MILE POST 7 WEST RIDGE RAILROAD RELOCATION, DAM EXTENSIONS, AND STREAM MITIGATION PROJECT ENVIRONMENTAL ASSESSMENT WORKSHEET (EAW)

RECORD OF DECISION – FINDING OF FACT 28.h
1975 CASAGRANDE REPORT

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CASAGRANDE CONSULTANTS
FOUNDATIONS & EARTHWORKS

TO

RESERVE PROJECT TEAM

STATE OF MINNESOTA

FINAL REPORT
ON EVALUATION OF PROPOSED DESIGN
MILEPOST 7 PROJECT

AUGUST 1975

40 Massachusetts Avenue/Arlington, Massachusetts 02174

Arthur Casagrande
Leo Casagrande
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CASAGRANDE CONSULTANTS — FOUNDATIONS & EARTHWORKS

August 20, 1975

Reserve Project Team
Room 424
1935 West County Road B2
Roseville, Minnesota 55113

Attention: Mr. Morris M. Sherman, Special Attorney

Subject: Final Report on Evaluation of Proposed Design of Milepost 7 Project

Gentlemen:

We submit herewith 12 copies of our final report on our evaluation of the proposed Design of the Milepost 7 project.

We hope that we have succeeded in presenting all pertinent information in a form that will be understood also by educated laymen.

It has been a pleasure working with the members of your team and the other consultants involved in this project, and we wish to thank you for this interesting and challenging assignment.

Respectfully submitted,

L. Casagrande

D. R. Casagrande

LC/DRC:wc

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I. INTRODUCTION

The purpose of this report is to submit our conclusions and recommendations regarding the proposed design of the Milepost 7 Tailings Storage Project and on the stabilization of the existing tailings delta. The various structures involved in this project are shown on the general location plan, Fig. 1. Our conclusions and recommendations were based on the following information:

1. Meeting at the offices of Michael Baker, Jr., Inc., Beaver, Pa., on April 26, 1975.
2. Meetings at your offices on May 2, 1975, and July 15, 1975.
3. Meeting at the offices of Reserve Mining Company on May 3, 1975.
4. Inspection flight over the Mesabi Range and the Reserve Mining Company operations, on May 3, 1975.
5. Visit to the Milepost 7 area and the tailings delta in the lake, on May 3, 1975.
6. A tour of the Taconite processing plant, on May 3, 1975.
7. Examination and testing of undisturbed samples and split-spoon samples, received on July 9, 1975, from 6 borings at the proposed locations of Dam No. 1 and Dam No. 2-3.
8. Examination and testing of samples of fine and coarse tailings from the Pilot Plant, received on July 28 and July 31, 1975.
9. Reports, letters, and drawings listed in Appendix IV.

Because of the limited time available for the preparation of this report it was not possible to respond to all items of concern as listed in the Official Memorandum prepared by the Reserve Project Team, dated June 10, 1975. However, we believe that we have dealt with all issues of importance regarding the safety of the tailings pond and the stabilization of the Delta.

We have reviewed all information which has been made available to us on this project and we commend the designers for their accomplishments within the relatively short period of time available. Of equal compentence are the extensive professional contributions by all others involved with this project.

II. BORINGS AND SUBSOIL PROFILE

In order to obtain a clear picture of the in-situ properties of the foundation strata at the dam sites, we requested by letter of May 8, 1975, that undisturbed and split-spoon samples be sent to us from several new borings made adjacent to existing borings at the proposed locations of Dam No. 1 and Dam No. 2-3. Under the supervision of W. A. Wahler & Associates, Palo Alto, California, six borings were made by Braun Engineering Testing, Minneapolis, Minnesota, close to existing boring Nos. 1002, 1072, 1077, 3004, 3037, and 3056. The locations of the borings at Dam No. 1 and Dam No. 2-3 are shown in Figs. 2 and 3, respectively.

The field logs of the six borings, prepared by W. A. Wahler & Associates, are presented in Appendix I.

Our descriptions of the samples based on visual and manual examination, and the results of classification tests and strength tests, together with other pertinent information, are presented in Tables 1 to 6, Appendix II. It should be noted that our description of the soil samples is not necessarily the same as given in the boring logs because the inspector who prepared the logs could only examine the soil at the ends of the sample tubes and the soil cleaned out of the hole between samples.

On the basis of all borings and the geologic survey by Michael Baker, Jr., Inc. and W. A. Wahler & Associates, during June, 1975, the subsoil profile at the proposed Milepost 7 site can be divided into essentially three groups of materials as follows:

The Lacustrine Stratum, a varved clay deposit, underlies the topsoil and ranges in thickness from zero on the valley slopes, above about El. 1200, to over 40 ft in the center of the valley. In undisturbed state, the clay is stiff to very stiff and brittle to a depth of 8 to 10 ft, and firm to stiff and brittle at greater depth. The top 5 to 10 ft of the clay are highly fissured, but fissures were found also at greater depths.

Except for the top few feet, the clay is stratified with silt and sand layers. The average thickness of the individual varves is less than one inch, but locally clay and silt layers may be up to several feet thick.

The lacustrine deposit contains some angular or sub-angular pebbles and occasionally also stones of several inches in size. Locally, this deposit contains pockets or lenses of glacial till several feet thick (see e.g. boring No. CASA 3004), which may have been deposited by ice rafting. The lacustrine deposit has been preconsolidated to its full depth either by drying or by temporary surcharge such as soil or ice which was later removed.

The Glacial Till Stratum, which underlies the lacustrine deposit, ranges in thickness from zero near the tops of the valley slopes, where bedrock is exposed, to over 100 ft in the bottom of the valley. The till primarily consists of clayey, angular silt, sand and gravel, but locally also contains larger particles. In situ it is very compact or hard, with the water content generally below the plastic limit.

Because of its dense nature and clay content, the glacial till is relatively impervious, except for isolated pockets or lenses of till which may not contain any clay and could therefore be quite pervious.

The Surficial Pervious Deposits consist of talus deposits along the east slope of the valley and isolated deposits of sand-gravel throughout the area. They were disclosed by the geologic survey conducted in June, and are approximately indicated in plan on Michael Baker, Jr., Inc., drawing titled MAP OF PRELIMINARY GEOLOGIC RECONNAISSANCE. It is our understanding that exploratory work is in progress to determine the extent of these deposits and how their presence will affect the design of the four dams.

III. LABORATORY INVESTIGATIONS ON SOIL SAMPLES

General Description

From the six boring Nos. CASA-1002, -1072, -1077, -3004, -3037, and -3056, a total of 50 undisturbed samples and 18 split-spoon samples were obtained and shipped to our laboratory. The undistured samples were taken with 30 in. long, 3 in. diameter thin-wall steel tubes, and the length of the samples ranged from 7.5 in. to 27 in.

In the laboratory each tube was cut by means of a special band saw into several sections. The sample was removed from each section by means of a hydraulic jack.

Except for three short sections of silt which were reserved for permeability tests, all samples were cut lengthwise using a wire saw, and a longitudinal section through the center was allowed to dry slowly in the humid room to disclose and accentuate the stratification. At natural water content, the majority of the lacustrine samples have a fairly uniform reddish-brown color. However, after drying the silt and fine sand layers were light-colored, while the clay layers were still dark in color.

The dried sections were examined and representative photographs were taken; these are presented in Appendix III. As can be seen in the photographs, the samples show many signs of disturbance, the majority of which was caused by the sampling tube getting caught on a large pebble or stone which was then pushed down by the cutting edge. The cutting edge of a number of the tubes was found to have been severely damaged, and the lower portion of two tubes had even been deformed into an oval cross-section. Examples of severe disturbance of clay, stratified with silt and fine sand, are shown in photographs No. 18 and No. 23, Appendix III. A typical example for a partially disturbed varved clay is shown in photograph No. 22. It also should be pointed out that completely healed shear displacements of the type visible on the right in photograph Nos. 20 and 21 were due to natural causes (possibly resulting from a minor readvance of the ice sheet during the last glaciation or by a slide) and were not caused by the sampling operation. On the other hand, fresh shear displacements of the type shown in photograph Nos. 9, 10, 11, and 16, were created by excessive local pressure exerted on the clay by pebbles or stones during pushing of the tube, or by a partially dented cutting edge.

Classification and Strength Tests

In Tables 1 to 6, Appendix II, are listed the results of the natural water content determinations and of the liquid and plastic limit tests. Because the relation between natural water contents and limits is significant they are plotted in Figs. 4 to 9. In addition, the limits have been plotted in the plasticity chart in

Fig. 10. In Fig. 11 we have plotted the results of Atterberg limit tests conducted by Soil Exploration Company for Klohn Leonoff Consultants Ltd., and this figure shows good agreement with our results, Fig. 10. From the position of the points on the plasticity chart it can be concluded that the majority of the clay layers contain active clay minerals, located well above the A-line, with liquid limits ranging up to over 100. The lower liquid limits on these plots indicate that the clay contains more silt and sand particles; and liquid limits of between approximately 25 and 35 are indicative of clayey silts and sands, including clayey glacial till.

When clays containing active clay minerals, such as montmorillonite, are disturbed, they lose part of their undisturbed in-situ strength, and in presence of free water such clays will swell. This would occur even in a relatively undisturbed sample because of the reduction in confinement when removed from the ground. Since this varved clay contains numerous silt and fine sand layers, sample disturbance has caused the clay layers to absorb pore water from adjoining silt and fine sand layers which resulted in further loss in strength of the clay and apparent drying of silt and sand layers as compared with the undisturbed in-situ condition. This was clearly visible when examining the varved clay in our laboratory.

For the above reasons the water content of the clay layers, as determined in our laboratory and as recorded in Tables 1 to 6 of Appendix II, and Figs. 4 to 9, are somewhat too high. For the same reasons the water-plasticity ratios in the last column of the tables, i.e. the ratio of natural water content minus plastic limit to liquid limit minus plastic limit (plasticity index), expressed in percent, are also too high. The strength of a soil in the remolded state decreases with increasing water-plasticity ratio, and becomes very low as the water content approaches the liquid limit (ratio = 100).

Unconfined compression tests and triaxial tests require a minimum height of the specimen of 3 in. Because not enough undisturbed clay was available for such conventional strength tests, the range of the unconfined compressive strength of undisturbed clay layers was obtained by means of a pocket penetrometer, and the shear strength was determined by means of a TORVANE device. The results of these strength tests are recorded in Tables 1 to 6, Appendix II.

Permeability Tests

From experience we know that, depending on the degree of plasticity of the clay layers, the coefficient of permeability in undisturbed state ranges between $k = 10^{-8}$ and 10^{-10} cm/sec. It is equally well known that, depending on the grain size distribution of the fine sand and silt varves, their coefficient of permeability may range between $k = 10^{-3}$ and 10^{-6} cm/sec, or from 100 times to 10 million times greater than the permeability of the clay layers.

To show that even the finest silt layers (also referred to as rock flour) in this varved clay stratum, has ample horizonatal permeability to assure an adequate rate of consolidation of the highly impervious clay layers, we reserved three sections of silt from sample-sections 6B and 6C of Boring No. CASA 1077 and 8C of Boring No. CASA 3056. However, the section from Boring No. CASA 3056 was found to be disturbed and was not tested.

Cylindrical specimens were trimmed from the two Boring No. CASA 1077 sections such that the flow of water during the permeability test would be in the horizontal direction of the in-situ material. The test specimens were consolidated in a triaxial chamber under a confining pressure of $\sigma_3 = 0.45$ kg/cm^2, which is equivalent to the in-situ effective stress. Both specimens were then saturated by applying vacuum at the top of the specimen and feeding deaired, distilled water into the bottom of the specimens for one day. The permeability tests were of the falling-head type, and gave the following results (computed for water temperature of 20°C):

Sample-Section 6B $k_{20} = 7.6x10^{-6}$ cm/sec

Sample-Section 6C $k_{20} = 4.8x10^{-6}$ cm/sec

Pertinent information of the permeability tests are given in Table 1, and the grain size curves for the two specimens are presented in Fig. 12.

From these results it can be concluded that the average horizontal permeability of all granular varves probably is of the order of $k = 10^{-4}$ to 10^{-5} cm/sec, i.e. somewhat greater than the permeability of the very fine-grained silt we tested.

IV. GLACIAL TILL BORROW AREAS

The total volume of glacial till required for the various dams and dikes is of the order of 2 million cubic yards. This means that an average of 5 ft of till would have to be excavated from all three borrow areas as shown on Reserve Mining Co.'s Dr. No. 292-0039. Since a certain percentage of the till will have to be wasted because of unsuitable gradation or water content, the average depth will be somewhat greater. Therefore, till would probably also have to be excavated from below the groundwater table. Draining the groundwater in such large areas by means of ditches on the uphill side of the areas, as proposed by Klohn Leonoff, will probably not be effective in keeping the water table below the excavation level, especially during the spring thaw. Our experience with the compaction of glacial till indicates that such soils are very sensitive to the water content during compaction. A few percent above optimum water content makes this material unsuitable for proper compaction.

The surface of the till in the borrow areas and in the embankments should always be sloped not less than 3% for proper drainage of precipitation.

It will not be desirable to expose bedrock in these areas. This could increase the seepage losses from the reservoir. However, since it is intended to stockpile any lacustrine soils overlying the till, these materials could be used to apply a blanket over any areas that are excavated to bedrock. Also, any pervious granular deposits exposed in the cut slopes or bottom of the borrow areas should be blanketed with impervious material.

V. COMMENTS ON DESIGN AND CONSTRUCTION OF MAIN DAMS

General Comments

In addition to removing any soft and organic soils from the foundations of the four dams, we recommend the following measures be carried out:

1. All test pits within the dam area and to a distance of 200 ft upstream from the upstream toe of a dam should be dewatered and then backfilled with compacted impervious material.

2. Where talus or surficial sand-gravel is within a dam foundation area, or if exposed bedrock with open jointing will be in direct contact with a dam, their depth and extent will have to be

investigated. In order to prevent excessive water losses through such zones the final design may have to incorporate one or several of the following measures:

a) If of limited depth and extent, excavate surficial talus and sand-gravel and replace by clayey glacial till or coarse tailings mixture, in conformance with the design of the dam, compacted in thin layers.

b) For pervious deposits of appreciable thickness and extent excavation of a minimum thickness of 5 ft and replacement with compacted clayey till may be satisfactory, provided that this blanket is tied to impervious material in upstream direction. Alternatively, the construction of a complete cutoff through such pervious deposits may become necessary.

c) Open joints in exposed bedrock should be filled with clay slurry or cement grout(under gravity pressure only)and, where feasible, covered with a several foot thick blanket of clay or clayey till.

3. Installation of a 5 ft thick drainage blanket of cobb tailings for Dam No. 1 and Dam No. 2-3 should be limited to the area downstream of the centerline of the main dam, and extending up the abutments to about El. 1200; and for Dam No. 4 and Dam No. 5 the drainage blanket should be limited to the area downstream of the impervious core, and extending up the abutments to El. 1225 at Dam No. 4 and El. 1200 at Dam No. 5. The downstream toe of all dams should be protected with rockfill of sufficient thickness to assure continued drainage from the blanket during freezing weather.

The glacial till and the coarse tailings should be placed in 12 in. thick lifts and compacted by two coverages of a heavy smooth-drum vibratory roller. In order to avoid problems with compaction of the glacial till, the water content must be carefully controlled to within two percent of optimum. No material should be placed on frozen fill and no frozen material should be placed in the embankments.

Dam No. 1

This dam will be safe as designed.

The investigation reported herein has confirmed our earlier assumption that the varved clay stratum contains numerous layers of silt and fine sand which, considering the slow rate of construction of the dam, would assure adequate drainage during consolidation of the clay layers, especially in view of the fact that the maximum thickness of the clay layers is only a few feet.

The combination of a drainage blanket under the starter dam and sand drains may result in the development of undesirable leakage from the tailings pond into the groundwater downstream of the dam. Apart from this problem, our experience with the effectiveness of sand drains is discouraging and may be summarized as follows:

1. The advantages and disadvantages of sand drains is a highly controversial topic. A number of papers have been published with settlement curves showing that a section of an embankment with sand drains is developing more rapid settlements as compared to a neighboring section without sand drains, i.e. with the implication that since the settlements are developing faster they will stop in a shorter period of time. Unfortunately, these settlement curves generally extend over only a short period of time. When sand drains are installed in a sensitive clay, the disturbance of the clay structure results in much greater

total settlements, which are reflected in long-term settlement records. A designer who staked his reputation on his recommendation to install sand drains, and has already published a paper "proving" that he was right on the basis of short-term records, may prefer not to publish another paper presenting the long-term records.

2. If it is decided that sand drains must be installed, disturbance to the structure of the clay can be reduced by prohibiting the driving of full displacement steel casings, and instead removing the clay (at much greater cost) by means of hollow-stem flight augers, or jetting. An alternate method would be to install "cardboard" wicks at close spacing, as developed in Sweden.

Because of the potential harmful effects of sand drains, and because of the proposed slow rate of increase in height of the embankments which will allow sufficient time for the foundation soils to consolidate, it is our considered judgment that neither sand drains nor a drainage blanket should be installed under the starter dam No. 1. To disperse any doubts in the minds of the designers about the safety of this starter dam, we recommend (1) replacing the El. 1150 berms of the starter dam by 1 on 6 slopes, as shown in Fig. 14, which will decrease the applied stresses in the foundation soils, and (2) constructing a test embankment without sand drains and with numerous piezometers to monitor the built-up and dissipation of pore pressure in the varved clay.

The glacial till used for construction of the starter dam should be well-graded and should not contain less than 5% of clay sizes.

Dam No. 2-3

This dam will be safe as designed.

For reasons discussed above, installation of a drainage blanket and sand drains under the starter dam should not be considered. However, a 5 ft thick drainage blanket should be placed between the downstream toe of the starter dam and the downstream toe of the main dam.

The type of glacial till for the construction of the starter dam should meet the same specifications as recommended for Starter Dam No. 1.

Dam No. 4

Since the foundation conditions at this site have not yet been investigated, we can make no definite statement about the adequacy of the design, except that it will probably be safe as designed. Depending on the type and thickness of foundation soils existing at this site it may be necessary to extend the glacial till core in form of a cut-off to an impervious foundation stratum.

If the downstream shell overlies impervious material the design should incorporate a 5 ft thick drainage blanket under the downstream shell.

Dam No. 5

The same considerations presented above for Dam No. 4 apply also for Dam No. 5. In addition, because even a well-compacted mixture of cobbs and filter tailings will be relatively pervious, we recommend that also this dam be designed with a central core of clayey glacial till.

VI. SETTLEMENTS OF DAMS UNDERLAIN BY LACUSTRINE STRATUM

For the following reasons we conclude that the magnitude of dam settlements will be smaller than computed by the designers, and the rate of settlement will be faster.

1. The majority of the consolidation tests on which the settlement analyses were based, were performed on partially disturbed samples of clay. In undisturbed state, the void ratio-pressure curves display a rather sharp, well defined transition between the virgin compression branch and the preconsolidation branch. Depending on the degree of disturbance this transition becomes more gradual. Therefore, the more disturbed the clay specimen, the greater will be the coefficient of consolidation.

2. The granular layers in the lacustrine stratum will contribute only a small fraction to the settlements as compared to the clay layers. We estimate that between 30% and 50% of the lacustrine stratum consists of granular layers and, therefore, the total thickness of clay contributing to settlements will be substantially less than probably assumed by the designers.

Because the numerous granular layers in the varved clay stratum will act as reinforcement against shear, this will greatly reduce the probability of abrupt differential settlements developing, except possibly close to the steep east abutment of Dam No. 1 and Dam No. 2-3. Furthermore, the borings did not disclose any sharp discontinuities in the compressibility of the foundation materials. However, if cracks should develop, we agree with the designers that these dams would be self-healing.

VII. WATER LOSSES THROUGH FOUNDATIONS AND THROUGH DAMS

Assuming that locally-existing pervious areas in the pond foundation are sealed as recommended under Chapters IV and V in this report, and that sand drains are not installed, we agree with the designers that water losses through the varved clay stratum and through glacial till will be neglibible. Furthermore, both of these materials would act as an effective filter to prevent passage of even the finest fibrous particles.

When computing the water losses through the dams the designers assumed that the existence of a wide beach of fine tailings, with a small coefficient of permeability, will prevent water from getting into direct contact with the much more pervious main body of the dam. To check the permeability of the two materials involved, we made one permeability test on each of the following two specimens:

1. Fine tailings deposited into the permeameter under water, with the finer material being removed from the surface as the coarser fraction settled in the water. The test was conducted with the tailings in a loose state.

2. A mixture of 75.5% (by weight) cobbs and 24.5% filtered tailings. (This is in the same proportion as these materials will be produced.) This mixture was moistened to prevent segregation and compacted into the permeameter in layers.

Both samples were tested using a constant-head method. The coefficient of permeability (at 20°C) of these specimens is as follows:

Fine tailings $k_{20} = 4.5\text{x}10^{-5}$ cm/sec

Coarse tailings $k_{20} = 3.7\text{x}10^{-3}$ cm/sec

Pertinent data for the test specimens is given in Table 1, and the grain size curves of these specimens and of a specimen of the fine tailings as received are shown in Fig. 13.

The above permeabilities agree approximately with the figures used by the designers in their computations (note that their values are in terms of ft/min.). However, we believe that for the following reasons the water losses may, at times, be greater than computed by the designers:

1. After the height of a dam has been increased by an additional stage, spigotting may be continued from the new crest in which case it will require some time for a beach of fine tailings to cover the 1 on 2 slope of the dam. During this interim period, water from the spigotting operation would be able to enter directly into the relatively pervious body of the dam.

2. During prolonged rainfall and periods of melting snow the large surface area of the crest and downstream slope of the dams will temporarily store appreciable quantities of water which, during its seepage through the dam, may leach some of the finest fibrous particles and will contribute appreciably to the seepage water which has to be pumped back into the pond. E.g., one inch of precipitation on the area of Dam No. 1 will contribute about 6 million gallons to the seepage water. This does not include the water contributed by the catchment areas, which may be an additional 4 million gallons for a one-inch rainfall.

The ground surface contours downstream of Dam No. 1 indicate that additional seepage collection ditches may be necessary just downstream of the toe of the dam on the west abutment and within 3000 ft of the east end of the dam, to channel the seepage water to the reclaim ponds.

VIII. STABILIZATION OF TAILINGS DELTA AND STABILITY OF STRUCTURES ON DELTA

Except for the design of riprap for earth dams, we are not experts on coastal problems concerning protection against wave action. Our questions and comments on the proposed Delta stabilization may, therefore, be of only marginal significance. However, we have the following comments concerning the dike designed to stabilize the Delta:

1. Unless a properly designed and constructed inverted filter underlies the armor rock on the beach, gradual erosion of the beach from beneath the armor may eventually result in the collapse of the proposed rock dike.

2. Repeated costly maintenance of the armor and dike may force the mining company to eventually abandon all or at least a major portion of the Delta.

For the above reasons we believe that it may be important to analyze what the consequences would be of a gradual loss of the existing Delta by erosion. Since the potentially harmful fibrous particles are reportedly predominantly of colloidal sizes, i.e. less than about $5x10^{-6}$ mm size, we have attempted to establish whether the Delta contains a significant amount of colloidal particles, or whether practically all colloidal sizes have already been washed into the lake during formation of the Delta.

During our meeting on July 15, 1975, at the offices of the Reserve Project Team, we asked Dr. James R. Kramer whether in his opinion the Delta contains a significant fraction of the potentially harmful colloidal tailings. Dr. Kramer was quite outspoken in his belief that practically all of the colloidal sizes were washed directly into the lake from the launders. He confirmed this opinion in his "Note on Reserve Delta and Tailings Composition", dated 17th July, 1975. An areal photograph taken by us during our inspection in May, Photo No. 1, encourages us to agree with Dr. Kramer that the large quantities of water discharging from the two launders would effectively carry all colloidal particles directly into the lake.

The report by Professor Donald H. Gray titled PARTICLE SIZE ANALYSIS & RELATIVE DENSITY TESTS ON TACONITE TAILINGS FROM SILVER BAY, MINNESOTA, dated 9 May 1973, contains the grain size analysis of six samples of tailings taken at depths of 1 and 3 ft from locations near the two launders. Four of the samples did not contain any particles smaller than approximately 0.2 mm, one sample contained approximately 14% smaller than the No. 200 mesh (0.074 mm), and another sample contained approximately 66% of particles smaller than the No. 200 mesh. If the harmful particles are predominantly of a size smaller than 5×10^{-6} mm (see page 2 of Dr. Kramer's Note), it is reasonably safe to conclude that even the finest particles of most of the above six samples would not be potentially harmful.

Of equal or even greater importance are the results of 29 grain size determinations on specimens from the Delta by Soil Exploration Co. of St. Paul, Minn., transmitted by Klohn Leonoff Consultants to Reserve Mining Co. by letter dated June 19, 1975. The test specimens were taken in 5 borings, Nos. 1001 to 1005, at depths ranging from 0.5 ft to 81 ft. The locations of these borings are shown in Fig. 15. Of the 29 specimens, 23 were found to contain between 2 and 10% particles smaller than the No. 200 mesh (0.074 mm), four specimens contained between 12 and 15%, one sample contained 22% and one sample had 27% passing No. 200 mesh. The percent of particles smaller than the No. 200 mesh is plotted as a function of depth in Fig. 16, which illustrates that the distribution of fines is fairly uniform with depth in the Delta. The shapes of the grain size curves indicate that even the specimen containing 27% smaller than No. 200 mesh, had little or no colloidal sizes of the critical range.

From the available data we are inclined to conclude that (1) as soon as tailings are no longer discharged onto the Delta, lake pollution will decrease dramatically, and (2) even severe erosion of the Delta should not contribute significantly to hazardous lake pollution.

On the basis of the grain size distribution of the tailings in the Delta, in conjunction with the range of the standard penetration resistance, plotted vs. depth in Fig. 17, we conclude that even heavy structures could be built on spread footings. However, in areas where the Delta may be subject to erosion, structures would have to be supported on piles or piers.

IX. CONCLUSIONS AND RECOMMENDATIONS

It is our considered opinion that the basic design of the Milepost 7 tailings pond, as proposed by Klohn Leonoff Consultants, is safe beyond human doubt. If we recommend relatively minor modifications to this design and to the methods of construction, it is only in an attempt to improve upon the overall effectiveness of this project.

Site Characteristics

Milepost 7 is well suited for the purpose of developing the proposed tailings pond. The foundation conditions for the construction of Dam No. 1 and Dam No. 2-3 are satisfactory and, although the sites for Dam No. 4 and Dam No. 5 have not yet been adequately investigated, the foundation conditions at these locations will probably be equally satisfactory.

Construction Materials

Both the glacial till, intended for construction of the starter dams, for the core of Dam No. 4 and for the diversion and reclaim dikes, and the coarse tailings (cobbs + filter tailings) are ideal construction materials. In compacted state, the angle of internal friction of these two angular materials is more than adequate to assure stability of the slopes.

Dam Design, Stability Analyses and Safety

Although the design of the dams is satisfactory, we believe the following recommendations would improve the overall integrity of this project:

1. The starter dam for Dam No. 1 should be designed without sand drains and without drainage blanket. To improve the stability of this starter dam the berms should be replaced by 1 on 6 slopes, as shown in Fig. 14. Construction of a full-scale test section, including piezometer observations, would provide convincing evidence that sand drains are not necessary.

2. The drainage blanket under Dam No. 1 and Dam No. 2-3 should be 5 ft thick and should extend downstream of the centerline of the main dam, and up to about El. 1200. If it is decided that a drainage blanket is necessary at Dam No. 4 and Dam No. 5, it should be placed under the downstream shell, and up to El. 1225 at Dam No. 4 and El. 1200 at Dam No. 5.

3. Dam No. 5 should be designed with a central core of clayey glacial till, similar to Dam No. 4.

4. All materials should be compacted in 12 in. lifts with two passes of a heavy vibratory steel drum roller. Fill should not be placed on frozen material and no frozen materials should be placed in the dams or dikes.

5. During construction the surface of all impervious zones of the dams and dikes should be sloped transversely not less than 3% for proper surface drainage.

6. All dams should have a clean rockfill toe at the downstream side, with a proper filter between rockfill and drainage blanket, to assure continued drainage during freezing weather.

7. At no time should the tailings pond elevation be permitted to rise to within 10 ft of the crest elevation of the lowest dam without an adequate spillway.

We believe that the in-situ shear strength of the varved clay stratum is appreciably greater than the 600 psf used by the designers in their stability analyses. Therefore, the factor of safety against foundation failure will be greater than that computed by the designers.

"Piping" could not develop through a well-compacted mixture of cobbs and filter tailings, in combination with a flat downstream slope. Also, such an embankment could not slump, even during a severe earthquake.

Settlements of Dams and Effects of Slow Regional Uplift

The settlements of Dam No. 1 and Dam No. 2-3 will be smaller and the rate of settlement will be faster than predicted because the designers based their analysis on (1) consolidation tests of partially disturbed clay specimens, and (2) apparently on the assumption that the lacustrine stratum consists only of clay.

We do not anticipate sharp differential settlements except possibly close to the steep east abutment of Dam No. 1 and Dam No. 2-3. However, because of the self-healing properties of the coarse tailings this should cause no problems.

A gradual regional uplift will have no detrimental effect on the dams or on the tailings pond.

Coarse Tailings Stockpile

On the basis of the high friction angle of the coarse tailings, we are of the opinion that even in loosely-dumped state the stockpile will be stable. Although we do not foresee any serious dust problem, dust may develop during dry and windy periods and would have to be alleviated by such means as occasional spraying with water or covering unused sections of the area with a thin layer of soil and developing vegetation.

Glacial Till Borrow Areas

For reasons discussed under Chapter IV we recommend that the designers review the proposed procedure of excavation with particular attention to questions of drainage and working the borrow area to obtain glacial till of suitable gradation. It may be most economical to process the till in the borrow area to eliminate oversize material.

Instrumentation of Dams

We underscore the importance of instrumentation to monitor the performance of the dams and foundations, as proposed by Klohn Leonoff Consultants. In particular, we recommend installation of standpipe-type piezometers along several cross-sections of all dams, and extending to the bottom of the embankments and to several elevations in the lacustrine stratum. These piezometer pipes should be extended as the dams are raised, and those piezometers that will be covered by the pond should be changed to pneumatic-type when the pond level reaches that location. All piezometer pipes should be well-protected against damage during construction and should be provided with secure caps. The piezometers must be frequently monitored during the intitial stages of construction, and then on a regular basis for the life of the structures.

All observational data should be reviewed periodically by a board of consultants.

Hydrology and Stream Diversions

We are not specialized in the field of hydrology and stream diversions, and can only state that our review of the available information has not uncovered any items of questionable integrity. It is our impression that except for the following minor item, all design details have been competently dealt with. In their design report, Klohn Leonoff Consultants state that it is not essential to form a tight seal when the diversion culvert through Dam No. 1 is grouted. In our opinion, the fine tailings must not be depended on to seal any leaks through this culvert.

Dust and Erosion Problems

We do not anticipate serious dust problems arising from storage of coarse tailings or during placement and compaction of tailings in the dams. Any small particles attached to cobb tailings will be washed into the voids by rain and by any necessary sprinkling during compaction operations. However, we visualize that the topography of this area may cause wind eddies which could result in erosion of dry soil, including wind transport of the finer particles of filter tailings. If such wind erosion should develop, it could be controlled by watering or vegetation.

Unless the surface of the tailings pond beach is kept wet at all times, a serious dust problem could develop because of the fine gradation of these tailings. In such an event, installation of a sprinkler system may become necessary.

We see no serious problems with erosion of the coarse tailings by runoff from precipitation because, unless the rate of precipitation is exceptionally severe, most of it will enter directly into the tailings deposit. If there should be some gullies formed by surface runoff, the eroded material would be deposited either in the tailings pond or in the reclaim areas downstream of the dams. Any gullies should be promptly filled.

Reclamation and Perpetual Maintenance

In order to assure that the tailings pond, including the slopes of the four dams, will remain relatively problem-free for an indefinite period of time, the following measures will be necessary:

1. Development of vegetative growth on the downstream slope of the dams as soon as a new construction stage has been completed, as proposed by Klohn Leonoff Consultants. If necessary, a veneer of soil will have to be placed on the

slopes to support plant life. However, any erosion channels which may develop along the slopes as a result of heavy precipitation or spring runoff would have to be promptly filled to prevent more serious problems.

2. Once the tailings pond is filled, or if its use is interrupted or discontinued prematurely, several feet of coarse tailings should be spread over the entire area and graded such that any surface runoff drains toward the spillway. The area should then be vegetated, using a thin layer of soil if necessary.

After the above measures have been executed, any surface runoff will not be contaminated with potentially harmful particles nor will there be any dust problems to deal with. These measures will also, for practical purposes, prevent seepage into the fine tailings and into the dams, and it should be possible to discontinue the collection and recycling of water from the reclaim areas downstream of the dams. Some water will continue to seep indefinitely from the toes of the dams, but tests will probably show that this water is not a health hazard.

Stabilization of Delta and Stability of Structures on Delta

From all available information we conclude that the pollution of the lake will rapidly diminish as soon as an on-land tailings disposal system is placed in operation.

We are not convinced that the proposed method of stabilizing the Delta by means of a rock dike will be adequately effective. If, on the other hand, it should be decided by the State that gradual erosion of the Delta will not be potentially harmful, then the State need not be concerned with the effectiveness of the proposed Delta stabilization. In our opinion, the best solution to this problem

Should be determined by an observational approach. I.e. before deposition of tailings in the lake is discontinued, obtain as much information as possible about the size and character of the Delta and about the lake in the immediate vicinity of the Delta; then, continually monitor these parameters after tailings deposition is discontinued. These data will form a basis for determining the rate of erosion and what measures, if any, may be necessary to prevent erosion. At the same time, several test sections could be constructed and monitored to determine the most effective method.

The bearing capacity of the Delta is adequate to support heavy structures on spread footings. In areas which may be subject to erosion all structures would have to be built on piles or piers.

We recommend that the question of erosion of the Delta front be studied by a board of specialists with extensive experience in control of beach erosion.

Inspection of Dams and Dikes During Construction and After Completion

Close supervision of all aspects of construction by a team of experienced inspectors under the guidance of an engineer thoroughly familiar with this project is of utmost importance. In addition, to the designers' and mining company's inspectors, the State should set up a program of regular inspection to assure that the dams are being constructed in accordance with the design. This program of inspection should be continued indefinitely after the dams are completed. Of particular importance are frequent inspections of all dam slopes and of downstream abutment slopes with special attention to any visible leakage, development of erosion channels, and dust problems requiring attention. The Engineer in charge of this inspection will have to be responsible for obtaining the advice of experts whenever unusual problems develop.

Establishment of Board of Consultants

In recent years it has become common practice that the design of all important dams be reviewed by a board of independent consultants who also periodically inspect the construction. We recommend that the State nominates such a board or requires that the Owners do so.

Respectfully submitted,

L. Casagrande

D. R. Casagrande

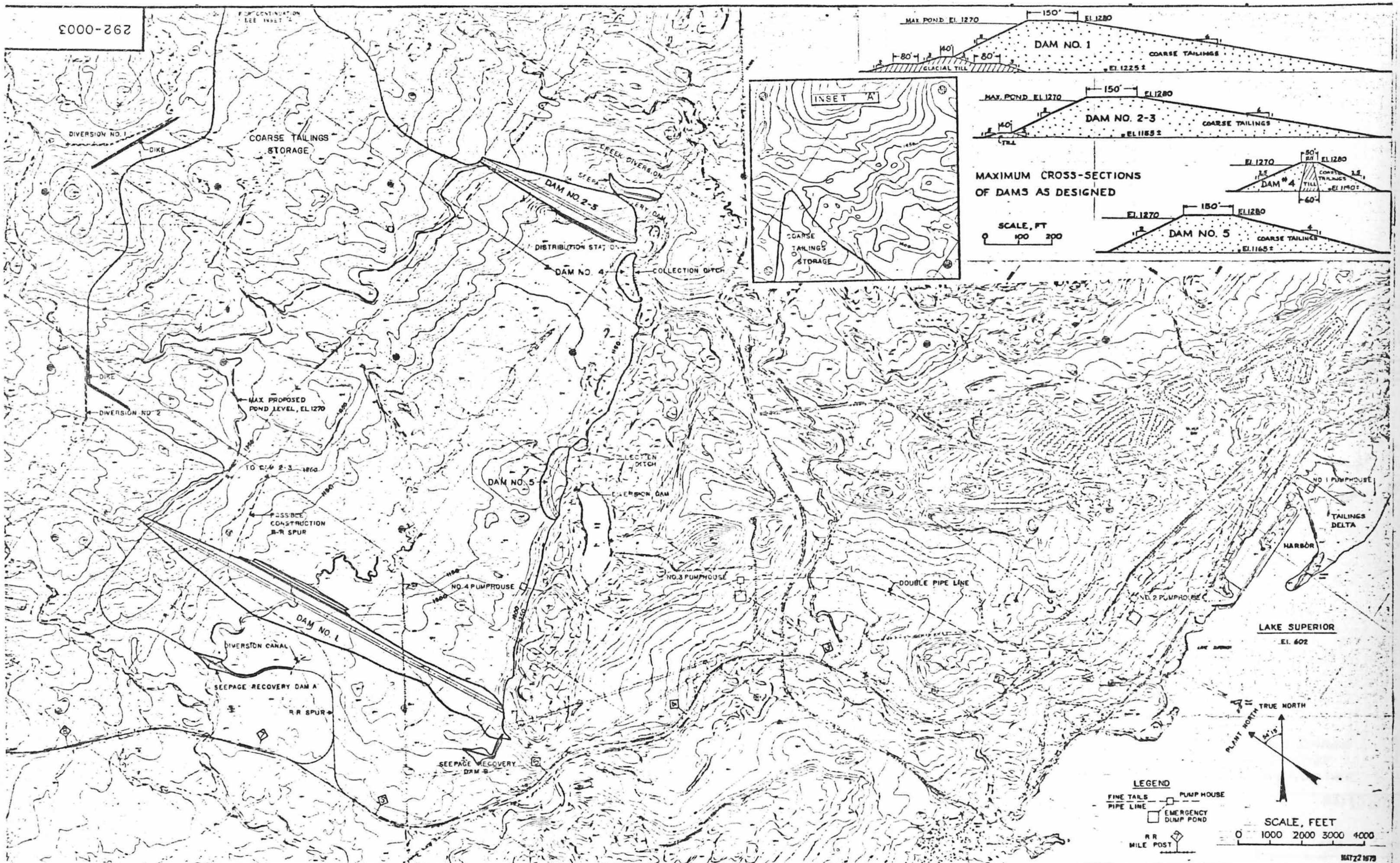
TABLE 1

RESERVE MINING PROJECT: MILEPOST 7

RESULTS OF PERMEABILITY TESTS

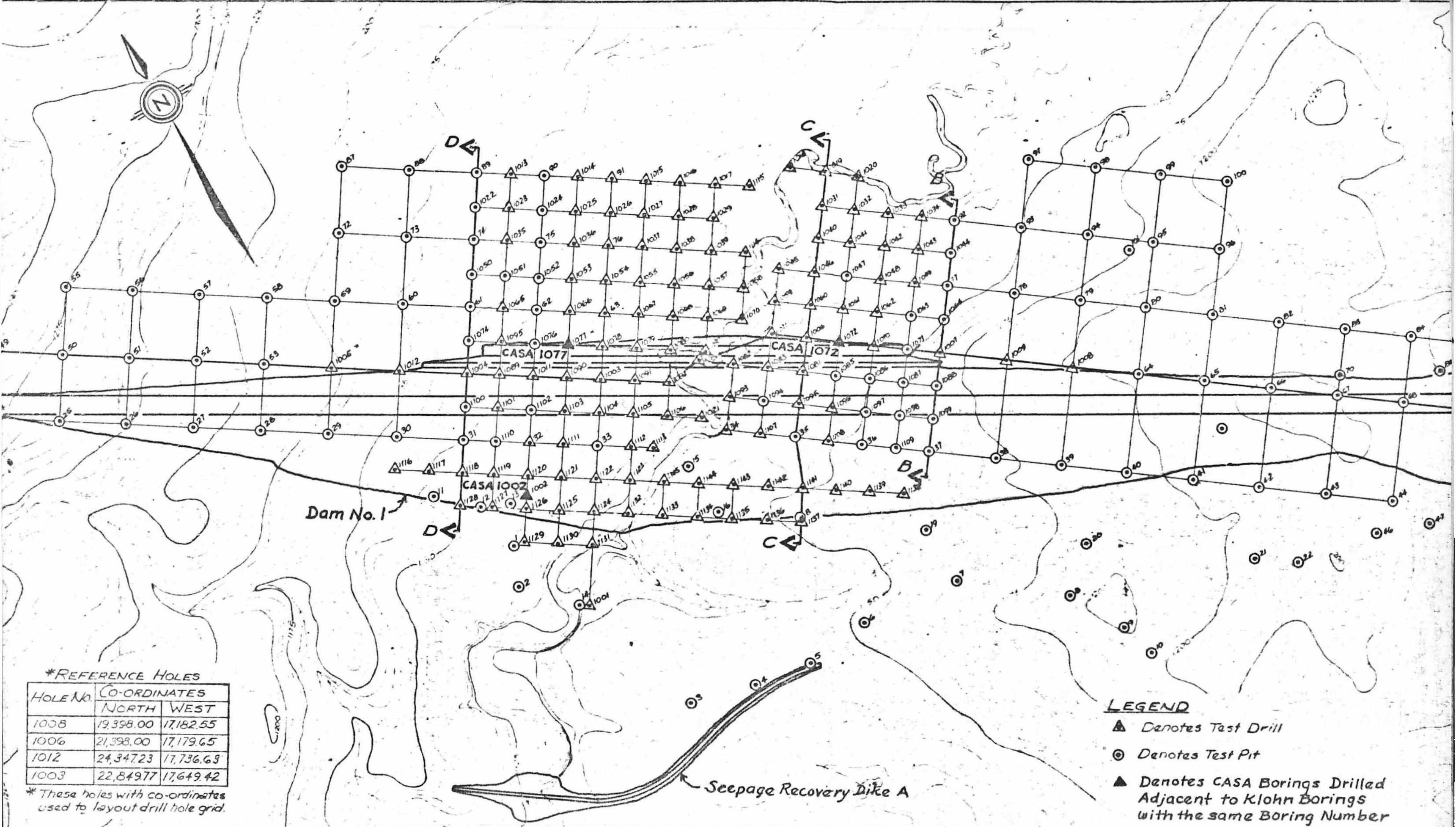
Material	Location	Depth ft	Type of Specimen	Dry Unit Weight, pcf	Water Content, %	Confining Pressure in Test, kg/cm^2	Gradient	Coef. of Permeability at $20^{\circ}C$, cm/sec
Silt	Bor.1077/6B	15.0	Undisturb.	104.1	24.5	0.45	35	7.60×10^{-6}
Silt	Bor.1077/6C	16.0	Undisturb.	103.3	23.4	0.45	34	4.82×10^{-6}
Fine Tailings	Pilot Plant	-	Compacted	102.1	28.6	0	12	4.47×10^{-5}
Coarse Tailings	Pilot Plant	-	Compacted	127.2	9.2	0	7	3.68×10^{-3}

Photo 1: Reserve Mining Company's Tailings Delta in Lake Superior at Silver Bay, Minnesota; May 3, 1975.



Note: Outlines and Cross-Sections of Dams added by Casagrande Consultants

FIG. 1 - GENERAL LOCATION PLAN AND CROSS-SECTIONS OF DAMS



*REFERENCE HOLES

HOLE No.	CO-ORDINATES	
	NORTH	WEST
1008	19,398.00	17,182.55
1006	21,398.00	17,179.65
1012	24,347.23	17,736.63
1003	22,849.77	17,649.42

* These holes with co-ordinates used to layout drill hole grid.

REFERENCE DRAWINGS

See drawing no. 292-0035 for details of section A-A.
See drawing no. 292-0036 for details of sections B-B, C-C, & D-D.

MAY 15 1975

Note: Locations of CASA Borings and Outline of Dam added by Casagrande Consultants

Scale: A 500' 0 500' 1000'

Klohn Leonoff Consultants Ltd.
CIVIL & GEOTECHNICAL ENGINEERS
VANCOUVER CALGARY WINNIPEG, CANADA

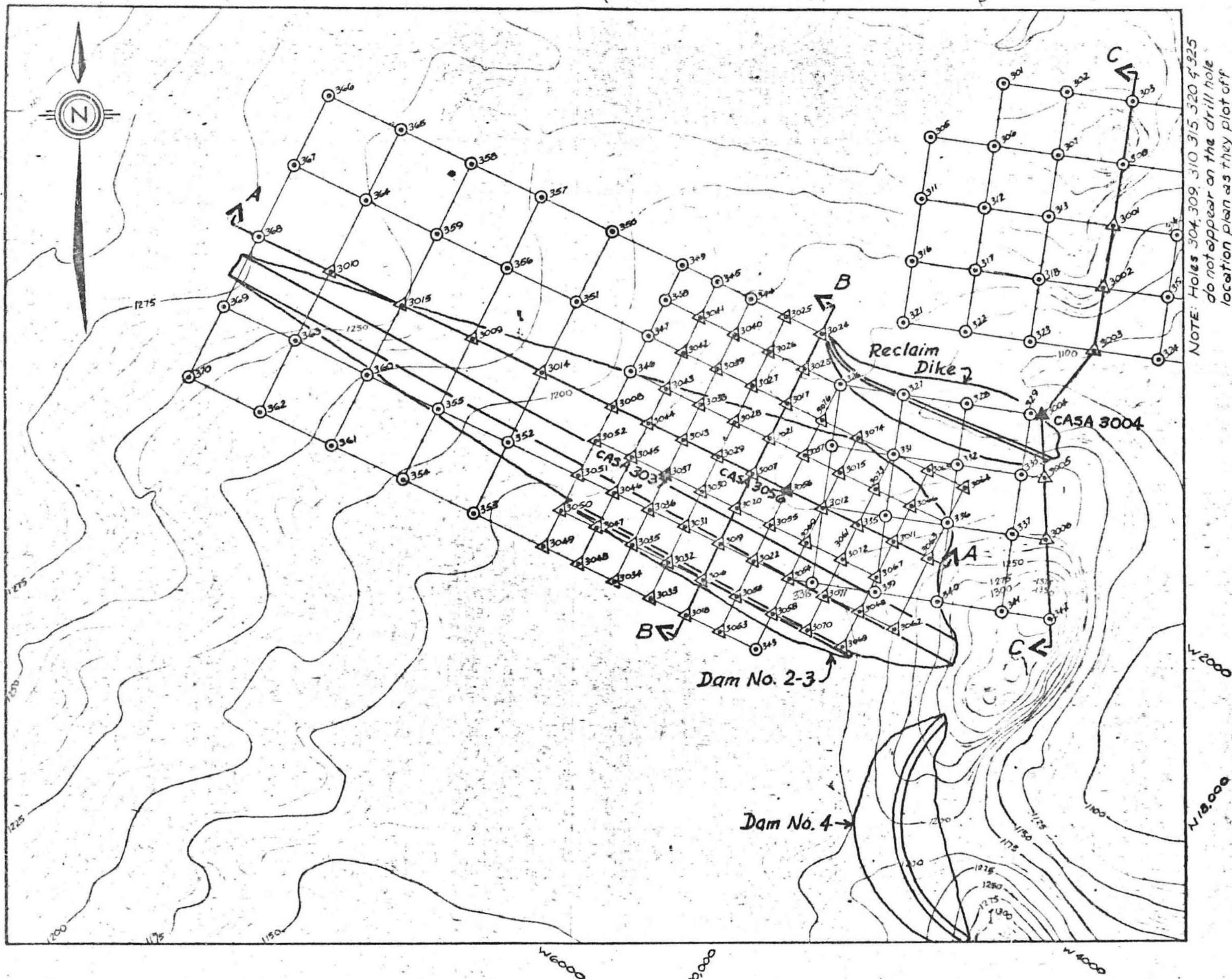
LOCATION		
DRAWN	E. Pharey	4-1-75
CHECKED		
ENGINEER		
APPROVED		
SCALE	As shown	

RESERVE MINING COMPANY — DEPARTMENT

MILE POST NO. 7 SITE
TAILING DISPOSAL AREA
DAM SITE NO. 1
TEST HOLE LOCATION PLAN

292-0022

FIG. 2 - LOCATIONS OF BORINGS AT DAM NO. 1



*REFERENCE HOLES

HOLE No	CO-ORDINATES	
	NORTH	WEST
3006	19,759.56	1949.80
3003	20, 95.00	763.00
3004	20,233.82	1291.03
3001	20,545.90	44.00
3015	23,990.76	3007.93
3011	20,528.30	2492.61

* These holes with co-ordinates used to layout drill hole grid.

REFERENCE DRAWINGS

See drawing no. 292-0037 for details of sections A-A & B-B.

See drawing no. 292-0038 for details of section C-C.

LEGEND

▲ Denotes Test Drill

⊙ Denotes Test Pit

▲ Denotes CASA Borings Drilled Adjacent to Klohn Borings with the same Boring Number

Note: Locations of CASA borings and outlines of dams added by Casagrande Consultants

MAY 1 5 1975

Scale: A 500' — 500' 1000'

...plan, specification or report was ...by direct supervision and that I ...fessional Engineer under the laws

[signature] ...1975 — Reg. No. 11100

Klohn Leonoff Consultants Ltd.
CIVIL & GEOTECHNICAL ENGINEERS
VANCOUVER · CALGARY · WINNIPEG, CANADA

RESERVE MINING COMPANY

LOCATION — DEPARTMENT

DRAWN E. Pearey 3-27-75
CHECKED
ENGINEER
APPROVED
SCALE As shown

MILE POST No. 7 SITE
TAILING DISPOSAL AREA
DAMSITE No. 2-3
TEST HOLE LOCATION PLAN

292-0023

FIG. 3 - LOCATIONS OF BORINGS AT DAM NO. 2-3

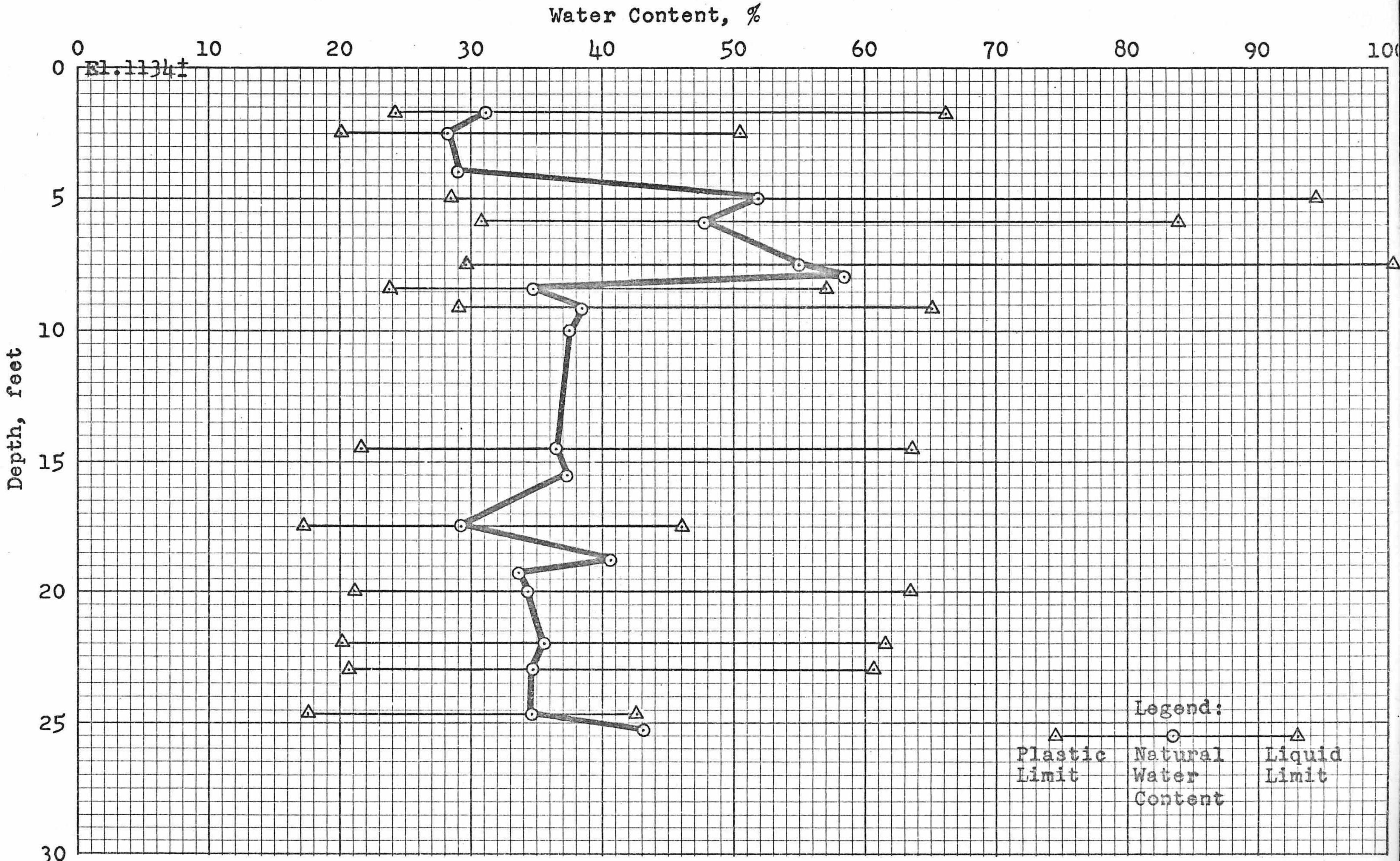


FIG. 4 - WATER CONTENTS AND ATTERBERG LIMITS OF SAMPLES FROM BORING NO. CASA 1002

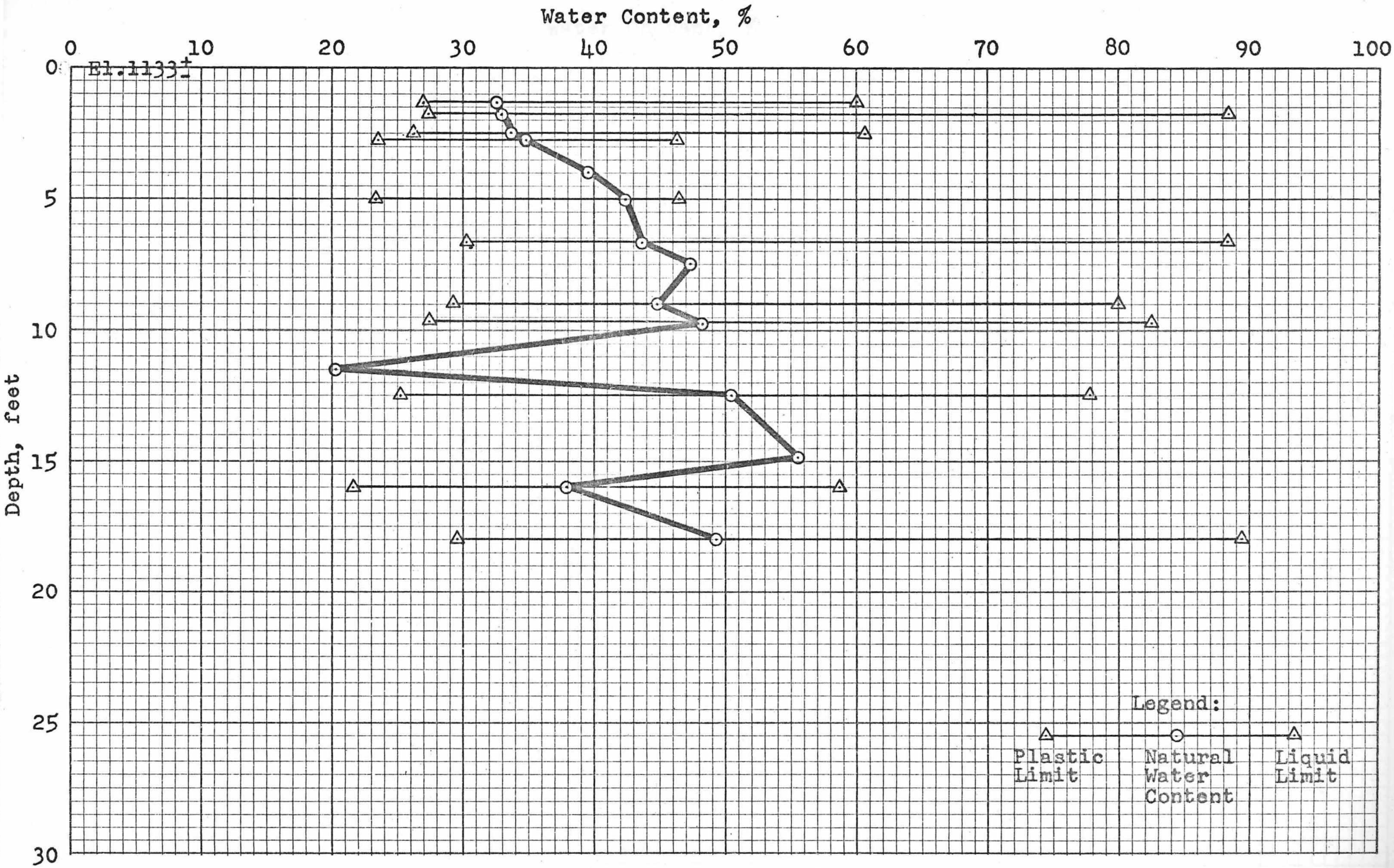


FIG. 5 - WATER CONTENTS AND ATTERBERG LIMITS OF SAMPLES FROM BORING NO. CASA 1072

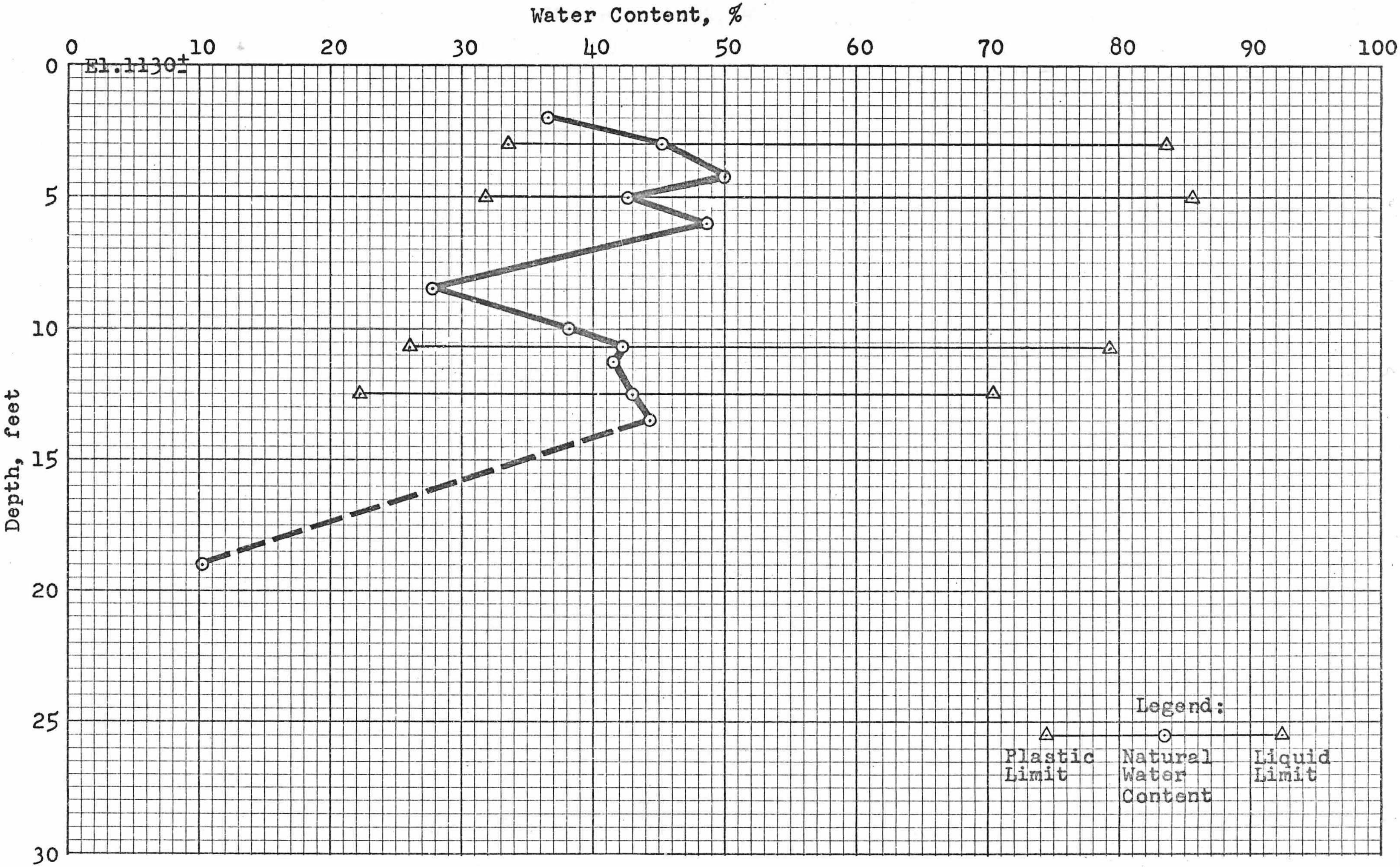


FIG. 6 - WATER CONTENTS AND ATTERBERG LIMITS OF SAMPLES FROM BORING NO. CASA 1077

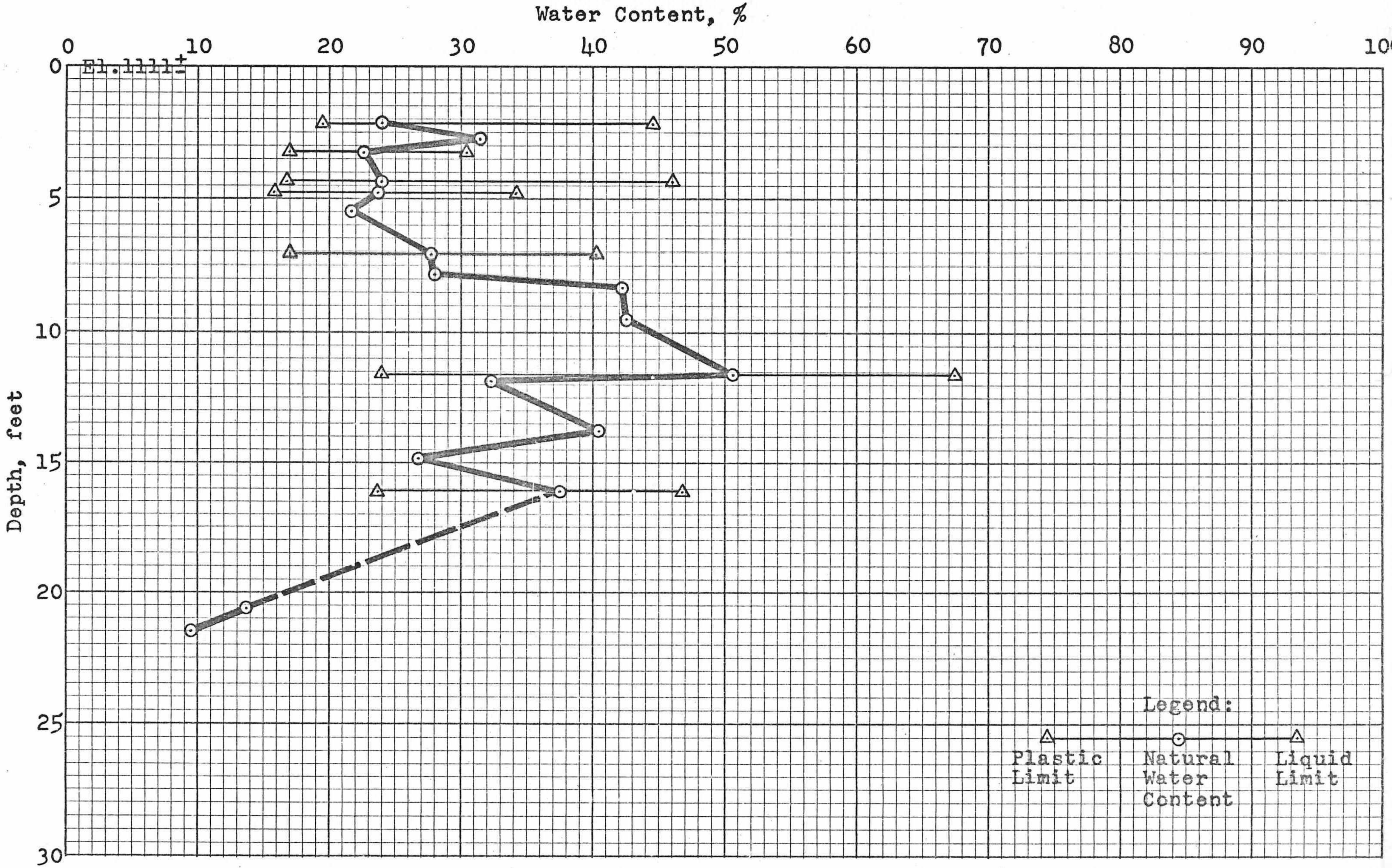


FIG. 7 - WATER CONTENTS AND ATTERBERG LIMITS OF SAMPLES FROM BORING NO. CASA 3004

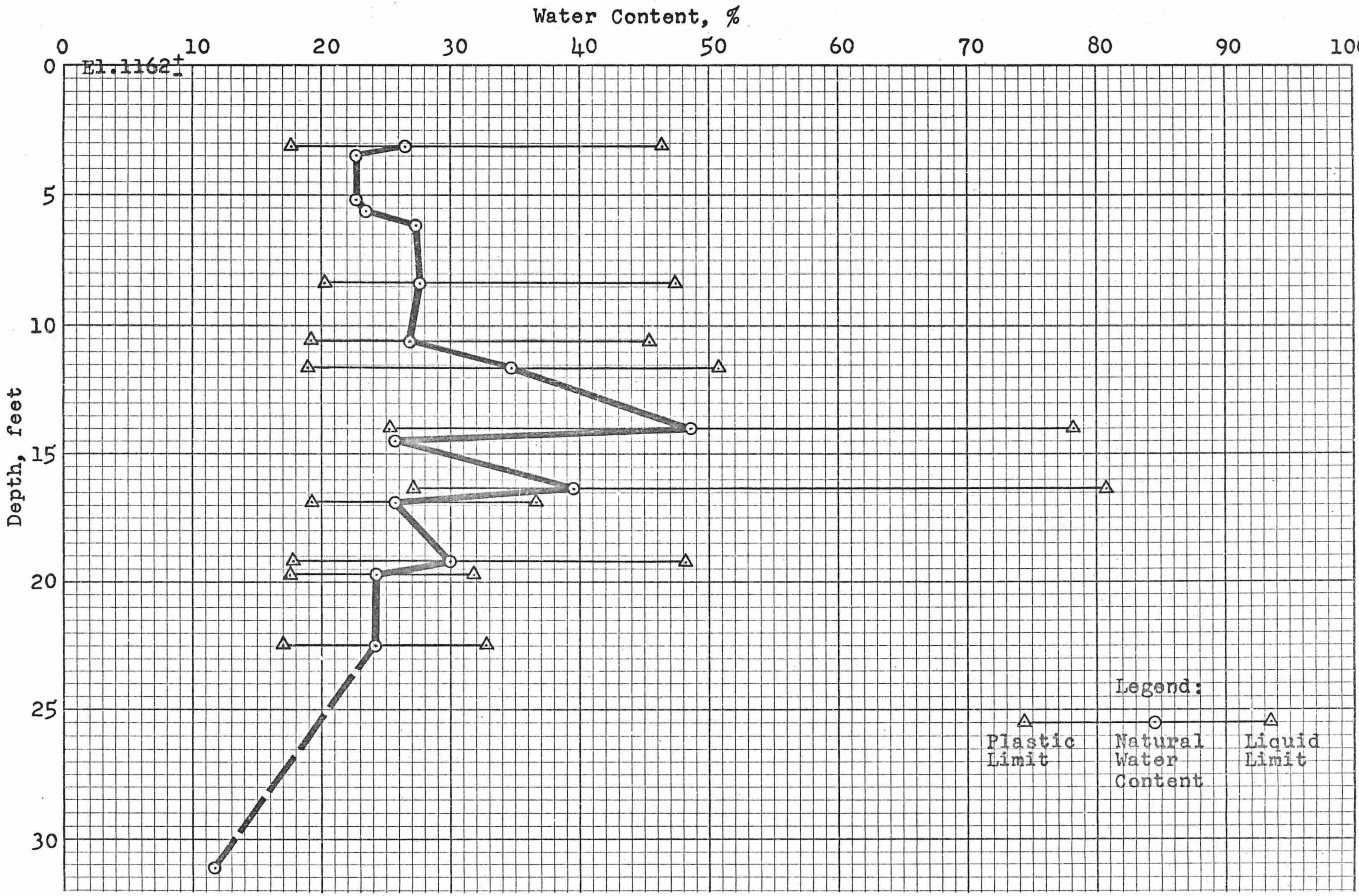


FIG. 8 - WATER CONTENTS AND ATTERBERG LIMITS OF SAMPLES FROM BORING NO. CASA 3037

APPENDIX II

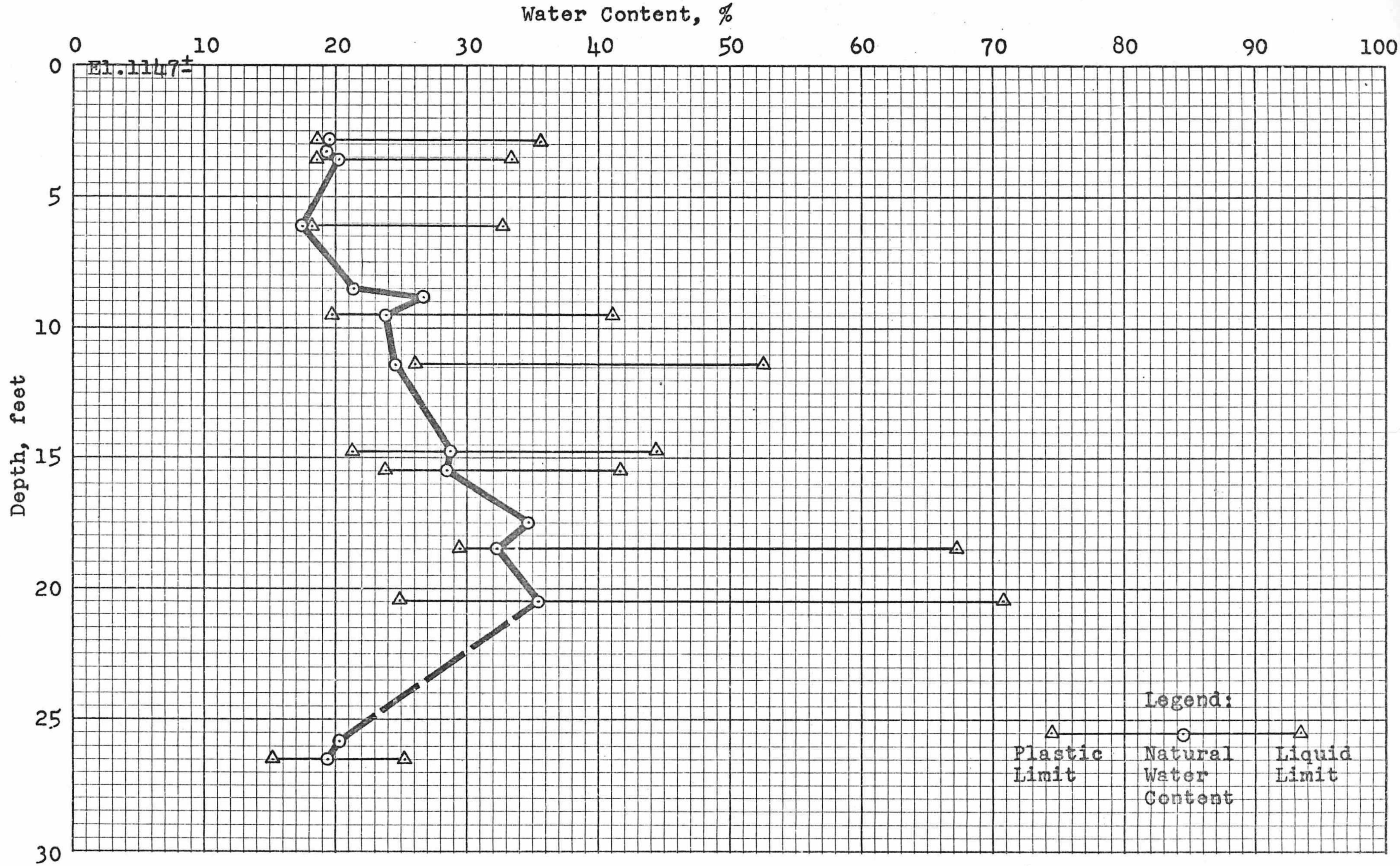


FIG. 9 - WATER CONTENTS AND ATTERBERG LIMITS OF SAMPLES FROM BORING NO. CASA 3056

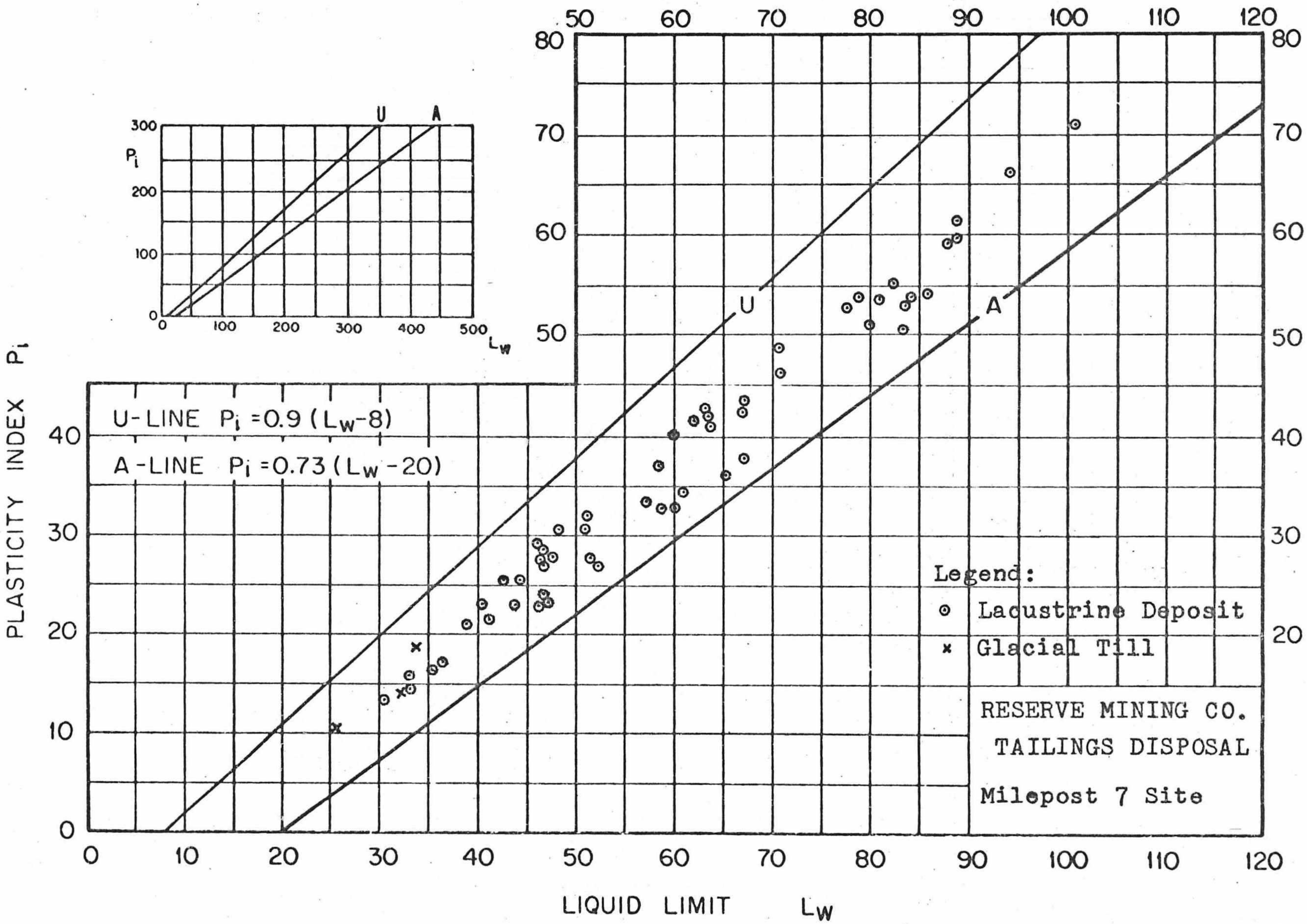


FIG. 10 - PLASTICITY CHART: CASA BORINGS

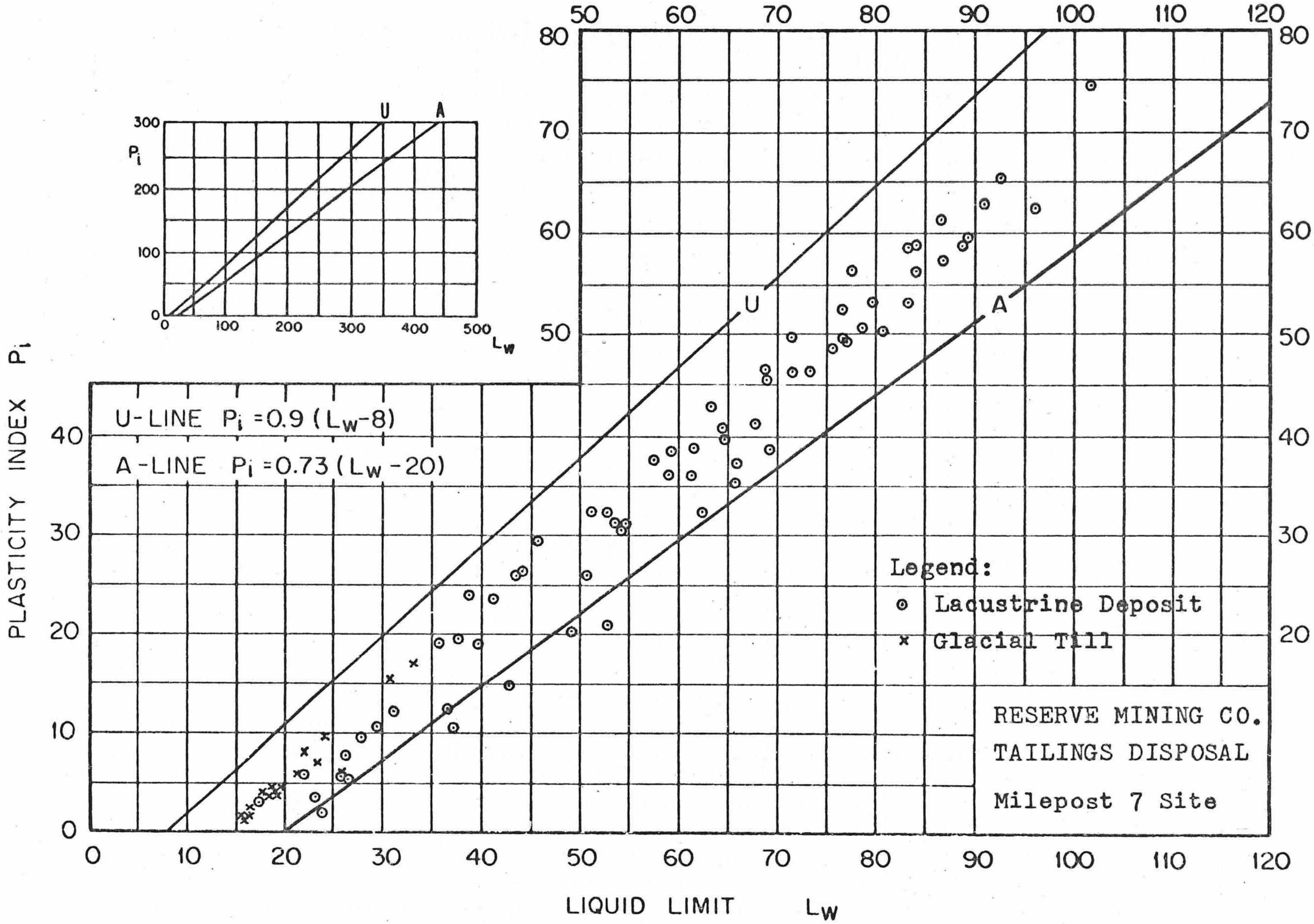
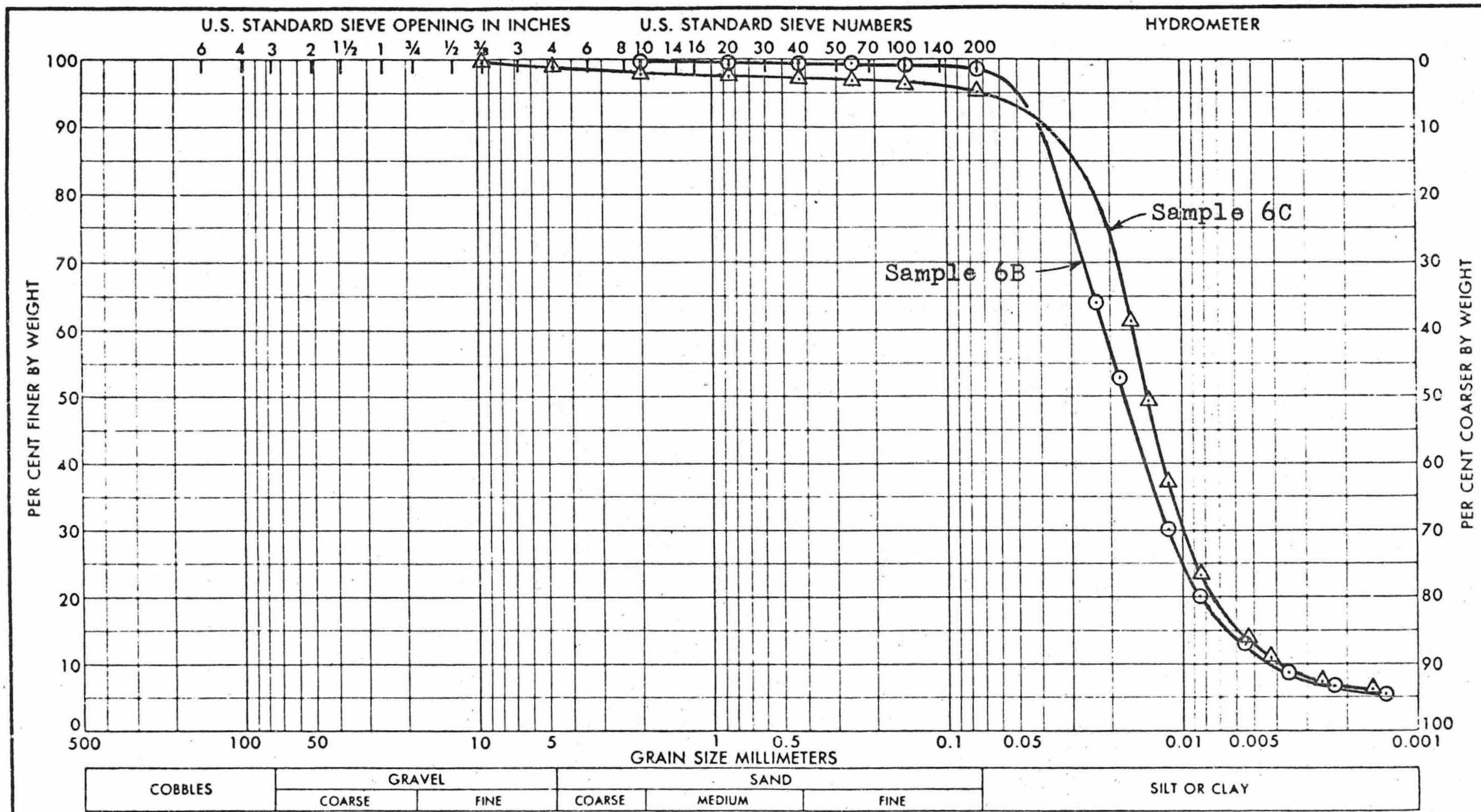


FIG. 11 - PLASTICITY CHART: KLOHN LEONOFF CONSULTANTS BORINGS & TEST PITS



SAMPLE NO	ELEV OR DEPTH	CLASSIFICATION	NAT W%	LL	PL	PI
⊙ 6B	15.0'	Silt				
△ 6C	16.0'	Silt				

GRADATION CURVES

PROJECT RESERVE MINING COMPANY
TAILINGS DISPOSAL
AREA Milepost 7 Site
BORING NO. CASA 1077
DATE August 1975

FIG. 12 - GRAIN SIZE CURVES OF SILT USED FOR PERMEABILITY TESTS

CASAGRANDE CONSULTANTS

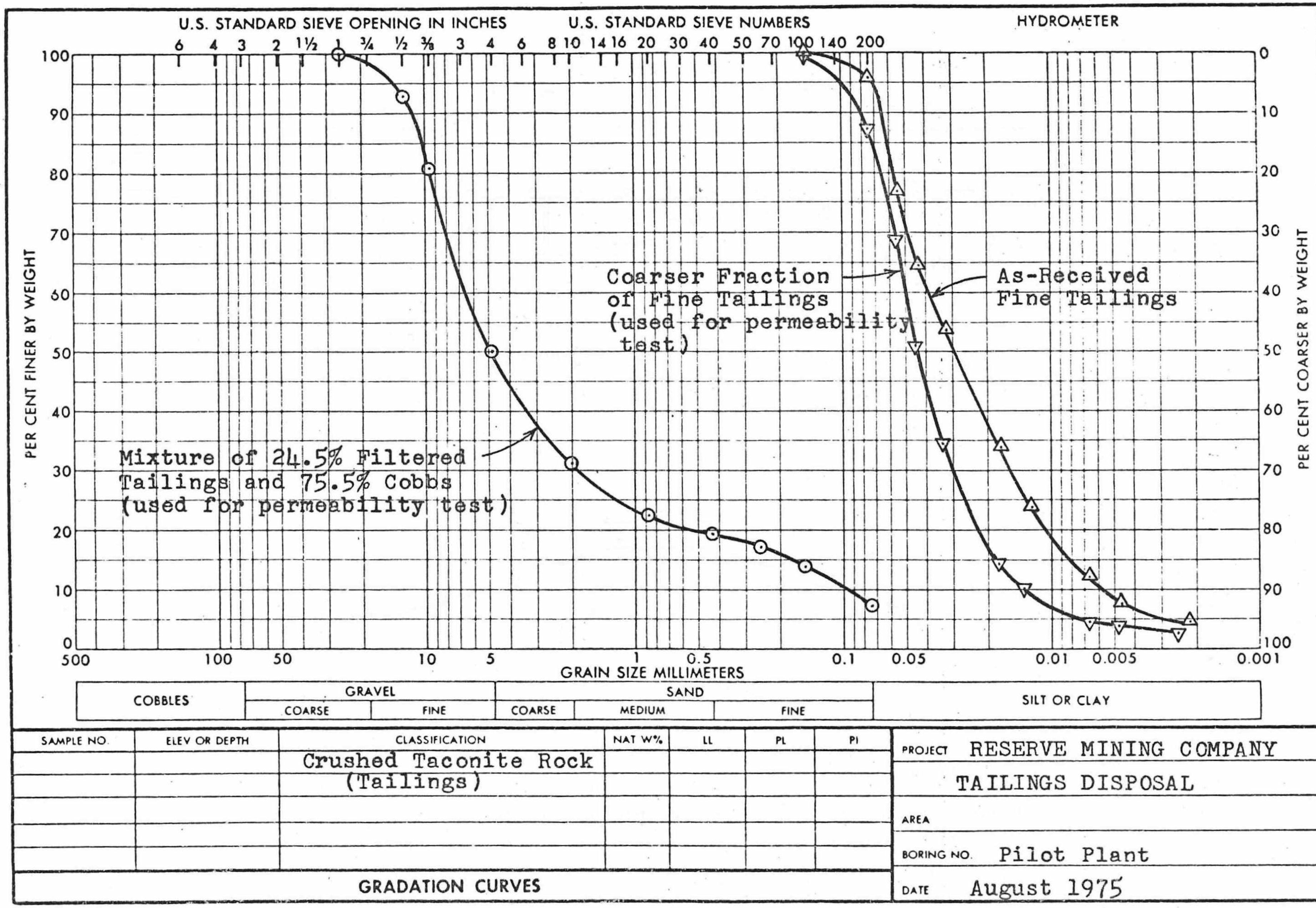
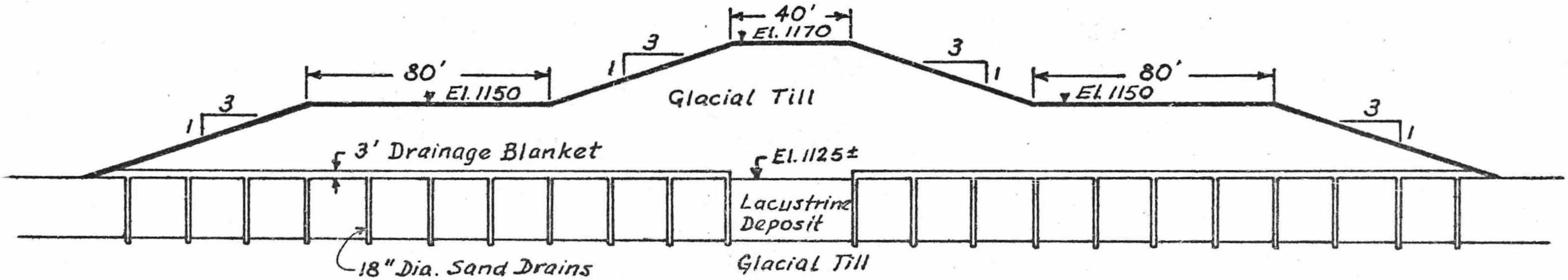
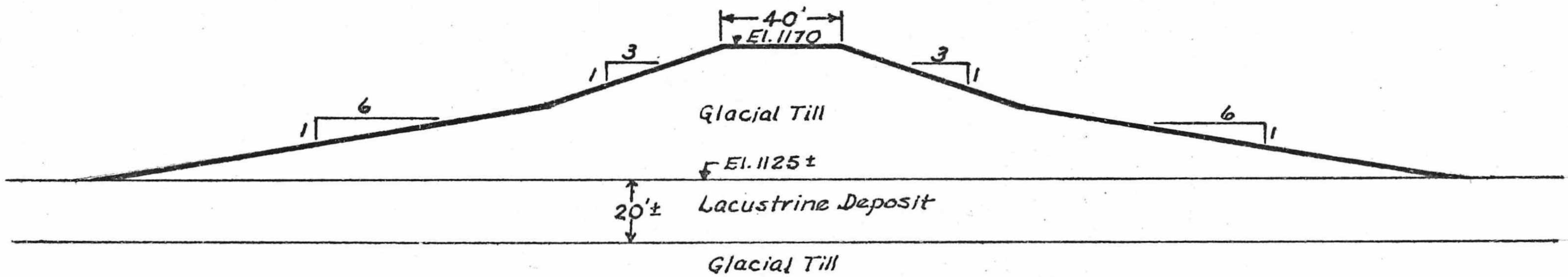


FIG. 13 - GRAIN SIZE CURVES OF TAILINGS



DESIGN PROPOSED BY KLOHN LEONOFF CONSULTANTS LTD.

SCALE : 1" = 50'



DESIGN PROPOSED BY CASAGRANDE CONSULTANTS

FIG. 14 - PROPOSED CROSS-SECTIONS FOR STARTER DAM NO. 1

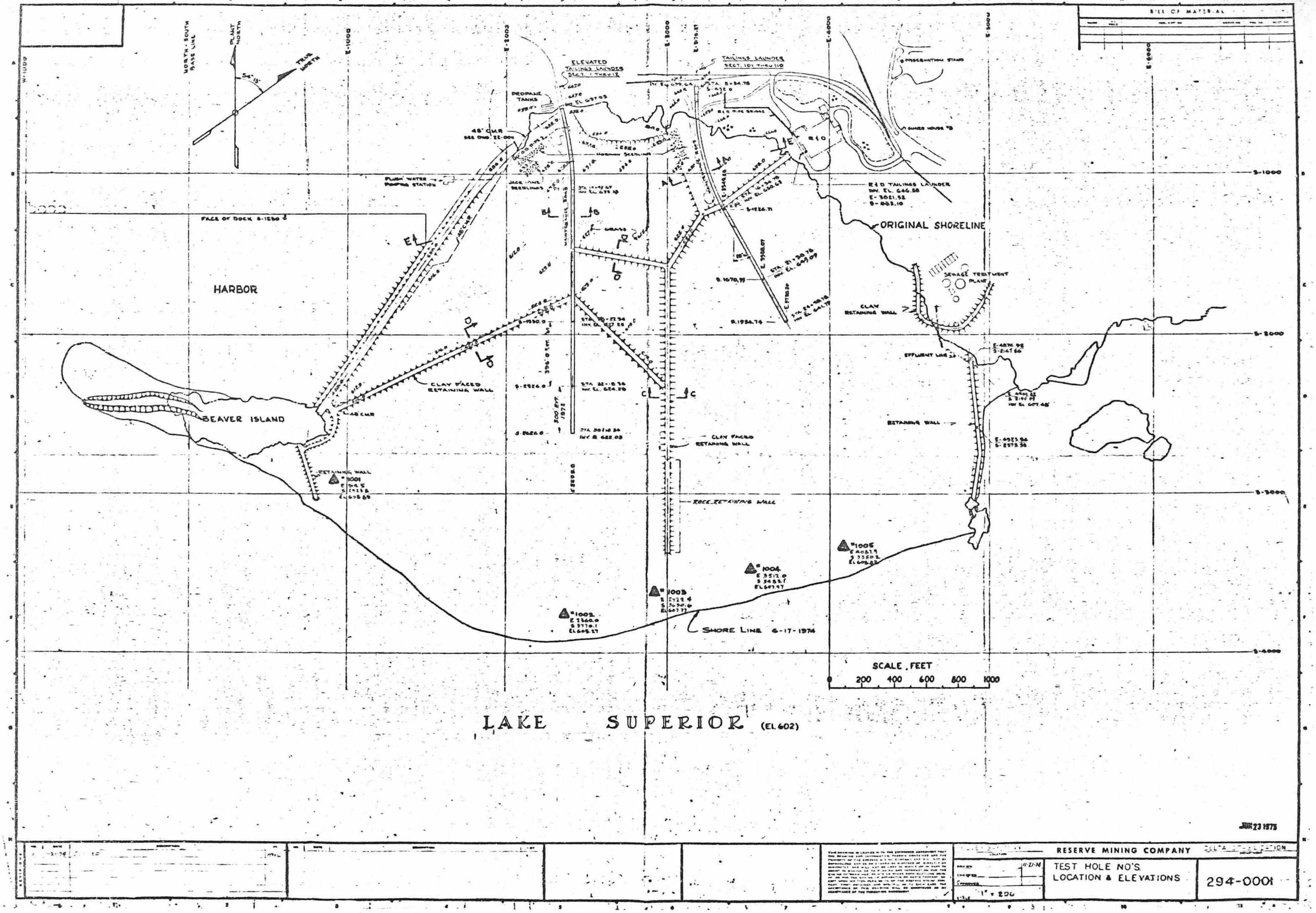


FIG. 15 - LOCATION PLAN OF BORINGS ON TAILINGS DELTA

APPENDIX IV
APPENDIX III
APPENDIX II
APPENDIX I

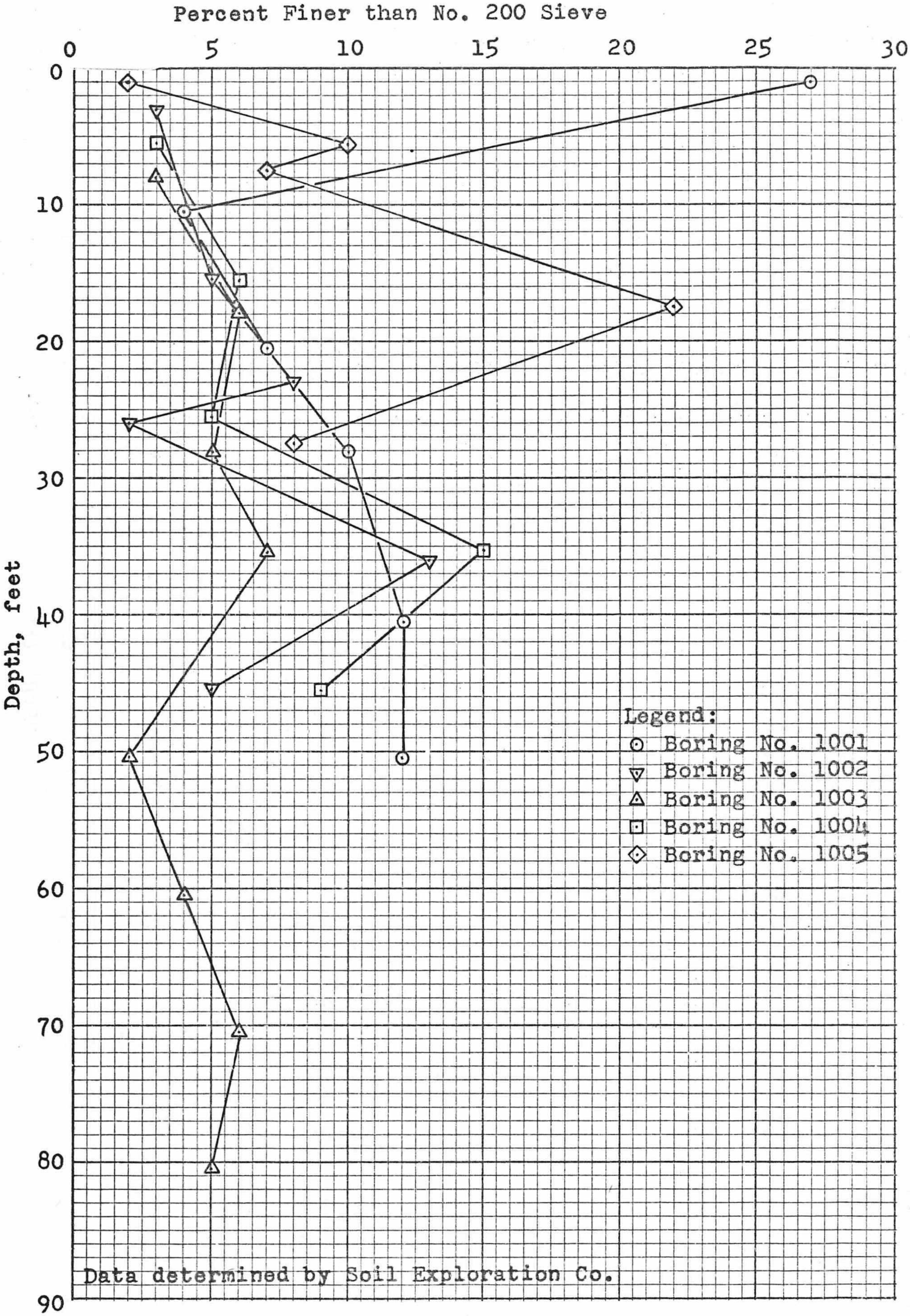


FIG. 16 - PERCENT OF TAILINGS IN DELTA FINER THAN NO. 200 SIEVE

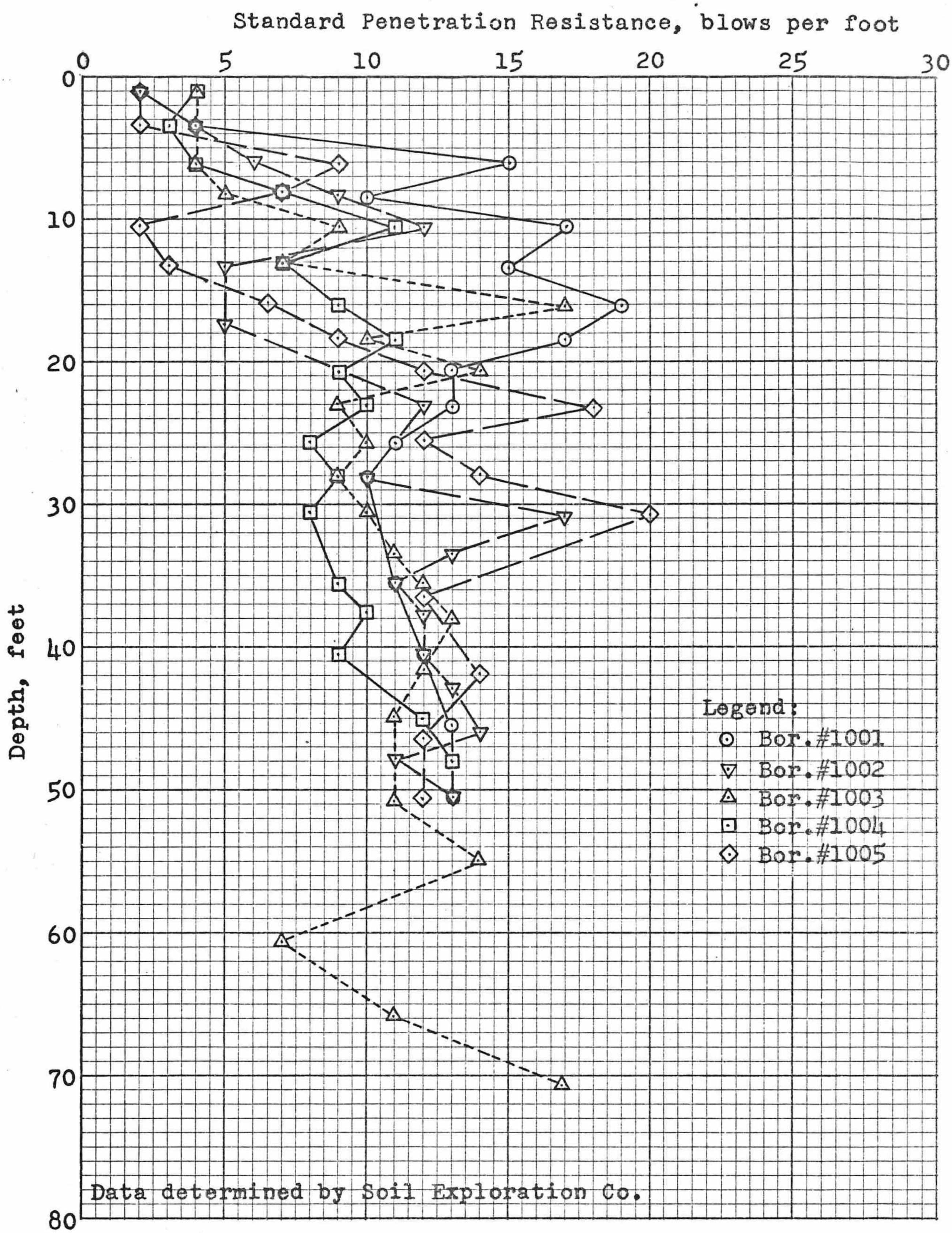


FIG. 17 - STANDARD PENETRATION RESISTANCE IN THE TAILINGS DELTA

APPENDIX I

FIELD LOGS OF BORINGS

CASA-1002, -1072, -1077, -3004, -3037, -3056

PREPARED BY W. A. WAHLER & ASSOCIATES

DRILL RIG TRUCK MOUNTED CME 75	HOLE ELEVATION	LOGGED BY ASBUANGAN
GROUNDWATER DEPTH (BELOW GROUND SURFACE) 5.0' (6-16-75)	HOLE DIAMETER 6 1/2"	DATE DRILLED 6/13/75

NOTE: CASAGRANDE HOLE DRILLED ABOUT 20' N of KLOHN DRILL HOLE 1002.

ELEVATION (Depth)	CLASS.	DESCRIPTION · FIELD IDENTIFICATION	SAMPLE NUMBER	MODE	REMARKS
0		0.0 - 28.5 LACUSTRINE DEPOSIT		AD	Drilled with hollow stem auger (AD)
			PS-1	PS	Sampled with thinwall stationary piston sampler (PS).
2	CH	- red clay; firm; highly plastic; damp; varved.	1.0'-3.0'	1.6* / 2.0	100 to 300 psi applied hydraulic pressure. * recovery ratio indicated by fraction.
				AD	
4	CH	- red clay; stiff; highly plastic; damp; varved.	PS-2 3.5'-5.5'	PS 2.0 / 2.0	100 to 300 psi. Groove along side of sample probably caused by hard rock fragment
				AD	
6	CH	- red clay; stiff; highly plastic; damp.	PS-3 6.0'-8.0'	PS 1.9 / 2.0	100 to 300 psi. Sides of tube squeezed on bottom 8", probably by rock in the clay.
8				AD	
10	CH	- reddish brown silty clay; - probably some included hard rock fragments; highly plastic; stiff; damp.	PS-4 8.5-10.5	PS 1.7 / 2.0	100 to 300 psi. Dented tip of tube;
12	ML	- brown sandy silt; firm; moist.	PS-5 11.0'-12.8	PS 1.8 / 1.8	100 to 400 psi. Dented tip of tube.
		(change)		AD	
14					
16	CH	- reddish brown clay; highly plastic; stiff; damp.	PS-6 14.0'-16.0'	PS 1.9 / 2.0	100 to 300 psi.
				AD	
18	SM-CL	- brown silty sand and reddish brown silty clay at tip of tube; dense and firm; wet.	PS-7 17.0-18.1	PS 1.1 / 1.1	100 to 500 psi. Water level after sampling PS-7 - 12.5'.
				AD	Water level 1/2 hour after previous reading - 5'.
20			PS-8 18.5-20.5	PS 2.0 / 2.0	100 to 400 psi. Bent tip of tube.

W.A. WAHLER & ASSOCIATES — PALO ALTO · NEWPORT BEACH · CALIF	MILEPOST 7 SITE	SOIL EXPLORATION DRILL HOLE LOG	HOLE NO. CASA 1002
	PROJECT NO.	DATE	SHEET NO. 1 OF 2

APPENDIX II

APPENDIX III

APPENDIX IV

DRILL RIG TRUCK MOUNTED CME 75	HOLE ELEVATION	LOGGED BY ASDOURIAN
GROUNDWATER DEPTH (BELOW GROUND SURFACE)	HOLE DIAMETER 6 1/2"	DATE DRILLED 6-13-75

ELEVATION (Depth)	CLASS.	DESCRIPTION - FIELD IDENTIFICATION	SAMPLE NUMBER	MODE	REMARKS
20	CH	- reddish brown clay; included coarse sand to fine gravel angular rock fragments; highly plastic; firm to stiff; damp.		AD	
22	CH	- reddish brown clay at tip of tube; highly plastic; stiff; damp.	PS-9 21.5-23.5'	PS 2.0/2.0	100 to 300 psi applied pressure. Tip of tube slightly dented
24				AD	
26	CL	- clay at tip of tube; little fine fine and included coarse angular sand fragments; brown; stiff.	PS-10 24.5-26.5'	PS 2.5/2.0	100 to 200 psi.
				AD	Easy drilling to 27.0' Rough in gravelly material from 27.0'-27.5'. Cleaned out auger cuttings inside hollow stem by jetting to 27.5'.
28		- red clay in split spoon to 28.5'	SPT-1 27.5-29.0' (gravel-sand)	DR 0.6/1.5	Drove standard split spoon with 140 lb hammer and 30" free fall (DR.) 5/.5' 7/.5' 10/.5'
		28.5-33.0 : GLACIAL TILL			
30		GRAVEL AND SAND; clay binder; red; dense		AD	Rough drilling in gravelly material to 32.0'
32		- gravelly sandy clay; red; dense	SPT-2 32.0'-33.5	DR 1.0/1.5	5/.5' 37/.5' 71/.5'
34		BOTTOM OF HOLE 33.5'			Water level after pulling out auger, 5:30 p.m., 6/15/75 - 5.0
0.0'		SHALLOW HOLE DRILLED 1.5' NW OF MAIN HOLE TO RESAMPLE DEPTH INTERVAL FROM 4.0'-8.5'			
36 / 4.0'		- red clay; highly plastic; stiff; damp.	PS-11 4.0'-6.5'	PS 1.3/2.5	Sampled with thin wall piston sampler; 100 to 200 psi. Part of sample left in hole. Drilled to 6.5
38 / 8.0		- red clay; highly plastic; stiff; damp.	PS-12 6.5-8.5	PS 1.3/2.0	100 to 200 psi applied pressure; part of sample left in hole.
40					

W.A. WAHLER & ASSOCIATES	MILEPOST 7 SITE -	SOIL EXPLORATION DRILL HOLE LOG	HOLE NO. CASA 1002
PALO ALTO • NEWPORT BEACH • CALIF.	PROJECT NO.	DATE	SHEET NO. 2 OF 2

DRILL RIG TRUCK-MOUNTED CME 75	HOLE ELEVATION	LOGGED BY A.S. GUANGAN
GROUNDWATER DEPTH : 5.3' (6-12-75) (BELOW GROUND SURFACE)	HOLE DIAMETER 6½"	DATE DRILLED 6/11-12/75

NOTE: CASAGRANDE HOLE LOCATED WITHIN 10' OF KLOHN DRILL HOLE 1072

ELEVATION (Depth)	CLASS.	DESCRIPTION FIELD IDENTIFICATION	SAMPLE NUMBER	MODE	REMARKS
		0.0' - 19.0' LACUSTRINE DEPOSIT		AD	Drilled w/ 6" hollow stem auger (AD).
2.0	CH	0.0' - 2.5' CLAY, red; firm to stiff; damp; highly plastic; upper 2.0' probably disturbed from road traffic.	PS-1 1.0' - 3.0'	PS 2.0 * / 2.0	Sampled with thin wall stationary Piston sampler; 3" O.D. Applied hydraulic pressure from 100 to 200 psi. (PS) * recovery ratio indicated by fraction.
		change in tube ?		AD	Drilled to 3.5'.
4.0	CL-CH (MH)	2.5'-9.0' - moderate reddish brown silty clay to clayey silt; firm to stiff; moist; moderate to highly plastic.	PS-2 3.5-5.5	PS 2.0 / 2.0	100 to 200 psi applied pressure.
6.0				AD	
		- moderate reddish brown silty clay to clayey silt; firm to stiff; moist; moderately to highly plastic.	PS-3 6.0'-8.0'	PS 1.8 / 2.0	100 psi. applied pressure
8.0		change in tube ?		AD	
10.0	CL	9.0'- 15.0 - grayish-brown silty clay at tip of tube; firm to stiff; damp; moderately plastic.	PS-4 8.5-10.5	PS 2.0 / 2.0	100-200 psi applied pressure.
				AD	
12.0		- brown silty clay at tip of tube; some included rock fragments.	PS-5 11.0'-13.0'	PS 2.0 / 2.0	200-300 psi applied pressure; Dented tip of tube due to rock fragment
				AD	
14.0		change in tube ?			
16.0	CH	15.0' - 18.0' - CLAY, red; stiff; moist; highly plastic; some included hard rock fragments at 16.0'.	PS-6 14.0'-16.5	PS 2.5 / 2.5	200 psi applied pressure increasing to 400 psi in last 2", Dented tip of tube due to rock fragment
				AD	
18.0	CL	change in tube ? 18.0'-19.0' CLAY, sandy; some angular, hard, rock fragments; stiff; damp;	PS-7 17.5'-19.5'	PS 2.0 / 2.0	200-300 increasing to 500 psi in last 2", Water at 16.0'.
20.0	GP-SP	19.0'- 24.0 GLACIAL TILL - gravel, sand, and clay; red, brown;		AD	Rough drilling in gravelly material from 19.0'-20.0'.

W.A. WAHLER & ASSOCIATES PALO ALTO • NEWPORT BEACH • CALIF.	MILEPOST 7 SITE	SOIL EXPLORATION DRILL HOLE LOG PROJECT NO. / DATE / SHEET NO. 1 OF 2	HOLE NO. CASA 1072

APPENDIX II

APPENDIX III

APPENDIX IV

DRILL RIG TRUCK MOUNTED CME 75	HOLE ELEVATION	LOGGED BY X. S. BUANGAN
GROUNDWATER DEPTH (BELOW GROUND SURFACE)	HOLE DIAMETER 6½"	DATE DRILLED 6/11-12/75

ELEVATION (Depth)	CLASS.	DESCRIPTION FIELD IDENTIFICATION	SAMPLE NUMBER	MODE	REMARKS
					Rough drilling from 20.0' to 21.0' in rocky material.
	GP-SP		SPT-1 21.0'-22.0'	DR .5/1.0	Drove standard split-spoon (DR) with 140 lb hammer falling 30". (DR) 7/.5' 15/.5'
22.0		- medium to coarse angular sand and sandy clay in split spoon; red; medium dense;		AD	Rough drilling with hollow stem auger from 21.0' to 24.0', in gravelly material. Cleaned out bottom 3' of hollow stem by jetting with chopping bit.
24.0		- reddish brown gravel and silty clay.	SPT-2 24.0-25.5	DR 1.0/1.5	Stopped 5:30 p.m. 6-11-75 Resumed 9:00 a.m. 6-12-75 Water level before drilling - 0.3'. Washed out hole to 24.0'. Drove standard split spoon from 24-25.5 7/.5 18/.5' 18/.5'
26.0		BOTTOM OF HOLE-25.5			Water level after pulling augers - 5.3'.
28.0					
30.0					
32.0					
34.0					
36.0					
38.0					
40.0					

W.A. WAHLER & ASSOCIATES	MILEPOST 7 SITE	SOIL EXPLORATION DRILL HOLE LOG	HOLE NO.
PALO ALTO • NEWPORT BEACH • CALIF.	PROJECT NO.	DATE	SHEET NO. 2 OF 2	CASA 1072

APPENDIX II

PRELIMINARY - Subject to revision

DRILL RIG TRUCK-MOUNTED CME 75	HOLE ELEVATION	LOGGED BY A.S. SLANGAN
GROUNDWATER DEPTH (BELOW GROUND SURFACE) Initially encountered at 9.5' Flowing (6-11-75)	HOLE DIAMETER 6½"	DATE DRILLED 6-10-75

NOTE: CASAGRANDE HOLE : LOCATED ON CENTER OF ACCESS ROAD WITHIN 10' OF KLOHN DRILL HOLE 1077

ELEVATION (Depth)	CLASS.	DESCRIPTION FIELD IDENTIFICATION	SAMPLE NUMBER	MODE	REMARKS
		0.0'-15.0' LACUSTRINE DEPOSIT		AD	Drilled with hollow stem auger (AD). Sampled with thin wall stationary piston sampler (PS). 100 to 200 psi applied hydraulic pressure.
2.0	CH	upper 2' probably disturbed from road traffic. – red clay at tip of tube; stiff; damp; highly plastic; varved.	PS-1 1.5'-3.5'	PS 2.0*/2.0	* recovery ratio indicated by fraction.
				AD	Easy drilling.
4.0			PS-2	PS.	150 psi applied pressure
6.0	CH	– red clay at tip of tube; stiff; damp; highly plastic; varved.	4.0'-6.5'	2.5/2.5	
				AD	Easy drilling
8.0		– horizontal stratification at tip of PS-3; some thin (1/8" thick) fine sand lenses.	PS-3 7.0'-9.0'	PS 2.0/2.0	200 psi applied pressure
				AD	Easy drilling
10.0	CL	water encountered at 9.5'. – sandy clay at tip of tube at 11.5' reddish brown; stiff; damp.	PS-4 9.5'-11.5'	PS 1.9/2.0	300 psi applied pressure. Tip of tube slightly dented, probably due to small rock fragments.
				AD	Easy drilling.
12.0		– change in tube –clay with little sand at tip of tube.	PS-5 12.0'-14.0'	PS 2.0/2.0	300 psi applied pressure Dented tip of tube due to rock.
14.0		1½" angular hard rock fragment in auger cuttings		AD	Easy drilling.
16.0	ML	15.0(?)-17.0' SILT, sandy; some coarse sand; moderate brown; firm; wet. sandy silt at tip of tube	PS-6 14.5-16.5	PS 2.0/2.0	200 psi applied pressure After sampling PS-6 water level rose from 9.5' to ground surface flowing at approx 3 gpm.
				AD	Drilled to 17.0'. Rough drilling in gravelly material at 17.0'. Attempted piston sampler at 17' but hit refusal (600 psi applied pressure) Drilled to 18.0'.
18.0	GC	17.0'-19.3 GLACIAL TILL GRAVEL AND SAND; some clay; mostly angular gravel; reddish brown; very dense.	SPT-1 18.0'-18.2'	AD DR 1/2	Drove standard split spoon with 140 lb hammer and 30" free fall (DR) 150 blows/.2'
				AD	Rough drilling to 19.0'.
			SPT-2 19.0'-19.3'	DR 3/3	100/.3'
20.0		BOTTOM OF HOLE-19.3'			

W.A. WAHLER & ASSOCIATES	MILEPOST 7 SITE	SOIL EXPLORATION DRILL HOLE LOG		HOLE NO. CASA 1077
PALO ALTO • NEWPORT BEACH • CALIF.	PROJECT NO.	DATE	SHEET NO. 1 OF 1	

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DRILL RIG CME 55 MOUNTED ON 1 FN160	HOLE ELEVATION	LOGGED BY A.S. BUANGAN
GROUNDWATER DEPTH (BELOW GROUND SURFACE) FLOWING (6-19-75)	HOLE DIAMETER 6½"	DATE DRILLED 6/18/75

NOTE: CASAGRANDE HOLE LOCATED 12 FEET WEST OF KLOHN HOLE 3004.

ELEVATION (Depth)	CLASS.	DESCRIPTION FIELD IDENTIFICATION	SAMPLE NUMBER	MODE	REMARKS
0		0.0'-0.5 TOPSOIL: clay, dark brown; organic; boulder near surface.		AD	Drilled with hollow stem auger (AD)
	CH	0.5-16.5' LACUSTRINE DEPOSIT			
2		- red clay, silty; some coarse sand; stiff; damp.	PS-1 1.5-3.5	PS 1.8* / 2.0	Sampled with thin wall stationary piston sampler (PS). 100 to 300 psi applied hydraulic pressure. * recovery ratio indicated by fraction.
4				AD	
		- moderate red silty clay; sandy fine to coarse sand; some fine gravel; moderate to highly plastic; stiff; damp.	PS-2 4.0'-6.0'	PS 2.0 / 2.0	100 to 250 psi; dented tip of tube Rough drilling in boulder at 5.7'.
6				AD	
		- red clay; highly plastic; stiff; damp; block structure.	PS-3 6.5-8.5	PS 1.8 / 2.0	100 to 250 psi.
8				AD	
		(change in tube) ?			
	CL	- brown silty clay, slightly sandy; moderately plastic; firm; moist.	PS-4 9.0-11.0'	PS 2.0 / 2.0'	100 to 200 psi; little water at top of tube.
10					
				AD	
12	ML	- brown clayey silt to sandy silt; low to moderate plasticity; firm; moist.	PS-5 12.0'-14.0'	PS 2.5 / 2.0	100 to 200 psi; top 6" of sample is slough Water level in hollow stem auger at 10:00 a.m. - 12.4'
14					
	SC	- moderate red clayey sand; fine to coarse sand; medium dense; moist.	PS-6 14.5'-16.5'	PS 2.0' / 2.0	100 to 250 psi; Tube tip slightly dented.
16		? (change)			
	SC	16.5'-20.0' - red gravelly clayey sand; medium dense; wet.	SPT-1 16.5-18.0	DR 0.3 / 1.5	Drove standard split spoon; with 140 lb hammer and 30" free fall (DR) 5/.5' 8/.5' 10/.5' Most of sample fell down hole. Drilled to 18.0'. Water rose to surface and flowing 5 min. after drilling to 18'.
18		- red clayey sandy gravel; dense; (sample extruded in the field).	PS-7; 18.0-18.5	PS 4/.5	Jetted hole to wash out slough before piston sampling.
		- red gravel and sand; little clay; medium dense; wet.	SPT-2 18.5-20.0'	DR 0.6 / 1.5	100 to 600 psi applied pressure. Bent tip of tube. Sample extruded in the field. Artesian flow after sampling - about 1 gpm. 7/.5' 8/.5' 15/.5'
20					

W.A. WAHLER & ASSOCIATES	MILEPOST 7 SITE -	SOIL EXPLORATION DRILL HOLE LOG	HOLE NO. CASA 3004
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DRILL RIG CME 55 MOUNTED ON ... ENGINE	HOLE ELEVATION	LOGGED BY ASBUANGAN
GROUNDWATER DEPTH (BELOW GROUND SURFACE)	HOLE DIAMETER 6 1/2"	DATE DRILLED 6/18/75

ELEVATION (Depth)	CLASS.	DESCRIPTION FIELD IDENTIFICATION	SAMPLE NUMBER	MODE	REMARKS
20	GP-SP	20.0'-26.5' GLACIAL TILL	SPT-3 200'-21.5'	DR 1.0/1.5	Drilled to 20.0'. Rough drilling. Jetted hole to wash out slough. Drive sample 13/.5' 21/.5' 35/.5'
22		- gravel and sand with clay binder; red; very dense; damp.		AD	Very rough drilling from 22.0' to 22.5'. No artesian flow after drilling to 22.5'.
		- gravel and sand; little fines; red; very dense; damp	SPT-4 22.5-23.5'	DR 1.0/1.0	38/.5', 100/.5'
24					Rough drilling to 25.0'.
26		- gravel and sand, little fines. red; very dense; damp	SPT-5 25.0'-26.5'	DR 1.0/1.5	18/.5', 42/.5, 58/.5'
		BOTTOM OF HOLE 26.5'			Water level after pulling auger 1:30p.m. - artesian flow.
28					Water level at 5:00p.m. - artesian flow 1-2 gpm. Water level at 8:00 a.m 6/19/75 - artesian flow.
30					
2					
4					
6					
8					
0					

APPENDIX II

PRELIMINARY

W.A. WAHLER & ASSOCIATES	MILEPOST 7 SITE	SOIL EXPLORATION DRILL HOLE LOG	HOLE NO.
PALO ALTO • NEWPORT BEACH • CALIF.	PROJECT NO.	DATE	SHEET NO. 2 OF 2	CASA 3004

DRILL RIG CME 55 MOUNTED ON FN 160	HOLE ELEVATION	LOGGED BY A. S. BANGAN
GROUNDWATER DEPTH 0.0 (6-18-75) (BELOW GROUND SURFACE)	HOLE DIAMETER 6½"	DATE DRILLED 6/17/75

NOTE: CASAGRANDE HOLE DRILLED 6FT. S20W OF KLOHN HOLE 3037.

ELEVATION (Depth)	CLASS.	DESCRIPTION FIELD IDENTIFICATION	SAMPLE NUMBER	MODE	REMARKS
0		0.0'- 1.0' CLAY; dark brown; organic material; topsoil.		AD	Drilled with hollow stem auger (AD).
		1.0'-20.0' LACUSTRINE DEPOSIT			
2	CH	red clay at tip of tube; some sand and included hard gravel; firm to stiff; damp; highly plastic.	PS-1 2.0'-3.7	PS 1.3*/1.7	Sampled with thin wall stationary piston sampler. 100 psi applied hydraulic pressure increasing to 400 psi in last 2". Dented tip of tube due to rock. * recovery ratio indicated by fraction.
4				AD	Rough drilling in bouldery material from 4.0' to 5.0'.
6	CH	red clay; included gravels or boulders; stiff; damp; highly plastic	PS-2 5.0'-6.8	PS 1.8/1.8	100 to 400 psi increasing to 600 psi in last 1". Bottom 12" of tube crumpled probably by boulders. Groove along sides of sample.
8	CL-ML	reddish brown silty clay and silt; little fine sand; very stiff; damp; varved.	PS-3 7.5-9.0'	PS 1.3/1.5	100 to 400 psi increasing to 600 psi in last 1". Tip of tube slightly dented.
				AD	Rough drilling in cobble at 9.0'.
10	ML	change in tube ? brown clayey, sandy silt; included rock fragments; stiff; damp.	PS-4 10.0'-12.0'	PS 2.0/2.0	100 psi gradually increasing to 600 psi. Bottom 6" of tube squeezed in probably by rock.
12				AD	Rough drilling in rock at 11.5'.
14	CH	change in tube ? red clay; stiff; damp; highly plastic.	PS-5 13.0'-15.0'	PS 2.0/2.0	100 to 300 psi.
16	CL	change in tube ?	PS-6 16.0'-18.0'	PS 2.0/2.0	100 psi gradually increasing to 300 psi.
18		brown silty clay; stiff; damp		AD	Easy drilling.
20		moderate reddish brown silty clay; little sand; some included rock fragments; stiff; damp;	PS-7 19.0'-20.0	PS 1.0/1.0	100-200 psi, increasing to to 400 at last 1". Probably in rock fragment.

MILEPOST 7 SITE.

W.A. WAHLER & ASSOCIATES	SOIL EXPLORATION DRILL HOLE LOG	HOLE NO.
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DRILL RIG CME 55 MOUNTED ON FN 160	HOLE ELEVATION	LOGGED BY A. BUANGAN
GROUNDWATER DEPTH (BELOW GROUND SURFACE)	HOLE DIAMETER 6 1/2"	DATE DRILLED 6/17/75

ELEVATION (Depth)	CLASS.	DESCRIPTION FIELD IDENTIFICATION	SAMPLE NUMBER	MODE	REMARKS
20		20.0' - 30.0'		AD	Easy drilling.
22	ML	- brown sandy silt; some fine sand lenses and gravel; stiff; damp.	PS-8 22.0-22.8	PS 0.8/0.8	100-300 psi increasing to 600 psi at bottom 1". Probably in rock. Bent tip of tube. Sample loose inside tube.
				AD	Rough drilling 22.5' - 24.0'
24		- brown sandy silt; clayey; some fine gravel; stiff; moist.	PS-9 24.0-24.5	PS .5/.5	100 to 200 psi increasing to 600 psi at bottom 1". Dented tip of tube. Sample loose inside tube.
				AD	Slightly rough drilling to 26.0'.
26		- brown sandy silt; clayey; some clean sand pockets and fine gravel; dense; moist.	SPT-1 26.0'-27.5	DR 1.0/1.5	Drove standard split spoon with 140 lb hammer and 30" free fall (DR). 5/.5' 16/.5' 22/.5'
28		(change in tube)		AD	
	CL	- reddish brown sandy clay with included fine gravel at tip of tube	PS-10 28.5-30.5	PS 1.2/2.0	100 to 300 psi. Rough sampling. Dented tip of tube
30		30.0'-39.5 . GLACIAL TILL			
	GP-SP	- reddish brown sand and gravel, clayey; very dense; damp.	SPT-2 30.5-32.0'	DR 1.5/1.5	42/.5' 54/.5' 110/.5'
32				AD	Rough drilling from 32.0' to 34.0'.
34	SP	- reddish brown gravelly sand, clayey; very dense; damp.	SPT-3 34.0'-35.5	DR 1.2/1.5	5/.5' 32/.5' 48/.5'
36				AD	Very rough drilling from 35.5' to 38.0' in gravelly material
38	SP	- reddish brown gravelly sand, clayey; very dense; damp	SPT-4 38.0'-39.5	DR 1.0/1.5	11/.5' 36/.5' 100/.5'. Water level after pulling auger 3:30 p.m. 6/17/75 - 10.0'. Water level after 1/2 hr - 10.0'. Water level 6/18/75 - 10.0'
40		BOTTOM OF HOLE - 39.5'			

W.A. WAHLER & ASSOCIATES — PALO ALTO • NEWPORT BEACH • CALIF.	MILEPOST 7 SITE -	SOIL EXPLORATION DRILL HOLE LOG — PROJECT NO. / DATE / SHEET NO. 2 of 2	HOLE NO. CAS-3037

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DRILL RIG CME 55 MOUNTED ON FN 160	HOLE ELEVATION	LOGGED BY A. S. BUANGAN
GROUNDWATER DEPTH (BELOW GROUND SURFACE) 0.0' (6-13-75)	HOLE DIAMETER 6½"	DATE DRILLED 6-12-75

NOTE: CASAGRANDE HOLE DRILLED 10' FEET EAST OF RESERVE HOLE NO. 3056

ELEVATION (Depth)	CLASS.	DESCRIPTION FIELD IDENTIFICATION	SAMPLE NUMBER	MODE	REMARKS
		0.0-0.5 CLAY, silty; dark brown; organic soil.		AD	Drilled with 6" hollow stem auger (AD)
		0.5-24.0' LACUSTRINE DEPOSIT			
2.0	CH		PS-1 2.0'-4.0'	PS 1.6*/2.0	Sampled with thin wall stationary piston sampler (PS) 200 to 400 psi applied hydraulic pressure. Tip of tube slightly dented. * recovery ratio indicated by fraction.
4.0		- red clay; little sand and fine gravel; highly plastic; stiff; damp; at tip of tube.		AD	Drilled to 5.0'. Some rock fragment.
6.0		- reddish brown clay with rock fragments; stiff; damp; at tip of tube.	PS-2 5.0'-6.7	PS 1.4/1.7	200 psi applied pressure increasing to 600 psi in last 2". Dented tip of tube.
				AD.	Drilled to 7.0'. Little rocky.
8.0		- reddish brown clay, mottled with gray; some included rock fragments; stiff; damp highly plastic;	PS-3 8.0'-10.0'	PS 1.7/2.0	Sampled through hollow stem. 200 to 600 psi applied pressure. Dented tip of tube.
10.0		change inside tube ?		AD	
12.0	ML	- brown sandy silt at tip of tube; stiff; damp;	PS-4 11.0'-12.8	PS 1.7/1.8	200 psi applied pressure increasing to 600 in last 3". Dented tip of tube.
				AD	Little rough drilling to 14.0'.
14.0	CH	- reddish brown silty clay at tip of tube; stiff; highly plastic; damp.	PS-5 14.0'-16.0'	PS 1.6/2.0	200 psi applied pressure gradually increasing to 600 psi.
16.0				AD	Easy drilling. No rock.
18.0	CH	- reddish brown clay mottled with gray; some included rock fragments; stiff; damp; highly plastic.	PS-6 17.0'-19.0'	PS 2.0/2.0	100 to 300 psi applied pressure.
20.0				AD	

W.A. WAHLER & ASSOCIATES PALO ALTO • NEWPORT BEACH • CALIF.	MILEPOST 7 SITE	SOIL EXPLORATION DRILL HOLE LOG	HOLE NO. CASA 3056
	PROJECT NO	DATE	SHEET NO. 1 OF 2

APPENDIX II

PRELIMINARY – Subject to Revision

DRILL RIG CME 55 MOUNTED ON FN 160	HOLE ELEVATION	LOGGED BY A. S. BUANGAN
GROUNDWATER DEPTH (BELOW GROUND SURFACE)	HOLE DIAMETER 6½"	DATE DRILLED 6/12/75

ELEVATION (Depth)	CLASS.	DESCRIPTION FIELD IDENTIFICATION	SAMPLE NUMBER	MODE	REMARKS
	CL	- reddish brown silty clay at tip of tube; stiff; damp.	PS-7 20.0'-22.0'	PS 1.9/2.0	200 to 400 psi applied pressure.
22.0'				AD	Water level at 19.0'
24.0'	ML-CL	change in tube ? 24.0'-27.0' - SILT, sandy to CLAY, sandy; brown; stiff; moist. - brown sandy silt at tip of tube.	PS-8 23.0'-25.0'	PS 2.0/2.0	200-400 psi applied pressure. Difficulty pulling out piston. Vacuum between piston and sample moved sample. Disturbed sample.
				AD	
26.0		- brown sandy clay at tip of tube	PS-9 26.0'-27.0'	PS 1.0/1.0	300 psi increasing to 700 psi at 27.0' apparently in rock. Tube was cut with saw because of extreme difficulty pulling out tube from sampler head.
		27.0'-37.5' - GLACIAL TILL		AD	Rough drilling from 27.0'-28.0'
28.0	ML-CL	SILT, sandy and CLAY, sandy; reddish brown to brown; included angular coarse sand and fine gravel; dense; damp. - brown gravelly sandy silt; some clay.	SPT-1 28.0'-29.5	DR 1.0/1.5	Drove standard split spoon with 140 lb hammer and 30" free fall (DR). 10/.5' 25/.5' 30/.5'
30.0				AD	Easy drilling Rough drilling in gravelly material at 31.0'.
32.0		- reddish brown sandy silt with included rock fragments.	SPT-2 32.0'-33.5'	DR 1.0/1.5	13/.5' 17/.5' 26/.5'
34.0				AD	Easy drilling to 36.0' in some rocky material Cleaned out cuttings in bottom of hollow stem by jetting, to get to 36.0' for drive sample
36.0		- reddish brown sandy clay; silty angular coarse sand and fine gravel; dense; damp	SPT-3 36.0'-37.5	DR 1.0/1.5	11/.5' 18/.5' 21/.5'
38.0		BOTTOM OF HOLE - 37.5'		AD	Water level after pulling out augers - 5.0' [illegible] Water level at surface 8:00 a.m. 6-13-75
40.0'					

W.A. WAHLER & ASSOCIATES PALO ALTO • NEWPORT BEACH • CALIF.	MILEPOST 7 SITE	SOIL EXPLORATION DRILL HOLE LOG	HOLE NO. CASA [illegible]
		PROJECT NO. / DATE / SHEET NO. 2 OF 2	

APPENDIX II

PRELIMINARY — Subject to revision

APPENDIX II

DESCRIPTION AND CLASSIFICATION TESTS

OF UNDISTURBED AND SPLIT-SPOON SAMPLES

APPENDIX II

Abreviations Used in Tables

q_p = Compressive strength by means of pocket penetrometer

c_v = Shear strength by means of TORVANE device

Note: In these tables, the length of "Empty" sections include the sealing wax.

Ground El. 1134.3±

Depth to Water Level 5.0 ft

TABLE 1

Undisturbed Sample Boring No. CASA 1002

Sheet No. 1

Project No. 755

Sample No. and Depth ft	Section No.	Length In.	Description	Consistency		Natural Water Content %	Liquid Limit	Plastic Limit	Plast. Index	Water Plast. Ratio %
				As Received	Remolded					
PS-1	A	17.0	Empty							
1.0-3.0	B	7.1	Reddish-brown clay; highly fissured. q_p = 1.7 to 2.2 tsf c_v = 0.93 tsf	stiff & brittle	firm	31.2	66.4	24.3	42.1	16
	C	11.4	Reddish-brown clay with a 3" zone of sandy clay in the middle; upper part fissured. q_p = 1.8 to 2.6 tsf c_v = 0.97 tsf	stiff to v. stiff brittle	firm to stiff	28.1	50.6	20.1	30.5	26

CASAGRANDE CONSULTANTS

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APPENDIX III

Ground El.

Depth to Water Level

TABLE 1 (cont'd)

Undisturbed Sample Boring No. CASA 1002

Sheet No. 2

Project No. 755

Sample No. and Depth ft	Section No.	Length In.	Description	Consistency		Natural Water Content %	Liquid Limit	Plastic Limit	Plast. Index	Water Plast. Ratio %
				As Received	Remolded					
PS-2	A	11.5	Empty							
3.5-5.5	B*	12.8	Reddish-brown clay with some layers of silt and clayey fine sand; and containing some small roots; fissured. q_p = 1.5 to 1.9 tsf c_v = 0.84 tsf	stiff & brittle	firm	29.1				
	C*	11.3	Reddish-brown clay with several layers and partings of brown silt and fine sand up to 1.5" thick; highly fissured. q_p = 1.8 to 2.2 tsf, c_v = 0.84 tsf } top q_p = 1.2 to 1.5 tsf, c_v = 0.71 tsf } bottom	firm to stiff & brittle	firm	52.0	94.5	28.5	66.0	36

* see Photo 1, App. III

CASAGRANDE CONSULTANTS

Ground El.

Depth to Water Level

TABLE 1 (cont'd)

Undisturbed Sample Boring No. CASA 1002

Sheet No. 3

Project No. 755

Sample No. and Depth ft	Section No.	Length In.	Description	Consistency		Natural Water Content %	Liquid Limit	Plastic Limit	Plast. Index	Water Plast. Ratio %
				As Received	Remolded					
PS-3	A	13.0	Empty.							
6.0-8.0	B*	11.0	Reddish-brown clay containing some pebbles and pockets of dark gray organic clay with roots and stems. q_p = 1.5 to 2.7 tsf c_v = 0.94 tsf	stiff to v.stiff & brittle	firm to stiff					
	C*	10.8	Reddish-brown clay with several thin layers and lenses of brown silt; fissured. q_p = 1.6 to 1.8 tsf, c_v = 0.89 tsf } top q_p = 1.0 to 1.2 tsf, c_v = 0.70 tsf } bottom Note: The lower half of this section of tube was slightly oval-shaped.	firm to stiff & brittle	soft to firm	55.1	100.5	29.7	70.8	36

* see Photo 2, App. III

CASAGRANDE CONSULTANTS

Ground El.

Depth to Water Level

TABLE 1 (cont'd)

Undisturbed Sample Boring No. CASA 1002

Sheet No. 4

Project No. 755

Sample No. and Depth ft	Section No.	Length In.	Description	Consistency As Received	Consistency Remolded	Natural Water Content %	Liquid Limit	Plastic Limit	Plast. Index	Water Plast. Ratio %
PS-4	A	15.9	Empty							
8.5-10.5	B*	8.9	Reddish-brown clay containing pebbles; highly fissured (almost a granular structure). q_p = 1.2 to 1.5 tsf, c_v = 0.74 tsf } bottom	firm to stiff & brittle	firm	38.5	65.1	29.1	36.0	26
	C*	11.4	Top 4.3" similar to Section B. q_p = 1.2 to 1.7 tsf c_v = 0.75 tsf	firm to stiff & brittle	firm	37.6				
			Remaining 7.1" is brown varved clay with pockets and lenses of silt and fine sand, and containing some pebbles up to 2" size. q_p = 2.1 to 2.2 tsf	stiff & brittle	firm					

* see Photo 3, App. III

Ground El.

Depth to Water Level

TABLE 1 (cont'd)

Undisturbed Sample Boring No. CASA 1002

Sheet No. 5

Project No. 755

Sample No. and Depth ft	Section No.	Length In.	Description	Consistency As Received	Consistency Remolded	Natural Water Content %	Liquid Limit	Plastic Limit	Plast. Index	Water Plast. Ratio %
PS-5	A	13.5	Empty							
11.0-12.8	B*	10.6	Top 3" is brown varved silt with some lenses of reddish-brown clay (disturbed). Middle 6" is brown sandy clay containing pebbles. Bottom 1.6" is varved brown silt and reddish-brown clay. q_p = 1.3 to 1.9 tsf, c_v = 0.59 tsf } bottom	firm to stiff & brittle	soft to firm					
	C*	11.3	Brown silt with two 1" layers of reddish-brown clay and a 1" layer of fine sand at bottom. q_p = 2.5 to 3.2 tsf, c_v = 0.70 tsf							

* see Photo 4, App. III

CASAGRANDE CONSULTANTS

Ground El. | TABLE 1 (cont'd) | Sheet No. 6

Depth to Water Level | Undisturbed Sample Boring No. CAȘA 1002 | Project No. 755

Sample No. and Depth ft	Section No.	Length In.	Description	Consistency		Natural Water Content %	Liquid Limit	Plastic Limit	Plast. Index	Water Plast. Ratio %
				As Received	Remolded					
PS-6	A	12.5	Empty							
14.0-16.0	B	11.4	Reddish-brown clay with one 0.5" layer of silt near the top of the section, and containing some pebbles; highly fissured (almost granular structure). q_p = 1.2 to 1.4 tsf c_v = 0.66 tsf	firm & brittle	soft	36.6	63.8	21.8	42.0	35
	C	11.5	Reddish-brown clay with several pockets and lenses of brown fine sand near the middle of the section, and containing pebbles; fissured. q_p = 0.9 to 1.1 tsf, c_v = 0.59 tsf } top; q_p = 1.6 tsf, c_v = 0.62 tsf } bottom	firm to stiff & brittle	soft to firm	37.4				

Ground El.

Depth to Water Level

TABLE 1 (cont'd)

Undisturbed Sample Boring No. CASA 1002

Sheet No. 7

Project No. 755

Sample No. and Depth ft	Section No.	Length In.	Description	Consistency As Received	Consistency Remolded	Natural Water Content %	Liquid Limit	Plastic Limit	Plast. Index	Water Plast. Ratio %
PS-7	A	21.9	Empty							
17.0-18.1	B	13.5	Reddish-brown clay with 0.2" of fine sand at the top and several small pockets and lenses of silt within the bottom 1/3; contains numerous pebbles; fissured. q_p = 1.2 to 1.3 tsf c_v = 0.68 tsf	firm & brittle	soft	29.3	46.1	17.2	28.9	42

CASAGRANDE CONSULTANTS

Ground El.

Depth to Water Level

TABLE 1 (cont'd)

Undisturbed Sample Boring No. CASA 1002

Sheet No. 8

Project No. 755

Sample No. and Depth ft	Section No.	Length In.	Description	Consistency		Natural Water Content %	Liquid Limit	Plastic Limit	Plast. Index	Water Plast. Ratio %
				As Received	Remolded					
PS-8	A	11.7	Empty							
18.5-20.5	B*	12.3	Reddish-brown clay containing pockets and lenses of brown fine sand and silt, and containing pebbles and stones up to 3.5" size; apparently disturbed.							
			Top 8"	soft to v. soft	soft to v. soft & sticky	40.7				
			Bottom 4.3"	firm	firm	33.9				
	C	10.8	(see next page)							

* see Photo 5, App. III

Ground El.

Depth to Water Level

TABLE 1 (cont'd)

Undisturbed Sample Boring No. CASA 1002

Sheet No. 9

Project No. 755

Sample No. and Depth ft	Section No.	Length In.	Description	Consistency		Natural Water Content %	Liquid Limit	Plastic Limit	Plast. Index	Water Plast. Ratio %
				As Received	Remolded					
PS-8 (cont'd)	C	10.8	Top 7" is reddish-brown clay containing some pebbles; fissured. q_p = 1.3 tsf c_v = 0.81 tsf	firm to stiff & brittle	soft to firm	34.4	63.6	21.1	42.5	31
			Remaining 3.8" is brown sandy clay containing some pockets and lenses of silt and some pebbles.	firm	soft					
			Note: Cutting edge dented.							

CASAGRANDE CONSULTANTS

Ground El.

Depth to Water Level

TABLE 1 (cont'd)

Undisturbed Sample Boring No. CASA 1002

Sheet No. 10

Project No.755

Sample No. and Depth ft	Section No.	Length In.	Description	Consistency As Received	Consistency Remolded	Natural Water Content %	Liquid Limit	Plastic Limit	Plast. Index	Water Plast. Ratio %
PS-9	A	11.7	Empty							
21.5-23.5	B	12.3	Reddish-brown clay marbled with some lenses and pockets of silt in the lower half of section, and containing numerous pebbles; fissured. Upper half appears disturbed. q_p = 1.2 tsf, c_v = 0.74 tsf } lower half	firm	soft	35.8	61.8	20.3	41.5	37
	C*	11.4	Reddish-brown clay with several small pockets and lenses of silt and fine sand; and containing numerous pebbles; fissured. q_p = 1.3 to 1.5 tsf c_v = 0.79 tsf	firm to stiff & brittle	soft to firm	35.0	60.8	20. 8	40.0	36

* see Photo 5, App. III

CASAGRANDE CONSULTANTS

Ground El. | **TABLE 1** (cont'd) | Sheet No. 11

Depth to Water Level | **Undisturbed Sample Boring No.** CASA 1002 | Project No. 755

Sample No. and Depth ft	Section No.	Length In.	Description	Consistency		Natural Water Content %	Liquid Limit	Plastic Limit	Plast. Index	Water Plast. Ratio %
				As Received	Remolded					
PS-10	A	9.4	Empty							
24.5-26.5	B	14.5	Top 5" is brown clay containing numerous pebbles. c_v = 0.16 tsf	soft	soft to v. soft	34.8	42.8	17.6	25.2	68
			Remaining 9.5" is reddish-brown clay containing some pebbles; fissured. q_p = 0.6 to 0.9 tsf c_v = 0.51 tsf	firm & brittle	soft	43.1				
	C*	11.2	Varved reddish-brown clay and brown silt, containing some pebbles up to 2.5" size; clay is fissured. Section partially disturbed. q_p = 0.8 to 1.0 tsf, c_v = 0.48 tsf } top; q_p = 1.3 to 1.5 tsf, c_v = 0.57 tsf } bottom	firm to stiff & brittle	soft to firm					

* see Photo 6, App. III

Ground El.

Depth to Water Level

TABLE 1 (cont'd)

Undisturbed Sample Boring No. CASA 1002

Sheet No. 12

Project No.755

Sample No. and Depth ft	Section No.	Length In.	Description	Consistency		Natural Water Content %	Liquid Limit	Plastic Limit	Plast. Index	Water Plast. Ratio %
				As Received	Remolded					
PS-11	A	19.7	Empty							
4.0-6.5	B*	15.0	Reddish-brown varved clay with layers of brown silt up to 1.5" thick; highly fissured. q_p = 1.6 to 1.8 tsf c_v = 0.83 tsf	stiff & brittle	firm	47.9	84.0	30.9	53.1	32
			Note: Sample PS-11 taken in redrilled boring adjacent to CASA 1002							

* see Photo 6, App. III

Ground El.

Depth to Water Level

TABLE 1 (cont'd)

Undisturbed Sample Boring No. CASA 1002

Sheet No. 13

Project No.755

Sample No. and Depth ft	Section No.	Length In.	Description	Consistency		Natural Water Content %	Liquid Limit	Plastic Limit	Plast. Index	Water Plast. Ratio %
				As Received	Remolded					
PS-12	A	20.4	Empty							
6.5-8.5	B	14.8	Upper 13.0" is reddish-brown clay; fissured. q_p = 0.8 to 1.2 tsf c_v = 0.62 tsf	firm & brittle	soft	58.5				
			Bottom 1.8" is brown silty clay. q_p = 1.3 to 1.7 tsf c_v = 0.91 tsf	firm to stiff & brittle	firm	34.7	57.2	23.8	33.4	33
			Note: Sample PS-12 taken in redrilled boring adjacent to CASA 1002							

Table 1 (cont'd) Sheet 14

Ground El.

Exploratory Boring No. CASA 1002

Depth to Water Level:

Project No. 755

Sample No.	Depth ft	No. of Blows per 6 in.	Description	Consistency As Received	Consistency Remolded	Nat. Water Cont. %	Liquid Limit	Plastic Limit	Plast. Index	Water Plast. Ratio %
SPT-1	27.5 to 29.0	5-7-10	Brown very clayey sand and gravel; angular to subangular particles (glacial till). Disturbed.	soft	soft					
SPT-2	32.0 to 33.5	5-37-21	Similar to SPT-1. Disturbed	soft	soft					

Ground El. 1133.3±

Depth to Water Level 5.3 ft

TABLE 2

Undisturbed Sample Boring No. CASA 1072

Sheet No. 1

Project No. 755

Sample No. and Depth ft	Section No.	Length In.	Description	Consistency As Received	Consistency Remolded	Natural Water Content %	Liquid Limit	Plastic Limit	Plast. Index	Water Plast. Ratio %
PS-1	A	8.7	Empty							
1.0-3.0	B*	15.4	Reddish-brown clay with one layer of brown silty clay; highly fissured. q_p = 0.7, 0.8 tsf c_v = 0.44 tsf	soft to firm & brittle	soft	33.0 32.6	88.5 60.0	27.3 27.0	61.2 33.0	9 clay 17 silty clay
	C*	8.8	Top 5.2" is reddish-brown clay containing some small hard nodules. q_p = 1.5 to 2.0 tsf c_v = 0.91 tsf	stiff & brittle	firm	33.7	60.7	26.2	34.5	22
			Bottom 3.6" is brown thinly-stratified clay, silt and fine sand. q_p = 3.6 tsf Entire sample highly fissured.	v. stiff & brittle	stiff	34.8	46.3	23.5	22.8	50

* see Photo 7, App. III

CASAGRANDE CONSULTANTS

Ground El.

Depth to Water Level

TABLE 2 (cont'd)

Undisturbed Sample Boring No. CASA 1072

Sheet No. 2

Project No. 755

Sample No. and Depth ft	Section No.	Length In.	Description	Consistency		Natural Water Content %	Liquid Limit	Plastic Limit	Plast. Index	Water Plast. Ratio %
				As Received	Remolded					
PS-2	A	12.9	Empty							
3.5-5.5	B*	11.0	Top 6" is reddish-brown clay. q_p = 1.6, 1.7 tsf c_v = 0.57 tsf	stiff & brittle	firm	39.7				
			Remainder is varved reddish-brown clay with numerous layers of brown silt and fine sand. q_p = 4.0 tsf	v. stiff to hard & brittle	crumbly					
	C*	11.7	Reddish-brown varved clay with brown silt and fine sand; layers ranging up to 1.5" thick. q_p = 1.7 tsf c_v = 0.80 tsf	stiff & brittle	firm	42.4	46.5	23.3	23.2	82

* see Photo 8, App. III

Ground El.

Depth to Water Level

TABLE 2 (cont'd)

Undisturbed Sample Boring No. CASA 1072

Sheet No. 3

Project No. 755

Sample No. and Depth ft	Section No.	Length In.	Description	Consistency		Natural Water Content %	Liquid Limit	Plastic Limit	Plast. Index	Water Plast. Ratio %
				As Received	Remolded					
PS-3	A	15.4	Empty							
6.0-8.0	B	8.7	Reddish-brown clay; fissured q_p = 1.4 to 1.7 tsf c_v = 0.84 tsf	stiff & brittle	firm	43.7	88.2	30.2	58.0	23
	C*	11.3	Reddish-brown clay; fissured q_p = 1.7 tsf c_v = 0.78 tsf	stiff & brittle	firm	47.2				

* see Photo 9, App. III

Ground El.

Depth to Water Level

TABLE 2 (cont'd)

Undisturbed Sample Boring No. CASA 1072

Sheet No. 4

Project No. 755

Sample No. and Depth ft	Section No.	Length In.	Description	Consistency As Received	Consistency Remolded	Natural Water Content %	Liquid Limit	Plastic Limit	Plast. Index	Water Plast. Ratio %
PS-4	A	11.0	Empty							
8.5-10.5	B	12.7	Reddish-brown clay; fissured. Contains some subangular pebbles in lower portion of section. q_p = 2.0 tsf	stiff & brittle	firm	44.9	80.0	29.2	50.8	31
	C*	11.6	Top 5" is reddish-brown clay; fissured. q_p = 1.7 tsf c_v = 0.83 tsf	stiff & brittle	firm	48.2	82.5	27.5	55.0	38
			Remainder is brown varved clay with numerous layers of silt up to 0.4" thick. 0.3" vertical shear displacement near center of sample.	stiff & brittle	crumbly					

* see Photo 9, App. III

CASAGRANDE CONSULTANTS

APPENDIX IV

APPENDIX III

Ground El.

Depth to Water Level

TABLE 2 (cont'd)

Undisturbed Sample Boring No. CASA 1072

Sheet No. 5

Project No. 755

Sample No. and Depth ft	Section No.	Length In.	Description	Consistency		Natural Water Content %	Liquid Limit	Plastic Limit	Plast. Index	Water Plast. Ratio %
				As Received	Remolded					
PS-5	A	10.5	Empty							
11.0-13.0	B*	13.3	Reddish-brown varved clay with layers of brown silt up to 0.8" thick (total thickness of silt layers greater than clay layers). Contains several pebbles. q_p = 1.9 tsf Sample has several shear planes; probably due to sampling.	stiff & brittle	firm	20.3				
	C*	11.5	Reddish-brown varved clay with layers of brown silt up to 3.7" thick. Total thickness of silt exceeds clay. q_p = 1.4, 1.7 tsf, c_v = 0.45 tsf } silt. Note: Cutting edge dented.	stiff & brittle	firm	50.4	77.9	25.2	52.7	48

* see Photo 10, App. III

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APPENDIX IV

APPENDIX III

Ground El.

Depth to Water Level

TABLE 2 (cont'd)

Undisturbed Sample Boring No. CASA 1072

Sheet No. 6

Project No. 755

Sample No. and Depth ft	Section No.	Length In.	Description	Consistency		Natural Water Content %	Liquid Limit	Plastic Limit	Plast. Index	Water Plast. Ratio %
				As Received	Remolded					
PS-6	A	9.0	Empty							
14.0-16.5	B	14.4	Reddish-brown clay containing a few pebbles; fissured sample partially disturbed. q_p = 0.5, 0.8 tsf } top c_v = 0.46 tsf } top q_p = 1.2, 1.4 tsf } bottom c_v = 0.59 tsf } bottom	firm to stiff & brittle	soft to firm	55.6				
	C	11.5	Reddish-brown clay containing a few pebbles; fissured. Sample partially disturbed. q_p = 1.3 to 1.7 tsf c_v = 0.60 tsf Note: Cutting edge dented.	firm to stiff & brittle	soft to firm	37.9	58.8	21.6	37.2	44

Ground El.

Depth to Water Level

TABLE 2 (cont'd)

Undisturbed Sample Boring No. CASA 1072

Sheet No. 7

Project No. 755

Sample No. and Depth ft	Section No.	Length In.	Description	Consistency		Natural Water Content %	Liquid Limit	Plastic Limit	Plast. Index	Water Plast. Ratio %
				As Received	Remolded					
PS-7	A	11.2	Empty							
17.5-19.5	B*	12.8	Reddish-brown varved clay containing some pebbles and with layers of brown silt up to 2" thick. Total silt exceeds total clay. Sample partially disturbed. q_p = 1.2 to 1.8 tsf, c_v = 0.44 tsf } bottom	firm to stiff & brittle	soft to firm	49.2	89.4	29.7	59.7	33
	C*	11.0	Top 6.5" is brown silt. Next 2.5" is brown fine sand, and bottom 2.0" is brown glacial till. q_p = 1.7 to 2.3 tsf, c_v = 0.49 tsf. Note: Cutting edge badly dented.	firm to stiff & brittle	crumbly					

* see Photo 11, App. III

Table 2 (cont'd) Sheet 8

Ground El.

Exploratory Boring No. CASA 1072

Depth to Water Level: Project No. 755

Sample No.	Depth ft	No. of Blows per 6 in.	Description	Consistency		Nat. Water Cont. %	Liquid Limit	Plastic Limit	Plast. Index	Water Plast. Ratio %
				As Received	Remolded					
SPT-1	21.0 to 22.0	7-15	Brown very clayey sand and gravel; angular to subangular particles (glacial till). Disturbed.	soft	soft					
SPT-2	24.0 to 24.5	?-18-18	Similar to SPT-1. Disturbed.	soft	soft					

Ground El. 1130.2± | TABLE 3 | Sheet No. 1

Depth to Water Level 9.5 ft | Undisturbed Sample Boring No. CASA 1077 | Project No. 755

Sample No. and Depth ft	Section No.	Length In.	Description	Consistency		Natural Water Content %	Liquid Limit	Plastic Limit	Plast. Index	Water Plast. Ratio %
				As Received	Remolded					
PS-1	A	12.6	Empty							
1.5-3.5	B	11.3	Reddish-brown clay with some silty clay marbling near top of section, and containing some pebbles; highly fissured. q_p = 0.7 to 0.9 tsf c_v = 0.65 tsf	firm & brittle	soft	36.6				
	C	11.3	Reddish-brown clay containing a few pebbles and small roots; highly fissured. q_p = 0.9 to 1.7 tsf c_v = 0.64 to 0.83 tsf	firm to stiff & brittle	soft to firm	45.2	83.7	33.5	50.2	23

CASAGRANDE CONSULTANTS

Ground El.

Depth to Water Level

TABLE 3 (cont'd)

Undisturbed Sample Boring No. CASA 1077

Sheet No. 2

Project No. 755

Sample No. and Depth ft	Section No.	Length In.	Description	Consistency As Received	Consistency Remolded	Natural Water Content %	Liquid Limit	Plastic Limit	Plast. Index	Water Plast. Ratio %
PS-2	A	6.0	Empty							
4.0-6.5	B	6.0	Reddish-brown clay; highly fissured. q_p = 1.3 to 1.9 tsf c_v = 0.86 tsf	firm to stiff & brittle	soft to firm	50.0				
	C	12.0	Reddish-brown clay containing a few pebbles; fissured. Also some small roots along several of the fissures. q_p = 1.8 to 2.5 tsf c_v = 0.95 tsf	stiff to v. stiff & brittle	firm to stiff	42.8	85.7	31.9	53.8	20
	D*	11.7	Top 5.2" is reddish-brown clay. q_p = 1.2 to 2.1 tsf c_v = 0.80 tsf Remaining 6.5" is brown varved silty clay with layers of silt up to 0.4" thick. Entire sample is highly fissured.	firm to stiff & brittle	soft to firm	48.7				

CASAGRANDE CONSULTANTS

* see Photo 19, App. III

Ground El.

Depth to Water Level

TABLE 3 (cont'd)

Undisturbed Sample Boring No. CASA 1077

Sheet No. 3

Project No. 755

Sample No. and Depth ft	Section No.	Length In.	Description	Consistency		Natural Water Content %	Liquid Limit	Plastic Limit	Plast. Index	Water Plast. Ratio %
				As Received	Remolded					
PS-3	A	12.5	Empty							
7.0-9.0	B*	11.7	Varved brown silty and reddish-brown clay containing some pebbles. Varves up to 0.9" thick. Total silt exceeds total clay. Clay is fissured. q_p = 1.2 to 1.4 tsf c_v = 0.60 tsf	firm & brittle	soft					
	C*	11.3	Varved reddish-brown clay and brown clayey silt, silt and fine sand. Clay layers up to 0.8" thick. Total clay about one-fourth of silt and fine sand. Clay is fissured. q_p = 1.4 to 2.4 tsf, c_v = 0.60 tsf } top; q_p = 1.2 to 1.4 tsf, c_v = 0.75 tsf } bottom	firm to stiff & brittle	soft	27.8				

CASAGRANDE CONSULTANTS

* see Photo 12, App. III

Ground El. ,

Depth to Water Level

TABLE 3 (cont'd)

Undisturbed Sample Boring No. CASA 1077

Sheet No. 4

Project No. 755

Sample No. and Depth ft	Section No.	Length In.	Description	Consistency		Natural Water Content %	Liquid Limit	Plastic Limit	Plast. Index	Water Plast. Ratio %
				As Received	Remolded					
PS-4	A	12.4	Empty							
9.5-11.5	B	11.7	Reddish-brown clay containing numerous pebbles in the upper half; slightly fissured. q_p = 1.4 to 1.8 tsf c_v = 0.88 tsf	firm to stiff & brittle	soft to firm	38.1				
	C	11.0	(see next page)							

Ground El.

Depth to Water Level

TABLE 3 (cont'd)

Undisturbed Sample Boring No. CASA 1077

Sheet No. 5

Project No. 755

Sample No. and Depth ft	Section No.	Length In.	Description	Consistency		Natural Water Content %	Liquid Limit	Plastic Limit	Plast. Index	Water Plast. Ratio %
				As Received	Remolded					
PS-4 (cont'd)	C	11.0	Reddish-brown clay containing a few thin seams of brown silt and fine sand and some pebbles in the upper one-third of the section, and one 0.2" layer of silt (dipping 5°) 2" from the bottom of the section; fissured above silt layer and highly fissured below.							
			q_p = 1.7 to 1.9 tsf, c_v = 0.80 tsf } top	stiff & brittle	firm	42.3	79.3	26.0	53.3	31
			q_p = 0.8 to 1.0 tsf, c_v = 0.54 tsf } bottom	firm & brittle	soft	41.6				

CASAGRANDE CONSULTANTS

APPENDIX IV

APPENDIX III

Ground El.

Depth to Water Level

TABLE 3 (cont'd)

Undisturbed Sample Boring No. CASA 1077

Sheet No. 6

Project No. 755

Sample No. and Depth ft	Section No.	Length In.	Description	Consistency As Received	Consistency Remolded	Natural Water Content %	Liquid Limit	Plastic Limit	Plast. Index	Water Plast. Ratio %
PS-5	A	11.4	Empty							
12.0-14.0	B*	12.3	Reddish-brown clay with a few partings of brown silt and containing a few pebbles; fissured. q_p = 1.5 to 1.8 tsf c_v = 1.0 tsf	stiff & brittle	firm	43.0	70.4	22.3	48.1	43
	C*	11.5	Reddish-brown clay with a few partings of brown silt and fine sand and one 0.4" layer of silt near the middle of the section, and containing some pebbles; fissured. q_p = 1.4 to 1.8 tsf, c_v = 1.0 tsf } top; q_p = 1.2 to 1.3 tsf, c_v = 0.66 tsf } bottom. Note: Cutting edge dented.	firm to stiff & brittle	firm	44.2				

* see Photo 13, App. III

CASAGRANDE CONSULTANTS

Ground El. | TABLE 3 (cont'd) | Sheet No. 7

Depth to Water Level | Undisturbed Sample Boring No. CASA 1077 | Project No. 755

Sample No. and Depth ft	Section No.	Length In.	Description	Consistency		Natural Water Content %	Liquid Limit	Plastic Limit	Plast. Index	Water Plast. Ratio %
				As Received	Remolded					
PS-6	A	10.4	Empty							
14.5-16.5	B*	13.7	Upper 5.7" is varved reddish-brown clay and brown silt; clay is fissured. Varves are from 0.1" to 0.3" thick, with total clay about equal to silt. q_p = 1.8 to 2.3 tsf c_v = 0.71 tsf Remaining 8.0" is brown silt with several partings of clay and containing pebbles up to 1.5" size.	stiff & brittle	firm					
	C*	11.5	Brown silt with two thin layers of reddish-brown clay, and containing pebbles up to 1.5" size.							

* see Photo 14, App. III

CASAGRANDE CONSULTANTS

Table 3 (cont'd) Sheet 8

Ground El.

Exploratory Boring No. CASA 1077

Depth to Water Level: Project No. 755

Sample No.	Depth ft	No. of Blows per 6 in.	Description	Consistency		Nat. Water Cont. %	Liquid Limit	Plastic Limit	Plast. Index	Water Plast. Ratio %
				As Received	Remolded					
SPT-1	18.0 to 18.2	150/2"	Reddish-brown clayey coarse sand and gravel; angular to subangular particles (glacial till). Disturbed.							
SPT-2	19.0 to 19.3	100/4"	Similar to SPT-1.	hard & brittle	crumbly	10.1				

Ground El. 1111.2± | TABLE 4 | Sheet No. 1

Depth to Water Level : overflowing | Undisturbed Sample Boring No. CASA 3004 | Project No.755

Sample No. and Depth ft	Section No.	Length In.	Description	Consistency		Natural Water Content %	Liquid Limit	Plastic Limit	Plast. Index	Water Plast. Ratio %
				As Received	Remolded					
PS-1	A	15.2	Empty							
1.5-3.5	B	8.8	Reddish-brown clay containing some pebbles up to 1.8" size. q_p = 2.0 to 2.2 tsf c_v = 1.20 tsf	stiff & brittle	firm	24.0	44.6	19.5	25.1	18
	C	11.1	Top 8.8" is reddish-brown clay containing some pebbles up to ½" size. q_p = 0.5 to 1.0 tsf c_v = 0.28 to 0.68 tsf	soft to firm	soft	31.5				
			Remaining 2.3" is brown silty clay containing numerous pebbles up to 1.5" size. q_p = 2.3 to 2.9 tsf c_v = 1.35 tsf	stiff to v. stiff	firm to stiff	22.6	30.4	17.0	13.4	42

CASAGRANDE CONSULTANTS

Ground El.

Depth to Water Level

TABLE 4 (cont'd)

Undisturbed Sample Boring No. CASA 3004

Sheet No. 2

Project No. 755

Sample No. and Depth ft	Section No.	Length In.	Description	Consistency		Natural Water Content %	Liquid Limit	Plastic Limit	Plast. Index	Water Plast. Ratio %
				As Received	Remolded					
PS-2	A	12.0	Empty							
4.0-6.0	B	11.9	Top 4.0" is reddish-brown clay containing some pebbles.	stiff	firm	24.0	46.0	16.8	29.2	29
			q_p = 1.5 to 1.8 tsf c_v = 0.75 tsf							
			Remaining 7.9" is brown silty and sandy clay containing pebbles (glacial till).	stiff & brittle	firm	23.8	34.2	15.8	18.4	43
			q_p = 1.9 to 2.2 tsf c_v = 1.23 tsf							
			Note: Below 6.5" tube cross-section only half full due to pebble or stone having been pushed down during sloping.							
	C	10.4	(see next page)							

Ground El.

Depth to Water Level

TABLE 4 (cont'd)

Undisturbed Sample Boring No. CASA 3004

Sheet No. 3

Project No. 755

Sample No. and Depth ft	Section No.	Length In.	Description	Consistency		Natural Water Content %	Liquid Limit	Plastic Limit	Plast. Index	Water Plast. Ratio %
				As Received	Remolded					
PS-2 (cont'd)	C	10.4	Brown silty and sandy clay containing numerous pebbles (subrounded to angular) up to 2" size (glacial till). q_p = 1.8 to 2.2 tsf c_v = 0.75 tsf Note: Cross-section of tube only partially filled within upper 8". Cutting edge dented.	stiff & brittle	firm	21.7				

Ground El. | TABLE 4 (cont'd) | Sheet No. 4

Depth to Water Level | Undisturbed Sample Boring No. CASA 3004 | Project No. 755

Sample No. and Depth ft	Section No.	Length In.	Description	Consistency		Natural Water Content %	Liquid Limit	Plastic Limit	Plast. Index	Water Plast. Ratio %
				As Received	Remolded					
PS-3	A	14.0	Empty							
6.5-8.5	B	10.2	Brown silty to sandy clay containing numerous pebbles (glacial till). q_p = 1.8 to 2.2 tsf	stiff & brittle	firm	27.7	40.1	17.0	23.1	46
	C*	10.8	Top 3" is brown silty and sandy clay containing pebbles (glacial till). q_p = 1.7 tsf	stiff & brittle	firm	28.0				
			Next 4" is a transition zone between glacial till and lake deposits.							
			Remaining 3.8" is reddish-brown clay with several pockets of brown silt; highly fissured. q_p = 1.5 to 1.8 tsf c_v = 0.68 tsf	stiff & brittle	firm	42.2				

* see Photo 15, App. III

CASAGRANDE CONSULTANTS

Ground El. | TABLE 4 (cont'd) | Sheet No. 5

Depth to Water Level | Undisturbed Sample Boring No. CASA 3004 | Project No. 755

Sample No. and Depth ft	Section No.	Length In.	Description	Consistency		Natural Water Content %	Liquid Limit	Plastic Limit	Plast. Index	Water Plast. Ratio %
				As Received	Remolded					
PS-4	A	10.9	Empty							
9.0-11.0	B*	13.0	Reddish-brown clay varved with brown silt and fine sand. Clay is intensely fissured (almost granular structure). Disturbed.	firm & brittle	soft	42.6				
	C*	10.7	Reddish-brown clay varved with brown silt, and containing one 2" pebble about in the middle. Varves from 0.1" to 1" thick, and dipping about 15^o. Total clay about equal total silt. Clay highly fissured. q_p = 1.6 to 2.0 tsf c_v = 0.56 tsf	stiff & brittle	firm					

* see Photo 16, App. III

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Ground El.

Depth to Water Level

TABLE 4 (cont'd)

Undisturbed Sample Boring No. CASA 3004

Sheet No. 6

Project No. 755

Sample No. and Depth ft	Section No.	Length In.	Description	Consistency		Natural Water Content %	Liquid Limit	Plastic Limit	Plast. Index	Water Plast. Ratio %
				As Received	Remolded					
PS-5	A	5.9	Empty							
12.0-14.0	B	5.8	Top 4" is reddish-brown clay.	soft	soft to v. soft	50.7	67.4	24.0	43.4	62 red
			Remainder is brown clay. Entire section appears disturbed. q_p = 0.2 tsf c_v = 0.40 tsf			32.3				brown
	C*	12.1	Reddish-brown clay varved with brown silt and fine sand and containing some pebbles to 1" size. Layers up to 1.5" thick. Upper half of section is soft and appears disturbed. Clay in lower half is highly fissured. q_p = 1.4 to 2.2 tsf, c_v = 0.60 tsf } bottom	firm to stiff & brittle	firm					

D* 11.4 (see next page)

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* see Photo 17, App. III

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Ground El. TABLE 4 (cont'd) Sheet No. 7

Depth to Water Level Undisturbed Sample Boring No. CASA 3004 Project No. 755

Sample No. and Depth ft	Section No.	Length In.	Description	Consistency		Natural Water Content %	Liquid Limit	Plastic Limit	Plast. Index	Water Plast. Ratio %
				As Received	Remolded					
PS-5 (cont'd)	D*	11.4	Varved reddish-brown clay, brown silt, and fine sand. Upper half of section is primarily silt, and lower half is mainly clay. Clay is highly fissured. q_p = 1.3 to 1.6 tsf, c_v = 0.59 tsf } top; q_p = 0.7 to 0.9 tsf, c_v = 0.59 tsf } bottom	firm to stiff & brittle	soft to firm	40.4				

* see Photo 17, App. III

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Ground El.

Depth to Water Level

TABLE 4 (cont'd)

Undisturbed Sample Boring No. CASA 3004

Sheet No. 8

Project No. 755

Sample No. and Depth ft	Section No.	Length In.	Description	Consistency		Natural Water Content %	Liquid Limit	Plastic Limit	Plast. Index	Water Plast. Ratio %
				As Received	Remolded					
PS-6	A	9.4	Empty							
14.5-16.5	B*	14.5	Top 6.5" is reddish-brown clay mixed with a few thin layers of brown silt, and containing some pebbles.	soft	soft	26.9				
			q_p = 0.5 to 0.6 tsf							
			c_v = 0.43 tsf							
			Remaining 8.0" is brown silt mixed with some reddish-brown clay.	soft to v. soft	v. soft & sticky					
			q_p = 0.2 tsf							
			c_v = 0.18 tsf							
			Note: Entire section badly disturbed.							
	C	10.8	(see next page)							

* See Photo 15, App. III

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Ground El.

Depth to Water Level

TABLE 4 (cont'd)

Undisturbed Sample Boring No. CASA 3004

Sheet No. 9

Project No. 755

Sample No. and Depth ft	Section No.	Length In.	Description	Consistency		Natural Water Content %	Liquid Limit	Plastic Limit	Plast. Index	Water Plast. Ratio %
				As Received	Remolded					
PS-6 (cont'd)	C	10.8	Top 2.7" is brown clay marbled with some red clay; disturbed. q_p = 0.5 tsf	soft	soft	37.4	46.9	23.8	23.1	59
			Remaining 8.1" is brown sandy clay containing some pebbles (glacial till). q_p = 1.3 to 1.5 tsf	firm & brittle	soft					

Table 4 (cont'd)

Sheet 10

Ground El.

Exploratory Boring No. CASA 3004

Depth to Water Level:

Project No.755

Sample No.	Depth ft	No. of Blows per ft	Description	Consistency As Received	Consistency Remolded	Nat. Water Cont. %	Liquid Limit	Plastic Limit	Plast. Index	Water Plast. Ratio %
SPT-1	16.5 to 18.0	5-8-10	Brown very clayey sand and gravel; angular to subangular particles (glacial till). Disturbed.	soft	soft					
SPT-2	18.5 to 20.0	7-8-15	Similar to SPT-1.	soft	soft					
SPT-3	20.0 to 21.5	13-21-35	Brown clayey sand and gravel; angular to subangular particles (glacial till).	hard & brittle	stiff to crumbly	13.8				
SPT-4	20.5 to 23.5	38-100	Similar to SPT-3.	hard & brittle	stiff to crumbly	9.6				
SPT-5	25.0 to 26.5	18-42-58	Similar to SPT-3.	hard & brittle	crumbly					

Ground El. 1162.5±

Depth to Water Level : at surface

TABLE 5

Undisturbed Sample Boring No. CASA 3037

Sheet No. 1

Project No. 755

Sample No. and Depth ft	Section No.	Length In.	Description	Consistency As Received	Consistency Remolded	Natural Water Content %	Liquid Limit	Plastic Limit	Plast. Index	Water Plast. Ratio %
PS-1	A	20.6	Empty							
2.0-3.7	B	10.9	Reddish-brown clay containing numerous small pebbles and with one 1.5" layer of brown clayey sand. q_p = 1.0 to 1.7 tsf, c_v = 0.54 tsf (top); q_p = 2.0, 2.3 tsf, c_v = 1.22 tsf (middle)	firm to stiff & brittle	soft to firm	26.5 (clay) 22.7 (clayey sand)	46.2	17.8	28.4	31 clay clayey sand

CASAGRANDE CONSULTANTS

Ground El.

Depth to Water Level

TABLE 5 (cont'd)

Undisturbed Sample Boring No. CASA 3037

Sheet No.2

Project No.755

Sample No. and Depth ft	Section No.	Length In.	Description	Consistency		Natural Water Content %	Liquid Limit	Plastic Limit	Plast. Index	Water Plast. Ratio %
				As Received	Remolded					
PS-2	A	14.1	Empty							
5.0-6.8	B	9.7	Top 4.5" is reddish-brown clay containing some pebbles. q_p = 1.5 tsf c_v = 0.88 tsf	firm to stiff & brittle	soft to firm	22.8				
			Lower portion is brown clay containing some pebbles. q_p = 3.7, 3.9 tsf c_v = 1.8 tsf	v. stiff & brittle	stiff to crumbly	23.6				
			Note: Some sealing wax also found at the bottom of this section.							
	C	10.5	(see next page)							

CASAGRANDE CONSULTANTS

Ground El.

Depth to Water Level

TABLE 5 (cont'd)

Undisturbed Sample Boring No. CASA 3037

Sheet No. 3

Project No. 755

Sample No. and Depth ft	Section No.	Length In.	Description	Consistency		Natural Water Content %	Liquid Limit	Plastic Limit	Plast. Index	Water Plast. Ratio %
				As Received	Remolded					
PS-2 (cont'd)	C	10.5	Reddish-brown clay containing some pebbles up to 2" size. Also some voids caused by pushing stones during sampling. q_p = 4.4 tsf Note: This section of sample tube badly deformed and cutting edge badly dented.	hard & brittle	crumbly	27.2				

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Ground El.

Depth to Water Level

TABLE 5 (cont'd)

Undisturbed Sample Boring No. CASA 3037

Sheet No. 4

Project No. 755

Sample No. and Depth ft	Section No.	Length In.	Description	Consistency		Natural Water Content %	Liquid Limit	Plastic Limit	Plast. Index	Water Plast. Ratio %
				As Received	Remolded					
PS-3	A	21.0	Empty							
7.5-9.0	B	14.0	Top 4.5" is reddish-brown clay containing some angular to subangular pebbles up to 1" size. q_p = 1.5 to 2.3 tsf c_v = 0.80 tsf	stiff & brittle	firm	27.7	47.4	20.2	27.2	28
			Remainder is reddish-brown clayey silt containing some pebbles and pockets and lenses of fine sand. Contains shear planes. q_p = 4.0 tsf	hard & brittle	crumbly					

Ground El.

Depth to Water Level

TABLE 5 (cont'd)

Undisturbed Sample Boring No. CASA 3037

Sheet No. 5

Project No. 755

Sample No. and Depth ft	Section No.	Length In.	Description	Consistency		Natural Water Content %	Liquid Limit	Plastic Limit	Plast. Index	Water Plast. Ratio %
				As Received	Remolded					
PS-4	A	15.9	Empty							
10.0-12.0	B	8.0	Top 3.5" is reddish-brown clay containing some pebbles. q_p = 1.0, 1.1 tsf c_v = 0.60, 0.73 tsf	firm to stiff	firm	26.9	46.3	19.1	27.2	29
			Remainder is brown silt containing pockets and lenses of fine sand. q_p > 4.5 tsf	hard & brittle	crumbly					
	C*	9.0	(see next page)							

* see Photo 18, App. III

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APPENDIX III

Ground El.

Depth to Water Level

TABLE 5 (cont'd)

Undisturbed Sample Boring No. CASA 3037

Sheet No. 6

Project No. 755

Sample No. and Depth ft	Section No.	Length In.	Description	Consistency		Natural Water Content %	Liquid Limit	Plastic Limit	Plast. Index	Water Plast. Ratio %
				As Received	Remolded					
PS-4 (cont'd)	C*	9.0	Top 5" is reddish-brown clay with some layers and lenses of brown silt; contains some pebbles up to 1" size. q_p = 1.7 tsf c_v = 0.92 tsf	stiff & brittle	firm	34.9	50.9	19.0	31.9	50
			Remainder is brown silt with some pockets of reddish-brown clay and brown sand.	hard & brittle	crumbly					
			Note: Lower half of this section of sample tube badly deformed.							

* see Photo 18, App. III

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APPENDIX III

Ground El. | **TABLE** 5 (cont'd) | Sheet No. 7

Depth to Water Level | **Undisturbed Sample Boring No.** CASA 3037 | Project No. 755

Sample No. and Depth ft	Section No.	Length In.	Description	Consistency		Natural Water Content %	Liquid Limit	Plastic Limit	Plast. Index	Water Plast. Ratio %
				As Received	Remolded					
PS-5	A	10.5	Empty							
13.0-15.0	B	13.6	Top 6.5" is brown silt with several pockets and lenses of reddish-brown clay, and containing some pebbles up to 1.5" size. (This portion of sample obviously disturbed.)							
			Remainder is reddish-brown clay; highly fissured. q_p = 1.2 to 1.6 tsf c_v = 0.70 tsf	firm to stiff & brittle	soft to firm	48.7	79.2	25.2	54.0	43
	C	11.3	Reddish-brown clay with a few zones containing pebbles, and one 2" pocket or lense of brown silt; clay is highly fissured. q_p = 1.1 to 1.6 tsf c_v = 0.73 tsf	firm to stiff & brittle	soft to firm	25.8				

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Ground El.

Depth to Water Level

TABLE 5 (cont'd)

Undisturbed Sample Boring No. CASA 3037

Sheet No. 8

Project No. 755

Sample No. and Depth ft	Section No.	Length In.	Description	Consistency		Natural Water Content %	Liquid Limit	Plastic Limit	Plast. Index	Water Plast. Ratio %
				As Received	Remolded					
PS-6	A	10.0	Empty							
16.0-18.0	B	14.0	Top 9.0" is reddish-brown clay containing a few pebbles. q_p = 0.8 to 0.9 tsf c_v = 0.62	firm	soft	39.5	80.8	27.0	53.8	24
			Remainder is brown clayey silt containing one 3" stone. q_p = 2.3 to 3.3 tsf c_v = 0.83 tsf	stiff to v. stiff & brittle	crumbly	25.8	36.5	19.2	17.3	38
	C*	11.1	Brown varved silt with some layers of reddish-brown clay. Sample disturbed.	stiff & brittle	firm to crumbly					

* see Photo 18, App. III

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Ground El.

Depth to Water Level

TABLE 5 (cont'd)

Undisturbed Sample Boring No. CASA 3037

Sheet No. 9

Project No. 755

Sample No. and Depth ft	Section No.	Length In.	Description	Consistency		Natural Water Content %	Liquid Limit	Plastic Limit	Plast. Index	Water Plast. Ratio %
				As Received	Remolded					
PS-7	A	23.3	Empty							
19.0-20.0	B	11.2	Top 5.3" is brown clay containing some pebbles. q_p = 0.6 tsf c_v = 0.29 tsf	soft	v. soft	30.0	48.1	17.9	30.2	40
			Remainder is brown silty and sandy clay containing some pebbles. q_p = 2.3 to 3.3 tsf c_v = 0.77 tsf Note: Cutting edge badly dented.	stiff to v. stiff & brittle	firm	24.1	31.8	17.7	14.1	46

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Ground El.

Depth to Water Level

TABLE 5 (cont'd)

Undisturbed Sample Boring No. CASA 3037

Sheet No. 10

Project No. 755

Sample No. and Depth ft	Section No.	Length In.	Description	Consistency		Natural Water Content %	Liquid Limit	Plastic Limit	Plast. Index	Water Plast. Ratio %
				As Received	Remolded					
PS-8	A	27.7	Empty							
22.0-22.8	B	7.8	Brown silty clay, clay, silty fine sand, and silt. Sample badly disturbed.	silty clay & clay are soft	v. soft	24.1	32.9	17.0	15.9	45
			Note: Cutting edge badly dented.	silt is hard & brittle	crumbly					

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Ground El.

Depth to Water Level

TABLE 5 (cont'd)

Undisturbed Sample Boring No. CASA 3037

Sheet No. 11

Project No. 755

Sample No. and Depth ft	Section No.	Length In.	Description	Consistency		Natural Water Content %	Liquid Limit	Plastic Limit	Plast. Index	Water Plast. Ratio %
				As Received	Remolded					
PS-9	A	25.0	Empty							
24.0-24.5	B	7.5	Brown fine sandy silt containing several small pebbles. Sample disturbed.							
	C	3.5	Empty							

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Ground El.

Depth to Water Level

TABLE 5 (cont'd)

Undisturbed Sample Boring No. CASA 3037

Sheet No. 12

Project No.755

Sample No. and Depth ft	Section No.	Length In.	Description	Consistency		Natural Water Content %	Liquid Limit	Plastic Limit	Plast. Index	Water Plast. Ratio %
				As Received	Remolded					
PS-10	A	16.5	Empty							
28.5-30.5	B	7.5	Brown clayey sand & gravel. Sample disturbed.							
	C	9.3	Brown clayey sand & gravel. Sample disturbed. Note: Cutting edge damaged.							

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Table 5 (cont'd)

Sheet 13

Ground El.

Exploratory Boring No. CASA 3037

Depth to Water Level:

Project No. 755

Sample No.	Depth ft	No. of Blows per 6 in.	Description	Consistency		Nat. Water Cont. %	Liquid Limit	Plastic Limit	Plast. Index	Water Plast. Ratio %
				As Received	Remolded					
SPT-1	26.0 to 27.5	5-16-22	Brown silt with several thin layers of lenses of fine sand and containing some angular pebbles; disturbed.	firm	crumbly					
SPT-2	30.5 to 32.0	42-45-110	Brown clayey sand and gravel; angular to subangular particles (glacial till).	hard & brittle	crumbly	10.8				
SPT-3	34.0 to 35.5	5-32-48	Similar to SPT-2.	hard & brittle	crumbly					
SPT-4	38.0 to 39.5	11-36-100	Similar to SPT-2; disturbed.	crumbly	crumbly					

Ground El. 1146.7±

Depth to Water Level: at surface

TABLE 6

Undisturbed Sample Boring No. CASA 3056

Sheet No. 1

Project No. 755

Sample No. and Depth ft	Section No.	Length In.	Description	Consistency		Natural Water Content %	Liquid Limit	Plastic Limit	Plast. Index	Water Plast. Ratio %
				As Received	Remolded					
PS-1	A	19.1	Empty							
2.0-4.0	B	4.8	Top 0.5" dark gray organic silt with some pieces of wood. Remaining 4.3" is reddish-brown clay with one 0.5" layer of brown fine to medium sand, and containing some pebbles; fissured. q_p = 1.5 to 1.7 tsf c_v = 1.20 tsf	firm to stiff & brittle	firm	19.5	35.5	18.6	16.9	5
	C	11.2	(see next page)							

CASAGRANDE CONSULTANTS

Ground El.

Depth to Water Level

TABLE 6 (cont'd)

Undisturbed Sample Boring No. CASA 3056

Sheet No. 2

Project No. 755

Sample No. and Depth ft	Section No.	Length In.	Description	Consistency		Natural Water Content %	Liquid Limit	Plastic Limit	Plast. Index	Water Plast. Ratio %
				As Received	Remolded					
PS-1 (cont'd)	C	11.2	Reddish-brown clay containing some pebbles up to 2" size; highly fissured.	stiff to v. stiff & brittle	firm to stiff & crumbly					
			q_p = 1.8 to 2.1 tsf, c_v = 1.20 tsf } top			19.2				
			q_p = 2.4 to 3.4 tsf, c_v = 1.63 tsf } middle			20.2	33.4	18.6	14.8	32
			q_p = 1.5 to 1.8 tsf, c_v = 1.25 tsf } bottom							
			Note: Bottom appears disturbed by pebble during sampling.							

CASAGRANDE CONSULTANTS

Ground El.

Depth to Water Level

TABLE 6 (cont'd)

Undisturbed Sample Boring No. CASA 3056

Sheet No. 3

Project No. 755

Sample No. and Depth ft	Section No.	Length In.	Description	Consistency As Received	Consistency Remolded	Natural Water Content %	Liquid Limit	Plastic Limit	Plast. Index	Water Plast. Ratio %
PS-2	A	18.7	Empty							
5.0-6.7	B	5.0	Reddish-brown clay containing numerous pebbles and stones up to 2.7" size; highly fissured. Most of section disturbed. q_p = 3.3 to 4.2 tsf c_v = 1.65 tsf	v. stiff to hard & brittle	stiff to crumbly					
	C	11.3	Reddish-brown and brown sandy clay containing numerous pebbles (glacial till); fissured. q_p = 3.8 to $>$ 4.5 tsf c_v = 1.62 to 2.04 tsf Note: Cutting edge badly dented.	hard to v. hard & brittle	crumbly	17.5	32.8	18.1	14.7	-4

Ground El. TABLE 6 (cont'd) Sheet No. 4

Depth to Water Level Undisturbed Sample Boring No. CASA 3056 Project No. 755

Sample No. and Depth ft	Section No.	Length In.	Description	Consistency		Natural Water Content %	Liquid Limit	Plastic Limit	Plast. Index	Water Plast. Ratio %
				As Received	Remolded					
PS-3	A	16.4	Empty							
8.0-10.0	B	7.7	Top 5.2" is reddish-brown clay containing pebbles.	firm	firm	21.3				
			q_p = 1.0 to 1.3 tsf c_v = 0.73 tsf							
			Remaining 2.5" is brown clay containing pebbles.	stiff to	firm to	26.7				
			q_p = 2.5 to 3.0 tsf c_v = 1.68 tsf							
	C	11.0	Brown clay containing numerous pebbles (glacial till).	v. stiff & brittle	stiff	23.9	41.0	19.8	21.2	14
			Note: Cutting edge dented.							

Ground El.

Depth to Water Level

TABLE 6 (cont'd)

Undisturbed Sample Boring No. CASA 3056

Sheet No. 5

Project No. 755

Sample No. and Depth ft	Section No.	Length In.	Description	Consistency As Received	Consistency Remolded	Natural Water Content %	Liquid Limit	Plastic Limit	Plast. Index	Water Plast. Ratio %
PS-4	A	14.9	Empty							
11.0-12.8	B*	9.3	Top 5.2" is brown clay containing numerous pebbles (glacial till).	disturbed		24.5	52.6	26.0	26.6	-6
			Remaining 4.1" is brown silty clay with a few partings of silt; fissured. q_p = 2.5 to 3.2 tsf c_v = 1.25 tsf	v. stiff & v. brittle	stiff	32.2				
	C*	11.3	(see next page)							

* see Photo 20, App. III

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Ground El.

Depth to Water Level

TABLE 6 (cont'd)

Undisturbed Sample Boring No. CASA 3056

Sheet No. 6

Project No. 755

Sample No. and Depth ft	Section No.	Length In.	Description	Consistency As Received	Consistency Remolded	Natural Water Content %	Liquid Limit	Plastic Limit	Plast. Index	Water Plast. Ratio %
PS-4 (cont'd)	C	11.3	Top 6" to 10" is varved reddish-brown clay and brown silt. Varves are irregular pattern. Clay is fissured. Lower portion is varved silt and clay overlying 2.5" of brown fine sand at bottom of section. A shear plane cuts diagonally across sample at a 60° angle (from horizontal) with indeterminable displacement (not due to sampling). q_p = 2.9 to 3.4 tsf c_v = 0.98 tsf Note: Cutting edge dented.	v.stiff & brittle	stiff					

Ground El. | TABLE 6 (cont'd) | Sheet No. 7

Depth to Water Level | Undisturbed Sample Boring No. CASA 3056 | Project No. 755

Sample No. and Depth ft	Section No.	Length In.	Description	Consistency		Natural Water Content %	Liquid Limit	Plastic Limit	Plast. Index	Water Plast. Ratio %
				As Received	Remolded					
PS-5	A	16.8	Empty							
14.0-16.0	B*	7.0	Top 6.5" is reddish-brown clay with one parting of fine sand and containing some pebbles up to 1" size. q_p = 0.8 tsf c_v = 0.58 tsf Bottom 0.5" is varved brown silt and fine sand. q_p = 1.7 to 2.1 tsf c_v = 0.68 tsf	firm	soft	28.7	44.3	21.2	23.1	32
	C*	11.5	(see next page)							

* see Photo 21, App. III

Ground El.

Depth to Water Level

TABLE 6 (cont'd)

Undisturbed Sample Boring No. CASA 3056

Sheet No. 8

Project No. 755

Sample No. and Depth ft	Section No.	Length In.	Description	Consistency		Natural Water Content %	Liquid Limit	Plastic Limit	Plast. Index	Water Plast. Ratio %
				As Received	Remolded					
PS-5 (cont'd)	C*	11.5	Top 3" to 6" is brown varved silt and fine sand containing several thin layers of reddish-brown clay. q_p = 3.0 to 4.0 tsf c_v = 1.10 tsf	v. stiff to hard & brittle	crumbly					
			Remaining 5.5" to 8.5" is varved reddish-brown clay containing layers of silt and fine sand up to 0.5" thick. Clay is fissured. q_p = 2.7 to 2.8 tsf c_v = 1.50 tsf Shear plane cuts diagonally across entire sample at an angle of 50° (from horizontal) with indeterminable displacement (not due to sampling).	v. stiff & brittle	stiff	28.4	51.7	23.9	27.8	16

* see Photo 21, App. III

Ground El.

Depth to Water Level

TABLE 6 (cont'd)

Undisturbed Sample Boring No. CASA 3056

Sheet No. 9

Project No. 755

Sample No. and Depth ft	Section No.	Length In.	Description	Consistency		Natural Water Content %	Liquid Limit	Plastic Limit	Plast. Index	Water Plast. Ratio %
				As Received	Remolded					
PS-6	A	11.3	Empty							
17.0-19.0	B*	13.1	Upper 10.5" is reddish-brown clay marbled with brown silt. Top 5" primarily silt. Obviously disturbed.							
			Remaining 2.6" is reddish-brown clay containing several partings of silt; fissured. q_p = 1.7 to 2.2 tsf c_v = 0.70 tsf	stiff & brittle	firm	34.8				
	C	11.0	Reddish-brown clay containing a few pebbles; highly fissured. q_p = 2.2 to 2.4 tsf, c_v = 0.84 tsf } top; q_p = 1.4 to 1.9 tsf bottom	firm to to stiff & brittle	firm	32.2	67.1	29.5	37.6	7

* see Photo 19, App. III

CASAGRANDE CONSULTANTS

Ground El.

Depth to Water Level

TABLE 6 (cont'd)

Undisturbed Sample Boring No. CASA 3056

Sheet No. 10

Project No. 755

Sample No. and Depth ft	Section No.	Length In.	Description	Consistency		Natural Water Content %	Liquid Limit	Plastic Limit	Plast. Index	Water Plast. Ratio %
				As Received	Remolded					
PS-7	A	12.9	Empty							
20.0-22.0	B*	11.2	Top 7.3" is reddish-brown clay containing some pebbles; fissured. q_p = 0.9 tsf c_v = 0.59 tsf	firm	soft	35.4	70.9	25.0	45.9	23
			Remaining 3.9" is brown silt with several 0.1" layers of reddish-brown clay, and containing some pebbles up 1" size. Upper ½ of section disturbed.	v. stiff & brittle	crumbly					
	C*	11.1	(see next page)							

* see Photo 22, App. III

CASAGRANDE CONSULTANTS

APPENDIX III

Ground El.

Depth to Water Level

TABLE 6 (cont'd)

Undisturbed Sample Boring No. CASA 3056

Sheet No. 11

Project No. 755

Sample No. and Depth ft	Section No.	Length In.	Description	Consistency		Natural Water Content %	Liquid Limit	Plastic Limit	Plast. Index	Water Plast. Ratio %
				As Received	Remolded					
PS-7 (cont'd)	C*	11.1	Brown silt varved with fine sand and reddish-brown clay, and containing some pebbles. Varves up to 1" thick. Clay only about 20% of sample; fissured. q_p = 2.5 to 3.0 tsf, c_v = 0.97 tsf } top q_p = 2.3 to 2.7 tsf, c_v = 0.58 tsf } bottom	stiff to v.stiff & brittle	firm to crumbly					

* see Photo 22, App. III

CASAGRANDE CONSULTANTS

APPENDIX III

APPENDIX IV

Ground El.

Depth to Water Level

TABLE 6 (cont'd)

Undisturbed Sample Boring No. CASA 3056

Sheet No. 12

Project No.755

Sample No. and Depth ft	Section No.	Length In.	Description	Consistency		Natural Water Content %	Liquid Limit	Plastic Limit	Plast. Index	Water Plast. Ratio %
				As Received	Remolded					
PS-8	A	7.3	Empty							
23.0-25.0	B*	4.5	Marbled brown silt and reddish-brown clay. Sample completely disturbed.	soft	soft & sticky					
	C*	12.2	Brown silt with some reddish-brown clay marbling. Sample completely disturbed.	v. soft	v. soft & sticky					
	D**	8.5	Brown silt marbled with reddish-brown clay. Sample completely disturbed.	soft	soft to v. soft & sticky					
	E	3.2	Empty + about ½" of water between wax plug and end cap.							

* see Photo 23, App. III

** see Photo 24, App. III

CASAGRANDE CONSULTANTS

Ground El.

Depth to Water Level

TABLE 6 (cont'd)

Undisturbed Sample Boring No. CASA 3056

Sheet No. 13

Project No.755

Sample No. and Depth ft	Section No.	Length In.	Description	Consistency		Natural Water Content %	Liquid Limit	Plastic Limit	Plast. Index	Water Plast. Ratio %
				As Received	Remolded					
PS-9 26.0-27.0	A	9.0	Empty + about ½" of free water + silt between wax plug and end cap.							
	B	4.0	Brown silt. Sample completely disturbed.	soft	soft					
	C*	11.0	Top 7.5" is brown silt.	firm to stiff	crumbly	20.3				
			Remaining 3.5" is brown sandy clay containing pebbles (glacial till). Entire sample disturbed.	firm	firm	19.4	25.3	15.1	10.2	42
			Note: Cutting edge badly dented.							

* see Photo 24, App. III

CASAGRANDE CONSULTANTS

APPENDIX IV APPENDIX III

Table 6 (cont'd)

Sheet 14

Ground El.

Exploratory Boring No. CASA 3056

Depth to Water Level:

Project No. 755

Sample No.	Depth ft	No. of Blows per 6 in.	Description	Consistency As Received	Consistency Remolded	Nat. Water Cont. %	Liquid Limit	Plastic Limit	Plast. Index	Water Plast. Ratio %
SPT-1	28.0 to 29.5	10-25-30	Reddish-brown clayey silt with some angular pebbles (glacial till).	hard & brittle	crumbly	9.6				
SPT-2	32.0 to 33.5	13-17-26	Similar to SPT-1.	hard & brittle	crumbly					
SPT-3	36.0 to 37.5	11-18-21	Similar to SPT-1.	hard & brittle	crumbly					

APPENDIX III

PHOTOGRAPHS OF REPRESENTATIVE
SAMPLE-SECTIONS OF LACUSTRINE
STRATUM

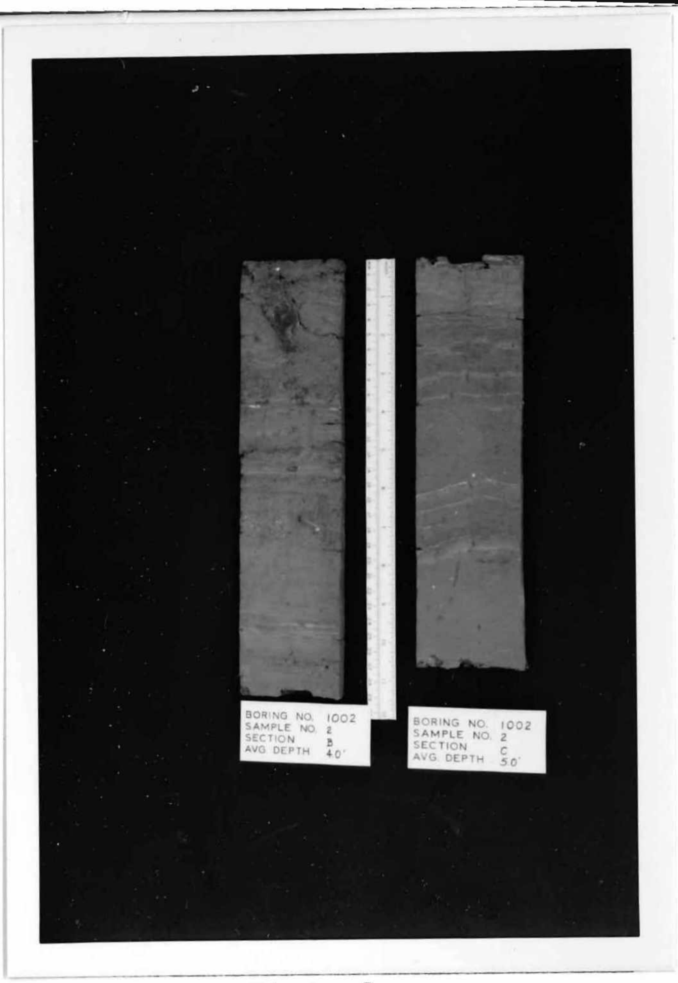


Photo 1

Photo 2

Photo 3

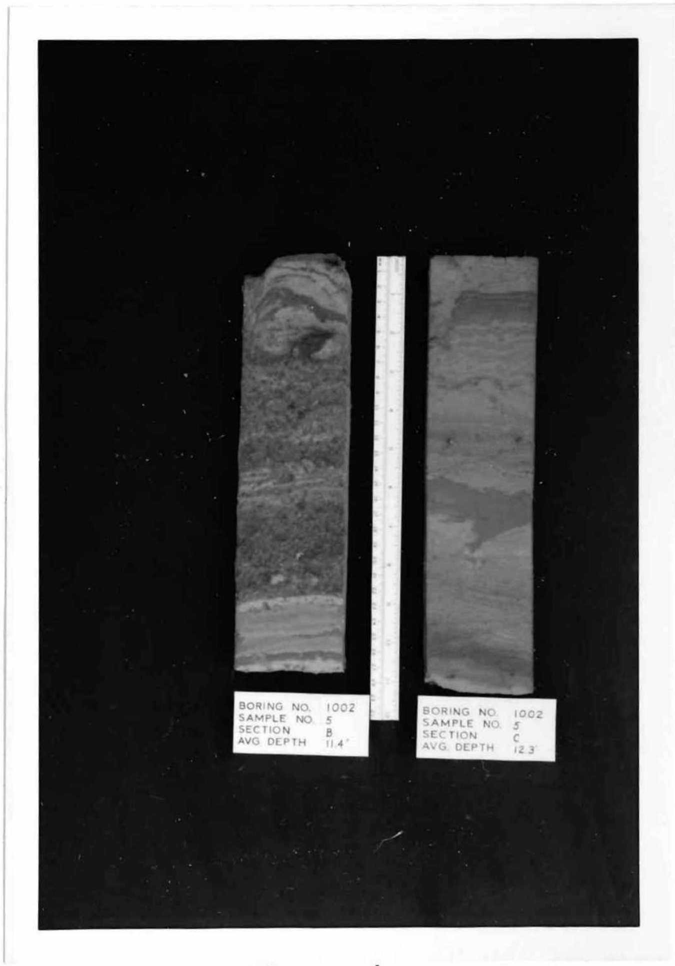


Photo 4

Photo 5

Photo 6

Photo 7

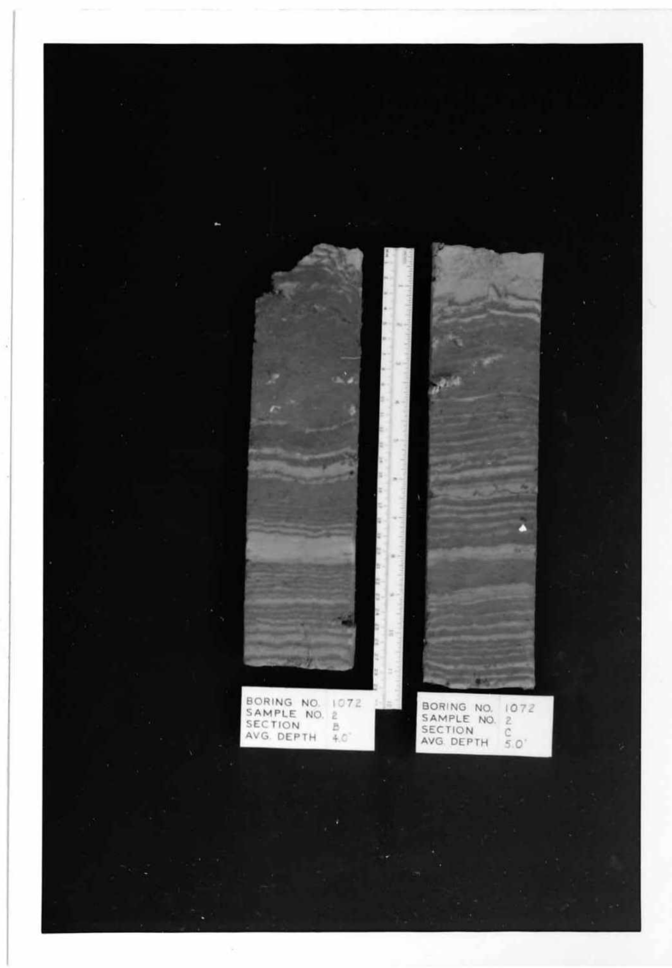
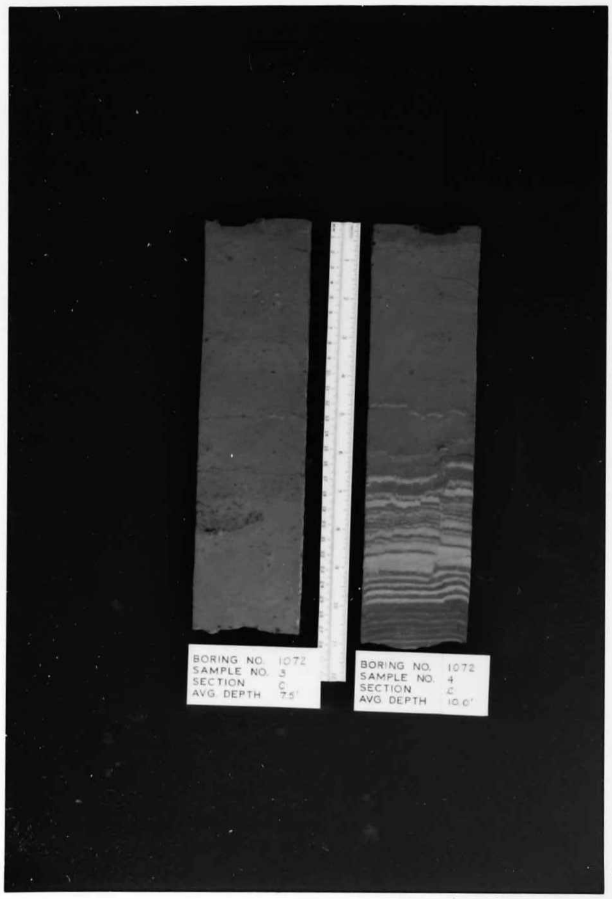


Photo 8



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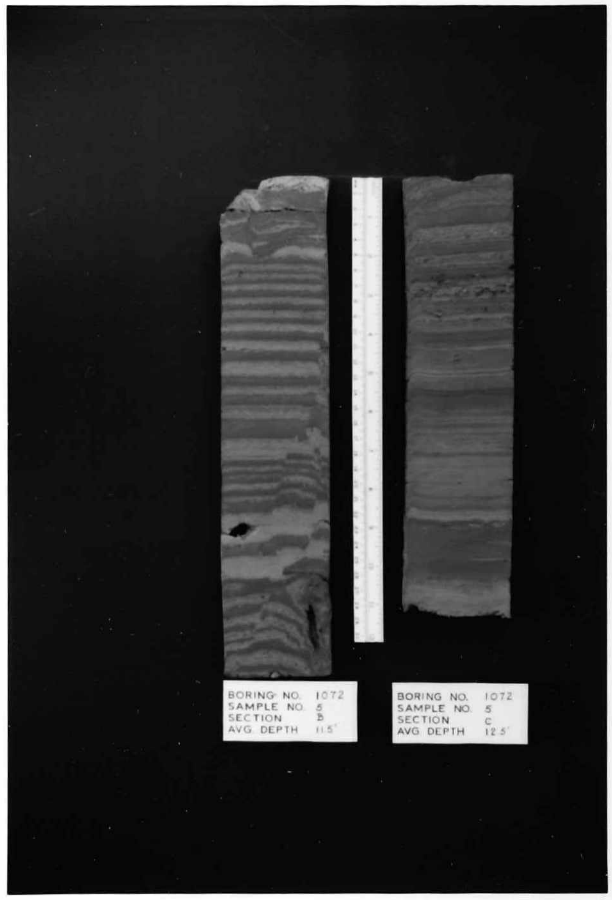

Photo 10

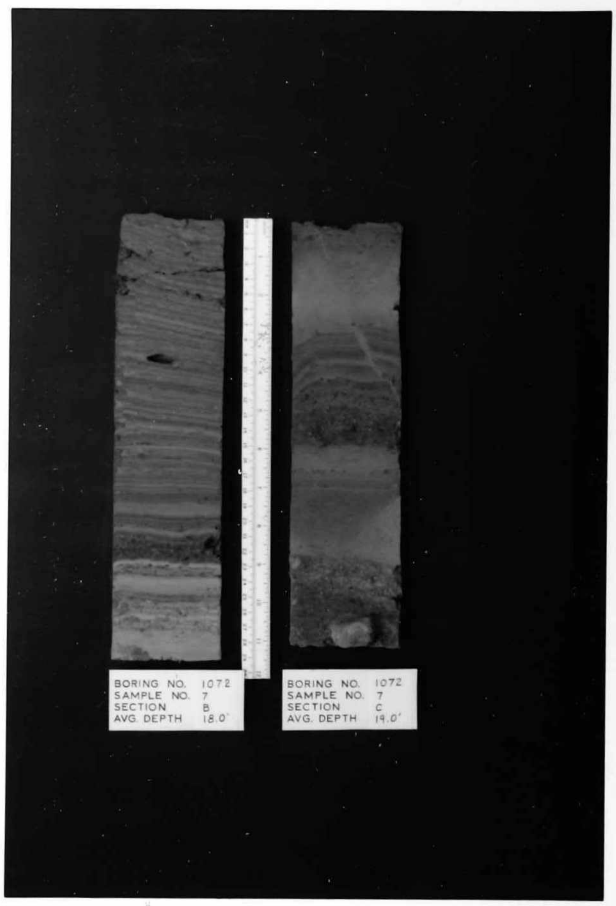

Photo 11

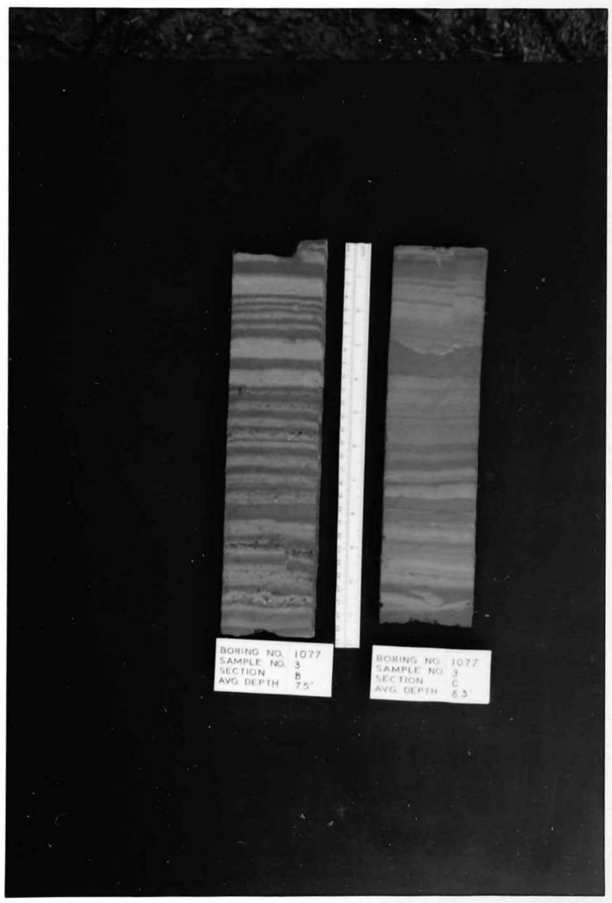

Photo 12

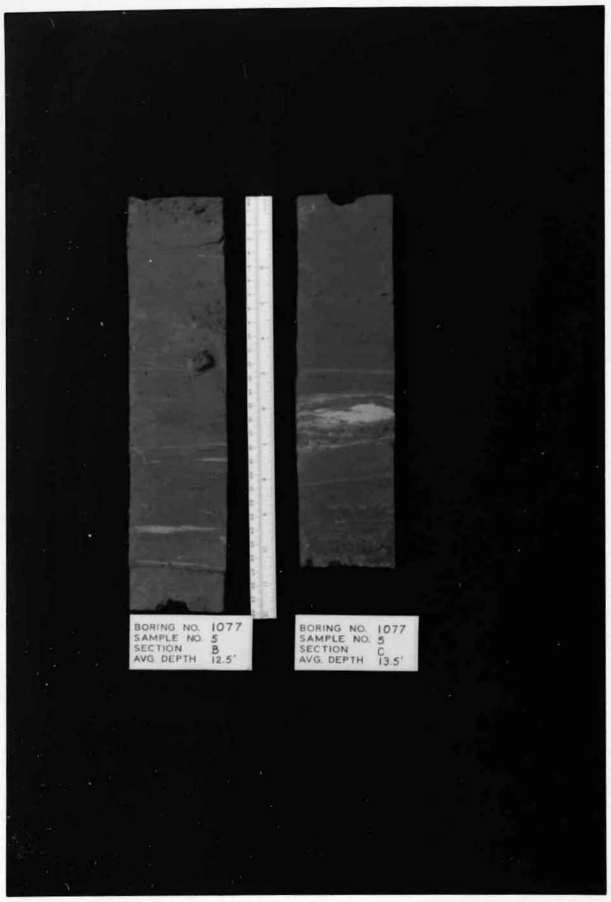

Photo 13

Photo 14

Photo 15

Photo 16

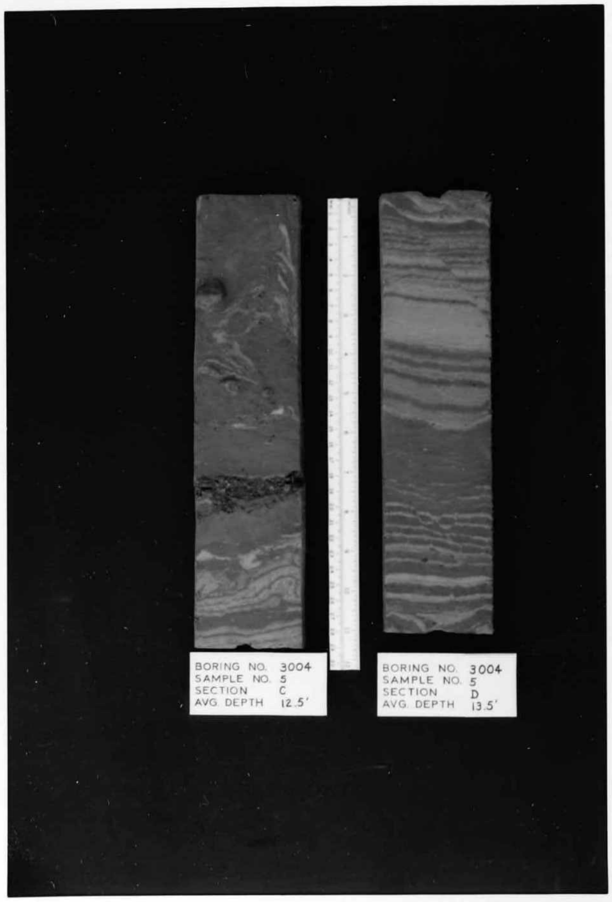

Photo 17

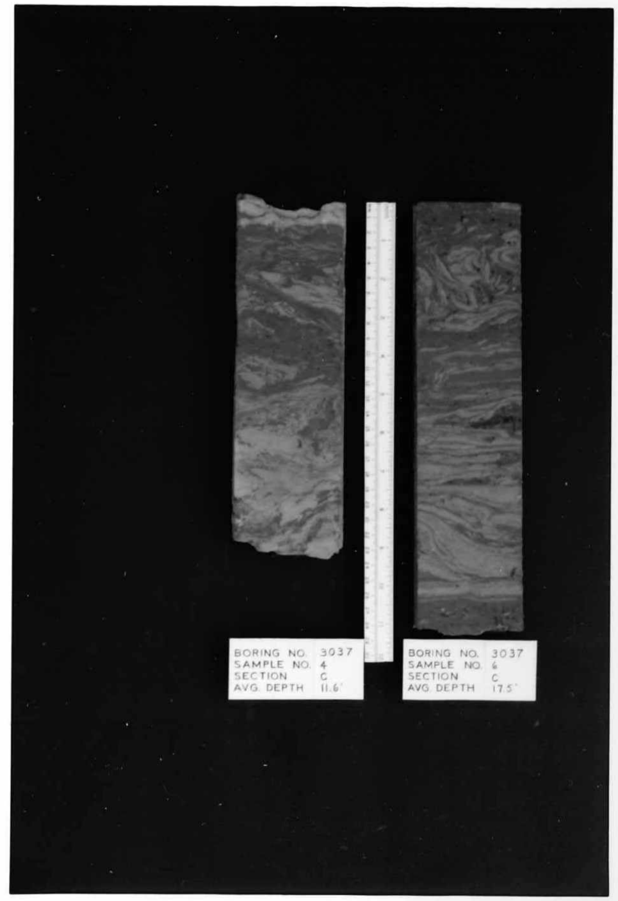

Photo 18

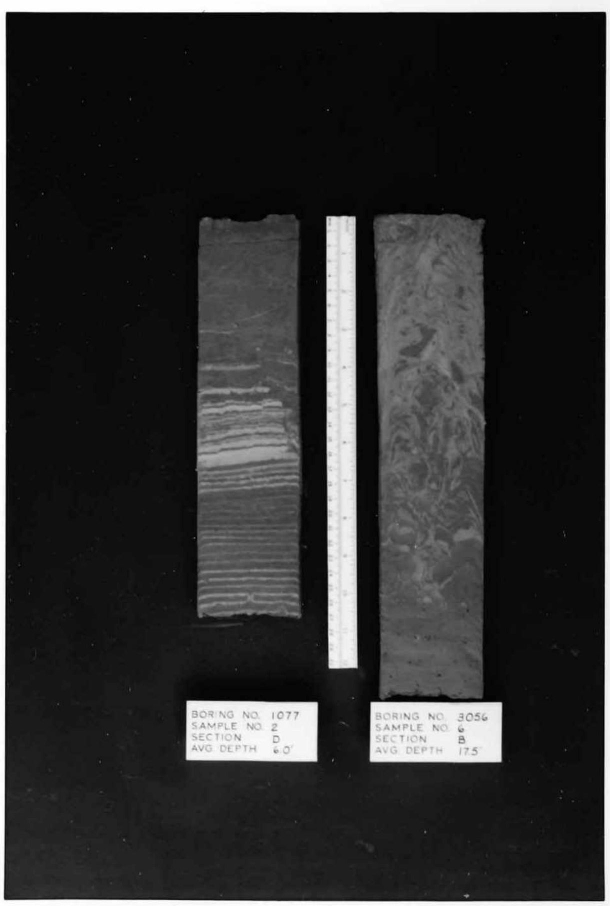

Photo 19

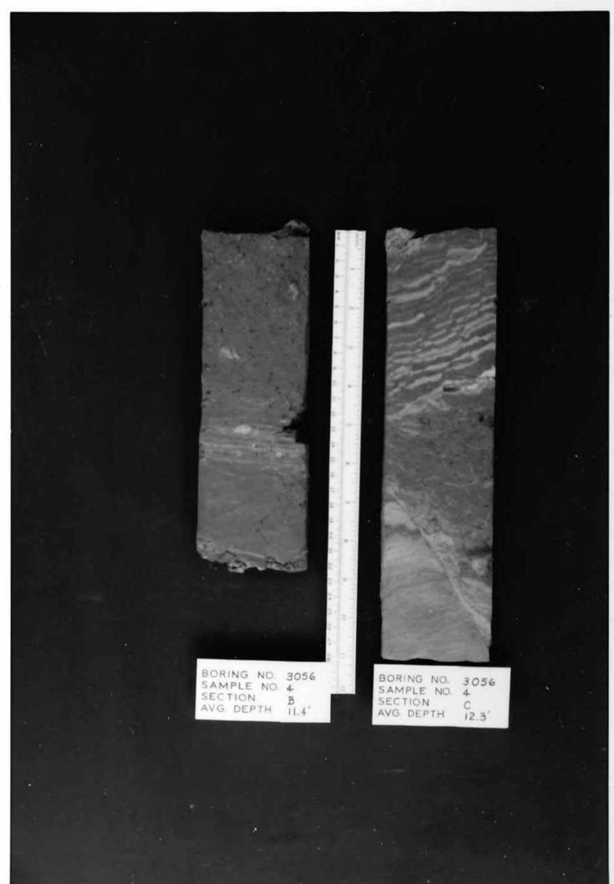

Photo 20

Photo 21

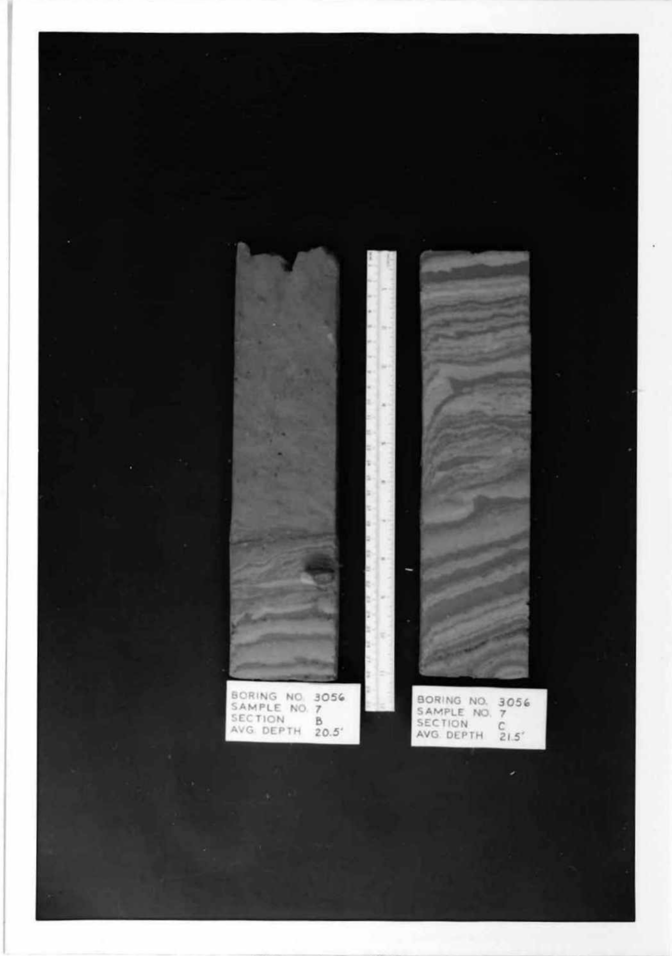

Photo 22

Photo 23

Photo 24

APPENDIX IV

LIST OF INFORMATION RECEIVED AND REVIEWED IN CONNECTION WITH THIS REPORT

List of Reports and Drawings

DESIGN REPORT, ON-LAND TAILINGS DISPOSAL STUDY, MILEPOST No. 7 SITE, APRIL 1975, by Klohn Leonoff Consultants Ltd.

FEASIBILITY REPORT, ON-LAND TAILINGS DISPOSAL STUDY, MILEPOST No. 7 SITE, by Klohn Leonoff Consultants Ltd.

FEASIBILITY REPORT, ON-LAND TAILINGS DISPOSAL STUDY, MILEPOST No. 7 SITE, APPENDIX A, VOLUME 1, by Klohn Leonoff Consultants Ltd.

FEASIBILITY REPORT, ON-LAND TAILINGS DISPOSAL STUDY, MILEPOST No. 7 SITE, APPENDIX A, VOLUME 2, by Klohn Leonoff Consultants Ltd.

MILE POST 7 ON-LAND TAILINGS DISPOSAL and AIR QUALITY PLAN, by Reserve Mining Company

CONSULTANT REPORTS ON MILE POST 7 SITE, by the Reserve Mining Company

PROGRESS REPORT, RESERVE MINING COMPANY, SILVER BAY, MINNESOTA: PERIOD ENDING MARCH 21, 1975, by Klohn Leonoff Consultants Ltd.

GENERAL GEOLOGY, MILE POST 7 SITE, January 1975, by Eugene A. Hickok and Associates

HYDROLOGICAL ANALYSIS, BEAVER RIVER WATERSHED, January 1975, by Eugene A. Hickok and Associates

Letter-Report by the Reserve Mining Company (signed by Mr. M. G. Woodle) to the State of Minnesota, dated March 7, 1975

Letter-Report by the Reserve Mining Company (signed by Mr. M. G. Woodle) to the State of Minnesota, dated February 1, 1975

ENVIRONMENTAL REPORT CONCERNING ON-LAND TAILINGS DISPOSAL AND AIR QUALITY PLAN FOR THE E. W. DAVIS WORKS, RESERVE MINING COMPANY, SILVER BAY, MINNESOTA, Volumes I, II, III, and Appendix, dated April 30, 1975, by Arthur D. Little, Inc.

EXECUTIVE SUMMARY of the Environmental Report, by Arthur D. Little, Inc.

GOVERNOR"S SITE INSPECTION TRIP, APRIL 1975, prepared by the State of Minnesota

TAILINGS DISPOSAL AND RESERVE MINING COMPANY, prepared by the State of Minnesota

FINAL DISPOSITION OF TAILINGS IN THE MILE POST 7 TAILINGS BASIN, FOR RESERVE MINING COMPANY, SILVER BAY, MINNESOTA, dated January 21, 1975, by Kaiser Engineers

RECLAMATION OF TAILINGS BASIN, dated January 21, 1975, by Reserve Mining Company

Letter from the Erie Mining Company to the Reserve Mining Company, dated January 21, 1975

Reserve Mining Company brochure titled "Mile Post 7 On-Land Tailings Disposal Plan"

Report by Reserve Mining Company titled MILE POST 7 ON-LAND TAILINGS DISPOSAL AND AIR QUALITY PLAN, revised May 26, 1975

Report by Reserve Mining Company titled ENVIRONMENTAL MONITORING PROGRAM, revised May 26, 1975

Report by Prof. Donald H. Gray titled PARTICLE SIZE ANALYSIS & RELATIVE DENSITY TESTS ON TACONITE TAILINGS FROM SILVER BAY, MINNESOTA, dated 9 May 1973

Report by Prof. Richard D. Woods titled FIELD DENSITY AND IOWA BORE HOLE SHEAR TESTS, dated May 10, 1973

Letter by Klohn Leonoff Consultants Ltd. to Reserve Mining Co., dated June 19, 1975, transmitting 29 grain size curves of Delta tailings samples

Report by Howard, Needles, Tammen & Bergendoff titled RED CLAY SETTLEMENT STUDIES, EMBANKMENTS AND STRUCTURES, 40th Avenue West to 27th Avenue West, Interstate Route 35, Duluth, Minnesota, dated May 27, 1964

Transcripts of first through fourth days of Hearings of the State of Minnesota vs Reserve Mining Co., held at Silver Bay, Minnesota, in June 1975, pages 229 to 840

Letter by W. A. Wahler & Associates to Morris M. Sherman, dated June 24, 1975, transmitting the field logs and location plans of recent borings

Letter by Michael Baker, Jr., Inc., to M. M. Sherman, dated June 30, 1975, transmitting field logs and location plans of recent borings

Letter by Michael Baker, Jr., Inc., to M. M. Sherman, dated July 3, 1975, transmitting Memoranda by John R. Rapp and by James V. Hamel on recent field observations and their implications on the proposed Milepost 7 project

"Note on Reserve Delta and Tailings Composition" by Dr. James R. Kramer, dated 17th July, 1975

Letter by W. A. Wahler & Associates to Morris M. Sherman, dated May 28, 1975, transmitting their compiled reference listing covering such subjects as shore protection facilities and health considerations of asbestos fibers

Letter by W. A. Wahler & Associates to Morris M. Sherman, dated July 3, 1975, transmitting ground surface elevations for the new borings

Letter report by Michael Baker, Jr., Inc., to Morris M. Sherman, dated May 30, 1975

Letter by the United States Department of Agriculture Soil Conservation Service to Rich Leonard, Oakdale, Minn., dated May 29, 1975, transmitting some strength values for "red clays"

PRELIMINARY OPEN FILE REPORT ON LAKE SUPERIOR RED CLAY, PROBLEM AND STUDY AREAS - MAY 1975, by Richard W. Leonard, Civil Engineer

WAVE ACTION AND BREAKWATER LOCATION, TACONITE HARBOR (Two Islands), LAKE SUPERIOR, MINNESOTA, Technical Memorandum No. 2-405, by the U.S. Army Corps of Engineers Waterways Experiment Station, Vicksburg, Miss., May 1955

Drawings (Reserve Mining Company):

Dr. No. 292-0003 "MILE POST No. 7 SITE TAILING DISPOSAL AREA: GENERAL PLAN"

Dr. No. 292-0022 "MILE POST No. 7 SITE TAILING DISPOSAL AREA: DAMSITE No. 1 TEST HOLE LOCATION PLAN"

Drawings (Reserve Mining Company):

Dr. No. 292-0023 "MILE POST No. 7 SITE TAILING DISPOSAL AREA: DAMSITE No. 2-3 TEST HOLE LOCATION PLAN"

Dr. No. 292-0026 "MILE POST No. 7 SITE TAILING DISPOSAL AREA: SCHEDULE, TAILING STORAGE STRUCTURE"

Dr. No. 292-0027 "MILE POST No. 7 SITE TAILING DISPOSAL AREA: VOLUMES-STORAGE, RESERVOIR"

Dr. No. 292-0030 "MILE POST No. 7 SITE TAILING DISPOSAL AREA: SUMMARY OF TEST DATA"

Dr. No. 292-0035 "MILE POST No. 7 SITE TAILING DISPOSAL AREA: DAMSITE No. 1 SUBSOIL PROFILE, SECTION A-A"

Dr. No. 292-0036 "MILE POST No. 7 SITE TAILING DISPOSAL AREA: DAMSITE No. 1 SUBSOIL PROFILE, SECTION B-B, C-C, D-D"

Dr. No. 292-0037 "MILE POST No. 7 SITE TAILING DISPOSAL AREA: DAMSITE No. 2-3 SUBSOIL PROFILE, SECTION A-A, B-B"

Dr. No. 292-0038 "MILE POST No. 7 SITE TAILING DISPOSAL AREA: DAMSITE No. 2-3 SUBSOIL PROFILE, SECTION C-C"

Dr. No. 292-0039 "MILE POST No. 7 SITE TAILING DISPOSAL AREA: BORROW PITS, LOCATIONS AND ESTIMATED VOLUMES"

Dr. No. 292-0041 "MILE POST No. 7 SITE TAILING DISPOSAL AREA: DAMSITE No. 1 - GENERAL ARRANGEMENT"

Drawings (Reserve Minging Company):

Dr. No. 292-0042 "MILE POST No. 7 SITE TAILING DISPOSAL AREA: DAMSITE No. 1 - STARTER DAM

Dr. No. 292-0044 "MILE POST No. 7 SITE TAILING DISPOSAL AREA: STARTER DAM - DAMSITE No. 1, SAND DRAIN DETAILS"

Dr. No. 292-0048 "MILE POST No. 7 SITE TAILING DISPOSAL AREA: TYPICAL SEEPAGE RECOVERY PUMP STATION"

Dr. No. 292-0050 "MILE POST No. 7 SITE TAILING DISPOSAL AREA: DAMSITE No. 2-3, GENERAL ARRANGEMENT"

Dr. No. 292-0060 "MILE POST No. 7 SITE TAILING DISPOSAL AREA: DAMSITE No. 4 - GENERAL ARRANGEMENT"

Dr. No. 292-0070 "MILE POST No. 7 SITE TAILING DISPOSAL AREA: DAMSITE No. 5 - GENERAL ARRANGEMENT"

Dr. No. 292-0081 "MILE POST No. 7 SITE TAILING DISPOSAL AREA: DIVERSION STRUCTURE No. 1"

Dr. No. 292-0083 "MILE POST No. 7 SITE TAILING DISPOSAL AREA: DIVERSION STRUCTURE No. 2"

Dr. No. 292-0090 "MILE POST No. 7 SITE TAILING DISPOSAL AREA: TAILING STORAGE, FINE AND COARSE TAILINGS"

Dr. No. 292-0092 "MILE POST No. 7 SITE TAILING DISPOSAL AREA: TAILING STORAGE, DETAIL EAST SIDE"

Dr. No. 294-0005 "MILE POST No. 7 DELTA STABILIZATION: SECTION FOR MODEL STUDIES

Drawings (Reserve Mining Company):

Dr. No. A-118 "LAKE CONTOURS DELTA AREA"

Dr. No. WA-73 "SILVER BAY AREA BATHYMETRY"

Composite Dr. (no number) "PROFILE-LAKE BOTTOM & TAILINGS FILL AREA SEPT. 5, 6 and 18, 1956"

Dr. No. 294-0001 "DELTA STABILIZATION: TEST HOLE NO'S. LOCATION & ELEVATIONS"

Sheet 27 - Topographic Map of Existing Delta

Dr. No. 22-0010-1 - "Delta Area Launder System, General Arrangement"

"MAP OF PRELIMINARY GEOLOGIC RECONNAISSANCE", prepared by Michael Baker, Jr., Inc., and W. A. Wahler & Associates, dated June 1975, with use of Reserve Mining Co. Dr. 292-0003