

68-F-204C  
Hwy. #7  
By-Pass  
PROPERTY  
ACQUISITION  
ST. MARY'S



# GEOCON LTD

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May 17, 1968.

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Department of Highways, Ontario  
Materials and Testing Division,  
Keele Street and Highway 401  
Downsview, Ontario.

Attention: Mr. A. Rutka, P. Eng.  
Materials and Testing Engineer

68-F-204c

re: Study of Soil Conditions,  
Property Acquisition,  
Highway No. 7 - By-pass,  
St. Mary's, Ontario

Dear Sirs:

This letter accompanies our detailed report on the above investigation.

We find that the overburden at the site in question consists of a succession of till strata, the most prominent being a clayey silt till which is also the formation referred to locally as "clay" raw material in cement manufacturing usage. Silty sand and gravel till was the next most prominent stratum encountered, and boulders were found to be present throughout the overburden as a whole. Groundwater under artesian pressure was encountered in the granular till strata and inclusions. The actual soil and groundwater conditions are described in detail in the report.

As part of the investigation into the suitability of the overburden at the subject site, for cement manufacturing purposes, a series of tests have been carried out to establish the physical and chemical characteristics of the clayey silt till stratum in particular. The results of these tests, which were carried out on samples obtained from the boreholes and the operational face at the existing clay pit, are presented in detail herein.

In summary, it is our conclusion that by virtue of the general similarity between the clayey silt till in the boreholes and the "clay" in the existing pit, and the fact that the latter is presently being used for cement manufacturing purposes, the clayey silt till at the subject site is also suitable

for this purpose. By the same reasoning, the silty sand and gravel till is not considered suitable. The above conclusions are also substantiated by consideration of the pertinent physical and chemical properties of the overburden, with the possible exception of the high content of magnesia in some of the samples. As discussed, however, our reservations with regard to magnesia content are subject to the review of an Authority on cement technology.

In the report, we have given approximate computed quantities of clayey silt till which would be made inaccessible by the proposed land acquisition. As discussed, however, the actual effective quantities which would be involved, depend on a variety of factors such as regulations governing setback distance between the pit brow and the highway, the site configuration adopted, practical and economical considerations associated with the clay mining operations, and the like.

We are at your disposal should you require additional information relating to this investigation or if we can be of further service otherwise, and trust that this report is sufficient for your present purposes.

Yours very truly,

GEOCON LTD



M. A. J. Matich, P. Eng.  
President

MAJM/em

T 9099.

T9099  
REPORT  
TO  
DEPARTMENT OF HIGHWAYS, ONTARIO  
ON  
STUDY OF SOIL CONDITIONS  
PROPERTY ACQUISITION  
HIGHWAY NO. 7 BY-PASS  
ST. MARY'S            ONTARIO

Distribution:

9 copies - Department of Highways, Ontario,  
Downsview, Ontario.

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Ltd

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## INTRODUCTION

Geocon Ltd has been retained by the Ontario Department of Highways, by letter dated February 19th, 1968, to investigate the suitability for cement manufacturing purposes, of the overburden within the proposed right of way for Highway No. 7 By-pass where the latter encroaches on property presently owned by the St. Mary's Cement Co. Limited. The strip of land in question is shown by the survey data on Drawing T9099-1, at the rear of this report.

The investigation was carried out using the following approach:

- (a) A geological reconnaissance of the general area was made, and as much pertinent information as possible obtained relative to present "clay" usage for cement manufacturing purposes at the St. Mary's Cement Co. Limited Plant.
- (b) Detailed exploratory boreholes with soil sampling at frequent vertical intervals were put down at three locations spanning the site in question.
- (c) Samples of "clay" from the clay pit presently being worked by the St. Mary's Cement Co. Limited were obtained for comparative analysis with the samples of overburden obtained from the boreholes.

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(d) Selected soils engineering classification tests were made on samples recovered from both the boreholes and the existing clay pit, for comparison purposes, and for analysis and checking against established criteria governing the acceptability of the overburden for cement manufacturing purposes.

(e) Samples from the boreholes and the clay pit were subjected to "100 percent chemical analysis" to determine the composition of overburden in terms of basic constituents known to be important in terms of usage for cement manufacture. The test results so obtained have been compared to results of X-ray analyses carried out elsewhere on the property by others in 1966, and made available to us by the Owner.

Throughout this report, the overburden is described using conventional soil mechanics terminology, in which the soil is identified in terms of the predominant grain size present in the samples. Consequently, what is normally referred to locally as "clay" raw material by the cement industry, is herein generally classified as a clayey silt till.

At the existing St. Mary's Cement Co. Limited clay pit, the working face is about 25 to 30 feet high, the height reportedly being limited to this value by considerations of trafficability of equipment used for excavation and hauling purposes. The soil profile exposed in the working face at the time of this investigation, consisted of about one foot of topsoil followed by about 10 feet of yellow-brown clayey silt till, then grey-brown clayey silt till. Boulders were dispersed at random throughout the soil profile, as were lenticular areas of predominantly gravel. The total overburden thickness in the vicinity of the existing limestone quarry is estimated to be in the range of 40 to 50 feet.

At the area in which boreholes were put down during this investigation, the total overburden thickness was found to be about 104 feet near the centre of the site. The predominant overburden stratum is a very dense clayey silt till which contains boulders and is similar in appearance and pattern of colouring to the material exposed in the working face at the clay pit. A wedge shaped layer of silty sand and gravel till with boulders was encountered below a depth of about 45 feet, and also as a basal layer directly above limestone bedrock. During drilling, groundwater under artesian pressure was encountered in the

upper of the two main sand and gravel till layers and in an inclusion of clayey sand and gravel.

The actual subsurface conditions observed in the clay pit, and encountered in the boreholes, are described in detail in Appendix I hereto.

### DISCUSSION

A number of factors are significant in assessing the suitability of the overburden at the subject site for cement manufacturing purposes.

These include:

- (i) the physical characteristics of the soil, and in particular its granulometric composition,
- (ii) the chemical composition of the soil, and
- (iii) practical considerations relating to mining of the soil, such as trafficability of excavating equipment, waste and boundary allowances, and the like.

#### A. Physical Characteristics

Since the Plant employs the "wet process", the most significant parameter in the present instance, in terms of physical characteristics, is the content of what is termed as uncombined silica in the form of sand and gravel. References such as Eckel (5) state that clay used in cement manufacture should be as free as possible of sand and gravel, and Meade (6) places an upper limit of 5 percent on such material coarser than the 100 mesh sieve. By reference to the grain size curves given in Appendix II, it may be seen that the content of sizes coarser than the 100 mesh sieve is greater than 5 percent for both the samples from the clay pit, and the clayey silt till obtained in the boreholes. In view of the fact that the clay pit samples

were representative of the material actually being used for cement manufacture at the time, presumably after suitable screening of the slurry to remove excess sand, it is considered that the clayey silt till at the subject site is also a suitable raw material, insofar as grain size distribution is concerned. On the other hand, the evidence is that the silty sand and gravel till is not suitable for use as a "clay" raw material for cement manufacturing purposes. This conclusion is based on tactile examination of all of the samples recovered during drilling in the sand and gravel tills and examination of the laboratory grain size distribution curves obtained on samples known to have a silt and clay content higher than was judged to be representative of these strata as a whole. The conclusion is confirmed also by information obtained relative to selective borrowing practices at the existing clay pit, and comments given by Hewitt (2) in 1960 to the effect that sandy overburden in this pit and clay too high in magnesia was rejected at that time.

#### B. Chemical Composition

Insofar as chemical composition is concerned, authoritative References such as Eckel (5) and Meade (6), indicate that the content of the following chemical constituents, both individually and in combination, are particularly significant in terms of suitability of a given clay for Portland cement manufacturing purposes: Silica ( $\text{SiO}_2$ ), Alumina ( $\text{Al}_2\text{O}_3$ ), Iron Oxide ( $\text{Fe}_2\text{O}_3$ ), Magnesia ( $\text{MgO}$ ), Lime ( $\text{CaO}$ ), Alkalies ( $\text{K}_2\text{O}$  and  $\text{Na}_2\text{O}$ ), and loss on ignition. However, inasmuch as Portland cement is formed by burning a mixture of two basic raw materials, viz. clay and lime (in this case limestone

B. Chemical Composition - (continued)

bedrock), it follows that the suitability of a given clay is not necessarily established on the basis of the chemical composition of the clay alone. The chemical composition of the limestone rock must also be considered, as the properties of the clay and limestone can supplement one another to produce a satisfactory mix, even if the properties individually of these two basic raw materials are not ideal.

As the terms of reference of this investigation thus far have been to examine the properties of the overburden at the subject site in terms of its suitability for cement manufacturing purposes, the following discussion considers the overburden on its own merits, without detailed consideration of the properties of the limestone rock, the source of which is located elsewhere on the St. Mary's Cement Co. Limited property. In this regard, References (5) and (6) give desirable criteria along the following lines for the significant chemical constituents mentioned above, considering the clay by itself. As discussed later, however, the final assessment of the suitability outright, or the degree to which the overburden at the site could be utilised for cement manufacturing purposes, may require chemical analyses of the limestone rock source and consultation with an Authority eminently qualified in cement technology:

1. Ideally the clays should not contain less than 55 percent silica and preferably from 60 to 70 percent.
2. The alumina and iron oxide together should not amount to more than one half the percentage of silica, and preferably this ratio should be about one third.

B. Chemical Composition - (continued)

3. Alkalies ( $\text{Na}_2\text{O}$  plus  $\text{K}_2\text{O}$ ) and Magnesia should be low, preferably not above 3 or 4 percent.
4. Roughly speaking, the clay should contain 2.5 to 4 times as much silica as alumina.
5. There should not be more iron oxide than alumina in the clay, the best proportion between the two being about 1 to 3.

For convenience, each of these criteria will be discussed separately below, in terms of the chemical test results obtained for both the borehole and clay pit samples.

1. The 1968 chemical tests on both the borehole and clay pit samples give a silica content in the range of 31 to 43 percent, i.e. below the desirable values. Even lower values were obtained by the St. Mary's Cement Co. Limited, as given in the "Report on Clay Reserve Studies 1965", dated January 19th, 1966. (A copy of this report is given in Appendix IV, and the results are referred to elsewhere in this report as the "1966 Tests"). This departure from ideal silica content values may in part be explainable in terms of the techniques used to prepare the samples for chemical testing, which probably result in less silica being present in the samples than there is on the average in the clay excavated from the pit by the full-face method. In any event, the apparent deficiency in silica in the clay is not in itself of major consequence, since it could readily be made good as required by the addition of silica sand of suitable quality and grading. It is therefore concluded that the clayey silt till is suitable in terms of its silica content, in the present instance.

2. The combined alumina plus iron oxide content does not exceed one half of the silica content in any of the borehole or clay pit samples tested during this investigation, and this criteria is therefore satisfied. This is also so for the 1966 Tests. The 1968 Tests, however, indicate a ratio of alumina plus iron oxide, to silica, of about 1/8 to 1/10, and the 1966 Tests similarly give a ratio of about 1/3 to 1/4. In this respect, therefore, it would appear that the clayey silt till at the subject site is not as suitable as the clay elsewhere on the St. Mary's Cement Co. Limited reserve.

It is known, however, that local areas of high iron content in the clay reserves as a whole are presently being worked for blending purposes, (see page XVIII of Appendix I). It thus appears that the desirable ratio of alumina plus iron oxide, to silica, can be produced by blending, and because of this clayey silt till at the subject site is considered suitable in terms of the criteria set forth under Item 2 above.

3. The total Alkalies in terms of  $\text{Na}_2\text{O}$  plus  $\text{K}_2\text{O}$  on all samples tested in 1968, was in the range of 0.10 to 0.18 percent, which is satisfactory.

On the other hand, the magnesia content of the 1968 borehole samples ranged from 3.44 to 14.20 percent averaging 8.14, while the corresponding range in the clay pit samples was from 3.59 to 11.30 percent with an average of 5.64. In view of the abnormally high magnesia contents of some samples in comparison to the criteria

under Item 3 above, and also the fact that in the past clay too high in magnesia was rejected at this pit, Hewitt (2), there is some doubt as to whether the clayey silt till overburden at the site in question is suitable for cement manufacturing purposes, without qualification.

In making the final assessment on this point, however, the following has to be taken into account:

- (i) From the 1966 Tests, the results from 10 boreholes (with typically 8 samples per borehole) gave a magnesia content always in excess of 3 percent, the range being 3.45 to 5.12 and the overall average about 4.77 percent.
- (ii) From (i) above, it is evident that the blending procedures presently being used at the pit enable usage of the clay with local zones of magnesia content of as high as 5 percent. The specific details of the blending are not available to us, and it is assumed that low magnesia clays or limestones are used where needed to dilute clay with excessive magnesia content. By the same token, it appears that the high magnesia content of some of the clay pit samples tested by ourselves in 1968, is being accommodated by suitable blending with other raw materials low in magnesia.

Perhaps the local high magnesia contents are offset by a low magnesia content in the limestone, for which there is some rather limited data published by Hewitt, (Refs. 2 and 3). These state that the magnesia content of the limestone from the St. Mary's Cement Co. Limited quarry was generally less than 2 percent down to a depth of 70 feet at one Diamond Drill hole designated BB49, where the overburden was 26 feet thick. In addition tests on four bulk samples are given with quoted magnesia contents of 0.86, 0.68, 0.34 and 11.28 percent, respectively. In this connection, Hewitt (2) states that "for manufacture of Portland cement, the limestone should contain less than 2.5 percent magnesia and preferably less than 2 percent magnesia", and from the limited published data all but one test indicates that the local limestone meets these criteria.

In any event, irrespective of the specific details of the



blending procedures being used, the similarity between the magnesia contents obtained in the 1968 tests on samples from the boreholes and operating clay pit would indicate that the clayey silt till at the subject site is also generally suitable as "clay" raw material. This conclusion is however, subject to the opinion of an Authority on cement technology and possibly also the outcome of additional chemical tests on the limestone rock source.

- (iii) The number of samples tested for chemical composition during this investigation, both from the boreholes and the clay pit, has been limited to a total of six from each source. Four out of six borehole samples have magnesia contents well above the range of the 1966 Test results; similarly two of the six clay pit samples have magnesia contents significantly above the general range as reported in 1966. It is possible that had more samples been tested from each source, the clayey silt till formation as a whole would look more favourable on a statistical basis, insofar as magnesia content is concerned.

In summary, therefore, it is concluded that by virtue of present usage the clayey till at the subject site is suitable for cement manufacturing purposes, despite the locally high magnesia contents; however, this conclusion is subject to the opinion of an Authority on cement technology.

4. For the borehole samples, the ratio of silica to alumina is about 10, i. e. well above the desirable limit of 4. However, the same pattern is also evident in the 1968 Tests on the samples from the clay pit.

In the 1966 Tests the usual percentages of silica and alumina were about 8 and 39 respectively, corresponding to a ratio of about 5. However, at one borehole, viz. No. 9 of Row 3, an alumina content of 5.37 percent was obtained in relation to 26.80 percent silica. The 1966 report attaches special significance to the fact that the alumina content at this borehole is lower than the usual value, and suggests additional confirmatory drilling.

From published data given by Eckel (5), it appears that deficiencies in alumina can be compensated for by addition of iron oxide, and it is presumed that this practice is being followed in order to lower the ratio of silica to alumina in the clay as used, and thus render it acceptable. In this connection, the addition of iron oxide is also desirable from the standpoint of criteria 5, a discussion of which follows.

5. All of the test results on samples recovered from this investigation, indicated that the alumina content was higher than the iron oxide. However, the ratio of iron oxide to alumina in the borehole samples is about 1 to 10 and thus below the desirable proportion of 1 to 3. For the clay pit samples the ratio is in the range of 1 to 3 and 1 to 5, approximately.

It would thus appear that addition of iron oxide would be required to reduce the alumina to iron oxide ratio, and as discussed above, this addition would serve a double purpose and make the clay more acceptable on the grounds of the criteria set out under item 4.

In connection with this item, it is noted that the 1966 Tests give a ratio of iron oxide to alumina of about 1 to 2.5.

To summarize therefore, this investigation has shown firstly that the physical and chemical characteristics of the clayey silt till overburden at the subject site are similar to the corresponding properties obtained on samples from the operating face of the existing clay pit. Because of this it is believed that the clayey silt till stratum is a suitable raw material for cement manufacturing purposes, although not necessarily in its entirety.

By a similar process of reasoning, the silty sand and gravel till is not considered suitable. From the standpoint of the results of chemical analyses on the bore-hole and clay pit samples recovered during this investigation, it is believed that with the possible exception of the content of magnesia, the composition of the clayey silt till is either satisfactory in its natural state or could be adjusted to satisfactory limits by suitable blending with raw materials, such as the limestone rock. We have some reservations about what appears to be an abnormally high magnesia content in some of the samples tested, although these reservations are subject to the opinion of an expert in cement technology. The suitability of the clayey silt till, especially where this occurs at considerable depth, is predicated to a certain extent by feasibility of mining, as discussed later.

With regard to chemical composition, a comparison is given in the Table in Appendix IV, between data obtained by chemical analysis in 1968 and results reportedly obtained by X-ray methods in 1966, elsewhere on the St. Mary's Cement Co. Limited property. This comparison shows significant differences between the two sets of results, particularly in terms of ferric oxide, alumina, calcium oxide, magnesia and alkali contents. As a consequence, the comparative ratios of silica to total of ferric oxide and alumina also show corresponding differences. We are not in a position to explain these dissimilarities between the two sets of results, and assume they are a consequence of variations in the composition of the soil rather than inherent differences between the two methods of analysis.

C. Practical Considerations

For purposes of this report, it is assumed that the present method of mining at the clay pit would be continued, namely a bench operation utilising shovels and trucks, with surface drainage of the pit and environs. It is also assumed that some of the otherwise usable clayey silt till would be sacrificed to facilitate trafficability on the pit floor following present practice; further that around the perimeter of the pit, adjacent to the highway, pit excavation would not extend beyond slope configurations which would give stability over the long term without special stabilising measures. In other words, it is not envisaged that special measures such as advance drainage using deep wells, or later use of retaining structures, would be employed so that steep slopes can be developed along the specified boundary between the highway and the pit.

D. Quantities

In examining the possible overall quantities of overburden (or usable material from the clay reserves) which will be made inaccessible for cement manufacturing purposes as a result of the Highway No. 7 By-Pass construction, two approaches have been used. Firstly, it has been assumed that the overburden which would be involved would be that corresponding to a shift of the St. Mary's Cement Co. Limited boundary from its present location to the proposed position. This involves a move at ground level of about 100 feet. Secondly, it was assumed that, in addition, a further 150 feet at ground level would be inaccessible in accordance with Reference 7,

D. Quantities - (continued)

which states on page 17, "the basic set back distance for a mining operation or for a clay, sand or gravel pit adjacent to a Provincial Highway is 210 feet from the centre line of a highway". In arriving at the figure of 150 feet, it is assumed that the highway right of way would be 120 feet wide.

With each of the above approaches, it has been assumed that excavation would not extend closer to the set back distance than the overall slope angle which is judged to be adequately stable over the long term, namely 2.5 horizontal to 1 vertical. In this connection, however, local experience indicates that steeper, and near vertical slopes can be used temporarily for the initial 30 to 40 feet of excavation, i.e. down to the first water-bearing and prominent stratum of silty sand and gravel till. On the other hand the slope in the clayey silt till, below the water-bearing silty sand and gravel till stratum, may have to be as flat as 3 horizontal to 1 vertical for long term stability depending on drainage measures used. It is considered reasonable, however, to use an overall slope of no flatter than 2.5 to 1 in computations of quantities since flattening of the lower part of the slope to 3 to 1 would involve a comparatively small amount of material and this could be available from the silty sand and gravel till and other reject from the clay pit.

Computations of quantities have also been based on straight line extrapolation of strata boundaries between boreholes, and excavation to the basal stratum of silty sand and gravel till to the east of Borehole 4, and

D. Quantities - (continued)

to the upper stratum of such till to the west of Borehole 4. An allowance of 10 percent has been made for normal wastage and reject, including the clayey silt till left as cover on the pit for trafficability reasons. On this basis, and considering only the approximately 100 foot width of acquisition, the total quantity of clayey silt till which would be involved for an overall slope of 2.5 to 1, (not including the prominent strata of silty sand and gravel till), is about 600,000 cubic yards. Allowing for an additional set back distance of 150 feet, the approximate quantities of clayey silt till involved would similarly be 1,500,000 cubic yards, approximately.

In the above quantities, no deductions have been made for "dead" space such as ramps or benches which may be required for access between the upper and lower levels of the pit, or the slopes left adjacent to the private property bordering the east end of the strip of land in question. At the same time, no deductions have been made for possible areas which may have to be abandoned on economic grounds because of say, the need to build special roadways for access, limitations of the excavation and hauling equipment, and so forth. Such factors may be important for the case of full depth excavation to the basal till. It is suggested therefore, that the economic feasibility of mining the clayey silt till to the full depth of about 90 feet (i. e. to the basal sand and gravel till stratum) would have to be also

D. Quantities - (continued)

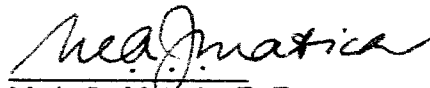
taken into account in the final assessment of the effective quantity of usable silty clay till which will be made inaccessible by the proposed property acquisition.

Respectfully submitted,



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H. W. Green, P. Eng.



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M. A. J. Matich, P. Eng.

MAJM/HWG/em

T 9099

## REFERENCES

1. Clay and Shale in Ontario, A Review -- by G.R. Guillet  
Ontario Department of Mines, March 1964.
2. The Limestone Industries of Ontario -- by D.F. Hewitt  
Ontario Department of Mines  
Industrial Mineral Report No. 5 -- 1960.
3. The Limestone Industries of Ontario 1958 - 1963 by D.F. Hewitt  
Ontario Department of Mines  
Industrial Mineral Report No. 13 -- 1964.
4. The Portland Cement Industry of Ontario -- by D.F. Hewitt  
Ontario Department of Mines  
Industrial Mineral Report No. 25 -- 1968.
5. Cements, Limes and Plasters -- by E.C. Eckel 1928.
6. Portland Cement - by R.K. Meade 1930.
7. Directions regarding Buildings, Structures, Signs and  
Land Use on or adjacent to the Kings Highway and those  
designated as Controlled -- Access Highways --  
Department of Highways Ontario, Publication LB-SB-47.



APPENDIX I

PROCEDURE

SITE AND GEOLOGY

SOIL CONDITIONS

CHEMICAL COMPOSITION

ST. MARY'S CEMENT CO. LIMITED CLAY PIT

OFFICE REPORTS ON SOIL EXPLORATION

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## PROCEDURE

The field work was carried out between March 4th, 1968 and April 2, 1968. During this period three boreholes in BX and AX casing size were put down vertically by a trailer-mounted continuous flight auger Penndrill model drill rig. Underreamers and mud-bits were used to facilitate installation of casing. Two inch diameter Shelby type thin-walled tube samples were taken in all three boreholes to a depth of about 25 feet. Below this depth the soil was too hard for sampling by Shelby tube and therefore two inch outside diameter standard split spoon samples (sampler equipped with sleeves) were taken down to 65 feet in Borehole 1A and to 90 feet each in Boreholes 6 and 4. In Boreholes 1A and 4 a modified split-spoon sampler of 1-13/16 inch outside diameter was used to obtain samples in the overburden below the above depths when casing size reduction from BX to AX size was necessitated because of boulders and very hard ground. In Borehole 1, the BX casing was broken at a depth of about 45 feet as a result of difficult drilling conditions and a new borehole, Borehole 1A, was put down about 5 feet 9 inches to the south of Borehole 1. Boreholes 1A and 6 were terminated in the stratum of very dense silty sand and gravel till with numerous boulders, at depths of 94.5 feet and 93.5 feet, respectively.

PROCEDURE (continued)

II

The borehole which was centrally located on the site, namely, Borehole 4, encountered bedrock at 103.7 feet depth and was terminated in bedrock at 133.7 feet. It was the only borehole in which bedrock was cored and this was carried out in AXT size. Piezometers were installed in Boreholes 4 and 6 at the elevations shown on the borehole logs.

Sampling was carried out using a driving energy of 4560 inch-pounds produced by a 240 pound hammer dropping 19 inches, since little penetration and thus sample recovery could be effected by the Standard Penetration Test procedure of a 140 pound hammer dropping 30 inches, which was initially attempted. Where blow counts on the sampler are recorded, these have been converted to a driving energy of 4200 inch-pounds using a ratio of 4560 to 4200. The driving resistances given on the borehole logs are thus not Standard "N" values.

The locations of the boreholes are shown on Drawing T9099-1, and the inferred soil and bedrock stratigraphy is given on Drawing T9909-2, both at the rear of this report. Detailed logs of the individual boreholes are given as Office Reports on Soil Exploration in Appendix I.

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Soil mechanics testing of the samples was carried out in the Laboratory of Geocon Ltd in Toronto. The chemical composition of both borehole and clay pit samples was determined at the Toronto Laboratories of Warnock-Hersey International Limited. Samples remaining after testing will be retained until March 1969, at which time you will be contacted for instructions regarding their disposal.

Survey work for location of the boreholes in the field was carried out by the Field Staff of the Department of Highways, Ontario, and under the supervision of Mr. Hugh McCoogan.

SITE AND GEOLOGY

The site investigated is located on the St. Mary's Cement Co. Limited property about one mile south of the Town of St. Mary's, Ontario in Perth County. The strip of land in question also lies along the east-west boundary line dividing Perth and Oxford Counties.

As part of the initial study of this problem, early and recent geological reports and maps were studied as indicated in the List of References given earlier in the report. In addition, aerial photographs were studied. The general area containing the

site is underlain by glacial till overlying limestone bedrock of the Delaware and Detroit formation, as described in References 2 and 3. The surface of the till sheet rises gently to the east and north-east from an elevation of about 1075 at the site to over 1200 to the east. The area is drained principally by the Thames River on which the Town of St. Mary's is located at its junction with Trout Creek. Drainage along these watercourses and in subsidiary creeks is generally to the south or west.

The surface of the till is flat or gently rolling for the most part and previous geological investigations have indicated that the area is located in a region which apparently was free of ice during the latter part of the Wisconsin glaciation. Reference 1. Furthermore, the area apparently was never occupied by glacial Lake Warren so that till generally extends directly to the surface of the ground (with the exception of the organic topsoil) and is not overlain by the Lake Warren clay deposits which are so widespread west and south of London, Ontario. This "island" so described within which St. Mary's is located, extends in large triangular fashion as far east as the Niagara Escarpment and as far north as Walkerton and Flesherton. The clays deposited in Lake Warren in all probability were derived from erosion of these tills.

In the site area, the soil deposits generally thicken between St. Mary's on the north and the site investigated. An estimate of the thickness of the overburden in the existing limestone quarry area is about 40 to 50 feet, whereas at the site under investigation, the soil deposits reach a thickness of about 104 feet in Borehole 4.

The till sheet overlying the limestone bedrock appears to be continuous throughout the site area except near the valley of the Thames River where sand and gravel overlying the till or bedrock is being excavated at the present time. In depth, however, the clay till does not maintain its typical nature throughout, for this investigation has shown that below a depth of about 50 feet below ground surface a wedge-shaped stratum of silty sand and gravel till which thickens towards the west, is present as shown on Geocon Ltd Drawing No. T9099-2. In this particular instance, the sand and gravel wedge appears to thin out before reaching the ground surface.

At the existing St. Mary's Cement Co. Limited "clay" pit where the upper portion of the clayey silt till is being excavated for use in the manufacture of cement, the till exhibits a certain amount of crude stratification. In addition, occasional lenticular flat-lying lenses of coarse sand and gravel of a few feet in horizontal

diameter and a foot or so in thickness have also been observed. It has been reported\* that undesirable pockets of sand in the clayey silt till have been encountered which, if sufficiently large, were rejected at the working face, rather than being transported to the Plant with the useable material. The height of the clay pit working face is approximately 25 feet, and is reportedly\* controlled at this height by the fact that its toe is at, or close to, an unstable water-bearing layer (presumably of silt or sand) which hampers trafficability of the excavating and hauling equipment presently being used. In addition, the stoney material of large size is reportedly\* to be rejected at the face to the extent practical, and the remainder is taken out at the Plant. A photograph of the stoney material which has been removed from the till at the Plant is given on Photograph 3 in Appendix III. It has been reported\* that the appearance of the till is much the same throughout the whole of the area of the clay pit excavated thus far, although its chemical composition apparently varies from place to place. The upper 9 or 10 feet of the clay till below the topsoil is generally of yellow-brown colour. Silty lenses occur in this layer and a sand seam a foot or so in thickness is

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\* Discussions with personnel of the St. Mary's Cement Co. Limited.

frequently exposed at its lower boundary. The upper yellow-brown layer has probably been formed by weathering of the underlying brown-grey or blue-grey till.

Bedrock is composed of bedded limestone which in the regional sense is reported to strike generally northwesterly with a very gentle southwesterly dip. At the limestone surface at one location along the rim of the quarry working face, the rock is jointed at  $070^{\circ}$  and  $160^{\circ}$  (azimuth). The glacial striae strike at about  $310^{\circ}$  at the same location.

#### SOIL CONDITIONS

##### Topsoil

The topsoil is black in colour and is composed of silt with a high proportion of organics. It is frequently 12 to 18 inches in thickness although roots extend to depths of a foot or more below this depth when viewed in full exposure at the clay pit.

##### Very Dense Clayey Silt Till with Boulders

Lying directly beneath the layer of topsoil, is a stratum of clayey silt till which may vary from reddish-grey to bluish grey or brownish grey from place to place beneath



Very Dense Clayey Silt Till with Boulders (continued)

an upper, oxidized yellow-brown weathered layer. The grey and yellow-brown parts of this overall stratum have been separated by a dotted line on the borehole logs and on the stratigraphic profile on Drawing T9099-2.

In the boreholes the yellow brown layer varies in thickness from 12.5 feet in Borehole 1 to 14.5 feet in Borehole 6 and 9 feet in Borehole 4. Laboratory examination of the soil samples from this stratum indicates that it contains layers of almost pure yellow silt and silty fine sand 6 inches to about 17 inches in thickness.

Directly underlying the surficial yellow-brown layer is the grey clayey silt till in which the predominant colouring is generally brownish-grey. For purposes of this description the clayey silt till stratum is assumed to extend from ground surface to 48 feet in Borehole 1 and to 90 feet and 88 feet depths respectively in Boreholes 4 and 6, except where interrupted by inclusions of silty sand and gravel till contained within it in the same three boreholes and described in the next section. These inclusions are also shown on Drawing No. T9099-2, attached. In Borehole 4 at a depth of about 66 feet, a 7.5 foot thick inclusion of loose clayey sand and gravel was encountered which at the time contained

Very Dense Clayey Silt Till with Boulders (continued)

water under artesian head.

Ten grain size analysis have been performed on samples from this overall stratum, the results of which are shown graphically on Figure 1 of Appendix II for the yellow-brown till, and on Figure 2 for the brown-grey till. For the lower part of the stratum of brown-grey till, the curves indicate a trend towards coarser material in a westerly direction, i. e. from Borehole 6 to Borehole 4. The grain size curves do not reflect the presence of rock particles greater than 2 inches in diameter, i. e. the inside diameter of the sampler used. Boulders were, however, encountered during drilling and are also visible in exposures of this formation in the existing clay pit.

Grain size analyses were carried out on samples of the clayey silt till taken from two areas of the existing clay pit which were being worked at the time of this investigation. The results are given for comparative purposes on Figures 4 and 5 of Appendix II.

Wet unit weight determinations from two samples from Borehole 1 indicated values of 129.2 pounds per cubic foot

Very Dense Clayey Silt Till with Boulders (continued)

and 121.5 pounds per cubic foot in the weathered layer and in the fresh till respectively. Moisture content determinations from 6 samples yielded values of 9.9 percent and 13.4 percent in the yellow brown layer and 7.4, 10.6, 18.2 and 10.8 percent in the brown-grey till. Atterberg limit tests carried out on samples from Boreholes 6 and 12 in the brown-grey till gave Liquid Limits of 17.5 and 21.5 and corresponding Plastic Limits of 11.8 and 12.6.

Chemical tests were carried out on samples from this stratum and the results are presented in Appendix IV.

In the yellow-brown till, the adjusted "N" values obtained ranged from 17 to 65 with an average value of 47. In Boreholes 1, 1A, 4 and 6 the adjusted "N" values obtained in the brown-grey till varied from 21 to greater than 100, with a general value in excess of 100. On the basis of these results, this stratum has been described as being in a very dense condition.

Very Dense Silty Sand and Gravel Till with Boulders

Very dense silty sand and gravel till was encountered in all boreholes as shown on the borehole logs and Drawing T9099-2. Below approximate elevation 1045 the silty sand and gravel till is

Very Dense Silty Sand and Gravel Till  
with Boulders (continued)

believed to occur in the form of wedges generally thickening to the west as shown and varying in thickness from 4 feet in Borehole 6 to 44 feet in Borehole 1 for the main deposit. Smaller deposits are shown and appear to vary from near zero thickness in Borehole 4 to about 5 feet in Borehole 1. The near zero thickness in Borehole 4 is inferred from the fact that localised caving occurred at about the same elevation as the silty sand and gravel layer of 5 foot thickness in Borehole 1.

Glacial tills, by the very nature of their method of formation, are generally heterogeneous in composition, particularly in regard to grain size. This is for the most part true of the tills encountered at this site. Nevertheless, observations of the till in the clay pit indicate occasional crude stratification over short distances and in fact layers of sand and gravel have been reported by the Cement Plant Personnel. For these reasons, it is logical to expect that the intersections of silty sand and gravel tills in each borehole do in fact extend in crudely regular stratification between the boreholes as inferred on the soil stratigraphy on Drawing T9099-2.

Very Dense Silty Sand and Gravel Till  
with Boulders (continued)

When the silty sand and gravel till layer was encountered primarily in Borehole 4 at a depth of 47 feet, a definite change in response to drilling was observed so that it became very difficult to continue with the flight augers with which the boring was started. Drill casing had to be employed and the borehole advanced by first drilling ahead of the casing with a mud bit or core barrel equipped with diamond bit. In Borehole 1A, a diamond-faced under-reamer was used in this stratum with success. In this stratum also, soil samples were most difficult to recover whereas in the clayey silt till they were comparatively easy to obtain. In the silty sand and gravel till stratum, the samples which were obtained more-or-less intact were believed to be recovered because they contained more fine-grained material than exists elsewhere in this stratum. In this respect, results of grain size analyses of samples which were recovered from this stratum are shown in Figure 6, Appendix II. In examining these results however, it should be borne in mind, that as already mentioned, the amount of fines present are higher than elsewhere in the stratum.

Very Dense Silty Sand and Gravel Till  
with Boulders (continued)

Because this formation is obviously unsuitable as "clay" for cement manufacturing purposes, no other detailed soil engineering or chemical tests were carried out on samples recovered.

In Boreholes 1, 1A, 4 and 6, "N" values obtained in this formation ranged from 78 to 127 with values generally being in excess of 100. From these results, these strata have been described as very dense.

Very Dense Silty Sand and Gravel Till  
with Numerous Boulders

Underlying the silty sand and gravel till stratum in Borehole 1A, and beneath the clayey silt till in Boreholes 4 and 6, is a stratum of silty sand and gravel till which is similar to the silty sand and gravel till above it except that it is believed to contain a larger percentage of boulders. Because of the high proportion of boulders, it was exceedingly difficult to penetrate and only in one borehole, namely, Borehole 4, was complete penetration achieved. Here, the till was found to overlie bedrock directly, its thickness being 13.7 feet. The high boulder content precluded the practical use of the Standard Penetration Test in the stratum.

Bedrock

One borehole only intersected bedrock and it was cored in AXT size. Core recovery was not large, believed to be due primarily to machine vibration rather than due to any abnormal or poor condition of the bedrock. The bedrock was cored to a depth of 30 feet and is composed of buff-grey fine to medium-grained fossiliferous limestone. A 6 inch void was encountered at a depth of about 15 feet below rock surface. Bedrock is generally dense and fresh but contains a weathered layer about 4 to 5 feet in thickness at the surface judging from the presence of weathered seams. The bedding indicates the rock to be nearly flat-lying.

WATER CONDITIONS

Temporary artesian conditions were encountered in Borehole 4 at a depth of about 70 feet where loose coarse clayey sand and gravel was encountered. A hydrostatic head of 7 feet was measured above ground surface in BX casing when the borehole was at this depth. A piezometer installed in this layer gave a water level at elevation 1006.6 about two months after installation which indicated that the artesian condition had completely dissipated by that time.

In Borehole 6, a piezometer was installed at a depth of 43 feet at the top of the silty sand and gravel till layer. Two months after installation, the piezometer registered a water level at elevation 1058.7. After completion of drilling operations in this Borehole and before installation of the piezometer, the Borehole was left open for a period of about two days. During this time, the Borehole filled up with soil inside the casing to a depth of about 32 feet below ground level. The casing was removed and the borehole washed to a depth of a little over 50 feet before soil material was introduced into the borehole upon which to rest the bottom of the piezometer. Because of the artesian condition producing a slight flow from the borehole it was difficult to force the piezometer tip down to the required depth.

In Borehole 1, water was observed coming into the borehole at a depth of about 5 feet below ground but this may have been due to the tile drainage system which was observed adjacent to Borehole 6, and thought to be generally prevalent throughout the farmland area.

#### CHEMICAL COMPOSITION

Six tube samples of the clayey silt till were picked at random from the three boreholes and, similarly, 6 bulk samples were selected from a group of 25 such samples taken from the



bench working face at the clay pit over several successive days. All twelve samples were sent to Warnock-Hersey International Limited in Toronto for "100 percent chemical analyses", to determine the content of basic constituents known to be important in terms of usage of the soil for cement manufacturing purposes. The results of these tests are given in Appendix IV.

Also included in Appendix IV are the results of X-ray analyses of soil samples taken from 9 Auger holes put down by others in 1966 on the St. Mary's Cement Co. Limited property south of the limestone quarry. These results were made available to us by the St. Mary's Cement Co. Limited. As can be seen from Table I, which contains a summary of these results together with comparative averages, there are significant differences between the two analyses particularly in the percentages reported for ferric oxide and alumina.

#### ST. MARY'S CEMENT CO. LIMITED CLAY PIT

##### Excavation of Clayey Silt Till

Immediately south of the limestone quarry area of the St. Mary's Cement Co. Limited plant a considerable amount of the existing clayey silt till, referred to locally as "clay" is being excavated from an operating pit and used in the manufacture of cement. General plant operations have been described previously

Excavation of Clayey Silt Till (continued)

by D. F. Hewitt in Ontario Department of Mines publications mentioned earlier as References 2, 3 and 4.

The approximate location of the working face in the pit at the time of this investigation is shown on Geocon Ltd Drawing No. T9099-2, as is also the approximate present location of the limestone quarry working face. No precise surveying was used in determining these locations. The "clay" in the clay pit is excavated by means of a shovel and truck operation as shown in Photograph 1, Appendix III, using the full-face method on a working face about 25 feet. high. The trucks carry the excavated clay to the Plant along a route located around the rim of the quarry. At the Plant, the clay is used, after extraction of the stone, in the "wet process" of cement manufacture. The stoney material extracted from the clay is presently being stock-piled as waste to the south of the Plant. A photograph of the waste stone pile is shown in Appendix III.

Excavation of the clay is a continuous year-round operation. It is reported\* that during the Winter, the topsoil is left in place and utilized to insulate the underlying clay till

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\* Discussions with personnel of St. Mary's Cement Co. Limited

Excavation of Clayey Silt Till (continued)

from the frost and thus facilitate digging operations. In the Summer, the topsoil is stripped and stock-piled for future use in landscaping.

Operation of the clay pit has extended over a fairly wide area and is reportedly\* controlled by a variety of factors. Although the appearance and structure of the clayey silt till in exposures in the pit is remarkably uniform, its chemical composition is understood\* to vary a great deal from place to place so that digging operations may encounter separate areas of high iron content, low alumina content or high silica. The various areas appear to be worked intermittently, presumably as called for by blending requirements to produce clay raw material with the desired chemical characteristics. Another factor which affects the clay pit operation is the trafficability of the construction equipment. During the period of this survey, it was reported that the elevation of the floor at the working face in the clay pit was selected so that the dipper shovel could manoeuvre without difficulty. This floor elevation reportedly had to be maintained about 3 feet above an unstable water-bearing silt layer, to prevent

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\* Discussions with personnel of St. Mary's Cement Co. Limited

Excavation of Clayey Silt Till (continued)

the shovel from becoming immobilized by sinking into the pit floor when continual digging took place in one location. In the Spring when thawing conditions prevailed, movement of the trucks was observed to be considerably hampered by the mud conditions produced in the clayey silt till. To the east of the main clay pit, a subsidiary pit in which the clay contained a high percentage of ferric oxide had to be temporarily abandoned. The only way it could be worked at the time, was to build a rock fill roadway into the pit in order that excavation and hauling equipment could operate without bogging down. It was reported that for the present, it was not economical to operate this subsidiary pit.

Natural drainage in the Plant area is in a direction which crosses the excavation areas from the east towards the Thames River located on the western side of the property. In order to continue excavation operations, temporary dykes and ditches have been constructed over the years to divert the main drainage stream, and it is understood that additional drainage measures will be utilised in the future for the same reason.

During excavation operations, vertical or near-vertical slopes are formed and found to be stable over the short term between excavation cycles. However, in one area where a finished slope was

Excavation of Clayey Silt Till (continued)

flattened by backfilling and then grassed about one year ago, a slope of about  $15^{\circ}$  on the average (about 3.5 horizontal to 1 vertical) is known to be stable. This slope configuration is much flatter than that adopted locally in road cuts in similar soils along existing Highways 7 and 19 where slopes of about  $25^{\circ}$  on the average were measured, i. e. about 2.2 horizontal to 1 vertical. The position of the groundwater table in the road-way cuts, however, is not known accurately. This factor must be borne in mind in assessing the long-term stable slope angles in clayey silt tills of the type at the subject site.

## EXPLANATION OF THE FORM "OFFICE REPORT ON SOIL EXPLORATION"

The object of this form is to enable a comprehensive study of the soil to be made by combining on one sheet all of the information obtained from the boring. An explanation of the various columns of the report follows.

### ELEVATION AND DEPTH

This column gives the elevation and depth of boundaries between the various soil strata. The elevation is referred to the datum shown in the general heading.

### WATER CONDITIONS

In this column the water level in the casing at the time of boring or the water table in the ground, determined by a series of observations in a piezometer or standpipe, is indicated to scale by a horizontal line with the symbol W.L. or W.T. above the line. A notation of any complicated groundwater conditions will be made in this column.

### DESCRIPTION

A description of the soil, using standard terminology, is contained in this column. The consistency of cohesive soils and the relative density of non-cohesive soils are described by the following terms:

<u>Consistency</u>	<u>U-Strength Tons/sq. ft.</u>	<u>Relative Density</u>	<u>Standard Penetration Resistance, Blows/ft.</u>
Very soft	0.03 to 0.25	Very loose	0 to 4
Soft	0.25 to 0.5	Loose	4 to 10
Firm	0.5 to 1.0	Compact	10 to 30
Stiff	1.0 to 2.0	Dense	30 to 50
Very stiff	2.0 to 4.0	Very dense	over 50
Hard	over 4.0		

### STRATIGRAPHIC PLOT

The stratigraphic plot follows the standard symbols of the National Research Council, Canada.

### ELEVATION SCALE

The information in all columns is plotted to a true elevation scale which is shown in this column.

### GRAPHS

The main body of the report forms a graph which is used to plot to correct elevation the important soil properties which are obtained through field and laboratory tests. The scales and symbols for the plotting are shown at the head of the column.

### OTHER TESTS

In this column are shown, by symbol, the other field or laboratory tests which have been performed on the soil and for which the results have not been plotted on the above graph.

### SAMPLES

The first three columns describe the condition, type and number of each sample obtained from the boring. The location and extent of each sample is plotted to scale.

In the last column is shown the penetration resistance in blows of 4200 inch-pounds required to drive one foot of the sampler into the ground. When a 2 inch Drive Sampler is used the result obtained is termed the "Standard Penetration Resistance".

**GEOCON**



CONTRACT I9099 BORING # 1A DATUM GEODETIC CASING BX & AX  
BORING DATE MAR 25 1968 REPORT DATE APR 11 1968 COMPILED BY AEL CHECKED BY MA-M  
SAMPLER HAMMER 27 LBS. DROP 13 INCHES (PENETRATION RESISTANCES CONVERTED TO BLOWS OF 4200 IN. LBS. ENERGY)

## SAMPLE TYPES

## ABBREVIATIONS



**DISTURBED  
FAIR  
GOOD  
LOST**

A.S. - AUGER SAMPLE  
S.T. - SLOTTED TUBE  
W.S. - WASHED SAMPLE  
D.O. - DRIVE-OPEN  
D.F. - DRIVE-FOOT VALVE  
C.S. - CHUNK SAMPLE

F.S - FOIL SAMPLE  
S.O - SLEEVE-OPEN  
S.F - SLEEVE-FOOT VALVE  
T.O - THIN WALLED OPEN  
R.C - ROCK CORE

V - IN-SITU VANE TEST  
M - MECHANICAL ANALYSIS  
U - UNCONFINED COMPRESSION  
QC - TRIAXIAL CONSOLIDATED UNDRAINED  
Q - TRIAXIAL UNDRAINED  
S - TRIAXIAL DRAINED

7 - WET UNIT WEIGHT  
K - PERMEABILITY  
C - CONSOLIDATION

WL - WATER LEVEL IN CASING  
WT - WATER TABLE IN SOIL

SOIL PROFILE				SAMPLES					
ELEV. DEPTH	WATER CONDITIONS	DESCRIPTION	STRAT. ELEV. SCALE	WATER CONTENT W%	OTHER TESTS	CONDITION	TYPE	NUMBER	PENETRATION RESISTANCE BLOWS/FT.
				⊙ NAT. ⊠ LW ▲ PW					
				DYNAMIC PENETRATION TEST BLOWS PER FOOT					
1074.4 C.O.		GROUND LEVEL	1080						
		NO SAMPLES TAKEN	1070						
		SEE BORE-OLE No 1	1060						
			1050						
			1040						
			1030						
1024.4 48.0		VERY DENSE BROWN - GREY SAND AND GRAVEL	1020				WS	1	-
1022.4 54.0		WITH BOULDERS	1010				WS	2	-
1017.4 57.0		VERY DENSE CLAYEY SILT	1000				WS	3	100
		VERY DENSE SILTY SAND AND GRAVEL TILL WITH BOULDERS	990			M	WS	4	100
			980			M	WS	5	100
			970			M	WS	6	100
			960			M	WS	7	100
			950			M	WS	8	100
			940			M	WS	9	100
			930			M	WS	10	100
			920			M	WS	11	100
			910			M	WS	12	-
			900			M	WS	13	-
			890			M	WS	14	-
			880			M	WS	15	-
			870			M	WS	16	-
			860			M	WS	17	63
			850			M	WS	18	-
			840			M	WS	19	67
			830			M	WS	20	-
			820			M	WS	21	100
			810			M	WS	22	-
			800			M	WS	23	-
			790			M	WS	24	-
			780			M	WS	25	-
			770			M	WS	26	-
			760			M	WS	27	-
			750			M	WS	28	-
			740			M	WS	29	-
			730			M	WS	30	-
			720			M	WS	31	-
			710			M	WS	32	-
			700			M	WS	33	-
			690			M	WS	34	-
			680			M	WS	35	-
			670			M	WS	36	-
			660			M	WS	37	-
			650			M	WS	38	-
			640			M	WS	39	-
			630			M	WS	40	-
			620			M	WS	41	-
			610			M	WS	42	-
			600			M	WS	43	-
			590			M	WS	44	-
			580			M	WS	45	-
			570			M	WS	46	-
			560			M	WS	47	-
			550			M	WS	48	-
			540			M	WS	49	-
			530			M	WS	50	-
			520			M	WS	51	-
			510			M	WS	52	-
			500			M	WS	53	-
			490			M	WS	54	-
			480			M	WS	55	-
			470			M	WS	56	-
			460			M	WS	57	-
			450			M	WS	58	-
			440			M	WS	59	-
			430			M	WS	60	-
			420			M	WS	61	-
			410			M	WS	62	-
			400			M	WS	63	-
			390			M	WS	64	-
			380			M	WS	65	-
			370			M	WS	66	-
			360			M	WS	67	-
			350			M	WS	68	-
			340			M	WS	69	-
			330			M	WS	70	-
			320			M	WS	71	-
			310			M	WS	72	-
			300			M	WS	73	-
			290			M	WS	74	-
			280			M	WS	75	-
			270			M	WS	76	-
			260			M	WS	77	-
			250			M	WS	78	-
			240			M	WS	79	-
			230			M	WS	80	-
			220			M	WS	81	-
			210			M	WS	82	-
			200			M	WS	83	-
			190			M	WS	84	-
			180			M	WS	85	-
			170			M	WS	86	-
			160			M	WS	87	-
			150			M	WS	88	-
			140			M	WS	89	-
			130			M	WS	90	-
			120			M	WS	91	-
			110			M	WS	92	-
			100			M	WS	93	-
			90			M	WS	94	-
			80			M	WS	95	-
			70			M	WS	96	-
			60			M	WS	97	-
			50			M	WS	98	-
			40			M	WS	99	-
			30			M	WS	100	-
			20			M	WS	101	-
			10			M	WS	102	-
			0			M	WS	103	-
						M	WS	104	-
						M	WS	105	-
						M	WS	106	-
						M	WS	107	-
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						M	WS	204	-
						M	WS	205	-
						M	WS	206	-
						M	WS	207	-
						M	WS	208	-
						M	WS	209	-
						M	WS	210	-
						M	WS	211	-
						M	WS	212	-
						M	WS	213	-
						M	WS	214	-
						M	WS	215	-
						M	WS	216	-
						M	WS	217	-
						M	WS	218	-
						M	WS	219	-
						M	WS	220	



## GEOCON

## OFFICE REPORT ON SOIL EXPLORATION

CONTRACT T9099 BORING # 4 DATUM GEODETIC CASING BX & AX  
 BORING DATE MAR 6-1968 REPORT DATE APR 15, 1968 COMPILED BY ASL CHECKED BY MAJUM  
 SAMPLER HAMMER WT. 240 LBS. DROP 19 INCHES (PENETRATION RESISTANCES CONVERTED TO BLOWS OF 4200 IN. LBS. ENERGY)

## SAMPLE CONDITION

 DISTURBED  
 FAIR  
 GOOD  
 LOST

A.S. - AUGER SAMPLE  
 S.T. - SLOTTED TUBE  
 W.S. - WASHED SAMPLE  
 D.O. - DRIVE-OPEN  
 D.F. - DRIVE-FOOT VALVE  
 C.S. - CHUCK SAMPLE

## SAMPLE TYPES

F.A. - FOIL SAMPLE  
 S.O. - SLEEVE-OPEN  
 S.F. - SLEEVE-FOOT VALVE  
 T.O. - THIN WALLED OPEN  
 R.C. - ROCK CORE  
 L/C. - LOST CORE

## ABBREVIATIONS

V - IN-SITU VANE TEST  
 M - MECHANICAL ANALYSIS  
 U - UNCONFINED COMPRESSION  
 UC - TRIAXIAL CONSOLIDATED UNDRAINED  
 Q - TRIAXIAL UNDRAINED  
 S - TRIAXIAL DRAINED  
 CA - CHEMICAL ANALYSIS  
 γ - WET UNIT WEIGHT  
 K - PERMEABILITY  
 C - CONSOLIDATION  
 WL - WATER LEVEL IN CASING  
 WT - WATER TABLE IN SOIL

## SOIL PROFILE

## DESCRIPTION

SOIL PLOT  
 ELEVATION  
 SCALE

WATER CONTENT WS

0 NAT. 0 LW Δ Pw

DYNAMIC PENETRATION TEST BLOWS PER FOOT

OTHER  
TESTS

## SAMPLES

CONDITION  
 TYPE  
 NUMBER  
 PENETRATION  
 RESISTANCE  
 BLOWS/FT.

GROUND LEVEL  
 TOPSOIL

VERY DENSE  
 YELLOW - BROWN  
 CLAYEY SILT TILL

VERY DENSE  
 BROWN GREY  
 CLAYEY SILT TILL  
 WITH BOULDERS

VERY DENSE  
 SILTY SAND  
 AND GRAVEL TILL  
 WITH BOULDERS

VERY DENSE  
 CLAYEY SILT TILL  
 WITH BOULDERS

LOOSE  
 CLAYEY SAND  
 AND GRAVEL

VERY DENSE  
 BROWN - GREY  
 CLAYEY SILT TILL  
 WITH BOULDERS

VERY DENSE  
 SILTY SAND  
 AND GRAVEL TILL  
 WITH NUMEROUS  
 BOULDERS

LIMESTONE  
 BEDROCK

END OF HOLE

M, CA

M, CA

M

M

RC  
RECON.  
28%

100%

22%

94%

100%

100%

85%

75%

HYD  
PUSH

DRIVEN

-

-

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## GEOCON

## OFFICE REPORT ON SOIL EXPLORATION

CONTRACT T 3099 BORING # 6 DATUM GEODETIC CASING BX  
 BORING DATE MAR 28-30/68 REPORT DATE APR 15, 1968 COMPILED BY AEL CHECKED BY MAIM  
 SAMPLER HAMMER WT. 240 LBS DROP 19 INCHES (PENETRATION RESISTANCES CONVERTED TO BLOWS OF 4200 IN. LBS. ENERGY)

## SAMPLE CONDITION



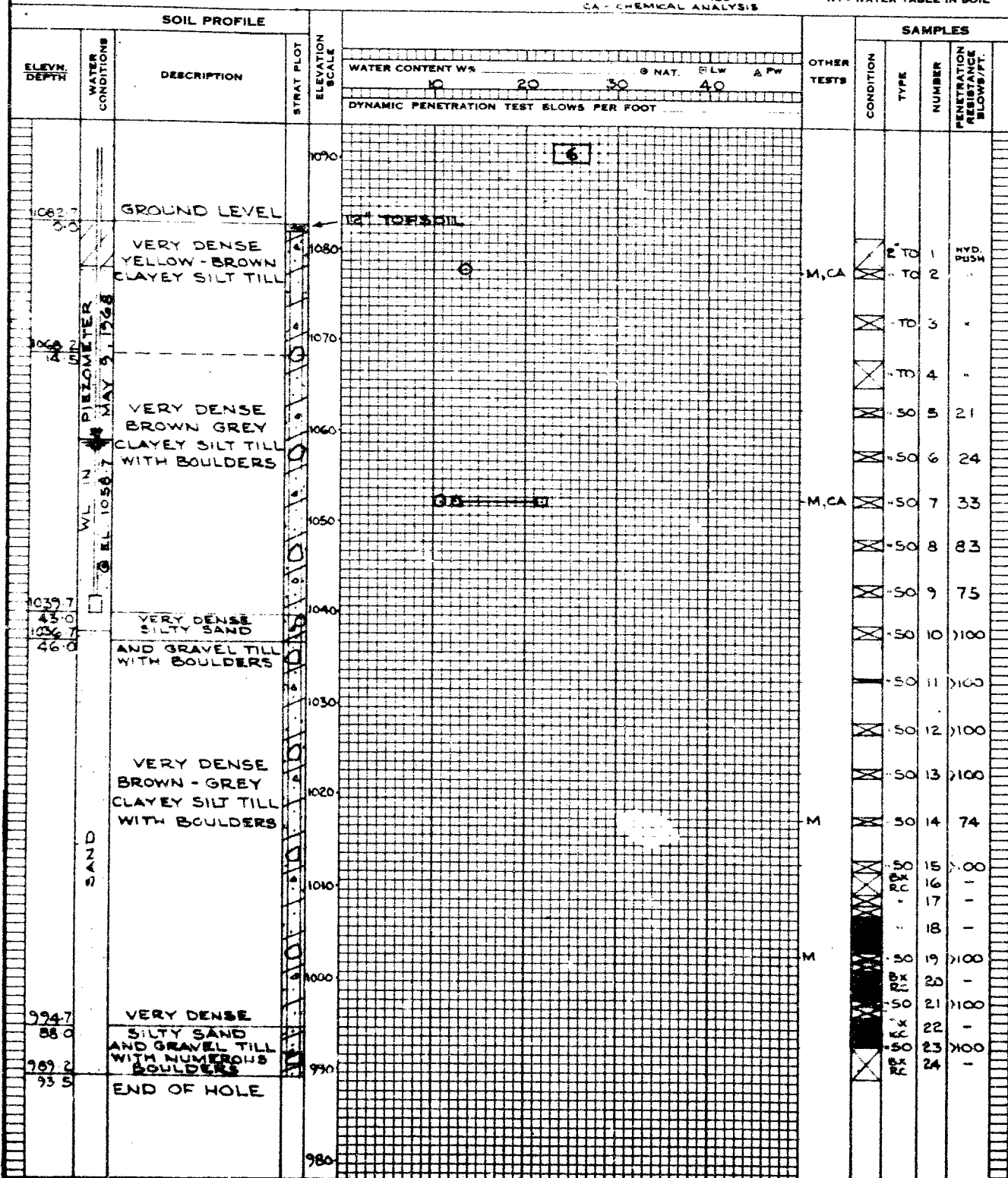
A.S. - AUGER SAMPLE  
 S.T. - SLOTTED TUBE  
 W.S. - WASHED SAMPLE  
 D.O. - DRIVE-OPEN  
 D.F. - DRIVE-FOOT VALVE  
 C.S. - CHUNK SAMPLE

## SAMPLE TYPES

F.S. - FOIL SAMPLE  
 S.O. - SLEEVE-OPEN  
 S.F. - SLEEVE-FOOT VALVE  
 T.O. - THIN WALLED OPEN  
 R.C. - ROCK CORE

## ABBREVIATIONS

V - IN-SITU VANE TEST  
 M - MECHANICAL ANALYSIS  
 U - UNCONFINED COMPRESSION  
 OC - TRIAXIAL CONSOLIDATED UNDRAINED  
 Q - TRIAXIAL UNDRAINED  
 S - TRIAXIAL DRAINED  
 CA - CHEMICAL ANALYSIS  
 Y - WET UNIT WEIGHT  
 K - PERMEABILITY  
 C - CONSOLIDATION  
 WL - WATER LEVEL IN CASING  
 WT - WATER TABLE IN SOIL



APPENDIX II

FIGURES -- LABORATORY TESTING

**GEOCON**

## BOREHOLE SAMPLES

APPENDIX II  
FIGURE I  
PROJECT T9099

WITH BOULDERS

PERCENT FINER THAN

GRAIN SIZE - MM

LEGEND

Sample No. 1

Sample No. 2

SIZE OF OPENING - INS. U.S.S. SIEVE SIZE - MESHES / IN. EQUIVALENT GRAIN DIAMETER - MM

Grain Size (mm)	Sample No. 1 (%)	Sample No. 2 (%)
100	100	100
60	100	100
40	100	100
20	100	100
10	100	100
6.3	100	100
4.75	100	100
3.55	100	100
2.5	100	100
1.75	100	100
1.18	100	100
0.85	100	100
0.6	100	100
0.425	100	100
0.3	100	100
0.25	100	100
0.2	100	100
0.15	100	100
0.125	100	100
0.1	100	100
0.075	100	100
0.06	100	100
0.05	100	100
0.04	100	100
0.035	100	100
0.03	100	100
0.025	100	100
0.02	100	100
0.015	100	100
0.0125	100	100
0.01	100	100
0.0075	100	100
0.006	100	100
0.005	100	100
0.004	100	100
0.0035	100	100
0.003	100	100
0.0025	100	100
0.002	100	100
0.0015	100	100
0.00125	100	100
0.001	100	100
0.00075	100	100
0.0006	100	100
0.0005	100	100
0.0004	100	100
0.00035	100	100
0.0003	100	100
0.00025	100	100
0.0002	100	100
0.00015	100	100
0.000125	100	100
0.0001	100	100
0.000075	100	100
0.00006	100	100
0.00005	100	100
0.00004	100	100
0.000035	100	100
0.00003	100	100
0.000025	100	100
0.00002	100	100
0.000015	100	100
0.0000125	100	100
0.00001	100	100
0.0000075	100	100
0.000006	100	100
0.000005	100	100
0.000004	100	100
0.0000035	100	100
0.000003	100	100
0.0000025	100	100
0.000002	100	100
0.0000015	100	100
0.00000125	100	100
0.000001	100	100
0.00000075	100	100
0.0000006	100	100
0.0000005	100	100
0.0000004	100	100
0.00000035	100	100
0.0000003	100	100
0.00000025	100	100
0.0000002	100	100
0.00000015	100	100
0.000000125	100	100
0.0000001	100	100
0.000000075	100	100
0.00000006	100	100
0.00000005	100	100
0.00000004	100	100
0.000000035	100	100
0.00000003	100	100
0.000000025	100	100
0.00000002	100	100
0.000000015	100	100
0.0000000125	100	100
0.00000001	100	100
0.0000000075	100	100
0.000000006	100	100
0.000000005	100	100

**M.I.T. GRAIN SIZE SCALE**

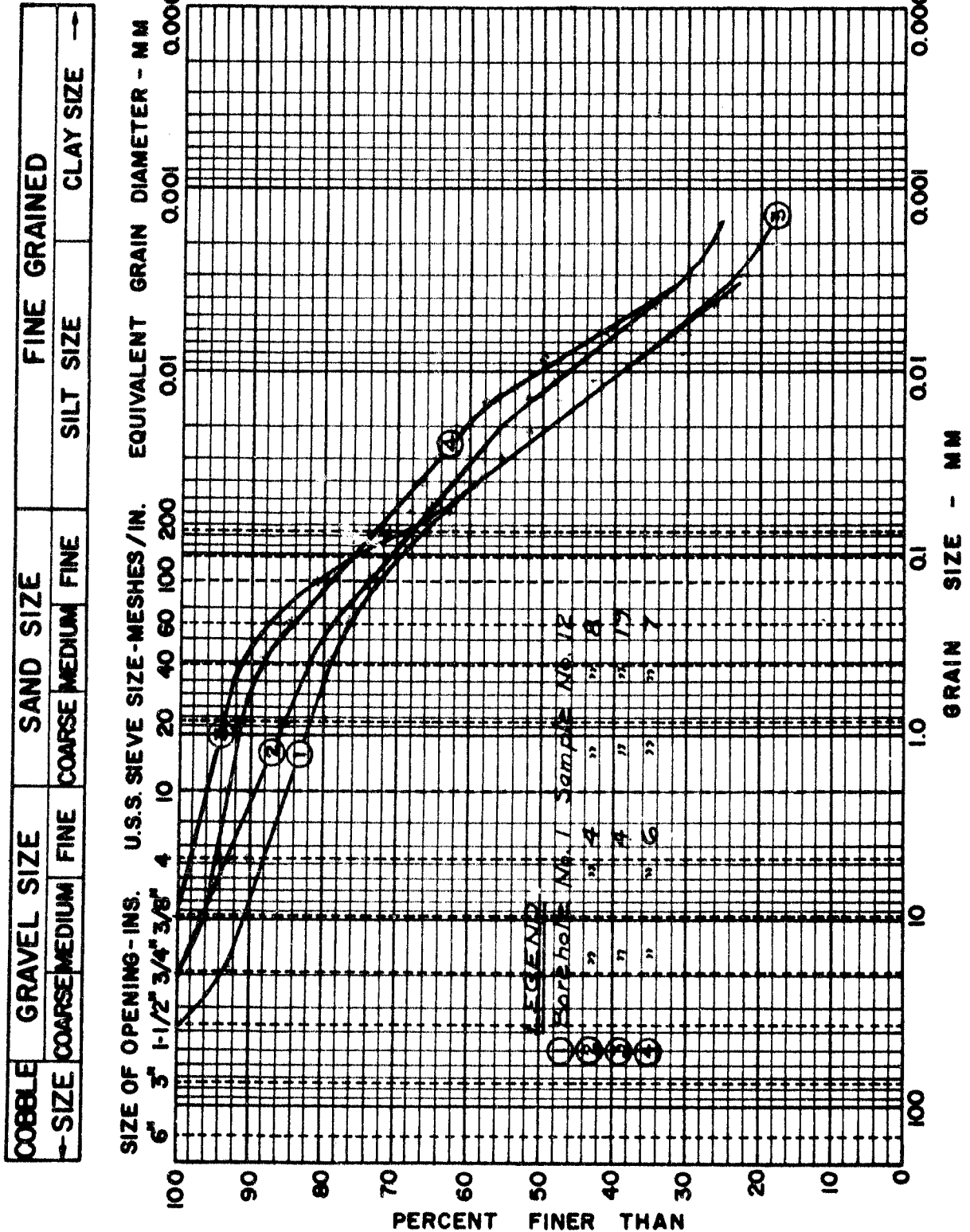
# GEOCON

# GRAIN SIZE DISTRIBUTION

BOREHOLE SAMPLES

APPENDIX II  
FIGURE 2  
PROJECT T9099

VERY DENSE, BROWN GREY  
CLAYEY SILT TILL  
WITH BOULDERS



GEOCON

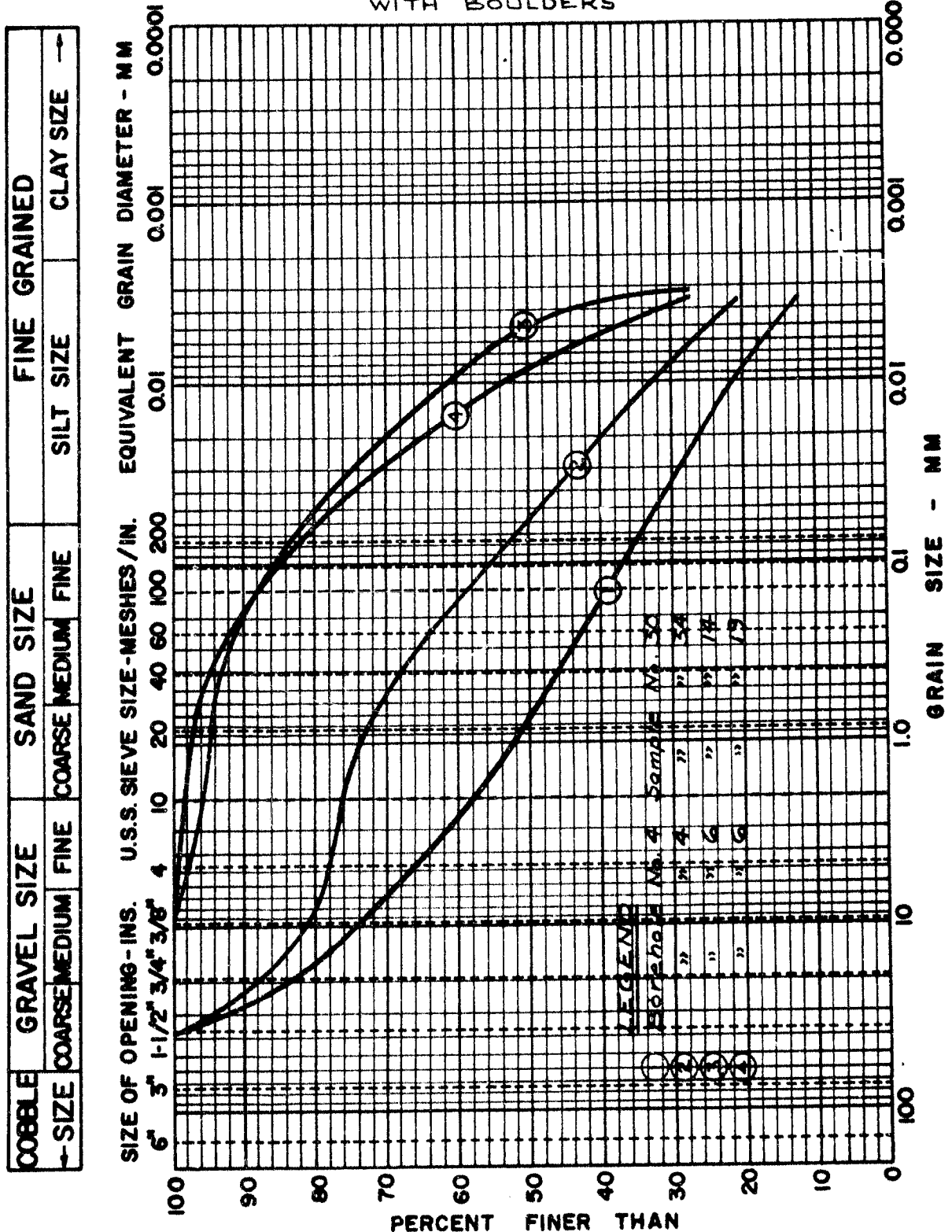
M.I.T. GRAIN SIZE SCALE

# GRAIN SIZE DISTRIBUTION

BOREHOLE SAMPLES

APPENDIX II  
FIGURE 3  
PROJECT T9099

LOWER STRATUM OF VERY DENSE BROWN GREY  
CLAYEY SILT TILL  
WITH BOULDERS



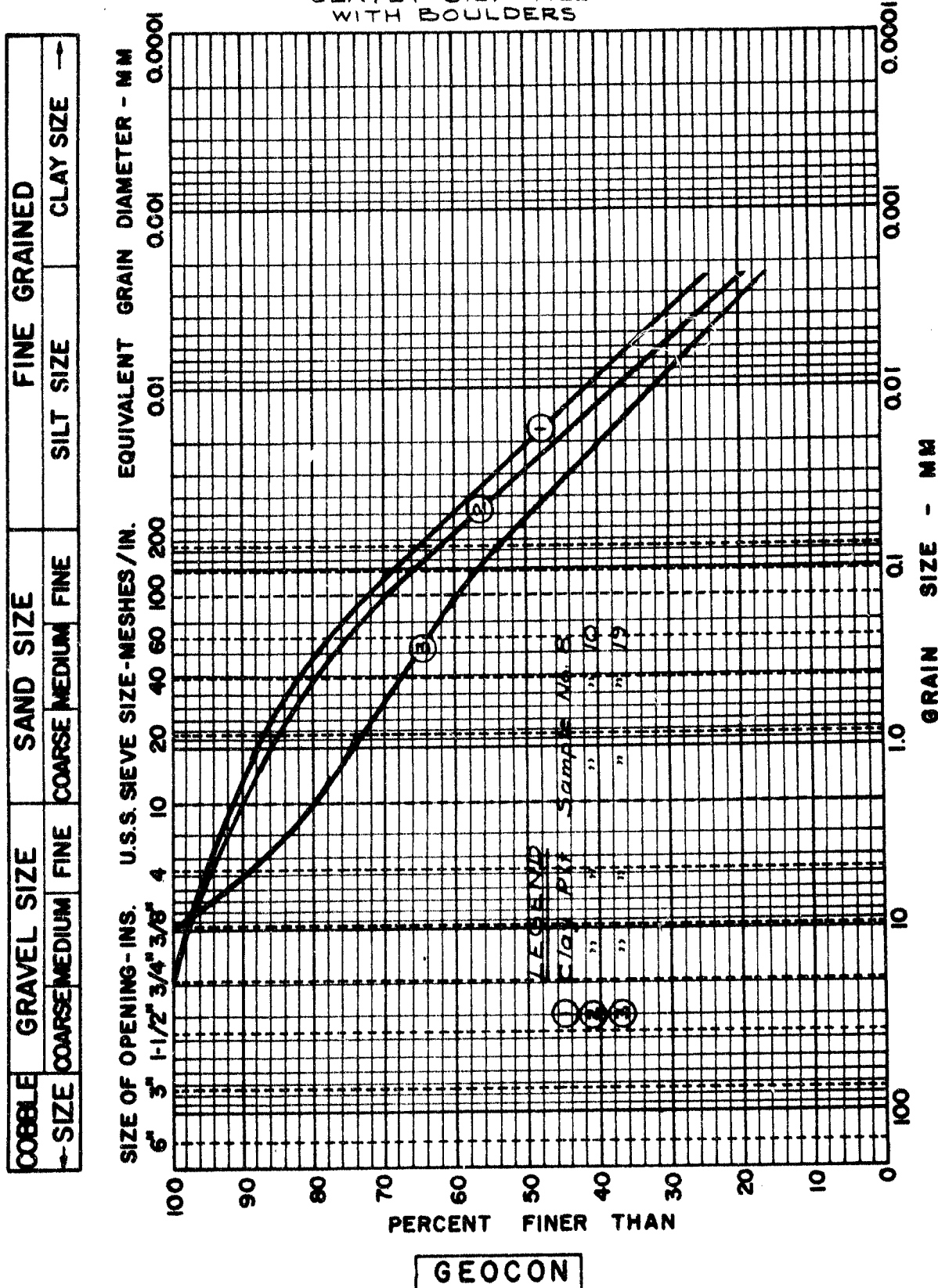
GEOCON

# GRAIN SIZE DISTRIBUTION

CLAY PIT SAMPLES

APPENDIX II  
FIGURE 4  
PROJECT T9099

VERY DENSE, YELLOW - BROWN  
CLAYEY SILT TILL  
WITH BOULDERS



M.I.T. GRAIN SIZE SCALE

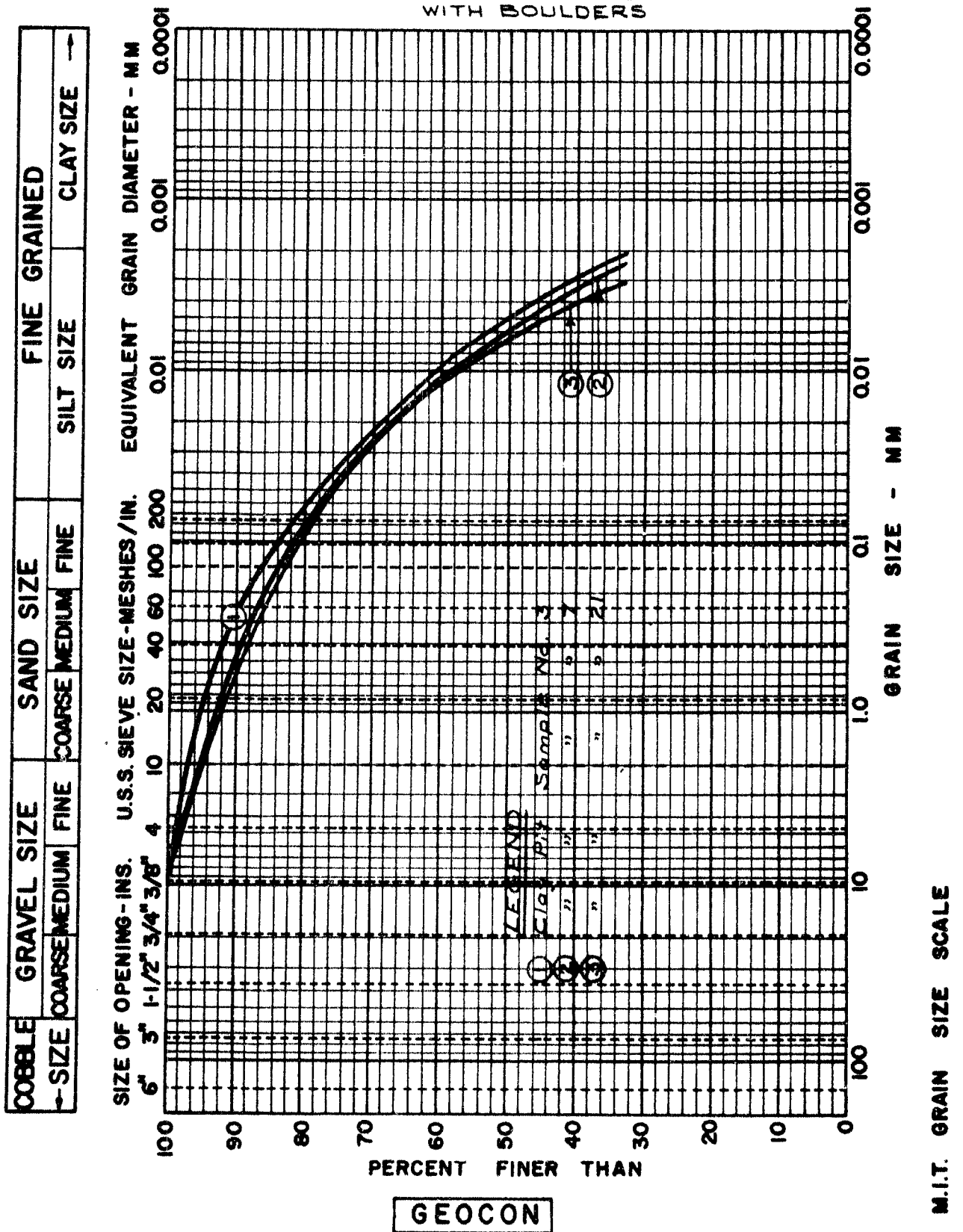


# GRAIN SIZE DISTRIBUTION

CLAY PIT SAMPLES

APPENDIX II  
FIGURE 5  
PROJECT T9099

VERY DENSE, BROWN GREY  
CLAYEY SILT TILL  
WITH BOULDERS

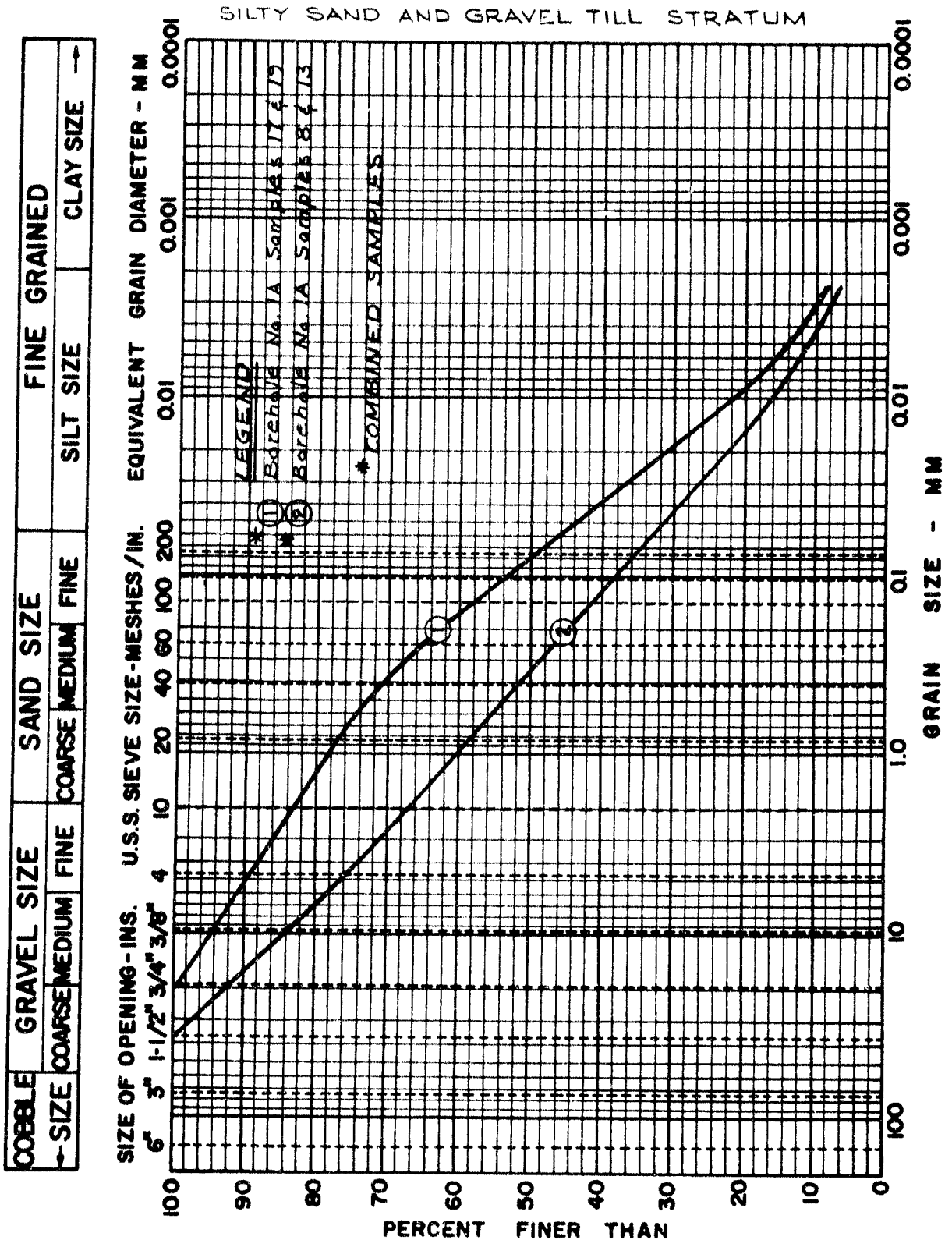




# GRAIN SIZE DISTRIBUTION

BOREHOLE SAMPLES

APPENDIX II  
FIGURE 6  
PROJECT T9099



GEOCON

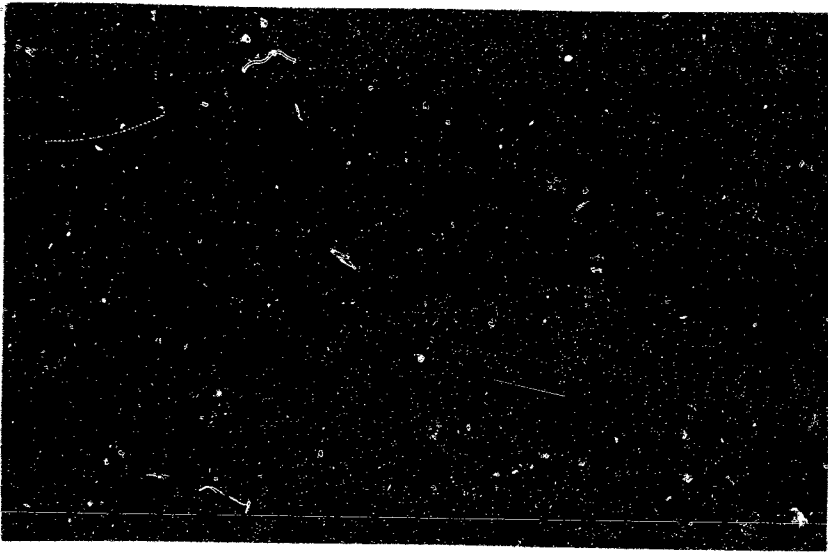
APPENDIX III

PHOTOGRAPHS

**GEOCON**

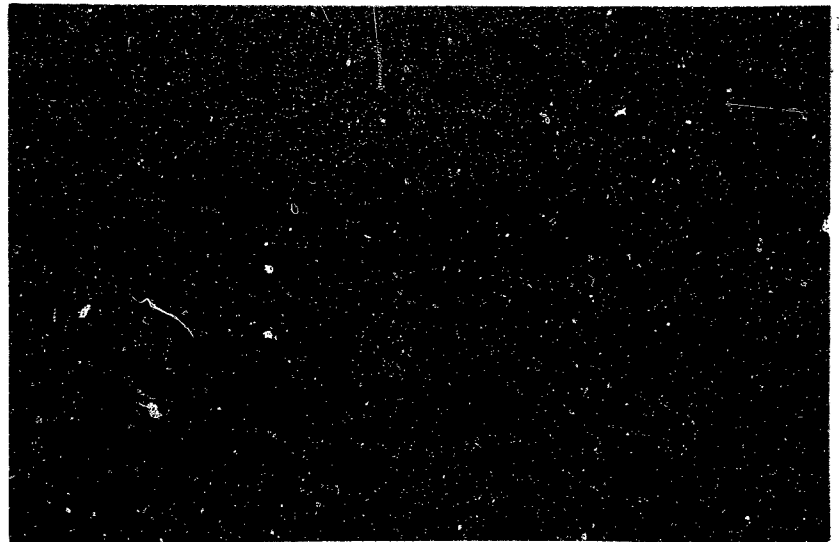
PHOTOGRAPH NO. 1

View of Clayey Silt Till  
Excavation St. Mary's  
Cement Company Plant



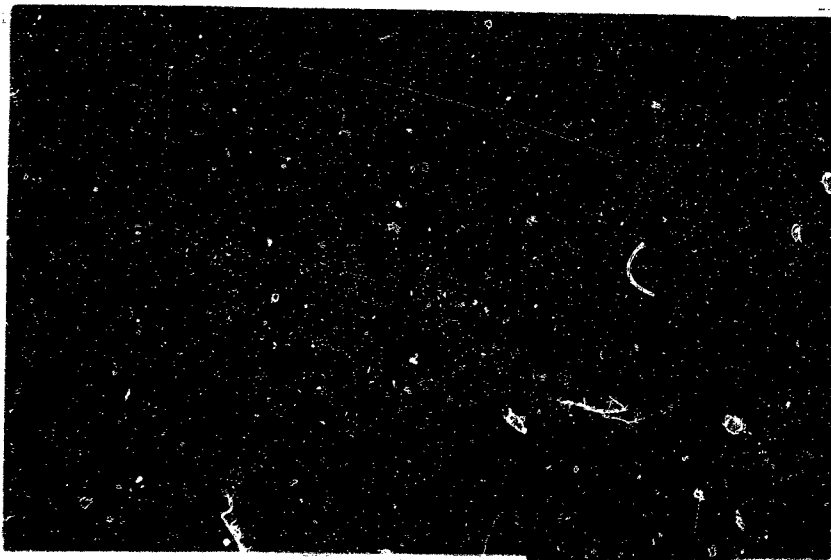
PHOTOGRAPH NO. 2

General View of  
Clay Pit Floor



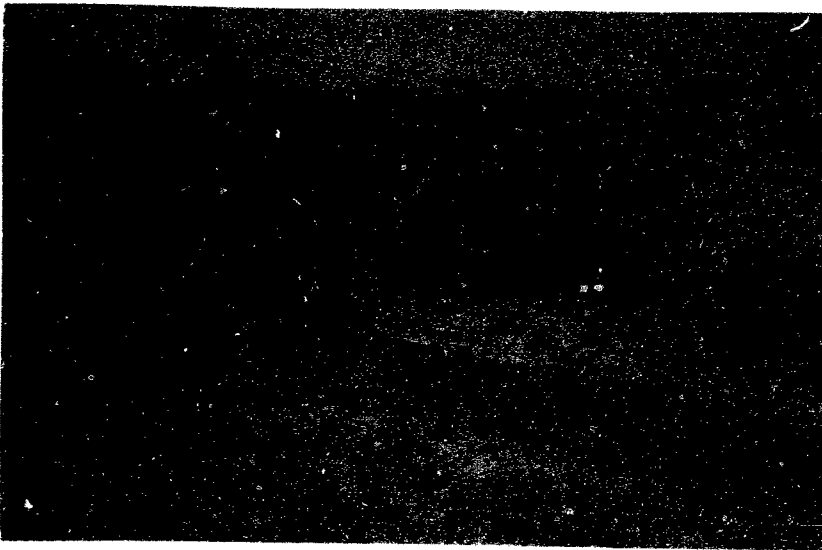
PHOTOGRAPH NO. 3

Stone Extracted from  
Clayey Silt Till  
(Near Centre of  
Photo).



PHOTOGRAPH NO. 1

View of Clayey Silt Till  
Excavation St. Mary's  
Cement Company Plant



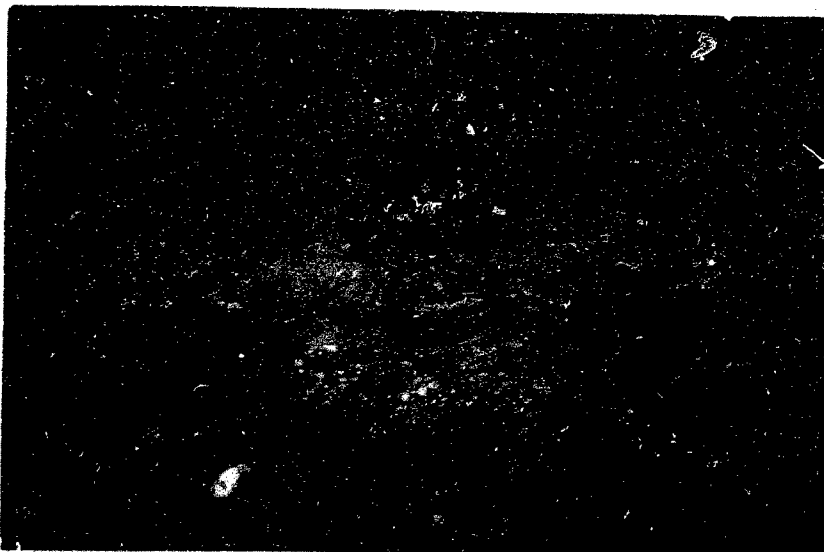
PHOTOGRAPH NO. 2

General View of  
Clay Pit Floor



PHOTOGRAPH NO. 3

Stone Extracted from  
Clayey Silt Till  
(Near Centre of  
Photo)



#### APPENDIX IV

1. CLAY RESERVE STUDIES -- 1966 REPORT PROVIDED BY  
ST. MARY'S CEMENT CO. LIMITED
2. 1968 CHEMICAL ANALYSES REPORT -- (BY WARNOCK HERSEY  
INTERNATIONAL LIMITED FOR GEOCON LTD)
3. SUMMARY OF CHEMICAL TEST RESULTS -- TABLE I

CLAY RESERVE STUDIES

1965

ST. MARY'S CEMENT CO., LIMITED  
ST. MARYS, ONTARIO

Jan. 19/66

CLAY RESERVE STUDY - 1965

Sixteen auger holes were drilled in July, 1965. Nine holes were sunk in the area south of the plant, and seven in the high ground across the Thames, north of the proposed new quarry. Areas considered in the following estimates are outlined on the attached rough sketches. Refer to St. Mary's Cement Co Property Boundaries, Drawing #5351-D for accurate measurements and hole locations.

The following assumptions were made for clay reserve calculations:

1. S.G. of the clay in place is 2.70. At 2.70, 1 cubic foot weighs 168 lb.
2. 600 lb. of raw material are required for 1 bbl of clinker, and 200 lb. of this is clay.
3. 1 bbl. requires  $\frac{200}{168} = 1.2$  cubic feet.

RESERVE CLAY ACROSS THE THAMES

The area considered is the high ground enclosed by the shaded area of diagram 1 attached.

Holes 1, 2, 3, 4, 5d, 6 and 7 were drilled in this area.

Number 7 and #5 were abandoned at 15' because of Boulders. The remaining holes were drilled to or below 30 feet. It is assumed that 30 feet of useable clay covers the area.

On this assumption, the area holds sufficient clay for 255 million barrels. Assuming 25% loss for waste, boundry allowance etc., this now represents

$$\frac{255 \times .75}{3.75} = 51 \text{ years supply}$$

Reserve clay in Area 2, south of the plant, enclosed by the shaded area shown on diagram 2 was calculated in a similar manner. This area seems to have fewer boulders. Holes were drilled to an average depth of 40 feet, and this figure is used in the reserve calculations.

*Re S.T.M. # 5546 - Actual depth probably about 80'*

At a uniform depth of 40 feet, there is sufficient clay for 455 million barrels. Again assuming 25% loss for waste and boundry allowance, this represents:  $\frac{455 \times .75}{3.75} = 90 \text{ years}$

Special attention should be paid to the area around hole 9. X-ray results of this hole indicate  $\text{Al}_2\text{O}_3$  of about 5% as against the usual 8% for the remaining holes. Future drilling may be considered in this area to confirm those results.

$\text{Al}_2\text{O}_3$  in general runs about 8%. It is interesting to note across the river that the  $\text{Al}_2\text{O}_3$  seems to decrease to about 6.5 to 7% at the north boundary.

To avoid repetition, general sample averages of each area, and hole 9 are attached to this report. The remaining chemical values if required, will be filed with the lab. copy.



GENERAL SAMPLE X-RAY RESULTS

CLAY DRILLING AREA SOUTH OF PLANT

<u>HOLE</u>	<u>LOSS</u>	<u>SiO<sub>2</sub></u>	<u>Fe<sub>2</sub>O<sub>3</sub></u>	<u>Al<sub>2</sub>O<sub>3</sub></u>	<u>CaO</u>	<u>MgO</u>	<u>K<sub>2</sub>O</u>
Row 1							
13	18.04	47.23	3.04	8.44	17.98	4.36	1.60
14	21.60	38.21	3.25	8.28	20.57	5.12	1.85
15	21.06	39.34	3.26	8.35	20.56	4.65	1.87
Row 2							
11	21.74	38.21	3.27	8.16	20.81	4.98	1.84
12	21.64	37.21	3.31	8.33	20.77	4.98	1.82
Row 3							
8S	21.64	39.28	3.58	8.42	20.00	4.89	1.71
8N	22.42	36.35	3.20	7.84	22.15	4.72	1.77
9	28.85	26.80	2.13	5.37	32.00	4.37	1.24
10	21.59	38.57	2.99	7.80	21.35	4.84	1.70

H O L E 2

<u>SAMPLE</u>	<u>LOSS</u>	<u>SiO<sub>2</sub></u>	<u>Fe<sub>2</sub>O<sub>3</sub></u>	<u>Al<sub>2</sub>O<sub>3</sub></u>	<u>CaO</u>	<u>MgO</u>
1	19.49	43.55	3.19	7.94 <sup>*</sup> 7.94	20.95	3.45
2	29.42	24.75	1.99	4.41 4.32	34.95	4.23
3	32.51	20.61	1.72	3.40 3.30	38.45	4.46
4	27.62	27.70	2.59	6.23 6.18	30.35	4.64
5	31.28	22.11	2.06	4.78 4.71	35.60	4.68
6	30.56	23.42	2.03	4.78 4.85	34.85	4.60
7	27.57	26.35	2.34	5.87 6.51	31.90	4.66
8	27.33	27.22	2.43	6.12 6.28	30.35	4.81
X Average	28.22	26.96	2.29	5.44 5.88	32.17	4.44
OSX	28.85	26.80	2.13	5.37	32.00	4.37
Bench	28.85	26.68	2.11	5.54	31.13	5.10

\* Recheck  
on New Briquettes  
Made Jan 27/66

N

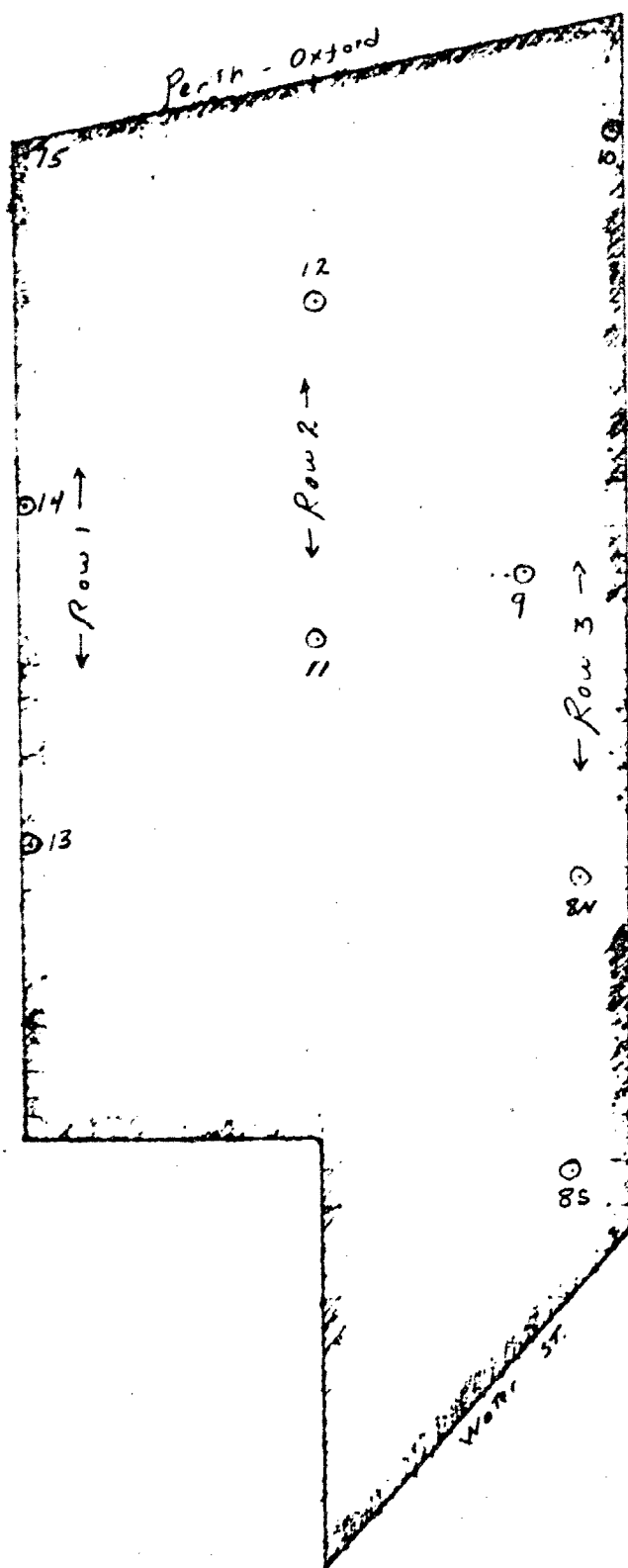


Diagram 2

Area South  
of Plant

Re Property Boundaries  
Dwg # 5351-D

1" = 800 ft

DEFECTS IN NEGATIVE DUE TO  
CONDITION OF ORIGINAL DOCUMENT



WARNOCK HERSEY  
INTERNATIONAL LIMITED

PROFESSIONAL  
SERVICES  
DIVISION

MAY -6

250 Madison Avenue, Toronto 7, Ont., Tel. 924-8881 - Telex 02-29033

## CERTIFICATE OF ANALYSIS

O. SORRA B. SC.  
CHIEF CHEMIST

Geocon Limited

14 Haas Road, Rexdale, Toronto, Ont.

Attn.: Mr. H.W. Green, P.Eng.

(Geological Engineer.)

TORONTO 7, May 1st, 1968

Laboratory No. 260/137

The following is the report of the Analysis of:

Six "Borehole Samples" of Clay and Six "Clay Pit Samples"

of Clay for complete analysis.

AS A MUTUAL PROTECTION TO CLIENTS THE PUBLIC AND OURSELVES ALL REPORTS ARE SUBMITTED AS THE CONFIDENTIAL PROPERTY OF CLIENTS, AND AUTHORIZATION FOR PUBLICATION OF STATEMENTS CONCLUSIONS OR EXTRACTS FROM OR REGARDING OUR REPORTS IS RESERVED PENDING OUR WRITTEN APPROVAL, SAMPLES WILL BE DISCARDED AFTER 30 DAYS FROM RECEIVAL DATE UNLESS INSTRUCTED OTHERWISE.

Please Note :

Complete analysis is outlined on the attached pages.

WARNOCK HERSEY INTERNATIONAL LIMITED  
PROFESSIONAL SERVICES DIVISION

CHIEF CHEMIST

A) Borehole Samples

	Borehole # 1 <u>Sample #3</u>	Borehole # 1 <u>Sample #12</u>	Borehole # 4 <u>Sample #8</u>	Borehole # 4 <u>Sample #19</u>	Borehole # 6 <u>Sample #2</u>	Borehole # 6 <u>Sample #7</u>
% Silica $\text{SiO}_2$	31.54	34.94	32.40	36.00	34.50	42.30
% Iron $\text{Fe}_2\text{O}_3$	0.48	0.35	0.28	0.24	0.33	0.32
% Alumina $\text{Al}_2\text{O}_3$	3.12	3.04	3.26	3.19	3.32	3.40
% Lime $\text{CaO}$	37.80	29.10	29.70	27.20	35.00	28.50
% Magnesia $\text{MgO}$	7.80	7.65	10.50	14.20	5.25	3.44
% Titanium $\text{TiO}_2$	Less than 0.1	less than 0.1	less than 0.1	less than 0.1	less than 0.1	less than 0.1
% Manganese $\text{MnO}$	Less than 0.1	less than 0.1	less than 0.1	less than 0.1	less than 0.1	less than 0.1
% Alkalies $\text{Na}_2\text{O}$ & $\text{K}_2\text{O}$	0.12	0.15	0.18	0.14	0.15	0.10
% Carbon Dioxide $\text{CO}_2$	18.6	20.4	22.3	18.7	19.6	18.3

( cont'd... )

A) Borehole Samples ( cont'd... )

	Borehole # 1 <u>Sample#3</u>	Borehole # 1 <u>Sample#12</u>	Borehole # 4 <u>Sample#8</u>	Borehole # 4 <u>Sample#19</u>	Borehole # 6 <u>Sample#2</u>	Borehole # 6 <u>Sample#</u>
% Moisture H <sub>2</sub> O	10.9	8.1	10.1	7.9	14.5	8.2
% Sulphates SO <sub>3</sub>	0.070	0.050	0.030	0.052	0.416	0.112
% Phosphates P <sub>2</sub> O <sub>5</sub>	0.149	0.155	0.131	0.099	0.179	0.110
% Chloride Cl	0.020	0.036	0.011	0.011	0.011	0.033
% Loss on Ignition	20.0	23.0	24.6	20.2	21.2	20.2
Total Percent	101.299	98.691	101.292	101.332	99.456	98.715

B) Clay Pit Samples

	<u>Sample # 5</u>	<u>Sample # 9</u>	<u>Sample # 14</u>	<u>Sample # 16</u>	<u>Sample # 22</u>	<u>Sample # 13</u>
% Silica SiO <sub>2</sub>	33.28	35.34	33.21	43.19	43.30	41.70
% Iron Fe <sub>2</sub> O <sub>3</sub>	0.56	0.96	0.76	0.69	0.81	0.88

( cont'd.... )

B) Clay Pit Samples( cont'd..... )

	<u>Sample # 5</u>	<u>Sample # 9</u>	<u>Sample # 14</u>	<u>Sample # 16</u>	<u>Sample # 22</u>	<u>Sample # 13</u>
% Alumina $\text{Al}_2\text{O}_3$	3.86	3.64	3.51	3.08	3.02	3.06
% Lime CaO	35.60	29.20	37.80	28.00	28.20	25.70
% Magnesia MgO	11.86	11.30	0.80	5.60	3.59	7.57
% Titanium $\text{TiO}_2$	Less than 0.1	less than 0.1	less than 0.1	less than 0.1	less than 0.1	less than 0.1
% Manganese MnO	Less than 0.1	less than 0.1	less than 0.1	less than 0.1	less than 0.1	less than 0.1
% Alkalies $\text{Na}_2\text{O}$ & $\text{K}_2\text{O}$	0.17	0.13	0.18	0.16	0.12	0.16
% Carbon Dioxide $\text{CO}_2$	19.4	19.2	22.8	16.4	16.7	16.9
% Moisture $\text{H}_2\text{O}$	18.0	10.7	8.8	13.2	9.9	9.8

( cont'd..... )

B) Clay Pit Samples ( cont'd..... )

	<u>Sample # 5</u>	<u>Sample # 9</u>	<u>Sample # 14</u>	<u>Sample # 16</u>	<u>Sample # 22</u>	<u>Sample # 13</u>
% Sulphates SO <sub>3</sub>	0.016	0.025	0.040	0.025	0.054	0.035
% Phosphates P <sub>2</sub> O <sub>5</sub>	0.446	0.190	0.321	0.330	0.626	0.343
% Chlorides Cl	0.056	0.016	0.034	0.034	0.032	0.019
Loss on Ignition	21.3	21.0	24.8	18.5	18.8	18.8
Total Percent	100.290	101.985	101.645	99.779	98.752	99.748

Note : The Carbon Dioxide and Moisture are not included  
when calculating the total percentage,

Respectfully submitted,  
WARNOCK HERSEY INTERNATIONAL LIMITED  
Professional Services Division

*O. Sorra*  
O. Sorra B.Sc.  
Chief Chemist



# SUMMARY OF CHEMICAL TEST RESULTS - TABLE I

COMPOUND	GEOCON BOREHOLES CHEMICAL TESTS						CLAY PIT SAMPLES CHEMICAL TESTS						1966 CLAY RESERVE STUDIES - X-RAY ANALYSIS BY ST. MARY'S CEMENT CO. LIMITED										OVERALL AVERAGES			AVERAGES OF CHEMICAL TESTS				COMPARISON OF ADJACENT BOREHOLES			
	BH-1	1	4	4	6	6	5	9	14	16	22	13	8S	8N	9	10	11	12	13	14	15	GEOCON BH'S	CLAY PIT	1966 RESULTS	YELLOW - BROWN TILL LAYER		BROWN - GREY TILL LAYER		GEOCON 1968	1966 RESULTS	GEOCON 1968	1966 RESULTS	
	SA-3	12	8	19	2	7																				GEOCON	CLAY PIT	GEOCON	CLAY PIT	BH. 1A	BH. 10	BH. 6	BH. 15
(1) SiO <sub>2</sub>	31.54	34.94	32.40	32.00	34.50	42.30	33.28	35.34	33.21	43.19	43.30	41.70	39.28	36.35	26.60	38.57	38.21	37.21	47.23	38.21	39.34	35.28	38.33	37.91	33.02	33.94	36.41	42.73	33.24	38.57	38.40	39.34	
(2) Fe <sub>2</sub> O <sub>3</sub>	0.48	0.35	0.23	0.24	0.33	0.32	0.56	0.96	0.76	0.69	0.81	0.88	3.58	3.20	2.13	2.99	3.27	3.31	3.04	3.25	3.26	0.33	0.78	3.11	0.40	0.76	0.30	0.79	0.41	2.99	0.32	3.26	
(3) Al <sub>2</sub> O <sub>3</sub>	3.12	3.04	3.22	3.19	3.32	3.40	3.86	3.64	3.51	3.05	3.02	3.06	8.42	7.84	5.37	7.80	8.16	8.33	8.44	8.28	8.35	3.22	3.36	7.89	3.22	3.67	3.22	3.04	3.08	7.80	3.36	8.35	
(4) CaO	37.80	29.10	29.70	27.20	35.00	28.50	35.60	29.20	37.80	28.00	28.20	25.70	20.00	22.15	32.00	21.35	20.81	20.77	17.98	20.57	20.56	31.21	30.75	21.80	36.40	34.20	28.62	27.30	33.45	21.35	31.75	20.56	
(5) MgO	7.60	7.65	10.50	14.20	5.25	3.44	4.86	11.30	0.80	5.60	3.59	7.67	4.89	4.72	4.37	4.84	4.98	4.98	4.36	5.12	4.65	8.14	5.63	4.77	6.52	5.65	8.95	5.62	7.72	4.84	4.34	4.65	
(6) TiO <sub>2</sub>	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1										0.1	0.1		0.1	0.1	0.1	0.1		0.1			
(7) MnO	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1										0.1	0.1		0.1	0.1	0.1	0.1		0.1			
(8) Na <sub>2</sub> O K <sub>2</sub> O	0.12	0.15	0.18	0.14	0.15	0.10	0.17	0.13	0.18	0.16	0.12	0.16	1.91	1.79	1.26	1.70	1.84	1.92	1.60	1.85	1.87	0.14	0.15	1.75	0.14	0.16	0.14	0.15	0.14	1.70	0.12	1.87	
(9) SO <sub>3</sub>	0.07	0.05	0.03	0.052	0.416	0.112	0.16	0.025	0.040	0.025	0.054	0.035										0.12	0.06		0.243	0.075	0.061	0.038	0.06		0.264		
(10) P <sub>2</sub> O <sub>5</sub>	0.149	0.155	0.131	0.099	0.179	0.110	0.446	0.190	0.321	0.330	0.626	0.343										0.137	0.376		0.164	0.319	0.124	0.433	0.152		0.144		
(11) Cl	0.02	0.036	0.011	0.011	0.011	0.033	0.050	0.016	0.034	0.034	0.032	0.019										0.020	0.031		0.015	0.023	0.030	0.028	0.028		0.022		
(12) LOSS ON IGNITION	20.0	23.0	24.6	20.2	21.2	20.2	21.3	21.0	24.8	18.5	18.8	18.8	21.64	22.42	28.85	21.59	21.74	21.64	18.04	21.60	21.06	21.53	20.53	22.06	20.60	22.5	22.0	18.6	21.50	21.59	20.2	21.06	
TOTAL	901.299	98.691	101.292	101.332	99.456	98.715	100.270	101.985	101.645	99.779	98.752	99.748	99.72	98.47	100.78	98.84	99.01	98.16	100.69	98.88	99.09	100.127	99.997	99.29	100.722	101.297	99.855	98.729	99.780	98.84	98.920	99.09	
(1) (2) + (3)	8.76	10.31	9.15	10.50	9.47	11.37	7.53	8.28	7.78	11.55	11.30	10.58	3.27	3.29	3.57	3.57	3.34	3.19	3.11	3.31	3.39	9.93	9.50	3.45	9.11	7.86	10.33	11.14	9.53	3.57	10.42	3.39	
CO <sub>2</sub>	18.6	20.4	22.3	18.7	19.6	18.3	19.4	19.2	22.8	16.4	16.7	16.9										19.45	18.56		19.1	20.7	19.92	16.66	19.50		18.9		
H <sub>2</sub> O	10.9	8.1	10.1	7.9	14.5	8.2	18.0	10.7	8.8	13.2	9.9	9.8										9.95	11.73		12.7	12.5	8.58	10.96	9.50		11.35		

PERTH

BLANSHARD

SOUTH

BOUNDARY

CONCESSION

LOT

17

LOT

ST. MARY'S CEMENT CO. L.

INST. N° 85552

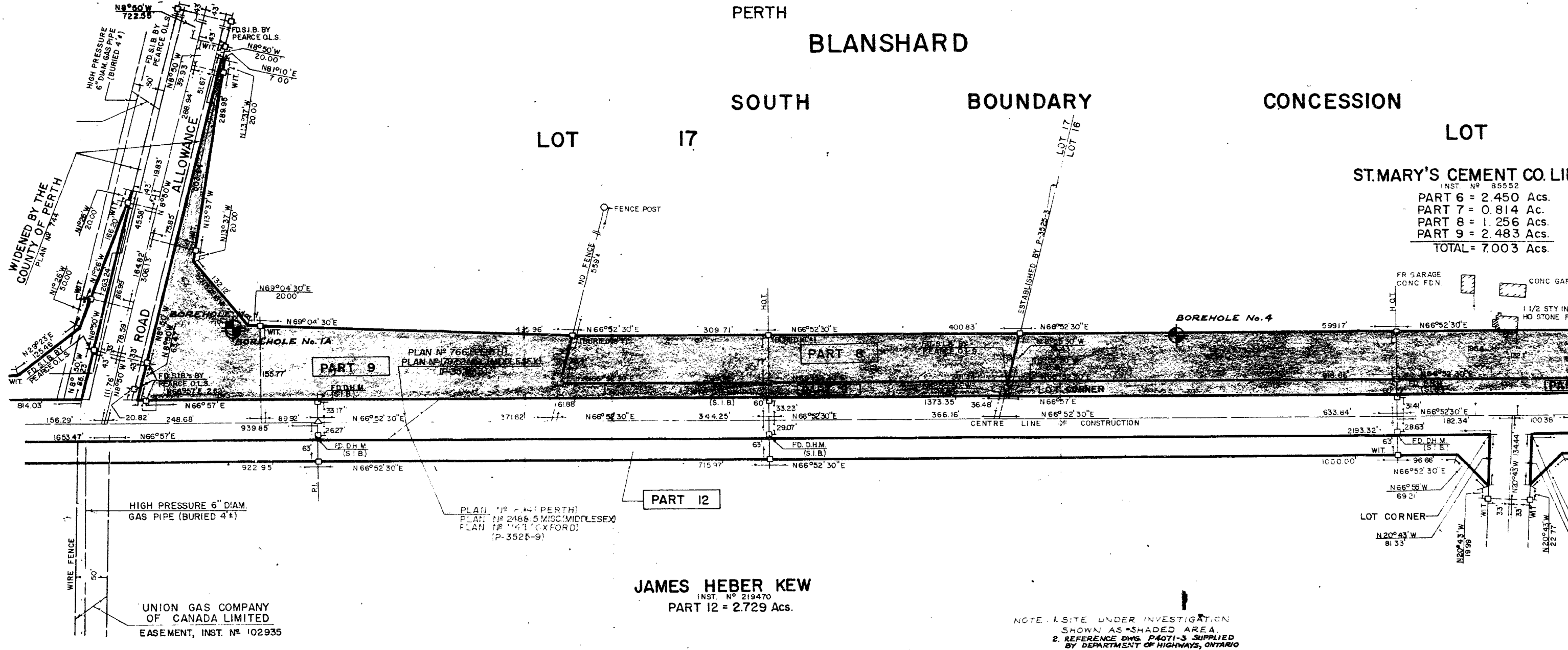
PART 6 = 2.450 Acs.

PART 7 = 0.814 Ac.

PART 8 = 1.256 Acs.

PART 9 = 2.483 Acs.

TOTAL = 7.003 Acs.



JAMES HEBER KEW

INST. N° 219470

PART 12 = 2.729 Acs.

NOTE: 1. SITE UNDER INVESTIGATION  
SHOWN AS SHADED AREA.  
2. REFERENCE DWG. P4071-3 SUPPLIED  
BY DEPARTMENT OF HIGHWAYS, ONTARIO

# BOUNDARY

## CONCESSION

LOT 16

**ST.MARY'S CEMENT CO.LIMITED**

INST. № 85552

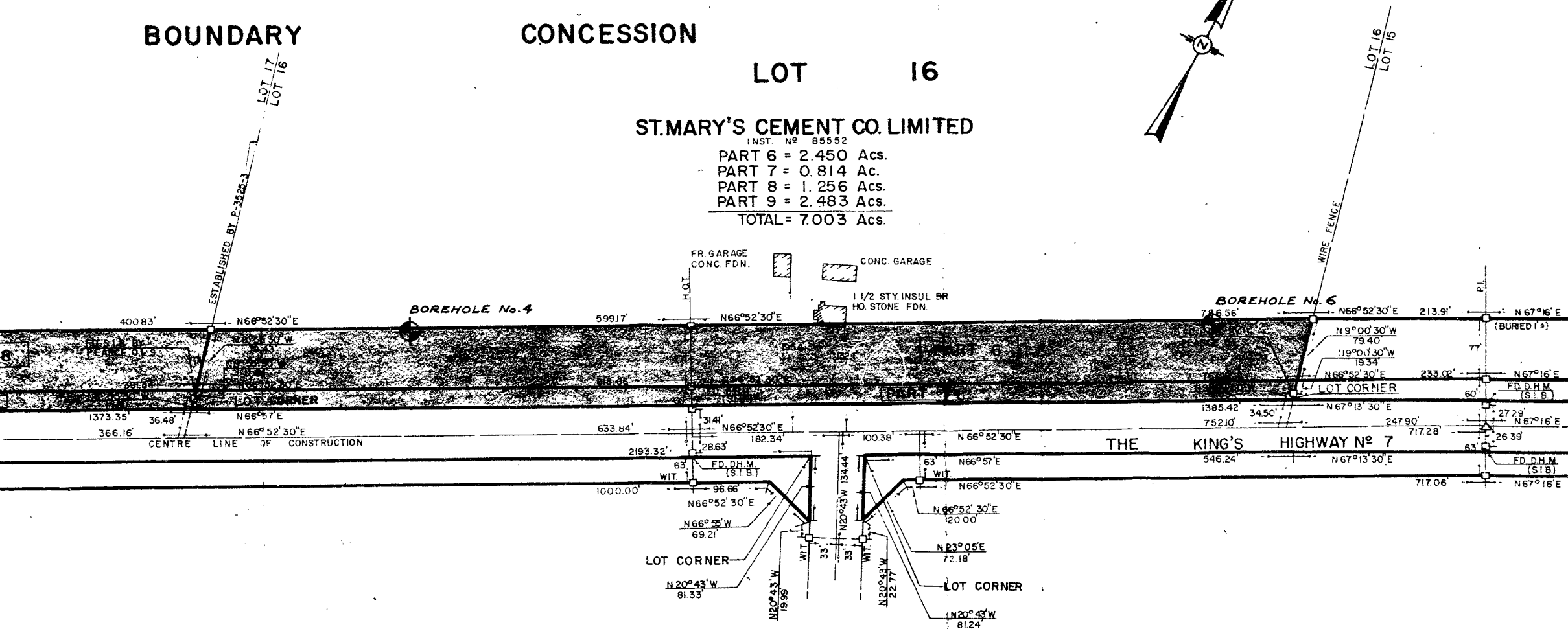
PART 6 = 2.450 Acs.

PART 7 = 0.814 Ac.

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DEPARTMENT OF HIGHWAYS, ONTARIO  
DOWNSVIEW ONTARIO  
**SOIL INVESTIGATION**  
PROPERTY ACQUISITION, HIGHWAY No. 7 BYPASS  
ST. MARY'S ONTARIO  
LOCATION OF BOREHOLES

GEOCON LTD

DATE: MAY 10, 1968 SCALE: 1" = 100'-0"

MADE AEL	CHKD. WHL	APRD. MAM	<b>No. T9098</b>
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