THE DEPARTMENT OF INDIAN AFFAIRS &
NORTHERN DEVELOPMENT

GRANULAR MATERIALS ASSESSMENT

PINE POINT HIGHWAY
HAY RIVER, N.W.T.

AN ASSESSMENT OF AGGREGATE DEPOSITS AT MILES 12 AND 17 SOUTH

PINE POINT HIGHWAY, HAY RIVER AREA

NORTHWEST TERRITORIES

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AIRPHOTO INTERPRETATION
BIOPHYSICAL INVENTORY AND ENVIRONMENTAL ASSESSMENT
REFUSE AND SOLID WASTE SYSTEMS
REMOTE SENSING

MEMBER: Association of Consulting Engineers of Canada

May 23, 1978

Mr. J. I. Inglis, A/Head
Land-Use Section
Northern Environmental Protection
and Ren. Res. Br.
Department of Indian and Northern Affairs
400 Laurier Avenue West, Room 1035
Ottawa, Ontario
K1A 0H4

Dear Sir:

RE: An Assessment of Granular Materials
Sources at Miles 12 and 17 South
Pine Point Highway, Hay River, N.W.T.
D.S.S. File No. 02SU.C7111-7-0691
Our File No. 78-128

We herewith submit fifty copies of our final report on the above granular deposits based on the Terms of Reference set out in the original contract, dated March 31, 1978.

The final draft report was reviewed by Mr. D. Seekings of your branch during a meeting at our office on May 15, 1978. This report incorporates the modifications agreed upon at that time.

It should be noted that this report is similar to the work carried out in our previous investigation of Mile 12, 21, and 31. The report on this previous work was submitted on December 30, 1977. However, the deposits investigated herein involve the construction of all-weather roads from the Pine Point Highway, whereas the previous deposits do not. Therefore, the potential expenditure of capital funds for road construction necessitated a more rigorous evaluation of the suitability of material for various uses. This was achieved through evaluating the quality of the materials based on the Ontario Ministry of Transportation and Communications specifications, versus the Canadian Standard Association criteria employed in the previous report.

This required additional tests on a larger number of samples, the results of which are set out herein.

We trust that the findings presented herein will be of further assistance in achieving the optimal use of these resources.

Yours very truly,

S. J. Glenn Bird, P. Eng.

George Woda
Geologist Petrographer

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1. ## SUMMARY 1.

Nine potential granular deposits located two to four miles south of N.W.T. Highway No. 5 between miles 11 and 17, from the junction of Highway No. 2 and Highway No. 5, were investigated. This investigation involved the excavation of 67 test pits using a track-mounted 3/4 cubic yard backhoe. All field investigation was conducted during the winter months to avoid the severe access difficulties imposed by the surrounding muskeg conditions. However, the existence of heavy frost in a surficial strata of bouldery granular material prevented excavation of some test pits, particularly in the Mile 17 south deposits. This hindered accurate determination of aggregate quality and quantity in some areas.

Preliminary laboratory analyses was conducted on all of the granular samples in our Hay River field laboratory. These analyses involved dry sieve analysis and visual examination, for the selection of representative or unique samples which were sent to Toronto for further analyses. Petrographic and wet sieve analyses were conducted on all of the samples that were subsequently sent to Toronto. In addition, organic impurity determination was conducted on those samples that exhibited potential for use in cement mortar or concrete.

It should be noted that Canadian Standards Association (C.S.A.) specifications and test procedures were used in our previous study and the more rigid American Society for Testing and Materials (A.S.T.M.) specifications as modified by the Ontario Ministry of Transportation and Communications (M.T.C.) have been used during this study. The C.S.A. standards, which permit a more general classification of material, were used in the first study due to its broader terms of reference and the proximity of the deposits to existing road access. However, due to the necessity of a large capital investment to construct an all-weather haul road to the Mile 12 and 17 south deposits, it was found necessary to conduct a more detailed assessment of the potential of the granular material for specific uses such as concrete aggregate, granular A, B and C and general fill material.* In other words, this information was required to determine if the large capital investment of road construction is economically feasible. It should also be noted that direct comparison between the C.S.A. and A.S.T.M. specifications of the test results is not always possible. For example, the acceptable upper petrographic number for concrete under the C.S.A. is 300 and under M.T.C. it is 140.

Of the nine deposits investigated,eight exhibit economic potential for the extraction of concrete aggregate, granular A, B or C or general fill material. With the exception of granular C and general fill material,very little of the material meets the required specifications. In order to meet these specifications the majority of material designated as possessing potential for concrete aggregate, granular A or granular B would require screening and/or washing. Further testing of any aggregate material is recommended prior to the use of this when considering the material for a particular use or application.

The existence of boulders and bouldery strata in many localities will necessitate varying amounts of secondary crushing and screening. In some areas a significant

*See Glossary of Technical Terms.

number of larger boulders will necessitate primary crushing up to 30" feed or primary screening using a rack or bar screen.

The extreme complexity and high variability of the material in some of the deposits prevented the recommendation of specific extraction and pit management practices. However, it is important that care be taken during extraction so that high quality material is not used for uses requiring lower specifications.

All granular deposits are covered with an overstory of predominantly 10-12" jack pine, with 8-10" dbh black spruce and occasional zones of white birch and poplar.

The granular deposits are underlain by a gently undulating ablation till which supports a perched water table condition. This may cause difficulties as the water table will be encountered during extraction and access can be difficult when softened underlying till is churned and remolded by heavy equipment.

The recommendations regarding changes in licencing practices and general pit management procedures contained in our previous report also apply to these deposits.

The excavation of test pits indicated a large seasonal fluctuation in the groundwater table elevation in the deposits. This is significantly higher in the summer than in the winter. Thus, there is a significant increase in the amount of granular material available from summer to winter extraction. Therefore, the estimated reserves of material available for the specific uses of concrete aggregate, Granular A, B and C and general fill material were calculated for both summer and winter extraction.

1. SUMMARY

As noted in our previous report, the potential reactivity of any aggregate intended for use in cement mortar or concrete should be tested prior to this use of the aggregate. All natural rocks and gravels react to some extent with the highly caustic solution existing in concrete but in certain cores these reactions proceed far enough to produce excessive expansion and cracking of the concrete. Two types of alkali-aggregate reaction occur: Alkali-silica reaction occurs between the alkalies in Portland cement and certain reactive silica constituents in aggregate. This type of potential reactivity may be identified from petrographic analysis alone. Analysis of the samples did not reveal any potentially reactive rocks. Alkali-carbonate reaction occurs between the Portland cement alkali and certain fine-grained dolomitic limestones.

Alkali-carbonate reactions have been diagnosed in connection with dolomitic limestone from the several quarries along the southern border of the Canadian Shield. It is not possible to determine the potential reactivity of an aggregate by petrographic analysis alone; thus it is recommended that further detailed testing, such as the Canadian Standards Association test A3.4(A23.2.23), be conducted.

1.1 Mile 12 South

The estimated reserves of granular material for the specific uses of concrete aggretate, Granular A, B and C and general fill material within each individual deposit (as designated on Dwg. No. HRS-2) appear in Table No. 4. The total estimated reserves of aggregate, for the specific uses, contained in the Mile 12 south deposits appear in Table No. 6.

1.2 Mile 17 South

The estimated total reserves of granular material for the specific uses of concrete aggregate, Granular A, B and C and general fill material within each individual deposit (as designated on Dwg. No. HRS-3) appear in Table No. 5. The total estimated reserves of aggregate, for the specific uses, contained in the Mile 17 south deposits appear in Table No. 7.

1.3 Selection of All-weather Haul Road Alignment

Based on 1978 road construction estimates as well as a comparison of 1978 haul costs in relation to the difference in distance from Hay River to the Mile 12 south and Mile 17 south deposits, via Route 1 and Route 2, respectively, the final route selection should be based on the following considerations:

(1) The estimate costs of constructing an all-weather haul road, to the specifications described in Section 3.11 of this report, to the Mile 12 south and Mile 17 south deposits via Routes 1 and 2 (see Dwg. No. HRS-1) are $226,000 and $94,000, respectively.

(2) If more than 134,000 m^3 (175,000 cubic yards) of aggregate is to be hauled to Hay River during some arbitrary time period, it would be more economical to construct a road along Route 1 to the Mile 12 south deposits.

(3) If less than 134,000 m^3 (175,000 cubic yards) of aggregate is to be hauled to Hay River, over the same arbitrary time period, it would be more economical to construct an all-weather haul road along Route 2 to the Mile 17 south deposits. This would also apply if the majority of the material is destined to a market situated east of these reserves.

Table No. 4

SUMMARY OF VOLUMES BY DEPOSIT AND POTENTIAL USE

MILE 12 SOUTH

Deposit #	Potential Aggregate Use	Winter Volume M^3 / yd^3	Summer Volume M^3 / yd^3
HR108A	A & concrete	N/A	N/A
	B	N/A	N/A
	C	N/A	N/A
	Gen. Fill	N/A	N/A
	TOTAL (±10%)	N/A	N/A
HR108B	A & concrete	N/A	N/A
	B	N/A	N/A
	C	70,000/ 90,000	40,000/55,000
	Gen. Fill	N/A	N/A
	TOTAL (±10%)	70,000/ 90,000	40,000/55,000
HR109A	A & concrete	70,000/ 90,000	45,000/60,000
	B	95,000/125,000	70,000/85 ,000
	C	150,000/195,000	80,000/105,000
	Gen. Fill	N/A	N/A
	TOTAL (±10%)	315,000/410,000	195,000/250,000
HR110A	A & concrete	100,000/130,000	70,000/ 90,000
	B	N/A	N/A
	C	105,000/135,000	65,000/ 85,000
	Gen, Fill	8,000/10,000	6,000/ 8,000
	TOTAL (± 10%)	213,000/275,000	141,000/183,000

Table No. 4 (cont'd)

SUMMARY OF VOLUMES BY DEPOSIT AND POTENTIAL USE

MILE 12 SOUTH (cont'd)

Deposit #	Potential Aggregate Use	Winter Volume M^3 / yd^3	Summer Volume M^3 / yd^3
HR111A	A & concrete	N/A	N/A
	B	120,000/160,000	85,000/110,000
	C	40,000/50,000	25,000/35,000
	Gen. Fill	25,000/35,000	15,000/20,000
	TOTAL (± 10%)	185,000/245,000	125,000/165,000
HR112A	A & concrete	55,000/70,000	35,000/45,000
	B	N/A	N/A
	C	N/A	N/A
	Gen. Fill	85,000/105,000	55,000/70,000
	TOTAL (± 10%)	140,000/175,000	90,000/115,000

Table No. 5

SUMMARY OF VOLUMES BY DEPOSIT AND POTENTIAL USE

MILE 17 SOUTH

Deposit #	Potential Aggregate Use	Winter Volume M^3 / yd^3	Summer Volume M^3 / yd^3
HR 123A	A & concrete	45,000/60,000	35,000/45,000
	B	105,000/140,000	70,000/90,000
	C	N/A	N/A
	Gen. Fill	100,000/130,000	65,000/80,000
	TOTAL (± 40%)	250,000/330,000	170,000/215,000
HR124A	A & concrete	35,000/45,000	25,000/35,000
	B	170,000/220,000	100,000/130,000
	C	265,000/340,000	95,000/125,000
	Gen. Fill	20,000/25,000	N/A
	TOTAL (± 40%)	490,000/630,000	220,000/290,000
HR125A	A & concrete	N/A	N/A
	B	N/A	N/A
	C	165,000/215,000	110,000/145,000
	Gen. Fill	N/A	N/A
	TOTAL (± 40%)	165,000/215,000	110,000 145,000

Table No. 6

Mile 12 South

TOTAL ESTIMATED VOLUMES OF RESERVES

	Winter (m^3)	Winter (yd^3)	Summer (m^3)	Summer (yd^3)
*Granular A	225,000	290,000	150,000	195,000
Granular B	215,000	285,000	155,000	200,000
Granular C	370,000	475,000	215,000	280,000
General Fill	115,000	150,000	75,000	100,000
TOTAL (±10%)	925,000	1,200,000	595,000	775,000

*Recommended material for concrete aggregate.

Table No. 7

Mile 17 South

TOTAL ESTIMATED VOLUMES OF RESERVES

	Winter		Summer	
	(m^3)	(yd^3)	(m^3)	(yd^3)
*Granular A	80,000	105,000	60,000	80,000
Granular B	275,000	360,000	165,000	215,000
Granular C	430,000	555,000	205,000	270,000
General Fill	125,000	160,000	65,000	80,000
TOTAL ($\pm$40%)	910,000	1,180,000	495,000	645,000

*Recommended material for concrete aggregate.

2. INTRODUCTION

2.1 Objectives

The objectives of this study are as follows:

(1) To determine the quality and quantity of granular resources to be found in potential economic deposits located south of Miles 12 and 17 of the Pine Point Highway (Hwy. No. 5) near Hay River, Northwest Territories.

(2) To recommend specific site development and resources management policies for these deposits, based on the suitability of the aggregate material for specific construction uses.

(3) To determine the economic viability of constructing an all-weather haul road south to these deposits from Hwy. No. 5.

(4) To select the best and most economical all-weather access road alignment to the deposits.

2.2 Previous Aggregate Studies in the Area

The Department of Indian Affairs and Northern Development commissioned a granular materials inventory of the Hay River area in 1973-1974.

According to the report prepared by the consultant, Ripley, Klohn & Leonoff Ltd., there are 8 sources within a 10-mile radius and an additional 15 sources within a 25-mile radius of the Hay River community. At the time the inventory was undertaken, 14 sources were recommended for development to provide 6.6 million cubic yards of general fill, coarse and fine aggregates. This was considered by the consultant to be the volume of material needed for the expansion of the community.

In July, 1975, in order to assess the quality and quantity of the granular material in certain deposits in the Hay River area, E. B. Owen of the Geological Survey of Canada conducted an investigation along the Pine Point Highway (Hwy. No. 5) from Hay River to the Buffalo River bridge. Owen concentrated on three deposits, located at Mile 12, Mile 21 and Mile 31. These mileages relate to the distances along the highway measured eastward from the junction of Highway Nos. 2 and 5. Owen stated that these three deposits may contain over half of the total quantity of material available to the community and recommended the implementation of a management plan.

The two previously-mentioned studies served to delineate potential granular deposits and made some comments regarding the quality and quantity of material. However, only limited test sampling and laboratory analyses were conducted.

In September, 1977, Bird and Hale Ltd., as prime consultants, and Bruce A. Brown Associates, as sub-consultants, were contracted to conduct a granular materials assessment of the aggregate deposits located at Miles 12, 21, 26 and 31 of Hwy. No. 5. The primary objectives of this study were to evaluate the general potential of the deposits to produce fine and coarse aggregate and general fill material. Further testing will be necessary to determine the suitability of the deposits to produce material for specific uses such as concrete aggregate or Granular A, B and C material. Of equal importance was the development of specific site development and resources management policies for the extraction of granular materials. Secondary objectives were to provide recommendations for the extension of pit licences and development and rehabilitation procedures to assure a ready supply of each available type of aggregate material to all local contractors or users, to control rehabilitation as aggregate is extracted, and to ensure that all granular materials are put to their optimum use. It was recommended in this study that an assessment of the deposits south of Mile 12 be conducted during winter months to avoid the severe summer access problems imposed by the surrounding muskeg conditions.

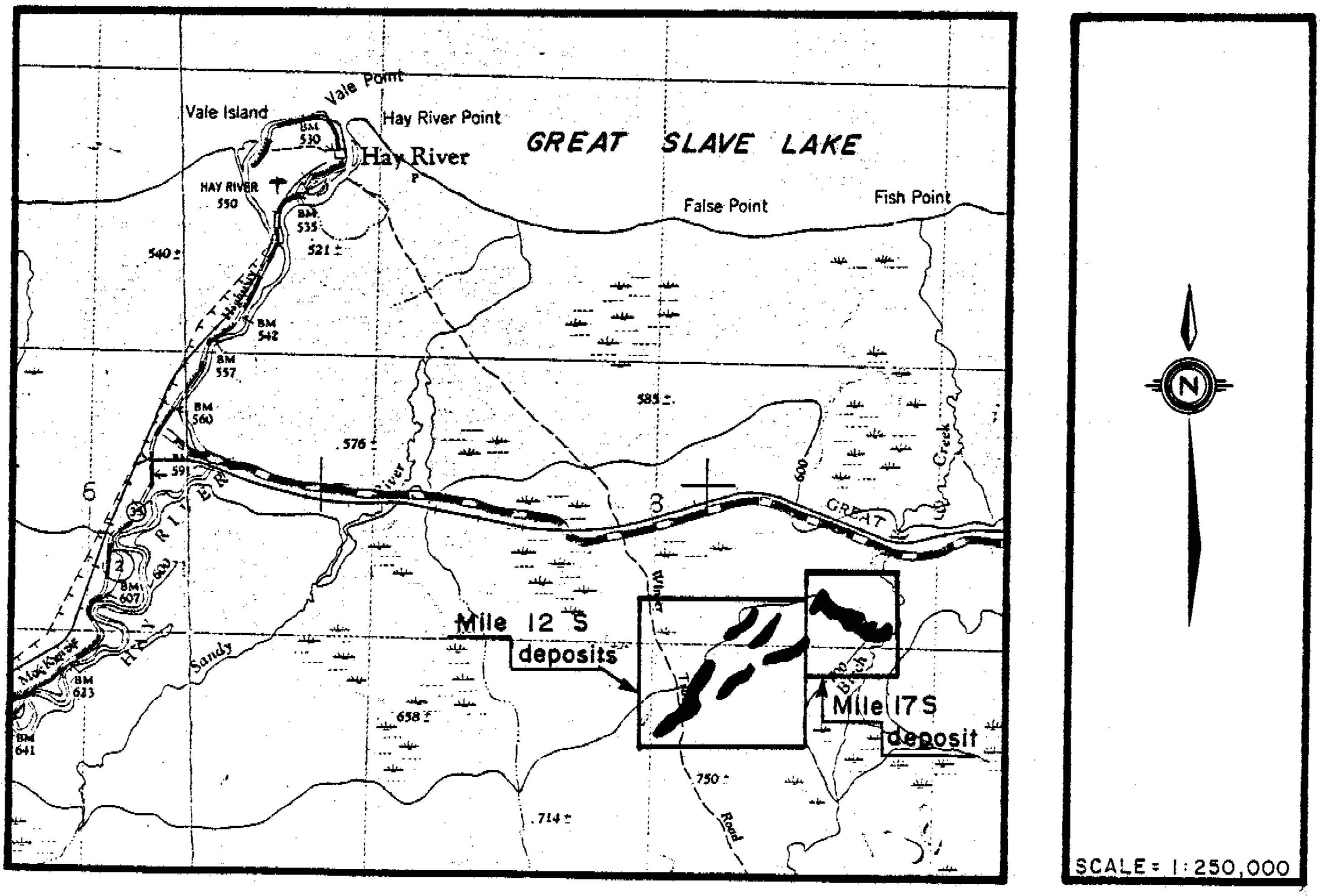
2.3 Study Area Location (see Key Map)

A group of five of the 15 potential sources cited by Ripley, Klohn and Leonoff Ltd. in their 1974 report are the subject of this report. These deposits cover approximately 130 hectares and are located south of Mile 12 and Mile 17 on the Pine Point Highway (Hwy. No. 5) (see Key Map).

2.4 Scope

The primary purpose of the study is to provide information regarding the suitability of the granular material for specific uses, such as concrete aggregate and Granular A, B and C and general fill material.

KEY MAP


Vale Point
Vale Island
Hay River Point
Hay River
GREAT SLAVE LAKE
HAY RIVER
550
BM 530
BM 535
521 ±
540 ±
False Point
Fish Point
BM 542
BM 557
BM 560
585 ±
576 ±
591
600
Creek
GREAT
RIVER
River
Sandy
BM 607
BM 633
BM 641
Mile 12 S
deposits
Mile 17S
deposit
658 ±
750 ±
714 ±
Road
SCALE = 1:250,000

The terms "reserve" and "resources" are used interchangeably in this inventory to describe estimated quantities of possible aggregate material.
However, the term "possible" has been applied according to performance standards of the Association of Professional Engineers of Ontario. According to these standards..."possible ore or inferred ore, is that material for which quantitative estimates are based largely on broad knowledge of the geologic character of the deposit for which there are few, if any, samples or measurements. The estimates are based on an assumed continuity or repetition for which there are reasonable geological indications; these indications may include comparisons with deposits of similar type. Bodies that are completely concealed may be included if there is specific evidence of their presence."

All aggregate reserve data cited in this report are preliminary, since it is based on geological appraisal and analyses of a limited number of field samples. Consequently, the selection and use of any aggregate material in these deposits for selected construction, manufacturing and industrial applications must be based on additional field and laboratory testing.

2.5 Terms of Reference

The terms of reference as set out in Contract No. OSU77-00423, dated March 31, 1978, are presented in Appendix A of this report.

These terms of reference were amended to include the assessment of potential aggregate deposits located south of Mile 17 (Hwy. No. 5). A copy of the letter authorizing this additional work is also included in Appendix A.

2.6 Acknowledgments

We wish to thank the following people for their valuable assistance during this project: Mr. Julian T. Inglis and Mr. Dan Seeking, Department of Indian and Northern Affairs, Ottawa, with whom contract negotiations were conducted; Messrs. Dale Longlitz, Head, Land Use Section, D.I.A.N.D., Yellowknife; Andrew Forbes, Resource Management Officer, Hay River; and Bob Lawson, Land Use Coordinatory, Territorial Government, Hay River, who contributed valuable information regarding local and regional land use management policy.

The cooperation of Mr. Stan Dean of Stan Dean Construction, Hay River, and Mr. Jack Rowe of Rowe Construction, Hay River, was invaluable in the estimation of the alternate all-weather haul road construction costs. They also provided useful information regarding local granular material requirements and physical terrain conditions.

3. METHODOLOGY

3.1 Data Review

No quantitative or qualitative study results, involving test sampling or analysis, have previously been published on the deposits located south of Miles 12 and 17 (Hwy. No. 5). However, unverified estimates of the quality and quantity of granular material in the deposits south of Mile 12 were included in the report published by Ripley, Klohn and Leonoff Ltd. (March, 1974). This report, as well as the report by E. B. Owen (1975) was reviewed prior to field investigations.

Both reports provided valuable information on the regional geology and geomorphology and on aggregate-bearing landforms in the Hay River area. To the knowledge of our study team, no other reports published outside our firm having specific reference to aggregate deposits in the Pine Point Highway-Hay River area were available.

3.2 Mapping Techniques

3.2.1 Base Map Preparation

The most recent (1972) aerial photographs of the study areas at a scale of approximately 1" = 2,050' were obtained from the National Airphoto Library in Ottawa. A semi-controlled mosaic showing the two study areas and the alternate all-weather haul road alignments was assembled. From this mosaic, photo chronaflexes at scales of 1" = 500' and 1" = 2,000', respectively, were produced. These chronaflexes served as reproducible base maps for the graphical presentation of alternative road alignments and granular material, as well as physical terrain information.

3.2.2 Airphoto Interpretation

The use of airphoto interpretation techniques facilitated the preliminary delineation of potential granular deposits. In addition, it aided in the development of the resulting interpretative field reconnaissance and testing program. Data was supplemented and verified as described in Section 3.3 of this report.

3.3 Topographic Reconnaissance and Ground Control

The topographic information required to calculate the estimated reserves was established by standard levelling techniques (i.e., automatic level and levelling rod). An arbitrary elevation of 100 feet (30 meters) was selected as the reference datum from which all intermediate spot elevations were referred on the deposits. Survey base lines were established in order to tie in the network of spot elevations and local boundaries and profiles of the deposits. The topographic contour lines appearing on Dwg. Nos. HRS-2 and HRS-3 have a contour interval of 5 feet (1.5 meters) and were interpolated from the network of spot elevations.

All horizontal distances were established by the use of stadia techniques. The ground truthing data required to accurately calculate the scale of the aerial photographs was obtained by surveying along a cut baseline and between seismic crosslines visible on the photographs.

3.4 Sample Testing Procedures and Aggregate Quality Specifications

All field and additional laboratory sample testing was conducted according to the American Society for Testing and Materials Specifications (A.S.T.M., 1977), as adopted by the Ontario Ministry of Transportation and Communications (M.T.C.) The appropriate test procedures and related aggregate quality specifications are included in Appendix B.

3.5 Field Sampling Procedures

Tentative test pit locations were selected during the preliminary airphoto interpretation phase. In some areas it was necessary to alter the test pit locations due to topographic and access constraints.

Test pits up to 12 feet below grade were excavated using a MF 450S, 3/4 cubic yard, track-mounted hydraulic back-hoe.

Detailed records of soil conditions in each pit were recorded. A description of the material, depth to water table and the final depth of the test pit were also recorded and included.

Standard A.S.T.M. sampling procedures were used throughout the investigation. Composite 4" x 4" channel samples were obtained from freshly exposed pit walls. Also, where variable strata (in excess of 3 feet thickness) occurred, samples were taken from each stratum. Bulk

50 lb. samples were sealed in cloth or polypropylene mesh bags and labelled for transport to the field laboratory in Hay River.

Local contractors indicated an interest in some of the easily accessible and representative test pits being left open for their inspection. Mr. Andrew Forbes agreed that it would be possible to leave a maximum of 10 per cent of the holes open and suggested that the holes that were left open be indicated on the drawings. These are shown on Dwg. Nos. HRS-2 and HRS-3. The remaining test pits were backfilled and compacted to grade. The results of the test pit logs appear in Sections 4.1(ix) and 4.2 (ix) of this report.

3.6 Field Laboratory Procedures

Mechanical sieve analyses were performed on 58 representative samples in order to determine grain size distribution of the material. Bulk samples to be analyzed were coned and quartered, in accordance with A.S.T.M. standard methods, and dry sieved through a nest of U. S. standard screens of 1 1/2", 3/4", 3/8", #4, #8, #16, #30, #50, #100 and #200 sizes.

The size of bulk samples for mechanical analysis was dependent on the relative constituent proportion of cobbles and coarse gravel fractions. Samples with high stone content required 20 lb. for mechanical analysis, in order to obtain statistically valid results; while others with a high proportion of sand and fine gravels required only 10 lb. bulk samples to achieve the same level of accuracy.

Samples which were moist or exhibited slight cohesive properties due to the proportion of silt sizes present, were dried prior to mechanical analysis. The results of the dry sieve analysis for the deposits at Miles 12 and 17 south appear in Sections 4.1 (ix) and 4.2 (ix), respectively.

Following field laboratory investigations, all remaining sample material not sent to Toronto for further detailed analyses was placed in separate bags, re-sealed, numbered and wired closed for storage at the Hay River Forestry Station, for possible future reference, as requested by Mr. Andrew Forbes.

3.7 Additional Laboratory Procedures

The 58 samples tested in our field laboratory were compared and placed in 19 categories exhibiting similar physical characteristics based on field test results and visual examination. A representative 20 lb. sample was selected from each group and sent to Toronto for further analysis.

Mr. George Woda, Geologist-Petrographer (retired) from the Ontario Ministry of Transportation and Communications, acted as technical consultant on the project. He supervised the petrographic analysis, organic content determination and wet sieve analysis on the representative samples.

All laboratory testing was conducted according to A.S.T.M. or M.T.C. specifications (see Appendix B). These tests were conducted by Mr. William Moore, C.E.T., Geological

Technologist, and Mr. Robert Hill, Resource Management Technologist, of our firm under the direct supervision of Mr. George Woda.

Wet sieve and petrographic analyses were completed on all 19 samples. Qualitative organic impurity determination was conducted on all samples exhibiting potential for cement mortar or concrete aggregate.

The following test procedures were employed on all 19 representative samples: Each 20 lb. sample was coned and quartered. One quarter of this material was sieved to minus #4 mesh. Two test samples weighing between 250.0 and 275.0 grams were obtained. These samples were weighed individually and the weights recorded. Each sample was washed on the #200 sieve to remove all minus #200 mesh material. The samples were then dried in an oven at a constant temperature of $110^{\circ} \pm 5^{\circ}$C. The samples were then re-weighed and the percentage of fines (minus #200) was calculated.

In order to obtain approximately 1,000 grams of material passing 3/4" and retained on 3/8" sieve screens, one quarter of the coned and quartered sample was screened through these sieves. A petrographic analysis, according to M.T.C. specifications, was conducted on the samples. The granular material was categorized, as shown on the petrographic sheets included in Sections 4.1 (ix) and 4.2 (ix) of this report. The petrographic number for concrete and hot mix mulch and the corrected granular and 5/8" crushed petrographic numbers were calculated.

Organic impurities determination was conducted on all representative samples which exhibited acceptable petrographic numbers for use in cement mortar or concrete. This test indicates the presence of organic compounds in natural sand which may be injurious to cement mortar or concrete and furnishes a warning that further testing of the sands is necessary. The test method is included in Appendix B.

Based on the geological setting, mode of formation and visual inspection, it is assumed that the granular material in the Miles 12 and 17 south deposits consist of rock types similar to those encountered during our previous study. The results of previous magnesium sulphate soundness tests indicate a maximum weight loss of 6.5% after five test cycles. This loss is well within the accepted limit of 12% for concrete as set by M.T.C. Thus, it is assumed that all of the material has acceptable soundness for concrete, aggregate or lesser uses, such as Granular A and B material.

The results of all additional laboratory tests are included in Sections 4.1 (ix) and 4.2 (ix) of this report.

3.8 Qualitative and Quantitative Analysis of Granular Material

Results of the test pit logs and field and laboratory tests were evaluated. On Drawing Nos. HRS-2 and HRS-3 the granular material exhibiting the greatest potential for the specific uses of concrete aggregate, Granular A, B and C and general fill material were delineated. Although the optimum use designated for the granular material represents the majority of material in a particular area, the complexity and high variability of certain material will give rise to localized variations in optimum material use. In general, however, the designated materials satisfy the respective specifications and require no additional (or only minor) processing and upgrading.

The estimated volumes of available material for each potential use were calculated for both optimum summer and winter extraction. The depth of available material for summer extraction in the majority of the deposits will be limited by the groundwater table. Field observations and discussions with local contractors indicated that the water table in the deposits during summer months will be at the surface elevation of the surrounding muskeg deposits. Test pit excavations indicated an extremely high variation in the ground water table. Thus, the depth of material available for winter extraction will be limited by either the underlying ablation till or the significantly lower water table.

Discussion with local contractors and previous experience indicate that a minimum of 0.8 meters (2.5 feet) of granular material above groundwater table or unacceptable strata after stripping of overburden, is necessary to render extraction of the granular material economic. Therefore, areas possessing less than this depth of granular material were not delineated as granular material on Dwg. Nos. HRS-1, HRS-2 and HRS-3, nor were these areas included in the determination of possible granular material reserves.

The areal extent and extreme variability of the deposits, the difficulties encountered in excavating numerous test pits and the great fluctuations in groundwater table elevations hindered accurate determinations of available material. Therefore, all estimated volumes which appear in Sections 1.1 and 1.2 are approximate and are conditioned as indicated by their respective totals.

3.9 Vegetation and Wildlife Reconnaissance

Observations regarding existing vegetation and wildlife were recorded during field investigations. It was concluded that vegetative and wildlife conditions are similar to those described in the Ripley, Klohn and Leonoff Ltd., 1974, and the Bird and Hale Ltd, 1977, reports.

3.10 Selection of Alternate All-weather Haul Road Alignments (see Dwg. No. HRS-1)

Route 1

The Fort Smith winter road runs south from Mile 11 (Hwy. No. 5) and provided access to the Mile 12 south deposits in the past. Prior to field investigation, it was anticipated that this road would also serve as the most suitable alignment for the construction of an all-weather haul road to the deposits. The Fort Smith road currently transects large areas of open muskeg to avoid thick mature timber; therefore it was found necessary to recommend realignment of a major portion of this road. This alternative alignment was selected by airphoto interpretation techniques and later examined in the field.

Route 2

In order to provide road access to the granular deposits in the vicinity of Mile 17 south, a direct all-weather haul road alignment was selected from Hwy. No. 5, rather than via the Fort Smith road.

The alternate haul road alignments and test pit locations appear on Dwg. No. HRS-1, which is enclosed in Section 4.3 (vi) of this report. The test pit logs appear in Section 4.3 (v).

Airphoto interpretation also facilitated the location of potential access alignments, as indicated on Dwg. No. HRS-1, between the granular deposits.

3.11 Construction Specifications and Cost Estimate Determinations - All-weather Haul Roads

The specifications to which the all-weather haul road should be constructed were determined through discussions with local contractors. These construction specifications are presented in Section 4.3 (iii).

Airphoto interpretation and field investigations facilitated the inventory of physical terrain characteristics along the haul road alignments. This information was given to two local contractors who were asked to estimate the costs of road construction. These estimates were averaged and adjusted where necessary and are presented in Section 4.3 (ii).

4. OBSERVATIONS, CONCLUSIONS AND RECOMMENDATIONS

4.1 Mile 12 South Deposits

(i) Location and Existing Access (see Key Map)

This group of fine deposits is located approximately 4.5 miles south of Mile 11 of the Hay River-Pine Point Highway (Hwy. No. 5) and is approximately 21 miles from the Town of Hay River. Currently, only winter road access is available to the deposits via Hwy. No. 5 and the Fort Smith winter road.

(ii) Regional Geology

The study area, like the entire southern shore of Great Slave Lake near Hay River, is underlain by flat-lying Upper Devonian sedimentary rock. This rock is best shown in section in the incised Hay River channel extending north from Louise Falls to near Enterprise, some 20 miles southwest of the area of investigation. The predominant rock type consists of a uniform buff coloured, slightly dolomitized limestone, overlain by a mantle of uniform ablation till which was deposited by retreating ice. Over the ablation till a series of parallel shorelines were superimposed on the gently north-sloping terrain as the level of Great Slave Lake dropped in a series of stages as ice gradually receded down the MacKenzie River alignment.

The deposits of economic interest are late-stage glaciofluvial and glaciolacustrine features superimposed upon the ablation till.

(iii) Geomorphology

These discontinuous northeast-trending deposits resemble eskers or crevasse fillings formed as the stagnant Laurentide ice sheet melted. These deposits were modified by the wave and current action of post-glacial Great Slave Lake.

As a result, the southeast portions of Deposit Nos. HR109A to HR112A are higher in elevation than in the northwest portions. These areas exhibit aggregates typical to those of slightly modified esker landforms. Areas with a northwest exposure were modified to a landscape of gently sloping beach ridges and sand and gravel terraces.

Some areas, specifically Deposit HR108A, and the north portions of HR110A and HR112A were breached and/or completely submerged by post-glacial Great Slave Lake. This resulted in the majority of the granular material being removed and deposited as cuspate beaches found on the deposits of higher elevation located to the southeast.

The lower northeast and southwest extremities, as well as the northwest slopes of Deposits HR109 to HR112, inclusive, consist of stratified beach deposits of coarse sand and gravel containing a relatively high fines content (minus #200 mesh). The higher elevated southeast portions of these deposits contain sand and gravel typical of all esker landforms. In some locations there is a discontinuous surface layer of boulders with a maximum particle size of 3' diameter.

(iv) Groundwater Conditions

The Mile 12 south deposits are superimposed upon a relatively flat-lying till and a fine sandy till plain exhibiting imperfect drainage and muskeg conditions. No distinct drainage channels, creeks or streams are proximate to these deposits.

As all test pit excavations in these deposits were conducted during the winter months, it was not possible to accurately determine summer groundwater table elevations. However, based on the observations of water table conditions in the previously excavated areas and notably in Deposit HR109A (as well as discussions with local contractors), it was assumed that the summer groundwater table elevation in the deposits will coincide with the surface elevations of the surrounding muskeg deposits. Groundwater was encountered in some of the test pits at depths in excess of 5 feet below the elevation of the surrounding muskeg. Therefore, it may be concluded that the winter to summer water table fluctuation could range from 4 to 5 feet in elevation.

(v) Vegetation and Wildlife

Vegetation and wildlife observations were hindered by winter conditions. However, all observations indicate conditions similar to those described for the Mile 12 deposits as outlined in our previous report.

The undisturbed portion of the eskers contain a uniform overstory of black spruce (picea mariana) 6-12" dbh, 40-50'h, with jack pine (pinus banksiana) 8-15" dbh, 35-45' h, together forming a 65 to 75% canopy. The higher portions contain many windfalls, thus attesting to a lack of root fastness throughout the sandy subsoils.

The understory is predominantly caribou moss and grasses, with a few sedges and occasional wild rose (Rosa spp.). The transition zone to muskeg is characterized by densely covered dwarf tundra birch (Betula glandulosa) in areas of permanent surficial wetness and leather-leaf (Chamaedaphne calyculator) and grasses.

In areas of improved drainage, black spruce continues into the surrounding flat areas; however, diameters are generally 4-8" only, and the canopy is usually 40% maximum.

Areas underlain by granular materials are generally characterized by a very open understory which does not offer sufficient shelter or food sources for small mammals. Although squirrels, lynx, chipmunks and marten are reported in the general area, little direct evidence of other wildlife, except for songbirds, ravens and whiskey jacks, was found in the study area.

A few isolated caribou tracks were found, and minor trails were evident. Beaver are not associated with the flat-lying aggregate deposits but are not uncommon on the creeks which flow between the study areas north to Great Slave Lake.

Surrounding wetlands with dense understory, better shelter, and a greater variety of food sources provides a more suitable environment for small rodent and reptilian fauna.

Pit development to date has been restricted to dry operations, and this will likely continue in the future. Therefore, careful management can help to ensure little disruption through siltation or destruction of surrounding muskeg areas. The very nature of the soils discourages random vehicular access to the surrounding area.

The Ripley, Klohn and Leonoff Ltd., 1974, report indicates that these deposits serve as a grazing area for a small herd of caribou and is an important trapping area.

(vi) Previous Development

Deposit HR109A is the only deposit which has previously been developed for aggregate extraction. Discussions with local contractors indicate that this material was extracted during the winter and was used during the construction of the C.N.R. rail line which parallels Hwy. No. 5. A total of approximately 64,000 cubic meters (84,000 cubic yards) of granular material was extracted for this purpose from two borrow areas, located southwest of the Fort Smith winter road. No extraction has taken place since 1972, the exposure date of the aerial photography used in this study. The subject borrow areas are indicated on Dwg. No. HRS-2, as "Depleted Areas".

(vii) Present Reserve Area

The area dimensions of the granular deposits are listed below:

Deposit	Approximate Length (meters)	(feet)	Average Width (meters)	(feet)	Approximate Area (hectares)	(acres)
HR108A	N/A	N/A	N/A	N/A	N/A	N/A
HR108B	435	1,450	135	450	6.0	15.0
HR109A	1,800	6,000	102	340	19.0	47.0
HR110A	1,575	5,250	114	380	18.5	46.0
HR111A	1,200	4,000	90	300	11.0	27.0
HR112A	1,200	4,000	72	240	9.0	22.0

(viii) Quality and Quantity of Aggregate

The granular deposits have been divided into sections according to the potential of the areas for specific aggregate uses. These sections have been numbered 1 to 15 inclusive on Dwg. No. HRS-2. The approximate area, average estimated depth of working face, estimated volume, potential use and crushing potential of each section appear in Table No. 1.

As defined by the Ontario Ministry of Transportation and Communications "crushable granular material shall be defined as unprocessed gravel containing a minimum of 35% coarse aggregate larger than the #4 sieve".

The boulder content of the aggregate material within these deposits is highly variable within short distances. The majority of the material contains the occasional boulder which may range up to three feet in diameter.

TABLE NO. 1

QUALITATIVE AND QUANTITATIVE ANALYSIS OF GRANULAR MATERIAL

FOR MILE 12 SOUTH

Section (see Dwg. No. HRS-2)	Area (Hectares)	Average Estimate Depth of Working Face: Winter Extraction (m)	(ft)	Summer Extraction (m)	(ft)	Estimated (±25%) Volume Winter Extraction $(m^3)/(yd^3)$	Estimated (±25%) Volume Summer Extraction $(m^3)/(yd^3)$	Potential Use	Minimal Upgrading to Meet Concrete Aggregate Specifications	Required Upgrading for Concrete Aggregate	* Crushing Potential
1	7.6	1.8	(6)	0.9	(3)	105,000/135,000	50,000/ 70,000	C			X
2	5.8	2.1	(7)	1.5	(5)	95,000/125,000	70,000/ 85,000	B			X
3	2.5	3.7	(12)	2.4	(8)	70,000/ 90,000	45,000/ 60,000	A	X	Washing & screening	X
4	3.2	1.8	(6)	1.2	(4)	45,000/ 60,000	30,000/ 40,000	C			X
5	4.4	1.8	(6)	1.2	(4)	60,000/ 80,000	40,000/ 50,000	GF			X
6	3.0	2.4	(8)	1.5	(5)	55,000/ 70,000	35,000/ 45,000	A	X	Washing & screening	X
7	1.5	1.8	(6)	1.2	(4)	20,000/ 25,000	15,000/ 20,000	GF			X
8	11.4	1.2	(4)	0.8	(2.5)	105,000/135,000	65,000/ 85,000	C			X
9	1.0	1.2	(4)	0.8	(2.5)	8,000/ 10,000	6,000/ 8,000	GF			X
10	6.1	2.1	(7)	1.5	(5)	100,000/130,000	70,000/ 90,000	A	X	Washing & screening	X
11	6.1	1.5	(5)	0.9	(3)	70,000/ 90,000	40,000/ 55,000	C			
12	1.3	1.5	(5)	0.9	(3)	15,000/ 20,000	8,000/ 10,000	GF			X
13	3.6	1.5	(5)	0.9	(3)	40,000/ 50,000	25,000/ 35,000	C			X
14	5.3	3.0	(10)	2.1	(7)	120,000/160,000	85,000/110,000	B			X
15	0.9	1.5	(5)	0.9	(3)	10,000/ 15,000	6,000/ 8,000	GF			X

* See Appendix C

This may necessitate the use of a rock or bar screen to remove the boulders prior to the use of the material as granular A, B, or C material. The larger boulders retained on the bars could be stockpiled and when there are enough, they may be crushed. Also these boulders may be used for other purposes such as, rip-rap or gabion construction material. Generally the material designated as possessing potential for Granular A and B has a low boulder content and that designated as C and general fill has a relatively high content.

A description of the individual deposits and the unique characteristics of each are outlined below.

(a) Deposit HR108A

Airphoto interpretation and field investigation indicated this to be an extremely low-lying deposit having a maximum elevation above the surrounding muskeg of approximately 1 meter (3.28 ft.). The excavation of five test pits confirmed a maximum depth of approximately 1 meter (3.28 ft.) of well graded granular material containing numerous boulders and approximately 8% fines (passing #200, washed sieve). Silty clay was encountered in the bottom of all test pits.

For the reasons described in Section 3.8, the extraction of granular material in this does not appear to be economically feasible.

(b) Deposit HR108B

This is also a low-lying deposit which consists of approximately 80% sand by weight. Due to its topographic character it has limited summer extraction potential.

Winter extraction potential is much greater. This material does not exhibit crushing potential.

(c) <u>Deposit HR109A</u>

The results of all test pit excavation, and field and additional laboratory test results indicate that this deposit contains material which exhibits potential for concrete aggregate, as well as Granular A, B, and C material. In addition, all of this material would be suitable as fill. However, due to the large amounts of general fill available in other deposits it is recommended that this material be retained for uses requiring more rigid specifications.

The material in section 1 consists primarily of gravel and is gap graded. Section 2 is primarily gap graded sand, section 3 is well graded sand and gravel and section 4 contains approximately equal proportions of sand and gravel.

(d) <u>Deposit HR110A</u>

This deposit contains material which exhibits potential for granular A, C and general fill material. The northern portion of the deposit has an extremely low profile relative to the surrounding muskeg. Also the material contains a high boulder and fines content. Thus this area was not considered as an economical deposit.

The material in section 8 is predominantly sand and contains a highly variable fines content (6 to 12% wet sieve). Section 9 is predominately gravel and has a fines content of approximately 12%.

The material in Area 10 is well graded and consists primarily of gravel.

(e) Deposit HR111A

This deposit contains material which exhibits potential as Granular B, C and general fill material. Sections 12, 13 and 15 consist of approximately even portions of sand and gravel. The material in Section 14 is predominately gravel.

(f) Deposit HR112A

The majority of material in this deposit has been designated as general fill material primarily because it is gap graded. The area designated as potential Granular A material is well graded and consists primarily of gravel.

(IX) RESULTS OF LABORATORY TESTING AND TEST PIT LOGS

(Mile 12 South)

Ministry of Transportation and Communications
Ontario

COARSE AGGREGATE PETROGRAPHIC ANALYSIS

PIT NAME HR-109A LAB. NO. TP-8
DATE APRIL 22, 1978 FRACTION RETAIN 3/8 PASS 3/4 ANALYST W. R. MOORE

TYPE NO.	TYPE	WEIGHT	%	GRANULAR & 5/8" CRUSHED CORRECTION	
1	CARBONATES (hard)	632.0	64.0		
20	CARBONATES (slightly weathered)	44.0	4.4		
2	CARBONATES (sandy, hard)				
21	CARBONATES (sandy, medium hard)				
23	CARBONATES CRYSTALLINE (hard)	11.0	1.1		
3	SANDSTONE (hard)	9.0	0.9		
22	SANDSTONE (medium hard)				
4	GNEISS - SCHIST (hard)				
5	QUARTZITE (coarse and fine grained)				
6	GREYWACKE - ARKOSE (hard and medium hard)	20.0	2.0		
7	VOLCANIC (hard and slightly weathered)				
8	GRANITE - DIORITE - GABBRO	209.0	21.1		
9	TRAP				
	TOTAL GOOD AGGREGATE		93.5		
24	CARBONATES CRYSTALLINE (slightly weathered)			×2	
40	CARBONATES (soft; slightly shaley)			×2	
41	CARBONATES (sandy, soft and soft pitted)			×2	
42	CARBONATES (deeply weathered)	25.0	2.5		
25	GNEISS (soft) SCHIST (medium hard)			×2	
26	CHERT - CHERTY CARBONATES			×2	
27	GRANITE - DIORITE - GABBRO (brittle)			×2	
28	VOLCANIC (soft)			×2	
52	ENCRUSTATION	10.0	1.0	×2	2.0
29	ARGILLITE			×2	
	TOTAL FAIR AGGREGATE		3.5		
43	CARBONATES (shaley or clayey)	30.0	3.0		
44	CARBONATES (ochreous)				
45	CHERT - CHERTY CARBONATES (leached)			×5	
46	SANDSTONE (soft friable)			×3	
48	VOLCANIC (very soft, porous)			×3	
49	CARBONATES CRYSTALLINE (soft)			×3	
50	GNEISS (friable)			×3	
51	GRANITE - DIORITE - GABBRO (friable)			×3	
53	CEMENTATIONS			×3	
54	CEMENTATIONS (total)			×3	
55	SCHIST (soft)			×3	
56	SILTSTONE			×3	
	TOTAL POOR AGGREGATE		3.0		
60	OCHRE				
61	SHALE				
62	CLAY				
63	VOLCANIC OR SCHIST (decomposed)				
	TOTAL DELETERIOUS AGGREGATE				
	TOTALS	990.0	100.0		2.0

% GOOD 93.5 ×1 = 93.5
% FAIR 3.5 ×3 = 10.5
% POOR 3.0 ×6 = 18.0
% DELETERIOUS 0 ×10 = 0

EST. PERCENT CRUSHED	
EST. PERCENT FLATS & ELONGATED	

HOT MIX, MULCH AND CONCRETE P.N.	122.0
CORRECTED GRANULAR AND 5/8" CRUSHED P.N.	120.0

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COARSE AGGREGATE PETROGRAPHIC ANALYSIS

PIT NAME HR-109A LAB. NO. TP-9
DATE APRIL 25, 1978 FRACTION RETAIN 3/8, PASS. 3/4 ANALYST W. R. MOORE

TYPE NO.	TYPE	WEIGHT	%	GRANULAR & 5/8" CRUSHED CORRECTION	
1	CARBONATES (hard)	510	59.6		
20	CARBONATES (slightly weathered)	63	7.4		
2	CARBONATES (sandy, hard)				
21	CARBONATES (sandy, medium hard)				
23	CARBONATES CRYSTALLINE (hard)				
3	SANDSTONE (hard)				
22	SANDSTONE (medium hard)				
4	GNEISS - SCHIST (hard)				
5	QUARTZITE (coarse and fine grained)				
6	GREYWACKE - ARKOSE (hard and medium hard)	14	1.6		
7	VOLCANIC (hard and slightly weathered)				
8	GRANITE - DIORITE - GABBRO	146	17.1		
9	TRAP				
	TOTAL GOOD AGGREGATE		85.7		
24	CARBONATES CRYSTALLINE (slightly weathered)			×2	
40	CARBONATES (soft; slightly shaley)			×2	
41	CARBONATES (sandy, soft and soft pitted)			×2	
42	CARBONATES (deeply weathered)				
25	GNEISS (soft) SCHIST (medium hard)			×2	
26	CHERT - CHERTY CARBONATES			×2	
27	GRANITE - DIORITE - GABBRO (brittle)			×2	
28	VOLCANIC (soft)			×2	
52	ENCRUSTATION	117	13.7	×2	27.4
29	ARGILLITE			×2	
	TOTAL FAIR AGGREGATE		13.7		
43	CARBONATES (shaley or clayey)				
44	CARBONATES (ochreous)				
45	CHERT - CHERTY CARBONATES (leached)			×5	
46	SANDSTONE (soft friable)			×3	
48	VOLCANIC (very soft, porous)			×3	
49	CARBONATES CRYSTALLINE (soft)			×3	
50	GNEISS (friable)	1	0.1	×3	0.3
51	GRANITE - DIORITE - GABBRO (friable)			×3	
53	CEMENTATIONS			×3	
54	CEMENTATIONS (total)			×3	
55	SCHIST (soft)			×3	
56	SILTSTONE			×3	
	TOTAL POOR AGGREGATE		0.1		
60	OCHRE	4	0.5		
61	SHALE				
62	CLAY				
63	VOLCANIC OR SCHIST (decomposed)				
	TOTAL DELETERIOUS AGGREGATE		0.5		
	TOTALS	855	100.0		27.7

% GOOD 85.7 ×1 = 85.7

% FAIR 13.7 ×3 = 41.1

% POOR 0.1 ×6 = 0.6

% DELETERIOUS 0.5 ×10 = 5.0

HOT MIX, MULCH AND CONCRETE P.N.	132.4

EST. PERCENT CRUSHED	
EST. PERCENT FLATS & ELONGATED	

CORRECTED GRANULAR AND 5/8" CRUSHED P.N.	104.7

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Ministry of Transportation and Communications
Ontario

COARSE AGGREGATE PETROGRAPHIC ANALYSIS

PIT NAME HR 109 A LAB. NO. TP-14

DATE APRIL 22, 1978 FRACTION RETAIN 3/8, PASS 3/4 ANALYST W. R. MOORE

TYPE NO.	TYPE	WEIGHT	%	GRANULAR & 5/8" CRUSHED CORRECTION	
1	CARBONATES (hard)	610.0	61.0		
20	CARBONATES (slightly weathered)	74.0	7.4		
2	CARBONATES (sandy, hard)				
21	CARBONATES (sandy, medium hard)				
23	CARBONATES CRYSTALLINE (hard)	13.0	1.3		
3	SANDSTONE (hard)				
22	SANDSTONE (medium hard)				
4	GNEISS - SCHIST (hard)	10.0	1.0		
5	QUARTZITE (coarse and fine grained)				
6	GREYWACKE - ARKOSE (hard and medium hard)	20.0	2.0		
7	VOLCANIC (hard and slightly weathered)				
8	GRANITE - DIORITE - GABBRO	198.0	19.8		
9	TRAP				
	TOTAL GOOD AGGREGATE		92.5		
24	CARBONATES CRYSTALLINE (slightly weathered)			× 2	
40	CARBONATES (soft; slightly shaley)			× 2	
41	CARBONATES (sandy, soft and soft pitted)			× 2	
42	CARBONATES (deeply weathered)	14.0	1.4		
25	GNEISS (soft) SCHIST (medium hard)			× 2	
26	CHERT - CHERTY CARBONATES			× 2	
27	GRANITE - DIORITE - GABBRO (brittle)			× 2	
28	VOLCANIC (soft)			× 2	
52	ENCRUSTATION	52.0	5.2	× 2	10.4
29	ARGILLITE			× 2	
	TOTAL FAIR AGGREGATE		6.6		
43	CARBONATES (shaley or clayey)	9.0	0.9		
44	CARBONATES (ochreous)				
45	CHERT - CHERTY CARBONATES (leached)			× 5	
46	SANDSTONE (soft friable)			× 3	
48	VOLCANIC (very soft, porous)			× 3	
49	CARBONATES CRYSTALLINE (soft)			× 3	
50	GNEISS (friable)			× 3	
51	GRANITE - DIORITE - GABBRO (friable)			× 3	
53	CEMENTATIONS			× 3	
54	CEMENTATIONS (total)			× 3	
55	SCHIST (soft)			× 3	
56	SILTSTONE			× 3	
	TOTAL POOR AGGREGATE		0.9		
60	OCHRE				
61	SHALE				
62	CLAY				
63	VOLCANIC OR SCHIST (decomposed)				
	TOTAL DELETERIOUS AGGREGATE				
	TOTALS	1000	100		10.4

% GOOD 92.5 × 1 = 92.5

% FAIR 6.6 × 3 = 19.8

% POOR 0.9 × 6 = 5.4

% DELETERIOUS 0 × 10 = 0

EST. PERCENT CRUSHED	
EST. PERCENT FLATS & ELONGATED	

HOT MIX, MULCH AND CONCRETE P.N.	117.7
CORRECTED GRANULAR AND 5/8" CRUSHED P.N.	107.3

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Ministry of Transportation and Communications
Ontario

COARSE AGGREGATE PETROGRAPHIC ANALYSIS

PIT NAME HR 110A LAB. NO. TP-18
DATE APRIL 24, 1978 FRACTION RETAIN 3/8, PASS 3/4 ANALYST W. R. MOORE

TYPE NO.	TYPE	WEIGHT	%	GRANULAR & 5/8" CRUSHED CORRECTION	
1	CARBONATES (hard)	492.0	54.2		
20	CARBONATES (slightly weathered)	54.0	6.0		
2	CARBONATES (sandy, hard)				
21	CARBONATES (sandy, medium hard)				
23	CARBONATES CRYSTALLINE (hard)	14.0	1.5		
3	SANDSTONE (hard)	11.0	1.2		
22	SANDSTONE (medium hard)				
4	GNEISS - SCHIST (hard)				
5	QUARTZITE (coarse and fine grained)				
6	GREYWACKE - ARKOSE (hard and medium hard)	14.0	1.5		
7	VOLCANIC (hard and slightly weathered)				
8	GRANITE - DIORITE - GABBRO	209.0	23.0		
9	TRAP				
	TOTAL GOOD AGGREGATE		87.4		
24	CARBONATES CRYSTALLINE (slightly weathered)			×2	
40	CARBONATES (soft; slightly shaley)			×2	
41	CARBONATES (sandy, soft and soft pitted)			×2	
42	CARBONATES (deeply weathered)	21.0	2.3		
25	GNEISS (soft) SCHIST (medium hard)	9.0	1.0	×2	2.0
26	CHERT - CHERTY CARBONATES			×2	
27	GRANITE - DIORITE - GABBRO (brittle)			×2	
28	VOLCANIC (soft)			×2	
52	ENCRUSTATION	52.0	5.7	×2	11.4
29	ARGILLITE			×2	
	TOTAL FAIR AGGREGATE		9.0		
43	CARBONATES (shaley or clayey)				
44	CARBONATES (ochreous)				
45	CHERT - CHERTY CARBONATES (leached)			×5	
46	SANDSTONE (soft friable)			×3	
48	VOLCANIC (very soft, porous)			×3	
49	CARBONATES CRYSTALLINE (soft)			×3	
50	GNEISS (friable)	7.0	0.8	×3	2.4
51	GRANITE - DIORITE - GABBRO (friable)			×3	
53	CEMENTATIONS			×3	
54	CEMENTATIONS (total)			×3	
55	SCHIST (soft)			×3	
56	SILTSTONE			×3	
	TOTAL POOR AGGREGATE		0.8		
60	OCHRE				
61	SHALE	7.0	0.8		
62	CLAY	17.0	1.9		
63	VOLCANIC OR SCHIST (decomposed)				
	TOTAL DELETERIOUS AGGREGATE		2.7		
	TOTALS	907	100.0		15.8

% GOOD 87.4 ×1 = 87.4
% FAIR 9.0 ×3 = 27.0
% POOR 0.8 ×6 = 4.8
% DELETERIOUS 2.7 ×10 = 27.0

EST. PERCENT CRUSHED	
EST. PERCENT FLATS & ELONGATED	

HOT MIX, MULCH AND CONCRETE P.N.	146.2
CORRECTED GRANULAR AND 5/8" CRUSHED P.N.	130.4

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COARSE AGGREGATE PETROGRAPHIC ANALYSIS

PIT NAME HR - 110A LAB. NO. TP-20
DATE APRIL 22, 1978 FRACTION RETAIN 3/8 PASS 3/4 ANALYST R. HILL

TYPE NO.	TYPE	WEIGHT	%	GRANULAR & 5/8" CRUSHED CORRECTION	
1	CARBONATES (hard)	227.0	22.8		
20	CARBONATES (slightly weathered)	39.0	3.9		
2	CARBONATES (sandy, hard)				
21	CARBONATES (sandy, medium hard)				
23	CARBONATES CRYSTALLINE (hard)				
3	SANDSTONE (hard)				
22	SANDSTONE (medium hard)				
4	GNEISS - SCHIST (hard)				
5	QUARTZITE (coarse and fine grained)				
6	GREYWACKE - ARKOSE (hard and medium hard)				
7	VOLCANIC (hard and slightly weathered)				
8	GRANITE - DIORITE - GABBRO	264.0	26.6		
9	TRAP				
	TOTAL GOOD AGGREGATE		53.3		
24	CARBONATES CRYSTALLINE (slightly weathered)			×2	
40	CARBONATES (soft; slightly shaley)			×2	
41	CARBONATES (sandy, soft and soft pitted)			×2	
42	CARBONATES (deeply weathered)	32.0	3.2		
25	GNEISS (soft) SCHIST (medium hard)			×2	
26	CHERT - CHERTY CARBONATES			×2	
27	GRANITE - DIORITE - GABBRO (brittle)			×2	
28	VOLCANIC (soft)			×2	
52	ENCRUSTATION	373.0	37.6	×2	75.2
29	ARGILLITE			×2	
	TOTAL FAIR AGGREGATE		40.8		
43	CARBONATES (shaley or clayey)	46.0	4.6		
44	CARBONATES (ochreous)				
45	CHERT - CHERTY CARBONATES (leached)			×5	
46	SANDSTONE (soft friable)			×3	
48	VOLCANIC (very soft, porous)			×3	
49	CARBONATES CRYSTALLINE (soft)			×3	
50	GNEISS (friable)			×3	
51	GRANITE - DIORITE - GABBRO (friable)			×3	
53	CEMENTATIONS			×3	
54	CEMENTATIONS (total)			×3	
55	SCHIST (soft)			×3	
56	SILTSTONE			×3	
	TOTAL POOR AGGREGATE		4.6		
60	OCHRE	13.0	1.3		
61	SHALE				
62	CLAY				
63	VOLCANIC OR SCHIST (decomposed)				
	TOTAL DELETERIOUS AGGREGATE		1.3		
	TOTALS	994.0	100.0		75.2

% GOOD 53.3 ×1 = 53.3

% FAIR 40.8 ×3 = 122.4

% POOR 4.6 ×6 = 27.6

% DELETERIOUS 1.3 ×10 = 13.0

HOT MIX, MULCH AND CONCRETE P.N.	216.3

EST. PERCENT CRUSHED	
EST. PERCENT FLATS & ELONGATED	
CORRECTED GRANULAR AND 5/8" CRUSHED P.N.	141.1

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COARSE AGGREGATE PETROGRAPHIC ANALYSIS

PIT NAME *HR 112A* LAB. NO. *TP-24*

DATE *APRIL 22, 1978* FRACTION *RETAIN 3/8, PASS 3/4* ANALYST *R- HILL*

TYPE NO.	TYPE	WEIGHT	%	GRANULAR & 5/8" CRUSHED CORRECTION	
1	CARBONATES (hard)	164.0	16.4		16.4
20	CARBONATES (slightly weathered)	109.0	10.9		10.9
2	CARBONATES (sandy, hard)				
21	CARBONATES (sandy, medium hard)				
23	CARBONATES CRYSTALLINE (hard)				
3	SANDSTONE (hard)				
22	SANDSTONE (medium hard)				
4	GNEISS - SCHIST (hard)				
5	QUARTZITE (coarse and fine grained)				
6	GREYWACKE - ARKOSE (hard and medium hard)				
7	VOLCANIC (hard and slightly weathered)				
8	GRANITE - DIORITE - GABBRO	125.0	12.5		
9	TRAP				
	TOTAL GOOD AGGREGATE		39.8		
24	CARBONATES CRYSTALLINE (slightly weathered)			×2	
40	CARBONATES (soft; slightly shalay)			×2	
41	CARBONATES (sandy, soft and soft pitted)			×2	
42	CARBONATES (deeply weathered)	38.0	3.8		
25	GNEISS (soft) SCHIST (medium hard)			×2	
26	CHERT - CHERTY CARBONATES			×2	
27	GRANITE - DIORITE - GABBRO (brittle)			×2	
28	VOLCANIC (soft)			×2	
52	ENCRUSTATION	549.0	54.9	×2	109.8
29	ARGILLITE			×2	
	TOTAL FAIR AGGREGATE		58.7		
43	CARBONATES (shaley or clayey)				
44	CARBONATES (ochreous)				
45	CHERT - CHERTY CARBONATES (leached)			×5	
46	SANDSTONE (soft friable)			×3	
48	VOLCANIC (very soft, porous)			×3	
49	CARBONATES CRYSTALLINE (soft)			×3	
50	GNEISS (friable)			×3	
51	GRANITE - DIORITE - GABBRO (friable)			×3	
53	CEMENTATIONS			×3	
54	CEMENTATIONS (total)			×3	
55	SCHIST (soft)			×3	
56	SILTSTONE			×3	
	TOTAL POOR AGGREGATE				
60	OCHRE	15.0	1.5		
61	SHALE				
62	CLAY				
63	VOLCANIC OR SCHIST (decomposed)				
	TOTAL DELETERIOUS AGGREGATE		1.5		
	TOTALS	1000.0	100		109.8

% GOOD *39.8* ×1 = *39.8*

% FAIR *58.7* ×3 = *176.1*

% POOR *–* ×6 = *–*

% DELETERIOUS *1.5* ×10 = *15*

EST. PERCENT CRUSHED	
EST. PERCENT FLATS & ELONGATED	

HOT MIX, MULCH AND CONCRETE P.N.	*230.9*
CORRECTED GRANULAR AND 5/8" CRUSHED P.N.	*121.1*

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COARSE AGGREGATE PETROGRAPHIC ANALYSIS

PIT NAME HR 112A LAB. NO. TP-25A
DATE APRIL 26, 1978 FRACTION RETAIN 3/8, PASS 3/4 ANALYST W. R. MOORE

TYPE NO.	TYPE	WEIGHT	%	GRANULAR & 5/8" CRUSHED CORRECTION	
1	CARBONATES (hard)	80.0	10.3		
20	CARBONATES (slightly weathered)	60.0	7.7		
2	CARBONATES (sandy, hard)				
21	CARBONATES (sandy, medium hard)				
23	CARBONATES CRYSTALLINE (hard)				
3	SANDSTONE (hard)				
22	SANDSTONE (medium hard)				
4	GNEISS - SCHIST (hard)				
5	QUARTZITE (coarse and fine grained)				
6	GREYWACKE - ARKOSE (hard and medium hard)				
7	VOLCANIC (hard and slightly weathered)				
8	GRANITE - DIORITE - GABBRO	40.0	5.2		
9	TRAP				
	TOTAL GOOD AGGREGATE		23.2		
24	CARBONATES CRYSTALLINE (slightly weathered)			×2	
40	CARBONATES (soft; slightly shaley)			×2	
41	CARBONATES (sandy, soft and soft pitted)			×2	
42	CARBONATES (deeply weathered)	27.0	3.5		
25	GNEISS (soft) SCHIST (medium hard)			×2	
26	CHERT - CHERTY CARBONATES			×2	
27	GRANITE - DIORITE - GABBRO (brittle)			×2	
28	VOLCANIC (soft)			×2	
52	ENCRUSTATION	543.0	70.0	×2	140
29	ARGILLITE			×2	
	TOTAL FAIR AGGREGATE		73.5		
43	CARBONATES (shaley or clayey)	8.0	1.0		
44	CARBONATES (ochreous)				
45	CHERT - CHERTY CARBONATES (leached)			×5	
46	SANDSTONE (soft friable)			×3	
48	VOLCANIC (very soft, porous)			×3	
49	CARBONATES CRYSTALLINE (soft)			×3	
50	GNEISS (friable)	13.0	1.7	×3	5.1
51	GRANITE - DIORITE - GABBRO (friable)			×3	
53	CEMENTATIONS			×3	
54	CEMENTATIONS (total)			×3	
55	SCHIST (soft)			×3	
56	SILTSTONE			×3	
	TOTAL POOR AGGREGATE		2.7		
60	OCHRE				
61	SHALE	4.0	0.5		
62	CLAY				
63	VOLCANIC OR SCHIST (decomposed)				
	TOTAL DELETERIOUS AGGREGATE		0.5		
	TOTALS	775.0	99.9		145.1

% GOOD 23.2 ×1 = 23.2
% FAIR 73.5 ×3 = 220.5
% POOR 2.7 ×6 = 16.2
% DELETERIOUS 0.5 ×10 = 5.0

EST. PERCENT CRUSHED	
EST. PERCENT FLATS & ELONGATED	

HOT MIX, MULCH AND CONCRETE P.N.	264.9
CORRECTED GRANULAR AND 5/8" CRUSHED P.N.	119.8

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DRY SIEVE ANALYSIS AND TEST PIT LOGS

SAMPLE TP-1 (109 A) DATE APRIL 3, 1978 NAME W. R. MOORE

Remarks: GRAVEL - 51.2% SAND - 47.6% FINES - 1.2%

WASHED SIEVE (% FINES PASSING # 200) 8%

DRY SIEVING

Sieve No.	Mass Retained	Percent Retained	Cumulative % Passing
1½	0	–	–
3/4	157.7	12.0	88.0
3/8	217.6	16.7	71.3
4	295.2	22.5	48.8
10	323.9	24.7	24.1
16	134.1	10.2	13.9
30	116.6	8.9	5.0
50	33.1	2.5	2.5
100	8.1	0.6	1.9
200	9.4	0.7	1.2
PAN	11.9	0.9	
TOTALS	1307.6	100.0	

TEST PIT LOG

TEST PIT LOCATION (SEE DWG No HRS 2 & 3)

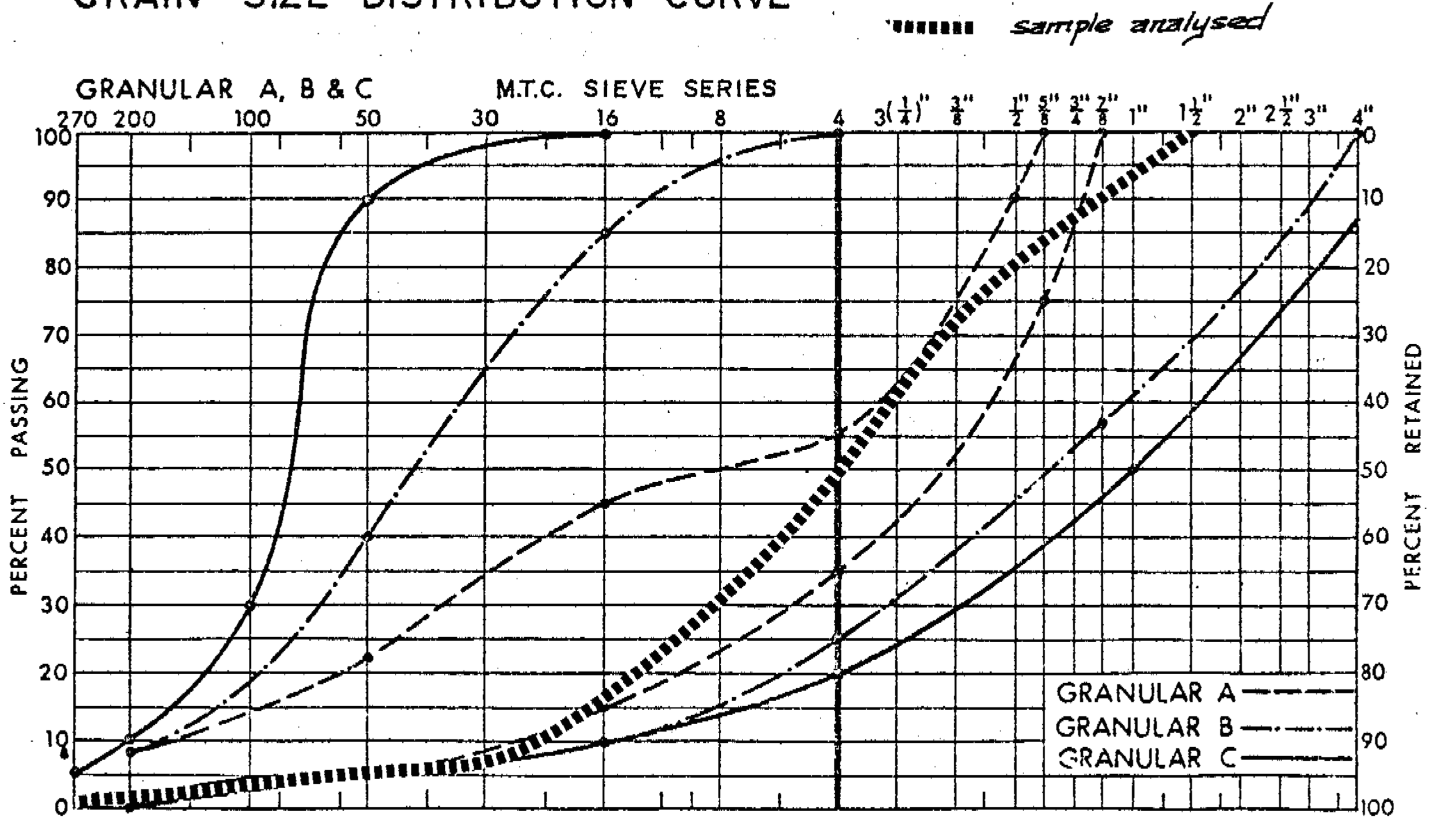
0'
fine gravel some sand

2'
stratified gravel some sand MPS-3"

6'
stratified gravel some sand and cobbles MPS-5"

8'
silty clay till

GRAIN SIZE DISTRIBUTION CURVE



DRY SIEVE ANALYSIS AND TEST PIT LOGS

SAMPLE ....TP-2 (109 A).... DATE ...APRIL 3, 1978. NAME .. R. HILL..........

Remarks : GRAVEL - 59.2% SAND - 38.6% FINES - 2.2%

WASHED SIEVE (% FINES PASSING #200) 8%

DRY SIEVING

Sieve No.	Mass Retained	Percent Retained	Cumulative % Passing
1½	796.5	-	-
3/4	454.8	25.5	74.5
3/8	331.3	18.6	55.9
4	268.1	15.1	40.8
10	235.8	13.2	27.6
16	185.8	10.4	17.2
30	149.5	8.4	8.8
50	56.8	3.2	5.6
100	35.9	2.0	3.6
200	25.6	1.4	2.2
PAN	28.0	1.6	
Totals	1771.6	100.0	

TEST PIT LOG

TEST PIT LOCATION (SEE DWG No HRS 2 & 3)

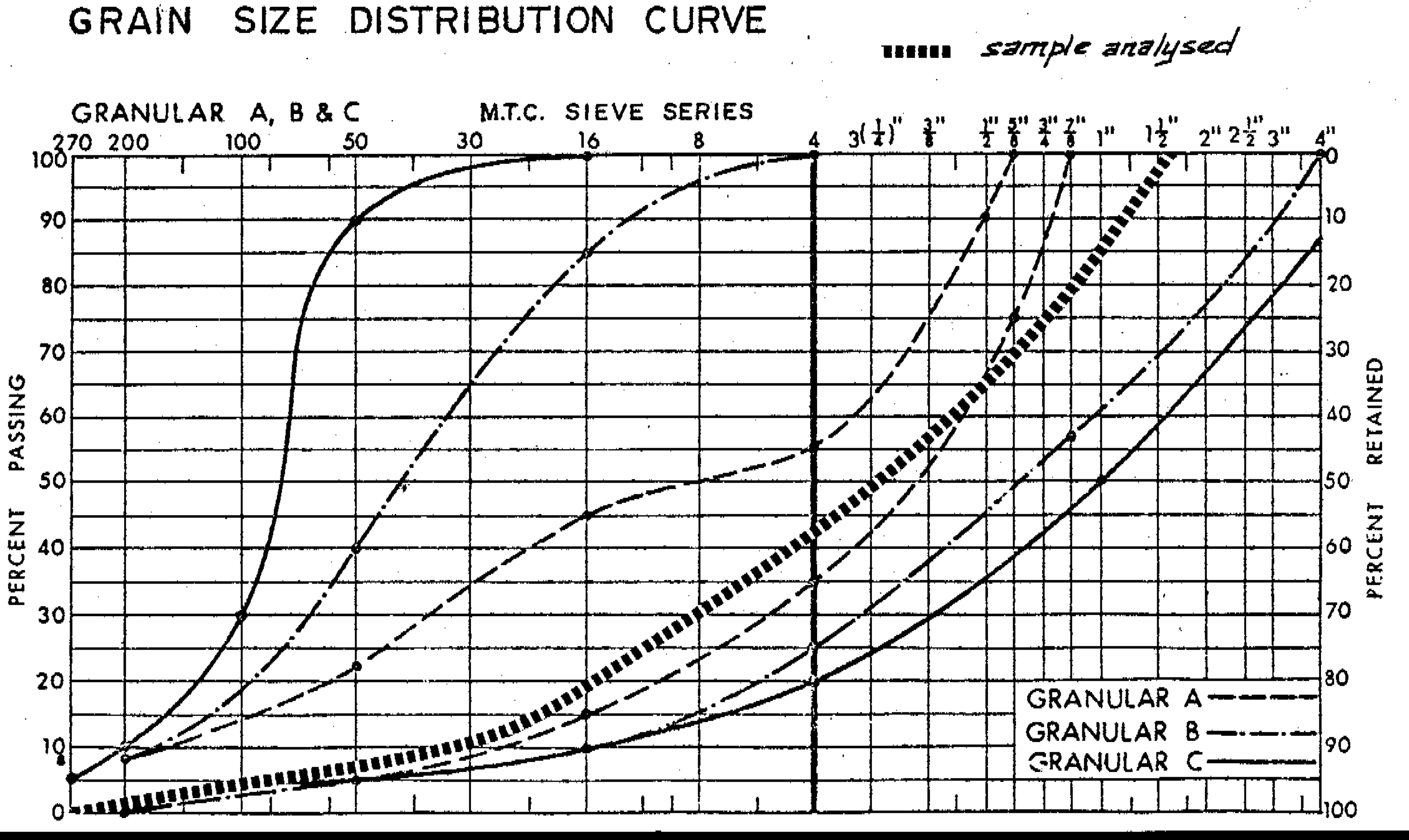
0'
silty fine sand

6'
stratified sand and gravel MPS-3

4'
fine sand with cobbles & occ. boulders MPS-10

6'
silty clay till

GRAIN SIZE DISTRIBUTION CURVE



DRY SIEVE ANALYSIS AND TEST PIT LOGS

SAMPLE TP-3 (109A) DATE APRIL 3, 1978 NAME W. R. MOORE

Remarks : GRAVEL 58.1 % SAND 40.1 % FINES 1.8 %

WASHED SIEVE (% FINES PASSING #200) 8 %

DRY SIEVING

Sieve No.	Mass Retained	Percent Retained	Cumulative % Passing
1½	836.7	-	-
3/4	219.8	14.6	85.4
3/8	338.9	22.4	63.0
4	318.2	21.1	41.9
10	252.9	16.7	25.2
16	162.9	10.8	14.4
30	129.7	8.6	5.8
50	24.0	1.6	4.2
100	18.5	1.2	3.0
200	18.7	1.2	1.8
PAN	22.0	1.6	
Totals	1505.6	100.0	

TEST PIT LOG

TEST PIT LOCATION (SEE DWG No HRS 2 & 3)

0′
fine - med. gravel some silt

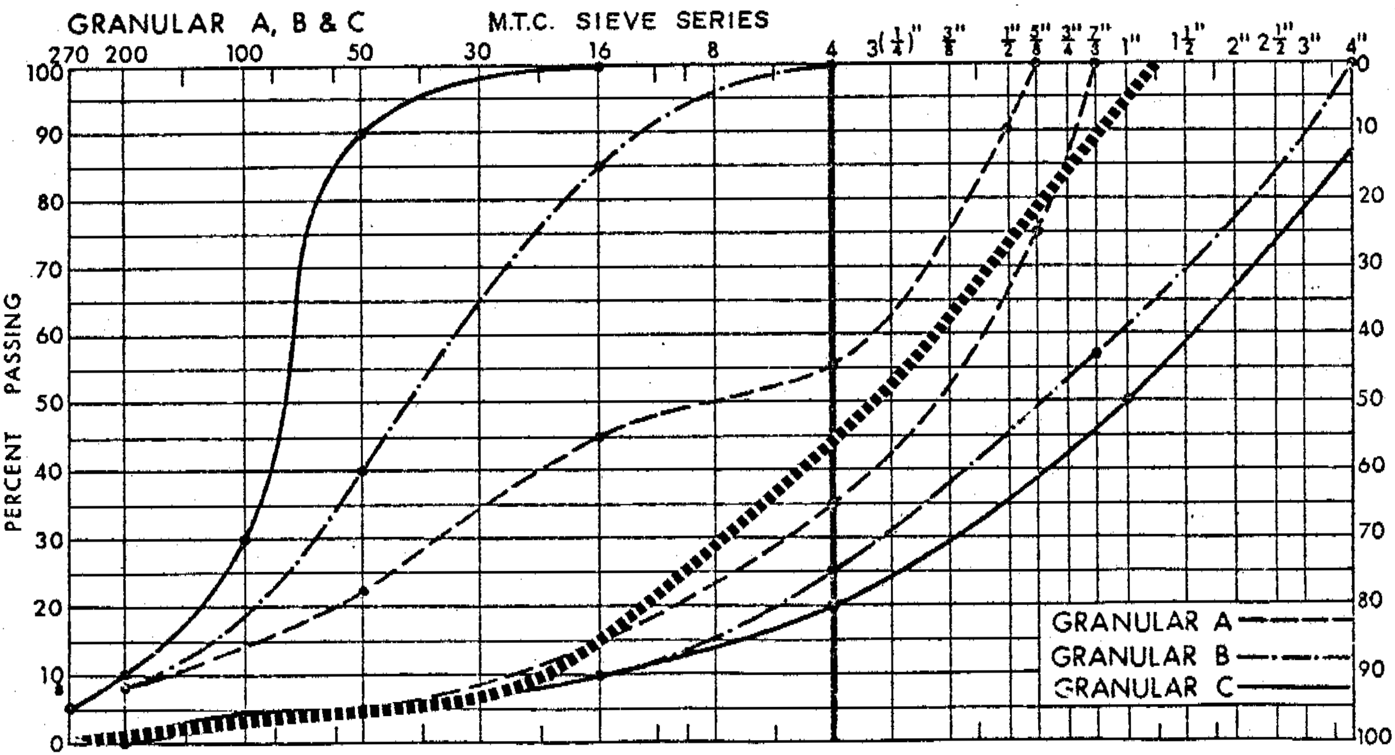
3′
mixed gravel MPS - 2′

assumed ▽ 6′
sand and boulders
MPS - 2

8′
silty clay till

GRAIN SIZE DISTRIBUTION CURVE

sample analysed



DRY SIEVE ANALYSIS AND TEST PIT LOGS

SAMPLE TP-4 (109A) DATE APRIL 3, 1978 NAME W. E. MOORE

Remarks : GRAVEL 54.9 % SAND 44.3 % FINES 0.8 %

WASHED SIEVE (% FINES PASSING #200) 8%

DRY SIEVING

Sieve No.	Mass Retained	Percent Retained	Cumulative % Passing
1½	121.6	-	-
3/4	81.6	5.5	94.5
3/8	369.6	25.2	69.3
4	356.2	24.2	45.1
10	349.0	23.7	21.4
16	183.1	12.5	8.9
30	83.4	5.7	3.2
50	12.1	0.8	2.4
100	11.3	0.8	1.6
200	11.3	0.8	0.8
PAN	23.1	1.6	
Totals	1480.7	100.0	

TEST PIT LOG

TEST PIT LOCATION (SEE DWG No HPS 2 & 3)

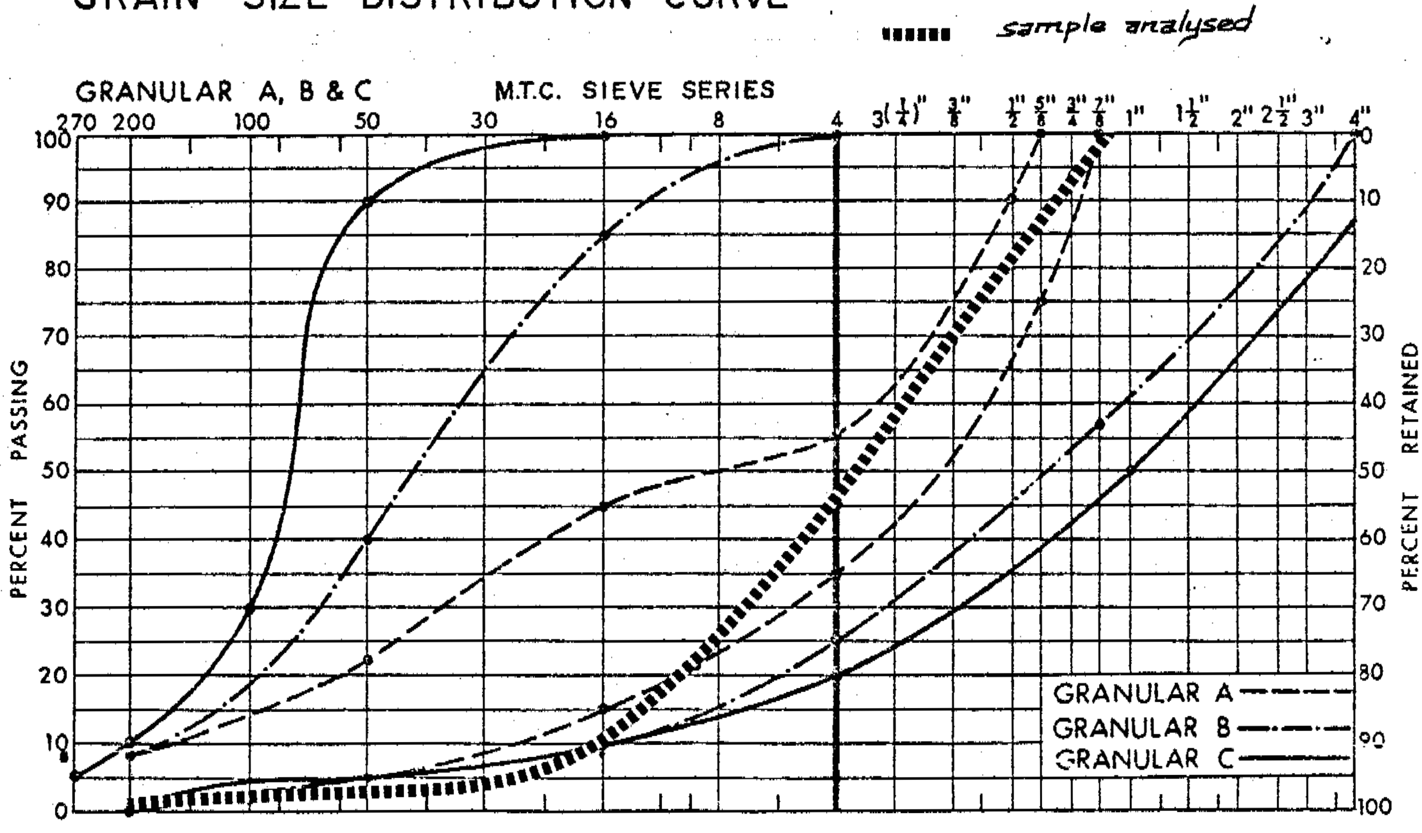
0' Topsoil

1' fine-med. gravel some silt

assumed ▽ med. gravel MPS-4"

4' Silty sand till

GRAIN SIZE DISTRIBUTION CURVE



DRY SIEVE ANALYSIS AND TEST PIT LOGS

SAMPLE TP5 (109A) DATE APRIL 3, 1978 NAME R. HILL

Remarks: GRAVEL 52.8% SAND 44.6% FINES 2.6%

WASHED SIEVE (% FINES PASSING #200) 8%

DRY SIEVING

Sieve No.	Mass Retained	Percent Retained	Cumulative % Passing
1½	282.5	-	-
3/4	319.9	24.2	75.8
3/8	219.5	16.6	59.2
4	158.0	12.0	47.2
10	203.9	15.4	31.8
16	211.1	16.0	15.8
30	124.0	9.4	6.4
50	17.0	1.3	5.1
100	16.1	1.2	3.9
200	16.5	1.3	2.6
PAN	23.2	1.8	
Totals	1309.2	100.0	

TEST PIT LOG

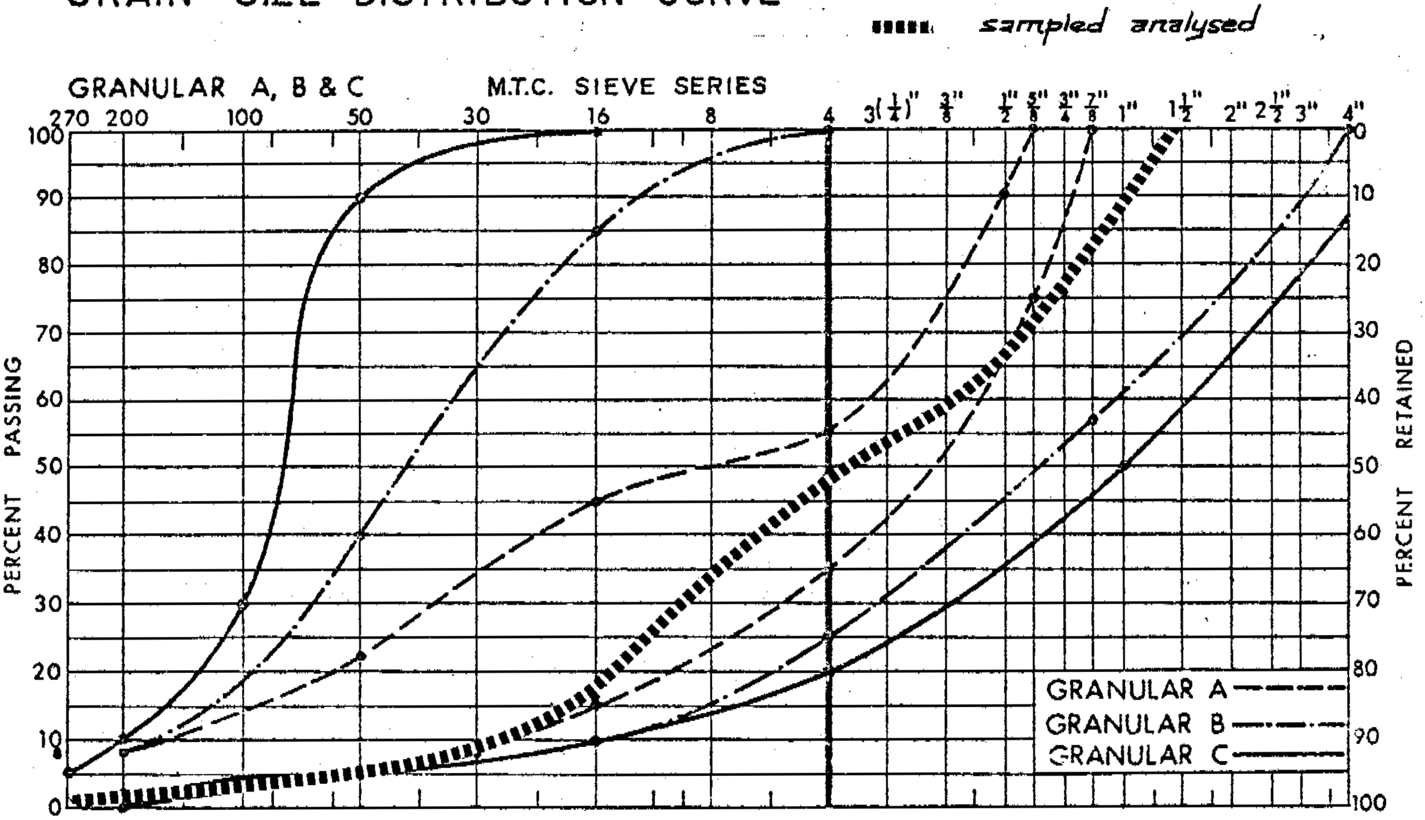
TEST PIT LOCATION (SEE DWG No HRS 2 & 3)

0'
Topsoil

1'
fine med. gravel some silt
MPS - 4"

3.5'
Silty sand till

GRAIN SIZE DISTRIBUTION CURVE



DRY SIEVE ANALYSIS AND TEST PIT LOGS

SAMPLE TP.6 (109 A) DATE APRIL 3, 1978 NAME W. R. MOORE

Remarks : GRAVEL 82·1% SAND 16·5 % FINES 1·4 %
WASHED SIEVE (% FINES PASSING #200) 8%

DRY SIEVING

Sieve No.	Mass Retained	Percent Retained	Cumulative % Passing
1½	553·1	-	-
3/4	917·4	53·2	46·8
3/8	316·1	18·3	28·5
4	182·4	10·6	17·9
10	121·2	7·0	10·9
16	75·8	4·4	6·5
30	58·2	3·4	3·1
50	8·7	0·5	2·6
100	8·6	0·5	2·1
200	11·9	0·7	1·4
PAN	21·6	1·3	
Totals	1721·9	100·0	

TEST PIT LOG

TEST PIT LOCATION (SEE DWG No HRS 2 & 3)

0'
Topsoil

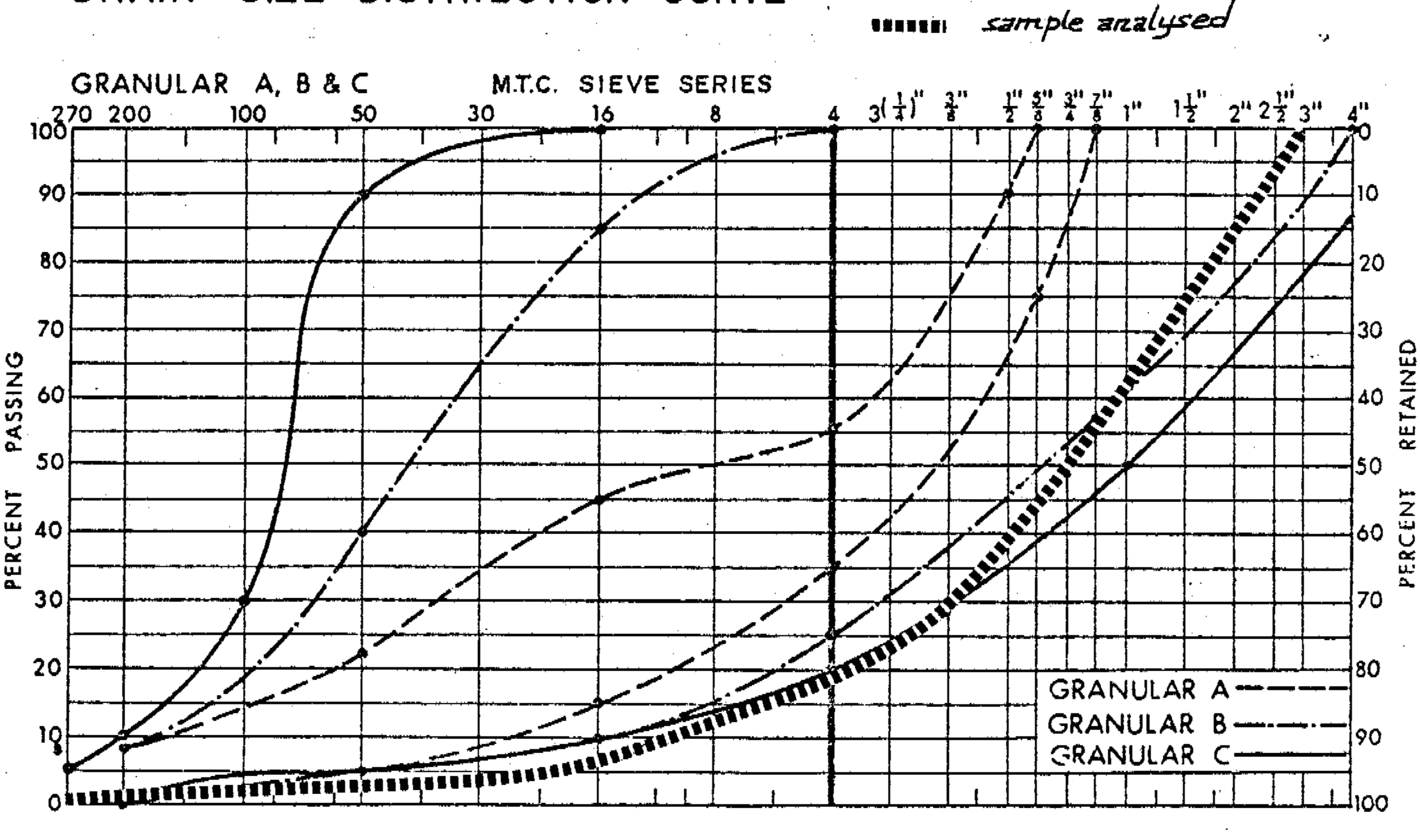
1'
fine med. gravel some cobbles

3.5'
coarse gravel with numerous cobbles MPS-5"

assumed ∇ 5'

6'
Silty sand till

GRAIN SIZE DISTRIBUTION CURVE



DRY SIEVE ANALYSIS AND TEST PIT LOGS

SAMPLE TP-8 (109A) DATE APRIL 3, 1978 NAME R. HILL

Remarks: GRAVEL 52.4% SAND 46.2% FINES 1.4%
WASHED SIEVE (% FINES PASSING #200) 6%

DRY SIEVING			
Sieve No.	Mass Retained	Percent Retained	Cumulative % Passing
1½	450.9	-	-
3/4	695.1	27.0	73.0
3/8	349.3	13.4	59.6
4	314.3	12.0	47.6
10	316.8	12.1	35.5
16	224.5	8.6	26.9
30	230.6	8.8	18.1
50	267.3	10.2	7.9
100	108.9	4.2	3.7
200	60.1	2.3	1.4
PAN	40.6	1.6	
Totals	2607.5	100.0	

TEST PIT LOG

TEST PIT LOCATION (SEE DWG No HRS 2 & 3)

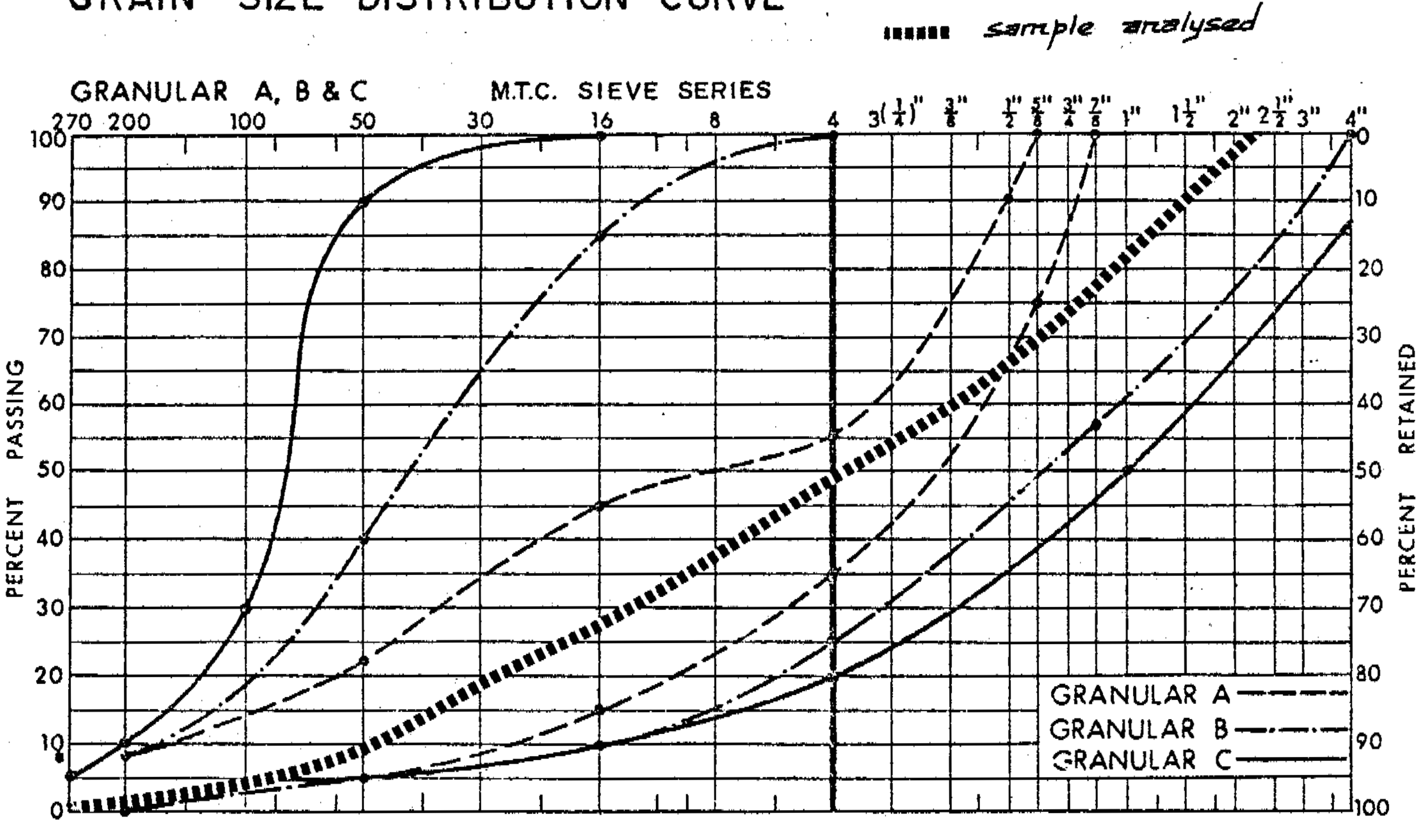
0'
Topsoil

6"
sand and gravel some silt MPS - 4"

2'
stratified sand and gravel some cobbles MPS-6"

12' ▽
clayey silt till

GRAIN SIZE DISTRIBUTION CURVE



DRY SIEVE ANALYSIS AND TEST PIT LOGS

SAMPLE T.P.-9 (109A) DATE APRIL 3, 1978 NAME R. HILL

Remarks: GRAVEL 37.8% SAND 60.1% FINES 2.1%

WASHED SIEVE (% FINES PASSING #200) 8%

DRY SIEVING

Sieve No.	Mass Retained	Percent Retained	Cumulative % Passing
1½	612.9	-	-
3/4	182.4	9.2	90.8
3/8	262.1	13.3	77.5
4	302.2	15.3	62.2
10	494.9	25.0	37.2
16	329.7	16.7	20.5
30	244.4	12.4	8.1
50	62.6	3.2	4.9
100	23.6	1.2	3.7
200	31.8	1.6	2.1
PAN	20.4	1.0	
Totals	1954.1	100.0	

TEST PIT LOG

TEST PIT LOCATION (SEE DWG No HRS 2 & 3)

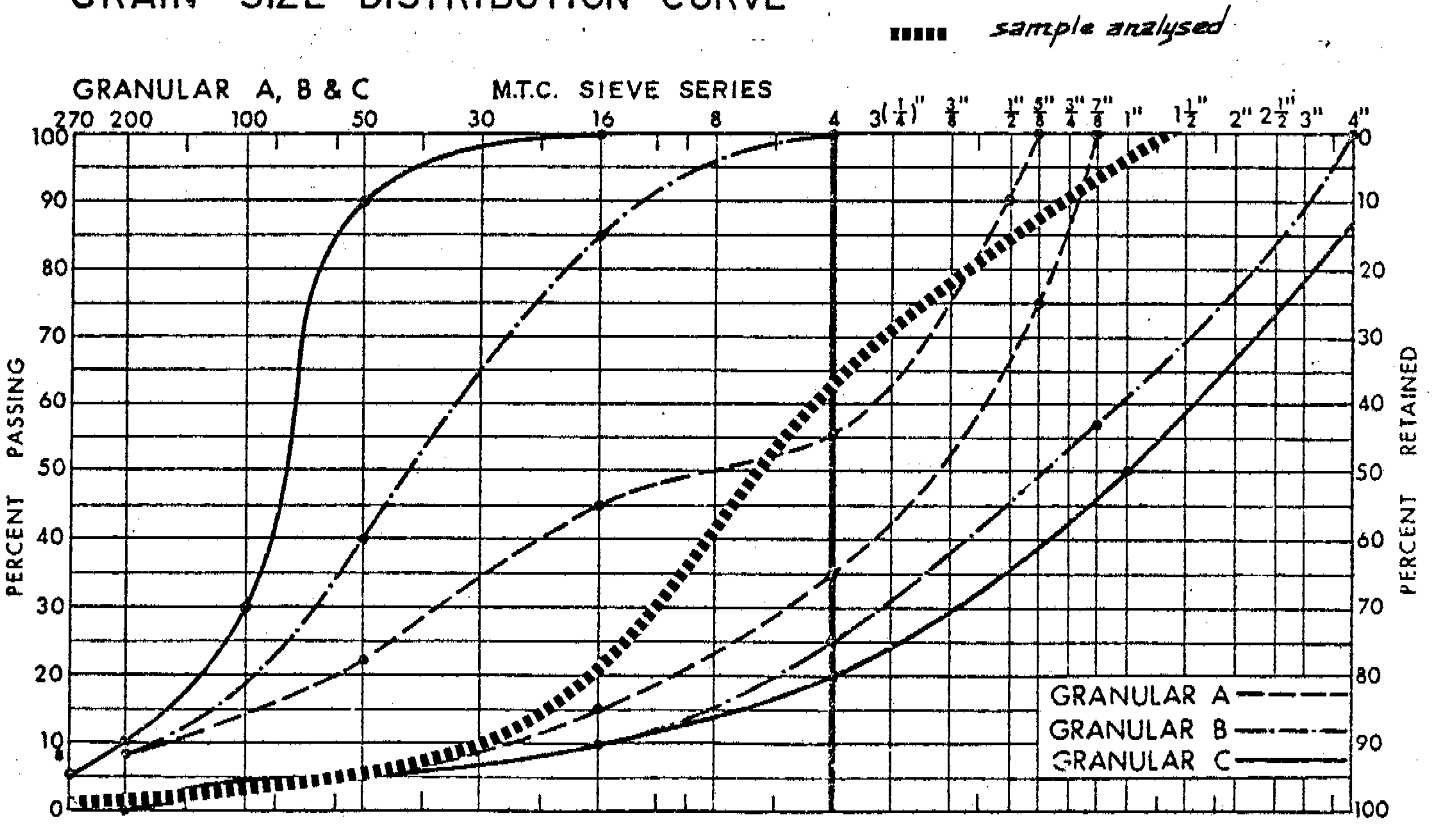
0' silty brown topsoil

1' Coarse sand and gravel some cobbles MPS-6"

3' Stratified silty sand & gravel with numerous cobbles and some boulders MPS-1'

6' ▽ refusal on frost

GRAIN SIZE DISTRIBUTION CURVE



DRY SIEVE ANALYSIS AND TEST PIT LOGS

SAMPLE *TP-12A (109A)* DATE *APRIL 3, 1978* NAME *R. HILL*

Remarks : *GRAVEL 35·2 % SAND 62·9 % FINES 1·9 %*

WASHED SIEVE (% FINES PASSING #200) 6 %

DRY SIEVING

Sieve No.	Mass Retained	Percent Retained	Cumulative % Passing
1½	0	-	-
3/4	56·0	4·8	95·2
3/8	190·6	16·3	78·9
4	165·3	14·1	64·8
10	185·2	15·8	49·0
16	116·6	10·0	39·0
30	149·0	12·7	26·3
50	185·9	15·9	10·4
100	72·2	6·1	4·3
200	28·0	2·4	1·9
PAN	18·2	1·6	
Totals	1167·0	100·0	

TEST PIT LOG

TEST PIT LOCATION (SEE DWG No HRS 2 & 3)

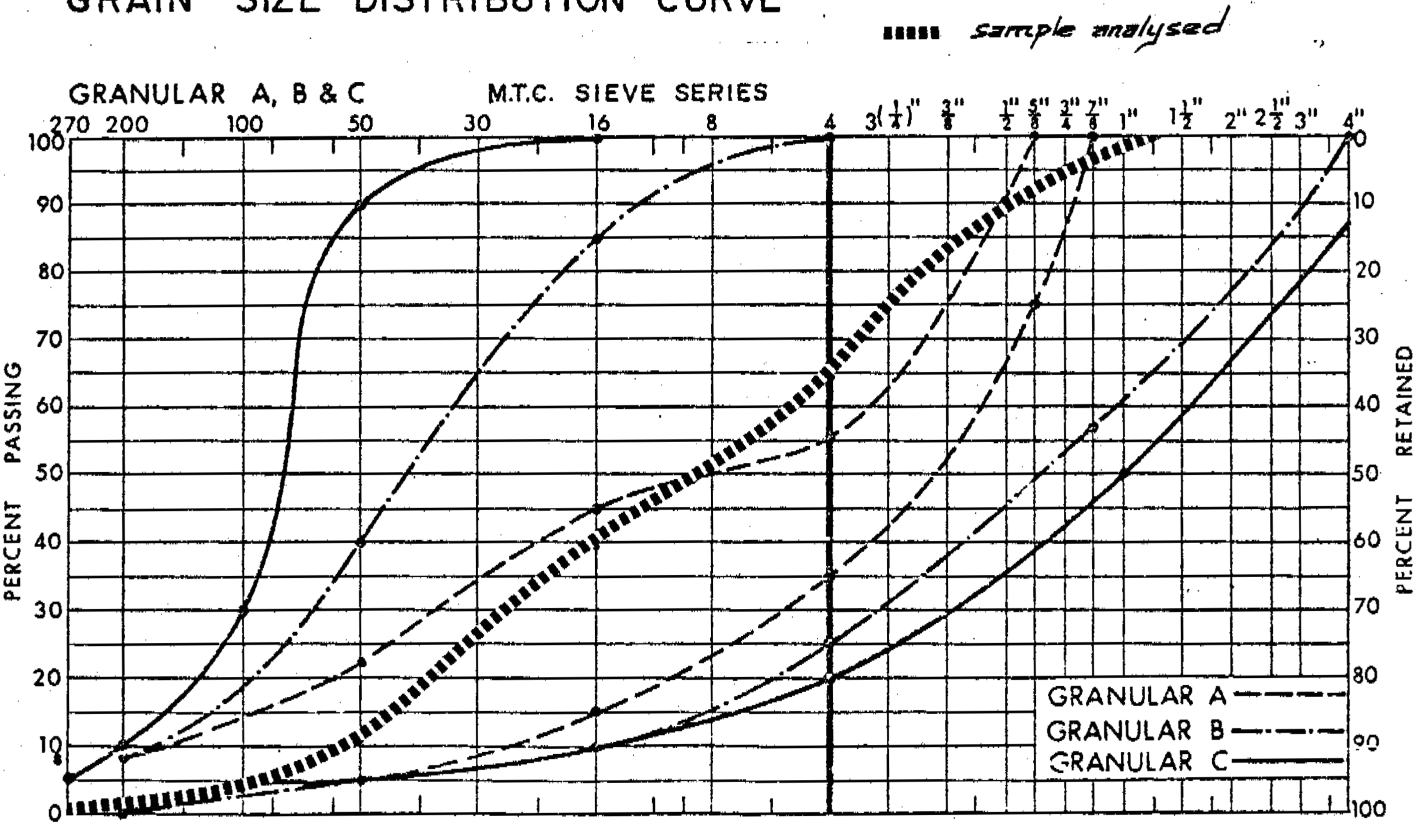
0'
dirty silty brown sand

Sample 12B *1'*
stratified fine gravel to cobbles MPS-4"

Sample 12A *8'*
med. sand · some gravel

12'+

GRAIN SIZE DISTRIBUTION CURVE



DRY SIEVE ANALYSIS AND TEST PIT LOGS

SAMPLE TP-12B (109A) DATE APRIL 3, 1978 NAME W. R. MOORE

Remarks: GRAVEL 67.0 % SAND 29.4 % FINES 3.6 %

WASHED SIEVE (% FINES PASSING #200) 6 %

DRY SIEVING

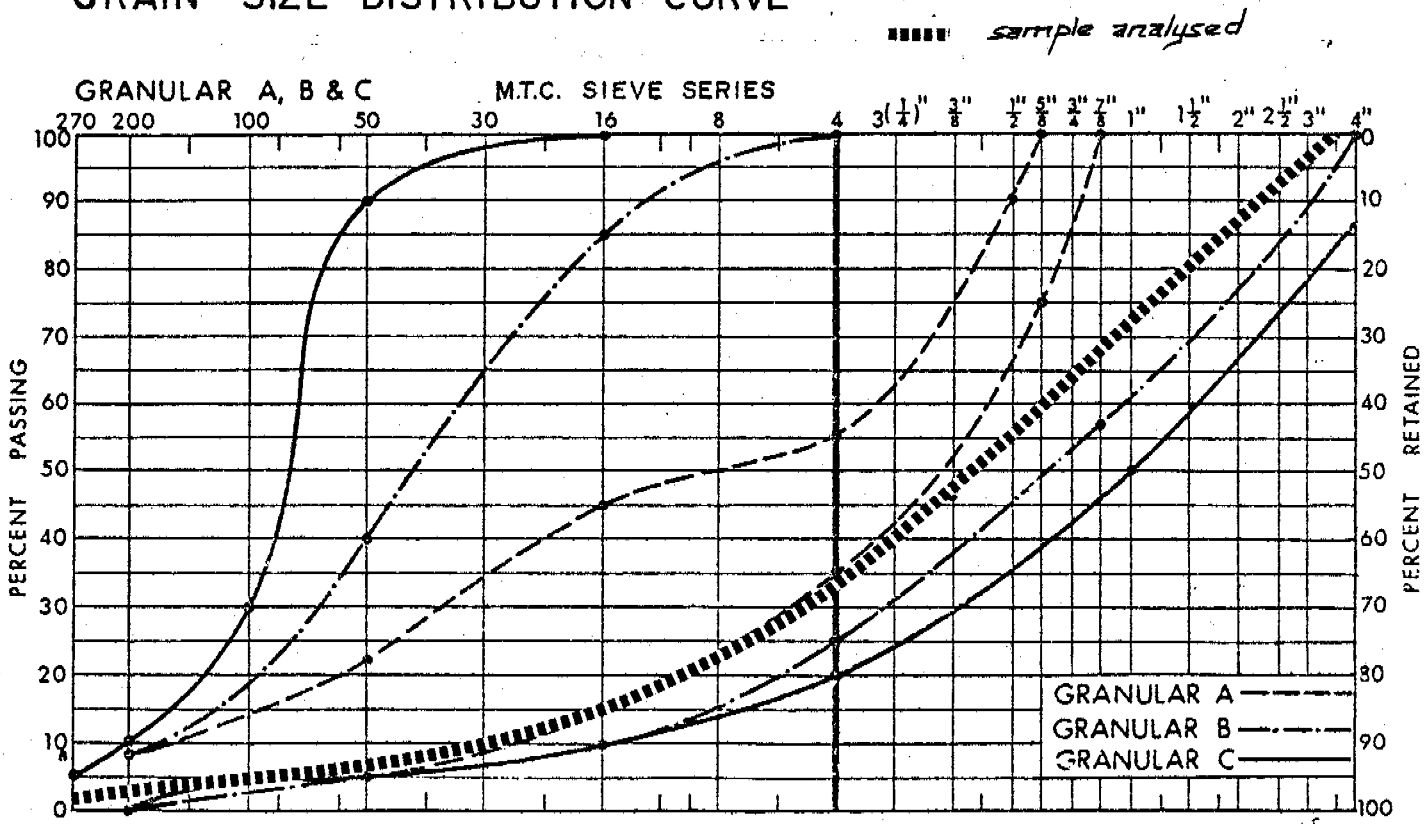
Sieve No.	Mass Retained	Percent Retained	Cumulative % Passing
1½	209.9	–	–
3/4	520.4	37.0	63.0
3/8	229.8	16.3	46.7
4	192.7	13.7	33.0
10	166.2	11.8	21.2
16	85.4	6.1	15.1
30	80.0	5.7	9.4
50	43.0	3.1	6.3
100	18.5	1.3	5.0
200	20.0	1.4	3.6
PAN	27.5	2.0	
Totals	1383.5	100.0	

TEST PIT LOG

TEST PIT LOCATION (SEE DWG No HRS 2 & 3)

Same as 12A (109A)

GRAIN SIZE DISTRIBUTION CURVE



DRY SIEVE ANALYSIS AND TEST PIT LOGS

SAMPLE TP-13 (109A) DATE APRIL 3, 1978 NAME R. HILL

Remarks: GRAVEL 48.4% SAND 50.5% FINES 1.1%

WASHED SIEVE (% FINES PASSING # 200) 9%

DRY SIEVING			
Sieve No.	Mass Retained	Percent Retained	Cumulative % Passing
1½	270.1	–	–
3/4	71.9	4.5	95.5
3/8	299.4	18.9	76.6
4	395.1	25.0	51.6
10	432.8	27.4	24.2
16	177.6	11.2	13.0
30	118.2	7.5	5.5
50	21.6	1.4	4.1
100	15.6	1.0	3.1
200	31.6	2.0	1.1
PAN	15.2	1.0	
Totals	1579.0	100.0	

TEST PIT LOG

TEST PIT LOCATION (SEE DWG No HRS 2 & 3)

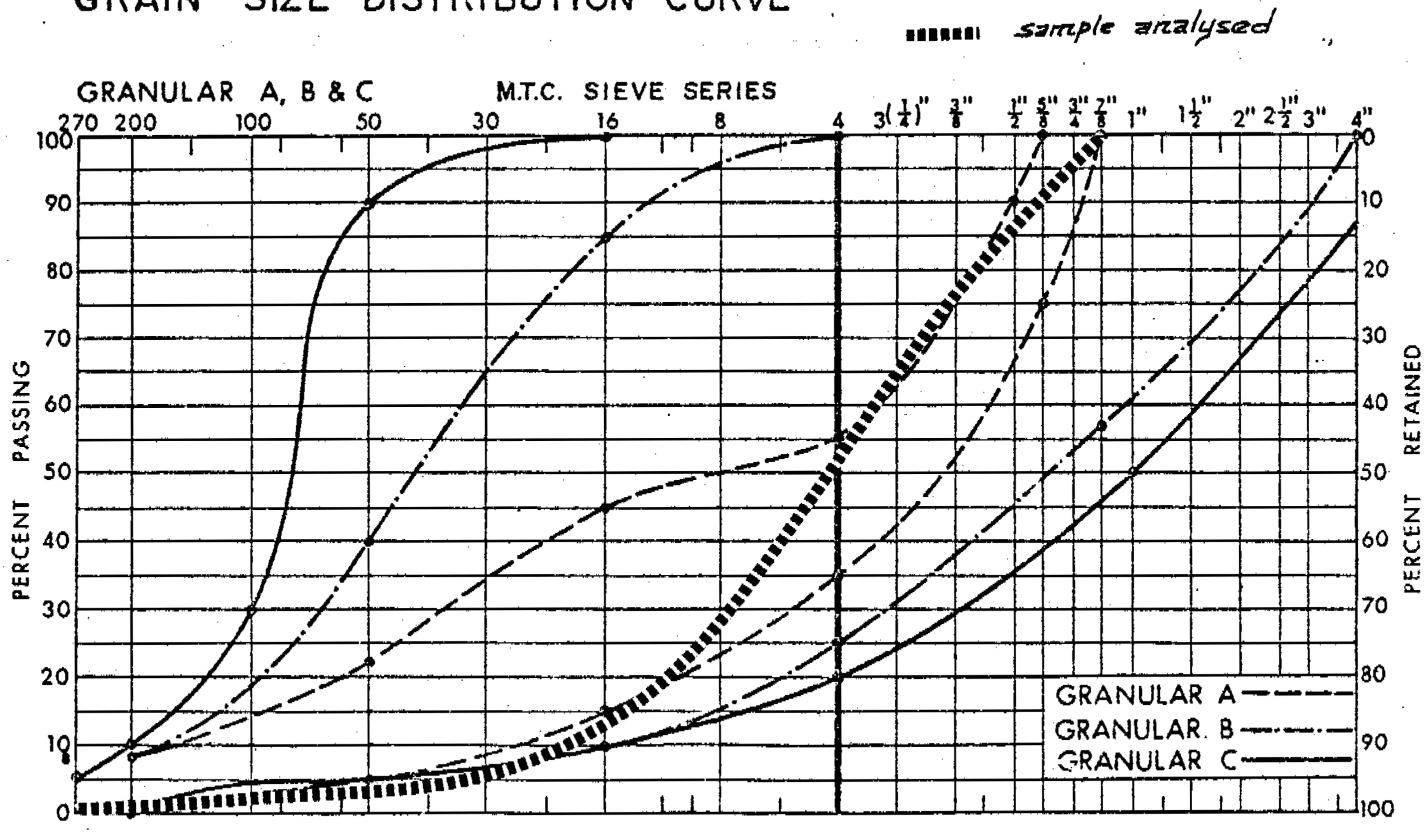
0' med. gravel - some sand

2' fine gravel, some sand

3' fine gravel to boulders M.P.S 1.5'

4.5' refusal on boulders

GRAIN SIZE DISTRIBUTION CURVE



DRY SIEVE ANALYSIS AND TEST PIT LOGS

SAMPLE TP 14 (109A) DATE APRIL 3 1978 NAME W. R. MOORE

Remarks : GRAVEL 54.3 % SAND 43.4 % FINES 2.3 %

WASHED SIEVE (% FINES PASSING #200) 9 %

DRY SIEVING

Sieve No.	Mass Retained	Percent Retained	Cumulative % Passing
1½	312.3	-	-
3/4	223.2	14.5	85.5
3/8	266.0	17.3	68.2
4	346.0	22.5	45.7
10	290.1	18.8	26.9
16	126.3	8.2	18.7
30	107.6	7.0	11.7
50	73.5	4.8	6.9
100	38.7	2.5	4.4
200	31.8	2.1	2.3
PAN	19.2	1.2	
Totals	1522.4	100.0	

TEST PIT LOG

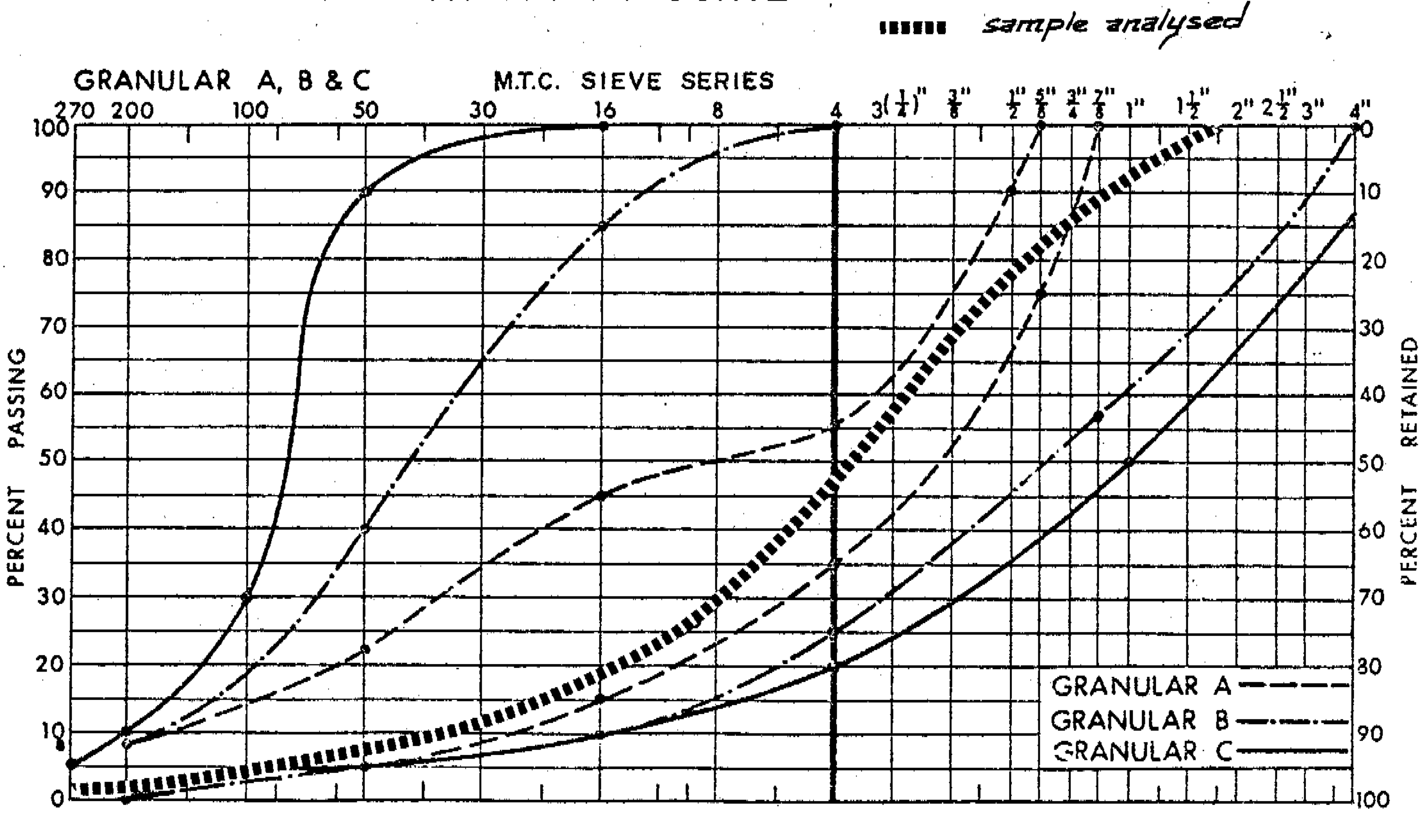
TEST PIT LOCATION (SEE DWG No HPS 2 & 3)

0'
Silty med. gravel with large boulders MPS-2'

3'
Silty med. gravel and cobbles

8'
med. gravel with some sand and cobbles

GRAIN SIZE DISTRIBUTION CURVE



DRY SIEVE ANALYSIS AND TEST PIT LOGS

SAMPLE TP-15 (109A) DATE APRIL 3, 1978 NAME W. R. MOORE

Remarks : GRAVEL 60·7 % SAND 36·8 % FINES 2·5 %
WASHED SIEVE (% FINES PASSING #200) 9%

DRY SIEVING			
Sieve No.	Mass Retained	Percent Retained	Cumulative % Passing
1½	258·0	–	–
3/4	417·5	25·3	74·7
3/8	291·0	17·6	57·1
4	294·0	17·8	39·3
10	257·9	15·6	23·7
16	129·7	7·9	15·8
30	96·9	5·9	9·9
50	74·1	4·5	5·4
100	23·3	1·4	4·0
200	25·4	1·5	2·5
PAN	28·0	1·7	
Totals	1637·8	100·0	

TEST PIT LOG

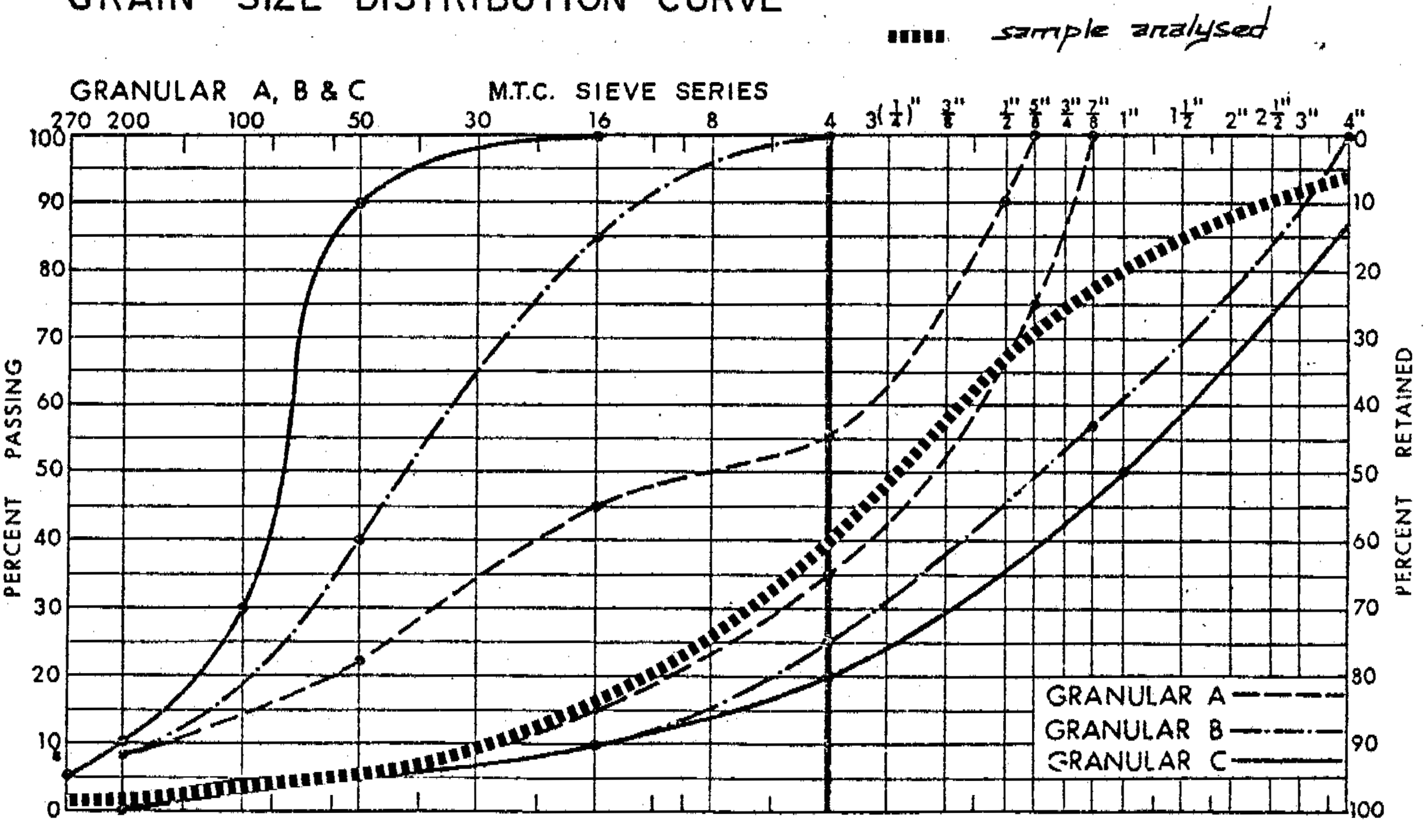
TEST PIT LOCATION (SEE DWG No HRS 283)

0'
Silty med gravel with cobbles MPS - 4"

2'
Silty med. gravel with boulders MPS - 1·5'

4' ∇ assumed
refusal on boulders

GRAIN SIZE DISTRIBUTION CURVE



DRY SIEVE ANALYSIS AND TEST PIT LOGS

SAMPLE TP-17 (110A) DATE APRIL 3, 1978 NAME W. R. MOORE

Remarks : GRAVEL 45.2% SAND 53.5% FINES 1.3%
WASHED SIEVE (% FINES PASSING #200) 10%

DRY SIEVING

Sieve No.	Mass Retained	Percent Retained	Cumulative % Passing
1½	280.5	–	–
3/4	451.1	22.4	77.6
3/8	254.6	12.6	65.0
4	205.3	10.2	54.8
10	203.7	10.1	44.7
16	130.8	6.5	38.2
30	241.9	12.0	26.2
50	341.6	17.0	9.2
100	98.3	4.9	4.3
200	59.6	3.0	1.3
PAN	17.4	0.1	1.2
Totals	2004.3	100.0	

TEST PIT LOG

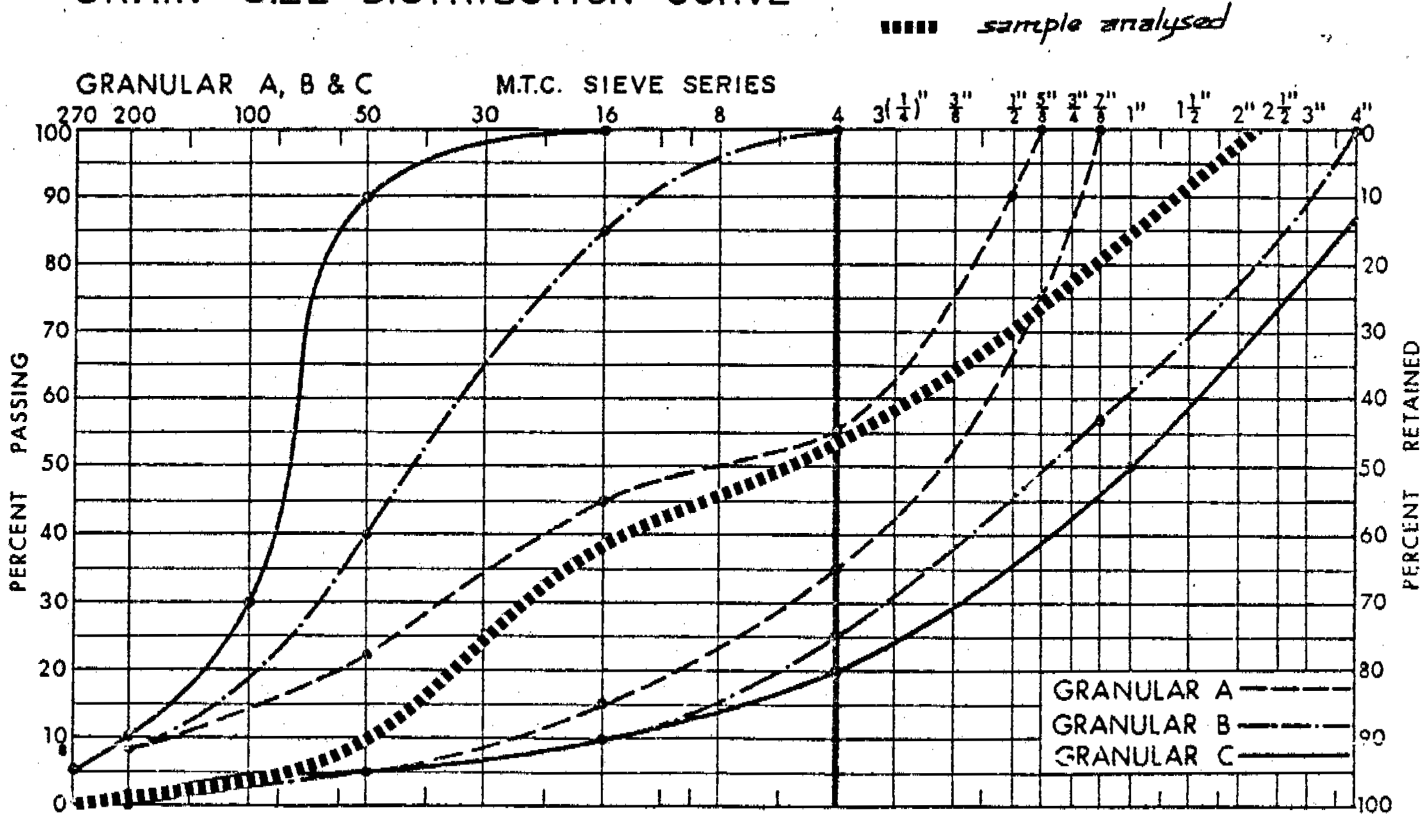
TEST PIT LOCATION (SEE DWG No HRS 2 & 3)

0'
sandy brown topsoil (high organic content)

6"
med. sand with numerous cobbles and boulders MPS-2'

3'+
refusal on boulders

GRAIN SIZE DISTRIBUTION CURVE



DRY SIEVE ANALYSIS AND TEST PIT LOGS

SAMPLE TP18 (110A) DATE APRIL 3, 1978 NAME R. HILL

Remarks: GRAVEL 47.9% SAND 48.9% FINES 3.2%

WASHED SIEVE (% FINES PASSING #200) 10%

DRY SIEVING			
Sieve No.	Mass Retained	Percent Retained	Cumulative % Passing
1½	683.2	–	–
3/4	315.2	19.7	80.3
3/8	249.8	15.6	64.7
4	202.0	12.6	52.1
10	190.2	11.9	40.2
16	110.7	6.9	33.3
30	146.7	9.2	24.1
50	164.7	10.3	13.8
100	81.2	5.1	8.7
200	87.7	5.5	3.2
PAN	39.1	2.4	
Totals	1587.3	100.0	

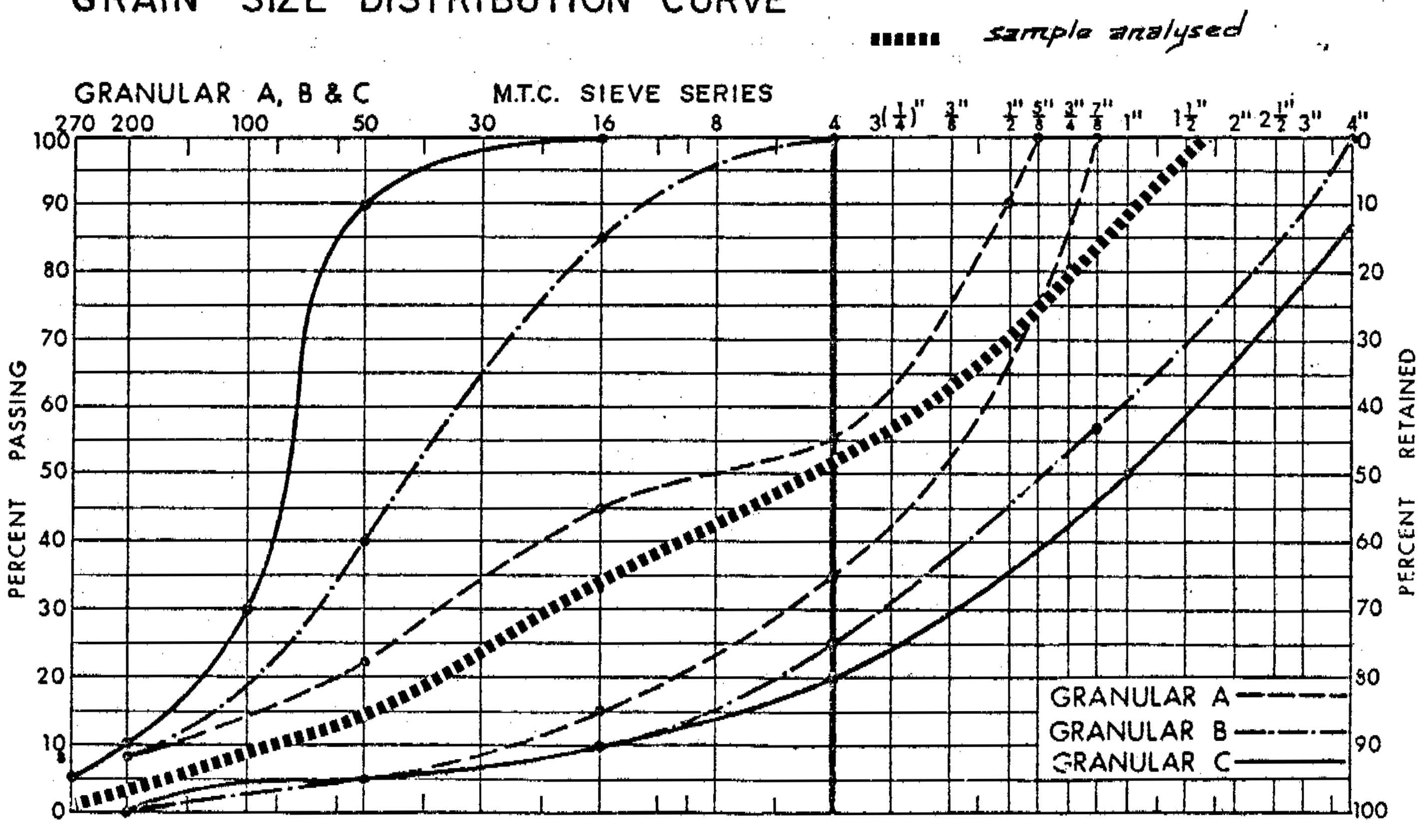
TEST PIT LOG

TEST PIT LOCATION (SEE DWG No HRS 2 & 3)

0'
fine sand and gravel with numerous cobbles and boulders MPS - 2'

3' ▼ assumed
refusal on boulders

GRAIN SIZE DISTRIBUTION CURVE



DRY SIEVE ANALYSIS AND TEST PIT LOGS

SAMPLE T.P. 19 (110A) DATE APRIL 3, 1978 NAME R. HILL

Remarks: GRAVEL 44.4% SAND 53.2% FINES 2.4%

WASHED SIEVE (% FINES PASSING #200) 6%

DRY SIEVING

Sieve No.	Mass Retained	Percent Retained	Cumulative % Passing
1½	477.9	-	-
3/4	369.9	21.0	79.0
3/8	189.8	10.8	68.2
4	222.7	12.6	55.6
10	223.9	12.7	42.9
16	216.7	12.3	30.6
30	400.9	22.7	7.9
50	60.8	3.4	4.5
100	17.9	1.0	3.5
200	20.0	1.1	2.4
PAN	25.0		
Totals	1747.6	100.0	

TEST PIT LOG

TEST PIT LOCATION (SEE DWG No HRS 2&3)

0'

Silty med. grained sand with some gravel and occ. cobbles

1'

Stratified coarse sand with numerous cobbles MPS - 6"

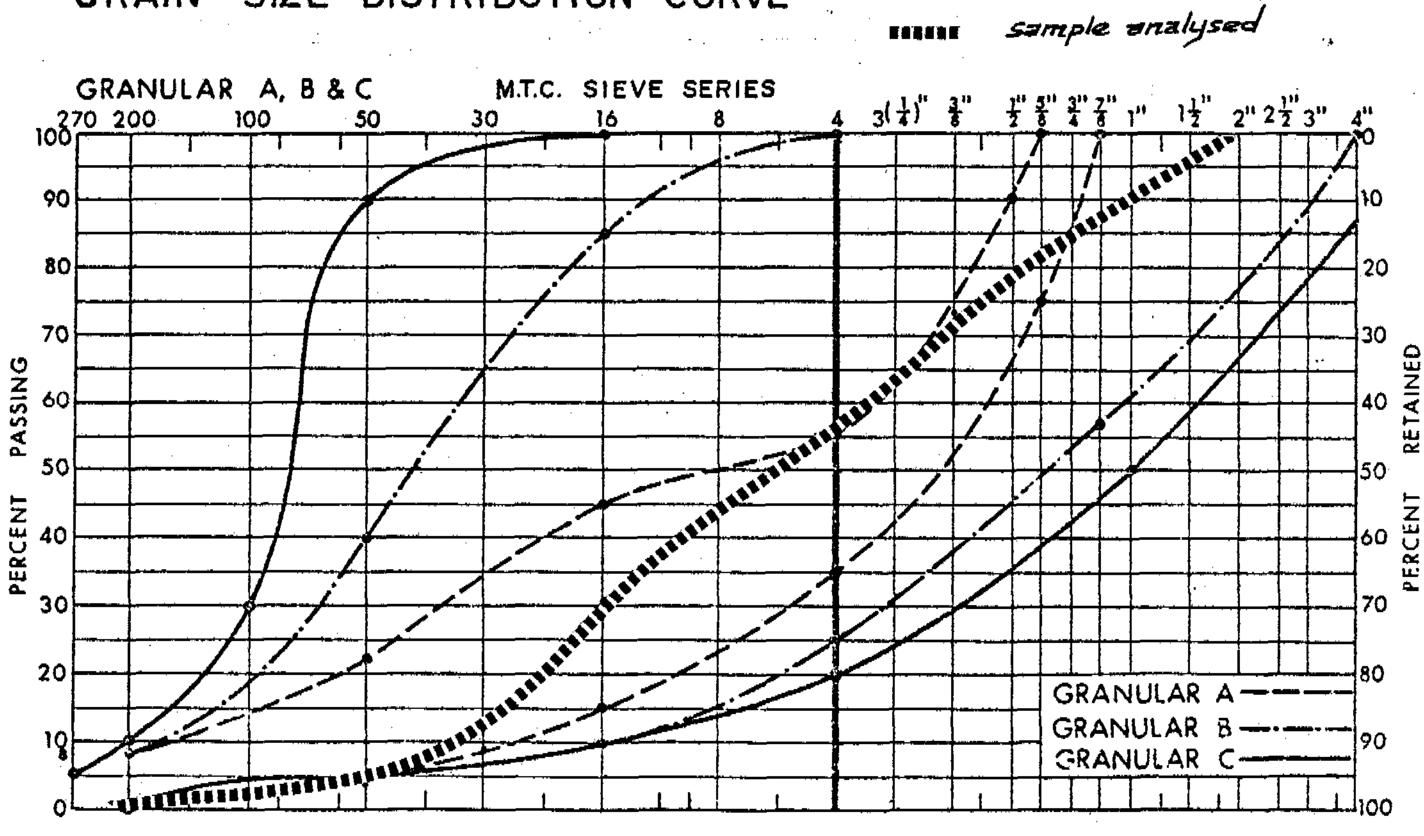
3'

coarse sand and gravel numerous cobbles and some boulders MPS - 1.5'

4.5'

assumed refusal on boulders

GRAIN SIZE DISTRIBUTION CURVE



DRY SIEVE ANALYSIS AND TEST PIT LOGS

SAMPLE TP 20 (110A) DATE APRIL 3, 1978 NAME W. R. MOORE

Remarks: GRAVEL 71.1% SAND 26.3% FINES 2.6%

WASHED SIEVE (% FINES PASSING #200) 12%

DRY SIEVING

Sieve No.	Mass Retained	Percent Retained	Cumulative % Passing
1½	416.3	–	–
3/4	364.5	18.5	81.5
3/8	571.9	29.0	52.5
4	465.5	23.6	28.9
10	277.4	14.1	14.8
16	91.0	4.6	10.2
30	63.0	3.2	7.0
50	27.8	1.4	5.6
100	25.2	1.3	4.3
200	32.7	1.7	2.6
PAN	40.3	2.0	
Totals	1959.3	100.0	

TEST PIT LOG

TEST PIT LOCATION (SEE DWG No HRS 2 & 3)

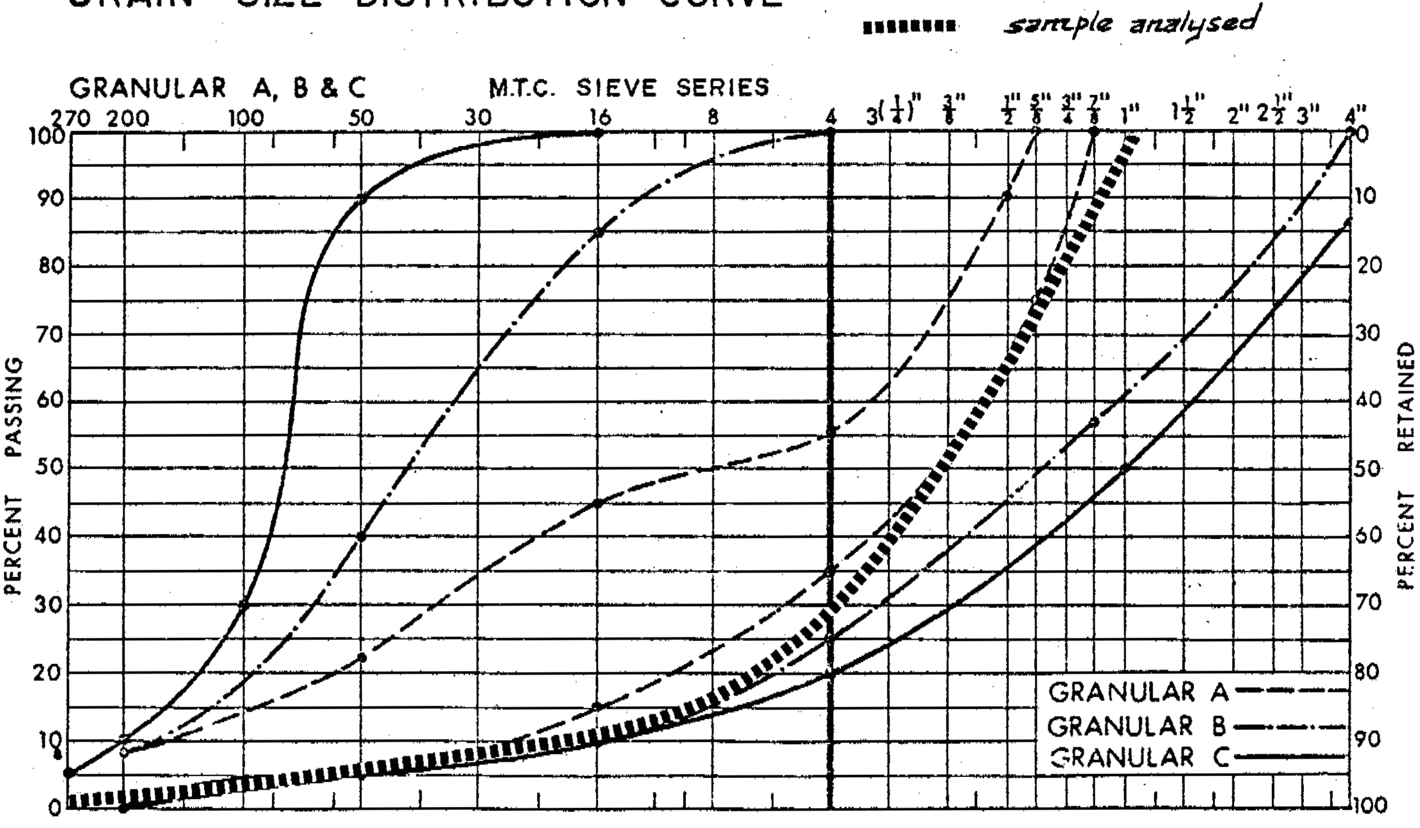
0'
sandy brown topsoil

6"
stratified fine to coarse gravel
Some cobbles MPS - 4"

3'
fine sand numerous boulders
MPS 2.5'

5'+
refusal on boulders

GRAIN SIZE DISTRIBUTION CURVE



DRY SIEVE ANALYSIS AND TEST PIT LOGS

SAMPLE *T.P. 21A (110A)* DATE *APRIL 3, 1978* NAME *W. R. MOORE*

Remarks : *GRAVEL 45·2% SAND 51·8% FINES 3·0%*
WASHED SIEVE (% FINES PASSING #200) 12%

DRY SIEVING

Sieve No.	Mass Retained	Percent Retained	Cumulative % Passing
1½	429·8	-	–
3/4	139·9	9·5	90·5
3/8	248·6	16·8	73·7
4	278·9	18·9	54·8
10	495·9	33·5	21·3
16	173·9	11·8	9·5
30	49·2	3·3	6·2
50	13·0	0·9	5·3
100	13·0	0·9	4·4
200	21·0	1·4	3·0
PAN	28·0	1·8	1·2
Totals	1461·4	100·0	

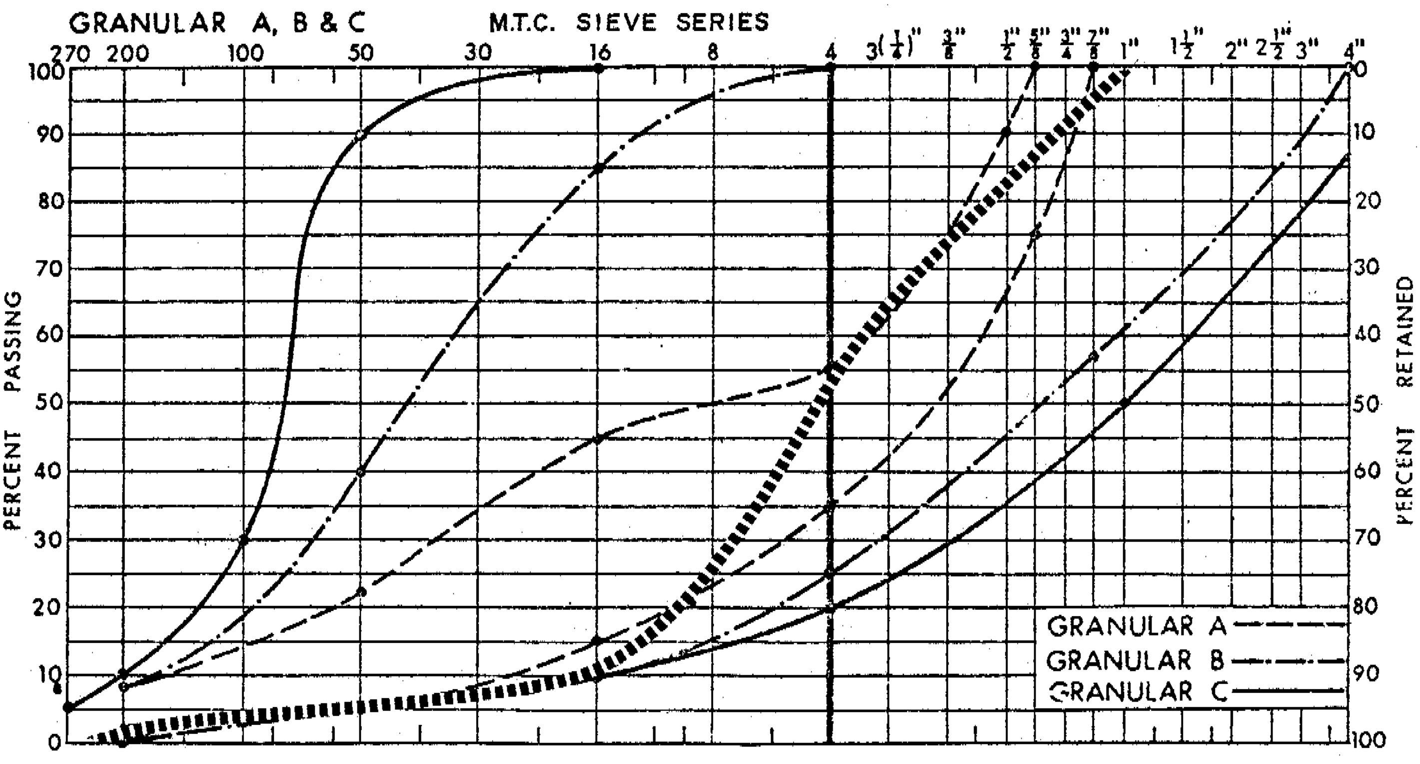
TEST PIT LOG

TEST PIT LOCATION (SEE DWG No HRS 2 & 3)

0'
sandy brown topsoil
6"
fine sand gravel with cobbles MPS - 3"
sample A
1.5
stratified fine to coarse gravel numerous cobbles MPS - 4"
4'
sample B
med. sand to cobbles and boulders MPS - 8"
5'
6'
refusal (frost)

GRAIN SIZE DISTRIBUTION CURVE

sample analysed



DRY SIEVE ANALYSIS AND TEST PIT LOGS

SAMPLE TP 21B (110A) DATE APRIL 3, 1978 NAME R. HILL

Remarks: GRAVEL 53.4% SAND 46.6% FINES 0%

WASHED SIEVE (% FINES PASSING #200) 12%

DRY SIEVING

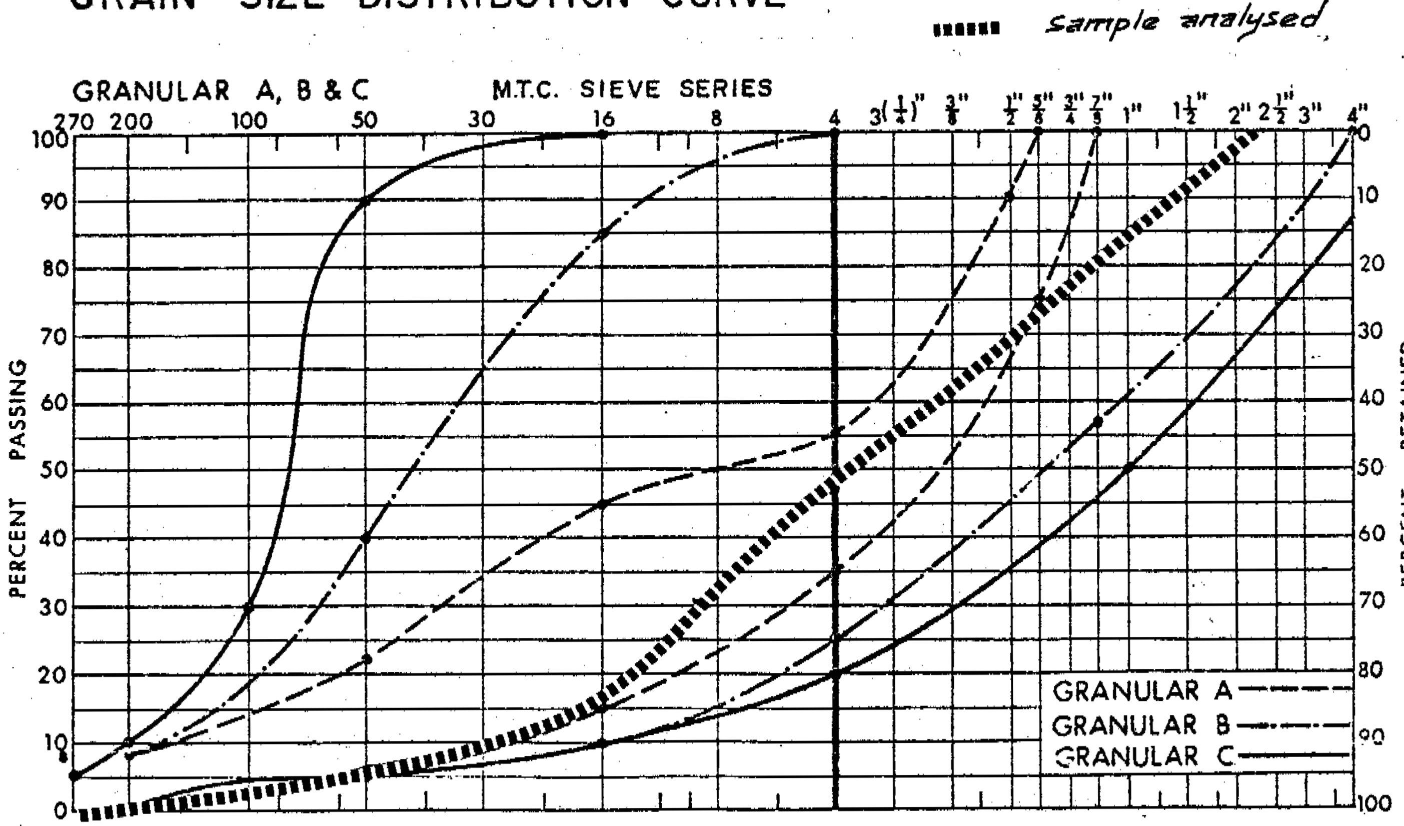
Sieve No.	Mass Retained	Percent Retained	Cumulative % Passing
1½	115.8	–	–
3/4	313.5	22.0	78.0
3/8	226.5	15.9	62.1
4	220.3	15.5	46.6
10	225.9	15.9	30.7
16	206.4	14.5	16.2
30	98.7	6.9	9.3
50	42.1	3.0	6.3
100	58.9	4.1	2.2
200	30.8	2.2	0.0
	17.0		
Totals	1440.1	100.0	

TEST PIT LOG

TEST PIT LOCATION (SEE DWG No HRS 2 & 3)

Same as TP 21 A (110A)

GRAIN SIZE DISTRIBUTION CURVE



DRY SIEVE ANALYSIS AND TEST PIT LOGS

SAMPLE TP 22 (110A) DATE APRIL 3, 1978 NAME R. HILL

Remarks : GRAVEL 57.5 % SAND 40.2% FINES 2.3%

WASHED SIEVE (% FINES PASSING #200) 10%

DRY SIEVING

Sieve No.	Mass Retained	Percent Retained	Cumulative % Passing
1½	504.3	-	-
3/4	507.1	24.7	75.3
3/8	373.2	18.2	57.1
4	299.1	14.6	42.5
10	254.5	12.4	30.1
16	138.5	6.7	23.4
30	124.7	6.1	17.3
50	103.3	5.0	12.3
100	84.6	4.1	8.2
200	122.1	5.9	2.3
PAN	30.6	1.5	
Totals	2037.7	100.0	

TEST PIT LOG

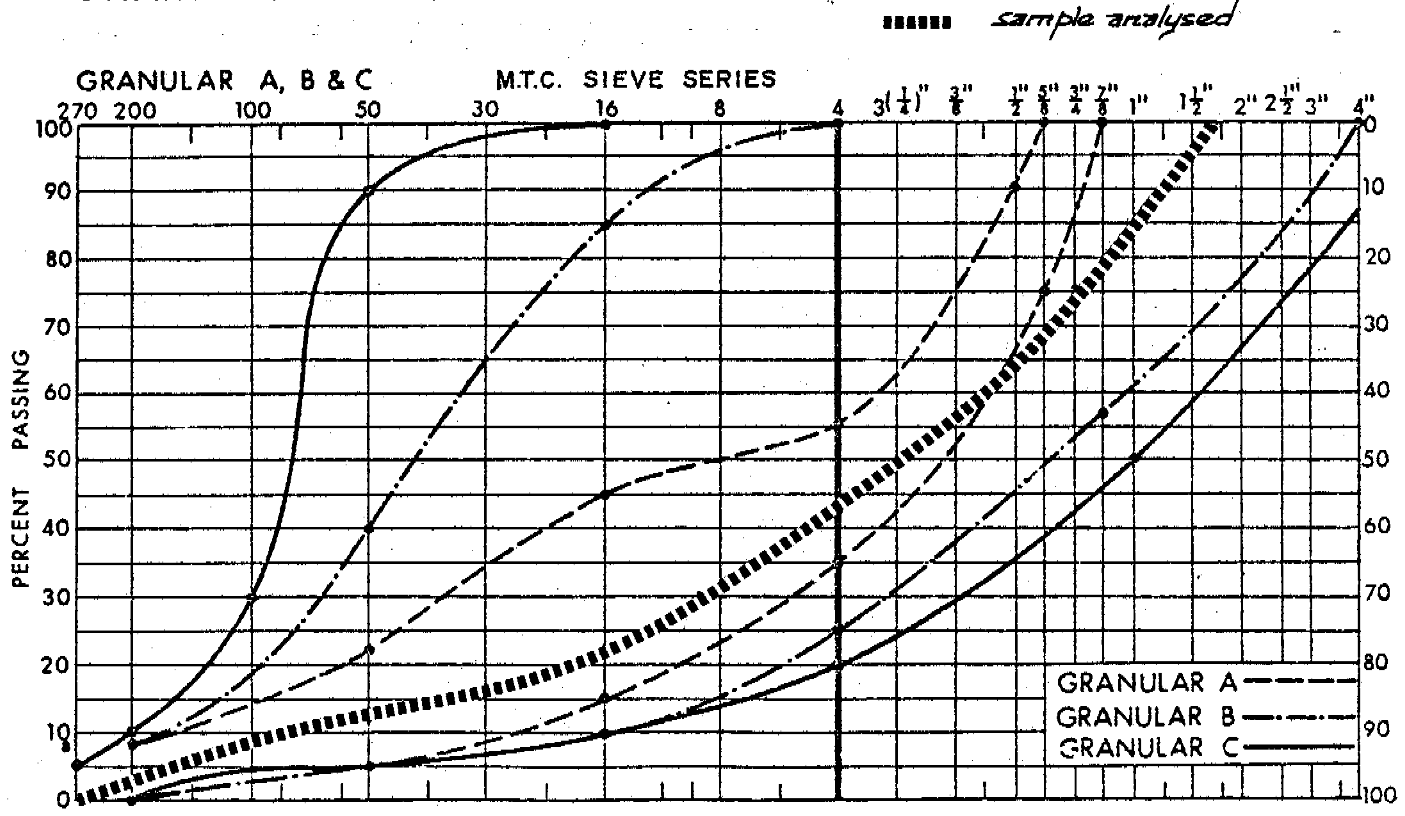
TEST PIT LOCATION (SEE DWG No HRS 2 & 3)

0'
sandy brown topsoil

6"
silty fine sand with numerous boulders MPS-3'

6' ▽ assumed
refusal on boulders

GRAIN SIZE DISTRIBUTION CURVE



DRY SIEVE ANALYSIS AND TEST PIT LOGS

SAMPLE TP 23 (112A) DATE APRIL 4, 1978 NAME R. HILL

Remarks: GRAVEL 68.7 % SAND 29.8 % FINES 1.5 %
WASHED SIEVE (% FINES PASSING #200) 12 %

DRY SIEVING			
Sieve No.	Mass Retained	Percent Retained	Cumulative % Passing
1½	–	–	–
3/4	74.0	4.6	95.4
3/8	504.3	31.2	64.2
4	532.0	32.9	31.3
10	378.4	23.4	7.9
16	34.0	2.1	5.8
30	33.4	2.7	3.1
50	9.3	0.6	2.5
100	6.0	0.4	2.1
200	9.8	0.6	1.5
PAN	21.8	1.3	
Totals	1603.0	100.0	

TEST PIT LOG

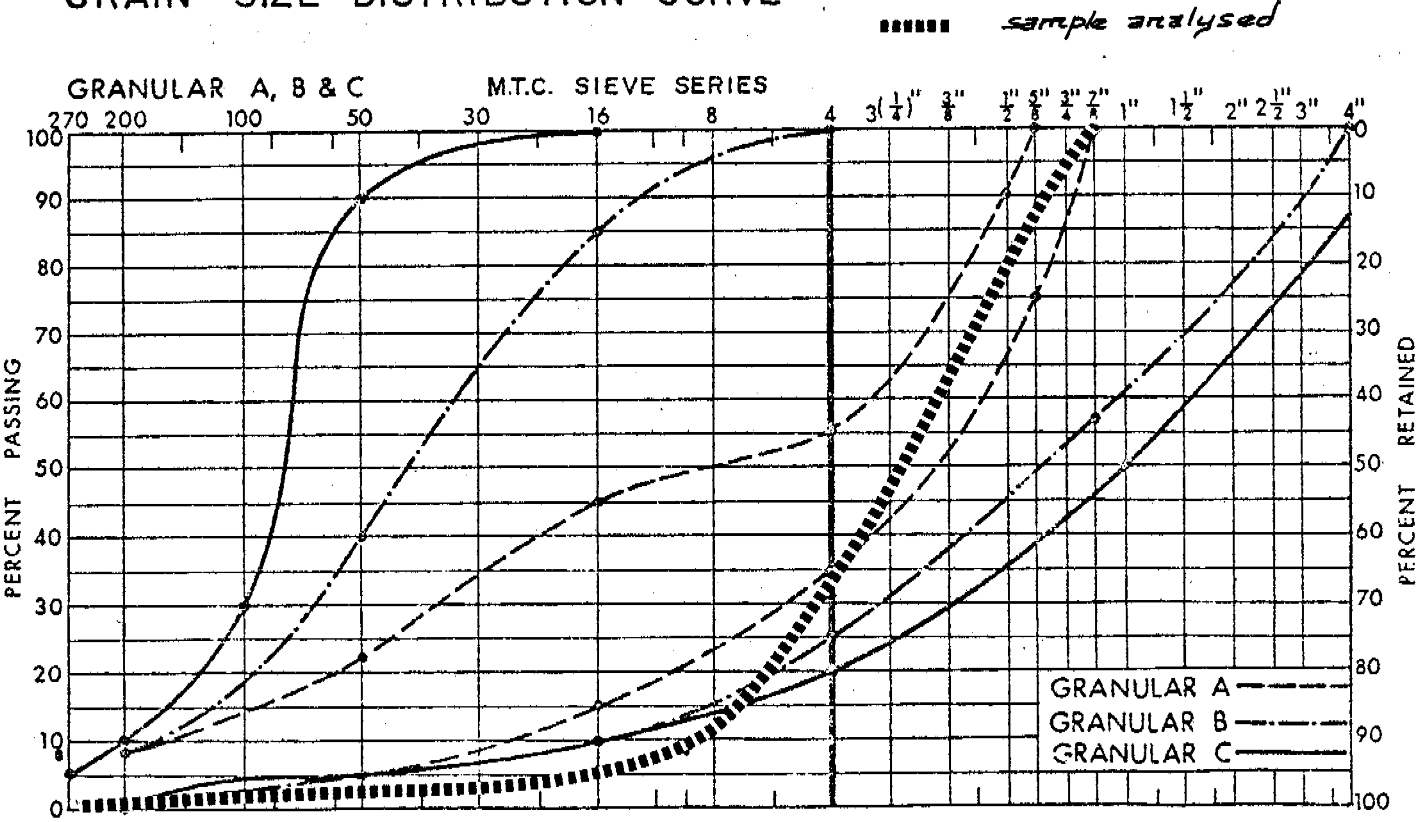
TEST PIT LOCATION (SEE DWG No HRS 283)

0'
silty fine sand to med. gravel

5'
silty fine sand to boulders with numerous cobbles, MPS 1.5'

7' ∇ assumed
refusal on boulders

GRAIN SIZE DISTRIBUTION CURVE



DRY SIEVE ANALYSIS AND TEST PIT LOGS

SAMPLE TP 24 (112A) DATE APRIL 4, 1978 NAME W. R. MOORE

Remarks: GRAVEL 75·8 % SAND 20·6 % FINES 3·6 %
WASHED SIEVE (% FINES PASSING #200) 12%

DRY SIEVING

Sieve No.	Mass Retained	Percent Retained	Cumulative % Passing
1½	341·4	—	—
3/4	359·8	17·7	82·3
3/8	751·3	36·9	45·4
4	431·0	21·2	24·2
10	213·1	10·5	13·7
16	81·0	4·0	9·7
30	57·9	2·8	6·9
50	22·2	1·1	5·8
100	18·9	0·9	4·9
200	27·2	1·3	3·6
PAN	45·9	2·3	
Totals	2008·3	100·0	

TEST PIT LOG

TEST PIT LOCATION (SEE DWG No HRS 2 & 3)

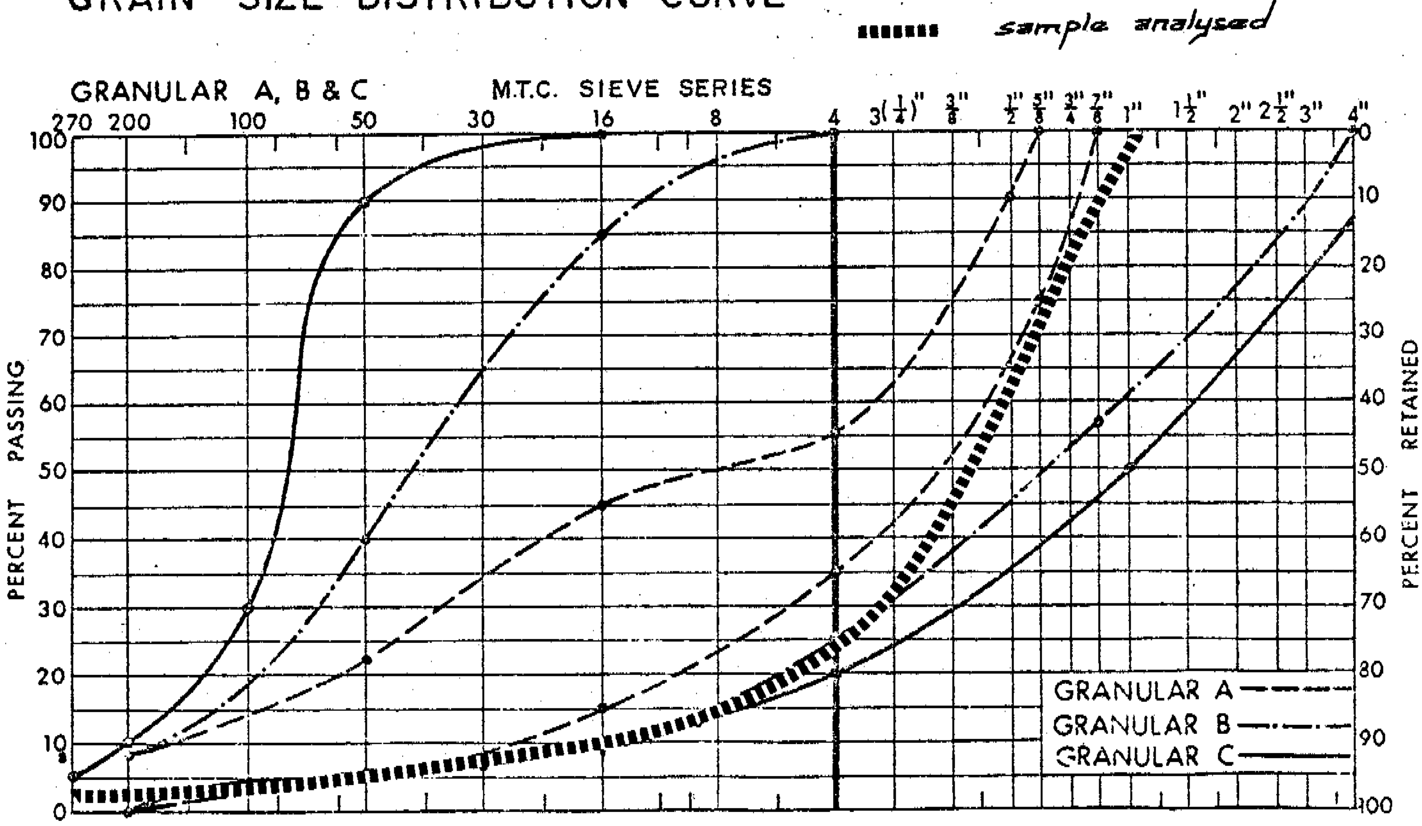
0'
Silty fine to med. gravel

1'
silty med. to coarse gravel with numerous cobbles, MPS-4"

3'
silty sand to boulders MPS-1·5'

5' ∇ assumed
refusal on boulders

GRAIN SIZE DISTRIBUTION CURVE



DRY SIEVE ANALYSIS AND TEST PIT LOGS

SAMPLE T.P. 25A (112A) DATE APRIL 4, 1978 NAME W. R. MOORE

Remarks: GRAVEL 48.1% SAND 48.9% FINES 3.0%
WASHED SIEVE (% FINES PASSING #200) 3%

DRY SIEVING			
Sieve No.	Mass Retained	Percent Retained	Cumulative % Passing
1½	446.1	–	–
3/4	317.6	17.0	83.0
3/8	269.9	14.5	68.5
4	309.8	16.6	51.9
10	445.2	23.9	28.0
16	246.5	13.2	14.8
30	139.3	7.5	7.3
50	46.8	2.5	4.8
100	15.2	0.8	4.0
200	17.8	1.0	3.0
PAN	33.4	1.8	
Totals	1841.5	100.0	

TEST PIT LOG

TEST PIT LOCATION (SEE DWG No HRS 2 & 3)

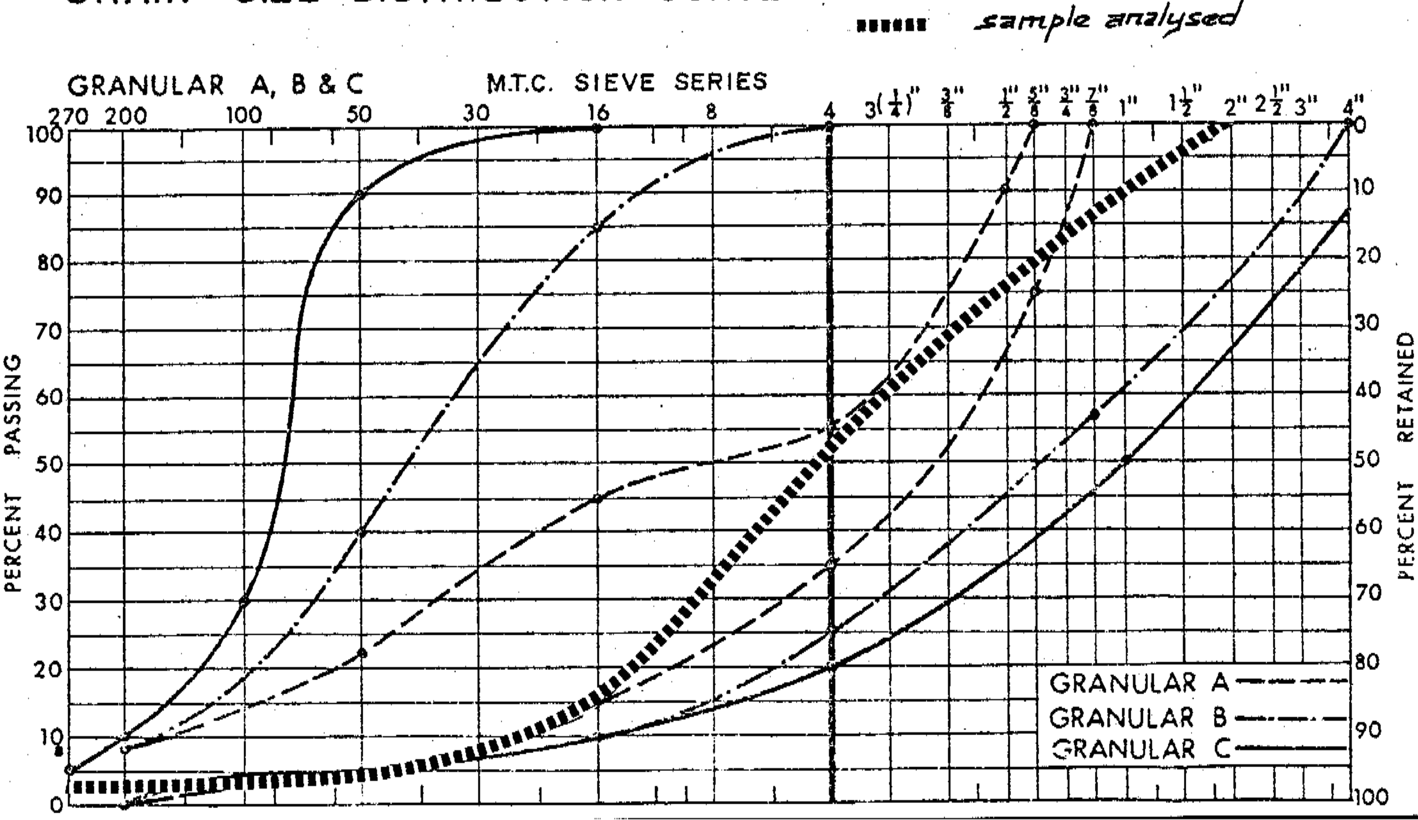
0'
silty fine gravel to cobbles MPS – 6"

1.5'
silty med. to coarse gravel occ. cobbles MPS – 3"

4'
coarse gravel to boulders some sand MPS – 2'

6'
refusal on boulders

GRAIN SIZE DISTRIBUTION CURVE



DRY SIEVE ANALYSIS AND TEST PIT LOGS

SAMPLE TP 25B (112A) DATE APRIL 4, 1978 NAME R. HILL

Remarks: GRAVEL 63.5% SAND 33.9% FINES 2.6%
WASHED SIEVE (% FINES PASSING #200) 3%

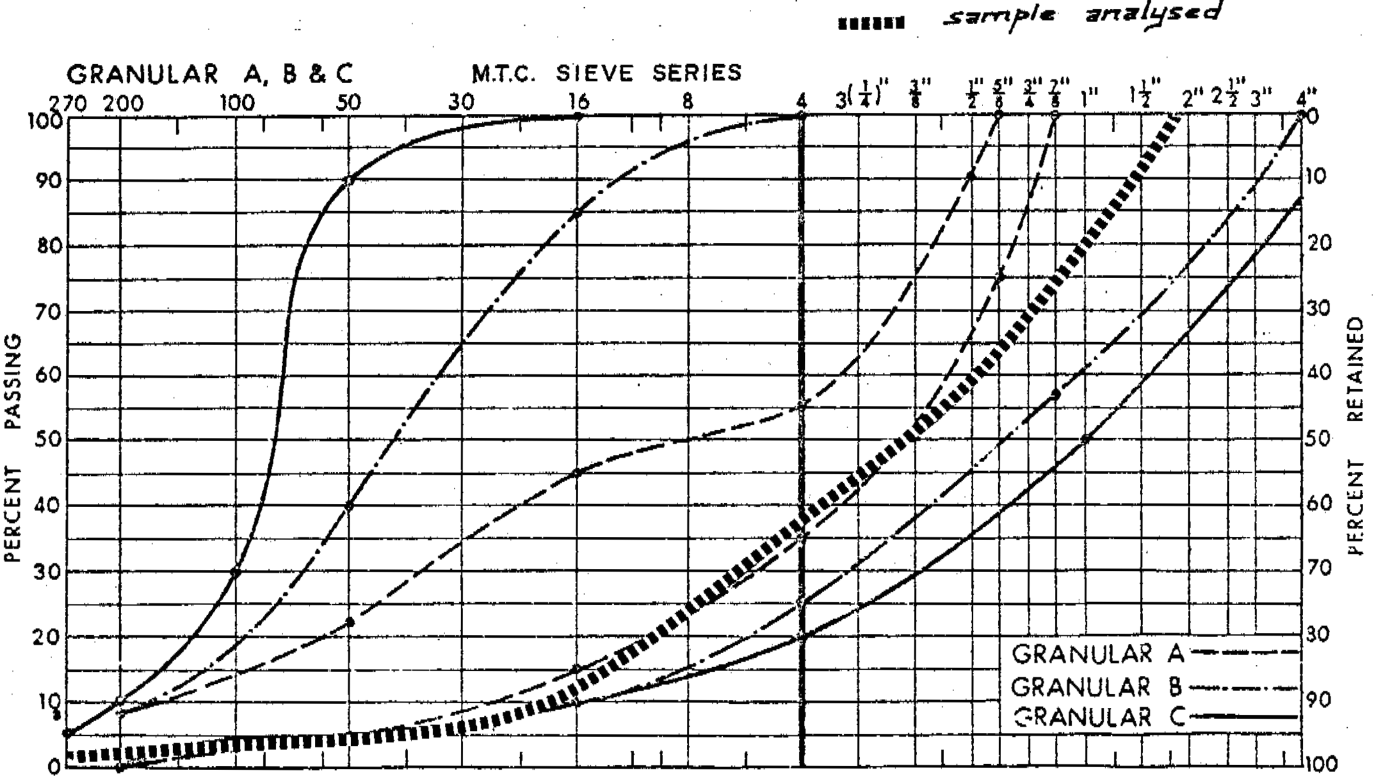
DRY SIEVING			
Sieve No.	Mass Retained	Percent Retained	Cumulative % Passing
1½	398.2	–	–
3/4	552.5	30.3	69.7
3/8	358.7	19.7	50.0
4	245.5	13.5	36.5
10	285.7	15.7	20.8
16	154.8	8.5	12.3
30	105.6	5.8	6.5
50	29.9	1.6	4.9
100	16.3	0.9	4.0
200	26.3	1.4	2.6
PAN	33.5	1.8	
Totals	1808.8	100.0	

TEST PIT LOG

TEST PIT LOCATION (SEE DWG No HRS 2 & 3)

Same as 25A (112A)

GRAIN SIZE DISTRIBUTION CURVE



DRY SIEVE ANALYSIS AND TEST PIT LOGS

SAMPLE T.P.-26 (112 A) DATE APRIL 4, 1978 NAME W. R. MOORE

Remarks: GRAVEL 52.8 % SAND 47.2 % FINES 0 %

WASHED SIEVE (% FINE PASSING #200) 3%

DRY SIEVING			
Sieve No.	Mass Retained	Percent Retained	Cumulative % Passing
1½	123.4	–	–
3/4	309.6	13.4	86.6
3/8	493.9	21.4	65.2
4	417.4	18.0	47.2
10	427.4	18.5	28.7
16	251.6	10.9	17.8
30	226.9	9.8	8.0
50	99.9	4.3	3.7
100	41.2	1.8	1.9
200	49.6	2.1	0.0
PAN	4.9	0.2	
Totals	2322.4	100.0	

TEST PIT LOG

TEST PIT LOCATION (SEE DWG No HRS 2 & 3)

0'
silty fine sand to boulders
MPS - 2'

3'
silty fine sand to cobbles
MPS - 6"

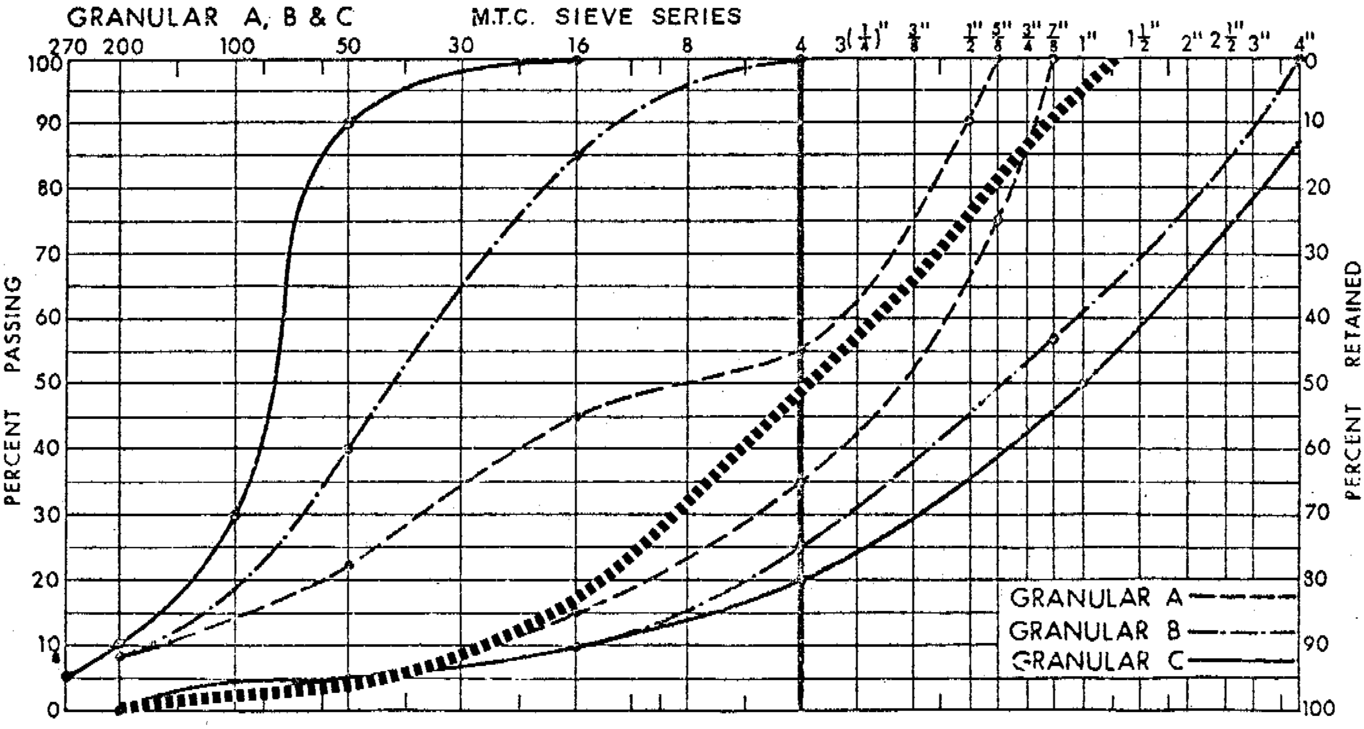
11' ∇
med. sand

11.5'
sandy silt

12'+

GRAIN SIZE DISTRIBUTION CURVE

sample analysed



DRY SIEVE ANALYSIS AND TEST PIT LOGS

SAMPLE T.P. 27 (112A) DATE APRIL 4, 1978 NAME W. R. MOORE

Remarks: GRAVEL 45.6 % SAND 52.0 % FINES 2.4 %

WASHED SIEVE (% FINES PASSING #200) 12 %

DRY SIEVING			
Sieve No.	Mass Retained	Percent Retained	Cumulative % Passing
1½	340.6	—	—
3/4	373.4	16.1	83.9
3/8	344.6	14.8	69.1
4	340.7	14.7	54.4
10	373.5	16.1	38.3
16	220.7	9.5	28.8
30	234.8	10.1	18.7
50	213.3	9.2	9.5
100	112.9	4.9	4.8
200	56.8	2.4	2.4
PAN	33.5	1.4	
Totals	2304.2	100.0	

TEST PIT LOG

TEST PIT LOCATION (SEE DWG No HRS 2 & 3)

0'

Silty sand to boulders MPS - 1'5'

1'

silty fine sand to cobbles occ. boulders MPS - 9"

8' ∇ assumed

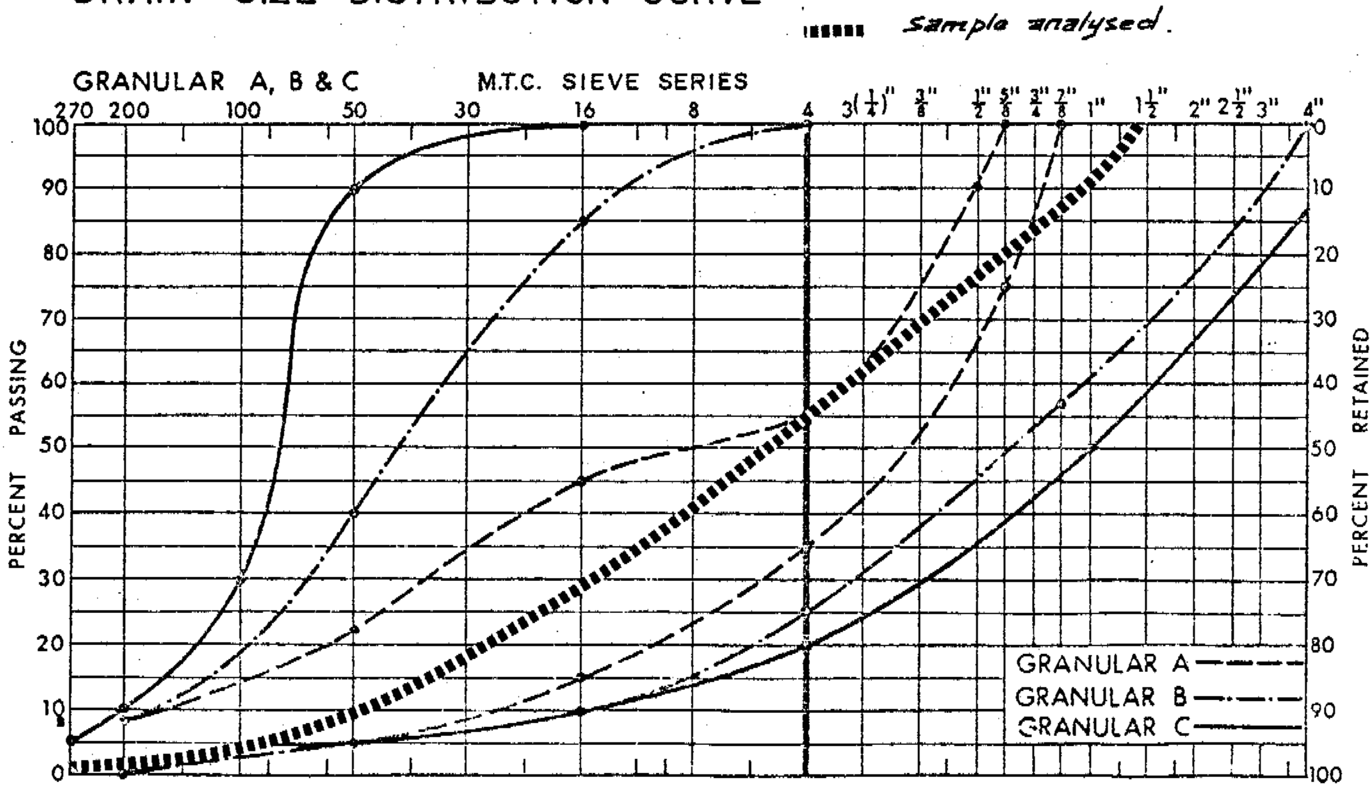
med. sand (frozen)

9'

clean fine sand to cobbles MPS - 5"

11'+

GRAIN SIZE DISTRIBUTION CURVE



DRY SIEVE ANALYSIS AND TEST PIT LOGS

SAMPLE TP-31 (III A) DATE APRIL 4, 1978 NAME W. R. MOORE

Remarks : GRAVEL 50.4 % SAND 47.4 % FINES 2.2 %
WASHED SIEVE (% FINES PASSING #200) 10 %

DRY SIEVING			
Sieve No.	Mass Retained	Percent Retained	Cumulative % Passing
1½	554.0	-	-
3/4	364.0	17.8	82.2
3/8	360.0	17.6	64.6
4	307.0	15.0	49.6
10	266.0	13.0	36.6
16	143.5	7.0	29.6
30	121.3	5.9	23.7
50	224.5	11.0	12.7
100	150.2	7.3	5.4
200	65.0	3.2	2.2
PAN	15.4	0.8	
Totals	2016.9	100.0	

TEST PIT LOG

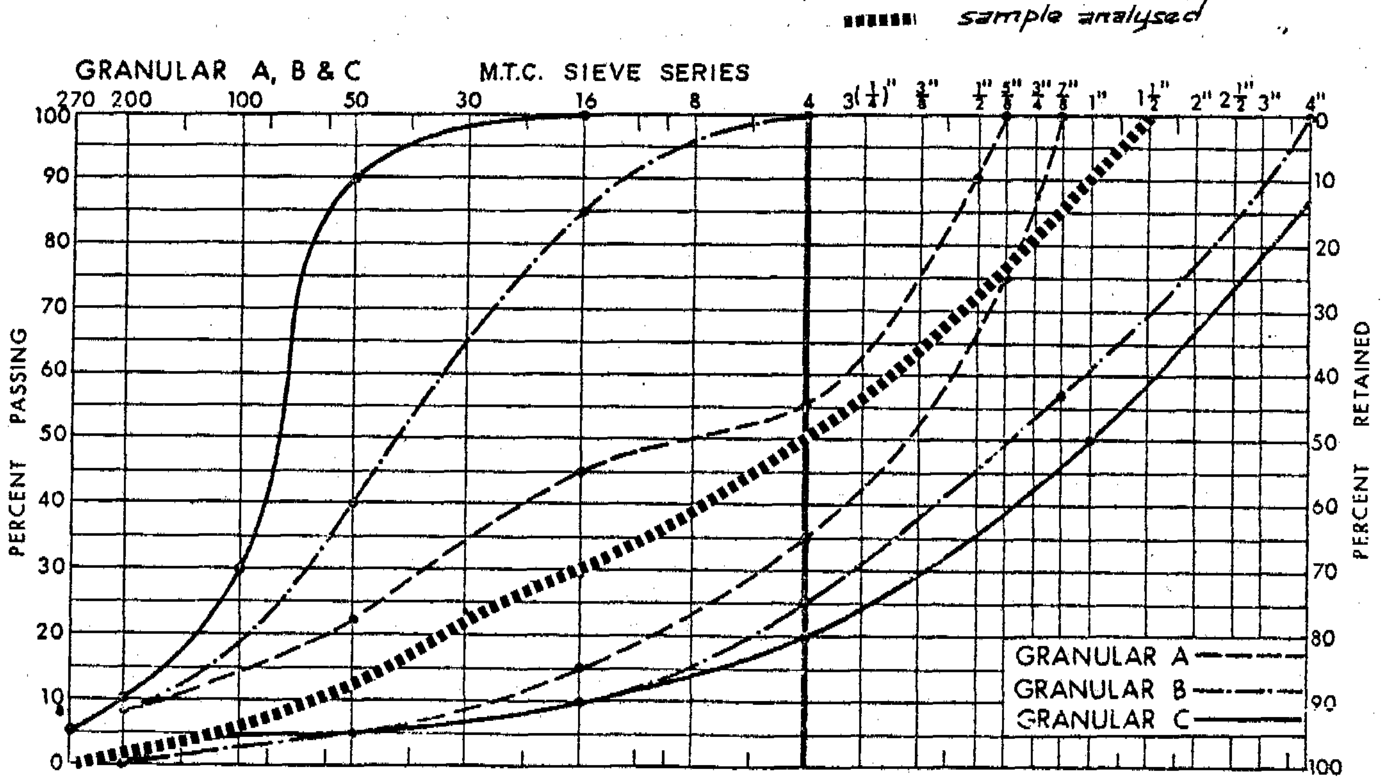
TEST PIT LOCATION (SEE DWG No HRS 2 & 3)

0'
med. sand to fine gravel
some boulders MPS-1'

3'
fine sand to fine gravel
some cobbles MPS-4"

5'+

GRAIN SIZE DISTRIBUTION CURVE



DRY SIEVE ANALYSIS AND TEST PIT LOGS

SAMPLE TP32 (111A) DATE APRIL 4, 1978 NAME W. R. MOORE

Remarks : GRAVEL 63.5% SAND 35.1% FINES 1.4%

WASHED SIEVE (% FINES PASSING # 200) 10%

DRY SIEVING

Sieve No.	Mass Retained	Percent Retained	Cumulative % Passing
1½	632.3	—	—
3/4	281.7	24.6	75.4
3/8	280.8	24.6	50.8
4	163.2	14.3	36.5
10	130.0	11.4	25.1
16	70.8	6.2	18.9
30	73.3	6.4	12.5
50	77.7	6.8	5.7
100	27.0	2.4	3.3
200	21.6	1.9	1.4
PAN	5.2	0.5	
Totals	1131.3	100.0	

TEST PIT LOG

TEST PIT LOCATION (SEE DWG No HRS 2 & 3)

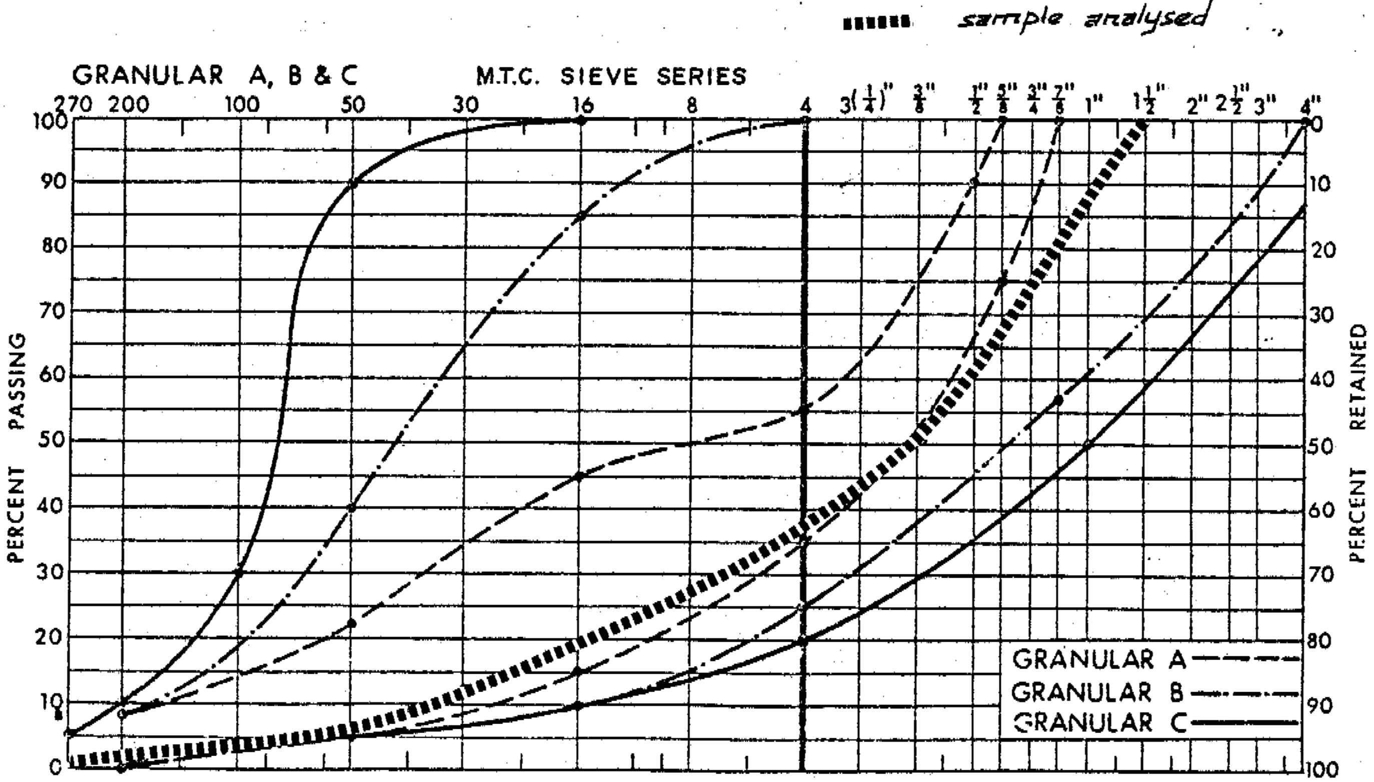
0'
medium sand - some boulders
MPS - 1'

1.5'
med. sand to fine gravel
Some boulders MPS - 10"

9'
med. sand to coarse gravel
MPS - 3"

11'
silty clay till

GRAIN SIZE DISTRIBUTION CURVE



DRY SIEVE ANALYSIS AND TEST PIT LOGS

SAMPLE TP 33 (111 A) DATE APRIL 4, 1978 NAME R. HILL

Remarks : GRAVEL 47.2 % SAND 50.4 % FINES 2.4 %

WASHED SIEVE (% FINES PASSING #200) 10 %

DRY SIEVING			
Sieve No.	Mass Retained	Percent Retained	Cumulative % Passing
1½	637	–	–
3/4	208	16.2	83.8
3/8	174.8	13.6	70.2
4	223.3	17.4	52.8
10	263.5	20.5	32.3
16	95.2	7.4	24.9
30	72.6	5.7	19.2
50	117	9.1	10.1
100	51	4.0	6.1
200	46.9	3.7	2.4
PAN	29.3	2.3	
Totals	1281.6	100.0	

TEST PIT LOG

TEST PIT LOCATION (SEE DWG No HRS 2 & 3)

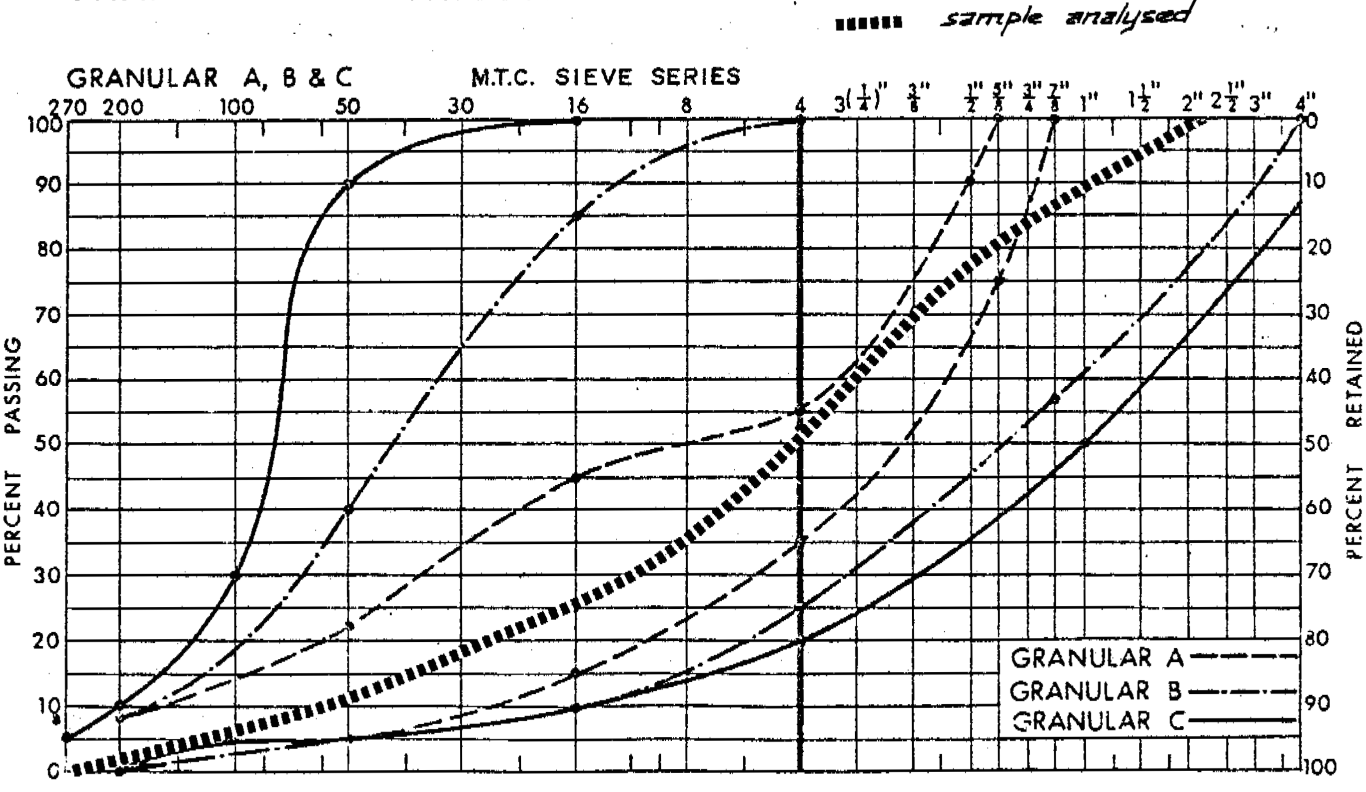
0'
med. sand and gravel
MPS-3"

2'
med. sand and gravel with large boulders
MPS-2'

7'
Med. sand and gravel with cobbles
MPS-6"

9'
silty clay till

GRAIN SIZE DISTRIBUTION CURVE



DRY SIEVE ANALYSIS AND TEST PIT LOGS

SAMPLE TP-34 DATE APRIL 4, 1978 NAME R. HILL

Remarks: GRAVEL 37.4 % SAND 61.9 FINES 0.7

WASHED SIEVE (% FINES PASSING #200) 10%

DRY SIEVING

Sieve No.	Mass Retained	Percent Retained	Cumulative % Passing
1½	–	–	–
3/4	268.2	11.0	89.0
3/8	306.6	12.5	76.5
4	340.1	13.9	62.6
10	323.9	13.2	49.4
16	177.6	7.3	42.1
30	565.9	23.1	19.0
50	339.1	13.9	5.1
100	41.6	1.7	3.4
200	65.6	2.7	0.7
	23.3	1.0	
Totals	2451.9	100.0	

TEST PIT LOG

TEST PIT LOCATION (SEE DWG No HRS 2 & 3)

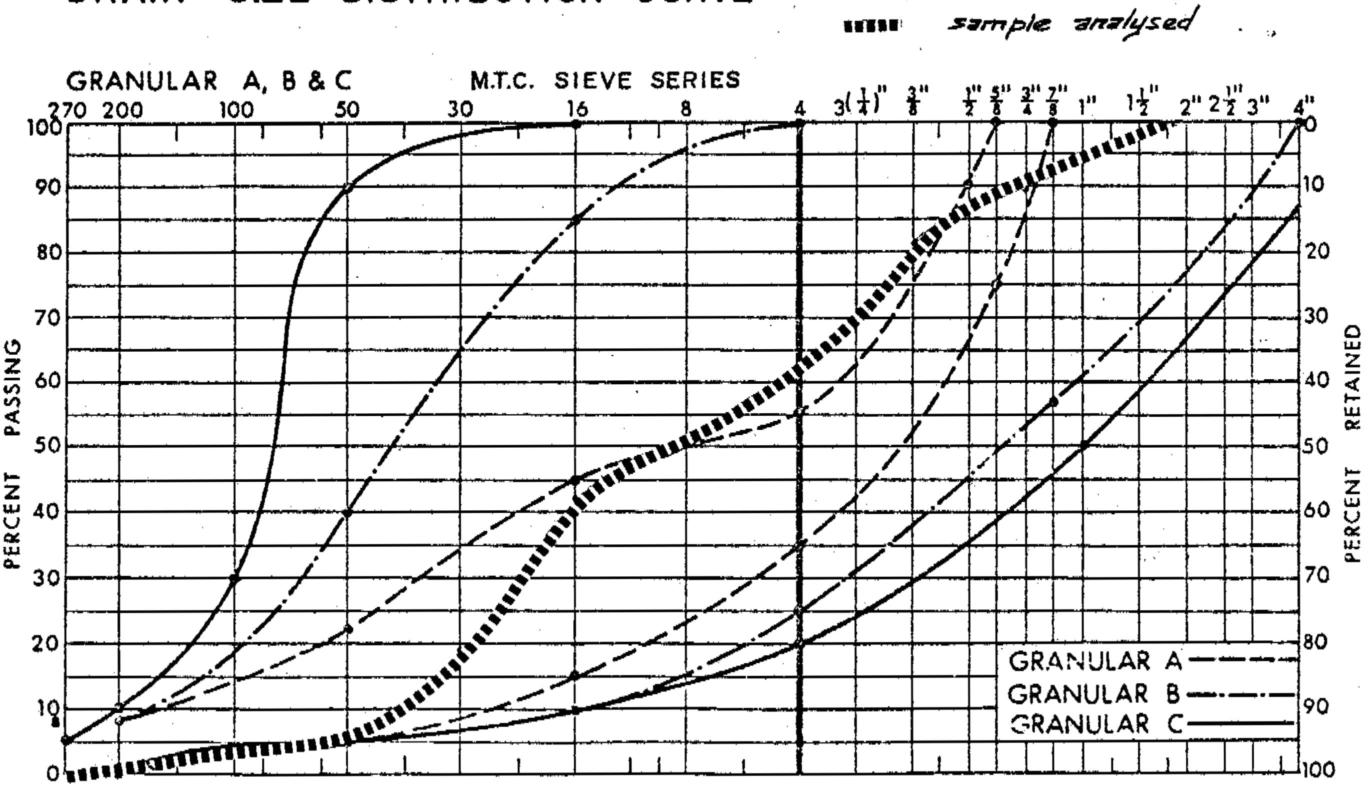
0' med. sand to fine gravel

2' coarse sand and gravel with occ. cobbles MPS-4"

3' med. sand to coarse gravel

5' Silty clay till MPS-1'

GRAIN SIZE DISTRIBUTION CURVE



DRY SIEVE ANALYSIS AND TEST PIT LOGS

SAMPLE ... TP-36 .... DATE .. APRIL 4, 1978 ... NAME ..... R. HILL ....

Remarks : GRAVEL 48.6 % SAND 49.2 % FINES 2.2

WASHED SIEVE (% FINES PASSING #200) 6%

DRY SIEVING			
Sieve No.	Mass Retained	Percent Retained	Cumulative % Passing
1½	137.5	–	–
3/4	504.3	18.5	81.5
3/8	466.8	17.2	64.3
4	350.5	12.9	51.4
10	336.7	12.4	39.0
16	198.2	7.3	31.7
30	288.7	10.6	21.1
50	268.9	9.9	11.2
100	103.2	3.8	7.4
200	141.8	5.2	2.2
PAN	46.7	1.7	
Totals	2705.8	100.0	

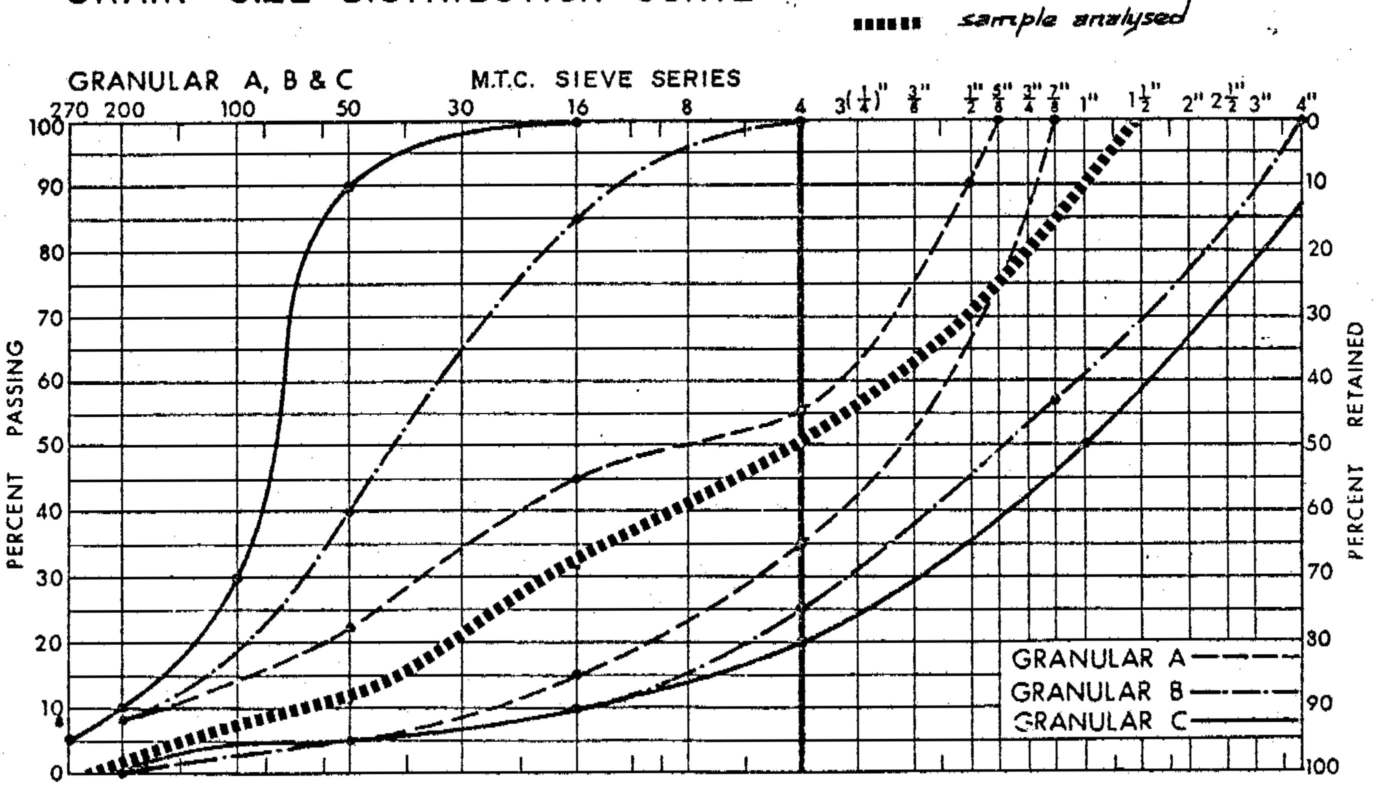
TEST PIT LOG

TEST PIT LOCATION (SEE DWG No HRS 2 & 3)

0'
fine sand to boulders, MPS-3'

4' ∇ assumed
refusal on boulders

GRAIN SIZE DISTRIBUTION CURVE



DRY SIEVE ANALYSIS AND TEST PIT LOGS

SAMPLE TP38A DATE APRIL 4, 1978 NAME R. HILL

Remarks: GRAVEL 53.4% SAND 45.2% FINES 1.4%

WASHED SIEVE (% FINES PASSING #200) 6%

DRY SIEVING

Sieve No.	Mass Retained	Percent Retained	Cumulative % Passing
1½	515·6	–	–
3/4	379·5	18·3	81·7
3/8	409·7	19·8	61·9
4	317·7	15·3	46·6
10	280·4	13·5	33·1
16	153·7	7·4	25·7
30	187·7	9·1	16·6
50	193·2	9·3	7·3
100	61·9	3·0	4·3
200	60·2	2·9	1·4
PAN	11·8	0·5	0·9
Totals	2055·8	100·0	

TEST PIT LOG

TEST PIT LOCATION (SEE DWG No HRS 2 & 3)

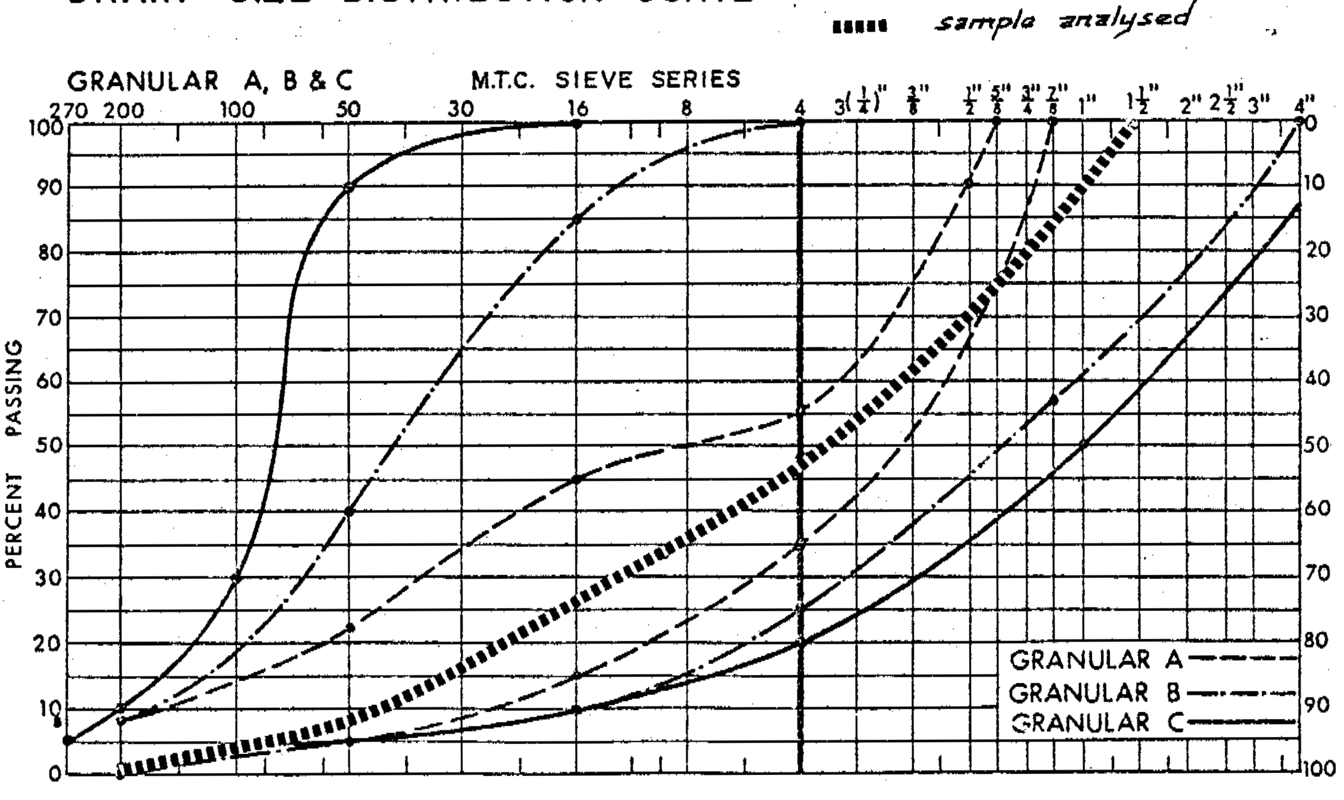
0' med to coarse gravel occ. cobbles MPS-4"

2' fine sand to boulders

8' wet med. sand, some gravel

10' silty fine sand till

GRAIN SIZE DISTRIBUTION CURVE



DRY SIEVE ANALYSIS AND TEST PIT LOGS

SAMPLE TP 38B DATE APRIL 4, 1978 NAME R. HILL

Remarks: GRAVEL 44.9% SAND 53.9% FINES 1.2%
WASHED SIEVE (% FINES PASSING #200) 6%

DRY SIEVING

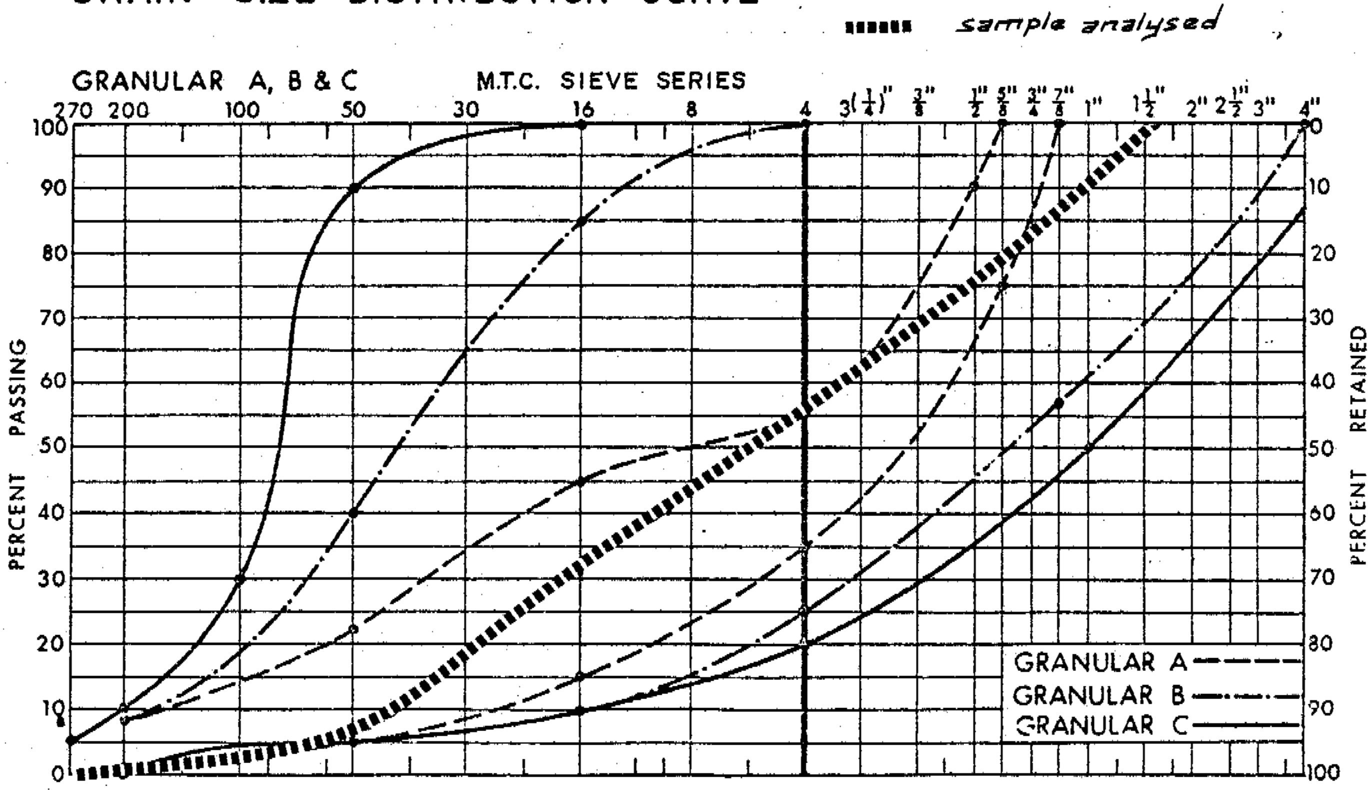
Sieve No.	Mass Retained	Percent Retained	Cumulative % Passing
1½	–	–	–
3/4	325.9	16.2	83.8
3/8	294.4	14.6	69.2
4	283.9	14.1	55.1
10	307.0	15.2	39.9
16	175.3	8.7	31.2
30	256.2	12.7	18.5
50	252.8	12.5	6.0
100	76.5	3.8	2.2
200	20.7	1.0	1.2
PAN	1.0	0.0	
Totals	1993.7	100.0	

TEST PIT LOG

TEST PIT LOCATION (SEE DWG No HRS 2 & 3)

Same as 38A

GRAIN SIZE DISTRIBUTION CURVE



DRY SIEVE ANALYSIS AND TEST PIT LOGS

SAMPLE *TP 40* DATE *APRIL 4, 1978* NAME *R. HILL*

Remarks: *GRAVEL 10.4% SAND 86.8% FINES 2.8%*

WASHED SIEVE (% FINES PASSING #200) 6%

DRY SIEVING

Sieve No.	Mass Retained	Percent Retained	Cumulative % Passing
1½	–	–	–
3/4	–	–	100
3/8	41.0	2.9	97.1
4	107.7	7.5	89.6
10	133.3	9.3	80.3
16	56.5	4.0	76.3
30	92.8	6.5	69.8
50	353.0	24.7	45.1
100	490.7	34.4	10.7
200	112.6	7.9	2.8
PAN	17.8	1.2	
Totals	1405.4	100.0	

TEST PIT LOG

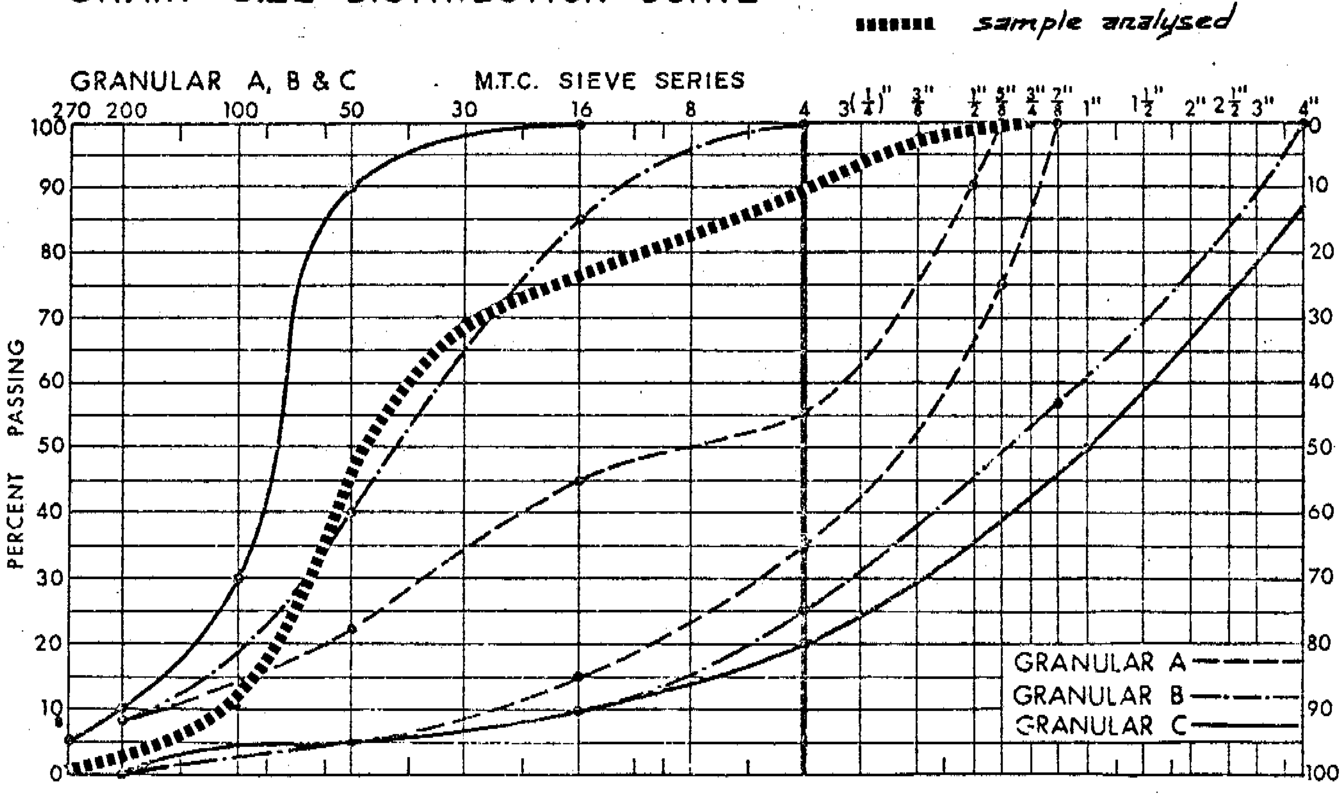
TEST PIT LOCATION (SEE DWG No HRS 2 & 3)

0'
med. sand to fine gravel

2'
fine sand and silt

3' ∇ assumed
silty clay till

GRAIN SIZE DISTRIBUTION CURVE



DRY SIEVE ANALYSIS AND TEST PIT LOGS

SAMPLE TP 41 DATE APRIL 4, 1978 NAME W. R. MOORE

Remarks : GRAVEL 26.7% SAND 70.6% FINES 2.7%
WASHED SIEVE (% FINES PASSING #200) 6%

DRY SIEVING			
Sieve No.	Mass Retained	Percent Retained	Cumulative % Passing
1½	-	-	-
3/4	217.6	9.2	90.8
3/8	145.8	6.2	84.6
4	266.7	11.3	73.3
10	333.8	14.1	59.2
16	222.5	9.4	49.8
30	281.9	11.9	37.9
50	506.5	21.4	16.5
100	184.5	7.8	8.7
200	142.2	6.0	2.7
PAN	69.9	3.0	
Totals	2371.4	100.0	

TEST PIT LOG

TEST PIT LOCATION (SEE DWG No HRS 2 & 3)

0'
fine to med. sand

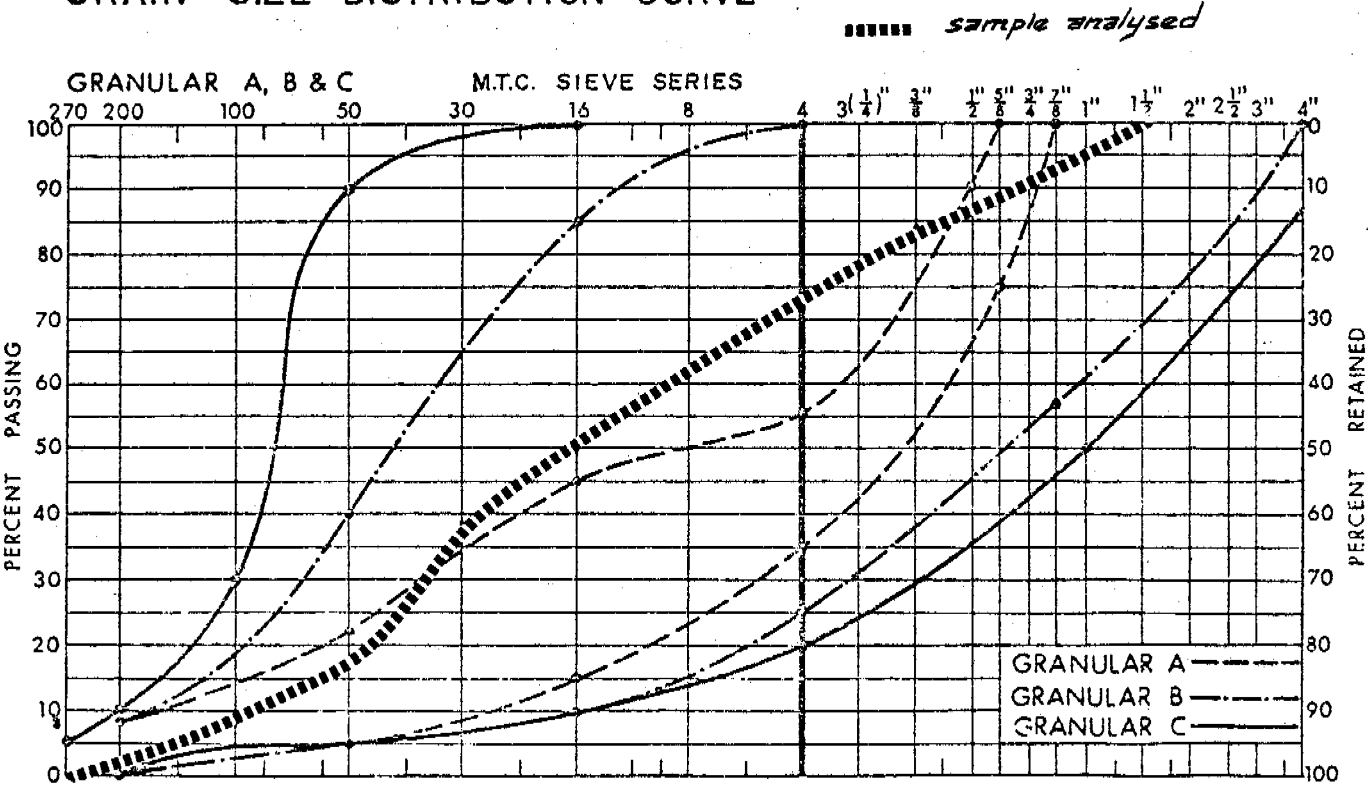
2'
med. sand and gravel
MPS - 2"

6'
medium sand

7' ▽

9
silty clay till

GRAIN SIZE DISTRIBUTION CURVE



DRY SIEVE ANALYSIS AND TEST PIT LOGS

SAMPLE TP42 DATE APRIL 4, 1978 NAME W. R. MOORE

Remarks: GRAVEL 11.9% SAND 85.5% FINES 2.6%
WASHED SIEVE (% FINES PASSING #200) 8%
CLAY LUMPS HELD ON LARGER SIEVES

DRY SIEVING

Sieve No.	Mass Retained	Percent Retained	Cumulative % Passing
1½	–	–	–
3/4	48.0	4.8	95.2
3/8	31.1	3.1	92.1
4	39.8	4.0	88.1
10	57.0	5.7	82.4
16	42.7	4.2	78.2
30	47.8	4.7	73.5
50	138.0	13.7	59.8
100	524.4	52.1	7.7
200	51.5	5.1	2.6
PAN	11.9	1.2	
Totals	992.2	100.0	

TEST PIT LOG

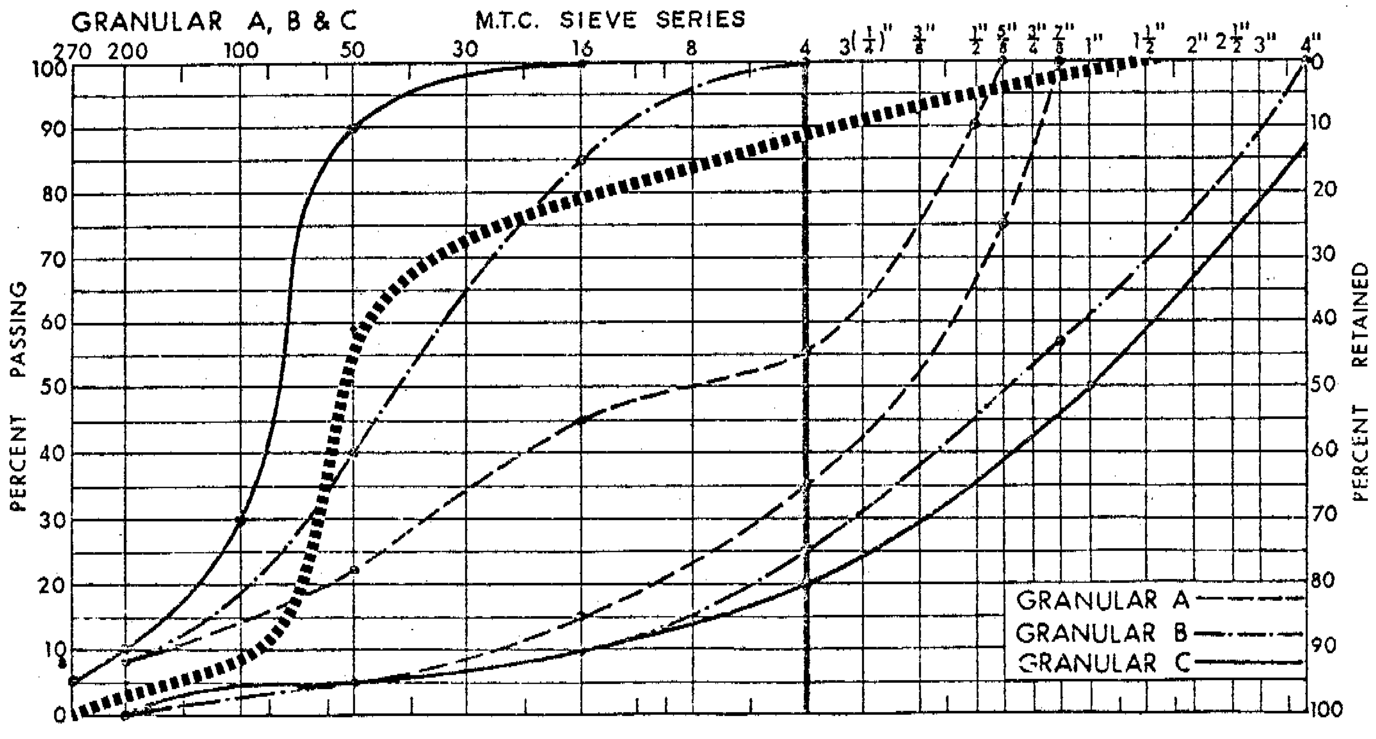
TEST PIT LOCATION (SEE DWG No HRS 2 & 3)

0'
silty sand and boulders
MPS-1

3' ▽ assumed
silty clay till

GRAIN SIZE DISTRIBUTION CURVE

▪▪▪▪▪▪ sample analysed



(X) GROUND PHOTOGRAPHS

Mile 12 South

GROUND PHOTOGRAPHS

(Mile 12 South)

Photo 1

Depleted area on Deposit HR109A. Pit could be extended with an approximate working face of 6 ft.

Photo 2

Typical gap-graded material found in the higher elevation areas of the Mile 12 deposits.

GROUND PHOTOGRAPHS (Mile 12 South)

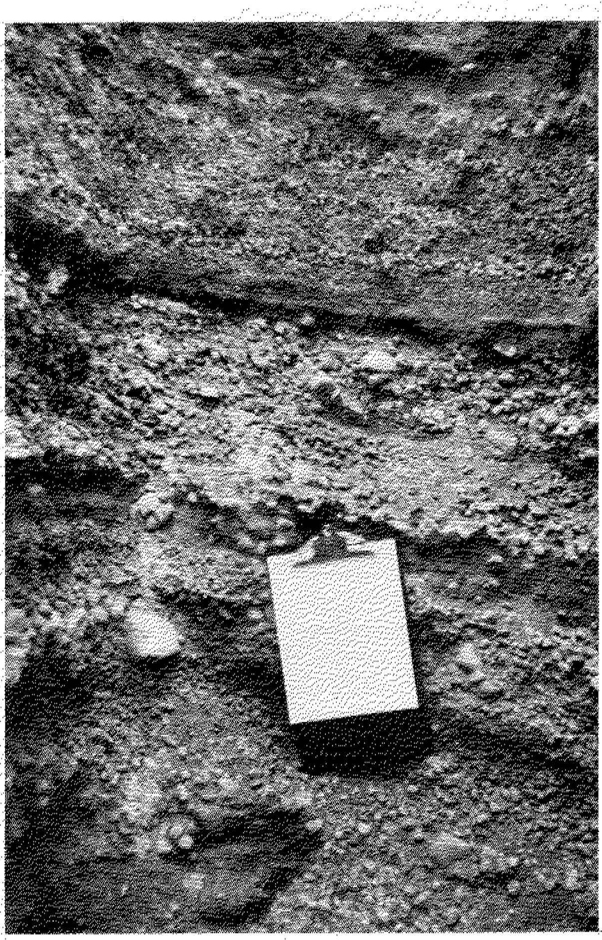


Photo 3

Stratified granular material which indicates the eskers have been reworked forming typical beach deposits. This material is found at the ends and along the northern portions of the eskers and has a high percentage of encrustation.

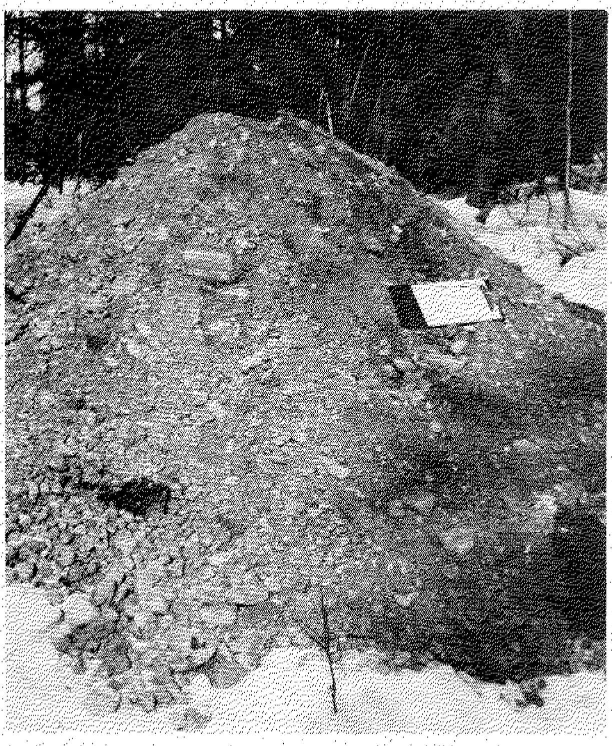
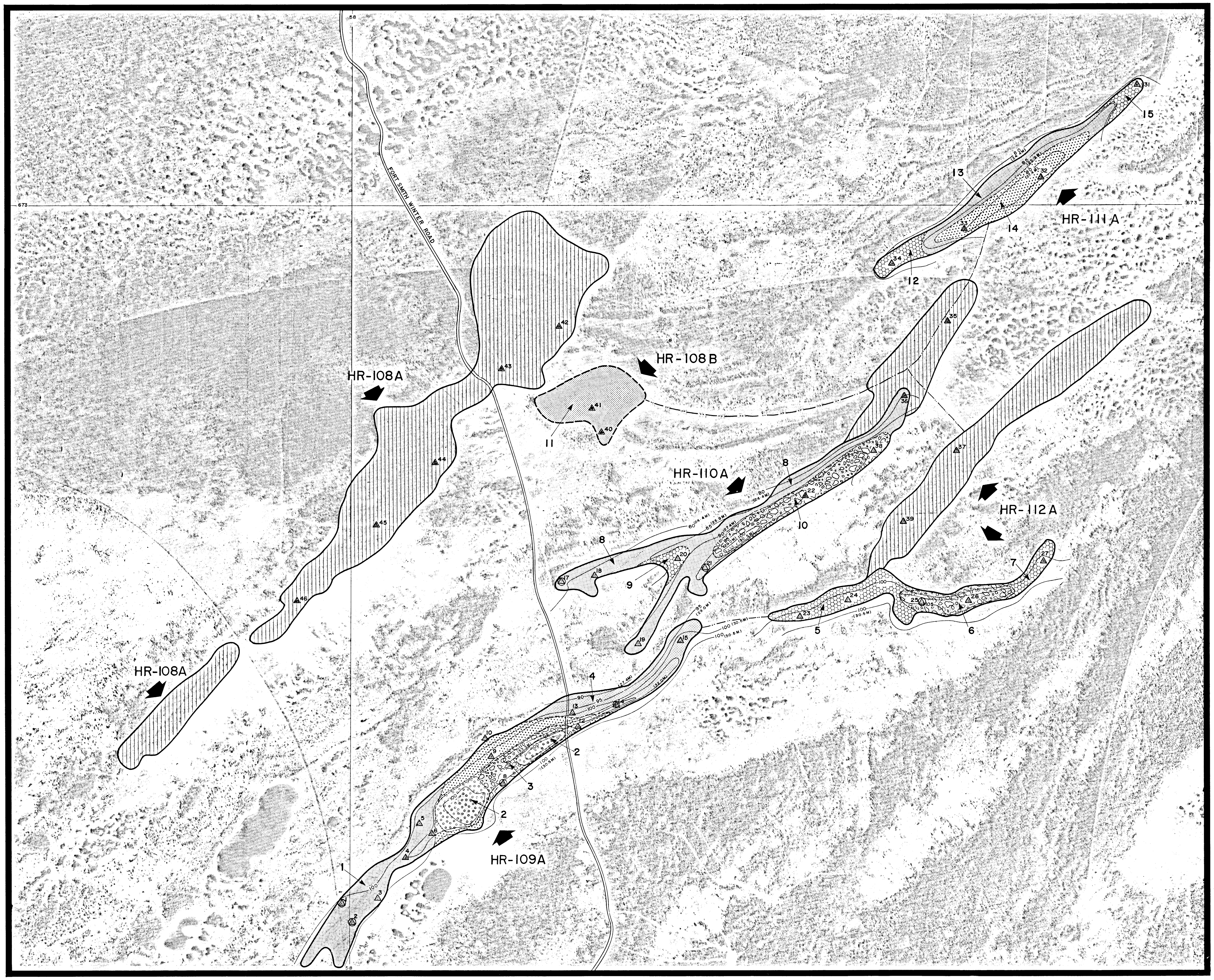
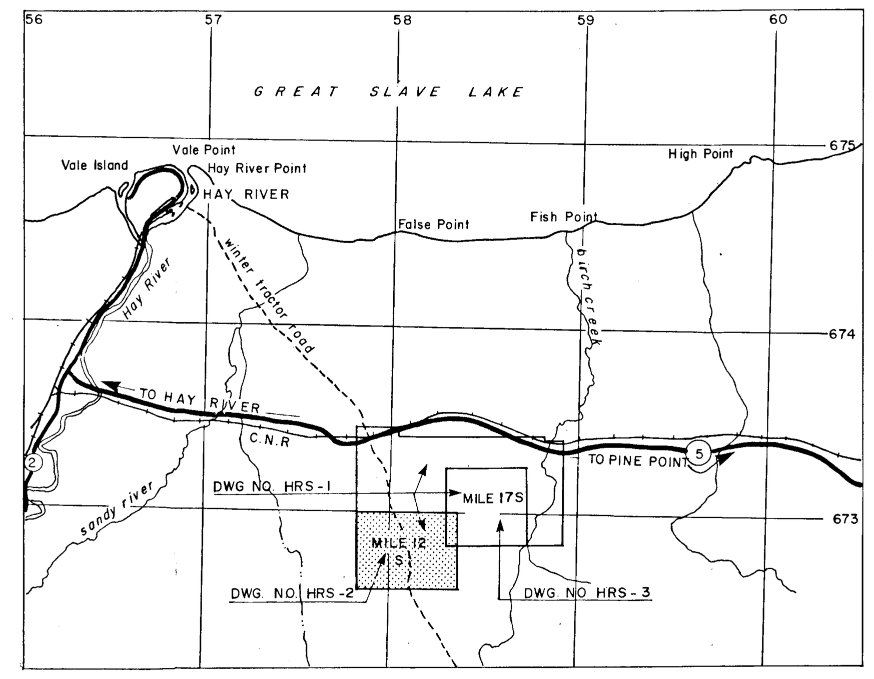


Photo 4

Excavated material from the test pit shown above. Note the lack of large boulders.





key map

SCALE = 1:250,000

Ref. N.T.S. MAP, BUFFALO LAKE, 85B, EDITION 2, MCE SERIES A 502 - 1967

LEGEND

POTENTIAL GRANULAR 'A' MATERIAL AND CONCRETE AGGREGATE

POTENTIAL GRANULAR 'B' MATERIAL

POTENTIAL GRANULAR 'C' MATERIAL

GENERAL FILL

DEPLETED AREA

MATERIAL PREVIOUSLY DELINEATED AS POTENTIAL GRANULAR DEPOSIT (EXTREMELY LIMITED ECONOMIC POTENTIAL)

TEST PIT LOCATIONS

HOLES LEFT OPEN

RECOMMENDED ADDITIONAL TEST PITS

DEPOSIT BOUNDARIES

100' (30.5M) ELEVATION CONTOUR LINES

POTENTIAL ACCESS BETWEEN DEPOSITS

THE DEPARTMENT OF INDIAN AFFAIRS AND NORTHERN DEVELOPMENT

GRANULAR MATERIALS INVENTORY

HWY. No. 5, HAY RIVER
NORTHWEST TERRITORIES **MILE 12 S**

SCALE: 1" = 500' ±	DATE: MAY, 1978
INTERPRETATION: W.R.M. & R.H.	DRAWN: A.B.
CHECKED: S.J.G.B.	CHECKED: W.R.M.
DATE OF PHOTOGRAPHY: 1972	DRAWING No: HRS-2 (77-128)

bird and hale ltd. 1263 Bay Street Toronto - Ontario

- Airphoto interpretation studies
- Engineering and environmental coordination

4.2 Mile 17 South Deposits

(i) Location and Existing Access (see Key Map)

This group of three deposits is located approximately 2.5 miles south of Mile 17 of the Hay River-Pine Point Highway (Hwy. No. 5) and is approximately 26 miles from the Town of Hay River.

Road access to the deposit is currently not available. However, access by tracked vehicle is possible on one of many seismic lines that cross the deposit.

(ii) Regional Geology

The entire southern shore of Great Slave Lake near Hay River, including the Mile 17 South study area, is underlain by flat-lying Upper Devonian sedimentary rock. This uniform buff-coloured, slightly dolomitized limestone is overlain by a cover of uniform ablation till deposited by the receding glaciers. The Hay River channel from Louise Falls to near Enterprise exposes a clear section of this development. As the glacial ice retreated, the level of Great Slave Lake fell, creating a series of parallel shorelines on the north-sloping terrain.

The deposits of economic interest are late-stage glaciofluvial and glaciolacustrine features superimposed upon the ablation till.

(iii) Geomorphology

These discontinuous east-west trending deposits resemble kames formed as the stagnant Laurentide ice sheet melted.

It is assumed that these formations were deposited upon a gently undulating or moderately rolling ablation till similar to that of the surrounding region. The current and wave action of post-glacial Great Slave Lake modified the deposits to varying degrees. For example, the south-central portions have the highest elevations and were modified only slightly. There is evidence to indicate that these contain sand and gravel typical of kame deposits. The occurrence of a surface layer containing numerous boulders (maximum particle size 3' dia.) prevented excavation and verification of material type in numerous locations.

The lower east-west extremeties and the north facing slopes of these deposits consist primarily of stratified beach deposits of sand and gravel.

(iv) Groundwater Conditions

The Mile 17 South deposits are superimposed upon a relatively flat-lying till and fine sandy till plain exhibiting imperfect drainage and muskeg conditions. No distinct drainage channels, creeks or streams are proximate to these deposits.

Test pits were excavated in these deposits during winter months; therefore, it was not possible to accurately determine typical summer groundwater table elevations.

However, as described in Section 4.1 (iv), there is evidence to indicate that the summer groundwater table elevation in the deposits will coincide with the surface elevation of the surrounding muskeg. Also, as described in Section 4.1 (iv), it was concluded that the summer to winter groundwater table fluctuation could range up to 4 or 5 feet in elevation.

(v) Vegetation and Wildlife

Vegetation and wildlife observations were hindered by winter conditions. However, all observations indicate conditions similar to those described for Mile 12 deposits as outlined in our previous report.

The undisturbed portion of the eskers contain a uniform overstory of black spruce (pinus mariana) 6-12" dbh, 40-45'h, with jack pine (pinus banksiana) 8-15"dbh, 35-45'h, together forming a 65-75% canopy. The higher portions contain many windfalls, thus attesting to a lack of root fastness throughout the sandy subsoils.

The understory is predominantly caribou moss and grasses, with a few sedges and occasional wild rose (Rosa spp.). The transition zone to muskeg is characterized by densely covered dwarf tundra birch (Betula Glandulosa) in areas of permanent surficial wetness and leather-leaf (Chamaedaphne calyculator) and grasses.

In areas of improved drainage, black spruce continues into the surrounding flat areas; however, diameters are generally 4-8" only, and the canopy is usually 40% maximum.

Areas underlain by granular materials are generally characterized by a very open understory which does not offer sufficient shelter or food sources for small mammals. Although squirrels, lynx, chipmunks and marten are reported in the general area, little direct evidence of other wildlife, except for song-birds, ravens and whiskey jacks, was found in the study area.

Surrounding wetlands with dense understory, better shelter and a greater variety of food sources provide a more suitable environment for small rodent and rep-tilian fauna.

It should be noted that numerous caribou tracks and evidence of browsing were observed throughout the entire Mile 17 South area and particularly on the deposits. Discussion with Mr. Andrew Forbes, Resource Management Officer, Northwest Land and Forest Service, Hay River, indicated that Woodlands Caribou are often sighted in this general area. Therefore, it is assumed that these deposits serve as a winter grazing area.

Pit development to date has been restricted to dry operations, and this will likely continue in the future. Therefore, careful management can help to ensure little disruption through siltation or destruc-tion of surrounding muskeg areas. The very nature of the soils discourages random vehicular access to the surrounding area.

(vi) Previous Development

There is no evidence of aggregate extraction in these deposits.

(vii) Present Reserve Area

The areal dimensions of these granular deposits are listed below:

Deposit	Approximate Length (meters)	(feet)	Average Width (meters)	(feet)	Approximate Area (hectares)	(acres)
HR123A	1,500	5,000	82.5	275	12.7	31.5
HR124A	3,150	10,500	120.0	400	39.0	96.4
HR125A	1,425	4,750	67.5	225	10.0	24.5

(viii) Quality and Quantity of Aggregate

The granular deposits have been divided into sections according to their potential for specific aggregate uses. These sections have been numbered 1 to 11, inclusive, on Dwg. No. HRS-3. The approximate area, average estimated depth of working face, estimated volume, potential use and crushing potential of each section appear in Table No. 2.

Due to the similarity of the M.T.C. specifications for concrete aggregate and Granular A material, all potential Granular A material may be upgraded to meet concrete aggregate specifications as indicated in Table No. 2.

As defined by the Ontario Ministry of Transportation and Communications, "crushable gravel contains a minimum of 35% coarse aggregate larger than the #4 sieve."

Due to the unpredictable topography of the underlying ablation till and the extreme difficulty encountered in excavating a large percentage of the test pits on these deposits, it was not possible to accurately determine aggregate volumes. Thus, all volumes are best estimates and are conditioned as indicated in Table No. 2.

It is recommended that the excavation of five additional test pits in the locations indicated on Dwg. No. HRS-3, to the underlying ablation till or groundwater table, would permit considerable refinement of the volume estimates.

The local contractors involved with this study indicated that this material could probably be excavated during the summer months. Such a sampling program would require the use of a bulldozer with a backhoe. Some means of clearing some mature timber to provide access for the backhoe will be required.

The test sampling could be conducted by personnel from the Land Use Management Branch, Hay River, under instruction from our firm, regarding sampling procedures and recording of test pit logs. The samples could then be sent to our office in Toronto for analysis. Finally, modification to the estimated volumes of material could be made.

TABLE NO. 2

QUALITATIVE AND QUANTITATIVE ANALYSIS OF GRANULAR MATERIAL

FOR MILE 17 SOUTH

ection See Dwg. o. HRS-3	Area (Hectares)	Average Estimated Depth of Working Face Winter Extraction		Summer Extraction		Estimated (±40%) Volume Winter Extraction	Estimated(±40%) Volume Summer Extraction	Potential Use	Material Requiring Minimal Upgrading to Meet Concrete Aggregate Specifications	Required Upgrading For Concrete Aggregate	* Crushing Potential
		(m)	(ft)	(m)	(ft)	$(m^3)/(yd^3)$	(m^3/yd^3)				
1	10.6	1.8	(6)	1.2	(4)	165,000/215,000	110,000/145,000	C			X
2	4.9	2.4	(8)	1.5	(5)	100,000/130,000	65,000/ 80,000	GF			X
3	1.7	3.0	(10)	2.4	(8)	45,000/ 60,000	35,000/ 45,000	A	X	Washing & screening	X
4	5.2	2.4	(8)	1.5	(5)	105,000/140,000	70,000/ 90,000	B			
5	7.7	1.5	(5)	0.9	(3)	100,000/130,000	60,000/ 75,000	B			X
6	12.2	1.5	(5)	0.9	(3)	160,000/210,000	95,000/125,000	C			X
7	1.7	2.4	(8)	1.5	(5)	35,000/ 45,000	25,000/ 35,000	A	X	Washing & screening	X
8	2.3	0.9	(3)	N/A	N/A	20,000/ 26,000	N/A N/A	GF			X
9	3.4	0.9	(3)	N/A	N/A	26,000/ 35,000	N/A N/A	C			X
10	5.2	1.5	(5)	0.9	(3)	70,000/ 90,000	40,000/ 50,000	B			X
11	9.5	0.9	(3)	N/A	N/A	75,000/100,000	N/A N/A	C			X

* See Appendix C

A description of the individual deposits and some of the unique characteristics of each are outlined below:

(a) Deposit HR123A

This deposit contains material which satisfies the specifications for use as Granular A and B material and general fill.

The material in Section 2 is predominantly gravel and has been designated as general fill due to a high fines content (18% wet sieve). However, the existence of discontinuous strata containing a high content of boulders (maximum particle size 3' dia.) may necessitate the use of a rock or bar screen prior to the use of this material as Granular A or B.

The larger boulders retained on the bars can be stockpiled for crushing. Also, these boulders may be used for other purposes, such as rip-rap, or gabion construction material.

Section 3 has the highest elevation on the deposit, and the material is predominantly sand.

The proportions of sand and gravel in Section 4 are highly variable, thus the crushability of this material also varies. The optimum use of this material is Granular B.

(b) Deposit HR124A

This deposit is extremely complex, and the quality of the material varies greatly.

The discontinuous boulder (maximum particle size 3' dia.) stratum is more extensive in this deposit than in the Mile 12 South or the other Mile 17 South deposits. The existence of this stratum may necessitate the use of a rack or bar screen to remove the boulders prior to the use of the granular material for uses higher than general fill. The larger boulders retained on the bars can be stockpiled and when there are enough, they can be crushed. Also, these boulders may be used for other purposes such as rip-rap or gabion construction material.

Sections 5 and 10 consist predominantly of sand and are most suited for use as Granular B material. The material in Sections 6, 9 and 11 is designated as Granular C material. This material has a high content of boulders (maximum particle size 3' dia.). Section 6 consists predominantly of gravel and 9 and 11 of predominantly sand.

Section 7, although delineated at surface, occurs as a subsurface stratum of sand and gravel. The difficulty encountered during excavation of numerous test pits in the area prevented a detailed investigation of this deposit. However, the material is predominantly gravel and has a high potential for Granular A. It will require minimal screening and washing to meet M.T.C. concrete aggregate specifications.

The material in Section 8 is designated as general fill due to an extremely high fines content (24% wet sieve).

(c) Deposit HR125A

Assessment of this deposit was outside the revised terms of reference. However, to provide an accurate indication of the estimated volumes and quality of granular material in the area, it was decided to investigate this deposit. Therefore, one test pit was excavated and one elevation survey was conducted down the seismic line that crosses both small deposits. The results of laboratory tests indicate this material to be predominantly gravel with a fines content of approximately 10% (wet sieve). The optimum use for this material is Granular C material. The topographic contours, and therefore volume determinations are based on limited survey information and airphoto interpretation.

(IX) RESULTS OF LABORATORY TESTING AND TEST PIT LOGS

(Mile 17 South)

Ministry of Transportation and Communications
Ontario

COARSE AGGREGATE PETROGRAPHIC ANALYSIS

PIT NAME *HR-123 A* LAB. NO. *TP30A*

DATE *APRIL 27, 1978* FRACTION *RETAIN 3/8, Pass 3/4* ANALYST *R. HILL*

TYPE NO.	TYPE	WEIGHT	%	GRANULAR & 5/8" CRUSHED CORRECTION	
1	CARBONATES (hard)	347·0	58·4		
20	CARBONATES (slightly weathered)	22·0	3·7		
2	CARBONATES (sandy, hard)				
21	CARBONATES (sandy, medium hard)				
23	CARBONATES CRYSTALLINE (hard)	18·0	3·0		
3	SANDSTONE (hard)	9·0	1·5		
22	SANDSTONE (medium hard)				
4	GNEISS – SCHIST (hard)				
5	QUARTZITE (coarse and fine grained)				
6	GREYWACKE – ARKOSE (hard and medium hard)	24·0	4·0		
7	VOLCANIC (hard and slightly weathered)				
8	GRANITE – DIORITE – GABBRO	120·0	20·2		
9	TRAP				
	TOTAL GOOD AGGREGATE		90·8		
24	CARBONATES CRYSTALLINE (slightly weathered)			×2	
40	CARBONATES (soft; slightly shaley)			×2	
41	CARBONATES (sandy, soft and soft pitted)			×2	
42	CARBONATES (deeply weathered)	20·0	3·4		
25	GNEISS (soft) SCHIST (medium hard)			×2	
26	CHERT – CHERTY CARBONATES			×2	
27	GRANITE – DIORITE – GABBRO (brittle)			×2	
28	VOLCANIC (soft)			×2	
52	ENCRUSTATION	20·0	3·4	×2	6·8
29	ARGILLITE			×2	
	TOTAL FAIR AGGREGATE		6·8		
43	CARBONATES (shaley or clayey)				
44	CARBONATES (ochreous)				
45	CHERT – CHERTY CARBONATES (leached)			×5	
46	SANDSTONE (soft friable)			×3	
48	VOLCANIC (very soft, porous)			×3	
49	CARBONATES CRYSTALLINE (soft)			×3	
50	GNEISS (friable)			×3	
51	GRANITE – DIORITE – GABBRO (friable)			×3	
53	CEMENTATIONS			×3	
54	CEMENTATIONS (total)			×3	
55	SCHIST (soft)	4·0	0·7	×3	2·1
56	SILTSTONE			×3	
	TOTAL POOR AGGREGATE		0·7		
60	OCHRE				
61	SHALE	8·0	1·3		
62	CLAY	2·0			
63	VOLCANIC OR SCHIST (decomposed)				
	TOTAL DELETERIOUS AGGREGATE		1·3		
	TOTALS	594	99·6		8·9

% GOOD *90·8* ×1 = *90·8*

% FAIR *6·8* ×3 = *20·4*

% POOR *0·7* ×6 = *4·2*

% DELETERIOUS *1·3* ×10 = *13·0*

EST. PERCENT CRUSHED	
EST. PERCENT FLATS & ELONGATED	

HOT MIX, MULCH AND CONCRETE P.N.	*128·4*
CORRECTED GRANULAR AND 5/8" CRUSHED P.N.	*119·5*

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COARSE AGGREGATE PETROGRAPHIC ANALYSIS

PIT NAME HR-111A LAB. NO. TP-31

DATE APRIL 27, 1978 FRACTION RETAIN 3/8 PASS 3/4 ANALYST W. R. MOORE

TYPE NO.	TYPE	WEIGHT	%	GRANULAR & 5/8" CRUSHED CORRECTION	
1	CARBONATES (hard)	548.0	64.4		
20	CARBONATES (slightly weathered)	54.0	6.3		
2	CARBONATES (sandy, hard)				
21	CARBONATES (sandy, medium hard)				
23	CARBONATES CRYSTALLINE (hard)				
3	SANDSTONE (hard)				
22	SANDSTONE (medium hard)				
4	GNEISS - SCHIST (hard)				
5	QUARTZITE (coarse and fine grained)				
6	GREYWACKE - ARKOSE (hard and medium hard)	26.0	3.0		
7	VOLCANIC (hard and slightly weathered)				
8	GRANITE - DIORITE - GABBRO	163.0	19.2		
9	TRAP				
	TOTAL GOOD AGGREGATE		92.5		
24	CARBONATES CRYSTALLINE (slightly weathered)			×2	
40	CARBONATES (soft; slightly shaley)			×2	
41	CARBONATES (sandy, soft and soft pitted)			×2	
42	CARBONATES (deeply weathered)	7.0	0.8		
25	GNEISS (soft) SCHIST (medium hard)			×2	
26	CHERT - CHERTY CARBONATES			×2	
27	GRANITE - DIORITE - GABBRO (brittle)			×2	
28	VOLCANIC (soft)			×2	
52	ENCRUSTATION	37.0	4.3	×2	8.6
29	ARGILLITE			×2	
	TOTAL FAIR AGGREGATE		5.1		
43	CARBONATES (shaley or clayey)				
44	CARBONATES (ochreous)				
45	CHERT - CHERTY CARBONATES (leached)			×5	
46	SANDSTONE (soft friable)			×3	
48	VOLCANIC (very soft, porous)			×3	
49	CARBONATES CRYSTALLINE (soft)			×3	
50	GNEISS (friable)			×3	
51	GRANITE - DIORITE - GABBRO (friable)			×3	
53	CEMENTATIONS			×3	
54	CEMENTATIONS (total)			×3	
55	SCHIST (soft)			×3	
56	SILTSTONE			×3	
	TOTAL POOR AGGREGATE		0.0		
60	OCHRE	16.0	1.8		
61	SHALE				
62	CLAY				
63	VOLCANIC OR SCHIST (decomposed)				
	TOTAL DELETERIOUS AGGREGATE		1.8		
	TOTALS	851.0	99.8		8.6

% GOOD 92.5 ×1 = 92.5

% FAIR 5.1 ×3 = 15.3

% POOR 0.0 ×6 = 0.0

% DELETERIOUS 1.8 ×10 = 18.0

EST. PERCENT CRUSHED	
EST. PERCENT FLATS & ELONGATED	

HOT MIX, MULCH AND CONCRETE P.N.	125.8

CORRECTED GRANULAR AND 5/8" CRUSHED P.N.	117.2

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COARSE AGGREGATE PETROGRAPHIC ANALYSIS

PIT NAME HR-110A LAB. NO. TP-38B
DATE APRIL 24, 1978 FRACTION RETAIN 3/8, PASS 3/4 ANALYST R. HILL

TYPE NO.	TYPE	WEIGHT	%	GRANULAR & 5/8" CRUSHED CORRECTION	
1	CARBONATES (hard)	385	66.7		
20	CARBONATES (slightly weathered)	8	1.4		
2	CARBONATES (sandy, hard)				
21	CARBONATES (sandy, medium hard)				
23	CARBONATES CRYSTALLINE (hard)				
3	SANDSTONE (hard)				
22	SANDSTONE (medium hard)				
4	GNEISS - SCHIST (hard)				
5	QUARTZITE (coarse and fine grained)	19	3.3		
6	GREYWACKE - ARKOSE (hard and medium hard)	6	1.0		
7	VOLCANIC (hard and slightly weathered)				
8	GRANITE - DIORITE - GABBRO	117	20.2		
9	TRAP				
	TOTAL GOOD AGGREGATE		92.6		
24	CARBONATES CRYSTALLINE (slightly weathered)			×2	
40	CARBONATES (soft; slightly shaley)			×2	
41	CARBONATES (sandy, soft and soft pitted)			×2	
42	CARBONATES (deeply weathered)	21	3.6		
25	GNEISS (soft) SCHIST (medium hard)			×2	
26	CHERT - CHERTY CARBONATES			×2	
27	GRANITE - DIORITE - GABBRO (brittle)			×2	
28	VOLCANIC (soft)			×2	
52	ENCRUSTATION	8	1.4	×2	2.8
29	ARGILLITE			×2	
	TOTAL FAIR AGGREGATE		5.0		
43	CARBONATES (shaley or clayey)				
44	CARBONATES (ochreous)				
45	CHERT - CHERTY CARBONATES (leached)			×5	
46	SANDSTONE (soft friable)			×3	
48	VOLCANIC (very soft, porous)			×3	
49	CARBONATES CRYSTALLINE (soft)			×3	
50	GNEISS (friable)			×3	
51	GRANITE - DIORITE - GABBRO (friable)			×3	
53	CEMENTATIONS			×3	
54	CEMENTATIONS (total)			×3	
55	SCHIST (soft)			×3	
56	SILTSTONE			×3	
	TOTAL POOR AGGREGATE				
60	OCHRE	14	2.4		
61	SHALE				
62	CLAY				
63	VOLCANIC OR SCHIST (decomposed)				
	TOTAL DELETERIOUS AGGREGATE		2.4		
	TOTALS	578	100		2.8

% GOOD 92.6 ×1 = 92.6

% FAIR 5.0 ×3 = 15.0

% POOR – ×6 = –

% DELETERIOUS 2.4 ×10 = 24.0

EST. PERCENT CRUSHED	
EST. PERCENT FLATS & ELONGATED	

HOT MIX, MULCH AND CONCRETE P.N.	131.6

CORRECTED GRANULAR AND 5/8" CRUSHED P.N.	128.8

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COARSE AGGREGATE PETROGRAPHIC ANALYSIS

PIT NAME HR 123A LAB. NO. TP 47

DATE APRIL 25, 1978 FRACTION RETAIN 3/8, PASS 3/4 ANALYST W. R. MOORE

TYPE NO.	TYPE	WEIGHT	%	GRANULAR & 5/8" CRUSHED CORRECTION	
1	CARBONATES (hard)	260·0	49·7		
20	CARBONATES (slightly weathered)				
2	CARBONATES (sandy, hard)				
21	CARBONATES (sandy, medium hard)				
23	CARBONATES CRYSTALLINE (hard)				
3	SANDSTONE (hard)	16·0	3·1		
22	SANDSTONE (medium hard)				
4	GNEISS - SCHIST (hard)				
5	QUARTZITE (coarse and fine grained)				
6	GREYWACKE - ARKOSE (hard and medium hard)	12·0	2·3		
7	VOLCANIC (hard and slightly weathered)				
8	GRANITE - DIORITE - GABBRO	142·0	27·2		
9	TRAP				
	TOTAL GOOD AGGREGATE		82·3		
24	CARBONATES CRYSTALLINE (slightly weathered)			×2	
40	CARBONATES (soft; slightly shaley)			×2	
41	CARBONATES (sandy, soft and soft pitted)			×2	
42	CARBONATES (deeply weathered)	27·0	5·2		
25	GNEISS (soft) SCHIST (medium hard)			×2	
26	CHERT - CHERTY CARBONATES			×2	
27	GRANITE - DIORITE - GABBRO (brittle)			×2	
28	VOLCANIC (soft)			×2	
52	ENCRUSTATION	55·0	10·5	×2	21·0
29	ARGILLITE			×2	
	TOTAL FAIR AGGREGATE		15·7		
43	CARBONATES (shaley or clayey)				
44	CARBONATES (ochreous)				
45	CHERT - CHERTY CARBONATES (leached)			×5	
46	SANDSTONE (soft friable)			×3	
48	VOLCANIC (very soft, porous)			×3	
49	CARBONATES CRYSTALLINE (soft)			×3	
50	GNEISS (friable)	3·0	0·6	×3	1·8
51	GRANITE - DIORITE - GABBRO (friable)			×3	
53	CEMENTATIONS			×3	
54	CEMENTATIONS (total)			×3	
55	SCHIST (soft)			×3	
56	SILTSTONE			×3	
	TOTAL POOR AGGREGATE		0·6		
60	OCHRE				
61	SHALE	8·0	1·5		
62	CLAY				
63	VOLCANIC OR SCHIST (decomposed)				
	TOTAL DELETERIOUS AGGREGATE		1·5		
	TOTALS	523	1000·0		22·8

% GOOD 82·3 ×1 = 82·3

% FAIR 15·7 ×3 = 47·1

% POOR 0·6 ×6 = 3·6

% DELETERIOUS 1·5 ×10 = 15·0

EST. PERCENT CRUSHED	
EST. PERCENT FLATS & ELONGATED	

HOT MIX, MULCH AND CONCRETE P.N.	148.0
CORRECTED GRANULAR AND 5/8" CRUSHED P.N.	125·2

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COARSE AGGREGATE PETROGRAPHIC ANALYSIS

PIT NAME HR 123 A LAB. NO. TP 50
DATE APRIL 24, 1978 FRACTION RETAIN 3/8, PASS 3/4 ANALYST R- HILL

TYPE NO.	TYPE	WEIGHT	%	GRANULAR & 5/8" CRUSHED CORRECTION	
1	CARBONATES (hard)	332	48.4		
20	CARBONATES (slightly weathered)	36	5.2		
2	CARBONATES (sandy, hard)				
21	CARBONATES (sandy, medium hard)				
23	CARBONATES CRYSTALLINE (hard)				
3	SANDSTONE (hard)				
22	SANDSTONE (medium hard)				
4	GNEISS - SCHIST (hard)				
5	QUARTZITE (coarse and fine grained)				
6	GREYWACKE - ARKOSE (hard and medium hard)				
7	VOLCANIC (hard and slightly weathered)				
8	GRANITE - DIORITE - GABBRO	173	25.2		
9	TRAP				
	TOTAL GOOD AGGREGATE		78.8		
24	CARBONATES CRYSTALLINE (slightly weathered)			×2	
40	CARBONATES (soft; slightly shaley)			×2	
41	CARBONATES (sandy, soft and soft pitted)			×2	
42	CARBONATES (deeply weathered)	13	1.9		
25	GNEISS (soft) SCHIST (medium hard)			×2	
26	CHERT - CHERTY CARBONATES			×2	
27	GRANITE - DIORITE - GABBRO (brittle)			×2	
28	VOLCANIC (soft)			×2	
52	ENCRUSTATION	122	17.8	×2	35.6
29	ARGILLITE			×2	
	TOTAL FAIR AGGREGATE		19.7		
43	CARBONATES (shaley or clayey)				
44	CARBONATES (ochreous)				
45	CHERT - CHERTY CARBONATES (leached)			×5	
46	SANDSTONE (soft friable)			×3	
48	VOLCANIC (very soft, porous)			×3	
49	CARBONATES CRYSTALLINE (soft)			×3	
50	GNEISS (friable)			×3	
51	GRANITE - DIORITE - GABBRO (friable)			×3	
53	CEMENTATIONS			×3	
54	CEMENTATIONS (total)			×3	
55	SCHIST (soft)			×3	
56	SILTSTONE			×3	
	TOTAL POOR AGGREGATE				
60	OCHRE	10	1.5		
61	SHALE				
62	CLAY				
63	VOLCANIC OR SCHIST (decomposed)				
	TOTAL DELETERIOUS AGGREGATE		1.5		
	TOTALS	686	100.0		35.6

% GOOD 78.8 ×1 = 78.8
% FAIR 19.7 ×3 = 59.1
% POOR – ×6 = –
% DELETERIOUS 1.5 ×10 = 15.0

HOT MIX, MULCH AND CONCRETE P.N.	152.9

EST. PERCENT CRUSHED	
EST. PERCENT FLATS & ELONGATED	

CORRECTED GRANULAR AND 5/8" CRUSHED P.N.	117.3

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COARSE AGGREGATE PETROGRAPHIC ANALYSIS

PIT NAME HR 125A LAB. NO. TP 51
DATE APRIL 24, 1978 FRACTION RETAIN 3/8, PASS 3/4 ANALYST W. R. MOORE

TYPE NO.	TYPE	WEIGHT	%	GRANULAR & 5/8" CRUSHED CORRECTION	
1	CARBONATES (hard)	448.0	46.9		46.9
20	CARBONATES (slightly weathered)	108.0	11.3		11.3
2	CARBONATES (sandy, hard)				
21	CARBONATES (sandy, medium hard)				
23	CARBONATES CRYSTALLINE (hard)				
3	SANDSTONE (hard)				
22	SANDSTONE (medium hard)				
4	GNEISS - SCHIST (hard)				
5	QUARTZITE (coarse and fine grained)				
6	GREYWACKE - ARKOSE (hard and medium hard)	25.0	2.6		
7	VOLCANIC (hard and slightly weathered)				
8	GRANITE - DIORITE - GABBRO	120.0	12.6		
9	TRAP				
	TOTAL GOOD AGGREGATE		73.4		
24	CARBONATES CRYSTALLINE (slightly weathered)			×2	
40	CARBONATES (soft; slightly shaley)			×2	
41	CARBONATES (sandy, soft and soft pitted)			×2	
42	CARBONATES (deeply weathered)	8.0	0.8		
25	GNEISS (soft) SCHIST (medium hard)			×2	
26	CHERT - CHERTY CARBONATES			×2	
27	GRANITE - DIORITE - GABBRO (brittle)			×2	
28	VOLCANIC (soft)			×2	
52	ENCRUSTATION	236.0	24.7	×2	49.4
29	ARGILLITE			×2	
	TOTAL FAIR AGGREGATE		25.5		
43	CARBONATES (shaley or clayey)				
44	CARBONATES (ochreous)				
45	CHERT - CHERTY CARBONATES (leached)			×5	
46	SANDSTONE (soft friable)			×3	
48	VOLCANIC (very soft, porous)			×3	
49	CARBONATES CRYSTALLINE (soft)			×3	
50	GNEISS (friable)	4.0	0.4	×3	1.2
51	GRANITE - DIORITE - GABBRO (friable)			×3	
53	CEMENTATIONS			×3	
54	CEMENTATIONS (total)			×3	
55	SCHIST (soft)			×3	
56	SILTSTONE			×3	
	TOTAL POOR AGGREGATE		0.4		
60	OCHRE				
61	SHALE	3.0	0.3		
62	CLAY	4.0	0.4		
63	VOLCANIC OR SCHIST (decomposed)				
	TOTAL DELETERIOUS AGGREGATE		0.7		
	TOTALS	956	100.0		50.6

% GOOD 73.4 ×1 = 73.4
% FAIR 25.5 ×3 = 76.5
% POOR 0.4 ×6 = 2.4
% DELETERIOUS 0.7 ×10 = 7.0

EST. PERCENT CRUSHED	
EST. PERCENT FLATS & ELONGATED	

HOT MIX, MULCH AND CONCRETE P.N.	159.3
CORRECTED GRANULAR AND 5/8" CRUSHED P.N.	108.7

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COARSE AGGREGATE PETROGRAPHIC ANALYSIS

PIT NAME HR 124 A LAB. NO. TP 52

DATE APRIL 25, 1978 FRACTION RETAIN 3/8, PASS 3/4 ANALYST W. R. MOORE

TYPE NO.	TYPE	WEIGHT	%	GRANULAR & 5/8" CRUSHED CORRECTION	
1	CARBONATES (hard)	372.0	44.1		
20	CARBONATES (slightly weathered)	196.0	23.3		
2	CARBONATES (sandy, hard)				
21	CARBONATES (sandy, medium hard)				
23	CARBONATES CRYSTALLINE (hard)				
3	SANDSTONE (hard)	25.0	3.0		
22	SANDSTONE (medium hard)				
4	GNEISS - SCHIST (hard)				
5	QUARTZITE (coarse and fine grained)				
6	GREYWACKE - ARKOSE (hard and medium hard)	29.0	3.4		
7	VOLCANIC (hard and slightly weathered)				
8	GRANITE - DIORITE - GABBRO	145.0	17.2		
9	TRAP				
	TOTAL GOOD AGGREGATE		91.0		
24	CARBONATES CRYSTALLINE (slightly weathered)	11.0	1.3	×2	2.6
40	CARBONATES (soft; slightly shaley)			×2	
41	CARBONATES (sandy, soft and soft pitted)			×2	
42	CARBONATES (deeply weathered)				
25	GNEISS (soft) SCHIST (medium hard)			×2	
26	CHERT - CHERTY CARBONATES			×2	
27	GRANITE - DIORITE - GABBRO (brittle)			×2	
28	VOLCANIC (soft)			×2	
52	ENCRUSTATION	54.0	6.4	×2	12.8
29	ARGILLITE			×2	
	TOTAL FAIR AGGREGATE		7.7		
43	CARBONATES (shaley or clayey)				
44	CARBONATES (ochreous)				
45	CHERT - CHERTY CARBONATES (leached)			×5	
46	SANDSTONE (soft friable)			×3	
48	VOLCANIC (very soft, porous)			×3	
49	CARBONATES CRYSTALLINE (soft)			×3	
50	GNEISS (friable)	11.0	1.3	×3	3.9
51	GRANITE - DIORITE - GABBRO (friable)			×3	
53	CEMENTATIONS			×3	
54	CEMENTATIONS (total)			×3	
55	SCHIST (soft)			×3	
56	SILTSTONE			×3	
	TOTAL POOR AGGREGATE		1.3		
60	OCHRE				
61	SHALE				
62	CLAY				
63	VOLCANIC OR SCHIST (decomposed)				
	TOTAL DELETERIOUS AGGREGATE				
	TOTALS	843	100.0		19.3

% GOOD 91 ×1 = 91

% FAIR 7.7 ×3 = 23.1

% POOR 1.3 ×6 = 7.8

% DELETERIOUS – ×10 = –

HOT MIX, MULCH AND CONCRETE P.N.	121.9

EST. PERCENT CRUSHED	
EST. PERCENT FLATS & ELONGATED	

CORRECTED GRANULAR AND 5/8" CRUSHED P.N.	102.6

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COARSE AGGREGATE PETROGRAPHIC ANALYSIS

PIT NAME HR 124 A LAB. NO. TP 59A

DATE APRIL 28, 1978 FRACTION RETAIN 3/8, PASS 3/4 ANALYST W. R. MOORE

TYPE NO.	TYPE	WEIGHT	%	GRANULAR & 5/8" CRUSHED CORRECTION	
1	CARBONATES (hard)	524.0	53.7		
20	CARBONATES (slightly weathered)	72.0	7.4		
2	CARBONATES (sandy, hard)				
21	CARBONATES (sandy, medium hard)				
23	CARBONATES CRYSTALLINE (hard)				
3	SANDSTONE (hard)	7.0	0.7		
22	SANDSTONE (medium hard)				
4	GNEISS - SCHIST (hard)				
5	QUARTZITE (coarse and fine grained)				
6	GREYWACKE - ARKOSE (hard and medium hard)				
7	VOLCANIC (hard and slightly weathered)	16.0	1.6		
8	GRANITE - DIORITE - GABBRO	135.0	13.9		
9	TRAP				
	TOTAL GOOD AGGREGATE		77.3		
24	CARBONATES CRYSTALLINE (slightly weathered)			× 2	
40	CARBONATES (soft; slightly shaley)			× 2	
41	CARBONATES (sandy, soft and soft pitted)			× 2	
42	CARBONATES (deeply weathered)	2.0	0.2		
25	GNEISS (soft) SCHIST (medium hard)			× 2	
26	CHERT - CHERTY CARBONATES			× 2	
27	GRANITE - DIORITE - GABBRO (brittle)			× 2	
28	VOLCANIC (soft)			× 2	
52	ENCRUSTATION	193.0	19.8	× 2	39.6
29	ARGILLITE			× 2	
	TOTAL FAIR AGGREGATE		20.0		
43	CARBONATES (shaley or clayey)				
44	CARBONATES (ochreous)				
45	CHERT - CHERTY CARBONATES (leached)			× 5	
46	SANDSTONE (soft friable)			× 3	
48	VOLCANIC (very soft, porous)			× 3	
49	CARBONATES CRYSTALLINE (soft)			× 3	
50	GNEISS (friable)	1.0	0.1	× 3	0.3
51	GRANITE - DIORITE - GABBRO (friable)			× 3	
53	CEMENTATIONS			× 3	
54	CEMENTATIONS (total)			× 3	
55	SCHIST (soft)			× 3	
56	SILTSTONE			× 3	
	TOTAL POOR AGGREGATE		0.1		
60	OCHRE	9.0	0.9		
61	SHALE	16.0	1.6		
62	CLAY				
63	VOLCANIC OR SCHIST (decomposed)				
	TOTAL DELETERIOUS AGGREGATE		2.5		
	TOTALS	975.0	99.9		39.9

% GOOD 77.3 × 1 = 77.3

% FAIR 20.0 × 3 = 60.0

% POOR 0.1 × 6 = 0.6

% DELETERIOUS 2.5 × 10 = 25.0

HOT MIX, MULCH AND CONCRETE P.N.	162.9

EST. PERCENT CRUSHED	
EST. PERCENT FLATS & ELONGATED	

CORRECTED GRANULAR AND 5/8" CRUSHED P.N.	123.0

Ministry of Transportation and Communications
Ontario

COARSE AGGREGATE PETROGRAPHIC ANALYSIS

PIT NAME HR 124A LAB. NO. TP59B
DATE APRIL 25, 1978 FRACTION RETAIN 3/8, PASS 3/4 ANALYST W. R. MOORE

TYPE NO.	TYPE	WEIGHT	%	GRANULAR & 5/8" CRUSHED CORRECTION	
1	CARBONATES (hard)	362.0	56.2		
20	CARBONATES (slightly weathered)	44.0	6.8		
2	CARBONATES (sandy, hard)				
21	CARBONATES (sandy, medium hard)				
23	CARBONATES CRYSTALLINE (hard)				
3	SANDSTONE (hard)				
22	SANDSTONE (medium hard)				
4	GNEISS - SCHIST (hard)				
5	QUARTZITE (coarse and fine grained)				
6	GREYWACKE - ARKOSE (hard and medium hard)	29.0	4.5		
7	VOLCANIC (hard and slightly weathered)				
8	GRANITE - DIORITE - GABBRO	177.0	27.4		
9	TRAP				
	TOTAL GOOD AGGREGATE		94.9		
24	CARBONATES CRYSTALLINE (slightly weathered)	17.0	2.6	×2	5.2
40	CARBONATES (soft; slightly shaley)			×2	
41	CARBONATES (sandy, soft and soft pitted)			×2	
42	CARBONATES (deeply weathered)				
25	GNEISS (soft) SCHIST (medium hard)			×2	
26	CHERT - CHERTY CARBONATES			×2	
27	GRANITE - DIORITE - GABBRO (brittle)			×2	
28	VOLCANIC (soft)			×2	
52	ENCRUSTATION	4.0	0.6	×2	1.2
29	ARGILLITE			×2	
	TOTAL FAIR AGGREGATE		3.2		
43	CARBONATES (shaley or clayey)				
44	CARBONATES (ochreous)				
45	CHERT - CHERTY CARBONATES (leached)			×5	
46	SANDSTONE (soft friable)			×3	
48	VOLCANIC (very soft, porous)			×3	
49	CARBONATES CRYSTALLINE (soft)			×3	
50	GNEISS (friable)	2.0	0.3	×3	0.9
51	GRANITE - DIORITE - GABBRO (friable)			×3	
53	CEMENTATIONS			×3	
54	CEMENTATIONS (total)			×3	
55	SCHIST (soft)			×3	
56	SILTSTONE			×3	
	TOTAL POOR AGGREGATE		0.3		
60	OCHRE	1.0	0.1		
61	SHALE	10.0	1.5		
62	CLAY				
63	VOLCANIC OR SCHIST (decomposed)				
	TOTAL DELETERIOUS AGGREGATE				
	TOTALS	646	100.0		7.3

% GOOD 94.9 ×1 = 94.9
% FAIR 3.2 ×3 = 9.6
% POOR 0.3 ×6 = 1.8
% DELETERIOUS 1.6 ×10 = 16.0

EST. PERCENT CRUSHED	
EST. PERCENT FLATS & ELONGATED	

HOT MIX, MULCH AND CONCRETE P.N.	122.3
CORRECTED GRANULAR AND 5/8" CRUSHED P.N.	115.0

3931 OBMT84 4-77

Ministry of Transportation and Communications Ontario

COARSE AGGREGATE PETROGRAPHIC ANALYSIS

PIT NAME HR 124A LAB. NO. TP-62

DATE APRIL 24, 1978 FRACTION RETAIN 3/8, PASS 3/4 ANALYST R. HILL

TYPE NO.	TYPE	WEIGHT	%	GRANULAR & 5/8" CRUSHED CORRECTION	
1	CARBONATES (hard)	53	4.7		4.7
20	CARBONATES (slightly weathered)	71	6.3		6.3
2	CARBONATES (sandy, hard)				
21	CARBONATES (sandy, medium hard)				
23	CARBONATES CRYSTALLINE (hard)				
3	SANDSTONE (hard)				
22	SANDSTONE (medium hard)				
4	GNEISS - SCHIST (hard)				
5	QUARTZITE (coarse and fine grained)				
6	GREYWACKE - ARKOSE (hard and medium hard)				
7	VOLCANIC (hard and slightly weathered)				
8	GRANITE - DIORITE - GABBRO	100	8.9		
9	TRAP				
	TOTAL GOOD AGGREGATE		19.9		
24	CARBONATES CRYSTALLINE (slightly weathered)			×2	
40	CARBONATES (soft; slightly shaley)			×2	
41	CARBONATES (sandy, soft and soft pitted)			×2	
42	CARBONATES (deeply weathered)	84	7.4		
25	GNEISS (soft) SCHIST (medium hard)			×2	
26	CHERT - CHERTY CARBONATES			×2	
27	GRANITE - DIORITE - GABBRO (brittle)			×2	
28	VOLCANIC (soft)			×2	
52	ENCRUSTATION	817	72.5	×2	145.0
29	ARGILLITE			×2	
	TOTAL FAIR AGGREGATE		79.9		
43	CARBONATES (shaley or clayey)				
44	CARBONATES (ochreous)				
45	CHERT - CHERTY CARBONATES (leached)			×5	
46	SANDSTONE (soft friable)			×3	
48	VOLCANIC (very soft, porous)			×3	
49	CARBONATES CRYSTALLINE (soft)			×3	
50	GNEISS (friable)	2	0.2	×3	0.6
51	GRANITE - DIORITE - GABBRO (friable)			×3	
53	CEMENTATIONS			×3	
54	CEMENTATIONS (total)			×3	
55	SCHIST (soft)			×3	
56	SILTSTONE			×3	
	TOTAL POOR AGGREGATE		0.2		
60	OCHRE				
61	SHALE				
62	CLAY				
63	VOLCANIC OR SCHIST (decomposed)				
	TOTAL DELETERIOUS AGGREGATE				
	TOTALS	1127	100.0		145.6

% GOOD 19.9 ×1 = 19.9

% FAIR 79.9 ×3 = 239.7

% POOR 0.2 ×6 = 1.2

% DELETERIOUS – ×10 = –

HOT MIX, MULCH AND CONCRETE P.N.	260.8

EST. PERCENT CRUSHED	
EST. PERCENT FLATS & ELONGATED	

CORRECTED GRANULAR AND 5/8" CRUSHED P.N.	115.2

3931 OBMT84 4-77

Ministry of Transportation and Communications
Ontario

COARSE AGGREGATE PETROGRAPHIC ANALYSIS

PIT NAME HR 124 A LAB. NO. TP-64

DATE APRIL 24, 1978 FRACTION RETAINE 3/8 PASS 3/4 ANALYST R. HILL

TYPE NO.	TYPE	WEIGHT	%	GRANULAR & 5/8" CRUSHED CORRECTION	
1	CARBONATES (hard)	318	48.8		
20	CARBONATES (slightly weathered)	40	6.1		
2	CARBONATES (sandy, hard)				
21	CARBONATES (sandy, medium hard)				
23	CARBONATES CRYSTALLINE (hard)				
3	SANDSTONE (hard)				
22	SANDSTONE (medium hard)				
4	GNEISS - SCHIST (hard)				
5	QUARTZITE (coarse and fine grained)				
6	GREYWACKE - ARKOSE (hard and medium hard)	24	3.7		
7	VOLCANIC (hard and slightly weathered)				
8	GRANITE - DIORITE - GABBRO	170	26.1		
9	TRAP				
	TOTAL GOOD AGGREGATE		84.7		
24	CARBONATES CRYSTALLINE (slightly weathered)			×2	
40	CARBONATES (soft; slightly shaley)			×2	
41	CARBONATES (sandy, soft and soft pitted)			×2	
42	CARBONATES (deeply weathered)	18	2.8		
25	GNEISS (soft) SCHIST (medium hard)			×2	
26	CHERT - CHERTY CARBONATES			×2	
27	GRANITE - DIORITE - GABBRO (brittle)			×2	
28	VOLCANIC (soft)			×2	
52	ENCRUSTATION	79.0	12.1	×2	24.2
29	ARGILLITE			×2	
	TOTAL FAIR AGGREGATE		14.9		
43	CARBONATES (shaley or clayey)				
44	CARBONATES (ochreous)				
45	CHERT - CHERTY CARBONATES (leached)			×5	
46	SANDSTONE (soft friable)			×3	
48	VOLCANIC (very soft, porous)			×3	
49	CARBONATES CRYSTALLINE (soft)			×3	
50	GNEISS (friable)			×3	
51	GRANITE - DIORITE - GABBRO (friable)			×3	
53	CEMENTATIONS			×3	
54	CEMENTATIONS (total)			×3	
55	SCHIST (soft)			×3	
56	SILTSTONE			×3	
	TOTAL POOR AGGREGATE				
60	OCHRE	3	0.5		
61	SHALE				
62	CLAY				
63	VOLCANIC OR SCHIST (decomposed)				
	TOTAL DELETERIOUS AGGREGATE		0.5		
	TOTALS	652			24.2

% GOOD 84.7 ×1 = 84.7

% FAIR 14.9 ×3 = 44.7

% POOR - ×6 =

% DELETERIOUS 0.5 ×10 = 5.0

HOT MIX, MULCH AND CONCRETE P.N.	134.4

EST. PERCENT CRUSHED	
EST. PERCENT FLATS & ELONGATED	

CORRECTED GRANULAR AND 5/8" CRUSHED P.N.	110.2

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DRY SIEVE ANALYSIS AND TEST PIT LOGS

SAMPLE TP30A (NEW DEPOSIT) DATE APRIL 4, 1978 NAME R. HILL

Remarks : GRAVEL 57·4% SAND 40·2% FINES 2·4%

WASHED SIEVE (% FINES PASSING #200) 18%

ORGANIC CONTENT UNACCEPTABLE FOR CONCRETE

DRY SIEVING			
Sieve No.	Mass Retained	Percent Retained	Cumulative % Passing
1½	460·6	–	–
3/4	537·4	31·4	68·6
3/8	230·5	13·5	55·1
4	214·0	12·5	42·6
10	186·2	10·9	31·7
16	83·0	4·9	26·8
30	51·2	3·0	23·8
50	78·5	4·6	19·2
100	171·3	10·0	9·2
200	116·0	6·8	2·4
PAN	18·4	1·1	
Totals	1686·5	100·0	

TEST PIT LOG

TEST PIT LOCATION (SEE DWG No HRS 2 & 3)

0'
fine sand to boulders MPS - 2'

2'
stratified sand and gravel/ Some cobbles MPS - 9'

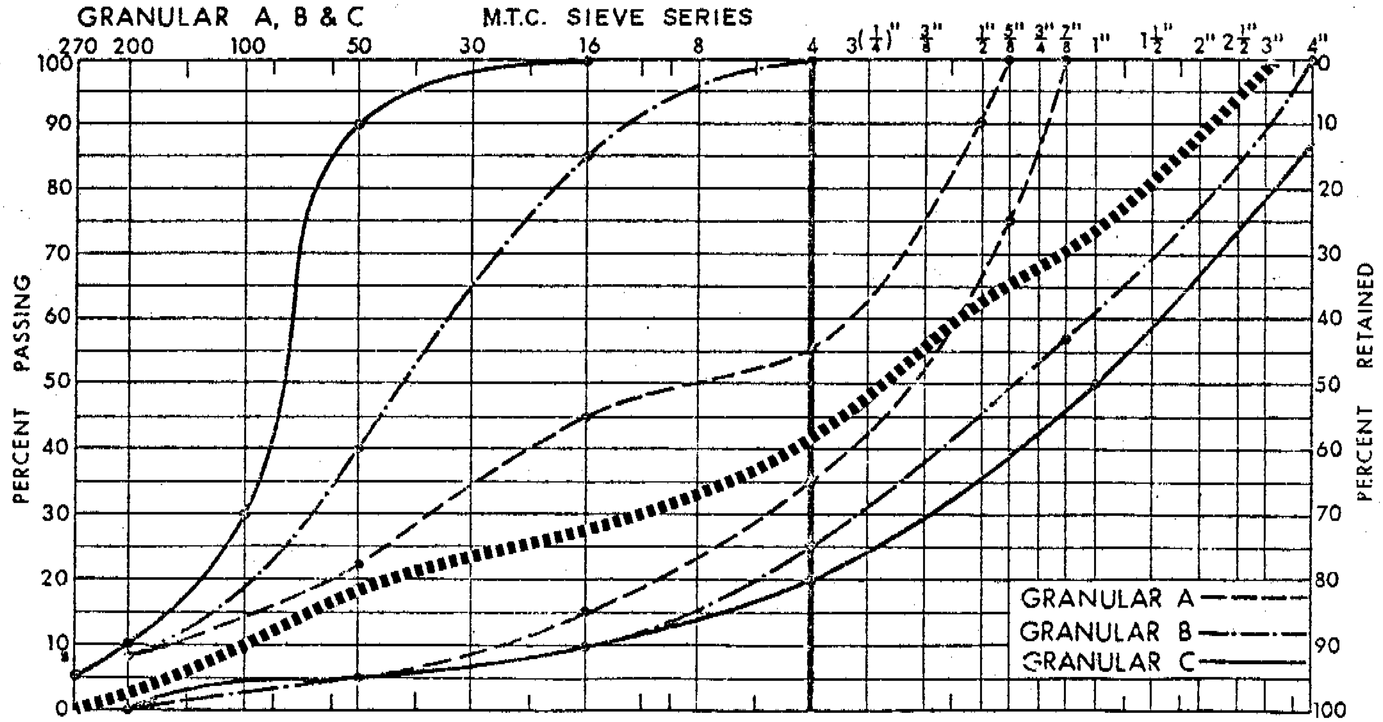
10'
clean med. sand

11'
wet med. fine sand

13'+

GRAIN SIZE DISTRIBUTION CURVE

sample analysed



DRY SIEVE ANALYSIS AND TEST PIT LOGS

SAMPLE TP 30B (NEW DEPOSIT) DATE APRIL 4, 1978 NAME R. HILL

Remarks: GRAVEL 20.6% SAND 77.9% FINES 1.5%
WASHED SIEVE (% FINES PASSING #200) 18%
ORGANIC CONTENT UNACCEPTABLE FOR CONCRETE

DRY SIEVING

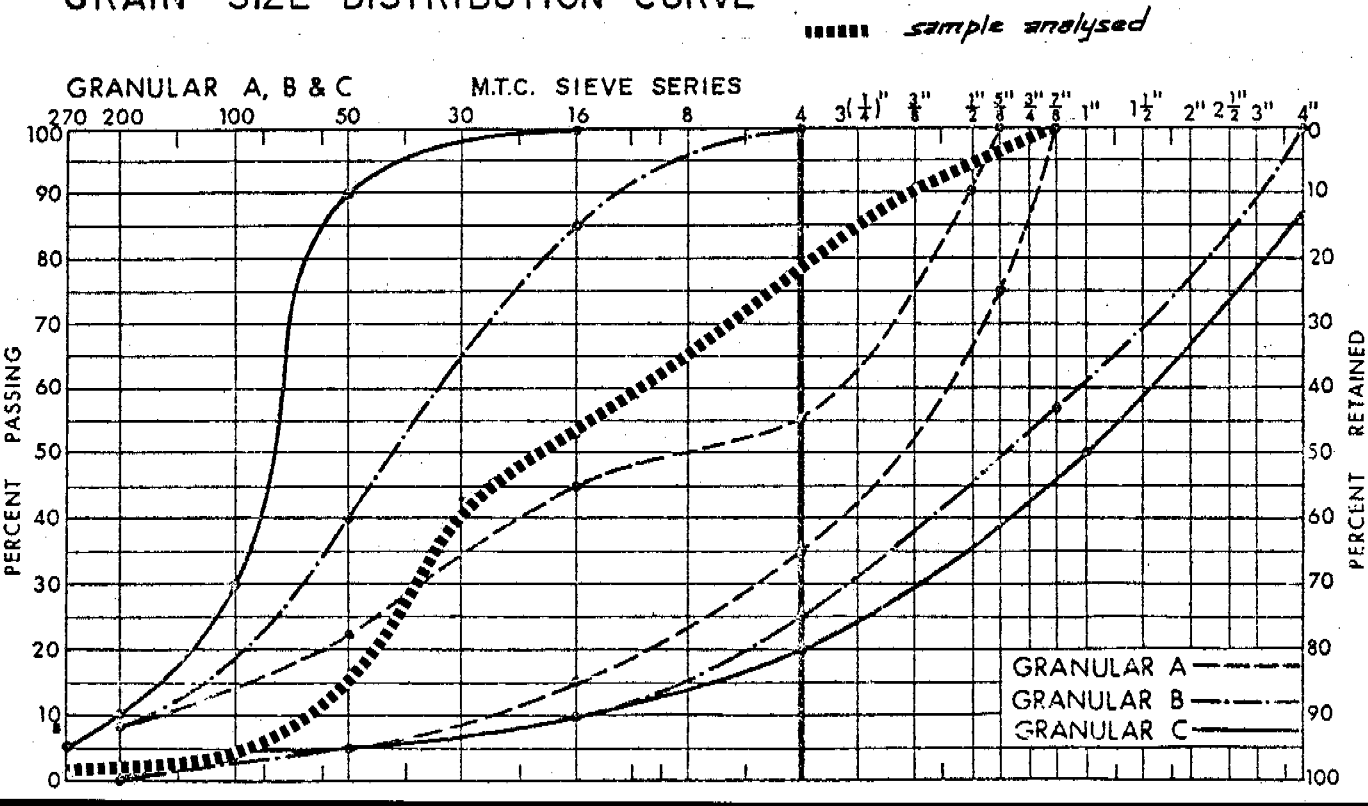
Sieve No.	Mass Retained	Percent Retained	Cumulative % Passing
1½	–	–	–
3/4	24.8	1.6	98.4
3/8	106.0	6.7	91.7
4	195.3	12.3	79.4
10	266.2	16.7	62.7
16	154.0	9.7	53.0
30	153.8	9.6	43.4
50	453.2	28.4	15.0
100	174.7	11.0	4.0
200	40.0	2.5	1.5
PAN	11.0	0.7	
Totals	1579.0	100.0	

TEST PIT LOG

TEST PIT LOCATION (SEE DWG No HRS 2 & 3)

Same as TP 30A (NEW DEPOSIT)

GRAIN SIZE DISTRIBUTION CURVE



DRY SIEVE ANALYSIS AND TEST PIT LOGS

SAMPLE TP 47 DATE APRIL 4, 1978 NAME W. R. MOORE

Remarks: GRAVEL 46.1 % SAND 51.2% FINES 2.7%
WASHED SIEVE (% FINES PASSING #200) 8 %

DRY SIEVING			
Sieve No.	Mass Retained	Percent Retained	Cumulative % Passing
1½	581.3	-	–
3/4	248.8	18.6	81.4
3/8	174.2	13.0	68.4
4	193.3	14.5	53.9
10	194.7	14.6	39.3
16	123.5	9.2	30.1
30	115.5	8.7	21.4
50	112.8	8.4	13.0
100	82.0	6.1	6.9
200	55.6	4.2	2.7
PAN	17.5	1.3	
Totals	1317.9	100.0	

TEST PIT LOG

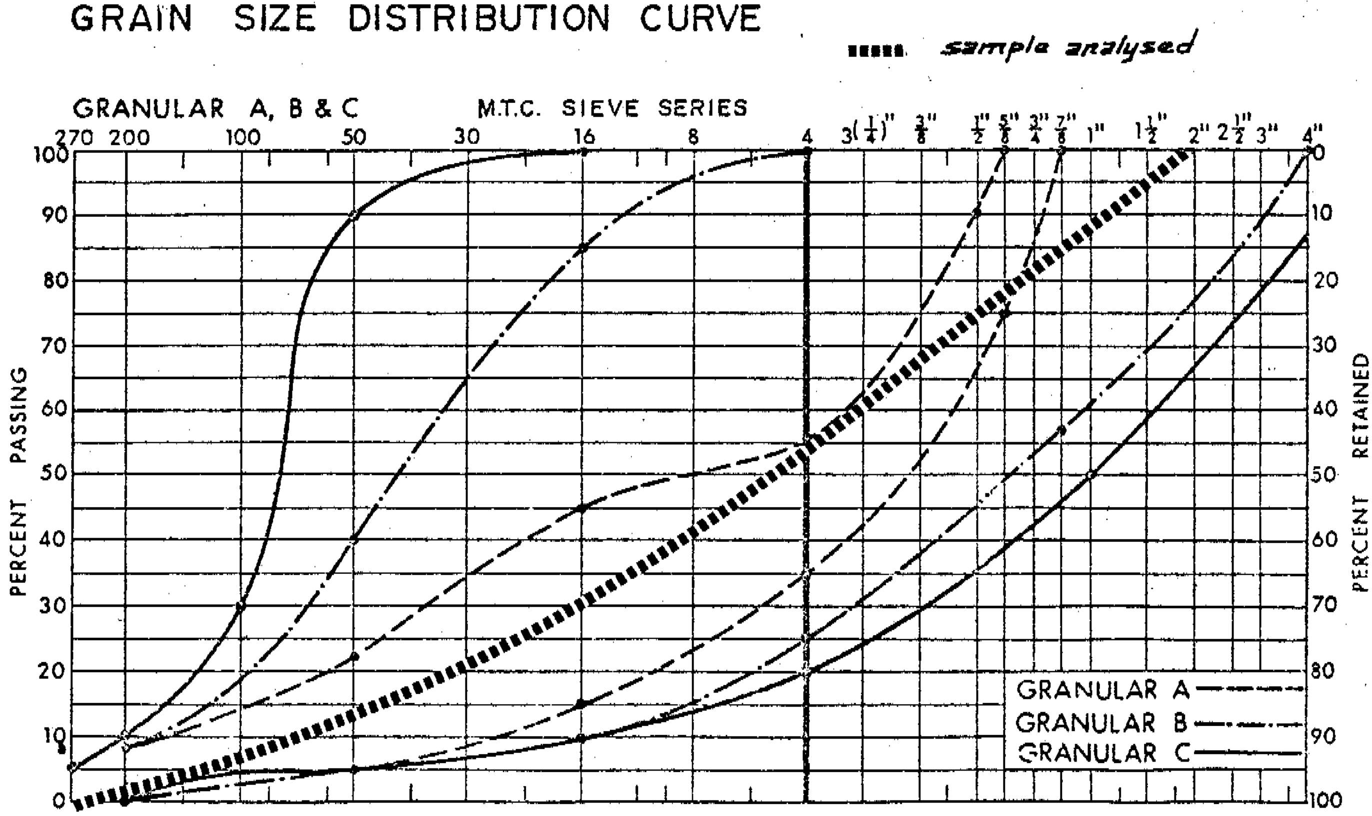
TEST PIT LOCATION (SEE DWG No HRS 283)

0'
fine to med. sand and boulders MPS-2.5'

2'
med. sand and gravel with cobbles and boulders MPS-1'

4'
refusal on boulders

GRAIN SIZE DISTRIBUTION CURVE



DRY SIEVE ANALYSIS AND TEST PIT LOGS

SAMPLE *TP48* DATE *APRIL 4, 1978* NAME *W. R. MOORE*

Remarks : *GRAVEL 32.7% SAND 65.0% FINES 2.3%*
WASHED SIEVE (% FINES PASSING #200) 8%

DRY SIEVING

Sieve No.	Mass Retained	Percent Retained	Cumulative % Passing
1½	364.5	—	—
3/4	109.7	11.0	89.0
3/8	100.0	10.0	79.0
4	117.0	11.7	67.3
10	169.3	17.0	50.3
16	146.2	14.7	35.6
30	138.3	13.9	21.7
50	87.0	8.7	13.0
100	41.5	4.2	8.8
200	64.8	6.5	2.3
PAN	18.0	1.8	
Totals	991.8	100.0	

TEST PIT LOG

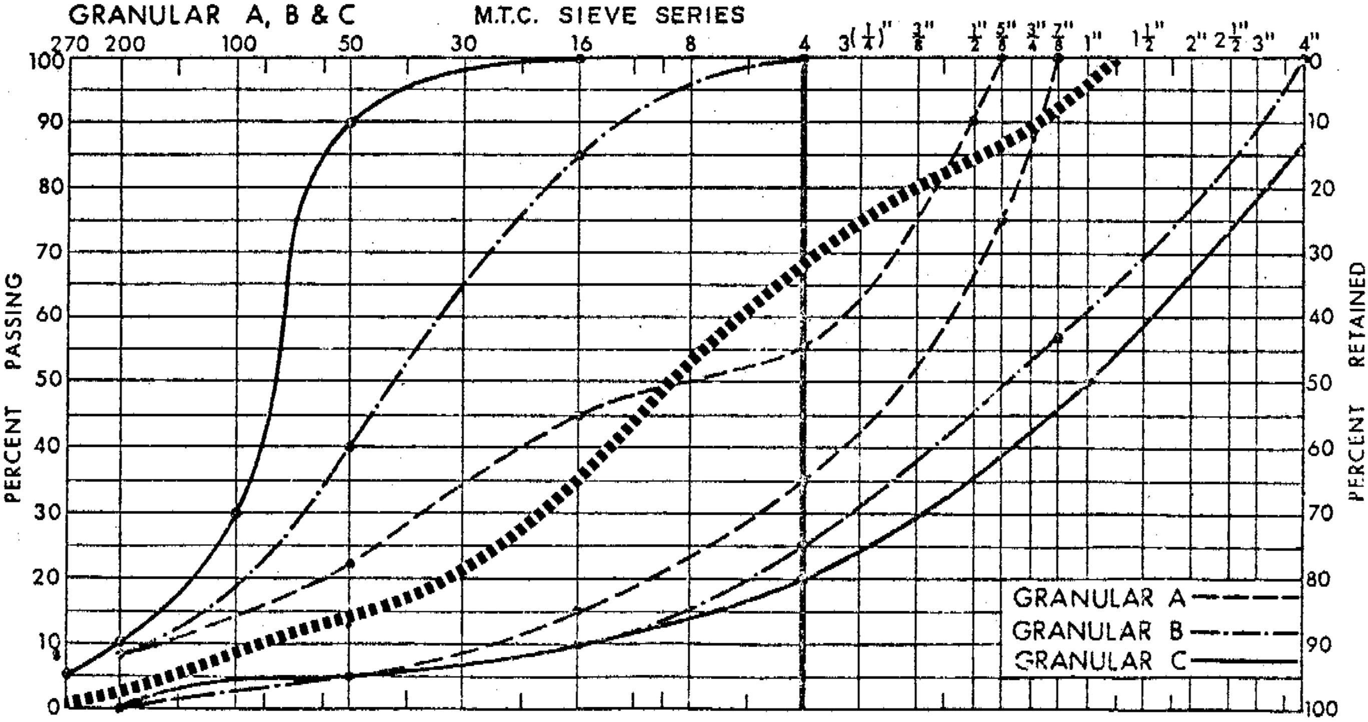
TEST PIT LOCATION (SEE DWG No HRS 2 & 3)

0'
fine to med. sand and boulders MPS - 2'

3'
refusal on boulders

GRAIN SIZE DISTRIBUTION CURVE

sample analysed



DRY SIEVE ANALYSIS AND TEST PIT LOGS

SAMPLE TP 49 DATE APRIL 5, 1978 NAME W.R. MOORE

Remarks : GRAVEL 39.7% SAND 57.7% FINES 2.6%
WASHED SIEVE (% FINES PASSING #200) 8%

DRY SIEVING			
Sieve No.	Mass Retained	Percent Retained	Cumulative % Passing
1½	399.0	—	—
3/4	271.4	15.5	84.5
3/8	192.8	11.0	73.5
4	230.0	13.2	60.3
10	324.0	18.5	41.8
16	211.5	12.1	29.7
30	154.5	8.8	20.9
50	161.5	9.2	11.7
100	91.3	5.2	6.5
200	67.8	3.9	2.6
PAN	24.0	1.4	
Totals	1728.8	100.0	

TEST PIT LOG

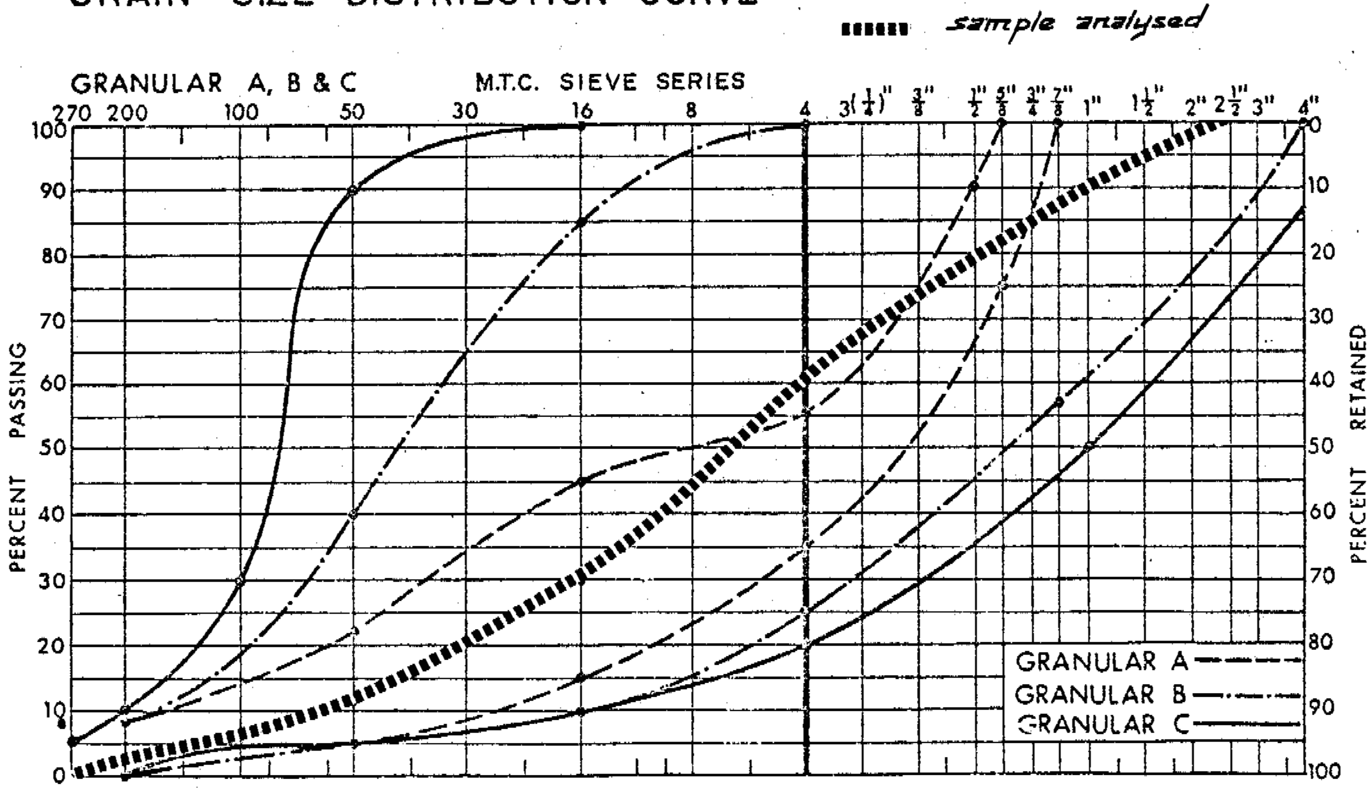
TEST PIT LOCATION (SEE DWG No HRS 2 & 3)

0'
fine sand and gravel

1'
fine sand and gravel with boulders MPS-1'

4'
refusal on boulders

GRAIN SIZE DISTRIBUTION CURVE



DRY SIEVE ANALYSIS AND TEST PIT LOGS

SAMPLE TP 50 DATE APRIL 5, 1978 NAME R. HILL

Remarks: GRAVEL 34.0 % SAND 64.4 % FINES 1.6 %
WASHED SIEVE (% FINES PASSING #200) 7 %

DRY SIEVING

Sieve No.	Mass Retained	Percent Retained	Cumulative % Passing
1½	239.0	—	—
3/4	101.4	7.9	92.7
3/8	152.5	11.8	80.3
4	184.7	14.3	66.0
10	256.1	19.9	46.1
16	212.5	16.5	29.6
30	250.6	19.4	10.2
50	66.5	5.2	5.0
100	21.4	1.7	3.3
200	21.4	1.7	1.6
PAN	10.5	0.8	
Totals	1277.6	100.0	

TEST PIT LOG

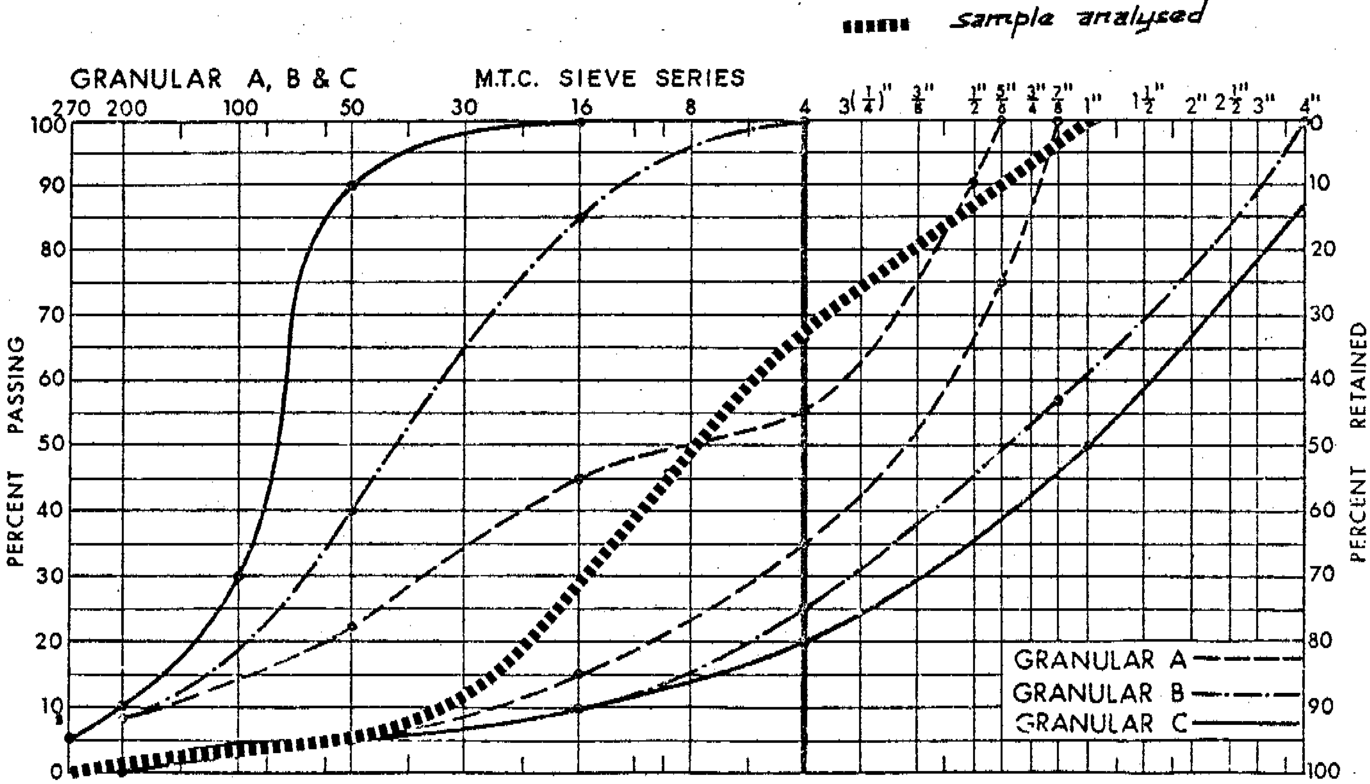
TEST PIT LOCATION (SEE DWG No HRS 2 & 3)

0'
med. sand and gravel
MPS - 1"

2'
stratified sand and gravel
some cobbles and boulders
MPS - 8"

6' ▽ assumed
silty clay till

GRAIN SIZE DISTRIBUTION CURVE



DRY SIEVE ANALYSIS AND TEST PIT LOGS

SAMPLE TP-51 DATE APRIL 5, 1978 NAME R. HILL

Remarks: GRAVEL 57.6 % SAND 39.7 % FINES 2.7 %

WASHED SIEVE (% FINES PASSING #200) 10 %

DRY SIEVING

Sieve No.	Mass Retained	Percent Retained	Cumulative % Passing
1½	88.2	-	-
3/4	282.7	18.3	81.7
3/8	325.7	21.1	60.6
4	280.5	18.2	42.4
10	282.6	18.3	24.1
16	159.8	10.4	13.7
30	117.0	7.6	6.1
50	24.6	1.6	4.5
100	12.0	0.8	3.7
200	15.7	1.0	2.7
PAN	21.1	1.4	
Totals	1521.7	100.0	

TEST PIT LOG

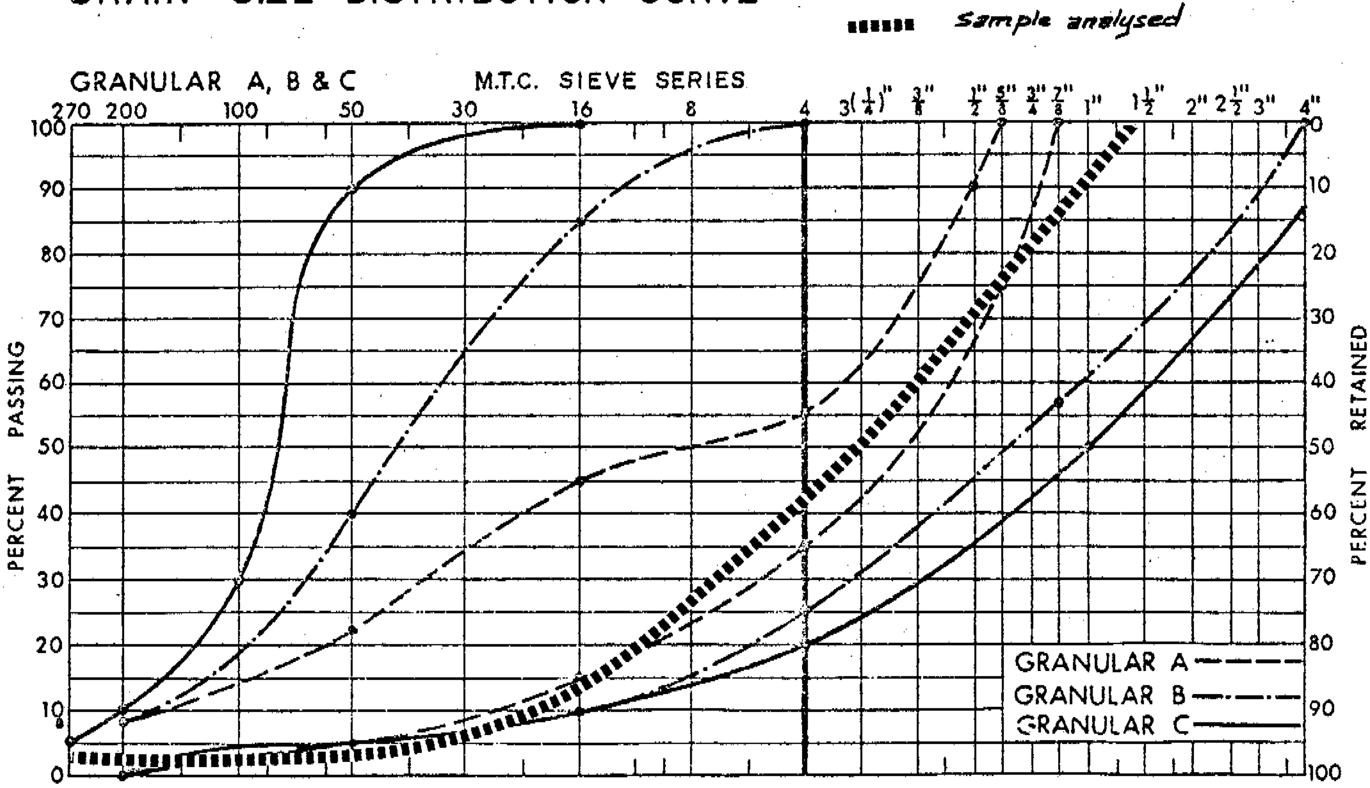
TEST PIT LOCATION (SEE DWG No HRS 2 & 3)

0'
fine sand and gravel MPS-2"

2'
stratified sand and gravel with cobbles MPS-8"

7' ∇ assumed
silty clay till

GRAIN SIZE DISTRIBUTION CURVE



DRY SIEVE ANALYSIS AND TEST PIT LOGS

SAMPLE TP 52 DATE APRIL 5, 1978 NAME W. R. MOORE

Remarks: GRAVEL 35.3% SAND 62.2% FINES 2.5%
WASHED SIEVE (% FINES PASSING #200) 6%

DRY SIEVING

Sieve No.	Mass Retained	Percent Retained	Cumulative % Passing
1½	205.4	–	–
3/4	78.9	5.3	94.7
3/8	192.8	13.0	81.7
4	253.0	17.0	64.7
10	380.6	25.6	39.1
16	262.0	17.6	21.5
30	136.2	9.2	12.3
50	63.5	4.3	8.0
100	31.0	2.1	5.9
200	50.8	3.4	2.5
PAN	14.6	1.0	
Totals	1463.4	100.0	

TEST PIT LOG

TEST PIT LOCATION (SEE DWG No HRS 2 & 3)

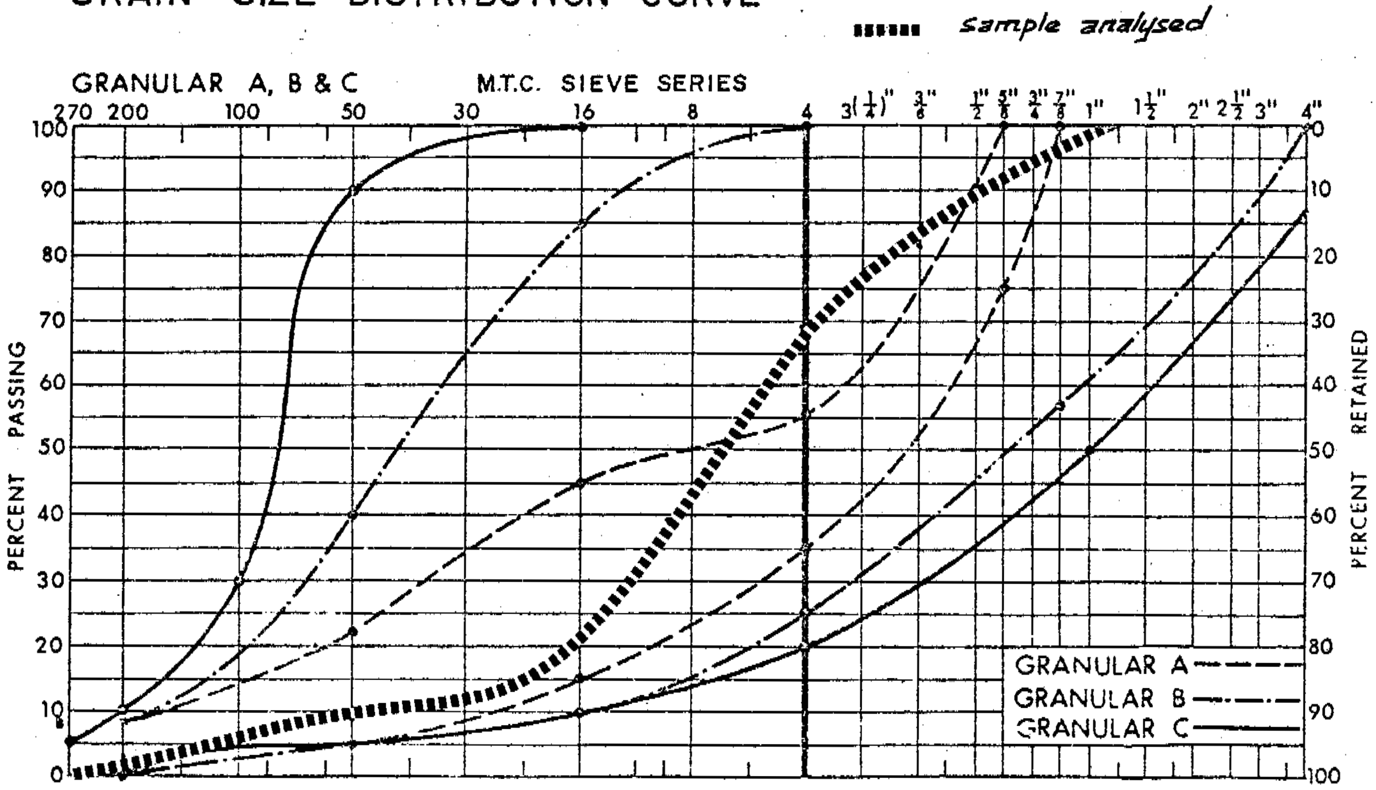
0'
fine sand and gravel MPS-1"

3'
stratified sand and gravel with cobbles MPS-8"

8'
fine to med. sand

10'
silty sand

GRAIN SIZE DISTRIBUTION CURVE



DRY SIEVE ANALYSIS AND TEST PIT LOGS

SAMPLE TP 53 DATE APRIL 5, 1978 NAME W. R. MOORE

Remarks: GRAVEL 41.5% SAND 54.2% FINES 4.3%
WASHED SIEVE (% FINES PASSING #200) 6%

DRY SIEVING

Sieve No.	Mass Retained	Percent Retained	Cumulative % Passing
1½	201.3	–	–
3/4	212.2	13.4	86.6
3/8	223.4	14.1	72.5
4	221.3	14.0	58.5
10	263.5	16.7	41.8
16	164.0	10.4	31.4
30	153.0	9.7	21.7
50	80.8	5.1	16.6
100	67.6	4.3	12.3
200	126.3	8.0	4.3
PAN	43.4	2.7	
Totals	1555.5	100.0	

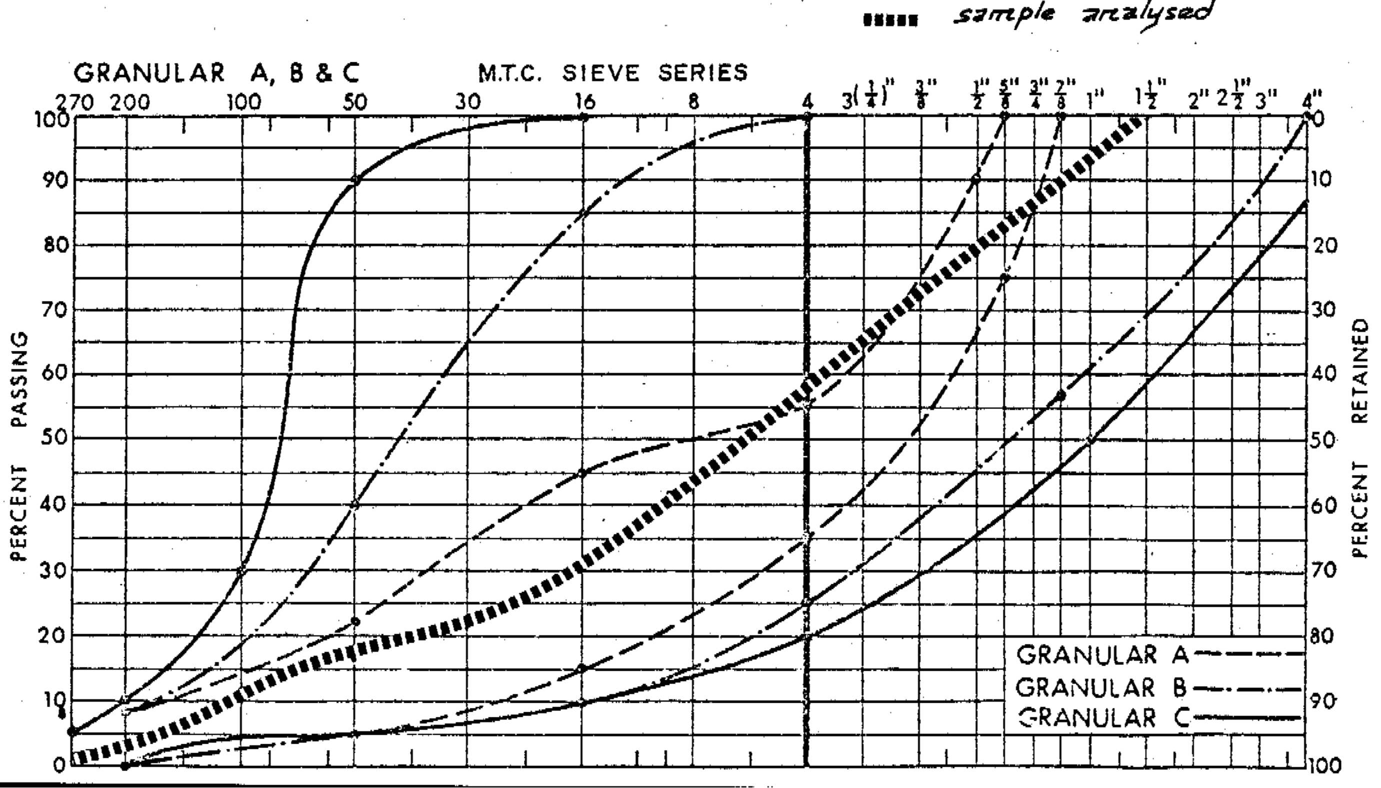
TEST PIT LOG

TEST PIT LOCATION (SEE DWG No HRS 2 & 3)

0'
silty fine sand to boulders
MPS - 2.5'

4.5'
refusal on boulders

GRAIN SIZE DISTRIBUTION CURVE



DRY SIEVE ANALYSIS AND TEST PIT LOGS

SAMPLE TP 54 DATE APRIL 5, 1978 NAME W.R. MOORE

Remarks: GRAVEL 38.2% SAND 59.3% FINES 2.5%
WASHED SIEVE (% FINES PASSING #200) 6%

DRY SIEVING

Sieve No.	Mass Retained	Percent Retained	Cumulative % Passing
1½	120.6	–	–
3/4	169.5	9.4	90.6
3/8	220.0	12.2	78.4
4	297.8	16.6	61.8
10	577.0	32.1	29.7
16	327.3	18.2	11.5
30	108.1	6.0	5.5
50	22.5	1.3	4.2
100	13.9	0.8	3.4
200	16.2	0.9	2.5
PAN	28.8	1.6	
Totals	1781.1	100.0	

TEST PIT LOG

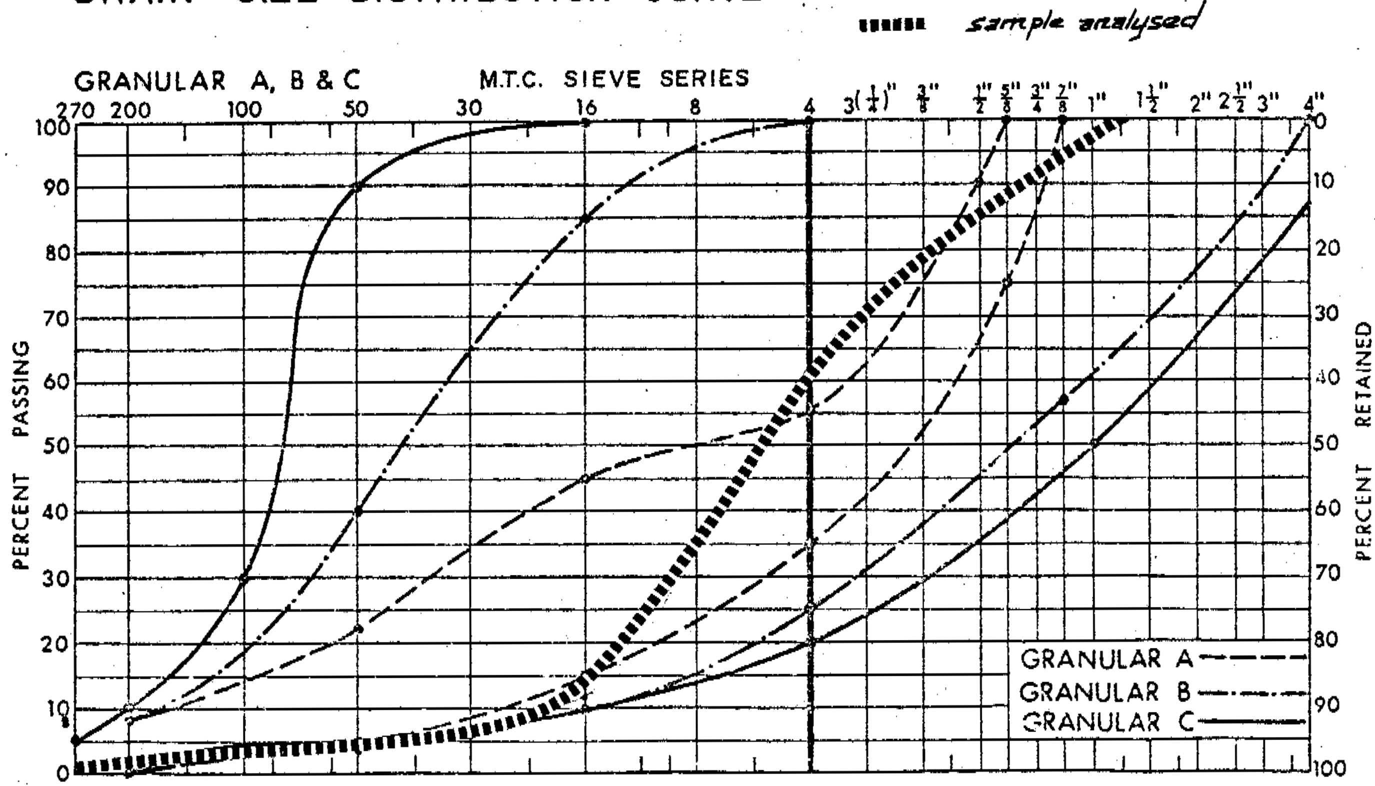
TEST PIT LOCATION (SEE DWG No HRS 2 & 3)

0'
fine to coarse gravel

2'
fine gravel to boulders
MPS - 2'

3.5'
silty clay till

GRAIN SIZE DISTRIBUTION CURVE



DRY SIEVE ANALYSIS AND TEST PIT LOGS

SAMPLE TP 55 DATE APRIL 5, 1978 NAME R. HILL

Remarks: GRAVEL 42.8 SAND 54.1 FINES 3.1

WASHED SIEVE (% FINES PASSING #200) 6%

DRY SIEVING

Sieve No.	Mass Retained	Percent Retained	Cumulative % Passing
1½	670.9	–	–
3/4	354.1	17.5	82.5
3/8	262.2	13.0	69.5
4	249.8	12.3	57.2
10	303.6	15.0	42.2
16	178.9	8.8	33.4
30	259.0	12.8	20.6
50	225.5	11.1	9.5
100	67.0	3.3	6.2
200	61.9	3.1	3.1
PAN	40.6	2.0	
Totals	2002.6	100.0	

TEST PIT LOG

TEST PIT LOCATION (SEE DWG No HRS 2 & 3)

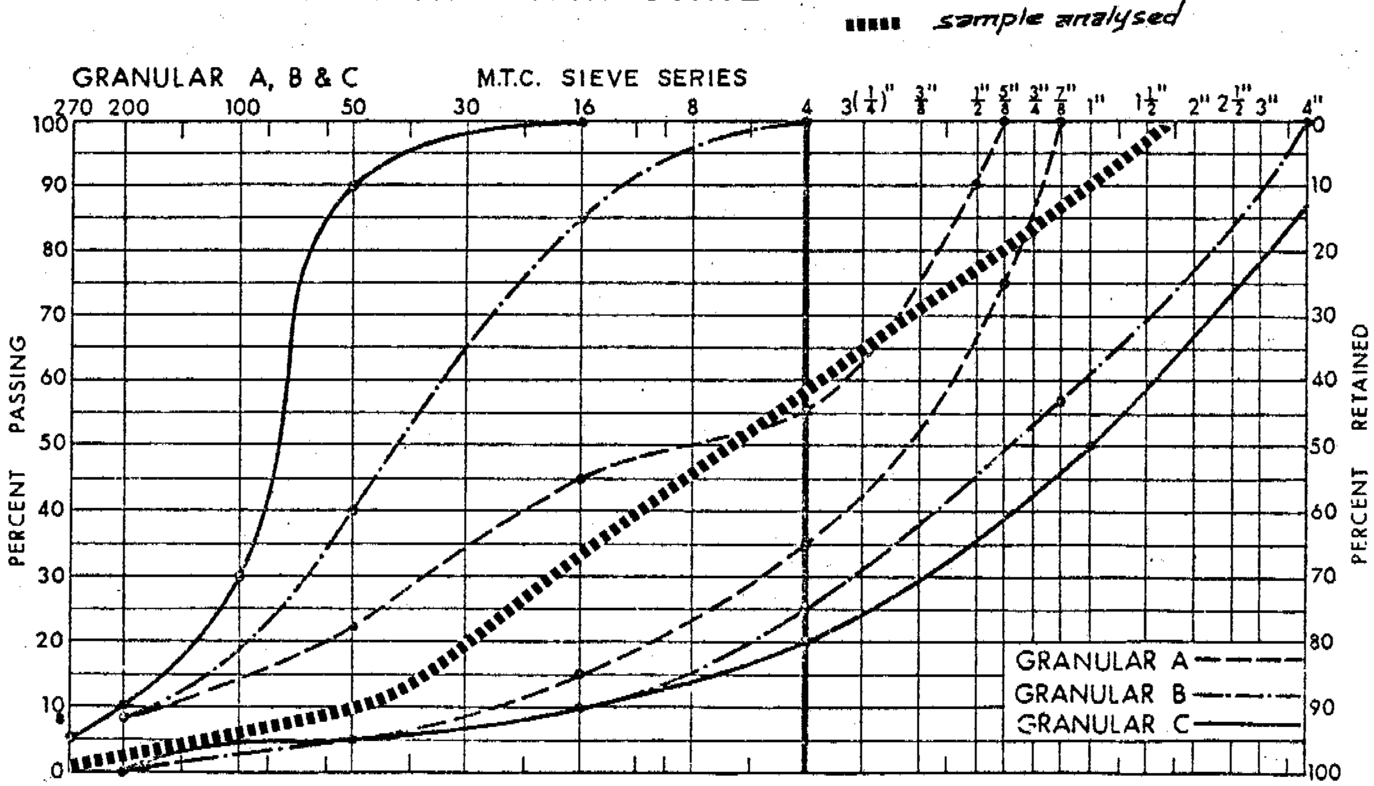
0'

fine sand to boulders MPS-2'

3.5'

silty clay till

GRAIN SIZE DISTRIBUTION CURVE



DRY SIEVE ANALYSIS AND TEST PIT LOGS

SAMPLE TP56A DATE APRIL 5, 1978 NAME W.R. MOORE

Remarks: GRAVEL 19.1 % SAND 79.0 % FINES 1.9 %
WASHED SIEVE (% FINES PASSING #200) 6%

DRY SIEVING			
Sieve No.	Mass Retained	Percent Retained	Cumulative % Passing
1½	–	–	–
3/4	113.9	6.5	93.5
3/8	108.0	6.1	87.4
4	114.8	6.5	80.9
10	309.3	17.5	63.4
16	612.2	34.7	28.7
30	437.0	24.8	3.9
50	19.5	1.1	2.8
100	7.7	0.4	2.4
200	8.1	0.5	1.9
PAN	15.9	0.9	
Totals	1746.4	100.0	

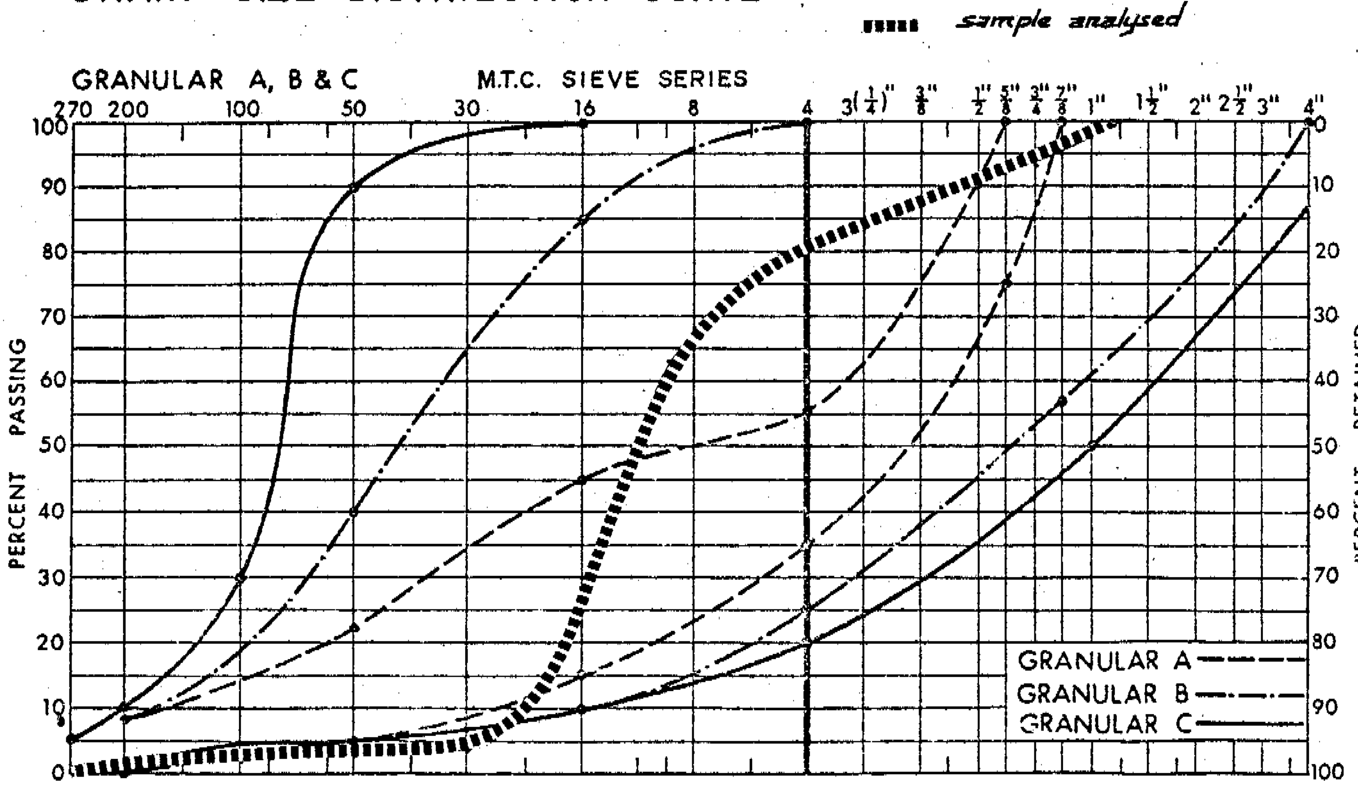
TEST PIT LOG

TEST PIT LOCATION (SEE DWG No HRS 2 & 3)

0'
coarse sand to coarse gravel
some cobbles and boulders
MPS - 2'

2.5'
silty clay till

GRAIN SIZE DISTRIBUTION CURVE



DRY SIEVE ANALYSIS AND TEST PIT LOGS

SAMPLE T.P. 57 DATE APRIL 5, 1978 NAME R. HILL

Remarks: GRAVEL 56.6 % SAND 40.0 % FINES 3.4 %
WASHED SIEVE (% FINES PASSING #200) 6%
MPS-2" (CEMENT ON LARGER PART)

DRY SIEVING

Sieve No.	Mass Retained	Percent Retained	Cumulative % Passing
1½	454.7	–	–
3/4	138.5	7.8	92.2
3/8	399.7	22.8	69.4
4	460.9	26.0	43.4
10	340.2	19.2	24.2
16	98.5	5.6	18.6
30	38.3	2.2	16.4
50	24.9	1.4	15.0
100	167.0	9.4	5.6
200	38.4	2.2	3.4
PAN	37.4	2.1	
Totals	1743.8	100.0	

TEST PIT LOG

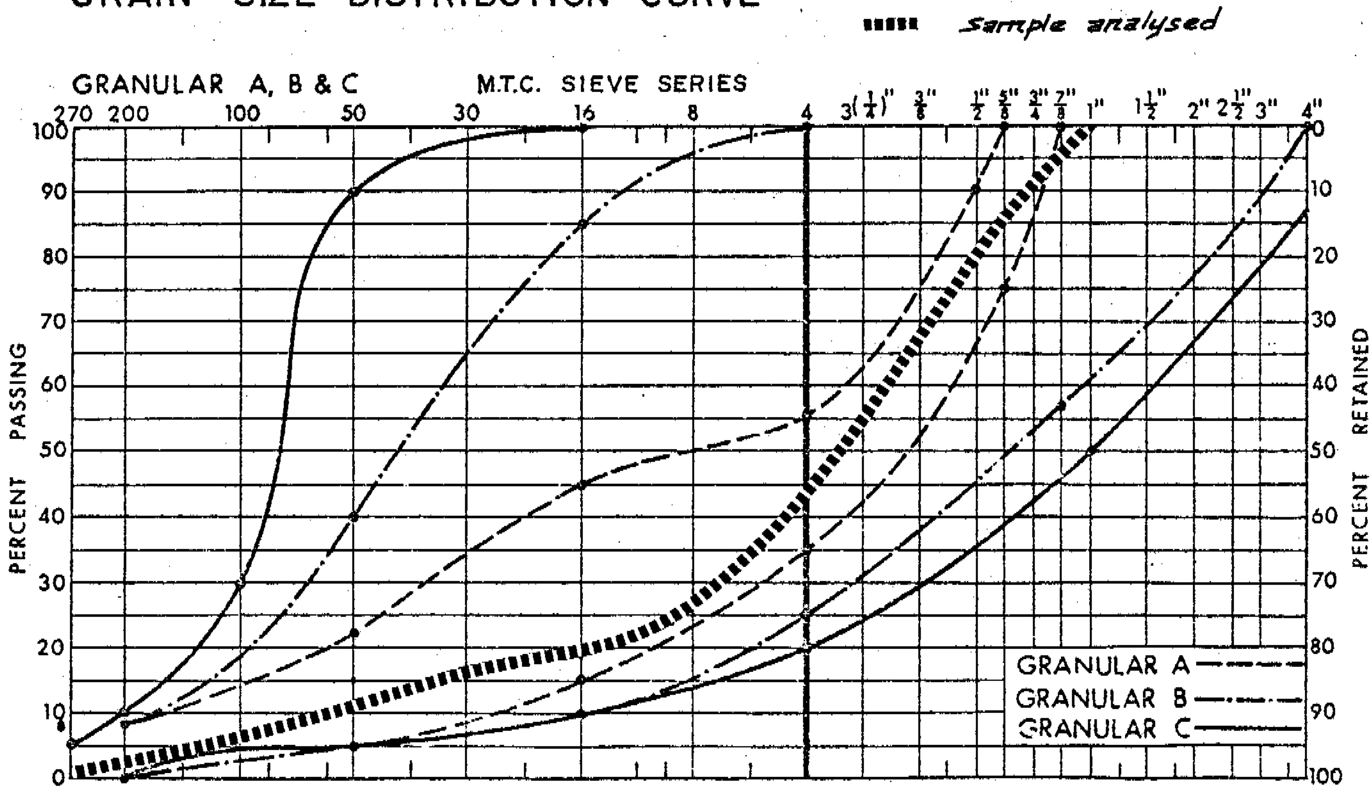
TEST PIT LOCATION (SEE DWG No HRS 2 & 3)

0'
fine sand - some boulders
MPS - 2'

1'
silty fine sand to boulders
MPS - 3'

3'
refusal on boulders

GRAIN SIZE DISTRIBUTION CURVE



DRY SIEVE ANALYSIS AND TEST PIT LOGS

SAMPLE TP 59 A DATE APRIL 5, 1978 NAME R. HILL

Remarks : GRAVEL 77.1% SAND 21.0% FINES 1.9%

WASHED SIEVE (% FINES PASSING #200) 10%

MPS - 2½"

DRY SIEVING			
Sieve No.	Mass Retained	Percent Retained	Cumulative % Passing
1½	704.7	-	-
3/4	596.5	35.9	64.1
3/8	390.9	23.5	40.6
4	294.2	17.7	22.9
10	158.0	9.5	13.4
16	48.2	2.9	10.5
30	46.3	2.8	7.7
50	42.2	2.5	5.2
100	21.1	1.3	3.9
200	33.6	2.0	1.9
PAN	5.5	0.3	
Totals	1636.5	100.0	

TEST PIT LOG

TEST PIT LOCATION (SEE DWG No HRS 2 & 3)

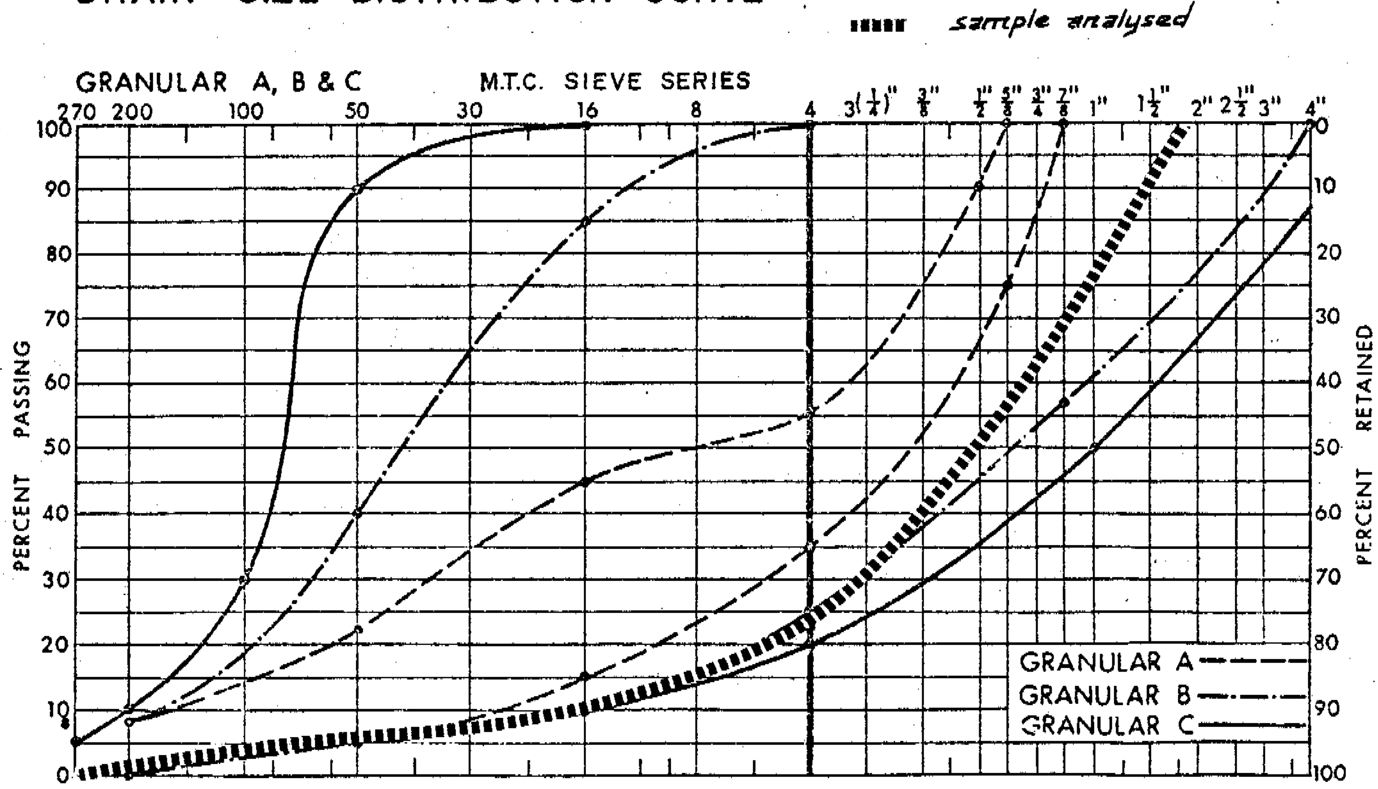
0'
silty fine sand and gravel
some cobbles and boulders
MPS - 3'

2'
stratified silty fine sand
to cobbles MPS - 5"

6'
fine to coarse gravel
MPS - 3"

8' ∇ assumed
refusal on frost

GRAIN SIZE DISTRIBUTION CURVE



DRY SIEVE ANALYSIS AND TEST PIT LOGS

SAMPLE TP 59 B DATE APRIL 5, 1978 NAME R. HILL

Remarks: GRAVEL 45.0 % SAND 53.8 % FINES 1.2 %
WASHED SIEVE (% FINES PASSING #200) 3%

DRY SIEVING

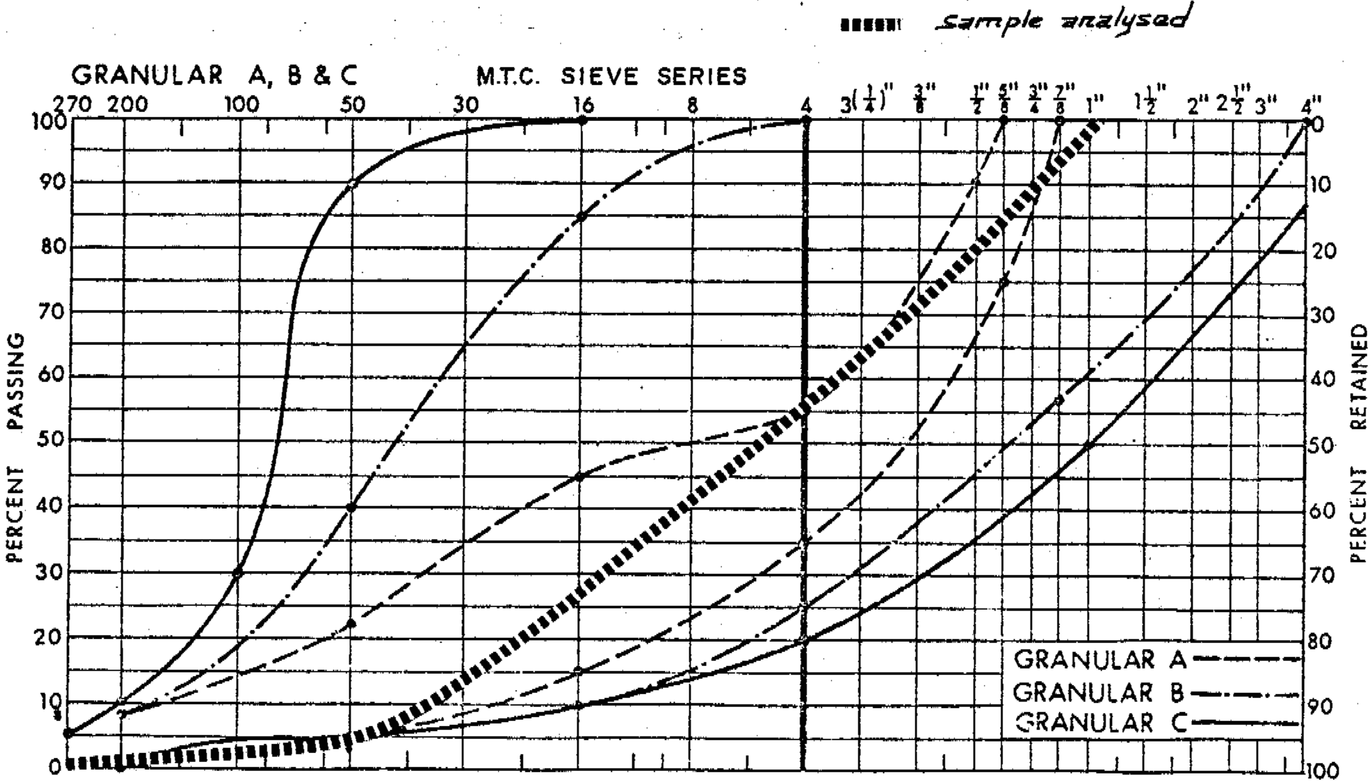
Sieve No.	Mass Retained	Percent Retained	Cumulative % Passing
1½	-	-	-
3/4	193.8	9.1	90.9
3/8	408.5	19.2	71.7
4	355.8	16.7	55.0
10	382.0	17.9	37.1
16	222.8	10.5	26.6
30	278.0	13.0	13.6
50	210.7	9.9	3.7
100	29.9	1.4	2.3
200	24.0	1.1	1.2
PAN	5.7	0.3	
Totals	2111.2	100.0	

TEST PIT LOG

TEST PIT LOCATION (SEE DWG No HRS 2 & 3)

Same as TP 59A

GRAIN SIZE DISTRIBUTION CURVE



DRY SIEVE ANALYSIS AND TEST PIT LOGS

SAMPLE ......TP 60.......... DATE ..APRIL 5, 1978..... NAME ...R. HILL..........

Remarks : GRAVEL 50.6% SAND 47.1% FINES 2.3%
WASHED SIEVE (% FINES PASSING # 200) 10%

DRY SIEVING

Sieve No.	Mass Retained	Percent Retained	Cumulative % Passing
1½	473.2	—	—
3/4	331.6	15.5	84.5
3/8	427.5	20.0	64.5
4	323.0	15.1	49.4
10	272.3	12.7	36.7
16	160.8	7.5	29.2
30	193.8	9.1	20.1
50	226.2	10.6	9.5
100	75.1	3.5	6.0
200	79.9	3.7	2.3
PAN	28.6	1.3	
Totals	2118.4	100.0	

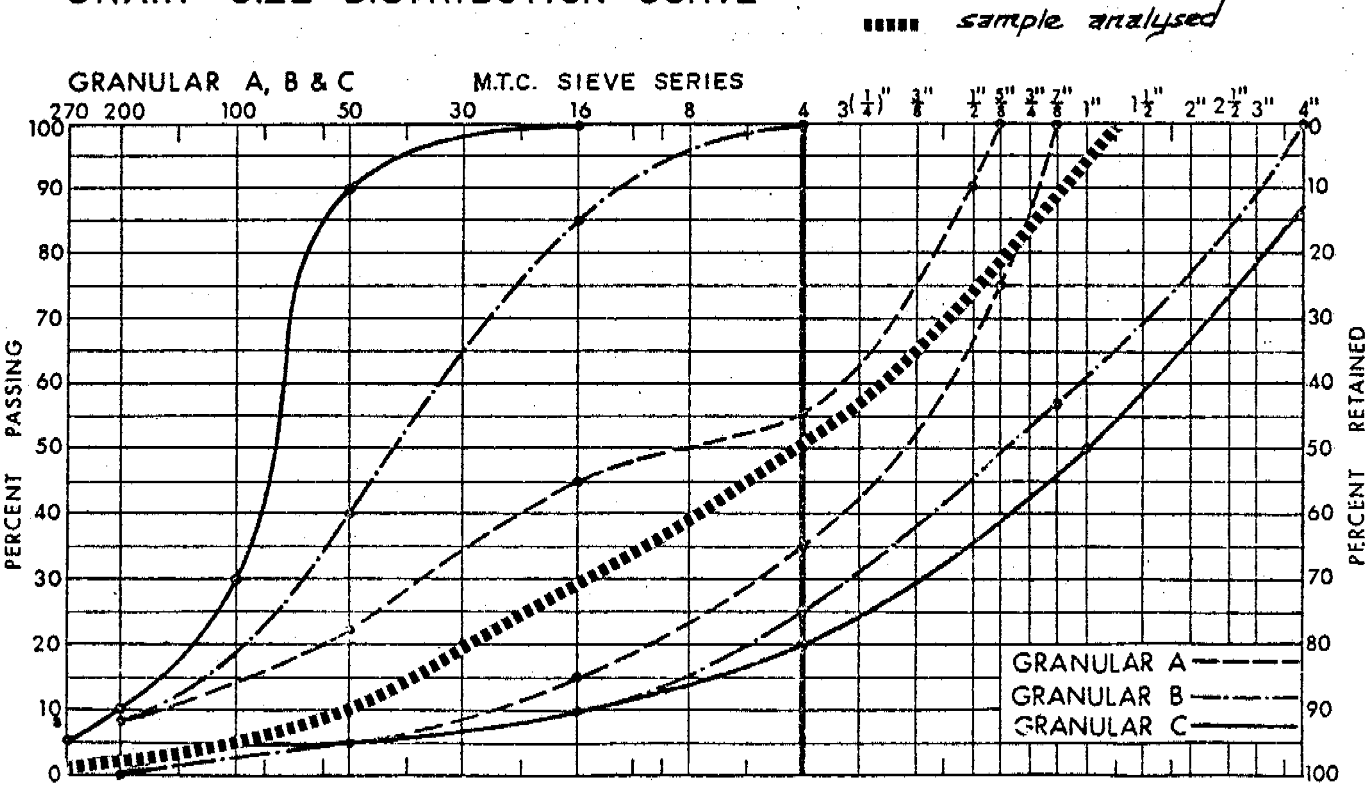
TEST PIT LOG

TEST PIT LOCATION (SEE DWG No HRS 2 & 3)

0'
silty fine sand to boulders
MPS-2'

3.5'
refusal on boulders (frost)

GRAIN SIZE DISTRIBUTION CURVE



DRY SIEVE ANALYSIS AND TEST PIT LOGS

SAMPLE T.P. 61 DATE APRIL 5, 1978 NAME R. HILL

Remarks: GRAVEL 50.2% SAND 46.6% FINES 3.2%
WASHED SIEVE (% FINES PASSING #200) 8%
ORGANIC CONTENT UNACCEPTABLE FOR CONCRETE

DRY SIEVING			
Sieve No.	Mass Retained	Percent Retained	Cumulative % Passing
1½	81.4	–	–
3/4	254.8	13.2	86.8
3/8	318.3	16.5	70.3
4	395.4	20.5	49.8
10	476.1	24.6	25.2
16	238.5	12.3	12.9
30	107.7	5.6	7.3
50	21.0	1.1	6.2
100	19.5	1.0	5.2
200	38.0	2.0	3.2
PAN	41.8	2.2	
Totals	1911.1	100.0	

TEST PIT LOG

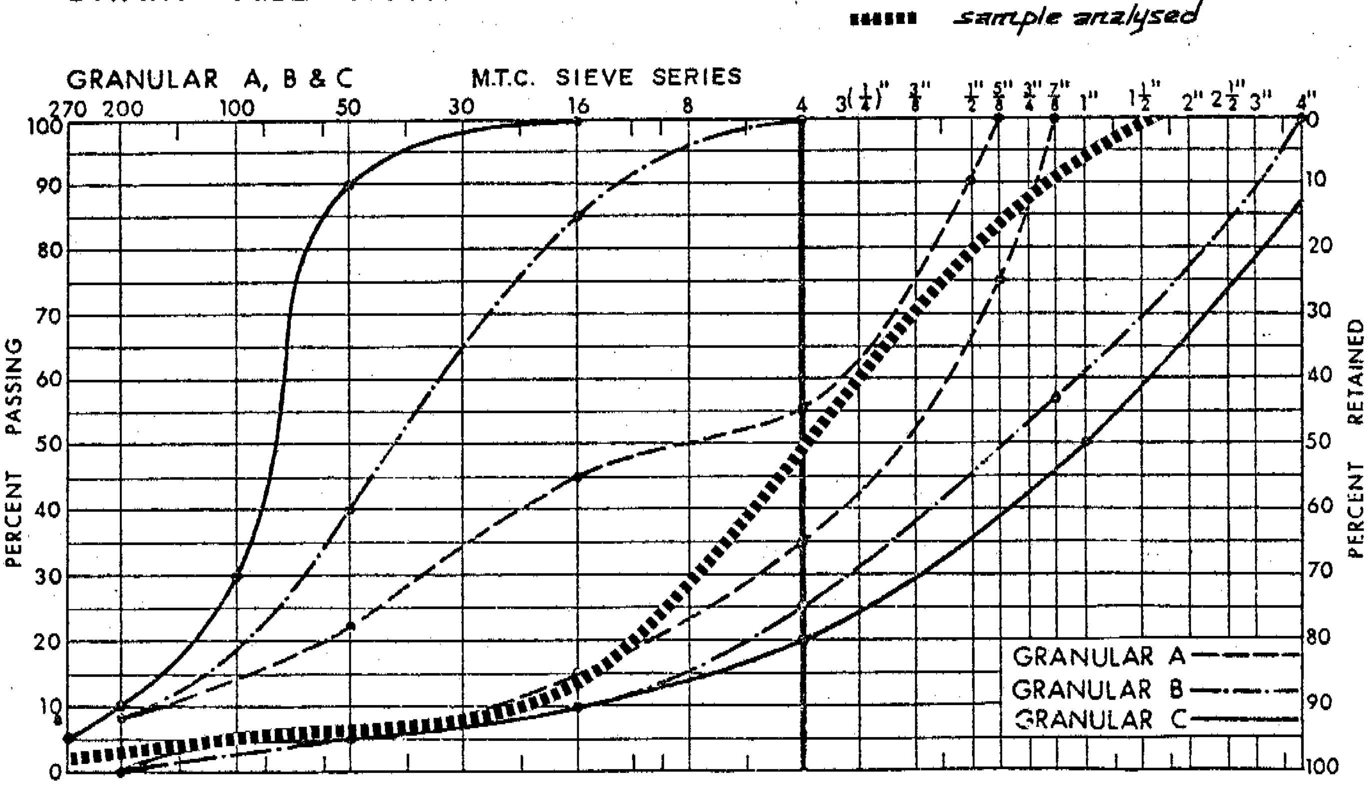
TEST PIT LOCATION (SEE DWG No HRS 2 & 3)

0'
fine to coarse gravel
some cobbles MPS - 5"

5'
silty fine sand to
boulders MPS - 2.5'

6'
refusal on boulders
(frost)

GRAIN SIZE DISTRIBUTION CURVE



DRY SIEVE ANALYSIS AND TEST PIT LOGS

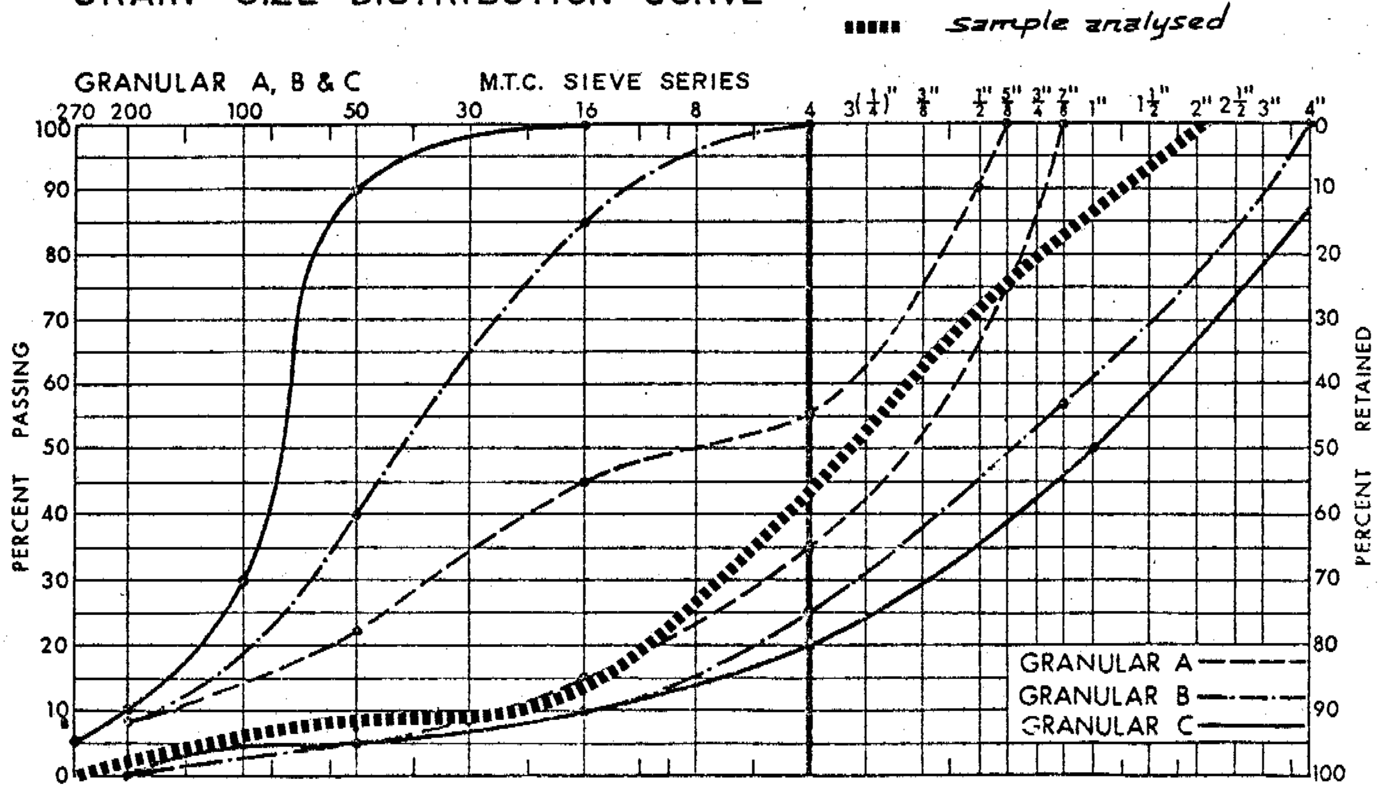
SAMPLE TP 62 DATE APRIL 5, 1978 NAME W. R. MOORE

Remarks : GRAVEL 55.6 % SAND 40.5 % FINES 3.9 %
WASHED SIEVE (% FINES PASSING # 200) 8%
ORGANIC CONTENT UNACCEPTABLE FOR CONCRETE

DRY SIEVING			
Sieve No.	Mass Retained	Percent Retained	Cumulative % Passing
1½	631.0	-	-
3/4	386.6	20.6	79.4
3/8	295.1	15.7	63.7
4	362.6	19.3	44.4
10	369.7	19.7	24.7
16	197.8	10.5	14.2
30	117.2	6.2	8.0
50	30.6	1.6	6.4
100	19.3	1.0	5.4
200	27.2	1.5	3.9
PAN	46.2	2.5	
Totals	1482.6	100.0	

TEST PIT LOG
TEST PIT LOCATION (SEE DWG No HRS 2 & 3)
0' fine to coarse gravel
1' Silty fine sand to cobbles MPS-4"
3' refusal on boulders (frost)

GRAIN SIZE DISTRIBUTION CURVE



DRY SIEVE ANALYSIS AND TEST PIT LOGS

SAMPLE: T.P. 64 DATE: APRIL 5, 1978 NAME: W. R. MOORE

Remarks: GRAVEL 56.2% SAND 38.3% FINES 5.5%
WASHED SIEVE (% FINES PASSING #200) 24%
ORGANIC CONTENT UNACCEPTABLE FOR CONCRETE

DRY SIEVING

Sieve No.	Mass Retained	Percent Retained	Cumulative % Passing
1½	–	–	–
3/4	447.0	22.9	77.1
3/8	330.3	16.9	60.2
4	320.4	16.4	43.8
10	266.4	13.7	30.1
16	131.6	6.7	23.4
30	97.8	5.0	18.4
50	77.9	4.0	14.4
100	71.4	3.7	10.7
200	100.6	5.2	5.5
PAN	106.4	5.5	
Totals	1949.8	100.0	

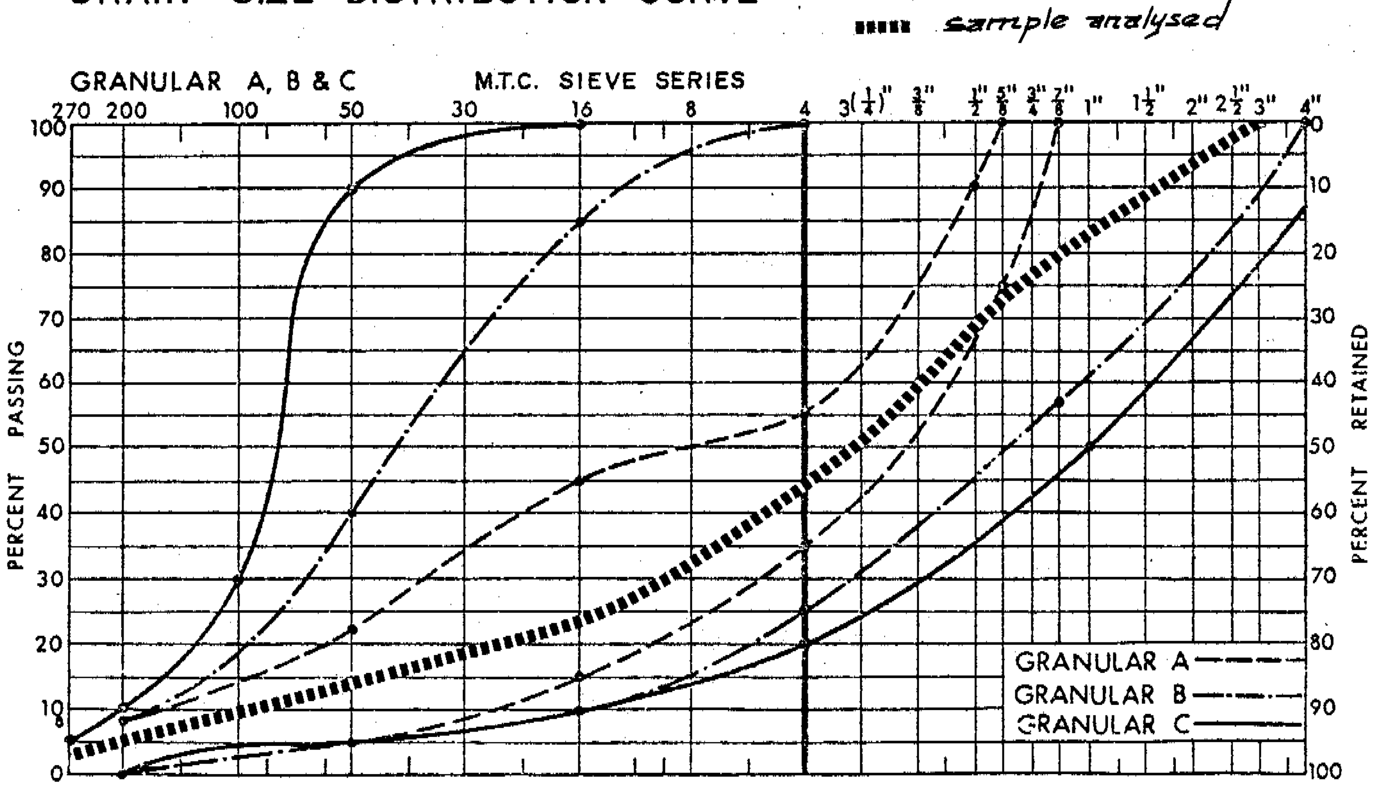
TEST PIT LOG

TEST PIT LOCATION (SEE DWG No HRS 2 & 3)

0'
silty fine sand to boulders
MPS - 3'

1.5'
refusal on boulders
(frost)

GRAIN SIZE DISTRIBUTION CURVE



DRY SIEVE ANALYSIS AND TEST PIT LOGS

SAMPLE TP-65 DATE APRIL 5, 1978 NAME W. R. MOORE

Remarks : GRAVEL 45.0% SAND 51.2% FINES 3.8%
WASHED SIEVE (% FINES PASSING #200) 8%
ORGANIC CONTENT UNACCEPTABLE FOR CONCRETE

DRY SIEVING

Sieve No.	Mass Retained	Percent Retained	Cumulative % Passing
1½	387.0	–	–
3/4	207.5	11.0	89.0
3/8	301.1	15.9	73.1
4	342.4	18.1	55.0
10	465.7	24.6	30.4
16	241.1	12.7	17.7
30	168.9	8.9	8.8
50	43.5	2.3	6.5
100	21.0	1.1	5.4
200	31.0	1.6	3.8
PAN	50.6	2.7	
Totals	1872.8	100.0	

TEST PIT LOG

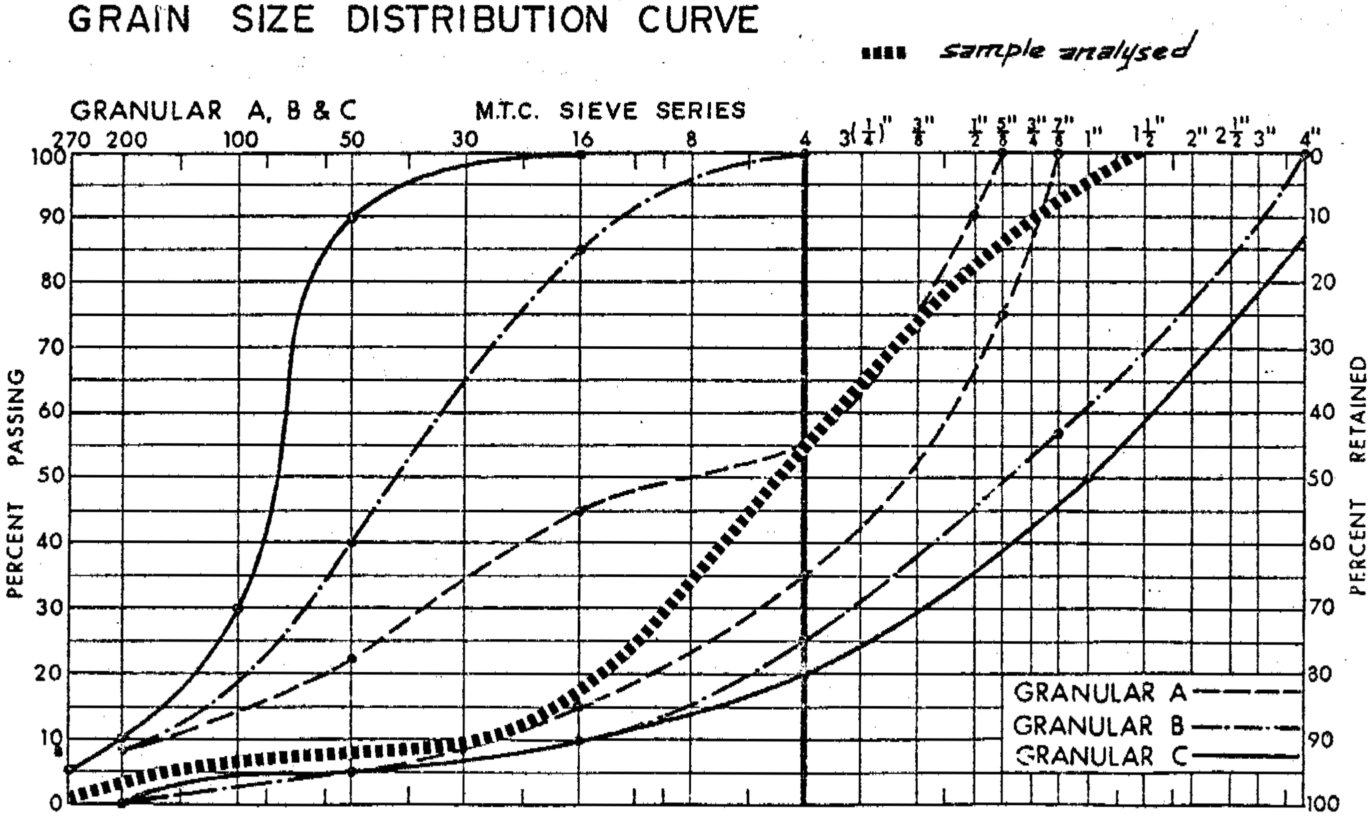
TEST PIT LOCATION (SEE DWG No HRS 2 & 3)

0'
fine to coarse gravel
Some sand and cobbles,
MPS - 4"

3.5'
fine sand to boulders
MPS - 2'

5.5'
refusal on boulders
(frost)

GRAIN SIZE DISTRIBUTION CURVE



DRY SIEVE ANALYSIS AND TEST PIT LOGS

SAMPLE TP 66 DATE APRIL 5, 1978 NAME R. HILL

Remarks : GRAVEL 45.1% SAND 52.3 % FINES 2.6 %
WASHED SIEVE (% FINES PASSING #200) 8%
ORGANIC CONTENT UNACCEPTABLE FOR CONCRETE

DRY SIEVING

Sieve No.	Mass Retained	Percent Retained	Cumulative % Passing
1½	-	-	-
3/4	232.6	12.0	88.0
3/8	199.2	10.3	77.7
4	439.9	22.8	54.9
10	568.6	29.4	25.5
16	209.8	10.9	14.6
30	156.2	8.1	6.5
50	37.0	1.9	4.6
400	15.7	0.8	3.8
200	22.4	1.2	2.6
PAN	29.2	1.5	
Totals	1910.6	100.0	

TEST PIT LOG

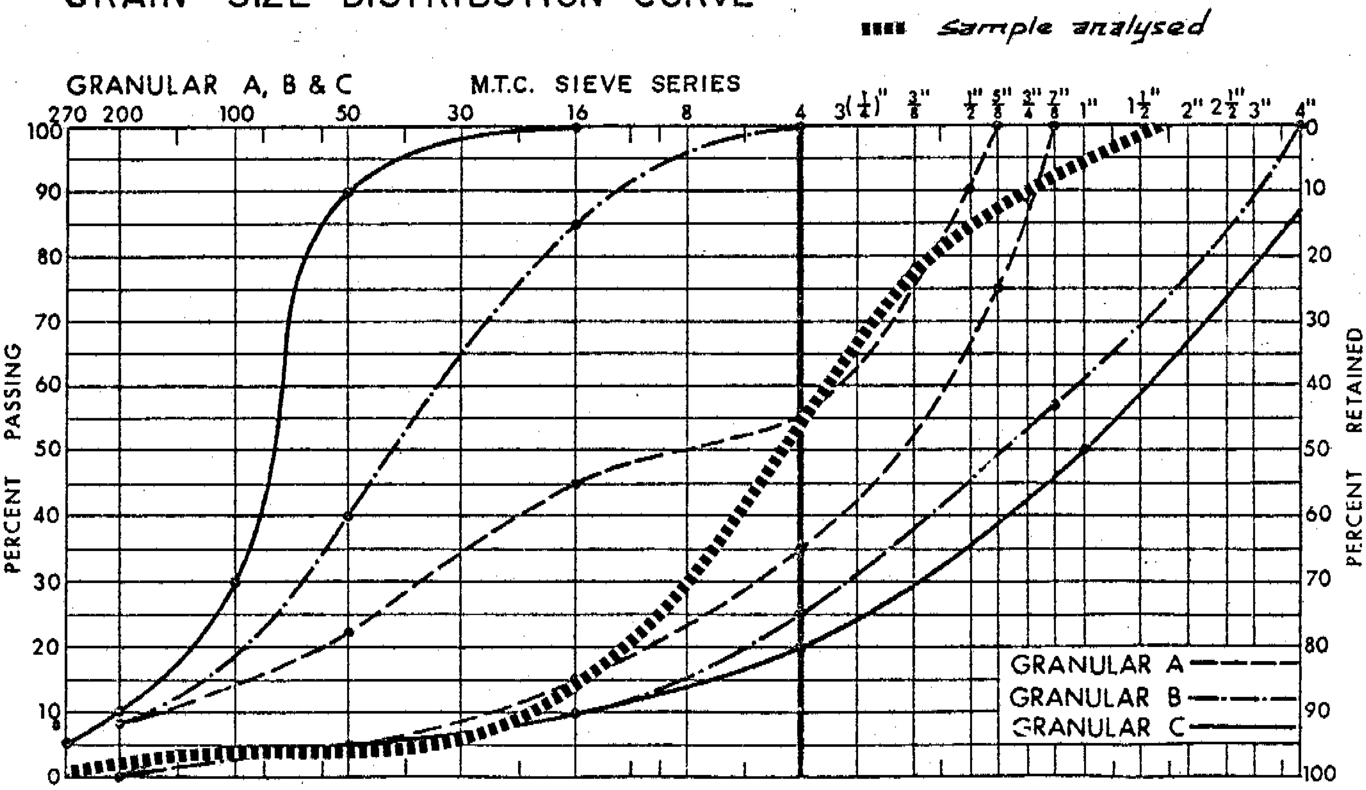
TEST PIT LOCATION (SEE DWG No HRS 2 & 3)

0'
fine to coarse gravel

2'
Silty fine sand to boulders
MPS - 2'

3.5'
refusal on boulders (frost)

GRAIN SIZE DISTRIBUTION CURVE



DRY SIEVE ANALYSIS AND TEST PIT LOGS

SAMPLE TP-67 DATE APRIL 5, 1978 NAME R. HILL

Remarks : GRAVEL 55.2% SAND 41.9% FINES 2.9%

WASHED SIEVE (% FINES PASSING #200) 8%

DRY SIEVING

Sieve No.	Mass Retained	Percent Retained	Cumulative % Passing
1½	234.5	—	—
3/4	399.4	19.5	80.5
3/8	443.2	21.6	58.9
4	288.8	14.1	44.8
10	246.0	12.0	32.8
16	93.8	4.6	28.2
30	127.9	6.2	22.0
50	231.2	11.3	10.7
100	99.5	4.8	5.9
200	53.2	3.0	2.9
PAN	48.0	2.3	
Totals	2031.0	100.0	

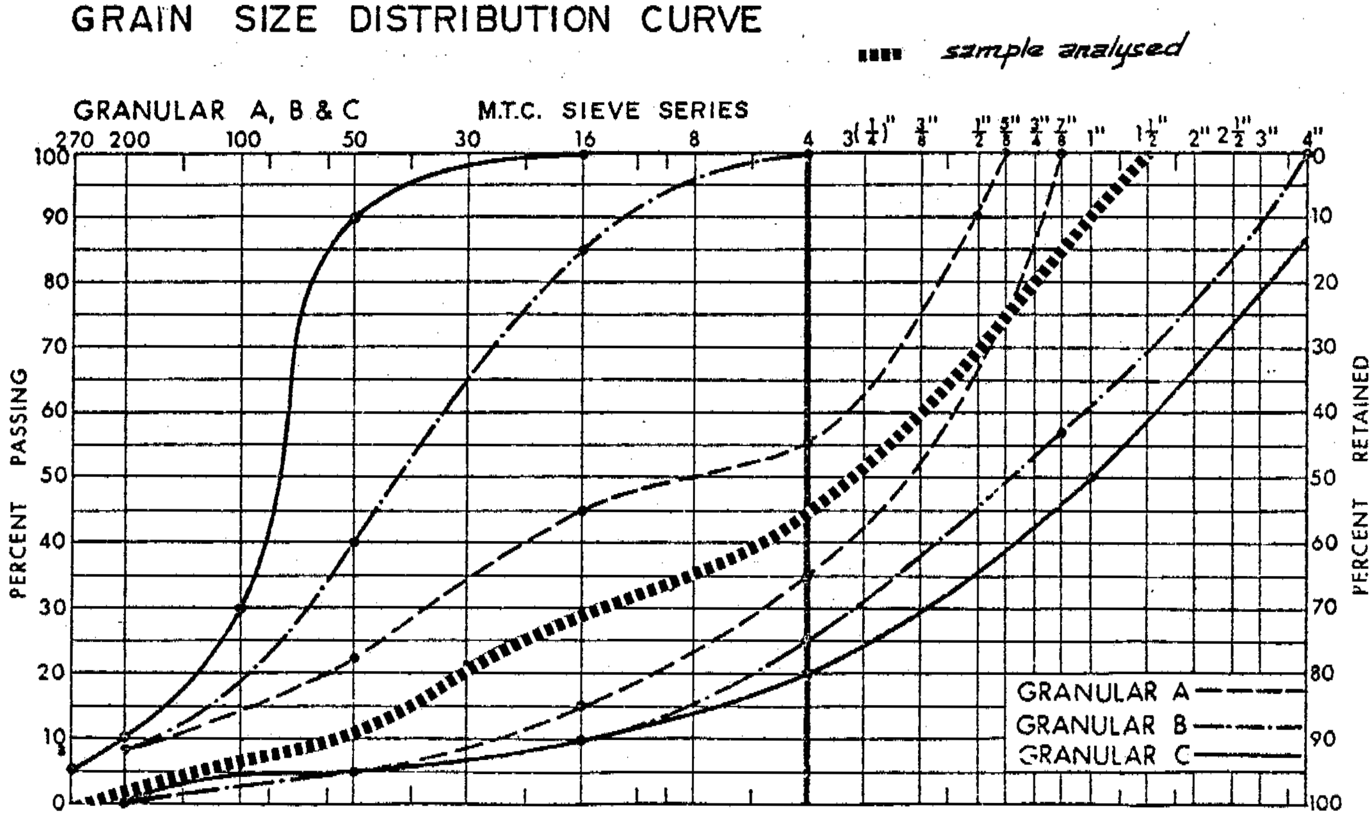
TEST PIT LOG

TEST PIT LOCATION (SEE DWG No HRS 2 & 3)

0'
silty fine sand to boulders
MPS - 2.5'

2.5'
refusal on boulders (frost)

GRAIN SIZE DISTRIBUTION CURVE



(X) GROUND PHOTOGRAPHS

(Mile 17 South)

GROUND PHOTOGRAPHS

(Mile 17 South)

Photo 1

Typical natural vegetation, predominantly jack pine, which covers the majority of the deposits.

Photo 2

Test pit excavated to approximately 6 feet on Deposit HR125A. Gives indication of well graded granular material.

GROUND PHOTOGRAPHS

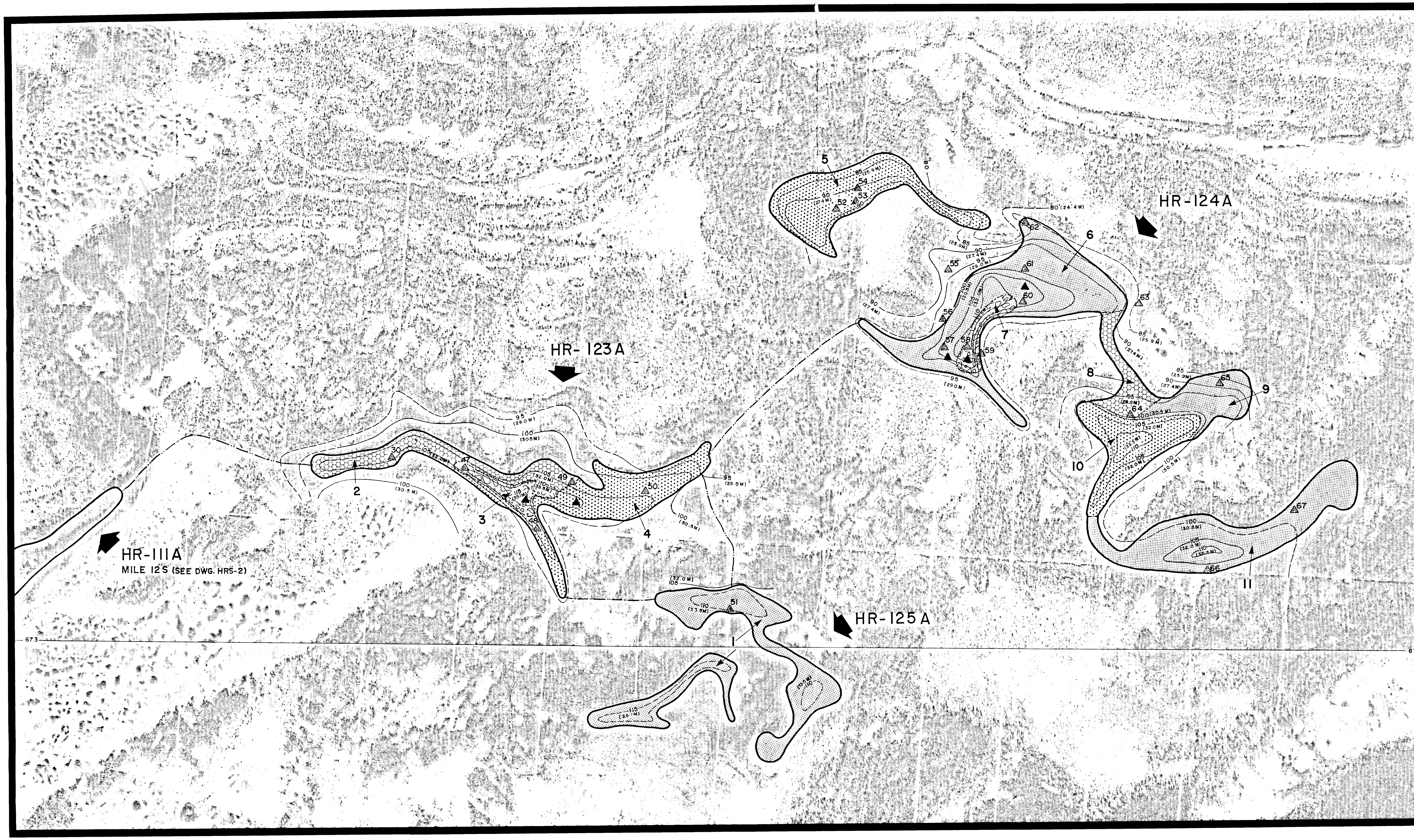
(Mile 17 South)

Photo 3

Material excavated from Deposit HR124A, showing fine sand overlain by a coarse bouldery material which could be used as general fill.

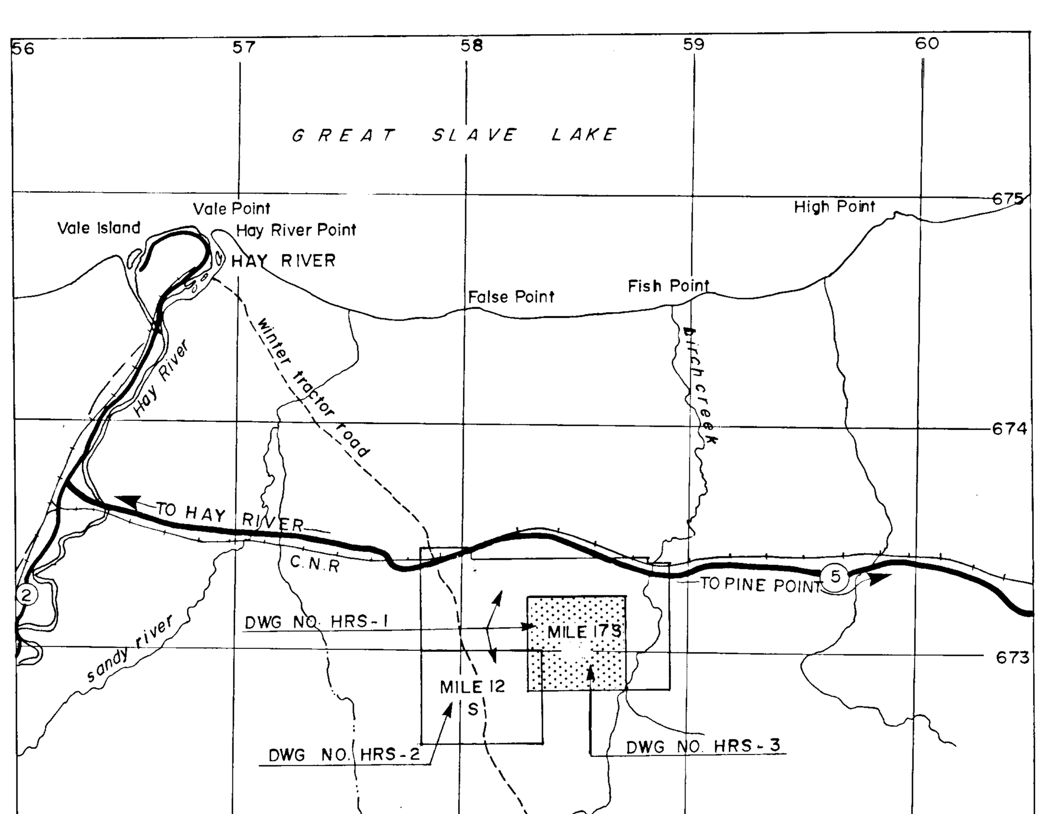
Photo 4

Typical frozen bouldery material which prevented test pit excavation in numerous locations. Note high percentage of large boulders necessitating primary crushing or screening.



key map

SCALE 1:250,000



Ref. N.T.S. MAP, BUFFALO LAKE
85B, EDITION 2, MCE
SERIES A 502 - 1967

LEGEND

- POTENTIAL GRANULAR 'A' MATERIAL AND CONCRETE AGGREGATE
- POTENTIAL GRANULAR 'B' MATERIAL
- POTENTIAL GRANULAR 'C' MATERIAL
- GENERAL FILL
- DEPLETED AREA
- TEST PIT LOCATIONS
- HOLES LEFT OPEN
- RECOMMENDED ADDITIONAL TEST PITS
- DEPOSIT BOUNDARIES
- 100' (30.5M) ELEVATION CONTOUR LINES
- POTENTIAL ACCESS BETWEEN DEPOSITS

THE DEPARTMENT OF INDIAN AFFAIRS AND NORTHERN DEVELOPMENT

GRANULAR MATERIALS INVENTORY

HWY. No. 5, HAY RIVER
NORTHWEST TERRITORIES **MILE 17 S**

SCALE: 1" = 500'±	DATE: MAY, 1978
INTERPRETATION: W.R.M. & R.H.	DRAWN: A.B.
CHECKED: S.J.G.B.	CHECKED: W.R.M.
DATE OF PHOTOGRAPHY: 1972	DRAWING No: HRS-3 (78-128)

bird and hale ltd. 1263 Bay Street Toronto - Ontario

- Airphoto interpretation studies
- Engineering and environmental coordination

4.3 All-Weather Haul Road Alignment, Alternatives
(see Dwg. No. HRS-1)

(i) Construction Cost Estimates

The cost of constructing an all weather haul road along each of the alternate alignments was determined as described in section 3.11. The local contractors were given the base data, including construction specifications, and physical terrain information as appears in Section 4.3(iii).

The estimated cost of each construction phase, the total cost, total length and cost per mile for each route appear in Table No. 3. It should be noted that the costs appearing in this table are estimated and are based on 1978 construction cost figures.

(ii) Comparison of Alternate Alignments

The final selection of the alignment, along which an all-weather haul road will be constructed, should be based primarily upon the quality and quantity of aggregate available at each deposit, as well as the total estimated cost of road construction along the respective alignments and the economics of travel time and haulage costs.

Table No. 3

CONSTRUCTION COST ESTIMATES (+20%) FOR ALTERNATE ALL-WEATHER HAUL ROAD ALIGNMENTS

Route No. 1	Clearing & Grubbing	Culverts	Ditching	Haulage of Granular Mat.	Grading & Compaction	Top Dressing	Total Cost	Total Length	Cost/Mile
	($)	($)	($)	($)	($)	($)	($)	(miles)	($)
1	26,000	4,200	23,100	120,600	47,000	4,700	226,000	4.4	51,300
2	13,700	2,800	8,900	49,100	17,000	2,400	94,000	2.3	40,900

As indicated in Table Nos. 4,5,6 and7,Sections 1.1 and 1.2, it is believed that a larger quantity of higher quality aggregate is available in the Mile 12 south deposits than in the Mile 17 south deposits. In addition, a greater amount of upgrading, particularly in the form of screening of large boulders, will be necessary in the Mile 17 deposits.

The total estimated cost of constructing an all-weather haul road along the Route 1 alignment, to the Mile 12 south deposits, is $226,000 as opposed to a cost of $94,000 to construct a road along the Route 2 alignment, to the Mile 17 South deposits (see Table No. 3, Section 4.3(ii)). Thus a cost increase of $132,000 to construct the haul road along the route 1 as opposed to route 2 alignment would result. The cost of constructing haul road access between the deposits will be similar regardless of the alignment that is chosen.

The total distance from the town of Hay River to the Mile 12 South deposit via Route 1 is approximately 34 kilometers (21 miles) and the distance to the Mile 17 South deposits via Route 2 is approximately 42 kilometers (26 miles). Thus based on a 1978 haulage cost of 15¢ per yard mile it would cost approximately $2,047,500 and $2,535,000 to haul 500,000 m^3 (650,000 cubic yds.) of aggregate from the Mile 12 south and Mile 17 south deposits, respectively, to Hay River. This represents $487,500 (1978) in additional haulage costs to remove the material from Mile 17 South as opposed to Mile 12 South.

Thus, comparing the additonal cost of construction along route 1 and the increased haulage cost as a result of hauling via Route 2, there is a potential saving of $355,500 in constructing the haul road along the Route 1 alignment.

Therefore, assuming removal of large quantities of granular material destined for use in areas west of the junction of Highway No. 5 and the Fort Smith road, construction of the all-weather haul road is recommended along Route 1 alignment. However, should only minor quantities of material be required or the majority of the material be destined for uses east of the junction of Highway No. 5 and the Fort Smith road, construction along Route 2 alignment should be considered.

(iii) BASE DATA FOR ACCESS ROAD CONSTRUCTION COST ESTIMATE DETERMINATIONS

bird and hale ltd.
CONSULTING ENGINEERS AND BIOLOGISTS

1263 BAY STREET
TORONTO, ONTARIO
M5R 2C1
416-925-1147

S.J. GLENN BIRD, M.A.Sc., P.Eng., O.L.S.
IAN M. HALE, M.A.Sc., P.Eng.

AIRPHOTO INTERPRETATION
BIOPHYSICAL INVENTORY AND ENVIRONMENTAL ASSESSMENT
REFUSE AND SOLID WASTE SYSTEMS
REMOTE SENSING

MEMBER: Association of Consulting Engineers of Canada

April 3, 1978

Dear Sir:

Re: Construction Cost Estimates for All-weather Haul Roads South From Miles 12 and 18 From Hay River, Hwy. No. 5
Our File No. 78-128

Our firm has been contracted by the Department of Indian Affairs and Northern Development to conduct a granular materials search and assessment in an area southeast of Mile 12, from Hay River, on Hwy. No. 5. This study also includes the location and determination of construction cost estimates for an all-weather haul road to provide access from Hwy. No. 5 to the proven deposits.

It has been our experience that the people best qualified to estimate road construction costs, given the terrain conditions along the route, are local contractors with road-building experience. Therefore, we are approaching three local contractors seeking their assistance in formulating the cost estimates. It should be noted that we require estimates only (±20%). It should also be noted that the final figures which will appear in our report will be an average of the estimates received and that the contractor's name will not be included with his individual estimate. However, the names of all contractors cooperating will be included in the final report.

Additional information such as physical terrain and culvert data necessary for the determination of construction cost estimates is included in the text of this report.

Yours cooperation will be appreciated.

Yours very truly,

William R. Moore, C.E.T.

WRM:nt

BACKGROUND INFORMATION

Two access routes are available. Route No. 1 starts at the junction of the Fort Smith winter road and Hwy. No. 5. Route No. 2 starts at Hwy. No. 5 just west of Birch Creek. You will find attached a sketch map of each route showing the location, physical terrain conditions and locations of granular material.

Physical Terrain Conditions

The physical terrain conditions along the routes as designated on the sketches and explained in the legend were determined through interpretation of aerial photographs and field investigations, including excavation with a backhoe. The majority of topographic slopes along both routes are gently undulating (less than 10%) and bedrock will not interfere with construction.

Construction Specifications

The road will serve as an all-weather haul road. It is assumed that an overall travelled surface width of 25 feet will be suitable. It is also assumed that pit run material will be suitable as top dressing.

Granular Fill Material

It is assumed that suitable fill material will be obtained from the closest granular deposits as indicated on the sketches. Also, it is assumed that no royalties will be charged on this material.

Clearing and Grubbing

Route No. 1 will involve the clearing and grubbing of approximately 14,600 feet of mature jackpine forest and approximately 8,500 feet of typical swamp vegetation consisting of small spruce and tamarack. Route No. 2 will require clearing and grubbing of approximately 2,000 feet of mature jackpine and poplar, approximately 5,000 feet of mature and immature jackpine, and 5,200 feet of scrub spruce, poplar and tamarack. It is assumed that a clearing width of approximately 50 feet will be sufficient.

Culverts

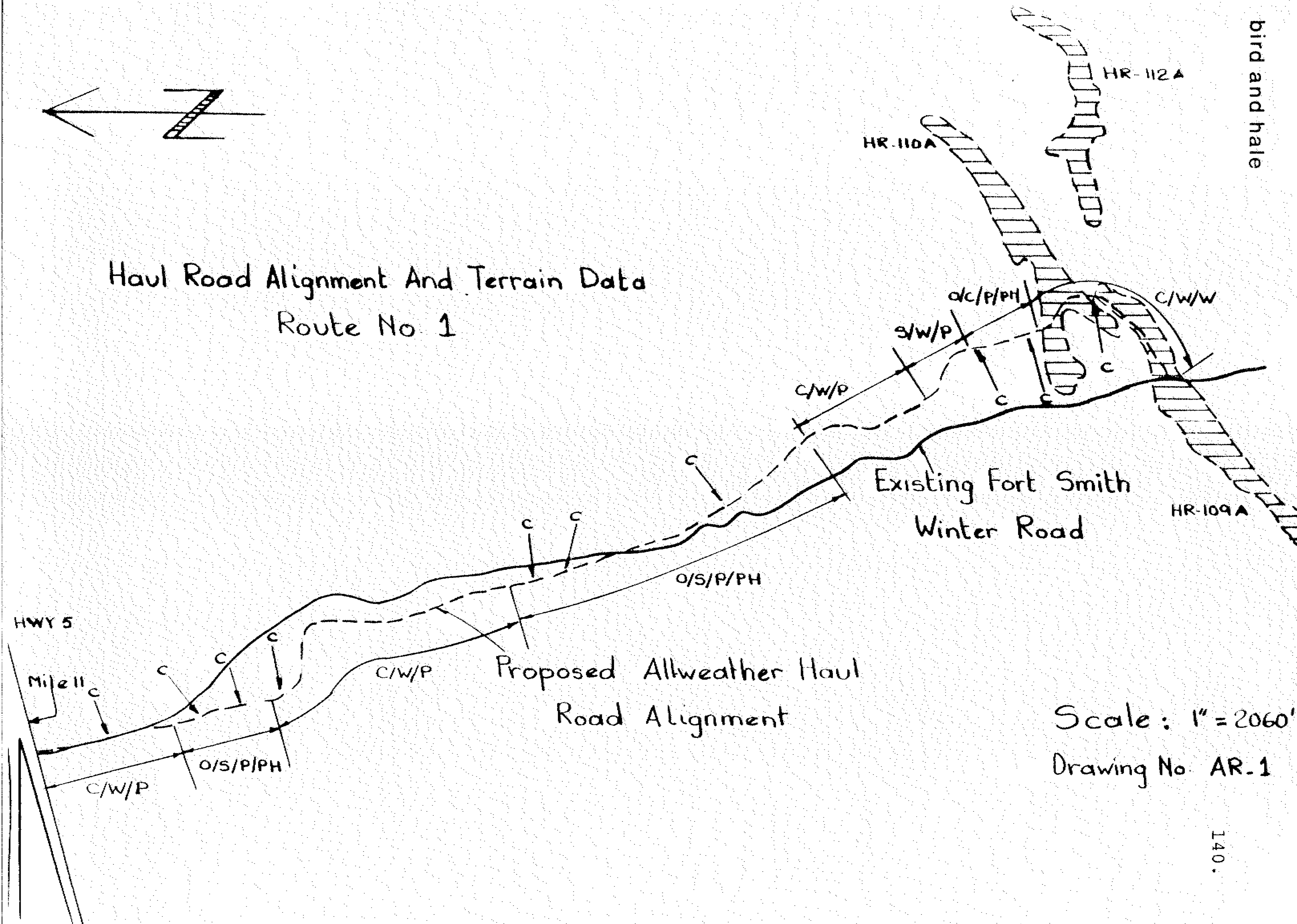
All culvert locations visible on the aerial photographs are indicated on the sketches. However, more may be required and this is left to personal judgment. Route No. 1 will require a minimum of four 24" and six 12" culverts. Route No. 2 will require five 24" and three 12" culverts.

Excavation of Organics and/or Placement of Fill Material

The choice of excavation of organics or displacement by the application of increased amounts of fill material is dependent upon which is most economical. It is assumed that should displacement by addition of fill be chosen, an additional one foot of fill will be required due to loss at the sides.

The cost estimate information would be most useful to us if it is listed under the following headings:

(1) Clearing and grubbing
(2) Excavation of organics
(3) Installation of culverts
(4) Placement of fill
(5) Grading


Haul Road Alignment And Terrain Data
Route No 1
HR-112A
HR-110A
HR-109A
O/C/P/PH
C/W/W
S/W/P
C/W/P
C
Existing Fort Smith
Winter Road
O/S/P/PH
HWY 5
Mile 11
Proposed Allweather Haul
Road Alignment
Scale : 1" = 2060'
Drawing No AR-1

PHYSICAL TERRAIN CHARACTERISTICS

AND

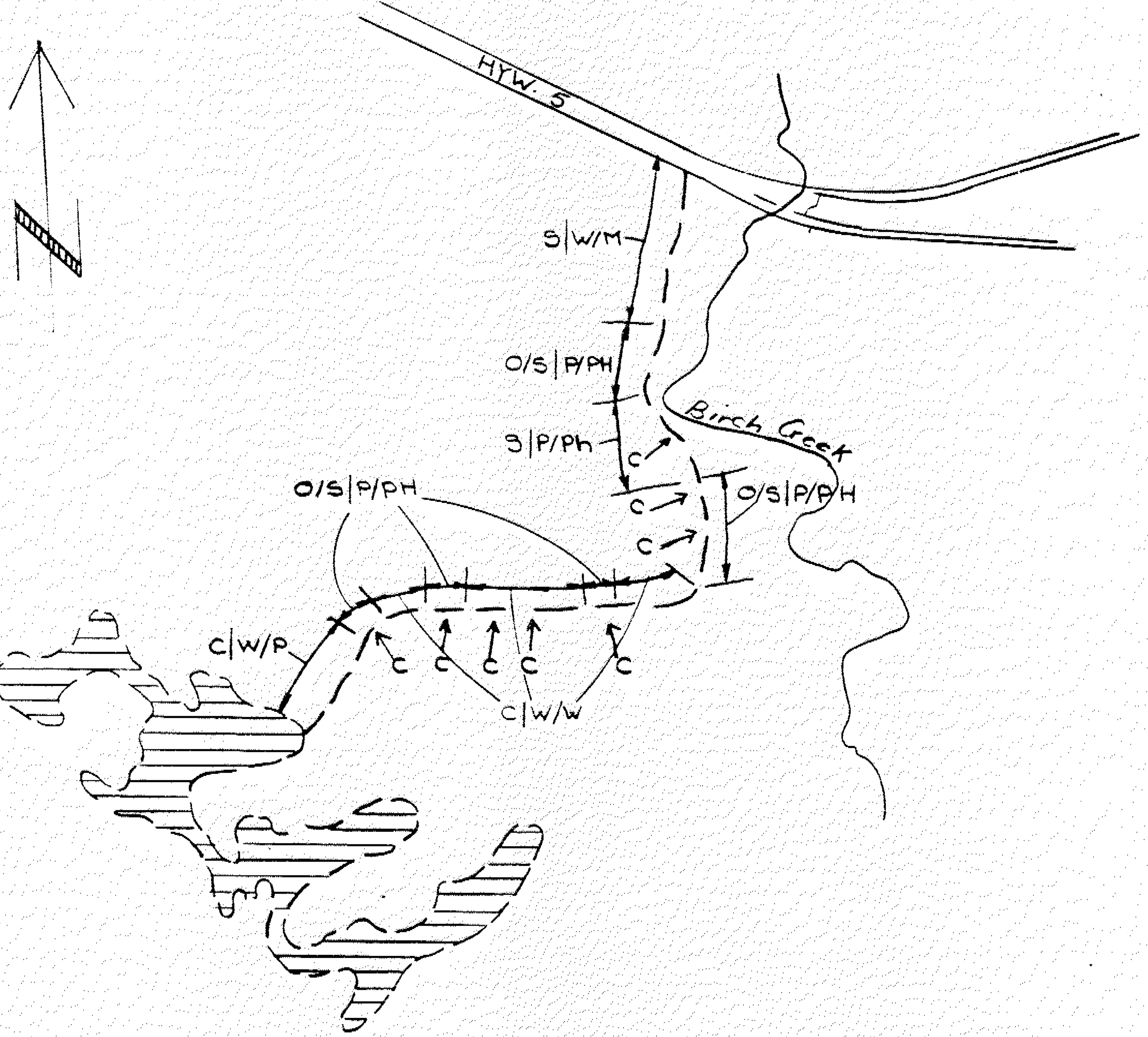
ROAD CONSTRUCTION PROCEDURES

ROUTE NO. 1

Terrain Characteristics (see Legend)	Approximiate Footage	Construction Procedures
C/W/W	3,300'	- clearing and grubbing - grading
C/W/P	10,100'	- clearing and grubbing - placement of 2' of fill - grading
S/W/P	1,200'	
O/C/P/PH	1,400'	- excavation of organic soil average 3' deep and placement of 5' of fill - or displacement of organics by placement of 6' of fill, whichever is most economical - grading
O/S/P/PH	7,100'	
TOTAL:	23,100' = 4.4 miles	

Haul Road Alignment And Terrain Data

Route No. 2



Scale 1" = 2060'

Drawing No. AR-2

PHYSICAL TERRAIN CHARACTERISTICS

AND

ROAD CONSTRUCTION PROCEDURES

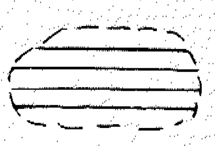
ROUTE NO. 2

Terrain Characteristics (see Legend)	Approximate Footage	Construction Procedures
C/W/W	3,400'	- clearing and grubbing - grading
C/W/P	1,600'	- clearing and grubbing
S/W/M	2,100'	- placement of 2' of fill - grading
S/P/PH	1,500'	- clearing and grubbing - placement of 3' of fill - grading
O/S/P/PH	3,700'	- excavation of organic soil, averaging 2' in depth and placement of 4' of fill - or displacement of organics by placement of 5' of fill, whichever is most economical - grading
TOTAL: 12,300' = 2.3 miles		

LEGEND

Soil Type / Internal Soil Drainage / Site Drainage

Soil Type	Internal Soil Drainage	Site Drainage
C - Sand & Gravel	W - Well	W - Well
S - Sand	M - Moderate	M - Moderate
F - Fine Grained Soil (Silt & Clay)	P - Poor	P - Poor
O - Organic Soil		Ph - Highwater Table Minor Constraint
/ - Stratified Soil e.g O/S Organic Soil over Sand		PH - Highwater Table Major Constraint

 Granular Materials

C⟶ Approx. Culvert Location

- - - - - Proposed All Weather Haul Road Allignment

(iv) CLARIFICATION OF TECHNICAL TERMINOLOGY

CLARIFICATION OF TECHNICAL TERMINOLOGY

The legend on the enclosed drawings defines the criteria mapped in brief terms. The following section expands on these definitions and outlines the significance of each in regard to the terms of reference of this report.

1. Average Slope

The slope of the terrain is divided into three categories: 0% to 10%, 10% to 20%, and over 20%. This is a significant factor as cut and fill, rate of runoff (including rapidity of groundwater recharge), severity of surface erosion and rate of groundwater flow (including septic tile bed effluents) each increase as the slope steepens. In general, if all other terrain conditions, including the on-site availability of borrow material, remain constant, increasing average slopes in an area indicate increasing development costs, particularly with regard to services, such as roads, water supply and sewage collection.

2. Depth of Overburden

The overburden is defined as the unconsolidated material overlying bedrock or boulder deposits, where the average boulder size is over 3 feet in diameter. The categories of less than 5 feet, variable with average depth ranging from 5 feet to 10 feet, and over 10 feet have been selected largely in relation to the ease or difficulty of installing underground services, assuming that the extra costs of blasting bedrock or excavating large boulders must be avoided if at all possible.

Moreover, a shallow depth of overburden has a direct influence on septic tile bed performance, as the effluent retention time is seriously reduced, and the underlying consolidated strata results in either underground ponding of the effluent or an increased rate of subsurface runoff.

3. Surface Soil Type

The soil types are divided into the following categories, according to the major constituent of the top 3 to 6 feet of overburden. Bedrock outcrop and its average slope are mapped independently of these soil types:

B - Boulders and cobbles, ranging in size from 152mm (6") upwards.

C - Coarse materials including sand and gravel ranging in size from fine sand .06 to .2mm (.0024" to .0079") to stones up to 152mm (6").

S - Sand only, ranging in size from fine sand .06 to .2 mm (.0024" to .0079") to coarse sand .84mm to 2.54mm (.033" to .1").

M - Mixture of soil particle sizes, including glacial tills with clays, silts, sand, gravel and boulders being present in a heterogeneous mixture.

F - Fine-grained soils, such as silts and/or clays.

O - Organic soils such as peat, normally having a maximum average depth of 3 feet, overlying mineral soils or bedrock. This category also refers to mineral soils with a high organic content.

Where significant stratification of soil types takes place within the top 6 feet of overburden, the condition is indicated by two soil symbols representing the predominant types, separated by an oblique; e.g., S/F, indicating sand stratified with silt and/or clay.

4. Soil/Site Drainage

4.1 Soil Drainage

The soil drainage conditions, functions of particle size, size distribution and soil density, are evaluated and categorized as follows:

W - Well drained soils, such as gravels, sand and loosely compacted tills. This category signifies rapid internal drainage, high porosity and permeability. These soils transmit water freely.

M - Moderately drained soils, such as sandy silts, medium compacted tills, etc. These soils inhibit the subsurface movement of water significantly.

P - Poorly drained soils, consisting primarily of silts, clays or organic soils, or glacial tills with high fines content or which have been highly compacted. These soils transmit water very poorly and are not free-draining.

4.2 Site Drainage

Site drainage is a function of elevation, regional and local slopes, aspect and depth of overburden, and to some extent, soil types. The map units are as follows:

W - Well drained sites do not retain surface water or pond after heavy rainstorms or spring run-off. They do not have high water table conditions. No particular remedial measures are required for development.

M - Moderately drained sites retain surface water in ponds for short periods after rainstorms or spring runoff, but eventually drain naturally. They are therefore frequently subject to seasonal or intermittent high water table conditions, which may often be controlled by ditching, etc., at slight additional development costs.

P - Poorly drained sites are subject to extensive ponding during and after heavy precipitation or peak runoff periods. Surface water may be retained permanently. These areas are subject to severe high water table conditions which will add substantially to development costs, and which may preclude the use of septic tanks for sewage treatment. Organic soils frequently accumulate to significant depths under these conditions. These areas may or may not be suitable for development.

H - High water table, generally within 3 to 5 feet of the ground surface, approaching the ground surface during wet periods of the year. Lowering of the water table is very difficult because of bedrock interference, or the general configuration of slopes in the area. The site may be low-lying with no suitable outlet for groundwater.

This symbol indicates severe constraints on development.

h - High water table as above, but can be rectified by relatively inexpensive means, such as grading or ditching. This symbol indicates minor to moderate constraints on development.

Areas of deep organic soils (over 3 feet in depth) are delineated as shown on the legends, without indicating the terrain considerations of topography, depth of overburden, poor drainage and high water table which are inherent in terrain of this nature.

(v) ROUTE LOCATION FIELD CHECK POINTS

FIELD CHECK POINTS

∇ denotes water table

X-1
- 0'
- silty fine sand
- ∇ 6'+

X-2
- ∇ 0'
- organics
- 1.5'
- fine sand
- 2'+

X-3
- ∇ 0'
- organics
- 1'
- fine sand
- 2'+

X-4
- 0'
- sand and gravel
- 3'+

X-5
- 0'
- silty fine sand to boulders
- 2'
- clayey silty sand till
- 3'+

X-6
- ∇ 0'
- organics
- 2.5'
- silty clay till
- 3'+

X-7
- ∇ 0'
- organics
- 6"
- fine to coarse sand, some gravel
- 2'+

X-8
- ∇ 0'
- organics
- 2'
- sand, gravel some cobbles
- 3'+

X-9
∇ 0'
organics
1'
fine sand
2'+

X-10
∇ 0'
organics
1.5'
fine sand
3'+

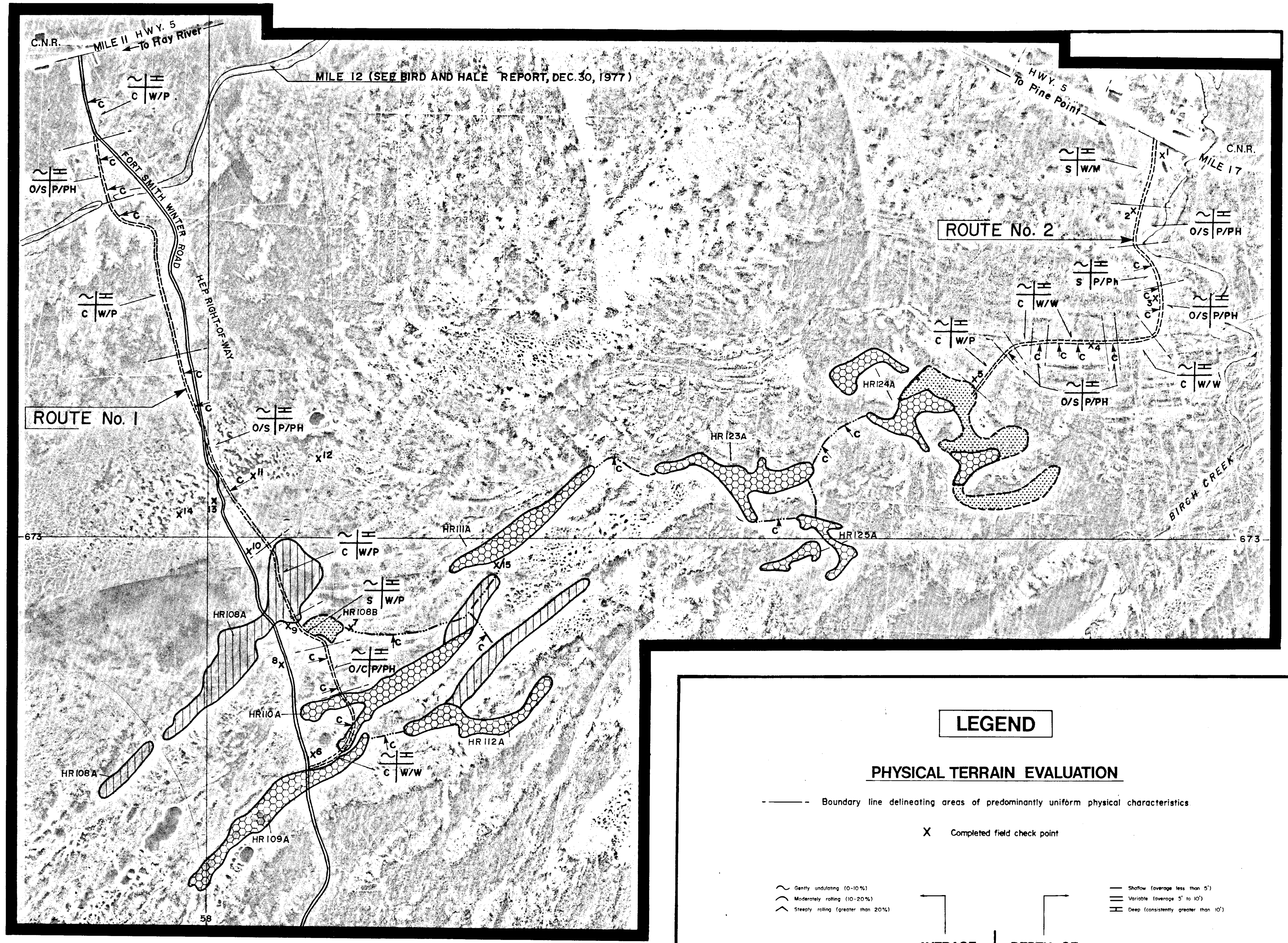
X-11
∇ 0'
organics
3'
silty fine sand
5'+

X-12
∇ 0'
organics
1.5'
silty fine sand
3'+

X-13
∇ 0'
organics
3'
silty fine sand
5 '+

X-14
∇ 0'
organics
3'
silty sand, some
gravel
5'+

X-15
∇ 0'
organics
2.5'
silty sand till
numerous boulders
3'+



LEGEND

	POSSIBLE GRANULAR DEPOSIT (ALL WEATHER EXTRACTION POTENTIAL)
	POSSIBLE GRANULAR DEPOSIT (OPTIMUM WINTER EXTRACTION POTENTIAL)
	MATERIAL PREVIOUSLY DELINEATED AS POTENTIAL GRANULAR DEPOSIT (EXTREMELY LIMITED ECONOMIC POTENTIAL)
	PROPOSED ALLWEATHER HAUL ROAD ALIGNMENT
	EXISTING ROAD
	POTENTIAL ACCESS BETWEEN DEPOSITS
C	POSSIBLE CULVERT LOCATION

LEGEND

PHYSICAL TERRAIN EVALUATION

Boundary line delineating areas of predominantly uniform physical characteristics

X Completed field check point

Gently undulating (0-10%)
Moderately rolling (10-20%)
Steeply rolling (greater than 20%)

AVERAGE SLOPES	DEPTH OF OVERBURDEN
SURFACE SOIL TYPE	SOIL / SITE DRAINAGE

Shallow (average less than 5')
Variable (average 5' to 10')
Deep (consistently greater than 10')

B BOULDERS and COBBLES
C COARSE - sand and gravel
S SAND
F FINES - silts and clays
M MIXED GRAIN SIZES
O ORGANIC - shallow peat overlying mineral soil
/ STRATIFIED SOILS

W Well drained
M Moderately drained
P Poorly drained
H High water table (severe constraints)
h High water table (minor constraints)

NOTE

1 The symbol within a terrain evaluation boundary represents predominant conditions in that area isolated local conditions within a boundary may differ slightly from those indicated

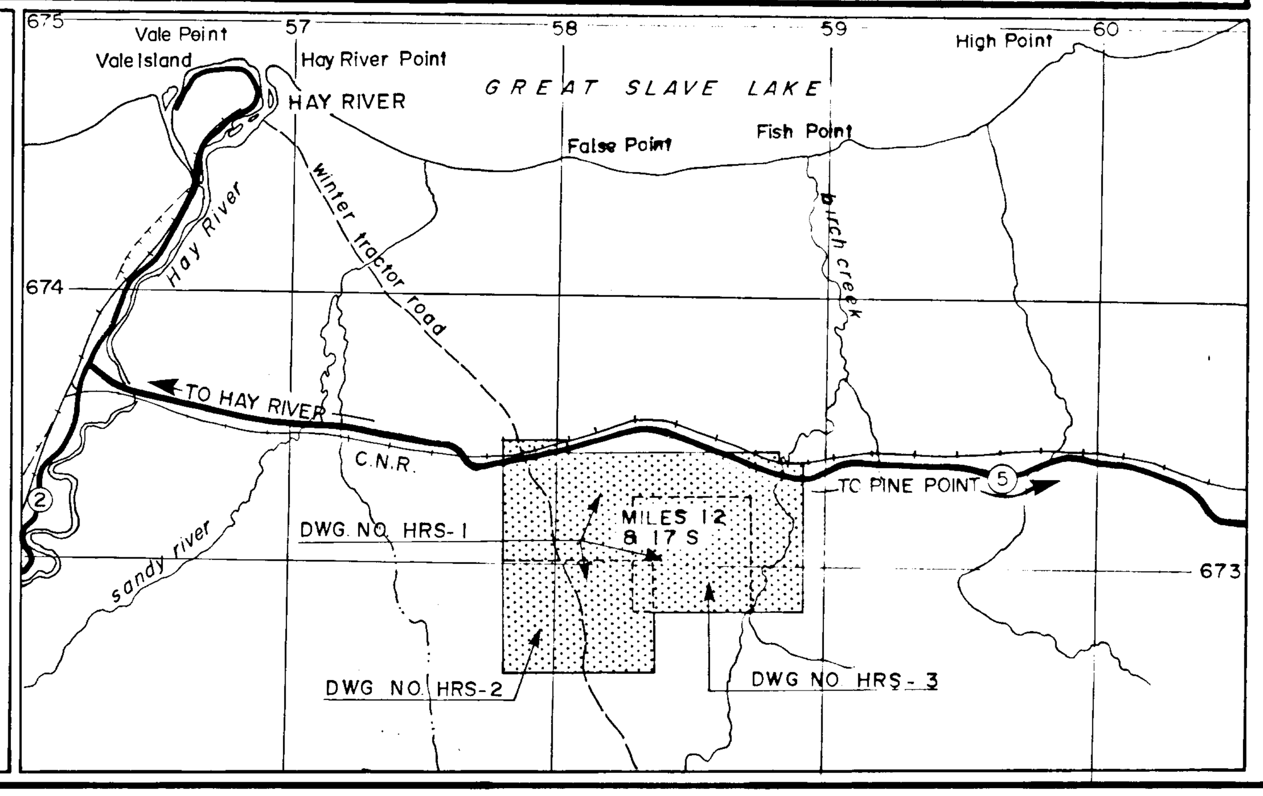
2 The information on this map has been derived by airphoto interpretation techniques and subsequent selective field checking

3 The information on this map is primarily intended to depict development constraints based on physical terrain characteristics

4 See Report, Appendix for tabulation of route terrain information

key map

SCALE 1:250,000



Ref. N.T.S MAP, BUFFALO LAKE, 85 B, EDITION 2 MCE. SERIES A 502 - 1967.

THE DEPARTMENT OF INDIAN AFFAIRS AND NORTHERN DEVELOPMENT

ALTERNATE ALLWEATHER HAUL ROAD ALIGNMENTS & GRANULAR DEPOSIT LOCATIONS
HIGHWAY NO. 5, HAY RIVER, NORTHWEST TERRITORIES

MILES 12 & 17S

SCALE : 1" = 2000'±	DATE : MAY, 1978
INTERPRETATION : W.R.M. & R.H.	DRAWN : A.B.
CHECKED : S. J. G. B.	CHECKED : W.R.M.
DATE OF PHOTOGRAPHY : 1972	DRAWING Nº : HRS - 1 (78-128)

bird and hale ltd. 1263 Bay Street - Toronto - Ontario

- Airphoto interpretation studies
- Engineering and environmental coordination

APPENDIX A

TERMS OF REFERENCE

ASSESSMENT OF GRANULAR MATERIAL SOURCES
HAY RIVER, N.W.T.
MILE 12 SOUTH SOURCES

BACKGROUND

The Department of Indian Affairs and Northern Development commissioned a granular materials assessment of the active pit areas at miles 12, 21 and 31 of NWT highway No. 5 in 1977-78. The consultant's report not only provided information on the quantity and quality of material in these areas but provided recommendations for licence, development and rehabilitation procedures. The report also pointed out that once the limited amount of fine aggregate at mile 12 was depleted, the nearest known source of such material would be at the mile 31 pit. Accordingly it was decided to undertake an assessment of the quality and quantity of material in the five structures south of the current mile 12 pit(identified in the 1973 Ripley, Klohn and Leonoff report as HR - 108 to HR 112 inclusive).

Terms of Reference

The principle objective of this study will be to determine the feasibility of opening up this complex for granular material extraction. In addition to an assessment of the quality and quantity of granular materials available in the complex, the department is looking for recommendations on optimal strategy for the orderly development and restoration of the complex. The contractor should pay special attention to the access to this area from Highway No. 5 and should include an estimate of road construction costs along the various alternative routes.

In general, the level of effort for this report should be similar to the previous report, "Granular Material Assessment, Pine Point Highway, Hay River, NWT".

REPORT FORMAT:

A comprehensive report of the geotechnical reconnaissance is required, together with detailed site development and restoration plans, and will be submitted in fifty (50) copies to DIAND on completion of the study, together with the original and negatives of all maps, photos, graphs, diagrams, etc. This report will be structured as follows:

i) Summary:

A brief outline of the objectives, methods and the principal findings of the survey.

ii) Table of Contents:

iii) Site Location Map:

On a topographic base at a scale of 1" - 4 miles showing the location of the sites surveyed together with potential and existing quarry sites identified during the field program.

iv) Introduction:

A brief outline of the nature and location of the survey.

v) Method and Results:

A description of the sampling and laboratory testing programs indicating the criteria used in selecting samples and the methods by which samples were obtained and handled with details of all treatments and tests employed. A clear statement of assumptions made in interpreting results, calculating volumes of material and determining its possible uses should be provided.

The following information is to be provided:

a) A geological sketch for each of the three complexes at a suitable scale.

b) Site photographs

c) Photo mosaic coverage at a scale of 1" = 500 ft. showing the location of all test pitting or drilling sites used in connection with the present survey and the location of those used in previous reports.

d) A description of the setting and geomophology of the source together with the distribution, volumes and quality of material. Estimated in place volumes and recoverable volumes should be stated.

e) A discussion of possible uses, ease of access, problems involved in the extraction of the material and a suggested development and restoration plan for each complex, including recommendation on how to subdivide each site.

f) Test hole logs and results of analyses

g) Glossary of technical terms

h) A contour plan showing 5 foot intervals of each of the three complexes.

APPENDIX B

SAMPLE TESTING PROCEDURES

AND AGGREGATE QUALITY SPECIFICATIONS

APPENDIX B

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AMERICAN NATIONAL STANDARD ANSI/ASTM D 75 - 71

American Association State Highway and Transportation Officials Standard AASHTO No.: T 2

Standard Methods of
SAMPLING AGGREGATES[1]

This Standard is issued under the fixed designation D 75: the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval.

1. Scope

1.1 These methods cover sampling of coarse and fine aggregates for the following purposes (Note 1):

1.1.1 Preliminary investigation of the potential source of supply,

1.1.2 Control of the product at the source of supply,

1.1.3 Control of the operations at the site of use, and

1.1.4 Acceptance or rejection of the materials.

NOTE 1—Sampling plans and acceptance and control tests vary with the type of construction in which the material is used. The preliminary investigation and sampling of potential aggregate sources and types occupies a very important place in determining the availability and suitability of the largest single constituent entering into the construction. It influences the type of construction from the standpoint of economics and governs the necessary material control to ensure durability of the resulting structu from the aggregate standpoint.

2. Applicable Documents

2.1 *ASTM Standards:*

D 2234 Collection of a Gross Sample of Coal[2]

E 105 Recommended Practice for Probability Sampling of Materials[3]

E 122 Recommended Practice for Choice of Sample Size to Estimate the Average Quality of a Lot or Process[3]

E 141 Recommended Practice for Acceptance of Evidence Based on the Results of Probability Sampling[4]

3. Securing Samples

3.1 *General*:

3.1.1 Sampling is equally as important as the testing, and the sampler shall use every precaution to obtain samples that will show the true nature and condition of the materials which they represent.

3.1.2 Samples for preliminary investigation tests are obtained by the party responsible for development of the potential source. Samples of materials for control of the production at the source or control of the work at the site of use are obtained by the manufacturer, contractor, or other parties responsible for accomplishing the work. Samples for tests to be used in acceptance or rejection decisions by the purchaser are obtained by the purchaser or his authorized representative.

3.1.3 Where practicable, samples to be tested for quality shall be obtained from the finished product. Samples from the finished product to be tested for abrasion loss shall not be subject to further crushing or manual reduction in particle size in preparation for the abrasion test unless the size of the finished product is such that it requires further reduction for testing purposes.

3.2 *Inspection:*

3.2.1 The material shall be inspected to determine discernible variations. The seller shall provide suitable equipment needed for proper inspection and sampling.

3.3 *Sampling*:

3.3.1 *Sampling from the Conveyor Belt*—Select units to be sampled by a random method from the production. Obtain at least three approximately equal increments, selected at random, from the unit being sampled and combine to form a field sample whose mass equals or exceeds the minimum recommended in 3.4.2. Stop the conveyor belt

[1] This specification is under the jurisdiction of ASTM Committee D-4 on Road and Paving Materials and is the direct responsibility of Subcommittee D04.30 on Methods of Sampling.

Current edition effective Nov. 22, 1971. Originally issued 1920. Replaces D 75 - 59 (1968).

[2] *Annual Book of ASTM Standards*, Part 26.

[3] *Annual Book of ASTM Standards*, Parts 15 and 41.

[4] *Annual Book of ASTM Standards*, Part 41.

while the sample increments are being obtained. Insert two templates, the shape of which conforms to the shape of the belt in the aggregate stream on the belt, and space them such that the material contained between them will yield an increment of the required weight. Carefully scoop all material between the templates into a suitable container and collect the fines on the belt with a brush and dust pan and add to the container.

3.3.2 *Sampling from a Flowing Aggregate Stream* (*Bins or Belt Discharge*)—Select units to be sampled by a random method from the production. Obtain at least three approximately equal increments, selected at random from the unit being sampled, and combine to form a field sample whose mass equals or exceeds the minimum recommended in 3.4.2. Take each increment from the entire cross section of the material as it is being discharged. It is usually necessary to have a special device constructed for use at each particular plant. This device consists of a pan of sufficient size to intercept the entire cross section of the discharge stream and hold the required quantity of material without overflowing. A set of rails may be necessary to support the pan as it is passed under the discharge stream. Take samples only from bins that are full, or nearly so, to minimize the chance of obtaining segregated material.

NOTE 2—The unit selected for sampling should not include the initial discharge from a conveyor or newly filled bin.

3.3.3 *Sampling from Stockpiles*—Avoid sampling from stockpiles whenever possible, particularly when the sampling is done for the purpose of determining aggregate properties that may be dependent upon the grading of the sample. If, on the other hand, circumstances make it mandatory to obtain samples from a stockpile of coarse aggregate or a stockpile of combined coarse and fine aggregate, design a sampling plan for the specific case under consideration. This approach will allow the sampling agency to use a sampling plan that will give a confidence in results obtained therefrom that is agreed upon by all parties concerned to be acceptable for the particular situation.

3.3.4 *Sampling from Roadway* (*Bases and Subbases*)—Sample units selected by a random method from the construction. Obtain at least three approximately equal increments, selected at random from the unit being sampled, and combine to form a field sample whose mass equals or exceeds the minimum recommended in 3.4.2. Take all increments from the roadway for the full depth of the material, taking care to exclude any underlying material. Clearly mark the specific areas from which each increment is to be removed; a metal template placed over the area is a definite aid in securing approximately equal increment weights.

3.4 *Number and Masses of Field Samples*:

3.4.1 The number of field samples (obtained by one of the methods described in 3.3) required depends on the criticality of, and variation in, the properties to be measured. Designate each unit from which a field sample is to be obtained prior to sampling. The number of field samples from the production should be sufficient to give the desired confidence in test results.

NOTE 3—Guidance for determining the number of samples required to obtain the desired level of confidence in test results may be found in Method D 2234, Recommended Practice E 105, Recommended Practice E 122, and Recommended Practice E 141.

3.4.2 The field sample masses cited are tentative. The masses must be predicated on the type and number of tests to which the material is to be subjected and sufficient material obtained to provide for the proper execution of these tests. Standard acceptance and control tests are covered by ASTM standards and specify the portion of the field sample required for each specific test. Generally speaking, the amounts specified in Table 1 will provide adequate material for routine grading and quality analysis. Extract test portions from the field sample by splitting or other appropriate methods.

4. Shipping Samples

4.1 Transport aggregates in bags or other containers so constructed as to preclude loss or contamination of any part of the sample, or damage to the contents from mishandling during shipment.

4.2 Shipping containers for aggregate samples shall have suitable individual identification attached and enclosed so that field reporting, laboratory logging, and test reporting may be facilitated.

TABLE 1 Size of Samples

Maximum Nominal Size of Aggregates[a]	Approximate Minimum Mass of Field Samples, lb (kg)[b]
Fine Aggregate	
No. 8 (2.36 mm)	25 (10)
No. 4 (4.75 mm)	25 (10)
Coarse Aggregate	
⅜ in. (9.5 mm)	25 (10)
½ in. (12.5 mm)	35 (15)
¾ in. (19.0 mm)	55 (25)
1 in. (25.0 mm)	110 (50)
1½ in. (37.5 mm)	165 (75)
2 in. (50 mm)	220 (100)
2½ in. (63 mm)	275 (125)
3 in. (75 mm)	330 (150)
3½ in. (90 mm)	385 (175)

[a] For processed aggregate the maximum nominal size of particles is the largest sieve size listed in the applicable specification, upon which any material is permitted to be retained.

[b] For combined coarse and fine aggregates (for example, base or subbase) minimum weight shall be coarse aggregate minimums plus 25 lb (10 kg).

By publication of this standard no position is taken with respect to the validity of any patent rights in connection therewith, and the American Society for Testing and Materials does not undertake to insure anyone utilizing the standard against liability for infringement of any Letters Patent nor assume any such liability.

AMERICAN NATIONAL STANDARD ANSI/ASTM C 136 - 76

American Association State Highway and Transportation Officials Standard
AASHTO No.: T 27

Standard Test Method for

SIEVE OR SCREEN ANALYSIS OF FINE AND COARSE AGGREGATES[1]

This Standard is issued under the fixed designation C 136; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval.

1. Scope

1.1 This method covers the determination of the particle size distribution of fine and coarse aggregates by sieving or screening.

2. Summary of Method

2.1 A weighed sample of dry aggregate is separated through a series of sieves or screens of progressively smaller openings for determination of particle size distribution.

3. Apparatus

3.1 *Balance*—A balance or scale accurate within 0.1 percent of the test load at any point within the range of use.

3.2 *Sieves or Screens*—The sieves or screens shall be mounted on substantial frames constructed in a manner that will prevent loss of material during sieving. Suitable sieve sizes shall be selected to furnish the information required by the specifications covering the material to be tested. The sieves shall conform to ASTM Specification E 11, for Wire-Cloth Sieves for Testing Purposes.[2]

3.3 *Oven*—An oven of appropriate size capable of maintaining a uniform temperature of 230 ± 9 F (110 ± 5 C).

4. Test Sample

4.1 The sample of aggregate to be tested for sieve analysis shall be thoroughly mixed and reduced by use of a sample splitter or by quartering (Note 1) to an amount suitable for testing. Fine aggregate shall be moistened before reduction to minimize segregation and loss of dust. The sample for test shall be approximately of the weight desired when dry and shall be the end result of the reduction method. Reduction to an exact predetermined weight shall not be permitted.

NOTE 1—The process of quartering and the correct use of a sample splitter are described in the "Manual of Concrete Testing."[3]

4.2 *Fine Aggregate*—The test sample of fine aggregate shall weigh, after drying, approximately the following amount:

Aggregate with at least 95 percent passing a No. 8 (2.36-mm) sieve	100 g
Aggregate with at least 85 percent passing a No. 4 (4.75-mm) sieve and more than 5 percent retained on a No. 8 sieve	500 g

In no case, however, shall the fraction retained on any sieve at the completion of the sieving operation weigh more than 4 g/in.^{2} of sieving surface.

NOTE 2—This amounts to 200 g for the usual 8-in. (203-mm) diameter sieve. The amount of material retained on the critical sieve may be regulated by (*1*) the introduction of a larger-opening sieve immediately above the critical sieve, or (*2*) selection of a sample of proper size.

4.3 *Coarse Aggregate*—The weight of the test sample of coarse aggregate shall conform with the following:

Maximum Nominal Size, Square Openings, in. (mm)	Minimum Weight of Sample, kg
⅜ (9.5)	2
½ (12.5)	4
¾ (19.0)	8

[1] This method is under the jurisdiction of ASTM Committee C-9 on Concrete and Concrete Aggregates and is the direct responsibility of Subcommittee C 09.03.05 on Methods of Testing and Specifications for Physical Characteristics of Concrete Aggregates.

Current edition approved Sept. 24, 1976. Published November 1976. Originally published as C 136 - 38 T. Last previous edition C 136 - 71.

[2] *Annual Book of ASTM Standards*, Parts 14 and 15.

[3] *Annual Book of ASTM Standards*, Part 14.

Maximum Nominal Size, Square Openings, in. (mm)	Minimum Weight of Sample, kg
1 (25.0)	12
1½ (37.5)	16
2 (50)	20
2½ (63)	25
3 (75)	45
3½ (90)	70

NOTE 3—It is recommended that sieves mounted in frames of 16-in. (406-mm) diameter or larger be used for testing coarse aggregate.

4.4 In the case of mixtures of fine and coarse aggregates, the material shall be separated into two sizes on the No. 4 (4.75-mm) sieve. The samples of fine and coarse aggregate shall be prepared in accordance with 4.2 and 4.3.

5. Procedure

5.1 Dry the sample to constant weight at a temperature of 230 ± 9 F (110 ± 5 C).

5.2 Nest the sieves in order of decreasing size of opening from top to bottom and place the sample on the top sieve. Agitate the sieves by hand or by mechanical apparatus for a sufficient period, established by trial or checked by measurement on the actual test sample, to meet the criterion for adequacy of sieving described in 5.3.

5.3 Continue sieving for a sufficient period and in such manner that, after completion, not more than 1 weight percent of the residue on any individual sieve will pass that sieve during 1 min of continuous hand sieving performed as follows: Hold the individual sieve, provided with a snug-fitting pan and cover, in a slightly inclined position in one hand. Strike the side of the sieve sharply and with an upward motion against the heel of the other hand at the rate of about 150 times/min, turn the sieve about one sixth of a revolution at intervals of about 25 strokes. In determining sufficiency of sieving for sizes larger than the No. 4 (4.75-mm) sieve, limit the material on the sieve to a single layer of particles. If the size of the mounted testing sieves makes the described sieving motion impractical, use 8-in. (203-mm) diameter sieves to verify the sufficiency of sieving.

5.4 Dry sieving alone is usually satisfactory for routine testing of normally graded aggregates. However, when accurate determination of the total amount passing the No. 200 (75-μm) sieve is desired, first test the sample in accordance with ASTM Method C 117, Test for Materials Finer than No. 200 (75-μm) Sieve in Mineral Aggregates by Washing.[2] Add the percentage finer than the No. 200 sieve determined by that method to the percentage passing the No. 200 sieve by dry sieving of the same sample. After the final drying operation in Method C 117, dry-sieve the sample in accordance with 5.2 and 5.3.

5.5 Determine the weight of each size increment by weighing on a scale or balance conforming to the requirements specified in 3.1, to the nearest 0.1 percent of the weight of the sample.

6. Calculation

6.1 Calculate percentages on the basis of the total weight of the sample, including any material finer than the No. 200 sieve determined in accordance with Method C 117.

7. Report

7.1 The report shall include the following:

7.1.1 Total percentage of material passing each sieve, or

7.1.2 Total percentage of material retained on each sieve, or

7.1.3 Percentage of material retained between consecutive sieves, depending upon the form of the specifications for use of the material under test. Report percentages to the nearest whole number, except for the percentage passing the No. 200 (75-μm) sieve, which shall be reported to the nearest 0.1 percent.

8. Precision

8.1 For coarse aggregate with a nominal maximum size of ¾-in. (19.0 mm) the precision indexes are given in Table 1; the values are given for different ranges of percentage of aggregate retained between two consecutive coarse aggregate sieves:

TABLE 1 Precision

	Percent in Size Fraction Between Two Consecutive Coarse Aggregate Sieves	Coefficient of Variation (1S%), Percent[b]	Standard Deviation (1S), Percent[a]	Difference Between Two Tests	
				Percent of Avg (D2S%)[b]	(D2S) Percent[a]
Multilaboratory	0 to 3	35	–	99	–
	3 to 10	–	1.2	–	3.4
	10 to 20	–	1.7	–	4.8
	20 to 50	–	2.2	–	6.2
Single-Operator	0 to 3	30	–	85	–
	3 to 50	–	1.4	–	4.0

[a] These numbers represent, respectively, the (1S) and (D2S) limits as described in ASTM Recommended Practice C 670 for Preparing Precision Statements for Test Methods for Construction Materials.[3]

[b] These numbers represent, respectively, the (1S%) and (D2S%) limits as described in Recommended Practice C 670.

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AMERICAN NATIONAL STANDARD ANSI/ASTM C 117 - 76

American Association State Highway and Transportation Officials Standard AASHTO No.: T 11

Standard Test Method for
MATERIALS FINER THAN NO. 200 (75-μm) SIEVE IN MINERAL AGGREGATES BY WASHING[1]

This Standard is issued under the fixed designation C 117; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval.

1. Scope

1.1 This method covers determination of the amount of material finer than a No. 200 (75-μm) sieve in aggregate by washing. Clay particles and other aggregate particles that are dispersed by the wash water as well as water-soluble materials also will be removed from the aggregate during the test.

2. Summary of Method

2.1 A sample of the aggregate is washed in a prescribed manner and the decanted wash water containing suspended and dissolved materials is passed through a No. 200 (75-μm) sieve. The loss in weight resulting from the wash treatment is calculated as weight percent of the original sample and is reported as the percentage of material finer than a No. 200 (75-μm) sieve by washing.

3. Apparatus

3.1 *Balance*—A balance or scale accurate within 0.1 percent of the test load at any point within the range of use.

3.2 *Sieves*—A nest of two sieves, the lower being a No. 200 (75-μm) sieve and the upper a No. 16 (1.18-mm) sieve, both conforming to the requirements of ASTM Specification E 11, for Wire-Cloth Sieves for Testing Purposes.[2]

3.3 *Container*—A pan or vessel of a size sufficient to contain the sample covered with water and to permit vigorous agitation without loss of any part of the sample or water.

3.4 *Oven*—An oven of sufficient size, capable of maintaining a uniform temperature of 230 ± 9 F (110 ± 5 C).

4. Test Specimen

4.1 The sample of the aggregate to be tested shall be thoroughly mixed and reduced by use of a sample splitter or by quartering (Note 1) to an amount suitable for testing. The aggregate shall be moistened before reduction to minimize segregation and loss of dust, and the test specimen shall be the end result of the reduction method. The weight of the test specimen, after drying, shall conform with the following:

Nominal Maximum Size	Minimum Weight, g
No. 8 (2.36 mm)	100
No. 4 (4.75 mm)	500
⅜ in. (9.5 mm)	2000
¾ in. (19.0 mm)	2500
1½ in. (37.5 mm) or larger	5000

Reduction to an exact predetermined weight shall not be permitted.

NOTE 1—The process of quartering and the correct use of a sample splitter are discussed in the "Manual of Concrete Testing."[3]

5. Procedure

5.1 Dry the test specimen to constant weight at a temperature of 230 ± 9 F (110 ± 5 C) and weigh to the nearest 0.1 percent of the weight of the specimen.

5.2 After drying and weighing, place the test specimen in the container and add suffi-

[1] This method is under the jurisdiction of ASTM Committees C-9 on Concrete and Concrete Aggregates and is the direct responsibility of Subcommittee C09.03.05 on Methods of Testing and Specifications for Physical Characteristics of Concrete Aggregates.

Current edition approved Sept. 24, 1976. Published November 1976. Originally published as C 117 - 35 T. Last previous edition C 117 - 69.

[2] *Annual Book of ASTM Standards*, Parts 14, 15, and 41.

[3] *Annual Book of ASTM Standards*, Part 14.

cient water to cover it (Note 2). Agitate the specimen with sufficient vigor to result in complete separation of all particles finer than the No. 200 (75-μm) sieve from the coarser particles, and to bring the fine material into suspension. Immediately pour the wash water containing the suspended and dissolved solids over the nested sieves, arranged with the coarser sieve on top. Take care to avoid, as much as feasible, the decantation of coarser particles of the sample.

NOTE 2—No detergent, dispersing agent, or other substance shall be added to the water.

5.3 Add a second charge of water to the specimen in the container, agitate, and decant as before. Repeat this operation until the wash water is clear.

5.4 Return all material retained on the nested sieves by flushing to the washed specimen. Dry the washed aggregate to constant weight at a temperature of 230 ± 9 F (110 ± 5 C) and weigh to the nearest 0.1 percent of the weight of the sample.

6. Calculation

6.1 Calculate the amount of material passing a No. 200 (75-μm) sieve, by washing, to the nearest 0.1 percent, as follows:

$$A = [(B - C)/B] \times 100$$

where:

A = percentage of material finer than a No. 200 (75-μm) sieve, by washing,
B = original dry weight of sample, g, and
C = dry weight of sample, after washing, g.

7. Precision

7.1 The multilaboratory standard deviation has been found to be 0.22 percent[4] for nominal ¾-in. (19.0-mm) maximum size coarse aggregate with less than 1.5 percent passing the No. 200 (7.5-μm) sieve. Therefore, results of two properly conducted tests from two different laboratories on samples of the same coarse aggregate should not differ by more than 0.62 percent.[4] The corresponding single-operator standard deviation has been found to be 0.10 percent.[4] Therefore, results of two properly conducted tests by the same operator on the same coarse aggregate should not differ by more than 0.28 percent.[4]

[4] These numbers represent, respectively, the (1S) and (D2S) limits as described in ASTM Recommended Practice C 670, for Preparing Precision Statements for Test Methods for Construction Materials, *Annual Book of ASTM Standards*, Part 14.

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AMERICAN NATIONAL STANDARD ANSI/ASTM C 40 - 73

American Association State Highway and Transportation Officials Standard
AASHTO No.: T 21

Standard Test Method for

ORGANIC IMPURITIES IN SANDS FOR CONCRETE[1]

This Standard is issued under the fixed designation C 40; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval.

1. Scope

1.1 This method covers an approximate determination of the presence of injurious organic compounds in natural sands which are to be used in cement mortar or concrete. The principal value of the test is to furnish a warning that further tests of the sands are necessary before they are approved for use.

2. Applicable Documents

2.1 *ASTM Standards:*

D 1544 Test for Color of Transparent Liquids (Gardner Color Scale)[2]

3. Apparatus

3.1 *Glass Bottles*—12-fluid oz (approximately 350-ml) colorless glass, graduated bottles of oval cross section, equipped with watertight stoppers or caps.

4. Reagent and Reference Standard Color Solution

4.1 *Reagent Sodium Hydroxide Solution (3 percent)*—Dissolve 3 parts by weight of sodium hydroxide (NaOH) in 97 parts of water.

4.2 *Reference Standard Color Solution*—Dissolve reagent grade potassium dichromate ($K_2Cr_2O_7$) in concentrated sulfuric acid (sp gr 1.84) at the rate of 0.250 g/100 ml of acid. The solution must be freshly made for the color comparison using gentle heat if necessary to effect solution.

5. Sample

5.1 A representative test sample of sand weighing about 1 lb (approximately 450 g) shall be obtained by quartering or by the use of a sampler.

6. Procedure

6.1 Fill a glass bottle to the 4½-fluid oz (approximately 130-ml) level with the sample of the sand to be tested.

6.2 Add a 3 percent NaOH solution in water until the volume of the sand and liquid, indicated after shaking, is 7 fluid ounces (approximately 200 ml).

6.3 Stopper the bottle, shake vigorously, and then allow to stand for 24 h.

7. Determination of Color Value

7.1 *Preferred Procedure*—At the end of the 24-h standing period, fill a glass bottle to the 2½-fluid oz (approximately 75-ml) level with the fresh reference standard color solution, prepared not longer than 2 h previously, as prescribed in 4.2. Then compare the color of the supernatant liquid above the test sample with that of the reference standard color solution and record whether it is lighter or darker or of equal color to that of the reference standard. Make the color comparison by holding the two bottles close together and looking through them.

7.2 *Alternative Procedure A*—To define more precisely the color of the liquid of the test sample, five color solutions may be used as prescribed in Table 1 of Method D 1544, using the following colors:

[1] This method is under the jurisdiction of ASTM Committee C-9 on Concrete and Concrete Aggregates and is the direct responsibility of Subcommittee C09.03.05 on Methods of Testing and Specifications for Physical Characteristics of Concrete Aggregates.

Current edition approved March 29, 1973. Published May 1973. Originally published as C 40 - 21 T. Last previous edition C 40 - 66 (1973).

[2] *Annual Book of ASTM Standards*, Parts 27, 28, and 29.

Gardner Color Standard No.	Organic Plate No.
5	1
8	2
11	3 (standard)
14	4
16	5

The preparation and comparison procedure described in 7.1 shall be used, except that the organic plate number which is nearest the color of one of the five prepared solutions shall be reported.

7.3 *Alternative Procedure B*—Instead of the procedures described in 7.1 or 7.2, the color of the supernatant liquid above the test sample may be compared with a glass having a color equivalent to the color of the reference standard color specified in 4.2.

NOTE—A suitable instrument consists of the glass color standard mounted in a plastic holder. For the benefit of users of the alternative procedure, the instrument is provided with all five organic plate number colors.

8. Interpretation of Results

8.1 If the color of the supernatant liquid is darker than that of the reference standard color solution, the sand under test shall be considered to possibly contain injurious organic compounds, and further tests should be made before approving the sand for use in concrete.

By publication of this standard no position is taken with respect to the validity of any patent rights in connection therewith, and the American Society for Testing and Materials does not undertake to insure anyone utilizing the standard against liability for infringement of any Letters Patent nor assume any such liability.

ANSI/ASTM C 88 - 76 — AMERICAN NATIONAL STANDARD

American Association State Highway and Transportation Officials Standard
AASHTO No.: T 104

Standard Test Method for
SOUNDNESS OF AGGREGATES BY USE OF SODIUM SULFATE OR MAGNESIUM SULFATE[1]

This Standard is issued under the fixed designation C 88; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval.

1. Scope

1.1 This method covers the testing of aggregates to determine their resistance to disintegration by saturated solutions of sodium sulfate or magnesium sulfate. It furnishes information helpful in judging the soundness of aggregates subject to weathering action, particularly when adequate information is not available from service records of the material exposed to actual weathering conditions. Attention is called to the fact that test results by the use of the two salts differ considerably and care must be exercised in fixing proper limits in any specifications which may include requirements for these tests.

NOTE 1—The values stated in the U.S. customary units are to be regarded as the standard.

2. Applicable Documents

2.1 *ASTM Standards:*

C 670 Recommended Practice for Preparing Precision Statements for Test Methods for Construction Materials[2,4]

E 11 Specification for Wire Cloth Sieves for Testing Purposes[2,3,4]

E 100 Specification for ASTM Hydrometers[3]

E 323 Specification for Perforated Plate Sieves for Testing Purposes[4]

3. Apparatus

3.1 *Sieves*—with square openings of the following sizes conforming to Specifications E 11 or Specification E 323, for sieving the samples in accordance with Sections 5, 6, and 8:

Fine Series	Coarse Series
No. 100 (150-μm)	5/16 in. (8.0 mm)
	3/8 in. (9.5 mm)
No. 50 (300-μm)	1/2 in. (12.5 mm)
	5/8 in. (16.0 mm)
No. 30 (600-μm)	3/4 in. (19.0 mm)
	1 in. (25.0 mm)
No. 16 (1.18-mm)	1 1/4 in. (31.5 mm)
No. 8 (2.36-mm)	1 1/2 in. (37.5 mm)
	2 in. (50 mm)
No. 5 (4.00-mm)	2 1/2 in. (63 mm)
	larger sizes by
No. 4 (4.75-mm)	1/2-in. spread

3.2 *Containers*—Containers for immersing the samples of aggregate in the solution, in accordance with the procedure described in this method, shall be perforated in such a manner as to permit free access of the solution to the sample and drainage of the solution from the sample without loss of aggregate.

NOTE 2—Baskets made of suitable wire mesh or sieves with suitable openings are satisfactory containers for the samples.

3.3 *Temperature Regulation*—Suitable means for regulating the temperature of the samples during immersion in the sodium sulfate or magnesium sulfate solution shall be provided.

[1] This method is under the jurisdiction of ASTM committee C-9 on Concrete and Concrete Aggregates and is the direct responsibility of Subcommittee C09.03.05 on Methods of Testing and Specifications for Physical Characteristics of Concrete Aggregates.

Current edition approved Sept. 24, 1976. Published November 1976. Originally published as C 88 - 31 T. Last previous edition C 88 - 73.

[2] *Annual Book of ASTM Standards*, Part 15.

[3] *Annual Book of ASTM Standards*, Part 41.

[4] *Annual Book of ASTM Standards*, Part 14.

3.4 *Balances*—For fine aggregate, a balance or scale accurate within 0.1 g over the range required for this test; for coarse aggregate, a balance or scale accurate within 0.1 percent or 1 g, whichever is greater, over the range required for this test.

3.5 *Drying Oven*—The oven shall be capable of being heated continuously at 230 ± 9 F (110 ± 5 C) and the rate of evaporation, at this range of temperature, shall be at least 25 g/h for 4 h, during which period the doors of the oven shall be kept closed. This rate shall be determined by the loss of water from 1-liter Griffin low-form beakers, each initially containing 500 g of water at a temperature of 70 ± 3 F (21 ± 2 C), placed at each corner and the center of each shelf of the oven. The evaporation requirement is to apply to all test locations when the oven is empty except for the beakers of water.

3.6 *Specific Gravity Measurement*—Hydrometers conforming to the requirements of Specification E 100, or a suitable combination of graduated glassware and balance, capable of measuring the solution specific gravity within ±0.001.

4. Special Solutions Required

4.1 Prepare the solution for immersion of test samples from either sodium or magnesium sulfate in accordance with 4.1.1 or 4.1.2 (Note 3). The volume of the solution shall be at least five times the solid volume of all samples immersed at any one time.

NOTE 3—Some aggregates containing carbonates of calcium or magnesium are attacked chemically by fresh sulfate solution, resulting in erroneously high measured losses. If this condition is encountered or is suspected, repeat the test using a filtered solution that has been used previously to test the same type of carbonate rock, provided that the solution meets the requirements of 4.1 and 4.2 for specific gravity.

4.1.1 *Sodium Sulfate Solution*—Prepare a saturated solution of sodium sulfate by dissolving a USP or equal grade of the salt in water at a temperature of 77 to 86 F (25 to 30 C). Add sufficient salt (Note 4), of either the anhydrous (Na_2SO_4) or the crystalline ($Na_2SO_4 \cdot 10H_2O$) form,[5] to ensure not only saturation but also the presence of excess crystals when the solution is ready for use in the tests. Thoroughly stir the mixture during the addition of the salt and stir the solution at frequent intervals until used. To reduce evaporation and prevent contamination, keep the solution covered at all times when access is not needed. Allow the solution to cool to 70 ± 2 F (21 ± 1 C). Again stir, and allow the solution to remain at the designated temperature for at least 48 h before use. Prior to each use, break up the salt cake, if any, in the container, stir the solution thoroughly, and determine the specific gravity of the solution. When used, the solution shall have a specific gravity not less than 1.151 nor more than 1.174. Discard a discolored solution, or filter it and check for specific gravity.

NOTE 4—For the solution, 215 g of anhydrous salt or 700 g of the decahydrate per liter of water are sufficient for saturation at 71.6 F (22 C). However, since these salts are not completely stable and since it is desirable that an excess of crystals be present, the use of not less than 350 g of the anhydrous salt or 750 g of the decahydrate salt per liter of water is recommended.

4.1.2 *Magnesium Sulfate Solution*—Prepare a saturated solution of magnesium sulfate by dissolving a USP or equal grade of the salt in water at a temperature of 77 to 86 F (25 to 30 C). Add sufficient salt (Note 5), of either the anhydrous ($MgSO_4$) or the crystalline ($MgSO_4 \cdot 7H_2O$) (Epsom salt) form, to ensure saturation and the presence of excess crystals when the solution is ready for use in the tests. Thoroughly stir the mixture during the addition of the salt and stir the solution at frequent intervals until used. To reduce evaporation and prevent contamination, keep the solution covered at all times when access is not needed. Allow the solution to cool to 70 ± 2 F (21 ± 1 C). Again stir, and allow the solution to remain at the designated temperature for at least 48 h before use. Prior to each use, break up the salt cake, if any, in the container, stir the solu-

[5] Experience with the test method indicates that a grade of sodium sulfate designated by the trade as dried powder, which may be considered as approximately anhydrous, is the most practical for use. That grade is more economically available than the anhydrous form. The decahydrate sodium sulfate presents difficulties in compounding the required solution on account of its cooling effect on the solution.

tion thoroughly, and determine the specific gravity of the solution. When used, the solution shall have a specific gravity not less than 1.295 nor more than 1.308. Discard a discolored solution, or filter it and check for specific gravity.

NOTE 5—For the solution, 350 g of anhydrous salt or 1230 g of the heptahydrate per litre of water are sufficient for saturation at 73.4 F (23 C). However, since these salts are not completely stable, with the hydrous salt being the more stable of the two, and since it is desirable that an excess of crystals be present, it is recommended that the heptahydrate salt be used and in an amount of not less than 1400 g/litre of water.

5. Samples

5.1 *Fine Aggregate*—Fine aggregate for the test shall be passed through a ³/₈-in. (9.5-mm) sieve. The sample shall be of such size that it will yield not less than 100 g of each of the following sizes, which shall be available in amounts of 5 percent or more, expressed in terms of the following sieves:

Passing Sieve	Retained on Sieve
No. 30 (600-μm)	No. 50 (300-μm)
No. 16 (1.18-mm)	No. 30 (600-μm)
No. 8 (2.36-mm)	No. 16 (1.18-mm)
No. 4 (4.75-mm)	No. 8 (2.36-mm)
⅜ in. (9.5-mm)	No. 4 (4.75-mm)

5.2 *Coarse Aggregate*—Coarse aggregate for the test shall consist of material from which the sizes finer than the No. 4 sieve have been removed. The sample shall be of such a size that it will yield the following amounts of the indicated sizes that are available in amounts of 5 percent or more:

Size (Square-Opening Sieves)	Weight, g
⅜ in. (9.5 mm) to No. 4 (4.75 mm)	300 ± 5
¾ (19.0 mm) to ⅜ in.	1000 ± 10
Consisting of:	
½ (12.5 mm) to ⅜-in. material	330 ± 5
¾ to ½-in. material	670 ± 10
1 ½ (37.5 mm) to ¾ in.	1500 ± 50
Consisting of:	
1 (25.0 mm) to ¾-in. material	500 ± 30
1 ½ to 1-in. material	1000 ± 50
2½ (63 mm) to 1½ in.	5000 ± 300
Consisting of:	
2 (50 mm) to 1 ½-in. material	2000 ± 200
2½ to 2-in. material	3000 ± 300
Larger sizes by 1-in. spread in sieve size, each fraction	7000 ± 1000

5.3 When an aggregate to be tested contains appreciable amounts of both fine and coarse material, having a grading with more than 10 weight percent coarser than the ⅜-in. (9.5-mm) sieve and, also, more than 10 weight percent finer than the No. 4 (4.75-mm) sieve, test separate samples of the minus No. 4 fraction and the plus No. 4 fraction in accordance with the procedures for fine aggregate and coarse aggregate, respectively. Report the results separately for the fine aggregate fraction and the coarse aggregate fraction, giving the percentages of the coarse and fine size fractions in the initial grading.

6. Preparation of Test Sample

6.1 *Fine Aggregate*—Thoroughly wash the sample of fine aggregate on a No. 50 (300 μm) sieve, dry to constant weight at 230 ± 9 F (110 ± 5 C), and separate into the different sizes by sieving, as follows: Make a rough separation of the graded sample by means of a nest of the standard sieves specified in 4.1. From the fractions obtained in this manner, select samples of sufficient size to yield 100 g after sieving to refusal. (In general, a 110-g sample will be sufficient.) Do not use fine aggregate sticking in the meshes of the sieves in preparing the samples. Weigh samples consisting of 100 ± 0.1 g out of each of the separated fractions after final sieving and place in separate containers for the test.

6.2 *Coarse Aggregate*—Thoroughly wash and dry the sample of coarse aggregate to constant weight at 230 ± 9 F (110 ± 5 C) and separate it into the different sizes shown in 5.2 by sieving to refusal. Weigh out quantities of the different sizes within the tolerances of 5.2 and, where the test portion consists of two sizes, combine them to the designated total weight. Record the weights of the test samples and their fractional components. In the case of sizes larger than ¾ in., record the number of particles in the test samples.

7. Procedure

7.1 *Storage of Samples in Solution*—Immerse the samples in the prepared solution of sodium sulfate or magnesium sulfate for not less than 16 h nor more than 18 h in such a manner that the solution covers them to a depth of at least ½ in. (Note 6). Cover the containers to reduce evaporation and prevent the accidental addition of extraneous substances. Maintain the samples immersed in the solution at a temperature of 70 ± 2 F (21 ± 1 C) for the immersion period.

NOTE 6—Suitably weighted wire grids placed over the sample in the containers will permit this coverage to be achieved with very lightweight aggregates.

7.2 *Drying Samples After Immersion*—After the immersion period, remove the aggregate sample from the solution, permit it to drain for 15 ± 5 min, and place in the drying oven. The temperature of the oven shall have been brought previously to 230 ± 9 F (110 ± 5 C). Dry the samples at the specified temperature until constant weight has been achieved. Establish the time required to attain constant weight as follows: with the oven containing the maximum sample load expected, check the weight losses of test samples by removing and weighing them, without cooling, at intervals of 2 to 4 h; make enough checks to establish required drying time for the least favorable oven location (see 3.5) and sample condition (Note 7). Constant weight will be considered to have been achieved when weight loss is less than 0.1 percent of sample weight in 4 h of drying. After constant weight has been achieved, allow the samples to cool to room temperature, when they shall again be immersed in the prepared solution as described in 7.1.

NOTE 7—Drying time required to reach constant weight may vary considerably for several reasons. Efficiency of drying will be reduced as cycles accumulate because of salt adhering to particles and, in some cases, because of increase in surface area due to breakdown. The different size fractions of aggregate will have differing drying rates. The smaller sizes will tend to dry more slowly because of their larger surface area and restricted interparticle voids, but this tendency may be altered by the effects of container size and shape.

7.3 *Number of Cycles*—Repeat the process of alternate immersion and drying until the required number of cycles is obtained.

8. Quantitative Examination

8.1 Make the quantitative examination as follows:

8.1.1 After the completion of the final cycle and after the sample has cooled, wash the sample free from the sodium sulfate or magnesium sulfate as determined by the reaction of the wash water with barium chloride ($BaCl_2$). Wash by circulating water at 110 ± 10 F (43 ± 6 C) through the samples in their containers. This may be done by placing them in a tank into which the hot water can be introduced near the bottom and allowed to overflow. In the washing operation, the samples shall not be subjected to impact or abrasion that may tend to break up particles.

8.1.2 After the sodium sulfate or magnesium sulfate has been removed, dry each fraction of the sample to constant weight at 230 ± 9 F (110 ± 5 C). Sieve the fine aggregate over the same sieve on which it was retained before the test, and sieve the coarse aggregate over the sieve shown below for the appropriate size of particle. For fine aggregate, the method and duration of sieving shall be the same as were used in preparing the test samples. For coarse aggregate, sieving shall be by hand, with agitation sufficient only to assure that all undersize material passes the designated sieve. No extra manipulation shall be employed to break up particles or cause them to pass the sieves. Weigh the material retained on each sieve and record each amount. The difference between each of these amounts and the initial weight of the fraction of the sample tested is the loss in the test and is to be expressed as a percentage of the initial weight for use in Table 1.

Size of Aggregate	Sieve Used to Determine Loss
2½ (63 mm) to 1½ in. (37.5 mm)	1¼ in. (31.5 mm)
1½ to ¾ in. (19.0 mm)	⅝ in. (16.0 mm)
¾ to ⅜ in. (9.5 mm)	5/16 in. (8.0 mm)
⅜ in. to No. 4 (4.75 mm)	No. 5 (4.0 mm)

9. Qualitative Examination

9.1 Make a qualitative examination of test samples coarser than ¾ in. (19.0 mm) as follows (Note 8):

9.1.1 Separate the particles of each test sample into groups according to the action produced by the test (Note 8).

9.1.2 Record the number of particles showing each type of distress.

NOTE 8—Many types of action may be expected. In general, they may be classified as disintegration, splitting, crumbling, cracking, flaking, etc. While only particles larger than $^3/_4$ in. in size are required to be examined qualitatively, it is recommended that examination of the smaller sizes be made in order to determine whether there is any evidence of excessive splitting.

10. Report

10.1 The report shall include the following data (Note 9):

10.1.1 Weight of each fraction of each sample before test.

10.1.2 Material from each fraction of the sample finer than the sieve designated in 8.1.2 for sieving after test, expressed as a percentage of the original weight of the fraction.

10.1.3 Weighted average calculated from the percentage of loss for each fraction, based on the grading of the sample as received for examination or, preferably, on the average grading of the material from that portion of the supply of which the sample is representative except that:

10.1.3.1 For fine aggregates (with less than 10 percent coarser than the $^3/_8$-in. (9.5-mm) sieve), assume sizes finer than the No. 50 (300-μm) sieve to have 0% loss and sizes coarser than the $^3/_8$-in. (9.5-mm) sieve to have the same loss as the next smaller size for which test data are available.

10.1.3.2 For coarse aggregate (with less than 10 percent finer than the No. 4 (4.75-mm) sieve), assume sizes finer than the No. 4 (4.75-mm) sieve to have the same loss as the next larger size for which test data are available.

10.1.3.3 For an aggregate containing appreciable amounts of both fine and coarse material tested as two separate samples as required in 5.3, compute the weighted average losses separately for the minus No. 4 and plus No. 4 fractions based on recomputed gradings considering the fine fraction as 100 percent and the coarse fraction as 100 percent. Report the results separately giving the percentage of the minus No. 4 and plus No. 4 material in the initial grading.

10.1.3.4 For the purpose of calculating the weighted average, consider any sizes in 5.1 or 5.2 that contain less than 5 percent of the sample to have the same loss as the average of the next smaller and the next larger size, or if one of these sizes is absent, to have the same loss as the next larger or next smaller size, whichever is present.

10.1.4 In the case of particles coarser than $^3/_4$ in. (19.0 mm) before test: (*1*) The number of particles in each fraction before test, and (*2*) the number of particles affected, classified as to number disintegrating, splitting, crumbling, cracking, flaking, etc., as shown in Table 2.

10.1.5 Kind of solution (sodium or magnesium sulfate) and whether the solution was freshly prepared or previously used.

NOTE 9—Table 1, shown with test values inserted for purpose of illustration, is a suggested form for recording test data. The test values shown might be appropriate for either salt, depending on the quality of the aggregate.

11. Precision

11.1 For coarse aggregate with weighted average sulfate soundness losses in the ranges of 6 to 16 percent for sodium and 9 to 20 percent for magnesium, the precision indexes are as follows:

	Coefficient of Variation (1S%), Percent[a]	Difference Between Two Tests (D2S%), Percent of Average[a]
Multilaboratory:		
Sodium sulfate	41	116
Magnesium sulfate	25	71
Single-Operator:		
Sodium sulfate	24	68
Magnesium sulfate	11	31

[a] These numbers represent, respectively, the (1S%) and (D2S%) limits as described in Recommended Practice C 670.

TABLE 1 Suggested Form for Recording Test Data (with Illustrative Test Values)

Sieve Size			Grading of Original Sample, percent	Weight of Test Fractions Before Test, g	Percentage Passing Designated Sieve After Test	Weighted Percentage Loss
Soundness Test of Fine Aggregate						
Minus No. 100 (150-μm)			5.0	...	...	...
No. 50 (300-μm) to No. 100			11.4	...	...	...
No. 30 (600-μm) to No. 50			26.0	100	4.2	1.09
No. 16 (1.18-mm) to No. 30			25.2	100	4.8	1.21
No. 8 (2.36-mm) to No. 16			17.0	100	8.0	1.36
No. 4 (4.75-mm) to No. 8			10.8	100	11.2	1.21
⅜ in. (9.5 mm) to No. 4			4.6	...	11.2[a]	0.52
Totals			100.0	...	...	5.4
Soundness Test of Coarse Aggregate						
2½ (63 mm) to 2 in. (50-mm)	2825 g	2½ to 1½ in.	20.0	4783	4.8	0.96
2 to 1½ in. (37.5-mm)	1958 g					
1½ to 1 in. (25.0-mm)	1012 g	1½ to ¾ in.	45.0	1525	8.0	3.60
1 in. to ¾ in. (19.0-mm)	513 g					
¾ in. to ½ in. (12.5-mm)	675 g	¾ to ⅜ in.	23.0	1008	9.6	2.20
½ in. to ⅜ in. (9.5-mm)	33 g					
⅜ in. to No. 4 (4.75-mm)			12.0	298	11.2	1.34
Totals			100.0	...	...	8.1

[a] The percentage loss (11.2 percent) of the next smaller size is used as the percentage loss for this size, since this size contains less than 5 percent of the original sample as received. See 5.3.

TABLE 2 Suggested Form for Qualitative Examination (with Illustrative Test Values)

Qualitative Examination of Coarse Sizes									
	Particles Exhibiting Distress								Total No. of Particles Before Test
Sieve Size	Splitting		Crumbling		Cracking		Flaking		
	No.	Percent	No.	Percent	No.	Percent	No.	Percent	
2½ (63 mm) to 1½ in. (37.5 mm)	2	7	...	...	2	7	...	...	29
1½ to ¾ in. (19.0 mm)	5	...	...	2	...	...	...	...	50

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PROCEDURE FOR THE PETROGRAPHIC ANALYSIS OF COARSE AGGREGATE

1. SCOPE

1.1 This procedure outlines the method to be employed in the petrographic analysis of coarse aggregate. It is a method of appraising the quality of coarse aggregate and provides a numerical means of expressing and comparing the quality of samples from the same or different sources.

1.2 This procedure does not attempt to describe the techniques used in petrographic analysis since it is assumed that the examination will be performed by persons qualified by experience to use such techniques for the recognition of the properties of rocks and minerals and subsequent classification of aggregate particles into rock types.

2. REFERENCE

2.1 ASTM C 294 - 69 -- Standard Descriptive Nomenclature of Constituents of Natural Mineral Aggregates

2.2 ASTM c 295 - 65 -- Standard Recommended Practice for Petrographic Examination of Aggregates for Concrete

2.3 British Standard 812: Part 1: 1975, Section 6 -- Description of Classification of Mineral Aggregates

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2.3 British Standard 812: Part 1: 1975, Section 6 -- Description of Classification of Mineral Aggregates

2.4 CSA Standard A 23.2.30 - 1973 -- Procedure for the Petrographic Analysis of Coarse Aggregate

3. DEFINITION

3.1 *Crushed particles* shall be those which have at least one freshly fractured and well defined face. The proportion of crushed particles shall be expressed as a percentage of the original mass of the coarse aggregate sample.

3.2 *Flat and elongated pieces* shall be those particles whose greatest mean dimension in the longitudinal axis compared to the least mean dimension in a plane perpendicular to the longitudinal axis exceeds a ratio of 4:1. The proportion of flat and elongated particles shall be expressed as a percentage of the original mass of the coarse aggregate sample.

4. APPARATUS

4.1 Hand lens of 10x magnification.

4.2 Alnico magnet.

4.3 Pocket knife of good quality with a blade hardness of between 5.5 and 6 on Mohs' scale.

4.4 Anvil and hammer suitable for breaking aggregate particles.

4.5 Five percent solution by volume of technical grade hydrochloride acid (22 Be').

4.6 Polyethelene squeeze bottle with a spout.

4.7 Stereoscopic microscope with final magnification from 4x to 25x and a source of illumination.

4.8 Balance having a capacity of 1 000 g, accurate to 0.5 g.

4.9 Source of light that provides excellent illumination of the working area.

5. PREPARATION OF SAMPLE

5.1 A representative sample of oven dried aggregate shall be prepared to the following approximate weights:

PASS	RETAIN	APPROX. MASS, g
19.0 mm (3/4")	9.50 mm (3/8")	1,000
13.2 mm (1/2")	9.50 mm (3/8")	500
9.5 mm (3/8")	6.70 mm (No. 3)	200
6.7 mm (No. 3)	4.75 mm (No. 4)	75

NOTE: Generally this examination is performed on the pass 19.0 mm (3/4 inch)/retained 9.5 mm (3/8") material. If the pass 19.0 mm (3/4")/retained 9.5 mm (3/8") material constitutes less than about 70 percent of the sample, the pass 9.5 mm (3/8")/retained 6.7 mm (no. 3) fraction shall also be examined. If the pass 19.0 mm (3/4")/retained 6.7 mm (no. 3) fractions constitute less than about 70 percent of the sample, the 6.7 mm (no. 3)/retained 4.75 mm (no. 4) fraction shall also be examined.

6. TEST PROCEDURE

6.1 The sample shall be spread on a tray or other flat working surface.

6.2 The aggregate shall be examined for coatings (such as clay), cementations and encrustations which may affect the bond with cement paste or asphalt. The type of coating and the degree to which it is bonded to the aggregate shall be noted.

6.3 If clay balls or other particles which may break down in water or with normal handling are present, these particles shall be separated out at this stage of the procedure.

6.4 The sample shall be examined visually for shape characteristics and the estimated percentages of crushed, flat and elongated particles noted.

6.5 When steps 6.1 through 6.4 are completed, the sample shall be washed to remove clay and dust coatings.

6.6 The washed sample shall be spread on a flat surface covered with a paper or cloth towel to absorb excess water.

6.7 Each particle in the sample shall be identified and classified into the rock type groups listed on Form OB-MT 84 or the supplementary rock type list (*TABLE 1*).

NOTE: The scratch and acid tests will, with visual examination, usually be sufficient to classify most rock particles. If any difficulty still exists following microscopic examination it shall be referred to a petrographer for identification and detailed petrographic study.

Ministry of Transportation and Communications
Ontario

COARSE AGGREGATE PETROGRAPHIC ANALYSIS

PIT NAME ____________ LAB. NO. ____________

DATE ____________ FRACTION ____________ ANALYST ____________

TYPE NO.	TYPE	WEIGHT	%	GRANULAR & 5/8" CRUSHED CORRECTION	
1	CARBONATES (hard)				
20	CARBONATES (slightly weathered)				
2	CARBONATES (sandy, hard)				
21	CARBONATES (sandy, medium hard)				
23	CARBONATES CRYSTALLINE (hard)				
3	SANDSTONE (hard)				
22	SANDSTONE (medium hard)				
4	GNEISS - SCHIST (hard)				
5	QUARTZITE (coarse and fine grained)				
6	GREYWACKE - ARKOSE (hard and medium hard)				
7	VOLCANIC (hard and slightly weathered)				
8	GRANITE - DIORITE - GABBRO				
9	TRAP				
	TOTAL GOOD AGGREGATE				
24	CARBONATES CRYSTALLINE (slightly weathered)			×2	
40	CARBONATES (soft; slightly shaley)			×2	
41	CARBONATES (sandy, soft and soft pitted)			×2	
42	CARBONATES (deeply weathered)				
25	GNEISS (soft) SCHIST (medium hard)			×2	
26	CHERT - CHERTY CARBONATES			×2	
27	GRANITE - DIORITE - GABBRO (brittle)			×2	
28	VOLCANIC (soft)			×2	
52	ENCRUSTATION			×2	
29	ARGILLITE			×2	
	TOTAL FAIR AGGREGATE				
43	CARBONATES (shaley or clayey)				
44	CARBONATES (ochreous)				
45	CHERT - CHERTY CARBONATES (leached)			×5	
46	SANDSTONE (soft friable)			×3	
48	VOLCANIC (very soft, porous)			×3	
49	CARBONATES CRYSTALLINE (soft)			×3	
50	GNEISS (friable)			×3	
51	GRANITE - DIORITE - GABBRO (friable)			×3	
53	CEMENTATIONS			×3	
54	CEMENTATIONS (total)			×3	
55	SCHIST (soft)			×3	
56	SILTSTONE			×3	
	TOTAL POOR AGGREGATE				
60	OCHRE				
61	SHALE				
62	CLAY				
63	VOLCANIC OR SCHIST (decomposed)				
	TOTAL DELETERIOUS AGGREGATE				
	TOTALS				

% GOOD ________ ×1 = ________

% FAIR ________ ×3 = ________

% POOR ________ ×6 = ________

% DELETERIOUS ________ ×10 = ________

EST. PERCENT CRUSHED	
EST. PERCENT FLATS & ELONGATED	

HOT MIX, MULCH AND CONCRETE P.N.	

CORRECTED GRANULAR AND 5/8" CRUSHED P.N.	

TABLE 1

	TYPE	REMARKS	CORRECTION FOR GRANULAR
GOOD	SEDIMENTARY CONGLOMERATE (hard)	Include with Sandstone #3.	16.0 mm (5/8") CRUSHED
	SEDIMENTARY CONGLOMERATE (medium hard)	Include with Sandstone #22.	-
	AMPHIBOLITE (hard)	Include with Gneiss #4.	-
	IRON BEARING QUARTZITE	Include with Quartzite #5.	-
	MAGNETITE (in Trap)	Include with Trap #9.	-
	SULPHIDES (in Trap)	Include with Trap #9.	-
	EPIDOTE (hard) (in Trap)	Include with Trap #9.	-
	IRON FORMATION (hard, medium hard)	Write in.	-
FAIR	AMPHIBOLITE (soft)	Include with Gneiss #25.	X2
	PYRITE	Write in	-
	FLINT , JASPER and VOLCANICS (extremely fine grained and glassy)	Write in	X2
	VOLCANICS (ochreous)	Write in	X2
POOR	SEDIMENTARY CONGLOMERATE (soft, friable)	Include with Sandstone #46	X3
	CALCITE	Include with Carbonates #49	X3
	AMPHIBOLITE (friable)	Include with Gneiss #50	X3
	CRYSTALLINE CARBONATES (very friable)	Write in	X3

TABLE 1 continued

	TYPE	REMARKS	CORRECTION FOR GRANULAR &' 5/8" (16.0mm) CRUSHED
DELETERIOUS	IRON FORMATION (very soft)	Include with Ochre #60	-
	SLATE	Include with Shale #61	-
	KAOLIN, TALC & GYPSUM	Include with Clay #62	-

6.8 In the identification, classification and description of each particle, the following features may be relevant:

6.8.1 Particle shape;

6.8.2 Particle surface texture;

6.8.3 Mineral grain size;

6.8.4 Texture and structure, including observations of pore space, packing of grains and degree of cementation;

6.8.5 Colour;

6.8.6 Mineral composition;

6.8.7 Significant heterogeneities such as: fossils and clay or shale partings;

6.8.8 Physical properties such as: scratch hardness, fracture, porosity, toughness and specific gravity (heft);

6.8.9 Physical condition such as: weathered, cracked, split, flakey and decomposed;

6.9 On the completion of the examination, each group of rock types shall be weighed to the nearest gram (0.5 g in the case of the pass 6.7 mm [no. 3] retained 4.7 mm [no. 4] fraction) and recorded on Form OB-MT-84. If any rock types are present which are not found on this form, the category in which they shall be recorded will be found in the supplementary rock types list (*TABLE 1*).

7. CALCULATION

7.1 The percentage of each rock type shall be calculated to the nearest 0.1 percent. The percentages of good, fair, poor and

and deleterious particles shall also be calculated. The sum of the subtotals shall be 100 percent.

7.2 The Petrographic Number for hot mix, mulch and concrete shall be calculated as the sum of the products of the percentage of each petrographic category (good, fair, poor or deleterious) multiplied by the appropriate factor for each category.

7.3 If the material is to be used for granular or 16.0 mm (5/8") crushed, a correction shall be applied which reflects the differing environmental conditions in which the material is used. The percentage of each rock type in the fair and poor categories shall be multiplied by the appropriate correction factor on Form OB-MT-84. The sum of the values obtained shall be subtracted from the Petrographic Number for hot mix, mulch and concrete to obtain the corrected Petrographic Number for granular or 16.0 mm (5/8") crushed use.

7.4.1 When the test is performed on several test fractions, a weighted average value shall be calculated as follows:

> Multiply the percentage (based on the "as received" coarse aggregate sample portion) of each fraction by the Petrographic Number for that fraction. The sum of those products divided by 100 is the weighted average Petrographic Number for the "as received" sample.

7.4.2 For the purpose of calculating the weighted average consider any sizes (not tested) that contain less than 5 percent of the "as received" sample to have the same value as the average of the next smaller and the next larger size or if one of these sizes is missing, to have the same value as the next larger or smaller size, whichever is present.

8. REPORTING OF RESULTS

The *petrographic number* for a particular application shall be reported to the nearest whole number.

9. GENERAL NOTES

9.1 In the event that there are a significant number of particularly absorptive particles, they should be dried before weighing so that water absorbed during washing will not unduly influence the weight.

9.2.1 Due to the time consuming nature of petrographic examination on the smaller coarse aggregate sizes, a rather shorter procedure is sometimes used.

9.2.2 A full petrographic examination shall always be performed on the largest aggregate size of a sample. If smaller sizes are also to be tested they may be more quickly separated into the petrographic categories "good" and "deleterious" without exact separation of these materials into rock type groups. The nature of the material in the "good" and "deleterious" categories will be readily apparent from examination of the complete petrographic analysis on the largest size. Those particles that fall into the "fair" and "poor" categories must be separated into rock type groups.

9.2.3 If the nature of the material is doubtful a full petrographic analysis of the smaller sizes must be performed.

9.3 The factors applied to each rock type are based on laboratory studies and in-service performance for the intended use and the prevailing conditions in Ontario. These factors may not apply under other conditions and in other areas. *The factors are subject to periodic review and shall be changed when necessary to reflect current experience.*

9.4.1 The Petrographic number may be used as the sole quality assurance test provided that previous test and performance data have established the quality of the source and that any change in quality will be apparent in petrographic analysis.

9.4.2 When assessing the quality of a sample from new or problem sources or where there is a lack of previous test data, then all quality tests must be performed and considered before the decision on its suitability is made.

APPENDIX A

ALKALI AGGREGATE REACTION

NOTE: *This Appendix is not a mandatory part of this Standard.*

A1. GENERAL

A1.1 Research and testing in the last 15 years has revealed that a form of concrete deterioration occurring in several regions in Canada results from a reaction between the alkali components in Portland cement and certain active minerals in some rock types. All natural rocks and gravels react to some extent with the highly caustic solution existing in concrete but in certain cases these reactions proceed far enough to produce excessive expansion and cracking of the concrete.

A1.2 Corrective measures have been developed which permit, in most cases, reactive aggregate to be used with a high degree of safety. In all cases of alkali-aggregate reaction the preventive measures include eliminating or reducing one more of the three reactants or conditions: high alkali, usually from the cement; highly moist environment; and the reactive component of the aggregate.

A1.3 In a very limited number of cases, e.g. an environment that is continually moist and where even a small expansion would be unacceptable, it may prove impossible to use an aggregate that contains reactive rock types.

A1.4 Replacement of a portion of the cement by a pozzolanic material has effectively reduced expansion in many cases of alkali-silica reaction. The alkali-carbonate rock reaction, however, has been shown to be relatively unresponsive to pozzolans.

A2. TYPES OF ALKALI-AGGREGATE REACTION

A2.1 Alkali-Silica Reaction. The first instances of this problem were observed in various locations in the United States and involved the reaction between the alkalies in Portland cement and certain reactive silica constituents in the aggregate (opals, cherts, chalcedonies and certain glassy or cryptocrystalline volcanic rocks).

More recently, a similar form of this reaction was observed in Canada which involved certain siliceous rocks such as graywacke, argillite, phyllite, schist and quartzite, found in the Appalachians and the Canadian Shield as well as siliceous shalestones found in some prairie sands and gravels.

Because of the detailed identification of rock types carried out in a number of published investigations, many sources of silicious aggregate may be evaluated as potentially expansive by petrography alone. If the petrographic analysis indicates that the source contains potentially reactive rocks, it is recommended that one or more of the preventative measures be employed at least until data from the mortar bar test, described later in this Appendix, are available.

A2.2 Alkali-Carbonate Reaction. This form of reaction is between the Portland cement alkali and certain fine-grained dolomitic limestones. Alkali-carbonate reactions have been diagnosed in Ontario in connection with dolomitic limestones from several quarries along the southern border of the Canadian Shield.

Although the alkali-carbonate reaction has been extensively studied in recent years it is not possible to determine by petrographic examination alone whether a particular rock will cause excessive expansion if used with high alkali cement. Accordingly potentially reactive rocks should be evaluated in the length change tests noted in this Appendix.

A3. TESTS FOR ALKALI-AGGREGATE REACTIVITY

A3.1 General. The several types and degrees of alkali-expansivity found in some Canadian aggregate require that each affected region or source be treated as a separate engineering problem. It is therefore necessary to develop, with research and field experience, limits of alkali content, degree of expansion and time of test conditioning for each affected region.

Several methods for detecting potential alkali reactivity have been proposed. However, such methods do not provide direct or quantitative information on the degree of expansion to be expected or tolerated in service. Therefore, evaluation of potential alkali-expansivity of an aggregate should be based on judgment in terms of interpretation of test data and performance of field structures. It follows that the decision to use a particular corrective measure must be based on such judgment.

A3.2 ASTM Standard C295, Petrographic Examination of Aggregates for Concrete. The petrographic test is particularly useful when evaluating a potential alkali-silica reaction since many reactive rock types have been identified by past research work.

The test is less satisfactory for potential alkali-carbonate reactive rocks since the criteria identified with known expansive rocks have been observed in satisfactory nonexpansive rocks.

A3.3 ASTM Standard C227, Potential Alkali Reactivity of Cement-Aggregate Combinations (Mortar-Bar Method). This test method can be used with a high degree of confidence to identify potential alkali-silica reactive aggregate and to evaluate the effectiveness of using low alkali cement, pozzolanic materials and other potential corrective measures. Limits, however, must be developed for each type of reaction.

Linear expansions of about 0.04 per cent or more indicate potentially deleterious reactivity. Times for such limits to be reached must be determined from comparative test data. The shape of expansion curves is often of importance in making judgment, using reference aggregate of known expansivity. A Portland cement may be considered as a high alkali cement when the total alkali calculated as sodium oxide exceeds 0.80 per cent. A low alkali cement is one which contains less than 0.60 per cent, calculated as sodium oxide. A very slow reaction may require a modified form of the test, usually one or more of higher temperature, added extra alkali, or a higher concentration of rock type under test.

A3.4 CSA Standard A23.2.24, Test for Alkali Aggregate Reaction. This test method can be used with a high degree of confidence to identify potential alkali-carbonate reactive aggregate and to evaluate the effectiveness of using low alkali cement and other potential corrective measures. Limits, however, must be developed for each type of reaction.

Linear expansions of about 0.03 per cent or more indicate potentially deleterious reactivity. In other respects the comments above on the Mortar-Bar test (Clause A3.3) apply here.

For concrete that will be subjected to moist environment for most of its service life and where expansion will cause distress in adjacent concrete, i.e. a bridge deck, expansion should be considered excessive if it exceeds 0.02 per cent at 3 months.

For concrete in a relatively dry environment for most of its service life expansion should be considered excessive if it exceeds 0.04 per cent at 3 months.

Such expansive aggregate can generally be safely used only in conjunction with a low alkali cement (i.e. less than 0.60 per cent expressed as sodium oxide). Potentially expansive aggregate to be used in concrete in a moist environment for most of its service life, should be evaluated in concrete prisms in conjunction with a low alkali cement.

Some rock types continue to expand well beyond the 3 month period and where possible expansion measurements should be continued beyond 3 months until expansion has virtually ceased.

A3.5 **ASTM Standard C586, Potential Alkali Reactivity of Carbonate Rocks for Concrete Aggregates (Rock Cylinder Method).** This test may be useful in determining the relative expansive properties between various rock types that may exist in a quarry and may indicate the need for further testing of the aggregate in concrete prisms. Limits, however, must be developed for each type of reaction.

This test has been limited to the alkali-carbonate rock reaction. Recent extensive work on reactive siliceous, sedimentary rocks in the Appalachians and the Canadian Shield has demonstrated some applicability of this method in these cases. However, the test is not applicable to the alkali-silica problem involving opals, cherts, chalcedonies, etc.

As an indirect test this method is useful in preliminary evaluation of a quarry source but does not lend itself to development of acceptance or rejection requirements.

A4. CEMENT-AGGREGATE REACTION

A4.1 Deleterious reactivity of aggregate in concrete, for reasons other than alkali reactivity, have been reported in various parts of Canada.

A4.2 One test designed to detect certain unsound aggregate is ASTM Standard C342, Potential Volume Change of Cement-Aggregate Combinations. Cement aggregate combinations tested by this procedure where expansion equals or exceeds 0.20 per cent at an age of 1 year may be considered unsatisfactory for use in concrete exposed to wide variations of temperature and degree of saturation with water.

Aggregate producing excessive expansion in this test do not generally respond to the use of a low alkali cement.

A5. GENERAL ASSESSMENT OF REACTIVE AGGREGATE

A5.1 The Authority or other contractual party having the responsibility of assessing whether a particular aggregate is acceptable or not is well advised to seek advice from technically qualified people preferably prior to the commencement of a laboratory evaluation programme. Technical knowledge regarding areas of Canada where reactive aggregate have been identified is readily available on a national and local level and methods of detecting and diagnosing problems of this type are well established and relatively simple to use.

A6. REFERENCES

A6.1 Attention is drawn to the paper "Interaction of Concrete Aggregate and Portland Cement Situation in Canada" by E. G. Swenson published in Engineering Journal (Engineering Institute of Canada) May 1972. The paper contains 41 references regarding an alkali-aggregate and cement aggregate reactivity.

Ministry of Transportation and Communications

Ontario

MTC FORM 1002
October, 1977

MATERIAL SPECIFICATION FOR AGGREGATES – CONCRETE

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1002.05 LIGHTWEIGHT AGGREGATES

1002.06 PRODUCTION, HANDLING & STORAGE

1002.06.01 General
.02 Batch Plant Storage Bins

1002.07 SAMPLING AND TESTING

1002.01 SCOPE

This specification prescribes the specific requirements for aggregates for use in Portland cement concrete.

1002.02 REFERENCES

This specification refers to the following standards, publications or specifications:

Ministry Construction Specifications

Form 313 Concrete Pavement & Concrete Base

Form 904 Concrete Structures

Ministry Material Specifications

Form 1000 Aggregates – General
Form 1002 Aggregates – Concrete
Form 1350 Concrete Materials and Production

CSA Standards

A23.1 (73) Concrete Materials and Methods of Concrete Construction.

ASTM Standards

C33 (74) Concrete Aggregates, Spec. for.

C40 (73) Organic Impurities in Sands for Concrete, Test for.

C330 (76) Lightweight Aggregates for Structural Concrete, Spec. for.

1002.03 FINE AGGREGATE –SPECIFIC REQUIREMENTS

1002.03.01 General

Fine aggregates shall conform to the general requirements as specified in Form 1000 and to the specific requirements herein provided.

For the construction of a Portland cement concrete surface which will be subjected to traffic wear, such as a pavement, bridge deck or approach slab, manufactured sand made from the same or similar type of rock as that used for the coarse aggregate will not be accepted, regardless of its quality, due to the danger of polishing.

Screenings, unless processed as necessary to provide a product equal in quality and gradation to that of a manufactured sand, will not be accepted for use in the manufacture of Portland cement concrete.

Where use of a manufactured sand is proposed and the Ministry finds at the time the mix design is made, or at any subsequent time during the work, that a natural blending sand is required to produce a concrete of the specified properties and quality, then the Contractor shall provide a suitable natural blending sand. This sand shall be supplied, separately handled, stockpiled and proportioned in accordance with the designated mix design at no additional cost to the Ministry.

1002.03.02 Gradation Requirements

Unless otherwise specified, fine aggregates shall be uniformly graded within the limits of Table I.

TABLE I
GRADATION REQUIREMENTS FOR FINE AGGREGATES

MINISTRY SIEVE DESIGNATION	PERCENTAGE PASSING
3/8"	100
No. 4	95-100
No. 8	80-100
No. 16	50-85
No. 30	25-60
No. 50	5-30
No. 100	0-10
No. 200	0-3 Natural Sand 0-6 Manufactured Sand

NOTE:

1. See Form 1000 for table of sieve equivalents.
2. The fineness modulus shall not be less than 2.3 nor more than 3.1.
3. There shall be not more than 45% retained between any two consecutive sieve sizes.

4. Percentage passing No. 200 shall be determined by washing and sieving.
5. Determination of grading, including loss by washing and sieving and fineness modulus are based on dry weights.
6. Where mix design or other criteria require the use of a grading not as specified above, the required grading will be defined by the Materials and Laboratory Services Section.
7. A fine aggregate which meets the gradation requirements of C.S.A. Standard A23.1, will meet the gradation requirements of this specification.
8. No oversize material is permitted.
9. For acceptable uniformity of production, the variation in fineness modulus shall not exceed 0.20, comparing samples during processing with the sample upon which initial acceptance was based.

1002.03.03 Physical Requirements

(1) **Organic Impurities:** The fine aggregate when subjected to the sodium hydroxide colorimetric test (A.S.T.M. C40) shall not produce a colour darker than the standard solution or organic plate number 3. A fine aggregate failing this test may be approved if it meets the requirements of the structural strength test.

(2) **Soundness:** When fine aggregate is subjected to five cycles of the magnesium sulphate soundness test, the weighted percentage of loss shall not exceed 16 percent by weight.

(3) **Structural Strength:** When subjected to the structural strength test, mortar specimens containing the fine aggregate shall develop a compressive strength at the age of 7 days when using normal Portland cement, of not less than 95% of the strength developed by a similar mortar made from another portion of the same sample which has been washed in a 3% solution of sodium hydroxide, as specified in A.S.T.M. Specification Designation C33.

(4) **Petrographic Analysis:** The fine aggregate shall meet the current Ministry petrographic requirements.

(5) Irrespective of compliance with the physical requirements in this Section, a fine aggregate may be accepted or rejected on the basis of accelerated freeze-thaw testing or past field performance.

1002.04 COARSE AGGREGATE – SPECIFIC REQUIREMENTS

1002.04.01 General

Coarse aggregates shall conform to the general requirements as specified in Form 1000 and to the specific requirements herein provided.

1002.04.02 Gradation Requirements

Coarse aggregate shall be graded uniformly from the sieve representing the nominal maximum size of the aggregate to the No. 4 sieve.

The nominal maximum size of the aggregate shall be that Ministry Sieve Designation larger than the largest designated sieve on which not less than 10% of the aggregate is retained.

Concrete Structures

For concrete, the quality of which is governed by Form 1350, the nominal size shall be 3/4".

For such concrete, unless otherwise specified, the gradation of the coarse aggregate shall be within the limits provided in Table II.

Concrete Pavement and Concrete Base

For concrete, the quality of which is governed by Form 313 unless otherwise specified, the gradation of the coarse aggregates shall be within the limits provided in Table III.

The Contractor may elect to use either a combination of No. 20 and No. 21 gradings, or a combination of No. 20A and No. 21A gradings, to produce a product within the specified combined grading.

TABLE II

GRADATION REQUIREMENTS – COARSE AGGREGATES FOR STRUCTURAL CONCRETE

NOMINAL MAXIMUM SIZE	MINISTRY SIEVE DESIGNATION* – PERCENTAGE PASSING								
	2 inch	1½ inch	1 inch	7/8 inch	3/4 inch	5/8 inch	1/2 inch	3/8 inch	No. 4
1½ inch	100	95-100	60-90		35-70			10-30	0-5
1 inch		100	95-100	70-90			25-60		0-10
3/4 inch			100		90-100	65-90		20-55	0-10
1/2 inch					100		90-100	40-70	0-15
**3/8 inch							100	85-100	10-30

* As detailed in Form 1000, Section 1000.05.02

** Not more than 10% of 3/8 inch nominal maximum size material shall pass the No. 8 sieve.

TABLE III

GRADATION REQUIREMENTS – COARSE AGGREGATES FOR CONCRETE PAVEMENT OR BASE

GRADING	MINISTRY SIEVE DESIGNATION* – PERCENTAGE PASSING						
	2 inch	1-1/2 inch	1 inch	3/4 inch	1/2 inch	3/8 inch	No. 4 (3/16 inch)
No 20		100	48-68	20-35	0-10		
No 21				100	90-100	30-60	0-10
COMBINED		100	58-82	36-64	18-50	6-27	0-5
OR ALTERNATIVELY							
No. 20A	100	90-100	20-55	0-15		0-5	
No. 21A			100	90-100		20-55	0-10
COMBINED	100	95-100		35-70		10-30	0-5

*As detailed in Form 1000, Section 1000.05.01

The required proportions of the selected coarse aggregate combination will be specified by the Ministry in the mix design designated for the contract, and will be those which obtain the maximum unit weight for the combined coarse aggregates.

Generally No. 20 and No. 21 gradings may be found more suitable where aggregates are processed with portable crushing equipment. The gradings for No. 20A and No. 21A aggregates correspond to the gradings for 1½ inch to 3/4 inch and 3/4 inch to No. 4 respectively of C.S.A. Standard A23.1.

NOTES: (Referring to Tables II and III)

(1) These gradations represent the extreme limits which shall determine the suitability for use from all sources of supply. The gradation from any one source shall be reasonably uniform and not subject to the extreme percentages of gradation specified.

(2) Attention is called to the fact that the size or shape of aperture and type of screen specified for determining compliance with specifications for the gradation of coarse aggregate has no relation to those used in the production of the material.

(3) Sieve analysis is based on dry weights and includes material passing No. 4 sieve.

(4) When the nominal maximum sizes are the same, these gradings correspond to the requirements of C.S.A. Standard A 23.1.

(5) Where mix design or other criteria require the use of a grading other than as specified in Tables II and III, the required grading will be defined by the Materials and Laboratory Services Section.

1002.04.03 Physical Requirements

Coarse aggregates shall conform to the requirements of Table IV.

TABLE IV

PHYSICAL REQUIREMENTS – COARSE AGGREGATES

TEST	ACCEPTANCE REQUIREMENT	
	Concrete Pavement (Form 313)	Concrete Structures (Form 904) Concrete Base (Form 313)
Los Angeles Abrasion Loss, % Max.	35	35
Magnesium Sulphate Soundness, 5 cycles Loss, % Max.	12	12
Absorption, % Max.	2	2
Petrographic Number, Max.	125	140
Clay Lumps, % Max.	0.25	0.25
Thin and elongated pieces, % Max.	20	20
Passing No. 200 sieve, % Max. for gravel	1	1
for crushed rock	2	2

NOTE:

(1) Where concrete in a structure forms the surface upon which vehicular traffic will directly travel, the physical requirements for "concrete pavement" shall apply to the aggregate used.

(2) For slag aggregate the allowable maximum value for Los Angeles Abrasion and Absorption shall conform to current Ministry requirements for slag aggregate.

(3) Percentage passing No. 200 shall be determined by washing and sieving.

(4) Irrespective of compliance with the physical requirements of Table IV a Coarse Aggregate may beaccepted or rejected on the basis of the results of accelerated freeze-thaw testing or past field performance.

1002.04.04 Restriction on Use of Coarse Aggregate in Concrete

Because of the possibility of alkali-carbonate reactivity, use of coarse aggregates from the Gull River (Black River) Formation, for Portland cement concrete, is subject to the following restrictions additional to the requirements of Form 1002.

(1) As far as has been established, the exposed rock in the following potential dolomitic limestone sources is free of all alkali-carbonate reactivity problem and may be used subject to the normal conditions of the Specifications as to quality requirements, etc., except as qualified under Section (3) below when the rock is not yet exposed and tested.

NAME	TOWNSHIP	LOCATION
Robindale Quarry	Richmond Twp. Lot 22, Conc. VIII and IX	Robindale Station
Storey & McFarland Quarries	Fredericksburgh No. Lot 19, Conc. VIII	East Limits of Napanee
Lake Ontario Portland	Sophiasburgh Twp. Lot 14, Conc. 1	North of Picton
McFarland Quarry	Kingston Twp. Lot 8, Conc. IV	North West of Westbrook
P. Wallace (Carter Construction)	N. Fredericksburgh Lot 28, Conc. VII	3 Miles North East of Napanee
Canada Cement Quarry	Thurlow Twp. Lots 23 and 24 Broken Front	5 Miles East of Belleville
Cedarhurst Quarries	Somerville Twp. Lots 37, 38 Conc. Fronting on River	Coboconk

(2) Special conditions apply to the following quarries:

Pittsburg Quarry
Pittsburg Twp., Lot 5, Conc. 1, 2 Miles North East of Kingston.

The upper lifts in this quarry are reactive and shall in no circumstances be used. Acceptable material can be produced from certain of the lower lifts below the "green band" in the 30' – 36', 48' – 60' levels.

Frontenac Quarry
Kingston Twp., Lot 26, Conc. III, 1 Mile North of Kingston.

Material in the 0' – 12' level and in the "green band" is not acceptable. Acceptable material occurs in the 13' – 48' level.

If coarse aggregate is to be obtained from these sources, the areas and levels acceptable to the Ministry will be defined by the Engineer. The stone shall then be quarried so that firstly, all objectionable material above the level and area to be worked shall be removed. Only when this is done to the satisfaction of the Ministry, shall the acceptable material be quarried. When production of material from the acceptable areas is underway, this material alone shall be quarried, processed, and stockpiled separately; any simultaneous secondary production of material from unacceptable areas for other uses will not be permitted.

Limestone Products Limited – Uhthoff Quarry
Orillia Twp., Lot 10, Conc. IV, 6 Miles North West of Orillia.

Coarse aggregate produced from approximately the top 30 feet of this quarry (above the bed known as U2) and coarse aggregate produced from approximately the lower 15 feet of this quarry (below the bed known as U1 and to the bottom of the bed known as UC) will be acceptable for Portland cement concrete. Aggregate produced from other beds is not acceptable.

McGinnis and O'Connor – Elginburg Quarry
Kingston Twp., Lot 13, Conc. V, 0.8 Miles West of Elginburg.

Coarse aggregate produced from the top 17' of the quarry only will be acceptable for Portland cement concrete.

Allan G. Cook Ltd., Quarry
Tay Township, Lot 9, Conc. XIV, 3 1/2 Miles West of Waubaushene.

Coarse aggregate produced from the top 12' of the quarry only will be acceptable for Portland cement concrete.

(3) Aggregates which are essentially dolomitic limestone in nature from sources in the Gull River formation not listed in (1) or (2) above, (including lifts in quarries which are not at present exposed and tested), will only be acceptable as follows:

(i) The full depth of the lift the Contractor intends to use shall be opened for sampling. The stone so obtained shall, when incorporated in a concrete prism using high alkali cement (alkali content 1.1% or greater) and when cured at 100% relative humidity and 23°C, show no significant expansion (not greater 0.02%) or other distress after 84 days. The minimum time for quality testing of such aggregates is therefore four months before suitability of the quality will be known, and before material may be processed.

OR

(ii) If the Contractor wishes to process aggregate before this, he may do so provided the material so produced from each distinct lithological sequence is separately processed and stockpiled. Such material will be acceptable for use in Portland cement concrete only if testing as described above shows it to be free of reactivity. Again, a period of four months for such testing is required before suitability of the material is known.

Any further information or advice required on this alkali-carbonate reactivity problem should be sought from the Engineer.

1002.05 LIGHTWEIGHT AGGREGATES

Lightweight aggregates shall conform to the requirements of the current A.S.T.M. Specification C330.

1002.06 PRODUCTION, HANDLING AND STORAGE

1002.06.01 General

All production, processing, stockpiling and blending operations shall conform to Form 1000.

Initial stockpiles shall be built a minimum of one week prior to use. Thereafter, materials shall be retained in stockpiles at the construction site or site of an Approved Ready Mixed Concrete Operation for at least twenty-four hours before use.

Direct discharge of aggregates from the producing plant to the concrete batch plant storage bins, without intermediate stockpiling, will not be permitted. Direct discharge of aggregates from trucks or railcars to concrete batch plant storage bins without intermediate stockpiling will only be permitted where aggregates are drawn from established stockpiles of approved materials.

1002.06.02 Batch Plant Storage Bins

Batchplant storage bins shall be of sufficient capacity to contain at least four times the weight of aggregate required for any one batch. They shall have the smallest practical horizontal dimensions. Bottoms of bins shall slope not less than 50° from the horizontal towards a centre outlet.

When required during Cold Weather Concreting, (See Form 1350) batch plant bins shall be equipped to uniformly heat the aggregate.

Fine aggregate batch plant bins shall be left empty overnight and recharged when required, in order to avoid accumulation of wet material at the bottom of the bin.

1002.07 SAMPLING AND TESTING

All sampling and testing shall be as required in Form 1000. Attention is drawn to the requirements, including time for 1000.04 of Form 1000. Stockpiling of each aggregate, already processed to the required grading and tested and approved as to quality, from which samples are to be taken for mix design, shall contain 10% (or such smaller quantity as required by the Engineer) of the total quantity of aggregate needed for the class of concrete for which the mix design is required.

Ministry of Transportation and Communications

Ontario

MTC FORM 1003
October, 1977

MATERIAL SPECIFICATION FOR AGGREGATES – HOT MIX ASPHALTIC CONCRETE

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1003.08 AGGREGATE PROCESSING, HANDLING, & STOCKPILING

1003.08.01 Processing

1003.01 SCOPE

This specification prescribes the specific requirements for aggregates for use in hot mix asphaltic concrete.

1003.02 REFERENCES

This specification refers to the following standards, publications or specifications:

Ministry Material Specifications

Form 1000 Aggregates – General

1003.03 LOCATION, SAMPLING AND TESTING OF AGGREGATE SOURCE

After receipt of notice of award of the Contract, the Contractor shall notify the Engineer, in writing, of the location of the sources of all aggregates which the Contractor proposes to supply. It is emphasized that the onus for locating all aggregates is on the Contractor.

Aggregates to be supplied by the Contractor may be obtained from sources of his own selection, except that where "Designated Aggregates" are specified, such aggregates shall be obtained from Ministry Designated Aggregate Sources as defined in this specification.

The Engineer shall sample and test the proposed sources when they have been properly opened to his satisfaction. All sampling and testing and the time required for testing shall be as described in Form 1000.

The Contractor shall not change any source of supply until he has notified the District Engineer in writing and obtained his approval.

1003.04 REQUIREMENTS OF A MINISTRY DESIGNATED AGGREGATE SOURCE

1003.04.01 General

A Ministry Designated Aggregate Source shall be an aggregate supply operation equipped to produce aggregates of acceptable quality meeting the specifications of the Ministry.

1003.04.02 Materials

Aggregates from a Ministry Designated Aggregate Source may be gravels, quarried rock, slags, provided the source is of such a nature and extent as to ensure acceptable processed aggregates of a consistent gradation and quality.

The materials shall be obtained from a single deposit except where otherwise approved by the Ministry.

1003.04.03 Equipment and Facilities

Equipment and facilities employed in a Ministry Designated Aggregate Source and the operation and use of such equipment and facilities when producing aggregates for the Ministry's use shall be subject to the Ministry's approval. Equipment shall consist of any or all of the following as are required to produce a particular aggregate; crushing, screening, washing, blending, handling, and weighing equipment. Facilities shall consist of adequate storage bins and stockpiling areas, together with capable personnel to operate and maintain the equipment and the production programme.

The equipment and facilities may be retained on the site at all times or may be installed on the site on an as required basis to produce those aggregates for which the source has obtained Ministry approval.

1003.04.04 Conditions of Approval

The Ministry's approval of a particular material from a Ministry Designated Aggregate Source is subject to the following conditions, and the failure of the source to satisfy these conditions will be cause for the withdrawal of the approval of any or all of the materials from that source.

(i) The aggregate offered for use shall be of consistent, acceptable gradation and quality and shall satisfy all the requirements for the particular material.

(ii) When the source of the raw materials is changed, when a change in the character of the materials occurs, or when the performance of the materials is found to be unsatisfactory, the Ministry use of the materials shall be discontinued until a reappraisal by the Ministry proves the source to be satisfactory.

1003.04.05 Application for Approval

Application for Ministry approval of an aggregate shall be made by the supplier in writing to the Manager, Engineering Materials Office. Test samples of the aggregates for which the supplier requests approval will be taken by the Ministry's personnel from processed stockpiles of not less than 1,000 tons.

1003.05 FINE AGGREGATE

Fine aggregate shall conform to the general requirements specified in MTC Form 1000 and to the specific requirements herein provided.

For the construction of asphaltic concrete pavements which will be subject to extended traffic wear and for which limestone or dolomite is used for the coarse aggregate, 50% or more of the fine aggregate shall be other than limestone or dolomite because of the danger of polishing.

1003.05.01 Gradation Requirements for Fine Aggregate

Fine aggregate shall be consistently graded and shall meet the gradation requirements shown in Table I.

TABLE I

GRADATION REQUIREMENTS FOR TOTAL FINE AGGREGATE

Ministry Sieve Designation*	PERCENTAGE PASSING		
	H.L. 1 & 3	H.L. 2	H.L. 4, 5, 6, & 8
3/8 inch	–	100	–
No. 4 (3/16")	100	85-100	100
No. 8	80-100	70-90	70-100
No. 16	55-90	50-75	40-90
No. 30	35-70	30-55	20-70
No. 50	15-40	15-35	10-40
No. 100	5-15	5-16	3-15
No. 200	0-5	3-8	0-7

* As detailed in Form 1000

NOTE:

1. All gradations shall be determined by washing and sieving and shall be based on dry weights.

2. The above gradation represents the extreme limits which shall determine suitability for use. The gradation shall be reasonably consistent and not subject to the extreme percentage of gradation specified above. The fraction retained between any two consecutive sieves (excluding the No. 200 sieve) shall not be less than 5%.

3. For H.L. 1 fine aggregate, a tolerance of 10% of material passing the 3/8 inch sieve, and retained on the No. 4 (3/16 inch) sieve shall be permitted.

4. For H.L. 3, H.L. 4, H.L. 5, H.L. 6, and H.L. 8 fine aggregate, a tolerance of 15% of material passing the 3/8 inch sieve and retained on the No. 4 (3/16 inch) sieve shall be permitted when this oversize meets the coarse aggregate quality requirements for the intended use. If this oversize does not meet the coarse aggregate quality requirements for the intended use, a tolerance of 10% of material passing the 3/8 inch sieve and retained on the No. 4 (3/16 inch) sieve shall be permitted.

5. Regardless of the amount of oversize, the maximum size of this oversize shall be restricted to 100% passing the 3/8 inch sieve.

1003.05.02 Physical Requirements For Fine Aggregates

The fine aggregate shall be composed of clean, hard, durable particles and shall meet the quality requirements shown below.

1. **Soundness:** When the fine aggregate is subjected to *five cycles of the magnesium sulphate soundness test*, the loss by weight shall not exceed the following:

   H.L. 1 & 3 .... 16%
   H.L. 2,4,5,6 & 8 .... 20%

2. **Petrographic Analysis:** *The fine aggregate shall meet* the current Ministry petrographic requirements.

3. **Fines passing No. 200 sieve:** In any fine aggregate, not more than 20% of the material passing the No. 200 sieve shall be finer than .002 mm in size.

4. **Sand Abrasion:** The fine aggregate shall meet the current Ministry abrasion requirements.

Irrespective of compliance with these physical requirements, fine aggregates may be accepted or rejected on the basis of past field performance.

1003.06 COARSE AGGREGATE

Coarse aggregates shall conform to the general requirements specified in Form 1000 and to the specific requirements herein approved.

1003.06.01 Gradation Requirements For Coarse Aggregate

Coarse aggregate shall be consistently graded and shall meet the gradation requirements shown in Table II.

TABLE II

GRADATION REQUIREMENTS FOR COARSE AGGREGATE

Ministry Sieve Designation*	PERCENTAGE PASSING		
	H.L. 1 & 3	H.L. 4 & 5	H.L. 6 & 8
1 inch			100
3/4 inch			90-100
5/8 inch		100	65-90
1/2 inch	100	70-86	
3/8 inch	50-73	30-52	20-55
No. 4 (3/16")	0-10	0-10	0-10

* As detailed in Form 1000

NOTE:

1. These gradations represent the extreme limits which shall determine the suitability for use from all sources of supply. The gradation from any one source shall be reasonably consistent and not subject to the extreme percentages of gradation specified.

2. The size and shape of aperture specified for determining compliance with specifications for the size of coarse aggregate is not necessarily the size or shape of aperature or type of screen used in the production of the material.

TABLE III

PHYSICAL REQUIREMENTS FOR COARSE AGGREGATE

	H.L. TYPE				
	1	3	4	5, 6	8
Los Angeles Abrasion — Grades "B", "C", "D", Loss % Max.	15	35	35	35	35
Magnesium Sulphate Soundness — 5 Cycles — Loss % Max.	5	12	12	12	12
Absorption by Weight — % Max.	1.0	1.75	2.0	1.75	1.75
Petrographic Number — Max.	100	135	160	140	160
Loss by Washing — % Max. Passing No. 200 Sieve	1	1.3*	1.3*	1.3*	1.3*
Flat & Elongated Pieces — % Max.	20	20	20	20	20
Crushed Material — % Min.	100	60	60	60	60

*NOTE:

When quarried rock is used as a source of coarse aggregate, a maximum of 2% passing the No. 200 sieve shall be permitted.

Irrespective of compliance with the physical requirements of Table III, coarse aggregates may be accepted or rejected on the basis of past field performance.

1003.06.02 Physical Requirements For Coarse Aggregate

Coarse aggregate shall conform to the physical requirements shown in Table III.

1003.07 FILLER

Filler shall consist of mineral filler, hydrated lime, portland cement, asbestos fibre, or other material as designated and currently approved by the Ministry for use in asphaltic concrete.

1003.07.01 Mineral Filler

Mineral filler shall consist of thoroughly dry limestone or other mineral dust approved by the Ministry, shall conform to the current Ministry requirements for chemical analysis and quality, and shall be consistently graded to meet the following gradation requirements.

Passing No. 30 Sieve 100%
Passing No. 200 Sieve — not less than 80%

1003.08 AGGREGATE PROCESSING, HANDLING AND STOCKPILING

All processing, handling, and stockpiling operations shall conform to Form 1000.

A minimum of three (3) days' notice shall be given by the Contractor to the Engineer prior to the day that stockpiling of aggregate at the asphalt plant site is started.

1003.08.01 Processing

The aggregates shall be processed so as to meet the appropriate requirements as outlined in this specification.

The processed aggregates shall be separated into fine aggregate and coarse aggregate which shall be stockpiled separately.

Aggregates separated during processing, aggregates secured from different sources, and aggregates from the same source but of different gradations shall be placed in individual stockpiles.

Where primary and secondary screenings are produced, they shall be stockpiled separately.

Aggregates which have become mixed with foreign matter of any description or aggregates which have become mixed with each other shall not be used and shall be removed from the stockpile immediately.

Ministry of Transportation and Communications

Ontario

MTC FORM 1010
October, 1977

MATERIAL SPECIFICATIONS FOR AGGREGATES, GRANULAR A, B, C, D, AND 5/8" CRUSHED TYPES A & B

INDEX

1010.01 SCOPE

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1010.03 GENERAL REQUIREMENTS

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1010.06 PHYSICAL REQUIREMENTS

1010.01 SCOPE

This specification covers the specific requirements for aggregates for use as granular subbase, base and surface course; mulching; shouldering; and backfill to sewers, culverts and other structures.

1010.02 REFERENCES

This specification refers to the following standards, publications or specification:

Ministry Material Specifications

Form 1000 Aggregates – General

1010.03 GENERAL REQUIREMENTS

The requirements of Form 1000 shall apply to this specification.

1010.04 REQUIREMENTS FOR GRANULAR A & 5/8" CRUSHED AGGREGATES TYPES A & B

Granular A and 5/8" crushed aggregates types A & B shall satisfy all requirements of Tables 1 and 2 of this specification and unless otherwise specified shall be:

Crushed rock composed of hard, uncoated, cubical fragments, produced from rock formations or boulders of uniform quality,

or

Crushed gravel composed of hard, durable, uncoated particles, produced from naturally formed deposits.

or

Crushed slag produced from iron blast furnace slag or blended nickel slag.

1010.05 REQUIREMENTS FOR GRANULAR B, C AND D

Granular B, C and D shall be composed of clean, hard, durable uncoated particles and shall satisfy all requirements of Tables 1 and 2 of this specification for the material required.

Granular B and C shall be obtained from deposits of sand or gravel, talus rock, quarries, disintegrated granite, mine waste, iron blast furnace slag or blended nickel slag, clinkers, or other suitable granular materials.

Crushing of Granular B and C shall not be required except that the Contractor may, at his option, elect to crush any oversize present in the deposit as an alternative to screening.

Granular D shall be crushed rock screenings or slag screenings, and may be used as an alternate to Granular B or C as subbase material, excluding backfill to subdrains and culverts.

1010.06 PHYSICAL REQUIREMENTS

Irrespective of compliance with the physical requirements, aggregates may be accepted or rejected based on past field performance.

TABLE 1

PHYSICAL REQUIREMENTS

PHYSICAL TEST	5/8" Crushed Type 'A'	Granular 'A' and 5/8" Crushed Type 'B'	Granular 'B' and 'C'	Granular 'D'
Los Angeles Abrasion Grades 'B', 'C', 'D' Loss, % Max.	35	60	—	—
Petrographic Number, Max.	160	200	250	—
Percent Crushed, Minimum*	60	50	—	—
Plasticity Index	0	0	0	0

* The percent of crushed material will be determined by examining the fraction retained on the No. 4 sieve and dividing the weight of the crushed particles by the total weight retained on the No. 4 sieve.

TABLE 2

GRADATION REQUIREMENTS

Ministry Sieve Designation	% Passing by Weight					
	5/8" Crushed		Granular 'A'	Granular 'B'	Granular 'C'	Granular 'D'
	Type A	Type B				
6"	–	–	–	–	100	–
4"	–	–	–	100	–	–
1"	–	–	–	–	50 – 100	–
7/8"	–	–	100	57 – 100	–	–
5/8"	100	100	75 – 100	–	–	–
1/2"	75 – 95	75 – 95	65 – 90	–	–	–
3/8"	50 – 80	50 – 80	–	–	–	100
No. 4	25 – 50	25 – 50	35 – 55	25 – 100	20 – 100	50 – 100
No. 16	10 – 40	10 – 40	15 – 45	10 – 85	10 – 100	20 – 55
No. 50	2 – 20	2 – 20	5 – 22	5 – 40	5 – 90	10 – 30
No. 100	0 - 10	2 – 13	–	–	4 – 30	–
No. 200	0 – 5	0 – 8*	0 – 8*	0 – 8	0 – 10	0 – 12
No. 270	–	–	–	–	0 – 5	–

* Where Granular 'A' and 5/8" crushed Type 'B' is obtained from rock quarry sources, a maximum of 10% passing the No. 200 will be permitted.

APPENDIX C

GLOSSARY OF TECHNICAL TERMS

GLOSSARY OF TECHNICAL TERMS

Concrete Aggregate: For the purposes of this report, concrete aggregate is defined as material which meets the specification for concrete aggregate as stipulated in Appendix B of this report.

Aggregates generally occupy 60 to 80 per cent of the volume of concrete. Hence, their characteristics influence the properties of concrete. Aggregates also influence concrete's mix proportions and economy. They must conform to certain requirements and should consist of clean, hard, strong, and durable particles free of chemicals, coatings of clay or other fine materials that may affect hydration and bond of the cement paste.

Weak, friable or laminated aggregate particles are undesirable. Aggregates containing natural shale or shaley particles, soft and porous particles, and certain types of chert should be especially avoided, since they have poor resistance to weathering. Visual inspection will often disclose weaknesses in coarse aggregates. All aggregates that do not have reasonably reliable service records should be tested for compliance with requirements.

Granular "A" Material: For the purposes of this report Granular A material is defined as granular material which meets the specifications for Granular "A", as stipulated in Appendix B of this report. Granular A material which is screened to minus 7/8" is generally used for road top dressing, and crushed 5/8" (approx. 40% crushed) may serve as compacted granular base for asphalt or concrete road surfacing.

GLOSSARY..

<u>Granular "B" and "C" Material:</u> For the purpose of this report, Granular B and C material is defined as granular material which meets the specifications for Granular B and C material, as stipulated in Appendix B of this report. This material generally serves as sub-base material for road construction. It does not require washing.

<u>General Fill:</u> This material may contain crushables and sand in proportions, but contains over 10% fines (#200 mesh) dry weight, and is therefore not suited for higher uses such as concrete. If crushed for road materials, it contributes to extremely dusty conditions because of silt sizes.

<u>Crushing</u>: Crushing is done to reduce the size of large boulders or cobbles. This is done with a jaw, cone or roller crusher. A primary crusher is used to break up the large boulders. They are then fed to a secondary crusher where they are broken up again to a smaller size.

<u>Rip-Rap</u>: Broken rock used for the protection of bluffs or structures exposed to wave actions, etc.

<u>Gabion</u>: A cylindrical or rectangular container, usually formed from wire mesh, filled with earth or rock, used as protection against erosion along stream beds and road cuts, etc.

<u>Encrustation</u>: A coating on particles by other cementing media (i.e., calcareous, clayey phosphorous, iron and silica, etc). For Granular A material, a maximum

of 5% of the particles should have encrustation.

Crevasse Filling: A relatively straight ridge of stratified sand and gravel, till or other sediments, formed by the filling of a crevasse in a stagnant glacier which later melted. Crevasse fillings may resemble eskers but are not generally as winding or branching. Most crevasse fillings are much wider and have more nearly level tops compared to narrower eskers, whose top surface generally undulates. Bends in crevasse fillings tend to be angular and crossings of different generations of crevasse fillings are not uncommon.

Cuspate Beach Deposit: A series of naturally formed low mounds of beach material separated by crescent-shaped troughs at more or less regular intervals along the beach face.

Crushable Granular Material: Unprocessed gravel containing a minimum of 35% coarse aggregate larger than #4 sieve.

Eskers: A long, narrow, commonly sinuous ridge composed of well- and partly-washed ice-contact granular drift--chiefly sand and gravel with minor silt, cobbles, boulders and till inclusions. Eskers may also be composed almost wholly of sand and silt with and without a cover of boulders or ablation till. Because eskers are ice-contact deposits let down after melting of the supporting ice walls, they usually show complex irregular bedding and collapse structures. Eskers may exhibit reticulate, braided, branching, and dendritic patterns; but most commonly they occur as a single serpentine ridge.

Kame: A short, irregular ridge, hill, or mound of stratified drift deposited in contact with glacier ice by meltwater. Kames may form in holes and fissures on, in, and under stagnant glacier ice as well as, more commonly, at the margin of the glacier on the adjoining deglaciated land surface. Thus kame deposits may be deposited in superglacial, englacial, subglacial, or ice-marginal positions. They may appear as a single mound, as groups of clusters of closely associated sharply irregular hummocky mounds and ridges (kame moraine, kame field, kame complex, or kame group), as an isolated more or less flat-topped mesalike mound (kame delta), or as kettled or nonkettled terraces deposited between the former ice margin and nearby vally wall (kame terrace).

Till: Nonsorted, nonstratified sediment carried or deposited by a glacier.

Well Graded Soil: Material possessing more than one grain size, but lacking intermediate size(s).

Fine Aggregate: This material predominantly passes #4 mesh (i.e., 4 holes per inch) but produces fine gravels as a by-product which is retained when screened. Uses include blending product for concrete and asphaltic concrete, brick and mortar sand.

GLOSSARY...

Coarse Aggregate: This material contains a majority of gravel sizes of 1" and upward that requires crushing through 3/4" secondary jaws for road surfacing, concrete, etc. The size of cobbles and boulders and their relative quantities vary, and some materials require secondary crushing, screening, etc., while others contain significant number of large boulders for which primary crushing up to 30" feed is necessary.

Screening: Aggregates are screened in order to separate them into specific sizes. Screens may be a woven mesh of wire, a plate with holes of a specific size in it, or a set of racks and bars. Material larger than the opening in the screen is caught or retained on the screen, while material smaller than the opening passes through.

Washing: Aggregates are washed to remove coatings of silt or clay (fines) from them. The aggregate may be placed on a screen, then sprayed with jets of water to wash away the fines. A more sophisticated method is called flotation, where the fines are skimmed off a suspension of water and finely ground rock.

Dbh: Diameter breast high.

h: Height.

M.P.S.: Maximum particle size.

$\overline{\nabla}$: Denotes water table.