAIN SIZE DISTRIBUTION



SAMPLE DESCRIPTION BROWN SANDY SILT - ORGANIC

PROJECT DAWSON CITY
JOB No. E-381C DATE MAY 8, 1922
SAMPLE No. TH.# 12
DEPTH 4'

SUMMARY TEST RESULTS

JOB No. E - 3[illegible] C

TEST HOLE	DEPTH	NATURAL WATER CONTENT	Atterberg Limits			MECHANICAL ANALYSIS (M.I.T. CLASSIFICATION)				SPECIFIC GRAVITY	ORGANIC CONTENT %	DRY DENSITY PCF	SOIL CLASSIFICATION (UNIFIED)
			W_L	W_P	PI	% CLAY	% SILT	% SAND	%GRAVEL				
	feet	%	%	%	%								
2	5	123.6	46.3	N/P							13.93		OH
2	11	81.7				5	70	25					
4	5	79.9	48.4	N/P		5	80	15			15.25		OH
4	7	86.5	40.5	N/P									OH
4	9	63.6	39.0	N/P							11.10		OH
5	4	48.2	41.8	N/P									OH
5	10	43.1				8	40	52			5.85		
5	16	32.5						98	2				
6	3.5 - 5	31.9	37.0	N/P							7.69		OH

N/P - Non Plastic

E. W. BROOKER & ASSOCIATES LTD.

Drwg. No.

JOB No. E - 38 C

MMARY OF TEST RESULTS

TEST HOLE	DEPTH	NATURAL WATER CONTENT	Atterberg Limits			MECHANICAL ANALYSIS (M.I.T. CLASSIFICATION)				SPECIFIC GRAVITY	ORGANIC CONTENT %	DRY DENSITY PCF	SOIL CLASSIFICATION (UNIFIED)
			W_L	W_P	PI	% CLAY	% SILT	% SAND	%GRAVEL				
	feet	%	%	%	%								
7	8	36.1	27.7	N/P		6	85	9					OH
8	4	28.6	30.8	N/P									OH
9	2	31.4	45.8	N/P									OH
9	4	9.8				6	32	62					
9A	15	3.5					14	67	19				
11	10	56.5				4	54	42			16.02		
11	13	2.7						31	69				
12	4	25.0				4	62	32					

N/P - Non Plastic

Drwg. No.

APPENDIX D

GROUND THERMAL REGIME

D-1 General

Restoration of old buildings in Dawson City will probably be a gradual process carried out over an extensive period of time. An opportunity therefore, exists to carefully observe performance of initial reconstruction efforts in order that the techniques can be verified or improved at new locations. In order to relate observed performance of building foundations to site conditions, data must be accumulated which adequately describes the site and how it changes with time. One of the most important site parameters in a region of discontinuous permafrost, which is usually seriously affected by development, is the ground thermal regime. As part of the general subsurface study carried out at Dawson, three temperature sensing cables were installed in boreholes as described in Subsection 2.4 of the report. The purpose of these installations is:

a. to verify the existance of permafrost at specific locations.

b. to determine temperature of the permafrost and the depth to which seasonal thawing occurs.

c. to determine, wherever possible, the effect of construction disturbance on ground temperature.

Readings have been taken periodically throughout the summer of 1972 and it is anticipated that they will be continued for approximately 1 more year. The readings obtained to date are presented in this appendix together with a brief explanation of conclusions which have arisen from them.

D-2 Temperature Data and Equipment Details

Ground temperature data collected at the three instrumented sites are summarized in Table D-1. These data have also been plotted versus depth in Figures D-1 to D-3.

TABLE D-1

GROUND TEMPERATURE DATA

Location	No.[1]	Depth (ft)	Ground Temperature °F (Corrected for 32°F Calibration Check)							
			April 20	April 22	April 23	April 30	June 4	Aug 31	Oct 25	Nov 9
Post Office[2] Borehole No. 4 (Inst. Apr. 19)	1	5.8	30.4	31.0	30.9	30.9	30.6	32.4	32.0	Unable To Obtain Readings
	2	6.3	30.7	30.8	30.7	30.7	30.2	32.2	32.6	
	3	7.3	31.0	29.8	29.6	29.6	29.6	32.0	32.0	
	4	8.3	30.8	29.8	29.5	29.2	28.8	31.2	30.6	
	5	9.3	31.3	29.7	39.3	28.9	28.5	30.3	30.7	
	6	10.3	31.4	30.0	29.6	28.8	28.2	31.2	31.2	
	7	11.3	31.6	31.6	31.6	28.8	28.0	28.6	29.8	
	8	13.3	31.9	31.9	32.2	28.7	28.2	29.4	29.4	
Commissioners Residence Borehole No. 9 (Inst. Apr. 21)	1	5.0		30.8	30.4	31.4	32.0	34.6	33.8	32.2
	2	5.5		31.2	31.4	31.8	31.8	33.6	33.4	32.4
	3	6.5		32.7	32.2	32.5	32.2	32.6	32.8	32.8
	4	7.5		33.2	32.5	32.7	32.5	32.3	32.5	32.7
	5	8.5		33.4	32.7	32.8	32.2	32.4	32.4	32.4
	6	9.5		33.4	32.8	32.8	32.0	32.2	32.2	32.4
	7	10.5		33.5	33.0	33.0	32.2	32.4	32.6	32.8
	8	12.5		34.2	33.1	33.8	32.8	33.0	33.6	33.8
Red Feather Saloon Borehole No. 5 (Inst. Apr. 20)	1	Surface	39.9	36.4	33.0	36.0	55.4	49.4	30.0	29.0
	2	0.8	40.5	23.5	24.8	32.2	42.2	44.4	31.6	31.4
	3	2.8	40.9	23.7	23.3	27.4	30.2	34.4	31.8	31.8
	4	4.8	43.3	23.6	23.5	25.2	28.6	29.8	31.6	31.0
	5	6.8	41.5	24.1	23.8	25.4	27.2	28.8	31.4	30.2
	6	8.8	40.6	25.2	25.0	26.4	27.2	28.4	29.0	29.8
	7	13.8	37.5	26.9	26.6	27.0	26.4	27.2	28.6	28.8
	8	18.8	46.8	28.0	27.6	27.8	26.6	27.0	28.0	28.4

[1] Refers to thermistor number on switch box.

[2] Borehole location No. 4 disturbed by construction activity after June 4 readings.

The equipment utilized for the field installations are production items from Atkins Technical Incorporated (PR99-3 thermistors and 3F01 electronic thermometer). The thermistors were mounted on a rubber coated, shielded, 8 lead cable, then covered by a copper sleeve, sealed with silicon for waterproofing and the assembly encased in heat shrinkable tubing. The shield was used as a common return and a 17 pin Amphenol plug provided a convenient connector to a rotary switch box.

Immediately after pre-fabrication of the thermistor cables in the laboratory, their calibration was checked by immersion in an ice-water bath. Where the temperature readings differed from 32 ± 0.2°F, a correction factor was determined for application to the actual field measurements. If the correction factor exceeds 1 fahrenheit degree, that particular thermistor is replaced before sending the cable to the field. The correction factors, which must be applied to the cables installed in Dawson, are summarized in Table D-2. The accuracy of the system is believed to be approximately ±0.2°F.

D-3 Interpretation of Data

The data obtained from the two undisturbed sites (Red Feather Saloon and Commissioners Residence) has verified the following.

a. The sandy gravel soil underlying Borehole location No. 5 is frozen to a depth greater than 20 feet. (It is difficult to determine this from drilling alone because of the techniques used). The maximum recorded depth of penetration of the 32°F isotherm is 4.8 feet at this site, whereas the estimated depth of the permafrost table (Table 1) is 5.5 feet, which is in reasonable agreement.

b. Permafrost is not present at Borehole location No. 9.

Borehole location No. 4, which is behind the old Post Office, has been disturbed by construction activities. Gravel has been placed in this area as a result of

TABLE D-2

THERMISTOR READING CORRECTION CONSTANTS

Location	No.	Depth (ft)	Add Correction F°
Post Office Borehole No. 4	1	5.8	0
	2	6.3	0
	3	7.3	0
	4	8.3	-1.0
	5	9.3	-0.3
	6	10.3	0
	7	11.3	-0.4
	8	13.3	0
Commissioners Residence Borehole No. 9	1	5.0	0
	2	5.5	0.4
	3	6.5	0
	4	7.5	0.3
	5	8.5	-0.6
	6	9.5	-1.0
	7	10.5	-0.6
	8	12.5	0
Red Feather Saloon Borehole No. 5	1	Surface	0
	2	0.8	0
	3	2.8	0
	4	4.8	0
	5	6.8	0
	6	8.8	0
	7	13.8	0
	8	18.8	0

foundation reconstruction. The thermistor cable data indicates that thaw extended to a depth of approximately 7.3 feet at this location during the past summer season. This represents an increased active layer thickness of about 2 feet, based on the original estimated position of the permafrost table (Table 1, Page 4 of text). Approximately 1.3 feet of the thawed permafrost consists of silt with an excess ice content of about 25%. Drainage of this proportion of excess water will result in a settlement of approximately 0.3 feet. A ground surface elevation taken at this location on September 13, when compared with the original borehole elevation taken in April, indicates that the ground surface actually settled 0.4 feet during the interim time. A result which is to be expected based on change of the ground thermal regime.

D-4 Future Considerations

Thickening of the active layer due to construction this past summer at the Post Office site is believed to be a temporary condition. Continued data aquisition for at least one more year is considered essential and will be undertaken in order to substantiate that the gravel pad will eventually perform its function as an insulator, retarding further permafrost degradation and perhaps causing the permafrost table to aggrade somewhat. Ground temperature readings will continue to be acquired on a monthly basis throughout the next year. It is hoped that this data can be utilized in conjunction with periodic elevation readings of specific points on the new foundation to eventually allow an engineering evaluation of performance of the gravel pad.

GROUND TEMPERATURE PROFILE
RED FEATHER SALOON (B.H.#5)

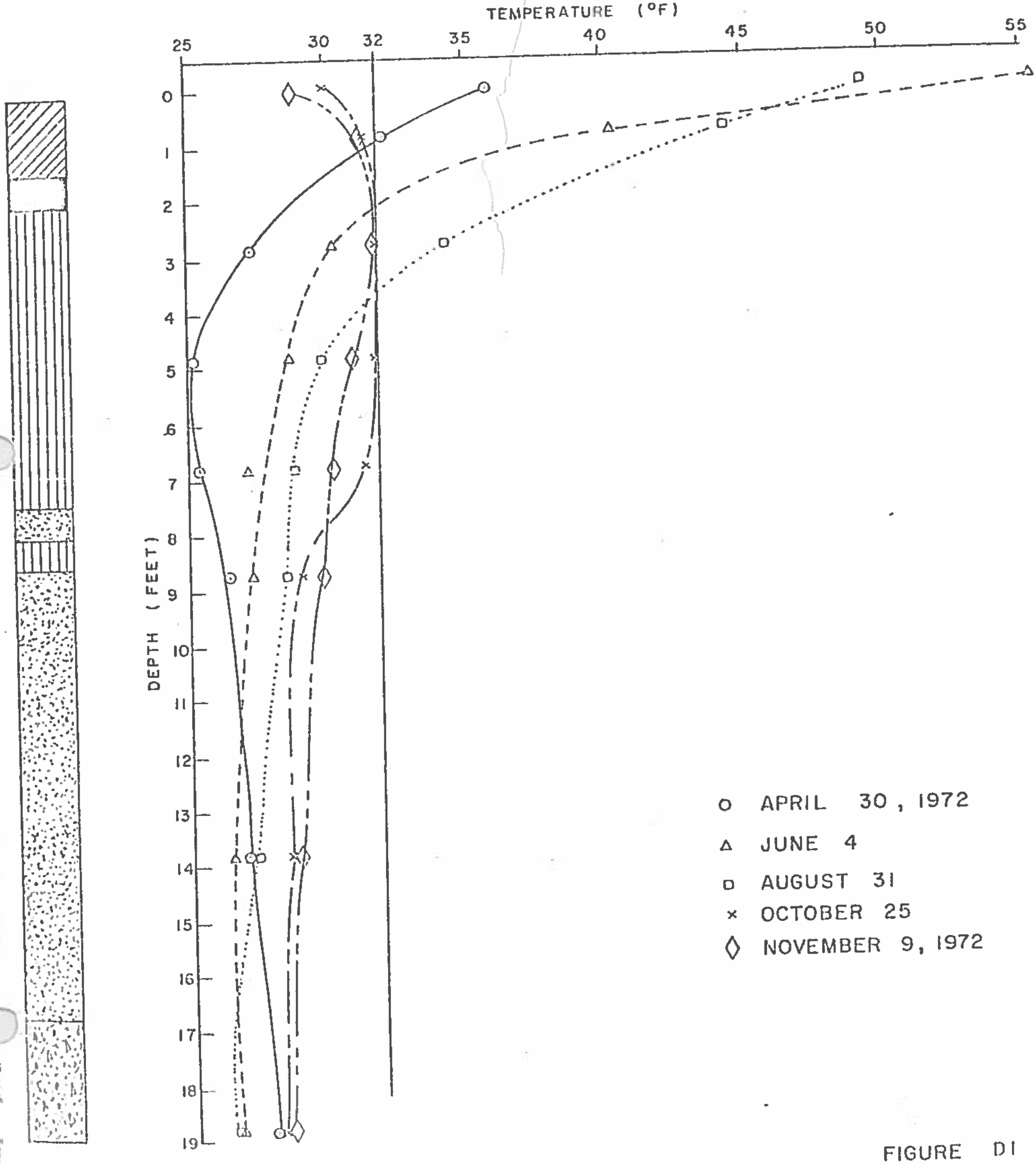


FIGURE D1

GROUND TEMPERATURE PROFILE
COMMISSIONER RESIDENCE (B.H.#9)

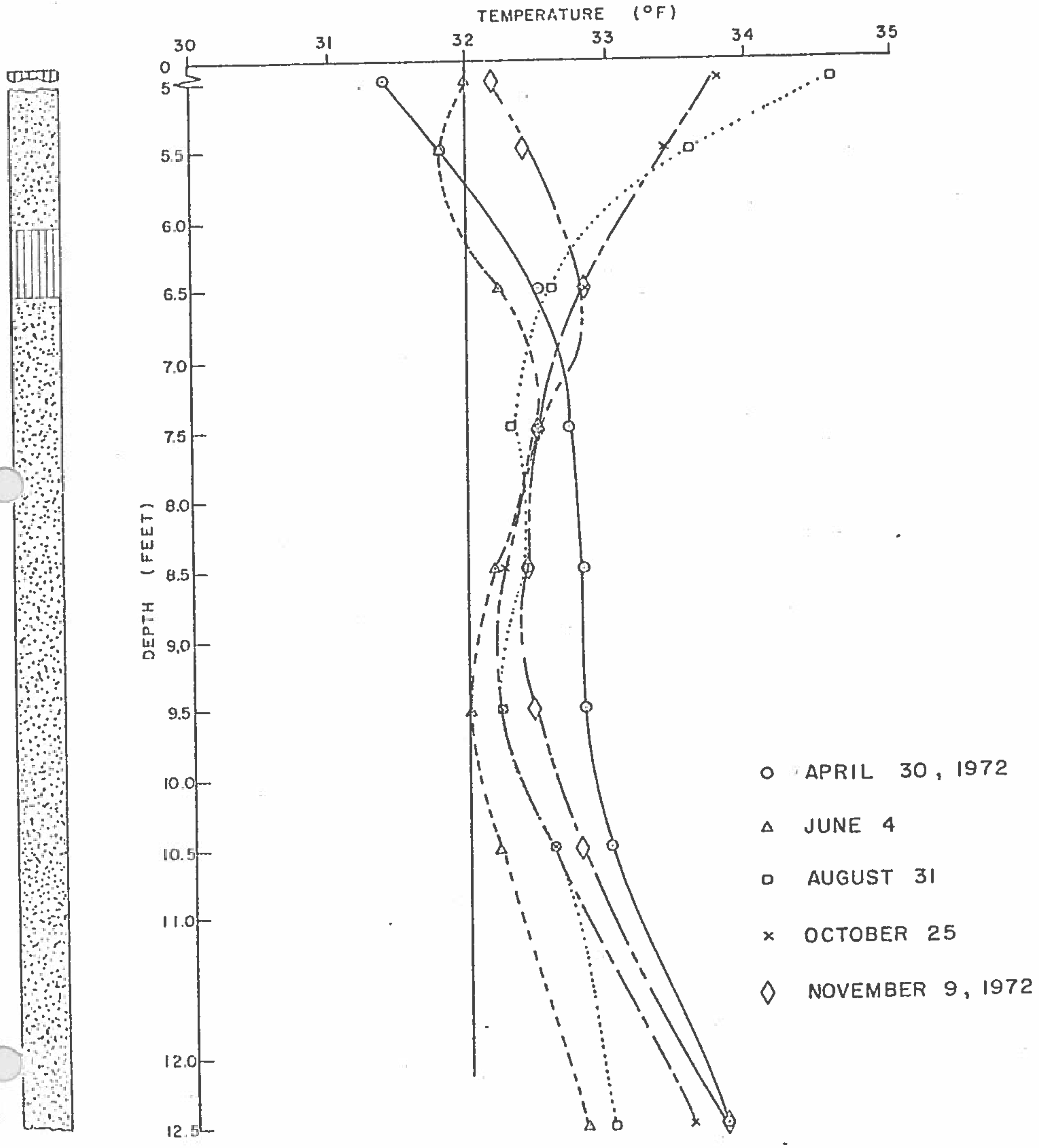


FIGURE D2

GROUND TEMPERATURE PROFILE
POST OFFICE (B.H. #4)

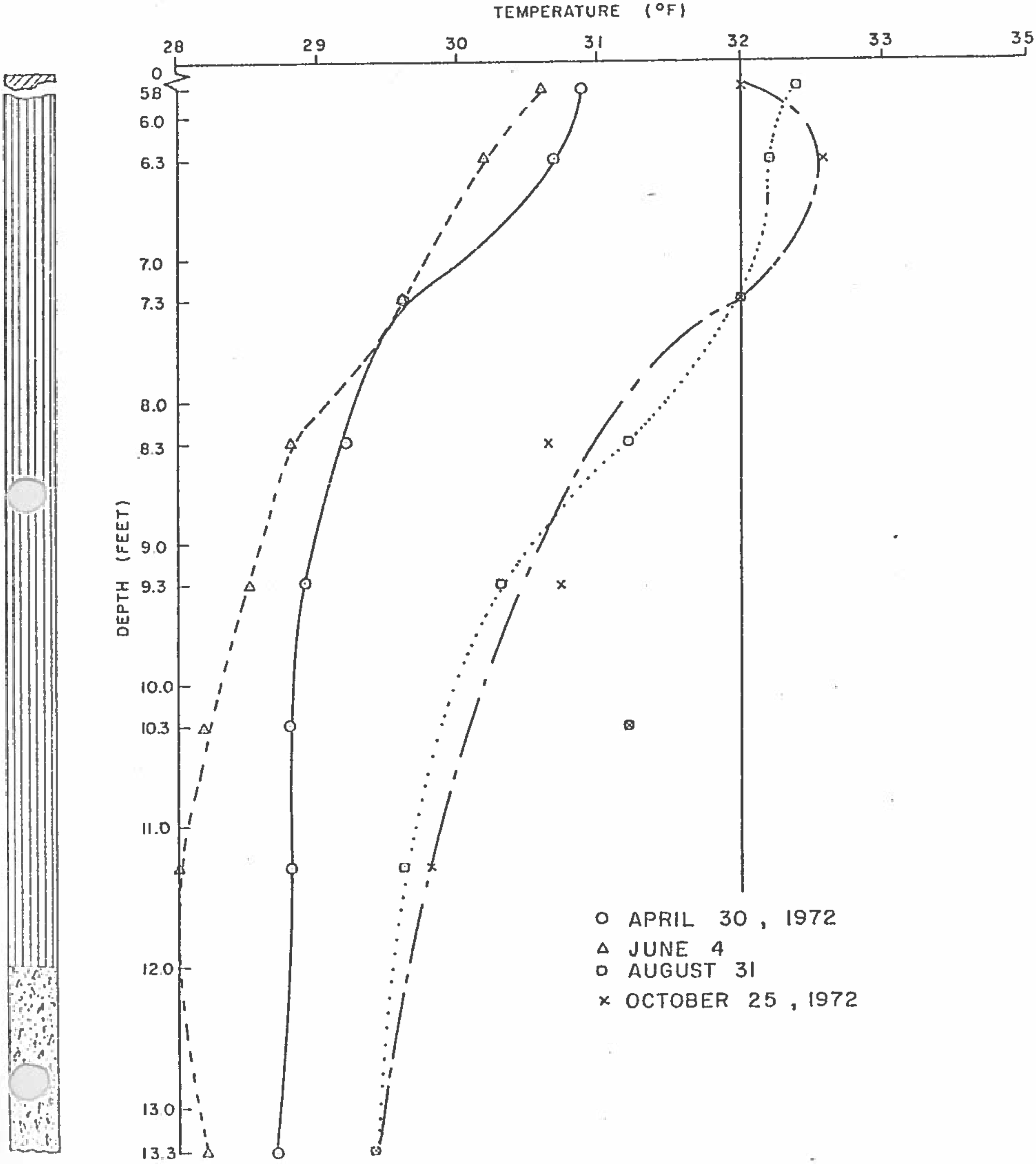


FIGURE D3

eba

consulting civil engineers

D.W.Hayley, MSc.P.Eng.
vice president

February 25, 1975

Government of Canada
Department of Indian and Northern Affairs
Restoration Services
66 Slater Street
Ottawa, Ontario
K1A 0H4

Attention: Mr. Ed Clow

Received Feb 26/75

Dear Ed,

Further to our telephone discussion today I am enclosing a copy of our report on the Robert Service School, Dawson, Yukon. You will see from reading this report that the site investigation was carried out after the foundations were installed and ultimately the foundations had to be completely reconstructed. I believe this information will be very useful to you for future restoration design.

We appologize for the lengthy delay in completing our report on the Post Office. As I explained to you, the circumstances were beyond our control. Consequently I will have a technician in Dawson this week and he will collect a set of data for me. We will do what we can to assemble the information as soon as possible and we will certainly get a report to you before March 31.

Please feel free to discuss with me any problems you have with foundation design at Dawson. There is a chance that I will be in Montreal in March. If this is the case I will try to find some time to visit with you.

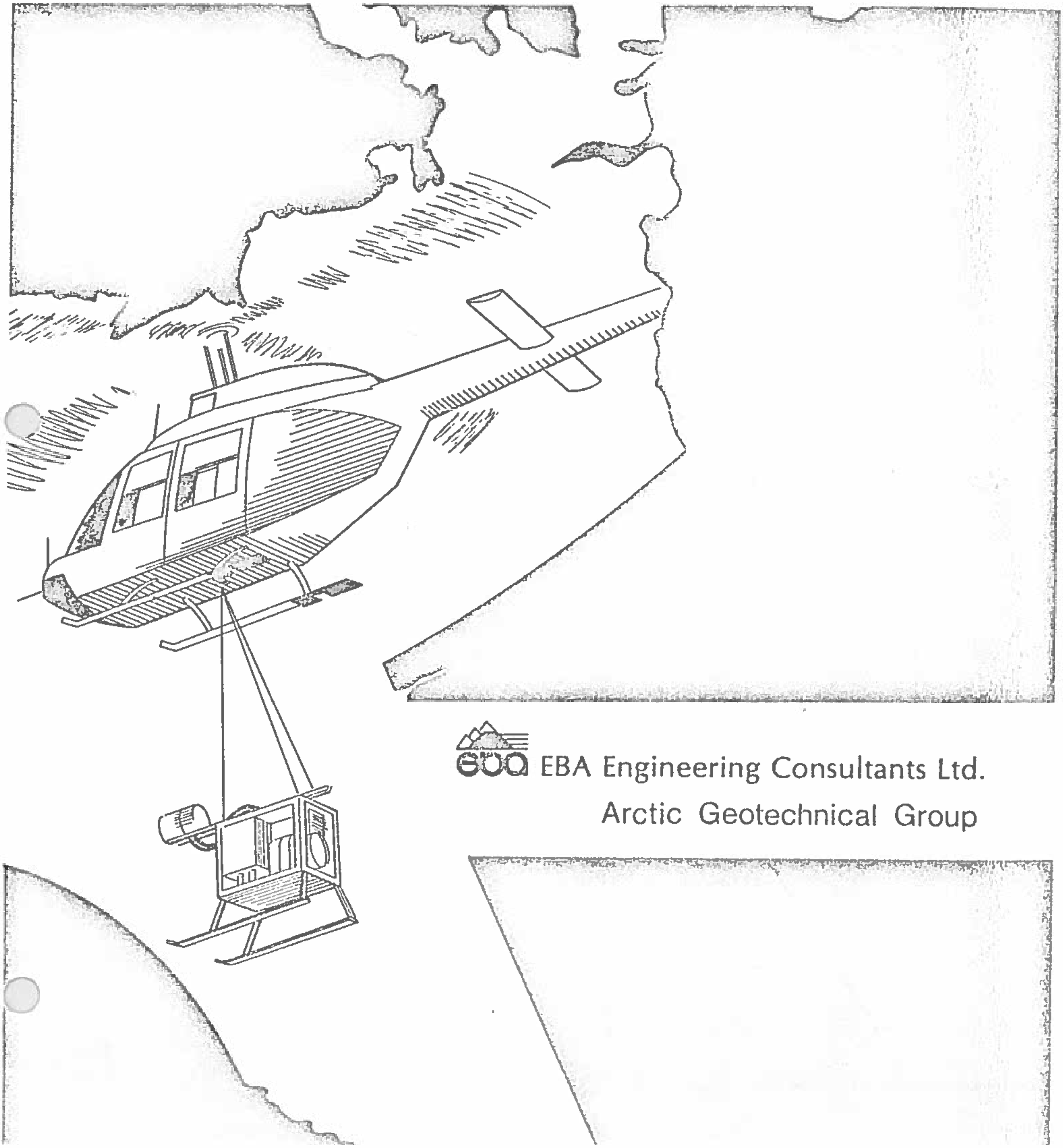
Yours truly,

EBA Engineering Consultants Ltd.

D.W. Hayley, P. Eng

DWH:lmh

SITE INVESTIGATION
ROBERT SERVICE SCHOOL
DAWSON, YUKON



EBA Engineering Consultants Ltd.
Arctic Geotechnical Group

SITE INVESTIGATION
AND
PILE FOUNDATION EVALUATION
ADDITION TO ROBERT SERVICE SCHOOL
DAWSON, YUKON

Submitted To:

GOVERNMENT OF THE YUKON TERRITORY

DEPARTMENT OF HIGHWAYS AND PUBLIC WORKS

WHITEHORSE

JULY, 1974

TABLE OF CONTENTS

I. INTRODUCTION

The Government of the Yukon Territory retained EBA Engineering Consultants Ltd. to assess the adequacy of foundation units for the new addition to Robert Service School in Dawson Yukon. The foundation had been installed during the fall of 1973 in anticipation of structural erection during the 1974 summer construction season.

The foundation design utilized was a modified, expanded base cast-in-place pile. This design was an alternative proposed by the contractor to modify a deep pad footing designed by the structural consultant. The deep pad footing had been recommended previously be EBA for a nearby Arena Site. The foundations were drilled through frozen organic silt and bear on the surface of permafrost gravel. Pile bell formation was found to be a difficult task in frozen soil and a visiting engineer from YTG Department of Highways and Public Works reported that the full design base diameter of 48 inches was not achieved. In response to concerns expressed by the Architect and Structural Engineer over adequacy of the system, EBA were requested to determine the following.

a. Pile bell diameter on at least two of the heavier loaded piles.

b. Bearing capacity of the underlying gravel.

c. A restoration procedure if remedial work is found to be necessary.

This report summarizes the field procedures undertaken, the findings and consequent foundation reconstruction recommendations.

The study was authorized by Mr. J. Rounds, Projects Architect for the Yukon Territorial Government on February 20, 1974. Throughout the study discussions were held and guidance obtained from Mr. B. Wood, Wood and Gardner Architects and Mr. A.R. Waldie, P. Eng., Morrison and Berretti Engineering.

II. FIELD INVESTIGATION AND SITE CONDITIONS

2.1 General

Fortunately, a background of data was available to draw on prior to planning of the field work. A general report prepared by EBA for the Department of Indian and Northern Affairs described building foundation conditions in Dawson, based on numerous exploratory borings drilled during the winter 1972. The available data indicated that high ice content permafrost silt overlies a dense frozen alluvial gravel. Depth to the gravel layer was anticipated to be between 12 and 15 feet at the site.

2.2 Drilling Program

Three exploratory boreholes were drilled amongst the pile cluster in the school yard on March 29 to 31, 1974. In addition, six shallow holes were drilled in an attempt to determine the size of existing pile bells. The six shallow holes were not logged in detail. Drilling was carried out out using a Failing 1000 rotary drill which was equiped to use either water or air as the circulating medium for return of cuttings. It was particularly important that air be used for the pile investigation holes since the holes must be dry enough to allow actual examination of the concrete base.

Both air and water were used during drilling of the detailed boreholes. Sampling of the underlying gravel and/or bedrock was attempted with a standard 2 inch OD split spoon and an NX diamond core barrel however, neither of these procedures was found to be successful. For the most part, the nature of the underlying frozen gravel was assessed by examining cuttings and observing performance of the drill bit.

2.3 Nature of the Gravel Layer

The gravel layer was encountered in the nine holes drilled, quite consistently at a depth of 12 to 13 feet. During foundation reconstruction, the upper surface of the gravel was inspected insitu on April 23, 1974 by entering an open pile hole. At this time it was found that a layer of cobbles exists in the silt at the gravel surface, in fact the gravel surface was not as well defined as indicated in the exploratory borings since the silt and gravel were mixed over a depth of approximately 6 to 12 inches. In the one pile hole inspected, the layer of cobbles was found to be 4 to 6 inches thick.

A large representative sample of the gravel was obtained from the pile hole at the time of the inspection. Gradation analysis has been established for this sample and it was examined by an EBA Engineering Geologist. The geologists report and results of the analysis are included In Appendix C.

The gravel was found to be very well graded soil with greater than 20% finer than a No. 200 sieve. Most fragments are subrounded to angular, becoming more angular in the finer fractions. Although it is predominantly alluvial material, the angular nature of most particles suggests that it is a high terrace with possibly some colluvium from the slopes above mixed into it.

The gravel stratum is believed to be thaw stable soil. If the gravel thaws sometime throughout the life of a structure significant settlements are not anticipated. The recommended bearing capacity for foundations on the frozen gravel is 12,000 psf.

III. INVESTIGATION OF EXISTING PILES

3.1 Field Data

Two of the heavily loaded piles, C-4 and K-4, were chosen for an investigation of the bell diameter. Results of this investigation are shown in Drawing A-2. Four holes were drilled alongside the steel pipe at pile K-4 in an attempt to intersect the edge of the base. Three of these holes were sucessful and the horizontal distance from the edge of the hole to the edge of the pipe was measured utilizing a plumb bob to ensure the correct horizontal distance was carried from the bottom to the top of the pile. From an analysis of the data from these three holes it was concluded that the pile bell diameter at pile location K-4 is 28± 1 inch.

Two holes were drilled alongside pile C-4. Neither of these holes encountered the concrete base and both penetrated into the gravel layer slightly. It can be concluded from these observations that the pile base diameter is somewhat less than 34 inches.

3.2 Recommendations

It is obvious from the two piles investigated that the belling operation was unsuccessful in the frozen silt. It was recommended that the foundation system be checked assuming that there is no effective bell on the piles (24 inch diameter) considering that the allowable bearing capacity is 12,000 psf.

IV. FOUNDATION RECONSTRUCTION

4.1 General

Based on the findings of the pile bell investigation and detailed drilling program. Only nine of the piles installed during the fall of 1973 were found to be acceptable. It was recommended by EBA that the building be moved slightly and an entire new set of foundations installed. This was accepted by the architect, structural engineer, owner and contractor at a meeting held in Edmonton on April 5th, 1974.

4.2 New Foundation Construction

The new foundations were constructed by drilling a straight shaft up to 54 inches in diameter. Cleaning the surface of the gravel by hand methods and placing a precast footing on a thin grout leveling pad. A steel pipe column base was anchored into the pad and the foundation pipe field welded into place. Granular backfill was then loose dumped in the annular hole above the footing around the steelpipe.

4.3 Field Inspection

During the early stages of new foundation construction two full time site inspectors were at the job site. One senior technician, Mr. D.D. Yaremko, from EBA examined the adequacy of the cleaned footing excavations prior to placement of the precast slab. However, overall inspection responsibility resided with Mr. N. Anderson, P. Eng. of the Department of Highways and Public Works, YTG.

Construction difficulties were encountered with the silt impregnated cobble layer overlying the alluvial gravel. The site was visited on April 23, 1973 by the author and it was determined that this layer of cobbles must be removed from beneath foundations elements. This was done effectively by the contractor using an air operated jack hammer. After the procedure was established, foundation installation was reasonably uncomplicated.

The inspection report prepared by the EBA technician and letter subsequent to the site visit by the author are included as Appendix D.

V. CLOSURE

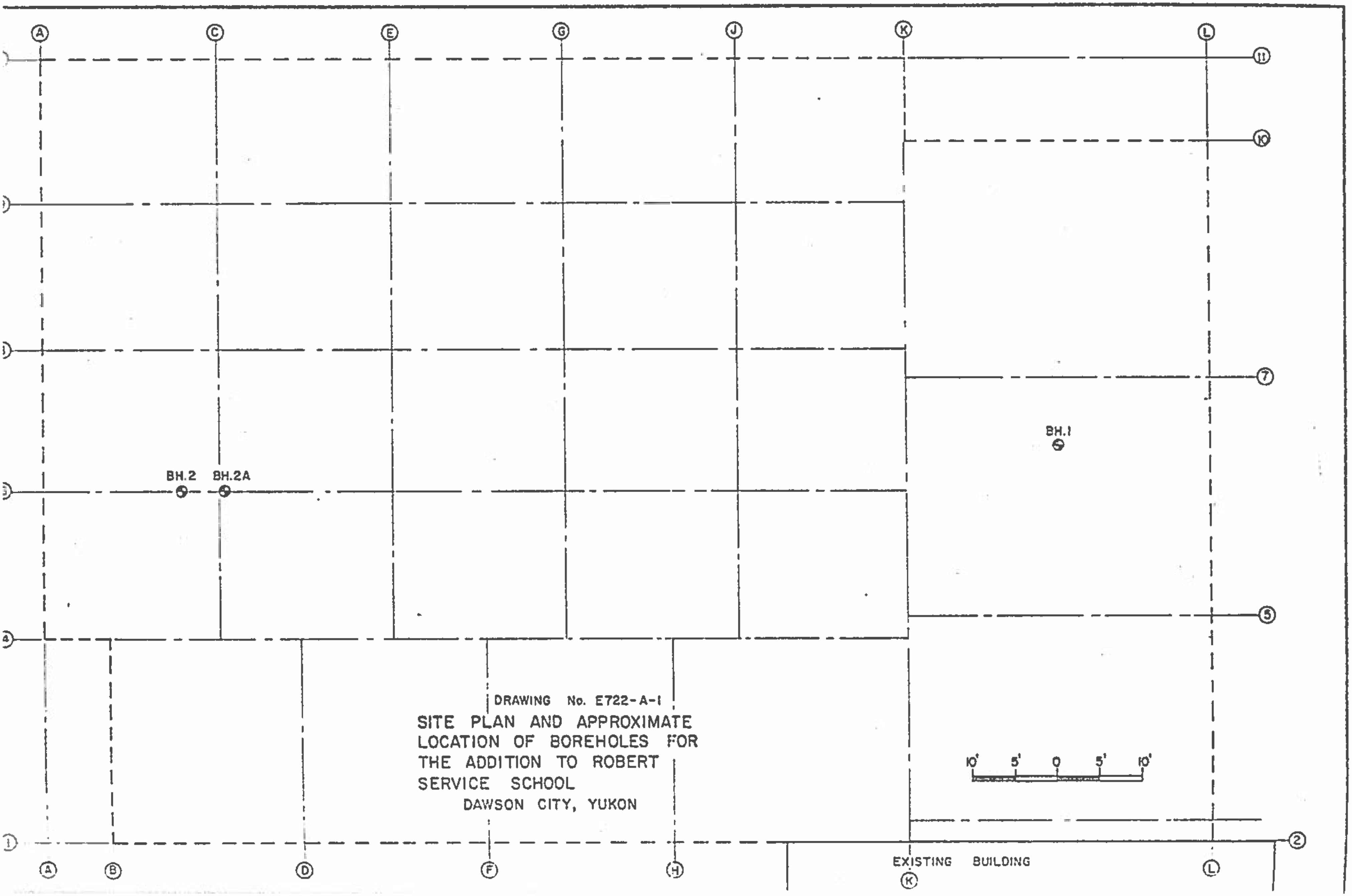
It is believed that a stable foundation has been achieved in a region where building instability due to foundation movements is a normally accepted occurrence. In view of the unique design used for this area it is suggested that some performance data be collected over the next few years. This can readily be done with a series of control points on the new structure on which an elevation survey is periodically taken. The elevation survey should be referenced to one of the deep benchmarks installed in the townsite by EBA for the Department of Indian and Northern Affairs.

Respectfully Submitted,

EBA Engineering Consultants Ltd.

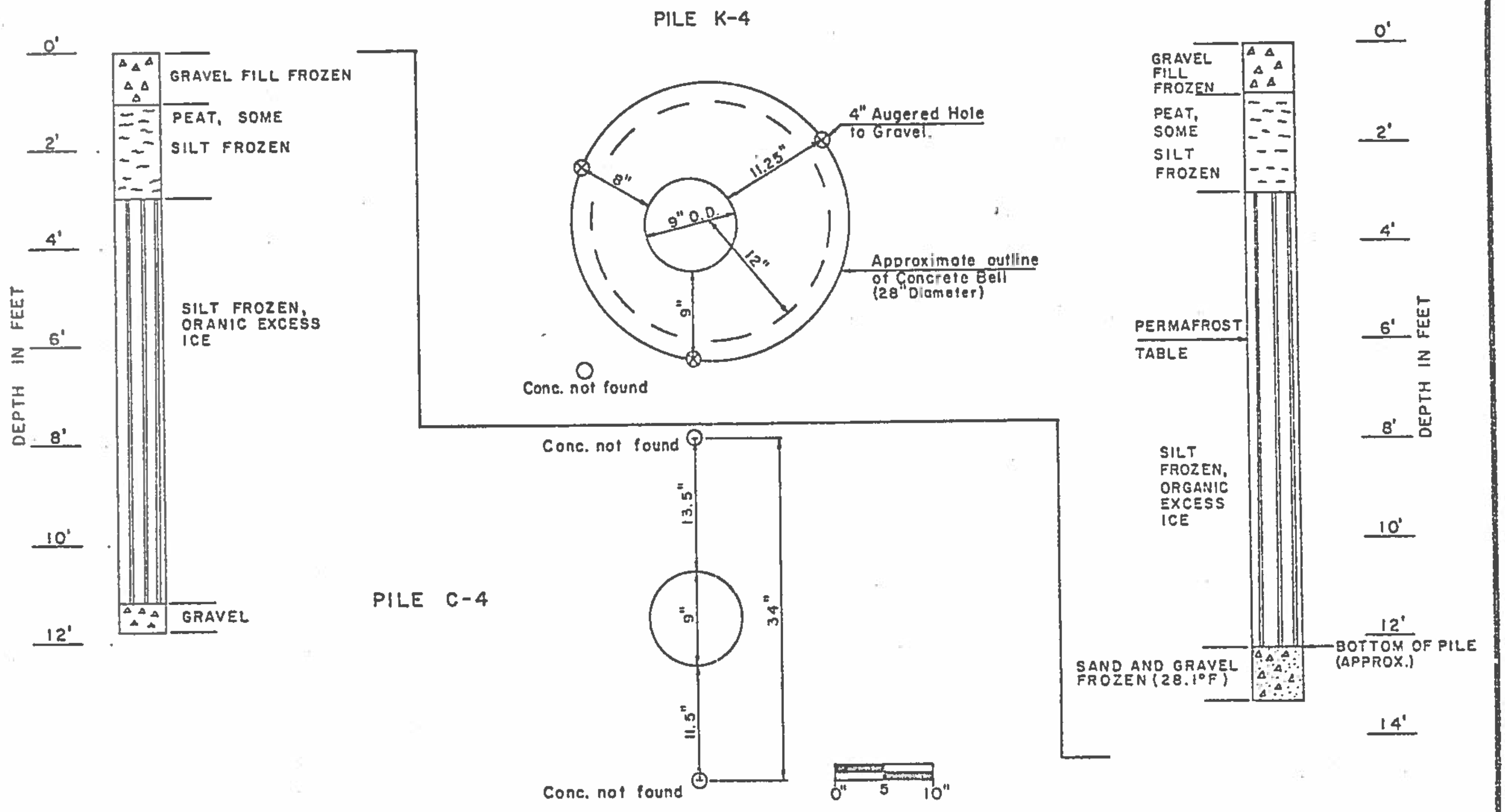
Don W. Hayley, P. Eng.

DWH:lmh



DRAWING No. E722-A-1

SITE PLAN AND APPROXIMATE LOCATION OF BOREHOLES FOR THE ADDITION TO ROBERT SERVICE SCHOOL
DAWSON CITY, YUKON



DWN BY: FRB
DATE DWN: 3 APR. 74
SCALE: AS SHOWN
JOB No. E-722

Engineering Consultants Ltd.

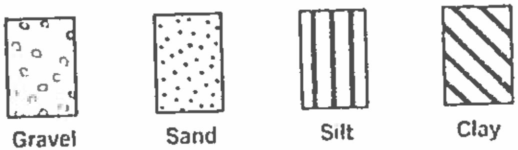
PILE BELL INVESTIGATION
ROBERT SERVICE
SCHOOL

DWG
E 722-A2

SYMBOLS AND TERMS USED ON BORING LOGS

SOIL TYPES

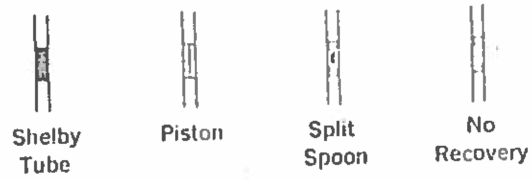
(SHOWN IN SYMBOL COLUMN)



Predominant type shown heavy

SAMPLER TYPES

(SHOWN IN SAMPLES COLUMN)



▽ POSITION OF FREE GROUND WATER IN BOREHOLE

TERMS DESCRIBING CONSISTENCY OR CONDITION

COARSE GRAINED SOILS (major portion retained on No. 200 sieve): includes (1) clean gravels and sands, and (2) silty or clayey gravels and sands. Condition is rated according to relative density, as determined by laboratory tests.

DESCRIPTIVE TERM	RELATIVE DENSITY	N BLOWS PER FOOT
Loose	0 to 40%	0 to 10
Medium, dense	40 to 70%	10 to 30
Dense	70 to 100%	30 to 50

The number of blows, N, on a 2" O.D. split spoon sampler of a 140 lb. wt. falling 30" required to drive the sampler a distance of 1' from 6" to 18".

FINE GRAINED SOILS (major portion passing No. 200 sieve): includes (1) inorganic and organic silts and clays, (2) gravelly, sandy, or silty clays, and (3) clayey silts. Consistency is rated according to shearing strength, as indicated by penetrometer readings or by unconfined compression tests.

DESCRIPTIVE TERM	UNCONFINED COMPRESSIVE STRENGTH TON/SQ. FT.
Very soft	less than 0.25
Soft	0.25 to 0.50
Firm	0.50 to 1.00
Stiff	1.00 to 2.00
Very stiff	2.00 to 4.00
Hard	4.00 and higher

Note: Slickensided and fissured clays may have lower unconfined compressive strengths than shown above, because of planes of weakness or cracks in the soil. The consistency ratings of such soils are based on penetrometer readings.

TERMS CHARACTERIZING SOIL STRUCTURE

Slickensided — having inclined planes of weakness that are slick and glossy in appearance.

Fissured — containing shrinkage cracks, frequently filled with fine sand or silt; usually more or less vertical.

Laminated — composed of thin layers of varying color and texture.

Interbedded — composed of alternate layers of different soil types.

Calcareous — containing appreciable quantities of calcium carbonate.

Well graded — having wide range in grain sizes and substantial amounts of all intermediate particle sizes.

Poorly graded — predominantly of one grain size, or having a range of sizes with some intermediate size missing.

BOREHOLE LOG
PERMAFROST REGION

DEPTH (feet)	SOIL DESCRIPTION	SAMPLE	GROUND ICE CONDITION	MOISTURE CONTENT % ⊘ SPT RESISTANCE ▲ 10 20 30 40 50 60 70
	GRAVEL FILL		Seasonal Frost	
2	PEAT -dark brown			
4	SILT -med. to dark grey -organic firm -trace of fine sand -soft		Temp. @5½ 26.4°	
6			Unfrozen	
8			Permafrost Vs 5 - 10% Temp. @ 10½ 29.4°	
10				
12				
14	GRAVEL -coarse -some cobbles and boulders			
16				
18				
20	BEDROCK -med. hard, green grey serpentinite (chip samples only) -hard, uniform drilling		Frozen No evidence of excess ice	
22				
24				
26				
28				
30	END OF HOLE @ 30'			
32				

eba	PROJECT Dawson School	DATE 3/29/74 LOGGED BY JK ELEVATION DEPTH 30'	HOLE NO. TH 1 SHEET 1 of 1

BOREHOLE LOG
PERMAFROST REGION

DEPTH (feet)	SOIL DESCRIPTION	SAMPLE	GROUND ICE CONDITION	MOISTURE CONTENT % ● SPT RESISTANCE △ 10 20 30 40 50 60 70
	GRAVEL FILL		Seasonal Frost	
2	PEAT -dark brown -fibrous			
4	SILT -med. to dark grey -organic, soft to firm -trace of fine sand		Unfrozen	
6		☒	Permafrost Vr 5 - 10%	
8				
10			Temp 31.8°	
12	GRAVEL -med. to coarse -sandy -with cobbles and boulders -very hard drilling		Frozen No evidence of excess ice	
14				
16				
18				
20				
22				
24	END OF HOLE @ 22½			
26				
28				
30				
32				

PROJECT
Dawson School.

DATE 3/30/74
LOGGED BY JK
ELEVATION
DEPTH 22½

HOLE NO.
2
SHEET
1 of 1

BOREHOLE LOG
PERMAFROST REGION

DEPTH (feet)	SOIL DESCRIPTION	SAMPLE	GROUND ICE CONDITION	MOISTURE CONTENT % ⊕ SPT RESISTANCE △ 10 20 30 40 50 60 70
	GRAVEL (FILL)-med. brown sandy, fine to coarse, some cobbles		Frozen Seasona	
2	PEAT -dark borwn			
4	SILT -med. grey some organics non plastic			
6			Permafrost	
8			Vr 15 - 20%	
10	SAND -med. grey, silty, fine grained, uniform	☒	Temp. 30.8° Vs - 1" top of gravel	
12	GRAVEL-med. brown sandy fine to med. some cobbles		NF	
14	END OF HOLE			
16				
18				
20				
22				
24				
26				
28				
30				
32				

eba

PROJECT
Dawson City School

DATE 3/31/74
LOGGED BY JK
ELEVATION
DEPTH 12½'

HOLE NO.
2A
SHEET
1 of 1

APPENDIX C

REPORT ON GRAVEL SAMPLE EXAMINATION

PROJECT: Robert Service School Addition, Dawson Yukon, Job E-722

DATE SAMPLES: April 23, 1974 / DWH

SOURCE: Pile Hole D-1 base of completed excavation (approx. 13 ft)

GRADATION: Gravel (55%), sandy (33%), Silty (22%) grain size distribution curve attached

DESCRIPTION: Gravel
- immature
- the gravel sizes are rounded to sub-rounded for the coarsest fraction (1½ - 3/8) - most are chipped to broken below the 3/8 broken rounded to broken pebbles are dominant

Sand
- immature
- most particles angular to sub-angular becoming more angular in finer fractions
- less than 15% of the coarse fraction of the sample cannot be called alluvial

PETROLOGY: (visual estimate)

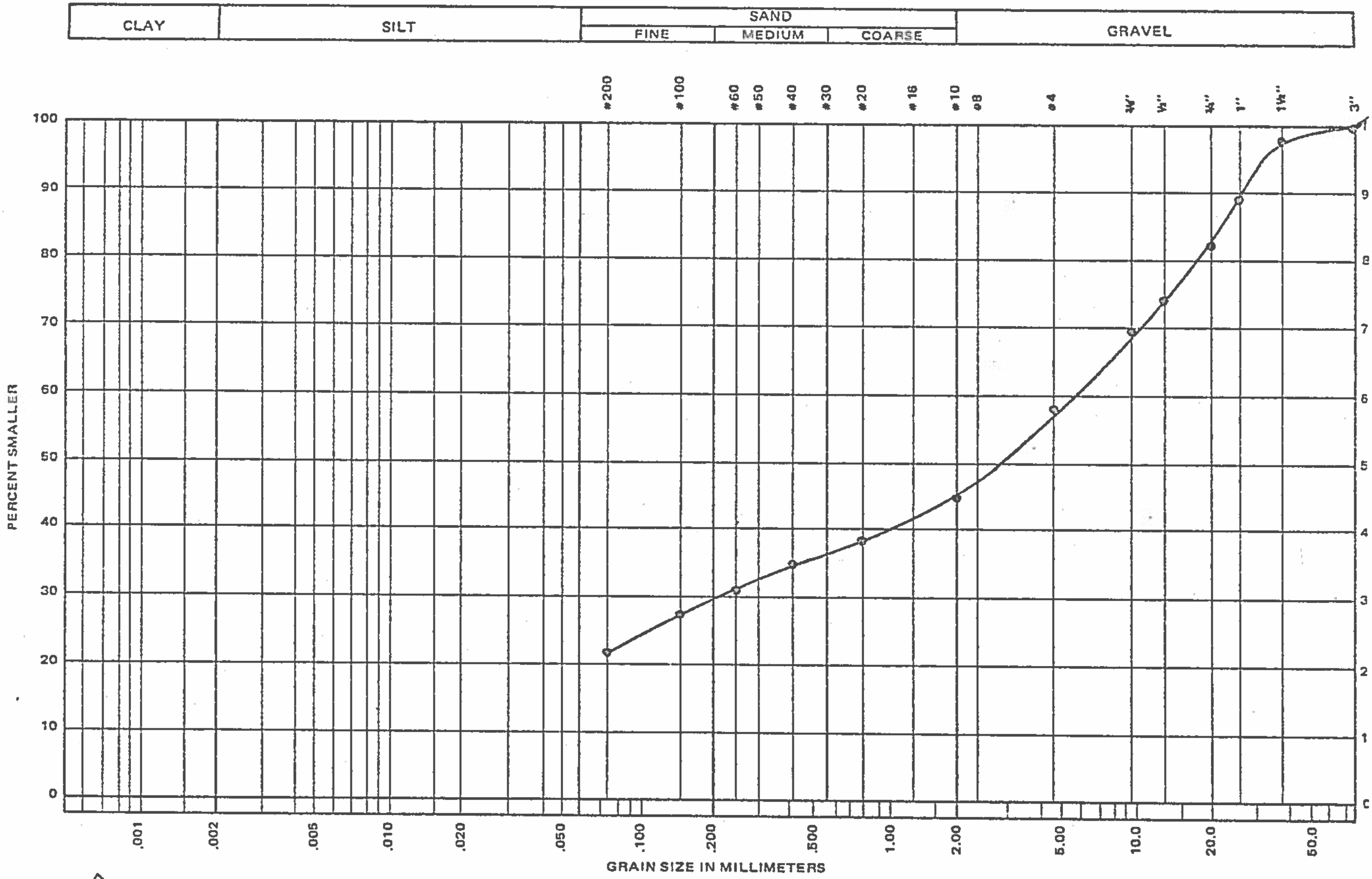
10% - Quartz
25 - Pyroxene - peridotite
15 - Serpentinite
Trace - Schist & Gneiss
15 - Sandstone
Trace - Basalt
Trace - Chert
15 - Diorite
10-15 - Others, Limestone?

100%

note: Some native iron or iron fragments were found and one small fragment of glass.

Neil R. MacLeod, P. Eng.
Engineering Geologist

GRAIN SIZE DISTRIBUTION



FIGURE

E. W. Brooker & Associates Ltd.

SAMPLE DESCRIPTION Dawson Gravel
Pile Hole D-1

PROJECT Robert Service School
JOB No. E-835 DATE APRIL 24/74
SAMPLE No.
DEPTH 13-14 ft

EBA Engineering Consultants Ltd.

D. W. HAYLEY, P.Eng.
vice president

April 25, 1974

Government of the Yukon Territory
Department of Highways and Public Works
Box 2703
Whitehorse Yukon

Attention: Mr. Jeff Rounds, Project Architect

Dear Jeff:

Subject: Site Inspection - Robert Service School, Dawson City

Foundation Installation for the new addition to the Robert Service School was inspected on April 23, 1974. Difficulties associated with construction were discussed on site at that time with yourself, the structural consultant and the contractor. With regard to geotechnical matters it is my understanding that the following was resolved.

a. An unforeseen layer of silt with cobbles is present above the gravel bearing stratum. In the one hole inspected, this layer was approximately 4 to 6 inches thick. The frozen, ice rich silt will be detrimental to foundation performance thus the cobbles must be removed and the hole cleaned to the gravel surface prior to installation of the precast footings.

b. Since the auger does not seem to be effective in removing the cobble layer, hand excavation will be required. For this purpose , a jack hammer or pavement breaker has been suggested to the contractor.

c. The screened quartz sand from Lovett Gulch is acceptable material for the leveling pad in the base of the excavation. The sand must be mixed with cement in a proportion of at least 1 bag of cement to 2 bags of sand and it should be placed at a slump which is found by experimentation on site to be workable when the pad is leveled. The thickness of the leveling pad should be kept to a minimum, preferably not in excess of 2 inches (average). In selected cases, a thicker leveling pad may be acceptable, however this must only be placed after approval from the site inspector.

d. It is desirable not to continue drilling until an acceptable procedure for cleaning the holes and installation of footings has been developed. When such a procedure has been established, the rig may proceed ahead of the installation crew in order to expedite the work. The contractor should exercise caution in this respect in order that the holes do not stand open for an unreasonable length of time. Any open holes must be covered to limit air circulation in the interim between drilling and installation of the precast footing. The contractor should be cognisant that either the government safety inspector or the construction inspector may require that any hole subject to a sloughing condition be cased.

I trust you will find those coments helpfull. Please feel free to discuss with me any aspect of this foundation reconstruction.

Yours truly,

EBA Engineering Consultants Ltd.

D.W. Hayley, P. Eng.

cc B. Wood
A. Waldie
B. Nilsen
N. Anderson
D. Yaremko

DWH/tmf

ELMER W. BROOKER & ASSOCIATES LTD.

MEMORANDUM

TO: D. Hayley
FROM: D. Yaremko
JOB NO.: E 835
DATE: May 2/74
SUBJECT: Pile Foundation Inspection - Robert Service School

April 17/74

- Site clear of snow, piles layed out 4'6" N.W. of original plan.
- Western Caisson Piling Rig in Whitehorse - Broken down air compressor.
- Precast Slabs: 5 poured on April 15/74
  8 poured on April 16/74

April 18/74

- Piling rig arrived in late evening from Whitehorse

April 19/74

- 13 precast footings arrived on site
- Mast & Kelly being mounted onto rig.

April 20/74

Started auguring pile H-1 using 40" 0 Auger. Augered to 12' (approx. 2 hours drilling time). Encountered cobbles 6" to 10" 0 which drill rig could not penetrate to. Inspected bottom of pile - cobbles in silt, high ice content, gravel layer 6" - 8" below cobble layer. Suggested the use of jack hammer for removal of cobbles - non available in town. Cobbles and silt removed to gravel layer using hammer and chisel.

April 21/74

- 36" precase pad installed on 1" ready-mix concrete at setting depth of 12'6". thickness of levelling pad 3" to 5" approximate 5" slump
- load of angular boulders for backfill material arrived on site from pit N. of town - inspected and rejected.
- Inspected cemetry pit for backfill - too silty.

DISTRIBUTION

- Sandy gravel backfill material from Bonanza Creek Pit approximately 10 miles from town.

- Pipe welded onto plate & pile partially backfilled

- Drill rig augered pile D-1 to cobbles

- Hole not cleaned to gravel layer.

April 22/74

- Backfill completed on Pile H-1

- Started removing cobble and silt layer (Pile D-1) with hammer and chisel

- Piling rig augered pile F-1 to 11'. Hole cleaned by hammer and chisel to 11'6"

- Compressor and rock drill arrived in afternoon - not effective for removing cobbles

- Sand being screened from backfill material for use of levelling pad and placed into Pile F-1 1 to 3" thick. Precast set on sand levelling pad - 4" off centre, removed and hole left open.

- Pile holes appear to be too small for precast pads.

April 23/74

- Drilling ordered to shut down by Y.T.G. Engineer until remaining open pile holes were backfilled

- Job superintendent gone for compressor to Clinton Creek.

April 24/74

- Cleaning and widening bottoms of piles D-1 and F-1 lowered precast into F-1 and found that contractor was placing 42" precast instead of 36"

- Removed sand levelling pad from F-1 and set precast on mortar levelling pad 2" to 4" depth of mortar used with sand cement ratio of 2-1, slump approximately 2" due to water entering hole, sluffing from top.

- Set D-1 on sand cement mortar @ 11'6" water in hole, top sluffing.

- Drill rig augered L-1$^+$ to cobble layer. Augered K-1$^+$ to approximately 8' encountered cobble, removed by hand.

- Government safety inspector arrived on job site and issued ordinance for the use of casing for pile holes.
- Pile D-1 being welded without casing - observed by safety inspector.
- Piles D-1 and F-1 not backfilled
- Culvert being welded to use as casing

<u>April 25/74</u>

- Welded and backfilled Piles D-1 and F-1, casing being used.
- Rig augered pile B-1 to cobbles - approximately 1' to hand clean, no jack hammer on job site.
- Rig finished augering K-1$^+$ to cobbles
- Both holes not cleaned to gravel.

<u>April 26/74</u>

- Pile B-1 hand cleaned and set on 2" - 6" mortar pad at depth of 11'6"
- Mortar cube samples taken for strength tests
- Jack hammer arrived in afternoon, cleaned L-1$^+$ to gravel and set on mortar pad at 13'
- Drill rig augered piles A-4 and A-6 to cobbles.

<u>April 27/74</u>

- Pile K-1$^+$ cleaned out to 12'6" precast set on mortar, pipe welded and backfilled
- Pile A-4 cleaned out to 11'4" precast set, mortar cube samples taken and left at bottom of hole until April 29. Mortar mold frozen to bottom of hole, cubes set - very weak and fragile.

<u>April 29/74</u>

- Pile A-6 cleaned, large cobble along side of hole at bottom, couldn't remove. 2" to 6" mortar levelling pad used. Pipe welded, setting depth 12'. Backfilled.

D. Hayley

April 29/74

- Pile A-8 drilled, cleaned and set at 11'9" - cobble along side at bottom of hole, precast not set on cobble - pipe welded and backfilled.

- Pile A-9: Bottom generally level, 2 to 3" mortar levelling pad used, precast set at 11'

- Pile A-11 drilled to cobble stones.

- Approximate time to jack hammer and clean hole is 1 hour.

April 30/74

- Pile A-11 Cleaned and precast set, 2 to 3" mortar pad used, precast appeared off level, inspected and precast sitting along wall of hole. Informed superintendent and precast re-set properly.

- Pile C-11 augered to cobbles - Attachment arrived for drill rig kelly bar - 3' extention with pilot point attached to Kelly bar and auger throughout diameter of hole to loosen cobbles, very effective, minimizes jack hammering time. Extension point penetrates through cobbles and into gravel layer. Hole cleaned out 42" precast set approximately 6" into gravel layer on 2-4" mortar pad. Setting depth: 12'6".

- Pile E-11 Setting depth 12'6".

- Contractor cleaning pile E-11 when I left, drill rig augering along line L.

- Production improving immensely

- 13 piles set

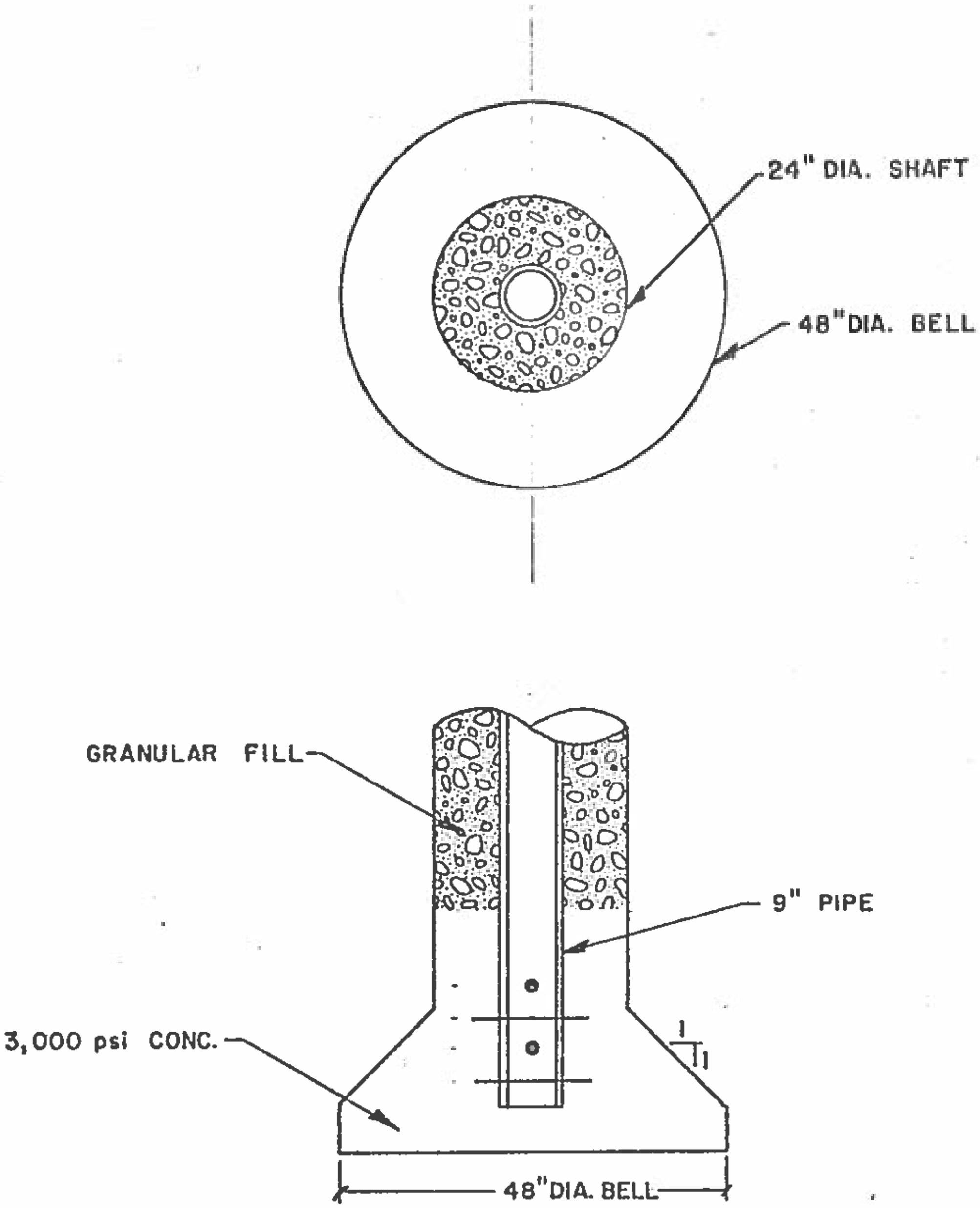
- Surface ground conditions wet.

- Contractor using casing in every hole.

D. Yaremko

DY/sjm

ORIGINAL FOUNDATION DESIGN



NOTE

All piles to bear on dense frozen gravel layer approx. 12' - 0" Below existing grade as defined in specs. Each pile to be visually inspected prior to placing concrete to ensure there is no loose material on this layer.

FROM MORRISON & BERRETTI ENGINEERING DRAWING SK-I FIGURE I

TABLE A-1

POINT ELEVATION ON PAD FOOTINGS

OLD POST OFFICE

POINT	ELEVATION SEPT 14/73	CHANGE FT.	ELEVATION NOV 20/73	CHANGE FT.	ELEVATION DEC 11/73	CHANGE FT.	ELEVATION FEB 15/74	CHANGE FT.
1	1053.66	0.0	1053.59	-0.07	1053.54	-0.12	1053.55	-0.11
2	1053.70	0.0	1053.70	0	1053.63	-0.07	1053.63	-0.07
3	1053.58	0.0	1053.62	+0.04	1053.56	-0.02	1053.57	-0.01
4	1053.47	0.0	1053.51	+0.04	1053.47	0	1053.47	0
5	1053.64	0.0	1053.51	-0.13	1053.58	-0.06	1053.58	-0.06
6	1053.59	0.0	1053.52	-0.07	1053.49	-0.10	1053.50	-0.09
7	1053.67	0.0	1053.58	-0.09	1053.55	-0.12	1053.59	-0.08
8	1053.75	0.0	1053.67	-0.08	1053.66	-0.09	1053.59	-0.08
	APRIL 1/74		APRIL 25/74		AUG/74 (DINA)		FEB 26/75	
1	1053.52	-0.14	1053.57	-0.09	1053.50	-0.16	1053.49	-0.17
2	1053.61	-0.09	1053.68	-0.02	1053.61	-0.09	1053.60	-0.10
3	1053.56	-0.02	1053.62	+0.04	1053.50	-0.08	1053.48	-0.10
4	1053.48	+0.01	1053.54	+0.07	1053.41	-0.06	1053.38	-0.09
5	1053.59	-0.05	1053.64	0	1053.49	-0.15	1053.49	-0.15
6	1053.52	-0.07	1053.55	-0.04	1053.38	-0.21	1053.45	-0.14
7	1053.60	-0.06	1053.63	-0.04	1053.55	-0.12	1053.53	-0.14
8	1053.71	-0.04	1053.73	-0.02	1053.62	-0.13	1053.61	-0.14

NOTE: 1) Elevations referred to TBM in Alley @ Elevation 1056.79

2) Point locations shown on Figure 1, Page 3.

TABLE A-2

GROUND TEMPERATURE DATA

APRIL 20 TO NOV 9, 1972

Location	No.[1]	Depth (ft)	Ground Temperature °F (Corrected for 32°F Calibration Check) April 20	April 22	April 23	April 30	June 4	Aug 31	Oct 25	Nov 9
Post Office[2] Borehole No. 4 (Inst. Apr. 19)	1	5.8	30.4	31.0	30.9	30.9	30.6	32.4	32.0	Unable To Obtain Readings
	2	6.3	30.7	30.8	30.7	30.7	30.2	32.2	32.6	
	3	7.3	31.0	29.8	29.6	29.6	29.6	32.0	32.0	
	4	8.3	30.8	29.8	29.5	29.2	28.8	31.2	30.6	
	5	9.3	31.3	29.7	39.3	28.9	28.5	30.3	30.7	
	6	10.3	31.4	30.0	29.6	28.8	28.2	31.2	31.2	
	7	11.3	31.6	31.6	31.6	28.8	28.0	28.6	29.8	
	8	13.3	31.9	31.9	32.2	28.7	28.2	29.4	29.4	
Commissioners Residence Borehole No. 9 (Inst. Apr. 21)	1	5.0		30.8	30.4	31.4	32.0	34.6	33.8	32.2
	2	5.5		31.2	31.4	31.8	31.8	33.6	33.4	32.4
	3	6.5		32.7	32.2	32.5	32.2	32.6	32.8	32.8
	4	7.5		33.2	32.5	32.7	32.5	32.3	32.5	32.7
	5	8.5		33.4	32.7	32.8	32.2	32.4	32.4	32.4
	6	9.5		33.4	32.8	32.8	32.0	32.2	32.2	32.4
	7	10.5		33.5	33.0	33.0	32.2	32.4	32.6	32.8
	8	12.5		34.2	33.1	33.8	32.8	33.0	33.6	33.8
Red Feather Saloon Borehole No. 5 (Inst. Apr. 20)	1	Surface	39.9	36.4	33.0	36.0	55.4	49.4	30.0	29.0
	2	0.8	40.5	23.5	24.8	32.2	42.2	44.4	31.6	31.4
	3	2.8	40.9	23.7	23.3	27.4	30.2	34.4	31.8	31.8
	4	4.8	43.3	23.6	23.5	25.2	28.6	29.8	31.6	31.0
	5	6.8	41.5	24.1	23.8	25.4	27.2	28.8	31.4	30.2
	6	8.8	40.6	25.2	25.0	26.4	27.2	28.4	29.0	29.8
	7	13.8	37.5	26.9	26.6	27.0	26.4	27.2	28.6	28.8
	8	18.8	46.8	28.0	27.6	27.8	26.6	27.0	28.0	28.4

[1] Refers to thermistor number on switch box.

[2] Borehole location No. 4 disturbed by construction activity after June 4 readings.

TABLE A-2 (CONT'D)

SEPT 14, 1973 TO FEB 26, 1975

Location	No.	Depth (ft)	Ground Temperature ^{o}F (Corrected for $32^{o}F$ Calibration Check)						
			Sept. 14 1973	Nov. 22 1973	Dec. 30 1973	Feb. 15 1974	March 22 1974	March 29 1974	Feb. 26 1975
Red Feather	1	5.8	59.1	8.0	9.3	9.8	22.0	22.2	28.4
Saloon	2	6.3	41.4	23.9	23.6	20.4	17.2	18.1	24.2
Borehole No. 5	3	7.3	35.0	31.8	30.0	24.5	19.0	20.2	29.4
(Inst. Apr. 20)	4	8.3	31.2	31.4	--	--	--	--	--
	5	9.3	30.0	30.6	30.0	26.8	23.6	23.9	30.8
	6	10.3	29.8	30.4	30.0	27.0	25.4	25.6	30.7
	7	11.3	28.7	29.4	29.5	26.8	27.6	27.5	29.7
	8	13.3	28.2	29.0	29.3	28.5	28.4	28.2	--
Commissioners			Sept. 14	Nov. 20	Dec. 30				Feb. 26
Residence									
Borehole No. 9	1	5.0	37.9	33.8	33.0				32.1
(Inst. Apr. 21)	2	5.5	37.5	33.7	33.0				31.5
	3	6.5	37.4	35.1	34.4				32.4
	4	7.5	35.6	34.6	34.1				32.3
	5	8.5	34.6	34.1	33.7				32.2
	6	9.5	34.1	33.8	33.6				32.8
	7	10.5	33.5	34.4	33.2				33.3
	8	12.5	33.6	35.2	35.2				33.1

TABLE A-3

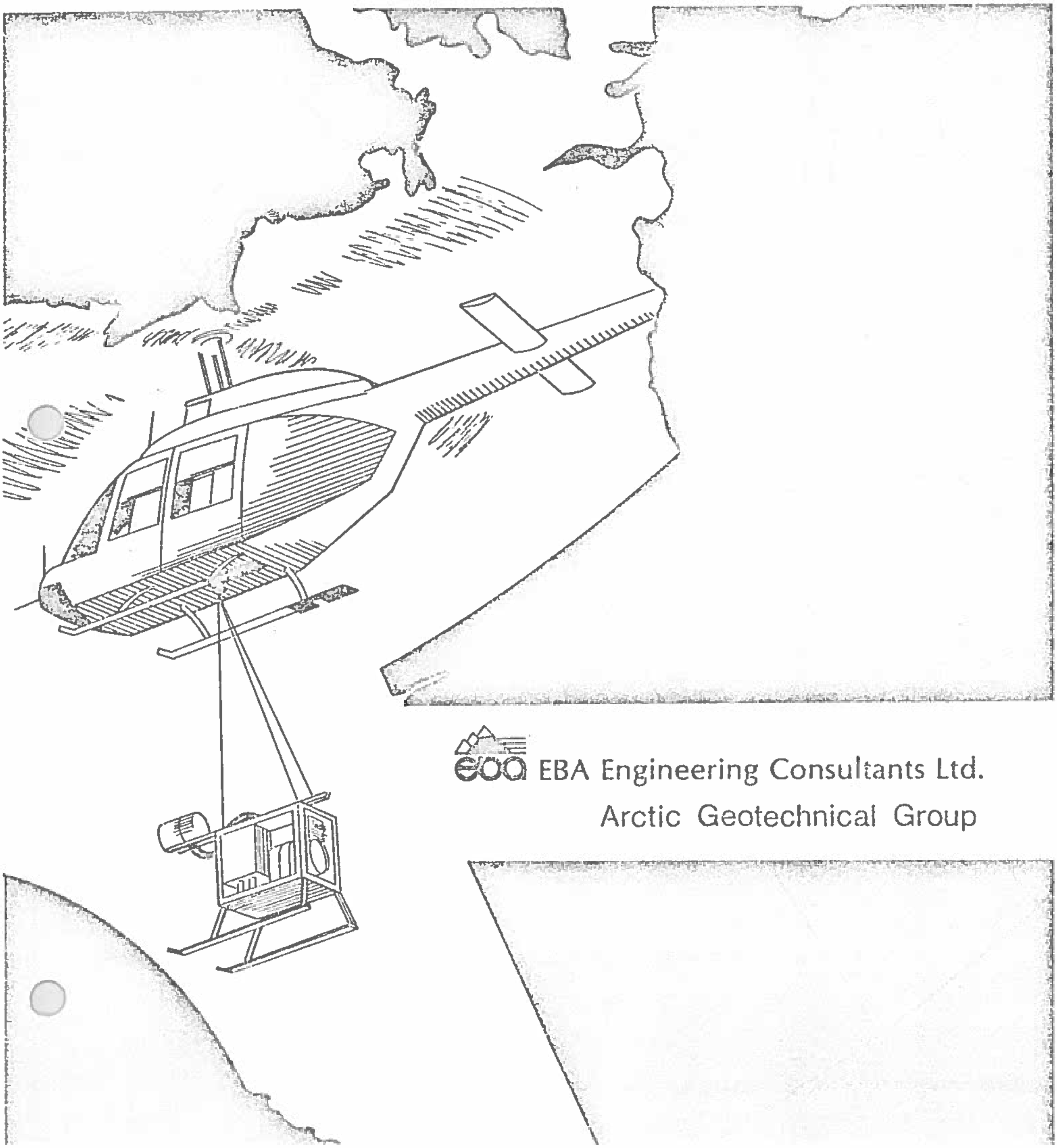
GROUND TEMPERATURE DATA

RUBYS' PLACE

Location	No.[1]	Depth (Ft)	Ground Temperature °F (Corrected for 32°F Calibration Check)			
			Dec 30 1973	Feb 15 1974	March 22 1974	March 29 1974
Rubys' Place	1	4	9.1	6.9	4.8	9.8
	2	4	11.3	8.4	5.6	10.0
	3	4	11.1	8.4	5.8	10.3
	4	4	11.2	8.2	4.5	--

NOTE: String Horizontal at bottom of excavation.

FOUNDATION PAD PERFORMANCE
AND
GROUND TEMPERATURE OBSERVATIONS
DAWSON YUKON



EBA Engineering Consultants Ltd.
Arctic Geotechnical Group

FOUNDATION PAD PERFORMANCE
AND
GROUND TEMPERATURE OBSERVATIONS
DAWSON YUKON

Submitted To:

DEPARTMENT OF INDIAN AND NORTHERN AFFAIRS
RESTORATION SERVICES

APRIL, 1975

EBA Engineering Consultants Ltd.

TABLE OF CONTENTS

I. INTRODUCTION

As part of an ongoing program of building restoration in Dawson, Yukon The Department of Indian and Northern Affairs (DINA) retained EBA to monitor performance of a gravel pad foundation. The gravel pad is the new surface preparation for the Historic old post office, the first restored building under the government scheme. The performance monitoring program, carried out under Contract No. 156-73, was an extension of a comprehensive study of subsurface conditions in Dawson conducted by EBA (then E.W. Brooker and Associates) and submitted to DINA in December, 1972.[1]

The scope of work conducted under this monitoring program includes:

a. Periodic elevation survey of selected exterior pad footings at the restored Post Office.

b. Installation of two frost stable benchmarks.

c. Periodic readings of thermistor strings installed during the initial subsurface investigation.

A brief description of the program, a presentation of data collected and a discussion of it is presented in this report.

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[1] "Report on Subsurface Conditions, Dawson Yukon" by E.W. Brooker and Associates submitted to Department of Indian Affairs and Northern Development December 22, 1972.

II. ELEVATION SURVEY - POST OFFICE

2.1 Program

A periodic elevation survey on the Post Office footings was initiated on September 14, 1973. The structure had been temporarily set on timber cribs that summer (1973) and the old basement cleaned and filled with coarse gravel and cobbles. The pad was completed to grade and the structure lowered onto numerous surface wooden footings supporting a short extendable steel pipe column. Eight of the surface wooden pads, all on the perimeter of the structure, were chosen for the monitoring program.

The elevation survey was initially referenced to a temporary benchmark which was the top of a vertical support rail for a power pole in the lane behind the structure. (Elevation 1056.79, Sept. 14, 1973) Due to the remote location, reading frequency was erratic. Eight reliable sets of readings were taken during the period September 14, 1973 to February 26, 1975 (18 months). The readings were taken by:

a. A local resident hired to take "monthly" readings
b. EBA Technicians when passing near the town
c. DINA construction personnel

2.2 Results

The location of elevation points are shown in Figure No. 1. Also shown in Figure No. 1 are the changes in elevation with respect to the initial set of readings. A table with the actual elevation data is included in Appendix A, Table A-1.

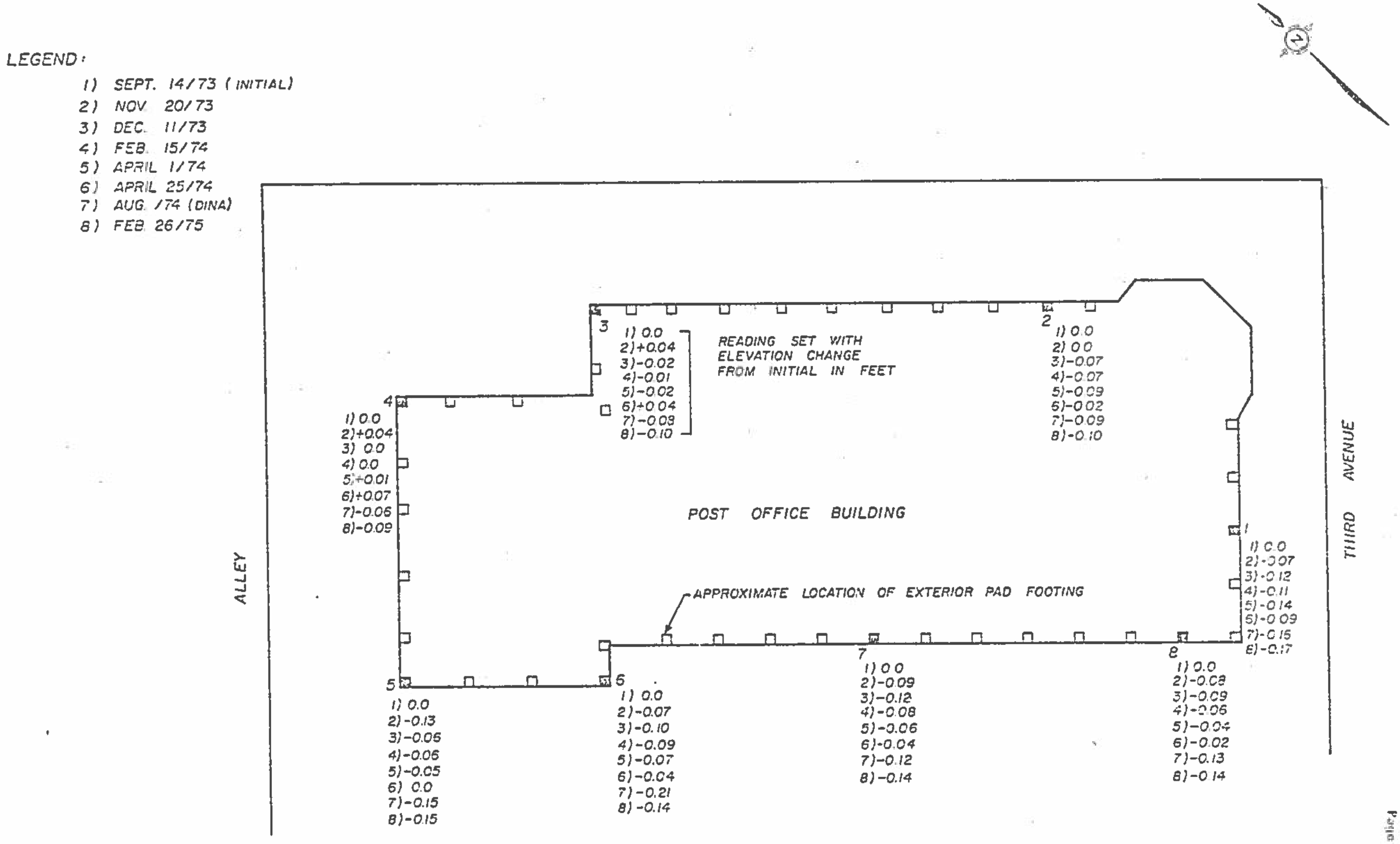

FIGURE 1 SETTLEMENT SURVEY ON POST OFFICE BUILDING - DAWSON CITY, YUKON

Settlement of the eight points ranged from 0.09 ft. to 0.17 ft. with an average of 0.13 ft. over the 18 month period.

Settlement was found to be relatively uniform, which is surprising, considering the variable depth of gravel fill under the structure (only the east half had a basement thus the gravel pad is much thicker there). It is evident that settlement is slightly greater on the south and west sides of the building, where the gravel surface is exposed to more direct sunlight.

2.3 Benchmark Installation

Two deep benchmarks were installed in the townsite in March, 1974. The installation was carried out by EBA for DINA under a separate contract (344-73). The purpose of the benchmarks is not only for the settlement monitoring program but for future restoration work in the townsite. The locations, chosen by DINA personnel, are nearby two buildings referred to as the Dawson Daily News and Ruby's Place.

A sketch showing the benchmark design is shown in Figure No. 2. The design is standard for permafrost regions, with an outer sleeve protecting the benchmark rod from frost action through the zone of severe seasonal ground temperature fluctuations. At Dawson, the sleeve was extended to the bottom of the icy permafrost silt and the inner pipe burried at least five feet into the dense frozen alluvial gravel which underlies the townsite.

For purposes of the post office monitoring program, a temporary elevation (1052.93) was set on the benchmark at the Dawson Daily News relative to

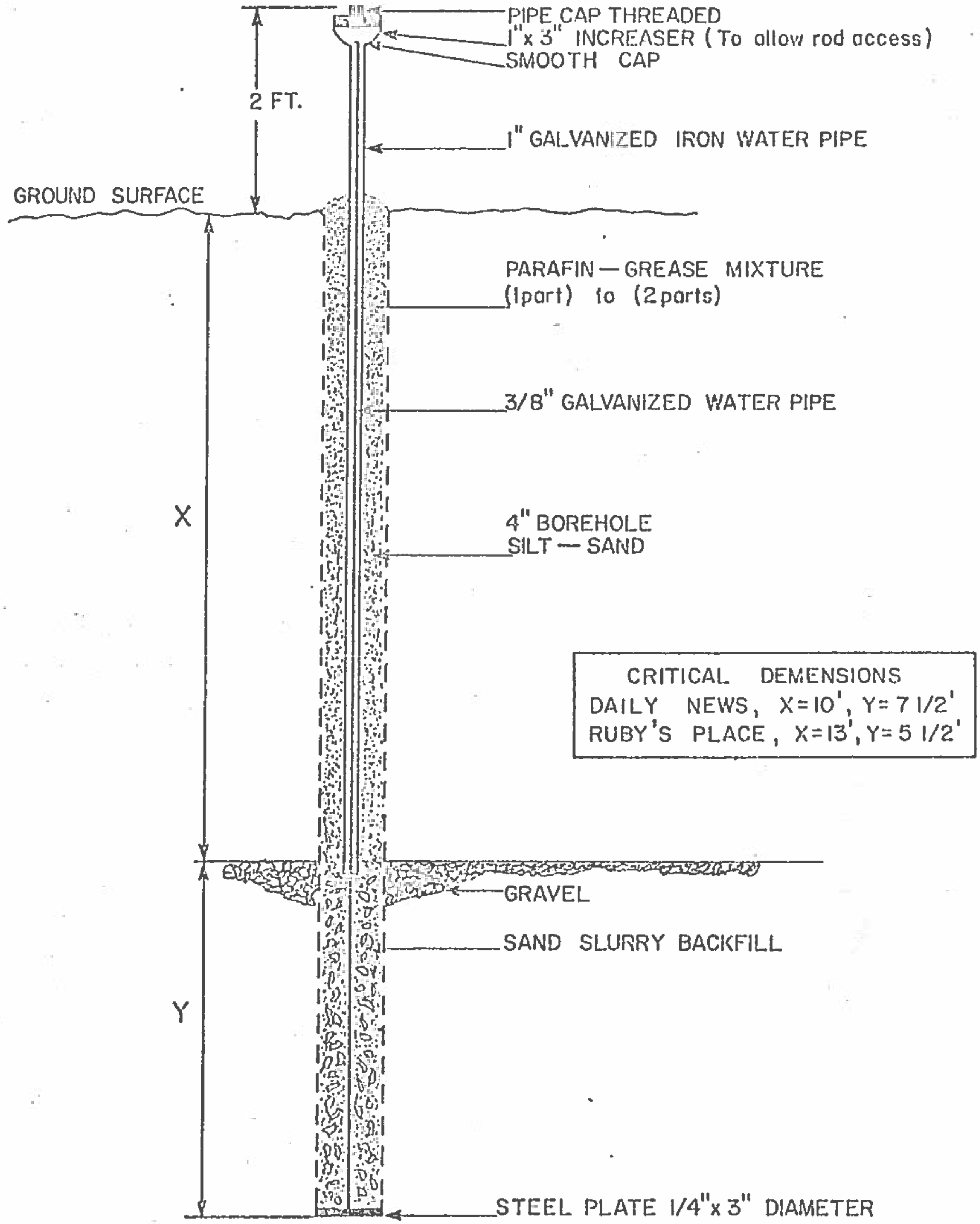

FIGURE 2 DEEP BENCH MARK DESIGN —— DAWSON YUKON

the temporary benchmark in the alley. Actual geodetic elevation of the two deep benchmarks was subsequently set by DINA personnel. The geodetic elevation was not utilized for this program.

III. GROUND TEMPERATURE DATA

Ground temperature was recorded from a string of thermistors installed in each of three boreholes drilled during the general field investigation program. Installation details for these instruments together with the first 6 months of observational data is summarized in the report on subsurface conditions referred to previously. An additional seven sets of readings were obtained from the thermistor string installed at the Red Feather Saloon and four sets from the string at the Commissioners Residence. Unfortunately, readings could not be obtained beyond October 25th, 1972 at the Post Office Site because the cable was destroyed during construction. All readings obtained from the installations is summarized in Table A-2, Appendix A.

Restoration of the foundation at Ruby's place entailed excavation under the existing structure to a depth of approximately four feet. Just prior to backfill placement in December, 1973, a horizontal thermistor string was installed along the bottom of the excavation. The string, which has four equally spaced thermistors, was positioned along the minor axis of the structure. Readings were obtained only during the winter, 1974. These are presented in the Table A-3, Appendix A.

IV. DISCUSSION AND RECOMMENDATIONS

4.1 Post Office

Performance of the post office pad foundation has been excellent. In general, the mangitude of settlements is within reasonable expectations. There is some evidence of frost heaving at the northwest corner of the structure, points 3 and 4 however the magnitude of movement is less than 0.1 feet. The frost heaving which was recorded during the winter of 1974 was recovered as settlement the following summer.

The most severe differential settlement was recorded at point 5 where 0.15 feet of settlement occurred during the summer, 1974. Water was noted to be ponded adjacent to the pad at points 5 and 6 during that summer. Ponded water presents a severe risk to the structure, which depends on maintaining the permafrost for its stability. Drainage should be improved in this region, moreover, the exposed surface of the gravel pad on the south side of the structure should be covered with topsoil and adequately landscaped. The northwest end of the structure, referred to as the annex, is the most serious region of concern because the thickness of permafrost organic silt is greatest there. Measured movements, both heave and settlement, have been greatest to date at this end of the building.

4.2 Rubys' Place

The below ground gravel pad design used at Ruby's Place is a questionable procedure. It is understood that excavation is necessary in order to maintain an authentic building elevation while accommodating the gravel pad. Replacement of natural soil with gravel will ultimately cause some permafrost degradation. Differential settlements will however be reduced significantly by the pad and the foundation should ultimately stabilize after several years. It is strongly recommended that the crawl space below Rubys' Place be well ventilated in winter and closed during summer. Moreover, thermistor readings should be continued at this location.

4.3 Future Projects

The first gravel pad foundation used in the permafrost area of the town has performed reasonably well to date. Seasonal ground surface movements in the order of 0.1 feet should be expected due to frost heave. Moreover, settlement may continue for several years at a diminishing rate. The monitoring program has shown that the pattern of settlement is somewhat dependent upon surface conditions and exposure. Fortunately the magnitude of settlements has been within the range that can reasonably be tolerated by the structure involved. The structure can be releveled periodically with a minimum of difficulty.

The main problems associated with the pad foundation design are:

a. There is a high risk of heave or settlement.
b. Finished floor elevation for the completed structure is difficult to control without excavation, which defeats the prime purpose of the pad.

These problems are overcome by utilizing a deep pad footing design as described in the general report on subsurface conditions referred to previously. This technique was used under EBA supervision for an extension to the Robert Service School in Dawson. At that site, a 4 to 5 foot diameter hole was augered to the underlying gravel with a caisson drilling rig and precast circular pad footings placed in the hole. Steel pipe columns were then field welded to a steel plate cast into the footing and the hole backfilled with granular fill. The installation is described in detail in a report prepared by EBA[1] for the Government of the Yukon Territory. A copy of this report has been forwarded previously to DINA with consent of the Yukon Government.

It is not practical to consider use of a caisson drilling rig for work under an existing structure, however, hand excavation to the gravel surface is feasible. With the aid of a jack hammer, excavation in the frozen silt is a practical design. Since each footing would be capable of supporting a considerable load (15,000 psf recommended bearing pressure) use of deep grade beams to minimize the number of footings would be desireable.

Respectfully submitted,

EBA Engineering Consultants Ltd.

D. W. HAYLEY

Don W. Hayley, P. Eng.

DWH:lmh

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[1] "Site Investigation and Pile Foundation Evaluation, Addition to Robert Service School, Dawson Yukon". Prepared by EBA for Government of the Yukon Territory, Department of Highways and Public Works July, 1974.

APPENDIX A

SUMMARY OF ELEVATION AND GROUND TEMPERATURE DATA

Table XXXI

Module of ventilation of crawl space for different widths of the building, thermal resistance of the floor and floor surface temperature in the first storey (calculated without taking wind pressure into account)

WIDTH OF BLDG. M	THERMAL RESIST. OF FLOOR M^2 HR·DEG./K/CAL	TEMP. OF FLOOR OF FIRST STOREY, DEG.	VENTILATION MODULE OF THE CRAWL SPACE FOR THE ZONE:		
			SUBARCTIC	TEMPERATE	SOUTHERN
15	1	15	0,0015	0,005	0,025
		30	0,005	0,015	0,03
	2	15	0,001	0,003	0,012
		30	0,002	0,007	0,020
	3	15	0,0005	0,002	0,007
		30	0,001	0,004	
30	1	15	0,0025	0,008	OPEN
		30	0,0075	0,025	»
	2	15	0,0015	0,006	0,015
		30	0,0035	0,010	0,03
	3	15	0,0007	0,003	0,007
		30	0,0022	0,005	0,010
50	1	15	0,003	0,010	OPEN
		30	0,01	0,03	»
	2	15	0,002	0,007	0,020
		30	0,005	0,015	OPEN
	3	15	0,001	0,004	0,10
		30	0,003	0,007	OPEN

Area req'd/side of Bldg.

d - distance from the centre of the building to the middle of the perimeter wall in the transverse direction,

ϑ_{ng} - temperature of the ground surface outside the crawl space,

ϑ_{pg} - temperature of the ground surface in the crawl space.

The thermal balance of the crawl space at the beginning of freezing of the thawed layer has the form:

$$Q_1 + Q_2 + Q_3 + Q_5 = 0. \qquad (6.22)$$

Freezing of the layer of soil at the base of the building thawed during the summer, taking into account freezing from above as well as from below due to heat losses into the permafrost for any time interval t, is determined by the formula:

$$h = -\lambda_{fr}R + \sqrt{(\lambda_{fr}R + h_o')^2 - \lambda_{fr}\frac{\vartheta_c - \vartheta_3}{40\omega}t} -$$

$$-\lambda_{fr}\frac{\vartheta_o - \vartheta_3}{40\omega\sqrt{\pi a}}\left(\sqrt{t_o + t} - \sqrt{t_o}\right), \qquad (6.23)$$

where t_o - time from the beginning of thawing up to the calculation time.

In formula (6.23) the first two components express the value of freezing of the thawed layer in the crawl space from above and the last component expressed freezing from below.

After freezing of the seasonally thawed layer near the structure and its base, the thermal balance takes on the form:

$$Q_1 + Q_2 + Q_5 + Q_6 = 0. \qquad (6.24)$$

During this time ventilation can be substantially decreased or even stopped if the following relation is satisfied:

$$Q_1 \leq |Q_2 + Q_6| . \qquad (6.25)$$

For a rough consideration of heat losses Q_6, Table XXIX can be used in which the maximum dimensions of the heated building (in metres) are given under which in specific circumstances the frozen state of the foundation soil can be preserved without ventilation and even without a crawl space exclusively because of heat flow through the frozen soil. As introductory values in Table XXIX we have:

mean temperature of the ground surface (in practive the mean temperature the outside air) for the four coldest months of the winter - ϑ_{ng};

The conventional notations used in formulae (6.3), (6.9) and (6.10) ar iven below:

ϑ_1 - air temperature in the first storey of building in degrees,

ϑ_c - air temperature in the crawl space in degrees,

ϑ_{dp} - dew point of the outside air, in degrees,

ϑ_o - temperature of the perennially frozen strata at the depth of zero annual amplitude, in degrees

R_{fl} - thermal resistance of the floor above the crawl space. m^2 x hours x degrees/kcal,

R - thermal resistance to heat transfer from the ground surface to the air in the crawl space, m^2 x hours x degrees/kcal,

λ_T, λ_{fr} - heat conductivity coefficient of thawed and frozen ground, kcal/m x hours x degrees,

a - diffusivity coefficient of frozen ground m^2/hours

ω - quantity of frozen water in the soil, kg/m^3,

α_n - coefficient of heat transfer from the air in the crawl space to the floor, kcal/m^2 x hours x degrees,

h_o - depth of thaw of the ground before the beginning of the calculation time interval t, m (initial depth of thaw),

t - calculation of time interval in hours,

$$m = \vartheta_1 + (\lambda_T R + h_o + \lambda_T R_{fl}) \frac{30\omega R_{fl}.}{t}$$

Supplementary changes in air temperature in the crawl space due to ventilation and heat flow to and from the crawl space through the perimeter wall of the building is taken into account by corrections ϑ in the formulae. For the crawl space of apartment buildings this correction ϑ, should be taken as 0.5 - 1.5°C. For crawl spaces of buildings with large heat emission where accelerated ventilation of the crawl space by cool outside air reduces the depth of thaw under the building, the value of ϑ should be taken within the range of -0.5 to -1.5°C. The limits of these corrections were derived by considering the minimum increase in air exchange with simultaneous minimum increase in depth of thaw. The accuracy in choosing the calculation formula for determing the air temperature in the crawl space is further checked by the thermal balance from which the air exchange between the outside air and the air in the crawl space is determined. If according to calculations the quantity of air required to maintain the air temperature in the crawl space as calculated with formulae 6.8, 6.9 and 6.10 has a negative value the mula is incorrect and the air temperature should be recalculated with another formula.

Table XXIX

Maximum dimensions of heated buildings which do not require cooling arrangements to retain the foundation soil in a frozen state, in metres

temp @ 0 amplitude

temp. inside ground floor.

temp of ground surface outside crawl space

θ_{NG}	θ_0	R_{SI} \ θ_1	5	10	15	20	30
—50	—10	1	15×10	10×20	5×10	—	—
		2	30×60	20×40	10×20	5×10	—
		3		30×60	20×40	10×20	5×10
—25	— 5	1	5×10	—	—	—	—
		2	20×40	10×20	5×10	—	—
		3	30×60	20×40	10×20	5×10	—
—10	— 2	1	3×6	—	—	—	—
		2	7×14	5×10	—	—	—
		3	10×20	7×14	5×10	—	—

Table XXX

Mean monthly temperature, relative humidity and air density, ground surface temperature, wind velocity in the vicinity of the building site

MONTH	AIR TEMP. °C	TEMP. OF DEW POINT OF OUTSIDE AIR	REL. HUM. OF AIR	AIR DENSITY Kg/m³	GROUND SURF. TEMP. °C	WIND VELOCITY m/SEC.
I	—43,2	—	80,4	1,41	—42,0	1,1
II	—35,6	—	82,0	1,40	—36,0	1,1
III	—22,4	—	77,4	1,38	—23,0	1,1
IV	— 8,1	—	66,6	1,33	— 7,3	2,1
V	5,6	— 1,0	59,6	1,27	—	2,5
VI	15,5	7,2	60,8	1,23	—	2,2
VII	18,9	12,0	64,6	1,22	—	2,1
VIII	14,7	10,0	73,4	1,22	—	2,0
IX	6,1	3,0	74,6	1,27	—	2,0
X	— 7,9	—	81,6	1,33	— 6,9	1,9
XI	—27,5	—	83,1	1,37	—26,4	1,5
XII	—39,5	—	81,0	1,41	—38,0	1,1

The temperature in the crawl space is regulated monthly.

Module of Ventilation

: The ratio of the total area of openings per side to the area of the floor above the crawlspace.

Width of Bldg. ft	Thermal Resistance	Floor Temp Grnd. Fl.	Ventilation Module		
			SubArctic	Temperate	Southern
50' ±	4.88	60°	0.0015	0.005	0.025
		80°	0.005	0.015	0.03
	9.76	60°	0.001	0.003	0.012
		80°	0.002	0.007	0.020
	14.64	60°	0.0005	0.002	0.007
		80°	0.001	0.004	—
100' ±	4.88	60°	0.0025	.008	OPEN
		80°	.0075	.025	OPEN
	9.76	60°	.0015	.006	.015
		80°	.0035	.010	.003
	14.64	60°	.0007	.003	.007
		80°	.0022	.005	.010
165' ±	4.88	60°	.003	.010	OPEN
		80°	.01	.03	OPEN
	9.76	60°	.002	.007	.020
		80°	.005	.015	OPEN
	14.64	60°	.001	.004	.010
		80°	.003	.007	OPEN

R for fir, pine & softwoods = 1.25 per inch thickness