RESPONSE TO NRC QUESTIONS
RADWASTE MODIFICATION
OYSTER CREEK NUCLEAR POWER STATION

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B/100

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

1.0 INTRODUCTION

1.1 General

The results of a geotechnical study relating to proposed Radwaste and Off-Gas Buildings for the Oyster Creek Nuclear Power Station are presented in a report prepared by Woodward-Clyde Consultants (WCC), dated 4 February 1975. The study was based on the design assumption that foundation media of Seismic Category I structures (such as the proposed Radwaste Building) would have to be resistant to liquefaction during the Safe Shutdown Earthquake (SSE). At the Oyster Creek site, the SSE has a magnitude less than 5.0, and an associated peak ground surface acceleration of 0.22 g.

In order to complete their review of the WCC study, NRC requested answers to questions relating to the study outlined in the 4 February 1975 report. However, the current NRC staff position with regard to the seismic design requirements for the proposed Radwaste Building, is that the foundation media shall not liquefy during the Operating Basis Earthquake (OBE). The OBE would produce a peak ground surface acceleration of 0.11 g; i.e., one-half of that of the SSE.

The results of detailed response analyses are presented in the 4 February 1975 report. These analyses are based on a peak ground surface acceleration twice that associated with the OBE. For the depth range of interest at the Oyster Creek site, the shear stresses produced by ground motions may be considered to be approximately proportional to ground surface acceleration. Based on this premise, the shear stresses induced by the OBE were taken to be one-half those determined in the response analyses made previously for the SSE.

Evaluating liquefaction potential based on a peak ground surface acceleration of 0.11 g required changes in the figures and tables presented in our report of 4 February 1975. These changes are described below.

1.2 Evaluation of Liquefaction Potential During OBE Based on Simplified Procedure Using Relative Density Data

The method of analysis is the same as described in Section 1.10.3.1 (p. 43) of the 4 February 1975 report, except for the following changes as compatible with current NRC position:

1. A peak ground surface acceleration of 0.11 g was used (compared to 0.22 g used originally). An average grain size of 0.25 mm was used in the new analysis for both the conservative and the less conservative approaches (compared to 0.1 mm and 0.9 mm, respectively, in the 4 February 1975 report).

2. Strength at 10 cycles was used (compared to strength at 5 cycles, as used in the 4 February 1975 report). The choice of 10 cycles is compatible with the acceleration ratio (a_{ave}/a_{max}) of 0.65 used in the simplified procedure (Seed and Idriss, 1971).

3. A constant correction factor C_r of 0.57 was used, regardless of the relative density.

The results of calculations based on the modifications referred to above, are shown in Fig. 1.10.2A, wherein relative densities determined in laboratory tests on undisturbed samples are plotted versus depth, along with curves defining zones of different liquefaction potential; refer to Section 1.10.3.1 of the 4 February 1975 report for discussion of the significance of the three zones indicated. The plot includes data from both the proposed Radwaste and Off-Gas Building sites. It should be noted that all of the data points plot in Zone III (liquefaction unlikely).

1.3 Evaluation of Liquefaction Potential During OBE Based on Simplified Procedure Using N-Value Data

The relative density versus depth curves defining the three zones of different liquefaction potential shown in Fig. 1.10.2A were converted to N-value versus depth relationships, by means of correlations developed by Gibbs and Holtz (1957), as reported by Seed and Idriss (1971). The results of these calculations are shown in Fig. 1.10.3A, together with N-values measured during the 1973 exploration program, along with N-values measured in the exploration programs of 1964 and 1968. This plot includes N-values associated with the proposed Off-Gas site. All of the N-values plot in Zone III (liquefaction unlikely).

1.4 Overall Evaluation of Liquefaction Potential During OBE Based on Simplified Procedure

As evident from the data plotted in Fig. 1.10.2A and Fig. 1.10.3A using the simplified procedure, all measured relative densities and N-values fall in Zone III, indicating liquefaction of the Cape May, Cohansey Formation and sand inclusions in the Upper Clay Layer to be unlikely during the OBE.

1.5 Evaluation of Liquefaction Potential During OBE of Upper Portion of Cohansey Formation Based on Response Analyses and Laboratory Cyclic Tests

The approach that was used for the OBE was similar to that described in the 4 February 1975 report for the SSE, except for the following changes as compatible with the current NRC staff position:

1. The peak shear stresses summarized in Table 1.10.2 of the 4 February 1975 report were divided by 2.0 to obtain shear stresses compatible with a peak ground surface acceleration of 0.11 g. The peak shear stresses associated with the OBE are summarized in Table 1.10.2A. The computed equivalent uniform shear stress amplitudes (associated with the OBE) are summarized in Table 1.10.3A.

2. A correction factor $C_r = 0.57$ was used (compared to the value 0.66 referred to in the 4 February 1975 report).

The calculated safety factors against liquefaction during the OBE are summarized in Table 1.10.6A and Fig. 1.10.5A.

1.6 Conclusions With Regard to the Liquefaction Potential of Upper Portion of Cohansey Formation Based on Response Analyses and Laboratory Cyclic Tests

As shown by Table 1.10.6A and Fig. 1.10.5A, the factors of safety against both initial liquefaction and the development of ±10% average strain are high. This indicates that the sand deposits underlying the Oyster Creek site are non-liquefiable with respect to the OBE, a conclusion compatible with that based on the qualitative analyses using the "simplified procedure".

2.0 RESPONSE TO QUESTIONS RAISED BY NRC

2.1 General

In Enclosure 1 of a letter by Mr. George Lear, Chief, Operating Reactors Branch #3, of Division of Reactor Licensing of NRC to Jersey Central Power & Light Company, dated 14 August 1975, a series of questions are raised related to the WCC report entitled "Geotechnical Study, Proposed Radwaste and Off-Gas Buildings, Oyster Creek Nuclear Power Station", dated 4 February 1975. In Enclosure 2 of that same letter, it is stated that "the foundation media of structures housing the radwaste systems should not liquefy during the Operating Basis Earthquake". The evaluations of liquefaction described in the WCC report of 4 February 1975 assumed a peak ground surface acceleration of 0.22 g, which corresponds to the SSE, as opposed to the current criterion of 0.11 g, which corresponds to the Operating Basis Earthquake (OBE).

In responding to the series of questions raised by NRC, we have reevaluated the liquefaction potential of the foundation media at the site of the proposed Radwaste Building, using a peak ground surface acceleration of 0.11 g; refer to

Section 1.0 of this report. The responses to the NRC questions are based, in part, on this reevaluation.

Unless a figure or table number, which is not in the "324 series", is followed by the letter "A", the figure or table is in the WCC report dated 4 February 1975; the letter "A" pertains to figures or tables resulting from the reevaluation of liquefaction potential using the operating basis earthquake as described in Section 1.0 of this report.

2.2 Responses to Questions

Question 324.1

(a) "You have not adequately sampled and evaluated the natural deposits directly below the proposed radwaste building. Thirteen borings are shown on Fig. 1.3.1 at this location. Only twc borings (W1 and W4) of 13 completely sampled the entire subsurface materials of interest in a meaningful way."

Response

The scope of the exploration program at the Oyster Creek site is described in Section 1.7 of the report, dated 4 February 1975. The program consisted of 13 borings made during November and December 1973, and in early 1974, and nine borings made in October 1974. The latter borings were made to "expand the data bank", a suggestion which was made by the NRC staff during an informal meeting on 15 August 1974. At that meeting, it was pointed out by members of the NRC staff that relatively few borings had been made within the proposed building area (W1, W4, and W11). The suggestion was made that more information was needed concerning the details of stratigraphy of the Upper Clay Layer, and that more samples be obtained for cyclic testing. No indication was given, at that time, that the number of standard penetration test (SPT) results was deficient, or that that type of test be emphasized in the evaluation of the ground stability of the site. Although we believe that the SPT can provide useful input to a liquefaction evaluation, we also believe that the properties (relative density and cyclic undrained shear strength) of undisturbed samples provide a more detailed basis to evaluate the liquefaction potential. Liquefaction assessment based on N-values is very useful in a preliminary evaluation of liquefaction potential. However, in planning our exploration program, primary emphasis was given to obtaining undisturbed samples, with secondary emphasis being given to SPT.

Expansion of the data bank required that undisturbed samples be obtained to: (a) assess the in-situ relative density of the site soils; (b) perform additional laboratory cyclic strength tests; and (c) assess the continuity of sand inclusions in the Upper Clay Layer. The three borings that had been made within the building area, as well as those made outside of that area, consistently exhibited high SPT values in the Cape May Formation, clearly demonstrating (as discussed in the 4 February 1975 report) the non-liquefiability of that deposit for the postulated earthquake. Consequently, no additional information on the Cape May Formation was considered necessary, and no samples were taken in that deposit during the October 1974 boring program; the borings were drilled through the Cape May Formation in order to expedite the exploration program. Virtually continuous undisturbed samples were taken in the Upper Clay Layer in all of the borings made in October 1974. In all but two of those borings (W16 and W17), undisturbed samples were taken down to the very dense portion of the Cohansey Formation, the denseness of which was confirmed by means of an SPT. The undisturbed sampling frequency was high, with the distance between sampling operations being only 1 ft to 2 ft. It is our opinion that a distance between undisturbed samples of less than 1 ft might contribute to sample disturbance.

The borings made in October 1974 were not extended much below a depth of 50 ft, since the results of previous borings clearly showed that there is a marked increase in the relative density of the Cohansey Formation below that depth, confirming the adequacy (but not necessarily the necessity) of founding Seismic Category I structures at, or below, that level.

In summary, a very detailed boring program was carried out within the site of the proposed Radwaste Building; furthermore, the borings that were made outside of that site penetrate deposits that have the same depositional history as those underlying the proposed building site, and provide data that can be used to evaluate site subsurface conditions. We acknowledge that relatively few SPT were made in the upper portion of the Cohansey Formation in borings located within the site of the proposed Radwaste Building, but we believe that this is more than offset by the 14 direct relative density determinations made in the laboratory on undisturbed samples from borings made within the proposed building area, and the 32 such measurements on undisturbed samples from borings in close proximity to the proposed building site. It is our opinion that the SPT provides useful data which can be used in evaluations of in-situ relative density and in liquefaction analyses. However, conversion of the results of SPT to relative density requires the use of a correlation (e.g., that proposed by Gibbs and Holtz) which necessarily has its own errors and uncertainties. It is our opinion that direct determination of relative density from laboratory tests on undisturbed samples is a more reliable approach than indirect determination from SPT results.

(b) "You have almost ignored the use of the standard penetration test (SPT) sampler in your investigation of the subsurface conditions immediately under the proposed site. Much of the data presented to evaluate liquefaction conditions are based on SPT data."

Response

We agree that much of the data presented to interpret liquefaction case histories was obtained by means of the SPT. However, as indicated in our response to the previous question, we believe that the properties (relative density and cyclic undrained shear strength) of undisturbed samples provide a more reliable basis to judge liquefaction potential than does evaluation based on N-values. This opinion appears to be consistent with the current position of NRC; refer to NRC Standard Review Plan, Subsection 2.5.4.8, dated June 1975.

The state-of-the-art concerning evaluation of liquefaction potential has advanced considerably since the earlier studies were made, which were based solely on SPT results. Major steps in this advance have been the development of cyclic laboratory test procedures to evaluate liquefaction resistance, and more recently, the recognition of the importance of using undisturbed samples in those laboratory tests.

On the other hand, we acknowledge that the SPT can provide useful input to a liquefaction evaluation. In line with this, the use of the SPT was not "almost ignored". This is evidenced by the fact that all the available data were used in the qualitative evaluation of liquefaction potential; refer to Section 1.10.3 of our report. As indicated previously, we believe that the information obtained in borings outside the proposed building area can be used to evaluate conditions below point falls within Zone II, and that is very close to the boundary of Zones II and III; refer to Fig. 324.1.1. Furthermore, as indicated previously, we believe that data obtained from borings made outside the plan limits of the proposed building should also be included in the liquefaction evaluation, since the geologic histories of the deposits, both within and outside of the proposed building limits, are the same. We say this despite the fact that most of the less favorable SPT data were obtained in borings located outside of the proposed building limits. Considering all the data, only few data points were plotted in Zone II where liquefaction can be considered as possible; refer to Fig. 324.1.2. At the time we were making our evaluation of liquefaction potential during the SSE, we interpreted the data plotted in Fig. 324.1.2 to indicate that a more detailed analysis was required and, therefore, we made a quantitative evaluation of liquefaction potential of the upper portion of the Cohansey Formation based on stresses determined in a response analyses and strength based on cyclic triaxial tests involving undisturbed samples.

In addition to the above line of reasoning, an evaluation of liquefaction case histories demonstrates that the upper portion of the Cohansey Formation would not liquefy during either the SSE or the OBE. The upper portion of the Cohansey Formation at the proposed Radwaste Building site has an average N-value of 22 bl/ft. The SSE has a magnitude less than 5.0 and a peak ground surface acceleration of 0.22 g. Case histories referred to by Castro (1975) have been reevaluated by Yegian and Oweis (1975), taking magnitude into account. Magnitude is an important consideration in the evaluation, since most of the earthquakes referred to by Castro (1975) have large magnitudes; i.e., 7.0, or greater. The reevaluation of these earthquake data, as applied to the Oyster Creek site and SSE, is illustrated in Fig. 324.1.3. This figure clearly demonstrates that, even for the SSE, an N-value of 22 bl/ft would be more than sufficient to preclude lique-faction; it follows that the same conclusion is drawn for the OBE. These conclusions are compatible with those drawn in our report of 4 February 1975; namely, that both qualitative and quantitative liquefaction evaluations indicate that the Cohansey Formation is non-liquefiable relative to the SSE, and, therefore, non-liquefiable relative to the OBE.

The procedure suggested by Yegian and Oweis is similar to a suggestion made by Whitman (1971). In interpreting earth-quake data, Whitman normalized the shear stresses to a standard 20 cycles employing the strength relationship by Lee and Seed (1967) for 20% double-amplitude strain. For example, the Alaskan earthquake of 1964 was estimated to have 120 significant cycles. To convert to an equivalent earthquake of 20 cycles, the shear stresses causing failure will be approximately 50% greater than those corresponding to 120 cycles.

A copy of the Yegian and Oweis (1975) reference is included in Appendix 324.A.

respect to liquefaction, was adequately developed. This is apparent when reading the PSAR, wherein liquefaction is not a major consideration. Based on the results of liquefaction studies for the Radwaste Building, it is possible that much shallower foundations would be possible for the structures referred to in the question.

Question 324.2

"You have not provided sufficient evidence to support your conclusions regarding the previous loading of the clay in the upper clay formation. Only one consolidation test is provided for materials under the Radwaste Building. Provide additional data to support your evaluation of previous loadings."

Response

Three consolidation tests were made on specimens of the Upper Clay Layer, two from within, or near, the site of the proposed Radwaste Building, and one from the site of the proposed Off-Gas Building. The preconsolidation pressures and overconsolidation ratios (OCR), along with various index properties (initial water content, liquid and plastic limits and liquidity index) are presented for these three specimens in Table 324.2.1. Although the samples involved were taken at three different locations within the same geologic deposit, the test data are quite similar. In each case, the preconsolidation pressure is 10 ton/ft^2, or greater (range 10 ton/ft^2 to 12 ton/ft^2)

with the liquidity index ranging between 0.08 and 0.23. Both the very high preconsolidation pressure and very low liquidity index are indicative of a highly overconsolidated soil. This is further evidenced by the values of OCR presented in Table 324.2.1; the values range between 8 and 10. The sample taken from within the proposed building area (boring W4, Sample U3C) had a preconsolidation pressure (11 ton/ft^2), liquidity index (0.18) and OCR (8), all of which are representative of the characteristics of the three specimens of the Upper Clay Layer on which consolidation tests were run. This is further demonstrated by the similarity of the consolidation curves plotted in Fig. 324.2.1.

The heavily overconsolidated character of the Upper Clay Layer is further demonstrated by the liquidity indices of the 15 specimens for which such determinations were made; see Table 324.2.2. The liquidity index is typically less than 0.4, indicating a heavily overconsolidated clay. The contention that the Upper Clay Layer is heavily overconsolidated is further supported by the ratio of undrained shear strength to vertical consolidation pressure ($s_u/\bar{\sigma}_v$) for the Upper Clay Layer. In cases where clay is normally loaded, the ratio $s_u/\bar{\sigma}_v$ is given reasonably well by the following empirical relationship (Bjerrum and Simons, 1960):

$$s_u/\bar{\sigma}_v = 0.10 + 0.004\ I_p\ ;$$

where I_p is the plasticity index expressed in percent.

The samples listed in Table 324.2.2 have plasticity indices that are typically less than 45%. Using a plasticity index of 45%, the above relationship yields a ratio $s_u/\bar{\sigma}_v$ of 0.28. This suggests that ratios of $s_u/\bar{\sigma}_v$ much in excess of 0.3 indicate heavily overconsolidated clays. The ratio is summarized in Table 324.2.3 for 14 samples of the Upper Clay Layer for which undrained shear strength was determined and the actual value of $S_u/\bar{\sigma}_v$ could be calculated.

Examination of the data in Table 324.2.3 reveals that all values of the ratio are 0.5, or more, with values typically 0.7, or greater, indicating heavily overconsolidated clay.

We conclude that the Upper Clay Layer is heavily overconsolidated. The results of the three consolidation tests performed on samples of the layer are very similar even though they were obtained at different locations. These test results provide sufficient data to evaluate the compressibility of the Upper Clay Layer, including the portion that underlies the site of the proposed Radwaste Building.

<u>Question 324.3</u>

> "The clays are described as organic deposits. Organic soils are generally poor foundation materials. Evaluate secondary compression which can be very large for organic soils. Discuss the results of your evaluation."

Response

The view expressed in Question 324.3 is certainly valid for normally consolidated soils. However, organic clays, when heavily overconsolidated, as are both the Upper and Lower Clay Layers, are relatively incompressible and have small rates of secondary compression. The coefficient of secondary compression ($C\alpha$) of the Upper Clay Layer determined in the laboratory tests varied from 5.5×10^{-4} in./in./log cycle of time to 7.3×10^{-4} in./in./log cycle of time within the range of stress levels of interest; the corresponding value determined for the Lower Clay Layer was 3.3×10^{-4} in./in./log cycle of time. However, because of its considerable depth and high degree of overconsolidation, the Lower Clay Layer would contribute very little to the settlement of the Radwaste Building.

Taking an average thickness of the Upper Clay Layer to be 15 ft, and assuming $C\alpha = 7 \times 10^{-4}$ in./in./log cycle of time, we calculate the secondary compression of that layer to be 0.126 in./log cycle of time. We estimate that primary consolidation of the Upper Clay Layer will take about one year. Consequently, we estimate that secondary compression will contribute about 1/8 in. to total settlement between the first and tenth year and about 1/4 in. between the first and 100th year. Our estimate of the total settlement of the Radwaste Building indicated values between 2-1/2 in. and 4 in. Consequently, settlement due to secondary compression of this heavily overconsolidated soil would be but a small fraction of the total amount.

Question 324.4

"The data provided regarding the continuity of the deposits of the sand included in the upper clay is not sufficient. Provide cross-sections to show the sand strata in the upper clay. The boring logs do not contain a detailed description terminology required to assess the continuity of these strata. Provide detailed stratigraphic information to support your conclusions that these strata are not continuous."

Response

Cross-sections on which detailed stratigraphy is indicated for each boring are presented in Appendix 324-B. As concluded in Section 1.5.2.6.2 of the 4 February 1975 report, the sand deposited in the Upper Clay Layer is typically in the form of lenses and inclusions. In Section 1.10.3.1.2 of the same report it is concluded that such inclusions are non-liquefiable under the SSE and would therefore be non-liquefiable under the OBE.

Question 324.5

"Provide copies of boring logs and reports for the proposed Oyster Creek Unit No. 2. Also provide copies of the Casagrande report for this site."

Response

Copies of both the logs and the Casagrande reports are presented in Appendix 324-C.

Question 324.6

"Based on the boring logs presented we cannot assess the depth of the fill encountered. Document your evaluation of the depth of the fill encountered and discuss the methods employed."

Response

The distinction between the fill and underlying naturally deposited soil was made based on field and laboratory examination of the spoon samples recovered. The fill is a reworked material with no identifiable structure and is generally mottled in color. Occasionally, pieces of wood were encountered in the fill. In most cases, the underlying natural soil was of the Cape May Formation, which has a more identificable structure and colors which are banded or are uniform. In two cases (W2 and W5), the underlying natural soil was the Upper Clay Layer; the latter is readily identifiable. In three cases (W3, W4 and OW1), no fill was encountered.

Question 324.7

"The data in Table 1.8.2 does not support your statement that the undrained shear strength (s_u), indicated values of s_u between 1 and 2 tsf. The average triaxial shear and vane shear strength is less than 1 tsf. Explain."

Response

The range given in the report is correct if all of the strength data are considered, including that determined by the 63 Torvane tests and the 62 pocket penetrometer tests.

Question 324.8

"Discuss the possibility of the groundwater level increasing during the life of the plant, and the effect on the liquefaction potential."

Response

The Oyster Creek Nuclear Power Station is underlain by two aquifers. These are the Cape May aquifer and the underlying Cohansey aquifer. The Cape May is a water table aquifer while the Cohansey is a confined (or artesian) aquifer.

The plant site is bordered on two sides by tidal rivers and on a third side by Barnegat Bay. The Cape May is hydraulically connected to these waters, and its water level is, therefore, in part, controlled by sea level. At the plant site, this formation is directly recharged by rainfall, and large rainfalls can cause short duration increases in water level (approximately a 2 in. rise in water level for each inch of rainfall, assuming a 50% recharge (Hardt and Hilton, 1969) and a 25% porosity). However, due to the plant site's proximity to tidal water, excess water in the Cape May will rapidly discharge to these tidal water bodies. Unless there is a change in sea level relative to the Cape May aquifer, it is not likely that there will be any long-term increases in the water level of the Cape May.

The main recharge area for the Cohansey is to the northwest of the plant site in the Pine Barrens. The USGS has an observation well in Whiting, New Jersey, approximately 10 miles from the plant site, which is completed in the Cohansey. Continuous water level records have been obtained from this well since 1952 (see Fig. 342.8.1). Between 1952 and 1972 inclusive (21 years of record), the total water level fluctuation was 8.75 ft, and the maximum 1972 water level was only 0.63 ft less than the maximum level recorded in that well. Another USGS observation well, located near the Garden State Parkway, is approximately two to three miles from the plant site. Water levels have been measured sporadically in this well since 1967 (see Fig. 324.8.1). Between 1967 and 1973 inclusive, fluctuation was 2.22 ft (compared with 4.22 ft for the Whiting Well for the same period) and the maximum water level for the period was recorded in 1972. The maximum water level for 1973 was only 0.42 ft less than that for 1972. The rainfall for 1972 was approximately 15 in. above the mean (see Fig. 324.8.1), while the rainfall for 1973 was less than that for 1972, but still well above average. Piezometer P1, which was installed in 1973, has, during a period of over one year, fluctuated very little (about 1 ft; ie, between el 6 ft and el 7 ft). The records of the two USGS observation wells indicate that the maximum piezometric level in the Cohansey Formation in 1973 was within about 1 ft of the maximum level recorded since 1952. The rainfall records suggest that the 1972 piezometric level is probably within about 1 ft of the maximum level since 1952.

Based on the above data, which are illustrated in Fig. 324.8.1, we conclude that water levels in the Cape May and Cohansey Formations are not likely to rise above el 13 ft and el 8 ft, respectively, during the life of the proposed Radwaste Building. The effect on liquefaction potential would be minimal. If one conservatively assumes the piezometric level in the Cohansey Formation would rise to the same level as the Cape May Formation (say to el 13), then the factors of safety against liquefaction summarized in Table 1.10.6A and Fig. 1.10.5A would be reduced by 8% to 10%. The resulting factors of safety would still be very high, and quite satisfactory.

Question 324.9

> "Describe the backfill procedure used to place the fill near boring W2, W5, and W9. Explain the reason for the extremely loose condition of the fill."

Response

The area near borings W2, W5, and W9 is remote from the original Oyster Creek Unit 1 structures and as such backfill was required by applicable specification to provide for a plant yard area backfilled and smooth graded but without specific density requirements.

Question 324.10

"Your evaluation of the significant number of cycles in the liquefaction analysis is not consistent with Lee and Chan data for a_{ave}/a_{max} equal 0.65. A number of 10 appears more reasonable for the simplified procedure. This higher value will result in an increase in the likelihood of liquefaction for each strata. Evaluate and compare the results based on 5 and 10 cycles. Duplicate the appropriate figures in the report at 10 equivalent stress cycles. Use a C_r value of 0.57 in all calculations and report the results."

Response

As explained in Section 1.2, a qualitative evaluation of liquefaction potential during the OBE was made using the simplified procedure (Seed and Idriss, 1971) based on 10 cycles and C_r value of 0.57. The results are summarized in Fig. 1.10.2A and 1.10.3A. An evaluation based on five cycles was used in our report, dated 4 February 1975, and was somewhat less conservative. However, the laboratory (uncorrected) cyclic stress ratio for 10 cycles is 0.246 for a relative density of 50% (Seed and Idriss, 1971) based on an average grain size D_{50} = 0.25 mm. The corresponding value for five cycles is approximately 0.27; the degree of conservatism involved is quite small. The figures (Fig. 1.10.2A and 1.10.3A), however, are based on 10 cycles and C_r = 0.57 as requested.

Question 324.11

"Less than half of the relative density test data is representative of the Radwaste Building location. Discuss the justification for using any data other than that obtained at this location. Provide a correlation with SPT data and relative density data."

Response

Relative density data from borings W3, W9, and W10A were used in evaluating the liquefaction potential at the site. These borings are located 50 ft to 120 ft from the proposed Radwaste Building location. The relative density measurements from those borings, together with data from the borings located within the proposed building area, are presented in Fig. 1.10.2 of our report and also Fig. 1.10.2A presented here; it should be recognized that these values are based on direct determination of the relative density in the laboratory using undisturbed samples.

Examination of Table 1.8.3 of the report dated 4 February 1975 reveals that there were six relative density measurements involving undisturbed samples which are less than 60%. Five of these values are associated with borings outside the building area (W2, W3, W9, and W10A). It is our opinion that, in evaluating liquefaction potential, not considering data from borings W2, W3, W9, and W10A would be imprudent and unconservative, since the soil strata underlying those boring locations (which are relatively close to the location of the proposed Radwaste Building) have the same geologic histories and involved the same depositional processes as the corresponding strata underlying the proposed building area.

A correlation between the SPT data and relative density data (obtained from laboratory tests on undisturbed samples) is given in Fig. 324.11.1. This plot indicates that both sources of relative density data have similar distributions of values.

Question 324.12

> "Recalculate the uniform shear stress amplitude given in Table 1.10.3 using five cycles for conversion (p. 52) and report the results."

Response

The uniform shear stress amplitudes given in Table 1.10.3 of our report have been recalculated using five cycles for conversion. As explained in Section 1.0, the shear stresses were reduced to be compatible with the current NRC position with regard to the design earthquake. This position resulted in assigning 0.11 g for the peak ground surface acceleration instead of the 0.22 g used in the 4 February 1975 report. The results of the recalculation are presented in Table 324.12.1.

Question 324.13

> "Provide the pore pressure, stress, strain, and the number of cycles data in graphic format for the cyclic tests used in this evaluation. Provide the factor of safety against 10% double amplitude strain."

Response

The factors of safety (best estimate and lower bound) against 10% double amplitude (±5% average) strain were calculated in accordance with the procedures outlined in our report, but using induced shear stresses based on a peak ground surface acceleration of 0.11 g (instead of the 0.22 g used in our report, dated 4 February 1975) and also using a C_r value of 0.57 instead of 0.66. These results are presented in Table 324.13.1. The best estimate refers to the average strength value, while the lower bound is based on the average strength minus one standard deviation.

Graphical presentations of the results of the cyclic strength tests are given in Appendix D.

Question 324.14

(a) "Designate a maximum, total, and differential settlement criterion for this structure."

Response

Settlement criteria have been established as follows, based on a design check for anticipated settlement:

a. Maximum total settlement - 3-1/2 inches

b. Maximum differential settlement - 1-1/2 inches.

In establishing these criteria, the foundation mat was modeled as a plate on elastic springs with wall stiffness considered.

The soil was modeled to 700 ft, in diameter and 1000 ft, in depth to achieve good boundary conditions for both upper bound and lower bound soil module. A realistic load distribution from the super structure and equipment was established. The computer program stardyne was used to perform the calculations.

It should be noted that previously identified estimates of maximum total and differential settlement had been made assuming uniform load distribution and without considering the effects of wall stiffness.

It has been verified that the structures and other design features, such as interconnections, will accept the total and differential settlement thus calculated with appropriate safety margin.

(b) "Provide a settlement monitoring program for the life of the structure."

Response

A settlement monitoring program will be carried out. Markers will be placed at 25-ft spacing around the perimeter of the proposed structure. Vertical movements will be measured by taking level readings using remote benchmarks. It is anticipated that readings can be taken to within ±0.1 in. accuracy. In order to measure movements of the mat inside the building, a hose level instrument will be used. An accuracy to within

±0.01 in. is anticipated. Six pins will be installed at appropriate locations inside the building and readings will be taken at regular intervals.

Measurements will be made on weekly to bi-weekly basis during the first year. Depending on the progress of settlement, an appropriate interval will be selected after the first year. We plan to start taking readings following the completion of the mat foundation for the proposed buildings as soon as placing markers and pins becomes possible.

3.0 REFERENCES

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TABLE 1.10.2A

CALCULATED PEAK SHEAR STRESSES FOR THE OPERATING BASIS EARTHQUAKE (OBE)

Method of Analysis	Accelerogram	Calculated Peak Shear Stress, τ_{max} (lb/ft^2) Depth (ft) 32	40	44	48
Site Response Analysis	State Building	297	375	403	425
	Parkfield	346	415	444	473
	Artificial	336	406	450	491
Simplified Procedure of Seed & Idriss (1971) using average stress attenuation coefficient	Not Applicable	375	441	463	484

TABLE 1.10.3A

COMPUTED EQUIVALENT UNIFORM SHEAR-STRESS AMPLITUDES AT VARIOUS DEPTHS WITHIN THE UPPER PORTION OF THE COHANSEY FORMATION FOR THE OPERATING BASIS EARTHQUAKE (OBE)

Accelerogram	Equivalent Uniform Shear-Stress Amplitude, τ_d (lb/ft^2) Depth Below Ground Surface (ft) 32	40	44	48
State Building	211	266	286	302
Parkfield	267	319	342	364
Artificial	244	300	333	364
Maximum Value	267	319	342	364

TABLE 1.10.6A

SUMMARY OF CALCULATED FACTORS OF SAFETY
UPPER PORTION OF THE COHANSEY FORMATION
FOR THE OPERATING BASIS EARTHQUAKE (OBE)

Depth Below Ground Surface (ft)	Calculated Factors of Safety			
	Initial Liquefaction		±10% Average Strain	
	Best[1] Estimate	Lower[2] Bound	Best[1] Estimate	Lower[2] Bound
32	2.43	2.02	3.68	2.97
40	2.36	1.96	3.60	2.88
44	2.38	1.97	3.59	2.90
48	2.40	1.98	3.63	2.90

[1]Based on average strength value.

[2]Based on strength value equal to average minus one standard deviation.

TABLE 324.2.1
SUMMARY OF CONSOLIDATION TEST RESULTS
UPPER CLAY LAYER

Boring No.	Sample No.	Depth (ft)	Water Content (%)	Liquid Limit (%)	Plastic Limit (%)	Liquidity Index	Preconsolidation Pressure (ton/ft^2)	Overconsolidation Ratio (OCR)
W3	U4C	33.6	42.1	72	33	0.23	10	10
W4	U3C	21.1	45.3	84	37	0.18	11	8
W8	U6B	28.6	45.1	92	41	0.08	12	10

TABLE 324.2.2

SUMMARY OF LIQUIDITY INDICES

Boring No.	Sample No.	Depth (ft)	Natural Water Content (%)	Liquid Limit (%)	Plastic Limit (%)	Liquidity Index
W1	U2C	17.5	47.9	77	40	0.21
	S7	19.0	49.7	54	29	0.83
	S8	23.7	39.1	65	32	0.22
W2	U2B	20.8	41.3	79	39	0.06
W3	S7B	18.0	41.0	70	34	0.19
	S8	22.7	45.6	78	32	0.30
	S9A	29.7	43.9	71	32	0.31
	U4C	33.6	41.4	72	33	0.22
W4	U3C	21.1	44.3	84	37	0.16
	S8	25.7	44.2	77	36	0.20
W5	U6C	33.3	28.0	54	28	0.00
	S10A	34.0	27.8	38	20	0.43
W6	S7	24.7	45.6	77	34	0.27
	S9	34.7	45.4	65	33	0.39
W8	U6B	28.6	42.6	92	41	0.03

TABLE 324.2.3

SUMMARY OF RATIO $s_u/\bar{\sigma}_v$

Boring No.	Sample No.	Depth (ft)	$s_u/\bar{\sigma}_{vo}$
W1	U3B	21.6	0.53
W3	U4B	33.0	1.14
W4	U3B	20.7	0.80
W12	S2B	20.3	0.85
W13A	S2C	20.1	1.03
	S2E	20.6	1.35
W14	S2C	20.2	0.77
W16	S1D	18.4	0.69
	S3C	21.8	0.61
W17	S1D	19.0	0.55
	S3C	22.3	0.67
W18	S1B	18.2	0.92
	S2E	21.3	0.71
W19	S2D	20.7	0.48

TABLE 324.12.1

COMPUTED EQUIVALENT UNIFORM SHEAR-STRESS AMPLITUDES AT VARIOUS DEPTHS WITHIN THE UPPER PORTION OF THE COHANSEY FORMATION USING 5 CYCLES FOR CONVERSION FOR THE OPERATING BASIS EARTHQUAKE (OBE)

	Equivalent Uniform Shear-Stress Amplitude, τ_d (lb/ft^2) Depth Below Ground Surface (ft)			
Peak Amplitude of 0.22 g)	32	40	44	48
State Building	196	251	270	284
Parkfield	261	313	335	357
Artificial	268	329	366	399

TABLE 324.13.1

SUMMARY OF CALCULATED FACTORS OF SAFETY IN UPPER PORTION OF COHANSEY FORMATION FOR 10% DOUBLE-AMPLITUDE (±5% AVERAGE) STRAIN FOR THE OPERATING BASIS EARTHQUAKE (OBE) - a_{max} = 0.11 g

Depth Below Ground Surface (ft)	Calculated Factor of Safety: Best Estimate	Lower Bound
32	2.72	2.26
40	2.66	2.19
44	2.68	2.19
48	2.69	2.23

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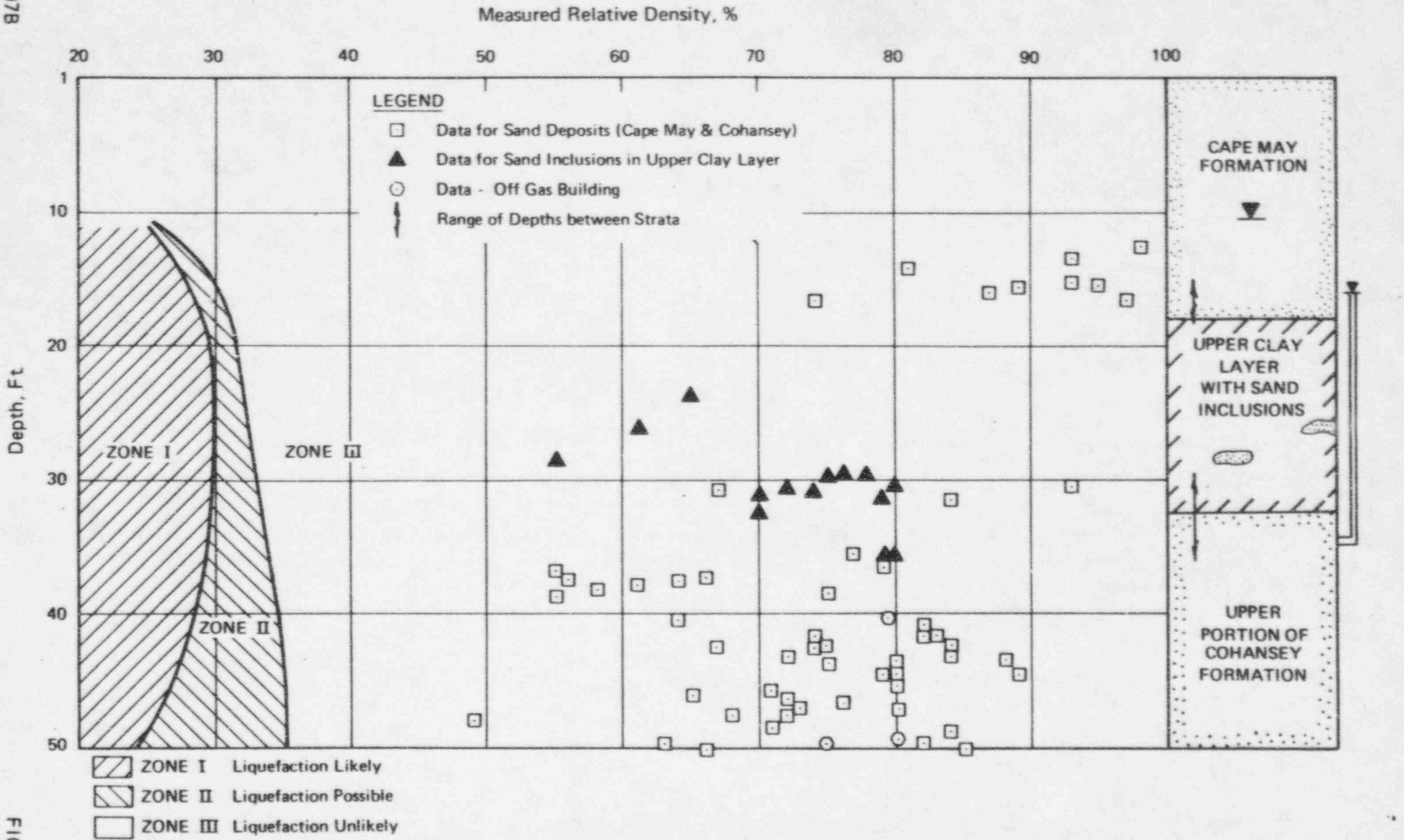
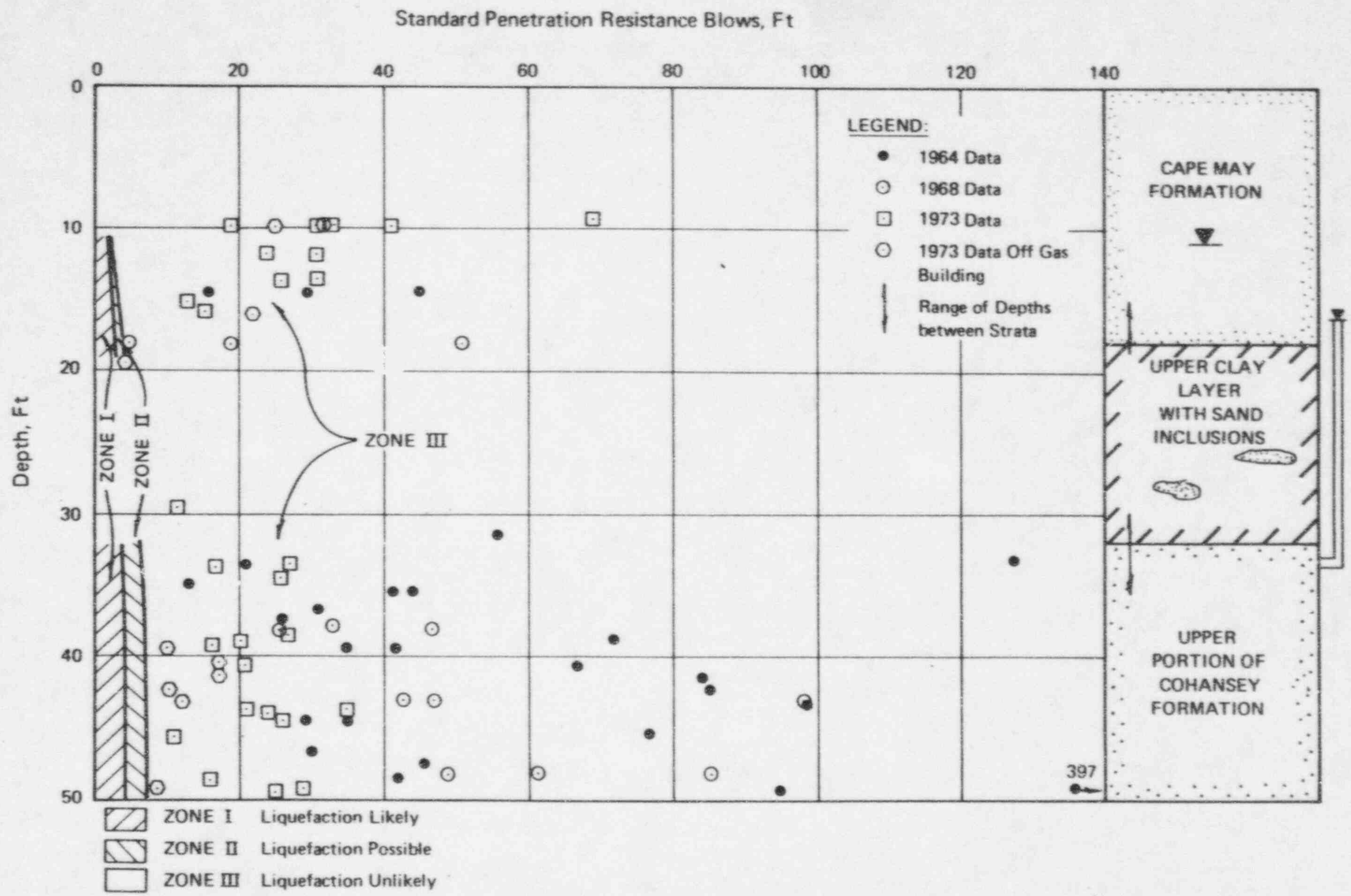


EVALUATION OF LIQUEFACTION POTENTIAL DURING OBE (a_{max} = 0.11g)
BY SIMPLIFIED PROCEDURE USING
MEASURED RELATIVE DENSITY

FIG. 1.10.2 A



EVALUATION OF LIQUEFACTION POTENTIAL DURING OBE (a_{max} = 0.11g)
BY SIMPLIFIED PROCEDURE
USING STANDARD PENETRATION RESISTANCE

FIG. 1.10.3A

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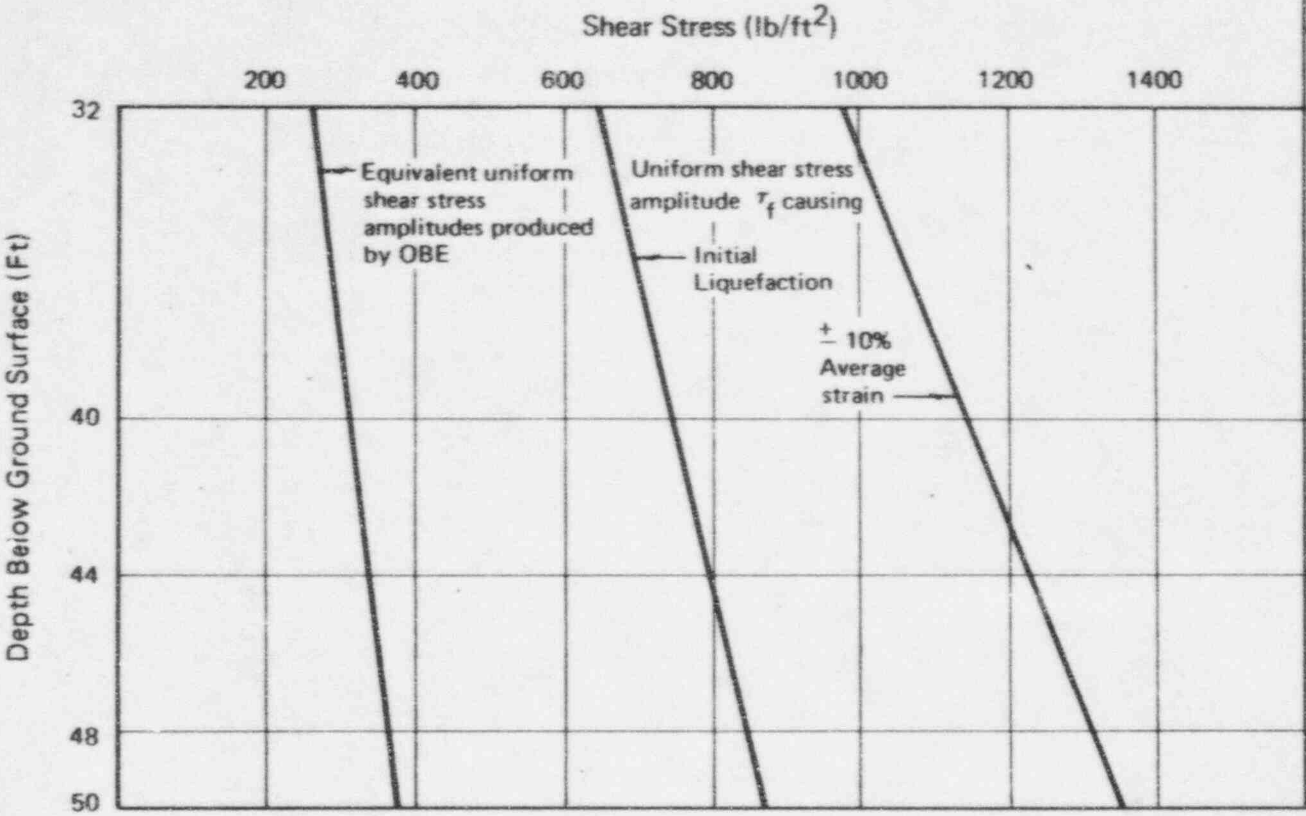

Depth (Ft)	Factor of Safety: Initial Liquefaction, Best Estimate[1]	Factor of Safety: Initial Liquefaction, Lower Bound[2]	Factor of Safety: ± 10% Average Strain, Best Estimate[1]	Factor of Safety: ± 10% Average Strain, Lower Bound[2]
32	2.43	2.02	3.68	2.97
40	2.36	1.96	3.60	2.88
44	2.38	1.97	3.59	2.90
48	2.40	1.98	3.63	2.90

(1) Based on average strength
See table 1.10.5, 4 Feb 1975 report

(2) Based on average strength
minus one standard deviation
See table 1.10.5, 4 Feb 1975 report

**EVALUATION OF LIQUEFACTION POTENTIAL
IN UPPER PORTION COHANSEY FORMATION DURING OBE
BASED ON SITE RESPONSE ANALYSES
AND LABORATORY CYCLIC TESTS**

FIG. 1.10.5 A

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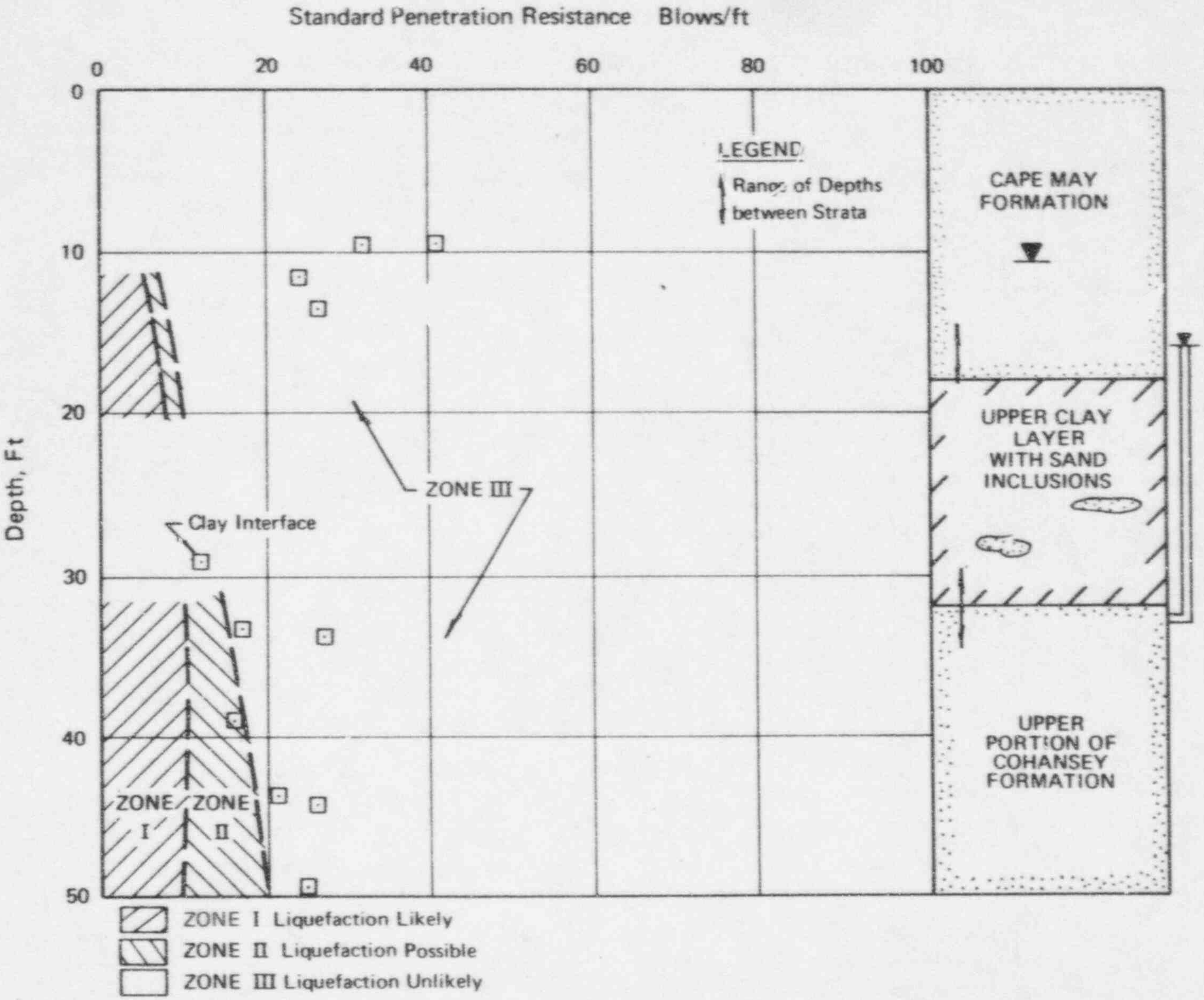
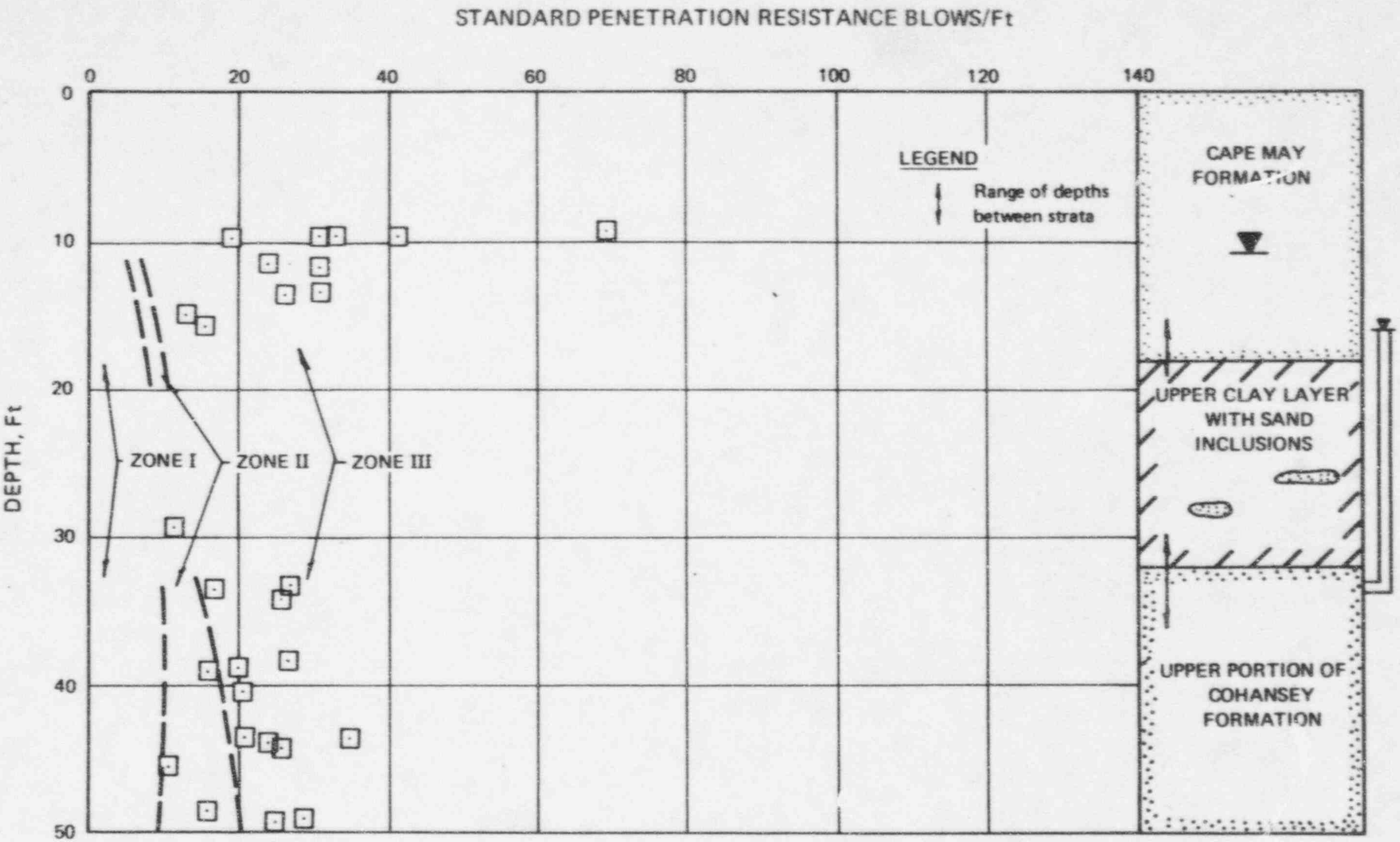


EVALUATION OF LIQUEFACTION POTENTIAL DURING SSE (a_{max} = 0.22 g) USING N VALUES FROM BORINGS BENEATH RADWASTE BUILDING

FIG. 324.1.1



ZONE I Liquefaction Likely

ZONE II Liquefaction Possible

ZONE III Liquefaction Unlikely

EVALUATION OF LIQUEFACTION
POTENTIAL BY SIMPLIFIED PROCEDURE (a_{max} = 0.22 g)
USING STANDARD PENETRATION RESISTANCES
FROM 1973 INVESTIGATION

FIG. 324.1.2

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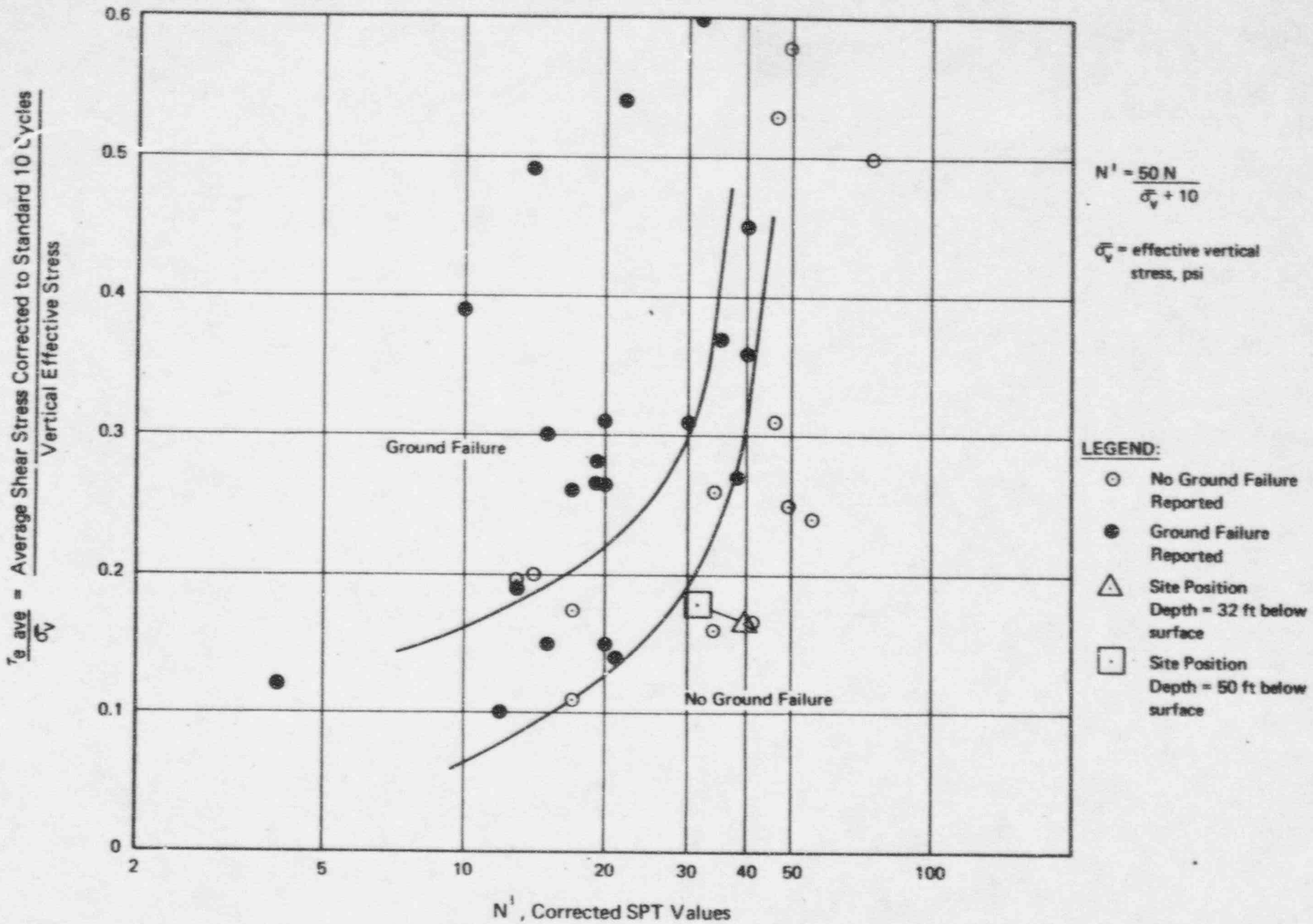
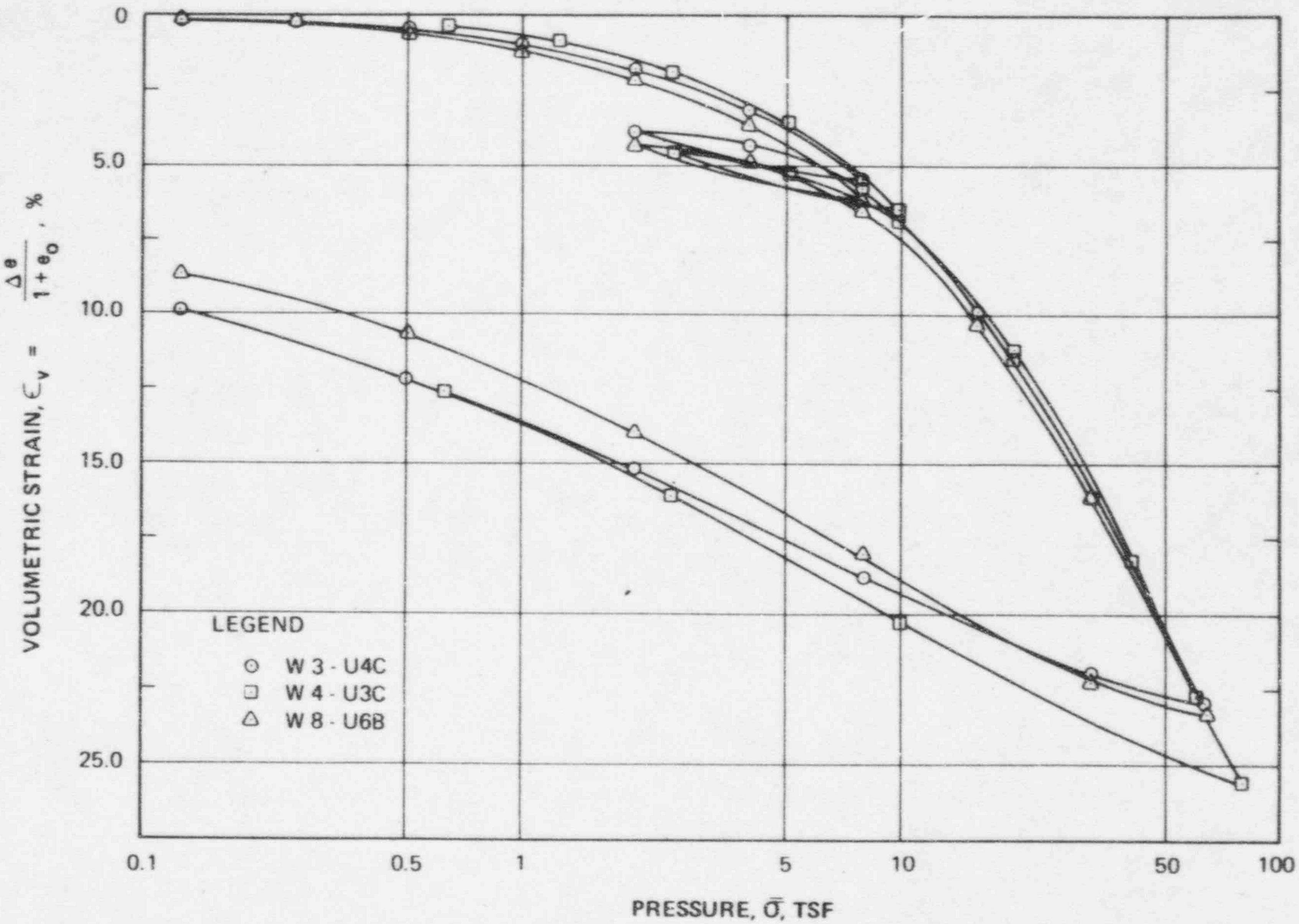


EVALUATION OF LIQUEFACTION POTENTIAL DURING SSE (a_{max} = 0.22g) BASED ON REPORTED CASE HISTORIES
After Yegian and Oweis (1975)

FIG. 324.1.3



RESULTS OF CONSOLIDATION TESTS – UPPER CLAY LAYER

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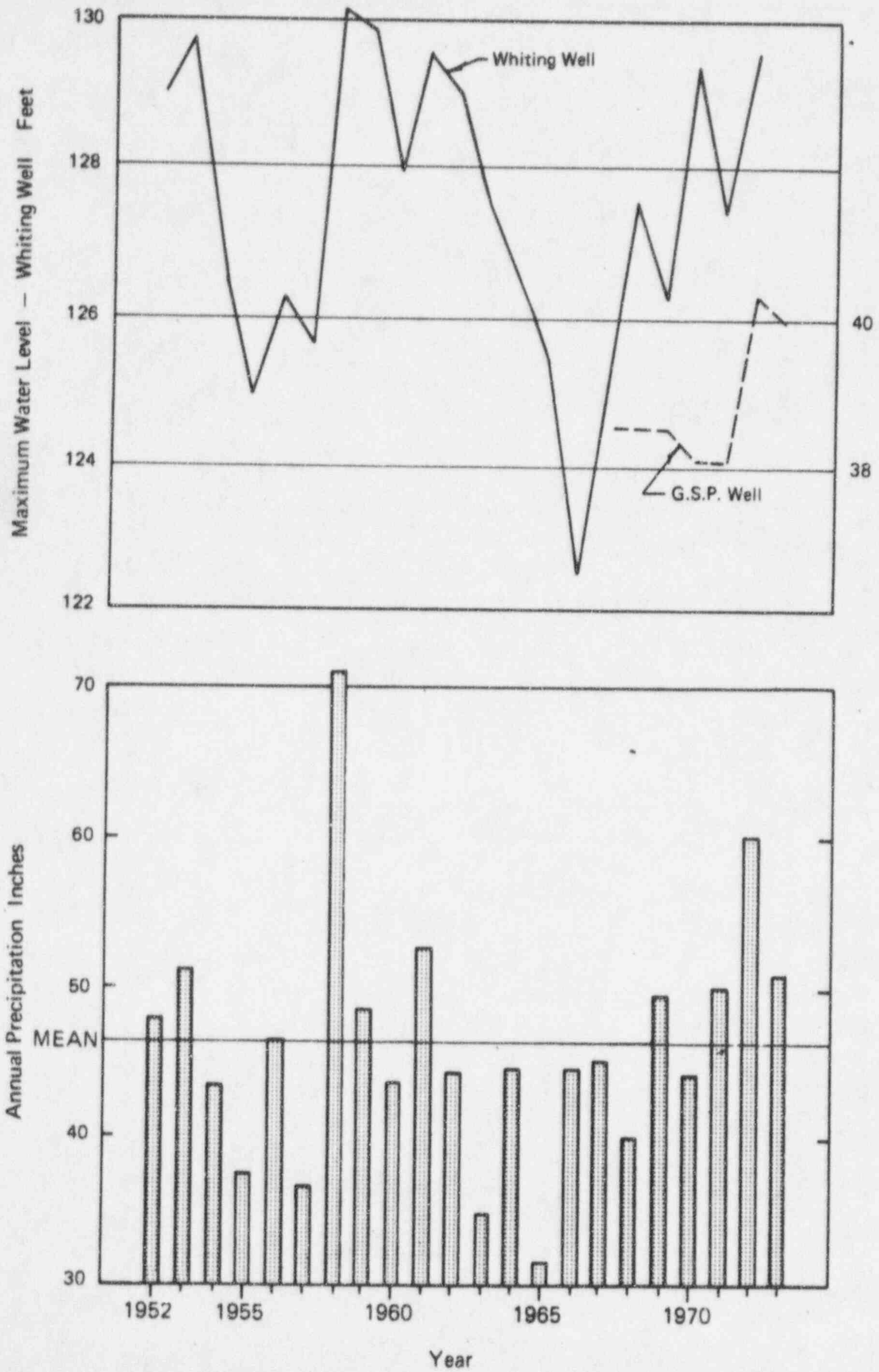
FIG. 324.2.1



REPORTED GROUNDWATER LEVELS IN COHANSEY FORMATION AND RAINFALL RECORD IN THE VICINITY OF THE SITE

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FIG. 324.8.1

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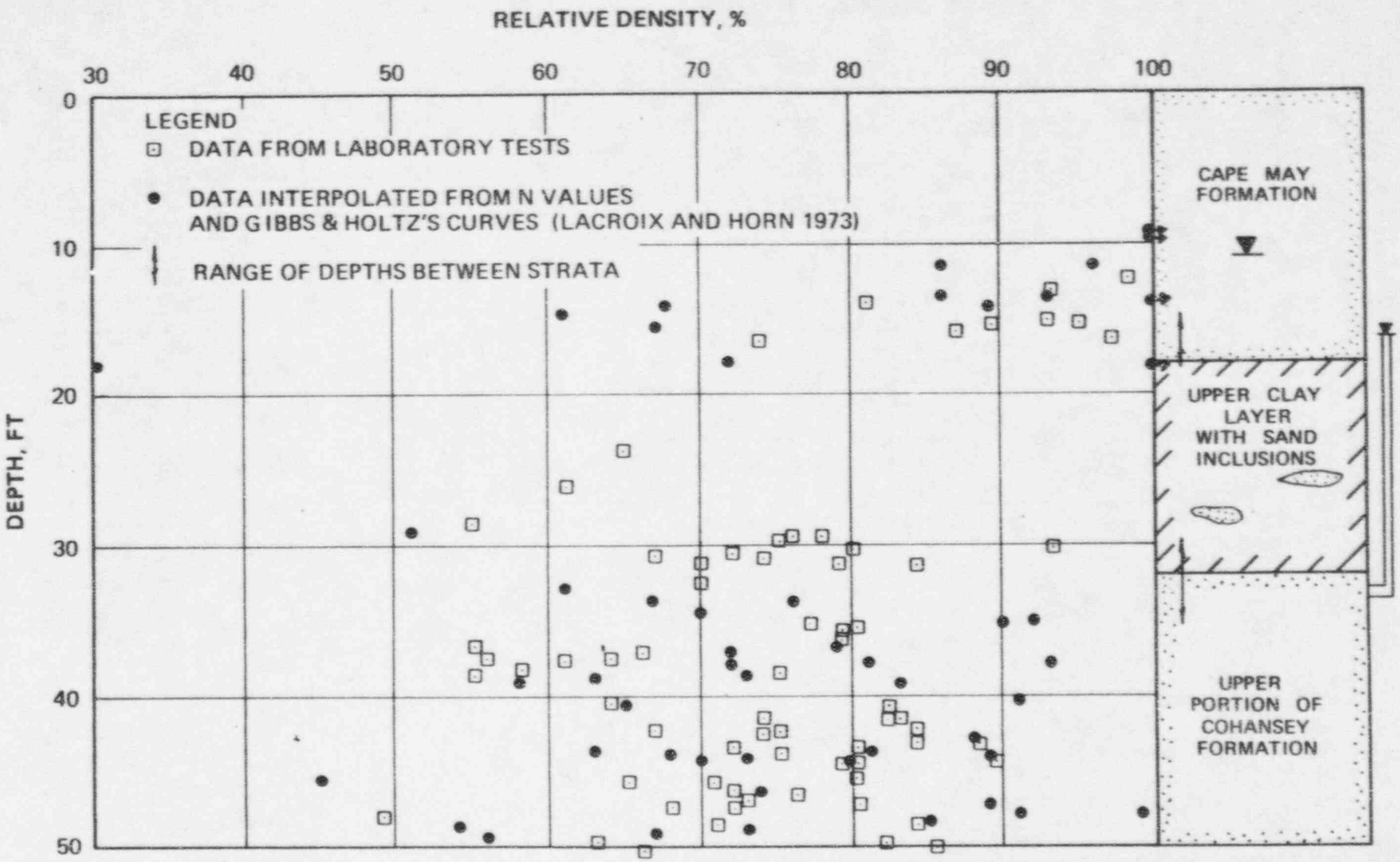

CORRELATION OF MEASURED RELATIVE DENSITIES
AND RELATIVE DENSITIES FROM S P T DATA

FIG. 324.11.1

APPENDIX 324-A

SUPPORTING TECHNICAL PUBLICATIONS

EFFECTS OF SAND COMPACTION ON LIQUEFACTION DURING THE TOKACHIOKI EARTHQUAKE

YORIHIKO OHSAKI*

1. FOREWORD

During the Tokachioki earthquake of 1968, a site of sandy ground showed a variety of damage features due to liquefaction. A part of the ground consisted of loose sand and the other part was of dense sand, the latter suffering little damage. The part of loose sand had been compacted locally by means of vibroflotation, which demonstrated its effectiveness for preventing liquefaction.

In this paper, the characteristics of sand deposits before and after the earthquake and the features of damage are described to offer field-observational information useful for the establishment of criteria concerning the occurrence of liquefaction.

2. SITE AND SOIL CONDITIONS

The site of the paper-manufacturing plant is located in the city of Hachinohe which lies,

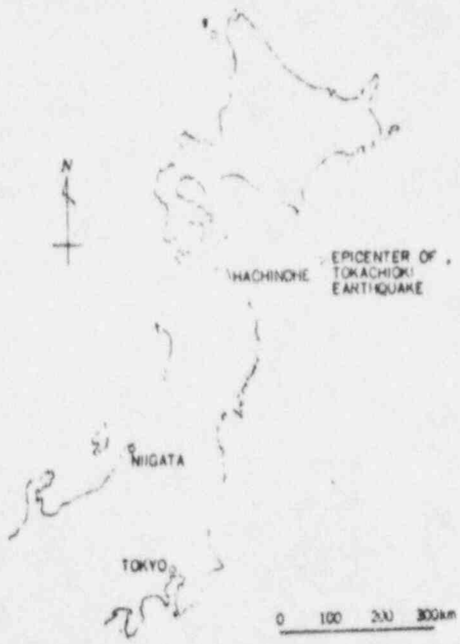

Fig. 1. Location of Hachinohe City

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Written discussions on this report should be submitted before January 1, 1971.

as shown in Fig. 1, about 560 kilometers north of Tokyo.

The site with an area of about 660,000 m^2 is a flat, sandy beach fronting on the Pacific Ocean, its ground elevation being in the range from 2.5 to 5.0 m. The west side of the site is bordered by a diluvial, coastal terrace of elevation 20 to 25 m.

The ground of the site consists of sands almost entirely down to a depth of more than 20 m from the ground surface, containing a large quantity of iron sand. Eight exploratory borings P-1 through P-8 were performed in the site at the locations shown in Fig. 2, and an example of the boring logs is represented in Fig. 3, in which it will be noticed that N-values of the standard penetration test are extremely small down to a depth of about 5 meters from the ground surface. This portion had once been excavated to collect iron sand and backfilled with the waste sand. Such excavation and backfilling had been made almost all over the site, as shown in Fig. 4, except in a wood at the central part of the site and along a few paths within the site. There were several swampy places along the west border of the site.

The ground water table is not deeper than 1.5 meters everywhere in the site and, therefore, almost entire mass of the sand is saturated with the ground water.

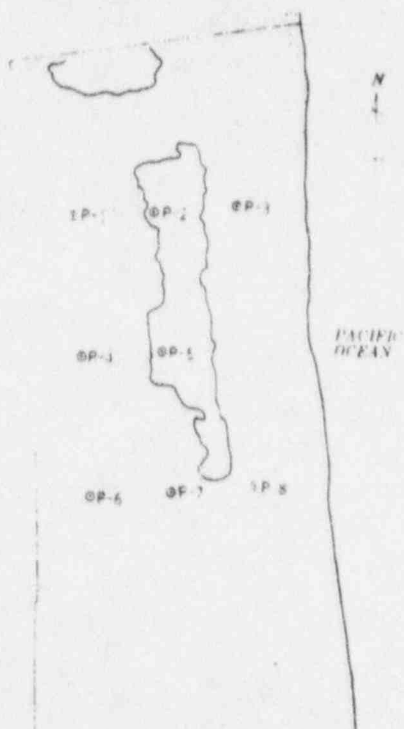

Fig. 2. Site and Locations of Exploratory Borings

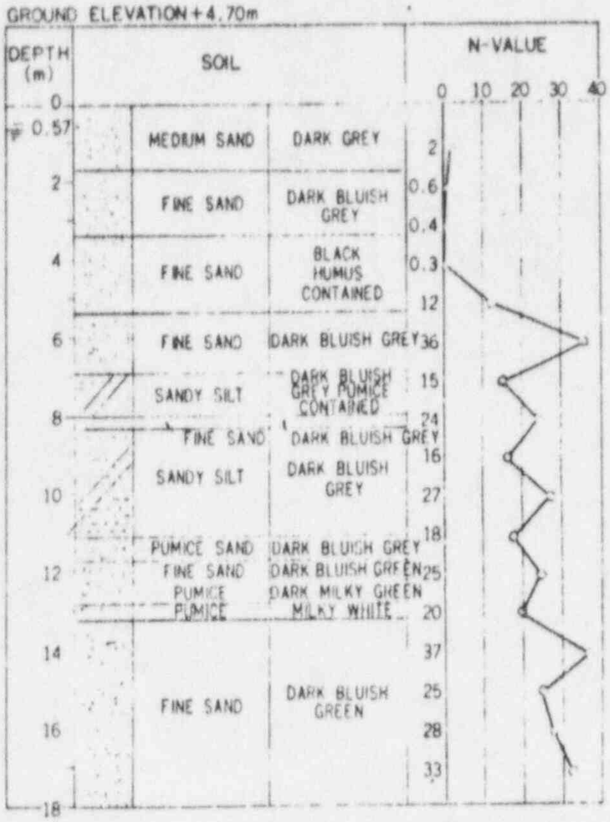

Fig. 3. An Example of Boring Logs

3. EXPERIENCES OF THE NIIGATA EARTHQUAKE OF 1964

The construction of the manufacturing plant was schemed in the early fall of 1964, which was immediately after the Niigata earthquake of June 16, 1964.

Being asked engineering advices in connection to the problems of liquefaction of sandy ground, the writer tentatively pointed out, based on the experiences of the Niigata earthquake, the following five items as the conditions under which the ground would liquefy during an earthquake of a considerable intensity, resulting in heavy damage to structures:

(1) Most of the soil from the ground surface down to a depth of 15 to 20 m consists of sands.

(2) It is submerged under the ground water table.

(3) Its age of deposition is young.

(4) It consists of pure, uniform sands of medium grain size, i.e., i) the content of silt and/or clay is less than 10 per cent, ii) its 60-per cent grain size is in the range of 0.2 to 2.0 mm, and iii) its coefficient of uniformity is less than 5. In other words, its grain-size distribution curve lies in the hatched zone in Fig. 5.

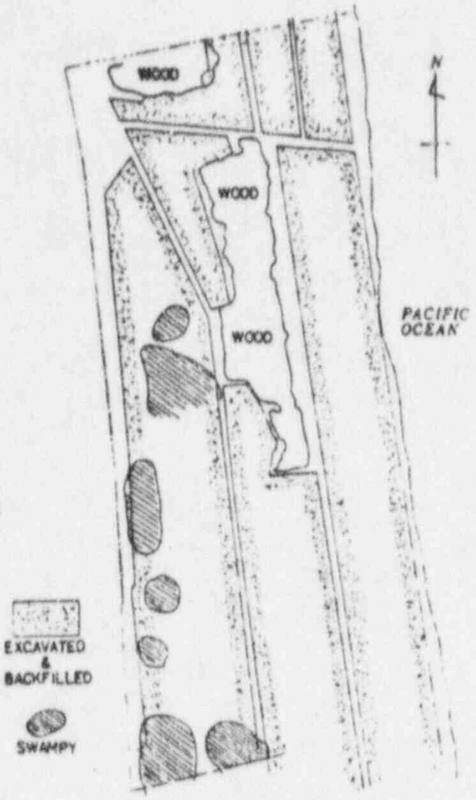

Fig. 4. Excavated and Backfilled Areas

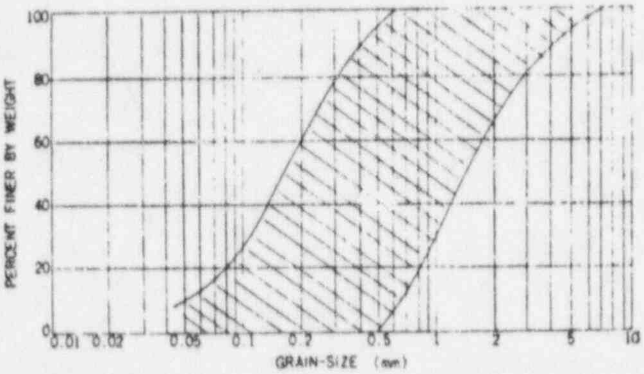

Fig. 5. Critical Zone for Grain-Size Distribution Curves

(5) Its compactness is loose and the N-values of the standard penetration test are smaller than the critical value represented by an expression

$$N_{cr} = 2z \qquad (1)$$

in which z denotes a depth in m.

4. FOUNDATION PLANNING

When the soil conditions in the site are compared with the criteria in the preceding section, it is readily apparent that (1) the constitution of the ground, (2) the ground water condition and (3) the age of deposition are completely the case.

As for the grain-size of the sands, the grain-size distribution curves for samples taken from the top 5 m of the ground lie in the hatched zone in Fig. 6, indicating that most of them are within the critical range represented in Fig. 5.

Furthermore, if the line of the critical N-values expressed by eq. (1) is drawn overlapping the curve of actual N-values, for instance, of Fig. 3, then Fig. 7 is obtained, which indicates that the actual N-values are smaller than the critical ones in a range from the ground surface down to a depth of approximately 5 m.

Based on the above considerations, a possibility was foreseen quite definitely that the soils in the site, specifically the loose sands near the ground surface, would liquefy during a future earthquake and cause heavy damage to buildings and facilities.

As a result, an adoption of pile foundation was suggested to support vertical loads from buildings and facilities and it was confirmed by a pile loading test that a reinforced concrete pile of 30 cm in diameter and 7 m in length could develop an allowable bearing capacity of 22 tons.

Even if piles are used, however, the experiences of the Niigata earthquake indicate that, if the mass of soil around the piles was liquefied, the bearing capacity was reduced because of the loss in surface friction and overburden effects upon the pile point and, at the same time, the lateral resistance of the pile disappeared almost completely.

To provide against such destructive situations, it was decided to compact the loose sands between the piles so that they possessed N-values larger than the critical values

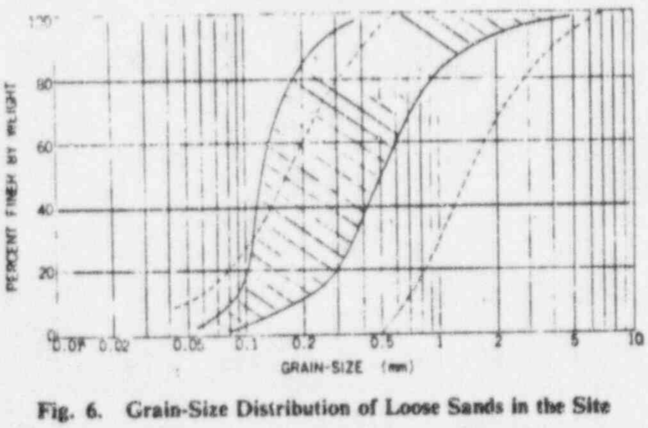

Fig. 6. Grain-Size Distribution of Loose Sands in the Site

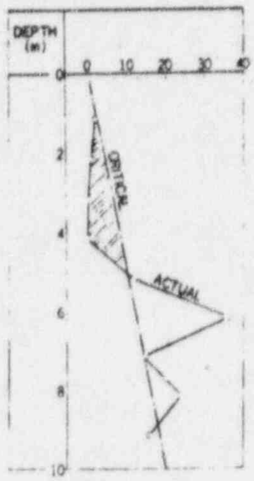

Fig. 7. A Comparison of Critical and Actual N-values

expressed by eq. (1). As a method of compaction, a vibroflotation process was finally suggested after technical and economical comparisons with several other methods.

5. VIBROFLOTATION TESTS

Prior to the actual application of the vibroflotation process, a series of field tests were carried out in the site. Namely, as shown in Fig. 8, the mass of loose sands was compacted by a vibroflotation equipment at 19 points of a regular, triangular configuration. The pitch and the filling material for each test were as tabulated in Table 1.

Table 1. Pitches and Filling Materials for Vibroflotation Tests

Test	Pitch (m)	Filling Material
No. 1	1.20	
No. 2	1.50	Sand
No. 3	1.80	
No. 4	1.20	Gravel

Outlines of the vibroflotation equipment are as follows:

Effective length	7.00 m
Outer diameter	17.78 cm
Driving power	15 HP
Eccentric weight	23.4 kg
Eccentricity	47 mm
Amplitude	4.3 mm
Speed	1260 rpm

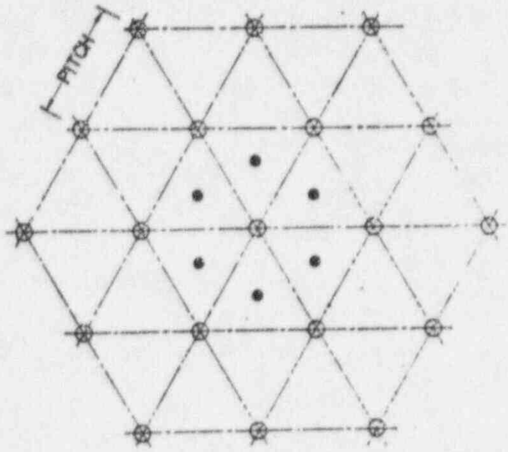

Fig. 8. Vibroflotation Tests

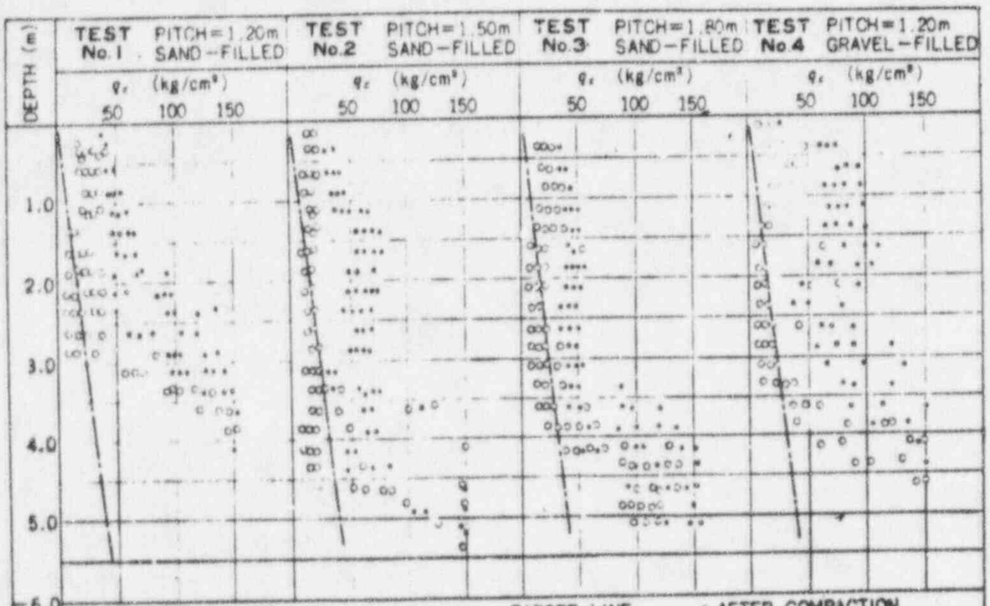

Fig. 9. Results of Vibroflotation Tests

Before and after the compaction, densities of the mass of sands were measured at intermediate points shown in Fig. 8 by means of a cone penetrometer to check the effects of compaction. The results of tests were as shown in Fig. 9. It was known with respect to the cone penetrometer that, between the penetration resistance q_c and the N-value of the standard penetration test, a relation

$$q_c = 4N$$

held approximately. Therefore, from eq. (1),

$$(q_c)_{critical} = 8z \tag{2}$$

where z denotes a depth in meters. A "target" line, i.e., a line expressed by eq. (2) is drawn in each of Fig. 9. It is observed in Fig. 9 that the loose sands have been compacted beyond the target line irrespective of the pitch of vibroflotation, and that gravel is more effective as filling material than sand.

6. CONSTRUCTION OF FOUNDATIONS

Apparently it should be recommended to apply, if possible, both pile-driving and compaction to all buildings and facilities. However, by reason of economy and time limitation the actual construction of foundations was performed in the following way:

Group I—For structures of primary industrial importance such as pulping plant, paper-

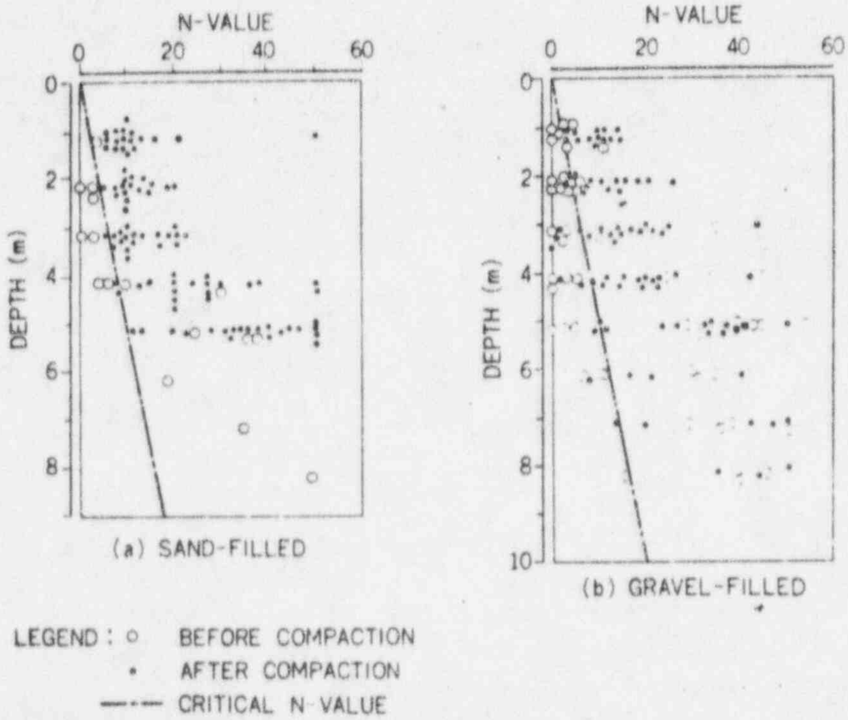

Fig. 10. N-Values after Improvement

making plant, power plant, etc., a compaction by means of vibroflotation was first performed covering all building areas in a triangular configuration of 1.55 m in pitch and using sands as filling material, and then reinforced concrete piles of 30 cm in diameter were driven to the bearing stratum at a depth of 6 to 7 m. Pile-driving was performed after the completion of vibroflotation process in expectation of further compaction effects by pile-driving.

After compaction and pile-driving the densities of thus compacted mass of sands were measured by the standard penetration tests. The results are shown in Fig. 10(a), indicating that the sands were fairly successfully compacted beyond the critical N-value.

Group II—For structures of secondary industrial importance such as warehouses, office buildings, etc., the ground beneath the columns and the grade beams was compacted stripwise by means of vibroflotation with 1.55-m pitch down to a depth of 6 to 7 m. As filling material, gravel was used and the effects of compaction was as shown in Fig. 10(b). Then, footings of the building were placed upon thus compacted ground without piles. Most tanks for chemicals were included in this group.

Group III—For structures of minor industrial importance, neither pile foundations nor compaction process were adopted.

Fig. 11. Location of Buildings and Structures

Thus, the total number of vibroflotation processes amounted to 16,841, that is,

for Group I	13,354
for Group II	3,487
for Group III	0
Total	16,841

The locations of structures belonging to the above three groups are illustrated in Fig. 11.

7. DAMAGE BY TOKACHIOKI EARTHQUAKE

The paper-manufacturing plant was completed in January, 1967, and about one and half years after the completion it was attacked by the Tokachioki earthquake of May 16, 1968. The seismic data of the earthquake were as follows:

Epicenter ....40.7°N, 143.7°E
Focal depth ....approximately 20 kilometers
Magnitude ....M = 7.8 by Gutenberg-Richter scale.

The location of the epicenter was as previously shown in Fig. 1 and the distance from the city of Hachinohe was approximately 180 kilometers. According to the record of a strong motion accelerograph installed at the harbor of Hachinohe, the maximum acceleration was 225 gals.

Structures, underground pipings, roads, private railway tracks, timber yards and so forth in the plant were more or less damaged during the earthquake. The damage was mostly due to liquefaction of the sandy ground. A certain vibrational damage such as failure and buckling of steel bracings, shearing failure of rivets, falling of a ceiling duct, cracking of cover-concrete in steel columns, was also involved; however, it was quite minor.

The damage due to liquefaction will be described in some detail in the following:

(1) Excavated, backfilled and not compacted portion of the ground liquefied almost all over, causing subsidence and cracking as shown in Photo 1, and eruption of sand and water as shown in Photos 2 and 3. The distribution of liquefied zones and major cracking of the ground is roughly sketched in Fig. 12. It was clearly observed that liquefaction took place most intensively at formerly swampy places.

(2) In the wood and along the former paths, where the ground had not been excavated, no liquefaction occurred. Therefore, at the boundaries between those areas and adjacent liquefied zones, there appeared fault-like differences in the ground surface elevation as shown in Photo 4, amounting to about 50 cm at a maximum.

(3) No visible, structural damage was caused to the structures belonging to Group I, except slight settlements of the floor slabs which were placed directly upon the compacted ground surface. According to a precise leveling after the earthquake, differential settlements in the structures of the Group were 9.8 mm on an average and 14 mm at a maximum.

(4) To the structures belonging to Group II the damage was also slight. However, the settlements of floor slabs placed on the not-compacted ground surface were considerably large and the maximum settlement amounted to about 40 cm. A warehouse of the Group moved horizontally by about 40 cm. Differential settlements in the structures belonging to the Group were 15.0 mm on an average and 103 mm at a maximum. The warehouse

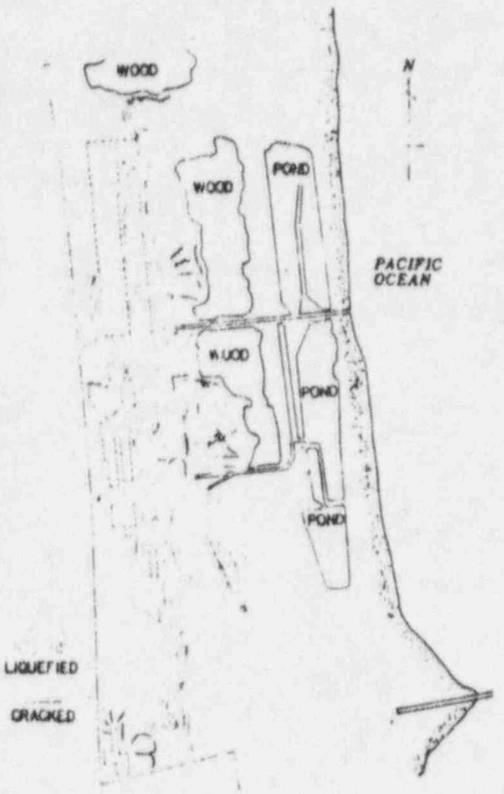

Fig. 12. Liquefaction and Cracking of the Ground

which settled the most is shown in Photo 5.

(5) Structures and facilities belonging to Group III were damaged heavily. An example of the tilting of tanks is shown in Photo 6. Fortunately, however, no overturning occurred since every structure of the Group was not so heavy in weight. Furthermore, two important features of damage were observed in relation to the piping system of the plant, that is, failures of pipings at the entrance into structures, as shown in Photo 7, due to displacement of the structure and subsidence of the liquefied ground adjacent to the structure, and failures of underground pipes which were running through the not-compacted ground. These two features may be a trivial matter from a structural viewpoint but, in fact, were important in the sense that the operation of the whole plant had to be stopped for about a month after the earthquake because of such failures of the piping system.

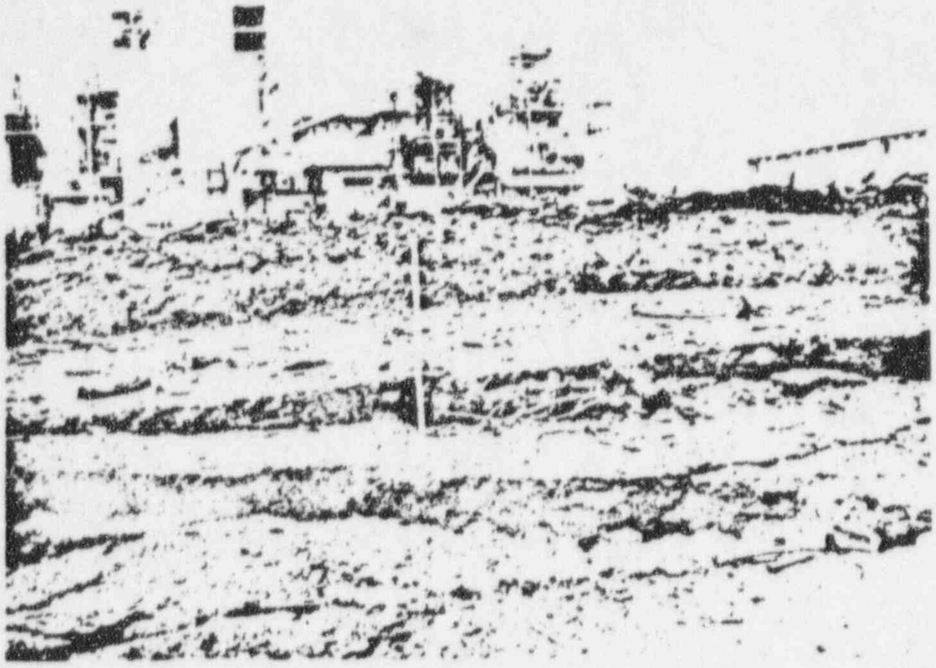

Photo 1. Cracking of the Ground

Photo 2. Sand-Crater

Photo 3. Sand-Craters

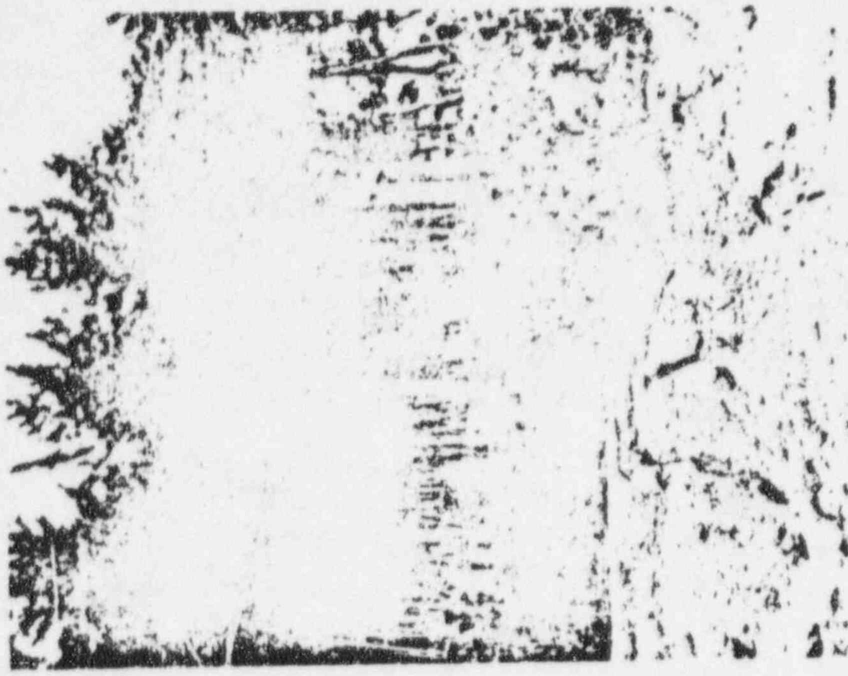

Photo 4. Boundary efied and Not-Liquefied Zones

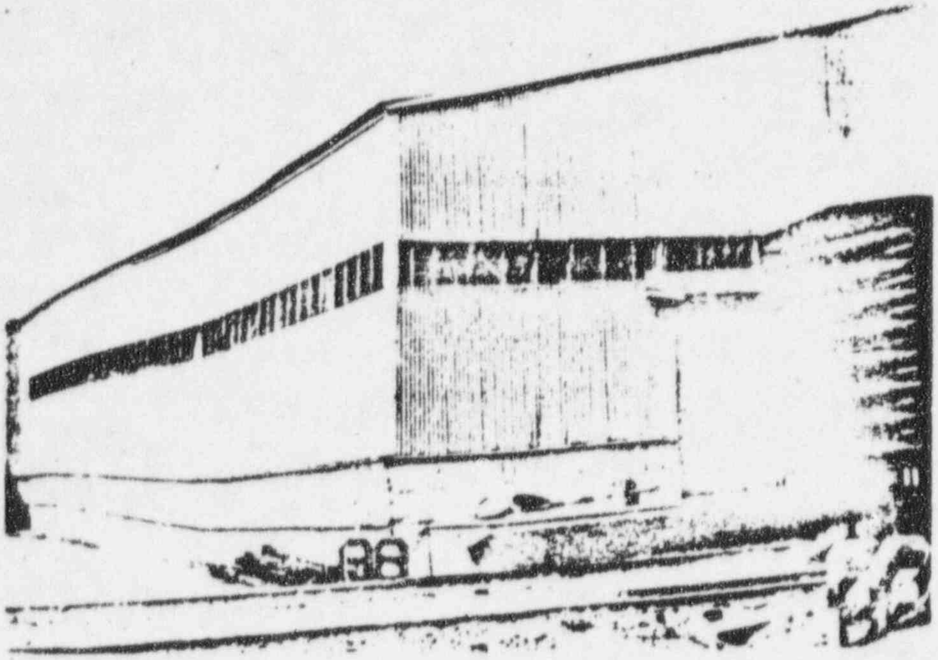

Photo 5. Differential Settlement of Building

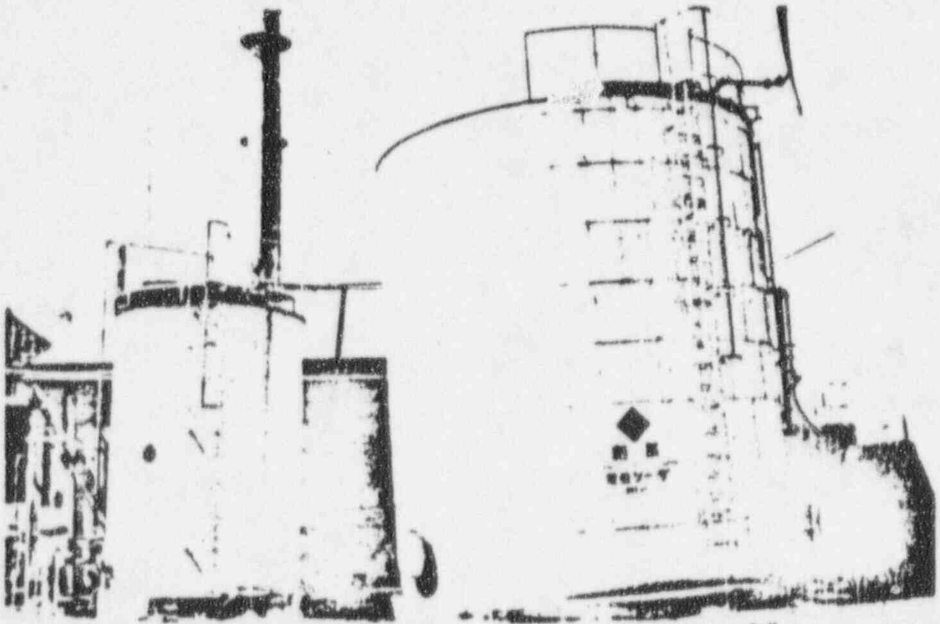

Photo 6. Tilting of Tanks

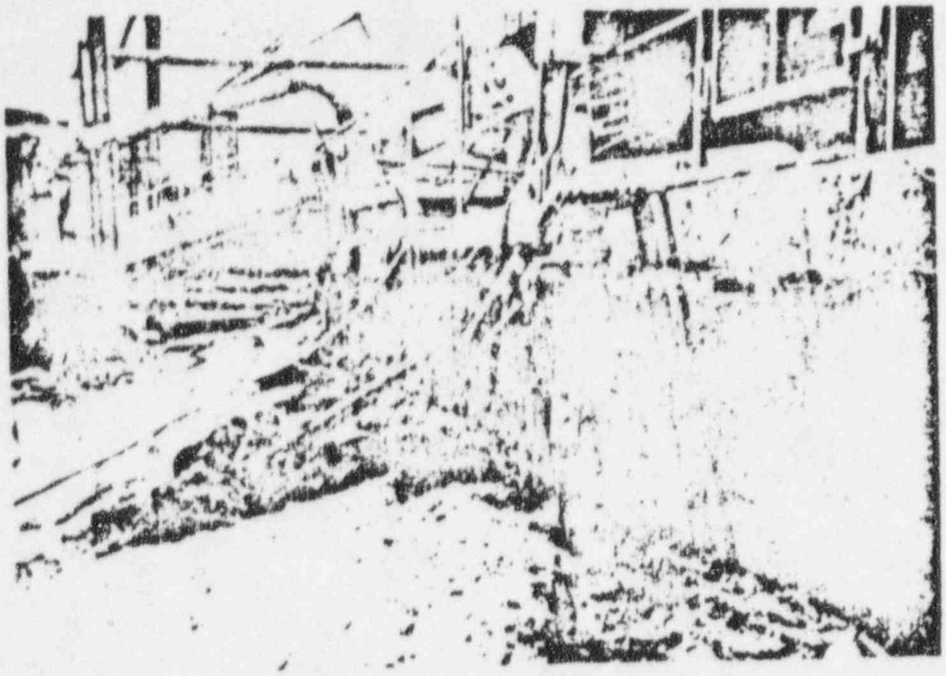

Photo 7. Failure of Piping

8. CHANGE IN SOIL CONDITIONS

Approximately 20 days after the earthquake, borings were carried out in the site at the locations P-1, P-2, P-4, P-5 and P-6 previously shown in Fig. 2, the results of which were quite interesting and important in that they furnished information on the change in soil conditions before and after the earthquake.

Location P-6:

At this location the ground was apparently liquefied. As shown in Fig. 13, N-values of the standard penetration test, which had been extremely small before the earthquake, increased to considerable values, indicating that the loose sands were liquefied, consolidated and, as a result, were compacted by the earthquake motion. Increased N-values are around the critical N-values of eq. (1), suggesting that the latter represents a stable state.

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Locations P-2 and P-5:

As previously shown in Fig. 2, these points are located in the wood at the central part of the site, where fairly dense sand had not been disturbed by excavation or backfilling. Therefore, there occurred no liquefaction during the earthquake. The changes of N-values before and after the earthquake are shown in Fig. 15, in which it can be seen that

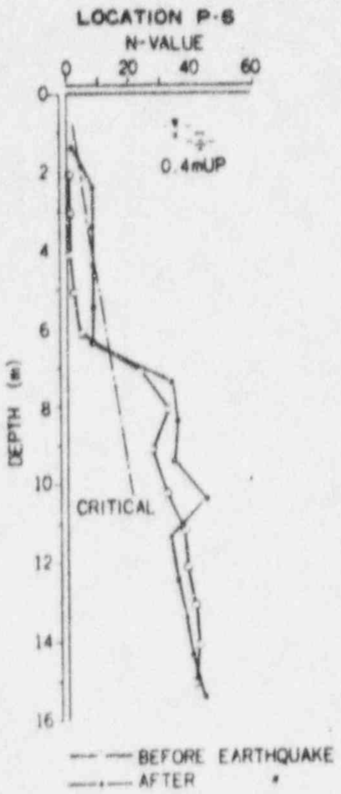

Fig. 13. Change of N-Values at Location P-6

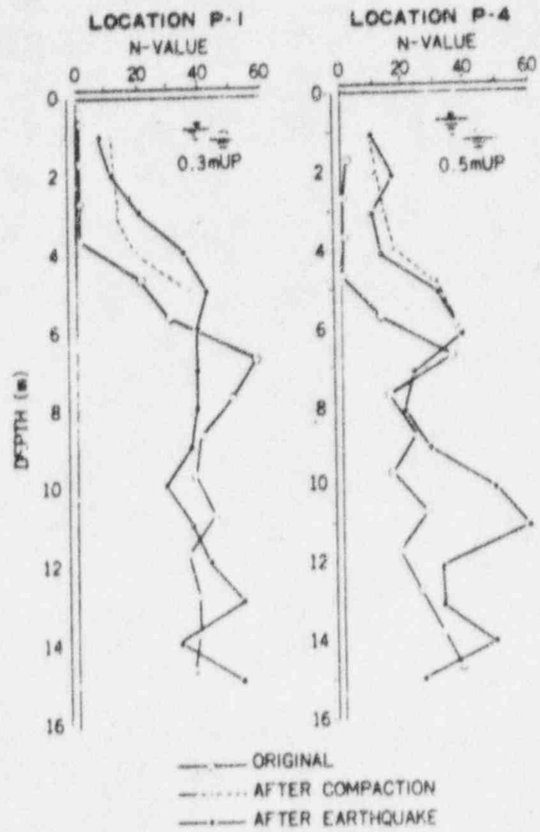

Fig. 14. Changes of N-Values at Locations P-1 and P-4

the dense sand near the ground surface was rather loosened.

At every boring location the ground water table became somewhat shallower after the earthquake.

9. CONCLUDING REMARKS AND ACKNOWLEDGEMENTS

In the preceding sections, features of damage to sandy ground during a severe earthquake and several related matters have been discussed. It is the writer's viewpoint, however, that this paper is of interim nature at the present state since the experience at this site would become more contributory to the solution of liquefaction problems, provided that more accurate and reliable determination of the field density of sand would be performed. Such a supplementary and, at the same time, more essential measurement program is now being projected.

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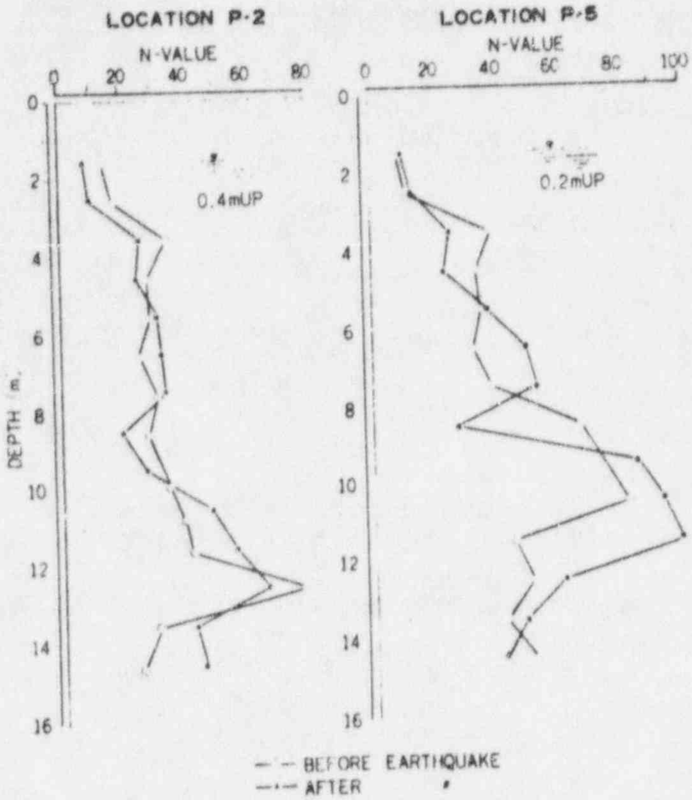

Fig. 15. Changes of N-Values at Locations P-2 and P-5

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LIQUEFACTION AND CYCLIC MOBILITY
OF SATURATED SANDS[1]

Discussion by Mishac K. Yegian,[2] A.M. ASCE
and Issa S. Oweis,[3] M. ASCE

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The writers attempted to employ this plot in their liquefaction studies for a site along the east coast of the United States. The postulated earthquake for this site is of magnitude 5.0; with a peak ground surface acceleration of 0.22 gravity at the site. A liquefaction analysis was made of a sand layer extending from 32 ft to 50 ft below ground surface. The water table is at a depth of 11 ft below ground surface. The average standard penetration resistance, N, in the sand layer is 22 blows/ft. Measured relative densities from undisturbed sample had an average value of 75%. Results from dynamic response analyses and liquefaction testing on "undisturbed" samples indicated ample safety factors against liquefaction. Using the

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The writers reexamined the data used by the author and decided to employ Fig. 12 to incorporate magnitude-dependent shear stress converson factor R. For the cases involving magnitudes greater than 7.2 which, as previously stated, constituted 95% of the critical data points, a constant value of R equal to 0.85 was adopted. This value of R corresponds to a magnitude of 7.2 as suggested by Fig. 12. For the rest of the available data, the value of R was chosen on the basis of Fig. 12. Figure 13 presents the writers' data and suggested critical band.

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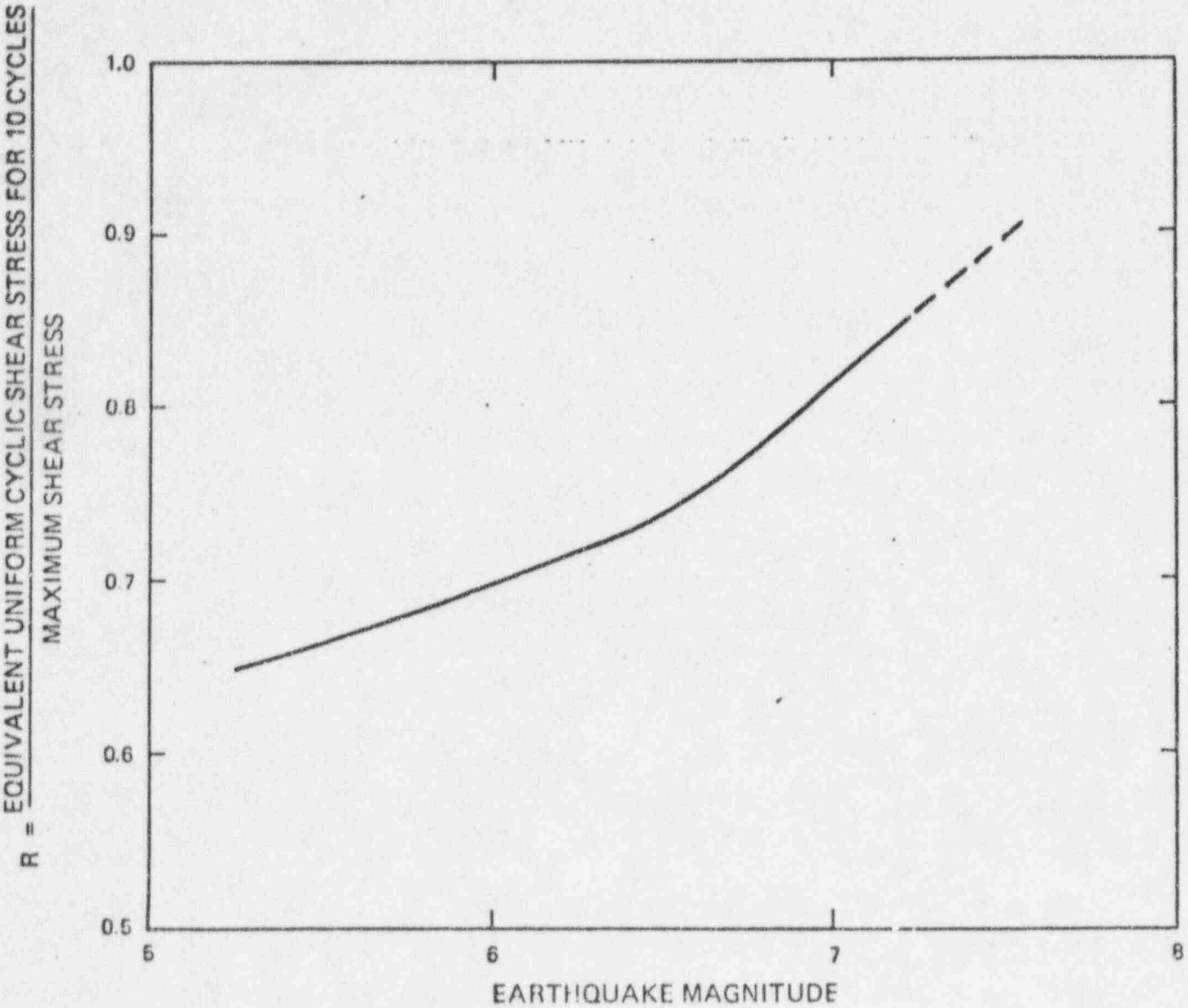
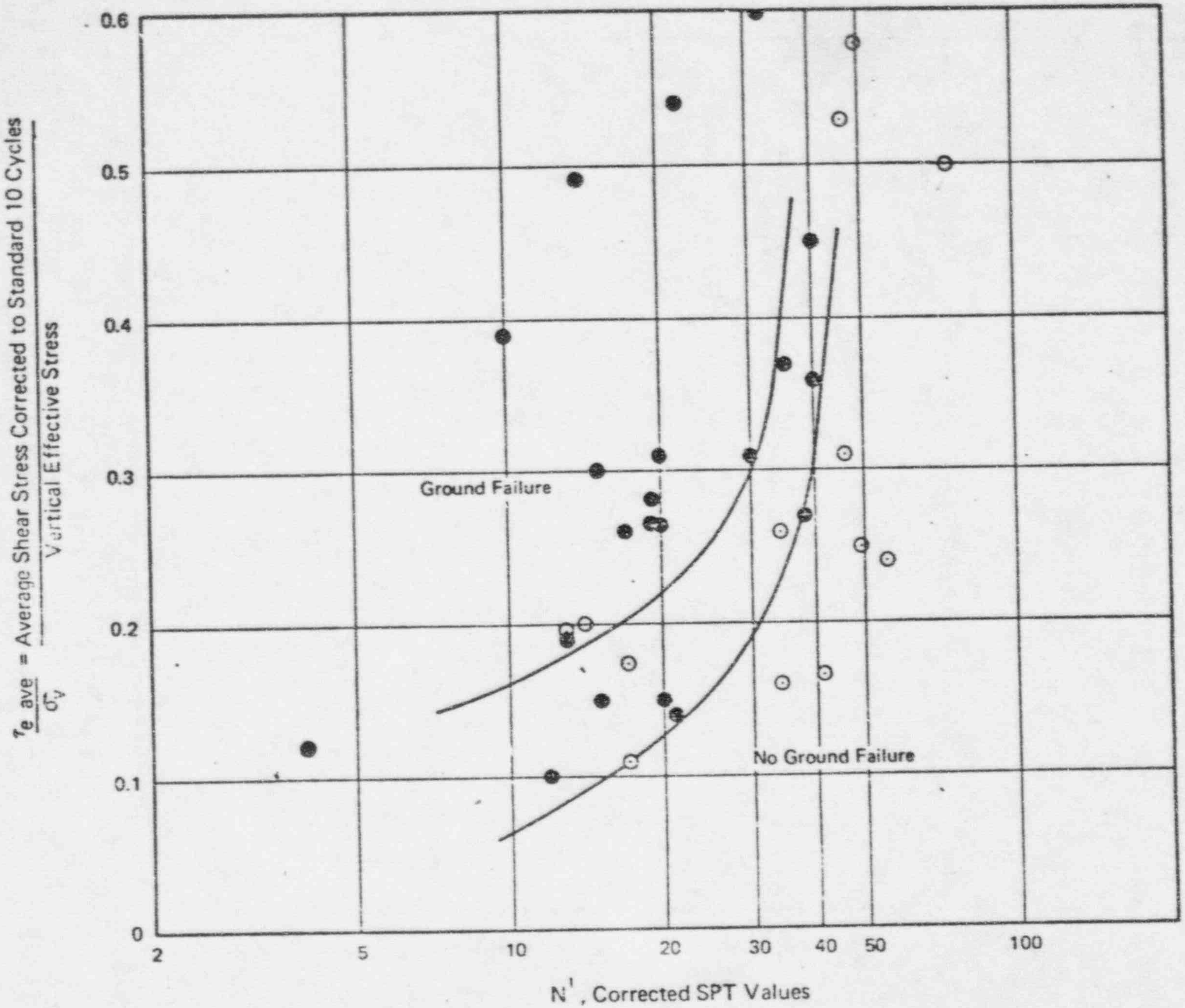


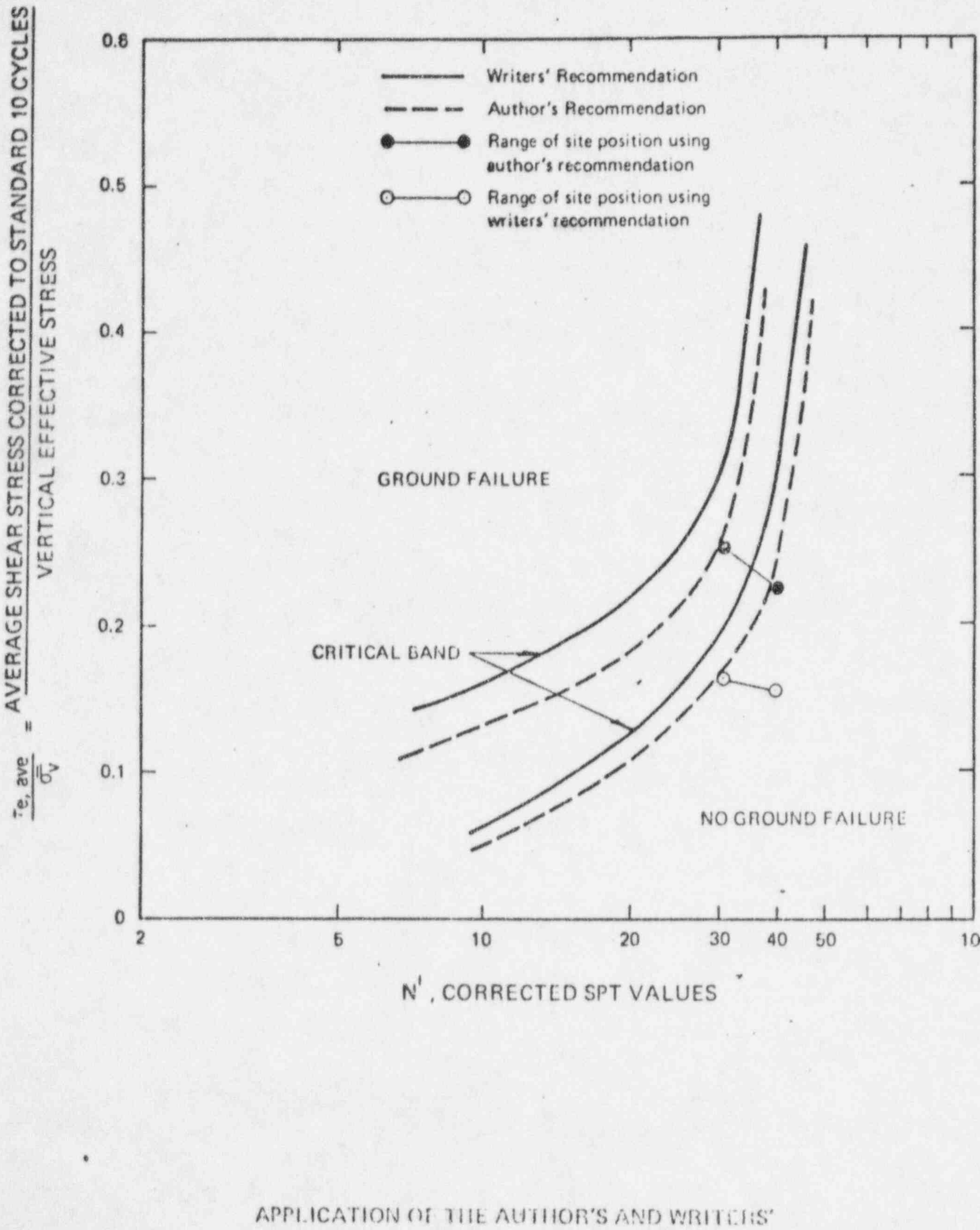
SHEAR STRESS CONVERSION FACTOR, R FOR 10 SIGNIFICANT CYCLES AS FUNCTION OF EARTHQUAKE MAGNITUDE (AFTER LEE AND CHAN, 1972)

FIG. 12



SHEAR STRESS NORMALIZED TO TEN SIGNIFICANT
CYCLES VS. CORRECTED SPT VALUES

FIG. 13



APPLICATION OF THE AUTHOR'S AND WRITERS' RECOMMENDATIONS TO AN EAST COAST SITE

FIG. 14

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APPENDIX 324-B

CROSS-SECTIONS
UPPER CLAY LAYER

Photo 3. Sand-Craters

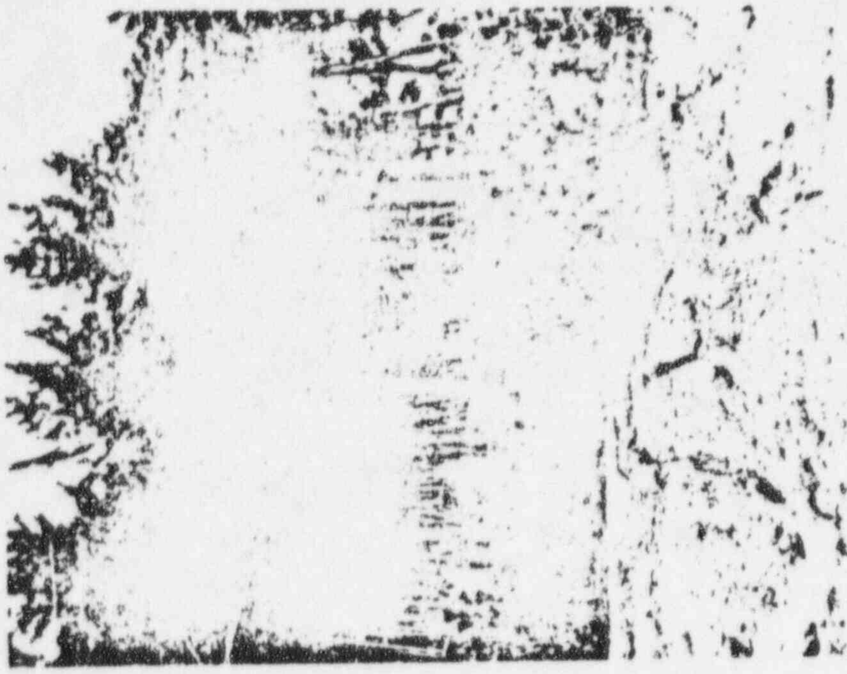
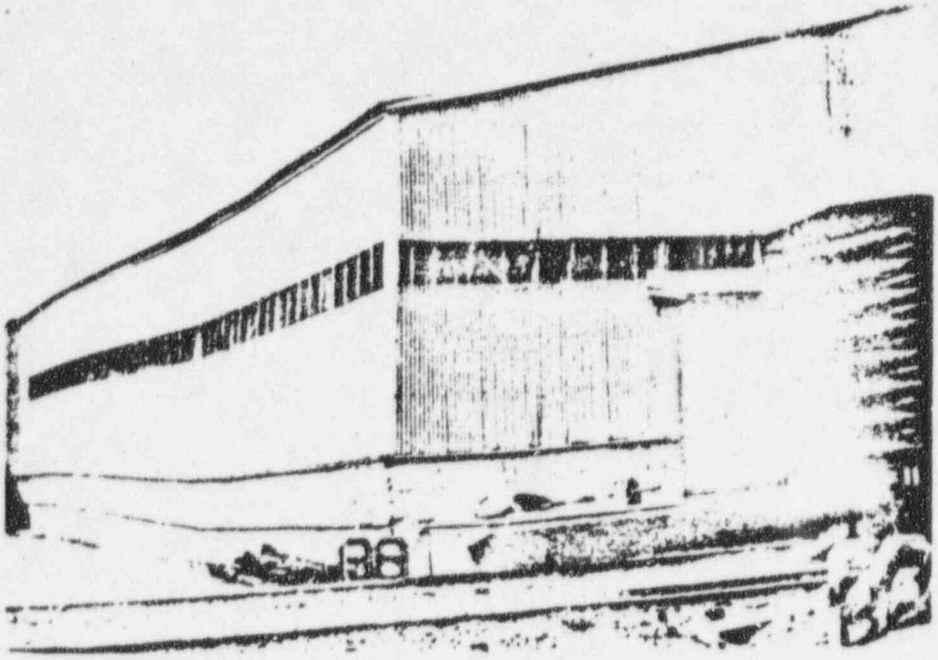


Photo 4. Boundary between Liquefied and Not-Liquefied Zones



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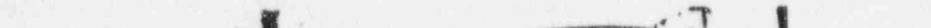

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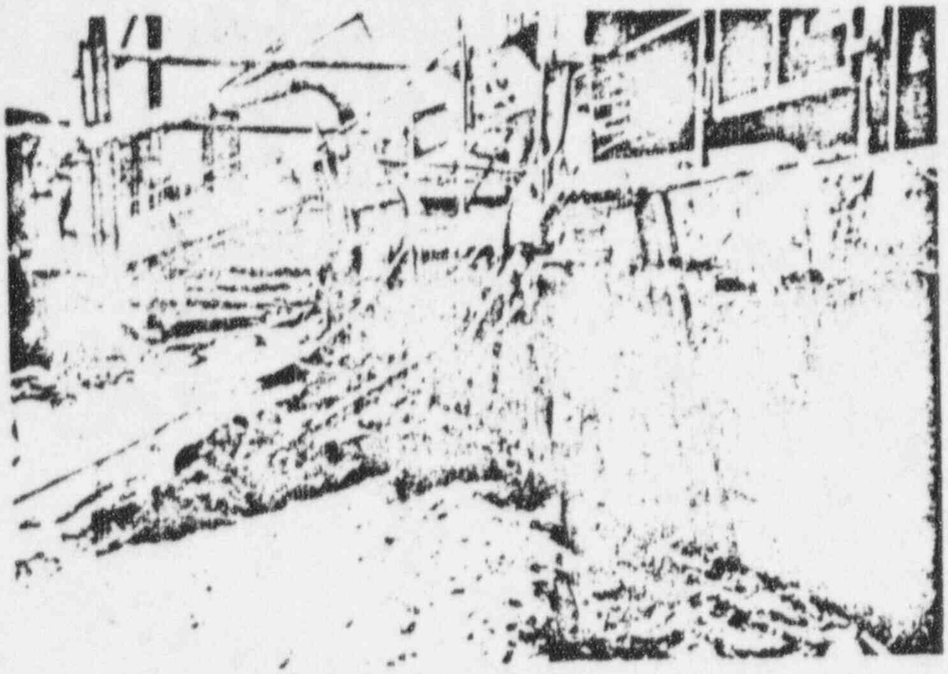

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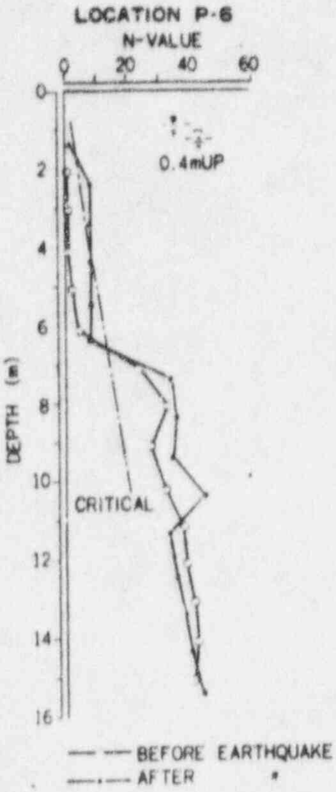
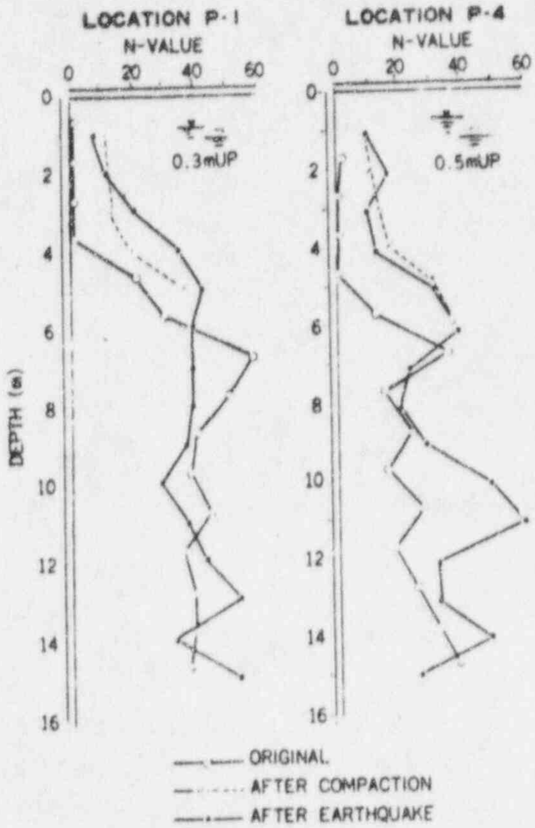


Fig. 13. Change of N-Values at Location P-6



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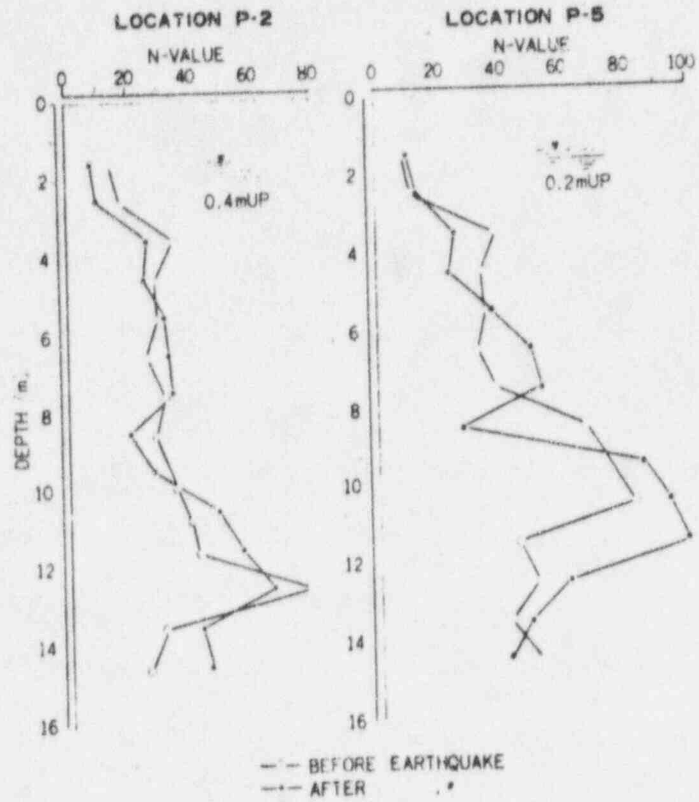

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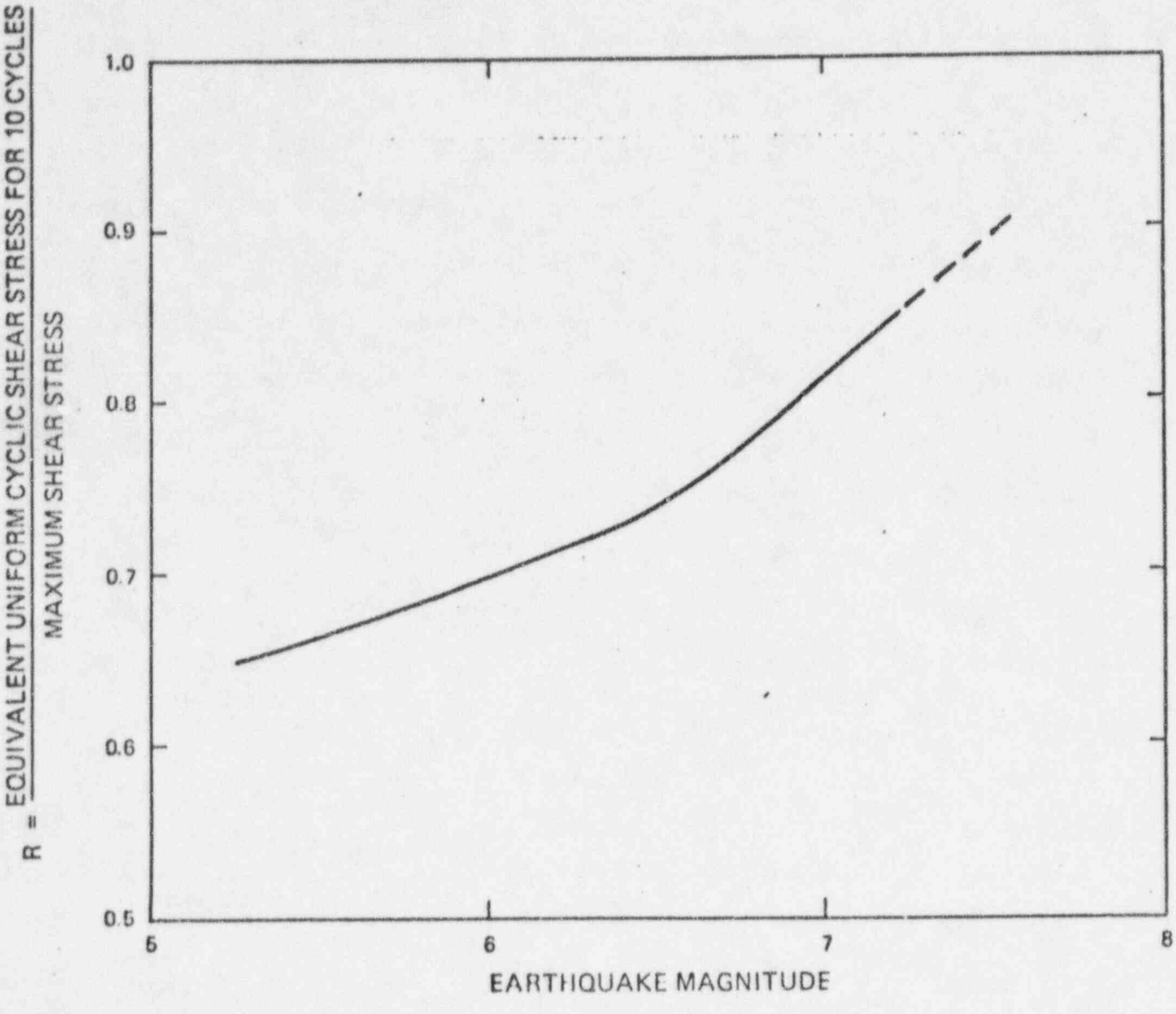

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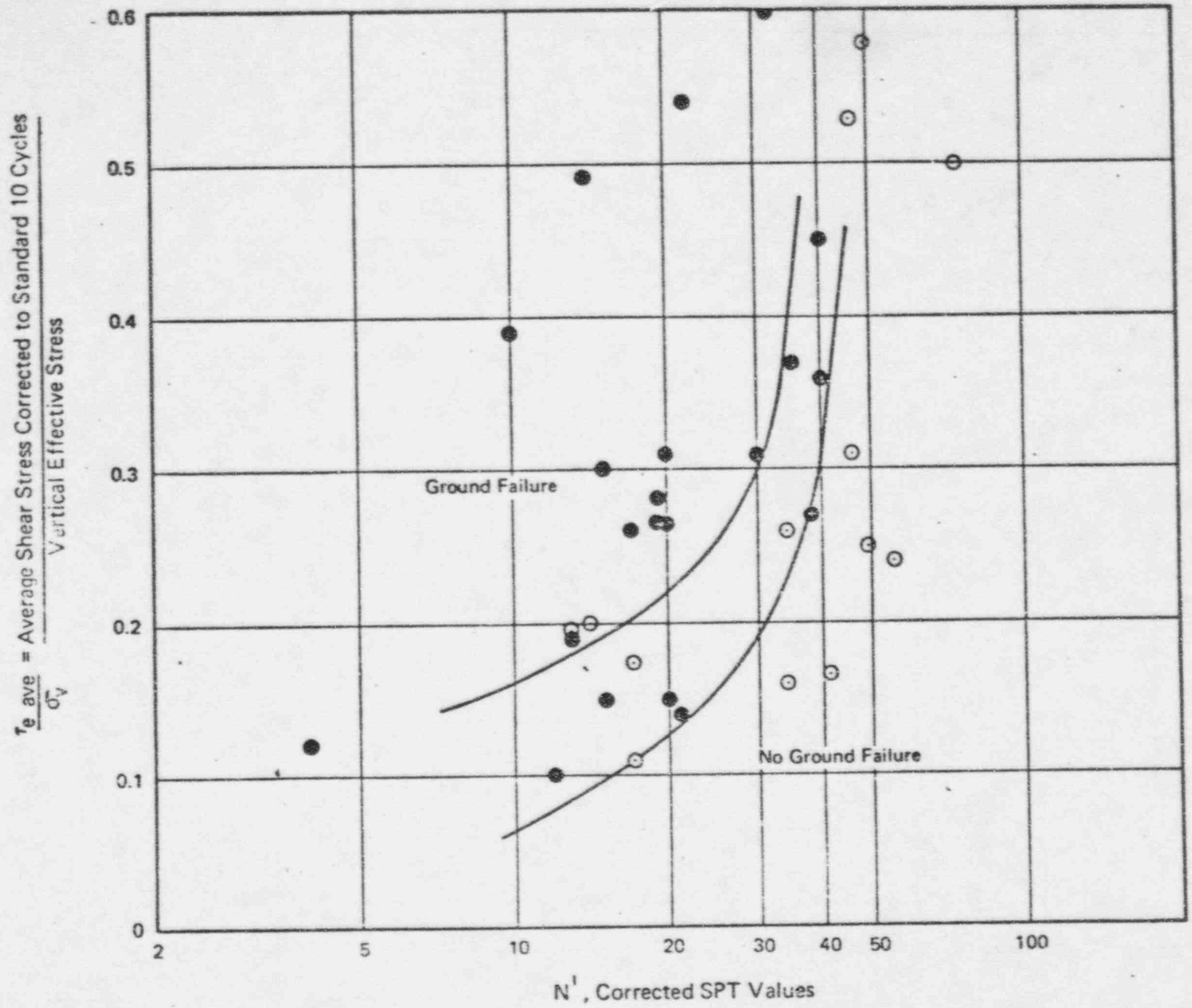
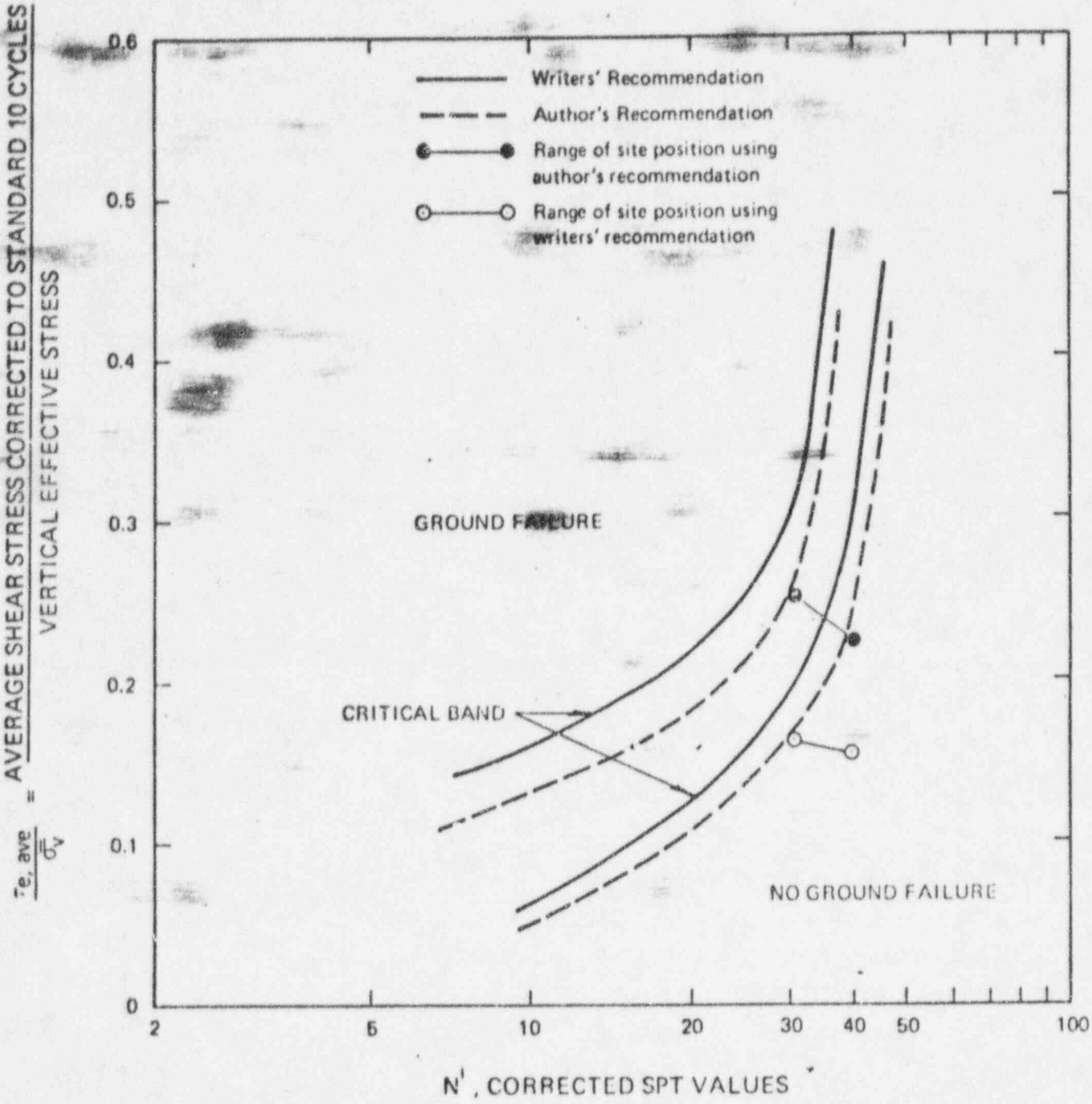


SHEAR STRESS NORMALIZED TO TEN SIGNIFICANT CYCLES VS. CORRECTED SPT VALUES

FIG. 12



APPLICATION OF THE AUTHOR'S AND WRITERS' RECOMMENDATIONS TO AN EAST COAST SITE

FIG. 14

APPENDIX 324-B

CROSS-SECTIONS UPPER CLAY LAYER

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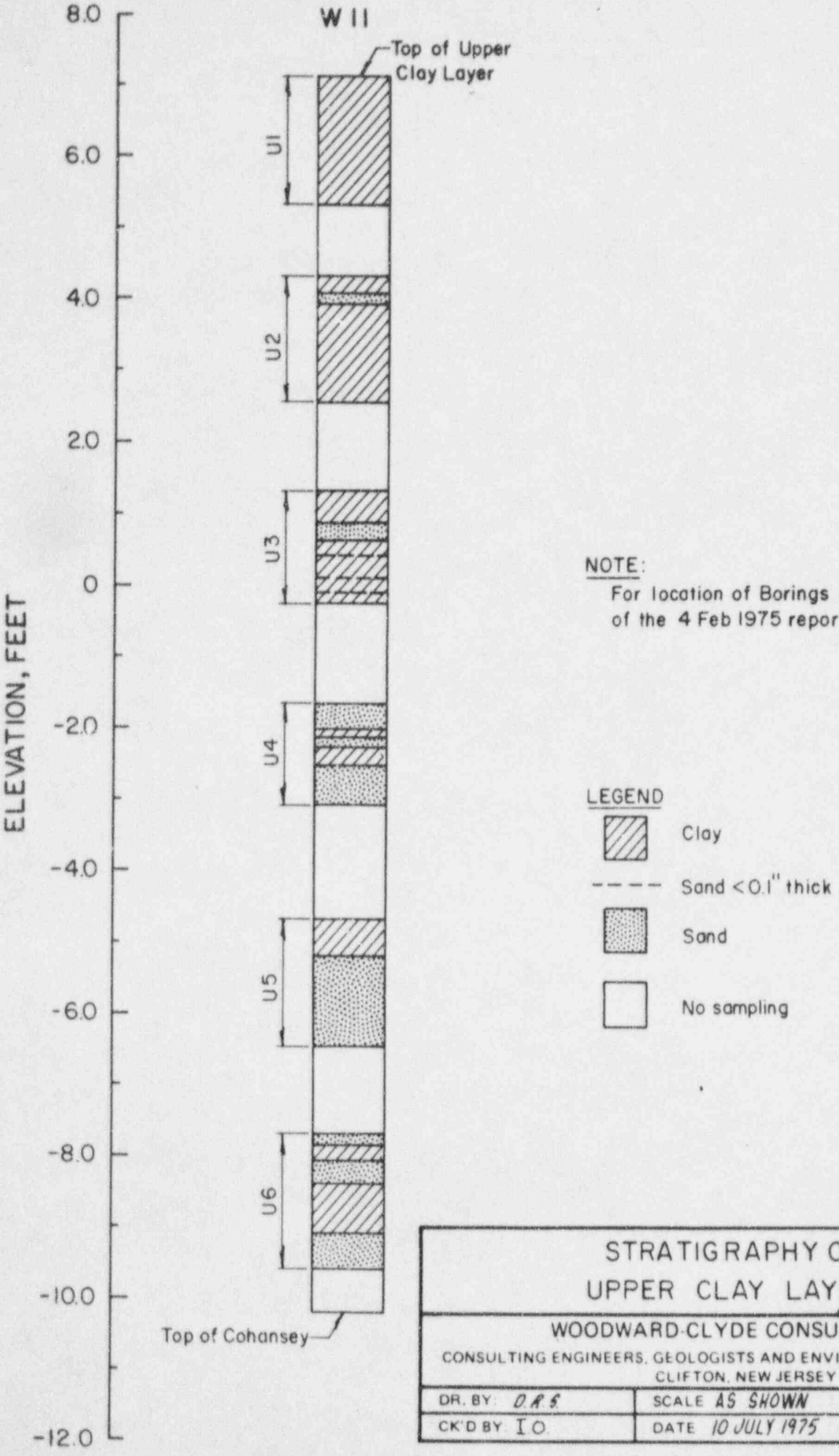
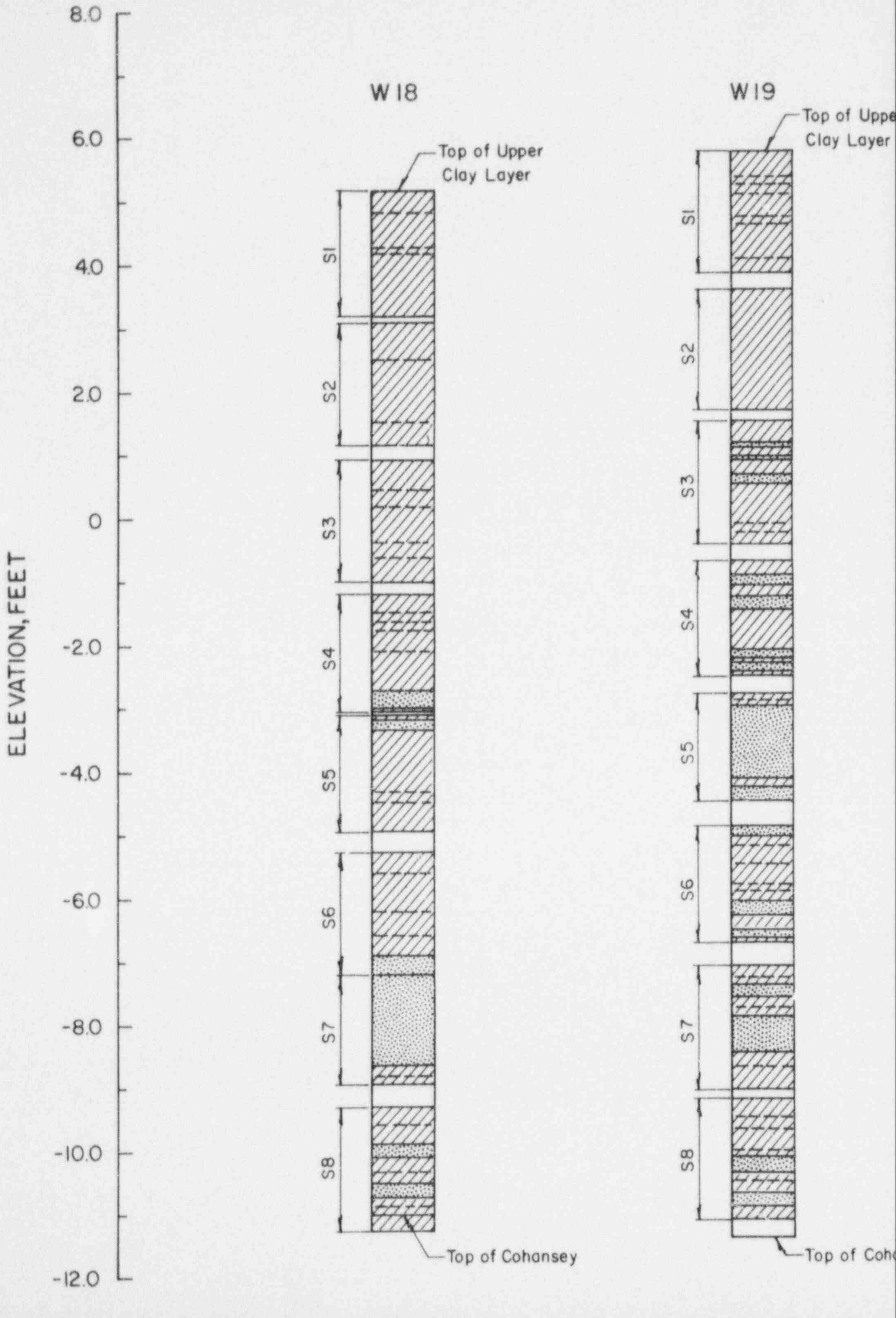
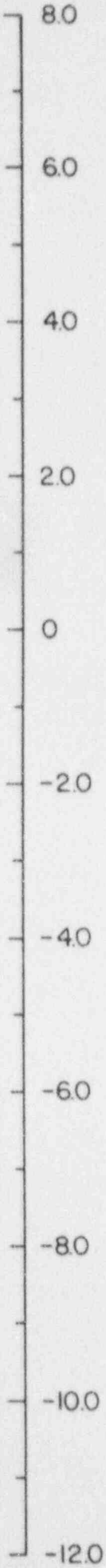


NOTE:
For location of Borings see Fig 1.3.1 of the 4 Feb 1975 report

STRATIGRAPHY OF UPPER CLAY LAYER		
WOODWARD-CLYDE CONSULTANTS CONSULTING ENGINEERS, GEOLOGISTS AND ENVIRONMENTAL SCIENTISTS CLIFTON, NEW JERSEY		
DR. BY: D.R.S.	SCALE AS SHOWN	PROJ. NO. 73C807B
CK'D BY: I.O.	DATE 10 JULY 1975	FIG. NO. 324.B.2



ELEVATION, FEET
8.0
6.0
4.0
2.0
0
-2.0
-4.0
-6.0
-8.0
-10.0
-12.0
W18
W19
Top of Upper Clay Layer
Top of Cohansey
S1
S2
S3
S4
S5
S6
S7
S8



ey

NOTE:

For location of Borings see Fig 1.3.1 of the 4 Feb 1975 report

LEGEND

- Clay
- ---- Sand <0.1" thick
- Sand
- No sampling

9604220210-02

STRATIGRAPHY OF UPPER CLAY LAYER

WOODWARD-CLYDE CONSULTANTS
CONSULTING ENGINEERS, GEOLOGISTS AND ENVIRONMENTAL SCIENTISTS
CLIFTON, NEW JERSEY

DR. BY ORS	SCALE AS SHOWN	PROJ NO. 73C807B
CK'D BY IO	DATE 10 JULY 1975	FIG NO. 324.B.3

73C807B

APPENDIX 324-C

DATA RELATIVE TO
OYSTER CREEK UNIT 2

ARTHUR CASAGRANDE
LEO CASAGRANDE

Oyster Creek No. 2

ARTHUR CASAGRANDE
LEO CASAGRANDE

Pierce Hall
Cambridge, Mass 02138

October 14, 1968

Mr. P. Nardone
Project Manager
Burns and Roe
700 Kinderkamack Road
Oradell, N. J. 07649

Subject: Oyster Creek No. 2
Relative Density Tests on Undisturbed
Sand Samples from Borings 19 and 20

Dear Mr. Nardone:

In accordance with your letter of September 30, we have performed relative density tests on the ten undisturbed samples of sand which were taken from borings 19 and 20. These samples were brought to our laboratory by car on September 30.

Five of the samples were taken in steel tubes with an outside diameter of three inches and a wall thickness of one-eighth inch, and five samples in brass tubes having the same dimensions. All tubes were 30 in. long. They were taken with a Model 200 Mayhew truck-mounted drill rig, using an Osterberg sampler with a 3.125 in. diameter piston.

The actual length of the samples inside the tubes ranged between 12 in. and 24 in. The portion of each sample that appeared sufficiently undisturbed to permit relative density determinations ranged between 5 in. and 14 in. All samples had disturbed material in the upper portion, and several showed also sample disturbance in the bottom portion.

The sands in these samples were generally clean, i.e. containing less than 5% passing a No. 200 sieve. The majority of the samples were fine to medium sands having uniform gradation. Several samples contained layers with a wider gradation which ranged into fine gravel, as can be seen in Figs. 1 and 2. All changes in gradation were gradual, without distinct stratification. However, some of the samples showed color stratification of yellow and gray. All these characteristics, and particularly the absence of distinct stratification and cross-bedding, and also the high relative densities which are reported below, are typical for beach deposits.

The results of 13 relative density determinations on sections of the samples which appeared to be sufficiently undisturbed, are listed in Table 1, together with other pertinent information. Grain size analyses were performed on all test specimens and the results are plotted in Figs. 1, 2 and 3.

As can be seen in Table 1, the relative densities of the test specimens ranged between 80% and 103%, with an arithmetic mean of 93.5% of all results. There appears to be no distinct variations in relative densities of the sands between the depths of 43 and 74 ft.

It is of interest to compare these results with relative densities reported in Table 4 of our report dated September 1968, for the sand layers between the depths of 81 and 99 ft. The principal purpose of that report was to investigate the properties of clay layers. However, since some of the undisturbed samples of clay contained sand layers, we performed on four specimens the relative density tests shown in that Table 4. Relative densities ranged between 87% and 103%, with an arithmetic mean of 95.2%; i.e. these results are similar to those listed in the appended Table 1. However, the sand layers between the clay layers were finer and contained about 7 to 8% of material passing a No. 200 sieve.

It is concluded from the relative density determinations that all sands below a depth of about 43 ft are dense to very dense and that they are safe beyond human doubt against liquefaction when subjected to a very severe earthquake.

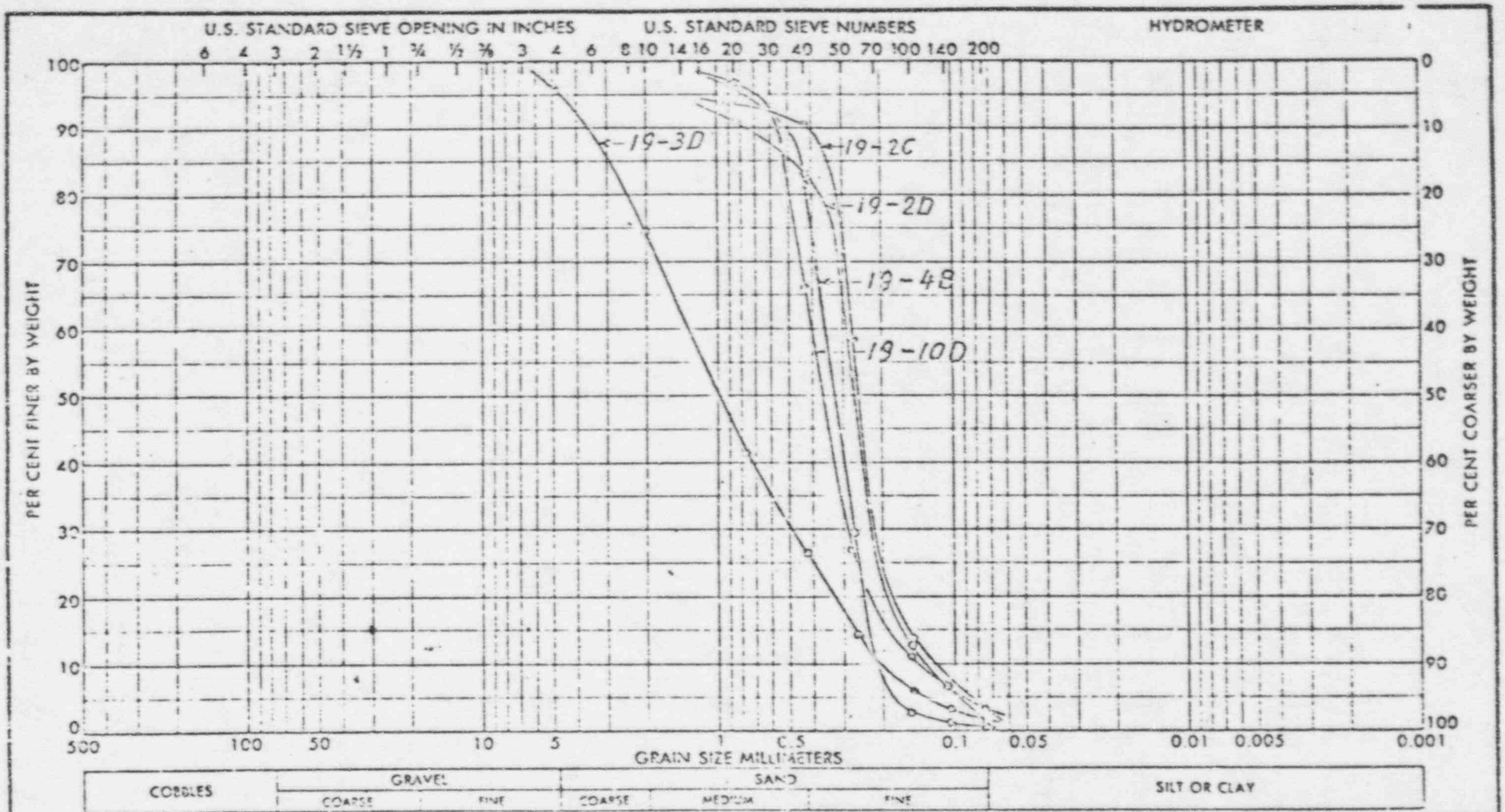
Sincerely yours,

A. Casagrande

A. Casagrande

AC:kd

Enc.



SAMPLE NO	ELEVATION DEPTH	CLASSIFICATION	NAT W%	LL	PL	PI
19-2C	44.6	Yellow & gray fine sand				
19-2D	45.6	Similar to 2C				
19-3D	49.5	Gray & yellow m. to c. sand				
19-4B	52.8	Red fine to medium sand				
19-10D	73.5	Tan fine to medium sand				

GRADATION CURVES

PROJECT 6813

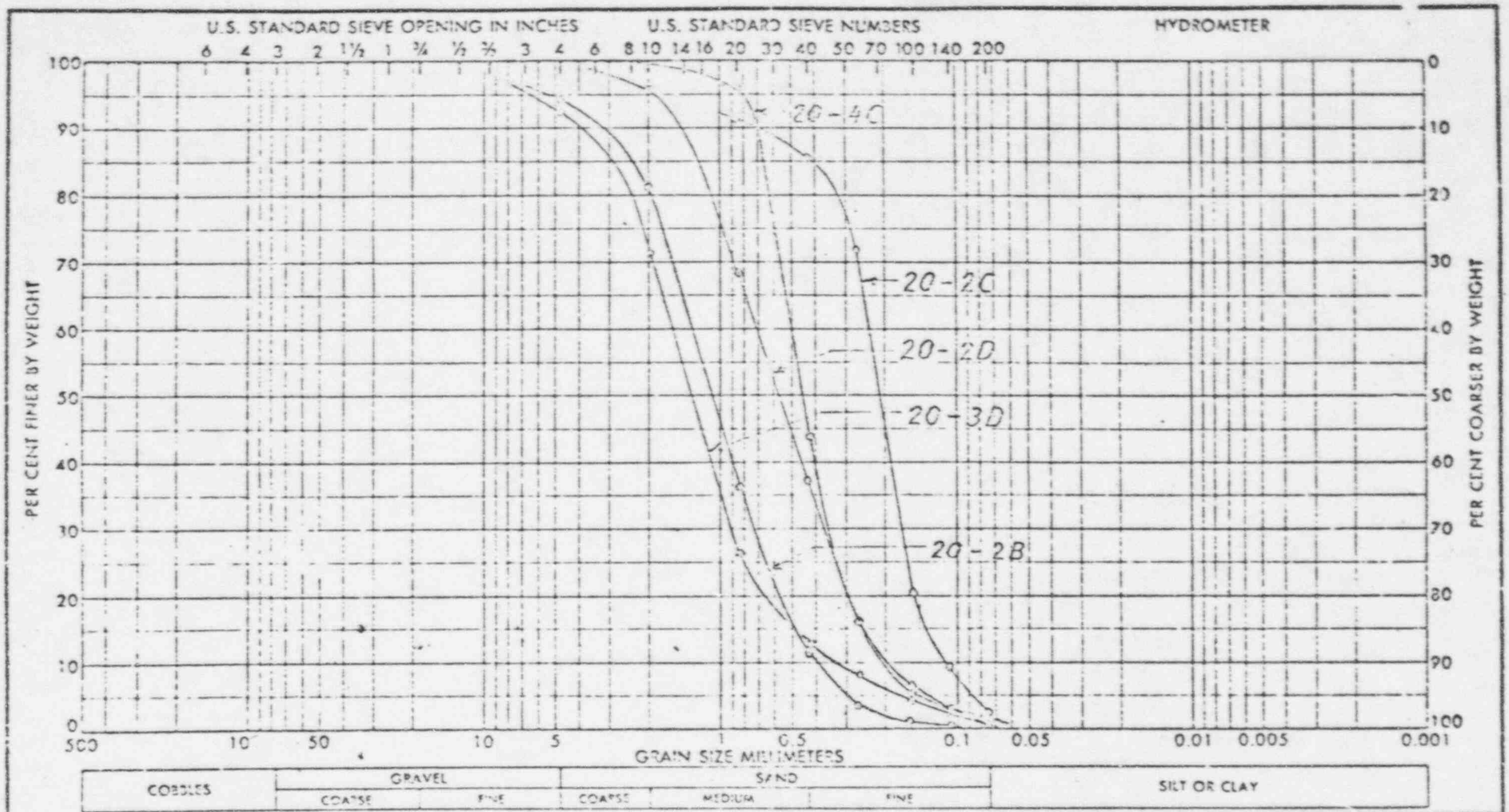
OYSTER CREEK PLANT

AREA UNIT No. 2

BORING NO 19

DATE October 1968

FIG.



SAMPLE NO	ELEV. OR DEPTH	CLASSIFICATION	NAT W%	LL	PL	PI
20-2B	43.0	Red med. to coarse sand				
20-2C	43.4	Yellow & gray fine sand				
20-2D	44.2	Brown medium sand				
20-3D	49.5	Similar to 2B				
20-4C	51.6	Red fine to med. sand				

GRADATION CURVES

PROJECT 6813

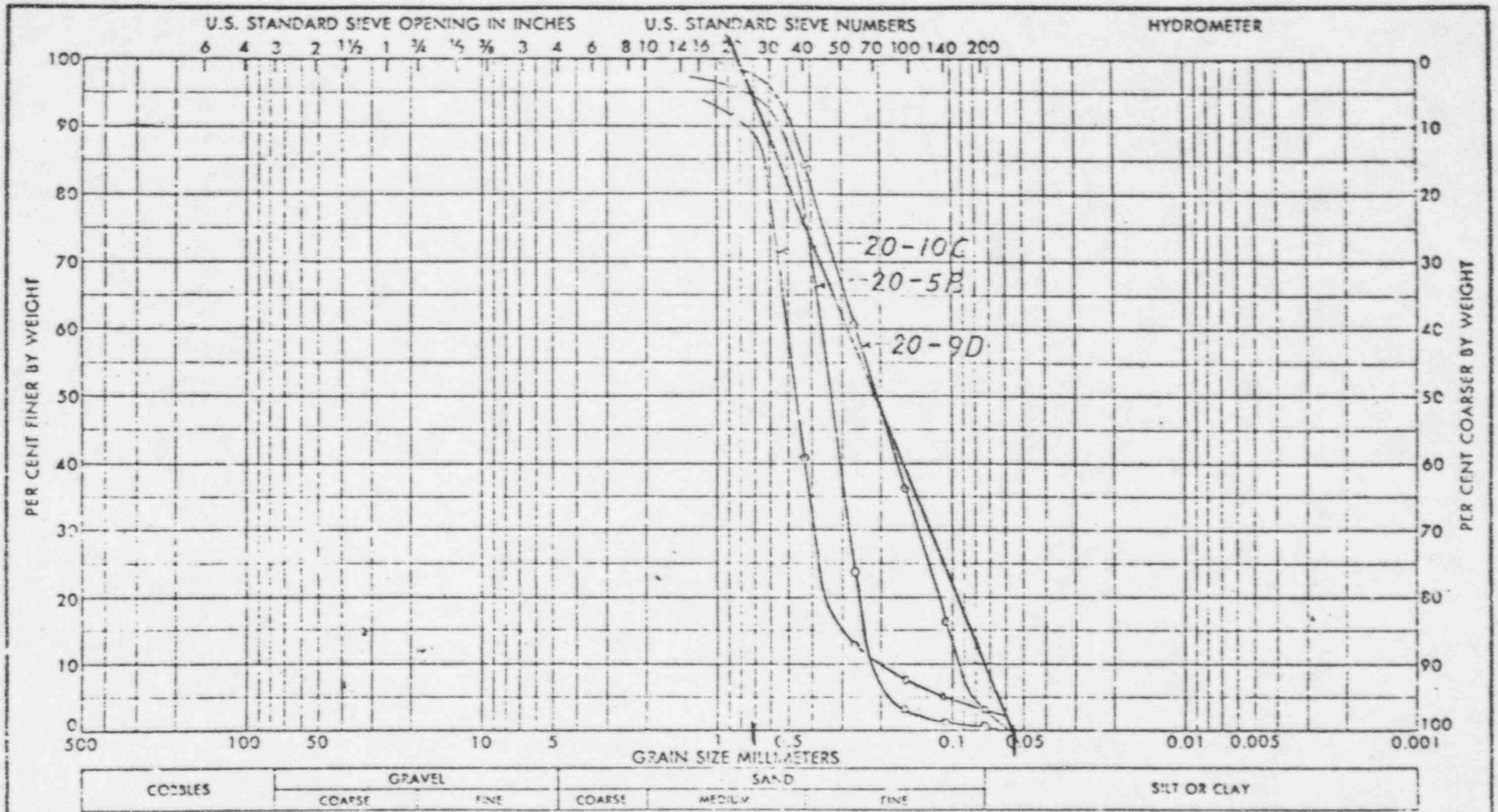
OYSTER CREEK PLANT

AREA UNIT No. 2

BORING NO 20

DATE October 1968

FIG. 2



SAMPLE NO.	ELEV. OR DEPTH	CLASSIFICATION	NAT. W%	LL	PL	PI
20-5B	54.8	Tan fine to med. sand	Cr=2.0			2.2
20-9D	63.2	Similar to 5B			13.2	
20-10C	73.4	Gray medium sand				

PROJECT 6813

OYSTER CREEK PLANT

AREA UNIT No. 2

BORING NO. 20

DATE October 1968

GRADATION CURVES

20-5B, Cr: 2.2, D50: 0.21

FIG. 2

TABLE 1

RELATIVE DENSITY TESTS ON UNDISTURBED

SAND SPECIMENS

BORINGS NO. 19 AND NO. 20 (El.~+20)

Boring, Sample & Section No.	Depth ft	Dry Unit Weight lb/cu ft	Relative Density %
20-2B	43.0	113.5	95
20-2C	43.4	105.0	103
20-2D	44.2	117.0	96
19-2C	44.8	104.5	99
19-2D	45.6	103.0	92
20-3D	48.0	118.5	81
19-3D	49.5	121.2	101
20-4C	51.6	104.8	80
19-4B	52.8	100.5	81
20-5B	54.8	101.5	92
20-9D	69.2	109.0	101
20-10C	72.4	122.3	103
19-10D	73.5	115.0	90

Report

to

BURNS AND ROE

on

FOUNDATION INVESTIGATION

for the

OYSTER CREEK NUCLEAR POWER PLANT - UNIT No. 2

by

A. & L. Casagrande

Pierce Hall
Cambridge, Mass.
September 1968

TABLE OF CONTENTS

TABLE OF CONTENTS (Continued)

LIST OF FIGURES

LIST OF TABLES

I. INTRODUCTION

During May 1968, exploratory borings No. 1 to 16 were carried out at the site for Unit No. 2 by the boring contractor Warren George. In 15 of these borings, standard split-spoon samples were taken at approximately 5 ft intervals, except at elevations where 3 in. undisturbed samples were taken in five of these borings. In only one boring were consecutive undisturbed samples taken from the stratum between depths of about 80 and 100 ft, which was found to contain clay layers.

Of the 16 borings, seven were stopped at a depth of about 51 ft, one at 75 ft, one at 102 ft, five at 150 ft, one at 200 ft and one was advanced to a depth of 252 ft.

In June 1968, we received the logs of borings 1 to 16 and the split-spoon samples from borings 4 and 5. Examination of these samples disclosed the presence of thin layers of organic clay at a depth of about 100 ft. Furthermore, the boring logs indicated that similar thin clay layers may be found between the depths of about 80 and 100 ft. Therefore, we requested that the nine undisturbed samples from boring 14, which were taken between the depths of 80 and 102, be sent to us for detailed examination and testing. These samples were transported to us by Mr. W. G. Thorpe by automobile on July 8, 1968.

The purpose of this report is to present the following data and results of our investigations:

1. The description, with a few classification tests, of the split-spoon samples from borings 4 and 5.

2. The detailed description and classification tests of the undisturbed samples from boring 14, including relative density tests on undisturbed specimens of sand layers.

3. Compressive strength tests on undisturbed specimens of the organic clay layers from boring 14.

4. Consolidation tests on undisturbed specimens of organic clay layers from boring 14.

5. Computation of contribution to settlements from consolidation of the clay layers.

6. Estimation of probable range of settlements for Unit No. 2 based on (1) a comparison of the borings from Units No. 1 and No. 2 and (2) a review of the observed settlements of Unit No. 1.

II. GENERAL DESCRIPTION OF SOIL STRATA

The ground surface for all borings 1 to 16 was approximately El. 20. Therefore, it is convenient to use for reference depths from the ground surface.

All subsoil strata are found to extend horizontally across the entire site. They are described under the following subheadings.

Stratum A - Compact Sand

This stratum is probably a beach sand deposit. It extends to an average depth of 17 ft (El. +3), with a minimum depth of 14 (El. +6) and a maximum depth of 20 ft (El. zero).

The majority of the standard penetration resistance values "N" averages between 25 and 40 blows/ft. The minimum "N" values in all borings, omitting one extreme value, range between 20 and 51. The maximum "N" values range between 34 and 70.

Stratum B - Dark-colored Organic Clay

This stratum ranges between the average depths of 17 and 34 ft (El. +3 to El. -14), thus averaging 17 ft in thickness. The top surface varies between the depths of 14 and 20 ft, (El. +6 and El. zero), and the bottom surface between the depths of 25 and 39 ft (El. -5 and El. -19).

The consistency of this clay stratum varies erratically between stiff and medium soft, indicating that during its deposition, it has been subjected to drying cycles.

The standard penetration resistance values "N" range between the extremes of 3 and 32, with the majority of the blowcounts ranging between 10 and 20. The higher blowcounts are undoubtedly influenced by interbedded layers of sand.

Stratum C - Compact Fine Sand

This stratum of light-brown, medium to fine sand extends from the bottom of the overlying organic clay to an average depth of about 80 ft (El. -60).

Burns and Roe has tentatively proposed to excavate all soils to a depth of 50 ft (El. -30), and then backfill to foundation grade El. -20 with properly compacted granular materials. Therefore, it is of interest to review the "N" values in this sand stratum separately between the depths of 40 and 50 ft (since excavation to a depth of 40 ft would be necessary to eliminate all clay) and below a depth of 50 ft.

The "N" values between the depths of 40 and 50 ft are listed below for all borings, using the abbreviation "R" for "N" values greater than 100, which is usually referred to as "Refusal".

Boring No.	"N" Values Between Depths of 40 and 50 ft
1	37
2	68-68
3	49-R
4	R-R
5	98-85
6	17-R
7	47-43-61
8	58-57
9	44-42
10	59-62
11	R-40
12	51-42
13	35-38
14	R-R
15	28-17

The "N" values below a depth of 50 are listed for the eight deep borings in the following summary.

Boring No.	"N" Values Between Depths of 50 and 80 ft
2	29-R-R-78-72-29-34
3	49-R-R-R-72-40
4	50 R-95-R-R-R-R
5	50 91-22-R-R-59-64
6	85-R-R-83-73-R-54-R
10	58-29-R-62-85-85
14	70-R-R-R-89-77
15	23-R-R-R-R-R

In the six borings which were stopped at about 51 ft, the single "N" value obtained in each boring, starting with the blowcount at a depth of 50, was as follows:

Boring No.	7	8	9	11	12	13
"N" Value	37	R	38	32	6	R

Of the total of 29 "N" values recorded between the depths of 40 and 50 ft, there were six refusals and only three values less than 30.

Of the total of 57 "N" values determined in this stratum between the depths of 50 and 80 ft, there were 22 refusals (R), and only five values less than 30. Four of these five "N" values range between 22 and 29, and they were preceded or followed by very high blowcounts.

The last split-spoon sample which was taken in boring 12 from depth 50.0 to 51.5 ft, showed blowcounts of only 3/3/3, i.e. N = 6. This absence of any increase in resistance between the successive blowcounts for 6-inch penetrations, indicates that the blowcount was taken in badly disturbed sand, probably sand which had been subjected to a "quick" condition created by faulty technique.

As disclosed by the "N" values, it can be seen that there is no difference in the compactness of the sand stratum between the depths of 40 to 50 ft and below 50 ft.

The boring contractor, Warren George, used boring equipment and techniques for determining the "N" values which are similar to those used by the Raymond Company. Since we have extensive experience with "N" values in sands obtained by the Raymond Company, we assume that the "N" values obtained by these two contractors are comparable On this basis, we conclude that a sand stratum with "N" values as listed above, and with only occasional blowcounts falling below 30, has relative densities substantially greater than 70%. This conclusion is also substantiated by the results of relative density determinations of undisturbed samples of the sand from Stratum D (87% to 103%), in which the average "N" values were actually smaller than in Stratum C, as presented under the next heading.

On the basis of this review, it is concluded that the sand deposit below a depth of 50 ft is generally very compact.

Stratum D - Stratified Fine Sands and Thin Layers of Clay

Between the average depths of 80 ft and 105 ft (El. -60 to El. -85) there is a stratum of dark-gray and brown fine sands, usually slightly silty, containing thin layers of dark-brown organic clay. In the und. urbed samples from boring 14, the greatest thickness of a clay layer was found to be 5 in. The majority of the clay layers were less than one inch thick. Based on accurate measurements of the thickness of all clay layers in the nine undisturbed samples from boring 14, it is estimated that the combined thickness of all clay layers in this stratum is approximately 5.5 ft.

The "N" values in this stratum varied erratically between the extremes of 14 and Refusal, depending on whether the resistance was developed chiefly in the compact sand layers or whether clay layers were encountered.

The "N" values in this stratum ranged as follows:

Boring No.	"N" Values in Stratum D
2	34-40-66
3	25-26
4	26-27-26-61
5	26-R
6	54-R-R
10	14-23-69-69
14	44 (one determination interrupting sequence of undisturbed samples)
15	23-23-R

Of the total of 22 "N" values, four were in excess of 100 (refusal) and 10 values were smaller than 30.

The clay layers were found to be hard and brittle in the undisturbed state. Further information on the properties of these clay layers are presented in Chapters V and VI.

Stratum E - Very Compact, Fine to Medium Sands

Underlying Stratum D is a massive stratum of very compact, gray, fine to medium sand. In boring 2, it was found to extend to the bottom of the boring, depth 200 ft (El. -180). In boring 4, this stratum was found to extend to a depth of 218 ft (El. -198).

The majority of the "N" values are in excess of 100, i.e. refusal. The single relatively low value of N = 40, in boring 15 was obtained immediately beneath Stratum D, at a depth of 105 to 106.5 ft. The other nine "N" values at greater depths were all refusals, i.e. in excess of 100.

Stratum F - Very Deep Clay Layers in Boring 4

In boring 4, two very hard clay layers were encountered between the depths of 218 and 230 ft (El. -198 and El. -210), and between 243 and 251 ft (El. -223 and El. 231). The "N" values in these clay layers ranged between 69 and 93.

III. SPLIT-SPOON SAMPLES FROM BORINGS 4 AND 5

Only from borings 4 and 5 were the split-spoon samples sent to us for examination. The description of these samples, together with other pertinent information and the results of some classification tests are recorded in Tables 1 and 2.

IV. DESCRIPTION OF UNDISTURBED SAMPLES FROM BORING 14, AND CLASSIFICATION TESTS

Nine undistrubed 3 in. diameter samples were obtained from boring 14 between the depths of 80 and 102 ft. In our laboratory these samples were cut into sections averaging 6 in. long, and each section was extruded and examined. All clay layers were recovered with great care and were used for various tests. Several layers of sand that appeared to be quite undisturbed and which showed no significant variations in gradation, were used for relative density tests.

A summary of all pertinent information on these samples, including the results of the classification tests, is contained in Table 3.

The in situ dry unit weights and corresponding relative density tests on four sand specimens, cut from sand layers which were of sufficient thickness to permit such determinations, are listed in Table 4. The relative densities ranged between 87 and 103%. The grain size curves for the same and also several other sand specimens are plotted in Fig. 1 and 2.

Table 5 contains a listing of the thickness of all clay layers which were found in the undisturbed samples, together with their natural water contents and the Atterberg Limits.

In the plasticity chart in Fig. 3 are plotted, in the conventional manner, the results of the Atterberg Limit tests determined on "undried" specimens. As can be seen, almost all points fall slightly to considerably below the A line. This is typical for organic clays. On this plot are also shown the results of tests performed on oven-dried material. These points are connected to the positions of the "undried" material by dashed lines. As can be seen, the plasticity index is reduced by more than 50% by ovendrying, which is also typical for organic clays.

V. COMPRESSIVE STRENGTHS OF UNDISTURBED CLAY SPECIMENS

The results of unconfined compression tests are listed in Table 6, and three representative stress-strain curves are plotted in Fig. 4. As indicated in Table 6, four of the test specimens broke prematurely by splitting and gave the lowest strength values. Those specimens which failed with well-developed shear planes gave compressive strengths between 5 and 8 kg/sq cm (tsf).

It was observed that the most brittle clay layers had natural water contents below the plastic limit. A specimen of such a layer was kept under water for a period of four weeks and showed no signs of swelling. By comparison, other clay layers were found to have water contents substantially higher than the plastic limit. It is believed that such clay layers had suffered excessive strains during sampling which broke the structural bonds, releasing the swelling potential and causing water to be absorbed from the adjacent sand layers. Therefore, the compressive strength results reported below are probably on an average substantially smaller than the in situ strength of these clay layers.

VI. CONSOLIDATION TESTS ON UNDISTURBED CLAY SPECIMENS

The results of six consolidation tests on specimens cut from those clay layers which appeared to be least disturbed, are shown in Table 7 and in Figs. 5 to 10. As can be seen, the void ratio-pressure curves disclose a well-developed preconsolidation pressure, which are indicated in the figures by a heavy horizontal bar, and which are summarized in Table 7. They indicate a preconsolidation pressure ranging between 10 and 1[illegible] tsf.

From these few consolidation tests, it is not possible to conclude whether the preconsolidation was produced by drying or by a substantial thickness of additional overburden which was later eroded. It would be of interest to obtain the opinion of a geologist who has specialized in the soil deposits of the east coast.

In the consolidation test shown in Fig. 9, the swelling and recompression characteristics were determined within the load range of 9.0 and 0.75 tsf. The slope of this rebound loop yields the recompression index $C_r = 0.022$.

VII. ESTIMATION OF SETTLEMENTS

The most reliable basis for an estimation of the settlements of Unit No. 2 are the observed settlements of Unit No. 1, provided it is proven that the subsoil conditions at both units are similar. In addition, our measurements of the thickness and compressibility of the clay layers permit an analysis of the contribution to the settlements from consolidation of these clay layers. These two avenues of analysis are presented under the following sub-headings.

1. Comparison of Subsoil Conditions at Units No. 1 and No. 2

When comparing the description of the soil strata and the "N" values which are contained in the boring logs for Unit No. 1 with those for Unit No. 2, one must keep in mind that these two sets of borings were carried out by different boring contractors using different equipment. The soil names which are used by boring foremen are "highly individualistic". Such men have no training in soil mechanics. Particularly the older boring foremen are accustomed to using the term "silt" for all organic fine-grained soils which in soil mechanics are classified as organic clays and organic silt-clays.

The borings for Unit No. 1 were made by Sprague & Henwood, and in their logs the term "silt" is used both for the upper organic clay stratum as well as for the clay layers which we found between the depths of 80 and 105 ft at site for Unit No. 2, i.e. in Stratum D as designated in this report. This Stratum D can be identified clearly also in all those borings for Unit No. 1 which extend to sufficient depths when keeping in mind what is meant by the term "silt" in those boring logs.

From such a comparison, the conclusion is justified that all subsoil strata extend essentially horizontally beneath both units and have similar properties. However, the "N" values cannot be used to demonstrate this similarity because the standard penetration resistances values "N" depend greatly on the equipment and techniques used for determining the blowcount. For example, we have made comparative investigations between the "N" values obtained at another site by Sprague & Henwood and other boring contractors, and we have observed that (1) the "N" values obtained by Sprague & Henwood are consistently and very substantially greater than those obtained by the other contractors, and (2) that even the same contractor using two different types of equipment will obtain quite different "N" values at the same location and within the same stratum.

2. Settlements of Reactor Unit No. 2 Estimated from Observed Settlements of Reactor Unit No. 1

According to the data contained in the Burns and Roe letter of August 16, addressed to the writers, the settlements of Reactor Unit No. 1 from start of construction until May 1968 have ranged between 0.055 and 0.062 ft. By comparison, we have estimated settlements of "less than one inch" in our letter to Burns and Roe dated July 3, 1964. We agree with your conclusion that the settlements of Unit No. 1 have approached their ultimate value. Certainly any additional total and differential settlements will be negligible.

Since Reactor Unit No. 2 will be founded at an elevation about 11 ft higher than Unit No. 1, and also, because it will apply a slightly greater unit load at foundation grade El. -20, the settlements of Unit No. 2 would be correspondingly greater.

On the basis of these considerations, we conclude that the settlements of Reactor Unit No. 2 will probably range well below 1.5 in., and that they will be very uniform.

<u>Contribution to the Settlements from Consolidation of Clay Layers</u>

The combined thickness of all clay layers listed in Table 5 is 48 in. By increasing this thickness in the ratio of the total thickness of Stratum D to the total length of the undisturbed samples from boring 14, one arrives at an estimate for the total thickness of all clay layers of 5.5 ft.

The bottom of the mat for Reactor Unit No. 2 will be at El. -20, i.e. 11 ft higher than the bottom of the mat for Reactor Unit No. 1.

After excavation to El. -20 is completed, the effective stress in the middle of Stratum D will be $p = 1.67$ tsf. Assuming that Unit No. 2 will apply a loading of $\Delta p = 4.0$ tsf, we obtain an effective stress of 5.67 tsf in the middle of stratum D. This increase in effective stress will cause a decrease ΔH in the total thickness $H = 5.5$ ft of the clay layers which is computed as follows:

$$\Delta H = H \frac{C_r}{1 + e} \log \frac{p + \Delta p}{p} = 0.39 \text{ in.}$$

Based on this result, it is concluded that only about 0.3 in. of the total settlements of Unit No. 1 was caused by compression of the highly compact sand strata, and the remainder was caused by consolidation of the organic clay layers in Stratum D.

VIII. SUMMARY AND CONCLUSIONS

Comparison of the borings and soil test data for Units No. 1 and No. 2 shows that both areas are underlain by the same sequence of horizontal strata.

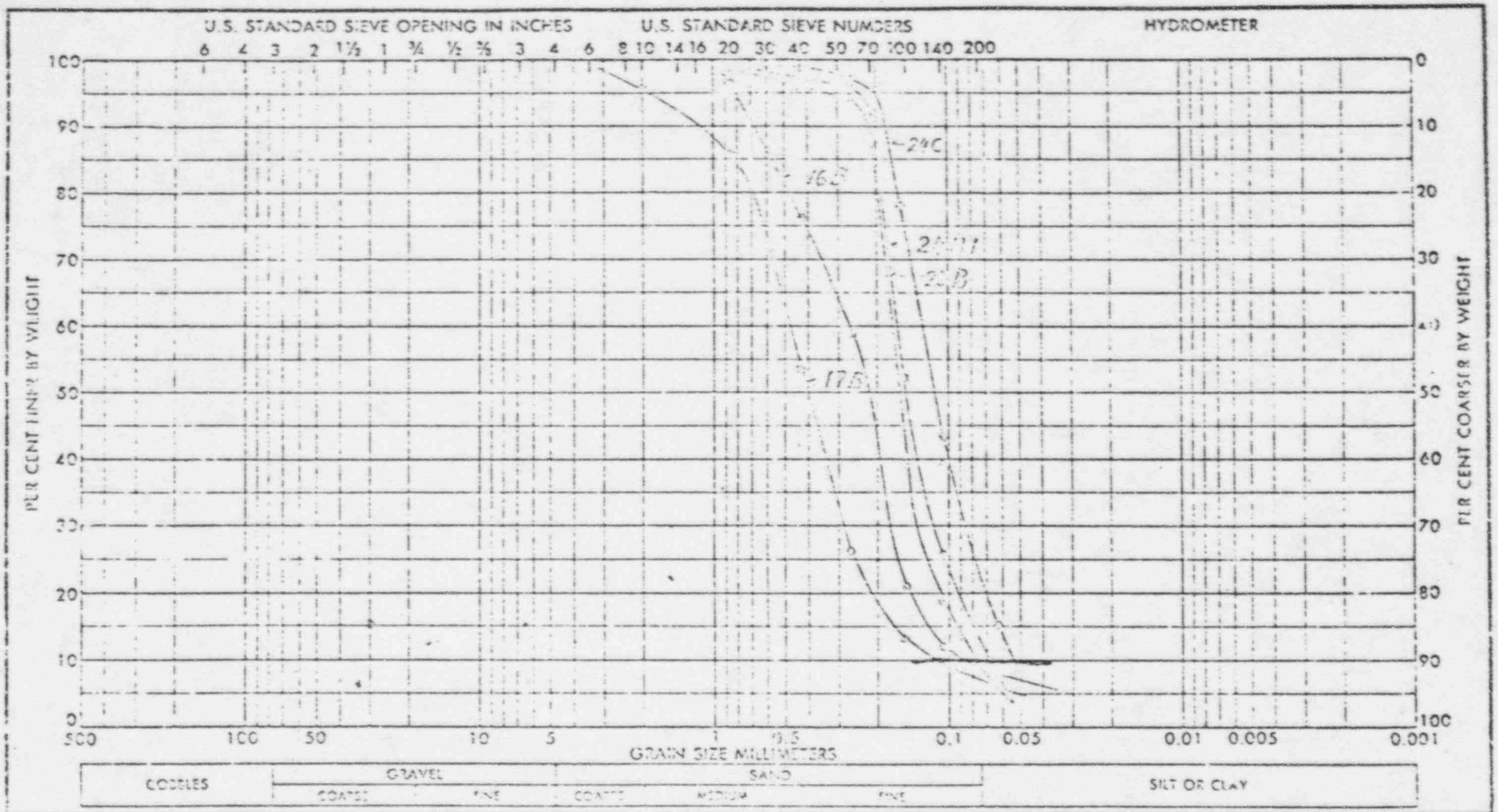
Below the proposed foundation grade for the Reactor Unit No. 2, i.e. El. -20, to approximately El. -60, there is a compact stratum of sand. This sand stratum is underlain by stratified compact sand and thin layers of clay, extending to an average El. -85. Below that stratum there are very compact sands and occasional very hard clay layers extending to great depth.

From the standpoint of the performance of the structures, the significant subsoil strata are the sands and the thin clay layers which extend from the bottom of the mat for the Reactor Unit No. 2 at El. -20 down to El. -85.

From all available information and test results, we conclude that the relative density of the sands below El. -20 are on an average substantially greater than 70%.

The compressibility of the thin clay layers will contribute only about 0.4 in. to the settlements of the Reactor Unit No. 2.

The total settlement of the reactor Unit No. 2 will probably range well below 1.5 in., and they will be very uniform. For practical purposes, these settlements will occur during the construction period, and post-construction settlements will be of negligible magnitude.



SAMPLE NO	ELEV OR DEPTH	CLASSIFICATION	NAT WC	LL	PL	PI
16 B	-61.6	Gray fine to med. sand				
17 B	-65.0	Gray fine to med. sand				
[illegible]	[illegible]	Gray fine sand				
[illegible]	[illegible]	Dark gray fine sand				
24 C	-79.9	Dark gray silty fine sand				

GRADATION CURVES

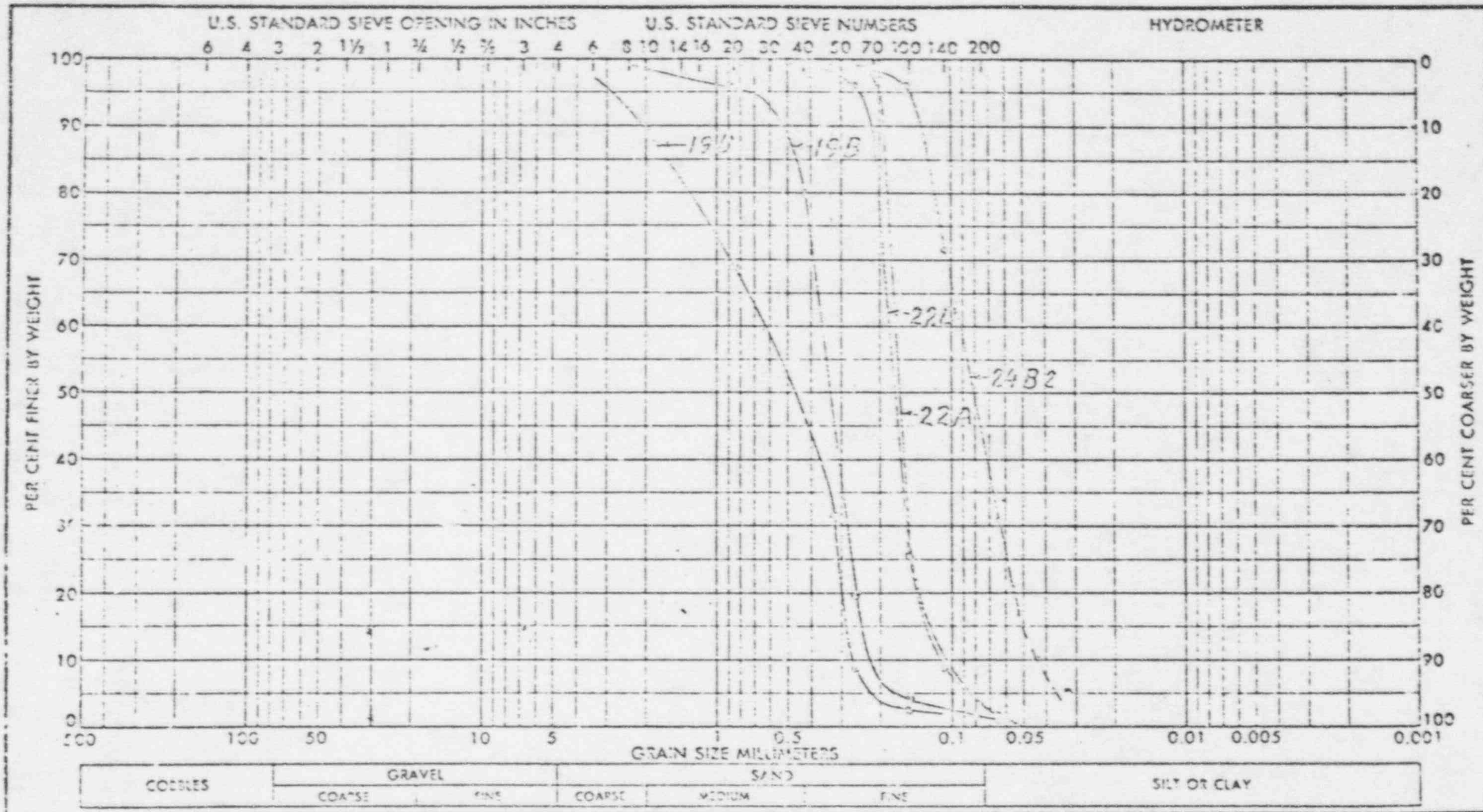
PROJECT 6613

SAND LAYERS OF STRATUM D

AREA UNIT No. 2

BORING NO 14

DATE Sept. [illegible]



SAMPLE NO	ELEV OR DEPTH	CLASSIFICATION	NAT W%	LL	PL	PI
19 B	-6[illegible].7	Dark gray fine sand				
19 [illegible]	-69.5	Dark gray fine to med. sand				
[illegible]A	-74.4	Dark gray fine sand				
2[illegible]	-75.3	Dark gray fine sand				
[illegible]	-79.4	Dark gray silty fine sand				

GRADATION CURVES

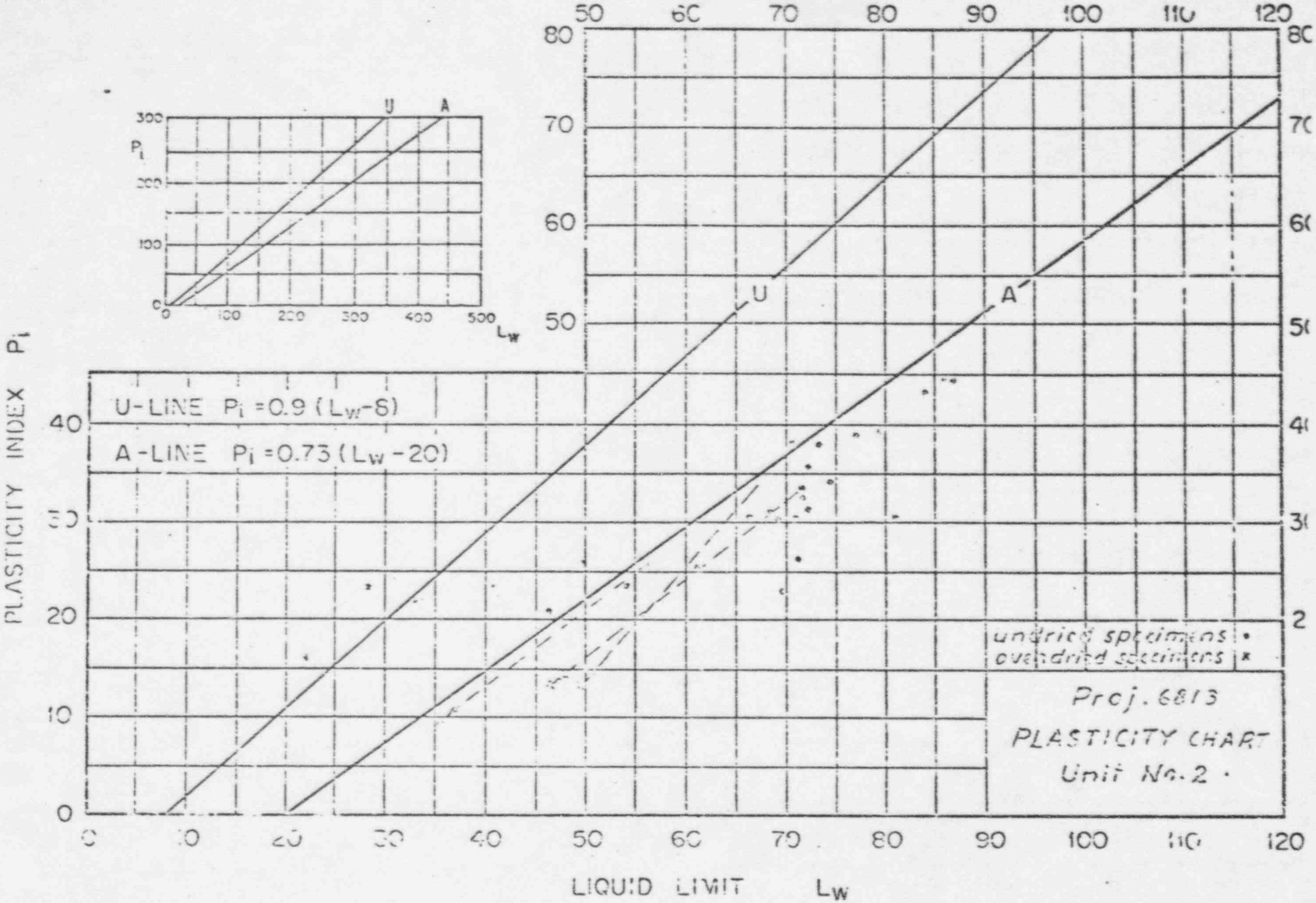
PROJECT 6813

SAND LAYERS OF STRATUM D

AREA UNIT No. 2

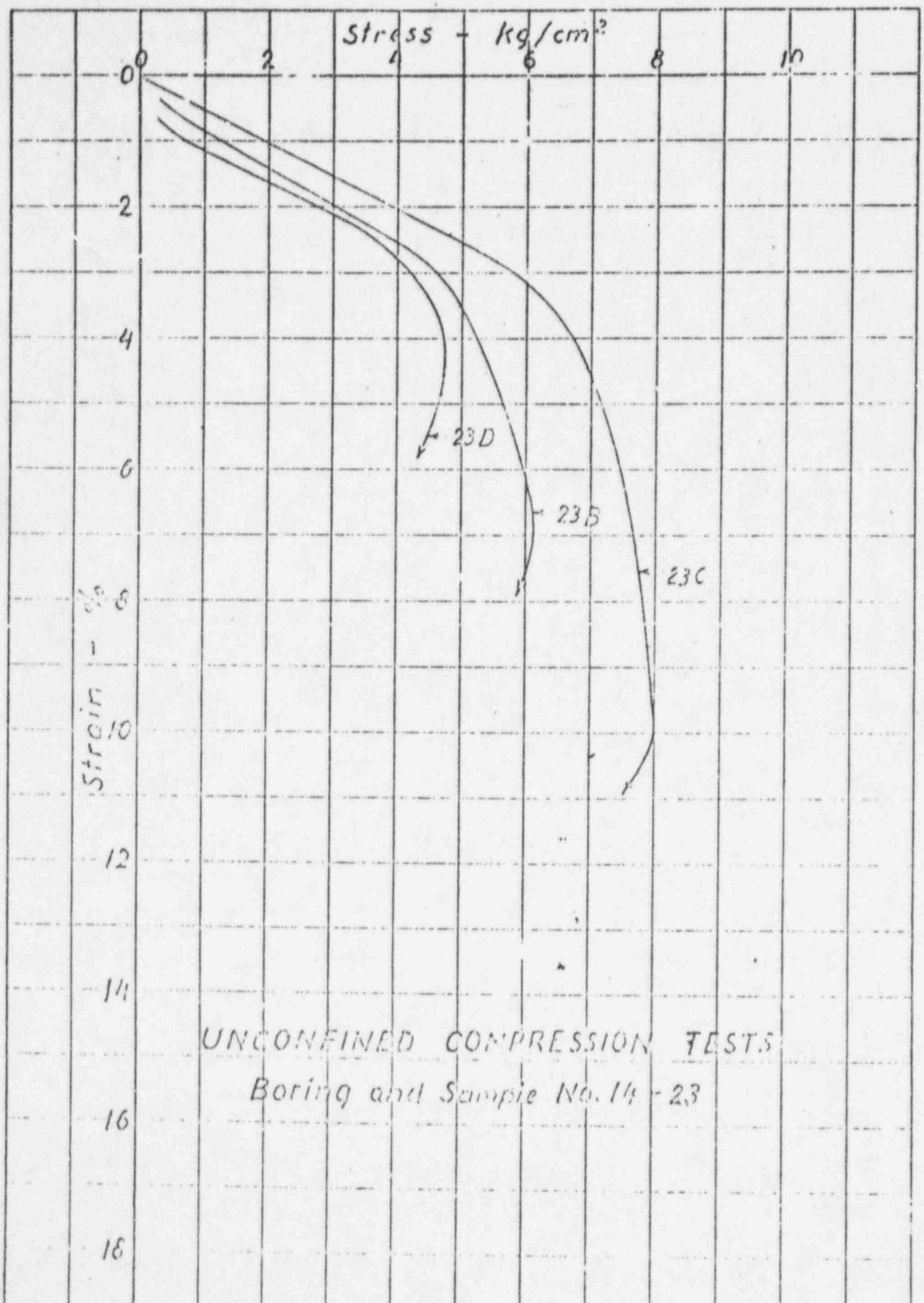
BORING NO 14

DATE Sept. '68



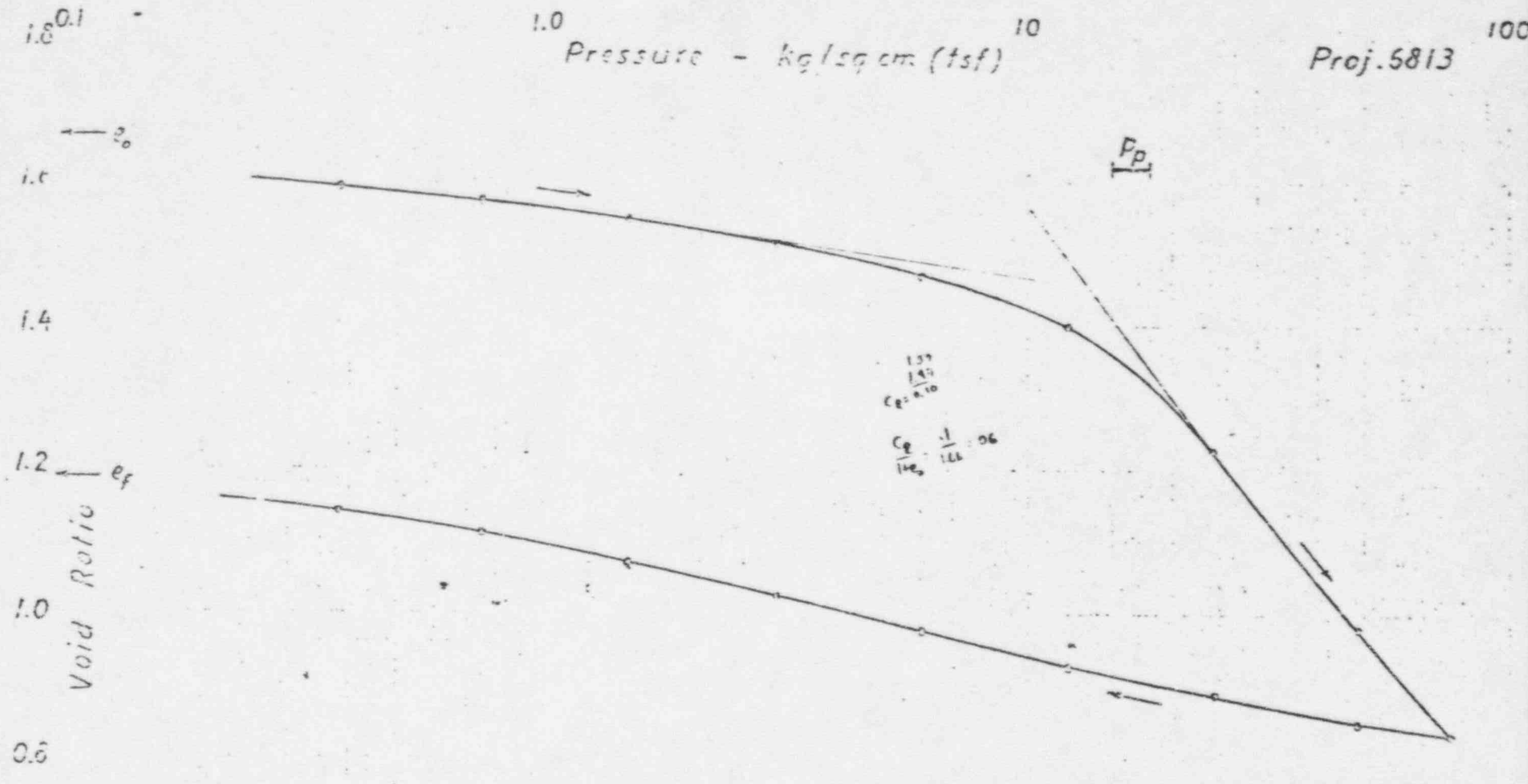
U-LINE Pi =0.9 (Lw-8)
A-LINE Pi =0.73 (Lw -20)
PLASTICITY INDEX Pi
LIQUID LIMIT Lw
U
A
undried specimens •
ovendried specimens x
Proj. 6813
PLASTICITY CHART
Unit No. 2

FIG.



UNCONFINED COMPRESSION TESTS
Boring and Sample No. 14 - 23

FIG. 4



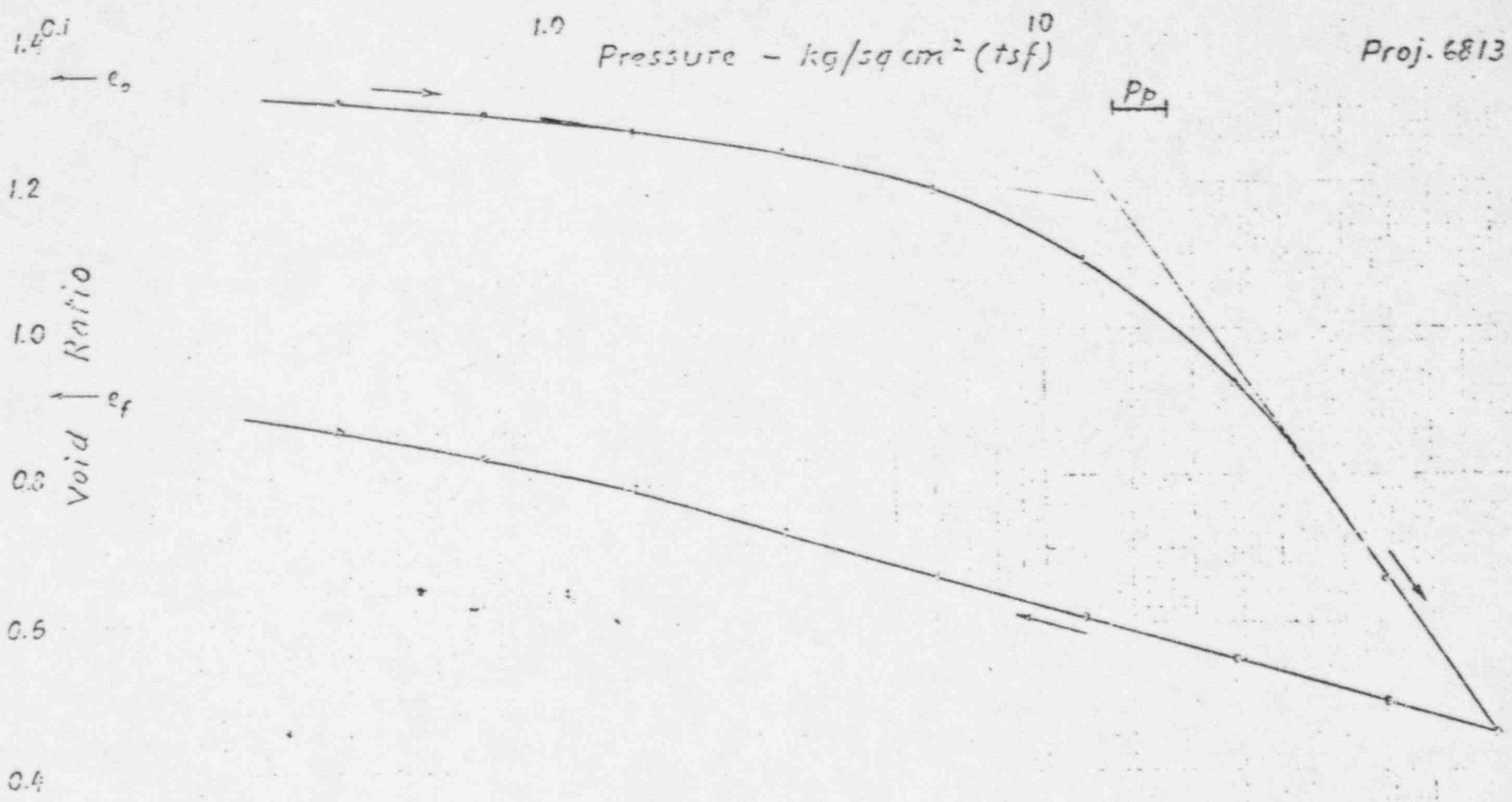
CONSOLIDATION TEST

Boring, Sample and Section No. 14-18C

Depth [illegible] ft

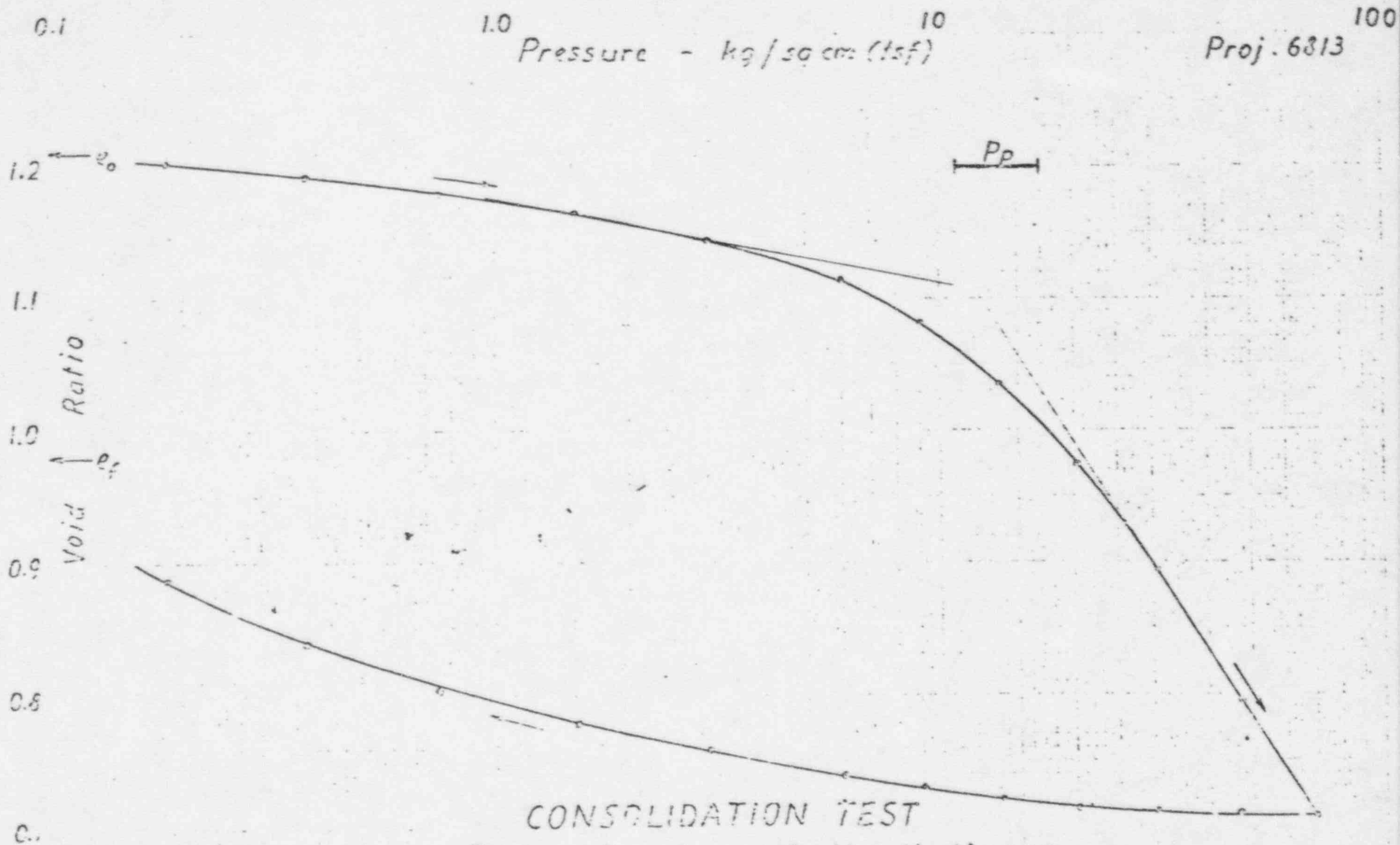
FIG. 5

Proj. 6813



CONSOLIDATION TEST
Boring, Sample and Section No. 14-19B
Depth 88.2 ft

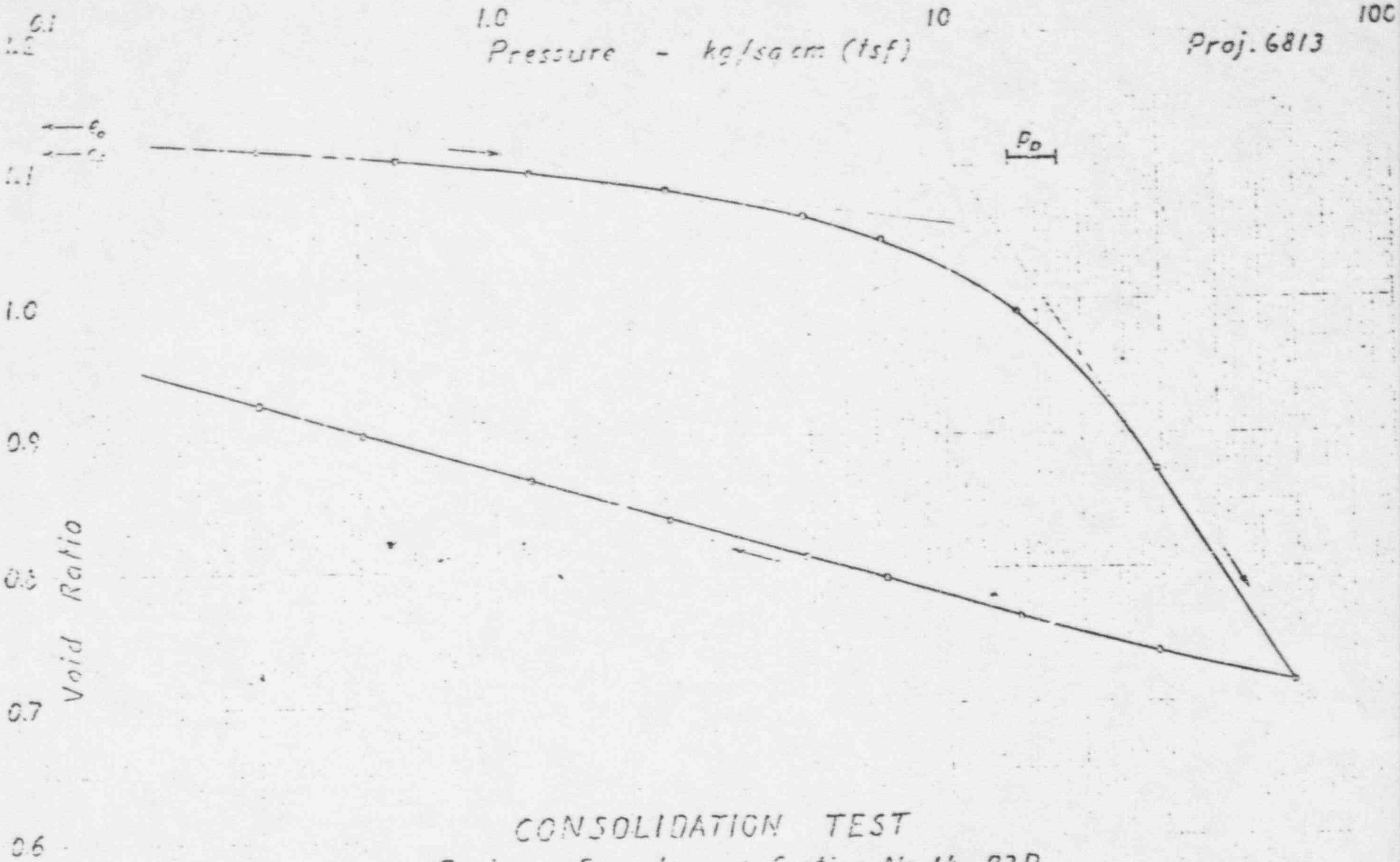
FIG. 6



CONSOLIDATION TEST
Boring, Sample and Section No. 14-20C
Depth 91.7 ft

FIG. 7

Proj. 6813



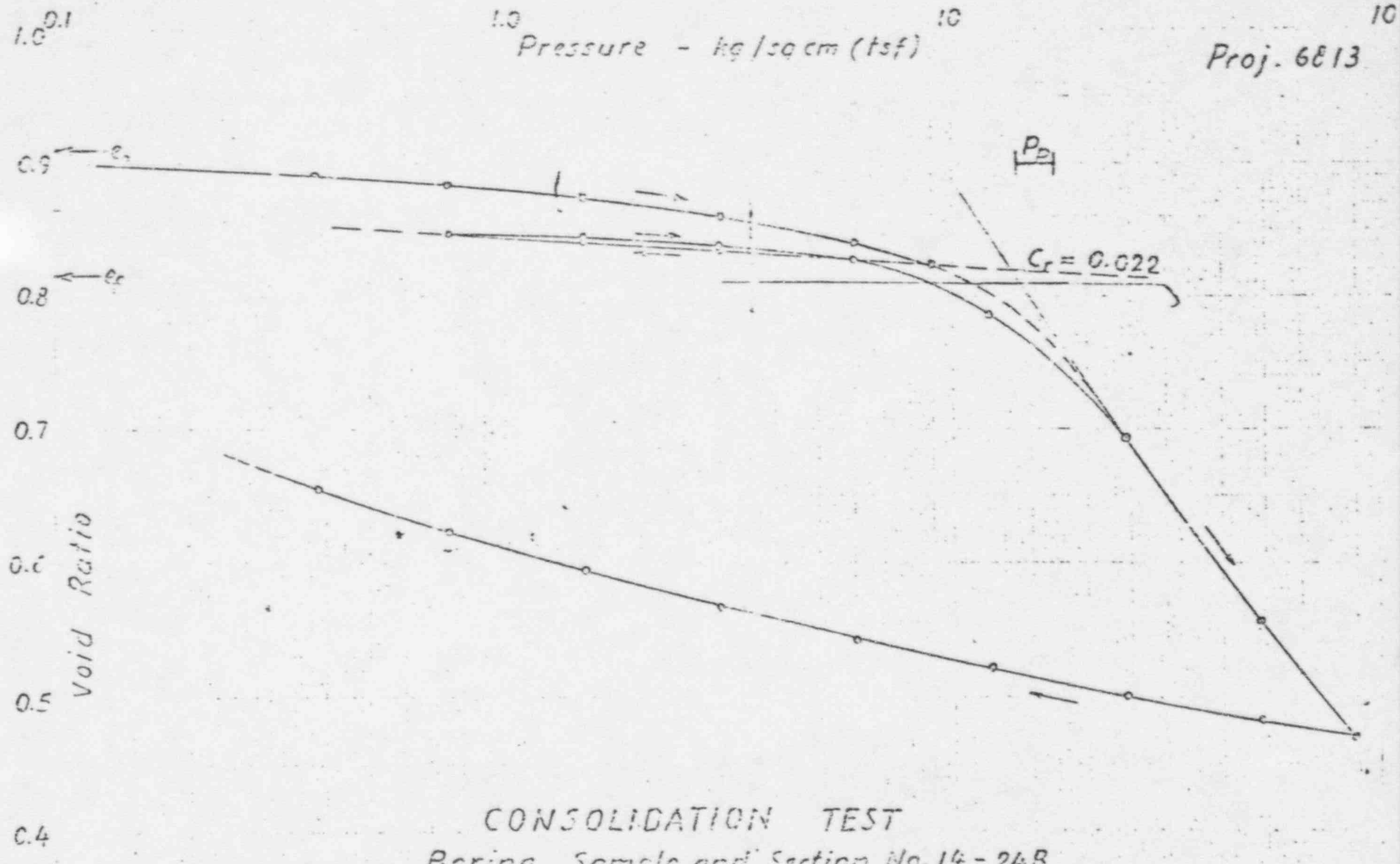
CONSOLIDATION TEST

Boring, Sample and Section No. 14-23D

Depth 27.8 ft

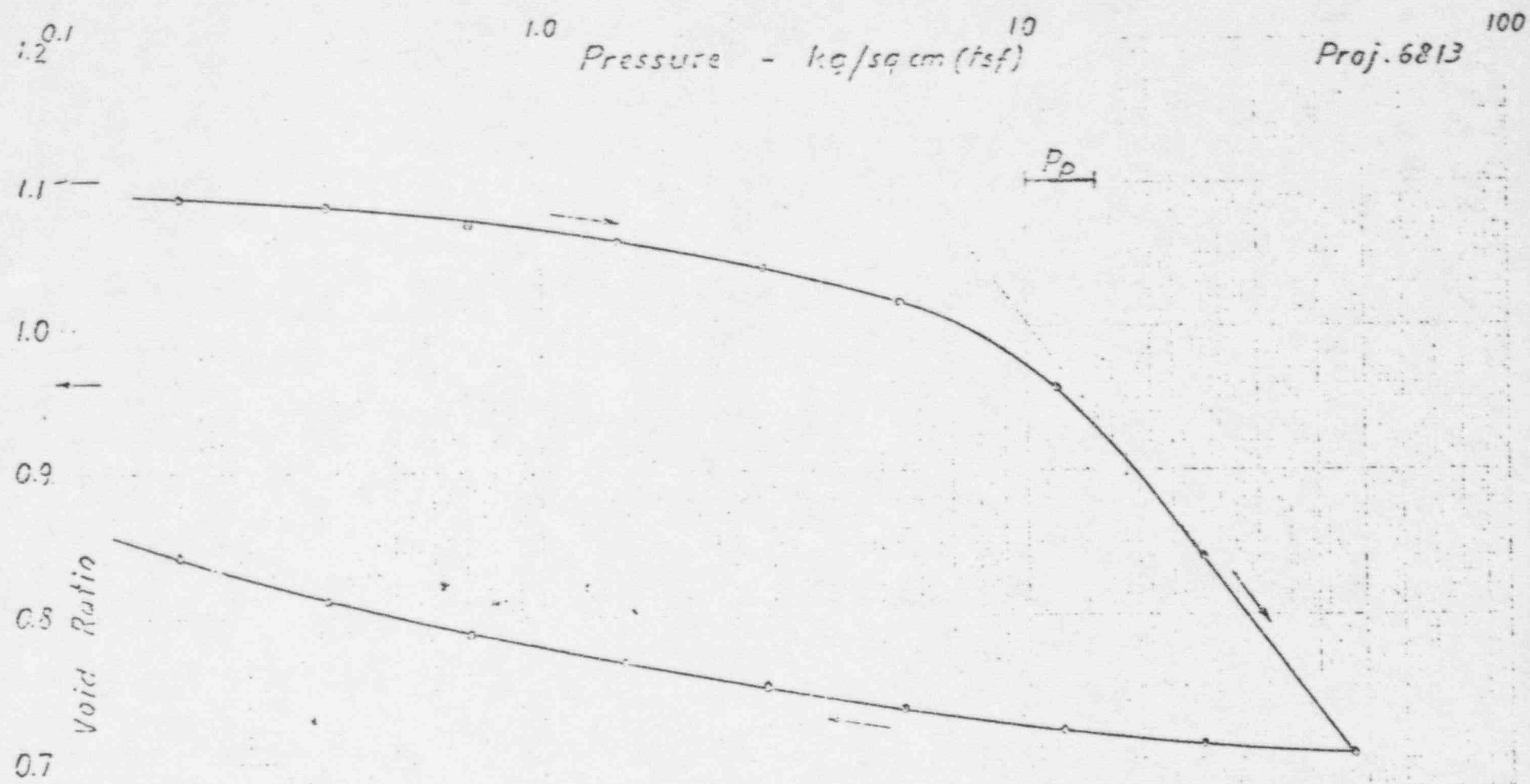
FIG. 8

Proj. 6813



CONSOLIDATION TEST
Boring, Sample and Section No. 14 - 24B
Depth 99.0 ft

FIG. 9



CONSOLIDATION TEST
Boring, Sample and Section No. 14-25B
Depth 101.6 ft

FIG. 10

Table 1

Exploratory Boring No. 4

Ground El. +20
Depth to Water Level 11.0 ft

Project No. 6813

Sample No.	Depth ft	Number of Blows per 6"	Description
1	5-6.5	15-27-36	Light brown subangular and subrounded slightly silty fine to medium sand containing numerous subangular and subrounded coarse sand and gravel particles up to 0.7" size.
2	10-11.5	19-25-26	Yellow subangular and subrounded silty fine sand.
3	15-16.5	4-5-8	Dark gray clay containing occasional layers of dark gray clayey silt up to 0.1" thickness. The clay is firm as received and soft when remolded.
4	20-21.5	[illegible]-5-7	Dark gray stratified clay and silty fine sand. The clay is firm as received and soft when remolded. Sample contains only one complete layer of each material - clay layer 1.2" thick, sand layer 0.9" thick. (LL=69.1; PL=32.3; water content = 49%).
5	25-25.5	5-7-9	Similar to Sample No. 4. Clay layers 1.2-2 ", sand layers 0.2 ".
6	30-31.5	12-19-34	Brown stratified silty fine sand and subangular silty fine to medium sand.
7	35-36.5	14-26-39	Light brown subangular slightly silty fine to medium sand.
8	40-41	83-218	Similar to Sample No. 7.
9	45-46	79-180	Light brown subangular slightly silty fine to medium sand.
10	50-51.5	36-49-54	Light brown silty fine sand.
11	55-56.5	33-44-51	Similar to Sample No. 10.

Exploratory Boring No. 4

Ground El. +20
Depth to Water Level 11.0 ft

Project No. 6813

Sample No.	Depth ft	Number of Blows per 6"	Description
12	60-61.5	31-43-64	Gray brown silty fine sand.
13	65-66.5	32-45-67	Similar to Sample No. 12.
14	70-71.5	26-49-84	Dark gray silty fine sand.
15	75-76.5	28-36-79	Dark gray very silty fine sand
16	80-81.5	11-12-14	Dark gray stratified clayey fine to medium sand and silty clay.
17	85-86.5	11-13-14	Similar to Sample No. 16.
18	90-91.5	11-12-14	Dark gray very silty fine sand
19	95-96.5	25-28-33	Similar to Sample No. 18.
20	100-101.5	5-3-14	Dark gray very silty fine sand containing 1" layer of dark gray organic clay, firm and brittle as received, very soft and sticky when remolded.
21	105-106.5	Jar sample from undisturbed sample tube	Dark gray subangular silty fine to medium sand. (Undisturbed sample not received)
22	110-111.5	10-19-64	Similar to Sample No. 21.
23	115-116.5	40-69-37	Dark gray very silty fine sand.
24	120-121.5	[illegible]-224-206	Gray silty fine sand.
25	125-126	90-23[illegible]	Gray subangular silty fine to medium sand.

Table I (Sheet 3)

Exploratory Boring No. 4

Ground El. +20

Depth to Water Level 11.0 ft

Project No. 6[illegible]

Sample No.	Depth ft	Number of Blows per 6"	Description
26	130-130.7	74-200/3"	Similar to Sample No. 25.
27	135-135.7	93-235/3"	Similar to Sample No. 25.
28	140-141	102-197	Similar to Sample No. 25.
29	145-146.5	74-152-170	Gray very silty fine sand.
30	150-150.3	50/4"	Gray subangular silty fine to medium sand.
31	155-155.3	50/3"	Similar to Sample No. 30.
32	160-160.2	50/2"	Similar to Sample No. 30.
33	165-165.2	50/2"	Similar to Sample No. 30.
34	170-170.3	50/3"	Similar to Sample No. 30.
35	175-175.2	50/2"	Similar to Sample No. 30.
36	180-180.3	50/3"	Gray subangular silty fine to medium sand, containing numerous subangular and subrounded coarser particles up to 0.3" size.
37	185-185.4	50/3.5"	Gray subangular very silty fine to medium sand.
38	190-190.4	50/4"	Similar to Sample No. 37.

Exploratory Boring No. 4

Ground El. +20
Depth to Water Level 11.0 ft

Project No. 6313

Sample No.	Depth ft	Number of Blows per ft 6"	Description
39	195-195.1	50/1"	Similar to Sample No. 37.
40	200-200.9	30-50/5"	Gray subangular silty fine to medium sand, containing numerous subangular and subrounded coarser particles up to 0.3" size and few pockets of gray clay up to 0.5" thickness.
41	205-205.5	50	Gray subangular very silty fine to medium sand.
42	210-210.3	5-/3"	Similar to Sample No. 41.
43	215-215.2	50/2"	Similar to Sample No. 41.
44	220-221.5	29-30-43	Dark gray and light gray mottled clay, hard and brittle as received, firm when remolded Compressive strength greater than 4.5 tsf capacity of penetrometer.
45	225-226.5	31-41-52	Similar to Sample No. 44 - hard (greater than 4.5 tsf capacity of penetrometer; LL=33.5; PL=17.0; w = 17%)
46	230	Jar sample from undisturbed sample tube	Gray angular silty fine to medium sand. (Undisturbed sample not received)
47	235-235.2	50/2"	Similar to Sample No. 46.
48	240-240.2	50/2"	Similar to Sample No. 46.

Exploratory Boring No. 5

Ground El. +20
Depth to Water Level

Project No. 6813

Sample No.	Depth ft	Number of Blows per ft 6"	Description
1	5-6.5	6-9-11	Stratified light brown very silty fine sand and gray fine sandy clay.
2	10-11.5	13-17-18	Light brown very silty fine sand.
3	15-16.5	6-2-3	Light brown stratified very silty fine sand and very soft clay. The clay layer is 1.5" thick, has light and dark brown stratifications, is firm as received and soft when remolded.
4	20-21.5	3-4-7	Dark gray clay, firm as received and soft when remolded. (The characteristics of the material appear to be similar to those of the clay in boring No. 4, Sample No. 4).
5	25-26.5	4-7-12	Stratified dark gray clay and light gray silty fine sand. The clay layers are from 0.2-1" thick, are stiff as received and soft when remolded. The sand layers are approx. 0.1" thick.
6	30-31.5	5-6-8	Similar to Sample No. 5.
7	35-36.5	5-10-16	Light brown angular and subangular silty fine to medium sand.
8	40-41.5	21-43-55	Similar to Sample No. 7.
9	45-46.5	21-36-49	Similar to Sample No. 7.
10	50-51.5	23-41-50	Similar to Sample No. 7.
11	55-56.5	10-10-12	Light brown angular and subangular silty fine to medium sand containing numerous particles of subangular coarse sand.
12	56-60.4	50/4"	Light brown angular and subangular silty fine to medium sand.

Exploratory Boring No. [illegible]

Ground El. +20

Depth to Water Level

Project No. 6813

Sample No.	Depth ft	Number of Blows per ft 6"	Description
13	65-66	42-52	Light brown silty fine sand.
14	70-71.5	22-23-36	Light brown silty fine sand.
15	75-76.5	17-26-39	Light brown silty fine sand.
16	80-81.5	6-12-14	Dark gray very silty fine sand.
17	85-87	Undisturbed sample. Sample not received.	
18	90-90.7	16-50/3"	Dark gray silty fine sand containing two 1" layers of dark gray organic clay, firm and brittle as received, very soft and sticky when remolded.
19	95-97	Undisturbed sample. Sample not received.	
20	100-101.5	7-12-16	Dark gray silty fine sand.
21	105-105.3	50/3"	Gray silty fine to medium sand containing few pockets of dark gray clay of thickness up to 0.4".
22	110-110.2	50/2"	Gray silty fine to medium sand.
23	115-115.2	50/2"	Gray silty fine to medium sand containing 0.5" layer of dark gray clay.
24	120-120.3	50/3"	Gray silty fine to medium sand.
25	125-125.4	50/4"	Gray silty fine sand containing numerous coarser subrounded and subangular particles up to 0.3" size.
26	130-131.5	39-46-54	Gray silty fine to medium sand.

Table 2 (Cont'd.)

Exploratory Boring No. 5

Ground El. +20

Depth to Water Level

Project No. 6813

Sample No.	Depth ft	Number of Blows per ft 6"	Description
27	135-135.3	50/3"	Similar to Sample No. 26.
28	140-140.4	50/5"	Similar to Sample No. 26.
29	145-145.4	50/4"	Similar to Sample No. 26.
30	150-150.4	50/4"	Similar to Sample No. 26.

TABLE 3

Ground El. ~ +20

Depth to Water Level

Undisturbed Sample Boring No. 14

Three-Inch Dia. Samples

Project No. 6813

Sample No. and Depth ft	Section No.	Length In.	Description	Consistency		Natural Water Content %	Liquid Limit	Plastic Limit	Plasticity Index	Water Plasticity Ratio %
				As Received	Remolded					
16	A	19.0	Empty + wax							
30 to 32	B	6.8	Gray fine to medium sand D_r = 103% , 102%	very compact						
	C	4.2	Wax 11" 46							
17	A	9.1	Empty + wax							
34 to 36	B	9.0	Gray and dark gray fine to medium sand (D_r = 88%) and one 0.3 in. thick layer of dark brown organic clay	hard & brittle	firm	43.4				
	C	9.0	Dark gray fine to medium sand with several layers of clay ranging from 0.2 to 1.2 in. in thickness	hard & brittle	firm	50.9 to 41.1	69.5	46.6	22.9	19
	D	2.9	Wax							

TABLE 3 (Sheet 2)

Ground El. ~ +20

Depth to Water Level

Undisturbed Sample Boring No. 14

Three-Inch Dia. Samples

Project No. 6813

Sample No. and Depth ft	Section No.	Length In.	Description	Consistency: As Received	Consistency: Remolded	Natural Water Content %	Liquid Limit	Plastic Limit	Plasticity Index	Water Plasticity Ratio %
[illegible]	A	6.7	Empty + wax							
36 to 38	B	4.3	Dark gray fine to medium sand and one 2.8 in. layer of dark brown clay (see Table 6 for strength data)	hard & brittle	firm	52.7	81.5	51.2	30.3	2
44'	C	6.2 (10.5")	Dark gray fine to medium sand with several clay layers ranging from 0.4 to 1.0 in. in thickness. Note: Specimen for consolidation test cut from 1.0 in. layer	hard & brittle	firm	45.5 48.0 50.6 59.9	73.3 68.2 72.3 79.5	35.3 37.3 41.7 40.2	38.0 [illegible].0 30.6 39.3	27 35 23 49
	D	12.8	Empty							

TABLE 3 (Sheet 3)

Undisturbed Sample Boring No. 14

Three-Inch Dia. Samples

Ground El.~+20

Depth to Water Level

Project No. 6813

Sample No. and Depth ft	Section No.	Length In.	Description	Consistency		Natural Water Content %	Liquid Limit	Plastic Limit	Plasticity Index	Water Plasticity Ratio %
				As Received	Remolded					
15	A	5.4	Empty + wax							
80 to 90	B	6.6	Dark gray fine sand with one-inch layer of dark brown clay. Note: consolidation test performed on clay layer.	hard & brittle	firm	50.7	85.8	41.1	44.7	21
	21.5" C 10% Dec	8.8	Dark gray fine to medium sand with several clay layers with total thickness of 1.2 in.	stiff & brittle	soft	51.7	76.8	37.8	39.0	36
	D	5.9	Dark gray fine to medium sand with several dark brown clay layers ranging from 0.5 to 0.7 in. in thickness	hard & brittle	firm	51.7 52.2 54.9	87.0 74.6 84.1	42.3 40.3 41.0	44.7 34.3 43.1	21 35 35
	E	3.1	Empty							

TABLE 3 (Sheet 4)

Undisturbed Sample Boring No. 14

Three-Inch Dia. Samples

Ground El. ~ +20

Depth to Water Level

Project No. 6813

Sample No. and Depth ft	Section No.	Length In.	Description	Consistency		Natural Water Content %	Liquid Limit	Plastic Limit	Plasticity Index	Water Plasticity Ratio %
				As Received	Remolded					
20	A	14.2	Empty + wax							
90 to 92	B	6.0	Dark gray fine sand - cross section of tube only partially filled							
	11.4" C 47%	5.4	Dark gray fine sand and one 2.3 in. layer of dark brown clay. Note: consolidation test performed on clay layer.	hard & brittle	firm	41.0	56.1	30.4	25.7	41
	D	4.4	Empty							

TABLE 3 (Sheet 5)

Ground El. ~ +20

Depth to Water Level

Undisturbed Sample Boring No. 14

Three-Inch Dia. Samples

Project No. 6813

Sample No. and Depth ft	Section No.	Length In.	Description	Consistency As Received	Consistency Remolded	Natural Water Content %	Liquid Limit	Plastic Limit	Plasticity Index	Water Plasticity Ratio %
22	A	14.1	Wax and badly disturbed dark gray fine sand							
94 to 96	B	7.7	Dark gray fine sand - badly disturbed							
	15.9" C 66% rec	8.2	Dark gray fine sand with several layers of dark brown clay ranging from 0.2 to 0.5 in. in thickness	hard & brittle	firm	34.3 to 43.7	54.1	30.3	23.8	17

TABLE 3 (Sheet 6)

Ground El. ~ +20

Undisturbed Sample Boring No. 14

Project No. 6813

Depth to Water Level

Three-Inch Dia. Samples

Sample No. and Depth ft	Section No.	Length In.	Description	Consistency		Natural Water Content %	Liquid Limit	Plastic Limit	Plasticity Index	Water Plasticity Ratio %
				As Received	Remolded					
23	A	7.6	Empty + wax							
96 to 98	B	8.6	Gray and dark gray fine sand with seven dark brown clay layers ranging from 0.2 to 1.5 in. in thickness	hard & brittle	firm	42.3 (31.7-52.9)	71.8	38.3	33.0	12
	C 22.4" 93% rec	7.8	Dark gray fine sand with several dark brown clay layers ranging from 0.1 to 1.6 in. in thickness (see Table 6 for strength data)	hard & brittle	firm	34.7 30.9	72.2 71.6	40.4 38.0	31.8 33.6	neg. neg.
	D	6.0	Dark gray fine sand with several layers of dark brown clay ranging from 0.4 to 1.1 in. in thickness. Note: Consolidation and strength tests performed on clay layers.	hard & brittle	firm	30.9 40.6 32.6 39.5	70.2 57.1	37.0 30.7	33.2 26.4	neg 37

TABLE 3 (Sheet 7)

Undisturbed Sample Boring No. 14

Three-Inch Dia. Samples

Ground El. ~+20

Depth to Water Level

Project No. 6313

Sample No. and Depth ft	Section No.	Length In.	Description	Consistency		Natural Water Content %	Liquid Limit	Plastic Limit	Plasticity Index	Water Plasticity Ratio %
				As Received	Remolded					
24	A	5.7	Empty + wax							
98 to 100	B	8.9	Dark gray fine sand (D_r=87%) with several layers of dark brown clay ranging from 0.5 to 1.7 in. in thickness. Note: Consolidation test performed on clay specimen.	hard & brittle	firm	38.6 34.2 28.9-41.3	61.3 66.5 50.0	35.8 36.0 35.0	25.5 30.5 15.0	11 neg.
	17.8" 74% C	8.9	Dark gray silty fine sand with dark brown clay layers ranging from 0.1 to 1.5 in. in thickness (see Table 6 for strength data)	hard & brittle	firm	33.2 34.7 41.0 43.9	46.4 61.0	25.7 34.0	20.7 26.9	37 29
	D	6.5	Wax and empty							

TABLE 3 (Sheet 3)

Undisturbed Sample Boring No. 14

Three-Inch Dia. Samples

Ground El. ~+20

Depth to Water Level

Project No. 6813

Sample No. and Depth ft	Section No.	Length In.	Description	Consistency		Natural Water Content %	Liquid Limit	Plastic Limit	Plasticity Index	Water Plasticity Ratio %
				As Received	Remolded					
25	A	15.4	Empty + wax							
100 to 102	B	5.7	Gray fine sand (disturbed) with one 1.8 in. thick layer of dark brown clay. Note: Consolidation test performed on clay specimen.	hard & brittle	firm	37.5	71.6	38.0	33.6	neg.
	14.6 -61% C see	8.9	Dark brown clay with several thin layers and numerous partings of fine sand (see Table 6 for strength data)	hard & brittle	firm	30.8 35.1 31.3	71.0	40.5	30.5	neg.

TABLE 4

RELATIVE DENSITY TESTS ON UNDISTURBED

SAND SPECIMENS

BORING NO. 14 (El. ~+20)

Sample & Section No.	Depth ft	Dry Unit Weight lb/cu ft	Relative Density %
16B	81.2	119.6	103
16B	81.6	119.6	102
17B	85.0	97.3	88
24B1	98.9	94.5	87

TABLE 5

CLASSIFICATION TESTS OF CLAY LAYERS

BORING NO. 14 (El. ~+20)

Sample & Section No.	Depth ft	Layer Thickness in.	Water Content %	Liquid Limit	Plastic Limit	Plasticity Index
17B	84.9	0.3	43.4			
17C	85.0	0.5	42.8			
17C	85.1	0.6	46.5	71.1	44.7	26.4
17D	85.2	0.2	41.1			
17D	85.3	0.3	43.1			
17D	85.5	0.3	42.8			
17D	85.8	1.2	50.9	69.5	46.6	22.9
18B	86.8	2.8	52.7	81.5	51.2	30.3
18C	87.1	1.0	48.0	68.2	37.2	31.0
18C	87.5	0.5	45.5	73.3	35.3	38.0
18C	87.6	0.4	50.6	72.3	41.7	30.6
18C	87.8	1.0	59.9	79.5	40.2	39.3
19B	88.2	1.0	50.7	85.8	41.1	44.7
19C	89.3	1.2	51.7	76.8	37.8	39.0

TABLE 5 (Sheet 2)

Sample & Section No.	Depth ft	Layer Thickness in..	Water Content %	Liquid Limit	Plastic Limit	Plasticity Index
19D	89.5	0.7	51.7	87.0	42.3	44.7
19D	89.6	0.7	52.2	74.6	40.3	34.3
19D	89.7	0.5	54.9	84.1	41.0	43.1
20C	91.7	2.8	41.0	56.1	30.4	25.7
			[ovendried] =	[35.3]	[25.5]	[9.8]
22C	95.5	0.4	40.9			
22C	95.6	0.3	34.3	54.1	30.3	23.8
22C	95.7	0.2	43.3			
22C	95.8	0.3	44.1			
22C	95.9	0.5	43.7			
23B	96.8	0.8	31.7;32.1			
23B	96.9	0.4	36.8			
23B	97.0	0.3	46.2			
23B	97.1	0.6	52.5			
23B	97.2 (9)	1.5	42.8;44.9	71.8	38.8	33.0
			[ovendried] =	[46.5]	[33.1]	[13.4]
23B	97.3	0.2	43.3			

TABLE 5 (Sheet 3)

Sample & Section No.	Depth ft	Layer Thickness in..	Water Content %	Liquid Limit	Plastic Limit	Plasticity Index
23B	97.3	0.6	49.9			
23C	97.2	0.1	58.0			
23C	97.2	0.4	45.3			
23C	97.3	1.0	34.7	72.2	40.4	31.8
23C	97.3	0.1	60.5			
23C	97.4	1.6	30.9	71.8	38.0	33.8
23D	97.5	1.0	30.9	70.2	37.0	33.2
			[ovendried] =	[49.7]	[36.1]	[13.6]
23D	97.7	0.8	30.8			
23D	97.8	1.1	40.6	57.1	30.7	26.4
23D	97.9	0.4	39.5			
23D	98.0	0.5	32.6			
24B	98.7	0.5	38.6	61.3	35.8	25.5
24B	98.8	1.7	28.9to41.3	50.0	35.0	15.0
24B	99.0	0.6	34.2	66.5	36.0	30.5
24C	99.1	1.5	32.2	46.4	25.7	20.7
24C	99.2	0.1	34.7			

TABLE 5 (Sheet [illegible])

Sample & Section No.	Depth ft	Layer Thickness in.	Water Content %	Liquid Limit	Plastic Limit	Plasticity Index
24C	99.3	0.9	41.8;43.9	61.0	34.1	26.9
24C	99.5	3.3	44.0	68.5	38.4	30.1
✓ 25B	100.7	1.8	37.5	71.6	38.0	33.6
25C	101.1	5.4	30.8;35.1	71.0	40.5	30.5
25C	101.5	3.1	31.3			

TABLE 6

UNCONFINED COMPRESSION TESTS

BORING NO. 14 (El. ~ +20)

Sample & Section No.	Depth ft	Compressive Strength kg/sq cm(tsf)	Failure Strain %	Water Content %
18B	87.2	4.2*	8.2	52.7
23B	96.9	6.1	6.7	44.9
23C	97.4	5.0	15.0	30.9
23C	97.6	8.0	9.8	45.3
23D	97.8	4.7*	5.9	39.1
24C	99.0	3.1*	7.5	44.0
25C	101.5	4.8*	12.0	30.8

*Failed prematurely with vertical cracks.

TABLE 7

SUMMARY DATA OF CONSOLIDATION TESTS

BORING NO. 14 (El. ~ +20)

Sample & Section No.	Depth ft	Preconsolid. Pressure p_c kg/sq cm(tsf)	Water Content %	Liquid Limit	Plastic Limit
18C	87.8	15-18	59.9	79.5	40.2
19B	88.2	14-18	50.7	85.8	41.1
20C	91.7	11-17	41.0	56.1	30.4
23D	97.8	14-18	40.6	57.1	30.7
24B	99.0	14-17	34.2	66.5	36.0
25B	101.6	10-14	37.5	71.6	38.0

Oyster Cr...

SHEET 1 OF 2

JOB LOCATION: Forked River, New Jersey

WARREN GEORGE, INC.

500 PALISADE AVENUE
JERSEY CITY, N.J. 07307

FOR: Burns and Roe

LOCATION Forked River NJ
HOLE NO. B 1
LINE & STA.
OFFSET

DEPTH ______ FT. ___ FT. CASING OUT DATE: ______
DEPTH ______ FT. ALL CASING OUT DATE: ______
DATE, START: 5-14-69
DATE, FINISH: 5-14-69
GROUND ELEVATION
GROUND WATER ELEVATION

CASING O.D. 4" I.D.
SAMPLER O.D. I.D.
DIAMOND BIT SIZE
WEIGHT OF HAMMER 140 # LBS.
INSIDE LENGTH OF SAMPLER ______ IN.
HAMMER FALL: CASING ______ SAMPLER 30"

DEPTH BELOW SURFACE	CASING BLOWS PER FOOT	SAMPLE NUMBER	SAMPLE DEPTHS ELEV. / FEET	SAMPLE RECOVERY	BLOWS PER 6" ON SAMPLER 0-6	6-12	12-18	DENSITY OR CONSIST. MOISTURE	PROFILE CHANGE DEPTH	FIELD IDENTIFICATION OF SOILS REMARKS
0									0"-9'	brown coarse to fine sand
		1	5'-6'6		16	22	24			
10		2	10'-11'6"		20	20	22		9'-17.6"	brown fine sand w/silt
		3	15'-16'6"		12	19	32			
20		4	20'-21'6"		5	6	7		17'6"-30'	dark gray silty clay
		5	25'-26'6"		6	14	18			
30		6	30'-31'6"		12	12	20		30'-34'	gray fine silty sand, tr. clay.
		7	35'-36'6"		11	14	19		34'-39'	brown silty clay w/sand layers.
40		8	40'-41'6"		21	20	17		39'-48'	see sheet 2

Soils Engineer:
Drilling Inspector:
Driller: Paul Mitchell
Helper:

JOB LOCATION: Forked River, New Jersey

WARREN GEORGE, INC.

500 PALISADE AVENUE
JERSEY CITY, N.J. 07307

FOR: Burns and Roe

SHEET 2 OF 2
LOCATION Forked River
HOLE NO. B 1
LINE & STA.
OFFSET

DEPTH ____ FT. ____ FT. CASING OUT DATE: ____
DEPTH ____ FT. ALL CASING OUT DATE: ____

DATE, START: 5-14-68
DATE, FINISH: 5-14-68

GROUND ELEVATION ____
GROUND WATER ELEVATION ____

CASING O.D. 4" I.D. ____
SAMPLER O.D. ____ I.D. ____
DIAMOND BIT SIZE ____

WEIGHT OF HAMMER 140# LBS.
INSIDE LENGTH OF SAMPLER ____ IN.

HAMMER FALL
CASING ____ SAMPLER ____

DEPTH BELOW SURFACE	CASING BLOWS PER FOOT	SAMPLE NUMBER	SAMPLE DEPTHS ELEV. / FEET	SAMPLE RECOVERY	BLOWS PER 6" ON SAMPLER 0-6	6-12	12-18	DENSITY OR CONSIST. MOISTURE	PROFILE CHANGE DEPTH	FIELD IDENTIFICATION OF SOILS REMARKS
0									39'-48'	brown fine sand w/silt
		9	45'-46'6"		18	22	27			
									48'-51'6"	brown coarse to fine san silt
50		10	50'-51'6"		16	22	9			
										50' of 4" pipe
										Ground Water
										16'6" 8 AM 5-15-68
										8.0' 3 PM 5-17-58
20										
30										
40										

Soils Engineer: ____
Drilling Inspector: ____

Driller: P. Mitchell
S. Blackwell
Helper: R. Eccles

JOB LOCATION:	WARREN GEORGE, INC.	
Forked River New Jersey	500 PALISADE AVENUE JERSEY CITY, N.J. 07307 FOR: Burns and Roe	SHEET 1 OF 5 LOCATION Forked River HOLE NO. B 2 LINE & STA. OFFSET

DEPTH ______ FT. ___ FT. CASING OUT DATE: ______ DATE, START: 5-21-58 GROUND ELEVATION ______

DEPTH ______ FT. ALL CASING OUT DATE: ______ DATE, FINISH: 5-21-58 GROUND WATER ELEVATION ______

CASING O.D. ______ I.D. ______ WEIGHT OF HAMMER 140# LBS. HAMMER FALL

SAMPLER O.D. ______ I.D. ______ INSIDE LENGTH OF SAMPLER ______ IN. CASING ______ SAMPLER 30"

DIAMOND BIT SIZE ______

DEPTH BELOW SURFACE	CASING BLOWS PER FOOT	SAMPLE NUMBER	SAMPLE DEPTHS ELEV. / FEET	SAMPLE RECOVERY	BLOWS PER 6" ON SAMPLER 0-6	6-12	12-18	DENSITY OR CONSIST. MOISTURE	PROFILE CHANGE DEPTH	FIELD IDENTIFICATION OF SOILS REMARKS
0									0"-10'6"	gray tan med to fine sand, trace silt, dry
		1	5'-6'6"		11	15	19			
10		2	10'-11'6"		13	12	12		10'6"-18'	tan, med to fine silty sand, wet
		3	15'-16'6"		5	7	17			
									18'-34'6"	dark gray silty clay w-sand layers.
20		4	20'-21'6"		3	3	5			
		5	25'-26'6"		6	16	11			
30		6	30'-31'6'		9	10	11			
		7	35'-36'6'		25	16	18		34'6"-40'	brn coarse to fine sand, trace silt. trace fine gravel
40		8	40'-41'6"		16	22	38			

Soils Engineer: ______ Driller: P. Mitchell

Drilling Inspector: ______ Helper: S. Blackwell

E. Eccles

JOB LOCATION: Forked River, New Jersey

WARREN GEORGE, INC.

500 PALISADE AVENUE
JERSEY CITY, N.J. 07307

FOR: Burns and Roe

SHEET 3 OF 5
LOCATION Forked River NJ
HOLE NO. B 2
LINE & STA.
OFFSET

DEPTH ____ FT. ____ FT. CASING OUT DATE: ____
DEPTH ____ FT. ALL CASING OUT DATE: ____
DATE, START: 5-21-68
DATE, FINISH: 5-21-68
GROUND ELEVATION
GROUND WATER ELEVATION

CASING O.D. ____ I.D. ____
SAMPLER O.D. ____ I.D. ____
DIAMOND BIT SIZE ____
WEIGHT OF HAMMER 140# LBS.
INSIDE LENGTH OF SAMPLER ____ IN.
HAMMER FALL: CASING ____ SAMPLER 30"

Depth below surface	Casing blows per foot	Sample number	Sample depths elev. / feet	Sample recovery	Blows per 6" on sampler 0-6	6-12	12-18	Density or consist. moisture	Profile change depth	Field identification of soils remarks
0									40'-47'	red . brn. med. to fine sand. trace silt
		9	45'-46'6"		18	32	36			
									47'-59'6"	brn. coarse to fine sand trace silt
10		10	50'-51'6"		16	12	27			
		11	55'-55'6"		50/6"					
20		12	60'-60'5"		50/5"				59'6" -69'	red brn. med to fine sand.
		13	65'-66'6"		23	36	42			
30		14	70'-71'6"		25	32	40		69'-82'	brown med. to fine sand.
		15	75'-76'6"		7	12	17			
40		16	80'-81'6"		10	15	19			

Soils Engineer: ____ Driller: ____
Drilling Inspector: ____ Helper: ____

JOB LOCATION: Forked River, New Jersey	WARREN GEORGE, INC. 500 PALISADE AVENUE JERSEY CITY, N.J. 07307 FOR: Burns and Roe	SHEET 3 OF 5; LOCATION Forked River NJ; HOLE NO. B 2; LINE & STA. ; OFFSET

DEPTH ______ FT. ___ FT. CASING OUT DATE: ______
DEPTH ______ FT. ALL CASING OUT DATE: ______
DATE, START: 5-21-63
DATE, FINISH: 5-21-63
GROUND ELEVATION ______
GROUND WATER ELEVATION ______

CASING O.D. ______ I.D. ______
SAMPLER O.D. ______ I.D. ______
DIAMOND BIT SIZE ______
WEIGHT OF HAMMER 140# LBS.
INSIDE LENGTH OF SAMPLER ______ IN.
HAMMER FALL: CASING ______ SAMPLER 30"

DEPTH BELOW SURFACE	CASING BLOWS PER FOOT	SAMPLE NUMBER	SAMPLE DEPTHS ELEV. / FEET	SAMPLE RECOVERY	BLOWS PER 6" ON SAMPLER 0-6	6-12	12-18	DENSITY OR CONSIST. MOISTURE	PROFILE CHANGE DEPTH	FIELD IDENTIFICATION OF SOILS REMARKS
80									69'-82'	(continued) brown med. to fine sand
									82'-107'	Alt. layers dark gray silty clay and fine sand.
		17	85'-86'6"		12	18	22			
90		18	90'-91'	Tube	Sand.	Jar	Sample			
		19	95'-96'6"		21	32	34			
100		20	100'-102 Tube	24"	Recovery					
		21	105'-106'6"		5	11	14			
									107'-200'1"	Dark med. fine sand. trace silt
110		22	110'-110'4"		50/4"					
		23	115'-115'5"		52/6"					
120		24	120'-120'5"		50/5"					

Soils Engineer: ______
Drilling Inspector: ______
Driller: P. Mitchell, S. Blackwell
Helper: R. Eccles

JOB LOCATION:	WARREN GEORGE, INC.	
Forked River New Jersey	500 PALISADE AVENUE JERSEY CITY, N.J. 07307 FOR: Burns and Roe.	SHEET 4 OF 5 LOCATION Forked River NJ HOLE NO. B 2 LINE & STA. OFFSET

DEPTH ____ FT. ____ FT. CASING OUT DATE: ____ DATE, START: 5-21-68 GROUND ELEVATION ____

DEPTH ____ FT. ALL CASING OUT DATE: ____ DATE, FINISH: 5-21-68 GROUND WATER ELEVATION ____

CASING O.D. ____ I.D. ____ WEIGHT OF HAMMER 140# LBS. HAMMER FALL

SAMPLER O.D. ____ I.D. ____ INSIDE LENGTH OF SAMPLER ____ IN. CASING ____ SAMPLER 30"

DIAMOND BIT SIZE ____

DEPTH BELOW SURFACE	CASING BLOWS PER FOOT	SAMPLE NUMBER	SAMPLE DEPTHS ELEV. / FEET	SAMPLE RECOVERY	BLOWS PER 6" ON SAMPLER 0-6	6-12	12-18	DENSITY OR CONSIST. MOISTURE	PROFILE CHANGE DEPTH	FIELD IDENTIFICATION OF SOILS REMARKS
120									107'-200'1" (continued)	Dark med. fine sand. trace silt
		25	125'-125'5"		50/5"					
130		26	130'-131'		40	52				
		27	135'-135'4"		50/4"					
140		28	140'-140'4"		50/4"					
		29	145'-145'4"		50/4"					
150		30	150'-150'6"		64/6"					
		31	155'-155'1"		50/1"					
160		32	160'-160'2"		50/2"					

Soils Engineer: ____ Driller: P. Mitchell

Drilling Inspector: ____ Helper: S. Blackwell, R. Eccles

WARREN GEORGE, INC.
500 PALISADE AVENUE
JERSEY CITY, N.J. 07307

JOB LOCATION: Forked River, New Jersey

FOR: Burns and Roe

SHEET 5 OF 5
LOCATION Forked River NJ
HOLE NO. B 2
LINE & STA. ____
OFFSET ____

DEPTH ____ FT. ____ FT. CASING OUT DATE: ____
DEPTH ____ FT. ALL CASING OUT DATE: ____
DATE, START: 5-21-68
DATE, FINISH: 5-21-68
GROUND ELEVATION ____
GROUND WATER ELEVATION ____

CASING O.D. ____ I.D. ____
SAMPLER O.D. ____ I.D. ____
DIAMOND BIT SIZE ____
WEIGHT OF HAMMER 140# LBS.
INSIDE LENGTH OF SAMPLER ____ IN.
HAMMER FALL: CASING ____ SAMPLER 30"

DEPTH BELOW SURFACE	CASING BLOWS PER FOOT	SAMPLE NUMBER	SAMPLE DEPTHS ELEV. / FEET	SAMPLE RECOVERY	BLOWS PER 6" ON SAMPLER 0-6	6-12	12-18	DENSITY OR CONSIST. MOISTURE	PROFILE CHANGE DEPTH	FIELD IDENTIFICATION OF SOILS REMARKS
160									107'-200'1" (continued)	Dark med. fine sand. trace silt
		33	165'-165'2"		50/2"					
170		34	170'-170'1"		50/1"					Ground Water 8'-2"
		35	175'-175'2"		50/2"					
180		36	180'-180'1"		50/1"					
		37	185'-185'2"		50/2"					
190		38	190'-190'2"		50/2"					
			195'-195'½"		50/½" No Recovery					
200		39	200'-200'1"		50/1"					

Soils Engineer: ____
Driller: P. Mitchell
Drilling Inspector: ____
Helper: S. Blackwell, R. Eccles

JOB LOCATION: Forked River, New Jersey

WARREN GEORGE, INC.

500 PALISADE AVENUE
JERSEY CITY, N.J. 07307

FOR: Burns and Roe

SHEET 1 OF 4
LOCATION Forked River, NJ
HOLE NO. B 3
LINE & STA.
OFFSET

DEPTH ____ FT. ____ FT. CASING OUT DATE: ____
DEPTH ____ FT. ALL CASING OUT DATE: ____

DATE, START: 5-23-68
DATE, FINISH: 5-23-68

GROUND ELEVATION
GROUND WATER ELEVATION

CASING O.D. 4" I.D.
SAMPLER O.D. 2" I.D.
DIAMOND BIT SIZE

WEIGHT OF HAMMER 140# LBS.
INSIDE LENGTH OF SAMPLER ____ IN.

HAMMER FALL
CASING ____ SAMPLER ____

DEPTH BELOW SURFACE	CASING BLOWS PER FOOT	SAMPLE NUMBER	SAMPLE DEPTHS ELEV. / FEET	SAMPLE RECOVERY	BLOWS PER 6" ON SAMPLER 0-6	6-12	12-18	DENSITY OR CONSIST. MOISTURE	PROFILE CHANGE DEPTH	FIELD IDENTIFICATION OF SOILS REMARKS
0									0'-8'6"	brown fine silty sand, tr. fine gravel
		1	5'-6'6"		11	18	21			
10		2	10'-11'6"		8	9	14		8'6"-18'	brn. fine silty sand. tr. clay
		3	15'-16'6"		9	15	14			
20		4	20'-21'6"		4	4	8		18'-33'6"	drk. gray silty clay, fine sand
		5	25'-26'6"		8	9	10			
30		6	30'-31'6"		8	12	15			
		7	35'-36'6"		10	11	13		33'6"-39'	gray-brn coarse to fine sand, silt and tr. clay
40		8	40'-41'6"		19	33	16		39'-47'	(on sheet two)

Soils Engineer:
Drilling Inspector:
Driller: P. Mitchell
Helper: S. Blackwell, R. Eccles

JOB LOCATION:	WARREN GEORGE, INC.	
Forked River New Jersey	500 PALISADE AVENUE JERSEY CITY, N.J. 07307 FOR: Burns and Roe	SHEET 2 OF 4 LOCATION Forked River NJ HOLE NO. B 3 LINE & STA. OFFSET

DEPTH ______ FT. ___ FT. CASING OUT DATE: ______ DATE, START: 5-23-68 GROUND ELEVATION ______

DEPTH ______ FT. ALL CASING OUT DATE: ______ DATE, FINISH: 5-23-68 GROUND WATER ELEVATION ______

CASING O.D. 4" I.D. ______ WEIGHT OF HAMMER 140# LBS. HAMMER FALL

SAMPLER O.D. 2" I.D. ______ INSIDE LENGTH OF SAMPLER ______ IN. CASING ______ SAMPLER ______

DIAMOND BIT SIZE ______

DEPTH BELOW SURFACE	CASING BLOWS PER FOOT	SAMPLE NUMBER	SAMPLE DEPTHS ELEV. / FEET	SAMPLE RECOVERY	BLOWS PER 6" ON SAMPLER 0-6	6-12	12-18	DENSITY OR CONSIST. MOISTURE	PROFILE CHANGE DEPTH	FIELD IDENTIFICATION OF SOILS REMARKS
0									39'-47'	brown coarse to fine sand, silt.
		9	45'-45'6"		56/6"					
									47'-60'	gray brn, med. to fine sand. trace silt
50		10	50'-51'6"		12	17	32			
		11	55'-55'3½"		50/3½"					
60		12	60'-61'		32	54			60-65'	gray fine sand
		13	65'-65'6"		52/6"				65'-73'	brn silty fine sand. tr. clay
70		14	70'-71'6"		15	32	40			
									73'-84'6"	drk. gray silty fine sand. tr. clay
		15	75'-76'6"		15	17	23			
80		16	80'-81'6"		10	13	12			

Soils Engineer: ______ Driller: P. Mitchell

Drilling Inspector: ______ Helper: S. Blackwell

R. Eosles

JOB LOCATION: Forked River, New Jersey

WARREN GEORGE, INC.
500 PALISADE AVENUE
JERSEY CITY, N.J. 07307

FOR: Burns and Roe

SHEET 3 OF 4
LOCATION Forked River NJ
HOLE NO. B 3
LINE & STA.
OFFSET

DEPTH ____ FT. ____ FT. CASING OUT DATE: ____
DEPTH ____ FT. ALL CASING OUT DATE: ____
DATE, START: 5-23-68
DATE, FINISH: 5-23-68
GROUND ELEVATION
GROUND WATER ELEVATION

CASING O.D. 4" I.D.
SAMPLER O.D. 2" I.D.
DIAMOND BIT SIZE
WEIGHT OF HAMMER 140# LBS.
INSIDE LENGTH OF SAMPLER ____ IN.
HAMMER FALL: CASING ____ SAMPLER ____

DEPTH BELOW SURFACE	CASING BLOWS PER FOOT	SAMPLE NUMBER	SAMPLE DEPTHS ELEV. / FEET	SAMPLE RECOVERY	BLOWS PER 6" ON SAMPLER 0-6	6-12	12-18	DENSITY OR CONSIST. MOISTURE	PROFILE CHANGE DEPTH	FIELD IDENTIFICATION OF SOILS REMARKS
0									73'-84'6"	(continued) drk. gray silty fine sand. tr. clay
		17	85'-86'6"		8	12	14		84'6"-87'	drk. gray med. to fine sand, tr. silt
									87'-108'	drk. gray silty clay and med to fine sand layers
10		18	90'-92' Tube	19"	recovery					
		19	95'-97' Tube	22"	recovery					
20		20	100'-101'6"		5	6	9			
		21	105'-107' Tube	23"	recovery					
									108'-150'2"	drk. gray med. to fine sand. tr. silt, tr. clay
30		22	110'-110'4"		50/4"					
		23	115'-115'4"		50/4"					
40		24	120'-120'6"		56/6"					

Soils Engineer: ____
Drilling Inspector: ____
Driller: P. Mitchell
Helper: S. Blackwell, J. Collins

JOB LOCATION: Forked River, New Jersey

WARREN GEORGE, INC.

500 PALISADE AVENUE
JERSEY CITY, N.J. 07307

FOR: Burns and Roe

SHEET 4 OF 4
LOCATION Forked River NJ
HOLE NO. B 3
LINE & STA.
OFFSET

DEPTH ____ FT. ____ FT. CASING OUT DATE: ____
DEPTH ____ FT. ALL CASING OUT DATE: ____

DATE, START: 5-23-68
DATE, FINISH: 5-23-68

GROUND ELEVATION ____
GROUND WATER ELEVATION ____

CASING O.D. ____ I.D. ____
SAMPLER O.D. ____ I.D. ____
DIAMOND BIT SIZE ____

WEIGHT OF HAMMER ____ LBS.
INSIDE LENGTH OF SAMPLER ____ IN.

HAMMER FALL
CASING ____ SAMPLER ____

DEPTH BELOW SURFACE	CASING BLOWS PER FOOT	SAMPLE NUMBER	SAMPLE DEPTHS ELEV. / FEET	SAMPLE RECOVERY	BLOWS PER 6" ON SAMPLER 0-6	6-12	12-18	DENSITY OR CONSIST. MOISTURE	PROFILE CHANGE DEPTH	FIELD IDENTIFICATION OF SOILS REMARKS
0 (120)									108-150'2"	dark gray med. to fine sand. tr. silt, tr. clay
		25	125'-125'3"		50/3"					
10 (130)		26	130'-130'6"		52/6"					
		27	135'-135'2"		50/2"					
20 (140)		28	140'-140'2"		50/2"					
		29	145'-145'3"		50/3"					
30 (150)		30	150'-150'2"		50/2"					Notes: 150' of 4" flush casing
										Ground Water 10'-5"
40 (160)										

Soils Engineer: ____
Drilling Inspector: ____
Driller: P. Mitchell
Helper: J. Blackwell, R. Ecclen

JOB LOCATION: Forked River, New Jersey

WARREN GEORGE, INC.

500 PALISADE AVENUE
JERSEY CITY, N.J. 07307

FOR: Burns and Roe

SHEET 1 OF 7
LOCATION Forked River NJ
HOLE NO. B 4
LINE & STA.
OFFSET

DEPTH ____ FT. ____ FT. CASING OUT DATE: ____
DEPTH ____ FT. ALL CASING OUT DATE: ____
DATE, START: 5-8-68
DATE, FINISH: 5-17-68
GROUND ELEVATION
GROUND WATER ELEVATION

CASING O.D. ____ I.D. ____
SAMPLER O.D. 2" I.D. ____
DIAMOND BIT SIZE ____
WEIGHT OF HAMMER 140# LBS.
INSIDE LENGTH OF SAMPLER ____ IN.
HAMMER FALL: CASING ____ SAMPLER 30"

Depth Below Surface	Casing Blows per Foot	Sample Number	Sample Depths Elev. / Feet	Sample Recovery	Blows per 6" on Sampler 0-6	6-12	12-18	Density or Consist. Moisture	Profile Change Depth	Field Identification of Soils Remarks
0									0"-14'	gray brn. med. to fine sand. w-trace fine gravel
		1	5'-6'6"		15	27	36			
10		2	10'-11'6"		19	25	26			
		3	15'-16'6"		4	5	8		14'-29'	dark silty clay and cly-silt w-sand lenses
20		4	20'-21'6"		4	5	7			
		5	25'-26'6"		5	7	9			
30		6	30'-31'6"		12	19	34		29'-50'	brn coarse to fine sand. trace silt
		7	35'-36'6"		14	26	39			
40		8	40'-41'		83	218				

Soils Engineer: ____
Drilling Inspector: ____
Driller: P. Mitchell
Helper: S. Blackwell, R. [illegible]

JOB LOCATION: Forked River, New Jersey	WARREN GEORGE, INC. 500 PALISADE AVENUE JERSEY CITY, N.J. 07307 FOR: Burns and Roe	SHEET 2 OF 7 LOCATION Forked River NJ HOLE NO. 3 4 LINE & STA. OFFSET

DEPTH ____ FT. ____ FT. CASING OUT DATE: ____ DEPTH ____ FT. ALL CASING OUT DATE: ____	DATE, START: 5-8-68 DATE, FINISH: 5-17-68	GROUND ELEVATION ____ GROUND WATER ELEVATION ____
CASING O.D. ____ I.D. ____ SAMPLER O.D. 2" I.D. ____ DIAMOND BIT SIZE ____	WEIGHT OF HAMMER 140# LBS. INSIDE LENGTH OF SAMPLER ____ IN.	HAMMER FALL CASING ____ SAMPLER 30"

DEPTH BELOW SURFACE	CASING BLOWS PER FOOT	SAMPLE NUMBER	SAMPLE DEPTHS ELEV. / FEET	SAMPLE RECOVERY	BLOWS PER 6" ON SAMPLER 0-6	6-12	12-18	DENSITY OR CONSIST. MOISTURE	PROFILE CHANGE DEPTH	FIELD IDENTIFICATION OF SOILS REMARKS
40									29'-50'	(continued) brn coarse to fine sand. tr. silt
		9	45'-46'		79	180				
50		10	50'-51'6"		36	49	54		50'-68'	brn-gray-med. to fine sand. trace silt
		11	55'-56'6"		33	44	51			
60		12	60'-61'6"		31	43	64			
		13	65'-66'6"		32	45	67			
70		14	70'-71'6"		26	49	84		68'-98'	dark gray silty med. to fine sand
		15	75'-76'6"		28	36	79			
80		16	80'-81'6"		11	12	14			

Soils Engineer: ____ Driller: P. Mitchell

Drilling Inspector: ____ Helper: S. Blackwell, R. Eccles

JOB LOCATION: Forked River New Jersey

WARREN GEORGE, INC.

500 PALISADE AVENUE
JERSEY CITY, N.J. 07307

FOR: Burns and Roe

SHEET 3 OF 7
LOCATION Forked River NJ
HOLE NO. B 4
LINE & STA.
OFFSET

DEPTH ______ FT. ____ FT. CASING OUT DATE: ______
DEPTH ______ FT. ALL CASING OUT DATE: ______
DATE, START: 5-8-68
DATE, FINISH: 5-12-68
GROUND ELEVATION ______
GROUND WATER ELEVATION ______

CASING O.D. ______ I.D. ______
SAMPLER O.D. 2" I.D. ______
DIAMOND BIT SIZE ______
WEIGHT OF HAMMER 140# LBS.
INSIDE LENGTH OF SAMPLER ______ IN.
HAMMER FALL: CASING ______ SAMPLER 30"

DEPTH BEL. ON SURFACE	CASING BLOWS PER FOOT	SAMPLE NUMBER	SAMPLE DEPTHS ELEV. / FEET	SAMPLE RECOVERY	BLOWS PER 6" ON SAMPLER 0-6	6-12	12-18	DENSITY OR CONSIST. MOISTURE	PROFILE CHANGE DEPTH	FIELD IDENTIFICATION OF SOILS REMARKS
80									68'-98' (continued)	dark gray silty med. to fine sand
		17	85'-86'6"		11	13	14			
90		18	90'-91'6"		11	12	14			
		19	95'-96'6"		26	28	33			
									98'-105'	dark gray silt w-clay and fine gray sand layers
100		20	100'-101'6"		5	8	14			
		21	105'-107' Tube						105'-218'	gray med. to fine sand. trace silt
110		22	110'-111'6"		10	19	64			
		23	115'-116'6"		40	69	87			
120		24	120'-121'6"		94	224	206			

Soils Engineer: ______
Drilling inspector: ______
Driller: P. Mitchell
Helper: S. Blackwell
R. Eccles

JOB LOCATION: Forked River, New Jersey

WARREN GEORGE, INC.
500 PALISADE AVENUE
JERSEY CITY, N.J. 07307

FOR: Burns and Roe

SHEET 4 OF 7
LOCATION Forked River NJ
HOLE NO. B 4
LINE & STA.
OFFSET

DEPTH ____ FT. ____ FT. CASING OUT DATE: ____
DEPTH ____ FT. ALL CASING OUT DATE: ____
DATE, START: 5-8-68
DATE, FINISH: 5-17-68
GROUND ELEVATION ____
GROUND WATER ELEVATION ____

CASING O.D. ____ I.D. ____
SAMPLER O.D. 2" I.D. ____
DIAMOND BIT SIZE ____
WEIGHT OF HAMMER 140# LBS.
INSIDE LENGTH OF SAMPLER ____ IN.
HAMMER FALL: CASING ____ SAMPLER 30"

DEPTH BELOW SURFACE	CASING BLOWS PER FOOT	SAMPLE NUMBER	SAMPLE DEPTHS ELEV. / FEET	SAMPLE RECOVERY	BLOWS PER 6" ON SAMPLER 0-6	6-12	12-18	DENSITY OR CONSIST. MOISTURE	PROFILE CHANGE DEPTH	FIELD IDENTIFICATION OF SOILS REMARKS
120									105'-218' (continued)	gray med. to fine sand. trace silt
		25	125'-126'		90	232				
130		26	130'-130'9"		74	200/3"				
		27	135'-135'9"		93	235/3"				
140		28	140'-141'		102	197				
		29	145'-146'6"		74	152	170			
150		30	150'-150'4"		50/4"					
		31	155'-155'3"		50/3"					
160		32	160'-160'2"		50/2"					

Soils Engineer: ____
Drilling Inspector: ____
Driller: P. Mitchell, S. Blackwell
Helper: R. Eccles

JOB LOCATION:	WARREN GEORGE, INC.	
Forked River New Jersey	500 PALISADE AVENUE JERSEY CITY, N.J. 07307 FOR: Burns and Roe	SHEET 5 OF 7 LOCATION Forked River NJ HOLE NO. B 4 LINE & STA. OFFSET

DEPTH ___ FT. ___ FT. CASING OUT DATE: ___ DEPTH ___ FT. ALL CASING OUT DATE: ___	DATE, START: 5-8-68 DATE, FINISH: 5-17-68	GROUND ELEVATION ___ GROUND WATER ELEVATION ___
CASING O.D. ___ I.D. ___ SAMPLER O.D. 2" I.D. ___ DIAMOND BIT SIZE ___	WEIGHT OF HAMMER 140# LBS. INSIDE LENGTH OF SAMPLER ___ IN.	HAMMER FALL CASING ___ SAMPLER 30"

DEPTH BELOW SURFACE	CASING BLOWS PER FOOT	SAMPLE NUMBER	SAMPLE DEPTHS ELEV. / FEET	SAMPLE RECOVERY	BLOWS PER 6" ON SAMPLER 0-6	6-12	12-18	DENSITY OR CONSIST. MOISTURE	PROFILE CHANGE DEPTH	FIELD IDENTIFICATION OF SOILS REMARKS
160									105'-218' (continued)	grey med. to fine sand. trace silt
		33	165'-165'2"		50/2"					
170		34	170'-170'3"		50/3"					
		35	175'-175'2"		50/2"					
180		36	180'-180'3"		50/3"					
		37	185'-185'3½"		50/3½"					
190		38	190'-190'4"		50/4"					
		39	195'-195'1"		50/1"					
200		40	20 '-200'11"		30	55/5"				

Soils Engineer: ___ Driller: P. Mitchell

Drilling inspector: ___ Helper: S Blackwell ~~R. Eccles~~

JOB LOCATION:	WARREN GEORGE, INC.	SHEET 6 OF 7
Forked River	500 PALISADE AVENUE	LOCATION Forked River NJ
New Jersey	JERSEY CITY, N.J. 07307	HOLE O. B 4
		LINE & STA.
	FOR: Burns and Roe	OFFSET

DEPTH ____ FT. ____ FT. CASING OUT DATE:	DATE, START: 5-8-68	GROUND ELEVATION
DEPTH ____ FT. ALL CASING OUT DATE:	DATE, FINISH: 5-17-68	GROUND WATER ELEVATION
CASING O.D. ____ I.D. ____	WEIGHT OF HAMMER 140# LBS.	HAMMER FALL
SAMPLER O.D. 2" I.D. ____	INSIDE LENGTH OF SAMPLER ____ IN.	CASING ____ SAMPLER 30"
DIAMOND BIT SIZE		

DEPTH BELOW SURFACE	CASING BLOWS PER FOOT	SAMPLE NUMBER	SAMPLE DEPTHS ELEV. / FEET	SAMPLE RECOVERY	BLOWS PER 6" ON SAMPLER 0-6	6-12	12-18	DENSITY OR CONSIST. MOISTURE	PROFILE CHANGE DEPTH	FIELD IDENTIFICATION OF SOILS REMARKS
200									105'-218' (continued)	gray med. to fine sand. trace silt
		41	205'-205' 6"		50/6"					
210		42	210'-210'3"		50/3"					
		43	215'-215'2"		50/2"					
									218'-230'	gray silty clay. very stiff.
220		44	220'-221'6"		29	30	48			
		45	225'-226'6"		31	41	52			
230		46	230'-232' Tube		Jar from tube				230'-243'	gray med. to fine sand. trace silt
		47	235'-235'2"		50/2"					
240		48	240'-240'2"		50/2"					

Soils Engineer: ____ Driller: P. Mitchell

Drilling Inspector: ____ Helper: S. Blackwell, ~~R. Eccles~~

JOB LOCATION: Forked River, New Jersey

WARREN GEORGE, INC.
500 PALISADE AVENUE
JERSEY CITY, N.J. 07307

FOR: Burns and Roe

SHEET 7 OF 7
LOCATION Forked River NJ
HOLE NO. B 4
LINE & STA.
OFFSET

DEPTH ____ FT. ____ FT. CASING OUT DATE: ____
DEPTH ____ FT. ALL CASING OUT DATE: ____
DATE, START: 5-8-68
DATE, FINISH: 5-17-68
GROUND ELEVATION ____
GROUND WATER ELEVATION ____

CASING O.D. 2" I.D. ____
SAMPLER O.D. ____ I.D. ____
DIAMOND BIT SIZE ____
WEIGHT OF HAMMER 140# LBS.
INSIDE LENGTH OF SAMPLER ____ IN.
HAMMER FALL: CASING ____ SAMPLER 30'

DEPTH BELOW SURFACE	CASING BLOWS PER FOOT	SAMPLE NUMBER	SAMPLE DEPTHS ELEV. / FEET	SAMPLE RECOVERY	BLOWS PER 6" ON SAMPLER 0-6	6-12	12-18	DENSITY OR CONSIST. MOISTURE	PROFILE CHANGE DEPTH	FIELD IDENTIFICATION OF SOILS REMARKS
240									230-243	(continued) gray med. to fine sand, trace silt
		49	245'-247' Tube	19" recovery					243'-251'	gray silty clay, very stiff
250		50	250'-251'6"		19	30	30			
									251'-251'6"	gray fine sand, some silt
260										
270										
40										

Notes

Ground Water Readings

11.0' 8 AM 5-9-68
11.0' 3 PM 5-17-68

Soils Engineer: ____
Drilling Inspector: ____
Driller: P. Mitchell
Helper: S. Blackwell, R. Eccles

JOB LOCATION: Forked River, New Jersey

WARREN GEORGE, INC.

500 PALISADE AVENUE
JERSEY CITY, N.J. 07307

FOR: Burns and Roe

SHEET 1 OF 4
LOCATION Forked River NJ
HOLE NO. B 5
LINE & STA.
OFFSET

DEPTH ____ FT. ____ FT. CASING OUT DATE: ____
DEPTH ____ FT. ALL CASING OUT DATE: ____
DATE, START: 5-17-68
DATE, FINISH: 5-17-68
GROUND ELEVATION ____
GROUND WATER ELEVATION ____

CASING O.D. ____ I.D. ____
SAMPLER O.D. 2" I.D. ____
DIAMOND BIT SIZE ____
WEIGHT OF HAMMER 140# LBS.
INSIDE LENGTH OF SAMPLER ____ IN.
HAMMER FALL: CASING ____ SAMPLER 30

DEPTH BEL-OW SURFACE	CASING BLOWS PER FOOT	SAMPLE NUMBER	SAMPLE DEPTHS ELEV. / FEET	SAMPLE RECOVERY	BLOWS PER 6" ON SAMPLER 0-6	6-12	12-18	DENSITY OR CONSIST. MOISTURE	PROFILE CHANGE DEPTH	FIELD IDENTIFICATION OF SOILS REMARKS
0									0"-18'	brown med. to fine sand. silt
		1	5'-6'6"		6	9	11			
10		2	10'-11'6"		13	17	18			
		3	15'-16'6"		6	2	3			
									18'-34'	dark silty clay. w-fine gray sand
20		4	20'-21'6"		3	4	7			
		5	25'-26'6"		4	7	12			
30		6	30'-31'6"		5	6	8			
									34'-40'	gray brown coarse to fine sand.
		7	35'-36'6"		5	10	16			
40		8	40'-41'6"		21	43	55			

Soils Engineer: ____
Driller: P. Mitchell
Drilling Inspector: ____
Helper: S. Blackwell, R. Eccles

JOB LOCATION:	WARREN GEORGE, INC.	SHEET 2 OF 4
Forked River	500 PALISADE AVENUE	LOCATION Forked River NJ
New Jersey	JERSEY CITY, N.J. 07307	HOLE NO. B 5
		LINE & STA.
	FOR: Burns and Roe	OFFSET

DEPTH ______ FT. ___ FT. CASING OUT DATE: ______ DATE, START: 5-17-68 GROUND ELEVATION ______

DEPTH ______ FT. ALL CASING OUT DATE: ______ DATE, FINISH: 5-17-68 GROUND WATER ELEVATION ______

CASING O.D. ______ I.D. ______ WEIGHT OF HAMMER 140# LBS. HAMMER FALL

SAMPLER O.D. 2" I.D. ______ INSIDE LENGTH OF SAMPLER ______ IN. CASING ______ SAMPLER 30# "

DIAMOND BIT SIZE ______

DEPTH BEL-OW SURFACE	CASING BLOWS PER FOOT	SAMPLE NUMBER	SAMPLE DEPTHS ELEV. / FEET	SAMPLE RECOVERY	BLOWS PER 6" ON SAMPLER 0-6	6-12	12-18	DENSITY OR CONSIST. MOISTURE	PROFILE CHANGE DEPTH	FIELD IDENTIFICATION OF SOILS REMARKS
40									40'-70'	brown coarse to fine sand
		9	45'-46'6"		21	36	49			
50		10	50'-51'6"		28	41	50			
		11	55'-56'6"		10	10	12			
60		12	60'-60' 4"		50/4"					
		13	65'-66'		42	52				
70		14	70'-71'6"		22	23	36		70'-77'6"	brown med. to fine sand. trace silt
		15	75'-76'6"		17	26	38			
80		16	80'-81'6"		6	12	14		77'6"-105'	gray med. to fine sand. tr. silt. occ silt & Clay Layer

Soils Engineer: ______ Driller: P. Mitchell / S. Blackwell

Drilling Inspector: ______ Helper: R. Eccles

JOB LOCATION: Forked River, New Jersey	WARREN GEORGE, INC. 500 PALISADE AVENUE JERSEY CITY, N.J. 07307 FOR: Burns and Roe	SHEET 3 OF 4 LOCATION Forked River NJ HOLE NO. B 5 LINE & STA. OFFSET

DEPTH ___ FT. ___ FT. CASING OUT DATE. ___	DATE, START: 5-17-68	GROUND ELEVATION
DEPTH ___ FT. ALL CASING OUT DATE: ___	DATE, FINISH: 5-17-68	GROUND WATER ELEVATION

CASING O.D. ___ I.D. ___ SAMPLER O.D. 2" I.D. ___ DIAMOND BIT SIZE ___	WEIGHT OF HAMMER 140# LBS. INSIDE LENGTH OF SAMPLER ___ IN.	HAMMER FALL CASING ___ SAMPLER 30"

DEPTH BELOW SURFACE	CASING BLOWS PER FOOT	SAMPLE NUMBER	SAMPLE DEPTHS ELEV. / FEET	SAMPLE RECOVERY	BLOWS PER 6" ON SAMPLER 0-6	6-12	12-18	DENSITY OR CONSIST. MOISTURE	PROFILE CHANGE DEPTH	FIELD IDENTIFICATION OF SOILS REMARKS
80									77'6"-105'	(continued) gray med. to fine sand. trace silt. occ. silt and clay layers
		17	85'-87' Tube							
90		18	90'-90'9"		16	50/3"				
		19	95'-97' Tube							
100		20	100'-101'6"		7	12	16			
		21	105'-105'3"		50/3"				105'-150'4"	gray medium fine sand. some silt. trace clay
110		22	110'-110'2"		50/2"					
		23	115'-115'2"		50/2"					
120		24	120'-120'3"		50/3"					

Soils Engineer: ___ Driller: P. Mitchell

Drilling Inspector: ___ Helper: S. Blackwell, R Eccles

JOB LOCATION:	WARREN GEORGE, INC.	SHEET 4 OF 4
Forked River New Jersey	500 PALISADE AVENUE JERSEY CITY, N.J. 07307	LOCATION Forked River NJ HOLE NO. B 5 LINE & STA. OFFSET
	FOR: Burns and Roe	

DEPTH ______ FT. ___ FT. CASING OUT DATE: ______ DATE, START: 5-17-68 GROUND ELEVATION ______

DEPTH ______ FT. ALL CASING OUT DATE: ______ DATE, FINISH: 5-17-68 GROUND WATER ELEVATION ______

CASING O.D. ______ I.D. ______ WEIGHT OF HAMMER 140# LBS. HAMMER FALL

SAMPLER O.D. 2" I.D. ______ INSIDE LENGTH OF SAMPLER ______ IN. CASING ______ SAMPLER 30"

DIAMOND BIT SIZE ______

DEPTH BELOW SURFACE	CASING BLOWS PER FOOT	SAMPLE NUMBER	SAMPLE DEPTHS ELEV. / FEET	SAMPLE RECOVERY	BLOWS PER 6" ON SAMPLER 0-6	6-12	12-18	DENSITY OR CONSIST. MOISTURE	PROFILE CHANGE DEPTH	FIELD IDENTIFICATION OF SOILS REMARKS
120									105'-150'4" (continued)	gray med. fine sand. some silt. trace clay
		25	125'-125'4"		50/4"					
130		26	130'-131'6"		39	46	54			
		27	135'-135'3"		50/3"					
140		28	140'-140'5"		50/5"					
		29	145'-145'4"		50/4"					
150		30	150'-150'4"		50/4"					Notes: 150 ' flush joint casing set.
160										

Soils Engineer: ______ Driller: P. Mitchell

Drilling Inspector: ______ Helper: S. Blackwell ~~R. Locles~~

WARREN GEORGE, INC.
500 PALISADE AVENUE
JERSEY CITY, N.J. 07307

JOB LOCATION: Forked River New Jersey

FOR: Burns and Roe

SHEET 1 OF 4
LOCATION Forked River NJ
HOLE NO. B 6
LINE & STA.
OFFSET

DEPTH ______ FT. ____ FT. CASING OUT DATE: ______
DEPTH ______ FT. ALL CASING OUT DATE: ______
DATE, START: 5-15-68
DATE, FINISH: 5-17-68
GROUND ELEVATION
GROUND WATER ELEVATION

CASING O.D. ______ I.D. ______
SAMPLER O.D. 2" I.D. ______
DIAMOND BIT SIZE
WEIGHT OF HAMMER 140# LBS.
INSIDE LENGTH OF SAMPLER ______ IN.
HAMMER FALL CASING ______ SAMPLER 30"

DEPTH BELOW SURFACE	CASING BLOWS PER FOOT	SAMPLE NUMBER	SAMPLE DEPTHS ELEV. / FEET	SAMPLE RECOVERY	BLOWS PER 6" ON SAMPLER 0-6	6-12	12-18	DENSITY OR CONSIST. MOISTURE	PROFILE CHANGE DEPTH	FIELD IDENTIFICATION OF SOILS REMARKS
0									0"-9'	brown med. fine sand, dry
		1	5'-6'6"		12	18	16			
10									9'-17'6"	brown fine sand, some silt, wet
		2	10'-11'6"		10	12	14			
		3	15'-16'6"		6	3	2			
									17'6"-34'	dark gray silty clay, sand layers
20		4	20'-21'6"		3	3	4			
		5	25'-26'6"		9	8	10			
30		6	30'-31'6"		4	6	6			
		7	35'-36'6"		7	6	9		34'-40'	gray-brn coarse to fine sand, very wet
40		8	40'-41'6"		9	8	9			

Soils Engineer: ______
Driller: P. Mitchell ~~S. Blackwell~~
Drilling Inspector: ______
Helper: R. Eccles

JOB LOCATION: Forked River, New Jersey	WARREN GEORGE, INC. 500 PALISADE AVENUE JERSEY CITY, N.J. 07307 FOR: Burns and Roe	SHEET 2 OF 4 LOCATION Forked River NJ HOLE NO. B 6 LINE & STA. OFFSET

DEPTH ____ FT. ____ FT. CASING OUT DATE: ____ DATE, START: 5-15-68 GROUND ELEVATION ____
DEPTH ____ FT. ALL CASING OUT DATE: ____ DATE, FINISH: 5-17-68 GROUND WATER ELEVATION ____

CASING O.D. ____ I.D. ____ WEIGHT OF HAMMER 140# LBS. HAMMER FALL
SAMPLER O.D. 2" I.D. ____ INSIDE LENGTH OF SAMPLER ____ IN. CASING ____ SAMPLER 30"
DIAMOND BIT SIZE ____

DEPTH BELOW SURFACE	CASING BLOWS PER FOOT	SAMPLE NUMBER	SAMPLE DEPTHS ELEV. / FEET	SAMPLE RECOVERY	BLOWS PER 6" ON SAMPLER 0-6	6-12	12-18	DENSITY OR CONSIST. MOISTURE	PROFILE CHANGE DEPTH	FIELD IDENTIFICATION OF SOILS REMARKS
40									40'-52'	red-brn coarse to fine sand. very wet.
		9	45'-45'3"		50/3"					
50		10	50'-51'6"		10	35	50			
									52'-70'	gray med to fine sand.
		11	55'-55'5"		50/5"					
60		12	60'-60'9"		42	50/5"				
		13	65'-66'6"		25	41	42			
70		14	70'-71'6"		21	26	47		70'-75'	Gray brown med to fine sand
		15	75'-75'6"		54/6"				75'-80'	brown med. to fine sand
80		16	80'-81'6"		14	24	30			

Soils Engineer: ____ Driller: P Mitchell
Drilling Inspector: ____ Helper: S. Blackwell, R. Eccles

JOB LOCATION: Forked River, New Jersey

WARREN GEORGE, INC.

500 PALISADE AVENUE
JERSEY CITY, N.J. 07307

FOR: Burns and Roe

SHEET 3 OF 4
LOCATION Forked River NJ
HOLE NO. B 6
LINE & STA.
OFFSET

DEPTH ____ FT. ____ FT. CASING OUT DATE: ____
DEPTH ____ FT. ALL CASING OUT DATE: ____

DATE, START: 5-15-68
DATE, FINISH: 5-17-68

GROUND ELEVATION
GROUND WATER ELEVATION

CASING O.D. ____ I.D. ____
SAMPLER O.D. 2" I.D. ____
DIAMOND BIT SIZE

WEIGHT OF HAMMER 140# LBS.
INSIDE LENGTH OF SAMPLER ____ IN.

HAMMER FALL: CASING ____ SAMPLER 30"

DEPTH BELOW SURFACE	CASING BLOWS PER FOOT	SAMPLE NUMBER	SAMPLE DEPTHS ELEV. / FEET	SAMPLE RECOVERY	BLOWS PER 6" ON SAMPLER 0-6	6-12	12-18	DENSITY OR CONSIST. MOISTURE	PROFILE CHANGE DEPTH	FIELD IDENTIFICATION OF SOILS REMARKS
80									80'-88'	gray med. to fine sand.
		17	85'-86'4"		27	37	50/4"			
									88'-103'	gray and brown silty clay w-gray sand layers
90		18	90'-92' Tube	22"	Recovery					
		19	95'-96'4"		21	39	50/4"			
100		20	100'-102' Tube	22"	Recovery					
									103'-150'	gray med. f. sand
		21	105'-105'3"		50/3"					
110		22	110'-110'2"		50/2"					
		23	115'-115'5"		50/5"					
120		24	120'- 120'11"		29	50/5"				

Soils Engineer: ____
Drilling Inspector: ____
Driller: P. Mitchell
Helper: S. Blackwell
~~R. Scales~~

JOB LOCATION: Forked River, New Jersey

WARREN GEORGE, INC.

500 PALISADE AVENUE
JERSEY CITY, N.J. 07307

FOR: Burns and Roe

SHEET 4 OF 4
LOCATION Forked River NJ
HOLE NO. B 6
LINE & STA.
OFFSET

DEPTH ____ FT. ____ FT. CASING OUT DATE: ____
DEPTH ____ FT. ALL CASING OUT DATE: ____
DATE, START: 5-15-68
DATE, FINISH: 5-17-68
GROUND ELEVATION ____
GROUND WATER ELEVATION ____

CASING O.D. ____ I.D. ____
SAMPLER O.D. 2" I.D. ____
DIAMOND BIT SIZE ____
WEIGHT OF HAMMER 140# LBS.
INSIDE LENGTH OF SAMPLER ____ IN.
HAMMER FALL: CASING ____ SAMPLER 30"

DEPTH BEL-OW SURFACE	CASING BLOWS PER FOOT	SAMPLE NUMBER	SAMPLE DEPTHS ELEV. / FEET	SAMPLE RECOVERY	BLOWS PER 6" ON SAMPLER 0-6	6-12	12-18	DENSITY OR CONSIST. MOISTURE	PROFILE CHANGE DEPTH	FIELD IDENTIFICATION OF SOILS REMARKS
120									103'-150' (continued)	gray med. to fine sand.
		25	125'-125'4"		50/4"					
130		26	130'-130'6"		55/6"					
		27	135'-135'5"		50/5"					
140		28	140'-140'4"		50/4"					
		29	145'-145'4"		50/4"					
150		30	150'-150'6"		68/6"					Notes: 150' of 4" flush joint pipe set. 150 ft. pipe. Ground water readings: 9.0' 8 am 5-16-68; 9.0' 8 am 5-17-68; 11' 3 pm 5-17-68
160										

Soils Engineer: ____
Drilling Inspector: ____
Driller: P. Mitchell
Helper: S. Blackwell, ~~R. Eccles~~

JOB LOCATION: Forked River New Jersey

WARREN GEORGE, INC.

500 PALISADE AVENUE
JERSEY CITY, N.J. 07307

FOR: Burns and Roe

SHEET 1 OF 2
LOCATION Forked River NJ
HOLE NO. B 7
LINE & STA.
OFFSET

DEPTH ______ FT. ____ FT. CASING OUT DATE: ______
DEPTH ______ FT. ALL CASING OUT DATE: ______
DATE, START: 5-12-68
DATE, FINISH: 5-13-68
GROUND ELEVATION
GROUND WATER ELEVATION

CASING O.D. ______ I.D. ______
SAMPLER O.D. 2" I.D. ______
DIAMOND BIT SIZE ______
WEIGHT OF HAMMER 140# LBS.
INSIDE LENGTH OF SAMPLER ______ IN.
HAMMER FALL: CASING ______ SAMPLER 30"

DEPTH BELOW SURFACE	CASING BLOWS PER FOOT	SAMPLE NUMBER	SAMPLE DEPTHS ELEV. / FEET	SAMPLE RECOVERY	BLOWS PER 6" ON SAMPLER 0-6	6-12	12-18	DENSITY OR CONSIST. MOISTURE	PROFILE CHANGE DEPTH	FIELD IDENTIFICATION OF SOILS REMARKS
0									0"-9'	gray brown med. to fine sand. dry
		1	5'-6'6"		18	30	29			
10		2	10'-11'6"		16	22	29		9'-15'3"	brown med. to fine sand wet
		3	15'-16'6"		3	7	12		15'3"-20'	dark gray fine silty sand some clay
20		4	20'-21'6"		10	9	12		20'-25'	dark gray silty clay, fine sand
		5	25'-26'6'		22	29	20		25'-30'	gray fine sand.
30		6	30'-31'6"		14	13	10		30'-35'	gray silty sand
		7	35'-36'6"		15	19	28	—	35'-44'	brown fine sand.
40		8	40'-41'6"		14	18	25			

Soils Engineer: ______ Driller: P. Mitchell
Drilling Inspector: ______ Helper: S Blackwell, R. Eccles

JOB LOCATION: Forked River, New Jersey	WARREN GEORGE, INC. 500 PALISADE AVENUE JERSEY CITY, N.J. 07307 FOR: Burns and Roe	SHEET 2 OF 2 LOCATION Forked River N HOLE NO. B 7 LINE & STA. OFFSET

DEPTH ___ FT. ___ FT. CASING OUT DATE: ___	DATE, START: 5-13-68	GROUND ELEVATION ___
DEPTH ___ FT. ALL CASING OUT DATE: ___	DATE, FINISH: 5-13-68	GROUND WATER ELEVATION ___

CASING O.D. ___ I.D. ___	WEIGHT OF HAMMER 140# LBS.	HAMMER FALL
SAMPLER O.D. 2" I.D. ___	INSIDE LENGTH OF SAMPLER ___ IN.	CASING ___ SAMPLER 30"
DIAMOND BIT SIZE ___		

DEPTH BELOW SURFACE	CASING BLOWS PER FOOT	SAMPLE NUMBER	SAMPLE DEPTHS ELEV. / FEET	SAMPLE RECOVERY	BLOWS PER 6" ON SAMPLER 0-6	6-12	12-18	DENSITY OR CONSIST. MOISTURE	PROFILE CHANGE DEPTH	FIELD IDENTIFICATION OF SOILS REMARKS
40									35'-44'	(continued) brown fine sand
		9	45'-46'6"		24	28	33		44'-51'6"	brown coarse to fine sand
50		10	50'-51'6"		21	23	14			
60										Notes: Ground Water Reading 8' 3 PM 5-17-68
70										
80										

Soils Engineer: ___ Driller: P. Mitchell

Drilling Inspector: ___ Helper: S. Blackwell, R. Eccles

JOB LOCATION: Forked River, New Jersey

WARREN GEORGE, INC.

500 PALISADE AVENUE
JERSEY CITY, N.J. 07307

FOR: Burns and Roe

SHEET 1 OF 2
LOCATION Forked River NJ
HOLE NO. B 8
LINE & STA.
OFFSET

DEPTH ____ FT. ____ FT. CASING OUT DATE: ____
DEPTH ____ FT. ALL CASING OUT DATE: ____
DATE, START: 5-15-68
DATE, FINISH: 5-15-68
GROUND ELEVATION
GROUND WATER ELEVATION

CASING O.D. ____ I.D. ____
SAMPLER O.D. 2" I.D. ____
DIAMOND BIT SIZE ____
WEIGHT OF HAMMER 140# LBS.
INSIDE LENGTH OF SAMPLER ____ IN.
HAMMER FALL
CASING ____ SAMPLER 30"

Depth Bel. on Surface	Casing Blows per Foot	Sample Number	Sample Depths Elev. / Feet	Sample Recovery	Blows per 6" on Sampler 0-6	6-12	12-18	Density or Consist. Moisture	Profile Change Depth	Field Identification of Soils Remarks
0									0"-10'	gray med. to fine sand. dry
		1	5'-6'6"		19	20	22			
10		2	10'-11'6"		10	14	18		10'-17'6"	gray brown fine sand. silt. wet.
		3	15'-16'6"		11	8	4		17'6"-28'	dark brown silty clay w-fine sand layers
20		4	20'-21'6"		5	8	9			
		5	25'-26'6"		4	10	12		28'-33'	brown silty fine sand. w-clay
30		6	30'-31'6"		5	8	17		33'-51'4"	brown coarse to fine sand.
		7	35'-36'6"		23	32	30			
40		8	40'-41'6"		15	30	28			

Soils Engineer: ____
Drilling Inspector: ____
Driller: P. Mitchell
Helper: S. Blackwell, R. Eccles

LOCATION: Forked River, New Jersey

WARREN GEORGE, INC.
500 PALISADE AVENUE
JERSEY CITY, N.J. 07307

FOR: Burns and Roe

SHEET 2 OF 2
LOCATION Forked River NJ
HOLE NO. B 8
LINE & STA.
OFFSET -

DEPTH ____ FT. ____ FT. CASING OUT DATE: ____
DEPTH ____ FT. ALL CASING OUT DATE: ____

DATE, START: 5-15-68
DATE, FINISH: 5-15-68

GROUND ELEVATION ____
GROUND WATER ELEVATION ____

CASING O.D. ____ I.D. ____
SAMPLER O.D. 2" I.D. ____
DIAMOND BIT SIZE ____

WEIGHT OF HAMMER 140# LBS.
INSIDE LENGTH OF SAMPLER ____ IN.

HAMMER FALL
CASING ____ SAMPLER 30"

DEPTH BELOW SURFACE	CASING BLOWS PER FOOT	SAMPLE NUMBER	SAMPLE DEPTHS ELEV. / FEET	SAMPLE RECOVERY	BLOWS PER 6" ON SAMPLER 0-6	6-12	12-18	DENSITY OR CONSIST. MOISTURE	PROFILE CHANGE DEPTH	FIELD IDENTIFICATION OF SOILS REMARKS
40									33'-51'4" (continued)	brown coarse to fine sand
		9	45'-46'6"		18	31	26			
50		10	50'-51'4"		17	30	50/4"			
										Ground Water Reading 7'10" 3 PM 5-17-68
60										
70										
80										

Soils Engineer: ____ Driller: P. Mitchell
Drilling Inspector: ____ Helper: S. Blackwell, R. Eccles

JOB LOCATION: Forked River, New Jersey

WARREN GEORGE, INC.

500 PALISADE AVENUE
JERSEY CITY, N.J. 07307

FOR: Burns and Roe

SHEET 1 OF 2
LOCATION Forked River NJ
HOLE NO. B 9
LINE & STA.
OFFSET 10.5' EAST

DEPTH ______ FT. ____ FT. CASING OUT DATE: ______
DEPTH ______ FT. ALL CASING OUT DATE: ______
DATE, START: 5-14-68
DATE, FINISH: 5-14-68
GROUND ELEVATION ______
GROUND WATER ELEVATION ______

CASING O.D. ______ I.D. ______
SAMPLER O.D. 2" I.D. ______
DIAMOND BIT SIZE ______
WEIGHT OF HAMMER 140# LBS.
INSIDE LENGTH OF SAMPLER ______ IN.
HAMMER FALL: CASING ______ SAMPLER 30"

DEPTH BELOW SURFACE	CASING BLOWS PER FOOT	SAMPLE NUMBER	SAMPLE DEPTHS ELEV. / FEET	SAMPLE RECOVERY	BLOWS PER 6" ON SAMPLER 0-6	6-12	12-18	DENSITY OR CONSIST. MOISTURE	PROFILE CHANGE DEPTH	FIELD IDENTIFICATION OF SOILS REMARKS
0									0"-9'6"	brown fine sand
		1	5'-6'6"		25	30	24			
10		2	10'-11'6"		10	14	15		9'6"-15'	brown silty fine sand
		3	15'-16'6"		11	16	17		15'-17'	brown fine sand. tr. silt
									17'-28'	dark gray silty clay. fine sand
20		4	20'-21'6"		4	4	5			
		5	25'-26'6"		7	7	7			
30		6	30'-31'6"		6	10	13		28'-34'6"	dark gray silty fine sand
		7	35'-36'6"		12	15	14		34'6"-40'	brown layers of silty clay and coarse to fine sand.
40		8	40'-41'6"		9	16	28			

Soils Engineer: ______
Drilling Inspector: ______
Driller: P. Mitchell
Helper: S. Blackwell, ~~R. Eccles~~

JOB LOCATION: Forked River, New Jersey

WARREN GEORGE, INC.

500 PALISADE AVENUE
JERSEY CITY, N.J. 07307

FOR: Burns and Roe

SHEET 2 OF 2
LOCATION Forked River NJ
HOLE NO. B 9
LINE & STA.
OFFSET 11.5' EAST

DEPTH ______ FT. ___ FT. CASING OUT DATE: ______
DEPTH ______ FT. ALL CASING OUT DATE: ______

DATE, START: 5-14-68
DATE, FINISH: 5-14-68

GROUND ELEVATION ______
GROUND WATER ELEVATION ______

CASING O.D. ______ I.D. ______
SAMPLER O.D. 2" I.D. ______
DIAMOND BIT SIZE ______

WEIGHT OF HAMMER 140# LBS.
INSIDE LENGTH OF SAMPLER ______ IN.

HAMMER FALL
CASING ______ SAMPLER 30"

DEPTH BELOW SURFACE	CASING BLOWS PER FOOT	SAMPLE NUMBER	SAMPLE DEPTHS ELEV. / FEET	SAMPLE RECOVERY	BLOWS PER 6" ON SAMPLER 0-6	6-12	12-18	DENSITY OR CONSIST. MOISTURE	PROFILE CHANGE DEPTH	FIELD IDENTIFICATION OF SOILS REMARKS
40									40'-45'	brown gray coarse to fine sand, some silt
		9	45'-46'6"		12	22	20		45'-47'	brown silty fine sand
									47'-51'6"	gray coarse to fine sand trace silt
50		10	50'-51'6"		10	18	20			
60										Notes: Ground Water Reading 13' 3 PM 5-17-68
70										
80										

Soils Engineer: ______
Drilling Inspector: ______

Driller: P. Mitchell
Helper: S. Blackwell, R. Eccles

JOB LOCATION: Forked River
New Jersey

WARREN GEORGE, INC.
500 PALISADE AVENUE
JERSEY CITY, N.J. 07307

FOR: Burns and Roe

SHEET 1 OF 3
LOCATION Forked River NJ
HOLE NO. B 10
LINE & STA.
OFFSET 71.0' EAST-[illegible]

DEPTH ____ FT. ____ FT. CASING OUT DATE: ____
DEPTH ____ FT. ALL CASING OUT DATE: ____
DATE, START: 5-13-68
DATE, FINISH: 5-13-68
GROUND ELEVATION ____
GROUND WATER ELEVATION ____

CASING O.D. ____ I.D. ____
SAMPLER O.D. 2" I.D. ____
DIAMOND BIT SIZE ____
WEIGHT OF HAMMER 140# LBS.
INSIDE LENGTH OF SAMPLER ____ IN.
HAMMER FALL: CASING ____ SAMPLER 30"

DEPTH BELOW SURFACE	CASING BLOWS PER FOOT	SAMPLE NUMBER	SAMPLE DEPTHS ELEV. / FEET	SAMPLE RECOVERY	BLOWS PER 6" ON SAMPLER 0-6	6-12	12-18	DENSITY OR CONSIST. MOISTURE	PROFILE CHANGE DEPTH	FIELD IDENTIFICATION OF SOILS REMARKS
0									0"-9'	brown med. to fine sand dry
		1	5'-6'6"		31	31	29			
10		2	10'-11'6"		21	228	21		9'-18'6"	brown fine sand w-grace silt, trace fine gravel wet
		3	15'-16'6"		16	21	26			
20		4	20'-21'6"		3	3	6		18'6"-33'	dark gray clay w fine sand layers
		5	25'-26'6"		6	7	9			
30		6	30'-31'6"		6	8	16			
		7	35'-36'6"		10	16	16		33'-60'	brown coarse to fine sand. traee of fine gravel
40		8	40'-41'6"		23	30	29			

Soils Engineer: ____
Drilling Inspector: ____
Driller: P. Mitcell
Helper: S. Blackwell
R. Eccles

JOB LOCATION: Forked River, New Jersey

WARREN GEORGE, INC.

500 PALISADE AVENUE
JERSEY CITY, N.J. 07307

FOR:

SHEET 2 OF 3
LOCATION Forked River NJ
HOLE NO. B 10
LINE & STA.
OFFSET 21.0' East-Wires

DEPTH ______ FT. ____ FT. CASING OUT DATE: ______
DEPTH ______ FT. ALL CASING OUT DATE: ______
DATE, START: 5-13-68
DATE, FINISH: 5-13-68
GROUND ELEVATION
GROUND WATER ELEVATION

CASING O.D. ______ I.D. ______
SAMPLER O.D. 2" I.D. ______
DIAMOND BIT SIZE ______
WEIGHT OF HAMMER 140# LBS.
INSIDE LENGTH OF SAMPLER ______ IN.
HAMMER FALL
CASING ______ SAMPLER 30"

DEPTH BELOW SURFACE	CASING BLOWS PER FOOT	SAMPLE NUMBER	SAMPLE DEPTHS ELEV. / FEET	SAMPLE RECOVERY	BLOWS PER 6" ON SAMPLER 0-6	6-12	12-18	DENSITY OR CONSIST. MOISTURE	PROFILE CHANGE DEPTH	FIELD IDENTIFICATION OF SOILS REMARKS
40									33'-60'	brown coarse to fine sand, trace fine gravel
		9	45'-46'6"		30	29	33			
50		10	50'-51'6"		26	27	31			
		11	55'-56'6"		13	16	13			
60		12	60'-60'3"		50/3"				60'-78'	brown med. to fine sand, trace silt
		13	65'-66'6"		18	24	38			
70		14	70'-71'6"		31	37	48			
		15	75'-76'6"		32	38	47			
80		16	80'-81'6"		5	6	8		78'-90'	dark gray fine silty sand

Soils Engineer: ______
Drilling Inspector: ______
Driller: P. Mitchell
Helper: S. Blackwell, R. Eccles

JOB LOCATION: Forked River New Jersey

WARREN GEORGE, INC.

500 PALISADE AVENUE
JERSEY CITY, N.J. 07307

FOR: Burns and Roe

SHEET 3 OF 3
LOCATION Forked River NJ
HOLE NO. B 10
LINE & STA.
OFFSET [illegible]

DEPTH ____ FT. ____ FT. CASING OUT DATE: ____
DEPTH ____ FT. ALL CASING OUT DATE: ____
DATE, START: 5-13-68
DATE, FINISH: 5-17-68
GROUND ELEVATION ____
GROUND WATER ELEVATION ____

CASING O.D. ____ I.D. ____
SAMPLER O.D. 2" I.D. ____
DIAMOND BIT SIZE ____
WEIGHT OF HAMMER 140# LBS.
INSIDE LENGTH OF SAMPLER ____ IN.
HAMMER FALL
CASING ____ SAMPLER 30"

DEPTH BELOW SURFACE	CASING BLOWS PER FOOT	SAMPLE NUMBER	SAMPLE DEPTHS ELEV. / FEET	SAMPLE RECOVERY	BLOWS PER 6" ON SAMPLER 0-6	6-12	12-18	DENSITY OR CONSIST. MOISTURE	PROFILE CHANGE DEPTH	FIELD IDENTIFICATION OF SOILS REMARKS
80									78'-90'	(continued) dark gray fine silty sand
		17	85'-86'6"		9	12	16			
90		18	90'-91'6"		18	26	43		90'-95'	gray med to fine sand
		19	95'-96'6"		19	28	41		95'-98'	gray fine sand. very wet
100		20	100'-101'6"		3	7	9		98'-101'6"	dark gray silty clay w-fine sand.
										Notes; Ground Water Reading 11' 3 pm 5-17-68
110										
120										

Soils Engineer: ____
Drilling Inspector: ____
Driller: P. Mitchell
Helper: S. Blackwell, R. Eckles

JOB LOCATION: Forked River New Jersey

WARREN GEORGE, INC.

500 PALISADE AVENUE
JERSEY CITY, N.J. 07307

FOR: Burns and Roe

SHEET 1 OF 2
LOCATION Forked River NJ
HOLE NO. B 11
LINE & STA.
OFFSET

DEPTH ______ FT. ____ FT. CASING OUT DATE: ______
DEPTH ______ FT. ALL CASING OUT DATE: ______
DATE, START: 5-14-68
DATE, FINISH: 5-14-68
GROUND ELEVATION
GROUND WATER ELEVATION

CASING O.D. ______ I.D. ______
SAMPLER O.D. 2" I.D. ______
DIAMOND BIT SIZE ______
WEIGHT OF HAMMER 140# LBS.
INSIDE LENGTH OF SAMPLER ______ IN.
HAMMER FALL CASING ______ SAMPLER 30"

DEPTH BELOW SURFACE	CASING BLOWS PER FOOT	SAMPLE NUMBER	SAMPLE DEPTHS ELEV. / FEET	SAMPLE RECOVERY	BLOWS PER 6" ON SAMPLER 0-6	6-12	12-18	DENSITY OR CONSIST. MOISTURE	PROFILE CHANGE DEPTH	FIELD IDENTIFICATION OF SOILS REMARKS
0									0"-3'	brown sand. fill
									3'-16'	brown med. fine sand. trace silt
		1	5'-6'6"		12	16	21			
10		2	10'-11'6"		11	14	23			
		3	15'-16'6"		12	9	6			
									16'-37'	dark gray silty clay
20		4	20'-21'6"		3	2	3			
		5	25'-26'6"		6	4	9			
30		6	30'-31'6"		10	10	12			
		7	35'-36'6"		12	14	17			
									37'-45'	brown coarse to fine sand silt
40		8	40'-40'9"		32	50/3"				

Soils Engineer: ______
Drilling Inspector: ______
Driller: P. Mitchell
Helper: S. Blackwell

JOB LOCATION: Forked River, New Jersey

WARREN GEORGE, INC.

500 PALISADE AVENUE
JERSEY CITY, N.J. 07307

FOR: Burns and Roe

SHEET 2 OF 2
LOCATION Forked River NJ
HOLE NO. B 11
LINE & STA.
OFFSET

DEPTH ____ FT. ____ FT. CASING OUT DATE: ____
DEPTH ____ FT. ALL CASING OUT DATE: ____
DATE, START: 5-14-68
DATE, FINISH: 5-14-68
GROUND ELEVATION
GROUND WATER ELEVATION

CASING O.D. ____ I.D. ____
SAMPLER O.D. 2" I.D. ____
DIAMOND BIT SIZE
WEIGHT OF HAMMER 140# LBS.
INSIDE LENGTH OF SAMPLER ____ IN.
HAMMER FALL CASING ____ SAMPLER 30"

DEPTH BELOW SURFACE	CASING BLOWS PER FOOT	SAMPLE NUMBER	SAMPLE DEPTHS ELEV. / FEET	SAMPLE RECOVERY	BLOWS PER 6" ON SAMPLER 0-6	6-12	12-18	DENSITY OR CONSIST. MOISTURE	PROFILE CHANGE DEPTH	FIELD IDENTIFICATION OF SOILS REMARKS
40 (0)									37'-45'	(continued) brown coarse to fine sand, silt
		9	45'-46'6"		16	17	23		45'-48'	brown coarse to fine sand, silt, with fine gravel
									48'-51'6"	red brown coarse to fine sand
50 (10)		10	50'-51'6"		14	15	17			
60 (20)										
70 (30)										
80 (40)										

Notes:

Ground Water Reading

11.0' 3 pm 5-17-68

Soils Engineer: ____
Drilling Inspector: ____
Driller: P Mitchell
Helper: S. Blackwell

JOB LOCATION: Forked River, New Jersey

WARREN GEORGE, INC.

500 PALISADE AVENUE
JERSEY CITY, N.J. 07307

FOR: Burns and Roe

SHEET 1 OF 2
LOCATION ~~Forked River NJ~~
HOLE NO. B 12
LINE & STA.:
OFFSET 21.0' EAST-WIRES

DEPTH ____ FT. ____ FT. CASING OUT DATE: ____
DEPTH ____ FT. ALL CASING OUT DATE: ____
DATE, START: 5-10-68
DATE, FINISH: 5-10-68
GROUND ELEVATION ____
GROUND WATER ELEVATION ____

CASING O.D. ____ I.D. ____
SAMPLER O.D. 2" I.D. ____
DIAMOND BIT SIZE ____
WEIGHT OF HAMMER 140# LBS.
INSIDE LENGTH OF SAMPLER ____ IN.
HAMMER FALL: CASING ____ SAMPLER 30"

DEPTH BELOW SURFACE	CASING BLOWS PER FOOT	SAMPLE NUMBER	SAMPLE DEPTHS ELEV. / FEET	SAMPLE RECOVERY	BLOWS PER 6" ON SAMPLER 0-6	6-12	12-18	DENSITY OR CONSIST. MOISTURE	PROFILE CHANGE DEPTH	FIELD IDENTIFICATION OF SOILS REMARKS
0									0"-10'	yellow med. to fine sand dry
		1	5'-6'6"		10	10	14			
10		2	10'-11'6"		18	26	24		10'-14'	yellow med to fine sand. some silt. wet
		3	15'-16'6"		2	2	4		14'-33'6"	dark gray silty clay
20		4	20'-21'6"		2	2	4			
		5	25'-26'6"		11	14	15			
30		6	30'-31'6"		5	6	9			
		7	35'-36'6"		13	15	16		33'6"-40'	yellow brown coarse to fine sand. tr. silt
40		8	40'-41'6"		23	21	30			

Soils Engineer: ____
Drilling Inspector: ____
Driller: P. Mitchell
Helper: S Blackwell, R. Eccles

JOB LOCATION: Forked River New Jersey

WARREN GEORGE, INC.

500 PALISADE AVENUE
JERSEY CITY, N.J. 07307

FOR: Burns and Roe

SHEET 2 OF 2
LOCATION Forked River NJ
HOLE NO. B 12
LINE & STA.
OFFSET 21.0' East wires

DEPTH ____ FT. ____ FT. CASING OUT DATE: ____
DEPTH ____ FT. ALL CASING OUT DATE: ____
DATE, START: 5-10-68
DATE, FINISH: 5-10-68
GROUND ELEVATION ____
GROUND WATER ELEVATION ____

CASING O.D. ____ I.D. ____
SAMPLER O.D. 2" I.D. ____
DIAMOND BIT SIZE ____
WEIGHT OF HAMMER 140# LBS.
INSIDE LENGTH OF SAMPLER ____ IN.
HAMMER FALL: CASING ____ SAMPLER 30"

DEPTH BELOW SURFACE	CASING BLOWS PER FOOT	SAMPLE NUMBER	SAMPLE DEPTHS ELEV. / FEET	SAMPLE RECOVERY	BLOWS PER 6" ON SAMPLER 0-6	6-12	12-18	DENSITY OR CONSIST. MOISTURE	PROFILE CHANGE DEPTH	FIELD IDENTIFICATION OF SOILS REMARKS
40									40'-49'	yellow brown fine sand
		9	45'-46'6"		19	25	17			
50		10	50'-51'6"		3	3	3		49'-51'6"	gray very wet loose coarse to fine sand
60										
70										
80										

Notes:
Ground Water Reading
10.0' 3 PM 5-17-68

Soils Engineer: ____ Driller: P. Mitchell
Drilling Inspector: ____ Helper: S. Blackwell, R. Eccles

JOB LOCATION: Forked River, New Jersey

WARREN GEORGE, INC.

500 PALISADE AVENUE
JERSEY CITY, N.J. 07307

FOR: Burns and Roe

SHEET 1 OF 4
LOCATION Forked River NJ
HOLE NO. B 13
LINE & STA.
OFFSET

DEPTH ______ FT. ____ FT. CASING OUT DATE: ______
DEPTH ______ FT. ALL CASING OUT DATE: ______
DATE, START: 5-15-68
DATE, FINISH: also 6-10-68
GROUND ELEVATION ______
GROUND WATER ELEVATION ______

CASING O.D. 2" & 4" I.D. ______
SAMPLER O.D. ______ I.D. ______
DIAMOND BIT SIZE ______
WEIGHT OF HAMMER 140# LBS.
INSIDE LENGTH OF SAMPLER ______ IN.
HAMMER FALL CASING ______ SAMPLER ______

DEPTH BELOW SURFACE	CASING BLOWS PER FOOT	SAMPLE NUMBER	SAMPLE DEPTHS ELEV. / FEET	SAMPLE RECOVERY	BLOWS PER 6" ON SAMPLER 0-6	6-12	12-18	DENSITY OR CONSIST. MOISTURE	PROFILE CHANGE DEPTH	FIELD IDENTIFICATION OF SOILS REMARKS
0									0"-9'	brown medium fine sand. (dry)
		1	5'-6'6"		21	32	38			
10		2	10'-11'6"		16	22	24		9'-15'2"	brown silty fine sand. some gravel, (wet)
		3	15'-16'6"		1	1	2		15'2"-30'6"	dark gray silty clay, w-fine sand layers
20		4	20'-21'6"		3	3	7			
		5	25'-26'6"		7	4	11			
30		6	30'-31'6"		5	8	7		30'6"-36'	brown silty fine sand. trace clay
		7	35'-36'6"		5	6	12		36'-40'	brown coarse to fine sand
40		8	40'-41'6"		14	18	17			

Soils Engineer: ______
Drilling Inspector: ______
Driller: P. Michell
Helper: S. Blackwell, R. Eccles

JOB LOCATION: Forked River, New Jersey

WARREN GEORGE, INC.
500 PALISADE AVENUE
JERSEY CITY, N.J. 07307

FOR: Burns and Roe

SHEET 2 OF 4
LOCATION Forked River NJ
HOLE NO. B 13
LINE & STA.
OFFSET

DEPTH ____ FT. ____ FT. CASING OUT DATE: ____
DEPTH ____ FT. ALL CASING OUT DATE: ____
DATE, START: 5-15-68 & 6-10-68
DATE, FINISH: ____
GROUND ELEVATION ____
GROUND WATER ELEVATION ____

CASING O.D. ____ I.D. ____
SAMPLER O.D. ____ I.D. ____
DIAMOND BIT SIZE ____
WEIGHT OF HAMMER ____ LBS.
INSIDE LENGTH OF SAMPLER ____ IN.
HAMMER FALL: CASING ____ SAMPLER ____

DEPTH BELOW SURFACE	CASING BLOWS PER FOOT	SAMPLE NUMBER	SAMPLE DEPTHS ELEV. / FEET	SAMPLE RECOVERY	BLOWS PER 6" ON SAMPLER 0-6	6-12	12-18	DENSITY OR CONSIST. MOISTURE	PROFILE CHANGE DEPTH	FIELD IDENTIFICATION OF SOILS REMARKS
40									40-49'	gray brown medium to fine sand, silt
		9	45'-46'6"		12	18	20			
50 / -10		10	50'-50'10"		32	50/4"			49'-50'10"	red brown medium to fine sand.
									50'10"-81'	gray medium to fine sand, trace silt
60 / -20										
70 / -30										
80 / -40										(continued)

Soils Engineer: ____
Drilling Inspector: ____
Driller: P. Mitchell
Helper: G. Van Glahn, R. Eccles & Blackwell

JOB LOCATION:
Forked River
New Jersey

WARREN GEORGE, INC.

500 PALISADE AVENUE
JERSEY CITY, N.J. 07307

FOR: Burns and Roe

SHEET 3 OF 4
LOCATION Forked River NJ
HOLE NO. B 13
LINE & STA.
OFFSET

DEPTH ______ FT. ___ FT. CASING OUT DATE: ______
DEPTH ______ FT. ALL CASING OUT DATE: ______
DATE, START: 5-15-68 6-10-68
DATE, FINISH: ______
GROUND ELEVATION ______
GROUND WATER ELEVATION ______

CASING O.D. ______ I.D. ______
SAMPLER O.D. ______ I.D. ______
DIAMOND BIT SIZE ______
WEIGHT OF HAMMER ______ LBS.
INSIDE LENGTH OF SAMPLER ______ IN.
HAMMER FALL
CASING ______ SAMPLER ______

DEPTH BELOW SURFACE	CASING BLOWS PER FOOT	SAMPLE NUMBER	SAMPLE DEPTHS ELEV. / FEET	SAMPLE RECOVERY	BLOWS PER 6" ON SAMPLER 0-6	6-12	12-18	DENSITY OR CONSIST. MOISTURE	PROFILE CHANGE DEPTH	FIELD IDENTIFICATION OF SOILS REMARKS (continued)
80									50'10"-81'	gray medium to fine sand trace silt
									81'-98'6"	dark gray silty clay w-layers of sand and silt
90										
									98'6"-153'	Gray medium to fine sand trace silt
100										
110										
120										(continued)

Soils Engineer: ______
Drilling Inspector: ______
Driller: P. Mitchell
Helper: C. Van Glahn
R. Eccles

JOB LOCATION: Forked River New Jersey

WARREN GEORGE, INC.

500 PALISADE AVENUE
JERSEY CITY, N.J. 07307

FOR: Burns and Roe

SHEET 4 OF 4
LOCATION Forked River NJ
HOLE NO. B 13
LINE & STA.
OFFSET

DEPTH ____ FT. ____ FT. CASING OUT DATE: ____
DEPTH ____ FT. ALL CASING OUT DATE: ____
DATE, START: 5-15-68 & 6-10-68
DATE, FINISH: ____
GROUND ELEVATION ____
GROUND WATER ELEVATION ____

CASING O.D. ____ I.D. ____
SAMPLER O.D. ____ I.D. ____
DIAMOND BIT SIZE ____
WEIGHT OF HAMMER ____ LBS.
INSIDE LENGTH OF SAMPLER ____ IN.
HAMMER FALL: CASING ____ SAMPLER ____

DEPTH BELOW SURFACE	CASING BLOWS PER FOOT	SAMPLE NUMBER	SAMPLE DEPTHS ELEV. / FEET	SAMPLE RECOVERY	BLOWS PER 6" ON SAMPLER 0-6	6-12	12-18	DENSITY OR CONSIST. MOISTURE	PROFILE CHANGE DEPTH	FIELD IDENTIFICATION OF SOILS REMARKS
0 / 120									98'6"-153'	(continued) gray medium to fine sand trace silt
10 / 130										
20 / 140										
30 / 150										
155										Notes: 50'4" pipe for Ground Water Reading 8.5' 3 pm 5-17-68
										Set 153' of 4" pipe
40 / 160										

Soils Engineer: ____
Drilling Inspector: ____
Driller: P. Mitchell, G. Van Clohn
Helper: R. Eccles

JOB LOCATION: Forked River, New Jersey

WARREN GEORGE, INC.

500 PALISADE AVENUE
JERSEY CITY, N.J. 07307

FOR: Burns and Roe

SHEET 1 OF 4
LOCATION Forked River NJ
HOLE NO. B 14
LINE & STA.
OFFSET

DEPTH ______ FT. ___ FT. CASING OUT DATE: ______
DEPTH ______ FT. ALL CASING OUT DATE: ______
DATE, START: 5-27-68
DATE, FINISH: 5-27-68
GROUND ELEVATION ______
GROUND WATER ELEVATION ______

CASING O.D. 4" I.D. ______
SAMPLER O.D. 2" I.D. ______
DIAMOND BIT SIZE ______
WEIGHT OF HAMMER 140# LBS.
INSIDE LENGTH OF SAMPLER ______ IN.
HAMMER FALL: CASING ______ SAMPLER ______

DEPTH BELOW SURFACE	CASING BLOWS PER FOOT	SAMPLE NUMBER	SAMPLE DEPTHS ELEV. / FEET	SAMPLE RECOVERY	BLOWS PER 6" ON SAMPLER 0-6	6-12	12-18	DENSITY OR CONSIST. MOISTURE
0								
		1	5'-6'6"		9	12	16	
10		2	10'-11'6"		12	18	20	
		3	15'-16'6"		3	16	23	
20		4	20'-21'6"		4	5	9	
		5	25'-26'6"		5	7	10	
30		6	30'-31'6"		5	[illegible]	9	
		7	35'-36'6"		6	9	11	
40		8	40'-40'10"		38	60/4"		

PROFILE CHANGE DEPTH	FIELD IDENTIFICATION OF SOILS REMARKS
0'-8'6"	gray fine sand, (dry)
8'6"-17'6"	brn fine silty sand w-clay (wet)
17'6"-36'	drk. gray silty clay w-fine sand
36'-47'	brn. coarse to fine sand. tr. silt

Soils Engineer: ______
Drilling Inspector: ______
Driller: P. Mitchell
Helper: S. Blackwell, R. Eccles

JOB LOCATION:	WARREN GEORGE, INC.	SHEET 2 OF 4
Forked River New Jersey	500 PALISADE AVENUE JERSEY CITY, N.J. 07307 FOR: Burns and Roe	LOCATION Forked River NJ HOLE NO. B 14 LINE & STA. OFFSET

DEPTH ______ FT. ___ FT. CASING OUT DATE: ______ DATE, START: 5-27-68 GROUND ELEVATION ______

DEPTH ______ FT. ALL CASING OUT DATE: ______ DATE, FINISH: 5-27-68 GROUND WATER ELEVATION ______

CASING O.D. 4" I.D. ______ WEIGHT OF HAMMER 140# LBS. HAMMER FALL

SAMPLER O.D. 2" I.D. ______ INSIDE LENGTH OF SAMPLER ______ IN. CASING ______ SAMPLER ______

DIAMOND BIT SIZE ______

DEPTH BELOW SURFACE	CASING BLOWS PER FOOT	SAMPLE NUMBER	SAMPLE DEPTHS ELEV. / FEET	SAMPLE RECOVERY	BLOWS PER 6" ON SAMPLER 0-6	6-12	12-18	DENSITY OR CONSIST. MOISTURE	PROFILE CHANGE DEPTH	FIELD IDENTIFICATION OF SOILS REMARKS
40									36'-47'	(continued) brn. coarse to fine sand. trace silt
		9	45'-45'4"		50/4"					
									47'-60'3"	red.-brn coarse to fine sand. tr. silt
50		10	50'-51'6"		29	30	40			
		11	55'-55'6"		54/6"					
60		12	60'-60'6"		68/6"				60'3"-70'	gray med. to fine sand. tr. silt
		13	65'-65'4"		50/4"					
70		14	70'-71'6"		26	39	50		70'-79'	brn. gray fine sand. tr. silt
		15	75'-76'6"		24	30	47			
80		16	80'-82' Tube	15" recovery					79-102'	(on sheet three)

Soils Engineer: ______ Driller: P. Mitchell

Drilling Inspector: ______ Helper: S. Blackwell ~~R. Eccles~~

JOB LOCATION: Forked River New Jersey

WARREN GEORGE, INC.

500 PALISADE AVENUE
JERSEY CITY, N.J. 07307

FOR: Burns and Roe

SHEET 3 OF 4
LOCATION Forked River NJ
HOLE NO. B 14
LINE & STA. -
OFFSET

DEPTH ____ FT. ___ FT. CASING OUT DATE: ____
DEPTH ____ FT. ALL CASING OUT DATE: ____
DATE, START: 5-27-68
DATE, FINISH: 5-27-68
GROUND ELEVATION ____
GROUND WATER ELEVATION ____

CASING O.D. ____ I.D. ____
SAMPLER O.D. ____ I.D. ____
DIAMOND BIT SIZE ____
WEIGHT OF HAMMER ____ LBS.
INSIDE LENGTH OF SAMPLER ____ IN.
HAMMER FALL CASING ____ SAMPLER ____

DEPTH BELOW SURFACE	CASING BLOWS PER FOOT	SAMPLE NUMBER	SAMPLE DEPTHS ELEV. / FEET	SAMPLE RECOVERY	BLOWS PER 6" ON SAMPLER 0-6	6-12	12-18	DENSITY OR CONSIST. MOISTURE	PROFILE CHANGE DEPTH	FIELD IDENTIFICATION OF SOILS REMARKS
80									79'-102'	drk. gray clay w-silt and sand layers
		17	84'-86' Tube	21"	recovery					
		18	86'-88' Tube	14"	recovery					
90		19	88'-90' Tube	22"	recovery					
		20	90'-92' Tube	17"	recovery					
		21	92'-93'6"		11	21	23			
		22	94'-96' Tube	24"	recovery					
		23	96'-98' Tube	18"	recovery					
120		24	98'-100' Tube	17"	recovery					
		25	100'-102' Tube	24"	recovery				102'-150'2"	gray silty med. to fine sand
		26	105'-105'6"		72/6"					
130		27	110'-110'6"		65/6"					
		28	115'-115'4"		56/4"					
140		29	120'-120'5"		50/5"					

Soils Engineer: ____
Drilling inspector: ____
Driller: P. Mitchell
S. Blackwell
Helper: R. Eccles

JOB LOCATION: Forked River New Jersey

WARREN GEORGE, INC.

500 PALISADE AVENUE
JERSEY CITY, N.J. 07307

FOR: Burns and Roe

SHEET 4 OF 4
LOCATION Forked River NJ
HOLE NO. B 14
LINE & STA.
OFFSET

DEPTH ____ FT. ____ FT. CASING OUT DATE: ____
DEPTH ____ FT. ALL CASING OUT DATE: ____
DATE, START: 5-27-68
DATE, FINISH: 5-27-68
GROUND ELEVATION ____
GROUND WATER ELEVATION ____

CASING O.D. 4" I.D. ____
SAMPLER O.D. 2" I.D. ____
DIAMOND BIT SIZE ____
WEIGHT OF HAMMER 140# LBS.
INSIDE LENGTH OF SAMPLER ____ IN.
HAMMER FALL: CASING ____ SAMPLER ____

DEPTH BELOW SURFACE	CASING BLOWS PER FOOT	SAMPLE NUMBER	SAMPLE DEPTHS ELEV. / FEET	SAMPLE RECOVERY	BLOWS PER 6" ON SAMPLER 0-6	6-12	12-18	DENSITY OR CONSIST. MOISTURE	PROFILE CHANGE DEPTH	FIELD IDENTIFICATION OF SOILS REMARKS
0 (120)									102'-150'2" (continued)	grey silty med. to fine sand
		30	125'-125'4"		50/4"					
10 (130)		31	130'-130'3"		50/3"					
		32	135'-135'2"		50/2"					
20 (140)		33	140'-140'2"		50/2"					
		34	145'-145'3"		50/3"					
30 (150)		35	150'-150'2"		50/2"					Notes: 150 feet of 4" pipe
40 (160)										Ground Water 12'-3"

Soils Engineer: ____
Drilling Inspector: ____
Driller: P. Mitchell
Helper: S. Blackwell, R. Eccles

JOB LOCATION: Forked River New Jersey	WARREN GEORGE, INC. 500 PALISADE AVENUE JERSEY CITY, N.J. 07307 FOR: Burns and Roe	SHEET 1 OF 4 LOCATION Forked River NJ HOLE NO. B 15 LINE & STA. OFFSET

DEPTH ______ FT. ___ FT. CASING OUT DATE: ______
DEPTH ______ FT. ALL CASING OUT DATE: ______
DATE, START: 5-31-68
DATE, FINISH: 5-31-68
GROUND ELEVATION ______
GROUND WATER ELEVATION ______

CASING O.D. 4" I.D. ______
SAMPLER O.D. 2" I.D. ______
DIAMOND BIT SIZE ______
WEIGHT OF HAMMER 140# LBS.
INSIDE LENGTH OF SAMPLER ______ IN.
HAMMER FALL
CASING ______ SAMPLER ______

DEPTH BELOW SURFACE	CASING BLOWS PER FOOT	SAMPLE NUMBER	SAMPLE DEPTHS ELEV. / FEET	SAMPLE RECOVERY	BLOWS PER 6" ON SAMPLER 0-6	6-12	12-18	DENSITY OR CONSIST. MOISTURE	PROFILE CHANGE DEPTH	FIELD IDENTIFICATION OF SOILS REMARKS
0									0'-10'	brn med to fine silty sand (wet) working in water
		1	5'-6'6"		3	2	5			
10		2	10'-11'6"		3	11	23		10'-14'6"	brn med to fine silty sand w-clay
		3	15'-16'6"		3	5	6		14'6"-34'	drk. gray silty clay w-silt and sand
20		4	20'-21'6"		4	6	7			
		5	25'-26'6"		6	6	5			
30		6	30'-31'6"		9	4	3			
		7	35'-36'6"		11	18	12		34'-45'	brn. coarse to fine sand. some silt
40		8	40'-41'6"		9	15	13			

Soils Engineer: ______
Drilling Inspector: ______
Driller: P. Mitchell
Helper: S Blackwell, R. Eccles

JOB LOCATION: Forked River, New Jersey

WARREN GEORGE, INC.

500 PALISADE AVENUE
JERSEY CITY, N.J. 07307

FOR: Burns and Roe

SHEET 2 OF 4
LOCATION Forked River NJ
HOLE NO. B 15
LINE & STA.
OFFSET

DEPTH ____ FT. ____ FT. CASING OUT DATE: ____
DEPTH ____ FT. ALL CASING OUT DATE: ____
DATE, START: 5-31-68
DATE, FINISH: 5-31-68
GROUND ELEVATION ____
GROUND WATER ELEVATION ____

CASING O.D. 4" I.D. ____
SAMPLER O.D. 2" I.D. ____
DIAMOND BIT SIZE ____
WEIGHT OF HAMMER 140# LBS.
INSIDE LENGTH OF SAMPLER ____ IN.
HAMMER FALL: CASING ____ SAMPLER ____

DEPTH BELOW SURFACE	CASING BLOWS PER FOOT	SAMPLE NUMBER	SAMPLE DEPTHS ELEV. / FEET	SAMPLE RECOVERY	BLOWS PER 6" ON SAMPLER 0-6	6-12	12-18	DENSITY OR CONSIST. MOISTURE	PROFILE CHANGE DEPTH	FIELD IDENTIFICATION OF SOILS REMARKS
40									34'-45'	(continued) brn. coarse to fine sand some silt
		9	45'-46'6"		10	5	12		45'-52'	brn silty fine sand
50		10	50'-51'6"		7	9	14			
									52'-60'1"	red-brn med to fine sand
		11	55'-55'8"		48	50/2"				
60		12	60'-60'6"		56/6"				60'1"-78'	gray fine sand. some silt
		13	65'-65'4"		50/4"					
70		14	70'-70'6"		47/6"					
		15	75'-75'4"		50/4"					
80		16	80'-81'6"		7	11	12		78'-102'	drk. gray med. to fine sand w-clay & silt layers

Soils Engineer: ____
Drilling Inspector: ____
Driller: P. Mitchell
Helper: S Blackwell, R. Eccles

JOB LOCATION: Forked River, New Jersey

WARREN GEORGE, INC.
500 PALISADE AVENUE
JERSEY CITY, N.J. 07307

FOR: Burns and Roe

SHEET 3 OF 4
LOCATION Forked River NJ
HOLE NO. B 15
LINE & STA.
OFFSET

DEPTH ______ FT. ____ FT. CASING OUT DATE: ______
DEPTH ______ FT. ALL CASING OUT DATE: ______
DATE, START: 5-31-68
DATE, FINISH: 5-31-68
GROUND ELEVATION
GROUND WATER ELEVATION

CASING O.D. 4" I.D.
SAMPLER O.D. 2" I.D.
DIAMOND BIT SIZE
WEIGHT OF HAMMER 140# LBS.
INSIDE LENGTH OF SAMPLER ______ IN.
HAMMER FALL: CASING ______ SAMPLER ______

DEPTH BELOW SURFACE	CASING BLOWS PER FOOT	SAMPLE NUMBER	SAMPLE DEPTHS ELEV. / FEET	SAMPLE RECOVERY	BLOWS PER 6" ON SAMPLER 0-6	6-12	12-18	DENSITY OR CONSIST. MOISTURE	PROFILE CHANGE DEPTH	FIELD IDENTIFICATION OF SOILS REMARKS
80									78'-102' (continued)	drk. gray med. to fine sand. w clay and silt layers
		17	85'-86'6"		8	9	14			
90		18	90'-92' Tube	18"	recovery					
		19	95'-95'9"		41	50/3"				
100		20	100'-102' Tube	18"	recovery					
									102'-110'	drk. gray fine sand w silt
		21	105'-106'6"		12	17	23			
110		22	110'-110'4"		50/4"				110'-150'4"	drk. gray med. to fine sand. tr silt, occ traces of clay
		23	115'-115'6"		52/6"					
120		24	120'-120'4"		50/4"					

Soils Engineer: ______ Driller: P. Mitchell
Drilling Inspector: ______ Helper: S Blackwell, R. Eccles

JOB LOCATION: Forked River, New Jersey	**WARREN GEORGE, INC.** 500 PALISADE AVENUE JERSEY CITY, N.J. 07307 FOR: Burns and Roe	SHEET 4 OF 4 LOCATION Forked River NJ HOLE NO. B 15 LINE & STA. OFFSET

DEPTH ____ FT. ____ FT. CASING OUT DATE: ____ DATE, START: 5-31-68 GROUND ELEVATION ____
DEPTH ____ FT. ALL CASING OUT DATE: ____ DATE, FINISH: 5-31-68 GROUND WATER ELEVATION ____

CASING O.D. 4" I.D. ____ WEIGHT OF HAMMER 140# LBS. HAMMER FALL
SAMPLER O.D. 2" I.D. ____ INSIDE LENGTH OF SAMPLER ____ IN. CASING ____ SAMPLER ____
DIAMOND BIT SIZE ____

DEPTH BELOW SURFACE	CASING BLOWS PER FOOT	SAMPLE NUMBER	SAMPLE DEPTHS ELEV. / FEET	SAMPLE RECOVERY	BLOWS PER 6" ON SAMPLER 0-6	6-12	12-18	DENSITY OR CONSIST. MOISTURE	PROFILE CHANGE DEPTH	FIELD IDENTIFICATION OF SOILS REMARKS
0									110'-150'4"	drk. gray med to fine sand. tr. silt. occ traces of clay
		25	125'-125'5"		52/5"					
130		26	130'-130'4"		50/4"					
		27	135'-135'5"		50/5"					
140		28	140'-140'5"		50/5"					
		29	145'-145'3"		50/3"					
150		30	150'-150/4"		65/4"					Notes: 150' of 4" flush casing Ground Water 9'-7"
160										

Soils Engineer: ____ Driller: P. Mitchell
Drilling Inspector: ____ Helper: S. Blackwell, R. Eccles

JOB LOCATION: Forked River New Jersey

WARREN GEORGE, INC.

500 PALISADE AVENUE
JERSEY CITY, N.J. 07307

FOR: Burns and Roe

SHEET 1 OF 2
LOCATION Forked River NJ
HOLE NO. B 16
LINE & STA.
OFFSET

DEPTH ____ FT. ____ FT. CASING OUT DATE: ____
DEPTH ____ FT. ALL CASING OUT DATE: ____

DATE, START: 5-30-68
DATE, FINISH: 5-30-68

GROUND ELEVATION ____
GROUND WATER ELEVATION ____

CASING O.D. 4" I.D. ____
SAMPLER O.D. ____ I.D. ____
DIAMOND BIT SIZE ____

WEIGHT OF HAMMER 140# LBS.
INSIDE LENGTH OF SAMPLER ____ IN.

HAMMER FALL
CASING ____ SAMPLER ____

DEPTH BELOW SURFACE	CASING BLOWS PER FOOT	SAMPLE NUMBER	SAMPLE DEPTHS ELEV. / FEET	SAMPLE RECOVERY	BLOWS PER 6" ON SAMPLER 0-6	6-12	12-18	DENSITY OR CONSIST. MOISTURE	PROFILE CHANGE DEPTH	FIELD IDENTIFICATION OF SOILS REMARKS
0									0'-9'	brn. med fine sand (dry)
10									9'-17'6"	brn fine sand some silt (wet)
20									17'6"-34'	dark gray silty clay, sand layers
30									34'-40'	gray-brown coarse to fine sand, (very wet)
40										

Soils Engineer: ____
Drilling Inspector: ____
Driller: P. Mitchell
Helper: S. Blackwell
R. Eccles

JOB LOCATION: Forked River New Jersey	**WARREN GEORGE, INC.** 500 PALISADE AVENUE JERSEY CITY, N.J. 07307	SHEET 2 OF 2
	FOR: Burns and Roe	LOCATION Forked River N.J.
		HOLE NO. B 16
		LINE & STA.
		OFFSET

DEPTH ____ FT. ____ FT. CASING OUT DATE: ____	DATE, START: 5-30-68	GROUND ELEVATION
DEPTH ____ FT. ALL CASING OUT DATE: ____	DATE, FINISH: 5-30-68	GROUND WATER ELEVATION

CASING O.D. 4" I.D.	WEIGHT OF HAMMER 140 LBS.	HAMMER FALL
SAMPLER O.D. I.D.	INSIDE LENGTH OF SAMPLER IN.	CASING SAMPLER
DIAMOND BIT SIZE		

DEPTH BELOW SURFACE	CASING BLOWS PER FOOT	SAMPLE NUMBER	SAMPLE DEPTHS ELEV. / FEET	SAMPLE RECOVERY	BLOWS PER 6" ON SAMPLER 0-6	6-12	12-18	DENSITY OR CONSIST. MOISTURE	PROFILE CHANGE DEPTH	FIELD IDENTIFICATION OF SOILS REMARKS
0 (40)									40'-52'	red-brown coarse to fine sand, very wet
10 (50)									52'-70'	gray medium to fine sand.
20 (60)										
30 (70)									70'-75'	Gray brown medium to fine sand
40 (80)										Ground Water 18'-5"

Soils Engineer:

Drilling Inspector:

Driller: P. Mitchell

Helper: S. Blackwell R. Engler

JOB LOCATION: Forked River New Jersey	**WARREN GEORGE, INC.** 500 PALISADE AVENUE JERSEY CITY, N.J. 07307 FOR: Burns and Roe	SHEET 1 OF 2 LOCATION Forked River NJ HOLE NO. 17 LINE & STA. OFFSET

DEPTH ____ FT. ____ FT. CASING OUT DATE: ____
DEPTH ____ FT. ALL CASING OUT DATE: ____
DATE, START: 9-17-68
DATE, FINISH: 9-17-68
GROUND ELEVATION ____
GROUND WATER ELEVATION ____

CASING O.D. 5" I.D. ____
SAMPLER O.D. 2" I.D. ____
DIAMOND BIT SIZE ____
WEIGHT OF HAMMER 140# LBS.
INSIDE LENGTH OF SAMPLER ____ IN.
HAMMER FALL CASING ____ SAMPLER 30"

DEPTH BELOW SURFACE	CASING BLOWS PER FOOT	SAMPLE NUMBER	SAMPLE DEPTHS ELEV. / FEET	SAMPLE RECOVERY	BLOWS PER 6" ON SAMPLER 0-6	6-12	12-18	DENSITY OR CONSIST. MOISTURE	PROFILE CHANGE DEPTH	FIELD IDENTIFICATION OF SOILS REMARKS
0									0'-16'	brown coarse to fine sand trace silt, some clay
10										
									16'-33'	gray silty clay, some fine sand
20										
30										
									33'-75'	brown medium to fine sand, trace silt and clay
40										

(continued)

Soils Engineer: ____
Driller: P. Mitchell
Drilling Inspector: ____
Helper: N. Parsons
[illegible]

JOB LOCATION: Forked River New Jersey

WARREN GEORGE, INC.
500 PALISADE AVENUE
JERSEY CITY, N.J. 07307

FOR: Burns and Roe

SHEET 2 OF 2
LOCATION Forked River NJ
HOLE NO. 17
LINE & STA.
OFFSET

DEPTH ____ FT. ____ FT. CASING OUT DATE: ____
DEPTH ____ FT. ALL CASING OUT DATE: ____
DATE, START: 9-17-68
DATE, FINISH: 9-17-68
GROUND ELEVATION
GROUND WATER ELEVATION

CASING O.D. 5" I.D.
SAMPLER O.D. 2" I.D.
DIAMOND BIT SIZE
WEIGHT OF HAMMER 140 # LBS.
INSIDE LENGTH OF SAMPLER ____ IN.
HAMMER FALL
CASING ____ SAMPLER 30"

DEPTH BELOW SURFACE	CASING BLOWS PER FOOT	SAMPLE NUMBER	SAMPLE DEPTHS ELEV. / FEET	SAMPLE RECOVERY	BLOWS PER 6" ON SAMPLER 0-6	6-12	12-18	DENSITY OR CONSIST. MOISTURE	PROFILE CHANGE DEPTH	FIELD IDENTIFICATION OF SOILS REMARKS
40		U1	40'-41'	12"	12"	push	3" tubes			(continued)
									33'-75'	brown medium to fine sand trace silt and clay
		U2	43'-45'		140#	drove	36	74		
		U3	47'-49'	20"		25		40		
50		U4	51'-53'	20½"		21		108		
		U5	55'-55'10"	10"	200/10"					
		6	58'-58'2"		50/2"					
60		7	60'6"-61'		58/6"					
		8	63'-63'6"		51/6"					
		9	65'6"-66'		54/6"					
		10	68'-68'9"		40	50/3"				
70		11	71'-72'			33		56		
75		12	74'-75'		24	63				
80										

Soils Engineer:
Drilling Inspector:
Driller: P. Mitchell ~~N. Parsons~~
Helper: F. Iaconilli

JOB LOCATION: Forked River New Jersey

WARREN GEORGE, INC.

500 PALISADE AVENUE
JERSEY CITY, N.J. 07307

FOR: Burns and Roe

SHEET 1 OF 2
LOCATION Forked River NJ
HOLE NO. 18
LINE & STA.
OFFSET

DEPTH ____ FT. ____ FT. CASING OUT DATE: ____
DEPTH ____ FT. ALL CASING OUT DATE: ____

DATE, START: 9-13-68
DATE, FINISH: 9-13-68

GROUND ELEVATION
GROUND WATER ELEVATION

CASING O.D. 6" I.D.
SAMPLER O.D. 2" I.D.
DIAMOND BIT SIZE

WEIGHT OF HAMMER 140# LBS.
INSIDE LENGTH OF SAMPLER ____ IN.

HAMMER FALL
CASING ____ SAMPLER 30"

DEPTH BELOW SURFACE	CASING BLOWS PER FOOT	SAMPLE NUMBER	SAMPLE DEPTHS ELEV. / FEET	SAMPLE RECOVERY	BLOWS PER 6" ON SAMPLER 0-6	6-12	12-18	DENSITY OR CONSIST. MOISTURE	PROFILE CHANGE DEPTH	FIELD IDENTIFICATION OF SOILS REMARKS
0									0'-14'6"	brown yellow coarse to fine sand, silt, trace clay
10										
									14'6"-31'	dark gray silty clay, some fine sand
20										
30										
									31'-76'6"	light brown medium to fine sand, trace silt, trace clay
40										(continued)

Soils Engineer:
Driller: P. Mitchell
~~N Parsons~~
Drilling Inspector:
Helper: ~~F. Iacunelli~~

JOB LOCATION:	WARREN GEORGE, INC.	SHEET 2 OF 2
Forled River New Jersey	500 PALISADE AVENUE	LOCATION Forked River NJ
	JERSEY CITY, N.J. 07307	HOLE NO. 18
		LINE & STA.
	FOR: Burns and Roe	OFFSET

DEPTH ____ FT. ____ FT. CASING OUT DATE: ____ DATE, START: 9-13-68 GROUND ELEVATION ____

DEPTH ____ FT. ALL CASING OUT DATE: ____ DATE, FINISH: 9-13-68 GROUND WATER ELEVATION ____

CASING O.D. 5" I.D. ____ WEIGHT OF HAMMER 140# LBS. HAMMER FALL

SAMPLER O.D. 2" I.D. ____ INSIDE LENGTH OF SAMPLER ____ IN. CASING ____ SAMPLER 30"

DIAMOND BIT SIZE ____

DEPTH BELOW SURFACE	CASING BLOWS PER FOOT	SAMPLE NUMBER	SAMPLE DEPTHS ELEV. / FEET	SAMPLE RECOVERY	BLOWS PER 6" ON SAMPLER 0-6	6-12	12-18	DENSITY OR CONSIST. MOISTURE	PROFILE CHANGE DEPTH	FIELD IDENTIFICATION OF SOILS REMARKS
40		1	40'-41'6"		22	37	41			(continued)
									31'-76'6"	light brown medium to fine s nd, trace silt, trace clay
		2	43'6"-45'		16	16	23			
		3	47'-48'6"		16	22	15			
50		4	50'6"-52'		9	10	56			
		5	54'-55'		57	143				
		6	57'-58'		97	161				
60		7	60'-61'6"			55	80			
		8	63'-64'		33	95				
		9	66'-67'		59	112				
70		10	69'-70'6"		27	23	28			
		11	72'6"-74'		23	31	38			
75		12	75'-76'6"		20	33	71			
										76'6"
80										

Soils Engineer: ____ Driller: P. Mitchell

Drilling Inspector: ____ Helper: N. Parsons, F. Iaconelli

JOB LOCATION: Forked River New Jersey

WARREN GEORGE, INC.
500 PALISADE AVENUE
JERSEY CITY, N.J. 07307

FOR: Burns and Roe

SHEET 1 OF 1
LOCATION Forked River NJ
HOLE NO. 10
LINE & STA.
OFFSET

DEPTH ______ FT. ____ FT. CASING OUT DATE: ______
DEPTH ______ FT. ALL CASING OUT DATE: ______
DATE, START: 9-13-68
DATE, FINISH: 9-13-68
GROUND ELEVATION ______
GROUND WATER ELEVATION ______

CASING O.D. 6" I.D. ______
SAMPLER O.D. 2" I.D. ______
DIAMOND BIT SIZE ______
WEIGHT OF HAMMER 140# LBS.
INSIDE LENGTH OF SAMPLER ______ IN.
HAMMER FALL
CASING ______ SAMPLER ______

DEPTH BELOW SURFACE	CASING BLOWS PER FOOT	SAMPLE NUMBER	SAMPLE DEPTHS ELEV. / FEET	SAMPLE RECOVERY	BLOWS PER 6" ON SAMPLER 0-6	6-12	12-18	DENSITY OR CONSIST. MOISTURE	PROFILE CHANGE DEPTH	FIELD IDENTIFICATION OF SOILS REMARKS
0									0'-14'6"	brown coarse to fine sand trace silty, some clay
10										
									14'6"-32'	dark grey silty clay, trace fine sand
20										
30										
									32'-49'	brown medium to fine sand trace silt, trace clay
40										(continued)

Soils Engineer: ______
Drilling Inspector: ______
Driller: P. Mitchell
Helper: R. Parsons
P. Iacovelli

JOB LOCATION: Forked River New Jersey

WARREN GEORGE, INC.

500 PALISADE AVENUE
JERSEY CITY, N.J. 07307

FOR: Burns and Roe

SHEET 2 OF 2
LOCATION Forked River NJ
HOLE NO. 10
LINE & STA.
OFFSET

DEPTH ____ FT. ____ FT. CASING OUT DATE: ____
DEPTH ____ FT. ALL CASING OUT DATE: ____
DATE, START: 9-13-66
DATE, FINISH: 9-13-66
GROUND ELEVATION
GROUND WATER ELEVATION

CASING O.D. 5" I.D.
SAMPLER O.D. 2" I.D.
DIAMOND BIT SIZE
WEIGHT OF HAMMER 140# LBS.
INSIDE LENGTH OF SAMPLER ____ IN.
HAMMER FALL CASING ____ SAMPLER ____

DEPTH BELOW SURFACE	CASING BLOWS PER FOOT	SAMPLE NUMBER	SAMPLE DEPTHS ELEV. / FEET	SAMPLE RECOVERY	BLOWS PER 6" ON SAMPLER 0-6	6-12	12-18	DENSITY OR CONSIST. MOISTURE	PROFILE CHANGE DEPTH	FIELD IDENTIFICATION OF SOILS REMARKS
40		U1	40'-42'	24"	900 Lbs press Pressure Per Sq. Inch				32'-49'	(continued) brown medium to fine sand, t ace silt, trace clay
		U2	44'-46'	24"	600 Lbs press Pressure per Sq. Inch					
		U3	48'-50'	24"	500 Lbs press pressure per Sq. inch.					
50									49'-51'	brown coarse to fine sand, trace silt
		U4	52'-54'	20½"	900 Lbs. press Pressure Per Sq. In.				51'-75'6"	brown medium to fine sand, trace silt, trace clay
		U5	56'-58'	17"	900 Lbs press pressure per Sq. Inch.					
60		6	60'-60'6"		50/6"					
		7	62'6"-63'		55/6"					
		8	65'-66'6"		20	23	32			
		9	68'6"-70'		20	20	17			
		U10	72'-74'	21"	800 Lbs Press Pressure Per Sq. Inch					
75		11	74'-75'6"		19	37	49			
										75'6"
80										

Soils Engineer: ____
Driller: P. Mitchell
Drilling Inspector: ____
Helper: N. Parsons, F. Iacovelli

JOB LOCATION: Forked River New Jersey

WARREN GEORGE, INC.

500 PALISADE AVENUE
JERSEY CITY, N.J. 07307

FOR: Burns and Roe

SHEET 1 OF [illegible]
LOCATION Forked River NJ
HOLE NO. 20
LINE & STA.
OFFSET

DEPTH ______ FT. ____ FT. CASING OUT DATE: ______
DEPTH ______ FT. ALL CASING OUT DATE: ______
DATE, START: 9-13-68
DATE, FINISH: 9-13-68
GROUND ELEVATION ______
GROUND WATER ELEVATION ______

CASING O.D. 5" I.D. ______
SAMPLER O.D. 2" I.D. ______
DIAMOND BIT SIZE ______
WEIGHT OF HAMMER 140# LBS.
INSIDE LENGTH OF SAMPLER ______ IN.
HAMMER FALL
CASING ______ SAMPLER ______

DEPTH BELOW SURFACE	CASING BLOWS PER FOOT	SAMPLE NUMBER	SAMPLE DEPTHS ELEV. / FEET	SAMPLE RECOVERY	BLOWS PER 6" ON SAMPLER 0-6	6-12	12-18	DENSITY OR CONSIST. MOISTURE	PROFILE CHANGE DEPTH	FIELD IDENTIFICATION OF SOILS REMARKS
0									0'-14'6"	brown medium to fine sand trace silt, some clay
10										
									14'6"-32'	gray silty clay
20										
30										
									32'-44'	brown medium to fine sand, trace clay
40										(continued)

Soils Engineer: ______
Driller: P. Mitchell
N Parsons
Drilling Inspector: ______
Helper: F. Iacenelli

JOB LOCATION: Forked River New Jersey

WARREN GEORGE, INC.
500 PALISADE AVENUE
JERSEY CITY, N.J. 07307

FOR: Burns and Roe

SHEET 2 OF 2
LOCATION Forked River NJ
HOLE NO. 20
LINE & STA.
OFFSET

DEPTH ____ FT. ____ FT. CASING OUT DATE: ____
DEPTH ____ FT. ALL CASING OUT DATE: ____
DATE, START: 9-18-68
DATE, FINISH: 9-18-68
GROUND ELEVATION
GROUND WATER ELEVATION

CASING O.D. 5" I.D. ____
SAMPLER O.D. 2" I.D. ____
DIAMOND BIT SIZE ____
WEIGHT OF HAMMER 140# LBS.
INSIDE LENGTH OF SAMPLER ____ IN.
HAMMER FALL: CASING ____ SAMPLER ____

DEPTH BELOW SURFACE	CASING BLOWS PER FOOT	SAMPLE NUMBER	SAMPLE DEPTHS ELEV. / FEET	SAMPLE RECOVERY	BLOWS PER 6" ON SAMPLER 0-6	6-12	12-18	DENSITY OR CONSIST. MOISTURE	PROFILE CHANGE DEPTH	FIELD IDENTIFICATION OF SOILS REMARKS
40		1	40'-40'3"		50/3"				32'-44'	(continues)
		U 2	42'6"-44'6"	23"	1,000 Lbs. Press Pressure Per Sq. Inch					brown medium to fine sand trace clay
									44'-50'6"	red coarse to fine sand
		U3	46'6"-48'6"	23"	1,000 Lbs. Press Pressure Per Sq. Inch					
50 / -10		U4	50'6"-52'	12"	1,000 Lbs Press Pressure Per Sq. Inch					
									50'6"-71'	brown medium to fine sand trace clay
		U5	54'-56	20"	1,000 Lbs Press Pressure Per Sq. Inch					
		6	58'-58'9"		49	50/3"				
60 / -20		7	61'-62'		48	51				
		8	64'-65'6"		20	40	40			
		U9	67'6"-69'6"	24"	900 Lbs. Press Pressure Per Sq. Inch					
70 / -30		U10	71'6"-73'6"	20"	1,000 Lbs Press Pressure Per Sq. Inch				71'-75'	gray fine sand
		11	73'6"-75'		28	58	99			
75										75'
80 / -40										

Soils Engineer: ____
Drilling Inspector: ____
Driller: P. Mitchell
Helper: N. Parsons
P. Peconelli

JOB LOCATION: Forked River New Jersey	**WARREN GEORGE, INC.** 500 PALISADE AVENUE JERSEY CITY, N.J. 07307	SHEET 1 OF 2
		LOCATION Forked River NJ
		HOLE NO. 21
		LINE & STA.
	FOR: Burns and Roe	OFFSET

DEPTH ___ FT. ___ FT. CASING OUT DATE:	DATE, START: 9-18-68	GROUND ELEVATION
DEPTH ___ FT. ALL CASING OUT DATE:	DATE, FINISH: 9-18-68	GROUND WATER ELEVATION

CASING O.D. 5" I.D.	WEIGHT OF HAMMER 140# LBS.	HAMMER FALL
SAMPLER O.D. 2" I.D.	INSIDE LENGTH OF SAMPLER ___ IN.	CASING ___ SAMPLER ___
DIAMOND BIT SIZE		

DEPTH BELOW SURFACE	CASING BLOWS PER FOOT	SAMPLE NUMBER	SAMPLE DEPTHS ELEV. / FEET	SAMPLE RECOVERY	BLOWS PER 6" ON SAMPLER 0-6	6-12	12-18	DENSITY OR CONSIST. MOISTURE	PROFILE CHANGE DEPTH	FIELD IDENTIFICATION OF SOILS REMARKS
0									0'-15'	brown sand trace silt, some clay
10										
									15'-32'	gray silty clay, some fine sand
20										
30										
									32'-39'	coarse to fine sand (brown)
40									39'-52'	(continued shee 2)

Soils Engineer: ___ Driller: P. Mitchell

Drilling Inspector: ___ Helper: N. Parsons

F. [illegible]

JOB LOCATION:	WARREN GEORGE, INC.	
Forked River New Jersey	500 PALISADE AVENUE JERSEY CITY, N.J. 07307	SHEET 2 OF 2 LOCATION Forked River NJ HOLE NO. 21 LINE & STA. OFFSET
	FOR: Burns and Roe	

DEPTH ____ FT. ____ FT. CASING OUT DATE: ____	DATE, START: 9-18-68	GROUND ELEVATION ____
DEPTH ____ FT. ALL CASING OUT DATE: ____	DATE, FINISH: 9-18-68	GROUND WATER ELEVATION ____

CASING O.D. 5" I.D. ____ SAMPLER O.D. 2" I.D. ____ DIAMOND BIT SIZE ____	WEIGHT OF HAMMER 140# LBS. INSIDE LENGTH OF SAMPLER ____ IN.	HAMMER FALL CASING ____ SAMPLER ____

DEPTH BELOW SURFACE	CASING BLOWS PER FOOT	SAMPLE NUMBER	SAMPLE DEPTHS ELEV. / FEET	SAMPLE RECOVERY	BLOWS PER 6" ON SAMPLER 0-6	6-12	12-18	DENSITY OR CONSIST. MOISTURE	PROFILE CHANGE DEPTH	FIELD IDENTIFICATION OF SOILS REMARKS
40		1	40'-40'6"		50/6"				39'-52'	(continued)
		U2	42'6"-44'	16"		88/12"	94/6"			red coarse to fine sand
		U3	46'-48'	18"		16/12"	43/12"			
50		U4	50'-51'6"			[illegible]	[illegible]			
		5	53'6"-53'10"		50/4"				52'-66'6"	brown medium to fine sand, trace clay
		6	56'-56'4"		50/4"					
		7	58'6"-59'4"		48	50/4"				
60		8	61'6"-62'		52/6"					
		9	64'-65'6"		30	40	51			
		10	67'6"-69'		16	33	45		66'6"-75'	fine gray sand
70		U11	71'-73'	20"		61/12"	101/12"			
		12	74'-75'		32	54				
75										75'
80										

Soils Engineer: ____ Driller: P. Mitchell

Drilling Inspector: ____ Helper: R. Parsons, F. Iaccarelli

JOB LOCATION: Forked River New Jersey	**WARREN GEORGE, INC.** 500 PALISADE AVENUE JERSEY CITY, N.J. 07307 FOR: Burns and Roe	SHEET 1 OF 2 LOCATION Forked River NJ HOLE NO. 22 LINE & STA. OFFSET

DEPTH ______ FT. ___ FT. CASING OUT DATE: ______
DEPTH ______ FT. ALL CASING OUT DATE: ______
DATE, START: 9-17-68
DATE, FINISH: 9-17-68
GROUND ELEVATION ______
GROUND WATER ELEVATION ______

CASING O.D. 5" I.D. ______
SAMPLER O.D. 2" I.D. ______
DIAMOND BIT SIZE ______
WEIGHT OF HAMMER 140# LBS.
INSIDE LENGTH OF SAMPLER ______ IN.
HAMMER FALL: CASING ______ SAMPLER 30"

DEPTH BELOW SURFACE	CASING BLOWS PER FOOT	SAMPLE NUMBER	SAMPLE DEPTHS ELEV. / FEET	SAMPLE RECOVERY	BLOWS PER 6" ON SAMPLER 0-6	6-12	12-18	DENSITY OR CONSIST. MOISTURE	PROFILE CHANGE DEPTH	FIELD IDENTIFICATION OF SOILS REMARKS
0									0'-15'6"	brown medium to fine sand trace silt, some clay
10										
									15'6"-31'	gray silty clay
20										
30										
									31'-39'	brown medium to fine sand
									39'-44'	(continued sheet 2)
40										

Soils Engineer: ______
Drilling Inspector: ______
Driller: P. Mitchell
N. Parsons
Helper: F. Iacorelli

JOB LOCATION:	WARREN GEORGE, INC.	SHEET 2 OF 2
Forked River New Jersey	500 PALISADE AVENUE	LOCATION Forked River NJ
	JERSEY CITY, N.J. 07307	HOLE NO. 22
		LINE & STA.
	FOR: Burns and Roe	OFFSET

DEPTH ____ FT. ____ FT. CASING OUT DATE: ____	DATE, START: 9-17-68	GROUND ELEVATION
DEPTH ____ FT. ALL CASING OUT DATE: ____	DATE, FINISH: 9-17-68	GROUND WATER ELEVATION

CASING O.D. 5" I.D.	WEIGHT OF HAMMER 140# LBS.	HAMMER FALL
SAMPLER O.D. 2" I.D.	INSIDE LENGTH OF SAMPLER ____ IN.	CASING ____ SAMPLER 30"
DIAMOND BIT SIZE		

DEPTH BELOW SURFACE	CASING BLOWS PER FOOT	SAMPLE NUMBER	SAMPLE DEPTHS ELEV. / FEET	SAMPLE RECOVERY	BLOWS PER 6" ON SAMPLER 0-6	6-12	12-18	DENSITY OR CONSIST. MOISTURE	PROFILE CHANGE DEPTH	FIELD IDENTIFICATION OF SOILS REMARKS
0 / 40		1	40'-40'6"		50/6"				34'-44'	(continued) red coarse to fine sand
		2	42'-6"-42'-10"		50/4"					
		3	45'-46'6"		12	20	20		44'-47'	brown medium to fine sand trace silt
		4	48'6"-50'		16	18	21		47'-53'	red coarse to fine sand
10 / 50										
		5	5[illegible]'-52'6"		50/6"					
		6	54'6"-54'11"		50/5"				53'-75'	brown medium to fine sand
		7	57'-57'[illegible]"		56	50/3"				
20 / 60		8	60'-60'6"		50/6"					
		9	62'6"-63'		52/6"					
		10	65'-6[illegible]'		38	50				
		11	68'-68'11"		33	50/5"				
30 / 70		12	71'-71'6"		50/6"					
		13	73'6"-75'		38	52	89			
75										75'
40 / 80										

Soils Engineer: ____________ Driller: P. Mitchell

Drilling Inspector: ____________ Helper: N. Persons

P. [illegible]

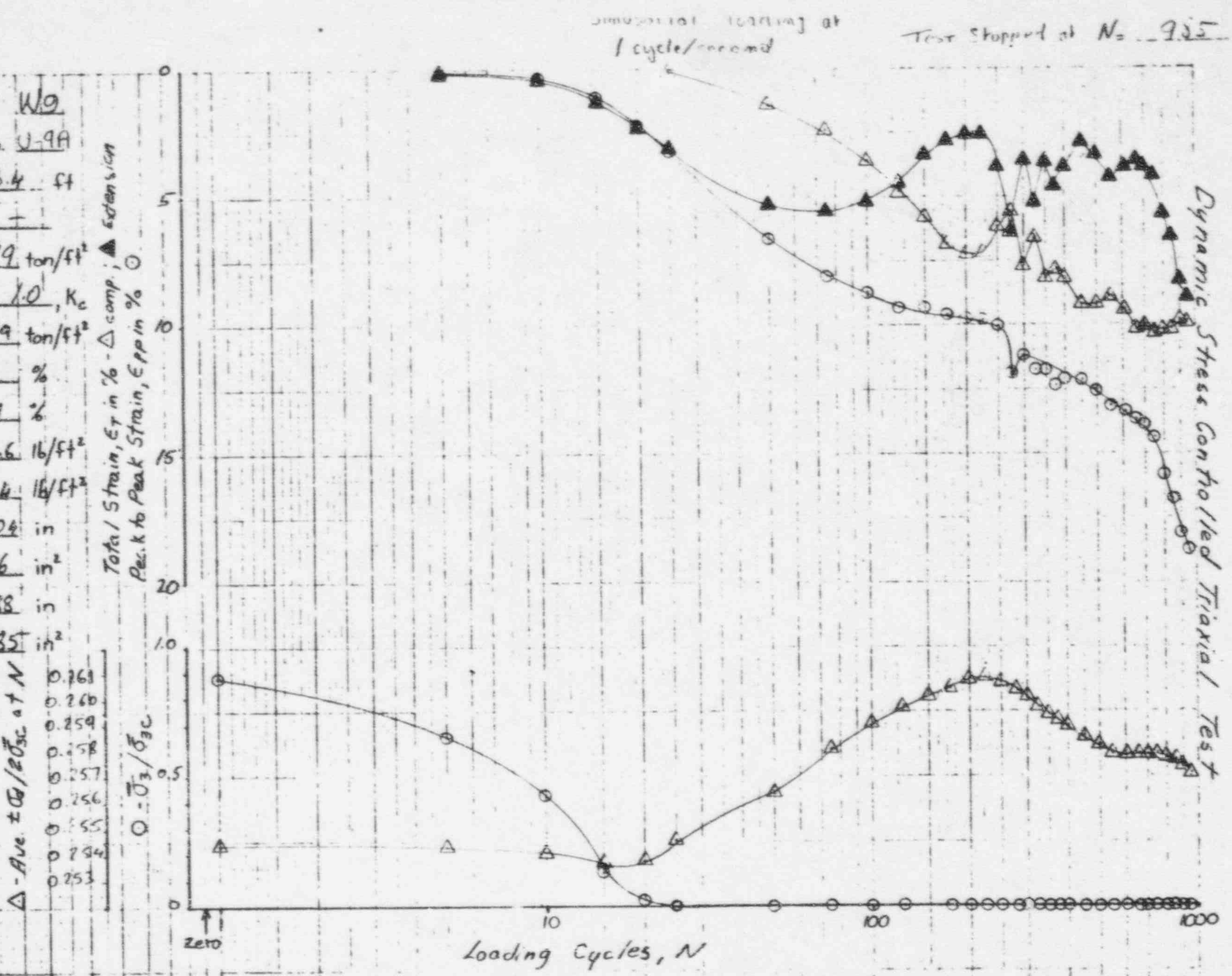
APPENDIX 324-D

RESULTS OF CYCLIC S"RENGTH TESTS

Dynamic Stress Controlled Triaxial Test

Test Stopped at N = 935

Boring No W9
Sample No. U-9A
Depth 43.4 ft
Test No. 1
$\bar{\sigma}_{3c}$ = 1.479 ton/ft²
σ_{1c}/σ_{3c} = 1.0, K_c
U_b = 8.459 ton/ft²
w_b = 21.1 %
w_f = 22.9 %
γ_{do} = 102.6 lb/ft²
γ_{dc} = 103.4 lb/ft²
L_o = 6.004 in
A_o = 6.416 in²
L_c = 5.988 in
A_c = 6.385 in²



Proj. No 73c807
Drawn by: JNL
Date: 1/4/74

Boring No W9

Sample No. U-6A

Depth 35.5 ft

Test No ____

$\bar{\sigma}_{3c}$ = 1.505 ton/ft²

$\sigma_{1c}/\bar{\sigma}_{3c}$ = 1.0, K_c

U_b = 6.983 ton/ft²

w_0 = 23.7 %

w_f = 23.9 %

γ_{d_0} = 101.1 lb/ft²

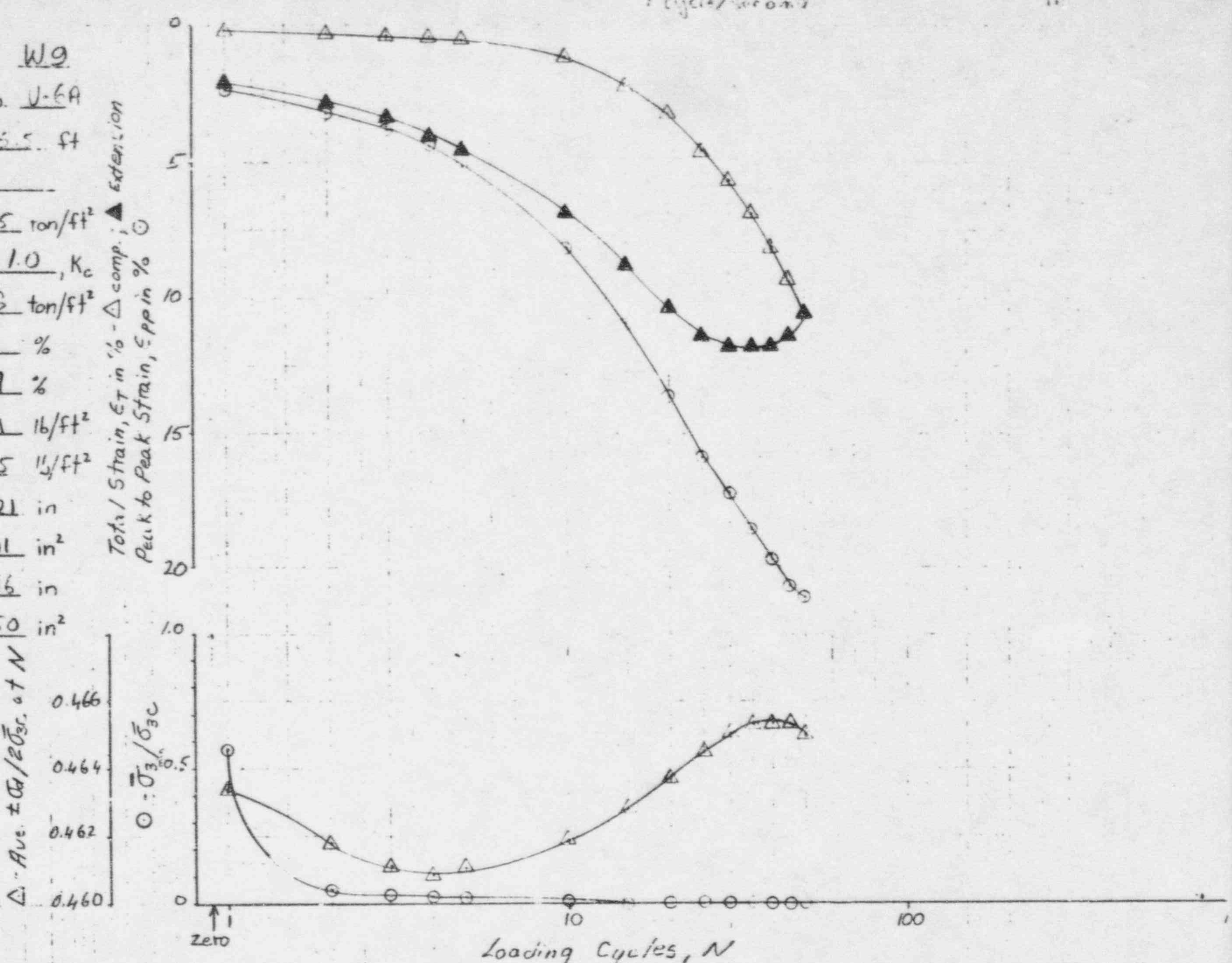
γ_{dc} = 102.5 lb/ft²

L_0 = 6.021 in

A_0 = 6.501 in²

L_c = 5.986 in

A_c = 6.450 in²



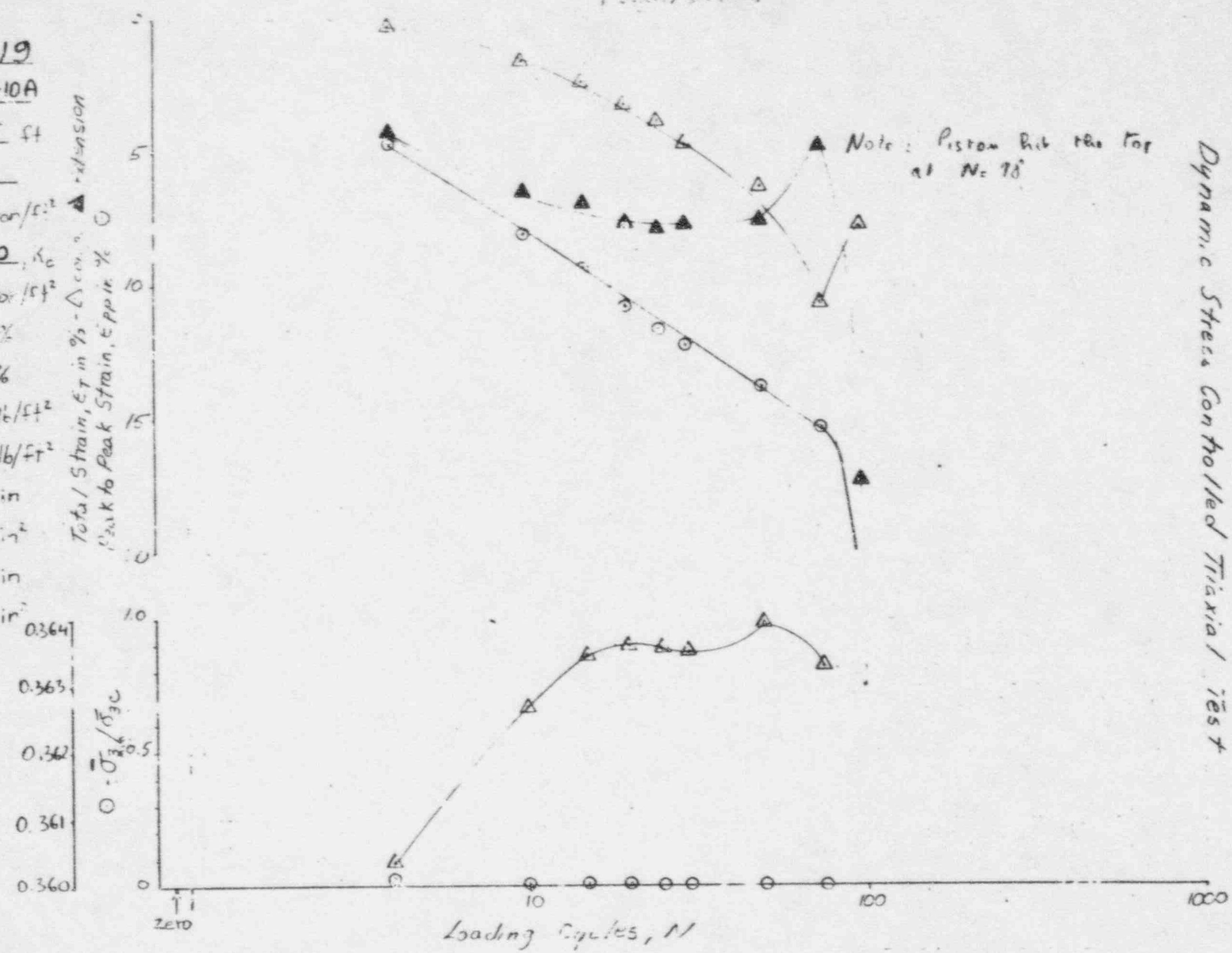
Proj. No 13c 501

Drawn by: JNC

Dynamic Stress Controlled Triaxial Test

Test Stopped at N= 106

Boring No. W9
Sample No. U-10A
Depth 46.5 ft
Test No. –
$\bar{\sigma}_{3c}$ = 1.505 ton/ft²
$\bar{\sigma}_{1c}/\bar{\sigma}_{3c}$ = 1.0, K_c
U_t = 6.983 ton/ft²
ω_i = 15.8 %
ω_f = 16.5 %
γ_{d_o} = 113.2 lb/ft²
γ_{dc} = 113.9 lb/ft²
L_o = 5.978 in
A_o = 6.456 in²
L_c = 5.969 in
A_c = 6.473 in²



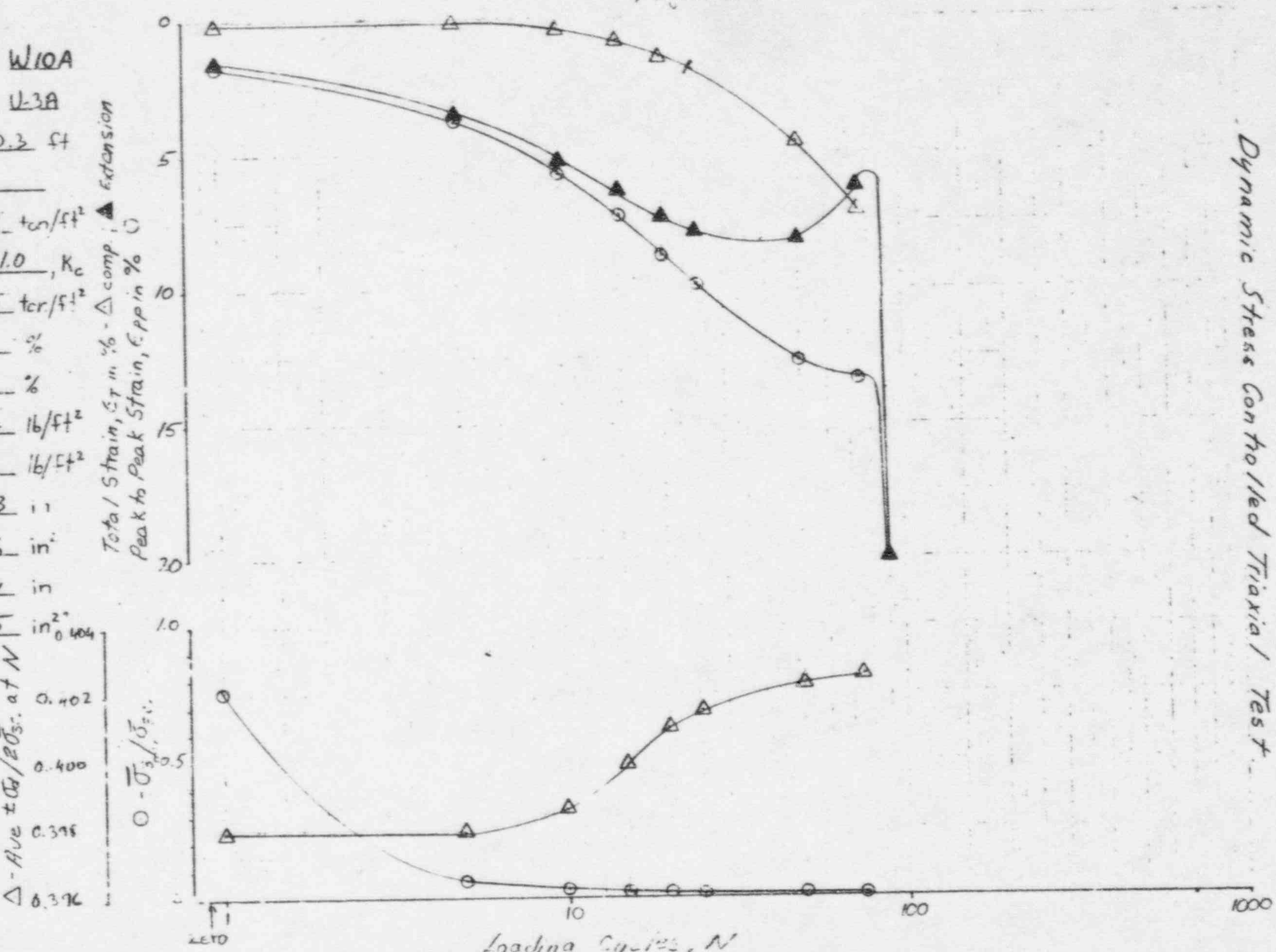
Proj No 73c 807
JNG
12/26/73

Dynamic Stress Controlled Triaxial Test

Sinusoidal loading at 1 cycle/second

Test Stopped at N = 91

Boring No. W10A
Sample No. U-3A
Depth 30.3 ft
Test No. ____
$\bar{\sigma}_{3c}$ = 2.469 ton/ft²
$\sigma_{1c}/\bar{\sigma}_{3c}$ = 1.0, K_c
U_t = 6.955 ton/ft²
ω_o = 27.0 %
ω_f = 26.7 %
γ_{d_o} = 96.2 lb/ft²
γ_{d_c} = 96.4 lb/ft²
L_o = 5.953 in
A_o = 6.506 in²
L_c = 5.944 in
A_c = 6.465 in²

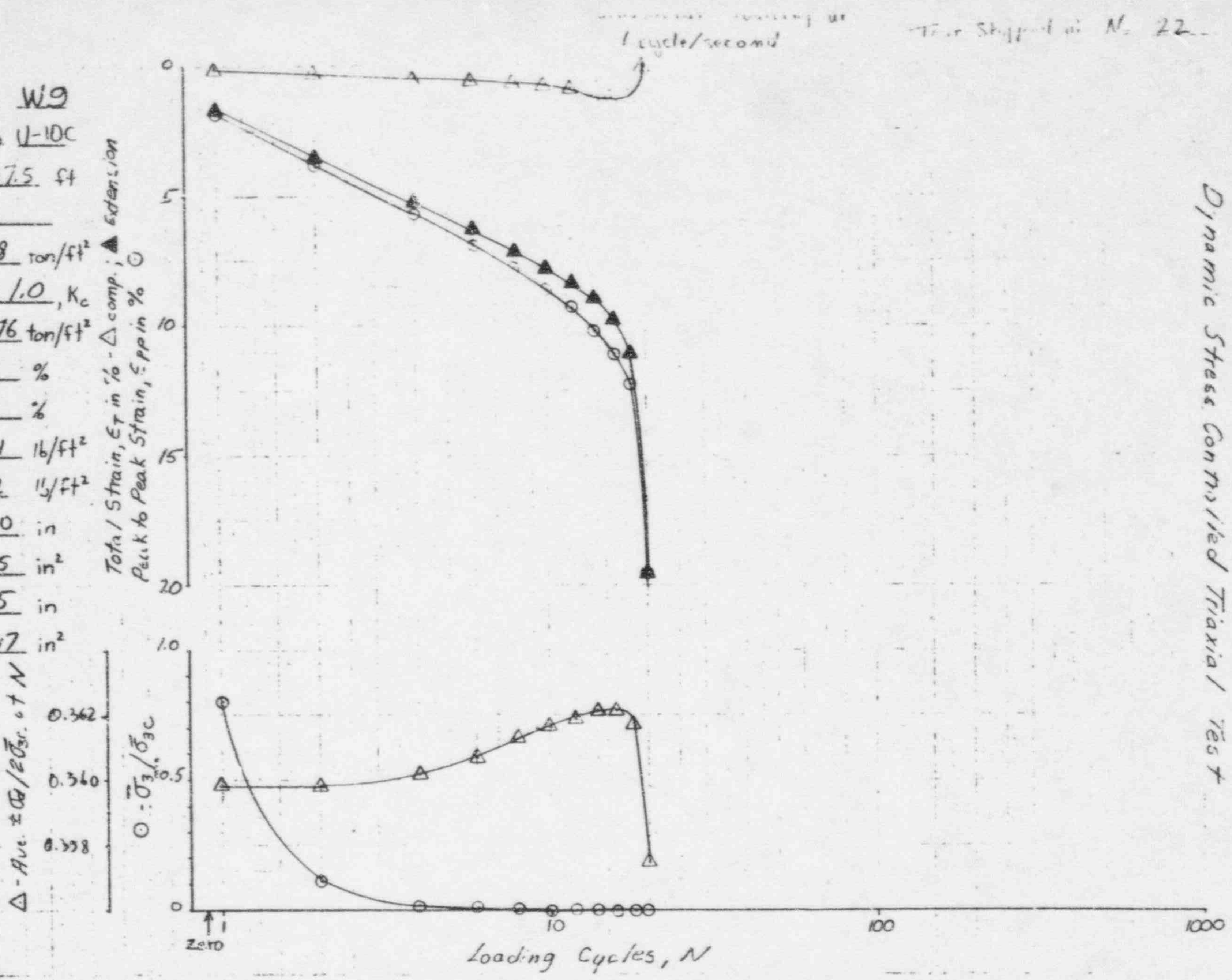


Proj No 73C 501
JNL
12/27/7?

Test Stopped at N = 22

Dynamic Stress Controlled Triaxial Test

Boring No. W9
Sample No. U-10C
Depth 47.5 ft
Test No. ____
$\bar{\sigma}_{3c}$ = 1.498 ton/ft²
$\sigma_{1c}/\bar{\sigma}_{3c}$ = 1.0, K_c
U_b = 6.976 ton/ft²
ω_b = 13.7 %
ω_f = 14.8 %
γ_{d_o} = 116.1 lb/ft²
γ_{dc} = 117.2 lb/ft²
L_o = 5.810 in
A_o = 6.595 in²
L_c = 5.795 in
A_c = 6.547 in²



Proj. No 73c 807
Drawn by: JNL
Date: 12/26/73

Test Stopped at N = 16

Boring No. W10A

Sample No. U-3B

Depth: 30.9 ft

Test No. ____

$\bar{\sigma}_{3c}$ = 2.684 ton/ft²

$\sigma_{1c}/\bar{\sigma}_{3c}$ = 1.0, K_c

U_b = 6.954⁺ ton/ft²

ω_o = 30.2 %

ω_f = 28.8 %

γ_{do} = 90.7 lb/ft²

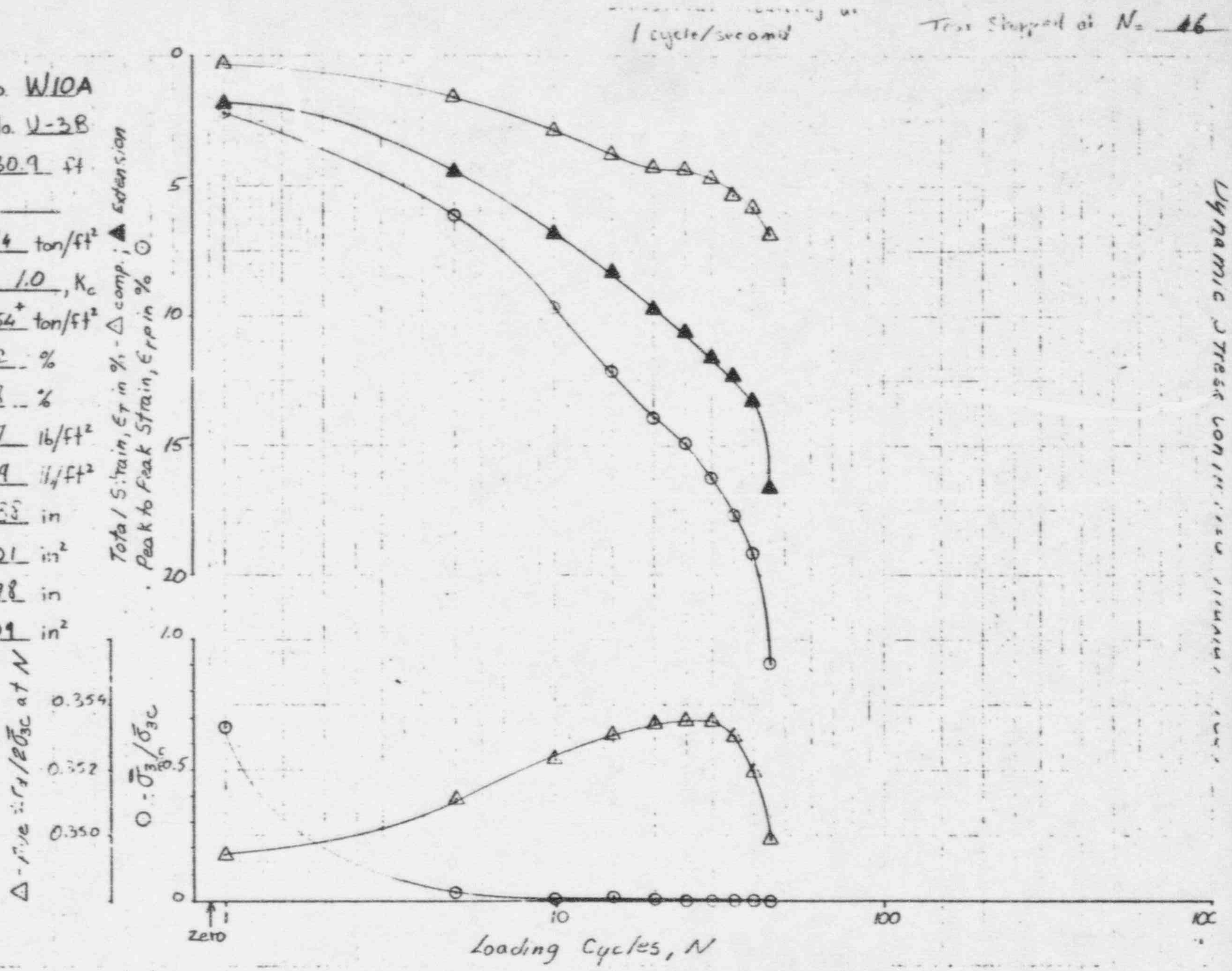
γ_{dc} = 97.9 lb/ft²

L_o = 5.938 in

A_o = 6.501 in²

L_c = 5.378 in

A_c = 6.409 in²



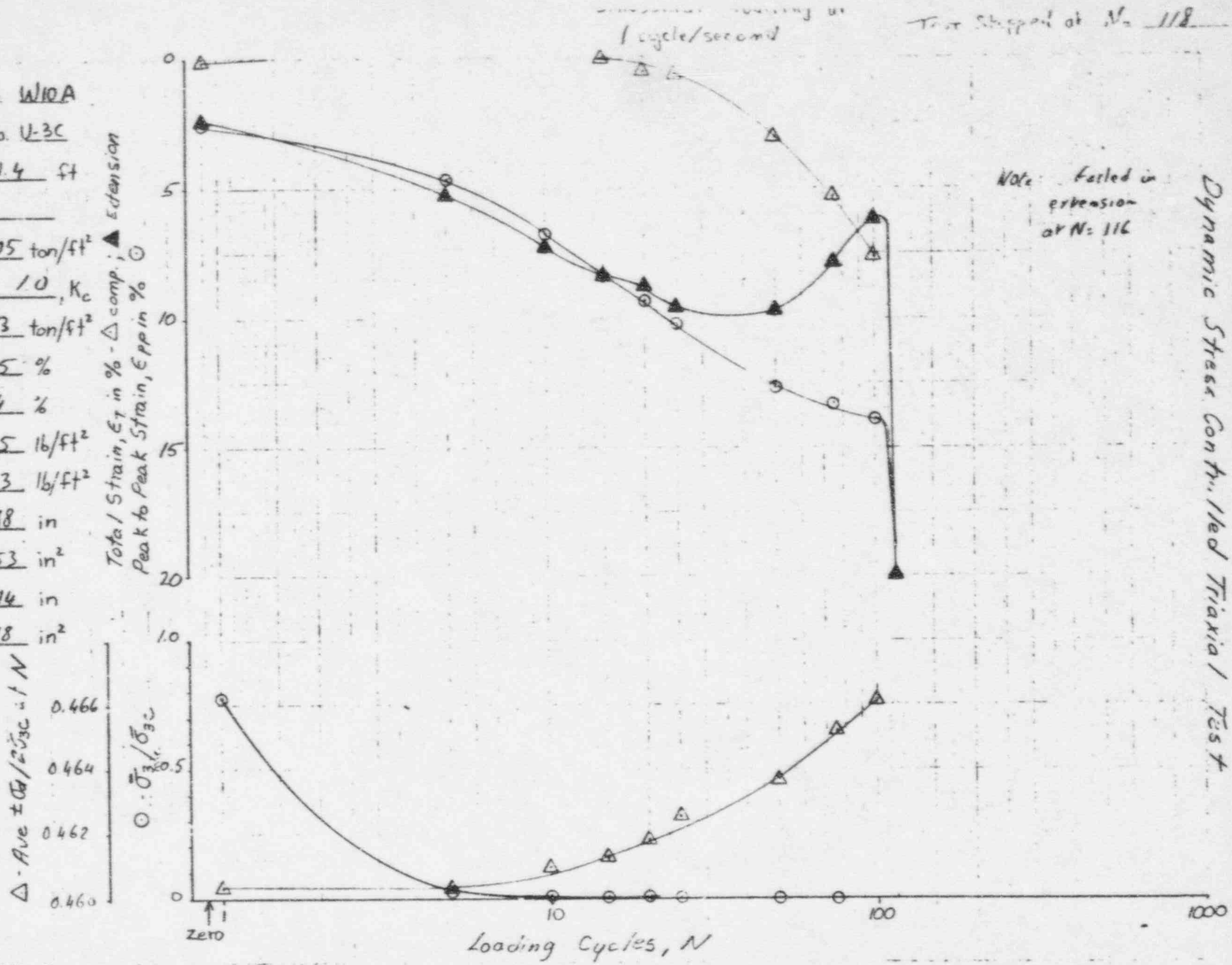
Proj. No. 73c807

Drawn by: JNL

Date: 11/27/73

Dynamic Stress Controlled Triaxial Test

Boring No. W10A
Sample No. U-3C
Depth 31.4 ft
Test No. ____
$\bar{\sigma}_{3c}$ = 1.505 ton/ft²
$\sigma_{1c}/\bar{\sigma}_{3c}$ = 1.0, K_c
U_b = 6.983 ton/ft²
ω_o = 27.5 %
ω_f = 27.4 %
γ_{do} = 94.5 lb/ft²
γ_{dc} = 95.3 lb/ft²
L_o = 5.988 in
A_o = 6.453 in²
L_c = 5.974 in
A_c = 6.418 in²



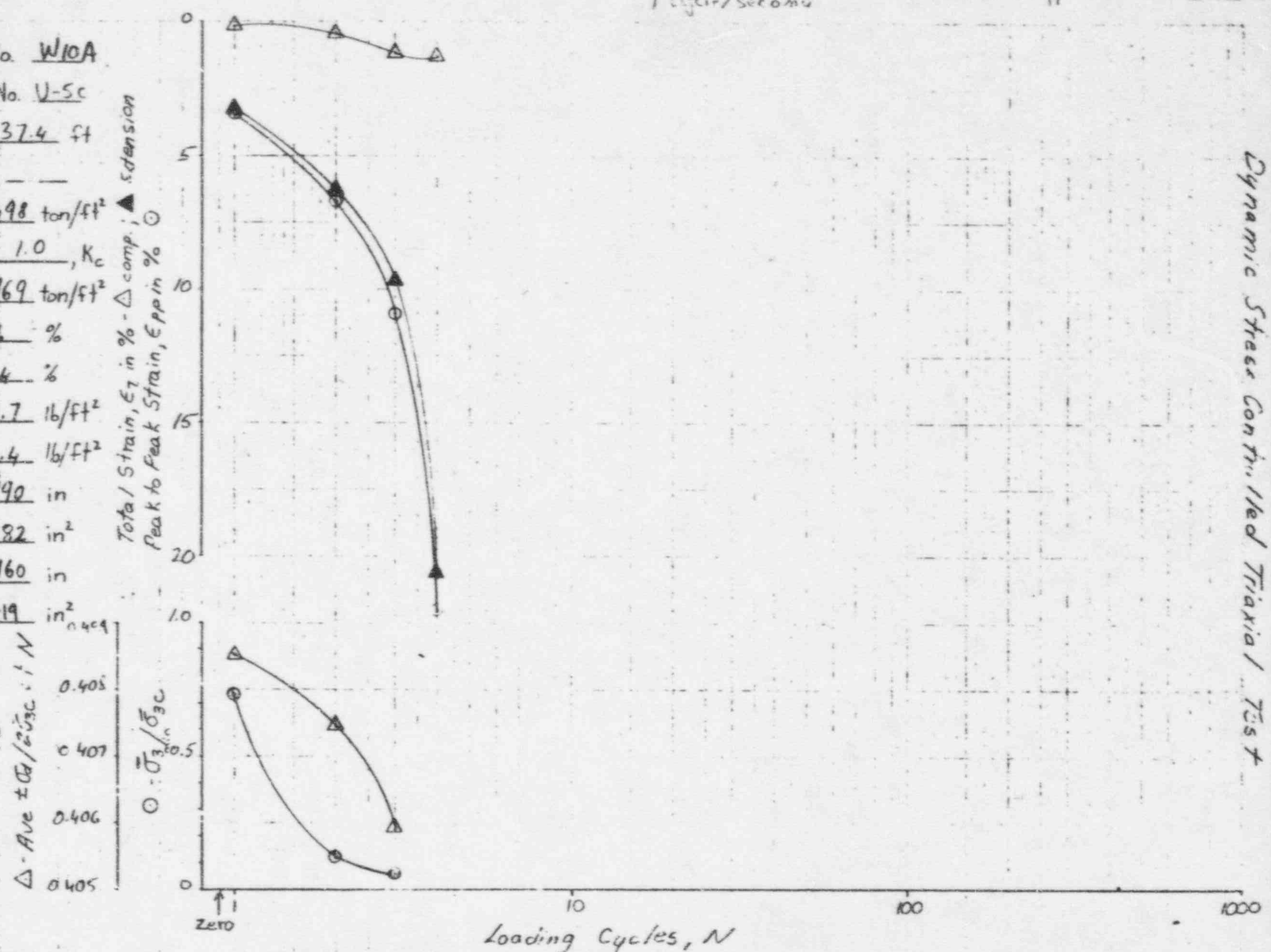
Proj. No 73c 307
Drawn by: JML
Date: 12/17/1973

Dynamic Stress Controlled Triaxial Test

Sinusoidal loading at 1 cycle/second

Test Stopped at N = 5

Boring No. W10A
Sample No. U-5c
Depth 37.4 ft
Test No. ___
$\bar{\sigma}_{3c}$ = 2.498 ton/ft²
$\sigma_{1c}/\bar{\sigma}_{3c}$ = 1.0, K_c
U_b = 6.969 ton/ft²
ω_o = 11.6 %
ω_f = 13.4 %
γ_{d_o} = 111.7 lb/ft²
γ_{dc} = 113.4 lb/ft²
L_o = 5.990 in
A_o = 6.482 in²
L_c = 5.960 in
A_c = 6.419 in²



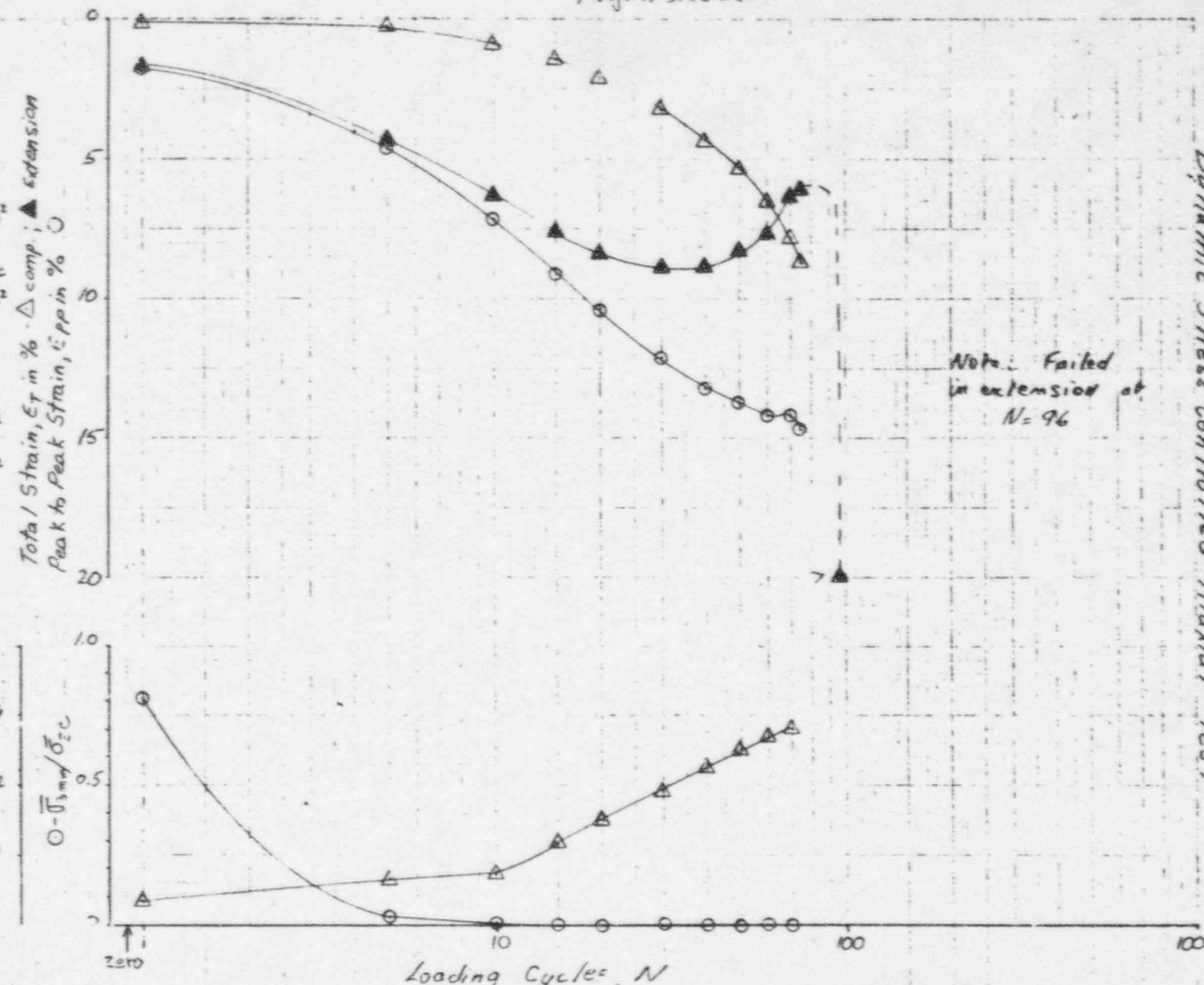
Proj. No 73C507
Drawn by: JNL
Date: 12/27/73

Dynamic Stress Controlled Triaxial Test

Sinusoidal loading at 1 cycle/second

Test Stopped at N= 96

Boring No. W10B
Sample No. U-7A
Depth 42.4 ft
Test No. ____
$\bar{\sigma}_{3c}$ = 2.487 ton/ft²
σ_{1c}/σ_{3c} = 1.0, K_c
U_b = 6.977 ton/ft²
ω_o = 23.5 %
ω_f = 23.9 %
γ_{do} = 99.2 lb/ft²
γ_{dc} = 99.9 lb/ft²
L_o = 6.006 in
A_o = 6.474 in²
L_c = 5.994 in
A_c = 6.441 in²

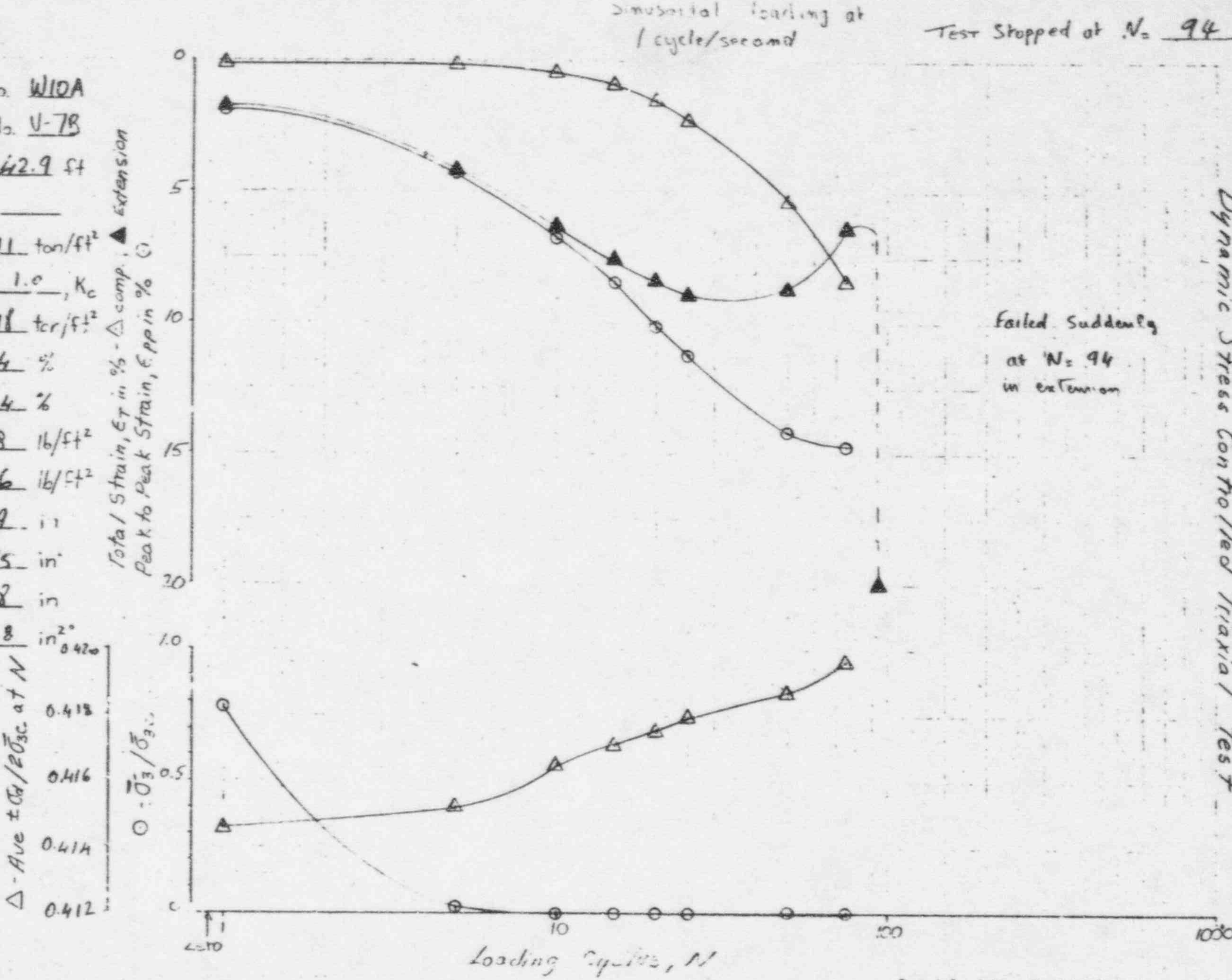


Proj. No 73C807
Drawn by: JNL
Date: 1/2/74

Dynamic Stress Controlled Triaxial Test

Test Stopped at N = 94

Boring No. W10A
Sample No. U-7B
Depth 62.9 ft
Test No. ____
$\bar{\sigma}_{3c}$ = 2.491 ton/ft²
$\sigma_{1c}/\bar{\sigma}_{3c}$ = 1.0, K_c
U_b = 6.998 ton/ft²
w_o = 25.4 %
w_f = 25.4 %
γ_{d_o} = 96.8 lb/ft²
γ_{d_c} = 97.6 lb/ft²
L_o = 5.999 in
A_o = 6.485 in²
L_c = 5.988 in
A_c = 6.448 in²



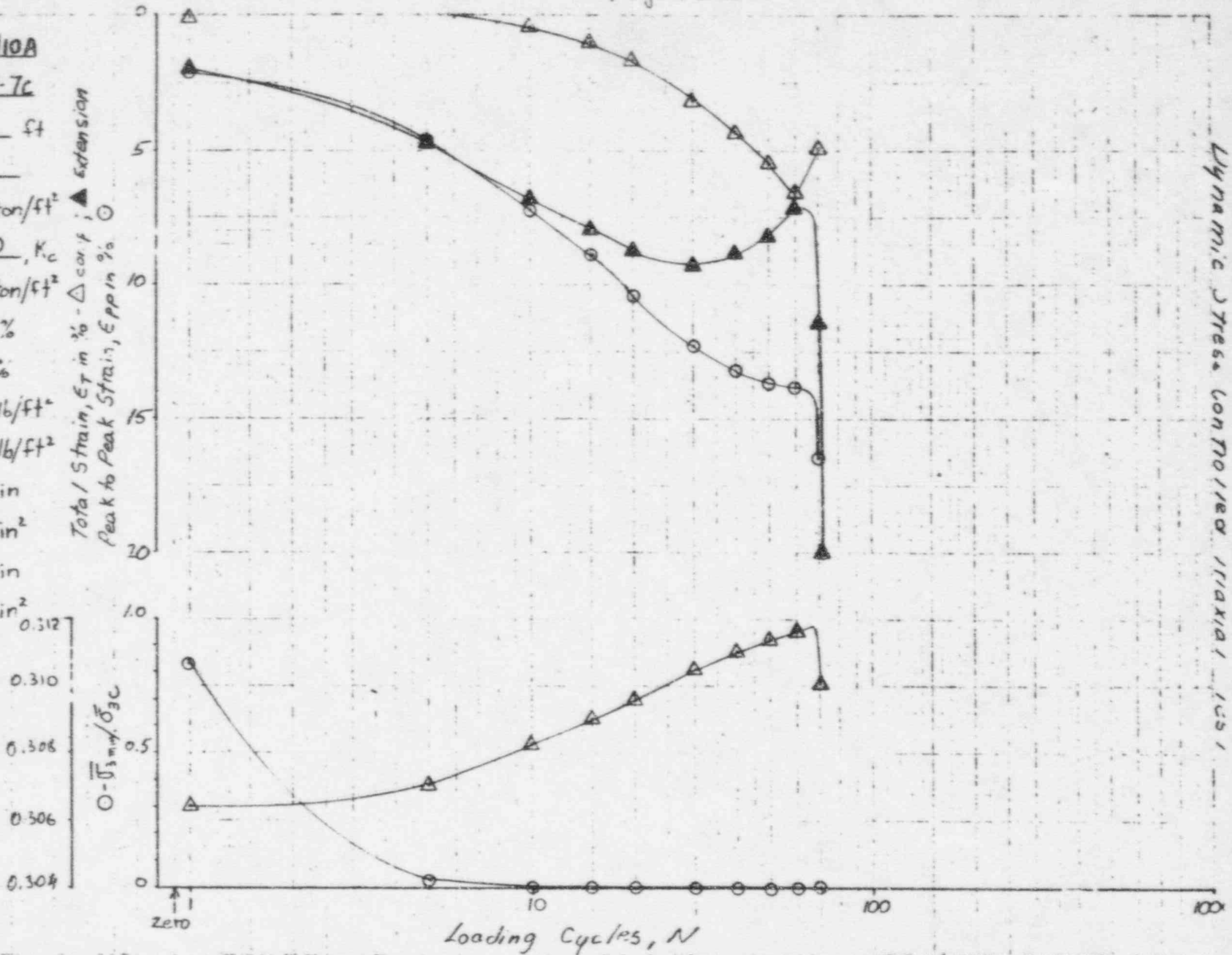
Proj. No. 73C 807
JNL
1/3/74

Sinusoidal loading at 1 cycle/second

Test Stopped at N = 71

Dynamic Stress Controlled Triaxial Test

Boring No. W10A
Sample No. U-7C
Depth 43.4 ft
Test No. ____
$\bar{\sigma}_{3c}$ = 2.505 ton/ft²
σ../σ.. = 1.0, K_c
U_b = 6.955 ton/ft²
ω_o = 25.0 %
ω_f = 24.5 %
γ_{d_o} = 97.2 lb/ft³
γ_{dc} = 97.9 lb/ft³
L_o = 6.024 in
A_o = 6.500 in²
L_c = 6.019 in
A_c = 6.446 in²



Proj. No. 73c 807
Drawn by: JNL
Date: 1/2/74

Dynamic Stress Controlled xial Test

Reconstituted Specimen — Sinusoidal loading at 1 cycle/second — Test Stopped at N = 39

Boring No. W-12

Sample No. S-11D

Depth 41.9 ft

Test No. ____

$\bar{\sigma}_{3c}$ = 1.49 ton/ft²

σ_{1c}/σ_{3c} = 1.0, K_c

U_b = 6.523 ton/ft²

ω_o = 23.23 %

ω_f = 23.71 %

γ_{d_o} = 100.65 lb/ft²

γ_{dc} = 100.90 lb/ft²

L_o = 6.0044 in

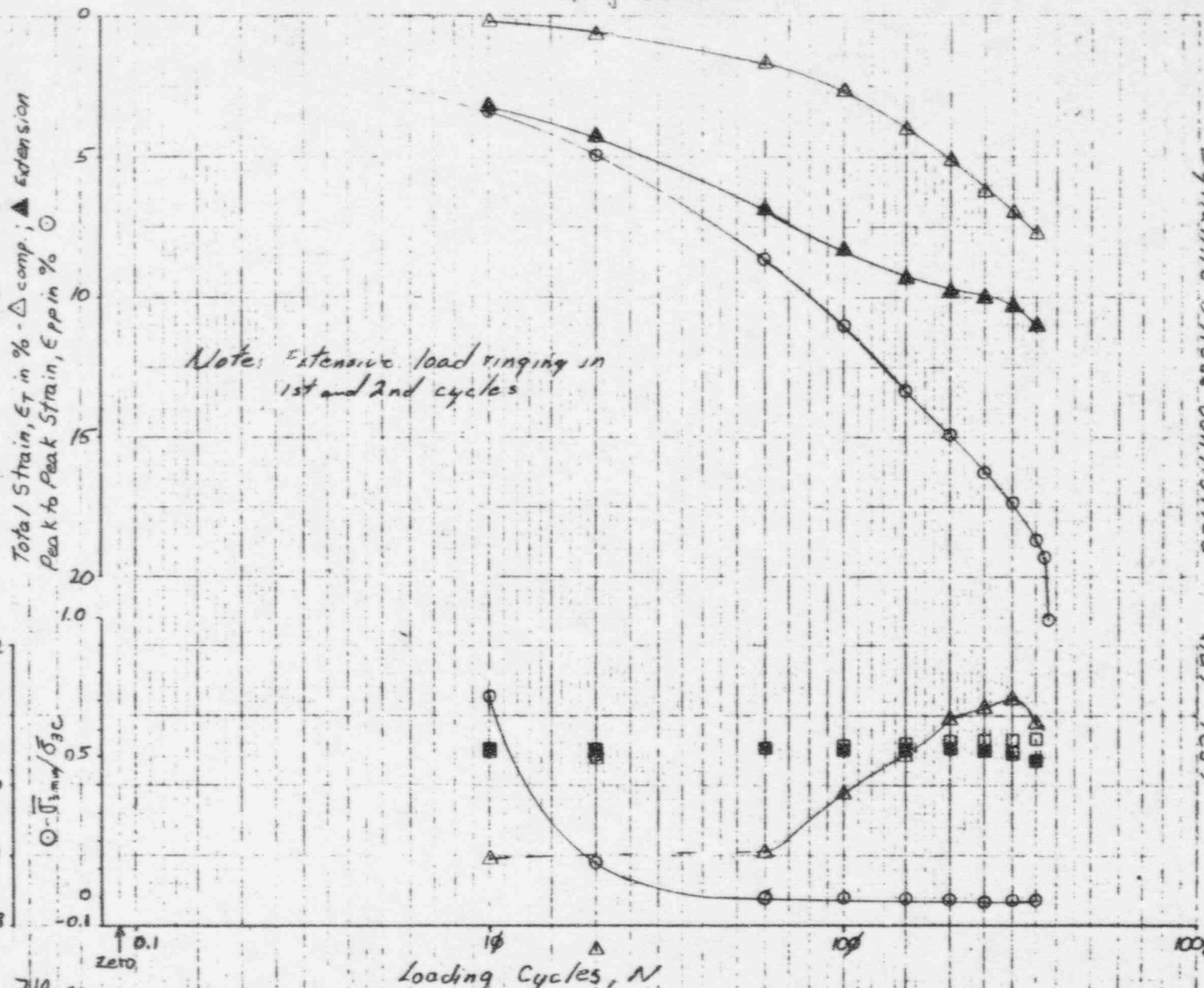
A_o = 6.466 in²

L_c = 5.9919 in

A_c = 6.407 in²

B_{factor} = 96.6 %

ΔL_c .0125 in ΔV_c = 7.10 cc



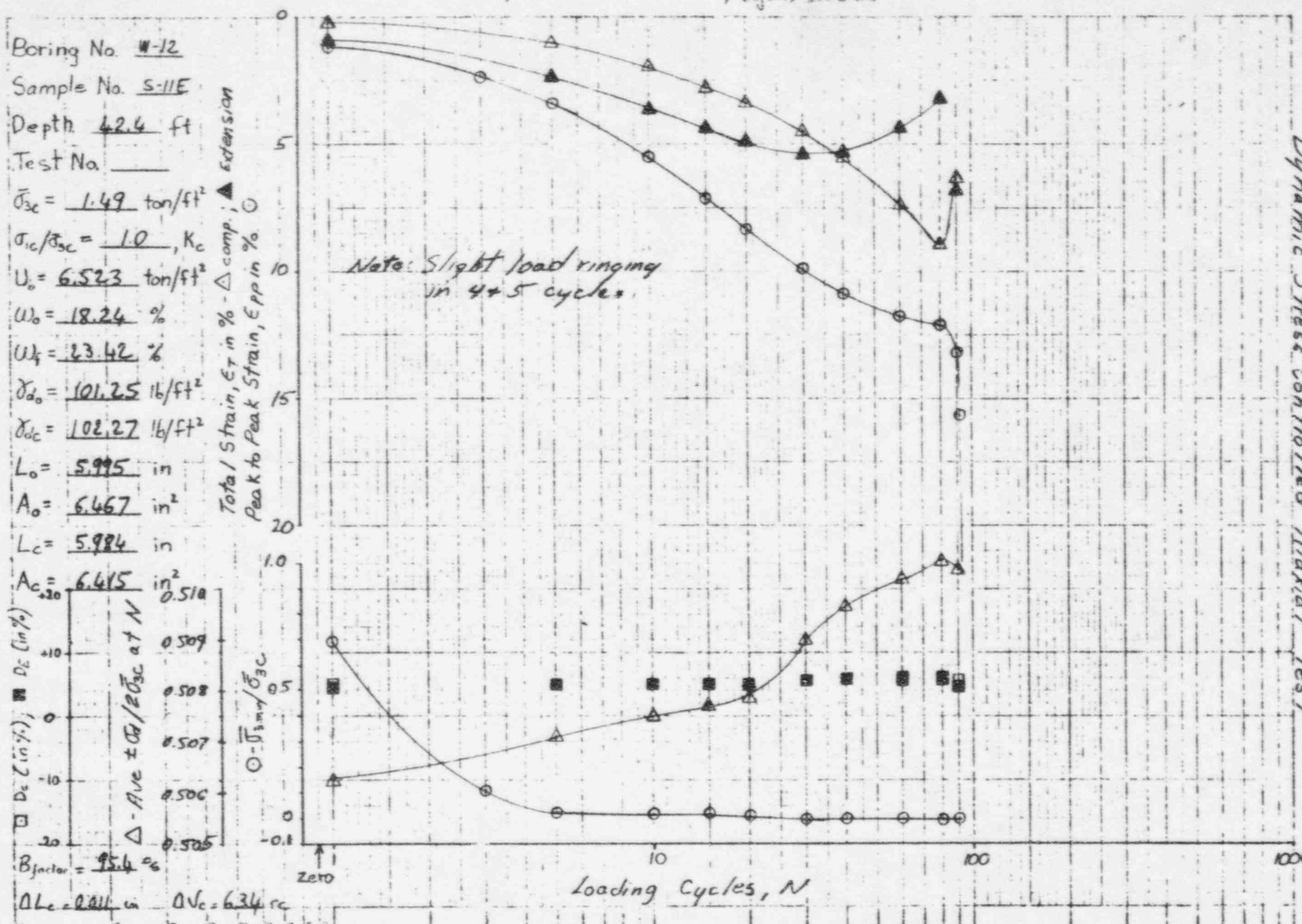
Proj. No: 73C807B

Drawn by: JB

Date: 10/23/74

Dynamic Stress Controlled Triaxial Test

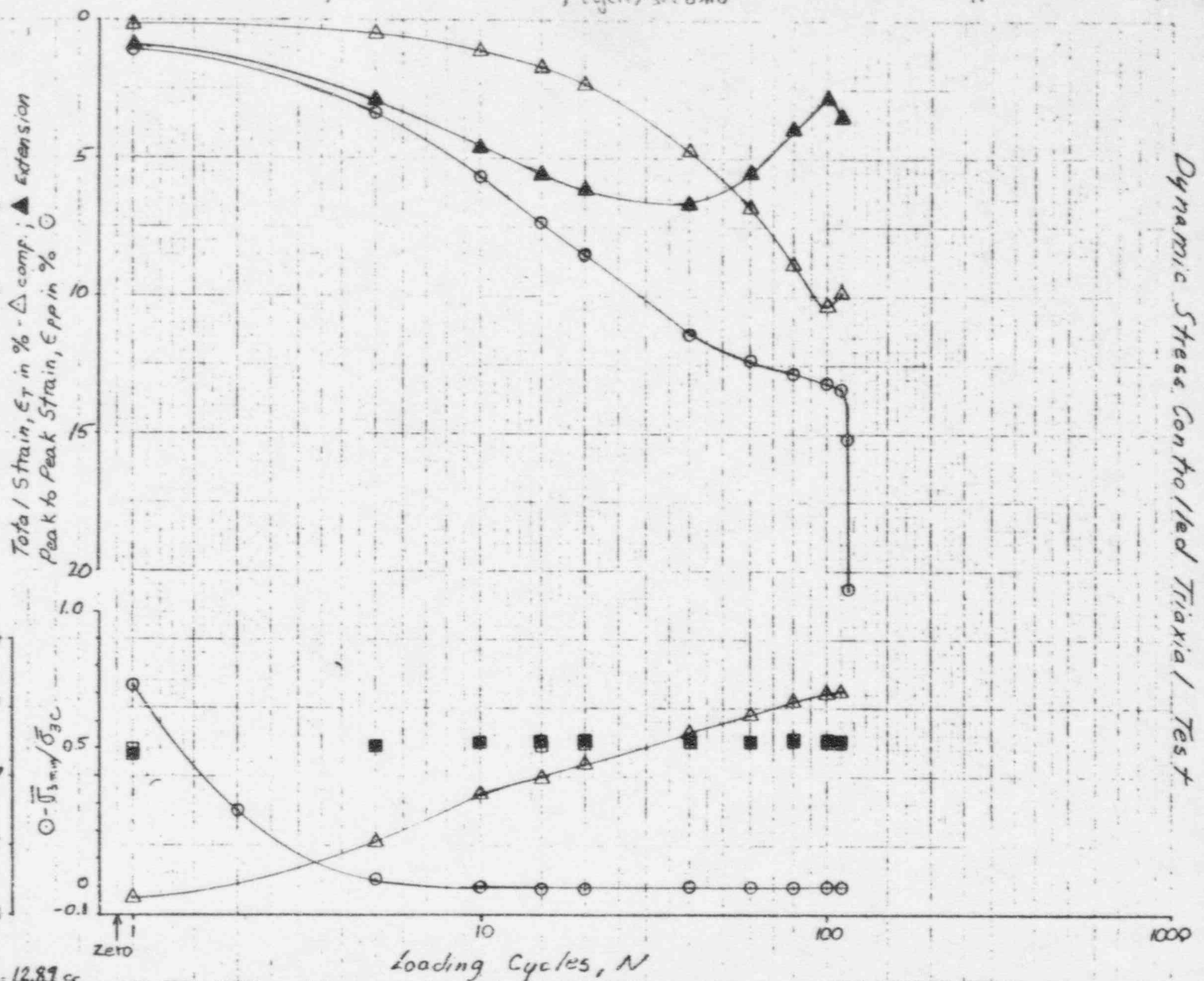
Reconstitued Specimen | Sinusoidal loading at 1 cycle/second | Test Stopped at N = 93



Proj. No: 73C807B
Drawn by: JB
Date: 10/23/74

Test Stopped at N = 117

Boring No. N-18
Sample No. S-11C
Depth 42.4 ft
Test No. ____
$\bar{\sigma}_{3c}$ = 1.501 ton/ft²
$\sigma_{1c}/\bar{\sigma}_{3c}$ = 1.0 , K_c
U_b = 7.199 ton/ft²
ω_o = 18.22 %
ω_f = 24.47 %
γ_{d_o} = 98.45 lb/ft³
γ_{dc} = 100.54 lb/ft³
L_o = 5.8718 in
A_o = 6.446 in²
L_c = 5.8610 in
A_c = 6.324 in²
B_{factor} = 95.7 %
ΔL_c = 0.0108 in ΔV_c = 12.89 cc



Proj. No. 73C807B
Drawn by: JB
Date: 11/4/74

Dynamic Stress Controlled Triaxial Test

Boring No. W-18

Sample No. S-12C

Depth 45.6 ft

Test No. ____

$\bar{\sigma}_{3c}$ = 1.515 ton/ft^2

$\sigma_{1c}/\bar{\sigma}_{3c}$ = 1.0, K_c

U_b = 7.199 ton/ft^2

ω_o = 18.74 %

ω_f = 22.43 %

γ_{d_o} = 102.15 lb/ft^3

γ_{dc} = 103.96 lb/ft^3

L_o = 6.0008 in

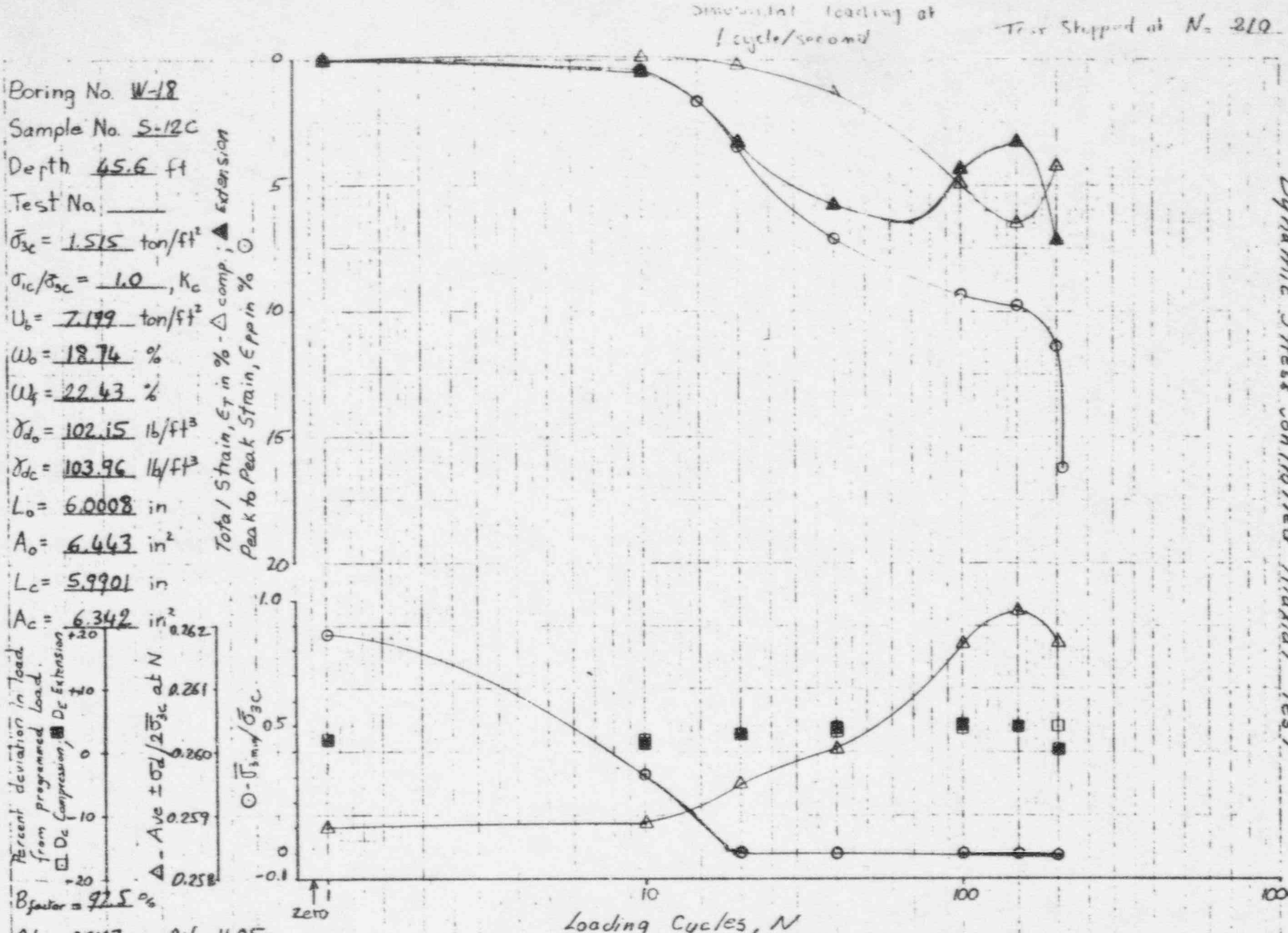
A_o = 6.443 in^2

L_c = 5.9901 in

A_c = 6.342 in^2

B_{factor} = 92.5 %

ΔL_c = 0.0107 in ΔV_c = 11.05 cc



Proj. No. 73C807B

Drawn by JB

Date 11/11/74

Dynamic Stress Controlled Triaxial Test

Sinusoidal loading at 1 cycle/second

Test Stopped at N = 105

Boring No. W-19

Sample No. S-11C

Depth 42.6 ft

Test No. ____

$\bar{\sigma}_{3c}$ = 1.508 ton/ft²

$\sigma_{1c}/\bar{\sigma}_{3c}$ = 1.0, K_c

U_b = 10.799 ton/ft²

ω_o = 18.31 %

ω_f = 25.71 %

γ_{d_o} = 96.15 lb/ft³

γ_{dc} = 98.57 lb/ft³

L_o = 5.995 in

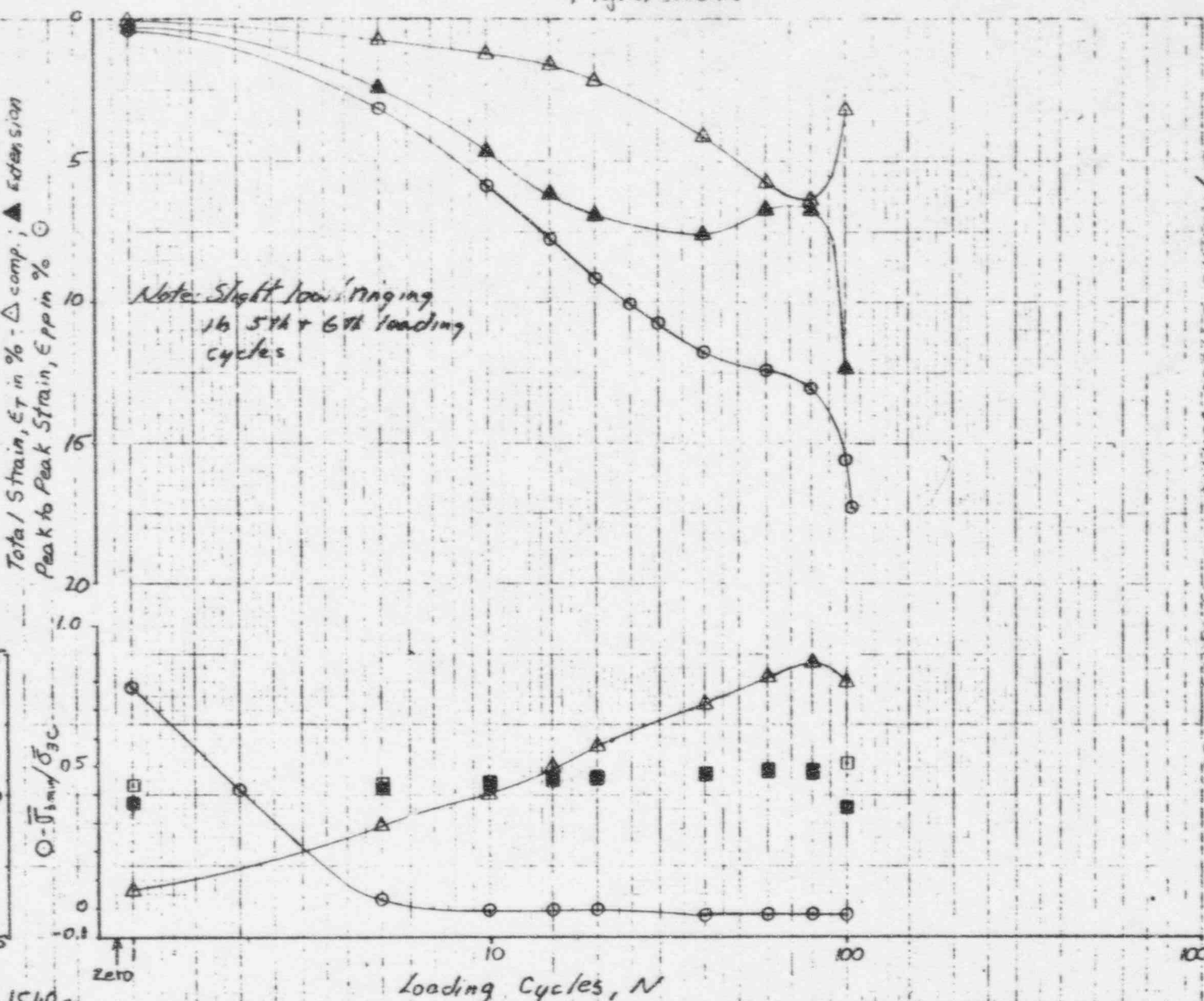
A_o = 6.381 in²

L_c = 5.9767 in

A_c = 6.243 in²

B_{factor} = 96.0 %

ΔL_c = .00183 in ΔV_c = 15.60 cc



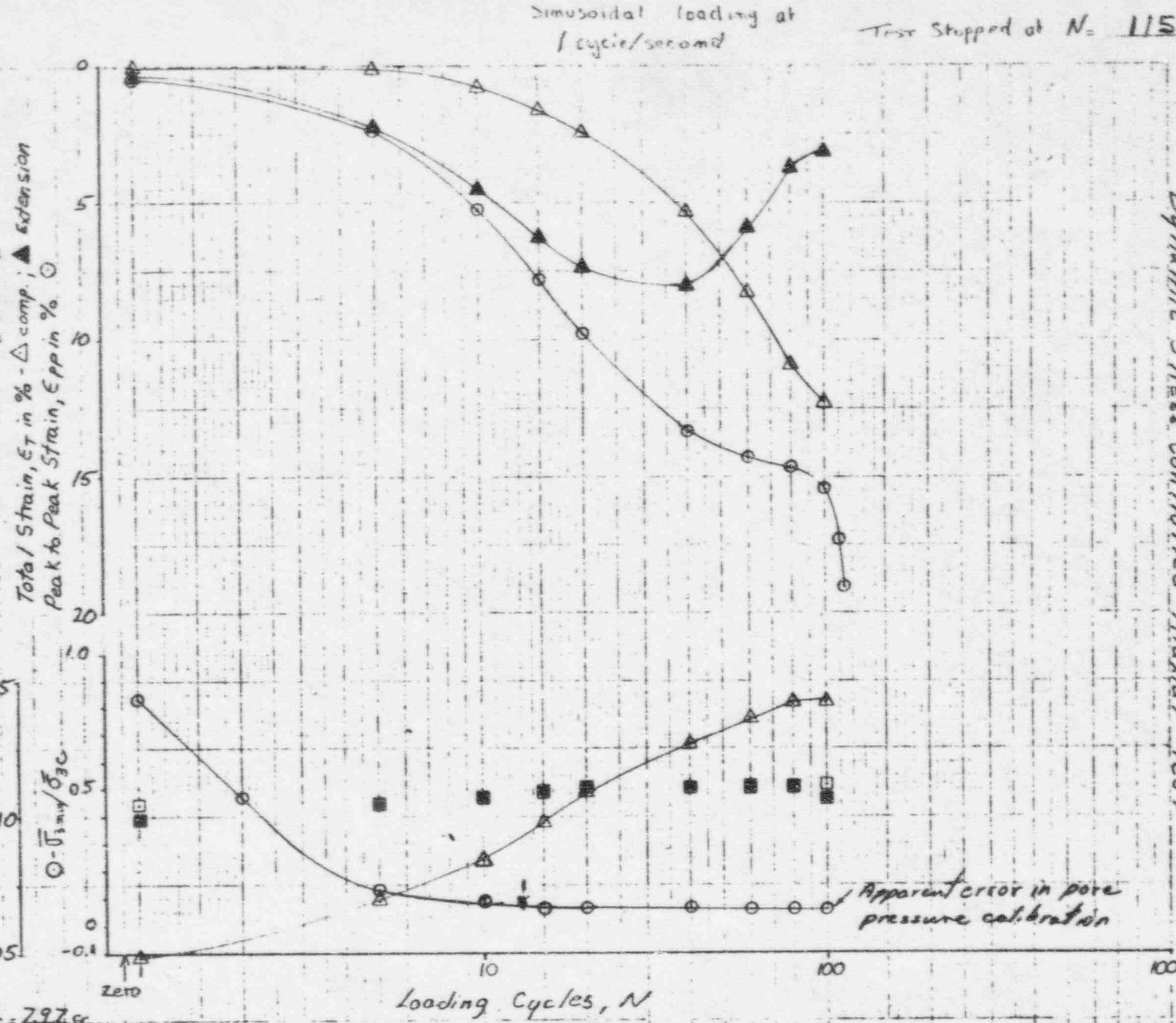
Proj. No: 73C807B

Drawn by: JB

Date: 11/18/74

Test Stopped at N= 115

Boring No. N-19
Sample No. S-11E
Depth 43.2 ft
Test No. ____
$\bar{\sigma}_{3c}$ = 1.497 ton/ft²
$\sigma_{1c}/\bar{\sigma}_{3c}$ = 1.0, K_c
U_b = 7.199 ton/ft²
ω_o = 20.31 %
ω_f = 23.53 %
γ_{do} = 100.81 lb/ft³
γ_{dc} = 102.09 lb/ft³
L_o = 6.0006 in
A_o = 6.457 in²
L_c = 5.9898 in
A_c = 6.387 in²
B_{factor} = 96.8 %
ΔL_c = 0.0108 in ΔV_c = 2.97 cc



Proj. No 73C807B
Drawn by: JB
Date: 11/18/74

Dynamic Stress Controlled Triaxial Test

~~Reconstituted Specimen~~

Sinusoidal loading at 1 cycle/second

Test Stopped at N = 43

Boring No. W-19

Sample No. S-12C

Depth 46.4 ft

Test No. ____

$\bar{\sigma}_{3c}$ = 1.512 ton/ft²

$\sigma_{1c}/\bar{\sigma}_{3c}$ = 1.0, K_c

U_b = 7.199 ton/ft²

ω_o = 21.66 %

ω_f = 21.00 %

γ_{d_o} = 103.7 lb/ft²

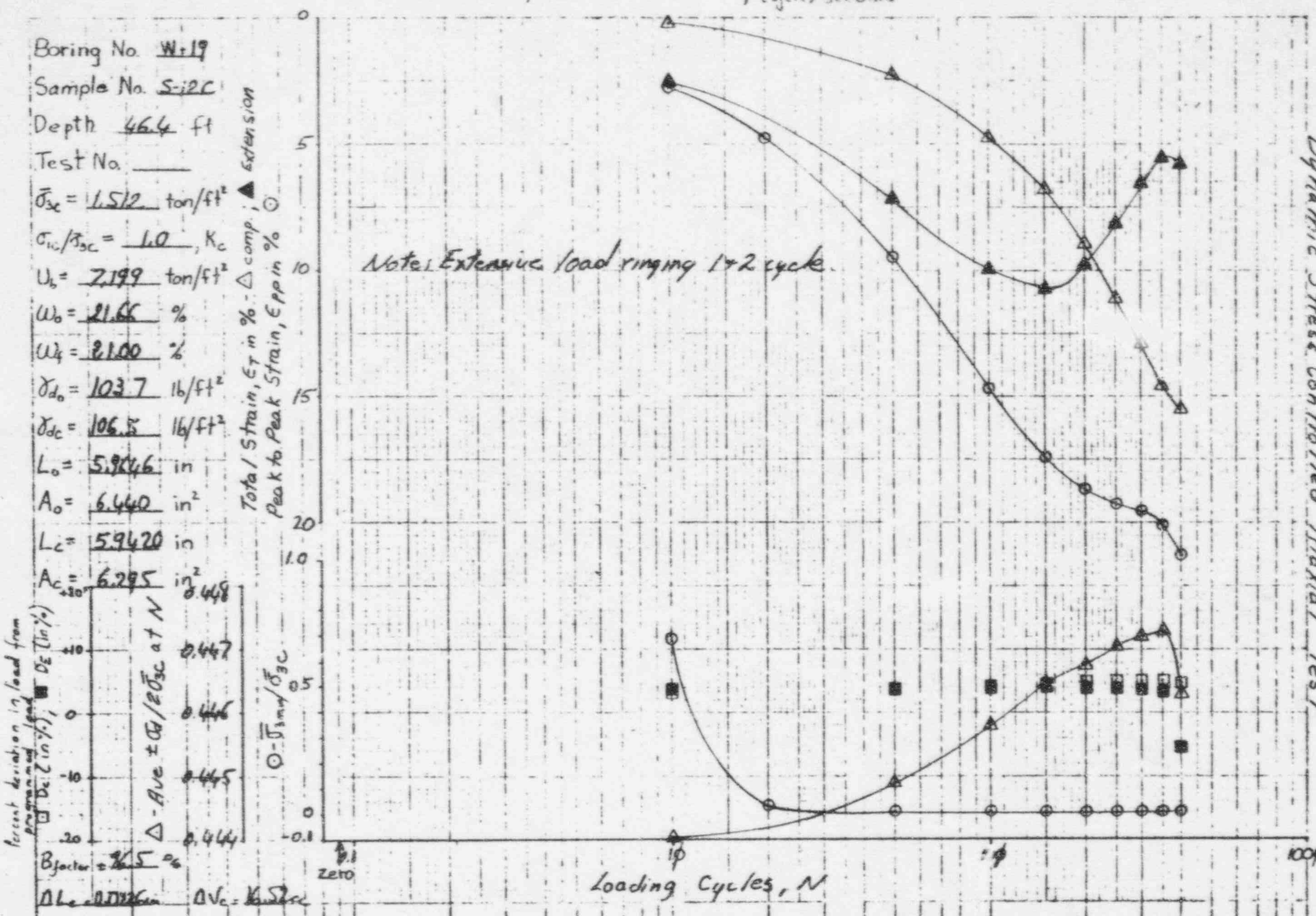
γ_{dc} = 106.5 lb/ft²

L_o = 5.9646 in

A_o = 6.440 in²

L_c = 5.9420 in

$A_{c+30''}$ = 6.295 in²



B_{factor} = 96.5 %

ΔL_c = .02226 in ΔV_c = 16.52 cc

Proj. No. 73C807B

Drawn by JB

Date 11/6/76

Dynamic Stress Controlled Triaxial Test

Reconstituted Specimen

Sinusoidal loading at 1 cycle/second

Test Stopped at N = 37

Boring No. W-19

Sample No. S-12B

Depth 45.9 ft

Test No. —

$\bar{\sigma}_{3c}$ = 1.483 ton/ft²

$\sigma_{1c}/\bar{\sigma}_{3c}$ = 1.0, K_c

U_b = 6.479 ton/ft²

ω_o = 18.31 %

ω_f = 21.23 %

γ_{d_o} = 104.04 lb/ft³

γ_{dc} = 106.08 lb/ft³

L_o = 5.9974 in

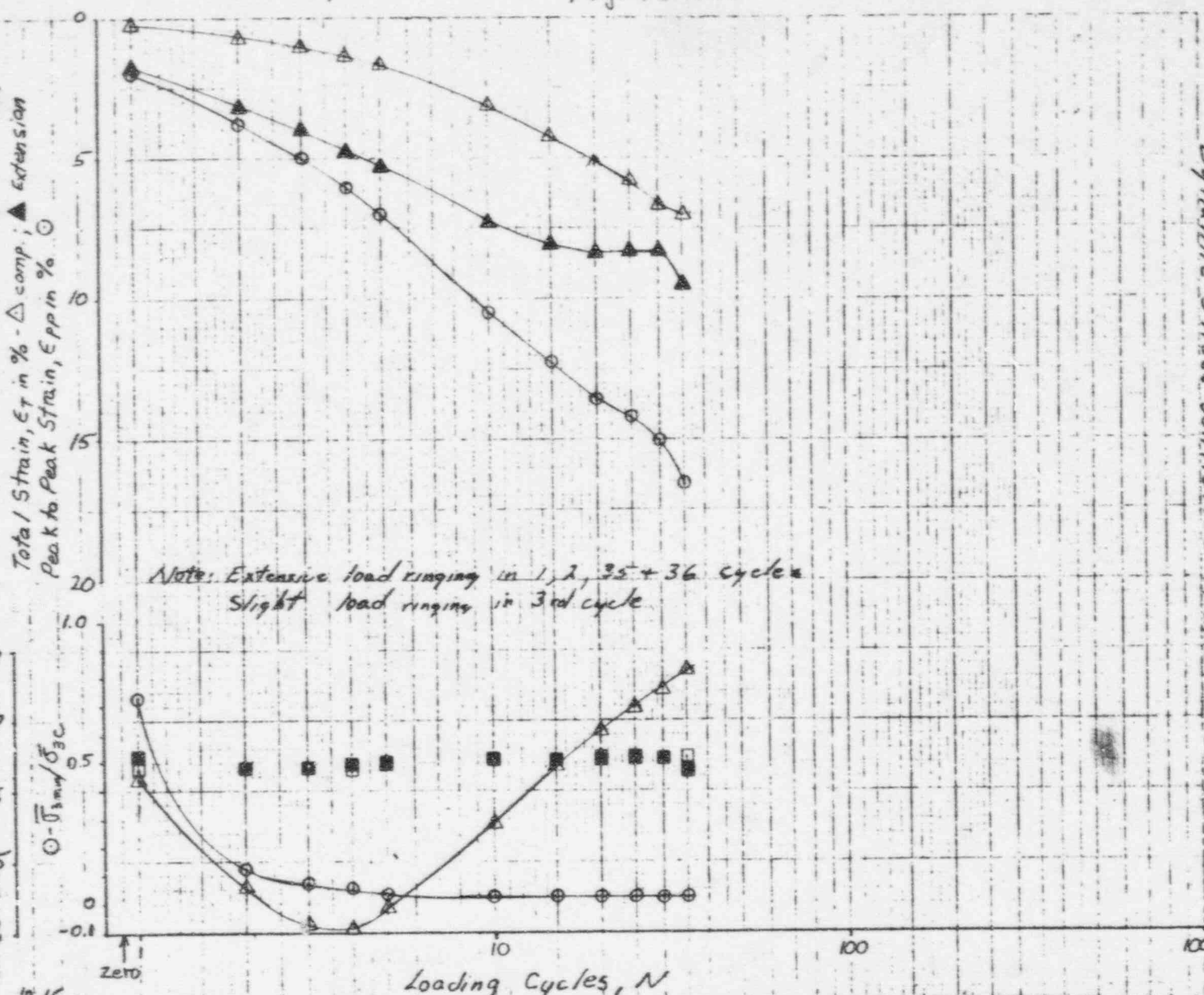
A_o = 6.440 in²

L_c = 5.9842 in

$A_{c,30}$ = 6.331 in²

B_{factor} = 95.5 %

ΔL_c = 0.0132 in ΔV_c = 12.16 cc



Proj. No. 73C807B

Drawn by: JB

Date: 10/24/74

Dynamic Stress Controlled Triaxial Test

~~Specimen~~

Sinusoidal loading at 1 cycle/second

Test Stopped at N = 55

Boring No. N-19

Sample No. S-12D

Depth 46.9 ft

Test No. ____

$\bar{\sigma}_{3c}$ = 1.515 ton/ft²

$\sigma_{1c}/\bar{\sigma}_{3c}$ = 1.0, K_c

U_b = 7.199 ton/ft²

ω_o = 18.61 %

ω_f = 18.66 %

γ_{do} = 109.12 lb/ft²

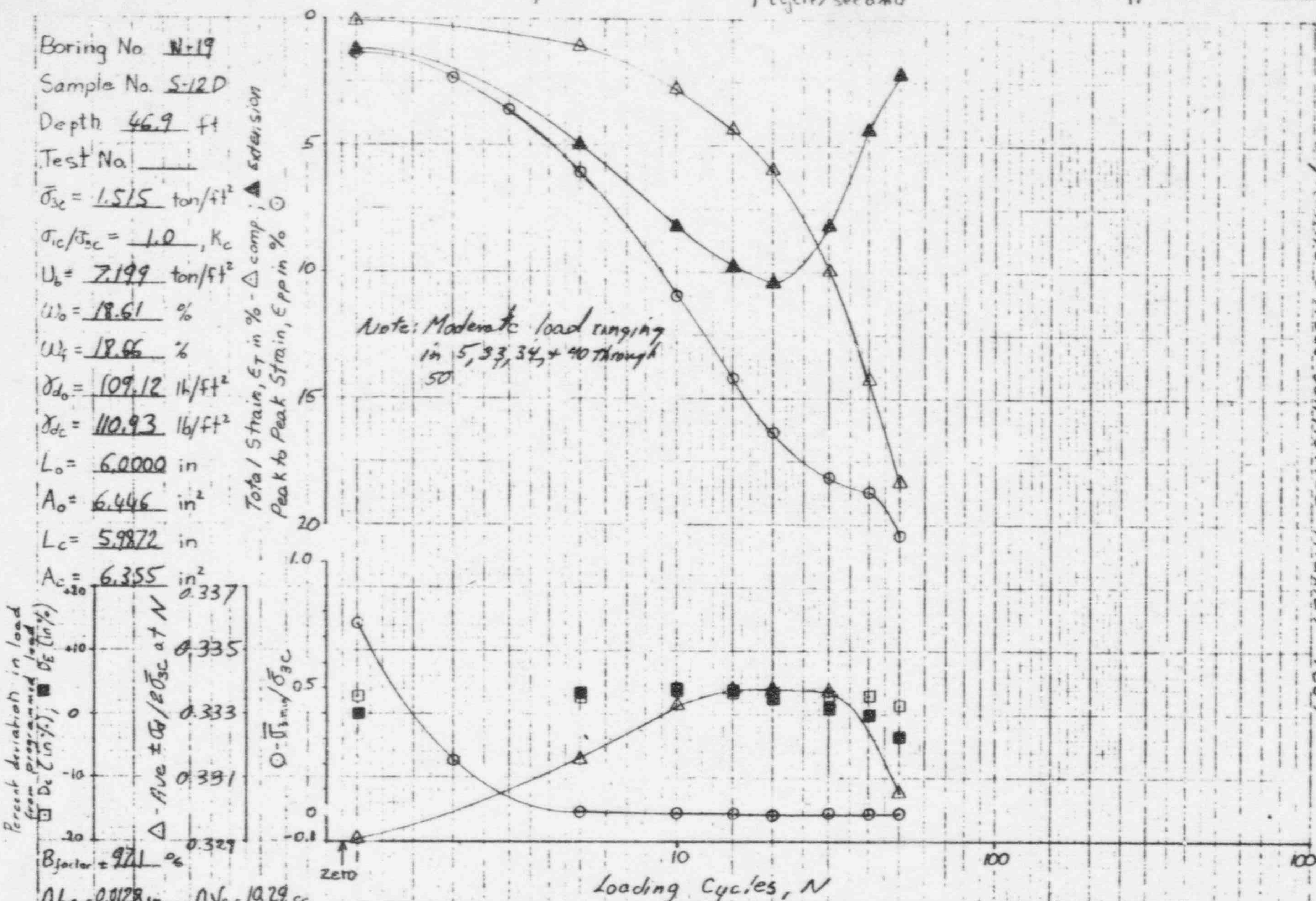
γ_{dc} = 110.93 lb/ft²

L_o = 6.0000 in

A_o = 6.446 in²

L_c = 5.9872 in

A_c = 6.355 in²



B_{factor} = 97.1 %

ΔL_c = 0.0128 in ΔV_c = 10.29 cc

Proj. No: 73C807B

Drawn by: JB

Date: 11/4/74