REPORT ON

GEOTECHNICAL STUDY RELATIVE

TO ESTABLISHING A COMMUNITY GRAVEL BORROW PIT FOR

BURWASH LANDING AND DESTRUCTION BAY, YUKON

FEBRUARY, 1983 CG10047

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Prepared for
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SUMMARY

A detailed geotechnical investigation of three existing gravel pit reserves along the Alaska Highway (YTG #10981, DIAND #11574 and YTG #10983) was undertaken, to provide information on the basis of which to establish a community borrow pit for the use of Burwash Landing and Destruction Bay, Yukon. It is intended that the chosen pit will satisfy the concrete aggregate and gravel fill requirements of the two communities.

Following a review of existing information, a comprehensive drilling and laboratory testing program was carried out. In all, 45 boreholes were drilled and sampled within the three deposits. Laboratory testing consisted of moisture content determinations and, on selected samples, visual petrographic analysis, sieve analysis, and Los Angeles abrasion and sulphate soundness tests. Borehole logs and laboratory test results are presented.

Principle findings of the study are as follows:

a) The M.P. 1086.2 site is a low volume deposit of fair to poor quality aggregate. With a 3:1 gravel-overburden stripping ratio, development does not appear warranted unless the overburden is used as fill material.

b) Reserves for the M.P. 1087.6 deposit are estimated at 22 300 m^3 proven and 81 500 m^3 probable, of good quality aggregate. This will be suitable for most construction purposes, with crushing and screening required to produce concrete aggregate.

c) At M.P. 1095.1 proven reserves are 90 000 m^3 of good quality aggregate, greater than 200 000 m^3 probable. Again though suitable for most purposes, the gravel will require crushing to produce concrete aggregate.

It is concluded that, while additional testing is needed in the southern section (when improved access is available), the borrow reserve at M.P. 1095.1 (YTG #10983) is most suitable for development as a large volume, good quality, gravel pit for the use of the two communities.

1.0 INTRODUCTION

Hardy Associates (1978) Ltd. was retained by the Department of Indian Affairs and Northern Development to carry out necessary geotechnical testing and assessment studies in connection with establishing a community gravel pit for Burwash Landing and Destruction Bay, Yukon. Authorization to proceed with the study was given on November 16, 1982 by Mr. G. N. Faulkner, Assistant Deputy Minister, Northern Affairs. Completed contract documents for the work were returned to Mr. G.Y. Williams, DIAND Contract Services Division, on December 13, 1982.

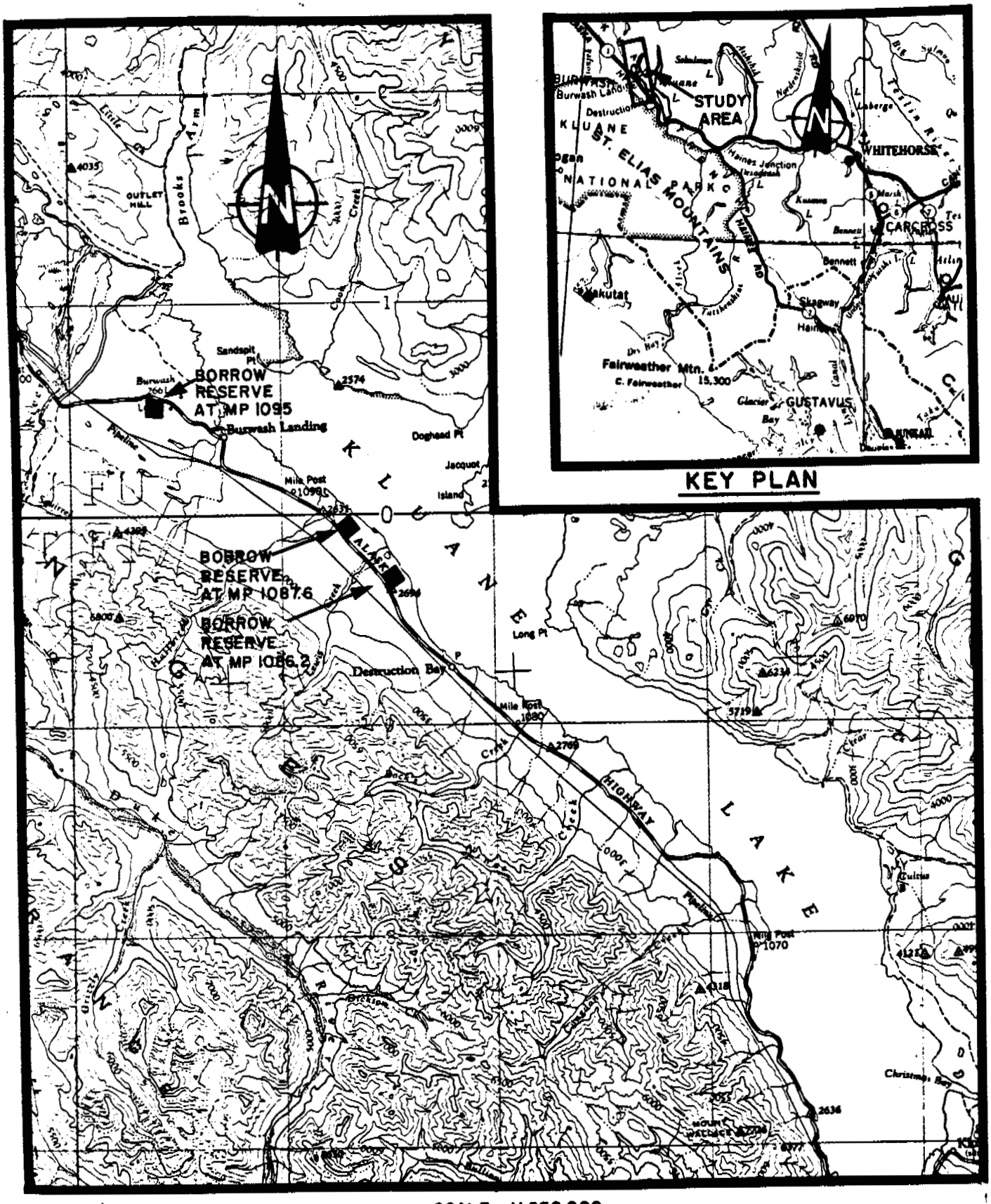
1.1 SCOPE OF STUDY

The prime objective of the study was to evaluate three existing borrow pit reserves, in connection with establishing a community borrow pit for the use of Burwash Landing and Destruction Bay. The chosen pit is to satisfy the demands for concrete aggregate and gravel fill for both communities. The three reserves are located adjacent to the Alaska Highway, between MP's 1086 and 1096 (Figure 1).

1.2 TERMS OF REFERENCE

Terms of reference for the study, as established in our Contract No. 82-348 with Department of Indian Affairs and Northern Development, were to:

1. Carry out a detailed field drilling program at the following existing borrow pit reserves;



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LOCATION PLAN

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FIG 1

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a) YTG Gravel Pit #10981 M.P. 1086.2 (KMP 1737.9)
b) DIAND Gravel Pit #11574 M.P. 1087.6 (KMP 1740.2)
c) YTG Gravel Pit #10983 M.P. 1095.1 (KMP 1752.2)

2. Conduct testing on representative samples to confirm the quality of the material in each pit and its suitability for various uses.

3. Prepare and submit a brief report, discussing the study methodology and presenting its results, providing an assessment of available aggregate volumes and suitability for various community uses, and presenting recommendations for pit development.

2.0 GEOLOGICAL SETTING

2.1 RELIEF AND TOPOGRAPHY

Physiographically, the borrow reserve sites lie in the Shakwak Trench, along the northeast side of the Kluane Ranges, St. Elias Mountains (Bostock, 1969). The M.P. 1086.2 and 1095.1 sites have undulating topography and slope gently to the north towards Kluane Lake, while the topography of borrow reserve at M.P. 1087.6 is hummocky, with a maximum relief of approximately 8 m to 10 m. Elevations of the three sites range from 821 m above sea level (asl) to 806 m asl (Figure 1).

2.2 BEDROCK GEOLOGY

According to Rampton (1981):

"The eugeosynclinal sequence of the Kluane Ranges and adjacent areas north of the Slims River consists primarily of

argillite, volcanic, and greenstone rocks of Permo-Triassic age."

2.3 SURFICIAL GEOLOGY

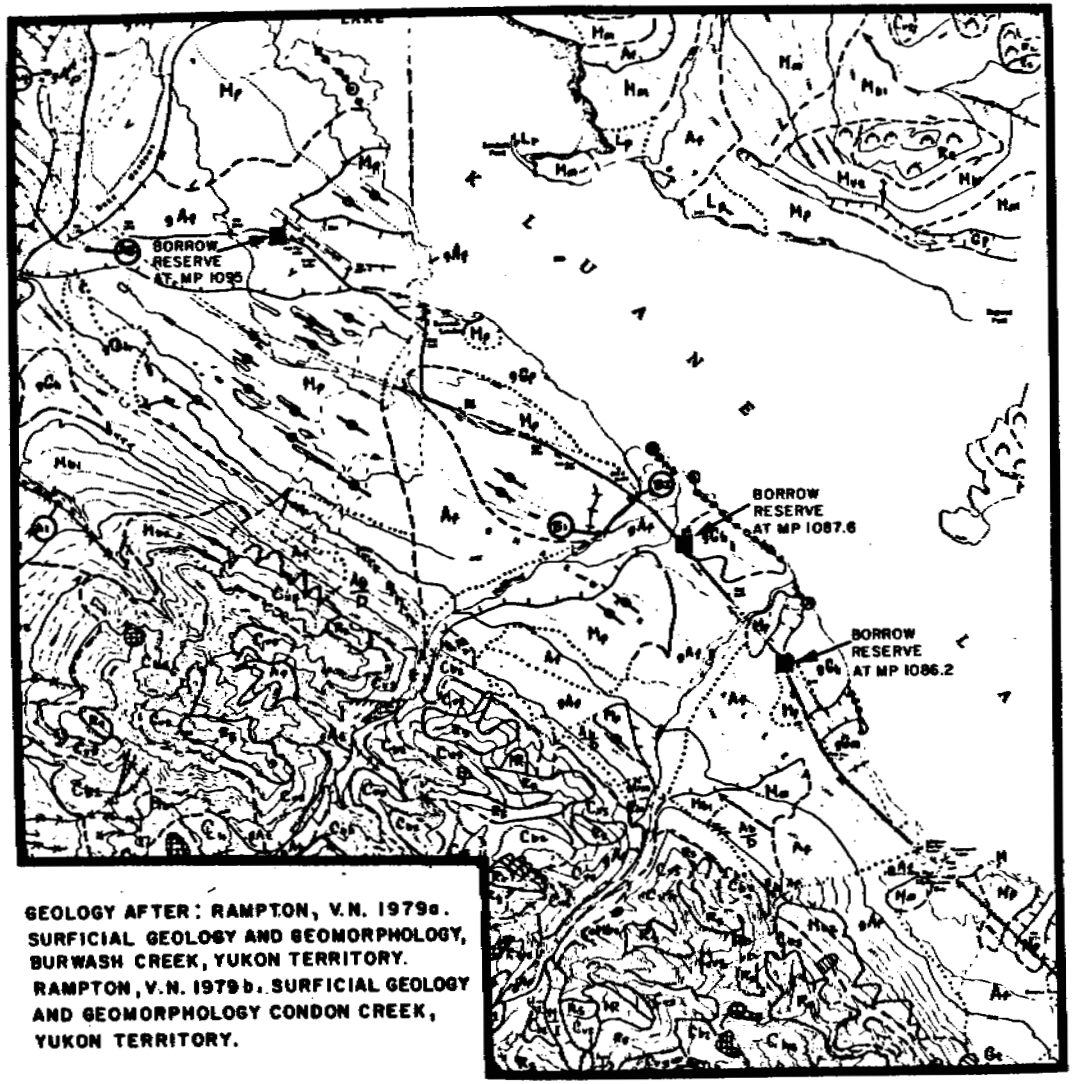
The surficial geology of the Burwash Landing/Destruction Bay area is shown on Figure 2 (after Rampton, 1979a; 1979b).

The Alaska Highway in this area follows the base of the Kluane Ranges, St. Elias Mountains, across a series of large coalescing alluvial fans which overlie glaciofluvial and morainal deposits (Rampton, 1977a; 1979b). As a result, the surficial geology is fairly complex and the three borrow reserves are all located on different surficial deposits. Thus, the borrow reserve at M.P. 1086.2 is located on a late Wisconsinan morainal deposit, which includes patches of glaciofluvial outwash material, the M.P. 1087.6 site is situated on a glaciofluvial kame terrace, and the M.P. 1095.1 site lies on a large alluvial fan of the Duke River (Figure 2).

The detailed surficial geology of the borrow sites is shown on Plates C1 to C3 (Appendix "C"), and described in Section 5.0.

2.4 DRAINAGE

The study areas slope towards Kluane Lake and have, for the most part, excellent surface drainage. Local depressional areas, however, are poorly drained and organic-infilled, for example, the extreme north-east corner of the M.P. 1086.2 site and the southern portion of the M.P. 1095.1 site. The poorly-drained organic areas are outlined on the individual site mosaics, in Appendix "C".



GEOLOGY AFTER: RAMPTON, V.N. 1979a. SURFICIAL GEOLOGY AND GEOMORPHOLOGY, BURWASH CREEK, YUKON TERRITORY. RAMPTON, V.N. 1979b. SURFICIAL GEOLOGY AND GEOMORPHOLOGY CONDON CREEK, YUKON TERRITORY.

EXPLANATION OF LANDFORM UNIT NOTATIONS

Compositional-Genetic Category — Age Modifier — Textural Modifier — Morphologic Modifier(s)

$\frac{C_{bl}}{D}$ Stratigraphic relationship given where thickness of upper unit is irregular and where underlying unit is a known compositional-genetic unit other than bedrock.

Compositional -Genetic Category[1]

- A- Alluvial Deposits: sand and gravel with veneer of fine sediment; Postglacial, rarely older; floodplain (A_p); modern.
- C- Colluvium: various materials, mainly rubble, including landslides (C_l); undifferentiated Pleistocene or ages taken spread (C_u); Neoglacial, mainly modern.
- D- Drift: undifferentiated till, sand, gravel, and lacustrine sediment; Late Wisconsinan (Macaulay).
- E- Eolian Deposits: sand, silt, or tephra; Postglacial.
- G- Glaciofluvial Deposits: sand and gravel with veneer of fine sediment; Late Wisconsinan (Macaulay).
- I- Ice; snow and firn veneer; Neoglacial.
- L- Lacustrine Deposits: mainly silt and clay with little fine sand; Late Wisconsinan (Macaulay).
- M- Morainal Deposits: till, silty/sandy, Late Wisconsinan (Macaulay); ice-cored moraines and debris-covered glaciers (Mi); and rock glaciers (Mr); rubble, Neoglacial.
- R- Bedrock: various types; pre-Pleistocene.

Textural Modifiers

- a- sand or gravel; (M- till containing a high proportion of sand, gravel, rubble, or boulders
- b- boulders, blocks, bouldery
- c- clay, clayey
- f- silt, clay, and fine sand; commonly with high organic content
- g- gravel, gravelly
- r- rubble; predominantly sand to boulder-sized fragments
- s- sand, sandy
- v- volcanic tephra, sand or fine gravel
- x- interbedded volcanic tephra (v) and sand (s) or fines (f); overlies gravel in alluvial fans ($_{x}A_{f}$)

Age Modifier

- A- Modern
- L- Late Wisconsinan (Macaulay)
- N- Neoglacial
- P- Postglacial
- X- Early Wisconsinan or Illinoian (Mirror Creek)

Morphologic Modifiers

- a- apron
- b- blanket[2]
- c- cored outcrop
- d- delta
- f- fan
- h- hummocky
- m- undulating, rolling
- p- plain, floodplain
- r- ridge, ridged
- s- steep slope (greater than 39°)-cliff
- t- terrace, terraced
- v- veneer[2]
- 1- gentle to moderate slope (5-19°)
- 2- moderate to steep slope (15-39°)

Geological boundary (distinct, approximate, assumed)
Drumlin, fluted till
Rock drumlin, crag and tail, fluted bedrock
Glacially scoured bedrock hillock
Esker
Kame
Kame terrace
Pingo scarcle (relict)
Rock glacier (Mr)
Altithermokarst terrace
Pingo
Thermokarst depression
Cored bedrock outcrop
Bedrock outcrop
Organic deposit
Landslide
Landslide scar

Kilometres 2 0 2 4 6 8 Kilometres
Miles 2 0 2 4 Miles

REVISIONS	REFERENCES	SCALE / DATE / MADE / CHKD. / APPD.	HARDY ASSOCIATES (1978) LTD. CONSULTING ENGINEERING & PROFESSIONAL SERVICES	SURFICIAL GEOLOGY
				No. CG10047 FIG 5

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2.5 PERMAFROST

The study area lies within the northern section of the discontinuous permafrost zone (Brown, 1967). Permafrost may be expected in all undisturbed areas with high ice content material occuring in the poorly drained areas. Permafrost was not encountered (to the depths drilled) in areas that have been stripped of vegetation. Low ice content permafrost can be expected in the higher, well drained, areas. During the field drilling program, permafrost was present at the M.P. 1095.1 site; no massive ice was encountered.

Expected active layer depths are in the range 0.5 m to 1.5 m, depending on material grain size and vegetation cover. Generally, coarse-grained soils with light vegetation will thaw to greater depths than fine-grained soils with heavy vegetation cover.

3.0 FIELD PROGRAM

A total of 45 boreholes was drilled on the three deposits: 15 boreholes at M.P. 1086.2, 10 holes at M.P. 1087.6 and 20 boreholes at M.P. 1095.1. Drilling was carried out between November 24 and 29, 1982. Borehole locations are shown on the photomosaic site plans (Plates C1 to C3) in Appendix "C".

3.1 METHODOLOGY

The drill rig utilized for this program was a CME 750 auger rig, supplied by Midnight Sun Drilling Ltd. of Whitehorse. Boreholes were augered and sampled under the supervision of a Hardy Associates (1978) Ltd. soil engineer. Except where

conditions prohibited, borings were put down to a maximum depth of 6 m.

Grab samples were taken at a regular interval from each borehole for moisture profile determination and sieve analysis. Bulk samples were obtained at selected sites for more detailed laboratory testing (see Section 4.0).

3.2 RESULTS

Borehole logs are presented, on Plates A1 to A45, in Appendix "A". The test drilling results for each borrow reserve are summarized and evaluated in Section 5.0.

4.0 LABORATORY TEST PROGRAM

Grab and bulk samples were retained from the boreholes and shipped to the Hardy Associates (1978) Ltd.'s Calgary laboratory for the detailed testing.

4.1 LABORATORY TEST PROCEDURES

Grab samples were taken from all test holes for sieve analysis (ASTM C136-82) and moisture content determinations. In addition, representative samples of coarse aggregate were tested for: petrographic analysis (ASTM C295), Los Angeles abrasion (ASTM C535-81) and soundness (ASTM C88-76).

4.2 LABORATORY TEST RESULTS

The results of the laboratory testing program are presented on Plates B1 to B22 and Tables B1 to B5 in Appendix "B". Test descriptions and criteria for evaluating the results are also provided.

In summary, petrographic analysis of five samples from the M.P. 1087.6 and 1095.1 deposits gave PN values ranging from 100.2 to 116.2. Los Angeles abrasion tests resulted in losses (for 50 revolutions) ranging from 13.4 to 20.4 percent. Sulphate soundness testing produced losses ranging from 0.33 to 2.66 percent. Results for the individual deposits are presented in Section 5.0.

5.0 DEPOSIT EVALUATIONS

The deposits are evaluated below, in terms of their potential as sources of coarse granular aggregate, with respect to: available volumes, material type and quality, development criteria and possible community uses.

5.1 EVALUATION CRITERIA

Proven and probable reserves (and overburden volumes) have been computed for each deposit. Proven coarse aggregate volume was calculated, assuming a 100 m setback from the Alaska Highway, using average granular material thickness extrapolated over an area extending approximately 15 m in all directions from the boreholes. Overburden volume was calculated similarly. In view of the stratigraphic variability at the M.P. 1086.2 site, the calculated proven

volume for that deposit was also reduced by a 20 percent contingency factor.

Probable reserves were calculated assuming the same proven deposit thickness and extrapolating over the area of the deposit considered, on the basis of airphoto interpretation, to be of geologically similar origin. No contingency allowance was included. In the case of the M.P. 1095.1 reserve, deposit thickness for calculation purposes was assumed to be 6 m, even though the presence of permafrost precluded drilling to this depth in all instances.

In evaluating the materials for possible community use, the granular materials classification presented on Table 1, (provided previously to us by DIAND), was used.

5.2 BORROW RESERVE AT M.P. 1086.2 (YTG #10981)

5.2.1 Deposit Description

This potential borrow site is located approximately 5 km northwest of Destruction Bay and 10 km southeast of Burwash Landing (Figure 1).

The site is located on Late Wisconsinan morainal deposits, which contain patches of outwash material (Rampton, 1979a). The site has undulating topography, with a maximum relief of 5 m. Drainage is good, except in the eastern part (which is low-lying). A portion of the site (in the vicinity of an existing pit) has been stripped of vegetation but the remainder is heavily treed (Plate C1).

TABLE 1

CLASSIFICIATION OF GRANULAR MATERIALS
(after DIAND)

SOURCE QUALITY DESCRIPTION	GENERAL DESCRIPTION OF MATERIAL	MINIMUM TECHNICAL IDENTIFICATION PARAMETERS	SUGGESTED USES OF MATERIAL
Excellent	Well graded sands and gravel, suitable for use as aggregate with a minimum of processing	Petrographic Number: 160 max. Los Angeles Abrasion Loss: 35% max. Soundness Loss (Magnesium Sulphate): 12% max., and meeting other requirements of CSA A23.1-1973	Portland cement, and asphaltic concrete aggregate, masonry sand, concrete block, surface coarse and roofing aggregate.
Good	Well graded sands and gravels, with varying quantities of silt.	Petrographic Number: 200 max. Los Angeles Abrasion Loss: 60% max. Fines greater than 10% passing the 200 sieve can be removed with minimum of processing	Granular base and subbase. Winter sand backfill for trenches and slabs. Pads for structures. Select backfill.
Fair	Poorly graded sands and gravels, with or without substantial silt content	Petrogaphic Number: 250 max. Can be processed to meet local frost susceptibility criteria	Granular subbase. General backfill material, pads for equipment.
Poor	Poorly graded granular soils of high silt content, possibly containing very weak particles and deleterious materials	Nil	General non-structural fill.

5.2.2 Field Investigation

Fifteen boreholes (BH's C1 to C15) were put down, on November 26 and 27, 1982. Borehole locations are shown on Plate C1, while logs are presented on Plates A1 to A15 and laboratory test results in Appendix "B" (Plates B1 to B5).

5.2.3 Material Type

Coarse, poorly graded, dirty gravel was encountered in ten of the boreholes; overburden thickness ranged from 3 m to nearly 6 m. The gravel occurs at shallowest depth in the northwestern part and at slightly greater depths close to the eastern edge of the site. The overburden, probably a glacial till, ranges from clayey silt to silty and gravelly sand. Permafrost was not encountered in any of the boreholes. Only BH C14 was found to be wet at completion.

5.2.4 Available Reserves

Coarse aggregate occurs predominantly in the northwestern portion of the deposit. An area of 8400 m^2 was outlined by the test drilling, with an average deposit thickness of 1.3 m. On this basis, proven reserves of 11 000 m^3 of coarse granular material are indicated. However, overburden thickness averages 3.8 m, giving a stripping ratio of roughly 3:1.

5.2.5 Material Quality

Grain size analyses were conducted on five samples from this deposit; results are presented on Plates B1 to B5 (Appendix "B"). The coarse aggregate is, in general, poorly graded and

dirty. Fines content varies from 7 to 31 percent, with an average of 21.8 percent.

Moisture contents range from about 2 percent to 9 percent for the gravels, with an average of 5 percent. Excepting BH C14, with a moisture content of 22 percent, the overburden also has low moisture contents (in the 5 to 10 percent range).

Detailed testing was not carried out on material from this deposit.

5.2.6 Community Uses

Generally, the coarse aggregate from this deposit has a high fines content and is of fair to poor quality (Table 1). On this basis, the material is suitable for use as granular subbase, general fill and pad construction.

The overburden material consists predominantly of silty sand and silt. It is of poor quality but could possibly be useful as general non-structural fill (Table 1). The material will be difficult to work, however, and frost susceptible.

5.2.7 Development Considerations

This borrow reserve has excellent all-weather access, via the Alaska Highway, to both communities.

The economics of extracting the gravel, with stripping ratio of 3:1, are poor unless the overburden can be utilized for general fill purposes. In any event, extraction will be

limited to the frost-free period, since winter development will be slow and costly (the material will be extremely difficult to rip in a frozen state).

5.3 BORROW RESERVE AT MP 1087.6 (DIAND #11574)

5.3.1 Deposit Description

This deposit is situated 7 km southeast of Burwash Landing and 8 km northwest of Destruction Bay (Figure 1).

The higher part of the site comprises a glaciofluvial kame terrace and alluvial fan deposits form the surrounding terrain. Most of the site is occupied by the kame terrace, which has up to 10 m of relief and is well drained.

As shown on Plate C2, a portion of this reserve has been excavated previously for granular borrow, and the vegetation has been partially stripped in the area around the existing pit. The undeveloped portion is sparsely to densely treed.

5.3.2 Field Investigations

Ten boreholes were drilled at this site, all to a depth of 6.0 m. Boreholes A1 and A3 were located at the base of the kame terrace, on alluvial fan deposits, while BH's A2, A6, A7 and A8 were located in the bottom of the existing pit. The remainder of holes were on top of the kame terrace. Access to much of the deposit was restricted by the dense forest cover and only a limited area could be tested. Borehole locations are shown on Plate C2 (Appendix "C"), detailed logs in Appendix "A" (Plates A16 to A25).

5.3.3 Material Type

Granular material was encountered in all boreholes, with overburden thickness ranging up to 2 m (average 0.45 m). Boreholes A1 and A3, encountered sand and dirty gravel, while borings in the bottom of the existing pit (A2, A7 and A8) intersected 6.0 m of clean but poorly graded gravel. The remaining terrace, encountered poorly graded, generally clean, gravel, with some sand lenses; overburden averaged 0.5 m in thickness.

5.3.4 Available Volumes

The greatest potential for granular material exists in the kame terrace, already partially developed by the existing excavation. Available reserves exist in three areas:

a) North of the existing pit.
b) Underlying the existing pit.
c) South of the excavation.

Test drilling to the north of the existing pit (BH's A4 and A5) proves coarse aggregate reserves of 5000 m^3, assuming an average overburden thickness of 1.3 m. Estimated probable reserves for this portion of the deposit are 18 000 m^3.

Boreholes A2, A6, A7 and A8, within the existing pit (area: 2100 m^2), intersected greater than 6 m of clean, poorly graded, medium to coarse gravel, giving reserves of 12 600 m^3, with no overburden. It is unlikely, however, that the pit will be extended below the level of the surrounding terrain, so that proven reserves from this portion of the deposit, are

estimated at about half the above total, or 6300 m^3. An additional 7200 m^3 of material occurs in the vicinity of BH A6, giving probable reserves of 13 500 m^3.

Boreholes A9 and A10, to the east of the existing pit, indicate greater than 6 m of coarse aggregate over an area of 1800 m^2, or proven reserves of approximately 11 000 m^3. On the average, 60 percent of this material is expected to be gravel sized, with the remainder predominantly sand. No overburden was encountered in this area. Probable reserves are estimated in the order of 50 000 m^3, extending over an area of 10 000 m^2. Overburden up to 1.5 m thick is expected over much of the latter area.

Total reserves for the M.P. 1087.6 deposit are 22 300 m^3 proven and 81 500 m^3 probable.

5.3.5 Material Quality

Moisture contents for this deposit are shown on the pertinent borehole logs (Plates A16 to A25), and grain size curves are presented Plates B8 to B10. Generally, the aggregate is coarse and poorly graded, with a low fines content. Testing of a sample from BH A4, gave a Los Angeles abrasion loss of 13.4 percent (Plate B6), a sulphate soundness loss of 0.33 percent (Plate B7), and petrographic number (PN) of 100.2 (Table B2). The PN for a sample from BH A2 was also 100.2 (Table B1).

5.3.6 Possible Community Uses

The results of the laboratory testing indicate the aggregate from this deposit is of good quality (Table 1), suitable for

most construction purposes. The coarseness and poor grading of the material suggest crushing will be necessary to meet the specifications for concrete aggregate. Fines may need to be added before the material can be used for road subgrades, bases or surface coarse, in the event crushing does not increase the fines content sufficiently.

5.3.7 Development Consideration

This deposit has an adequate volume of good quality material centrally located between the two communities, to warrant development.

Development should be continued from the existing excavation, both deepening and widening the work area. A 100 m buffer zone should be kept between the pit and the Alaska Highway. Overburden, where encountered, should be separated and stockpiled along the base of the kame terrace, for later use in rehabilitation and reclamation (or possibly to increase fines content of aggregate used as surface course). If possible, the topsoil should be stockpiled separately.

Extraction should ideally be timed for the summer season. Although moisture and fines contest are low enough to allow winter development, this is usually a slower and more costly process than summer development.

5.4 BORROW RESERVE AT MP 1095.1 (YTG #10983)

5.4.1 Deposit Description

This borrow site is, located on the south side of the Alaska Highway, 4 km and 18 km northwest of Burwash Landing and Destruction Bay, respectively.

The deposit is situated on a portion of the Duke River alluvial fan. The site is flat to gently sloping, has a maximum of 5 m to 6 m relief, and is moderately well drained. Depressional areas on the site tend to have poor drainage. Plate C3 shows general site conditions.

Adjacent to the highway, the site has been stripped of vegetation and excavated for borrow to a shallow depth. The remainder of the study area is heavily treed, with poor access (Plate C3).

5.4.2 Field Investigations

A total of twenty boreholes (B1 to B20) was drilled, on November 27 and 28, 1982, to a maximum depth of 6.0 m. Several holes could not be completed to the full depth because of auger refusal on boulders and/or permafrost. As shown on Plate C3, boreholes are distributed mainly in the northern portion of the borrow reserve, since the heavy tree cover prevented drilling test holes further back on the site. Detailed borehole logs are presented on Plates B26 to B45.

5.4.3 Material Type

All borings, except BH B17, encountered coarse and poorly graded, subrounded to subangular, gravel, with a low moisture and fines content, and some sand pockets. Overburden was absent in most of the holes as the site had previously been cleared and partially stripped. The extreme western portion of the deposit, which is low-lying and wet, is underlain by peat and/or silt (1.0 m to 3.0 m deep). Permafrost was encountered in many of the boreholes, particularly in the southern part where the vegetation has not been completely stripped.

5.4.4 Available Reserves

Test drilling has proven coarse aggregate in an area of roughly 20 000 m^2 (taking into account the 100 m setback from the Alaskan Highway). Assuming a 4.5 m minimum deposit thickness, 90 000 m^3 of predominantly coarse granular material is indicated, with little or no overburden. Since a deposit thickness of at least 6 m appears likely for most of the site (but could not be proven due to permafrost), probable reserves are estimated at considerably greater than 200 000 m^3. This probable volume should be treated with caution, however since drilling operations were limited to the northernmost one third of the site, due to very poor access.

5.4.5 Material Quality

Grain size curves are shown on Plates B11, B14, B17, B18, B21, B22 and B23. The aggregate is generally coarse and poorly graded, with a fines contents ranging from 1 percent to 7 percent. Material from borehole B4 had a PN of 108.3 (Table

B3) a Los Angeles abrasion loss of 18.5 percent (Plate B12), and a sulphate soundness loss of 0.71 percent (Plate B13). Aggregate from BH B9 had a PN of 116.2 (Table B4), an abrasion loss of 18.9 percent (Plate B15) and a soundness loss of 2.66 percent (Plate B16). Finally, material from BH B14 had a PN of 111.7 (Table B5), had an abrasion loss of 20.4 percent (Plate B19) and a soundness loss of 2.42 percent (Plate B20).

5.4.6 Possible Community Uses

The results of the laboratory testing indicate the aggregate is of good quality (Table 1). The grain size curves indicate crushing and processing will be required to produce a material that is suitable for most construction requirements.

5.4.7 Development Considerations

This proposed borrow site has excellent access, via the Alaska Highway, to both communities and is a large volume source of good to excellent quality aggregate. Since a small borrow pit is currently located on the site, development should proceed by expansion of this existing excavation.

Landuse regulations require that a 100 m buffer zone be maintained between the development and the Alaska Highway. As a result much of the existing pit will fall into this buffer zone. Additional development should be away from this setback area.

Test drilling encountered difficulties in penetrating the frozen gravels and it is expected that excavation will meet with the same problem. Development of the pit, therefore, should be a summer operation. Permafrost is not expected to

be encountered for the initial 4 or 5 m from the surface in the portion of the deposit that has been stripped of its surface vegetation. Expansion beyond this area will likely encounter permafrost near the ground surface, and a thaw-strip cycle method of mining in frozen ground is recommended. This involves exposing a large surface area of granular material to solar radiation to promote thawing. Excavation of unfrozen material may then be completed in layers or strips, as the thaw front progresses. Generally, coarse granular material will thaw from 0.2 m to 0.4 m per day. Site clearing well prior to development also promotes deeper thawing of the active layer.

Material obtained during a summer operation can be used directly or may be stockpiled for use during the winter months. Moisture and fines contents are generally low enough to permit winter development. However, ripping of undisturbed gravel is slower and more costly than the same process during the summer or excavating from a stockpile.

6.0 CONCLUSIONS

Findings of the study with respect to the three possible community gravel pit sites are, in summary, as follows:

a) The M.P. 1086.2 site is a low volume deposit of fair to poor quality aggregate. With a 3:1 gravel-overburden stripping ratio, development does not appear warranted unless the overburden is used as fill material.

b) Reserves for the M.P. 1087.6 deposit are estimated at 22 300 m^3 proven and 81 500 m^3 probable, of good quality aggregate. This will be suitable for most construction

purposes, with crushing and screening required to produce concrete aggregate.

c) At M.P. 1095.1 proven reserves are 90 000 m^3 of good quality aggregate, greater than 200 000 m^3 probable. Again though suitable for most purposes, the gravel will require crushing to produce concrete aggregate.

The M.P. 1086.2 site is a small volume source of poor quality gravel, with a high stripping ratio. The study results suggest that development is probably not warranted, even if the frost susceptible overburden materials were used for fill.

Based on material quality both the M.P. 1087.6 and 1095.1 sites are candidates for development as a community gravel pit. However, proven and probably aggregate volumes at the latter are considerably in excess of those of the former. Additional testing in the southern part of the M.P. 1095.1 deposit (which presently has poor access) will likely prove out considerably greater volumes.

It is our conclusion that the M.P. 1095.1 borrow reserve (YTG #10983) is most suited to development as a community gravel pit for Burwash Landing and Destruction Bay. It will be necessary to set up a crushing and screening operation to produce concrete aggregate: the material may be used for fill in the pit-run state or with only limited processing.

Respectfully Submitted,

HARDY ASSOCIATES (1978) LTD.

Per:

G. Dupuy, P.Geol.

Per:

I. Jones, M.Sc., P.Geol.

PROFESSIONAL GEOLOGIST I. JONES ALBERTA

THE ASSOCIATION OF PROFESSIONAL ENGINEERS, GEOLOGISTS and GEOPHYSICISTS OF ALBERTA
PERMIT NUMBER
P 226
HARDY ASSOCIATES (1978) LTD.

Per:

M. Stepanek, M.Sc., P.Eng.

GD:IJ:MS/lt
0.333

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APPENDIX "A"

BOREHOLE LOGS

EXPLANATION OF TERMS AND SYMBOLS

The terms and symbols used on the borehole logs to summarize the results of field investigation and subsequent laboratory testing are described in the following pages.

It should be noted that materials, boundaries, and conditions have been established only at the borehole locations, and are not necessarily representative of subsurface conditions elsewhere across the site.

TEST DATA

Data obtained from laboratory and field testing are shown on the grid at the appropriate depth interval.

The natural moisture (water) content of the soil at the time of drilling is plotted against depth, together with the plastic and liquid limits where determined.

Abbreviations, graphic symbols, and relevant test method designations are as follows:

⊙	w	natural moisture content (ASTM D 2216)
⊡	w_P	plastic limit (ASTM D 424)
△	w_L	liquid limit (ASTM D 423)
	NP	non plastic soil
——→		seepage
▼		observed water level

Other abbreviations and symbols are as shown on the borehole log sheet.

DEPTH

The depth of borehole below existing ground surface is shown. Corresponding elevations sometimes are shown with respect to the datum given.

SOIL CLASSIFICATION AND DESCRIPTION

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

The soil of each stratum is described using the Unified Soil Classification System[1] modified slightly so that an inorganic clay of "medium plasticity" is recognized.

The use of modifying adjectives may be employed to define the actual or estimated percentage range by weight of minor components. This is similar to a system developed by D.M. Burmister.[2]

The soil classification system is shown in greater detail on page 3.

1. "Unified Soil Classification System", Technical Memorandum 3-357 prepared for Office, Chief of Engineering, by Waterways Experiment Station, Vicksburg, Mississippi, Corps. of Engineers, U.S. Army. Vol. 1, March 1953.

2. American Society for Testing and Materials. Procedures for Testing Soils, "Suggested Methods of Testing for Identification of Soils", 4th Ed; pp 221-233, Dec. 1964.

SOIL SAMPLES

CONDITION — This column graphically indicates the depth and condition of the sample:

 undisturbed

 disturbed

 not recovered

TYPE — The type of sample is indicated in this column as follows:

A auger sample
B block sample
C rock core, or frozen soil core
D drive sample
P Pitcher tube sample
U tube sample (usually thin-walled)
W wash or air return sample
O other (see report text)

PENETRATION RESISTANCE — Unless otherwise noted this column refers to the number of blows (N) of a 140 pound (63.5 kg) hammer freely dropping 30 inches (0.76 m) required to drive a 2 inch (50.8 mm) O.D. open-end sampler 0.5 feet (0.15 m) to 1.5 feet (0.45 m) into the soil, or until 100 blows have been applied, in which case, the penetration is stated. This is the standard penetration test referred to in ASTM D 1586.

OTHER TESTS

In this column are tabulated results of other laboratory tests as indicated by the following symbols:

*C	Consolidation test
Fines	Percentage by weight smaller than #200 sieve
D_R	Relative density (formerly specific gravity)
k	Permeability coefficient
*MA	Mechanical grain size analysis and hydrometer test (if appropriate)
pp	Pocket penetrometer strength
*q	Triaxial compression test
q_u	Unconfined compressive strength
*SB	Shearbox test
SO_4	Concentration of water-soluble sulphate
*ST	Swelling test
TV	Torvane shear strength
VS	Vane shear strength (undisturbed-remolded)
ε_f	Unit strain at failure
γ	Unit weight of soil or rock
γ_d	Dry unit weight of soil or rock
ρ	Density of soil or rock
ρ_d	Dry density of soil or rock

* The results of these tests usually are reported separately.

SOIL CLASSIFICATION SYSTEM (MODIFIED U.S.C.)

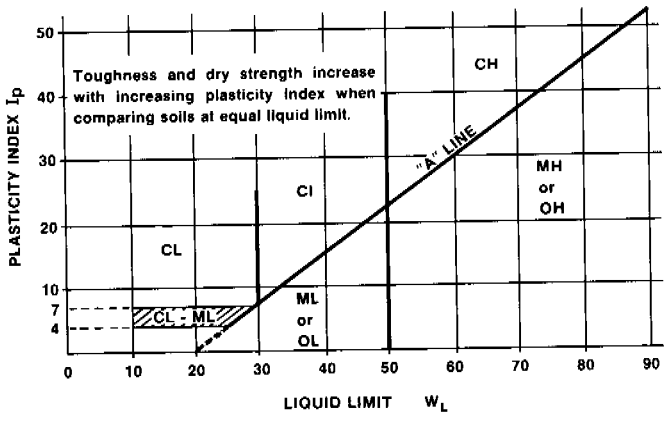
MAJOR DIVISION			GROUP SYMBOL	GRAPHIC SYMBOL	COLOR CODE	TYPICAL DESCRIPTION	LABORATORY CLASSIFICATION CRITERIA
HIGHLY ORGANIC SOILS			Pt		ORANGE	PEAT AND OTHER HIGHLY ORGANIC SOILS	STRONG COLOR OR ODOR, AND OFTEN FIBROUS TEXTURE
COARSE-GRAINED SOILS (MORE THAN HALF BY WEIGHT LARGER THAN NO. 200 SIEVE SIZE)	GRAVELS MORE THAN HALF COARSE FRACTION LARGER THAN NO. 4 SIEVE SIZE	CLEAN GRAVELS	GW		RED	WELL-GRADED GRAVELS, GRAVEL-SAND MIXTURES, < 5% FINES	$C_u = \frac{D_{60}}{D_{10}} > 6 \quad C_c = \frac{(D_{30})^2}{D_{10} \times D_{60}} = 1 \text{ to } 3$
			GP		RED	POORLY-GRADED GRAVELS, AND GRAVEL-SAND MIXTURES, < 5% FINES	NOT MEETING ALL ABOVE REQUIREMENTS
		DIRTY GRAVELS	GM		YELLOW	SILTY GRAVELS, GRAVEL-SAND-SILT MIXTURES > 12% FINES	ATTERBERG LIMITS BELOW "A" LINE OR $I_p < 4$
			GC		YELLOW	CLAYEY GRAVELS, GRAVEL-SAND-CLAY MIXTURES > 12% FINES	ATTERBERG LIMITS ABOVE "A" LINE, $I_p > 7$
	SANDS MORE THAN HALF COARSE FRACTION SMALLER THAN NO. 4 SIEVE SIZE	CLEAN SANDS	SW		RED	WELL-GRADED SANDS, GRAVELLY SANDS, < 5% FINES	$C_u = \frac{D_{60}}{D_{10}} > 4 \quad C_c = \frac{(D_{30})^2}{D_{10} \times D_{60}} = 1 \text{ to } 3$
			SP		RED	POORLY-GRADED SANDS, OR GRAVELLY SANDS, < 5% FINES	NOT MEETING ALL ABOVE REQUIREMENTS
		DIRTY SANDS	SM		YELLOW	SILTY SANDS, SAND-SILT MIXTURES > 12% FINES	ATTERBERG LIMITS BELOW "A" LINE OR $I_p < 4$
			SC		YELLOW	CLAYEY SANDS, SAND-CLAY MIXTURES > 12% FINES	ATTERBERG LIMITS ABOVE "A" LINE OR $I_p > 7$
FINE-GRAINED SOILS (MORE THAN HALF BY WEIGHT PASSES NO. 200 SIEVE SIZE)	SILTS BELOW "A" LINE ON PLASTICITY CHART; NEGLIGIBLE ORGANIC CONTENT		ML		GREEN	INORGANIC SILTS AND VERY FINE SANDS, ROCK FLOUR, SILTY SANDS OF SLIGHT PLASTICITY	$W_L < 50$
			MH		BLUE	INORGANIC SILTS, MICACEOUS OR DIATOMACEOUS, FINE SANDY OR SILTY SOILS	$W_L > 50$
	CLAYS ABOVE "A" LINE ON PLASTICITY CHART; NEGLIGIBLE ORGANIC CONTENT		CL		GREEN	INORGANIC CLAYS OF LOW PLASTICITY, GRAVELLY, SANDY, OR SILTY CLAYS, LEAN CLAYS	$W_L < 30$
			CI		GREEN-BLUE	INORGANIC CLAYS OF MEDIUM PLASTICITY SILTY CLAYS	$W_L > 30, < 50$
			CH		BLUE	INORGANIC CLAYS OF HIGH PLASTICITY, FAT CLAYS	$W_L > 50$
	ORGANIC SILTS & ORGANIC CLAYS BELOW "A" LINE ON PLASTICITY CHART		OL		GREEN	ORGANIC SILTS AND ORGANIC SILTY CLAYS OF LOW PLASTICITY	$W_L < 50$
			OH		BLUE	ORGANIC CLAYS OF HIGH PLASTICITY	$W_L > 50$

SEE CHART BELOW

1. All sieve sizes mentioned on this chart are U.S. Standard, ASTM E11.
2. Boundary classifications possessing characteristics of two groups are given combined group symbols eg GW-GC is a well-graded gravel-sand mixture with clay binder between 5% and 12%.
3. Soil fractions and limiting textural boundaries are in accordance with the Unified Soil Classification System, except that an inorganic clay of medium plasticity (CI) is recognized.
4. The following adjectives may be employed to define percentage ranges by weight of minor components:

and	50 - 36%
some	35 - 21%
little	20 - 11%
trace	10 - 1%

PLASTICITY CHART



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BOREHOLE LOGS

M.P. 1086.2

HARDY ASSOCIATES (1978) LTD.
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BOREHOLE LOG

PROJECT: BURWASH LANDING - DESTRUCTION BAY
GRAVEL STUDY MP 1086.2

LOGGED/DWN.	CKD.	DATE OF INVEST.	JOB NO.	HOLE NO.
JD/TF	GD	Nov. 26, 1982	CG 10047	C-1

WATER CONTENT: Wp - □ W - ○ W_L - △ PERCENT % (10 20 30 40 60 80)

DEPTH m	SOIL SYMBOL	SOIL DESCRIPTION (DATUM / SURFACE ELEVATION)	SOIL SAMPLE: CONDITION	SOIL SAMPLE: TYPE	SOIL SAMPLE: PENETRATION RESISTANCE	OTHER TESTS
		SILT some clay and organics, dark brown				DRILL TYPE: Rotary
1		GRAVEL silty, brown, fine to medium, poorly graded		A1		Grain size (see Pl. B-1)
2		SAND silty, little gravel, very fine to fine-grained				
3						
4						
		--less gravel				
5		--trace gravel				
		-- very fine-grained sand, little gravel		A2		
6		Bottom of Hole at 6.0m				

Plate A-1

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BOREHOLE LOG

PROJECT: BURWASH LANDING - DESTRUCTION BAY
GRAVEL STUDY
MP 1086.2

LOGGED/DWN.	CKD.	DATE OF INVEST.	JOB NO.	HOLE NO.
JD/TF	GD	Nov. 26, 1982	CG 10047	C-2

WATER CONTENT: Wp - □ W - ○ W_L - △ PERCENT % (10 20 30 40 50 60)

DRILL TYPE: Rotary

DEPTH m	SOIL SYMBOL	SOIL DESCRIPTION (DATUM / SURFACE ELEVATION)	SOIL SAMPLE: CONDITION	SOIL SAMPLE: TYPE	SOIL SAMPLE: PENETRATION RESISTANCE	OTHER TESTS
		SILT sandy, organic, reddish-brown				
1		SAND very gravelly, some silt, trace clay, dry, (Till-like)		A1		Grain size (see Pl. B-2)
2						
3		GRAVEL some silty sand, dirty				
4		SAND silty, very fine to fine-grained				
		-- little gravel				
5				A2		
6		Bottom of Hole at 6.0m				

Plate A-2

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BOREHOLE LOG

PROJECT: BURWASH LANDING - DESTRUCTION BAY GRAVEL STUDY

MP 1086.2

LOGGED/DWN.	CKD.	DATE OF INVEST.	JOB NO.	HOLE NO.
JD/TF	GD	Nov. 26, 1982	CG 10047	C-3

WATER CONTENT: Wp - □ W - ○ W_L - △ PERCENT % (10 20 30 40 50 60)

DRILL TYPE: Rotary

DEPTH m	SOIL DESCRIPTION	SOIL SAMPLE: CONDITION	SOIL SAMPLE: TYPE	SOIL SAMPLE: PENETRATION RESISTANCE	OTHER TESTS
	DATUM SURFACE ELEVATION				
	TOPSOIL organic, silty clay, dark brown				
1	SAND very fine to fine-grained, silty, some gravel, little clay, (Till-like)		A1		
2					
3	GRAVEL sandy, some silt, to 25mm Ø, poorly graded, very fine to fine-grained sand		A2		
4					
	-- silty, brown				
5					
6	Bottom of Hole at 6.0m				

Plate A-3

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BOREHOLE LOG

PROJECT: BURWASH LANDING - DESTRUCTION BAY GRAVEL STUDY MP 1086.2

LOGGED/DWN.	CKD.	DATE OF INVEST.	JOB NO.	HOLE NO.
JD/TF	GD	Nov. 26, 1982	CG 10047	C-4

DRILL TYPE: Rotary

WATER CONTENT: W_p - □ W - ○ W_L - △ PERCENT % (10 20 30 40 50 60)

DEPTH m | SOIL SYMBOL | SOIL DESCRIPTION (DATUM / SURFACE ELEVATION) | SOIL SAMPLE: CONDITION, TYPE, PENETRATION RESISTANCE | OTHER TESTS

DEPTH m	SOIL DESCRIPTION	SOIL SAMPLE TYPE	OTHER TESTS
	SILT organics, sandy, reddish-brown		
	SAND silty, very fine-grained, little clay		
1	-- some gravel to 25mm Ø, some silt, trace clay	A1	
2			
3	GRAVEL some silty sand, poorly graded, subangular to subrounded		
		A2	Grain size (see Pl. B-3)
4			
5			
6	Bottom of Hole at 6.0m		

Plate A-4

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BOREHOLE LOG

PROJECT: BURWASH LANDING - DESTRUCTION BAY GRAVEL STUDY

MP 1086.2

LOGGED/DWN.	CKD.	DATE OF INVEST.	JOB NO.	HOLE NO.
JD/TF	GD	Nov. 26, 1982	CG 14007	C-5

DRILL TYPE: Rotary

WATER CONTENT: Wp - □ W - ○ W_L - △ PERCENT % (10 20 30 40 50 60)

DEPTH m	SOIL DESCRIPTION	SOIL SAMPLE CONDITION	SOIL SAMPLE TYPE	PENETRATION RESISTANCE	OTHER TESTS
	DATUM SURFACE ELEVATION				
	TOPSOIL organic, reddish-brown				
	SAND silty, brown, very fine-grained, little clay -- trace gravel				
1			A1		
2					
3					
4					
5	GRAVEL sandy, some silt, some clay, (Till-like)		A2		Grain size (see Pl. B-4)
6	Bottom of Hole at 6.0m				

Plate A-5

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BOREHOLE LOG

PROJECT: BURWASH LANDING - DESTRUCTION BAY GRAVEL STUDY MP 1086.2

LOGGED/DWN. JD/TF | CKD. GD | DATE OF INVEST. Nov. 26, 1982 | JOB NO. CG 10047 | HOLE NO. C-6

DRILL TYPE: Rotary

WATER CONTENT: W_p - □ W - ○ W_L - △ PERCENT % (10 20 30 40 50 60)

DEPTH m | SOIL SYMBOL | SOIL DESCRIPTION | SOIL SAMPLE: CONDITION, TYPE, PENETRATION RESISTANCE | OTHER TESTS

DATUM

SURFACE ELEVATION

DEPTH m	SOIL DESCRIPTION	SOIL SAMPLE TYPE	OTHER TESTS
	TOPSOIL silty, sand, some organics, dark brown		
	SAND silty, brown, dry, very fine-grained, little clay		
1	-- trace gravel		
2			
3			
4	-- very gravelly, some silt and clay, (Till-like)	A1	Grain size (see Pl. B-5)
5			
6			
	Bottom of Hole at 6.0m		

Plate A-6

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BOREHOLE LOG

PROJECT: BURWASH LANDING - DESTRUCTION BAY GRAVEL STUDY

MP 1085.2

LOGGED/DWN.	CKD.	DATE OF INVEST.	JOB NO.	HOLE NO.
JD/TF	GD	Nov. 26, 1982	CG 10047	C-7

DRILL TYPE: Rotary

WATER CONTENT: Wp - □ W - ○ W_L - △ PERCENT % (10 20 30 40 50 60)

DEPTH m	SOIL SYMBOL	SOIL DESCRIPTION (DATUM / SURFACE ELEVATION)	SOIL SAMPLE: CONDITION	SOIL SAMPLE: TYPE	SOIL SAMPLE: PENETRATION RESISTANCE	OTHER TESTS
		SILT sandy, brown, trace clay, very fine to fine-grained sand, (Till-like)				
1		-- trace gravel				
		--- little to some gravel	☒	A1		
2						
3						
4						
5		--- trace gravel				
6		Bottom of Hole at 6.0m				

Plate A-7

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BOREHOLE LOG

PROJECT: BURWASH LANDING - DESTRUCTION BAY GRAVEL STUDY MP 1086.2

LOGGED/DWN.	CKD.	DATE OF INVEST.	JOB NO.	HOLE NO.
JD/TF	GD	Nov. 26, 1982	CG 10047	C-8

DRILL TYPE: Rotary

WATER CONTENT: W_p - □ W - ○ W_L - △ PERCENT % (10 20 30 40 50 60)

DEPTH m	SOIL SYMBOL	SOIL DESCRIPTION (DATUM / SURFACE ELEVATION)	SOIL SAMPLE CONDITION	SOIL SAMPLE TYPE	SOIL SAMPLE PENETRATION RESISTANCE	OTHER TESTS
		FILL sand, coarse, some silt, brown				
		PEAT dark brown, fibrous, some organic silt				
1		SAND silty, medium to coarse-grained, brown, some clay				
2						
3		--- trace gravel				
4						
5						
		GRAVEL some very fine sand, trace silt	X	A1		
6		Bottom of Hole at 6.0m				

Plate A-8

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BOREHOLE LOG

PROJECT: BURWASH LANDING - DESTRUCTION BAY GRAVEL STUDY MP 1086.2

LOGGED/DWN.	CKD.	DATE OF INVEST.	JOB NO.	HOLE NO.
JD/TF	GD	Nov. 26, 1982	CG 10047	C-9

DRILL TYPE: Rotary

OTHER TESTS:

WATER CONTENT: Wp - □ W - ○ W_L - △ PERCENT % (10 20 30 40 50 60)

DEPTH m	SOIL SYMBOL	SOIL DESCRIPTION (DATUM / SURFACE ELEVATION)	SOIL SAMPLE: CONDITION	SOIL SAMPLE: TYPE	SOIL SAMPLE: PENETRATION RESISTANCE
		SAND silty, brown, very fine-grained, some clay			
1		--- silty, fine-grained, trace gravel, dark brown		A1	
2					
3					
4		--- little gravel			
5		GRAVEL sandy, little silt, subangular			
				A2	
6		Bottom of Hole at 6.0m			

Plate A-9

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BOREHOLE LOG

PROJECT: BURWASH LANDING - DESTRUCTION BAY GRAVEL STUDY MP 1086.2

LOGGED/DWN.	CKD.	DATE OF INVEST.	JOB NO.	HOLE NO.
JD/TF	GD	Nov. 26, 1982	CG 10047	C-10

WATER CONTENT: Wp - □ W - ○ W_L - △ PERCENT % (10 20 30 40 50 60)

DRILL TYPE: Rotary

DEPTH m	SOIL SYMBOL	SOIL DESCRIPTION (DATUM / SURFACE ELEVATION)	SOIL SAMPLE: CONDITION	SOIL SAMPLE: TYPE	SOIL SAMPLE: PENETRATION RESISTANCE	OTHER TESTS
		SILT sandy, brown, trace clay, very fine to fine-grained sand, (Till-like)				
1		--- little to some gravel, fine-grained sand	☒	A1		
2						
3						
4		---boulders				
5		Bottom of Hole at 4.5m Refusal on boulders				

Plate A-10

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BOREHOLE LOG

PROJECT: BURWASH LANDING - DESTRUCTION BAY GRAVEL STUDY MP 1086.2

LOGGED/DWN.	CKD.	DATE OF INVEST.	JOB NO.	HOLE NO.
JD/TF	GD	Nov. 26, 1982	CG 10047	C-11

WATER CONTENT: Wp - □ W - ○ W_L - △ PERCENT % (10 20 30 40 50 60)

DRILL TYPE: Rotary

DEPTH m	SOIL SYMBOL	SOIL DESCRIPTION (DATUM / SURFACE ELEVATION)	SOIL SAMPLE: CONDITION	SOIL SAMPLE: TYPE	SOIL SAMPLE: PENETRATION RESISTANCE	OTHER TESTS
		TOPSOIL organic, reddish-brown				
		SILT sandy, light brown, fine-grained sand, (Till-like)				
1						
		--- some gravel, trace clay		A1		
2						
3						
4						
5						
				A2		
6		Bottom of Hole at 6.0m				

Plate A-11

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BOREHOLE LOG

PROJECT: BURWASH LANDING - DESTRUCTION BAY GRAVEL STUDY MP 1086.2

LOGGED/DWN.	CKD.	DATE OF INVEST.	JOB NO.	HOLE NO.
JD/TF	GD	Nov. 26, 1982	CG 10047	C-12

DRILL TYPE: Rotary

WATER CONTENT: Wp - □ W - ○ W_L - △ PERCENT % (10 20 30 40 50 60)

DEPTH m	SOIL SYMBOL	SOIL DESCRIPTION (DATUM / SURFACE ELEVATION)	SOIL SAMPLE: CONDITION	SOIL SAMPLE: TYPE	SOIL SAMPLE: PENETRATION RESISTANCE	OTHER TESTS
		TOPSOIL organic, sandy, brown				
1		SILT sandy, brown, little to some clay, (Till-like)				
2		--- trace gravel				
3		--- clayey, little gravel				
4						
		--- trace gravel		A1		
5						
6		Bottom of Hole at 6.0m				

Plate A-12

HT08 - 79/05

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BOREHOLE LOG

PROJECT: BURWASH LANDING - DESTRUCTION BAY GRAVEL STUDY MP 1086.2

LOGGED/DWN.	CKD.	DATE OF INVEST.	JOB NO.	HOLE NO.
JD/TF	GD	Nov. 26, 1982	CG 10047	C-13

DRILL TYPE: Rotary

WATER CONTENT: Wp - □ W - ○ W_L - △ PERCENT % (10 20 30 40 50 60)

DATUM

SURFACE ELEVATION

DEPTH m	SOIL SYMBOL	SOIL DESCRIPTION	SOIL SAMPLE CONDITION	SOIL SAMPLE TYPE	SOIL SAMPLE PENETRATION RESISTANCE	OTHER TESTS
1		SILT sandy, greyish-brown, (Till-like)				
2		-- trace clay, gravel		A1		
3						
4						
5						
6				A2		
		Bottom of Hole at 6.0m				

Plate A-13

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BOREHOLE LOG

PROJECT: BURWASH LANDING - DESTRUCTION BAY GRAVEL STUDY MP 1086.2

LOGGED/DWN.	CKD.	DATE OF INVEST.	JOB NO.	HOLE NO.
JD/TF	GD	Nov. 26, 1982	CG 10047	C-14

DRILL TYPE: Rotary

WATER CONTENT — Wp - □ W - ○ W_L - △ — PERCENT % — 10 20 30 40 50 60

DEPTH m	SOIL SYMBOL	SOIL DESCRIPTION (DATUM / SURFACE ELEVATION)	SOIL SAMPLE: CONDITION	SOIL SAMPLE: TYPE	SOIL SAMPLE: PENETRATION RESISTANCE	OTHER TESTS
		PEAT topsoil, dark brown				
1		CLAY organic, silty, brown, wet				
2		--- medium to high plastic, trace organics	X	A1		
		GRAVEL some clayey silt				
3		Bottom of Hole at 2.6m				

Plate A-14

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BOREHOLE LOG

PROJECT BURWASH LANDING - DESTRUCTION BAY
GRAVEL STUDY
MP 1086.2

LOGGED/DWN.	CKD.	DATE OF INVEST.	JOB NO.	HOLE NO.
JD/TF	GD	Nov. 27, 1982	CG 10047	C-15

WATER CONTENT
Wp - □ W - ○ W_L - △
PERCENT %
10 20 30 40 50 60

DEPTH m

SOIL SYMBOL

SOIL DESCRIPTION
DATUM
SURFACE ELEVATION

SOIL SAMPLE
CONDITION | TYPE | PENETRATION RESISTANCE

DRILL TYPE: Rotary

OTHER TESTS

Depth m	Soil Description	Sample Type
1	FILL silt, sandy, some fine gravel, brown	
2	PEAT organics, sandy, reddish-brown	
3		
4	SILT organic, sandy, some gravel, grey	
5		
6	GRAVEL some silty sand, subangular	A1
	Bottom of Hole at 6.0m	

Plate A-15

HT08 - 79/05

BOREHOLE LOGS

M.P. 1087.6

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BOREHOLE LOG

PROJECT: BURWASH LANDING - DESTRUCTION BAY GRAVEL STUDY

MP 1087.6

LOGGED/DWN.	CKD.	DATE OF INVEST.	JOB NO.	HOLE NO.
JD/TF	GD	Nov. 27, 1982	CG 10047	A-1

DRILL TYPE: Rotary

WATER CONTENT: Wp - □ W - ○ W_L - △ PERCENT % (10 20 30 40 50 60)

DEPTH m	SOIL DESCRIPTION (DATUM / SURFACE ELEVATION)	SOIL SAMPLE: CONDITION	SOIL SAMPLE: TYPE	SOIL SAMPLE: PENETRATION RESISTANCE	OTHER TESTS
0	FILL gravel, crushed, mixed with sandy clayey silt				
1	GRAVEL medium subangular, well-graded, some sand and silt				
		X	A1		
2	SAND silty, dark brown, very fine to fine-grained, little to some clay				
3					
4	-- trace gravel				
5	GRAVEL coarse, subangular, some silty sand, black				
		X	A2		
6	Bottom of Hole at 6.0m				

Plate A-16

HT08 - 79/05

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BOREHOLE LOG

PROJECT: BURWASH LANDING - DESTRUCTION BAY GRAVEL STUDY MP 1087.6

LOGGED/DWN.	CKD.	DATE OF INVEST.	JOB NO.	HOLE NO.
JD/TF	GD	Nov. 27, 1982	CG 10047	A-2

WATER CONTENT: Wp - □ W - ○ W_L - △ PERCENT % (10 20 30 40 50 60)

DEPTH m	SOIL SYMBOL	SOIL DESCRIPTION (DATUM / SURFACE ELEVATION)	SOIL SAMPLE: CONDITION	SOIL SAMPLE: TYPE	SOIL SAMPLE: PENETRATION RESISTANCE	DRILL TYPE / OTHER TESTS
		FILL gravel, crushed, trace sand				DRILL TYPE: Rotary
		GRAVEL fine to medium, trace sand, clean				
1				A1		
2						
3						
4						
5						Petrographic Analysis (Table B-1) L.A. Abrasion (Pl. B-6) Sulphate Soundness (Pl. B-7)
		-- medium, some sand		A2		
6		Bottom of Hole at 6.0m				

Plate A-17

HT08 - 79/05

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BOREHOLE LOG

PROJECT: BURWASH LANDING - DESTRUCTION BAY GRAVEL STUDY MP 1087.6

LOGGED/DWN.	CKD.	DATE OF INVEST.	JOB NO.	HOLE NO.
JD/TF	GD	Nov. 27, 1982	CG 10047	A-3

WATER CONTENT: Wp - □ W - ○ W_L - △ PERCENT % (10 20 30 40 50 60)

DRILL TYPE: Rotary

DEPTH m	SOIL SYMBOL	SOIL DESCRIPTION (DATUM / SURFACE ELEVATION)	SOIL SAMPLE: CONDITION	SOIL SAMPLE: TYPE	SOIL SAMPLE: PENETRATION RESISTANCE	OTHER TESTS
		SAND fine, silty, some medium gravel, brown				
1		SILT sandy, trace volcanic ash, brown		A1		
2		SAND fine to medium-grained, silty, dark brown				
3		--- trace gravel				
4		--- coarse, little silt, some gravel, dark brown				
5		— trace coarse gravel				
6		Bottom of Hole at 6.0m				

Plate A-18

HT08 - 79/05

HARDY ASSOCIATES (1978) LTD.
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BOREHOLE LOG

PROJECT: BURWASH LANDING - DESTRUCTION BAY GRAVEL STUDY MP 1087.6

LOGGED/DWN.	CKD.	DATE OF INVEST.	JOB NO.	HOLE NO.
JD/TF	GD	Nov. 27, 1982	CG 10047	A-4

DRILL TYPE: Rotary

WATER CONTENT: Wp - □ W - ○ W_L - △ PERCENT % (10 20 30 40 50 60)

DEPTH m	SOIL DESCRIPTION	SOIL SAMPLE: CONDITION	SOIL SAMPLE: TYPE	SOIL SAMPLE: PENETRATION RESISTANCE	OTHER TESTS
	DATUM SURFACE ELEVATION				
	SILT sandy, brown, frozen				
1	GRAVEL medium, some sandy silt, unfrozen		A1		
2	clean, trace sandy silt, coarse, subangular, well-graded				
3			A2		Petrographic Analysis (Table B-2) Sulphate Soundness (Pl. B-7) L.A. Abrasion (Pl. B-6)
4					
5					
6	Bottom of Hole at 6.0m				

Plate A-19

HT08 - 79/05

HARDY ASSOCIATES (1978) LTD.
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BOREHOLE LOG

PROJECT: BURWASH LANDING - DESTRUCTION BAY GRAVEL STUDY

MP 1087.6

LOGGED/DWN.	CKD.	DATE OF INVEST.	JOB NO.	HOLE NO.
JD/TF	GD	Nov. 27, 1982	CG 10047	A-5

WATER CONTENT — Wp - □ W - ○ W_L - △ — PERCENT % — 10 20 30 40 50 60

DRILL TYPE: Rotary

DEPTH m	SOIL SYMBOL	SOIL DESCRIPTION (DATUM / SURFACE ELEVATION)	SOIL SAMPLE: CONDITION	SOIL SAMPLE: TYPE	SOIL SAMPLE: PENETRATION RESISTANCE	OTHER TESTS
1		SILT sandy, reddish-brown				
2		GRAVEL medium, some sandy silt,				
			X	A1		
3						
4		--- trace brown silty sand				
5						
6		Bottom of Hole at 6.0m				

Plate A-20

HT08 - 79/05

HARDY ASSOCIATES (1978) LTD.
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BOREHOLE LOG

PROJECT: BURWASH LANDING - DESTRUCTION BAY GRAVEL STUDY MP 1087.6

LOGGED/DWN.	CKD.	DATE OF INVEST.	JOB NO.	HOLE NO.
JD/TF	GD	Nov. 27, 1982	CG 10047	A-6

DRILL TYPE: Rotary

WATER CONTENT — Wp - □ W - ○ W_L - △ — PERCENT % — 10 20 30 40 50 60

DEPTH m	SOIL DESCRIPTION (DATUM / SURFACE ELEVATION)	SOIL SAMPLE: CONDITION	SOIL SAMPLE: TYPE	SOIL SAMPLE: PENETRATION RESISTANCE	OTHER TESTS
	GRAVEL to 20mm Ø, well-graded, some silty sand				
1	-- coarse, to 50mm Ø, angular, poorly graded, few fines				
			A1		Grain size (see Pl. B-8)
2					
3	--- 25-50mm Ø, subangular		A2		
4					
5	-- 20mm Ø, well-graded				
			A3		
6	Bottom of Hole at 6.0m				

Plate A-21

HT08 - 79/05

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BOREHOLE LOG

PROJECT: BURWASH LANDING - DESTRUCTION BAY
GRAVEL STUDY MP 1087.6

LOGGED/DWN.	CKD.	DATE OF INVEST.	JOB NO.	HOLE NO.
JD/TF	GD	Nov. 27, 1982	CG 10047	A-7

WATER CONTENT
Wp - □ W - ○ W_L - △
PERCENT %
10 20 30 40 50 60

DEPTH m

SOIL SYMBOL

SOIL DESCRIPTION
DATUM
SURFACE ELEVATION

SOIL SAMPLE
CONDITION | TYPE | PENETRATION RESISTANCE

DRILL TYPE: Rotary

OTHER TESTS

Depth m	Soil Description	Sample Type
0	GRAVEL 20mm Ø, subangular, some silty sand, brown	
1		A1
2		
3	--- medium gravel	A2
4		
5	--- sandy, dark brown	
6	Bottom of Hole at 6.0m	

Plate A-22

HT08 - 79/06

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

BOREHOLE LOG

PROJECT: BURWASH LANDING - DESTRUCTION BAY GRAVEL STUDY MP 1087.6

LOGGED/DWN.	CKD.	DATE OF INVEST.	JOB NO.	HOLE NO.
JD/TF	GD	Nov. 27, 1982	CG 10047	A-8

WATER CONTENT: Wp - □ W - ○ W_L - △ PERCENT % (10 20 30 40 50 60)

DRILL TYPE: Rotary

DEPTH m	SOIL SYMBOL	SOIL DESCRIPTION (DATUM / SURFACE ELEVATION)	SOIL SAMPLE: CONDITION	SOIL SAMPLE: TYPE	SOIL SAMPLE: PENETRATION RESISTANCE	OTHER TESTS
1		GRAVEL poorly graded, some sand, brown				
		-- fine, some sand		A1		Grain size (see Pl. B-9)
2						
3						
4						
5						
		-- sandy, dark brown		A2		
6		Bottom of Hole at 6.0m				

Plate A-23

HT08 - 79/05

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BOREHOLE LOG

PROJECT: BURWASH LANDING - DESTRUCTION BAY GRAVEL STUDY MP 1087.6

LOGGED/DWN.	CKD.	DATE OF INVEST.	JOB NO.	HOLE NO.
JD/TF	GD	Nov. 27, 1982	CG 10047	A-9

WATER CONTENT: Wp - □ W - ○ W_L - △ PERCENT % (10 20 30 40 50 60)

DRILL TYPE: Rotary

DEPTH m	SOIL SYMBOL	SOIL DESCRIPTION (DATUM / SURFACE ELEVATION)	SOIL SAMPLE: CONDITION	SOIL SAMPLE: TYPE	SOIL SAMPLE: PENETRATION RESISTANCE	OTHER TESTS
1		SAND silty, reddish-brown, dry, very fine-grained, trace clay				
2		-- some gravel, to 100mm ø, poorly graded				
3		GRAVEL some silty sand, reddish-brown	X	A1		
4						
5						
6			X	A2		
		Bottom of Hole at 6.0m				

Plate A-24

HT08 - 79/05

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BOREHOLE LOG

PROJECT: BURWASH LANDING - DESTRUCTION BAY GRAVEL STUDY

MP 1087.6

LOGGED/DWN.	CKD.	DATE OF INVEST.	JOB NO.	HOLE NO.
JD/TF	GD	Nov. 27, 1982	CG 10047	A-10

WATER CONTENT: Wp - □ W - ○ W_L - △ PERCENT % (10 20 30 40 50 60)

DRILL TYPE: Rotary

DEPTH m	SOIL SYMBOL	SOIL DESCRIPTION (DATUM / SURFACE ELEVATION)	SOIL SAMPLE: CONDITION	SOIL SAMPLE: TYPE	SOIL SAMPLE: PENETRATION RESISTANCE	OTHER TESTS
1		GRAVEL to 25mm Ø, little sand, brown				
		--- gravel sizes to 50mm Ø		A1		Grain size (see Pl. B-10)
2		--- finer gravel sizes, poorly graded				
3						
4						
5		SAND trace coarse gravel, dark brown				
6				A2		
		Bottom of Hole at 6.0m				

Plate A-25

HT08 - 79/05

BOREHOLE LOGS

M.P. 1095.1

HARDY ASSOCIATES (1978) LTD.
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BOREHOLE LOG

PROJECT: BURWASH LANDING - DESTRUCTION BAY GRAVEL STUDY MP 1095.1

LOGGED/DWN.	CKD.	DATE OF INVEST.	JOB NO.	HOLE NO.
JD/TF	GD	Nov. 27, 1982	CG 10047	B-1

DRILL TYPE: Rotary

WATER CONTENT (Wp - □ W - ○ W_L - △, PERCENT %, 10 20 30 40 50 60)	DEPTH m	SOIL SYMBOL	SOIL DESCRIPTION (DATUM / SURFACE ELEVATION)	SOIL SAMPLE: CONDITION	SOIL SAMPLE: TYPE	SOIL SAMPLE: PENETRATION RESISTANCE	OTHER TESTS
			SILT sandy, trace volcanic ash, brown				
			GRAVEL coarse-grained, 75mm, medium graded				
	1		SAND coarse, silty, some gravel				
	2						
			GRAVEL medium, subangular, little silty sand		A1		
	3						
			--- finer, to 25mm Ø		A2		
	4						
	5		--- trace cobbles		A3		L.A. Abrasion (Pl. B-13) Sulphate Soundness (Pl. B-16)
	6		Bottom of Hole at 6.0m				

Plate A-26

HT08 - 79/05

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BOREHOLE LOG

PROJECT: BURWASH LANDING - DESTRUCTION BAY GRAVEL STUDY MP 1095.1

LOGGED/DWN.	CKD.	DATE OF INVEST.	JOB NO.	HOLE NO.
JD/TF	GD	Nov. 27, 1982	CG 10047	B-2

DRILL TYPE: Rotary

WATER CONTENT: Wp - □ W - ○ W_L - △ PERCENT % (10 20 30 40 50 60)

DEPTH m	SOIL SYMBOL	SOIL DESCRIPTION (DATUM / SURFACE ELEVATION)	SOIL SAMPLE: CONDITION	SOIL SAMPLE: TYPE	SOIL SAMPLE: PENETRATION RESISTANCE	OTHER TESTS
0		TOPSOIL organic, volcanic ash				
		GRAVEL coarse, to 50mm ø, sandy, clean				
1						
				A1		Grain size (see Pl. B-11)
2		--- cobbles, frozen				
3		Bottom of Hole at 2.5m Refusal on frozen cobbles				

Plate A-27

HT08 - 79/05

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BOREHOLE LOG

PROJECT: BURWASH LANDING - DESTRUCTION BAY GRAVEL STUDY MP 1095.1

LOGGED/DWN. JD/TF | CKD. GD | DATE OF INVEST. Nov. 27, 1982 | JOB NO. CG 10047 | HOLE NO. B-3

DRILL TYPE: Rotary

WATER CONTENT: Wp - □ W - ○ W_L - △ PERCENT % (10 20 30 40 50 60)

DEPTH m	SOIL SYMBOL	SOIL DESCRIPTION (DATUM / SURFACE ELEVATION)	SOIL SAMPLE: CONDITION	SOIL SAMPLE: TYPE	SOIL SAMPLE: PENETRATION RESISTANCE	OTHER TESTS
		GRAVEL coarse, to 75mm Ø, medium graded, little sandy silt				
1		--- finer gravel to 65mm Ø				
			X	A1		
2						
3		--- cobbles				
		Bottom of Hole at 3.0m Refusal on cobbles				
4						

Plate A-28

HT08 - 79/05

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BOREHOLE LOG

PROJECT: BURWASH LANDING - DESTRUCTION BAY GRAVEL STUDY MP 1095.1

LOGGED/DWN. JD/TF | CKD. GD | DATE OF INVEST. Nov. 27, 1982 | JOB NO. CG 10047 | HOLE NO. B-4

DRILL TYPE: Rotary

WATER CONTENT: Wp - □ W - ○ W_L - △ PERCENT % (10 20 30 40 50 60)

DATUM

SURFACE ELEVATION

DEPTH m	SOIL SYMBOL	SOIL DESCRIPTION	SOIL SAMPLE: CONDITION	SOIL SAMPLE: TYPE	SOIL SAMPLE: PENETRATION RESISTANCE	OTHER TESTS
1		GRAVEL coarse, to 75mm Ø, some silty sand -- finer gravel, 20mm Ø, poorly graded				
		-- cobbles				
2		-- coarse gravel, to 50-75mm Ø, some silty sand, grey	☒	A1		
3						
4						
						Petrographic Analysis (Table B-3)
5						L.A. Abrasion (Pl. B-12)
			☒	A2		Sulphate Soundness (Pl. B-13)
		-- coarse, subangular to subrounded				
6		Bottom of Hole at 6.0m				

Plate A-29

HT08 - 79/05

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BOREHOLE LOG

PROJECT: BURWASH LANDING - DESTRUCTION BAY GRAVEL STUDY MP 1095.1

LOGGED/DWN.	CKD.	DATE OF INVEST.	JOB NO.	HOLE NO.
JD/TF	GD	Nov. 27, 1982	CG 10047	B-5

WATER CONTENT: Wp - □ W - ○ W_L - △ PERCENT % (10 20 30 40 50 60)

DRILL TYPE: Rotary

DEPTH m	SOIL SYMBOL	SOIL DESCRIPTION (DATUM / SURFACE ELEVATION)	SOIL SAMPLE: CONDITION	SOIL SAMPLE: TYPE	SOIL SAMPLE: PENETRATION RESISTANCE	OTHER TESTS
1		GRAVEL coarse, to 75mm Ø, trace silty sand				
		-- finer gravel, to 25mm Ø, well-graded, some silty sand				
2				A1		
3		-- coarser gravel, subangular to to subrounded				
				A2		
4		-- cobbles				
		Bottom of Hole at 4.0m Refusal on cobbles				

Plate A-30

HT08 - 79/05

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BOREHOLE LOG

PROJECT: BURWASH LANDING - DESTRUCTION BAY GRAVEL STUDY MP 1095.1

LOGGED/DWN.	CKD.	DATE OF INVEST.	JOB NO.	HOLE NO.
JD/TF	GD	Nov. 27, 1982	CG 10047	B-6

DRILL TYPE: Rotary

WATER CONTENT: Wp - □ W - ○ W_L - △ PERCENT % (10 20 30 40 50 60)

DEPTH m	SOIL DESCRIPTION (DATUM / SURFACE ELEVATION)	SOIL SAMPLE: CONDITION	SOIL SAMPLE: TYPE	SOIL SAMPLE: PENETRATION RESISTANCE	OTHER TESTS
1	GRAVEL to 50mm ø, some silty sand, dark brown				
	-- cobbles	X	A1		
2					
3	-- trace cobbles	X	A2		
4	-- cobbles, frozen				
5	Bottom of Hole at 4.5m Refusal on cobbles and permafrost				

Plate A-31

HT08 - 79/05

HARDY ASSOCIATES (1978) LTD.
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BOREHOLE LOG

PROJECT: BURWASH LANDING - DESTRUCTION BAY GRAVEL STUDY MP 1095.1

LOGGED/DWN.	CKD.	DATE OF INVEST.	JOB NO.	HOLE NO.
JD/TF	GD	Nov. 27, 1982	CG 10047	B-7

WATER CONTENT: Wp - □ W - ○ W_L - △ PERCENT % (10 20 30 40 50 60)

DRILL TYPE: Rotary

DEPTH m	SOIL SYMBOL	SOIL DESCRIPTION (DATUM / SURFACE ELEVATION)	SOIL SAMPLE: CONDITION	SOIL SAMPLE: TYPE	SOIL SAMPLE: PENETRATION RESISTANCE	OTHER TESTS
		SILT organic, sandy, reddish-brown				
		GRAVEL coarse, clean, poorly graded				
1		--- subangular to subrounded	X	A1		Grain size (see Pl. B-14)
2		-- cobbles				
3		-- finer gravel				
		-- cobbles, frozen	X	A2		
4		Bottom of Hole at 4.0m Refusal on frozen cobbles				

Plate A-32

HT08 - 79/05

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BOREHOLE LOG

PROJECT: BURWASH LANDING - DESTRUCTION BAY GRAVEL STUDY MP 1095.1

LOGGED/DWN.	CKD.	DATE OF INVEST.	JOB NO.	HOLE NO.
JD/TF	GD	Nov. 27, 1982	CG 10047	B-8

WATER CONTENT: Wp - □ W - ○ W_L - △ PERCENT % (10 20 30 40 50 60)

DRILL TYPE: Rotary

OTHER TESTS:

DEPTH m	SOIL SYMBOL	SOIL DESCRIPTION (DATUM / SURFACE ELEVATION)	SOIL SAMPLE CONDITION	SOIL SAMPLE TYPE	PENETRATION RESISTANCE
1		SILT organic, sandy, reddish-brown, frozen			
		GRAVEL to 35mm Ø, some silty sand, angular, frozen		A1	
2					
3		-- sandy, cobbles			
				A2	
4		Bottom of Hole at 4.0m Refusal on frozen cobbles			

Plate A-33

HT08 - 79/05

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BOREHOLE LOG

PROJECT: BURWASH LANDING - DESTRUCTION BAY GRAVEL STUDY MP 1095.1

LOGGED/DWN.	CKD.	DATE OF INVEST.	JOB NO.	HOLE NO.
JD/TF	GD	Nov. 28, 1982	CG 10047	B-9

WATER CONTENT: Wp - □ W - ○ W_L - △ PERCENT % (10 20 30 40 50 60)

DRILL TYPE: Rotary

DEPTH m	SOIL SYMBOL	SOIL DESCRIPTION (DATUM / SURFACE ELEVATION)	SOIL SAMPLE: CONDITION	SOIL SAMPLE: TYPE	SOIL SAMPLE: PENETRATION RESISTANCE	OTHER TESTS
		FILL sand, silty, coarse, some gravel, frozen				
1		GRAVEL angular, to 25mm ø, some silty sand, unfrozen		A1		
		--- finer, gravel to 15mm				
2		--- coarser, to 35mm				
3		--- subangular to subrounded, poorly graded		A2		Petrographic Analysis (Table B-4) L.A. Abrasion (Pl. B-15) Sulphate Soundness (Pl. B-16)
4						
5						
6		Bottom of Hole at 6.0m				

Plate A-34

HT08 - 79/05

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BOREHOLE LOG

PROJECT: BURWASH LANDING - DESTRUCTION BAY GRAVEL STUDY MP 1095.1

LOGGED/DWN.	CKD.	DATE OF INVEST.	JOB NO.	HOLE NO.
JD/TF	GD	Nov. 28, 1982	CG 10047	B-10

WATER CONTENT: Wp - □ W - ○ W_L - △ PERCENT % (10 20 30 40 50 60)

DEPTH m	SOIL SYMBOL	SOIL DESCRIPTION (DATUM / SURFACE ELEVATION)	SOIL SAMPLE: CONDITION	SOIL SAMPLE: TYPE	SOIL SAMPLE: PENETRATION RESISTANCE	DRILL TYPE / OTHER TESTS
		GRAVEL some silty sand, frozen	☒	A1		Rotary
1		Bottom of Hole at 1.0m Refusal in frozen gravel				
2						

Plate A-35

HT08 - 79/05

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BOREHOLE LOG

PROJECT: BURWASH LANDING - DESTRUCTION BAY GRAVEL STUDY MP 1095.1

LOGGED/DWN.	CKD.	DATE OF INVEST.	JOB NO.	HOLE NO.
JD/TF	GD	Nov. 28, 1982	CG 10047	B-11

DRILL TYPE: Rotary

WATER CONTENT — Wp - □ W - ○ W_L - △ — PERCENT % — 10 20 30 40 50 60

DEPTH m	SOIL SYMBOL	SOIL DESCRIPTION	SOIL SAMPLE: CONDITION	SOIL SAMPLE: TYPE	SOIL SAMPLE: PENETRATION RESISTANCE	OTHER TESTS
		DATUM SURFACE ELEVATION				
		GRAVEL sandy, little silt, well graded				
1				A1		Grain size (see Pl. B-17)
2						
3						
4						
5						
				A2		
		--- coarse gravel				
6		Bottom of Hole at 6.0m				

Plate A-36

HT08 - 79/05

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BOREHOLE LOG

PROJECT: BURWASH LANDING - DESTRUCTION BAY GRAVEL STUDY MP 1095.1

LOGGED/DWN.	CKD.	DATE OF INVEST.	JOB NO.	HOLE NO.
JD/TF	GD	Nov. 28, 1982	CG 10047	B-12

WATER CONTENT: Wp - □ W - ○ W_L - △ PERCENT % (10 20 30 40 50 60)

DRILL TYPE: Rotary

DEPTH m	SOIL DESCRIPTION (DATUM / SURFACE ELEVATION)	SOIL SAMPLE CONDITION	SOIL SAMPLE TYPE	SOIL SAMPLE PENETRATION RESISTANCE	OTHER TESTS
1	GRAVEL occasional cobbles, some silty sand, frozen		A1		
2	--- medium gravel, to 25mm ø, unfrozen, poorly graded				
3	--- gravel to 25mm ø		A2		
4					
5	--- more coarse sand				
6			A3		
	Bottom of Hole at 6.0m				

Plate A-37

HT08 - 79/05

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BOREHOLE LOG

PROJECT: BURWASH LANDING - DESTRUCTION BAY GRAVEL STUDY MP 1095.1

LOGGED/DWN.	CKD.	DATE OF INVEST.	JOB NO.	HOLE NO.
JD/TF	GD	Nov. 28, 1982	CG 10047	B-13

WATER CONTENT: Wp - □ W - ○ W_L - △ PERCENT % (10 20 30 40 50 60)

DRILL TYPE: Rotary

DEPTH m	SOIL SYMBOL	SOIL DESCRIPTION (DATUM / SURFACE ELEVATION)	SOIL SAMPLE: CONDITION	SOIL SAMPLE: TYPE	SOIL SAMPLE: PENETRATION RESISTANCE	OTHER TESTS
		FILL gravel, coarse				
		SILT organic, sandy, dark brown				
1		GRAVEL coarse, subangular, clean				
2						
		--- coarse, poorly graded		A1		Grain size (see Pl. B-18)
3						
4						
5		--- more coarse sand				
				A2		
6		Bottom of Hole at 6.0m				

Plate A-38

HT08 - 79/05

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BOREHOLE LOG

PROJECT: BURWASH LANDING - DESTRUCTION BAY GRAVEL STUDY MP 1095.1

LOGGED/DWN.	CKD.	DATE OF INVEST.	JOB NO.	HOLE NO.
JD/TF	GD	Nov. 28, 1982	CG 10047	B-14

DRILL TYPE: Rotary

WATER CONTENT: Wp - □ W - ○ W_L - △ PERCENT % (10 20 30 40 50 60)

DEPTH m	SOIL SYMBOL	SOIL DESCRIPTION (DATUM / SURFACE ELEVATION)	SOIL SAMPLE: CONDITION	SOIL SAMPLE: TYPE	SOIL SAMPLE: PENETRATION RESISTANCE	OTHER TESTS
1		SAND silty, some gravel, brown, frozen, (Fill?)				
2		GRAVEL to 65mm, angular, some silty sand, unfrozen	☒	A1		
3						
4		--- coarse, subangular to subrounded, poorly graded	☒	A2		Petrographic Analysis (Table B-5) L.A. Abrasion (Pl. B-19) Sulphate Soundness (Pl. B-20)
5		--- sandy, coarse, dark brown				
6		Bottom of Hole at 6.0m				

Plate A-39

HT08 - 79/05

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BOREHOLE LOG

PROJECT: BURWASH LANDING - DESTRUCTION BAY GRAVEL STUDY MP 1095.1

LOGGED/DWN.	CKD.	DATE OF INVEST.	JOB NO.	HOLE NO.
JD/TF	GD	Nov. 28, 1982	CG 10047	B-15

WATER CONTENT: Wp - □ W - ○ W_L - △ PERCENT % (10 20 30 40 50 60)

DRILL TYPE: Rotary

DEPTH m	SOIL SYMBOL	SOIL DESCRIPTION	SOIL SAMPLE CONDITION	SOIL SAMPLE TYPE	SOIL SAMPLE PENETRATION RESISTANCE	OTHER TESTS
		DATUM SURFACE ELEVATION				
		GRAVEL to 65mm, subangular, some silty sand				
1				A1		
2						
3						
4						
		-- coarse, poorly graded		A2		
5		-- frozen				
6		Bottom of Hole at 6.0m				

Plate A-40

HT08 - 79/05

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

BOREHOLE LOG

PROJECT: BURWASH LANDING - DESTRUCTION BAY GRAVEL STUDY MP 1095.1

LOGGED/DWN.	CKD.	DATE OF INVEST.	JOB NO.	HOLE NO.
JD/TF	GD	Nov. 28, 1982	CG 10047	B-16

WATER CONTENT: Wp - □ W - ○ W_L - △ PERCENT % (10 20 30 40 50 60)

DRILL TYPE: Rotary

DEPTH m	SOIL SYMBOL	SOIL DESCRIPTION (DATUM / SURFACE ELEVATION)	SOIL SAMPLE: CONDITION	SOIL SAMPLE: TYPE	SOIL SAMPLE: PENETRATION RESISTANCE	OTHER TESTS
		TOPSOIL dark brown, some volcanic ash				
		GRAVEL coarse, sandy, poorly graded				
1						
2		-- coarse, poorly graded, trace sand	☒	A1		Grain size (see Pl. B-21)
3						
4						
		-- finer gravel 25mm, frozen				
5		-- cobbles	☒	A2		
		Bottom of Hole at 5.2m Refusal on frozen cobbles				
6						

Plate A-41

HT08 - 79/05

HARDY ASSOCIATES (1978) LTD.
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BOREHOLE LOG

PROJECT: BURWASH LANDING - DESTRUCTION BAY GRAVEL STUDY MP 1095.1

LOGGED/DWN.	CKD.	DATE OF INVEST.	JOB NO.	HOLE NO.
JD/TF	GD	Nov. 28, 1982	CG 10047	B-17

WATER CONTENT: Wp - □ W - ○ W_L - △ PERCENT % (10 20 30 40 50 60)

DRILL TYPE: Rotary

DEPTH m	SOIL SYMBOL	SOIL DESCRIPTION	SOIL SAMPLE: CONDITION	SOIL SAMPLE: TYPE	SOIL SAMPLE: PENETRATION RESISTANCE	OTHER TESTS
		DATUM SURFACE ELEVATION				
		TOPSOIL organic				
		SILT sandy, brown, some organics				
1						
			X	A1		
2						
3			X	A2		
		-- frozen				
		Bottom of Hole at 3.0m Refusal on permafrost				
4						

Plate A-42

HT08 - 79/05

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BOREHOLE LOG

PROJECT: BURWASH LANDING - DESTRUCTION BAY GRAVEL STUDY MP 1095.1

LOGGED/DWN.	CKD.	DATE OF INVEST.	JOB NO.	HOLE NO.
JD/TF	GD	Nov. 28, 1982	CG 10047	B-18

DRILL TYPE: Rotary

WATER CONTENT: Wp - □ W - ○ W_L - △ PERCENT % (10 20 30 40 50 60)

DEPTH m	SOIL DESCRIPTION	SOIL SAMPLE CONDITION	SOIL SAMPLE TYPE	PENETRATION RESISTANCE	OTHER TESTS
	DATUM SURFACE ELEVATION				
1	GRAVEL coarse, little sand, brown, unfrozen				
		X	A1		
2					
3					
4					
	---coarse, poorly graded, trace sand	X	A2		Grain size (see Pl. B-22)
5					
	--- more sand				
		X	A3		
6	Bottom of Hole at 6.0m				

Plate A-43

HT08 - 79/05

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BOREHOLE LOG

PROJECT: BURWASH LANDING - DESTRUCTION BAY
GRAVEL STUDY MP 1095.1

LOGGED/DWN. JD/TF | CKD. GD | DATE OF INVEST. Nov. 28, 1982 | JOB NO. CG 10047 | HOLE NO. B-19

DRILL TYPE: Rotary

WATER CONTENT: Wp - □ W - ○ W_L - △ PERCENT % (10 20 30 40 50 60)

DEPTH m	SOIL SYMBOL	SOIL DESCRIPTION (DATUM / SURFACE ELEVATION)	SOIL SAMPLE: CONDITION	SOIL SAMPLE: TYPE	SOIL SAMPLE: PENETRATION RESISTANCE	OTHER TESTS
		SILT organic, sandy, reddish-brown				
1		SAND trace silt and fine gravel, frozen		A1		
2		-- grey clay mixed with sand				
3						
4		GRAVEL some silty sand, frozen				
		Bottom of Hole at 4.0m Refusal on frozen ground				
5						

Plate A-44

HT08 - 79/05

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BOREHOLE LOG

PROJECT: BURWASH LANDING - DESTRUCTION BAY GRAVEL STUDY MP 1095.1

LOGGED/DWN.	CKD.	DATE OF INVEST.	JOB NO.	HOLE NO.
JD/TF	GD	Nov. 28, 1982	CG 10047	B-20

WATER CONTENT: Wp - □ W - ○ W_L - △ PERCENT % (10 20 30 40 50 60)

DEPTH m	SOIL SYMBOL	SOIL DESCRIPTION (DATUM / SURFACE ELEVATION)	SOIL SAMPLE: CONDITION	SOIL SAMPLE: TYPE	SOIL SAMPLE: PENETRATION RESISTANCE	DRILL TYPE / OTHER TESTS
		SILT organic, sandy, some volcanic ash, reddish-brown, frozen				Rotary
1		GRAVEL coarse, rounded, some silty sand, frozen				
			X	A1		
2						
			X	A2		Grain size (see Pl. B-23)
3		Bottom of Hole at 3.0m Refusal on coarse, frozen gravel				

Plate A-45

HT08 - 79/05

APPENDIX "B"

LABORATORY TEST RESULTS

APPENDIX "B"
LABORATORY TEST RESULTS

B.1 GRAIN SIZE ANALYSIS (ASTM C136-82)

Sieve analysis of aggregate samples provides a gradation for the bulk natural material, which may be compared with ideal curves for concrete aggregate, asphalt, etc.

B.2 LOS ANGELES ABRASION TEST (ASTM C535-81)

This test provides information on the hardness and roughness of an aggregate. A definite relationship exists between the strength of concrete and the quality of its constituent coarse aggregate, as measured by the Los Angeles Abrasion test. For most applications, a loss of less than 30 percent after 50 revolutions, is considered to indicate a good quality aggregate.

B.3 SULPHATE SOUNDNESS TEST (ASTM C88-76)

This test provides an indication of any structural weakness that may be present in the aggregate. A general relationship exits between the percentage weight loss in the test with the compressive strength and freezing and thawing durability of concrete made from the aggregate. In general, coarse aggregate is considered acceptable if the weighted loss is less than 12 percent, after 5 cycles.

B.4 PETROGRAPHIC ANALYSIS (ASTM C-295)

Petrographic analysis consists of a visual examination of aggregate particles and identification on the basis of mineralogy. Particles are assigned a rating on the basis of the known soundness or deleterious nature of the mineral type, a rating of 1 being the best and 10 being the worst. The weighted percentage of each mineral type is then multiplied by this rating number to produce a petrographic number (PN) for the aggregate. The following classification, recommendation by Ontario Hydro petrographers, is used in this report.

PN	RATING
100-110	Excellent
111-125	Good
126-140	Fair
141-155	Poor
155	Unsuitable

TABLE NO. B-1

SUMMARY OF ROCK TYPES COARSE FRACTION

M.P. 1087.6 Borehole A-2 Depth 5.8 m - 6.0 m

ROCK TYPE	CLASSIFICATION	WEIGHTED PERCENTAGES OF CONSTITUENTS IN EACH SIEVE FRACTION									Total Weighted Composition
		4"	3"	2"	1½"	1"	3/4"	½"	3/8"	#4	
Plutonics-acid	Good					1.1	1.7	2.5	1.0	3.2	9.5
Greenstone — ultra basic					3.0	1.6	4.0	8.4	4.8	11.8	33.6
Carbonates							1.1	1.1	0.6	1.7	4.5
Metamorphics						2.6	4.0	11.2	12.3	22.2	52.3
Volcanics	Fair									0.1	0.1
					3.0	5.3	10.8	23.2	18.7	39.0	100.0

PN = 100.2

TABLE NO. B-2

SUMMARY OF ROCK TYPES COARSE FRACTION

M.P. 1087.6 Borehole A-4 Depth 3.0 m - 3.3 m

ROCK TYPE	CLASSIFICATION	WEIGHTED PERCENTAGES OF CONSTITUENTS IN EACH SIEVE FRACTION									Total Weighted Composition
		4"	3"	2"	1½"	1"	3/4"	½"	3/8"	#4	
Plutonics-acid	Good				2.4	3.4	3.9	3.9	3.1	4.5	21.2
Greenstone-ultra basic					3.6	2.2	5.2	9.5	5.6	7.8	33.9
Carbonates						1.1	0.8	1.4	0.4	1.0	4.7
Metamorphics					1.2	3.4	5.2	7.8	9.2	13.3	40.1
Carbonates (weathered,soft)	Fair							0.1			0.1
					7.2	10.1	15.1	22.7	18.3	26.6	100.0

PN = 100.2

TABLE NO. B-3

SUMMARY OF ROCK TYPES COARSE FRACTION

M.P. 1095.1 Borehole B-4 Depth 5.5 m - 5.8 m

ROCK TYPE	CLASSIFICATION	WEIGHTED PERCENTAGES OF CONSTITUENTS IN EACH SIEVE FRACTION									Total Weighted Composition
		4"	3"	2"	1½"	1"	3/4"	½"	3/8"	#4	
Plutonics-acid	Good				1.5	3.4	4.3	3.5	4.6	4.1	21.4
Greenstone-ultra basic					1.5	3.6	3.8	3.3	2.9	2.6	17.7
Carbonates						1.2	1.7	1.8	0.8	0.9	6.4
Metamorphics					2.2	9.1	9.9	15.5	7.5	6.9	51.1
Volcanics	Fair						0.6	1.6	0.2	0.1	2.5
Carbonates (weathered, soft)							0.1	0.3			0.4
Volcanics (weathered, soft)	Poor						0.1	0.4			0.5
					5.2	17.3	20.5	26.4	16.0	14.6	100.0

PN = 108.3

TABLE NO. B-4

SUMMARY OF ROCK TYPES COARSE FRACTION

M.P. 1095.1 Borehole B-9 Depth 2.8 m - 3.0 m

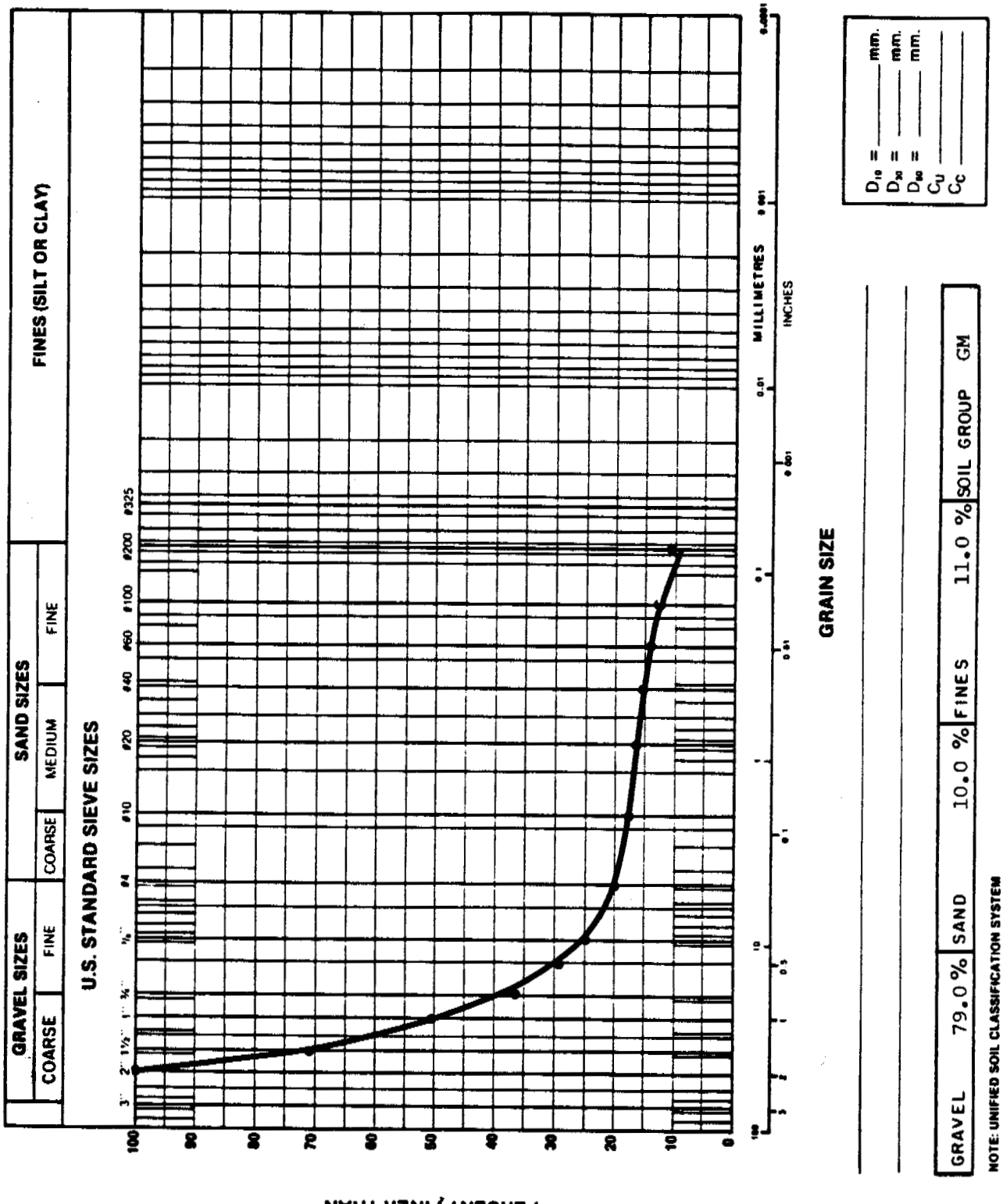
ROCK TYPE	CLASSIFICATION	WEIGHTED PERCENTAGES OF CONSTITUENTS IN EACH SIEVE FRACTION									Total Weighted Composition
		4"	3"	2"	1½"	1"	3/4"	½"	3/8"	#4	
Plutonics-acid	Good				1.9	0.9	3.4	4.6	4.3	4.8	19.9
Quartzite						0.9					0.9
Greenstone-ultra basic						3.2	2.9	4.8	2.6	4.6	18.1
Carbonates					0.9	0.9	1.5	2.5	1.1	1.4	8.3
Metamorphics					0.9	4.6	5.0	12.5	9.6	14.2	46.8
Volcanics	Fair					0.9	1.2	1.0	0.8	0.7	4.6
Volcanics (slightly weathered, soft, friable)	Poor							0.6	0.3	0.5	1.4
					3.7	11.4	14.0	26.0	18.7	26.2	100.0

PN = 116.2

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

GRAIN SIZE CURVE

PROJECT NO.	CG 10047
CLIENT	
BOREHOLE	C1 MP 1086.2
SAMPLE	A1
DEPTH (m)	1.0 - 1.5
TECHNICIAN	SK
DATE TESTED	82.12.21



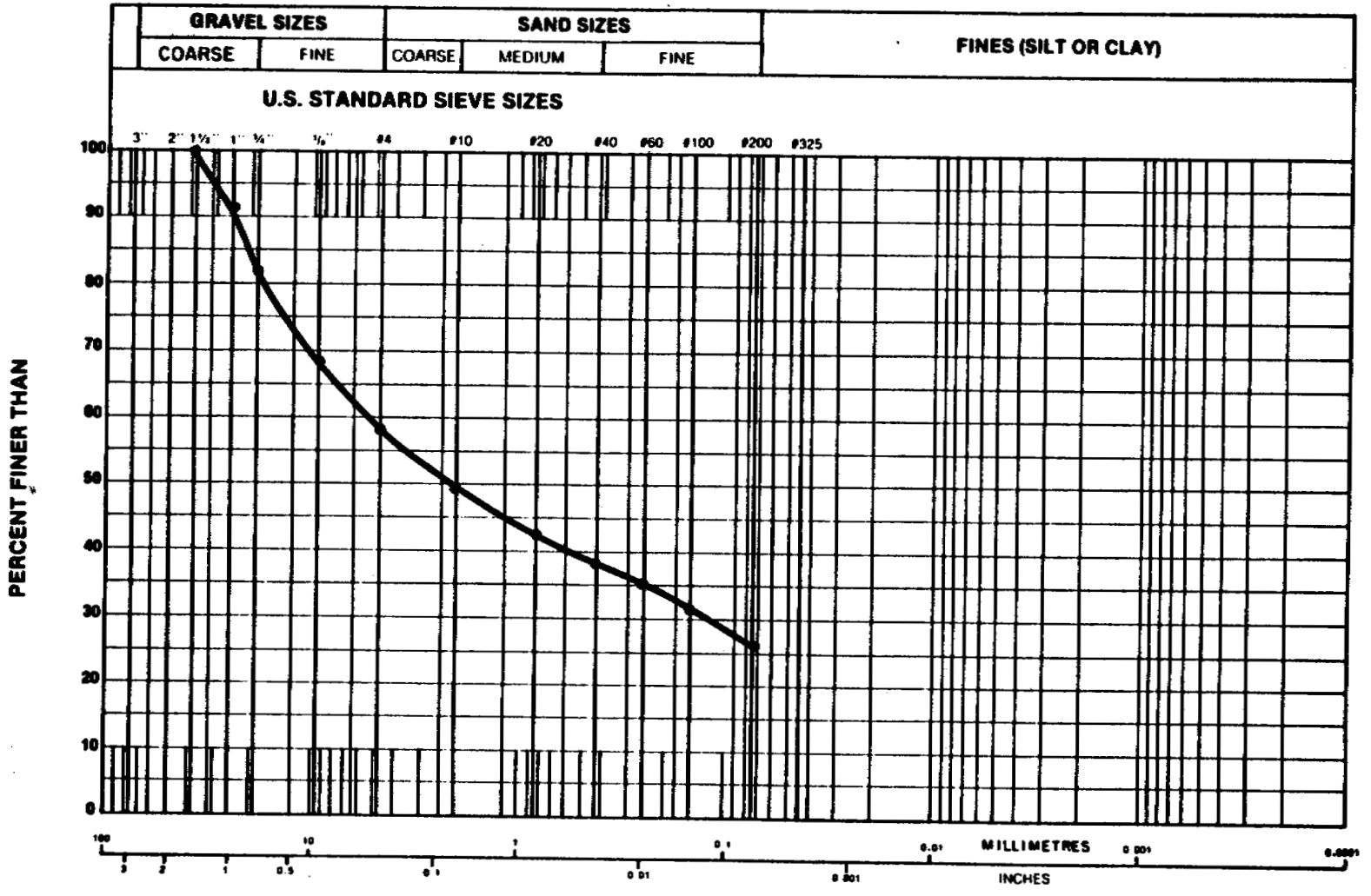
HT 64 80/11

PLATE B-1

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

GRAIN SIZE CURVE

PROJECT NO.	CG 10047
CLIENT	
BOREHOLE	C2
SAMPLE	A1
DEPTH (m)	1.0 - 1.5
TECHNICIAN	AB
DATE TESTED	82.12.15



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

GRAVEL	42.0%	SAND	32.0 %	FINES	26.0 %	SOIL GROUP	GM

NOTE: UNIFIED SOIL CLASSIFICATION SYSTEM

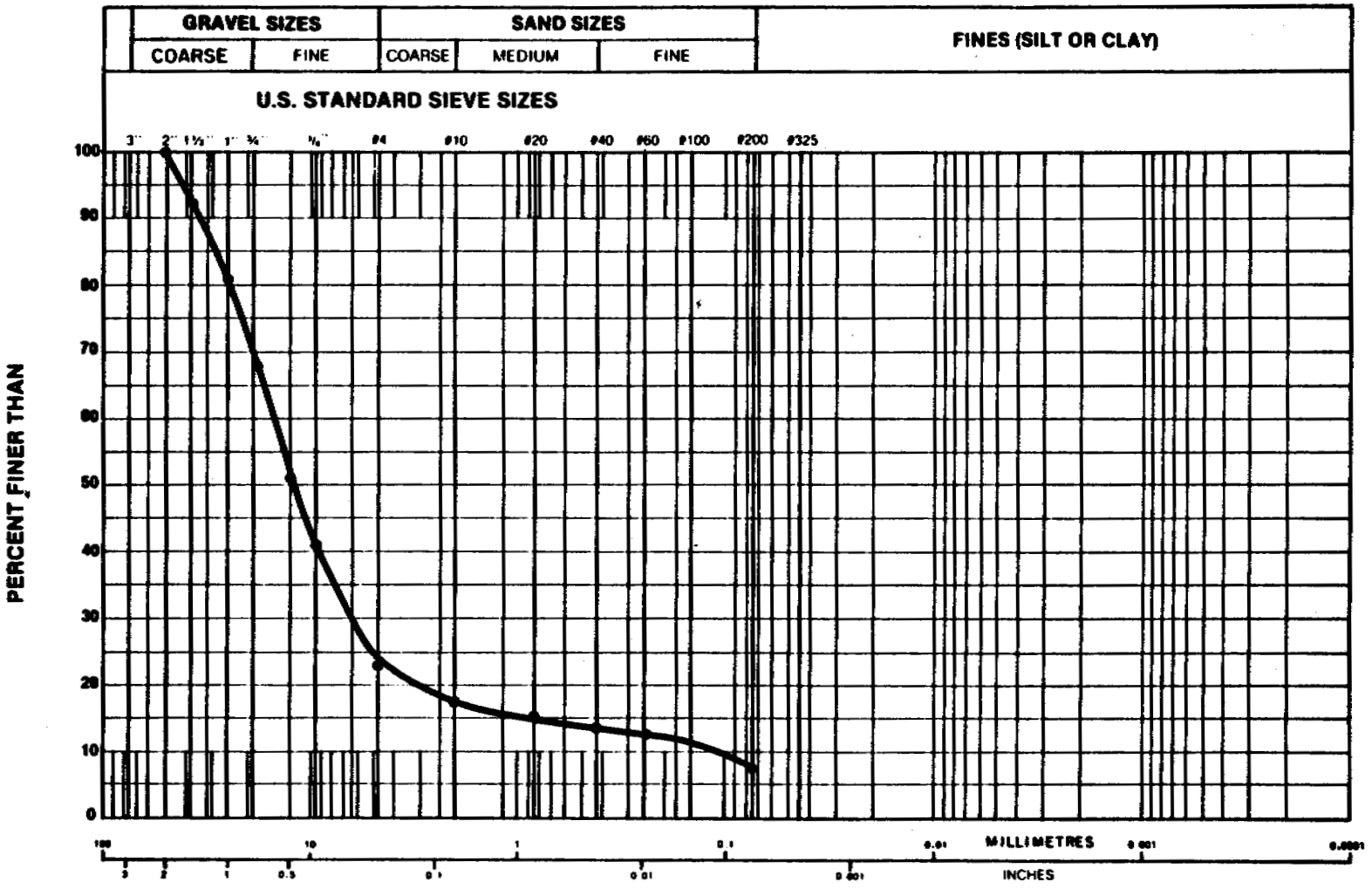
PLATE B-2

HT 64 80/11

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

GRAIN SIZE CURVE

PROJECT NO.	CG 10047
CLIENT	
BOREHOLE	C4 MP 1086.2
SAMPLE	A2
DEPTH (m)	3.5 - 4.0
TECHNICIAN AB	DATE TESTED 82.12.17



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

GRAVEL	77.0 %	SAND	16.0 %	FINES	7.0 %	SOIL GROUP	GM

NOTE: UNIFIED SOIL CLASSIFICATION SYSTEM

PLATE B-3

MT 64 80 11

HARDY ASSOCIATES (1978) LTD.
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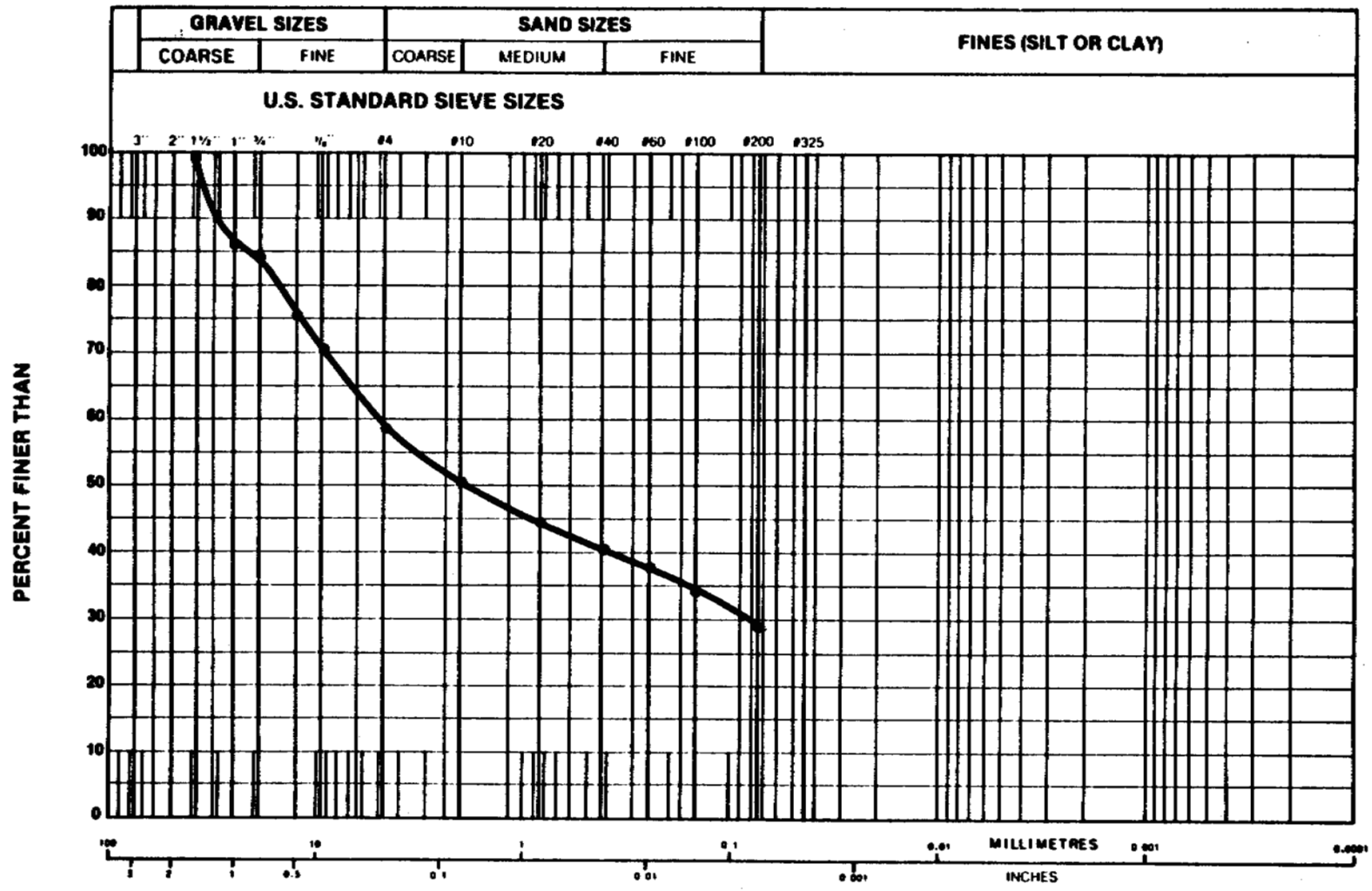
GRAIN SIZE CURVE

PROJECT NO.	CG 10047
CLIENT	
BOREHOLE	C5 MP 1086.2
SAMPLE	A2
DEPTH (m)	5.5 - 6.0
TECHNICIAN	AB
DATE TESTED	82.12.16



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

GRAVEL	42.0%	SAND	29.0 %	FINES	29.0%	SOIL GROUP

NOTE: UNIFIED SOIL CLASSIFICATION SYSTEM

PLATE B-4

MT 64 80/11

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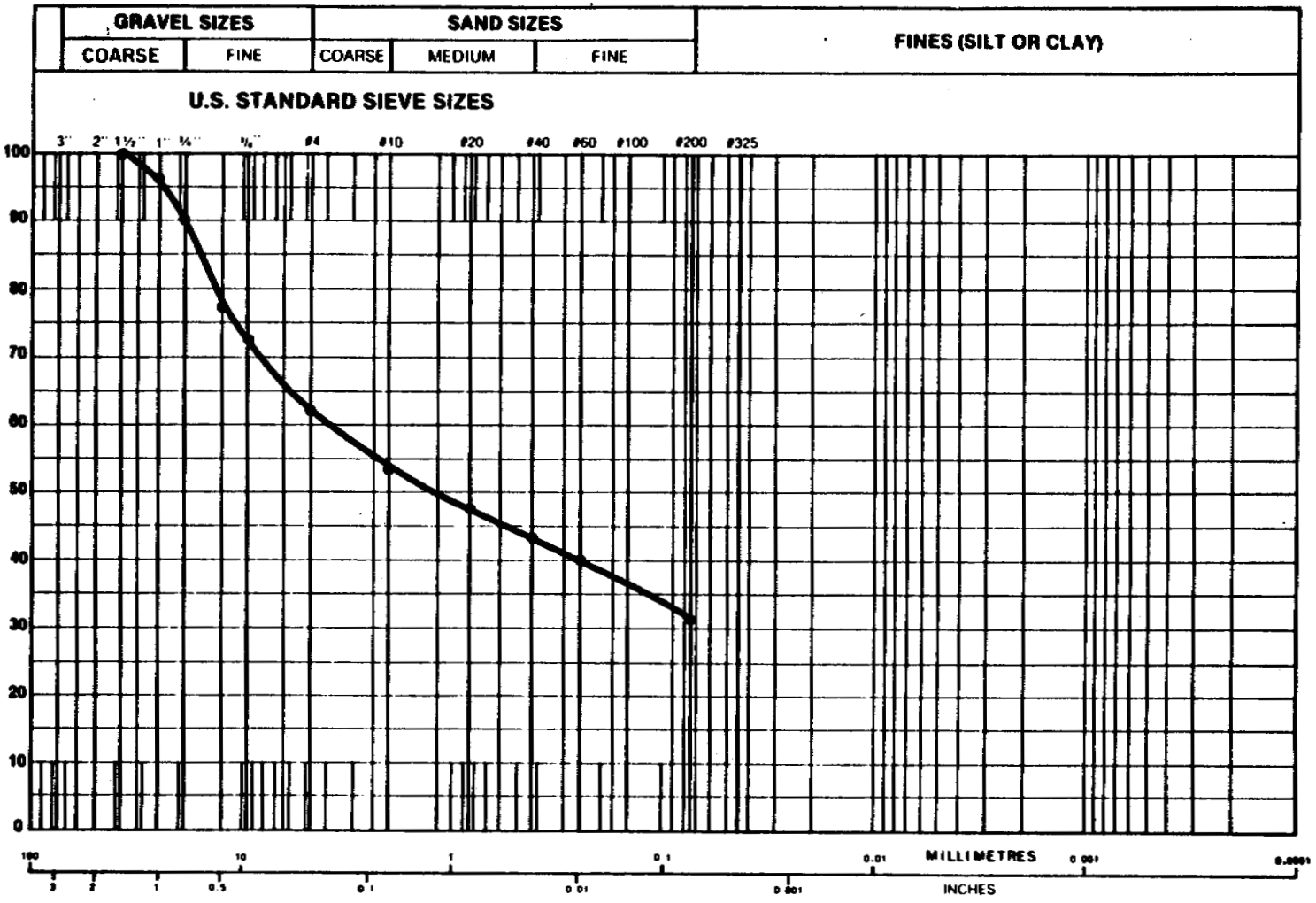
GRAIN SIZE CURVE

PROJECT NO.	CG 10047
CLIENT	
BOREHOLE	C6 MP 1086.2
SAMPLE	A1
DEPTH (m)	4.0 - 4.5
TECHNICIAN	AB
DATE TESTED	82.12.15



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

GRAVEL	38.0 %	SAND	31.0 %	FINES	31.0 %	SOIL GROUP

NOTE: UNIFIED SOIL CLASSIFICATION SYSTEM

PLATE B-5

MTG 64 80/11

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

LOS ANGELES ABRASION TEST REPORT

OFFICE Calgary
FILE 4195-CG-10047
DATE January 31, 1983
CLIENT P.O.
C.C.

TO: Mr. G. Dupuy, P. Eng.,
Hardy Associates (1978) Ltd.,
221 - 18 Street S.E.,
CALGARY, Alberta.
T2E 6J5

PROJECT: Burwash/Destruction Bay Gravel Samples

SOURCE TH A-4, MP 1087.6 3.0 - 3.3 m
TYPE OF SAMPLE Pit Run Material
SAMPLED BY Client
DATE SAMPLED Dec./82
DATE RECEIVED Dec. 16/82
DATE TESTED Jan. 27/83

MATERIAL GRADING: 'A'

	ACTUAL SIEVE SIZES			AMOUNT	
—	1 1/2"	+	1"	1250.0	g
—	1"	+	3/4"	1251.0	g
—	3/4"	+	1/2"	1249.7	g
—	1/2"	+	3/8"	1249.5	g
			TOTAL SAMPLE	5000.2	g

NO. OF REVOLUTIONS	500		
NO. OF SPHERES	12	TOTAL SAMPLE	5000.2 g
WT. OF SPHERES	4988.1 g	+ # 12 MATERIAL AFTER	4328.9 g
		- # 12 MATERIAL AFTER	671.3 g

$$\text{LOSS} = \frac{5000.2 - \#12}{\text{TOTAL SAMPLE}} \times 100 = \frac{671.3}{5000.2} \times 100 = 13.4\ \%$$

COMMENTS: Test performed in accordance with A.S.T.M. C-131

REPORT CERTIFIED J.W. Dupuy, P.Eng. TECHNICIAN E.K.

PLATE B-6

HARDY ASSOCIATES (1978) LTD.

CONSULTING ENGINEERING & PROFESSIONAL SERVICES

SOUNDNESS OF AGGREGATE

SULPHATE TEST REPORT

TO: Mr. G. Dupuy, P. Eng.,
Hardy Associates (1978) Ltd.,
Geotechnical Division,
221 - 18 Street S.E.,
CALGARY, Alberta.
T2E 6J5

FILE: 4195-CG-10047
DATE: February 7, 1983
CLIENT P.O.: -
C.C.: -

PROJECT BURWASH LANDING/DESTRUCTION BAY COMMUNITY GRAVEL STUDY

SOURCE TH A4 , MP.108.6 3.0-3.3
TYPE OF SAMPLE Pit Run Material
SAMPLED BY Client
DATE SAMPLED Dec./82
DATE RECEIVED Dec. 16/82
DATE TESTED Jan. 31/83

SOLUTION Magnesium Sulphate NUMBER OF CYCLES 5

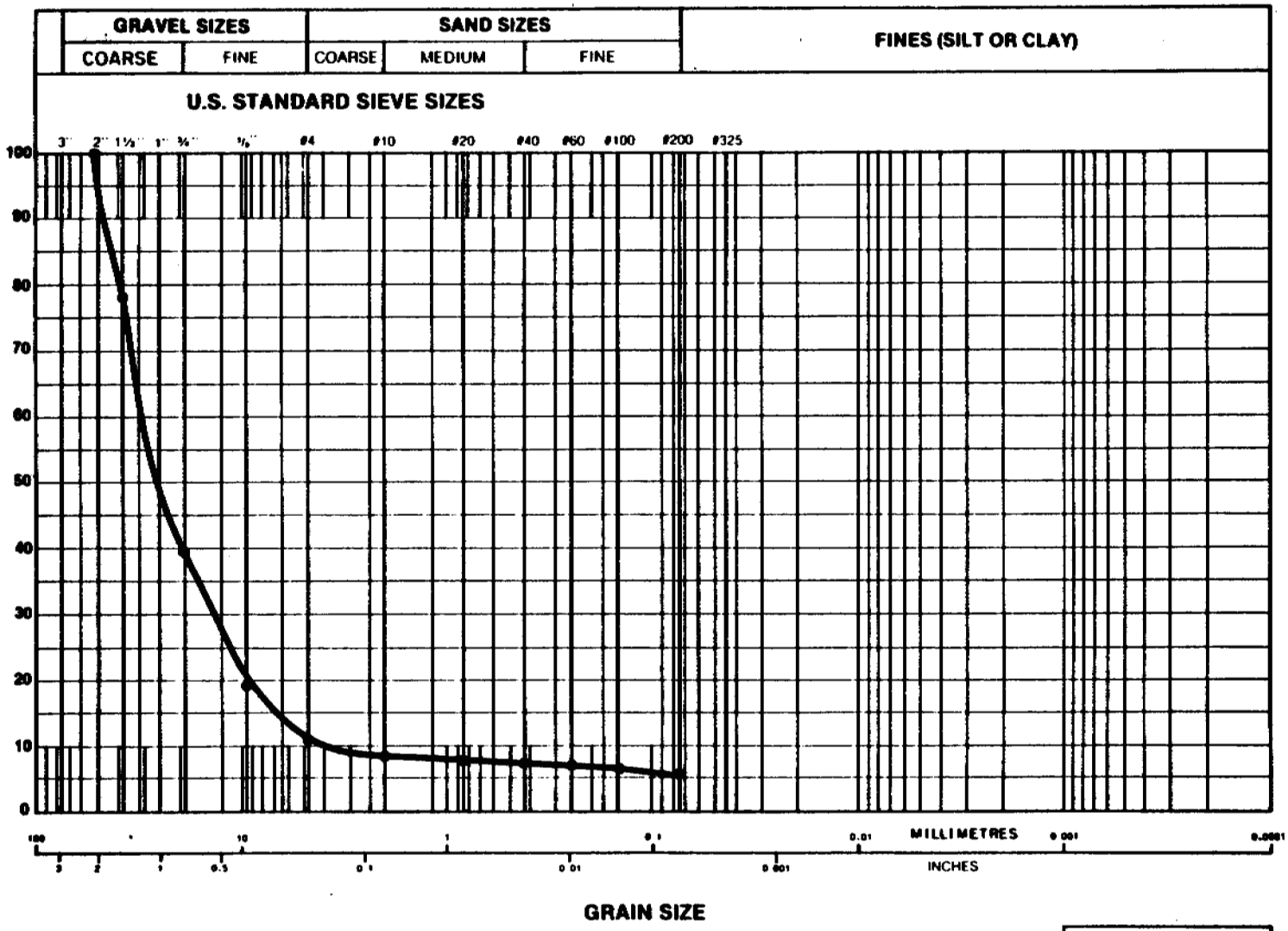
COARSE AGGREGATE				FINE AGGREGATE			
SIEVE SIZE		ORIGINAL GRADING PERCENT	Weighted AVERAGE PERCENT LOSS	SIEVE SIZE		ORIGINAL GRADING PERCENT	WEIGHED AVERAGE PERCENT LOSS
PASSING	RETAINED			PASSING	RETAINED		
3 IN.	2 IN.			3/8 IN.	NO. 4		
2 IN.	1 - ½ IN.	7.2	-	NO. 4	NO. 8		-
1 - ½ IN.	1 IN.	10.1	0.03	NO. 8	NO. 16		-
1 IN.	¾ IN.	15.1	0.01	NO. 16	NO. 30		-
¾ IN.	½ IN.	22.7	0.09	NO. 30	NO. 50		-
½ IN.	3/8 IN.	18.3	0.04	NO. 50	NO. 100		-
3/8 IN.	NO. 4 IN.	26.6	0.16	NO. 100			-
TOTALS		100.0	0.33	TOTALS		-	-

SIZE FRACTION	NO. PARTICLES	QUALITATIVE EXAMINATION OF PLUS ¾" MATERIAL
3" - 2"	ORIGINAL	
	FINAL	
2" - 1½"	ORIGINAL	
	FINAL	
1½" - 1"	ORIGINAL 12	Some pit holes were observed.
	FINAL 12	Some pit holes, and cracking was observed.
1" - ¾"	ORIGINAL 40	Some pit holes were observed.
	FINAL 40	Some pit holes were observed.

COMMENTS

REPORT CERTIFIED K. W. Dalmyn, BET TECHNICIAN R.L.D.

TESTED IN ACCORDANCE WITH ASTM C88



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

GRAIN SIZE CURVE

PROJECT NO.	CG 10047
CLIENT	
BOREHOLE	A-6 MP 1087.6
SAMPLE	A1
DEPTH (m)	1.5 - 1.5
TECHNICIAN	AB
DATE TESTED	82.12.16

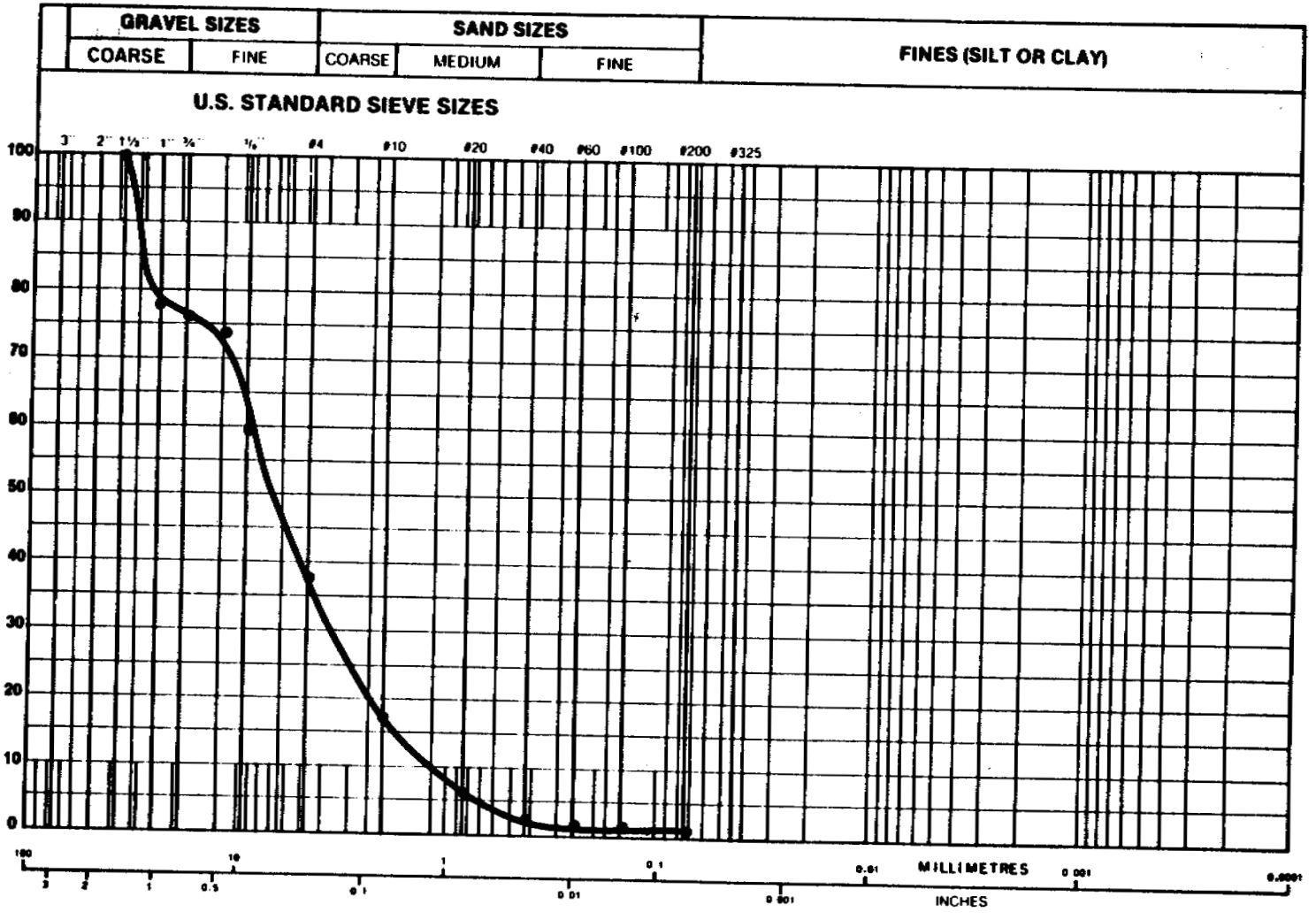
GRAVEL	91.0 %	SAND	4.5 %	FINES 5.5 %	SOIL GROUP GP

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

NOTE: UNIFIED SOIL CLASSIFICATION SYSTEM

PLATE B-8

MT 64 80/11



GRAVEL	63.0 %	SAND	36.0 %	FINES	1.0 %	SOIL GROUP	GP

NOTE: UNIFIED SOIL CLASSIFICATION SYSTEM

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

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

GRAIN SIZE CURVE

PROJECT NO. CG 10047
CLIENT
BOREHOLE A-8 MP 1087.
SAMPLE A1
DEPTH (m) 1.5 - 1.8
TECHNICIAN AB
DATE TESTED 82.12.16

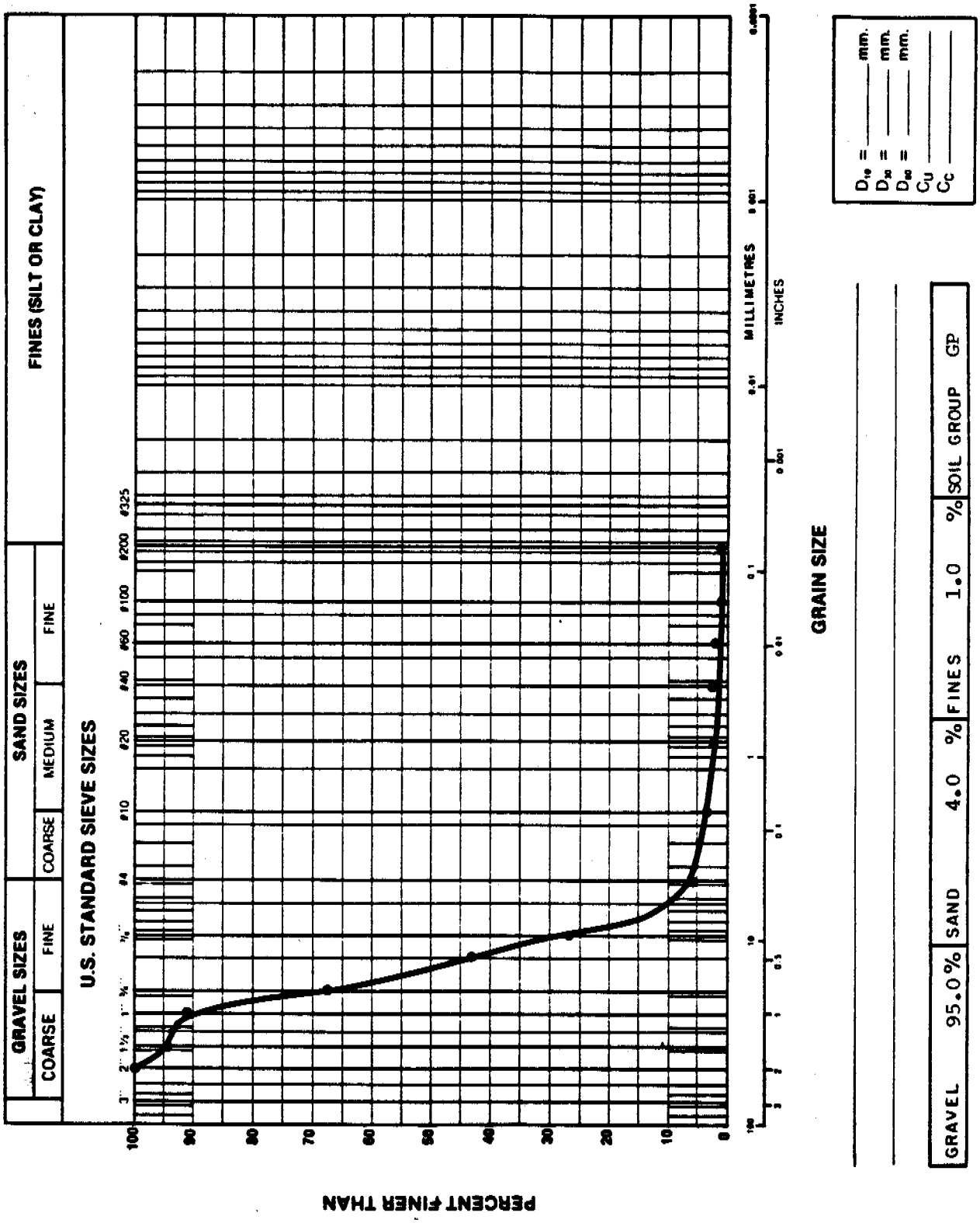
PLATE B-9

MT 04 80/11

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

GRAIN SIZE CURVE

PROJECT NO.	CG 10047
CLIENT	
BOREHOLE	A-10 MP 1087.6
SAMPLE	A1
DEPTH (m)	1.5 - 2.0
TECHNICIAN	AB
DATE TESTED	82.12.17



MT 64 80/11

PLATE B-10

TABLE NO. B-5

SUMMARY OF ROCK TYPES COARSE FRACTION

M.P. 1095.1 Borehole B-14 Depth 4.0 m - 4.2 m

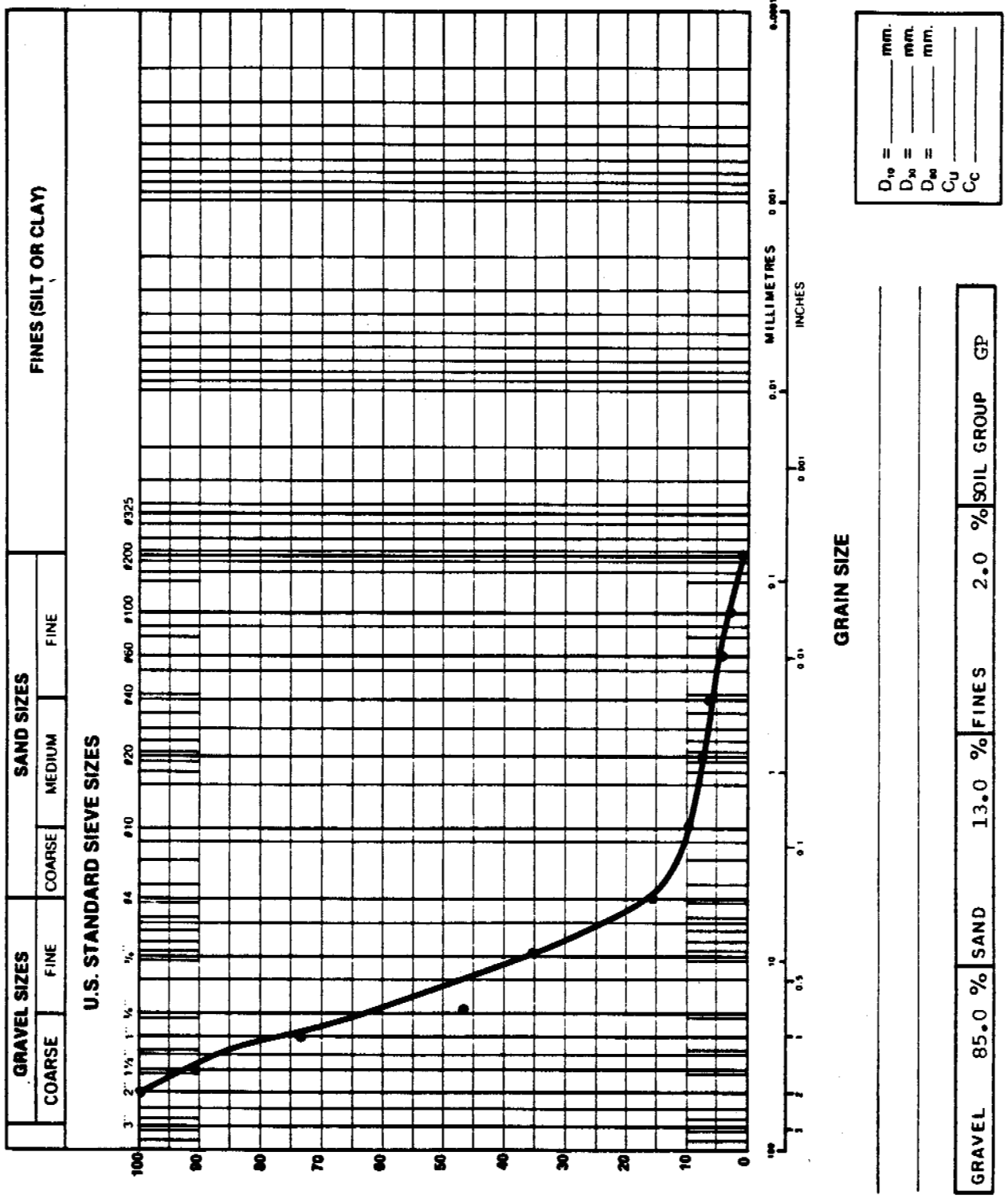
ROCK TYPE	CLASSIFICATION	WEIGHTED PERCENTAGES OF CONSTITUENTS IN EACH SIEVE FRACTION									Total Weighted Composition
		4"	3"	2"	1½"	1"	3/4"	½"	3/8"	#4	
Plutonic-acid	Good				1.3	4.4	6.1	6.8	4.7	6.7	30.0
Greenstone-ultra basic					2.8	1.0	1.4	2.9	2.4	3.3	13.8
Carbonates						1.0	1.8	1.6	1.1	1.3	6.8
Metamorphics					2.8	4.8	7.8	10.1	7.6	12.7	45.8
Volcanics	Fair					0.4	0.5	0.8	0.3	0.1	2.1
Volcanics (weathered, soft)	Poor						0.1	0.6	0.3	0.5	1.5
					6.9	11.6	17.7	22.8	16.4	24.6	100.0

PN = 111.7

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

GRAIN SIZE CURVE

PROJECT NO.	CG 10047
CLIENT	
BOREHOLE	B2 MP 1095.1
SAMPLE	A1
DEPTH (m)	1.5 - 2.0
TECHNICIAN AB	DATE TESTED 82.12.



GRAVEL	SAND	FINES	SOIL GROUP
85.0 %	13.0 %	2.0 %	GP

NOTE: UNIFIED SOIL CLASSIFICATION SYSTEM

HT 64 80/11

PLATE B-11

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

LOS ANGELES ABRASION TEST REPORT

OFFICE Calgary
FILE 4195-CG-10047
DATE January 27, 1983
CLIENT P.O.
C.C.

TO: Mr. G. Dupuy, P. Eng.,
Hardy Associates (1978) Ltd.,
221 - 18 Street S.E.,
CALGARY, Alberta.
T2E 6J5

PROJECT: BURWASH LANDING/DESTRUCTION BAY COMMUNITY GRAVEL STUDY

SOURCE TH B4 MP 1095.1 5.5 - 5.8 m
TYPE OF SAMPLE Pit Run Material
SAMPLED BY Client
DATE SAMPLED Dec./82
DATE RECEIVED Dec. 16/82
DATE TESTED Jan. 27/83

MATERIAL GRADING: 'A'

ACTUAL SIEVE SIZES			AMOUNT	
—	1 1/2"	+ 1"	1249.5	g
—	1"	+ 3/4"	1250.7	g
—	3/4"	+ 1/2"	1250.8	g
—	1/2"	+ 3/8"	1249.2	g
		TOTAL SAMPLE	5000.2	g
NO. OF REVOLUTIONS		500		
NO. OF SPHERES		12	TOTAL SAMPLE 5000.2	g
WT. OF SPHERES		4987.8 g	+ # 12 MATERIAL AFTER 4076.3	g
			- # 12 MATERIAL AFTER 923.9	g

$$\text{LOSS} = \frac{5000.2 - \#12}{\text{TOTAL SAMPLE}} \times 100 = \frac{923.9}{5000.2} \times 100 = 18.5\ \%$$

COMMENTS: Test performed in accordance with A.S.T.M. C-131

REPORT CERTIFIED K.M. Dellingham, CET
TECHNICIAN E.K.

PLATE B-12

HARDY ASSOCIATES (1978) LTD.

CONSULTING ENGINEERING & PROFESSIONAL SERVICES

SOUNDNESS OF AGGREGATE

SULPHATE TEST REPORT

TO: Mr. G. Dupuy, P. Eng.,
Hardy Associates (1978) Ltd.,
Geotechnical Division,
221 - 18 Street S.E.,
CALGARY, Alberta.
T2E 6J5

FILE: 4195-CG-10047
DATE: February 7, 1983
CLIENT P.O.: -
C.C.: -

PROJECT BURWASH LANDING/DESTRUCTION BAY COMMUNITY GRAVEL STUDY

SOURCE TH B4, MP.1095.1 5.5-5.8 m | TYPE OF SAMPLE Pit Run Material | SAMPLED BY Client
DATE SAMPLED Dec./82 | DATE RECEIVED Dec. 16/82 | DATE TESTED Jan. 31/83

SOLUTION Magnesium Sulphate NUMBER OF CYCLES 5

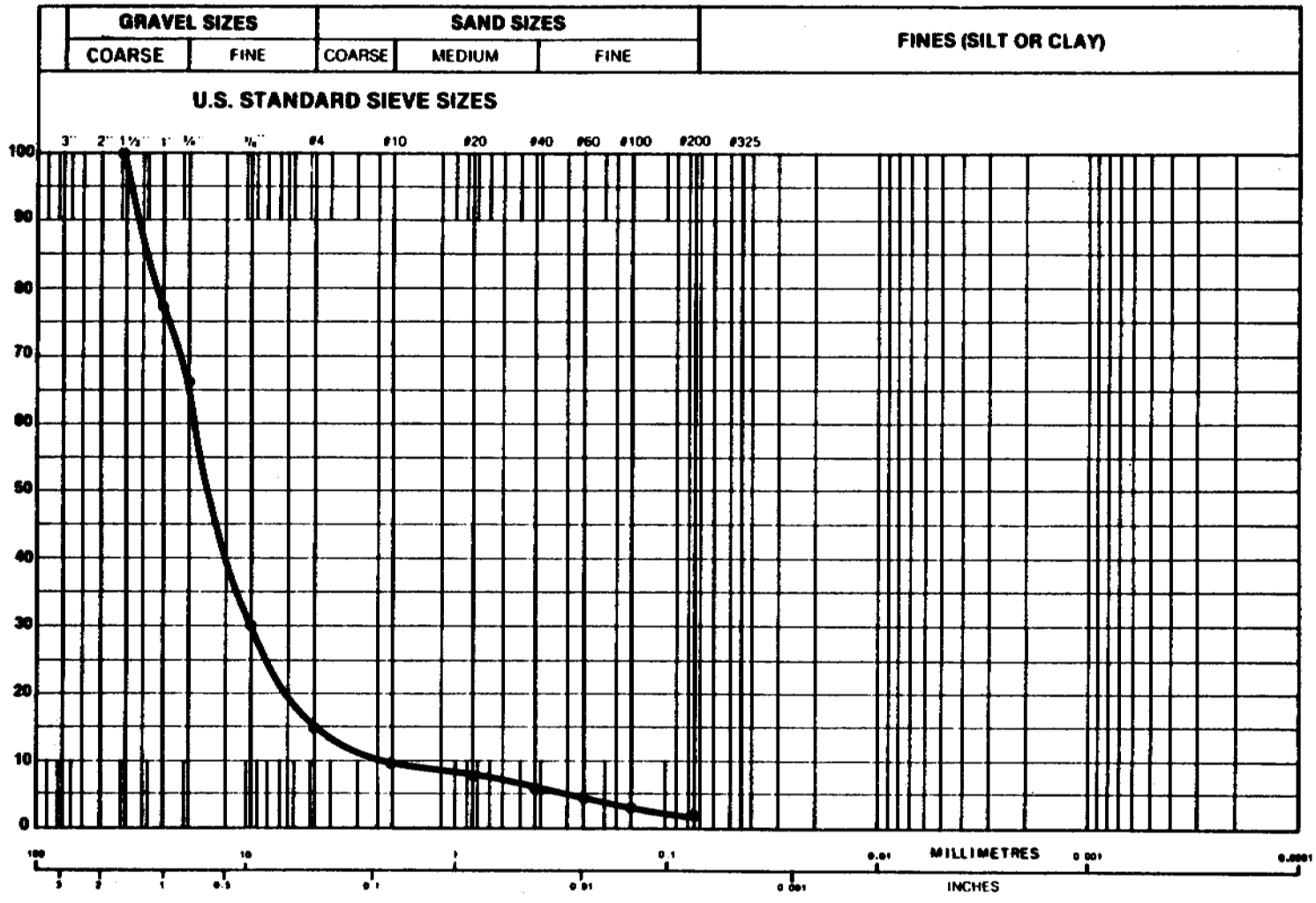
COARSE AGGREGATE				FINE AGGREGATE			
SIEVE SIZE		ORIGINAL GRADING PERCENT	Weighted AVERAGE PERCENT LOSS	SIEVE SIZE		ORIGINAL GRADING PERCENT	WEIGHED AVERAGE PERCENT LOSS
PASSING	RETAINED			PASSING	RETAINED		
3 IN.	2 IN.			3/8 IN.	NO. 4		
2 IN.	1 - ½ IN.	5.2	-	NO. 4	NO. 8		-
1 - ½ IN.	1 IN.	17.3	0.02	NO. 8	NO. 16		-
1 IN.	¾ IN.	20.5	0.01	NO. 16	NO. 30		-
¾ IN.	½ IN.	26.4	0.41	NO. 30	NO. 50		-
½ IN.	3/8 IN.	15.0	0.15	NO. 50	NO. 100		-
3/8 IN.	NO. 4 IN.	14.6	0.12	NO. 100			-
TOTALS		100.0	0.71	TOTALS		-	-

SIZE FRACTION	NO. PARTICLES	QUALITATIVE EXAMINATION OF PLUS ¾" MATERIAL
3" - 2"	ORIGINAL	
	FINAL	
2" - 1½"	ORIGINAL	
	FINAL	
1½" - 1"	ORIGINAL 22	Some cracks and pit holes were observed.
	FINAL 22	Some cracks and splitting was observed.
1" - ¾"	ORIGINAL 39	Some pit holes were observed.
	FINAL 39	Some cracks were observed.

COMMENTS:

REPORT CERTIFIED [signature] TECHNICIAN R.L.D.

TESTED IN ACCORDANCE WITH ASTM C88



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

GRAIN SIZE CURVE

PROJECT NO.	CG 10047
CLIENT	
BOREHOLE	B7 MP 1095.1
SAMPLE	A1
DEPTH (m)	1.2 - 1.4
TECHNICIAN	AB
DATE TESTED	82.12.17

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

GRAVEL	85.0%	SAND	13.0 %	FINES	2.0 %	SOIL GROUP	GP

NOTE: UNIFIED SOIL CLASSIFICATION SYSTEM

PLATE B-14

HT 64 80/11

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

LOS ANGELES ABRASION TEST REPORT

OFFICE Calgary
FILE 4195-CG-10047
DATE January 31, 1983
CLIENT P.O.
C.C.

TO: Mr. G. Dupuy, P. Eng.,
Hardy Associates (1978) Ltd.,
Geotechnical Division,
221 - 18 Street S.E.,
CALGARY, Alberta.
T2E 6J5

PROJECT: BURWASH LANDING/DESTRUCTION BAY COMMUNITY GRAVEL STUDY

TH B-1, MP 1095.1, 5.0-5.5 m
TH B-9
SOURCE 2.8 - 3.0 m
DATE SAMPLED Dec./82

TYPE OF SAMPLE Pit Run Material
DATE RECEIVED Dec. 16/82

SAMPLED BY Client
DATE TESTED Jan. 27/83

MATERIAL GRADING: 'A'

ACTUAL SIEVE SIZES			AMOUNT	
—	1 1/2"	+ 1"	1252.0	g
—	1"	+ 3/4"	1249.2	g
—	3/4"	+ 1/2"	1249.0	g
—	1/2"	+ 3/8"	1250.4	g
		TOTAL SAMPLE	5000.6	g
NO. OF REVOLUTIONS		500		
NO. OF SPHERES		12	TOTAL SAMPLE 5000.6	g
WT. OF SPHERES		4987.8 g	+ # 12 MATERIAL AFTER 4054.4	g
			- # 12 MATERIAL AFTER 946.2	g

LOSS = $\frac{5000.6 - \#12}{\text{TOTAL SAMPLE}} \times 100 = \frac{946.2}{5000.6} \times 100 = 18.9$ %

COMMENTS: Test performed in accordance with A.S.T.M. C-131
TH B-1 and TH B-9 materials were combined to make up
L.A. Abrasion Sample.

REPORT CERTIFIED W. W. Dingwall, C.E.T. TECHNICIAN E.K.

PLATE B-15

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

SOUNDNESS OF AGGREGATE
SULPHATE TEST REPORT

TO: Mr. G. Dupuy, P. Eng.,
Hardy Associates (1978) Ltd.,
Geotechnical Division,
221 - 18 Street S.E.,
CALGARY, Alberta.
T2E 6J5

FILE: 4195-CG-10047
DATE: February 7, 1983
CLIENT P.O.: -
C.C.: -

PROJECT BURWASH LANDING/DESTRUCTION BAY COMMUNITY GRAVEL STUDY

TH B1, MP.1095.1 5.0-5.5m
TH B9, MP.1095.1 Pit Run

SOURCE 2.8 - 3.0 m TYPE OF SAMPLE Material SAMPLED BY Client
DATE SAMPLED Dec./82 DATE RECEIVED Dec. 16/82 DATE TESTED Feb. 1/83

SOLUTION Magnesium Sulphate NUMBER OF CYCLES 5

COARSE AGGREGATE				FINE AGGREGATE			
SIEVE SIZE		ORIGINAL GRADING PERCENT	Weighted AVERAGE PERCENT LOSS	SIEVE SIZE		ORIGINAL GRADING PERCENT	WEIGHED AVERAGE PERCENT LOSS
PASSING	RETAINED			PASSING	RETAINED		
3 IN.	2 IN.			3/8 IN.	NO. 4		-
2 IN.	1 - ½ IN.	3.7	-	NO. 4	NO. 8		-
1 - ½ IN.	1 IN.	11.4	0.08	NO. 8	NO. 16		-
1 IN.	¾ IN.	14.0	0.06	NO. 16	NO. 30		-
¾ IN.	½ IN.	26.0	0.73	NO. 30	NO. 50		-
½ IN.	3/8 IN.	18.7	0.82	NO. 50	NO. 100		-
3/8 IN.	NO. 4 IN.	26.2	0.97	NO. 100			-
TOTALS		100.0	2.66	TOTALS		-	-

SIZE FRACTION	NO. PARTICLES	QUALITATIVE EXAMINATION OF PLUS ¾" MATERIAL
3" - 2"	ORIGINAL	
	FINAL	
2" - 1½"	ORIGINAL	
	FINAL	
1½" - 1"	ORIGINAL 16	Some cracking was observed.
	FINAL 16	Some pit holes, flaking and cracking was observed.
1" - ¾"	ORIGINAL 44	Some cracking was observed.
	FINAL 44	Some pit holes, flaking, and cracking was observed.

COMMENTS: TH #1 & TH #9 material was combined to make up Soundness Test Sample.

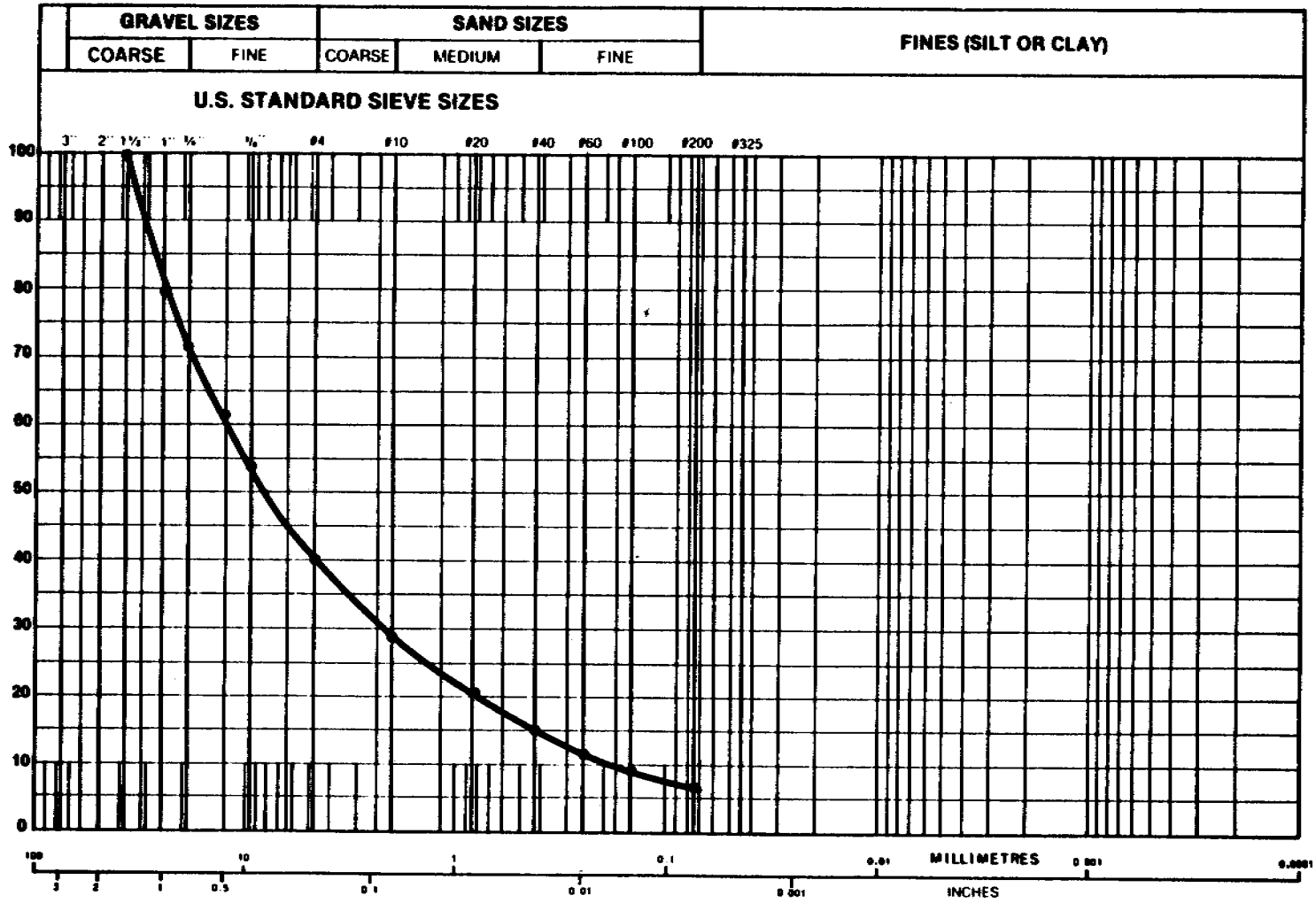
REPORT CERTIFIED R.L.D., CET TECHNICIAN R.L.D.

TESTED IN ACCORDANCE WITH ASTM C88

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

GRAIN SIZE CURVE

PROJECT NO. CG 10047
CLIENT
BOREHOLE B11 MP 1095.1
SAMPLE A1
DEPTH (m) 1.0 - 1.2
TECHNICIAN
DATE TESTED



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

GRAVEL	60.0 %	SAND	33.0%	FINES	7.0 %	SOIL GROUP	GW

NOTE: UNIFIED SOIL CLASSIFICATION SYSTEM

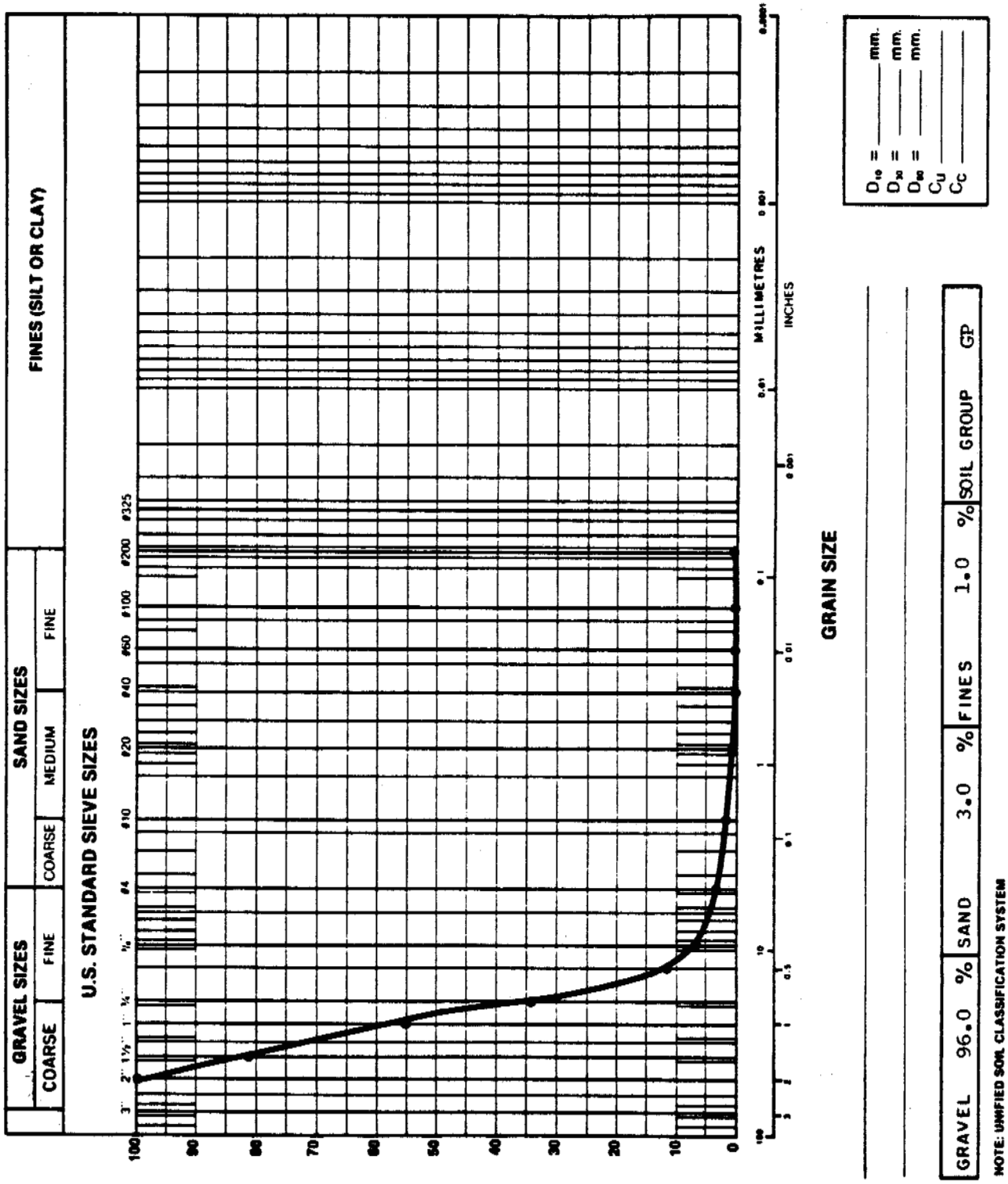
PLATE B-17

HT 64 80/11

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

GRAIN SIZE CURVE

PROJECT NO.	CG 10047
CLIENT	
BOREHOLE	B13 MP 1095.1
SAMPLE	A1
DEPTH (m)	2.3 - 2.5
TECHNICIAN	SK
DATE TESTED	82.12.19



GRAVEL	%	SAND	%	FINES	%	SOIL GROUP
96.0		3.0		1.0		GP

NOTE: UNIFIED SOIL CLASSIFICATION SYSTEM

HT 64 80/11

PLATE B-18

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

LOS ANGELES ABRASION TEST REPORT

OFFICE Calgary
FILE 4195-CG-10047
DATE Jan. 31, 1983
CLIENT P.O.
C.C.

TO: Mr. G. Dupuy, P. Eng.,
Hardy Associates (1978) Ltd.,
221 - 18 Street S.E.,
CALGARY, Alberta.
T2E 6J5

PROJECT: BURWASH LANDING/DESTRUCTION BAY COMMUNITY GRAVEL STUDY

SOURCE TH B-14, MP 1095.1 | TYPE OF SAMPLE Pit Run | SAMPLED BY Client
DATE SAMPLED 4.0 - 4.2 m Dec./82 | DATE RECEIVED Material Dec. 16/82 | DATE TESTED Jan. 27/83

MATERIAL GRADING: 'A'

ACTUAL SIEVE SIZES			AMOUNT	
—	1 1/2" +	1"	1252.1	g
—	1" +	3/4"	1250.9	g
—	3/4" +	1/2"	1249.8	g
—	1/2" +	3/8"	1247.9	g
		TOTAL SAMPLE	5000.7	g
NO. OF REVOLUTIONS		500		
NO. OF SPHERES		12	TOTAL SAMPLE	5000.7 g
WT. OF SPHERES		4987.7 g	+ # 12 MATERIAL AFTER	3981.5 g
			- # 12 MATERIAL AFTER	1019.2 g

$$\text{LOSS} = \frac{5000.7 - \#12}{\text{TOTAL SAMPLE}} \times 100 = \frac{1019.2}{5000.7} \times 100 = 20.4\ \%$$

COMMENTS: Test performed in accordance with A.S.T.M. C-131

REPORT CERTIFIED R.W. Dupuy, P.Eng. TECHNICIAN E.K.

PLATE B-19

HT53 79/11

HARDY ASSOCIATES (1978) LTD.

CONSULTING ENGINEERING & PROFESSIONAL SERVICES

SOUNDNESS OF AGGREGATE

SULPHATE TEST REPORT

TO: Mr. G. Dupuy, P. Eng.,
Hardy Associates (1978) Ltd.,
Geotechnical Division,
221 - 18 Street S.E.,
CALGARY, Alberta.
T2E 6J5

FILE: 4195-CG-10047
DATE: February 7, 1983
CLIENT P.O.: -
C.C.: -

PROJECT BURWASH LANDING/DESTRUCTION BAY COMMUNITY GRAVEL STUDY

SOURCE TH B14, MP. 1095.1 4.0-4.2 m
TYPE OF SAMPLE Pit Run Material
SAMPLED BY Client
DATE SAMPLED Dec./82
DATE RECEIVED Dec. 16/82
DATE TESTED Feb. 1/83

SOLUTION Magnesium Sulphate NUMBER OF CYCLES 5

COARSE AGGREGATE				FINE AGGREGATE			
SIEVE SIZE		ORIGINAL GRADING PERCENT	Weighted AVERAGE PERCENT LOSS	SIEVE SIZE		ORIGINAL GRADING PERCENT	WEIGHED AVERAGE PERCENT LOSS
PASSING	RETAINED			PASSING	RETAINED		
3 IN.	2 IN.			3/8 IN.	NO. 4		
2 IN.	1 - ½ IN.	6.9	-	NO. 4	NO. 8		-
1 - ½ IN.	1 IN.	11.6	0.24	NO. 8	NO. 16		-
1 IN.	¾ IN.	17.7	0.57	NO. 16	NO. 30		-
¾ IN.	½ IN.	22.8	0.17	NO. 30	NO. 50		-
½ IN.	3/8 IN.	16.4	0.42	NO. 50	NO. 100		-
3/8 IN.	NO. 4 IN.	24.6	1.02	NO. 100			-
TOTALS		100.0	2.42	TOTALS		-	-

SIZE FRACTION	NO. PARTICLES	QUALITATIVE EXAMINATION OF PLUS ¾": MATERIAL
3" - 2"	ORIGINAL	
	FINAL	
2" - 1½"	ORIGINAL	
	FINAL	
1½" - 1"	ORIGINAL 17	Some pit holes were observed.
	FINAL 17	Some pit holes and cracking was observed.
1" - ¾"	ORIGINAL 42	Some pit holes and cracking was observed.
	FINAL 41	Some pit holes, splitting, and flaking was observed.

COMMENTS:

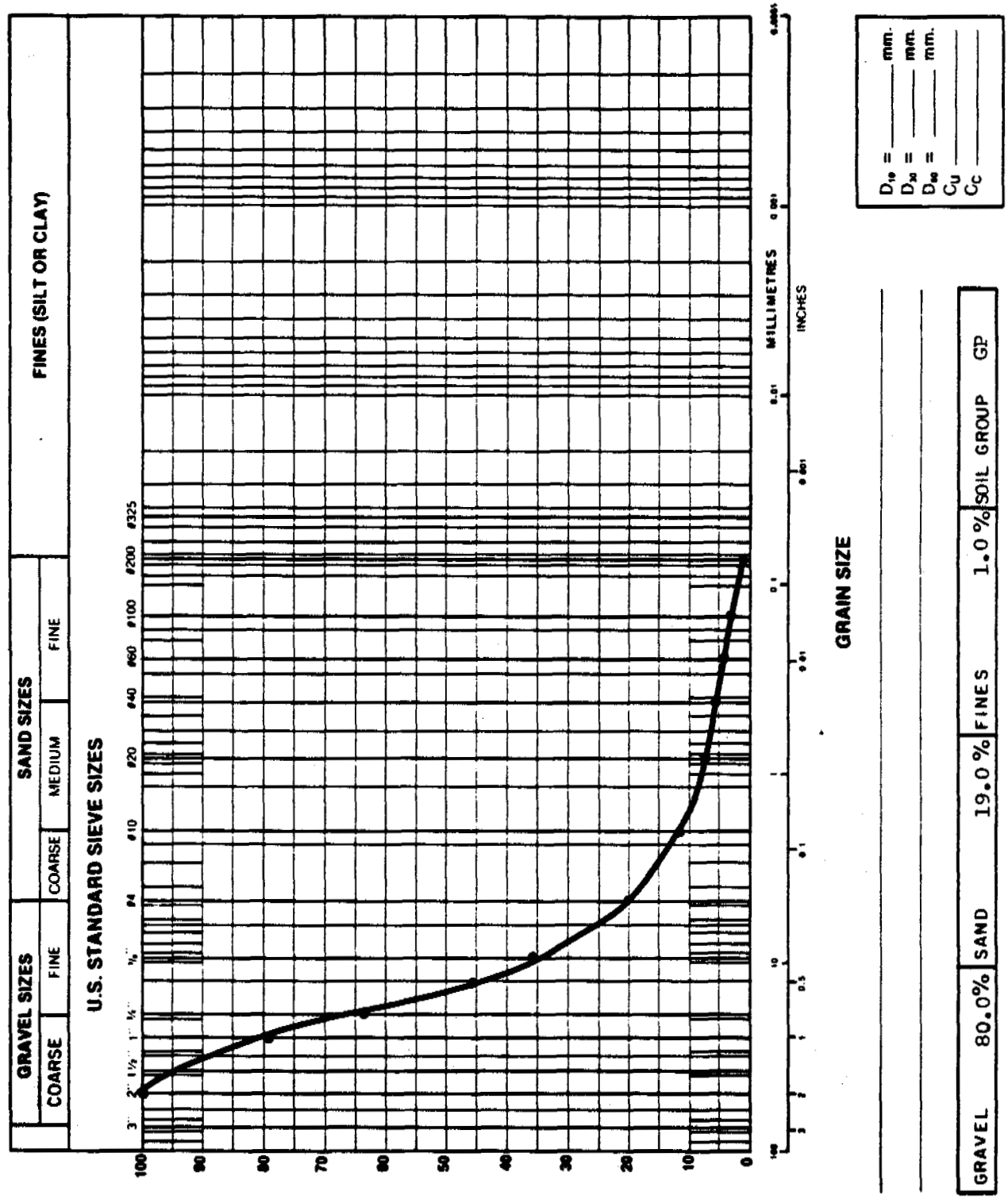
REPORT CERTIFIED J.W. Dallimore, CET TECHNICIAN R.L.D.

TESTED IN ACCORDANCE WITH ASTM C88

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

GRAIN SIZE CURVE

PROJECT NO.	CG 10047
CLIENT	
BOREHOLE	B16 MP 1095.1
SAMPLE	A1
DEPTH (m)	1.8 - 2.0
TECHNICIAN	SK
DATE TESTED	82.12.20



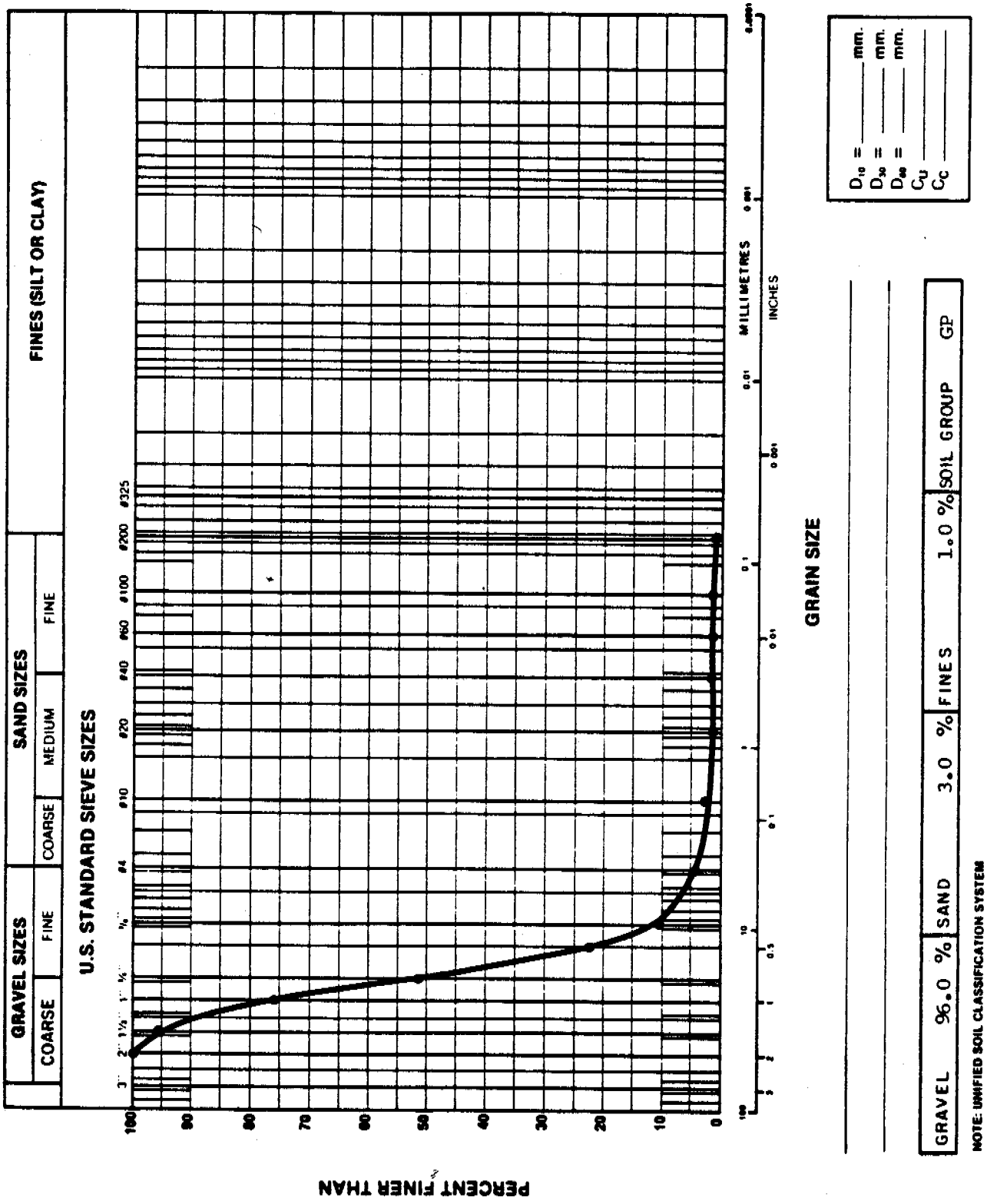
HT 64 80/11

PLATE B-21

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

GRAIN SIZE CURVE

PROJECT NO.	CG 10047
CLIENT	
BOREHOLE	B18 MP 1095.1
SAMPLE	A2
DEPTH (m)	4.3 - 4.5
TECHNICIAN	AB
DATE TESTED	82.12.16



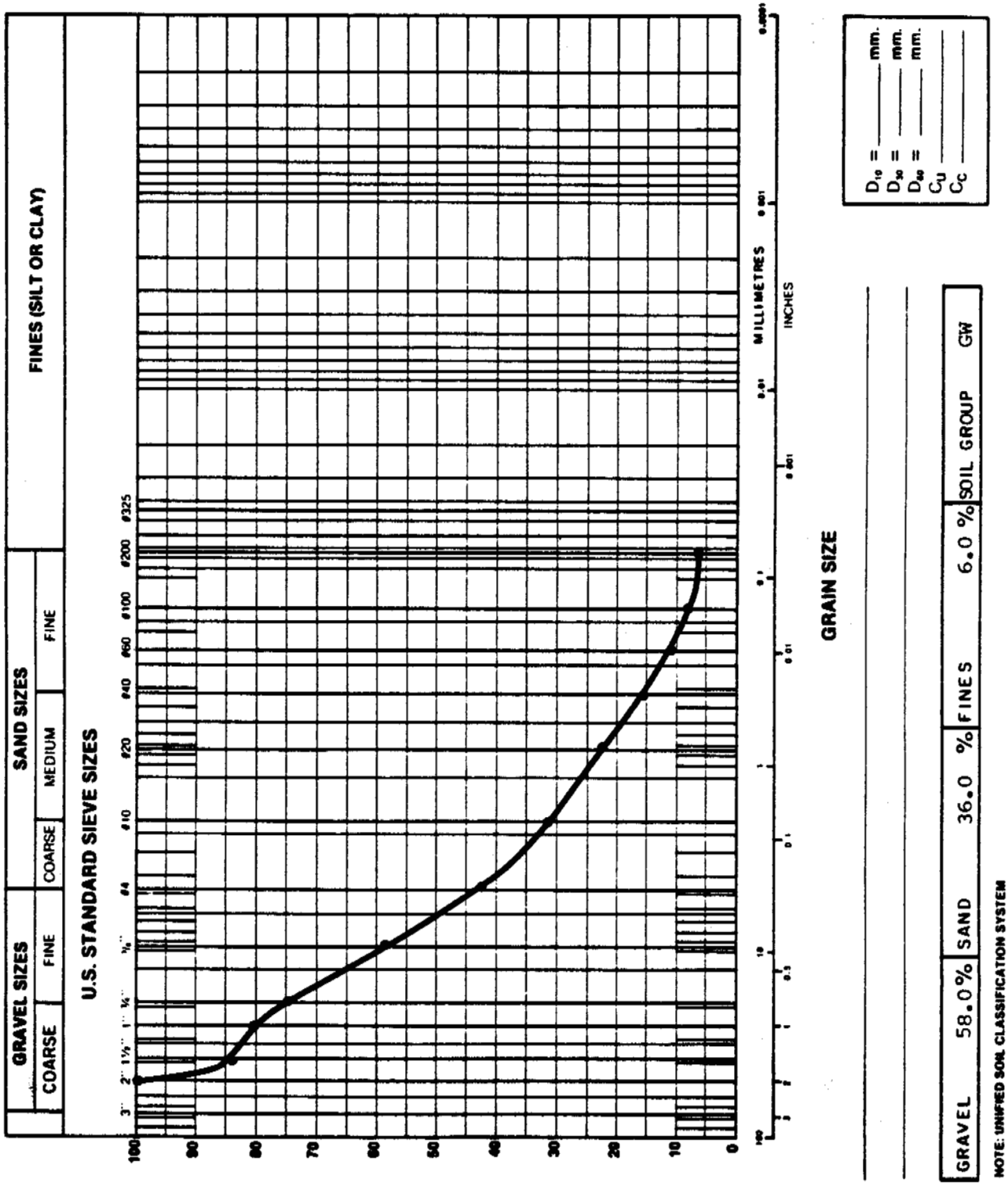
HT 64 80/11

PLATE B-22

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

GRAIN SIZE CURVE

PROJECT NO.	CG 10047
CLIENT	
BOREHOLE	B20 MP 1095.1
SAMPLE	A2
DEPTH (m)	2.8 - 3.0
TECHNICIAN	AB
DATE TESTED	82.12.17



GRAVEL	SAND	FINES	SOIL GROUP
58.0%	36.0 %	6.0 %	GW

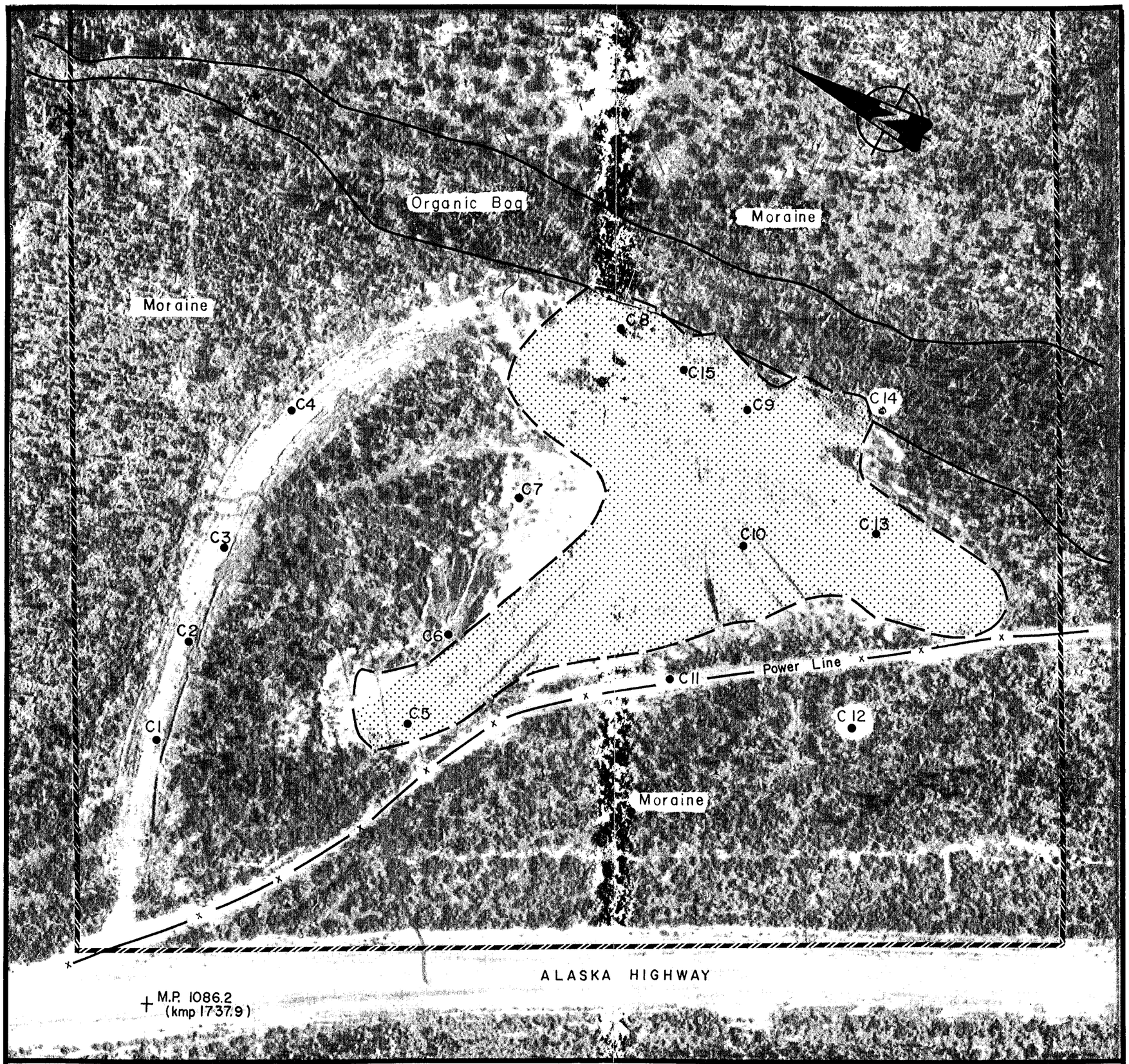
NOTE: UNIFIED SOIL CLASSIFICATION SYSTEM

HT 64 80/11

PLATE B-23

APPENDIX "C"

BORROW RESERVE SITE PLANS



LEGEND

- APPROXIMATE RESERVE BOUNDARY
- TERRAIN TYPE BOUNDARY
- EXISTING BORROW PIT
- C1 — BOREHOLE LOCATION

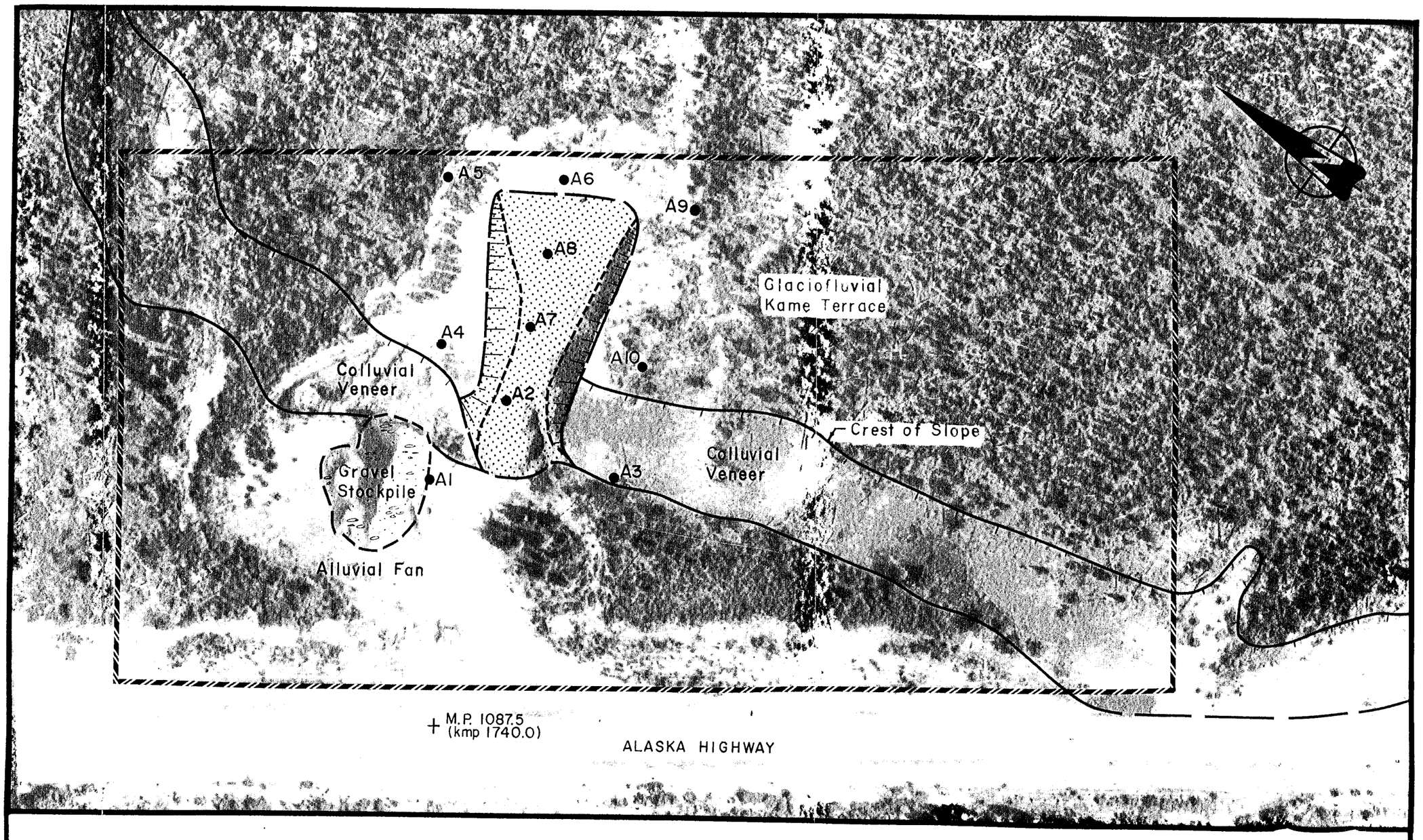
Scale 1:1000 (approx.)

HARDY ASSOCIATES (1978) LTD.

BORROW RESERVE YTG PIT #10981
M.P. 1086.2
SITE PLAN

CG 10047

PLATE C1



LEGEND

- APPROXIMATE RESERVE BOUNDARY
- TERRAIN TYPE BOUNDARY
- EXISTING BORROW PIT
- A2 BOREHOLE LOCATION

Scale 1:1000 (approx)

BORROW RESERVE DIAND PIT #11574
M.P. 1087.6
SITE PLAN

CG10047

PLATE C2

LEGEND

- APPROXIMATE RESERVE BOUNDARY
- TERRAIN TYPE BOUNDARY
- EXISTING BORROW PIT
- B1 BOREHOLE LOCATION

Scale 1:1000 (approx.)

HARDY ASSOCIATES (1978) LTD.

CONSULTING ENGINEERS & PROFESSIONAL SURVEYORS

BORROW RESERVE YTG PIT # 10983
M.P. 1095.6
SITE PLAN

CG10047

PLATE C3