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Cherry Island Landfill Expansion Project Wilmington, Delaware

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Terraqua Resources Corporation, "Site Suitability Report, Hydrogeologic and Geotechnical Evaluation of the Cherry Island Site," prepared for the Delaware Solid Waste Authority, January 1984.

SITE SUITABILITY REPORT

HYDROGEOLOGIC AND GEOTECHNICAL EVALUATION OF THE CHERRY ISLAND SITE

PREPARED FOR

DELAWARE SOLID WASTE AUTHORITY

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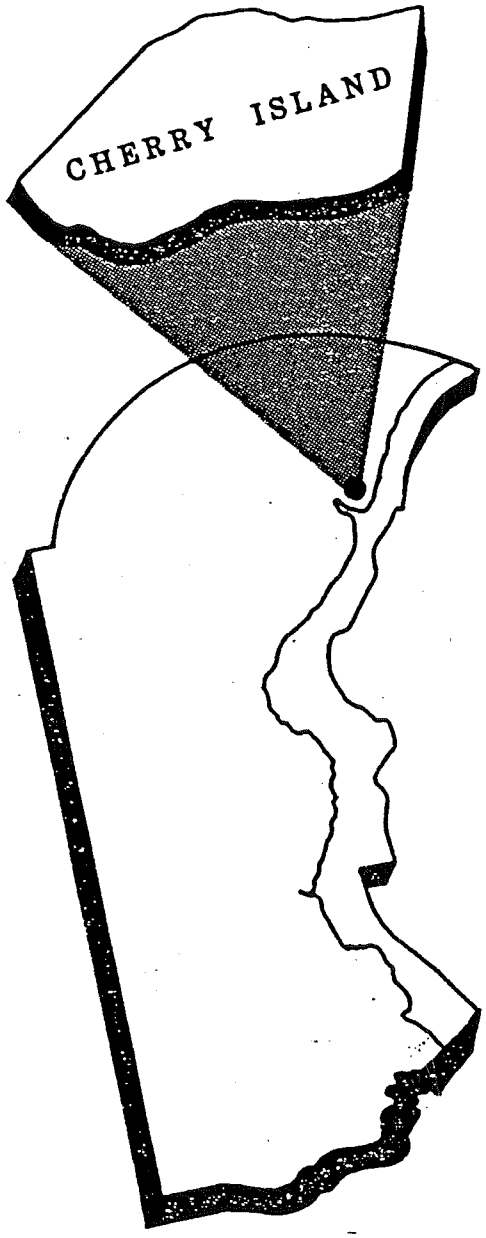
SITE SUITABILITY REPORT

HYDROGEOLOGIC and GEOTECHNICAL EVALUATION of the CHERRY ISLAND SITE



VOLUME 1

DELAWARE SOLID WASTE AUTHORITY

January 1984

SITE SUITABILITY REPORT

HYDROGEOLOGIC & GEOTECHNICAL

EVALUATION

OF THE

CHERRY ISLAND SITE

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SITE SUITABILITY REPORT
HYDROGEOLOGIC AND GEOTECHNICAL
EVALUATION OF THE
CHERRY ISLAND SITE

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1.0 BACKGROUND INFORMATION

1.1 Introduction

The following report, which evaluates the hydrogeologic and geotechnical suitability of the Cherry Island Site for a solid waste disposal facility, has been prepared on the behalf of the Delaware Solid Waste Authority (DSWA). The preparation of the report is the culmination of approximately three years of study. The study concerns the selection of a site in New Castle County which would provide the Authority with an effective, efficient, and environmentally sound means of solid waste disposal. This study was initiated in January 1981 when five pre-selected sites in New Castle County were factually evaluated. Based on this evaluation, which was reported to the Authority in February 1981, the Authority, with the aid of public comment, selected three sites for further evaluation. These sites were:

- Cherry Island
- Road 412
- Roberts Farm

The evaluation of the three sites was initiated in April 1981 and completed in January 1982 at which time a report entitled, "Site Suitability Study for the Northern Solid Waste Facility", was submitted to the Authority. This report contained engineering, economic, transportation, environmental, historical, cultural, and regulatory considerations.

Based on the January 1982 report, subsequent reviews and responses by various agencies and public comment, the Authority selected the Cherry Island site as its top priority location for a solid waste disposal facility in New Castle County. In regard to this decision, the Authority has held numerous meetings with the United States Army Corps of Engineers (COE). The COE currently utilizes the site for

dredge spoil disposal. The results of these meetings produced a scheme whereby coexistence of the site by both DSWA and the COE could be accomplished through the construction of earthen dikes, which would segregate the solid waste disposal operation from the dredge disposal activities.

In order to comply with regulatory requirements governing the Delaware Solid Waste Disposal Regulatory Program and to obtain information necessary for the preparation of a required hydrogeologic report and "Solid Waste Disposal Facility" permit application, the Authority authorized a detailed evaluation of the Cherry Island site.

The evaluation included the construction of approximately nineteen (19) test borings, six (6) auger borings, and eighteen (18) monitoring wells. Additionally, field vane shear testing and geophysical logging, including resistivity, gamma and self-potential, were conducted. Numerous soil samples were obtained for laboratory analyses as were representative groundwater samples. The results of these investigations are presented in the following chapters, along with supportive exhibits and preliminary engineering design drawings.

1.2 Location of Site

As shown on Figure 1-1, the Cherry Island site is located in the northern part of New Castle County on the north shore of the Christina River at its confluence with the Delaware River. The Wilmington Marine Terminal is situated on the southern shore of the Christina River. Access to the site is provided by the 12th Street exit of Route 495.

The site is comprised of a number of parcels of land which together total approximately 500 acres. Being used as a dredge disposal site for materials dredged from the river channels serving the Port of Wilmington, most of the area is covered with dredging spoils.

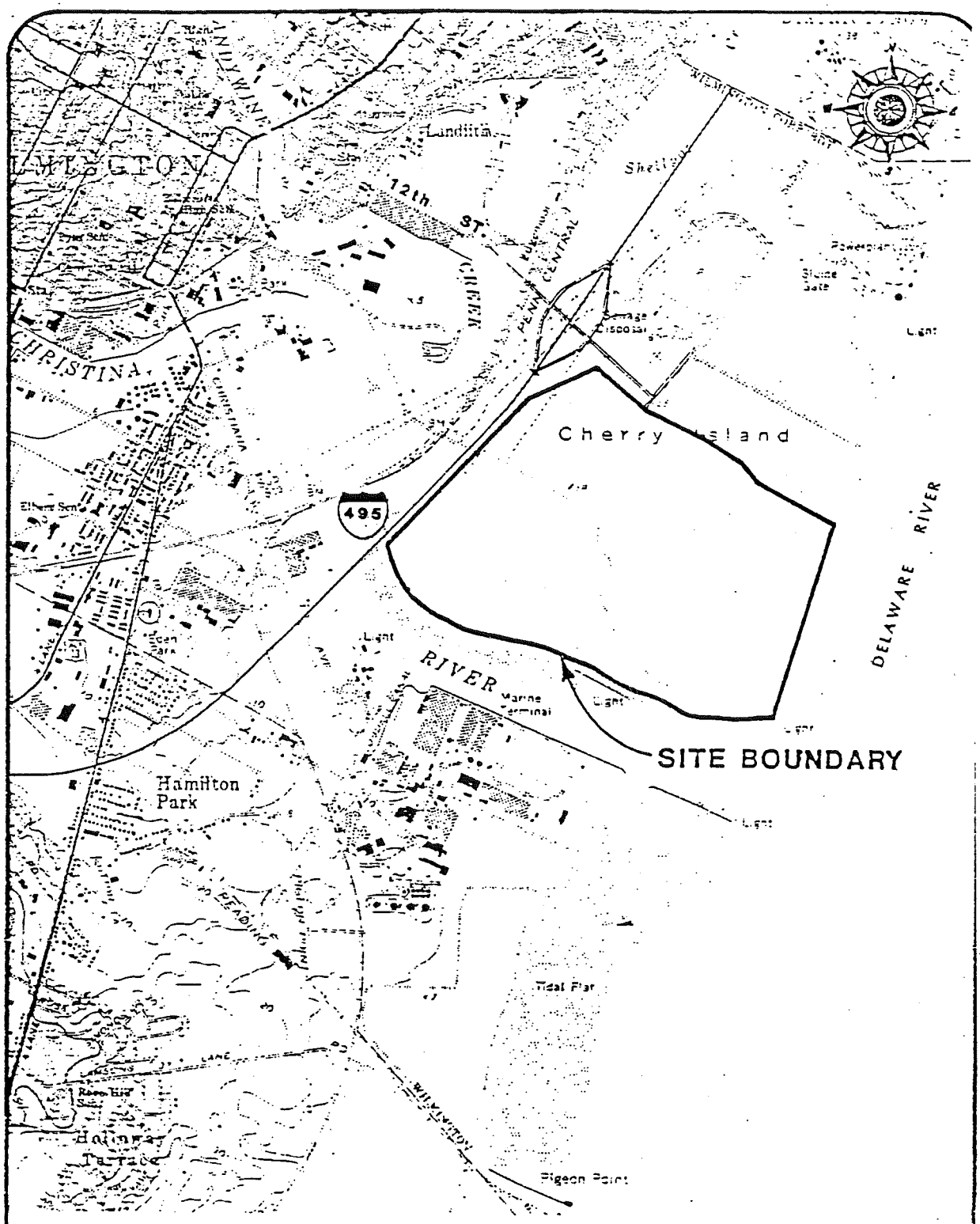


FIGURE 1-1
CHERRY ISLAND
LOCATION MAP

The site is encircled and bisected with earthen dikes which are composed of dredge spoil materials. The bisection of the site forms two distinct dredge disposal areas. These areas are referred to as the "Wilmington" area, the western portion of Cherry Island and the "Edgemoor area, the eastern portion of the island. The "Edgemoor" area is approximately 15 feet higher in elevation than the "Wilmington" area. Although the Authority plans to eventually utilize the entire island for solid waste disposal, the refuse disposal first phase will take place in an approximate 33 acre area located in the northern portion of the "Wilmington" area. In this area, an earthen embankment will be constructed along the southern boundary to segregate landfilling activities from dredge spoil disposal activities.

Along the western portion of the site, which parallels Route I-495, a power transmission line and two separate oil pipelines exist beyond the outer toe of the dredge disposal dike. Both water and sewer service are available near the site.

1.3 Physiography

As shown on the Physiographic Map presented as Figure 1-2 of this report, the Cherry Island site is situated in the Coastal Plain Physiographic Province. Topographically, this province is defined as a low lying and partially submerged area which is bordered to the east by the continental shelf and to the west by the Piedmont Province. The continental shelf, or eastern boundary of the Coastal Plain Province, lies nearly 100 miles offshore at a depth of approximately 100 fathoms (600 feet). The Piedmont Province consists of crystalline rocks and the contact between the Piedmont and Coastal Plain Province is referred to as the "Fall Line". At this contact, water flowing in streams has eroded away the softer overlying coastal plain sediments creating numerous small water falls. As indicated on Figure 1-2, the "Fall Line" lies approximately 4,500 feet northwest of the Cherry Island Site.

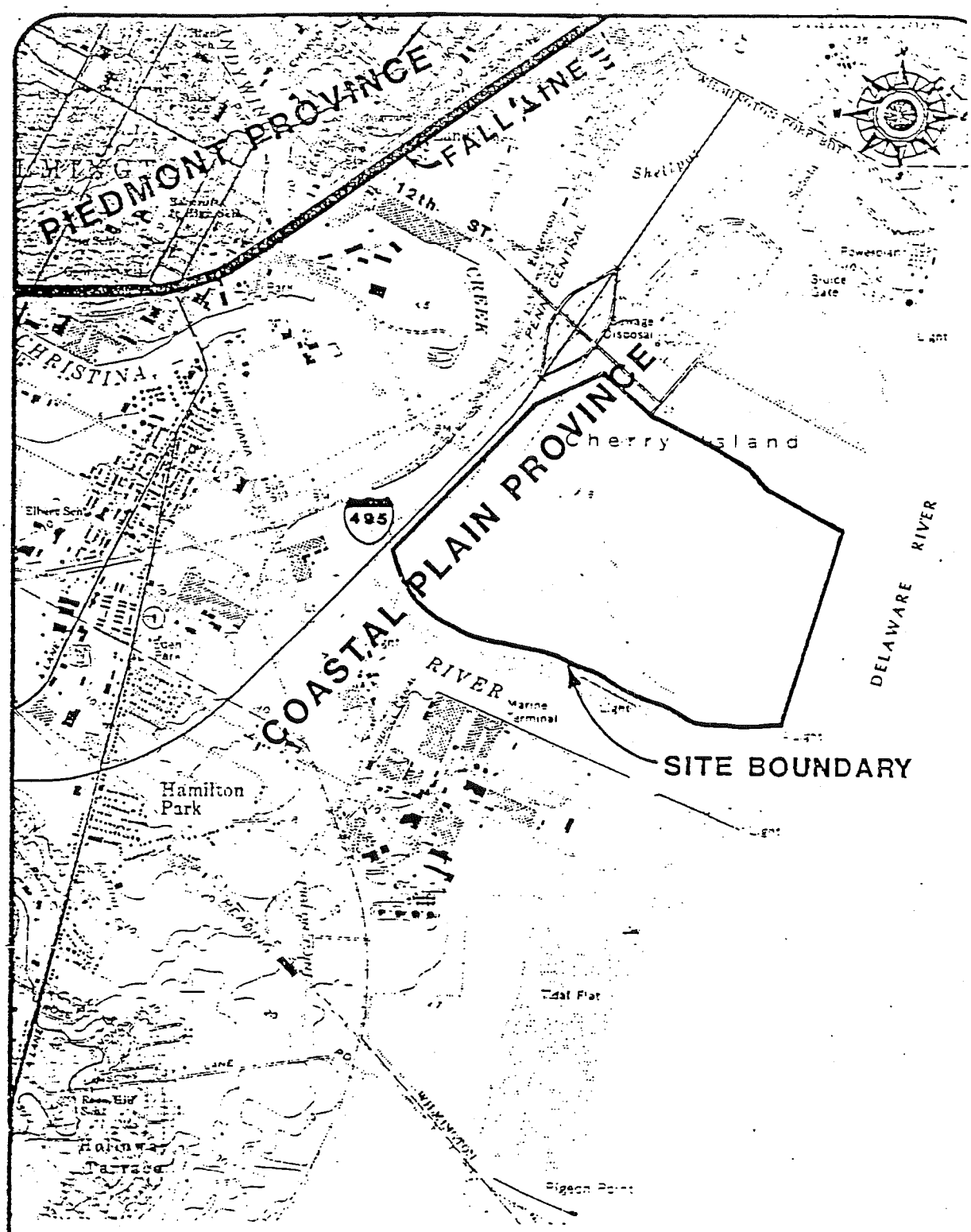


FIGURE 1-2
CHERRY ISLAND
PHYSIOGRAPHIC MAP

1.4 Area Geology

The Coastal Plain Province is comprised of a wedge-shaped mass of unconsolidated materials which consists of gravels, snads, silts, and clays. This wedge of materials, which overlies the crystalline basement, is thinnest at the Piedmont/Coastal Plain boundary and gradually thickens in a general southeastern direction towards the Continental Shelf. Sundstrom and Pickett, 1971, report that the thickness of the Coastal Plain sediments in New Castle County varies from 0 feet at the "Fall Line" in Wilmington to approximately 2,300 feet near the Smyrna River, which serves as the southern boundary of the County.

At the Cherry Island site, the Coastal Plain sediments vary in thickness from approximately 95 feet at the northernmost corner of the site to greater than 220 feet at the southeast corner of the site. These sediments range in age from Early Cretaceous (135 million years) to Recent and comprise several geologic formations.

As shown on Figure 1-3, northwest of Cherry Island in the Piedmont Province, metamorphic rocks consisting of hypersthene-quartz, andesine gneiss, and norite have been mapped. These metamorphic rocks are reported by Woodruff and Thompson, 1975, to be part of a metamorphic complex known to the preCambrian in age. Due primarily to their age, the metamorphic rocks are weathered for tens of feet.

Southeast of the "Fall Line" and at Cherry Island, the previously-defined metamorphic rocks are blanketed by the lower Cretaceous Potomac Formation. This formation is the oldest formation in the Coastal Plain. The formation consists predominantly of variegated red, gray, yellow, white silts, and clays containing interbedded white, gray, and rust-colored sands and some gravels. Although not shown on the map, the Potomac Formation is unconformably overlain by Quaternary age sediments consisting of the Columbia Formation and recent fluvial deposits.

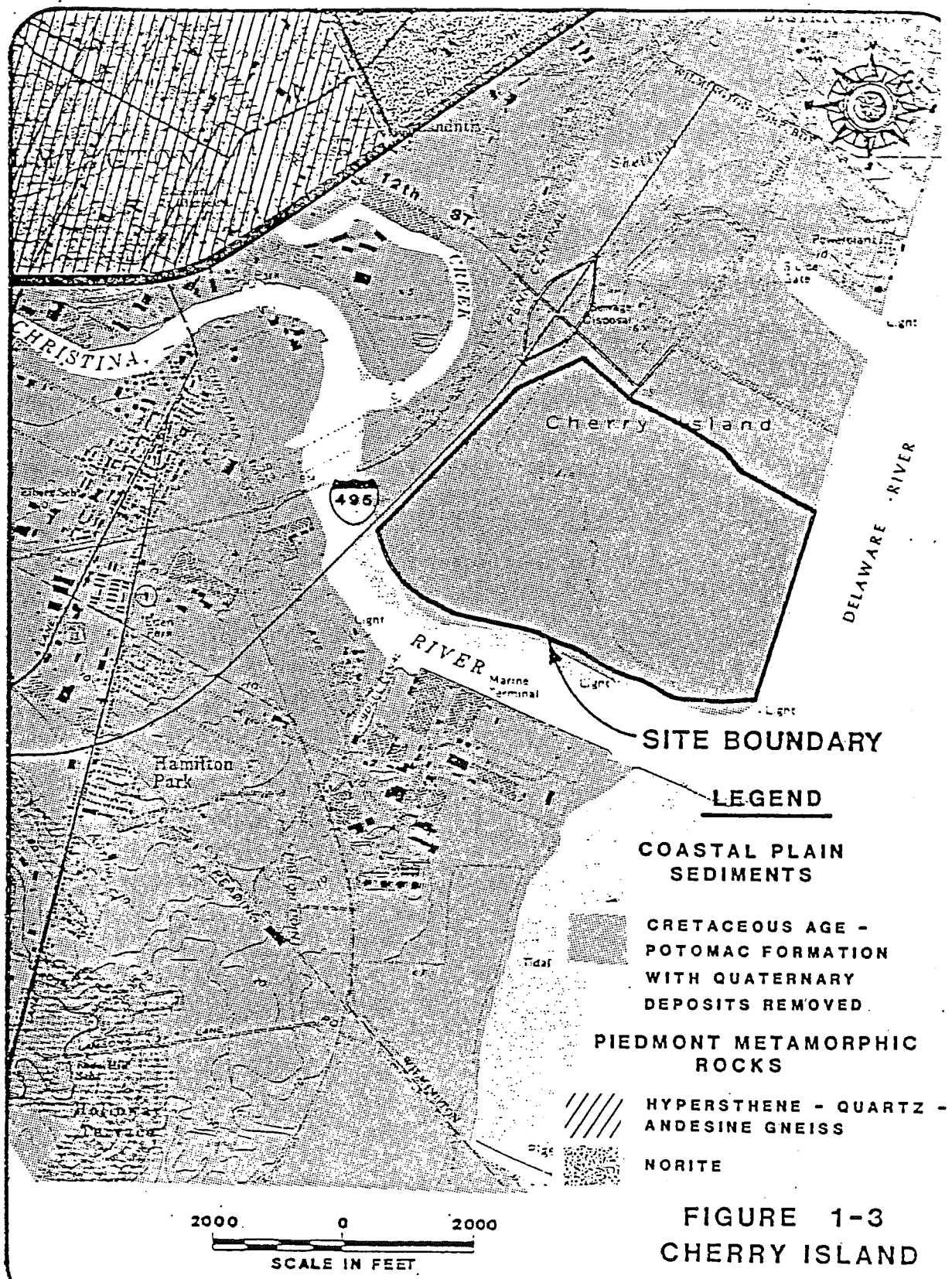


FIGURE 1-3
CHERRY ISLAND
GEOLOGIC MAP

The Columbia Formation is of Pleistocene age. This formation, for the most part, blankets the entire State of Delaware. In southern Delaware, the formation is thought to be of marine origin (Jordan, 1964). In New Castle County, the typical yellow-orange to tan-brown color sands and gravels, which comprise the Columbia Formation, are interpreted to be channel fill and associated river environment deposits.

Overlying the Columbia Formation, Holocene or recent age deposits appear. These deposits consist primarily of dark colored silts and clays with some sands and are found in the present day stream valleys and marshes. Consequently, much organic material is present. Dredge spoil materials have been placed on top of the recent deposits on Cherry Island. For the most part, the dredge spoil materials consist of sandy silty clays to clayey silts. On Cherry Island, these dredge spoil materials are very thick and form a flat featureless plain within the confines of the existing dikes. For purposes of this report, both the recent and dredge spoil materials are considered to be one unit.

2.0 HYDROGEOLOGY

2.1 General

This chapter on Hydrogeology has been prepared in partial fulfillment of the Delaware Department of Environmental Resources and Environmental Control's regulatory requirements pertaining to a proposed solid waste disposal site permit application. The information presented is based on extensive field investigations, subsequent monitoring, and analytical laboratory data.

2.2 Monitoring Well Installation Program

During the five week period extending from July 11, 1983, to August 10, 1983, a monitoring well installation program was conducted at the Cherry Island site. A. C. Schultes and Sons, Inc., of Woodbury, New Jersey, was contracted to perform the work. Eighteen monitoring wells were installed in various formations comprising the stratigraphic section of the site. The depths of the monitoring wells varied from 20 to 250 feet. Approximately 2,070 feet of drilling was accomplished during the installation period.

The locations of the eighteen monitoring wells are shown on Figure 2-1. In reference to this figure, the monitoring wells identified with the prefix letter "C" have been constructed in the Quaternary deposits, which include both the recent materials (C-103 and C-107) and the Pleistocene Age Columbia Formation. The monitoring wells identified with the prefix letter "P" have been constructed for the most part in the Cretaceous Age Potomac Formation. Table 2-1 defines the geologic deposit in which the individual monitoring wells were constructed.

TABLE 2-1

MONITORED DEPOSITS

Well No.	Quaternary Sediments		Cretaceous Sediments
	Recent	Columbia Formation	Potomac Formation
C-100	-	X	-
P-100	-	-	X
C-101	-	X	-
P-101	-	-	X
C-102	-	X	-
P-102	-	-	X
C-103	X	-	-
P-103	-	X	-
C-104	-	X	-
P-104	-	-	X
C-105	-	X	-
P-105	-	-	X
C-106	-	X	-
P-106	-	-	X
C-107	X	-	-
P-107	-	X	-
C-108	-	X	-
P-108	-	-	X

The monitoring wells were constructed for the purpose of identifying the types and thicknesses of the various sediments comprising the Cherry Island site. The wells were also constructed for the purpose of determining the depth of weathered crystalline basement sediments, the potentiometric surfaces of groundwater occurring in the Columbia Formation and Potomac Formation, and the quality of groundwater occurring in the dredge spoil deposits, Columbia Formation, and Potomac Formation.

In constructing each monitoring well, a Failing Model 1250 rotary drilling rig was utilized. Sediment types and thicknesses were determined through well bore sample collection at five foot intervals. Standard Penetration Resistance Testing (SPT) was also performed in the dredge spoil materials in monitoring wells C-100, C-102, C-105, C-106, and C-108. The purpose of the testing was to define the relative density or consistency of the dredge spoil materials comprising the diked sections of the site.

In order to determine groundwater elevations and flow directions, 4-inch diameter polyvinyl chloride (PVC) Schedule 40 casing with typically 10-foot long, 4-inch diameter PVC screen sections were installed in each well. Shorter screen sections were utilized depending on thicknesses of sandy units. The PVC screen had a number 10 slot opening size and was attached to the casing using a coupled connection bonded by a solvent which contained tetrahydrofuran. The screen section of each monitoring well was gravel packed with No. 1 Morie gravel to a minimum height of at least five feet above the screen setting. After grave packing, the annular space between the 8-3/4 inch diameter well bore and the PVC casing was sealed with bentonite (Baroid-Quick Gel) grout from the top of the gravel pack to within three feet of the surface. Grout was installed using one-inch drop pipe and tremie grout procedures. Following this, each monitoring well was developed using air lift and air surging techniques for periods varying from one to six hours. In developing each well, a portable air compressor and 1-1/2 inch diameter rubber drop hose were utilized. Finally, a 6-inch diameter steel protector casing with a locking cap was installed and the steel casing was set in cement grout at a depth of three feet. Each steel protector casing bears the well number on the side of the casing.

Due to the yearly large weed growth at the site during the spring and summer months, ten-foot high, 4-inch by 4-inch square timber posts were installed at each monitoring well location. The top of each post was painted with a fluorescent orange color to make the well locations more visible and preclude damage from construction equipment used on the island.

Water level measurements were made during the course of the well installation program and subsequent readings have been taken on a periodic basis through December, 1983. These readings will be further discussed in other sections of this report.

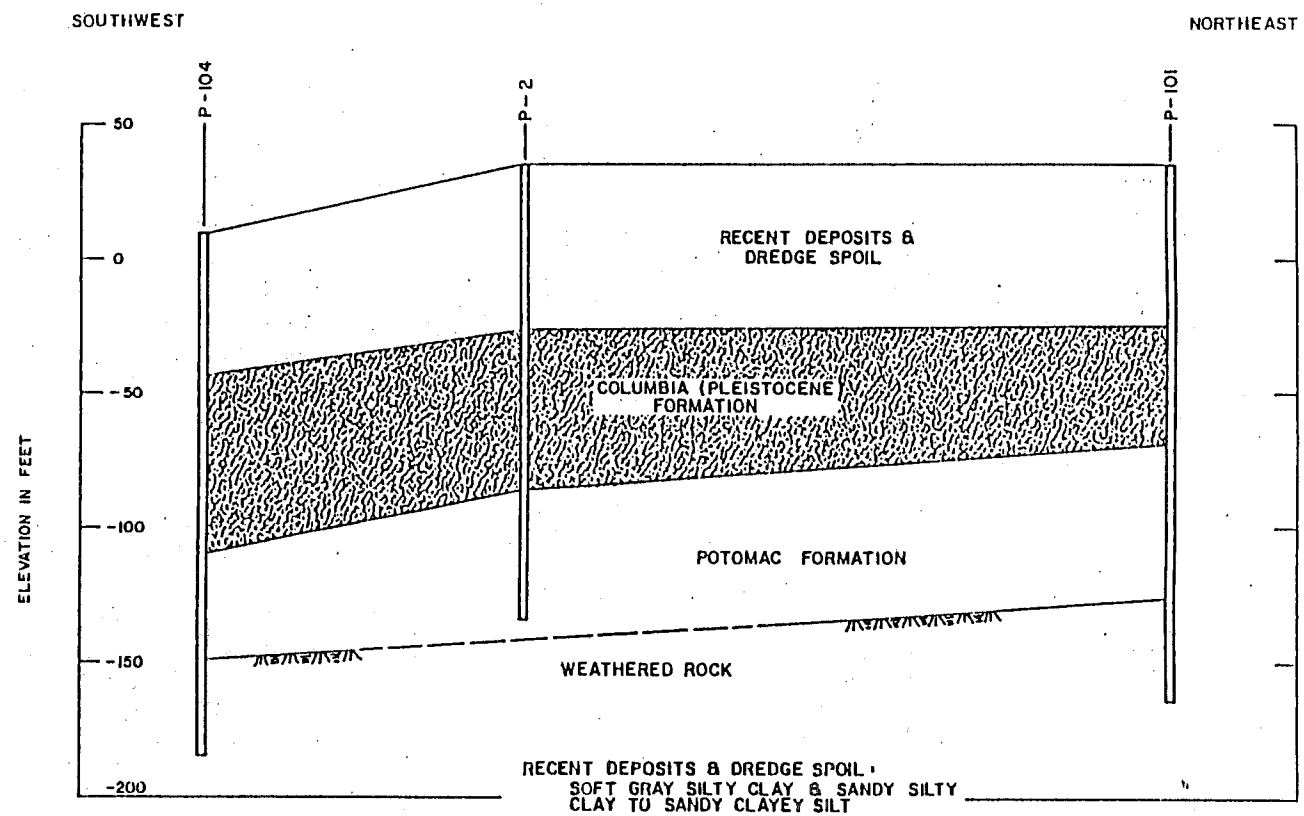
As previously stated, sediment samples were collected at five-foot intervals in the drilling of each well. These samples were utilized to prepare a geologic log of each monitoring well. The logs of the eighteen monitoring wells are included in Appendix A of this report.

In constructing the wells, the deeper "P" well, at each monitoring location, was first drilled and geophysically logged. The logging was performed by A. C. Schultes and Sons, Inc., and included electric self-potential, natural gamma ray and resistivity logging. Based on the geophysical logging of the deeper well, formation breaks and screen settings were determined for both the "C" and "P" well at each monitoring location. Due to the presence of silty/clayey zones within the Columbia Formation, the presence of sandy zones within the Potomac Formation and the similarity of weathered basement materials with overlying Potomac Formation materials, the distinction between formations was difficult. The geophysical logs of monitoring well P-100 through P-108 is included in Appendix B and a typical well profile is presented as Figure 2-2.

2.3 Description of Sediments

Based on the results of the monitoring well installation program, Figures 2-3 through 2-6, which are geologic cross-sections of the Cherry Island site, have been developed. In reference to these figures, the composition of the dredge spoil materials, recent deposits, and other Coastal Plain sediments comprising the site are variable.

The dredge spoil materials and underlying recent sediments consist predominantly of organic sandy silty clays and clayey silts. Within the recent deposits, several sandy zones were penetrated in the construction of the monitoring wells. For the most part, the dredge spoil materials and underlying recent sediments are soft and settlement-sensitive. In reference to Figures 2-3 and 2-4, these materials reach a thickness of approximately 50 feet and extend to



REFERENCE: FIGURE 2-1

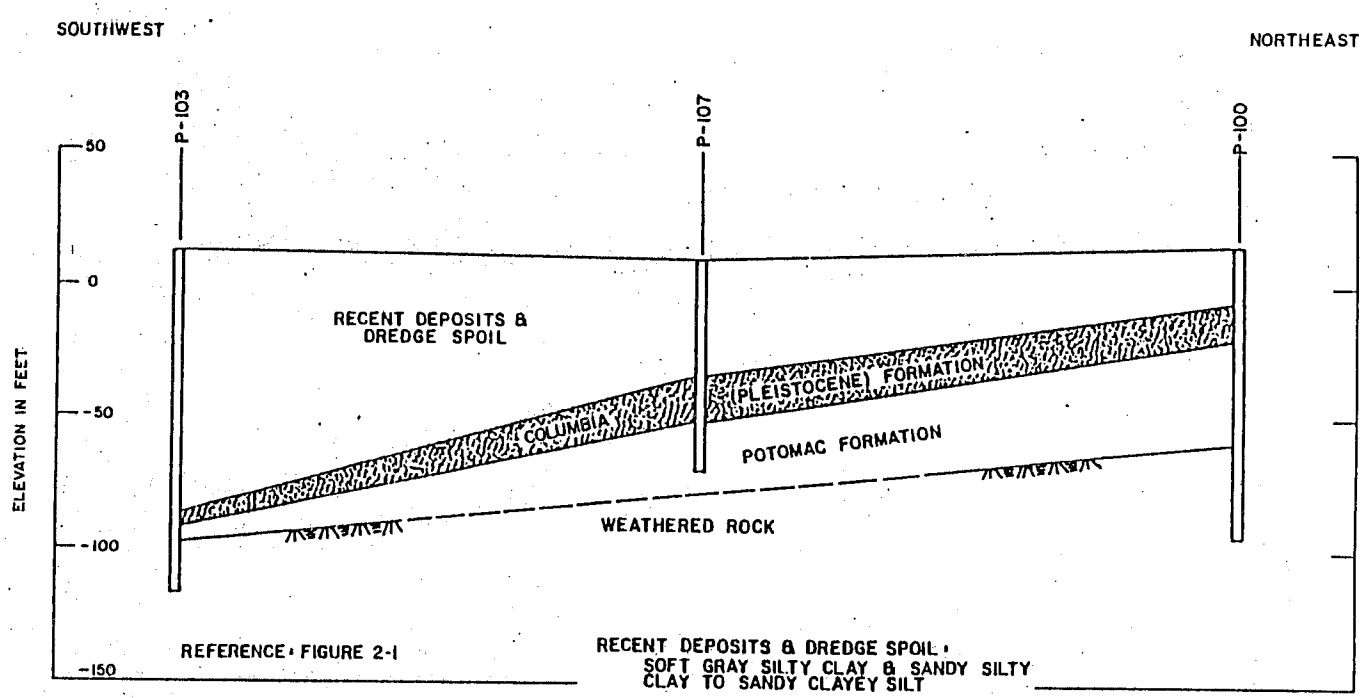
0 400 800
Scale in Feet

RECENT DEPOSITS & DREDGE SPOIL:
SOFT GRAY SILTY CLAY & SANDY SILTY CLAY TO SANDY CLAYEY SILT

COLUMBIA (PLEISTOCENE) FORMATION
MULTICOLOR FINE TO COARSE SAND AND GRAVEL WITH SILTY SAND, SILTY CLAY AND CLAYEY SILT LAYERS

POTOMAC FORMATION:
RED, GRAY, GREEN, CREAM CLAY, FINE SAND, SILT, SILTY SAND, SANDY SILT

FIGURE 2-5
GEOLOGIC CROSS-SECTION C-C
CHERRY ISLAND



RECENT DEPOSITS & DREDGE SPOIL:
SOFT GRAY SILTY CLAY & SANDY SILTY CLAY TO SANDY CLAYEY SILT

COLUMBIA (PLEISTOCENE) FORMATION
MULTICOLOR FINE TO COARSE SAND AND GRAVEL WITH SILTY SAND, SILTY CLAY AND CLAYEY SILT LAYERS

POTOMAC FORMATION:
RED, GRAY, GREEN, CREAM CLAY, FINE SAND, SILT, SILTY SAND, SANDY SILT

0 400 800
Scale in Feet

FIGURE 2-4
GEOLOGIC CROSS-SECTION B-B
CHERRY ISLAND

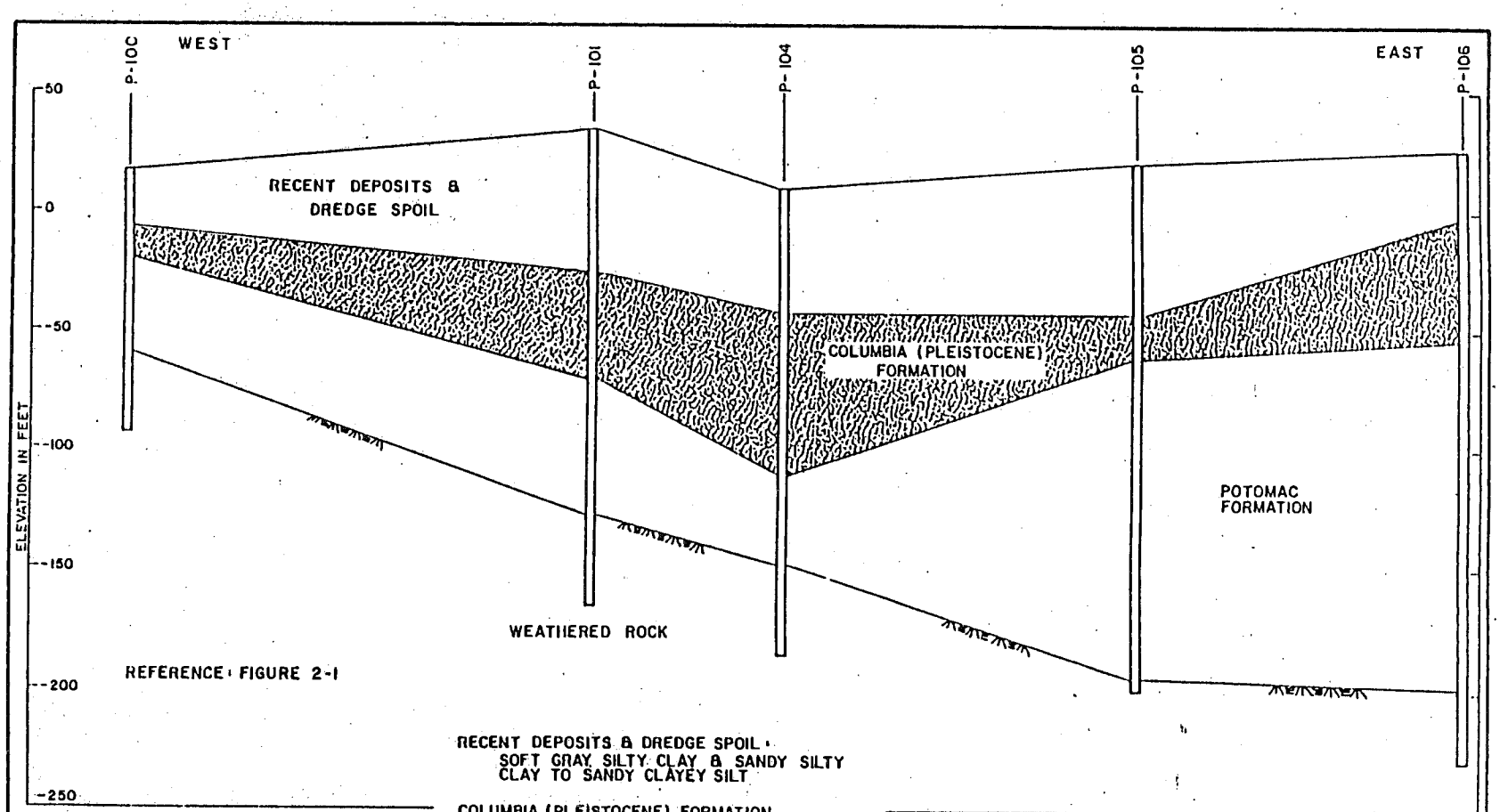


FIGURE 2-3
GEOLOGIC CROSS-SECTION A-A
CHERRY ISLAND

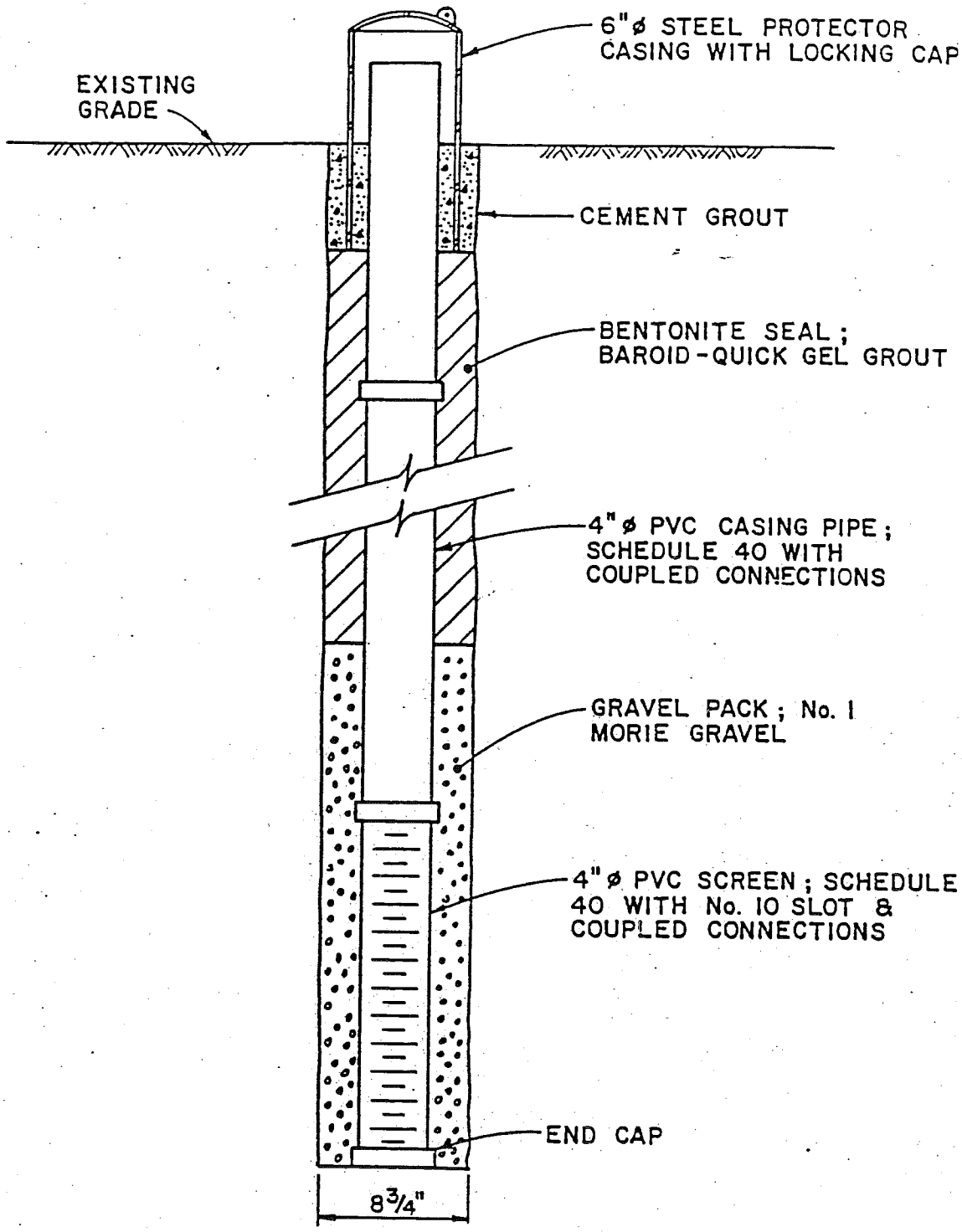
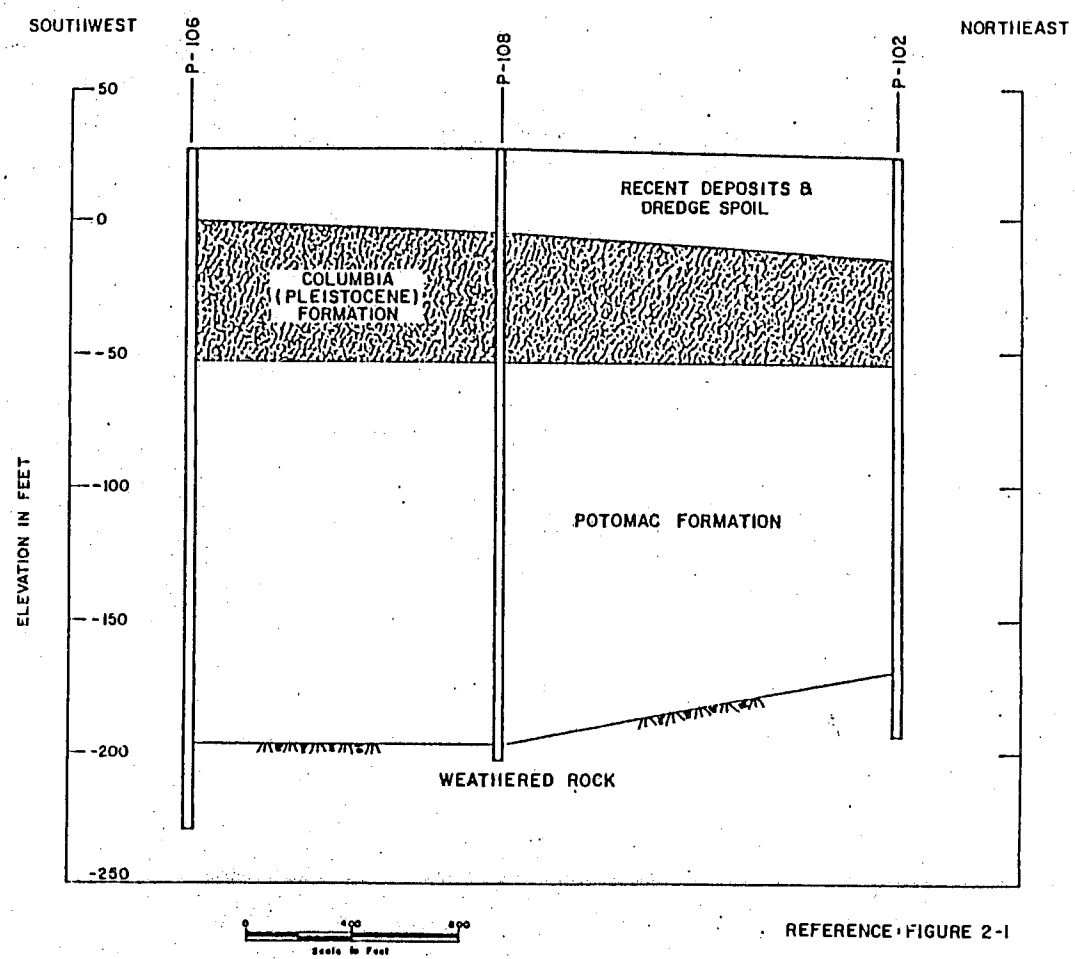


FIGURE 2-2
TYPICAL MONITORING WELL
CHERRY ISLAND



REFERENCE: FIGURE 2-1

RECENT DEPOSITS & DREDGE SPOIL:
SOFT GRAY SILTY CLAY & SANDY SILTY CLAY TO SANDY CLAYEY SILT

COLUMBIA (PLEISTOCENE) FORMATION
MULTICOLOR FINE TO COARSE SAND AND GRAVEL WITH SILTY SAND, SILTY CLAY AND CLAYEY SILT LAYERS

POTOMAC FORMATION:
RED, GRAY, GREEN, CREAM CLAY, FINE SAND, SILT, SILTY SAND, SANDY SILT

FIGURE 2-6
GEOLOGIC CROSS-SECTION D-D
CHERRY ISLAND

elevation -87 feet in the area of monitoring well P-103. In this area, which is adjacent to the Christina River, it is estimated that the river has eroded away some of the underlying Columbia Formation and that recent age black silty clay has been redeposited. Near monitoring well P-100, the recent deposits are only 20 feet thick. This boring is situated in the northern-most portion of the site, close to the "Fall Line" and outside the existing dikes. It is estimated that the 20-foot thickness at well P-100 represents the minimum thickness of dredge spoil and recent deposits present on Cherry Island. Additional information concerning the dredge spoil materials, which includes both engineering properties and permeability data, will be presented in other chapters of this report.

Immediately underlying the Holocene age materials, Pleistocene age sediments comprising the Columbia Formation were penetrated in each well. As indicated on the cross-sections, the Columbia Formation is only six to 18 feet thick along the western portion of the site, thickens to between 45 and 68 feet in the central portion of the site, and thins gradually to between 40 and 53 feet along the eastern portion of the site. Review of the logs contained in Appendix A indicates that the Columbia Formation consists primarily of multi-color fine to coarse sand and gravel with silty sand, silty clay, and clayey silt lenses. In general, the Columbia Formation reflects the structural configuration of the Coastal Plain because the sediments are thinnest nearer the "Fall Line" and gradually thickens down dip (southeast). Irregularities indicated on the cross-sections probably reflect erosion features of both the Christina and Delaware River.

Underlying the Columbia Formation, sediments of the Potomac Formation have been sampled in the construction of the deep monitoring wells. These sampled materials were found to be highly variable in color and texture. Penetrated materials consisted of multi-color silts and clays with thin silty sand to sandy silt layers. These layers were

typically on the order of five to ten feet thick and confined above and below by clayey materials. As shown on the geologic cross-section, Figure 2-3, the Potomac Formation varies from seven feet thick at monitoring well P-103 to 145 feet thick at the P-106 location. Reflecting the general structural configuration of the Coastal Plain, the Potomac thickness increases to the southeast. In this area of the Cherry Island site, a distinct clay horizon was noted on the geophysical logs of P-105, P-106, and P-108. Structural mapping techniques utilizing three point projections yielded a strike of N65°E and a southeastern dip of 20 feet per thousand.

Underlying the Potomac Formation, unconsolidated sediments derived from the weathering of the metamorphic rocks comprising the crystalline basement were penetrated to depths of 35 to 40 feet below the Potomac Formation. These sediments consisted of chiefly blue to green silty clays with chips of mica schist. As shown on Figure 2-3, the basement contact was relatively flat in the southeastern section of the site and gently rises toward the northwest. Structural analysis of the contact indicates a strike of approximately N50°F and a dip of approximately 20 feet per thousand to the southeast. The strike of the basement materials closely parallels the strike of the "Fall Line" northwest of the site in Wilmington.

2.4 Sediment Yield Potential

Although not used as a water supply on or within a half-mile radius of Cherry Island, both the previously-defined Columbia Formation and Potomac Formation are utilized as groundwater aquifers in New Castle County. These formations vary in their hydraulic properties and water-yielding capabilities.

On a county-wide basis, the Columbia Formation, which typically consists of medium to coarse sands and gravels, has a transmissivity value in the range of 16,000 to 100,000 gallons per day per foot and an average specific capacity of 14.8 gallons per minute per foot of

drawdown with a corresponding average yield of 362 gallons per minute (Sundstrom and Pickett, 1971). Being a water table aquifer, outside of the site, the storativity value of the Columbia Formation varies from 0.12 to 0.15. Previous studies on Cherry Island indicate the average hydraulic conductivity of the Columbia Formation at the site is 5×10^{-3} cm/sec or 110 gpd/sq.ft. (Michael Baker, Jr., 1981). Using an average thickness of approximately 40 feet (average of ten wells which penetrate the Columbia Formation on the site), the calculated transmissivity equates to 567 sq.ft./day or 4,239 gallons per day per foot. Comparison of this value with the reported transmissivity range for the County suggests that the yield potential of the Columbia Formation at the Cherry Island site is significantly less than could be expected in other areas of New Castle County. This reduction in yield potential is predicated on the fact that the Columbia Formation on Cherry Island is relatively thin, contains silty and clayey lenses, and is confined by a relatively thick sequence of impermeable dredge spoil and recent materials.

The yield of the eight monitoring wells which contained screen settings in the Columbia Formation varied from 1.5 to 50 gallons per minute with an average yield of 15 gallons per minute. Although this yield could be increased through the construction of larger diameter wells and increased screen lengths, it is doubtful the county average of 362 gallons per minute could be obtained. Also, the quality of water within the Columbia Formation precludes its use for potable consumption without treatment. This will be further discussed in this report.

The Potomac Formation, which typically consists of variegated silts and clays with many beds of sand that are usually laterally restrictive, is utilized for groundwater supplies in New Castle County. Groundwater is primarily obtained from two sandy zones which occur within the silt and clay materials. These sandy zones form an upper and lower hydraulic zone within the formation which provides millions of gallons per day of potable water. As reported by

Cherry Island has a third water surface. This surface has been created by a perched water table which occurs in the dredge spoil materials. This perched water table lies at or very close to the surface and is a result of dredging operations and the poor drainage of the spoil materials. Having a positive head above the potentiometric surface of the Columbia formation (Pleistocene sediments), leakage from the perched water table downward into the Columbia formation occurs, but at an extremely slow rate due to the 1×10^{-7} cm/sec and slower permeability of the dredge spoil materials.

2.8 Water Table Fluctuations

The Delaware Solid Waste Disposal Regulation requires that a separation of at least three feet be maintained between refuse deposits and the yearly high groundwater table. Further, the regulation defines groundwater as any water found under the surface of the earth. Since a perched water table exists on site and since this perched water table lies at or close to the surface, refuse will not be placed in excavated pits or trenches. In the first area of proposed refuse disposal or northern portion of the "Wilmington" area, dredge spoil has not been placed by the COE during the past two years and downward drainage of the perched water table is occurring. Based on the permeability of the dredge spoil materials, this drainage is slow. In order to accelerate the drainage and depress the perched water table surface, a drainage and aeration program will be initiated by the Authority in early 1984.

2.9 Water Quality

Upon completion and proper development of the various monitoring wells, a representative groundwater sample was obtained from each well for laboratory analyses. This sampling was conducted on October 6, 1983. Each sample was collected through the utilization of a small diameter submersible pump capable of pumping 5 to 10 gpm.

Prior to collecting each sample, each monitoring well was pumped until approximately three volumes of water was purged from the well casing. This purging was performed in order to insure that representative samples were obtained. All samples were placed in plastic or glass containers which contained preservatives and delivered to the laboratory the same day. The laboratory performing the analyses was Century Environmental Testing Labs, Inc., of Thorofare, New Jersey. Their certificate of analysis sheets are included in Appendix C.

In total, eighteen samples were obtained from the 4-inch diamter monitoring wells. In addition, two composite samples of groundwater contained in the dredge spoil materials were also obtained from 3/4-inch diameter piezometers installed in borings GP-6, GP-6A, GP-8, and GP-8A. Due to the limited volume of fluids in the piezometers, water obtained from boring GP-6 and GP-8 was combined to represent water at a depth of 40 feet. Similarly, water obtained from borings GP-6A and GP-8A were combined to represent groundwater at a depth of 20 feet. Samples were obtained from each piezometer through the use of a systaltic pump. One volume of water was purged from each piezometer several days prior to sampling.

The results of the chemical analysis of the twenty samples are summarized by formation name or age on Table 2-4 through 2-6. Table 2-7 summarizes the range of values and calculated mean concentration of each constituent by formation. Additionally, each table also shows the allowable Delaware drinking water standard for various constituents.

In reference to the tables, the quality of groundwater within all the formations occurring at the Cherry Island Site is poor. Further, the water occurring in the recent and dredge spoil deposits has the poorest quality followed by the Columbia Formation water and the Potomac Formation water.

The water occurring in the recent deposits and dredge spoil materials has a low pH and high alkalinity indicating the presence of acid neutralizing salts and a buffer condition. The water also had a high ammonia and Kjeldahl nitrogen content which can probably be attributed to the organic materials within the deposits. The mean concentrations of chlorides (370 ppm) and total dissolved solids (1,238 ppm) exceed the drinking water standard and indicate the water is brackish. This can be expected since the water originates from the brackish Christina and Delaware Rivers. The water is very hard which, in part, is caused by the large concentrations of sulfates and chlorides. These high concentrations of sulfates and chlorides are probably caused by evaporation of the water from the spoil when it is pumped on the site. The water occurring in the deposits has a very high mean iron (55 ppm) and manganese (60 ppm) content, both of which exceed the drinking water standard. This high concentration is probably caused by anaerobic conditions which reduce iron and manganese to highly soluble forms. This is evidenced by bright orange leachate seeps from stockpiled dredge spoil deposits. The dominant metal present in the water is sodium (233 ppm). Although the mean concentrations of the trace metals do not exceed the Delaware limits, a lead value of 0.08 was recorded in the monitoring well C-107 sample. The high total organic carbon concentration (210 ppm) suggests the presence of organic compounds within the water.

The water occurring in the Columbia Formation has a similar quality as the previously-defined dredge spoil water. This similarity is caused by seepage of the overlying dredge spoil water into the formation. The Columbia Formation has a high alkalinity and low pH indicating the presence of acid neutralizing salts. The water is considered brackish, as indicated by the high total dissolved solids (1,263 ppm), chlorides (449 ppm), and specific conductance (1,609 umhos). Both the total dissolved solids and chloride values exceed the drinking water standard. Note that the highest conductance and total dissolved solid values were in Columbia Formation monitoring

wells located adjacent to the Delaware River. This indicates leakage into the formation. Similar to the dredge spoil water, the mean iron (62.7 ppm) and manganese (85.3 ppm) values are very high. These high values are thought to be caused by the reducing conditions in the overlying recent deposits and dredge spoil materials. A high mean hardness value (579 ppm) coincides with a relatively high sulfate value (109 ppm). The high ammonia nitrogen value and total organic carbon value indicate the presence of organic compounds which are probably derived from the overlying dredge spoil deposits. Comparison of the mean trace metal concentrations with the Delaware drinking water limits indicates that the arsenic level exceeds the standard.

The water quality analyses of the Potomac Formation show that the overall quality is superior to either the dredge spoil or Columbia Formation water. The individual well total dissolved solid concentrations and chloride concentrations indicate that some leakage of brackish water into the formation is occurring even though the water can be considered fresh. The trace metal concentrations of the Potomac Formation water all meet the drinking water standards and the nitrogen values are low, indicating that organic materials are not present. Even though the mean iron (8.5 ppm) and manganese (18.7 ppm) values are considerably lower than the other formations, both values exceed the drinking water standard. The cause of the high values may be related to upgradient igneous and metamorphic materials.

Summarily, the water quality analyses indicate that water contained in the recent/dredge spoil deposits, Columbia Formation, and Potomac Formation is either brackish or contains undesireable concentrations of chlorides and total dissolved solids. This, coupled with high iron and manganese concentrations, make all waters unsuitable for human consumption without treatment.

2.10 Local Water Use

As indicated, there are no residential, industrial, or municipal wells within a quarter mile radius of the site. The closest such well is thought to be situated approximately 2,500 feet west-southwest of the Cherry Island site boundary.

The locations of the local wells are shown on Figure 2-9. Six distinct well fields having from one to three wells have been located. These wells which belong to Brandywine Chemical Company, Forbes Steel Corporation, and Artesian Water Company, vary in distance from 2,600 feet to 23,000 feet from the southern border of Cherry Island. A summarization of the six well fields is presented in Table 2-8.

Table 2-8
Cherry Island Site
Local Well Locations

Well Field No.	Well Field Name	No. of Wells	Distance From Cherry Island	Reported Yield
1	Brandywine Chemical	3	2,600 ft.	15-30 gpm
2	Forbes Steel Corp.	1	3,100 ft.	90 gpm
3	Collins Park*	1	13,700 ft.	300 gpm
4	Castle Hills*	3	17,200 ft.	750 gpm
5	Jefferson Farms*	2	19,400 ft.	600 gpm
6	Wilmington Manor Gardens*	3	23,200 ft.	500 gpm

* Owned by Artesian Water Company

2.11 Potential Groundwater Impacts

In the construction of any solid waste disposal facility, potential hydrogeologic impacts exist. These impacts include the potential

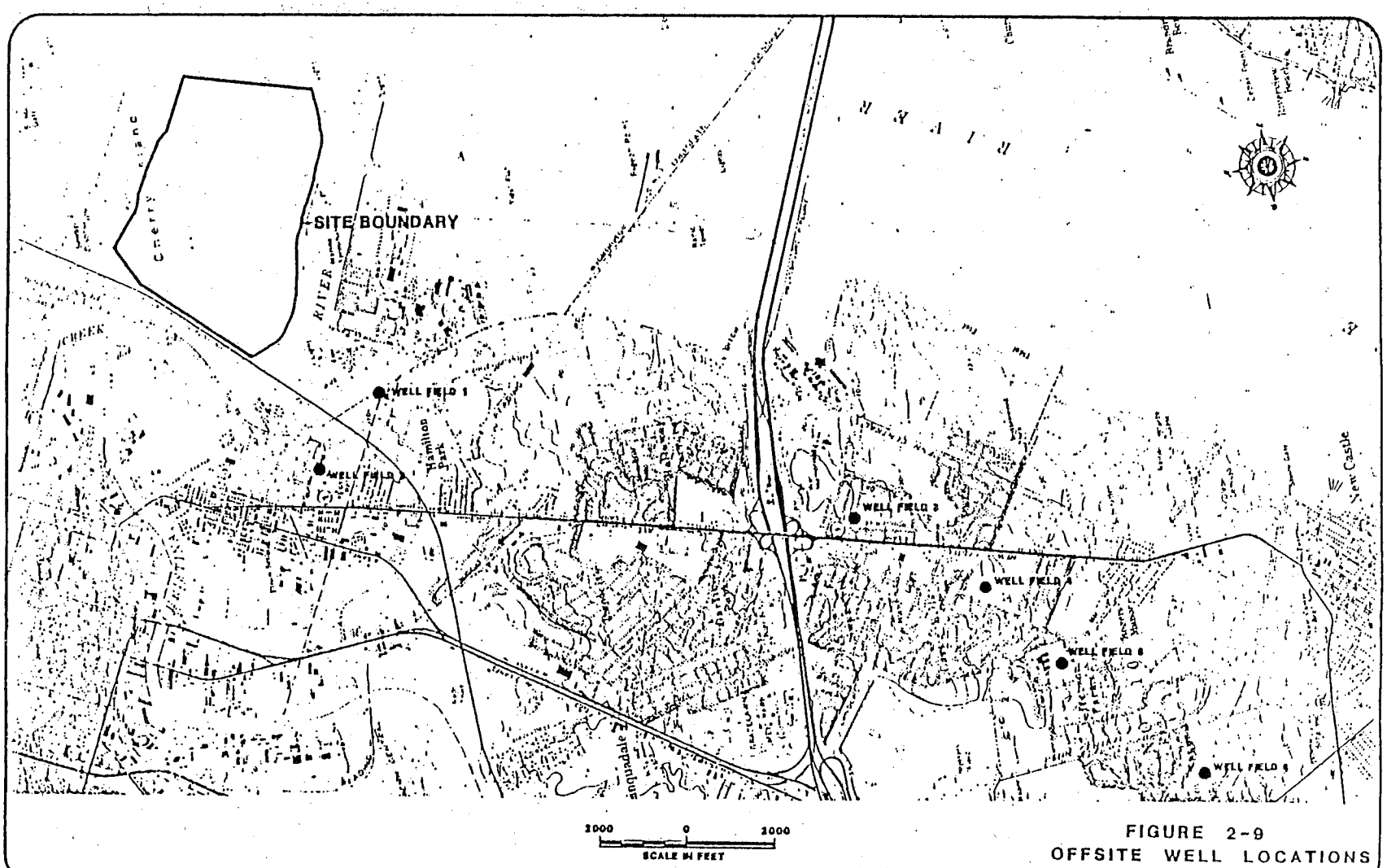


FIGURE 2-9
OFFSITE WELL LOCATIONS
CHERRY ISLAND

degradation of underlying groundwater in one or several aquifers and the potential contamination of surface water supplies. Based on the physical data, interpretative data, and laboratory analyses of selected soil and water samples, these impacts are discussed below.

As identified in Chapter 3 of this report, large settlements induced by the applied load of the separation dikes and the landfill will be experienced. These settlements preclude the utilization of a conventional lined disposal area and leachate collection system. The in situ dredge spoil materials, however, meet current regulatory requirements concerning permeability. In reference to the permeability data presented in Appendix D-6, the mean permeability value for the dredge spoil materials has been calculated to be 8×10^{-8} cm/sec.

This low value meets the existing 1×10^{-7} cm/sec criteria for natural soil liners. Accordingly, as proposed the Cherry Island site would make use of the existing dredge spoil materials as a natural soil liner. Leachate collection will be accomplished by gravel drains. Leachate will flow by gravity along the refuse/dredge spoil interface to these gravel drains which will then carry the leachate to sumps where it will be pumped to the existing nearby sewage treatment plant. The gravel drains will be placed to take advantage of differential settlements in each cell.

In the process of flowing toward the sump, some leachate may drain downward (seep) to the perched water table. This water table presently lies at or near the surface of Cherry Island and changes as dredging operations occur. In the northern portion of the "Wilmington Area" or first 33 acre area of refuse disposal, the perched water table lies at an elevation of approximately 20 feet. The potentiometric surface of the Columbia Formation lies at an elevation of 2.0 feet in this area. Due to the positive head difference between the perched water table and the Columbia formation, downward movement of leachate into the Columbia Formation

is possible. Using standard groundwater flow equations the amount of seepage that could occur has been calculated. This calculation is based on an area of 33 acres and a hydraulic conductivity of 8×10^{-8} cm/sec or 2.2×10^{-4} feet/day. The results of the calculation indicate that approximately 1,064 gpd (32 gpd/acre) of seepage can occur in the first area of refuse disposal. As seepage takes place, natural renovation will occur through cation-exchange. Further, as the seepage enters the Columbia Formation, it will be diluted with groundwater flowing within the aquifer. Using a hydraulic conductivity of 5×10^{-3} cm/sec and an average thickness of 25 feet, the flow occurring in the Columbia Formation in the northern 33 acre area has been calculated to be 3,420 gallons per day. This flow results in a 3.2:1 dilution ratio.

The amount of seepage that could enter the Potomac Formation has also been calculated using 33 acres as the potential vertical inflow area. The results of this calculation indicate that 657 gallons per day or slightly less than 20 gallons/day/acre could occur. A dilution ratio has not been calculated since the results of the exploration program do not support the existing of continuous sandy zones across the site.

From the standpoint of transit time or the amount of time that it takes for a drop of leachate to seep downward through the dredge spoil into the Columbia Formation, a calculation has been performed. In calculating the transit time an effective porosity of 0.3 and a dredge spoil thickness of 40 feet has been utilized. The results of the analysis indicate that it will take approximately 333 years for the leachate to reach the Columbia Formation. Note that this is probably true in the first area of refuse disposal but tidal fluctuation studies show that there is some hydraulic connection, along the eastern and western boundaries of the site, between the river and the Columbia Formation.

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2.12 Hydrogeologic Summary

The Cherry Island site is situated in the Coastal Plain Physiographic Province of Delaware and is underlain by a thick sequence of unconsolidated materials which includes dredge spoil, recent estuarine deposits, the Columbia Formation, the Potomac Formation, and weathered crystalline rock. The Columbia Formation and the Potomac Formation are utilized for groundwater supplies in New Castle County but are unimportant for such use in the Cherry Island area.

Monitoring wells and/or piezometers have been installed in the dredge spoil materials, Columbia Formation, and Potomac Formation and representative groundwater samples have been obtained for each stratigraphic unit. Based on these explorations, testing results and the resulting calculations for following hydrogeologic conclusions are presented:

1. A perched water table exists on site at or very near the existing land surface. The general level of this water table is expected to decline as each proposed refuse disposal area is isolated by earthen dikes from the on-going dredge disposal operation. Due to the very slow permeability of the dredge spoil, the decline of the perched water table will be slow but will be accelerated by ditching or other drainage techniques. The presence of the perched water table precludes placement of refuse in excavated pits or trenches. Leachate generated from the landfill may seep into the perched water table as it is flowing towards collection points. This seepage will continue to move downward toward the Columbia Formation and will move laterally toward both the Delaware and Christina rivers.

2. The Columbia Formation of Pleistocene age underlies the site and is confined or semi-confined by the overlying dredge spoil and recent deposits. Seepage into the Columbia Formation has been calculated to be 32 gpd/acre in the first 33 acre refuse

disposal area. This seepage is diluted by groundwater flowing within the Columbia Formation at a ratio of 3.2 to 1. Flow within the Columbia Formation is multi-directional but generally towards the Delaware and Christina rivers. Monitoring of wells along both the Delaware and Christina rivers showed water level changes varying from 0.33 to 1.25 feet in response to tidal fluctuations. Water quality testing indicates that groundwater within the Columbia Formation is of very poor quality and is unfit for human consumption without considerable treatment. There are no Columbia Formation wells within the general area of Cherry Island.

3. The Potomac Formation is the deepest and oldest unconsolidated deposit underlying the site. The formation serves as a principal source of groundwater in New Castle County. Monitoring wells constructed in the Potomac Formation on Cherry Island had groundwater yields varying from 1.5 to 25 gallons per minute but due to the thin nature of the sandy zones within the essentially silty clay formation, the maximum potential yield is probably less than 50 gallons per minute. Flow within the formation is towards the southeast and away from any existing wells situated southwest of the site. In general the flow gradient is extremely flat but steepens to some degree in the southeast corner of Cherry Island. This steepening may be structurally related or caused by distant pumping but is probably related to 0.8 to 1.0 foot tidal fluctuation responses which have been measured. Potentiometric surface data indicates that vertical seepage of leachate is possible in the first 33 acre area of refuse disposal. This seepage is estimated to be 20 gpd/acre. Water quality data indicates that groundwater within the formation contains excessive concentrations of iron and manganese and shows signs of salt water intrusion as indicated by high total dissolved solids and chlorides. The water does not meet existing drinking water standards.

4. The monitoring well exploration and installation program has revealed a fairly complex hydrogeologic regime for the Cherry Island site. This complexity is primarily created by past and on-going dredge disposal activities relating to the dredging of the river and the disposal of the dredged materials on Cherry Island. Although complex, the hydrogeologic regime is such that a solid waste disposal facility can e safely sited on Cherry Island without significant environmental degradation.

3.0 GEOTECHNICAL

3.1 Summary

3.1.1 Introduction

The purpose of this section is to present the evaluation of the field program performed to develop preliminary design criteria for the proposed landfill. This field program consisted of the performance of Standard Penetration Test borings at various locations around the site in order to obtain soil samples for laboratory testing and to establish design criteria for the construction of dikes, haul roads, and the landfill. The ultimate site consists generally of the northern half of Cherry Island (Figure 1-1), which is part of the Wilmington dredge spoil area on the west and the Edgemoor dredge spoil area on the east. The site is to be acquired from the Corps of Engineers (COE) in phases through a series of cooperating agreements to maximize dual usage by the COE for continued dredge spoil disposal and by the Delaware Solid Waste Authority (DSWA) for landfilling. The initial field program concentrated on the Edgemoor area; however, due to changes in the dredging schedule for Edgemoor and the necessity for timely development of a landfill site by DSWA, the northern portion of the Wilmington area was designated as the initial landfilling site. An additional program of test borings and laboratory testing was performed to accommodate this change in emphasis. Tests were also performed to assess workability for construction and for in situ permeability. Shallow ground water conditions were recorded at the time of drilling and periodically following the installation of PVC observation monitor wells. During the field program additional testing was performed to establish strength and compressibility characteristics of the soils. These tests also included the monitoring wells to establish hydraulic properties. The location of all field data points utilized during this evaluation are shown on Figure 2-1.

A summary of conclusions and recommendations follow in the remaining paragraphs of Section 3.1. Appendices D-1 through D-7 present a more detailed explanation of the data obtained, the analysis and recommended design parameters. All data obtained for this evaluation has been included in Appendices D-1 through D-9.

3.1.2 Subsurface Conditions

The geologic formations at the site have been discussed in Section 2 entitled, "hydrogeologic Considerations". The soils discussed in this Section relate to the geotechnical considerations that will affect landfill design. Basically three soil strata have been identified and for structural purposes have been classified as "Compressible Soils". The Structural Contour Map of Figure 3-1 indicates the estimated elevation contours of the first significant sand stratum encountered. Estimates based on this map indicate the "compressible" soils vary in thickness between 25 and 85 feet. A brief description of each of the three strata encountered as part of the compressible soils follows:

The surficial stratum (estimated to be 20-25 feet in thickness) consists of dredge spoil materials deposited by the COE during the maintenance dredging program of the Christina and Delaware rivers over the past 40 years. This stratum consists of dark gray and black organic high plasticity silt with traces of fine sand and organic fragments.

The intermediate stratum is primarily a dark gray high plasticity micaceous silt. The thickness of this layer ranges from 15 to 30 feet as encountered and is probably characteristic of "quiet water" depositional conditions. In the northern portion of the Wilmington area and in the northwestern side of the Edgemoor area, there exists a layer of organic marsh deposits approximately five feet in thickness at the base of the stratum. This layer consists of a

dark brown fiberous mat-like material and was encountered in varying combinations with silt materials in various locations throughout the site.

The basal layer of the compressible soils consists of a dark gray medium to high plasticity silt and clay interlayered with light gray fine grained laminae. These laminae depict short term, high energy depositional events and appear to increase in frequency with depth. This layer was encountered primarily on the eastern side of the Edgemoor site.

The results of field vane shear and unconfined compression tests indicate that the upper two strata have very low shear strengths (less than 500 psf) and the basal layer is of relatively higher shear strength. Figure 3-2 indicates the estimated base elevation of the relatively low shear strength soils. This zone is highly compressible and directly affects the stability of existing and proposed dikes and the landfilling sequence. Figures 3-3 and 3-4 illustrate stratigraphic profiles E-E and F-F indicated on Figure 3-1. The estimated location of the interface between the very low shear strength and relatively higher shear strength compressible soils is noted.

The results of laboratory and field testing are presented in Appendix D-1. A brief discussion and summary of the design parameters utilized for analysis is contained in Appendix D-3.

3.1.3 Administrative Area

The proposed structures for the administrative area include the scales, scale house building, and administrative offices. In addition, a maintenance building is being proposed, however, the location has yet to be established. Generally the administrative area will be in the north corner of the site, in the area that has been utilized for sludge drying by the City of Wilmington. Based

on test borings performed in this area, we anticipate the use of pile foundations to support structures and significant regrading to establish a grade which will accommodate the truck traffic and parking areas necessary for such a facility. We estimate that 80 ton piles, approximately 60 to 70 feet in length, could be utilized for these structures. An allowable design capacity of approximately 60 tons is recommended due to the soft soils. The existing storage lagoons in this area will require renovation to remove all unsuitable material. Compacted backfill materials will be required to achieve the design grade. It is anticipated that the existing grade of approximately elevation 15 will be utilized for the design grade in this area.

3.1.4 Paving

Paving to meet the anticipated truck traffic and necessary parking areas must accommodate the soft compressible soils which are also highly frost susceptible. The paving design will generally require imported granular materials and reinforced geotextile fabric to improve shear strength and minimize the loss of granular materials into the soft subgrade. The preliminary design of the paving section is as follows:

6 in. Hot Mix
12 in. Crushed Stone
Geotextile Fabric
12 in. Select Material
Geotextile Fabric
Compacted Subgrade

3.1.5 Dike Stability

The stability of existing and proposed dikes will be controlled by the soft compressible soils found throughout the site to varying depths. The low shear strength, high plasticity, and low rate of

pore pressure dissipation indicate that the loading rate (i.e. the rate of dike construction and landfilling) must accommodate these soil conditions. We anticipate that new dike construction will require fabric reinforcement at the interface with the existing subgrade. Stability analyses were performed for varying designs and soil parameters, which are summarized in Appendix D-4.

This analysis indicates the sensitivity of the strength parameters of the subsurface soils. For instance, an increase in cohesion from 150 PSF to 200 PSF represents the difference between failure and a stable dike. Side slopes of the dikes and landfilling rate must accommodate the thickness and shear strength of the subsurface soils. Soil conditions in the initial (Wilmington) site are of somewhat higher strength and lesser thickness than on the easterly side of the Edgemoor site. Our analysis indicates that dikes constructed for the Wilmington site could use side slopes of three horizontal to one vertical. However, dikes for the Edgemoor side will require a five horizontal to one vertical slope in order to minimize the potential for stability failure. The loading rate of landfilling for the initial site should be limited to ten feet in any one year. Based on the area of the site (approximately 30 acres) and the prescribed disposal tonnages, the site life for a height of 40 feet is estimated to be slightly in excess of five years. For the Edgemoor side of the site, landfilling should be limited to a 20 foot lift over the site. This lift should be allowed to consolidate the subsurface soils for a period of five years prior to the application of a second 20 foot lift over the site. This will be necessary to allow the soils to consolidate under the design load and thereby gain in strength.

The time for the strength gain has been estimated based on the laboratory testing. Actual field monitoring will be required to evaluate in situ conditions during load application. This monitoring may permit a more rapid loading schedule and a steeper slope for dike construction thereby saving soil costs.

In addition, a buffer of 100 feet between the toe of the landfill construction and the existing dikes on the north and east side will be required to minimize the potential for a shear failure to affect the existing dikes. Similarly a buffer of 50 feet between the toe of landfill and edge of right of way on the west of the Wilmington site should be maintained. This buffer zone may be utilized for surface drainage structures if necessary. It may also be used for future landfilling if strength gains are realized and indicated in the monitoring.

3.1.6 Settlement

The loads imposed by the new dike construction and the landfill will create large settlements. The amount of settlement will be directly related to the applied load and the thickness of compressible soils. Since the ultimate load applied across the site will be generally uniform, settlement will tend to "mirror" the thickness of compressible soils. Therefore the Structural Contour Map (Figure 3-1) may be used as a guide to estimate the settlement profiles across the site. We estimate primary settlements in excess of six feet on the east side of the Edgemoor site and approximately four feet on the Wilmington site. The compressible and organic nature indicate that secondary settlements will result in an additional eleven to eighteen percent of primary settlement in a 20-year period. Thus settlements of the existing ground surface in excess of seven feet should be anticipated for the landfill areas. For the dredge spoil area, where the density of fill is estimated to be 1.8 times that of refuse, these settlements may be in excess of ten feet.

Settlements in soils of this type become extremely difficult to estimate since the magnitudes generally extend beyond accepted theoretical limits, therefore settlements may exceed the estimated values.

The time rate of settlement is also directly related to soil type, thickness, and rate of loading. The high plasticity soils which offer excellent permeability for the impedance of leachate flow also react very slowly to load (i.e. time rate of settlement). This slow rate affects the rate of strength gain which accompanies settlement. Therefore while the low permeability soils are ideal for the base of the landfill, the slow time rate of settlement and strength gain must be accommodated in the design loading condition. Settlement analysis is discussed in Appendix D-5.

The estimated in situ permeability is in the range of 10^{-7} centimeters per second and a consolidated permeability after landfilling is estimated to be in the range of 10^{-8} centimeters per second. This results in a time rate of consolidation (90%) for the Wilmington site in excess of 25 years and for the east side in excess of 200 years for the deeper soils. It is estimated that the shear strength gain will approximately double in a five to ten year period following load application. Permeability data is discussed in Appendix D-6.

3.1.7 Construction Phasing

To accommodate the soft subsurface soils the landfilling activities must be phased to fill larger areas to lower heights rather than smallr areas to higher heights. After completion of the initial site, areas selected for landfilling should be based on criteria that meet the strength properties of the subsurface soils. Filling the surface to a maximum height of 20 feet and allowing approximately five years before placement of an additional lift will be required. In addition, a setback of 100 feet from the toe of the existing dike and an additional setback of 100 feet for the second lift will also be required. Due to the dual use of the site by the COE for dredging and the DSWA for landfilling, a program for phased utilization and cooperation must be developed. The placement of soil by the dredging method results in a soil surface

which cannot be traversed until substantial drying has occurred. Thus these conflicting requirements to maximize dredge disposal by the COE and the promotion of soil drying by DSWA will require close cooperation. After dredging and prior to landfilling, intermediate areas will be required to permit a ditching and dewatering system to render the dredge spoil areas tractable to equipment and the soils useable in construction. The location of leachate collection systems must also accommodate the settlement estimates. Systems should be designed for settlement now and in the future so as to continue to function under gravity. Systems which are not designed to accommodate settlement may require continuous pumping from various cells or locations to achieve leachate collection. Settlement of the dikes induced by the landfilling and by the dredge spoil activities will require maintenance to sustain the desired grade.

3.1.8 On-Site Soil Suitability

Review of the permeability data obtained from consolidation tests and falling head permeability tests indicates that the estimated existing in situ permeabilities are 1×10^{-7} cm/sec or less. This meets the Delaware Department of Natural Resources (DNREC) requirement of a permeability of 1×10^{-7} cm/sec or less for a natural liner. Analysis indicates that a further reduction in permeability (in the range of 10^{-8}) will result as consolidation under the design load occurs.

The suitability of on-site soils for construction will be directly related to workability problems. The fine grained silts, while of low permeability are substantially altered when wet. Mild rains make these soils slick on the surface and require significant drying periods. Upon complete drying, these materials tend to dust and blow thus significantly affecting site conditions. Therefore, to utilize on-site soils will require a commitment to establish a program for the advanced planning of area-wide excavations and dike

construction to permit a program of amending these soils through the admixture of lime or other materials. Large quantities of soil exist on the site and large quantities will be required for dike construction, daily cover, intermediate cover, fire breaks, and slope cover. Some of these requirements can be satisfied with the on-site soils if a workable condition for these soils can be maintained. Paramount to the workability of these soils will be a program to lower the existing water table and to promote surface runoff from the site as soon as possible. This will help maintain a lower moisture content in the soils. It is anticipated that the dike construction, with on-site soils, will also require the use of reinforcing fabrics to minimize the use of required off-site borrow materials.

3.1.9 Fly Ash Utilization

Through arrangements with Delmarva Power, fly ash from the Edgemoor Plant may be available for use as a construction material. Approximately 60,000 cubic yards of fly ash and 5,000 cubic yards of bottom ash are generated on an annual basis. Soil mechanics tests were performed to establish compatibility with the on-site soils and with admixtures of lime. Results of these tests are more fully discussed in Appendix D-7. Generally, the fly ash is a silt sized material which reacts to weather conditions in a similar manner to the on-site soils (i.e., sticky when wet, dusty when dry). The only benefit of the fly ash material is its low moisture content (25%) as produced. Mixing with the on-site soils (moisture contents above 80%) will result in a partial lowering of the moisture content. However, there is minimal structural improvement for the combined soil/fly ash and the practical mechanism for field blending remains to be established. Therefore, there appears to be little benefit in the use of fly ash as an admixture to on-site soils. The bottom ash is a much more granular material (similar to medium sand) and could be used quite readily as an admixture for

cover materials or directly in road base construction. Due to the granular nature of the bottom ash, it is not as susceptible to change in weather conditions.

3.2 Design Parameters

3.2.1 Planning

a. Establish a phasing plan to maximize land area and minimize dike construction and proximity to the on-going dredging program.

b. Commence a deep ditching program in the selected site as soon as possible in order to maximize the time period for seepage and drainage of water table conditions.

3.2.2 Structure Foundations

Finalize the structural details for the administration and maintenance areas and commence final design in these areas. Due to the apparent sloping subsurface conditions for pile foundation systems, we suggest that additional test borings be performed at the proposed locations for the structures in order to provide design criteria at the specific sites.

3.2.3 Dike Design

a. For the Wilmington site, use dike slopes of three horizontal to one vertical. Use a geotextile fabric at the dike base to improve stability and constructability on the existing soils.

b. Use off-site borrow materials meeting at a minimum the requirements of Delaware Type G, Grading F.

c. For the Edgemoor side of the site, dikes with slopes of five horizontal to one vertical should be anticipated. A full scale test embankment should be performed to evaluate the following:

- o Constructability using on-site soils and amendments such as lime and bottom ash.
- o Optimal location and design of geotextile reinforcement.
- o Provide instrumentation to monitor settlement, pore pressure dissipation, and slope movement to provide an economical slope design for dikes to be constructed on the deeper soft soils.

d. Dike materials should be placed in horizontal lifts not exceeding eight inches in loose thickness and compacted to at least 90 percent of the maximum density as determined by the Modified Proctor Test ASTM D-1557.

3.2.4 Landfill Design

Commence design of the landfill and include the following criteria:

a. Use the in-place soils on the site as the landfill liner.

b. Develop a phasing program for landfilling on the Edgemoor area to maximize area and minimize dike construction. Limit landfill height to a maximum 20 feet lift in any area in a five year period. To achieve the design grade of 40 feet of landfill, use two lifts of 20 feet each. A 100 foot setback from the existing north and east dikes and at the start of the second lift if recommended.

c. Landfilling should commence in the deeper compressible soil areas along the east side of the Edgemoor site to allow the greater anticipated settlement to occur and permit leachate collection systems to be constructed "up slope" as settlement in the deeper areas continue.

d. Cost estimates based on imported soil should be utilized as a conservative estimate of total project costs. The necessity for imported soil should await the completion of the evaluation of on-site soils.

e. Landfill slopes should be "benched" a minimum of 20 feet for each 20 feet in height.

3.2.5 On-Site Soils

Commence a detailed evaluation program of the workability of the on-site soils. This will probably include an on-site pilot project and could be used in conjunction with a test embankment construction program. A monitoring program should also be included in any pilot project in order to evaluate the soil properties controlling design. This may result in a reduction of the required dike secton which could have a significant cost saving effect. Monitoring of existing well points should be continued on a regular basis to evaluate the effects of additional dredging on the subsurface water table.

4.0 PRELIMINARY DESIGN

4.1 General Information

The site proposed for the location of the Delaware Solid Waste Authority's sanitary landfill to serve the needs of New Castle County is located as shown in Figure 1-1. This proposed landfill facility, referred to as the Northern Solid Waste Facility-2 (NSWF-2), will become the complementary land disposal facility to DSWA's existing resource recovery facility (NSWF-1) located at Pigeon Point. Access to the site from Pigeon Point will be by way of I-495 and 12th Street. Pigeon Point is approximately 8,000 feet south of the site. Most of the area under consideration is land reclaimed with dredging spoils. Additionally, the site continues to be used by the U.S. Army Corps of Engineers for disposal of materials dredged from the river channel serving the Port of Wilmington.

This site comprises a total of approximately 500 acres divided into nuemrous properties.

The site comprises a total of approximately 500 acres. It is divided into numerous parcels as shown in Figure 4-1. The site is zoned M-1 (Light Manufacturing) and M-2 (General Manufacturing) by the City of Wilmington. The M-1 District permits book publishing, laboratories, light manufacturing, wholesale sales and warehousing, retail stores or service establishments, restaurants, and public utility and service uses. The M-2 Zoning District permits all uses not otherwise prohibited. Only a few specific industrial uses are specifically prohibited - fertilizer manufacturing, explosive manufacturing, reduction of garbage, offal or dead animals on a commercial basis, and refining or processing of crude petroleum. No minimum lot area restrictions apply to either the M-1 or M-2 Zoning District.

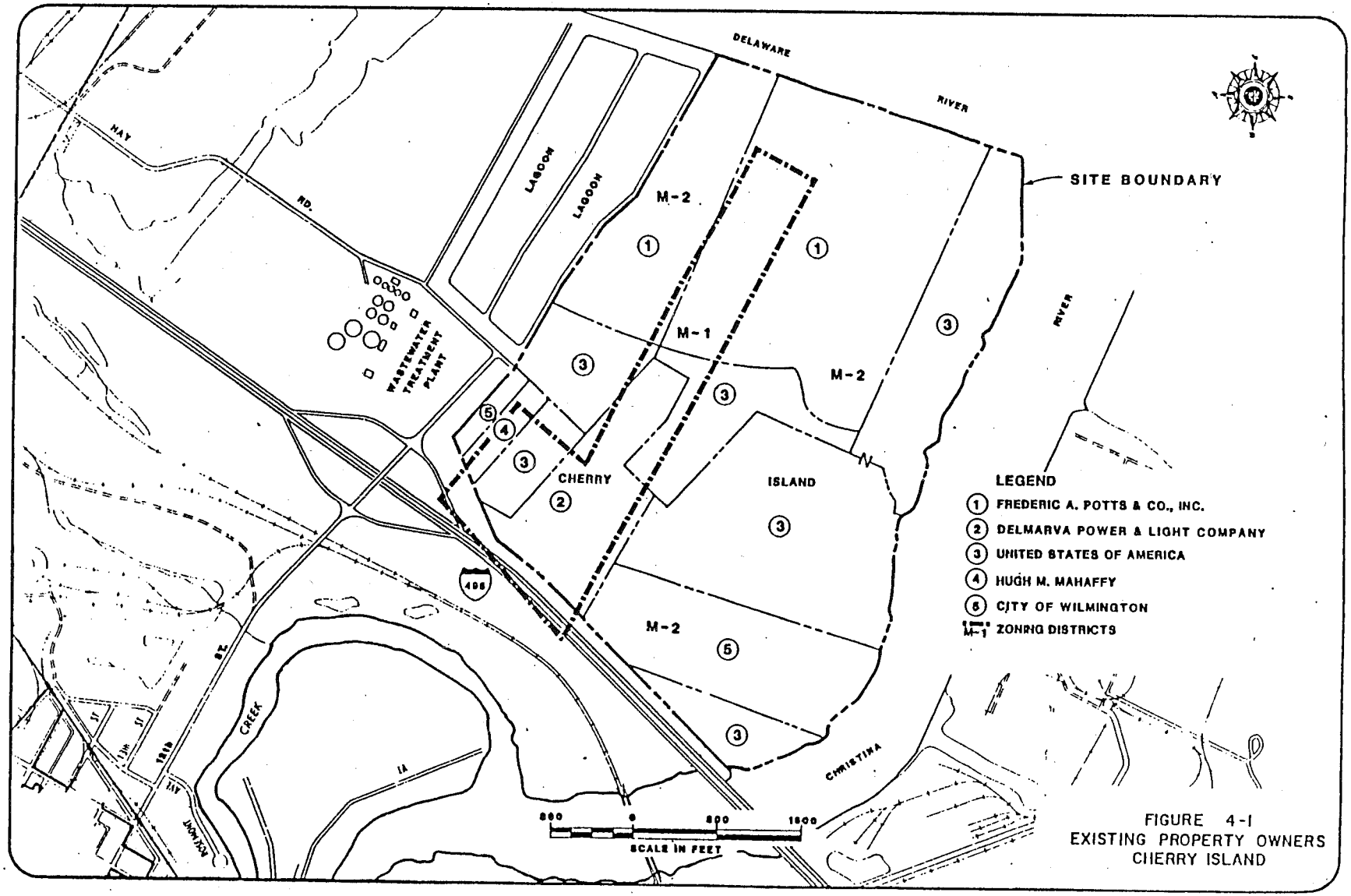


FIGURE 4-1
EXISTING PROPERTY OWNERS
CHERRY ISLAND

There are no dwellings within 300 yards of the proposed site. In addition, there are no cultural, recreational or natural areas and no known historic sites, national or state, within 300 yards of the proposed site.

The site is adjacent to I-495 which is elevated because of the Christina River bridge crossing. North bound traffic, therefore, has a clear unobstructed view of the site with no opportunity for screening the site to reduce the aesthetic impact that the landfill operations will produce. The site will therefore have a high degree of visibility, albeit the viewing public primarily will be who will view the site operations from a relatively fast moving vehicle, for a short period of time. However, because of the industrial character of the surrounding area and the ongoing earthmoving activities associated with the dredge disposal operation of the Corps of Engineers, the development of a landfill at Cherry Island will not adversely affect the quality of the area nor its landscape.

Elevations (Datum: Mean Sea Level) within each dredge disposal do not vary by more than 4 or 5 feet. A review of the topographic mapping prepared from recent aerial photography (August 1983) shows that the dike defining the "Edgemoor" dredge disposal area varies in elevation from 42 feet to 50 feet. The dike which defines the "Wilmington" dredge disposal area varies in elevation from 32 feet to 35 feet.

The dike on the east of the "Edgemoor" area, which fronts the Delaware River, rises sharply from the water line to the crest of the dike. On the south of the "Edgemoor" area, particularly as one approaches the Delaware River, there is a sharp rise from the Christina River to an elevation of approximately 12 feet. There is then a gradual rise over a 200' wide area to the toe of the dike which is at an elevation of approximately 30 feet.

At the toe of the dike on the south side of the "Wilmington" area there is a low lying area varying in elevation from 4 feet to 8 feet and varying in width from 100 feet to 200 feet. This low lying area continues around to the western side of the "Wilmington" area, where it at first widens considerably and then, as one proceeds north, is confined by earth fill ramps associated with the I-495 interchange located just beyond the northwest corner of the site.

Between the dike defining the western edge of the "Wilmington" area and I-495 are the rights-of-way of two petroleum pipelines, one power transmission line, and one sewer force main. The northwestern corner contains two lagoons currently used as sewage sludge drying facilities by the City of Wilmington.

Upgradient runoff from properties to the north and west are currently intercepted either by existing dikes and ditches or by existing highway drainage facilities and lower lying areas. Most of these existing barriers will not be altered and should still provide satisfactory control of upgradient runoff. Provisions for incorporation of sedimentation basin(s), ditches, swales, and other suitable methods for erosion control to preclude sediment laden discharges directly to the Christina or Delaware Rivers will be developed.

The dikes constructed by the Corps of Engineers over the years for the containment of dredge spoils serve to protect this site from inundation by the 100-year flood. The elevation of the 100-year flood at Cherry Island is estimated at approximately 10 feet. As indicated earlier, the tops of the dikes are well above this. Consequently, the 100-year flood plain criterion has little impact upon this site since most of the area of 10 feet elevation or less lies within the 200 foot property line buffer zone.

Cherry Island and its environs are not considered to be, or lie within, any State of Delaware Wetlands. Therefore, adherence to the wetlands criterion does not have an impact upon this site.

A minimum of 100 feet must be maintained between the edge of the disposal area and the edge of a body of water. Therefore, the edge of the disposal area is at least 100 feet from both the Delaware River and the Christina River.

The property line setback established by the DSWA is 200 feet. Therefore, there is a minimum 200 foot buffer zone around the perimeter of the site in which no wastes will be landfilled. Excluding this 200 feet from landfilling does not necessarily preclude its use for other purposes such as the location of service or access roads and support facilities.

The Cherry Island site has no agricultural value and the use of this site for a landfill would have no effect on agricultural productivity or potential productivity.

4.2 Design Considerations

For the 20+ year planning period being considered, refuse quantities are expected to increase in direct proportion to the projected increase in population for New Castle County. Based upon recent trends, per capita refuse generation rates are not expected to increase. The New Castle County population figures for the following years reflect an average annual population increase of approximately 1.1%.*

1980	-	399,002 (Census)
1990	-	445,100 (Projection)
2000	-	496,100 (Projection)

Therefore, the starting year refuse generation estimate has been increased at 1.1% per year.

Beginning year refuse generation:	380,000 tons
Processable portion**:	-260,000 tons
Non-processable (to be landfilled):	120,000 tons
Residues from processing (approx. 10%):	+ 26,000 tons
Total residues and non-processables:	146,000 tons

To this is added another 13,000 tons (5%) of processable wastes resulting from scheduled and non-scheduled facility outages giving a beginning year total of 159,000 tons.

The yearly increase in materials to be landfilled is shown in Table 4-1. This estimate is based upon processing 1000 TPD for the duration of the planning period. This is a conservative approach since it does not take into account the possibility of expanding plant capacity by adding additional processing units (physical plant expansion potential) or by increasing hours of operation.

The weighted average in-place density of the above wastes is estimated at 1300 lbs/c.y. (0.65 tons/c.y.). This value was derived from a consideration of the three types of waste which will be landfilled at the NSWF: (1) unprocessed mixed municipal refuse; (2) residues from the DRP; and (3) non-processable materials.

In-place densities of landfilled mixed municipal refuse vary from 700 lbs/c.y. to 1200 lbs/c.y. depending upon the type of compaction equipment used and the characteristics of the waste. For the purposes of this design, a 1000 lbs/c.y. in-place density was assumed.

*Population projection based upon data obtained from the New Castle County Department of Planning.

**Processable materials are defined as the solid waste which can be accepted and processed by the equipment integral to the Delaware Reclamation Project (DRP) at Pigeon Point.

TABLE 4-1

YEARLY INCREASE IN MATERIALS TO BE LANDFILLED

Year	Total Waste Stream (tons)	Yearly Total of Wastes to be Landfilled (tons)	Cumulative Wastes Landfill (tons)
1 (1985)	380,000	159,000	159,000
2	384,180	163,200	322,200
3	388,406	167,400	489,600
4	392,678	171,700	661,300
5	396,997	176,000	837,300
6	401,364	180,400	1,017,700
7	405,779	184,800	1,202,500
8	410,243	189,200	1,391,700
9	414,756	193,800	1,585,500
10	419,318	198,300	1,783,800
11	423,930	202,900	1,986,700
12	428,593	207,600	2,194,300
13	433,308	212,300	2,406,600
14	438,074	217,100	2,623,700
15	442,893	221,900	2,845,600
16	447,765	226,800	3,072,400
17	452,690	231,700	3,304,100
18	457,670	236,700	3,540,800
19	462,704	241,700	3,782,500
20	467,794	246,800	4,029,300
21	472,940	251,900	4,281,200
22	478,142	257,100	4,538,300
23	483,402	262,400	4,800,700
24	488,719	267,700	5,068,400
25	494,095	273,100	5,341,500
26	499,530	278,500	5,620,000
27	505,025	284,000	5,904,000
28	510,580	289,600	6,193,600
29	516,196	295,200	6,488,800
30	521,874	300,900	6,789,700

The in-place density of residue from the DRP will vary with moisture content and particle size. For the purposes of this design, it has been assumed to approximate that of cinders which is about 1450 lbs/c.y.

The in-place density of the non-processable fraction of the waste stream which includes construction and demolition debris (broken concrete, blocks, bricks, structural timber), logs, stumps, mattresses, bedsprings and rugs was estimated at 1300 lbs/c.y.

For estimating cover material requirements at this site it is assumed that the landfill will be operated as an "area fill." In accordance with DNREC regulations, it has been assumed that cover material (soil) will have to be applied at the end of each working day. Completed areas will have to be covered with 2 feet of cover material as soon after completion as possible. Consequently, a refuse to cover soil ratio of 3:1 (by volume) was utilized.

Disposal area finished sideslopes of 33% (approximately a 3:1 length to height ratio) are proposed. The finished grade of the top of the disposal area incorporates a slope of 2%.

A nominal height of 40 feet above the existing grade is used to determine site volumes. This represents the total depth of the landfill including cover material and wastes.

Because of the high moisture content soils and associated poor stability and high compressibility, it has been presumed that initial landfilling will be by the area fill method and will not involve any significant excavation into the dredge spoils which surficially blanket the site. Approximately 2,731,000 cubic yards of cover material will be needed over the life of the project if all of the subsequent disposal areas also are operated on this basis. It has been presumed that all of this material will have to be imported to the site. However, as experience is gained at this site in its

day-to-day operation, future disposal areas may be developed in such a manner that dredge materials can be excavated to provide additional disposal volumes and to meet cover material requirements.

Consequently, the dredge spoils do represent a significant potential source of cover materials. Their use, though, presents significant operational problems with regard to workability, compaction, and erodability. If utilized, methods would have to be developed to satisfactorily excavate and then dry the materials to facilitate placement.

The high moisture content and compressibility of the dredge spoils and river bottom sediments which comprise the surficial soils of this site, require that certain precautions must be taken in the design and operation of a sanitary landfill at Cherry Island. As detailed in earlier sections, no more than five feet of refuse should be deposited over any portion of the Edgemoor disposal areas within a year. Only a maximum of 20 feet is allowed in 5 years. In addition, a 100 foot setback from the toe of existing dikes must be maintained to insure stability of the refuse deposit and prevent soil failures from occurring. Likewise, a 100 foot setback from the top of slope of the first 20 foot depth of refuse and the toe of the slope of the second 20 foot depth of refuse must be maintained.

The the need to accommodate the continued use of the adjacent areas as dredge disposal sites by the Corps of Engineers is another constraint imposed upon the design and operation of the Cherry Island site. Dikes have to be constructed to allow for the joint use of the site. These dikes and associated construction details were described in previous sections.

4.3 Site Configuration

The administrative area proposed for this site is shown in Figure 4-2. Two pitless type truck scales, a separate weigh station

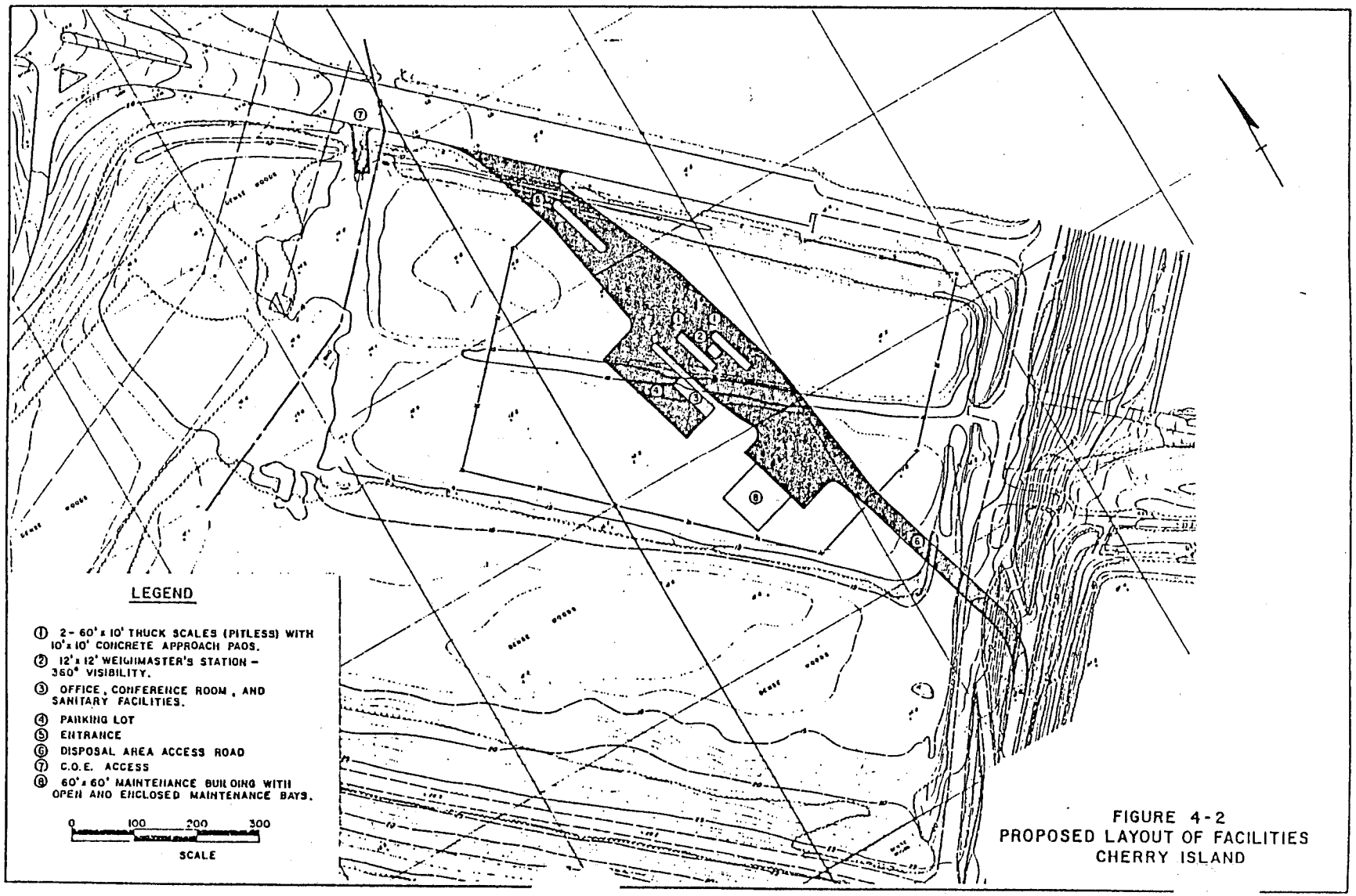


FIGURE 4-2
PROPOSED LAYOUT OF FACILITIES
CHERRY ISLAND

located between the two scales, and a separate office are deemed necessary for the operation of the facility. The administrative area will be fenced for security purposes. A landscaped entrance off of 12th Street will be provided. Another entrance will be provided for Corps of Engineers usage.

The landfill will be developed in phases. These phases are shown in Figure 4-3. The initial area to be developed (Phase 1) is approximately 33 acres. It will require the construction of 1,700 feet long dike across the southern side of the disposal area. On the east, this dike will tie into the existing dike separating the "Wilmington" and "Edgemoor" dredge disposal areas. On the west, it will join the existing western dike of the "Wilmington" dredge disposal area. The height of this new dike will be approximately 12 feet. It will have a crest 25 feet wide. Other details of this dike regarding its construction are discussed in Chapter 3. It will be necessary to construct this dike during the spring of 1984 in order to accommodate the Corps of Engineers and its planned 1984 spring/summer dredging of the Christina River.

A minimum buffer zone of 50 feet will be maintained between the right-of-way associated with the Christina Force Main and the western edge of the landfill.

The Phase 1 Area is estimated to have a life of approximately five years. With landfilling within the Phase 1 Area scheduled to commence in March 1985, this will accommodate the Authority until March 1990 at which time the Authority will need to move disposal operations to the Phase 2 Area.

The currently proposed dredging schedule as illustrated in Table 4-2 will necessitate the construction of the Phase 2 dike in 1988 and 1989.

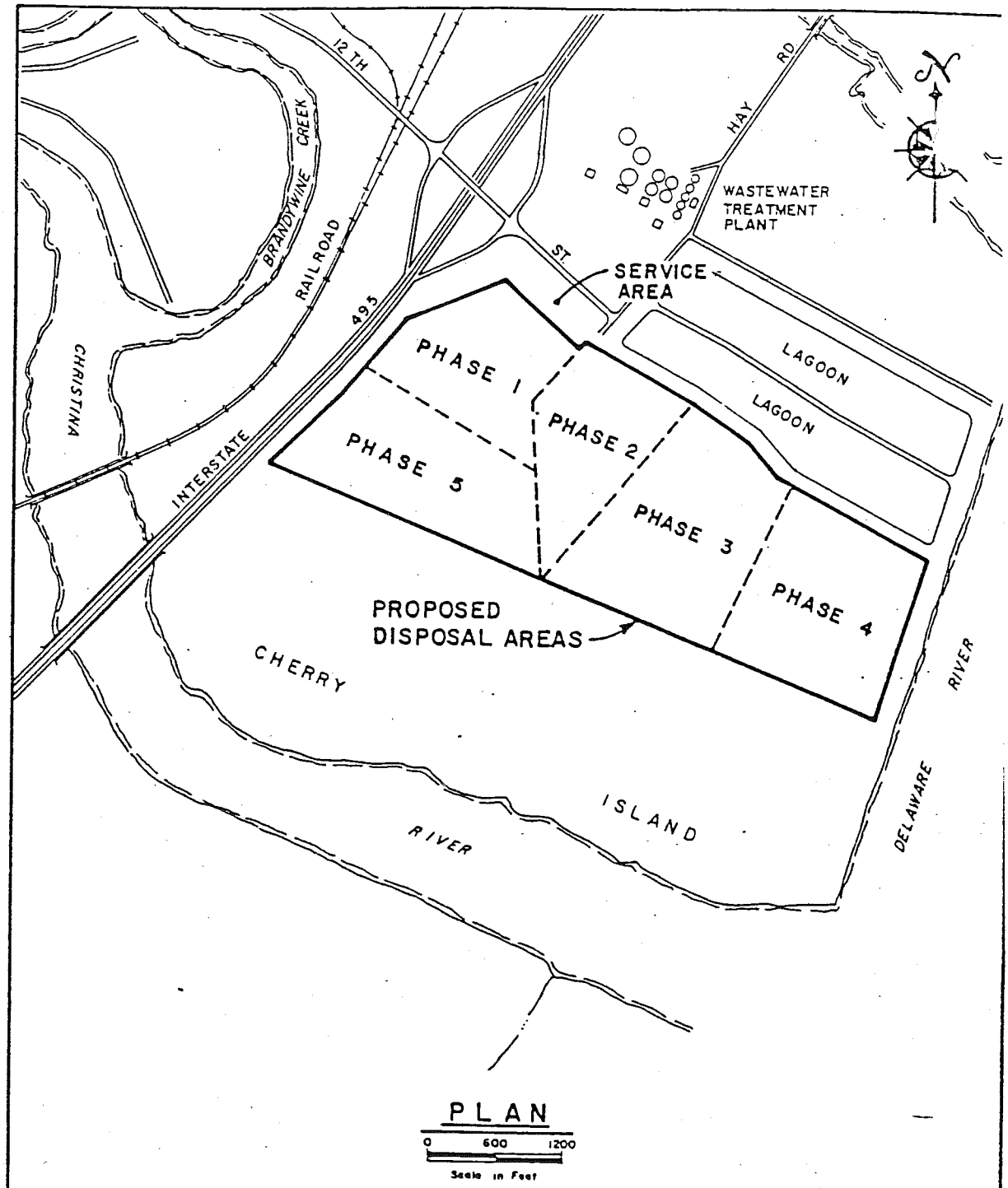


FIGURE 4-3
PROPOSED DISPOSAL
AREA SEQUENCING
CHERRY ISLAND

TABLE 4-2
10-Year Utilization Schedule for Cherry Island

	Corps of Engineers Dredging Schedule	Authority Dike Construction Schedule	Authority Disposal Area Utilization Schedule
1984	Wilmington	Phase 1	
1985	Wilmington		Phase 1
1986	Edgemoor		Phase 1
1987	Edgemoor		Phase 1
1988	Wilmington	Phase 2	Phase 1
1989	Wilmington	Phase 2	Phase 1
1990	Edgemoor		Phase 1 and Phase 2
1991	Edgemoor*		Phase 2
1992	Wilmington		Phase 2
1993	Wilmington		Phase 2
1994	Wilmington South		Phase 2

* From this point until approximately 2004, the Corps of Engineers will be utilizing the "Wilmington" and the proposed Wilmington South disposal areas exclusively. Around 2004 it is estimated that the elevation of the "Wilmington" side will match the elevation of the "Edgemoor" disposal site, thus allowing for the use of the entire southern half of Cherry Island for disposal of dredge materials on an alternating basis with Wilmington South.

Because of the depth of underlying compressible materials, certain precautions must be taken when landfilling in the Phase 2 Area as well as the remaining phases of the site. These precautions take the form of limitations on the rate of landfilling within these Phases. These limitations are described in Chapter 3.

4.4 Leachate Collection (Phase 1 Area)

It is proposed to divide the Phase 1 Area into three roughly equal sections which are referred to as cells. The base of each cell will be graded at a slope of 0.5% (1/2 foot/100 feet) with the lowest point in the southwest corner. A "herring-bone" pattern of lateral drains will feed a larger header drain. The header will a) discharge directly to a sump from which the leachate will be pumped to a connecting pressure sewer and then to the Christina Force Main; or b) as an alternative, discharge to a gravity interceptor which will direct flows to one large pump station and then to the Christina Force Main via a pressure sewer. The leachate collection drains will consist of a coarse stone aggregate wrapped with a non-woven filter fabric. The components of this system are shown in Figures 4-4 and 4-5 and are further described below.

The laterals shown are spaced 100 feet apart. Both the header and lateral drains consist of trenches filled with coarse stone aggregate (Del No. 103) and wrapped with a thick, non-woven filter fabric. Each drain is covered with a minimum 12-inch layer of coarse stone aggregate to protect the fabric. Because there could be differential settlement along the length of each drain, no piping is proposed. The resulting "french drain" design allows for a significant amount of flexure along the drain without disruption of the flow. This system should be the least impacted as a result of the anticipated differential settlements at the site.

The sizes of the drains are based on the assumption that the initial flows from the system will be the largest and will result from nearly

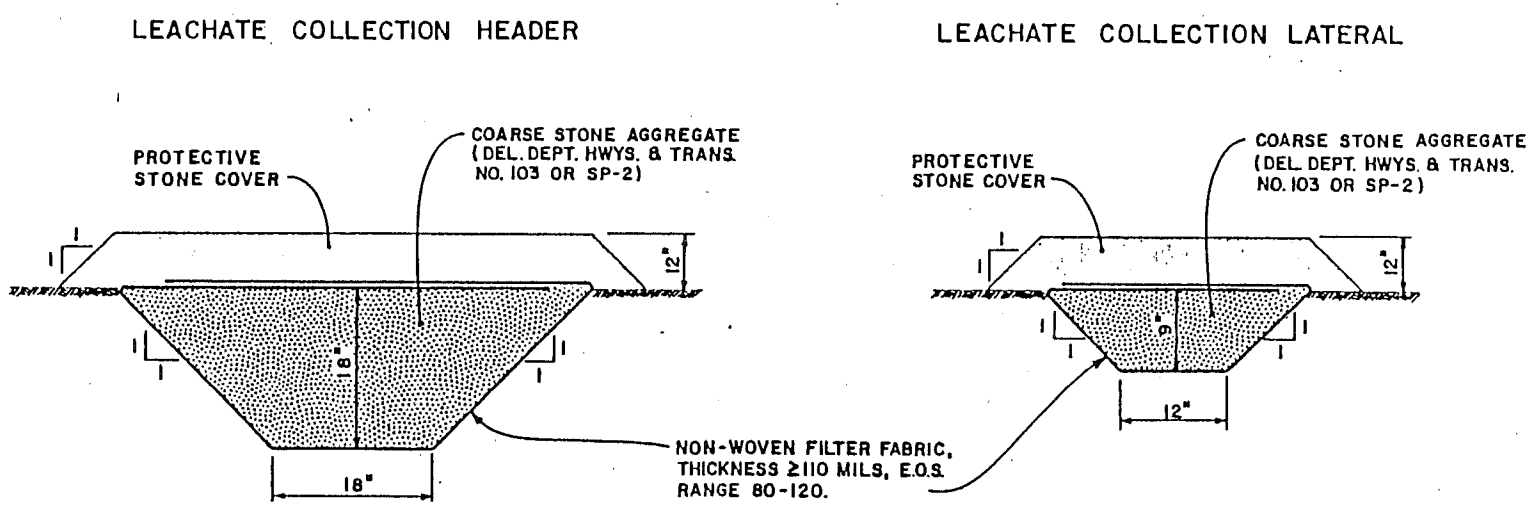
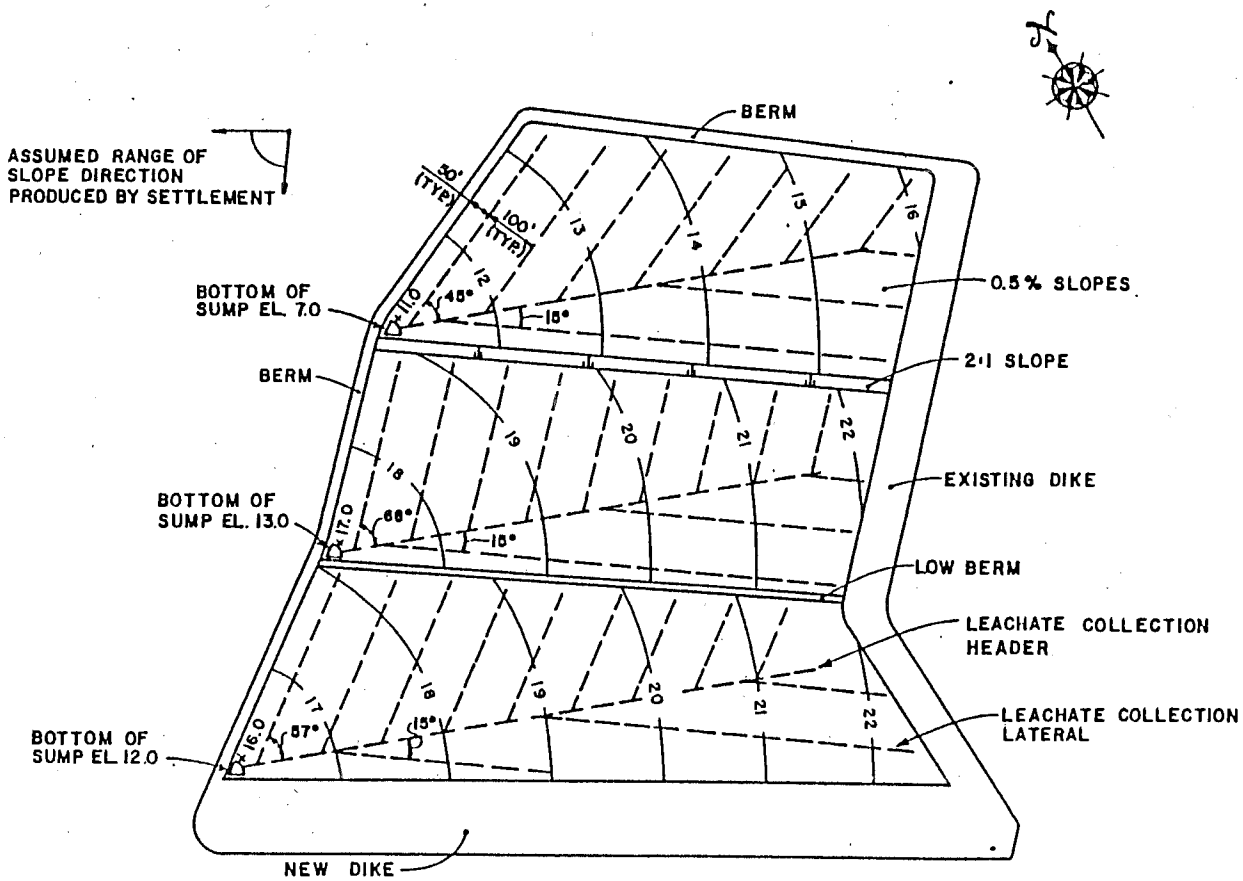


FIGURE. 4-4
CROSS-SECTION OF LECHATE COLLECTION HEADER & LATERAL
CHERRY ISLAND



PLAN
PHASE I DISPOSAL AREA

FIGURE 4-5
LAYOUT OF
LEACHATE COLLECTION SYSTEM
CHERRY ISLAND

all drains being uncovered at start up. Using average precipitation for the site, the estimated average flow from the system from captured run off will be approximately 7 gpm. From a combination of Darcy's Law (relating flow through a media to permeability, gradient, and cross-sectional area) and Hazen's approximation (relating grain size to permeability), the needed cross-sectional area of the drain was determined (using a given aggregate size and the design grdient of 0.5%). However, this calculated size handles only year-round average flow and would not be adequate to handle storm flows without some temporary retention of water within the basin. In addition, differential settlement could reduce the gradient in some areas and some initial infiltration of fines could occur which would reduce the effective cross-sectional area of the drains. For these reasons, the drains have been designed with 25 times the cross-sectional area necessary to handle year-round average flows.

Leachate collection systems for future landfill phases (Phase II - Phase V) will be developed when the detailed design for these areas are undertaken. Detailed design of the next disposal area probably will commence in 1987.

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APPENDIX A

MONITORING WELL LOGS

GILBERT ASSOCIATES, INC.

SOIL AND ROCK CLASSIFICATION SHEET

SHEET 1 OF 2

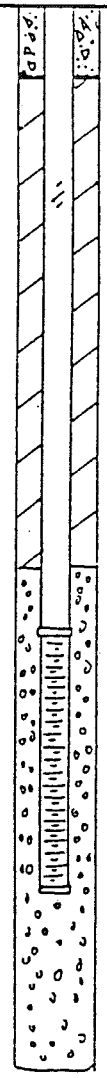
PROJECT: DSWA W.O. 04-5196-000 SITE AREA Cherry Island DRILL HOLE NO. C-1

CONTRACTOR: A. C. Schultes COORDINATES _____ ELEVATION 15.

DRILLER: C. Kramer GWL 0 HRS _____

CLASSIFIED BY: D. J. Stanislawczyk DATE: 8-3-83 24 HRS _____

Depth Ft.	Sample No.	SPT Blows/6 In. 6	12	18	Ft. Rec.	Profile	DESCRIPTION Density (or Consistency), Color Rock Or Soil Type - Accessories	U.S.C.S.	R.Q.D.	Soil Or Rock: Range Size / Core Run	Grain Shape / Rec. Core	REMARKS Chemical Comp, Geologic Data, Ground Water, Construction Problem etc. TOC = 18.7
0												
5	1	2	1	1	1		Black - clayey silt - trace of mica, sticky.					
10	2	1	1	1	1		As above - w/trace of light grey silty fine sand @ 12.0'					
15	3	1	2	2	3		As above, w/laminae of light grey sandy silt to silty fine sand					
20	4	1	2	4	4		Peat - dark brown fiberous					
25							25.0'					
	5	7	8	10	11		Medium dense - brown silty fine sand with trace of clay, micaceous					
30	6	2	3	3	7		As above w/thin layers of rust brown fine sand					
35	7	13	1	1	16		As above w/thin layer of grey clay					
40	8	3	8	20	70		Dense layered orange silty clay and brown sandy silt, no rock chips					
							TOTAL DEPTH 42'					



GAI - 227 9

GILBERT ASSOCIATES, INC.

SOIL AND ROCK CLASSIFICATION SHEET

SHEET 2 OF 2

PROJECT: DSWA W.O. 04-5196-000 SITE AREA Cherry Island DRILL HOLE NO. C-100

CONTRACTOR: A. C. Schultes COORDINATES _____ ELEVATION _____

DRILLER: C. Kramer GWL 0 HRS _____

CLASSIFIED BY: D. J. Stanislawczyk DATE: 8-3-83 24 HRS _____

Depth Ft.	Sample No.	SPT Blows/ 6 In. 6 12 18	Ft. Rec.	Profile	DESCRIPTION Density (or Consistency), Color Rock Or Soil Type - Accessories	U.S.C.S.	R.Q.D.	Soil Or Rock: Range Size / Core Run	Soil Or Rock: Grain Shape / Rec. Core	REMARKS Chemical Comp, Geologic Data, Ground Water, Construction Problems, etc.
					NOTES: 1) Set 4" diameter No. 10 slot PVC screen from 25' to 35'. 2) Gravel pack w/No. 1 Morie gravel 22'-8" to 42'. 3) Bentonite seal 3'-20'. 4) Develop 5 gpm. 5) Set protector casing and cap.					

GAI - 227 9/

GILBERT ASSOCIATES, INC.

SOIL AND ROCK CLASSIFICATION SHEET

SHEET 1 OF 1

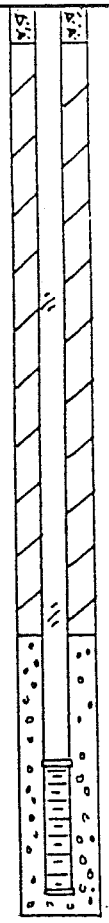
PROJECT: DSWA W.O. 04-5196-000 SITE AREA Cherry Island DRILL HOLE NO. C-10

CONTRACTOR: A.C. Shultes COORDINATES _____ ELEVATION 35.2

DRILLER: C. Kramer GWL 0 HRS _____

CLASSIFIED BY: D.J. Stanislawczyk DATE: 8-8-83 24 HRS _____

Depth Ft.	Sample No.	SPT Blows/6 In. (6 12 18)	Ft. Rec.	Profile	DESCRIPTION (Density (or Consistency), Color; Rock Or Soil Type - Accessories)	U.S.C.S.	R.Q.D.	Soil Or Rock: Range Size / Core Run	Soil Or Rock: Grain Shape / Rec. Core	REMARKS (Chemical Comp, Geologic Data, Ground Water, Construction Problems, etc.) TOC 39.72
0					0 - 6 Brown silty sand to sandy silt					
					6 - 10 Brown medium to coarse sand & fine gravel					
10					10 - 20 Dark brown to black clayey silt					
20					20 - 30 As above					
30					30 - 40 As above - more					
40					40 - 50 As above, with some fiberous organic material					
50					50 - 60 Dark grey to black clayey silt					
60					60 - 70 Dark brown fine to coarse sand w/rounded quartz gravel					
70					70 - 72 Sandy silt					
					TOTAL DEPTH 72'					
80					Notes: 1) Set 4" PVC screen from 60-70' No. 10 slot size. 2) Gravel pack 50-70'. 3) Bentonite seal 3-50'. 4) Develop 60 gpm. 5) Set protector casing & cap.					



GAI - 227 9/

GILBERT ASSOCIATES, INC.

SOIL AND ROCK CLASSIFICATION SHEET

SHEET 1 OF 1

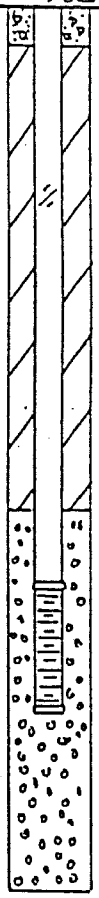
PROJECT: DSWA W.O. 04-5196-000 SITE AREA Cherry Island DRILL HOLE NO. C-102

CONTRACTOR: A.C. Schultes COORDINATES _____ ELEVATION 26

DRILLER: C. Kramer GWL 0 HRS _____

CLASSIFIED BY: D. J. Stanislawczyk DATE: 7-13-83 24 HRS _____

Depth Ft.	Sample No.	SPT Blows/6 In. 6	12	18	Ft. Rec.	Profile	DESCRIPTION Density (or Consistency), Color Rock Or Soil Type - Accessories	U.S.C.S.	R.Q.D.	Soil Or Rock: Range Size / Grain Shape	Core Run / Rec. Core	REMARKS Chemical Comp, Geologic Data, Ground Water, Construction Problems, etc. TOC 29.50'
0												
	1	2	1	1	3		Black Dredge Spoil - Clayey silt small gravel, layer					
10	2	2	1	1	1		Dredge Spoil - Soft black clayey silt					
	3	1	1	2	1		Dredge Spoil - Clayey silt, black, soft, low plasticity, organic material					
20	4	2	1	1	1		Black clayey silt with organic material					
	5	1	2	2	4		As above					
30	6	3	50	-	-		As above w/cobble @ 31.0'					
	7	-	-	-	-		No sample - cobble obstruction - very coarse sand & gravel 37' - 40'					
40	8	2	2	3	3		Wash sample - of silt - in coarse sand					
50							Set Screen in Sand 46' - 56'					
60							60 - 70 Over drill to allow coarse cuttings to settle					
70												



TOTAL DEPTH 70.0'

Notes:

1) Set 4" PVC screen No. 10 slot 46' - 56'.
2) Gravel pack - 40' - 70'.
3) Develop 5 gpm.
4) Bentonite seal - 3' - 40'.
5) Set protector casing & cap.

GILBERT ASSOCIATES, INC.

SOIL AND ROCK CLASSIFICATION SHEET

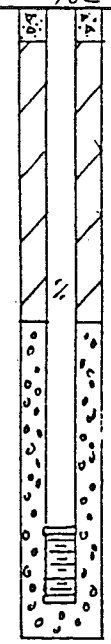
SHEET 1 OF 1

PROJECT: DSWA W.O. 04-5196-000 SITE AREA Cherry Island DRILL HOLE NO. C-103

CONTRACTOR: A.C. Schultes COORDINATES _____ ELEVATION 11.1

DRILLER: C. Kramer GWL 0 HRS _____

CLASSIFIED BY: D.J. Stanislawczyk DATE: 7-29-83 24 HRS _____

Depth Ft.	Sample No.	SPT Blows/6 In. (6 12 18)	Ft. Rec.	Profile	DESCRIPTION (Density (or Consistency), Color; Rock Or Soil Type - Accessories)	U.S.C.S.	R.Q.D.	Soil Or Rock: Range Size / Core Run	Soil Or Rock: Grain Shape / Rec. Core	REMARKS (Chemical Comp, Geologic Data, Ground Water, Construction Problems, etc.) TOC 14.8
0					0 - 10 Dredge Spoil - dark gray silty clay					
10					10 - 20 Dredge Spoil - drak gray silty clay					
20					20 - 30 Dredge Spoil - dark gray silty clay					
30					30 - 40 As above					
40					40 - 50 Trace of sand in between 42 - 45' - small thin layer					
50					TOTAL DEPTH 50'					

Notes:

1) Set 5' of 4" I.D. No. 10 slot PVC screen 42' - 47'.
2) Casing to 42' (4" PVC).
3) Gravel pack 25' - 50'.
4) Bentonite seal - 3' - 25'.
5) Develop 1½ gpm.

GILBERT ASSOCIATES, INC.

SOIL AND ROCK CLASSIFICATION SHEET

SHEET 1 OF 1

PROJECT: DSWA W.O. 04-5196-000 SITE AREA Cherry Island DRILL HOLE NO. C-104

CONTRACTOR: A.C. Schultes COORDINATES _____ ELEVATION _____

DRILLER: C. Kramer GWL 0 HRS _____

CLASSIFIED BY: D.J. Stanislawczyk DATE: 7-27-83 24 HRS _____

Depth Ft.	Sample No.	SPT Blows/6 In. 6	12	18	Ft. Rec.	Profile	DESCRIPTION Density (or Consistency), Color Rock Or Soil Type - Accessories	U.S.C.S.	R.Q.D.	Soil Or Rock: Range Size / Core Run	Grain Shape / Rec. Core	REMARKS Chemical Comp, Geologic Data, Ground Water, Construction Problems, etc. TOC 13.30'
0							0 - 10 Dredge Spoil - brownish black clayey silt, soft					
10							10 - 20 Dredge Spoil - brownish black clayey silt, soft					
20							20 - 30 Dredge Spoil - brownish black clayey silt, soft					
30							30 - 40 Dredge Spoil - brownish black clayey silt, soft					
40							40 - 50 Dredge Spoil - slightly sand w/organic material					
50							52 - 60 Dark grey sand - fine to medium grained with fine gravel					
60							TOTAL DEPTH 60'					

NOTES:

1) Set 5' of 4" diameter PVC w/No. 10 slot from 53' - 58' and 4" diameter PVC casing to 58' w/3' stickup.

2) Gravel pack 40' - 60'.

3) Develop 5 gpm.

4) Seal 3' - 40'.

5) Set protector casing and cap.

GAI - 227 9/72

GILBERT ASSOCIATES, INC.

SOIL AND ROCK CLASSIFICATION SHEET

SHEET 1 OF 2

PROJECT: DSWA W.O. 04-5196-000 SITE AREA Cherry Island DRILL HOLE NO. C-105

CONTRACTOR: A.C. Schultes COORDINATES _____ ELEVATION 21.4

DRILLER: C. Kramer GWL 0 HRS _____

CLASSIFIED BY: D.J. Stanislawczyk DATE: 7-25-83 24 HRS _____

Depth Ft.	Sample No.	SPT Blows/6 In. 6	12	18	Ft. Rec.	Profile	DESCRIPTION Density (or Consistency), Color Rock Or Soil Type - Accessories	U.S.C.S.	R.Q.D.	Soil Or Rock: Range Size / Core Run	Grain Shape / Rec. Core	REMARKS Chemical Comp, Geologic Data, Ground Water, Construction Problems, etc. TOC 24.90'
0												
5	1	1	1	1	1		Dredge Spoil - black silty clay - clayey silt w/organic material, soft.					
10	2	2	1	2	2		Dredge Spoil - black silty clay - clayey silt w/organic material, soft.					
15	3	1	1	1	1		Dredge Spoil - black silty clay - clayey silt w/organic material, soft.					
20	4	1	1	1	1		Dredge Spoil - black silty clay - clayey silt w/organic material, soft.					
25	5	1	1	1	1		As above, slightly micaceous.					
30	6	1	1	1	1		Black to brownish black silty fine sand to sandy silt, micaceous, soft.					
35	7	1	1	1	1		Black - dark brown clayey silt, micaceous, soft.					
40	8	1	1	1	2		Dark grey silt fine sand, micaceous, wet, very loose.					
45	9	1	1	2	3		As above, w/light gray sandy laminae.					
50												

GAI - 227 9/72

GILBERT ASSOCIATES, INC.

SOIL AND ROCK CLASSIFICATION SHEET

SHEET 2 OF 2

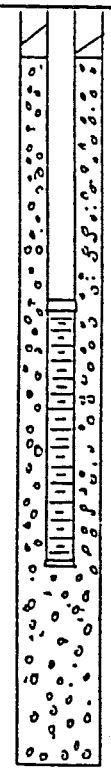
PROJECT: DSWA W.O. 04-5196-000 SITE AREA Cherry Island DRILL HOLE NO. C-105

CONTRACTOR: A.C. Schultes COORDINATES _____ ELEVATION 21.4

DRILLER: C. Kramer GWL 0 HRS _____

CLASSIFIED BY: D.J. Stanislawczyk DATE: 7-25-83 24 HRS _____

Depth Ft.	Sample No.	SPT Blows/6 In. 6	12	18	Ft. Rec.	Profile	DESCRIPTION Density (or Consistency), Color Rock Or Soil Type - Accessories	U.S.C.S.	R.Q.D.	Soil Or Rock: Range Size / Core Run	Grain Shape / Rec. Core	REMARKS Chemical Comp, Geologic Data, Ground Water, Construction Problems, etc.
50												
	10	1	1	1	2		Black - soft - clayey silt w/ sandy silt laminae, wet.					
55												
	11	1	1	1	3		As above, w/black organic material, very soft.					
60												
	12	2	1	3	4		Soft, silty clay - clayey silt, trace of organics.					
65												
	13	12	24	30	37		Dark gray - fine to coarse sand and gravel, gravel up to 1/2" and rounded, very dense.					
70												
75							Overdrill to allow cuttings to settle, 72' - 80'.					
80							TOTAL DEPTH 80'					



NOTES:

1) Set 4" PVC screen (62' - 72') and 4" casing (Screen No. 10 slot).

2) Gravel pack 52' - 80'.

3) Seal 3' - 52' w/bentonite.

4) Develop 50 gpm.

5) Set protector casing and cap.

GAI - 227 9/72

GILBERT ASSOCIATES, INC.

SOIL AND ROCK CLASSIFICATION SHEET

SHEET 1 OF 2

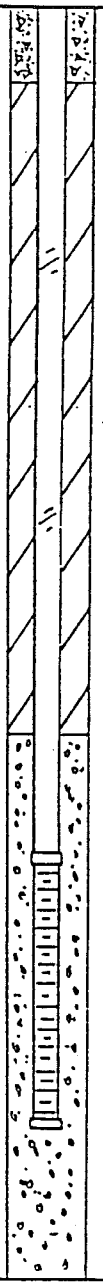
PROJECT: DSWA W.O. 04-5196-000 SITE AREA Cherry Island DRILL HOLE NO. C-106

CONTRACTOR: A.C. Schultes COORDINATES _____ ELEVATION 27.6

DRILLER: C. Kramer GWL 0 HRS _____

CLASSIFIED BY: D.J. Stanislawczyk DATE: 7-20-83 24 HRS _____

Depth Ft.	Sample No.	SPT Blows/6 In. 6	12	18	Ft. Rec.	Profile	DESCRIPTION Density (or Consistency), Color Rock Or Soil Type - Accessories	U.S.C.S.	R.Q.D.	Soil Or Rock: Range Size / Core Run	Grain Shape / Rec. Core	REMARKS Chemical Comp, Geologic Data, Ground Water, Construction Problems, etc. TOC 30.18'
0												
5	1	3	1	2	1		Dredge Spoil - Soft, clayey silt to silty clay, micaceous, traces of organic material.					
10	2	2	1	1	1		As above					
15	3	3	3	3	3		As above					
20	4	1	1	1	2		As above					
25	5	2	2	2	3		As above, trace of very fine sand.					
30	6	2	3	3	4		As above, micaceous.					
35	7	4	5	20	26		Dense-dark gray silty sand and gravel - gravel up to 1".					
40												
45							45 - 50 Medium to coarse sand and gravel.					
50												



GAI - 227 9/72

GILBERT ASSOCIATES, INC.

SOIL AND ROCK CLASSIFICATION SHEET

SHEET 2 OF 2

PROJECT: DSWA W.O. 04-5196-000 SITE AREA Cherry Island DRILL HOLE NO. C-106

CONTRACTOR: A.C. Schultes COORDINATES _____ ELEVATION 27.6

DRILLER: C. Kramer GWL 0 HRS _____

CLASSIFIED BY: D.J. Stanislawczyk DATE: 7-20-83 24 HRS _____

Depth Ft.	Sample No.	SPT Blows/ 6 In. 6 12 18	Ft. Rec.	Profile	DESCRIPTION Density (or Consistency), Color Rock Or Soil Type - Accessories	U.S.C.S.	R.Q.D.	Soil Or Rock: Range Size / Core Run	Soil Or Rock: Grain Shape / Rec. Core	REMARKS Chemical Comp, Geologic Data, Ground Water, Construction Problems, etc.
50					50 - 60 Gray sandy silt to silty clay - overcut to allow for cuttings to settle.					
55										
60					TOTAL DEPTH 60'					

NOTES:

1) Set 4" PVC No. 10 slot screen 34' - 44'.

2) Gravel pack w/No. 1 Morie gravel 29' - 60'.

3) Seal with bentonite 3' - 29'.

4) Develop 5 gpm.

5) Set protector casing and cap.

GAI - 227 9/72

GILBERT ASSOCIATES, INC.

SOIL AND ROCK CLASSIFICATION SHEET

SHEET 1 OF

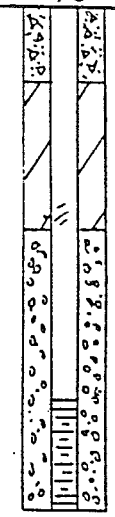
PROJECT: DSWA W.O. 04-5196-000 SITE AREA Cherry Island DRILL HOLE NO. C-

CONTRACTOR: A.C. Schultes COORDINATES ELEVATION 10.

DRILLER: C. Kramer GWL 0 HRS

CLASSIFIED BY: D.J. Stanislawczyk DATE: 8-2-83 24 HRS

Depth Ft.	Sample No.	SPT Blows/ 6 In. (6 12 18)	Ft. Rec.	Profile	DESCRIPTION Density (or Consistency), Color Rock Or Soil Type - Accessories	U.S.C.S.	R.Q.D.	Soil Or Rock: Range Size / Core Run	Soil Or Rock: Grain Shape / Rec. Core	REMARKS Chemical Comp, Geologic Data, Ground Water, Construction Proc etc. TOC 1
0										
5					0 - 10 Sand - Fill					
10										
15					10 - 20 Grey Clay - silty					
20					TOTAL DEPTH 20'					
25					NOTES: 1) Screen 16' - 20' (4" PVC). 2) Gravel 14' - 20' (No. 1 Morie) 3) Seal 3' - 14' (Bentonite). 4) Develop 1/4 gpm. 5) Set protector casing and cap.					



GAI - 22

GILBERT ASSOCIATES, INC.

SOIL AND ROCK CLASSIFICATION SHEET

SHEET 1 OF 2

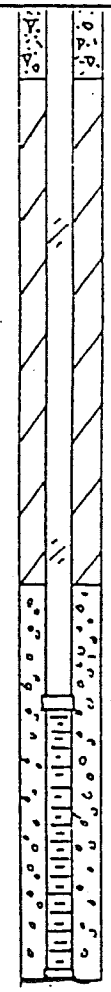
PROJECT: DSWA W.O. 04-5196-000 SITE AREA Cherry Island DRILL HOLE NO. C-108

CONTRACTOR: A.C. Schultes COORDINATES _____ ELEVATION 27.2

DRILLER: C. Kramer GWL 0 HRS _____

CLASSIFIED BY: D. J. Stanislawczyk DATE: 7-18-83 24 HRS _____

Depth Ft.	Sample No.	SPT Blows/6 In. 6	12	18	Ft. Rec.	Profile	DESCRIPTION Density (or Consistency), Color Rock Or Soil Type - Accessories	U.S.C.S.	R.Q.D.	Soil Or Rock: Range Size / Core Run	Grain Shape / Rec. Core	REMARKS Chemical Comp, Geologic Data, Ground Water, Construction Problems, etc. TOC 30.52
0												
5	1	5	6	11	8		Brown - soft clayey silt w/some fine sand					
10	2	1	1	1	2		Black - very soft clayey silt w/some organic material					
15	3	1	2	2	3		Dredge Spoil - soft, black clayey silt w/organic material					
20	4	2	3	5	4		Dredge Spoil - as above, trace very fine sand, slightly micaceous					
25	5	3	2	2	6		Dark Brownish Gray - clayey silt w/trace very fine sand, organic, slightly micaceous, soft					
30	6	7	16	23	18		Dense-Brown - fine coarse sand and gravel, wet					
35							30 - 40 - As above, w/more fine gravel					
40							40 - 50 - Silty, sand and gravel					
45												
50							TOTAL DEPTH 50'					



GAI - 227 9/72

GILBERT ASSOCIATES, INC.

SOIL AND ROCK CLASSIFICATION SHEET

SHEET 2 OF 2

PROJECT: DSWA W.O. 04-5196-000 SITE AREA Cherry Island DRILL HOLE NO. C-108

CONTRACTOR: A.C. Schultes COORDINATES _____ ELEVATION 27.2

DRILLER: C. Kramer GWL 0 HRS _____

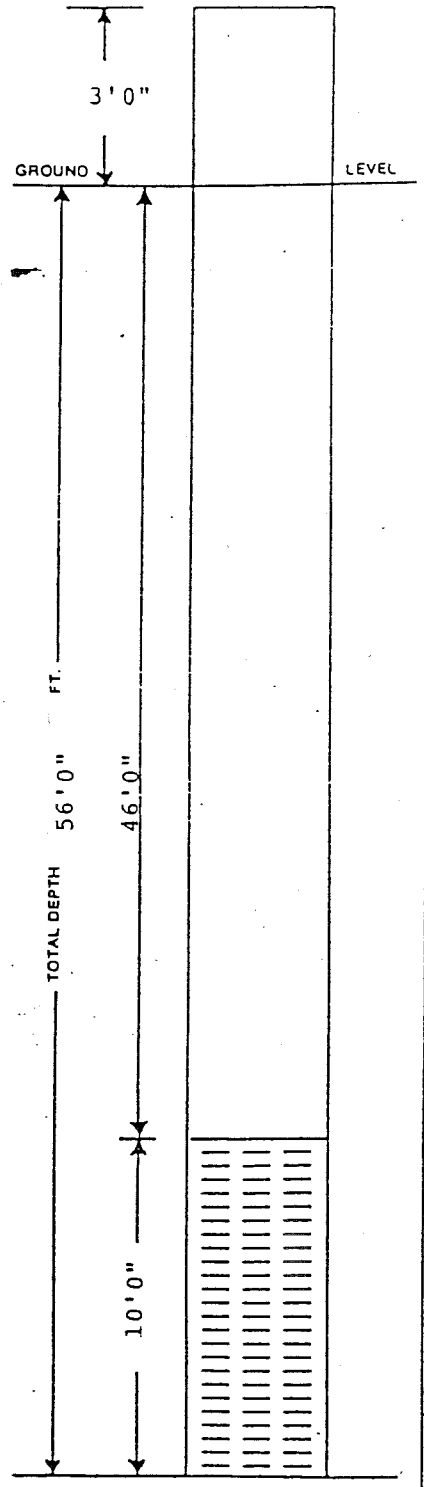
CLASSIFIED BY: D. J. Stanislawczyk DATE: 7-18-83 24 HRS _____

Depth Ft.	Sample No.	SPT Blows/ 6 In. (6 12 18)	Ft. Rec.	Profile	DESCRIPTION Density (or Consistency), Color Rock Or Soil Type - Accessories	U.S.C.S.	R.Q.D.	Soil Or Rock: Range Size / Core Run	Soil Or Rock: Grain Shape / Rec. Core	REMARKS Chemical Comp, Geologic Data, Ground Water, Construction Problems, etc.
					NOTES: 1) Set 4" PVC screen (No. 10 slot) from 28' - 38'. Hole caved, couldn't get casing to 40'. 2) Gravel pack w/No. 1 Morie gravel 23 - 38'. 3) Bentonite seal 3 - 23'. 4) Develop 10 - 15 gpm. 5) Set protector casing and cap.					

GAI - 227 9/72

A.C. SCHULTES & SONS, INC.

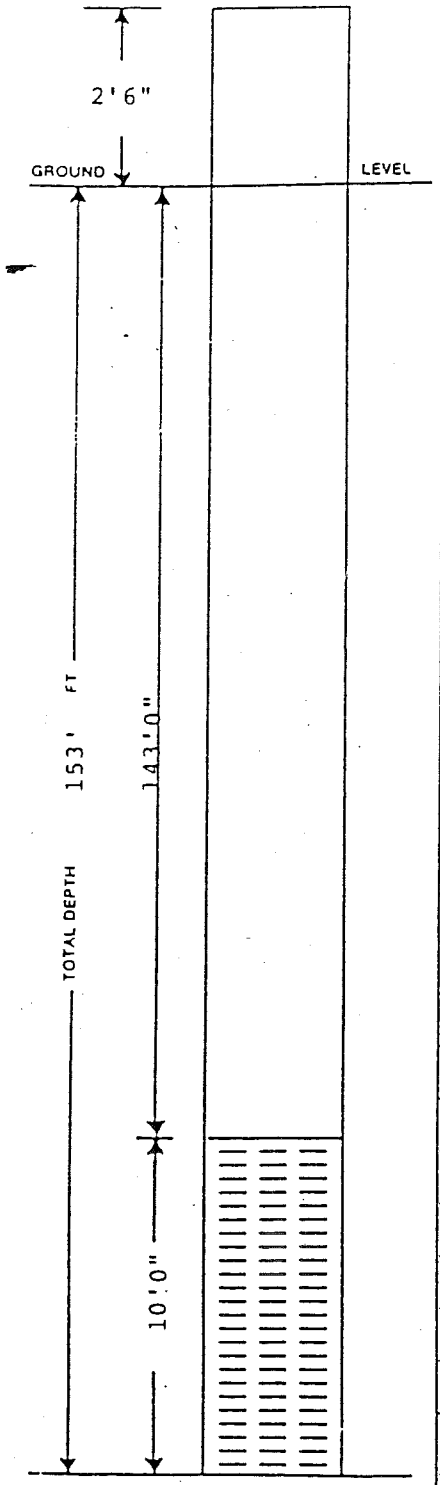
SINGLE CASED WELL



WELL LOG	FEET FROM GROUND SURFACE	NAME OF OWNER
Brown clay	0 to 2	Delaware Solid Wa
Gray clay, soft	2 - 21	Location Cherry Island, DE
Peat	21 - 24	Well No P-100
Silty sand	24 - 35	State Permit
Clay white	35 - 40	Job No 19531
Green clay, hard	40 - 50	Test Pumped (Hrs.) Blew 1 Hour
Sand yellow, hard	50 - 61	Capacity (GPM) 5
Orange clay	61 - 70	Static Level 13.25
Chips rock		Pumping Level
Silt	70 - 75	Datum
Fine white sand	75 - 95	Specific Capacity
Silt, green clay	95 - 103	Diameter of Casing 4"
Rock	103 - 110	Depth of Well (Ground) 56'0"
		Depth to Gravel 40'0"
		Gravel Size 1
		Length of Casing & Screen 59'
		Screen Material PVC
		Screen Mfg.
		Screen Dia. 4"
		Length of Screen 10'0"
		Top of Screen Fitting Couple
		Bottom of Screen Fitting Cap
		Slot Size .010
		Seal Material Bentonite
		Quantity 2 Bags
		Depth of Seal Material 3-40
		Drilling Machine 6B
		Date Well Completed August 3, 1983
		Driller C. Krammer

A.C. SCHULTES & SONS, INC.

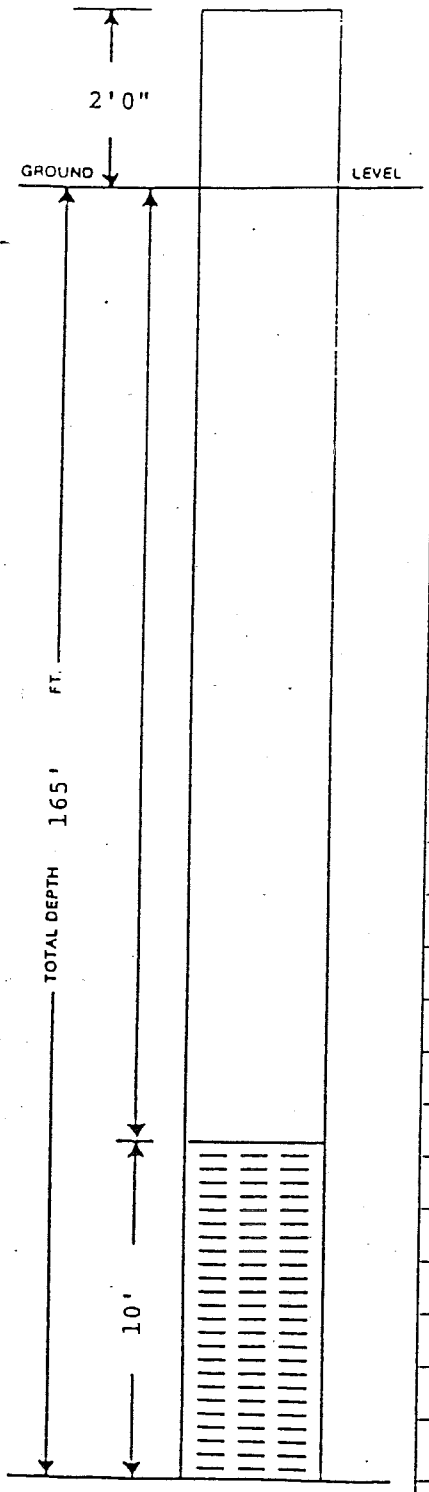
SINGLE CASED WELL



WELL LOG	FEET FROM GROUND SURFACE	NAME OF OWNER
Brown clay	0 to 4	Delaware Solid Waste
Gray clay, soft	4 - 6	Location: Cherry Island, D
White gravel	6 - 10	Well No: P-101
Gray clay	10 - 58	State Permit:
Sand & gravel white	58 - 73	Job No.: 19531
Silty sand	73 - 82	Test Pumped (Hrs.): Blew 1 Hou
Sand & gravel	82 - 98	Capacity (GPM): 5
Hard layer	98 - 99	Static Level: 34-2
Sand white, med	99 - 105	Pumping Level:
Silt	105 - 110	Datum:
Red clay, hard	110 - 125	Specific Capacity:
Silty sand, red	125 - 130	Diameter of Casing: 4"
Blue-green clay	130 - 133	Depth of Well (Ground): 153
Silty sand	133 - 140	Depth to Gravel: 135'
White fine sand hard packed	140 - 151	Gravel Size: 1
Sand streaks clay	151 - 163	Length of Casing & Screen: 156'
Silty green clay	163 - 165	Screen Material: PVC
Yellow clay, hard	165 - 170	Screen Mfg.:
Sand clay layers	170 - 185	Screen Dia.: 4"
Weather Zone	185 - 200	Length of Screen: 10'0"
		Top of Screen Fitting: Couple
		Bottom of Screen Fitting: Cap
		Slot Size: .010
		Seal Material: Bentonite
		Quantity: 5 Bags
		Depth of Seal Material: 3-135
		Drilling Machine: 6B
		Date Well Completed: August 5, 1983
		Driller: C. Krammer

A.C. SCHULTES & SONS, INC.

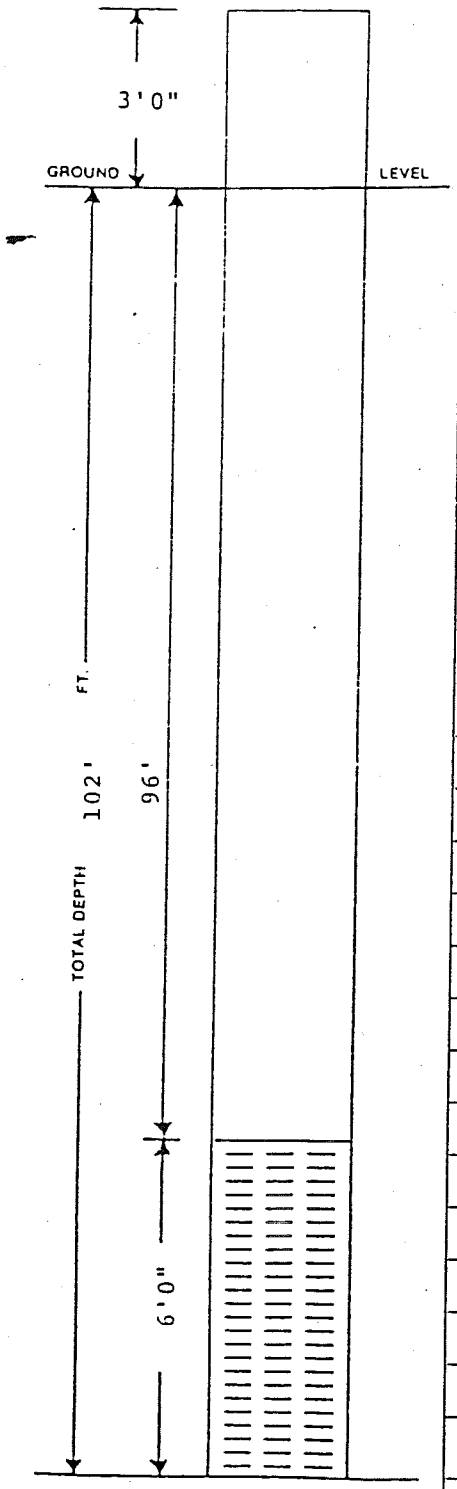
SINGLE CASED WELL



WELL LOG	FEET FROM GROUND SURFACE	NAME OF OWN.
Sand & stones	0 to 2	Delaware Solid Wast
Gray silt, soft	2 - 34	Location Cherry Island, D
Sand, rocks, white	34 - 45	Well No P-102
Clay layers rocks	45 - 80	State Permit
Rocks	80 - 92	Job No 19531
Clay silt rocks	92 -107	Test Pumped (Hrs) Blew 1 hou
Clay yellow hard	107 -115	Capacity (GPM) 1.5
Red clay, hard	115 -133	Static Level 25.2
Red clay hard layers	133 -150	Pumping Level
Sand silty	150 -189	Datum
Green clay	189 -218	Specific Capacity
		Diameter of Casing 4"
		Depth of Well (Ground) 165
		Depth to Gravel 145
		Gravel Size 1
		Length of Casing & Screen 167'
		Screen Material PVC
		Screen Mfg.
		Screen Dia. 4"
		Length of Screen 10'0"
		Top of Screen Fitting Couple
		Bottom of Screen Fitting Cap
		Slot Size .010
		Seal Material Bentonite
		Quantity 5 Bags
		Depth of Seal Material 3-145
		Drilling Machine 6B
		Date Well Completed July 12, 1983
		Driller

A.C. SCHULTES & SONS, INC.

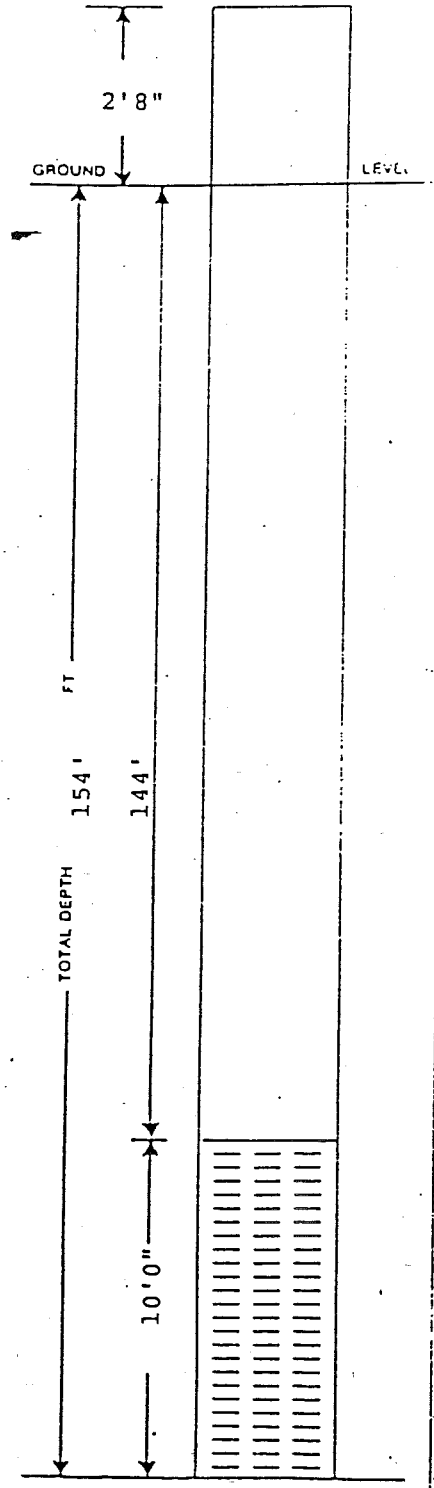
SINGLE CASED WELL



WELL LOG	FEET FROM GROUND SURFACE	NAME OF OWNER
Brown clay	0 to 5	Delaware Solid Waste
Gray clay, soft	5- 98	Location Cherry Island,
Sand & gravel, white	98-103	Well No P-103
Silty red clay	103-105	State Permit
Red clay, hard	105-107	Job No 19531
Green clay, hard	107-109	Test Pumped (Hrs.) Blew 1 Hou
Weather Zone	109-130	Capacity (GPM) 50
		Static Level 9.5
		Pumping Level
		Datum
		Specific Capacity
		Diameter of Casing 4"
		Depth of Well (Ground) 102'
		Depth to Gravel 86
		Gravel Size 1
		Length of Casing & Screen 105'
		Screen Material PVC
		Screen Mfg.
		Screen Dia. 4"
		Length of Screen 6'0"
		Top of Screen Fitting Couple
		Bottom of Screen Fitting Cap
		Slot Size 010
		Seal Material Bentonite
		Quantity 3 Bags
		Depth of Seal Material 3 - 86
		Drilling Machine 6B
		Date Well Completed July 28, 1983
		Driller C. Krammer

A.C. SCHULTES & SONS, INC.

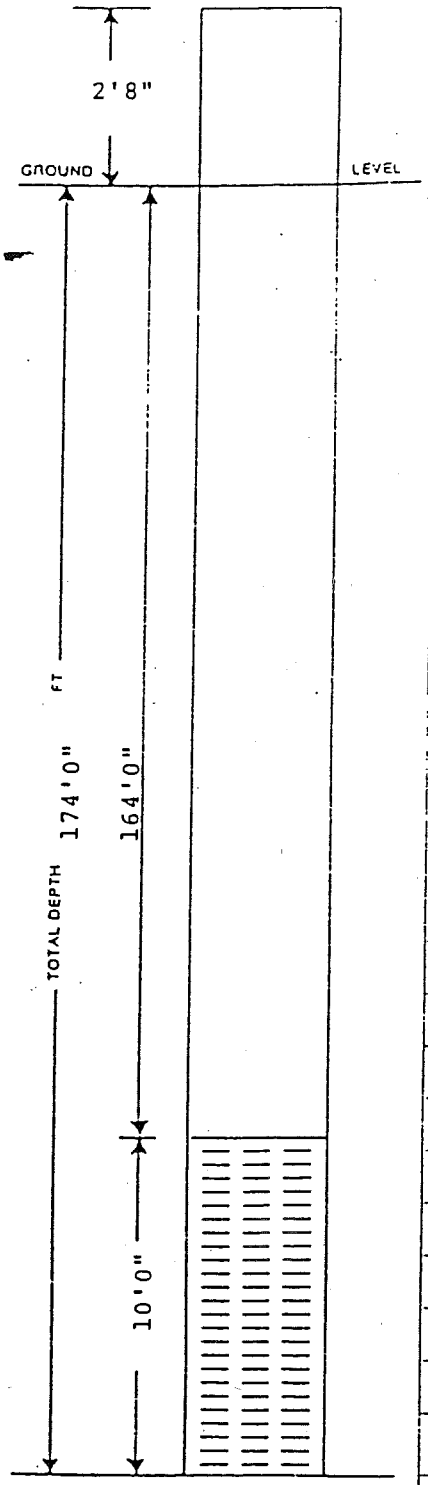
SINGLE CASED WELL



WELL LOG	FEET FROM GROUND SURFACE	NAME OF OWNER
Brown clay	0 to 7	Delaware Solid Waste
Gray clay, soft	7 - 58	Location: Cherry Island, DI
Sand white, med.	58 - 66	Well No.: P-104
Gray clay, soft	66 - 100	State Permit
Brown silty clay	100 - 110	Job No: 19531
Clay white, hard	110 - 120	Test Pumped (Hrs): Blew 1 Hou
Clay red, hard	120 - 130	Capacity (GPM): 25
Silty sand	130 - 133	Static Level: 9.1
Silty red clay	133 - 140	Pumping Level
Fine sand, white	140 - 145	Datum: G.L.
Sand streaks clay	145 - 155	Specific Capacity
Yellow		Diameter of Casing: 4"
Green clay, hard	155 - 162	Depth of Well (Ground): 154'
Silty sand	162 - 165	Depth to Gravel: 135'
Silty clay	165 - 173	Gravel Size: 1
Weather Zone	173 - 195	Length of Casing & Screen: 156'
		Screen Material: PVC
		Screen Mfg.
		Screen Dia.: 4"
		Length of Screen: 10'0"
		Top of Screen Fitting: Couple
		Bottom of Screen Fitting: Cap
		Slot Size: .010
		Seal Material: Bentonite
		Quantity: 5 Bags
		Depth of Seal Material: 3 - 135
		Drilling Machine: 6B
		Date Well Completed: July 27, 1983
		Driller

A.C. SCHULTES & SONS INC.

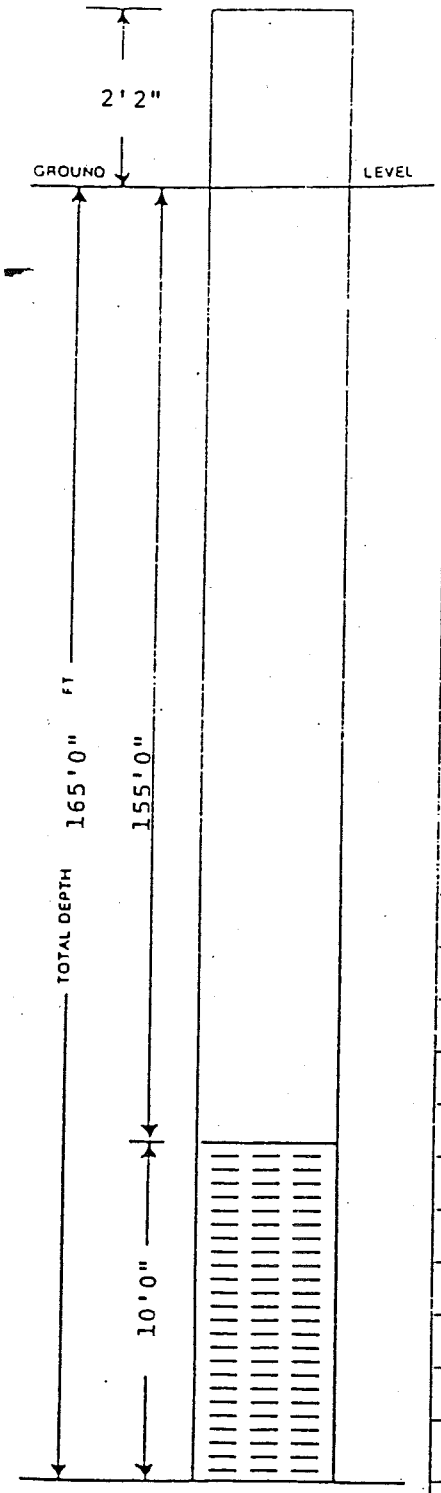
SINGLE CASED WELL



WELL LOG	FEET FROM GROUND SURFACE	NAME OF OWNER
Brown clay	0 to 6	Delaware Solid Waste
Gray clay, soft	6- 63	Location Cherry Island, DE
Sand & gravel white	63- 75	Well No. P-105
Red & white clay hard	75- 79	State Permit
Stone layers red clay	79- 81	Job No 19531
Fine white sand	81- 88	Test Pumped (Hrs.) Blew 1 Hou
Sand hard layers	88- 95	Capacity (GPM) 3
Silty sand brown	95-104	Static Level 20.0
White clay & Silty sand	104-108	Pumping Level
Sand & stones	108-125	Datum G.L.
White clay, hard	125-130	Specific Capacity
Sand fine white	130-134	Diameter of Casing 4"
Purple clay/ steak sand	134-144	Depth of Well (Ground) 174'0"
Sand fine white	144-146	Depth to Gravel 150
Red clay	146-149	Gravel Size 1
Silty sand Layers red clay	149-158	Length of Casing & Screen 177'
Red clay Yellow hard	158-163	Screen Material PVC
Silty sand, hard	163-177	Screen Mfg.
Red & white clay, hard	177-184	Screen Dia. 4"
Sand silty	184-194	Length of Screen 10'0"
Mixed clay, hard	194-220	Top of Screen Fitting Couple
		Bottom of Screen Fitting Cap
		Slot Size .010
		Seal Material Bentonite
		Quantity 6 Bags
		Depth of Seal Material 3-150
		Drilling Machine 6B
		Date Well Completed July 22,1983
		Driller C. Krammer

A.C. SCHULTES & SONS INC.

SINGLE CASED WELL

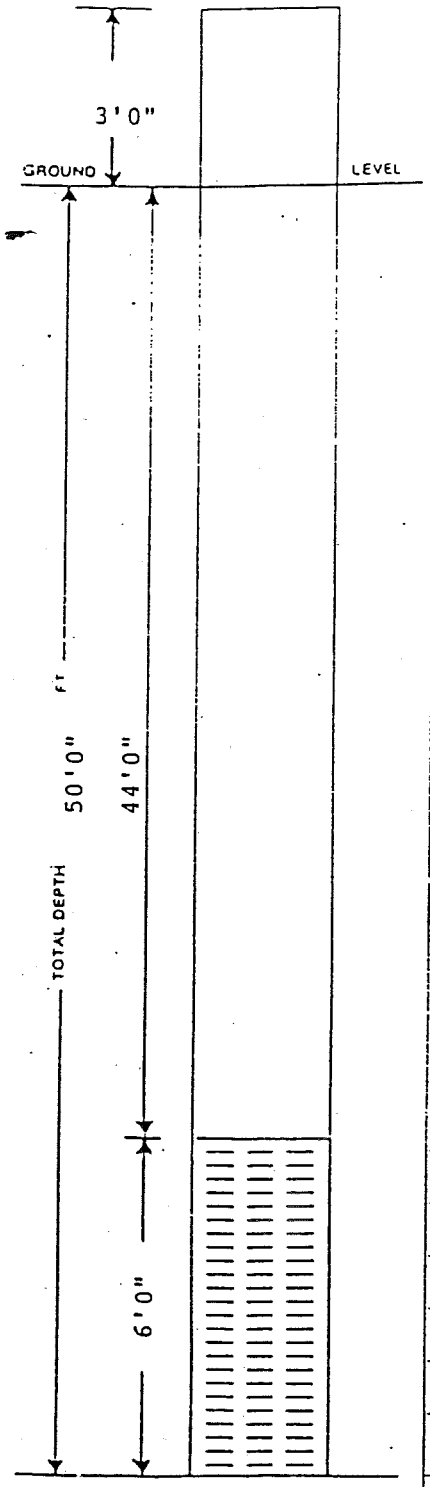


WELL LOG	FEET FROM GROUND SURFACE
Brown clay	0 to 5
Green silty clay	5- 34
Rocks & gravel	34- 45
Silty white clay	45- 83
Stones	83- 86
Green clay, hard	86- 96
Hard layers	96- 98
Clay	98-100
Silty clay	100-104
Green silty clay	104-113
Silty sand	113-116
Brown silty clay	116-120
Silty sand	120-135
Red & white clay hard	135-174
Silty sand	174-180
Clay hard	180-184
Sand hard white packed	184-195
Silty green clay	195-210
Blue clay, hard	210-215
Sand hard packed	215-219
Green silty clay	219-236
Green clay, hard	236-250
Weather Zone	250-255

NAME OF OWNER	
	Delaware Solid Waste
Location	Cherry Island, D
Well No	P-106
State Permit	
Job No	19531
Test Pumping Hrs	Blew 1 Hou
Capacity (GPM)	5
Static Level	28.3
Pumping Level	
Datum	G.L.
Specific Capacity	
Diameter of Casing	4"
Depth of Well (Ground)	165'
Depth to Gravel	138'
Gravel Size	1
Length of Casing & Screen	167'
Screen Material	PVC
Screen Mfg.	
Screen Dia	4"
Length of Screen	10'0"
Top of Screen Fitting	Couple
Bottom of Screen Fitting	Cap
Slot Size	.010
Seal Material	Bentonite
Quantity	6 Bags
Depth of Seal Material	3-138
Drilling Machine	6B
Date Well Completed	July 21, 1983
Driller	C. Krammer

A.C. SCHULTES & SONS, INC.

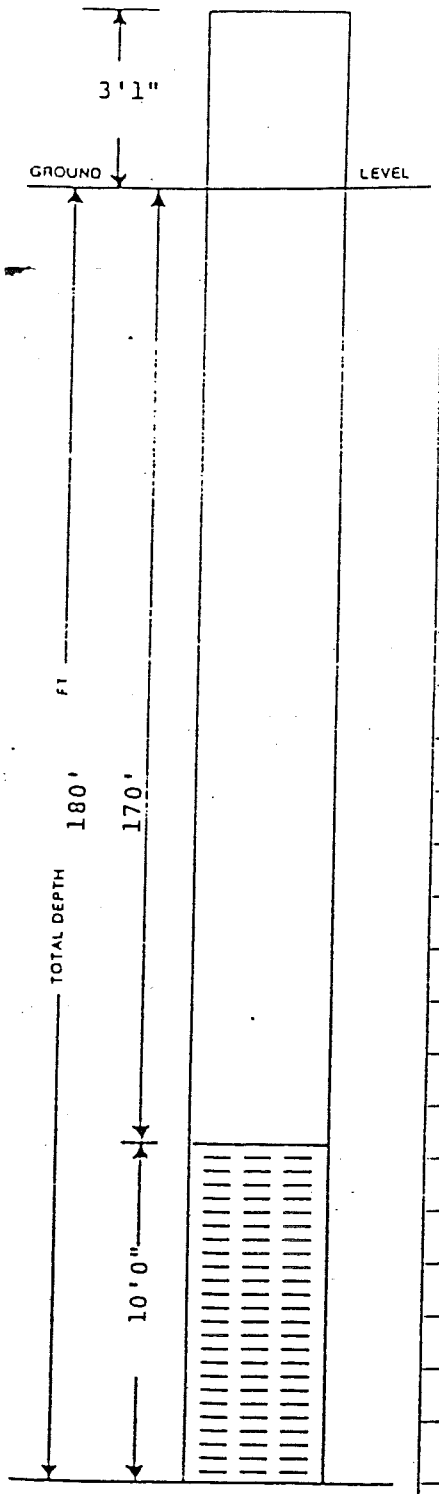
SINGLE CASED WELL



WELL LOG	FEET FROM GROUND SURFACE	NAME OF OWNER
Sand & fill	0 to 7	Delaware Solid Waste
Gray clay, soft	7 - 44	Location: Cherry Island, DE
Sand & gravel	44 - 52	Well No.: P-107
Weather zone	52 - 61	State Permit:
Red clay, hard	61	Job No: 19531
		Test Pumped (Hrs.): Blew 1 Hou
		Capacity (GPM): 30
		Static Level: 8'0"
		Pumping Level:
		Datum:
		Specific Capacity:
		Diameter of Casing: 4"
		Depth of Well (Ground): 50'0"
		Depth to Gravel: 39'0"
		Gravel Size: 1
		Length of Casing & Screen: 53'0"
		Screen Material: PVC
		Screen Mfg.:
		Screen Dia.: 4"
		Length of Screen: 6'0"
		Top of Screen Fitting: Couple
		Bottom of Screen Fitting: Cap
		Slot Size: .010
		Seal Material: Bentonite
		Quantity: 2 Bags
		Depth of Seal Material: 3-39
		Drilling Machine: 6B
		Date Well Completed: August 2, 1983
		Driller: C. Krammer

A.C. SCHULTES & SONS, INC.

SINGLE CASED WELL



WELL LOG	FEET FROM GROUND SURFACE	NAME OF OWNER
Brown clay	0 to 7	Delaware Solid Waste
Gray clay silty	7 - 30	Location: Cherry Island, D
Sand med white	30 - 31	Well No: P-108
Rocks & gravel	31 - 43	State Permit:
Silty sand	43 - 55	Job No: 19531
Rocks	55 - 58	Test Pumping (Hrs.): Blew 1 Hour
Silty sand	58 - 62	Capacity (GPM): 4
Sand med. white	62 - 85	Static Level: 26.25
Silty sand, gravel	85 - 115	Pumping Level:
Brown clay	115 - 127	Datum: G.L.
Hard layer	127 - 128	Specific Capacity:
Brown clay, hard	128 - 135	Diameter of Casing: 4"
Yellow clay, hard	135 - 141	Depth of Well (Ground): 183'
White clay, hard	141 - 145	Depth to Gravel: 160'
Silty sand	145 - 155	Gravel Size: 1
Red, white clay	155 - 174	Length of Casing & Screen: 180
Hard layers	174 - 175	Screen Material: PVC
Red clay, hard	175 - 195	Screen Mfg.:
Cemented sand	195 - 202	Screen Dia.: 4"
Green yellow clay	202 - 225	Length of Screen: 10'0"
Weather zone	225 - 230	Top of Screen Fitting: Couple
		Bottom of Screen Fitting: Cap
		Slot Size: .010
		Seal Material: Bentonite
		Quantity: 7 Bags
		Depth of Seal Material: 3-160
		Drilling Machine: 6B
		Date Well Completed: July 18, 1983
		Driller: C. Krammer

APPENDIX B

GEOPHYSICAL LOGS

TABLE B-1

GEOPHYSICAL INTERPRETATIONS

Well No.	Recent[1]	Formation Contact Depth (feet) Columbia	Potomac	Weathered Rock
P-100	0 - 21	21 - 35	35 - 95	95
P-101	6 - 60	60 - 104	104 - 162	162
P-102	0 - 38	38 - 78	78 - 192	192
P-103	0 - 98	98 - 103	103 - 109	109
P-104	0 - 52	52 - 120	120 - 158	158
P-105	0 - 63	63 - 81	81 - 214	214
P-106	0 - 28	28 - 80	80 - 224	224
P-107	0 - 44	44 - 61	61	---
P-108	0 - 31	31 - 80	80 - 223	223

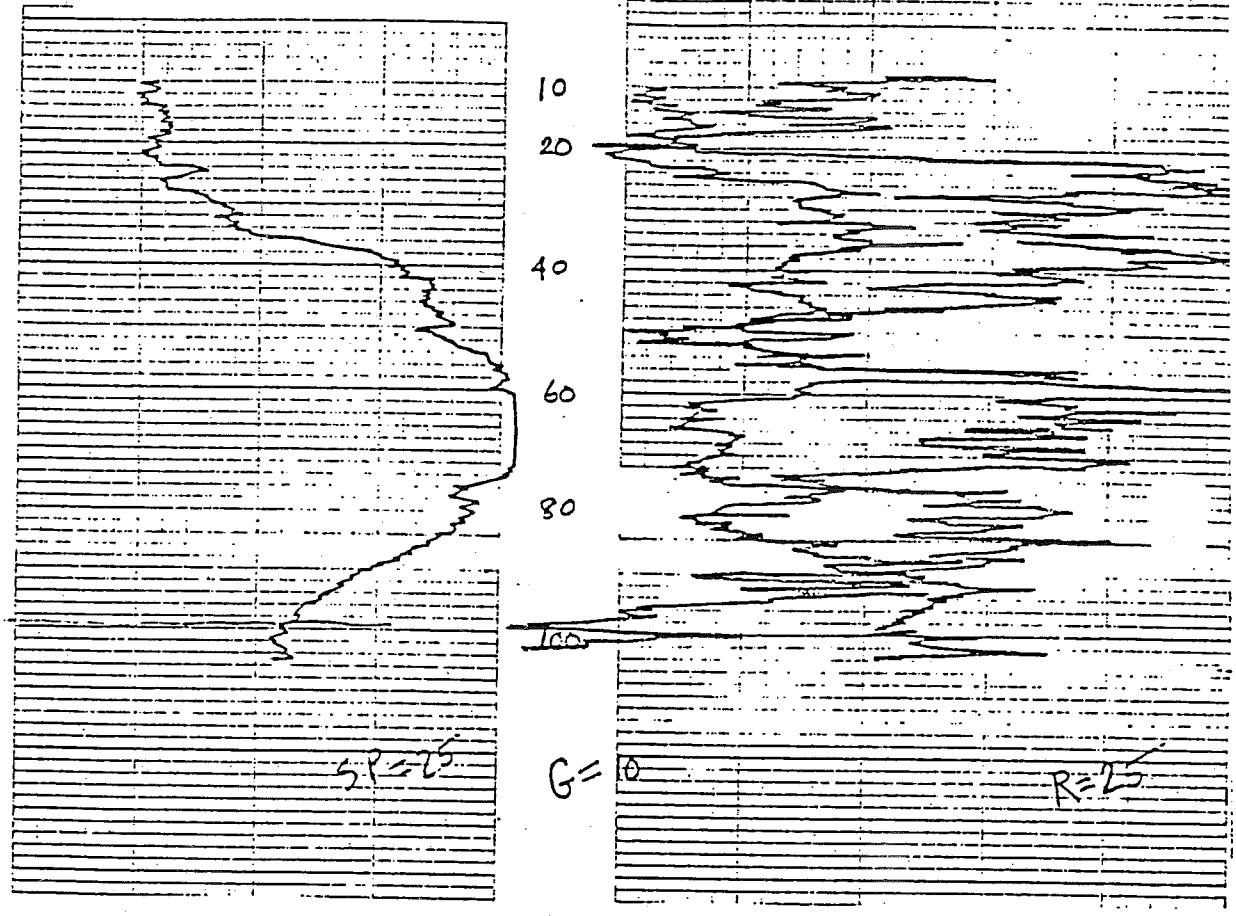
[1] Recent includes dredge spoil deposits

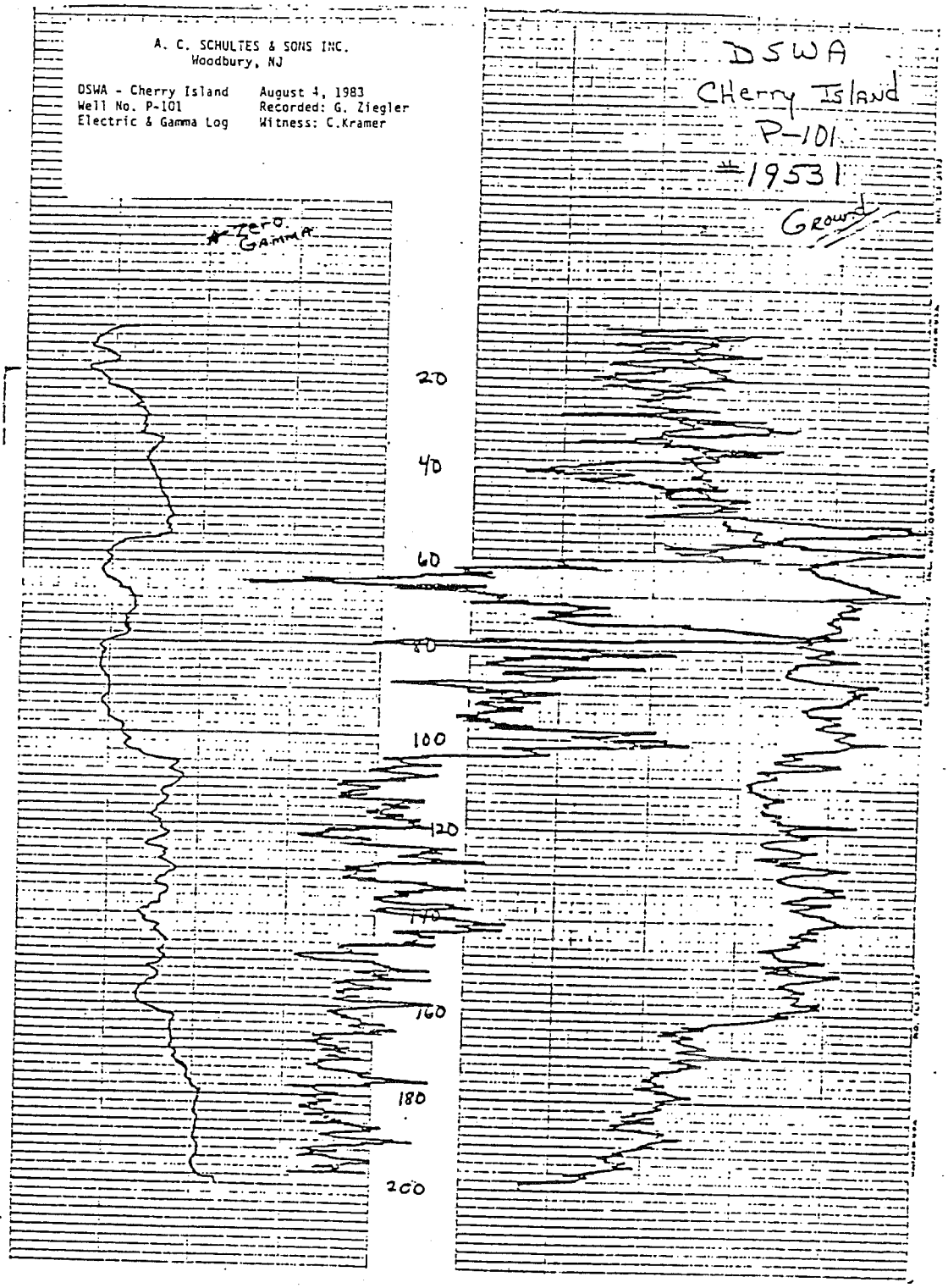
A. C. SCHULTES & SONS INC.
Woodbury, NJ

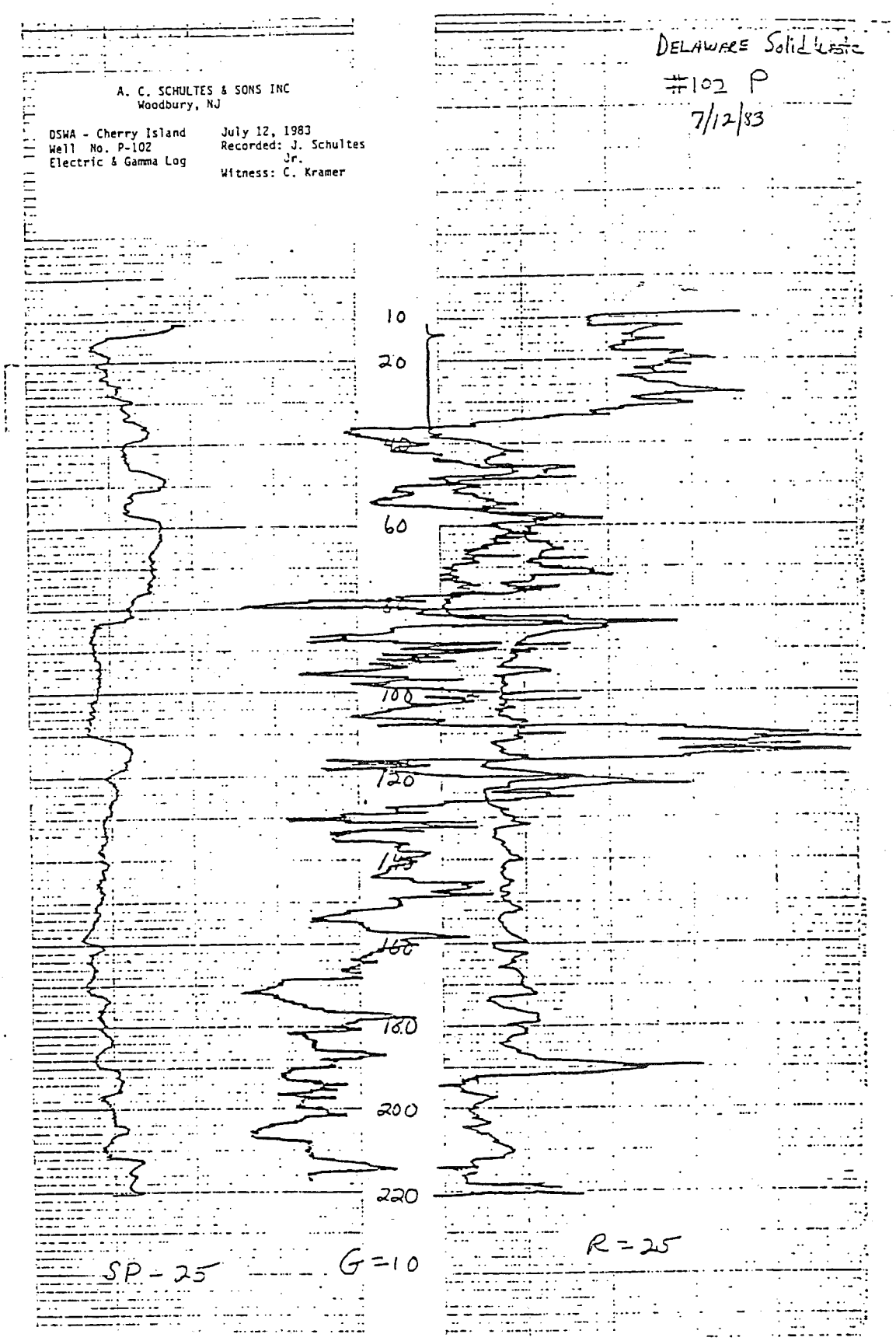
DSWA-Cherry Island
Well No. P-100
Electric & Gamma Log

August 2, 1983
Recorded: J.Schultes Jr
Witness: C. Kramer

DEL SOLID WAST
P-100
8/2/83
Ground Level
19531




A. C. SCHULTES & SONS INC.
Woodbury, NJ
DSWA - Cherry Island
Well No. P-101
Electric & Gamma Log
August 4, 1983
Recorded: G. Ziegler
Witness: C.Kramer
DSWA
Cherry Island
P-101
#19531
Ground
Zero Gamma
20
40
60
80
100
120
140
160
180
200

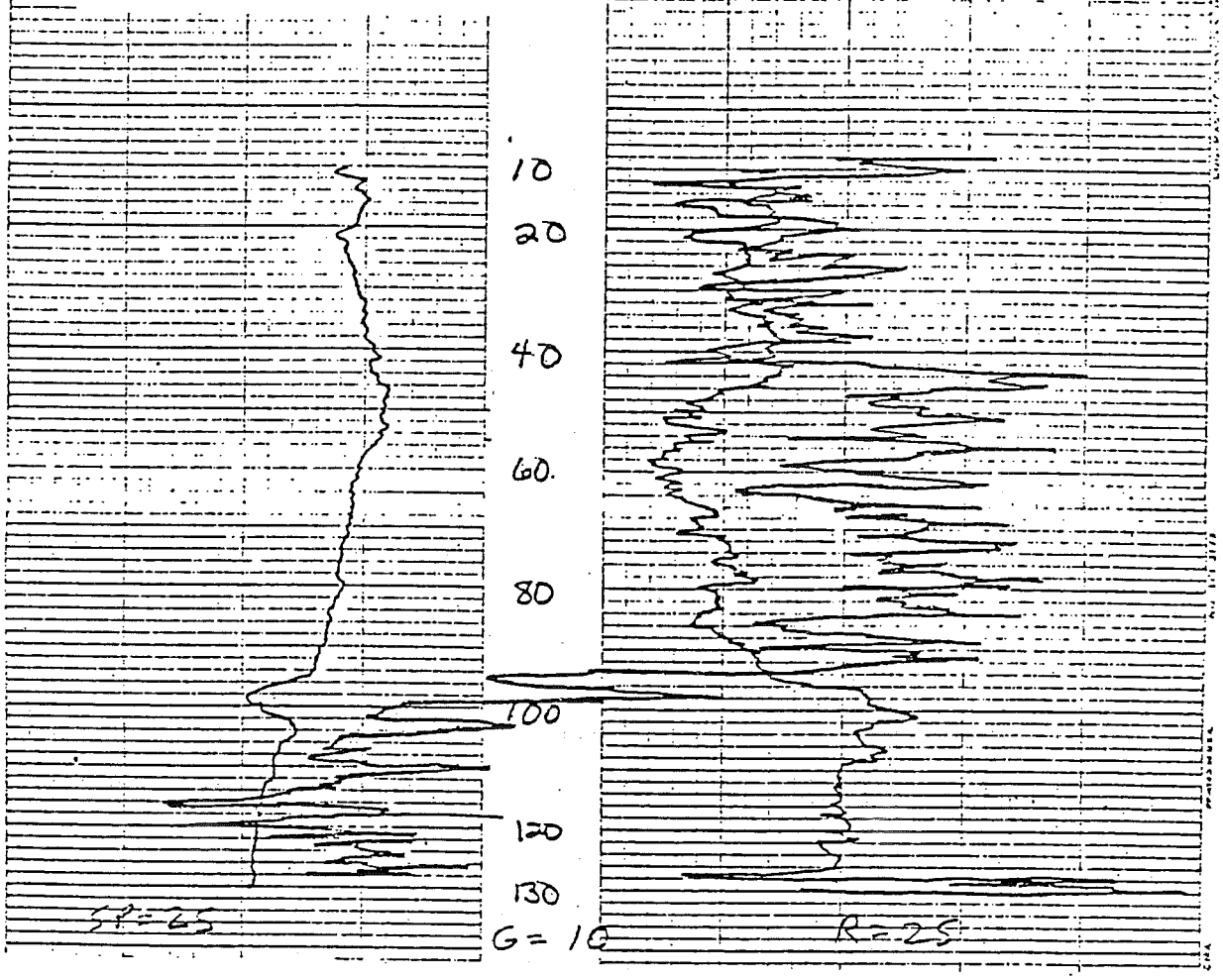

A. C. SCHULTES & SONS INC
Woodbury, NJ
DSWA - Cherry Island
Well No. P-102
Electric & Gamma Log
July 12, 1983
Recorded: J. Schultes Jr.
Witness: C. Kramer
DELAWARE Solid Waste
#102 P
7/12/83
10
20
60
100
120
140
160
180
200
220
SP - 25
G = 10
R = 25

A. C. SCHULTES & SONS INC
Woodbury, NJ

DSWA - Cherry Island
Well No. P-103
Electric & Gamma Log

July 28, 1983
Recorded: G. Ziegler
Witness: C. Kramer

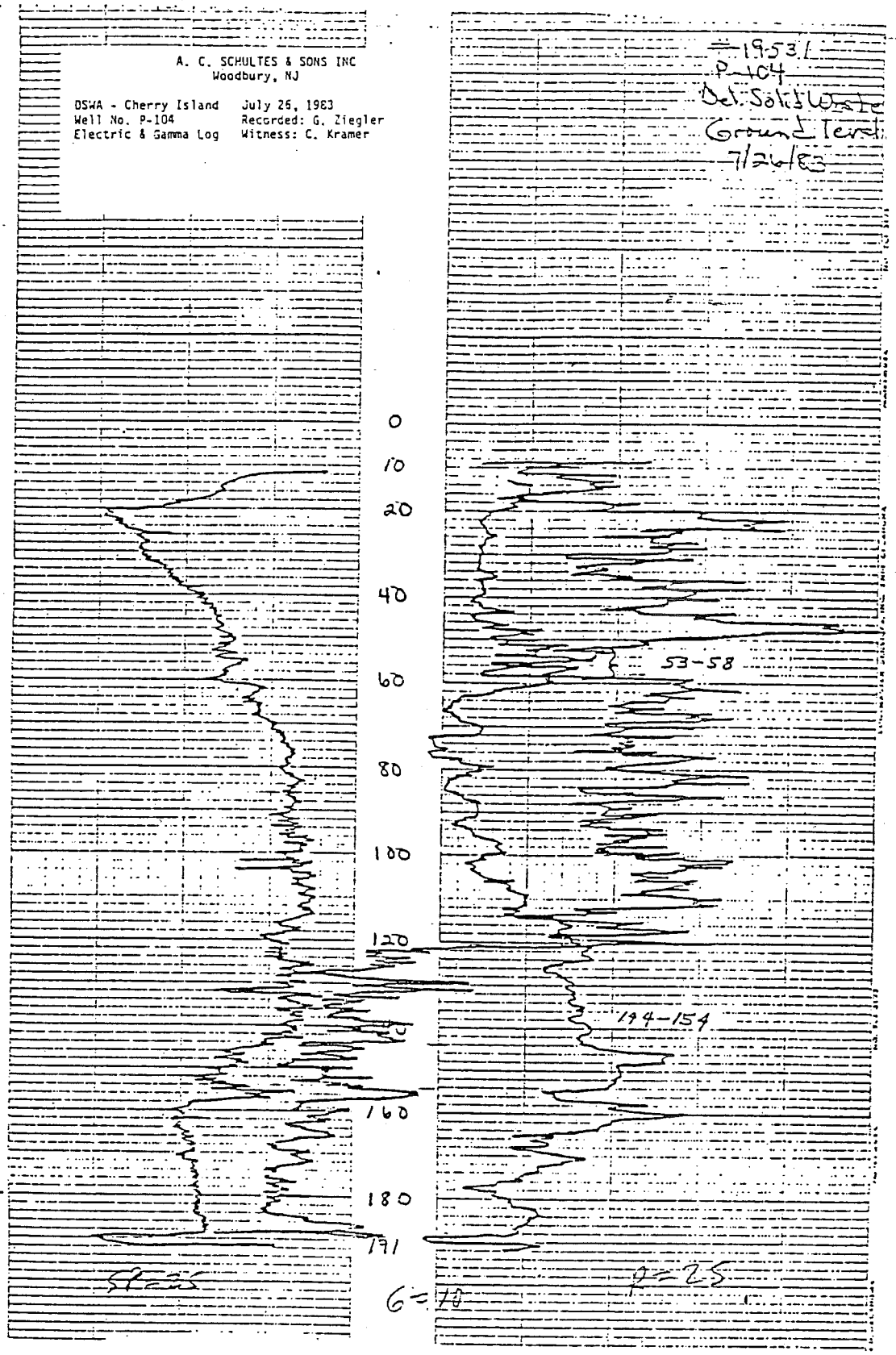
P-103
Del. Solid Waste Auth
19531

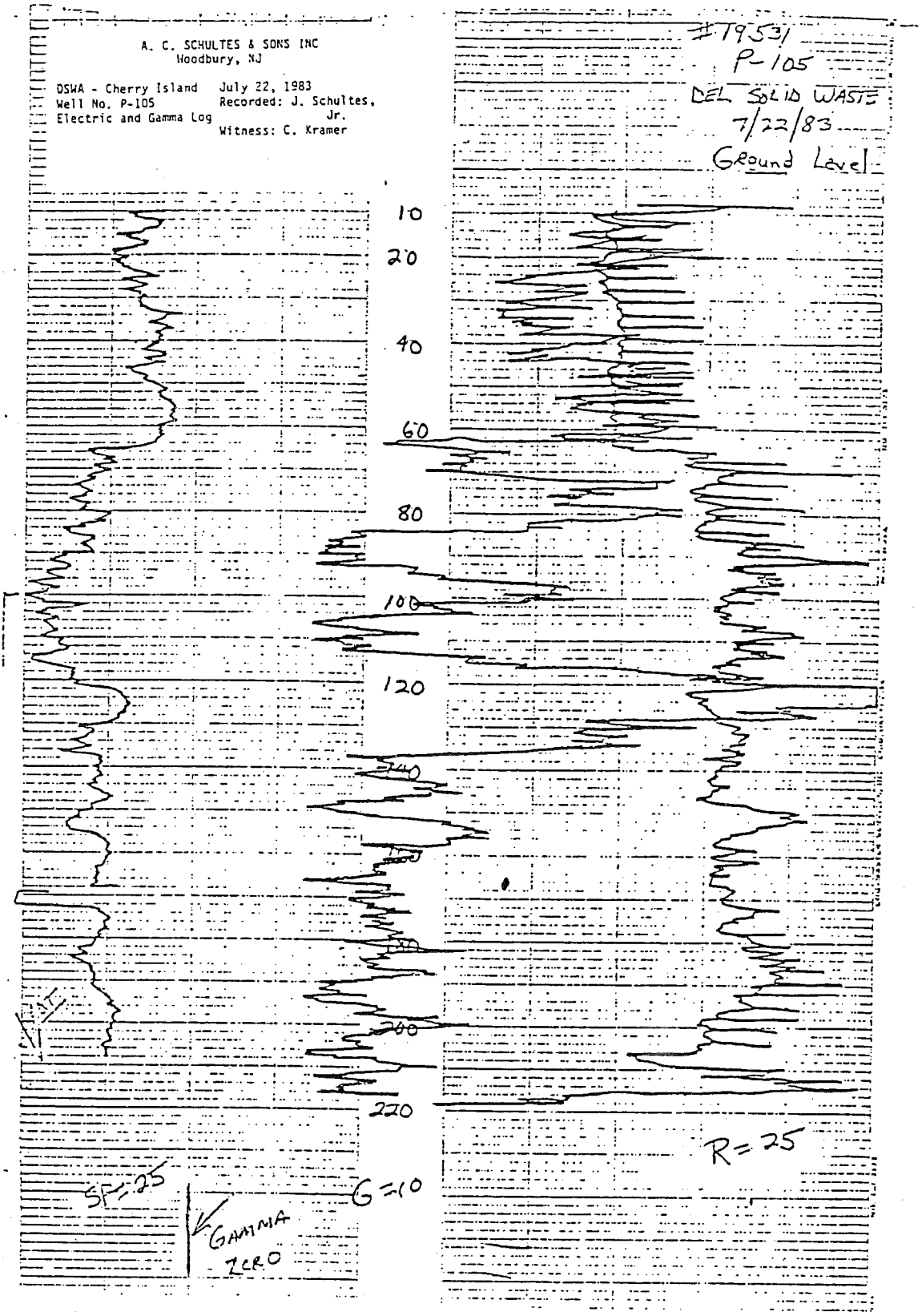


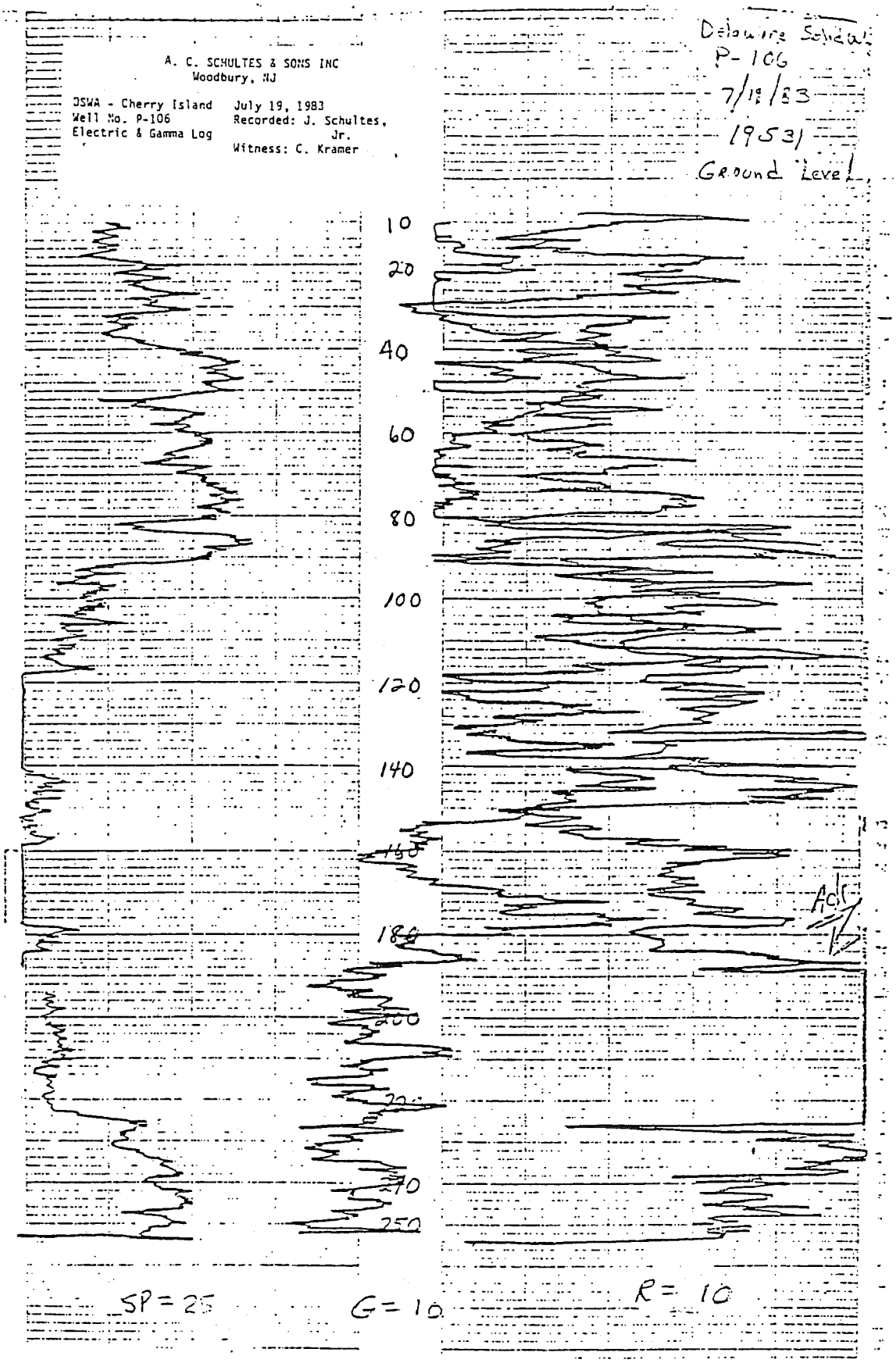
A. C. SCHULTES & SONS INC
Woodbury, NJ

OSWA - Cherry Island
Well No. P-104
Electric & Gamma Log

July 26, 1983
Recorded: G. Ziegler
Witness: C. Kramer




A. C. SCHULTES & SONS INC
Woodbury, NJ
DSWA - Cherry Island
Well No. P-105
Electric and Gamma Log
July 22, 1983
Recorded: J. Schultes, Jr.
Witness: C. Kramer
#19531
P-105
DEL SOLID WASTE
7/22/83
Ground Level
10
20
40
60
80
100
120
140
160
180
200
220
R=25
SP=25
G=10
GAMMA ZERO

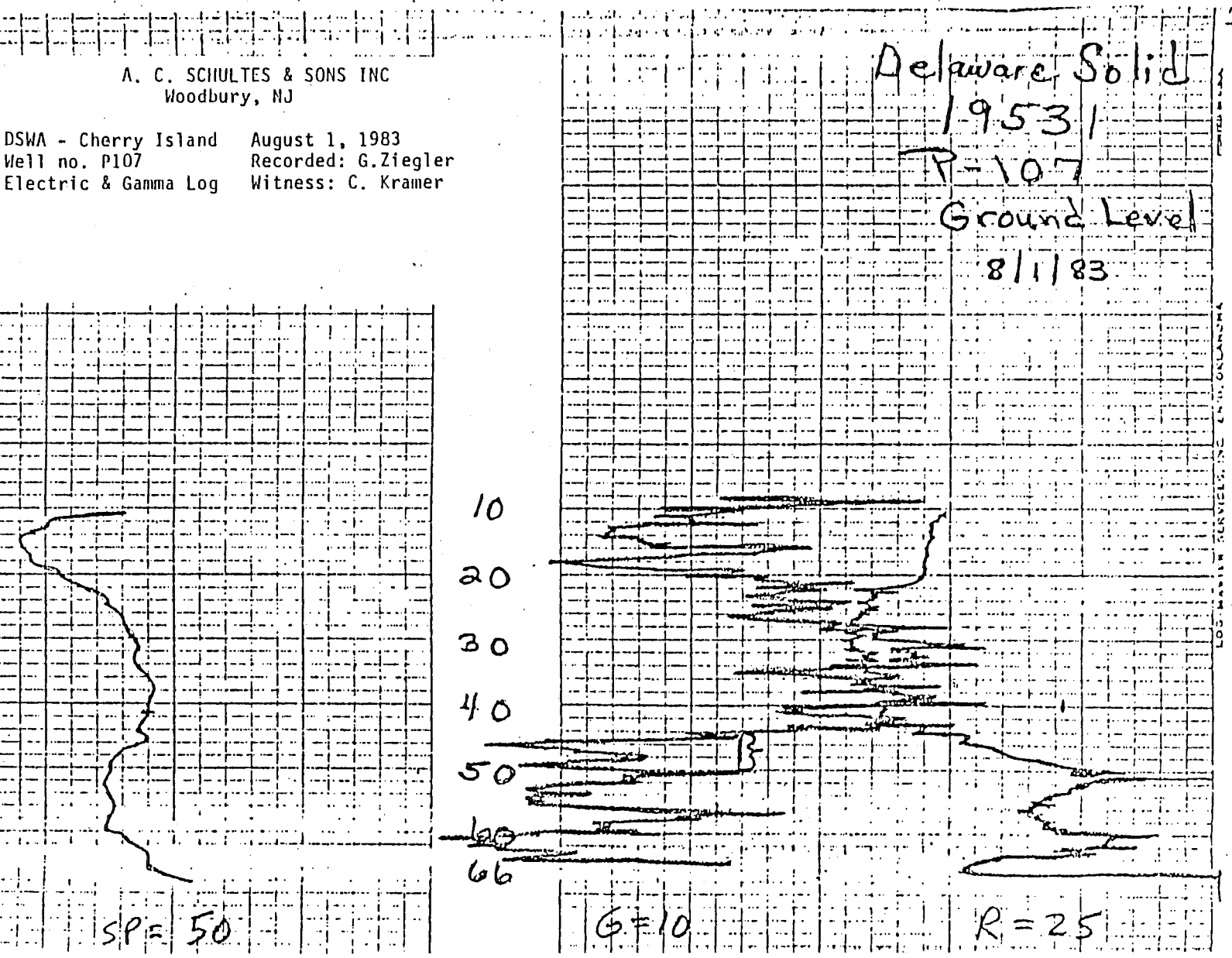

A. C. SCHULTES & SONS INC
Woodbury, NJ
DSWA - Cherry Island
Well No. P-106
Electric & Gamma Log
July 19, 1983
Recorded: J. Schultes, Jr.
Witness: C. Kramer
Delaware Solid Waste
P-106
7/19/83
1953
Ground Level
10
20
40
60
80
100
120
140
160
180
200
220
240
250
Adj
SP = 25
G = 10
R = 10

A. C. SCHULTES & SONS INC
Woodbury, NJ

DSWA - Cherry Island
Well no. P107
Electric & Gamma Log

August 1, 1983
Recorded: G.Ziegler
Witness: C. Kramer

Delaware Solid
19531
P-107
Ground Level
8/1/83

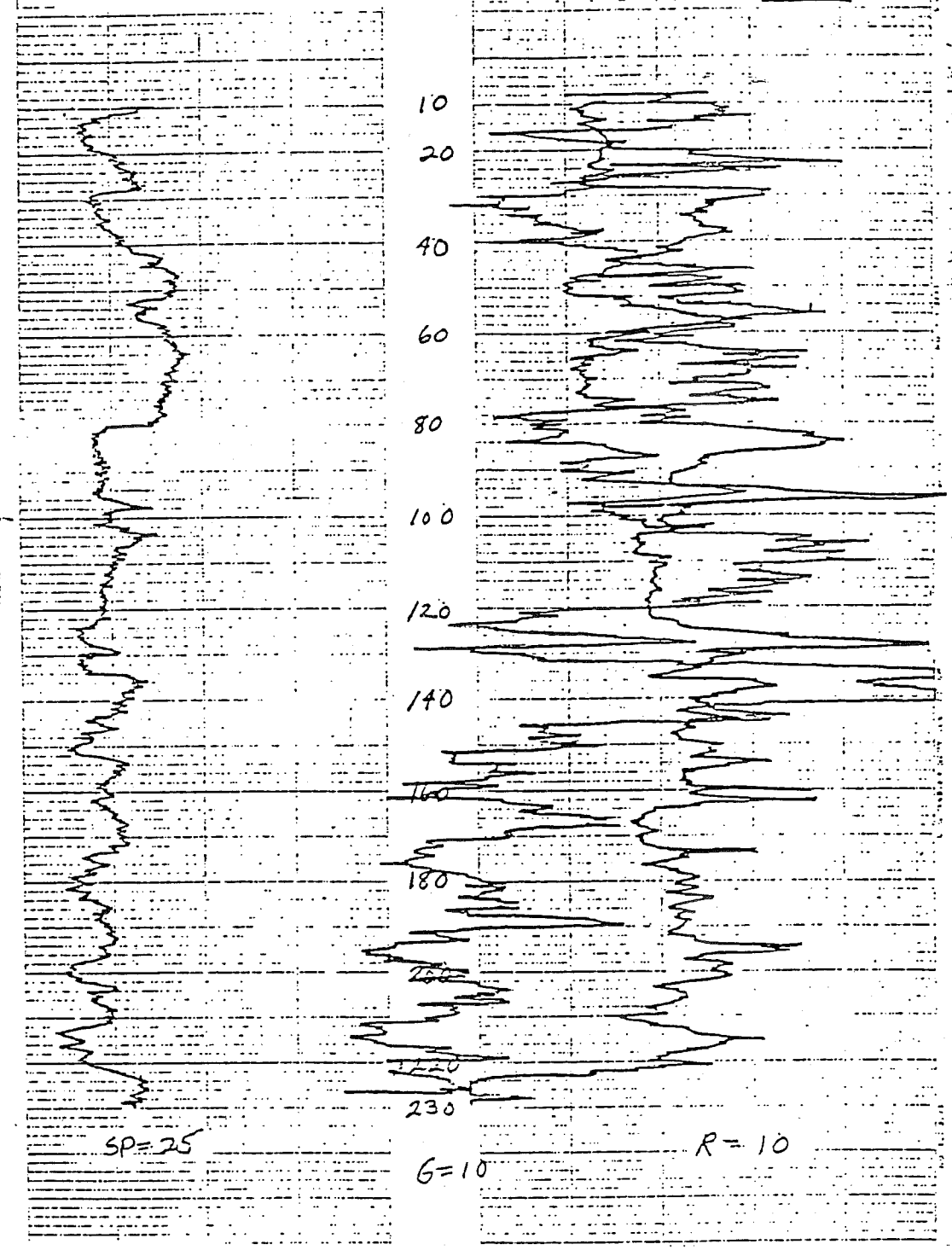


A. C. Schultes & Sons Inc
Woodbury, NJ

DSWA - Cherry Island
Well No. P-108
Electric & Gamma Log

July 14, 1983
Recorded: J. Schultes, Jr.
Witness: C. Kramer

P-108
DEL. SOLID WASTE
Cherry Island
Ground Level
7/14/83
19531



APPENDIX C

WATER QUALITY ANALYSES

CENTURY
Environmental Testing Labs, Inc.
P.O. Box 248/1501 Grandview Avenue/MidAtlantic Park/Thorofare, N.J. 08086/609-848-3939

ANALYSIS REPORT
NO. FF1293, FF1294
FF1295

CERTIFICATE OF ANALYSIS

CLIENT

Terraqua Resources Corp.
200 North Warner Rd.
Suite 300
King of Prussia, PA 19406
ATTN: Ed Hollis

LOG NUMBER	SAMPLE IDENTIFICATION
FF1293	C101
FF1294	C102
FF1295	C104

SAMPLE RECEIVED 10/6/83 ANALYSIS COMPLETED 10/31/83

COLLECTED BY Client

RESULTS (mg/L unless specified)

TEST PARAMETER	FF1293	FF1294	FF1295	TEST PARAMETER	FF1293	FF1294	FF1295
BOD_5*				Chlorine Demand			
COD				Chlorine Residual			
TOC	157	288	253	Chloride (CL)	320	490	580
Dissolved Oxygen				Silica			
Suspended Solids	93	110	206	Petroleum HYC.			
Total Solids	886	1590	1680	Hardness (as $CaCO_3$)	260	730	620
Dissolved Solids	793	1480	1470				
Sett. Solids (ml/L)							
pH	6.7	7.4	6.1				
Phenols				Aluminum			
Cyanide (Total)				Antimony			
Fluoride				Arsenic	0.02	1.4	0.01
Cyanide (Free)				Barium			
Surfactants (mg/L LAS)				Boron			
Oil & Grease (Freon)				Cadmium			
				Calcium (Ca)			
Nitrogen (KJD as N)	5.1	55	49	Chromium (Total)	<0.01	<0.01	<0.01
Nitrogen (Ammonia as N)	4.0	40.0	39	Chromium (Hexa)			
Nitrogen (Organic as N)				Copper	<0.01	<0.01	0.02
Nitrite (N)				Iron	88	54	57
Nitrate (N)	<1	<1	<1	Lead	<.01	.01	.01
Phosphate (P) Total				Magnesium (Mg)			
Phosphate (P) - Ortho				Manganese	112	70	90
Sulfate (SO_4)	5.0	3.0	3.0	Mercury	<.0002	<.0002	<.0003
Sulfite (SO_3)				Nickel	<.05	<.05	<.05
Sulfide				Potassium			
Color				Selenium	<.005	<.005	<.005
Turbidity (NTU)				Silver			
Conductivity (Micromons)	1,000	1,700	1,800	Sodium	192	284	512
Alk (Total) as $CaCO_3$	300	720	613	Tin			
				Titanium			
Fecal Coliform				Zinc	.04	.03	.25
Total Coliform							

* A minimum of 5 sample dilutions were used for this determination.

** Non-detectable, below the limit of detection.

LAB COMMENT:

LAB DIRECTOR

LAB CERTIFICATION NO. 03152
N.J. DEPARTMENT OF HEALTH

CENTURY
Environmental Testing Labs, Inc.
P.O. Box 248/1501 Grandview Avenue/MidAtlantic Park/Thorofare, N.J. 08086/609-848-3939

ANALYSIS REPORT
NO. FF1296, FF 7
FF1298

CERTIFICATE OF ANALYSIS

CLIENT
Terraqua Resources Corp.
200 North Warner Rd.
Suite 300
King of Prussia, PA 19406
ATTN: Ed Hollis

LOG NUMBER	SAMPLE IDENTIFICATION
FF1296	C105
FF1297	C106
Ff1298	C108

SAMPLE RECEIVED 10/6/83 ANALYSIS COMPLETED 10/31/83

COLLECTED BY Client

RESULTS (mg/L unless specified)

TEST PARAMETER	FF1296	FF1297	FF1298	TEST PARAMETER	FF1296	FF1297	FF1298
BOD_5*				Chlorine Demand			
COD				Chlorine Residual			
TOC	102	226	101	Chloride (CL)	370	555	530
Dissolved Oxygen				Silica			
Suspended Solids	216	284	132	Petroleum HYC.			
Total Solids	1050	2030	2210	Hardness (as $CaCO_3$)	330	860	1350
Dissolved Solids	830	1750	2080				
Sett. Solids (ml/L)							
pH	6.4	6.9	6.0				
Phenols				Aluminum			
Cyanide (Total)				Antimony			
Fluoride				Arsenic	0.02	0.39	0
Cyanide (Free)				Barium			
Surfactants (mg/L LAS)				Boron			
Oil & Grease (Freon)				Cadmium			
				Calcium (Ca)			
Nitrogen (KJD as N)	21	58	4.4	Chromium (Total)	<.01	0.03	0.02
Nitrogen (Ammonia as N)	21	42	3.0	Chromium (Hexa)			
Nitrogen (Organic as N)				Copper	0.01	0.04	0.05
Nitrite (N)				Iron	40.3	78.0	34.7
Nitrate (N)	<1	<1	<1	Lead	.03	.06	.02
Phosphate (P) Total				Magnesium (Mg)			
Phosphate (P) - Ortho				Manganese	63	116	51
Sulfate (SO_4)	6.3	105	710	Mercury	<.0002	<.0002	<.0002
Sulfite (SO_3)				Nickel	<.05	<.05	<.05
Sulfide				Potassium			
Color				Selenium	<.005	<.005	<.005
Turbidity (NTU)				Silver			
Conductivity (Micromons)	1200	1920	3050	Sodium	216	27.8	246
Alk (Total) as $CaCO_3$	320	720	170	Tin			
				Titanium			
Fecal Coliform				Zinc	0.11	0.28	0.42
Total Coliform							

* A minimum of 5 sample dilutions were used for this determination.

** Non-detectable, below the limit of detection.

LAB COMMENT:

LAB CERTIFICATION NO. 08153
N.J. DEPARTMENT OF HEALTH

LAB DIRECTOR

CENTURY
Environmental Testing Labs, Inc.
P.O. Box 248/1501 Grandview Avenue/MidAtlantic Park/Thorofare, N.J. 08086/609-848-3939

ANALYSIS REPORT
NO. FF1299, FF1300
FF1301

CERTIFICATE OF ANALYSIS

CLIENT

Terraqua Resources Corp.
200 North Warner Rd.
Suite 300
King of Prussia, Pa 19406
ATTN: Ed Hollis

LOG NUMBER	SAMPLE IDENTIFICATION
FF1299	P101
FF1300	P102
FF1301	P104

SAMPLE RECEIVED 10/6/83 ANALYSIS COMPLETED 10/31/83

COLLECTED BY Client

RESULTS (mg/L unless specified)

TEST PARAMETER	FF1299	FF1300	FF1301	TEST PARAMETER	FF1299	FF1300	FF1301
BOD_5*				Chlorine Demand			
COD				Chlorine Residual			
TOC	25	25	24	Chloride (CL)	120	250	290
Dissolved Oxygen				Silica			
Suspended Solids	<5	<5	23	Petroleum HYC.			
Total Solids	240	630	700	Hardness (as $CaCO_3$)	110	170	200
Dissolved Solids	240	630	680				
Sett. Solids (ml/L)							
pH	6.6	6.7	6.8				
Phenols				Aluminum			
Cyanide (Total)				Antimony			
Fluoride				Arsenic	<.002	<.002	<.002
Cyanice (Free)				Barium			
Surfactants (mg/L LAS)				Boron			
Oil & Grease (Freon)				Cadmium			
				Calcium (Ca)			
Nitrogen (KJD as N)	.46	1.0	4.6	Chromium (Total)	<.01	<.01	<.01
Nitrogen (Ammonia as N)	0.66	1.0	5.1	Chromium (Hexa)			
Nitrogen (Organic as N)				Copper	0.01	<.01	<.01
Nitrite (N)				Iron	0.72	1.08	13.7
Nitrate (N)	<1	<1	<1	Lead	<.01	<.01	<.01
Phosphate (P) Total				Magnesium (Mg)			
Phosphate (P) - Ortho				Manganese	0.77	1.16	33.0
Sulfate (SO_4)	60	69	42	Mercury	<.0002	<.0002	<.0002
Sulfite (SO_3)				Nickel	<.05	<.05	<.05
Sulfice				Potassium			
Color				Selenium	<.005	<.005	<.005
Turbidity (NTU)				Silver			
Conductivity (Micromens)	480	810	900	Sodium	68	166	140
Alk (Total) as $CaCO_3$	60	70	60	Tin			
				Titanium			
Fecal Coliform				Zinc	0.02	<.01	0.06
Total Coliform							

* A minimum of 5 sample dilutions were used for this determination.

** Non-detectable, below the limit of detection.

LAB COMMENT:

LAB CERTIFICATION NO: 03153
N.J. DEPARTMENT OF HEALTH

LAB DIRECTOR

CENTURY
Environmental Testing Labs, Inc.
P.O. Box 248/1501 Grandview Avenue/MidAtlantic Park/Thorofare, N.J. 08086/609-848-3939

ANALYSIS REPORT
NO. FF1302, FF
FF1304

CERTIFICATE OF ANALYSIS

CLIENT
Terraqua Resources Corp.
200 North Warner Rd.
Suite 300
King of Prussia, PA 19406
ATTN: Ed Hollis

LOG NUMBER	SAMPLE IDENTIFICATION
FF1302	P105
FF1303	P106
FF1304	P108

SAMPLE RECEIVED 10/6/83 ANALYSIS COMPLETED 10/31/83

COLLECTED BY Client

RESULTS (mg/L unless specified)

TEST PARAMETER	FF1302	FF1303	FF1304	TEST PARAMETER	FF1302	FF1303	FF1304
BOD_5*				Chlorine Demand			
COD				Chlorine Residual			
TOC	23	24	26	Chloride (CL)	290	250	340
Dissolved Oxygen				Silica			
Suspended Solids	<5	<5	<5	Petroleum HYC.			
Total Solids	630	580	720	Hardness (as $CaCO_3$)	190	140	160
Dissolved Solids	630	580	720				
Sett. Solids (ml/L)							
pH	7.5	6.7	6.7				
Phenols				Aluminum			
Cyanide (Total)				Antimony			
Fluoride				Arsenic	<.002	<.002	<.
Cyanide (Free)				Barium			
Surfactants (mg/L LAS)				Boron			
Oil & Grease (Freon)				Cadmium			
				Calcium (Ca)			
Nitrogen (KJD as N)	0.34	0.34	0.38	Chromium (Total)	<.01	<.01	<.01
Nitrogen (Ammonia as N)	0.21	<.05	0.44	Chromium (Hexa)			
Nitrogen (Organic as N)				Copper	<.01	<.01	<.01
Nitrite (N)				Iron	4.20	8.0	1.20
Nitrate (N)	<1	<1	<1	Lead	<.01	<.01	<.01
Phosphate (P) Total				Magnesium (Mg)			
Phosphate (P) - Ortho				Manganese	21	20	1.23
Sulfate (SO_4)	14	28	52	Mercury	<.0002	<.0002	.0005
Sulfite (SO_3)				Nickel	<.05	<.05	<.05
Sulfide				Potassium			
Color				Selenium	<.005	<.005	<.005
Turbidity (NTU)				Silver			
Conductivity (Micromhos)	860	830	980	Sodium	146	130	224
Alk (Total) as $CaCO_3$	98	98	70	Tin			
				Titanium			
Fecal Coliform				Zinc	0.19	0.14	0.02
Total Coliform							

* A minimum of 5 sample dilutions were used for this determination.

** Non-detectable, below the limit of detection.

LAB COMMENT:

LAB CERTIFICATION NO. 25153
N.J. DEPARTMENT OF HEALTH

LAB DIRECTOR

CENTURY
Environmental Testing Labs, Inc.
P.O. Box 248/1501 Grandview Avenue/Mid-Atlantic Park/Thorofare, N.J. 08086 609-848-3939

ANALYSIS REPORT
NO. FF1305, FF1306
FF1307

CERTIFICATE OF ANALYSIS

CLIENT
Terraqua Resources Corp.
200 North Warner Rd.
Suite 300
King of Prussia, PA 19406
ATTN: Ed Hollis

LOG NUMBER	SAMPLE IDENTIFICATION
FF1305	P100
FF1306	P103
FF1307	P107

SAMPLE RECEIVED 10/6/83 ANALYSIS COMPLETED 10/31/83
COLLECTED BY Client

RESULTS (mg/L unless specified)

TEST PARAMETER	FF1305	FF1306	FF1307	TEST PARAMETER	FF1305	FF1306	FF1307
BOD_5*				Chlorine Demand			
COD				Chlorine Residual			
TOC	53	135	61	Chloride (CL)	165	355	470
Dissolved Oxygen				Silica			
Suspended Solids	11	17	70	Petroleum HYC.			
Total Solids	750	970	1050	Hardness (as $CaCO_3$)	385	335	265
Dissolved Solids	735	955	980				
Sett. Solids (ml/L)							
pH	5.7	6.6	5.9				
Phenols				Aluminum			
Cyanide (Total)				Antimony			
Fluoride				Arsenic	<.002	0.01	0.01
Cyanide (Free)				Barium			
Surfactants (mg/L LAS)				Boron			
Oil & Grease (Freon)				Cadmium			
				Calcium (Ca)			
Nitrogen (KJD as N)	.64	35	19	Chromium (Total)	<.01	<.01	<.01
Nitrogen (Ammonia as N)	0.36	31	13	Chromium (Hexa)			
Nitrogen (Organic as N)				Copper	<.01	<.01	<.01
Nitrite (N)				Iron	31.6	32.9	78
Nitrate (N)	<1	<1	<1	Lead	<.01	<.01	<.01
Phosphate (P) Total				Magnesium (Mg)			
Phosphate (P) - Ortho				Manganese	54	60	96
Sulfate (SO_4)	240	4.0	23	Mercury	<.0002	<.0002	<.0002
Sulfite (SO_3)				Nickel	<.05	<.05	<.05
Sulfide				Potassium			
Color				Selenium	<.005	<.005	<.005
Turbidity (NTU)				Silver			
Conductivity (Micromhos)	860	1340	1260	Sodium	89.4	288	192
Alk. (Total) as $CaCO_3$	88	434	145	Tin			
				Titanium			
Fecal Coliform				Zinc	0.08	<.01	<.01
Total Coliform							

* A minimum of 5 sample dilutions were used for this determination.
** Non-detectable, below the limit of detection.

LAB COMMENT:

LAB CERTIFICATION NO. 03183
N.J. DEPARTMENT OF HEALTH

LAB DIRECTOR

CENTURY
Environmental Testing Labs, Inc.
P.O. Box 248/1501 Grandview Avenue/MidAtlantic Park/Thorofare, N.J. 08086/609-848-3939

ANALYSIS REPORT
NO. FF1308,F 9
FF1310

CERTIFICATE OF ANALYSIS

CLIENT
Terraqua Resources Corp.
200 North Warner Rd.
Suite 300
King of Prussia, PA 19406
ATTN: Ed Hollis

LOG NUMBER	SAMPLE IDENTIFICATION
FF1308	C100
FF1309	C103
FF1310	C107

SAMPLE RECEIVED 10/6/83 ANALYSIS COMPLETED 10/31/83
COLLECTED BY Client

RESULTS (mg/L unless specified)

TEST PARAMETER	FF1308	FF1309	FF1310	TEST PARAMETER	Ff1308	FF1309	Ff1310
BOD_5*				Chlorine Demand			
COD				Chlorine Residual			
TOC	141	207	298	Chloride (CL)	370	520	230
Dissolved Oxygen				Silica			
Suspended Solids	166	78	785	Petroleum HYC.			
Total Solids	1200	1430	1680	Hardness (as $CaCO_3$)	460	610	425
Dissolved Solids	1035	1350	890				
Sett. Solids (ml/L)							
pH	5.9	6.8	6.1				
Phenols				Aluminum			
Cyanide (Total)				Antimony			
Fluoride				Arsenic	0.02	0.01	0.[illegible]
Cyanide (Free)				Barium			
Surfactants (mg/L LAS)				Boron			
Oil & Grease (Freon)				Cadmium			
				Calcium (Ca)			
Nitrogen (KJD as N)	4.4	42	20	Chromium (Total)	<.01	<.01	0.04
Nitrogen (Ammonia as N)	4.0	37	14.2	Chromium (Hexa)			
Nitrogen (Organic as N)				Copper	<.01	<.01	0.10
Nitrite (N)				Iron	102	61	68
Nitrate (N)	<1	<1	<1	Lead	.01	<.01	.08
Phosonate (P) Total				Magnesium (Mg)			
Phosphate (P) - Ortho				Manganese	110	74	80
Sulfate (SO_4)	125	13	110	Mercury	<.0002	<.0002	<.0002
Sulfite (SO_3)				Nickel	<.05	<.05	<.05
Sulfide				Potassium			
Color				Selenium	<.005	<.005	<.005
Turbidity (NTU)				Silver			
Conductivity (Micromons)	1210	1570	1160	Sodium	174	268	150
Alk (Total) as $CaCO_3$	95	620	395	Tin			
				Titanium			
Fecal Coliform				Zinc	0.18	0.07	0.48
Total Coliform							

* A minimum of 5 sample dilutions were used for this determination.
** Non-detectable, below the limit of detection.

LAB COMMENT:

LAB CERTIFICATION NO. 03153
N.J. DEPARTMENT OF HEALTH

LAB DIRECTOR

CENTURY
Environmental Testing Labs, Inc.
P.O. Box 248, 1501 Grandview Avenue, MidAtlantic Park, Thorofare, N.J. 08086, 609-848-3939

ANALYSIS REPORT
NO. FF1311, FF131

CERTIFICATE OF ANALYSIS

CLIENT
Terraqua Resources Corp.
200 North Warner Rd.
Suite 300
King of Prussia, PA 19406
ATTN: Ed Hollis

LOG NUMBER	SAMPLE IDENTIFICATION
FF1311	6,8
FF1312	6A,8A

SAMPLE RECEIVED 10/6/83 ANALYSIS COMPLETED 10/31/83
COLLECTED BY Client

RESULTS (mg/L unless specified)

TEST PARAMETER	FF1311	FF1312	TEST PARAMETER	FF1311	FF1312
BOD_5*			Chlorine Demand		
COD			Chlorine Residual		
TOC	115	220	Chloride (CL)	310	420
Dissolved Oxygen			Silica		
Suspended Solids	32	148	Petroleum HYC.		
Total Solids	965	1930	Hardness (as $CaCO_3$)	350	850
Dissolved Solids	930	1780			
Sett. Solids (ml/L)					
pH	6.2	6.3			
Phenols			Aluminum		
Cyanide (Total)			Antimony		
Fluoride			Arsenic	0.02	0.03
Cyanide (Free)			Barium		
Surfactants (mg/L LAS)			Boron		
Oil & Grease (Freon)			Cadmium		
			Calcium (Ca)		
Nitrogen (KJD as N)	4.8	20	Chromium (Total)	<.01	0.03
Nitrogen (Ammonia as N)	0.96	16.1	Chromium (Hexa)		
Nitrogen (Organic as N)			Copper	0.17	0.17
Nitrite (N)			Iron	18.4	72
Nitrate (N)	<1	<1	Lead	0.01	0.04
Phosphate (P) Total			Magnesium (Mg)		
Phosphate (P) - Ortho			Manganese	16	69
Sulfate (SO_4)	50	430	Mercury	<.0002	<.0002
Sulfite (SO_3)			Nickel	<.05	<.05
Sulfide			Potassium		
Color			Selenium	<.005	<.005
Turbidity (NTU)			Silver		
Conductivity (Micromhos)	1310	1960	Sodium	218	298
Alk. (Total) as $CaCO_3$	275	445	Tin		
			Titanium		
Fecal Coliform			Zinc	0.17	0.15
Total Coliform					

* A minimum of 5 sample dilutions were used for this determination.
** Non-detectable, below the limit of detection.

LAB COMMENT:

LAB CERTIFICATION NO. 02153
N.J. DEPARTMENT OF HEALTH

LAB DIRECTOR

APPENDIX D

GEOTECHNICAL DATA

APPENDIX D-1

FIELD AND LABORATORY DATA SUMMARY

D-1 Field and Laboratory Test Summary

D1.1 Field Program

During the period July 5, 1983, through December 20, 1983, 30 test borings and six auger borings were performed by Sprague and Henwood, Inc., of Scranton, Pennsylvania, subcontractors to A. C. Schultes and Sons, Inc., of Woodbury, New Jersey, and Walton Corporation of Newark, Delaware. In addition, 25 1-1/4 inch diameter piezometers were installed in selected borings. This drilling program followed the recent placement of dredge spoil material on the Edgemoore site in June of 1983. This dredge spoil material made mobility on the site extremely difficult and special equipment considerations were necessary by the drillers to accommodate the desired locations on the site.

A track mounted CME 55 drill rig using hollow stem augers and a barge mounted skid drill rig using steel casing were used for the test borings and piezometer installations. A tripod setup was used for the auger borings at the south end of the site.

Included among the 30 borings were 11 shallow non-sample borings drilled to a depth of approximately 25 feet below the ground surface for purposes of piezometer installation only. The remaining 19 borings included split spoon sample at five foot intervals, 12 of which were drilled to the Potomac contact encountered at depths of 90 to 120 feet below the ground surface. In addition undisturbed Shelby tube samples were obtained for laboratory testing and vane shear tests were performed to evaluate in situ strength properties of the soft soils. Auger borings extended 15 feet below the ground surface and were performed for the purposes of evaluating the potential existence of granular soil at shallow depths. These borings were performed in areas where the pipes used to discharge the dredge spoil have been located in the past. Twelve deep piezometers were installed

at depths ranging from 45 to 60 feet below the ground surface to aid in evaluating the hydraulic gradient at the site. Pertinent information regarding the test borings and piezometers is summarized in Table D-1-1.

D1.2 Laboratory Program

A total of 244 jar samples and 51 undisturbed shelby tube samples were obtained from the Standard Penetration test borings. All samples were visually described and classified while in the field. In addition, 48 vane shear tests were performed during the drilling program. Samples were returned to our laboratory and tested to verify visual field description and to classify soil types. Tests were performed to evaluate compressibility and shear strength of the soils sampled. The test results are presented in the appendix of this report.

The number of laboratory tests performed are as follows:

No. of Tests Performed	Test Descriptions
282	Natural water content
221	Percent passing and no. 200 sieve
47	Unconfined compression tests
47	Atterberg limits tests
52	Shelby tube density tests
19	Consolidated tests
2	Consolidated undrained triaxial shear tests (three points each)
3	Standard Proctor tests

D1.3 Description of Tests

D1.3.1 Natural Water Content (A.S.T.M.: D 2216-71)

The moisture or water content of a soil is the ratio, expressed as a percentage, of the weight of water in a given mass of soil to the weight of the solid particles.

The data obtained from this test is used to characterize the soil, for correlation among test borings, and as an indicator of in situ soil conditions.

D1.3.2 Percent Passing a No. 200 Sieve (A.S.T.M.: D 1140-54)

This test is used to determine the amount of silt and clay (i.e. those particles with a diameter less than 74 microns) in a given soil sample. The mesh of a number 200 sieve is sized so as to allow a particle with a normal size less than 74 microns to pass.

Data from this test is used in the classification and correlation of soil samples and to evaluate the slope stability, hydraulic properties, compressibility, and frost susceptibility.

D1.3.3 Unconfined Compression Test (A.S.T.M.: D 2166-66)

Unconfined compressive strength is defined as the load per unit area at which a laterally unrestrained cylindrical, undisturbed soil sample with fail in a simple compression test. The strength is measured by applying a constant rate of strain on the sample recording the induced stress (load per unit area). The unconfined compressive strength is defined as the maximum stress attained.

This data is used to determine the cohesion of the sample which is by definition equal to 1/2 the unconfined compressive strength.

D1.3.4 Atterberg Limits (A.S.T.M.: D 423-66 and D 424-59)

D1.3.4.1 Liquid Limit (L.L.) (A.S.T.M.: D 423-66)

The liquid limit of a soil is defined as that water content, expressed as a percentage of the weight of the oven-dried soil, at the boundary between the liquid state and plastic state of the sample.

The boundary is arbitrarily defined as that water content at which a pat of soil placed in a brass cup, cut with a standard groove, and then dropped from a height of 1 cm, will undergo a groove closure of 1/2 inch when dropped 25 times (Bowles, 1970).

D1.3.4.2 Plastic Limit (P.L.) (A.S.T.M.: D 424-59)

The plastic limit of a soil is the water content, expressed as a percentage of the weight of the oven-dried soil, at the boundary between the plastic state and semisolid state in which the soil can exist.

The boundary is arbitrarily defined as that water content at which a thread of soil just crumbles when it is rolled down to a diameter of 1/8 inch (Bowles, 1971).

D1.3.4.3 Plasticity Index (P.I.)

The plasticity index of a soil is the difference between the liquid limit and plastic limit.

The Atterberg limits are used primarily for the identification and classification of soils, and for correlation within a soil mass. Some of the soil properties for the established classifications based on Atterberg limits are: stability, hydraulic parameters, compaction characteristics of fine grained, cohesiveness, and estimates of settlement in consolidation problems.

D1.3.5 Consolidation (One Dimensional Consolidation Properties) (A.S.T.M.: D 2435-70)

Consolidation is that plastic deformation and void ratio reduction of a soil mass which are a function of time (Bowles, 1970). The test is performed on a laterally constrained sample by determining the rate and magnitude of consolidation while the sample is being stressed and drained axially.

Data from this test is used to estimate the settlement that will result from the stresses induced in the soil mass from the placement of a structure upon the soil body. This test also provides the coefficient of consolidation (Cv) which is used to estimate the time rate of consolidation and the preconsolidation pressure (Pc), the maximum effective stress, under which the soil has fully compressed.

D1.3.6 Shelby Tube Density (A.S.T.M.: D 2937-71)

The method involves obtaining a relatively undisturbed soil sample by pushing a thin-walled cylinder (Shelby Tube) into the soil and retrieving a sample in the cylinder.

Since the volume of the sample is known, from the volume of the cylinder, and the weight of the sample can be measured, the density of the sampled strata can be determined.

The density of the subsurface soil is used to determine overburden pressure on a strata.

D1.3.7 Triaxial Compression Test

A cylinder specimen of soil is surrounded by a fluid, in a pressure chamber and subjected to an isotropic pressure, called the chamber pressure. An additional compressive load is then applied along the axis of the specimen. The specimen may be allowed to consolidate under the applied chamber pressure before being subjected to the axial loading; this type of test is referred to as a consolidated triaxial test. The excess pore pressures that build up during the application of the axial load may be vented; this would be a drained triaxial test.

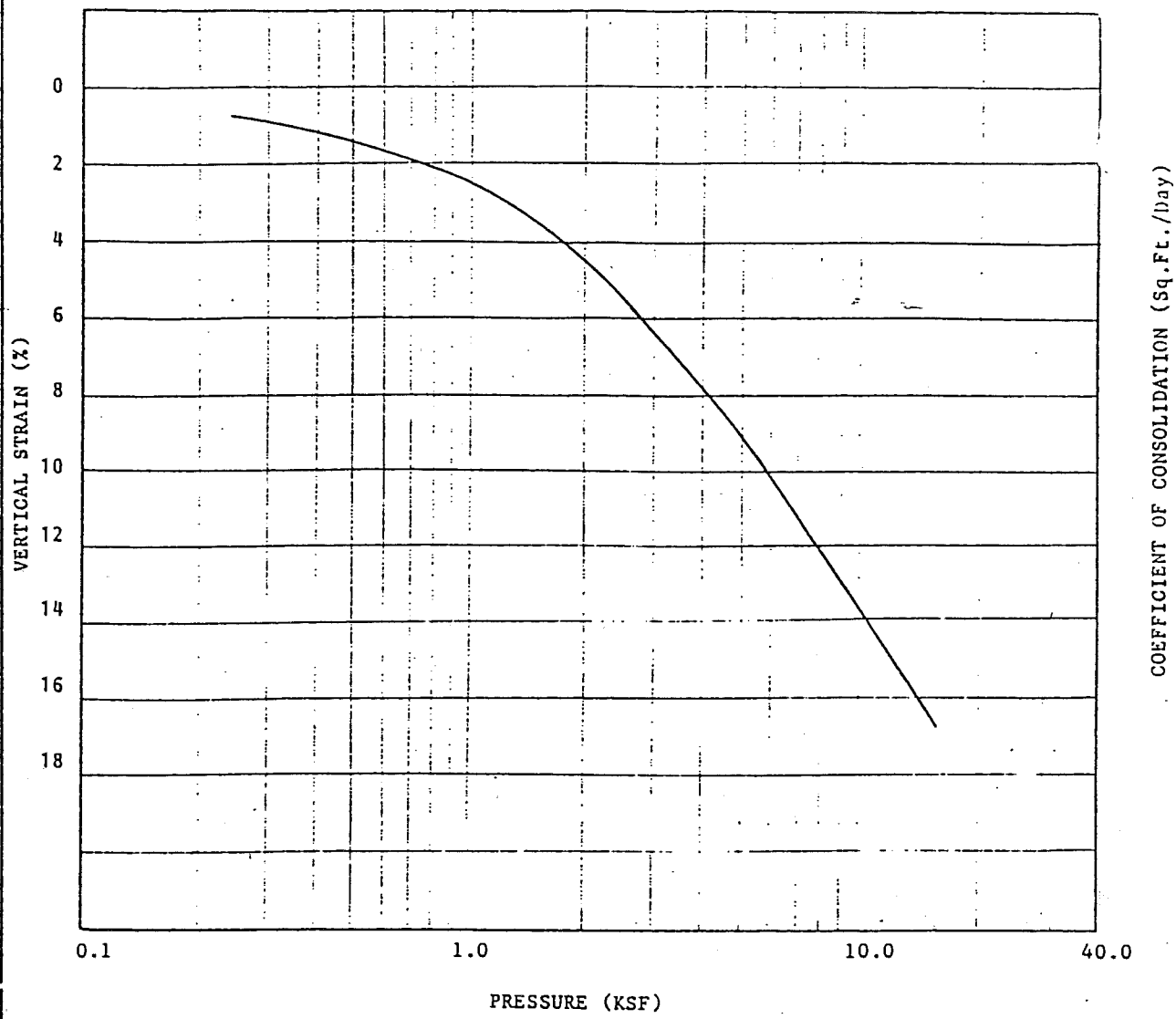
D1.3.8 Consolidated-Undrained Test

This is also termed consolidated-quick test or R test (abbreviated CU, CQ, or R). In this test, drainage takes place during the application of the confining pressure. Loading does not commence until the sample ceases to drain (or consolidate). The load or deviator stress is then applied to the specimen, with no attempt made to control the formation of excess pore pressure.

D1.3.9 Standard proctor (A.S.T.M.: D 698, Method A)

This test covers the determination of the relationship between the moisture content and density of soils when compacted in a four-inch mold with a 5.5 pound rammer dropped from a height of 12 inches. This method requires the material to pass a no. 4 sieve before testing.

A curve is plotted indicating the dry density obtained at varying moisture contents. Data from this curve is used to determine the optimum moisture content and maximum density that a given soil can be compacted.



Test Boring Number G-2 Depth 15.7

Atterberg Limits: LL 63, PI 21, U.S.C.S. Class. MH

Initial Moisture Content 71.5 % Initial Dry Density 54.9 PCF

Est. Existing Overburden Pressure, Po = 0.5 KSF

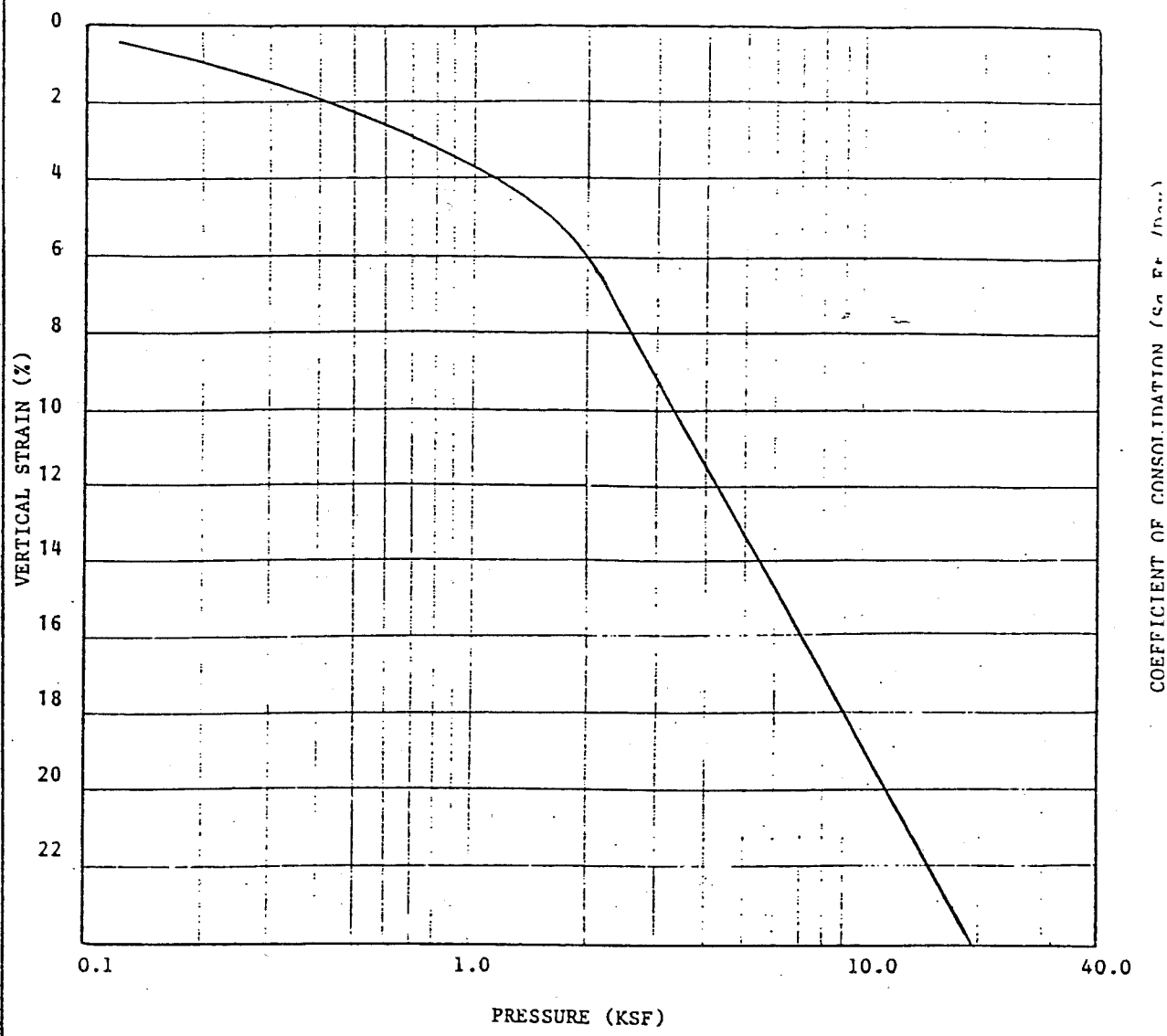
Est. Preconsolidation Pressure, Pc = 2.1 KSF

Sample Description Dark gray silt, trace fine sand, trace organics

CONSOLIDATION TEST
(A.S.T.M.: D-2435)
For
NSWF-2
Cherry Island
Wilmington, Delaware

DUFFIELD ASSOCIATES, INC.
Consulting Geotechnical Engineers
5400 Limestone Road
Newark, Delaware 19808

W. O. 410 | Figure D-1-1 | Date: October 21, 1983 | Sheet 2 of 19



Test Boring Number GP-3 Depth 16.5

Atterberg Limits: LL 74, PI 24, U.S.C.S. Class. MH

Initial Moisture Content 78.5 % Initial Dry Density 51.6 PCF

Est. Existing Overburden Pressure, Po = 0.5 KSF

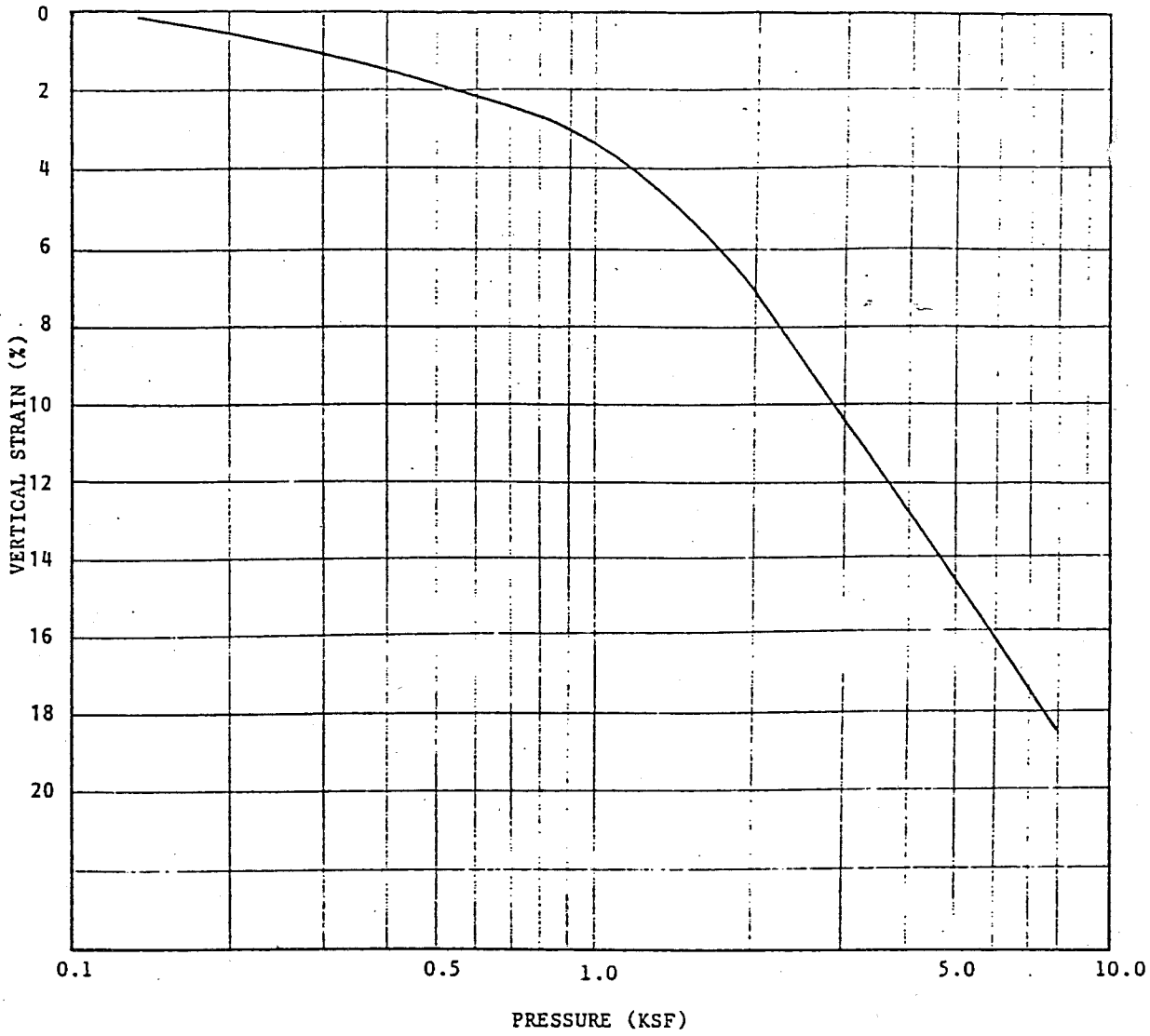
Est. Preconsolidation Pressure, Pc = 1.9 KSF

Sample Description Dark gray silt, trace fine sand, trace mica, trace organics

CONSOLIDATION TEST
(A.S.T.M.: D-2435)
For
NSWF-2
Cherry Island
Wilmington, Delaware

DUFFIELD ASSOCIATES, INC.
Consulting Geotechnical Engineers
5400 Limestone Road
Newark, Delaware 19808

W. O. 410	Figure D-1-1	Date: October 21, 1983	Sheet 3 of 19



Test Boring Number GP-4 Depth 16.1

Atterberg Limits: LL 80, PI 27, U.S.C.S. Class. MH

Initial Moisture Content 86.9 % Initial Dry Density 47.5 PCF

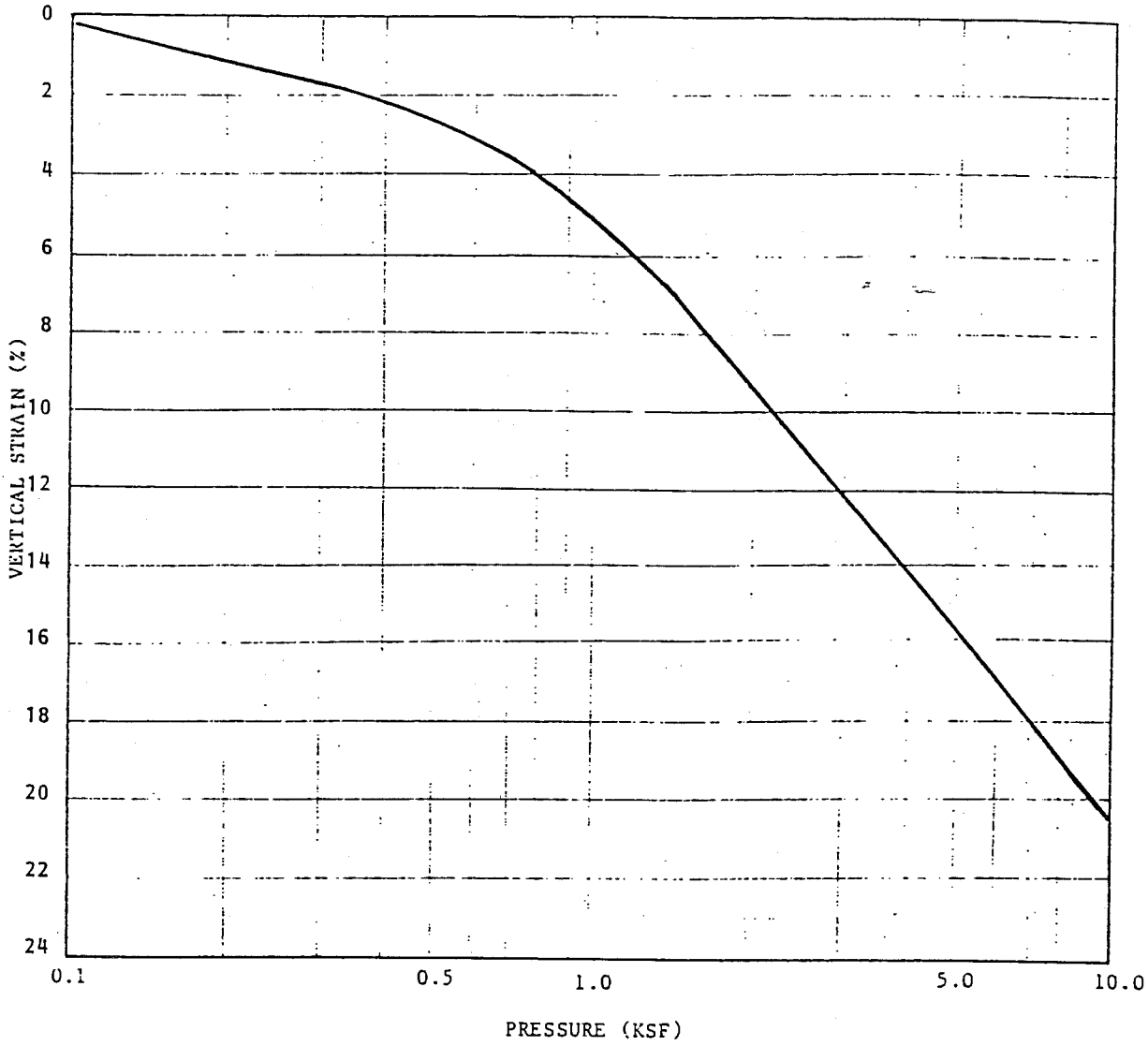
Est. Existing Overburden Pressure, Po = 0.5 KSF

Est. Preconsolidation Pressure, Pc = 1.3 KSF

Sample Description Dark gray silt, trace fine sand, trace organics

CONSOLIDATION TEST (A.S.T.M.: D-2435) For NSWF-2 Cherry Island Wilmington, Delaware	DUFFIELD ASSOCIATES, INC. Consulting Geotechnical Engineers 5400 Limestone Road Newark, Delaware 19808

W. O. 410	Figure D-1-1	Date: October 21, 1983	Sheet 4 of 19



Test Boring Number GP-6 Depth 16.1

Atterberg Limits: LL 85, PI 21, U.S.C.S. Class. MH

Initial Moisture Content 106.0 % Initial Dry Density 42.1 PCF

Est. Existing Overburden Pressure, Po = 0.5 KSF

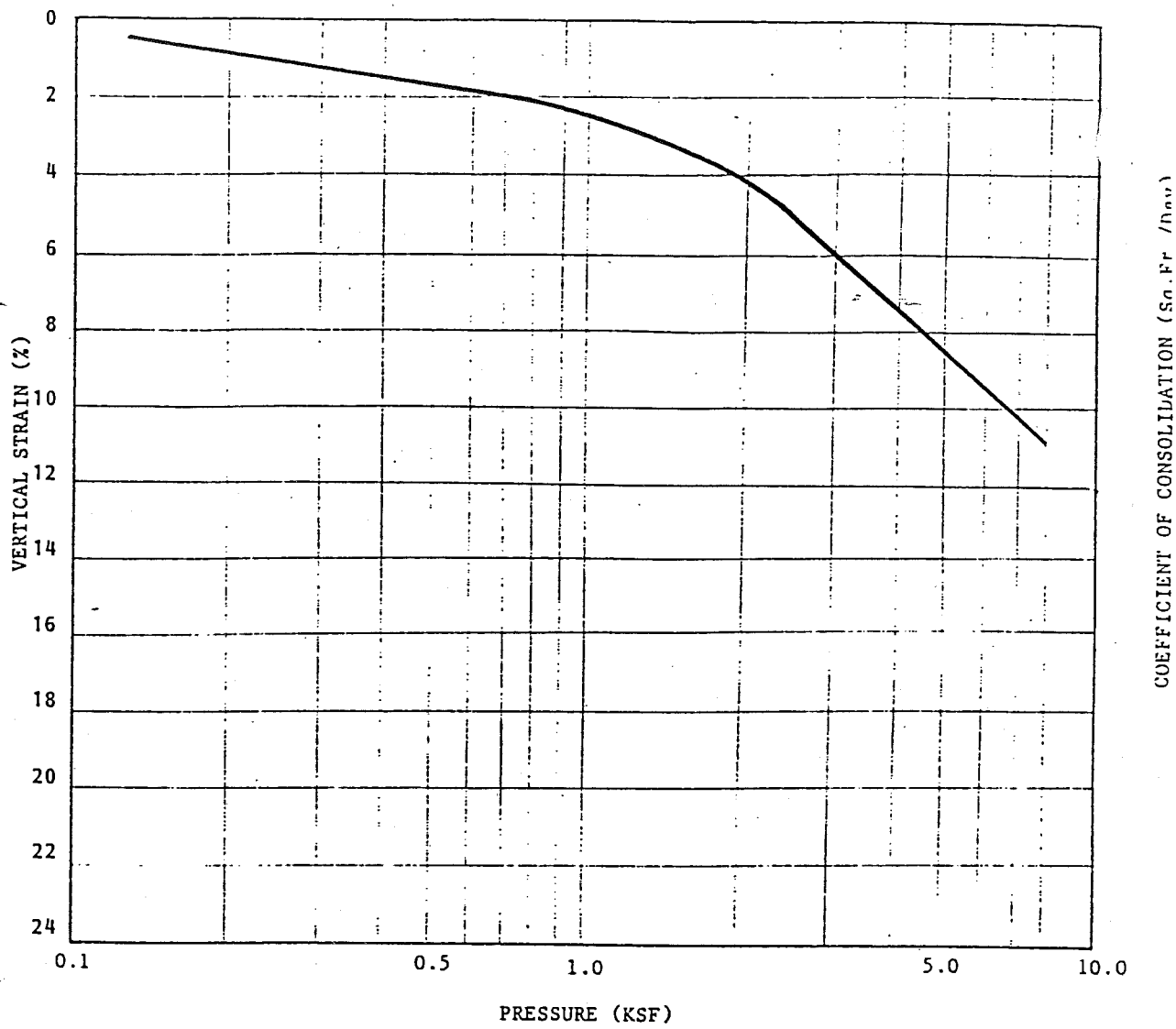
Est. Preconsolidation Pressure, Pc = 1.2 KSF

Sample Description Dark gray silt, trace fine little sand, some organics

CONSOLIDATION TEST
(A.S.T.M.: D-2435)
For
NSWF-2
Cherry Island
Wilmington, Delaware

DUFFIELD ASSOCIATES, INC.
Consulting Geotechnical Engineers
5400 Limestone Road
Newark, Delaware 19808

W. O. 410	Figure D-1-1	Date: October 21, 1983	Sheet 5 of 19



Test Boring Number GP-6 Depth 40.1

Atterberg Limits: LL 56, PI 23, U.S.C.S. Class. MH

Initial Moisture Content 48.8 % Initial Dry Density 69.4 PCF

Est. Existing Overburden Pressure, Po = 1.1 KSF

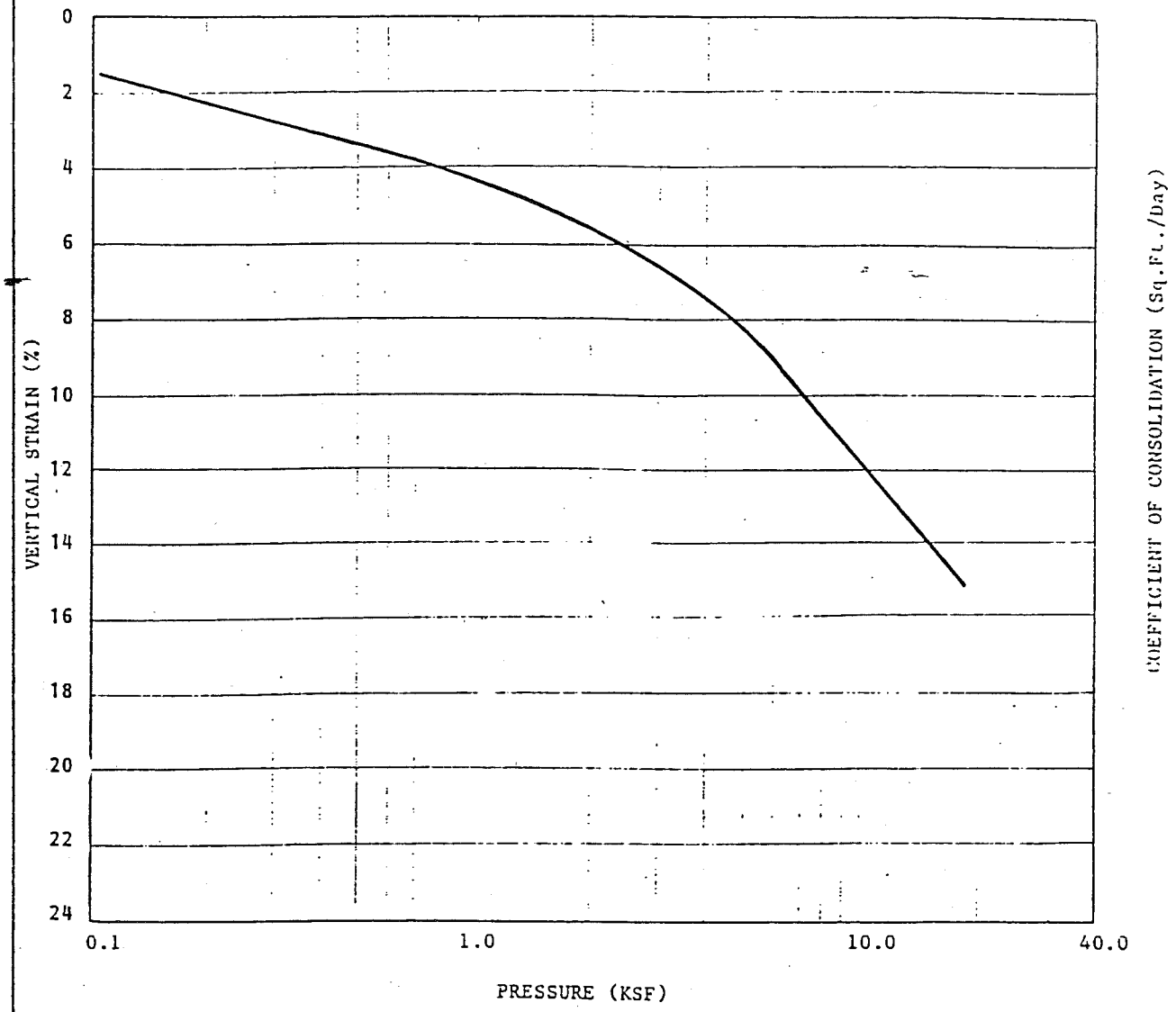
Est. Preconsolidation Pressure, Pc = 2.1 KSF

Sample Description Dark gray silt, trace fine sand

CONSOLIDATION TEST
(A.S.T.M.: D-2435)
For
NSWF-2
Cherry Island
Wilmington, Delaware

DUFFIELD ASSOCIATES, INC.
Consulting Geotechnical Engineers
5400 Limestone Road
Newark, Delaware 19808

W. O. 410	Figure D-1-1	Date: October 24, 1983	Sheet 6 of 19



Test Boring Number GP-6 Depth 41.2

Atterberg Limits: LL 56, PI 23, U.S.C.S. Class. MH

Initial Moisture Content 50.5 % Initial Dry Density 69.4 PCF

Est. Existing Overburden Pressure, Po = 1.1 KSF

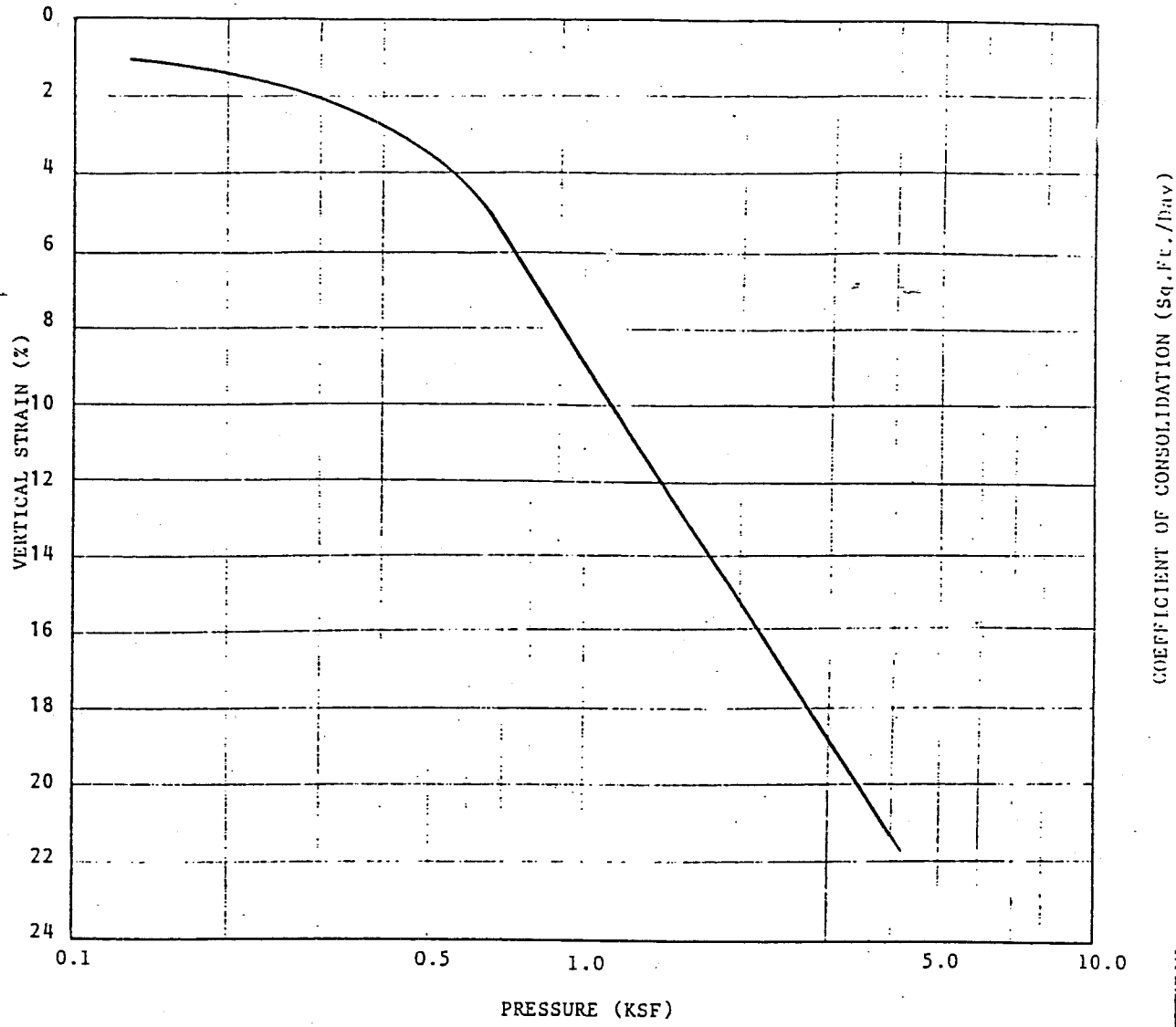
Est. Preconsolidation Pressure, Pc = 4.3 KSF

Sample Description Dark gray silt, trace fine sand

CONSOLIDATION TEST
(A.S.T.M.: D-2435)
For
NSWF-2
Cherry Island
Wilmington, Delaware

DUFFIELD ASSOCIATES, INC.
Consulting Geotechnical Engineers
5400 Limestone Road
Newark, Delaware 19808

W. O. 410 | Figure D-1-1 | Date: October 21, 1983 | Sheet 7 of 19



Test Boring Number GP-7 Depth 20.5

Atterberg Limits: LL 84, PI 40, U.S.C.S. Class. MH

Initial Moisture Content 100.3 % Initial Dry Density 41.4 PCF

Est. Existing Overburden Pressure, Po = 0.58 KSF

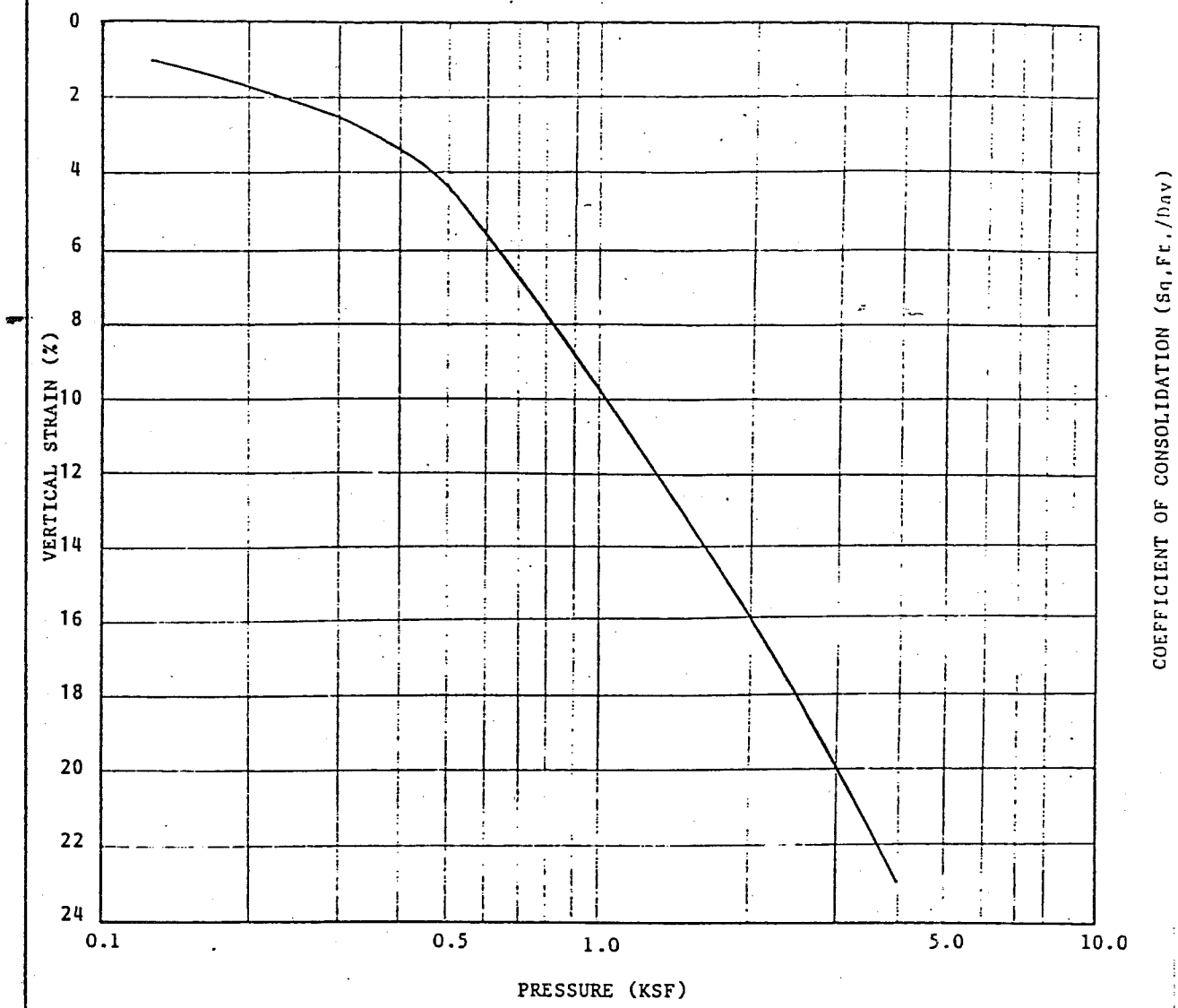
Est. Preconsolidation Pressure, Pc = 0.64 KSF

Sample Description Dark gray silt, trace to little organics, trace fine sand

CONSOLIDATION TEST
(A.S.T.M.: D-2435)
For
NSWF-2
Cherry Island
Wilmington, Delaware

DUFFIELD ASSOCIATES, INC.
Consulting Geotechnical Engineers
5400 Limestone Road
Newark, Delaware 19808

W. O. 410 | Figure D-1-1 | Date: October 21, 1983 | Sheet 8 of 19



Test Boring Number GP-7 Depth 20.8

Atterberg Limits: LL 84, PI 40, U.S.C.S. Class. MH

Initial Moisture Content 100.3 % Initial Dry Density 41.4 PCF

Est. Existing Overburden Pressure, Po = 0.58 KSF

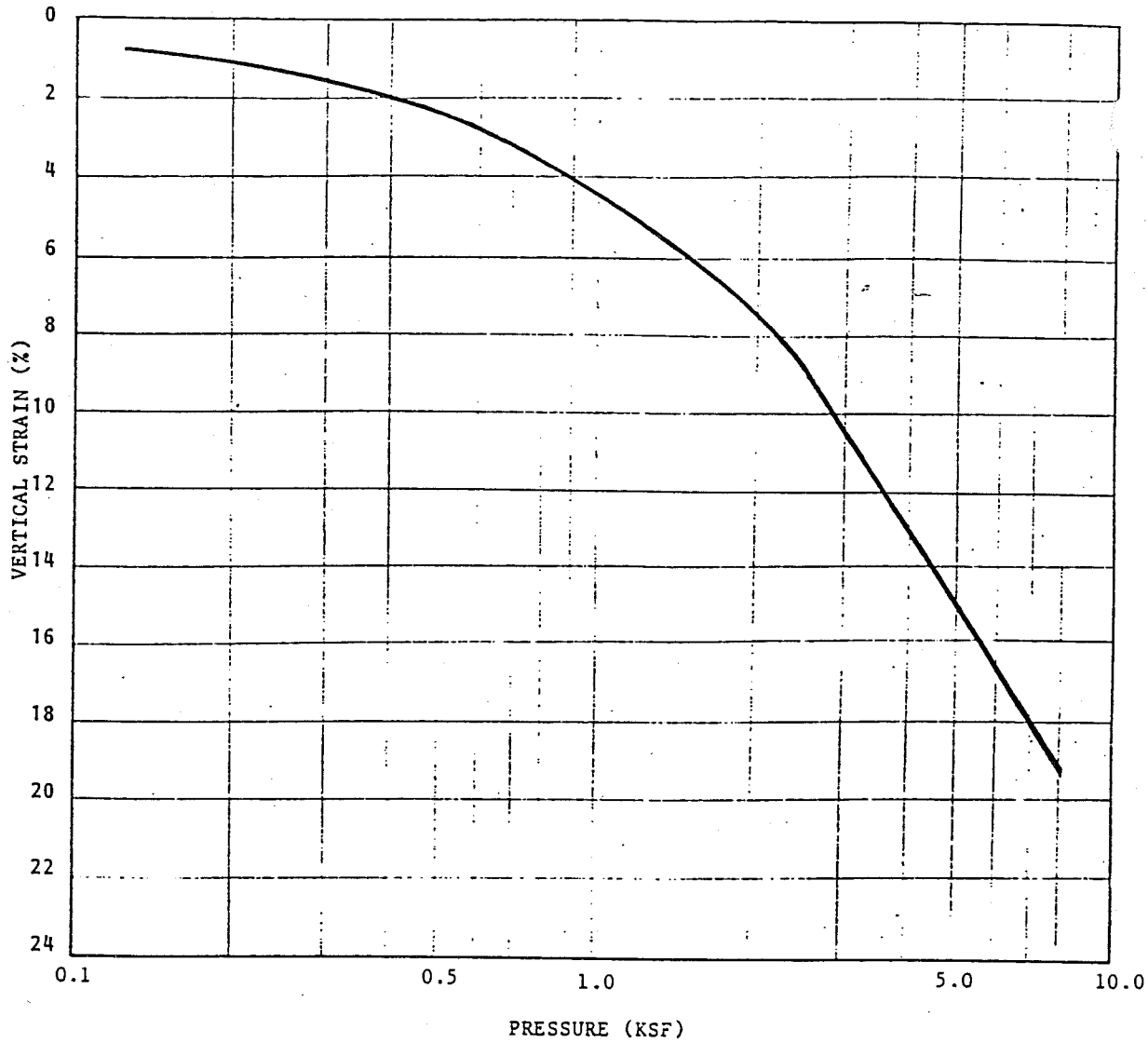
Est. Preconsolidation Pressure, Pc = 0.52 KSF

Sample Description Dark gray silt, trace fine sand, trace organics

CONSOLIDATION TEST
(A.S.T.M.: D-2435)
For
NSWF-2
Cherry Island
Wilmington, Delaware

DUFFIELD ASSOCIATES, INC.
Consulting Geotechnical Engineers
5400 Limestone Road
Newark, Delaware 19808

W. O. 410	Figure D-1-1	Date: October 21, 1983	Sheet 9 of 19



Test Boring Number GP-7 Depth 30.5

Atterberg Limits: LL 76, PI 36, U.S.C.S. Class. MH

Initial Moisture Content 89.7 % Initial Dry Density 46.2 PCF

Est. Existing Overburden Pressure, Po = 0.84 KSF

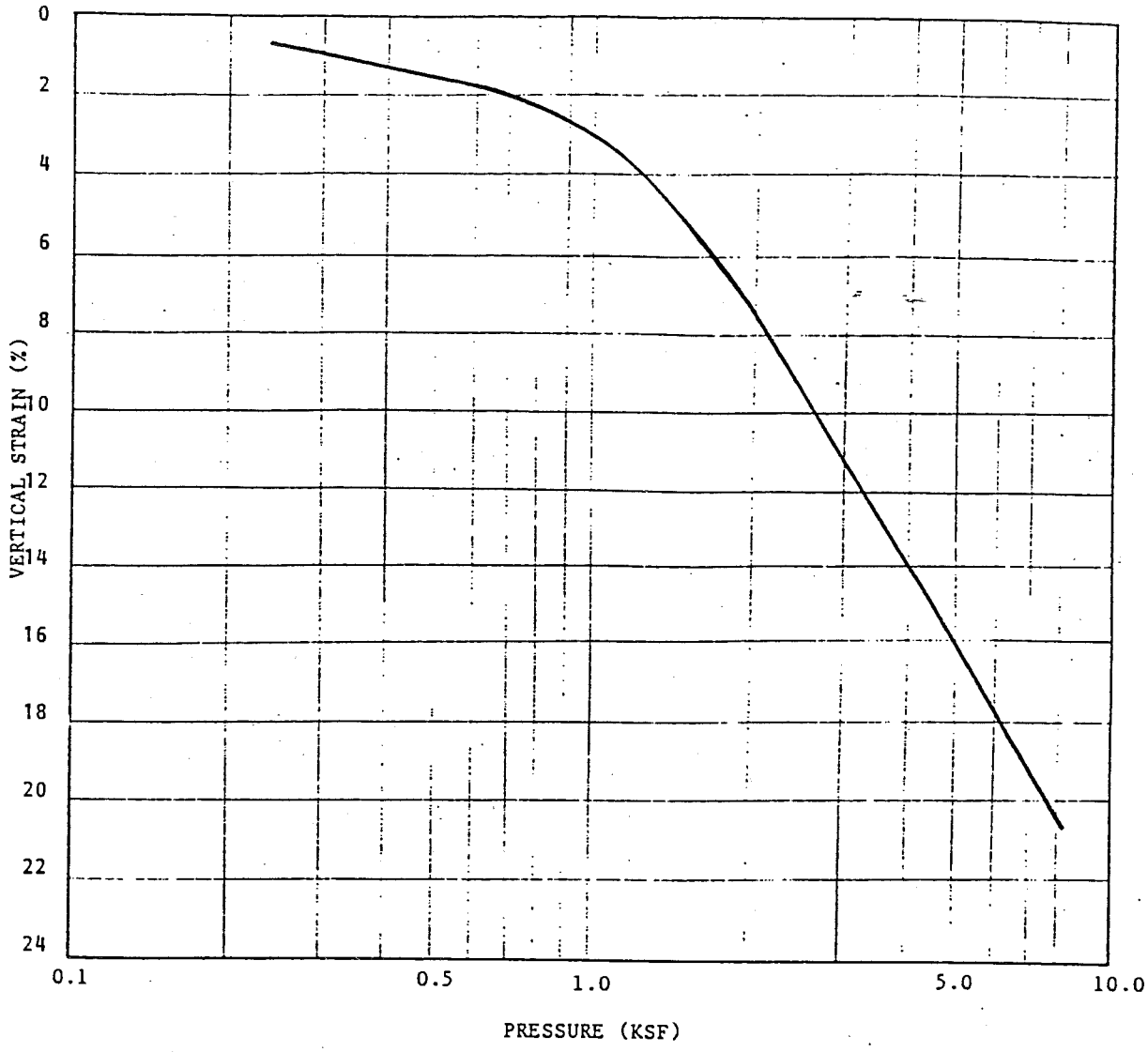
Est. Preconsolidation Pressure, Pc = 1.7 KSF

Sample Description Dark gray silt, trace fine sand, trace organics

CONSOLIDATION TEST
(A.S.T.M.: D-2435)
For
NSWF-2
Cherry Island
Wilmington, Delaware

DUFFIELD ASSOCIATES, INC.
Consulting Geotechnical Engineers
5400 Limestone Road
Newark, Delaware 19808

W. O. 410	Figure D-1-1	Date: October 24, 1983	Sheet 10 of 19



Test Boring Number GP-7 Depth 30.8

Atterberg Limits: LL 76, PI 36, U.S.C.S. Class. MH

Initial Moisture Content 89.7 % Initial Dry Density 46.2 PCF

Est. Existing Overburden Pressure, Po = 0.84 KSF

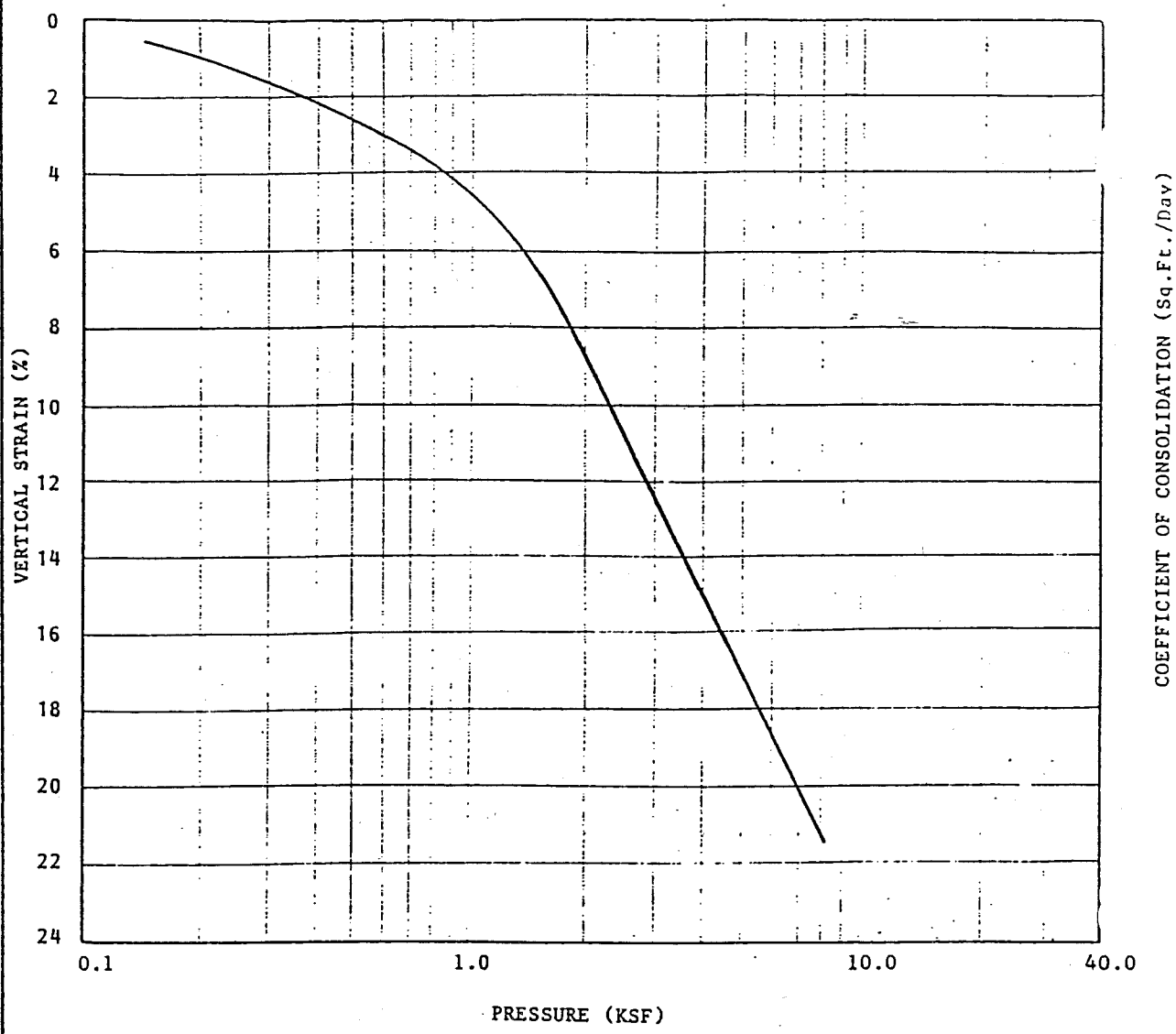
Est. Preconsolidation Pressure, Pc = 1.5 KSF

Sample Description Dark gray high plasticity silt with trace organics

CONSOLIDATION TEST
(A.S.T.M.: D-2435)
For
NSWF-2
Cherry Island
Wilmington, Delaware

DUFFIELD ASSOCIATES, INC.
Consulting Geotechnical Engineers
5400 Limestone Road
Newark, Delaware 19808

W. O. 410	Figure D-1-1	Date: October 21, 1983	Sheet 11 of 19



Test Boring Number GP-8 Depth 35.9

Atterberg Limits: LL 74, PI 23, U.S.C.S. Class. MH

Initial Moisture Content 94 % Initial Dry Density 44.9 PCF

Est. Existing Overburden Pressure, Po = 0.98 KSF

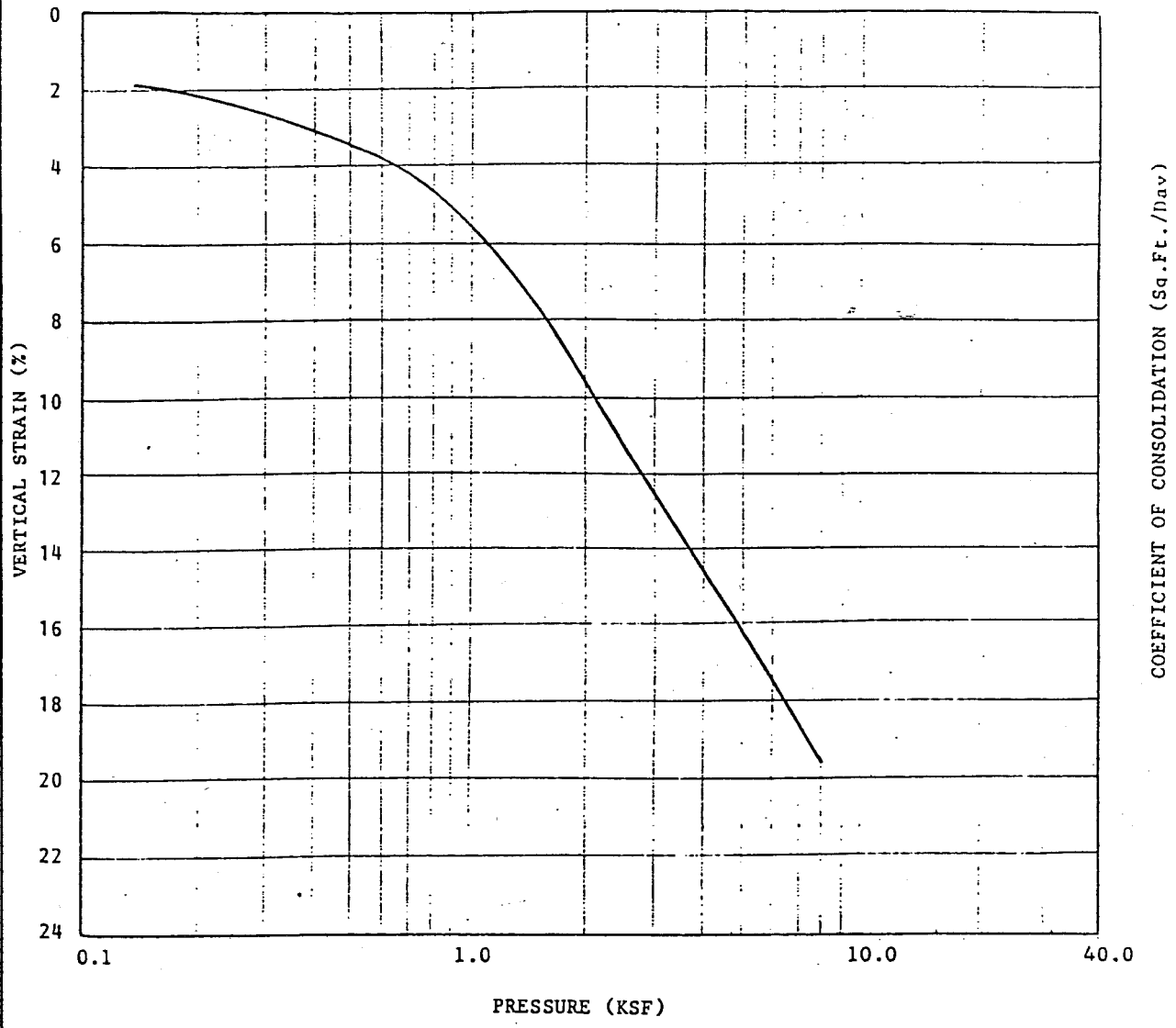
Est. Preconsolidation Pressure, Pc = 1.2 KSF

Sample Description Dark gray silt, trace fine sand, trace organics

CONSOLIDATION TEST
(A.S.T.M.: D-2435)
For
NSWF-2
Cherry Island
Wilmington, Delaware

DUFFIELD ASSOCIATES, INC.
Consulting Geotechnical Engineers
5400 Limestone Road
Newark, Delaware 19806

W. O. 410	Figure D-1-1	Date: October 21, 1983	Sheet 12 of 19



Test Boring Number GP-9 Depth 36.1

Atterberg Limits: LL 56, PI 16, U.S.C.S. Class. MH

Initial Moisture Content 70 % Initial Dry Density 56.1 PCF

Est. Existing Overburden Pressure, Po = 1.0 KSF

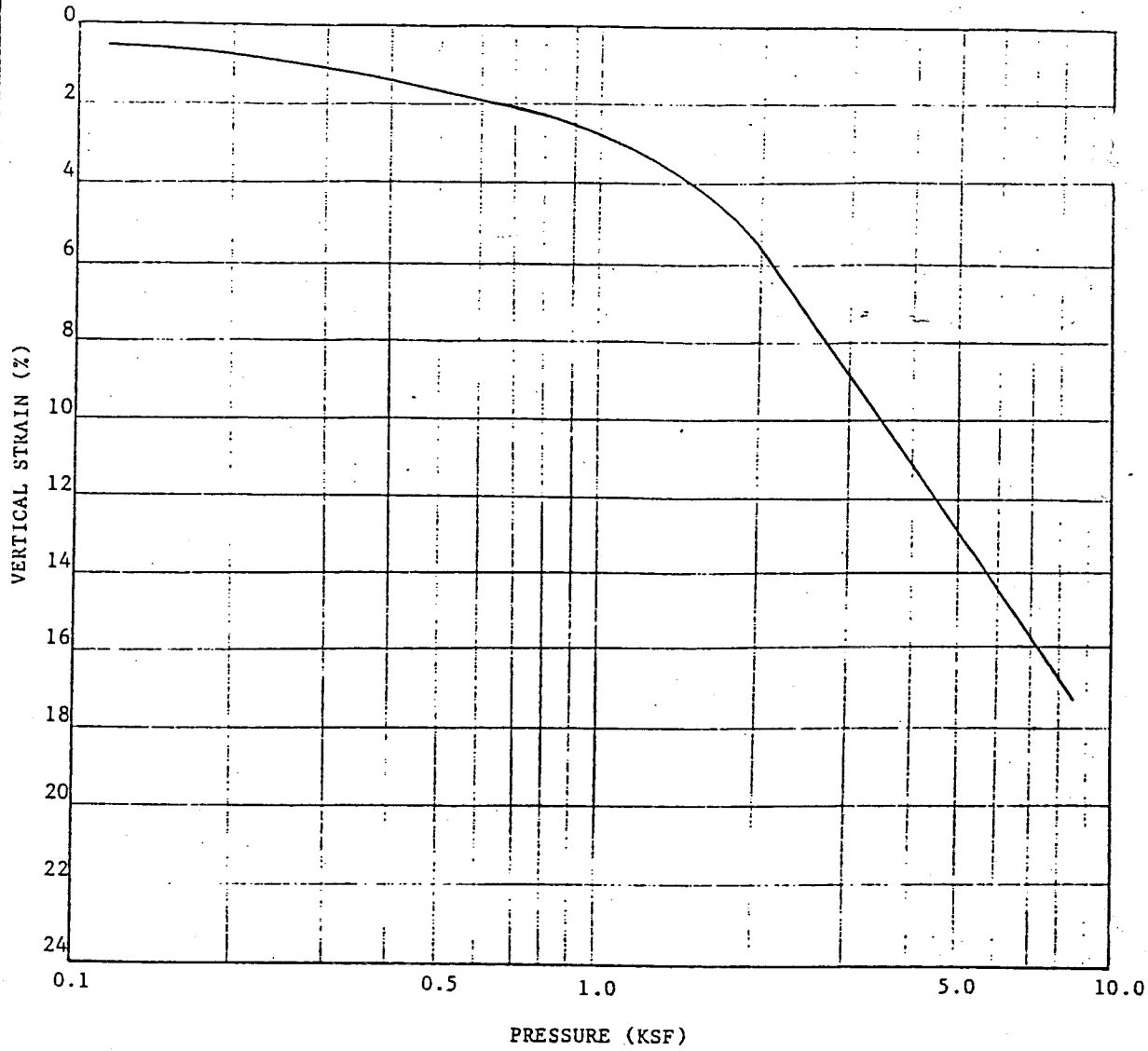
Est. Preconsolidation Pressure, Pc = 1.1 KSF

Sample Description Dark gray and black silt, trace fine sand, trace mica, trace organics

CONSOLIDATION TEST
(A.S.T.M.: D-2435)
For
NSWF-2
Cherry Island
Wilmington, Delaware

DUFFIELD ASSOCIATES, INC.
Consulting Geotechnical Engineers
5400 Limestone Road
Newark, Delaware 19808

W. O. 410	Figure D-1-1	Date: October 21, 1983	Sheet 13 of 19



Test Boring Number A-1 Depth 13.6'

Atterberg Limits: LL 21, PI 0, U.S.C.S. Class. ML-OL

Initial Moisture Content 47.1 % Initial Dry Density 69.7 PCF

Est. Existing Overburden Pressure, Po = 0.6 KSF

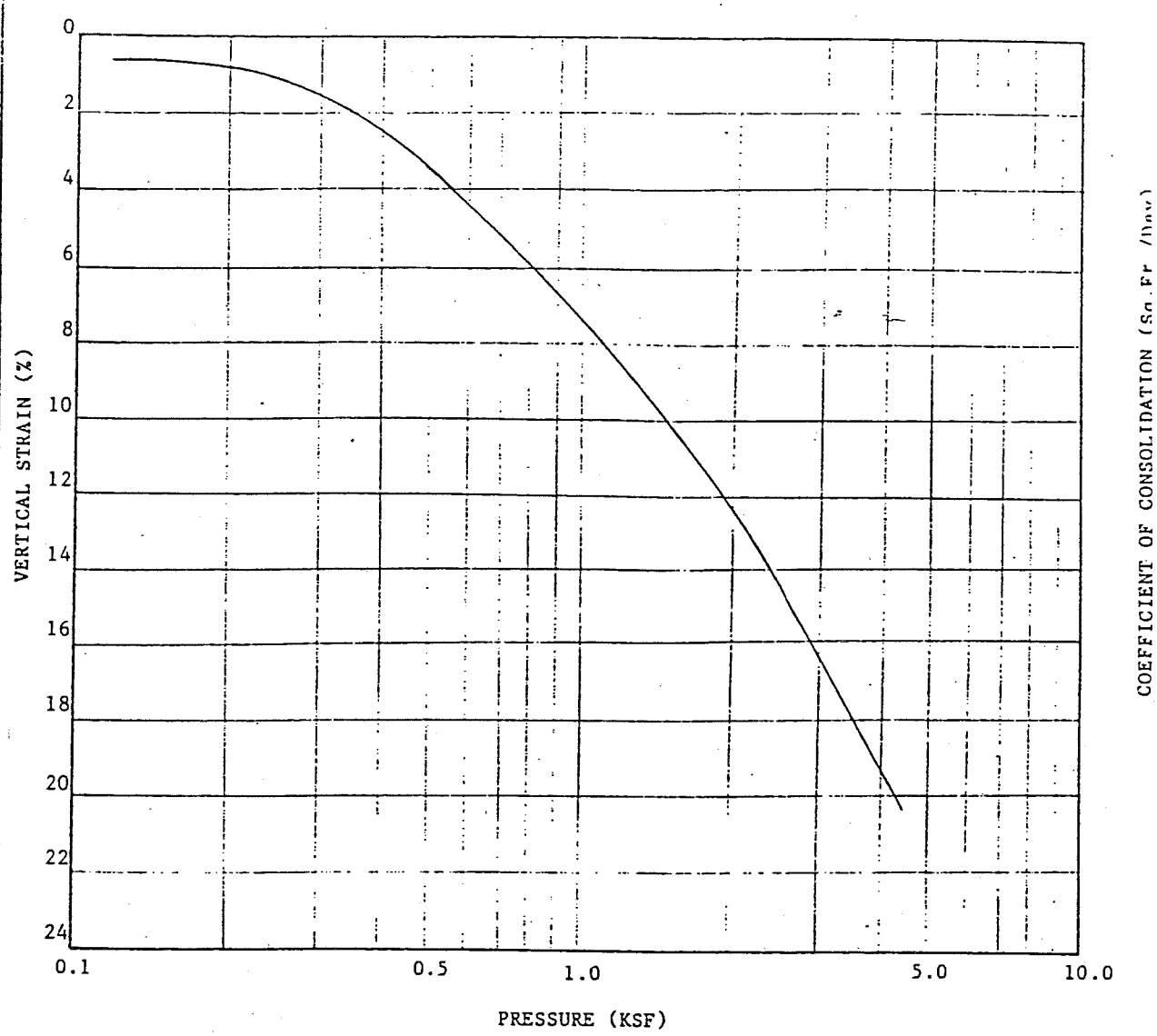
Est. Preconsolidation Pressure, Pc = 1.4 KSF

Sample Description Dark gray silt, little fine sand, trace organics, trace mica.

CONSOLIDATION TEST
(A.S.T.M.: D-2435)
For
NSWF-2
CHERRY ISLAND
WILMINGTON, DE

DUFFIELD ASSOCIATES, INC.
Consulting Geotechnical Engineers
5400 Limestone Road
Newark, Delaware 19808

W. O. 410	Figure D-1-1	Date: 11/23/83	Sheet 14 of 19



Test Boring Number A-1 Depth 27.0

Atterberg Limits: LL 65, PI 24, U.S.C.S. Class. MH

Initial Moisture Content 73.4 % Initial Dry Density 53.2 PCF

Est. Existing Overburden Pressure, Po = 1.0 KSF

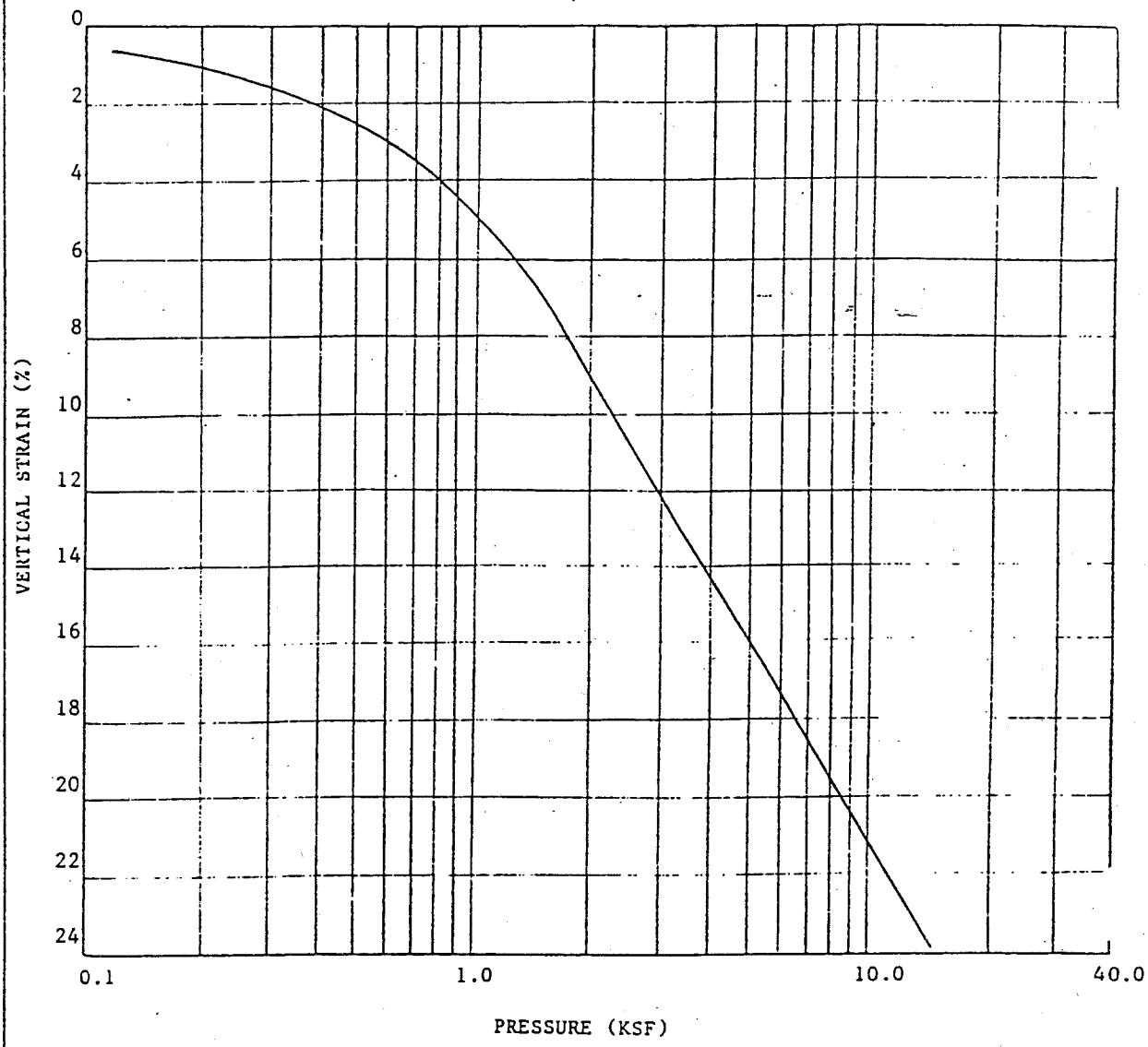
Est. Preconsolidation Pressure, Pc = 0.9 KSF

Sample Description Dark gray and medium gray silt, little organics, trace very fine sand.

CONSOLIDATION TEST-
(A.S.T.M.: D-2435)
For
NSWF-2
CHERRY ISLAND
WILMINGTON, DE

DUFFIELD ASSOCIATES, INC.
Consulting Geotechnical Engineers
5400 Limestone Road
Newark, Delaware 19808

W. O. 410	Figure D-1-1	Date: 11/23/83	Sheet 15 of 19.



Test Boring Number A2 Depth 12.6

Atterberg Limits: LL 60, PI 25, U.S.C.S. Class. MH-OH

Initial Moisture Content 76.8 % Initial Dry Density 53.0 PCF

Est. Existing Overburden Pressure, Po = 0.5 KSF

Est. Preconsolidation Pressure, Pc = 1.2 KSF

Sample Description Dark gray silt, trace very fine sand, trace organics, trace mica.

CONSOLIDATION TEST
(A.S.T.M.: D-2435)
For
NSWF-2
CHERRY ISLAND
WILMINGTON, DE

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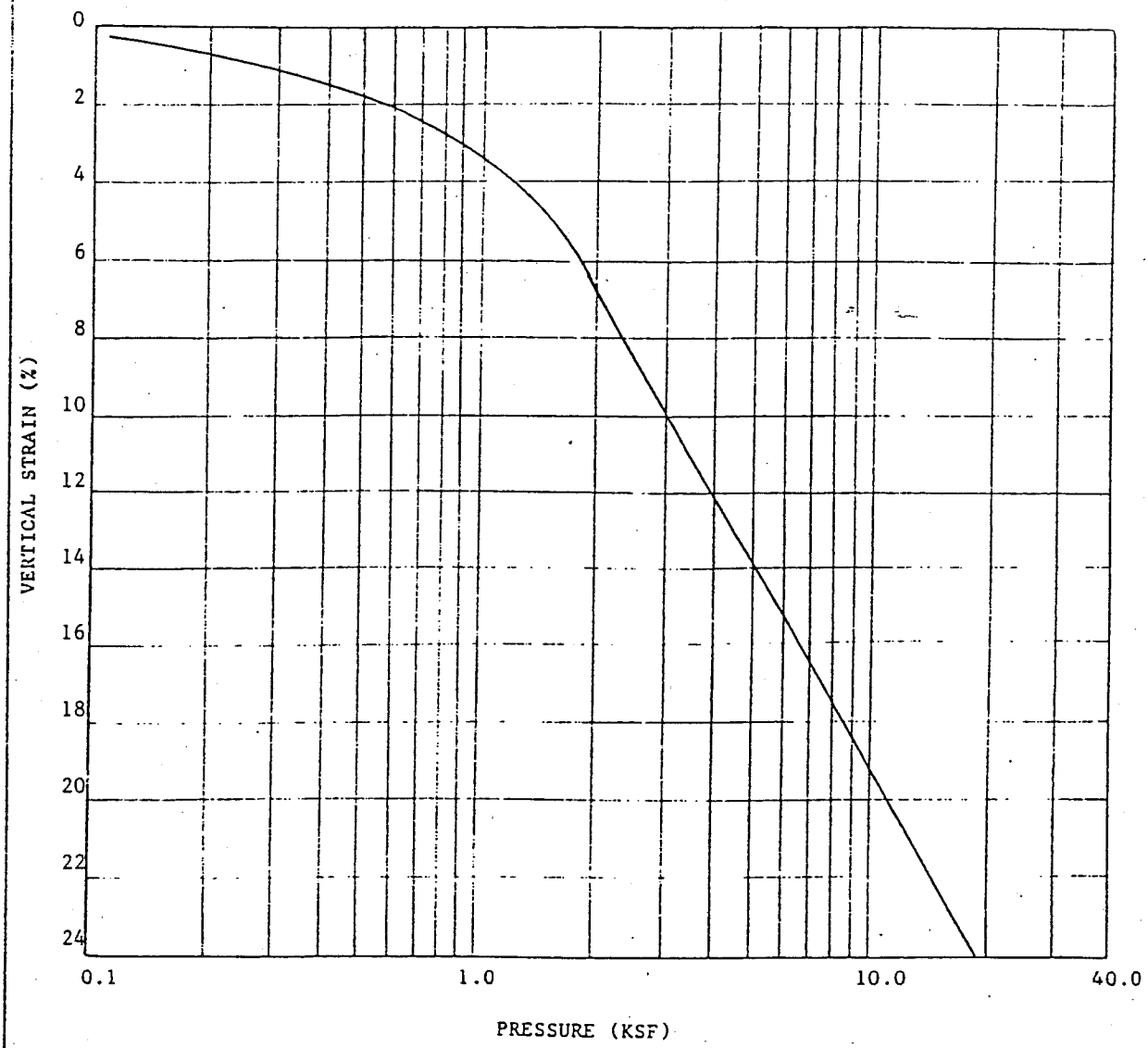
Newark, Delaware 19808



Test Boring Number A-3 Depth 25.1

Atterberg Limits: LL 72, PI 25, U.S.C.S. Class. MH

Initial Moisture Content 91.6 % Initial Dry Density 46.6 PCF

Est. Existing Overburden Pressure, Po = 0.9 KSF

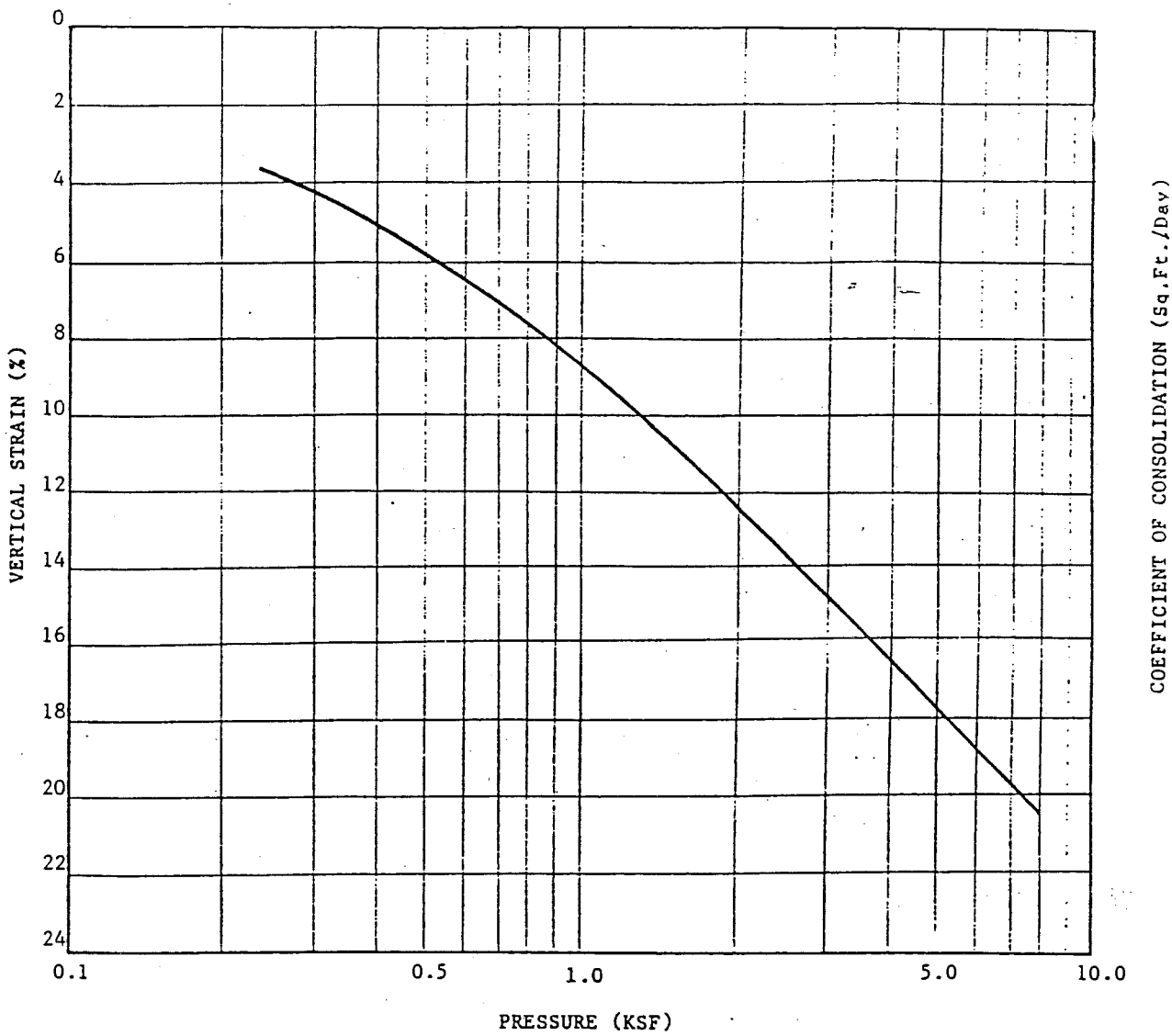
Est. Preconsolidation Pressure, Pc = 1.6 KSF

Sample Description Dark gray silt, trace fine sand, trace peat

CONSOLIDATION TEST
(A.S.T.M.: D-2435)
For
NSWF-2
CHERRY ISLAND
WILMINGTON, DE

DUFFIELD ASSOCIATES, INC.
Consulting Geotechnical Engineers
5400 Limestone Road
Newark, Delaware 19808

W. O. 410	Figure D-1-1	Date: 12/20/83	Sheet 17 of 19



Test Boring Number A-5 Depth 15.5'

Atterberg Limits: LL 26, PI 0, U.S.C.S. Class. ML-OL

Initial Moisture Content 39.3 % Initial Dry Density -- PCF

Est. Existing Overburden Pressure, Po = 0.6 KSF

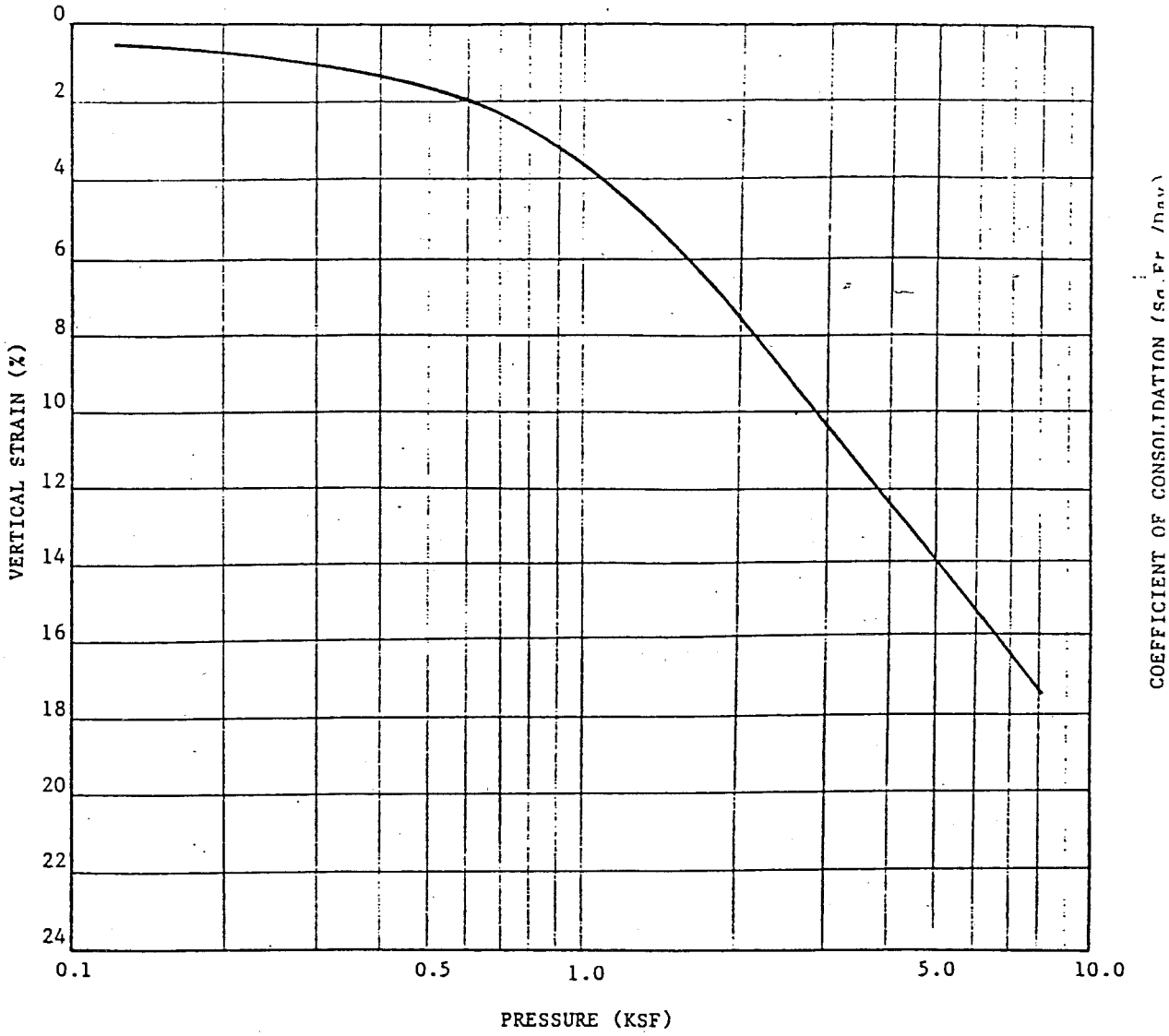
Est. Preconsolidation Pressure, Pc = 1.0 KSF

Sample Description Medium gray silt, trace very fine sand, trace organics

CONSOLIDATION TEST
(A.S.T.M.: D-2435)
For
NSWF-2
CHERRY ISLAND
WILMINGTON, DELAWARE

DUFFIELD ASSOCIATES, INC.
Consulting Geotechnical Engineers
5400 Limestone Road
Newark, Delaware 19808

W. O. 410	Figure D-1-1	Date: 12/27/83	Sheet 18 of 19



Test Boring Number #A-7 Depth 20.1

Atterberg Limits: LL 43, PI 10, U.S.C.S. Class. ML-OL

Initial Moisture Content 73.2 % Initial Dry Density 60.9 PCF

Est. Existing Overburden Pressure, Po = 0.7 KSF

Est. Preconsolidation Pressure, Pc = 1.0 KSF

Sample Description Dark gray silt, trace very fine sand, trace organics

CONSOLIDATION TEST
(A.S.T.M.: D-2435)
For
NSWF-2
CHERRY ISLAND
WILMINGTON, DELAWARE

DUFFIELD ASSOCIATES, INC.
Consulting Geotechnical Engineers
5400 Limestone Road
Newark, Delaware 19808

W. O. 410	Figure D-1-1	Date: 12/28/83	Sheet 19 of 19

Figure D-1-2

Triaxial Test Data (CU Test)
Plot of Effective Stress vs. Shear Stress
GP-6, 25.0 - 27.0 ft.
NSWF-2, Cherry Island

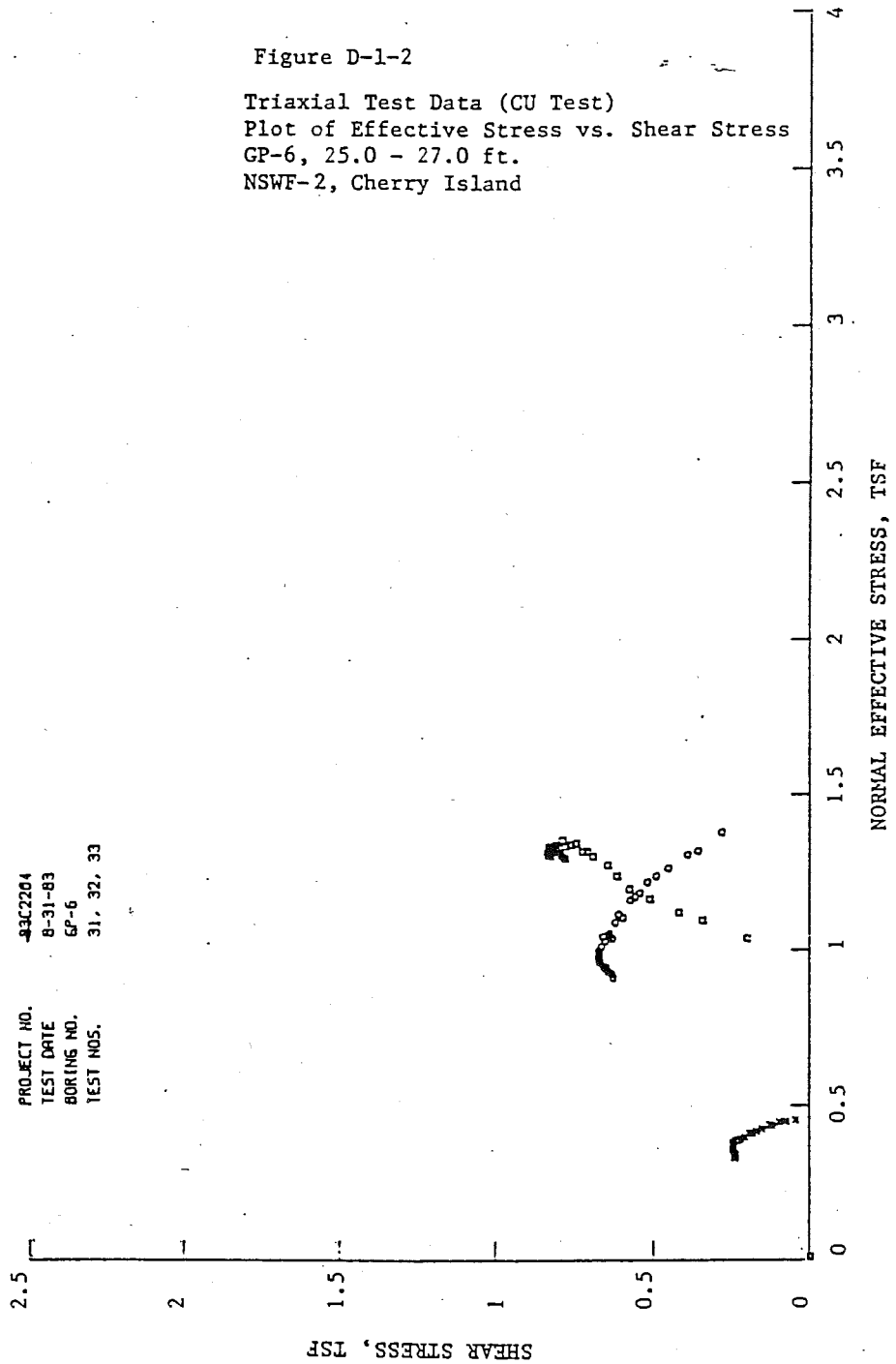
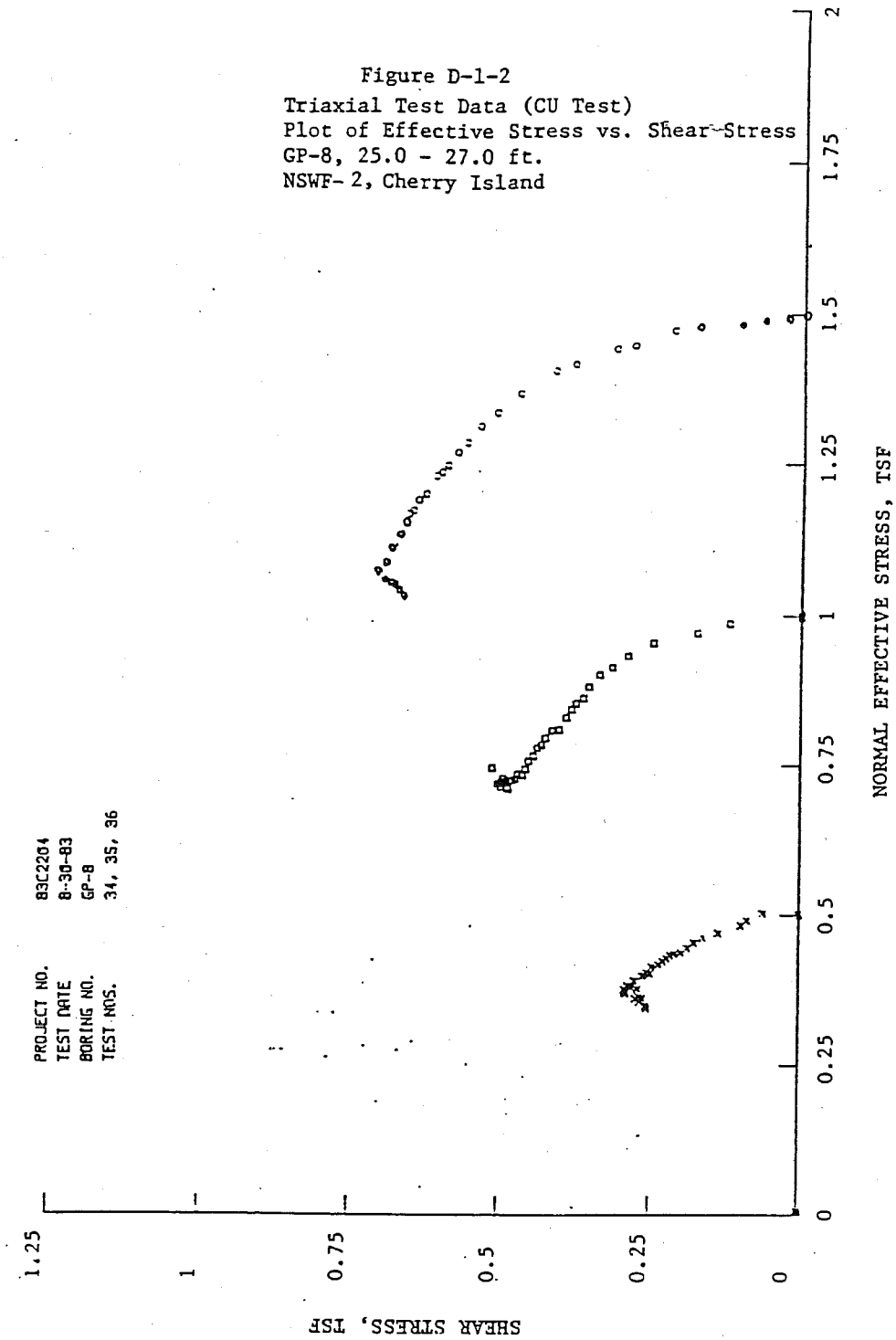


Figure D-1-2
Triaxial Test Data (CU Test)
Plot of Effective Stress vs. Shear Stress
GP-8, 25.0 - 27.0 ft.
NSWF-2, Cherry Island



APPENDIX D-2

GROUND WATER CONDITIONS

D-2 Ground Water Conditions

As part of the subsurface evaluation program temporary observation monitoring points were installed to evaluate ground water conditions and hydraulic gradients in the surficial materials. During the period July 14, 1983, to the present, water levels were recorded at all installed piezometers periodically. These data are summarized on Table D-2-1 which shows the bottom of the piezometer elevation and the elevation of ground water recorded on each date. At most locations, a shallow (approximately 10-15 feet) piezometer designated by the letter A (i.e., 3A), and a deep piezometer (approximately 10-15 feet) above the bottom of the compressible layer were installed. The purpose of the shallow and deep piezometers was to evaluate vertical gradients in the compressible soils. A review of Table D-2-1 indicates a vertical gradient toward the base of the layer; however, the head differences appear to range from less than one foot at Monitor 4 to greater than 16 feet at Monitor 7. In general, these data indicate a radial flow from the center of the site to the perimeter. Water levels appeared to decline uniformly approxiamtely 0.5 to 1 foot until mid-September and have presently rebounded to the initial elevations.

Ground water flow and the water table conditions and the encountered geologic formations are discussed in Section 2.

TABLE D-2-1

NSWF-2

CHERRY ISLAND

PIEZOMETER READINGS

Piezometer Number	Bottom of Piezometer Elevation	Piezometric Elevation (ft.) Date 8/26/83	9/02/83	9/16/83	9/27/83	10/07/83	10/14/83	10/21/83	11/02/83	11/18/83	12/27/83
3	- 4.8	23.1	23.1	22.7	22.8	22.7	23.0	22.6	22.8	22.7	23.8
3A	17.9	32.4	32.2	32.0	32.0	32.2	32.4	32.2	32.4	32.4	33.6
4	- 8.5	29.7	29.7	30.2	29.8	30.1	29.7	30.1	29.7	29.8	31.1
4A	16.5	30.6	30.6	29.7	30.5	29.9	30.4	29.9	30.5	30.6	31.3
5	- 6.1	31.2	30.9	30.9	31.0	30.8	31.0	30.9	31.0	31.1	31.9
5A	15.6	35.5	35.4	35.0	35.5	34.8	35.3	34.5	34.8	34.7	35.8
6	-10.8	--	--	--	22.9	23.2	23.5	23.0	23.9	23.3	--
6A	7.2	--	--	--	36.7	36.4	36.8	36.4	36.3	36.1	--
7	- 5.8	--	--	20.8	20.9	20.9	21.0	20.8	20.9	21.3	--
7A	19.0	--	--	37.7	37.8	37.3	37.5	37.4	37.6	37.6	--
8	- 8.8	--	--	35.4	35.5	35.4	35.0	33.9	33.4	33.4	--
8A	18.6	--	--	38.6	38.6	37.8	37.9	38.3	38.4	38.4	--
9	- 7.8	--	--	33.6	31.8	31.7	32.1	32.0	32.3	32.6	--
9A	18.9	--	--	37.1	37.0	36.7	36.8	36.6	36.6	36.8	--
11	-25.7	--	--	2.6	1.4	1.5	2.0	1.8	1.7	1.8	--

TABLE D-2-1 (Cont.)

NSWF-2

CHERRY ISLAND

PIEZOMETER READINGS

Piezometer Number	Bottom of Piezometer Elevation	Piezometric Elevation (ft.) Date 12/20/83	12/27/83
A-2	-15.25	2.30	1.9
A-2A	-4.95	11.3	12.0
A-3	-12.85	5.7	5.8
A-3A	-0.9	10.8	11.0
A-4	-4.7	18.1	20.5
A-4A	6.15	21.1	20.2
A-5	-13.8	--	4.5
A-5A	+4.6	--	20.2
A-6	-15.9	--	--
A-7	-25.8	0.90	0.50

APPENDIX D-3

DATA SUMMARY (ANALYSIS)

D-3-1 Data Summary (Analysis)

Based on the strength and compressibility testing performed in the field and laboratory programs, design parameters for each stratum encountered have been developed and are shown on Table D-3-1. These parameters are based on the range of test results and have been utilized for the analysis. Several figures indicating strength and density vs. depth are included in Figures D-3-1 through D-3-4. While local variations may exist, the selected parameters provide a general representation of the soils encountered in the Wilmington and Edgemoor areas at Cherry Island. For design purposes, the soils of the Wilmington side of the site have been treated as a uniform stratum while the soils of the Edgemoor side have been treated as three strata.

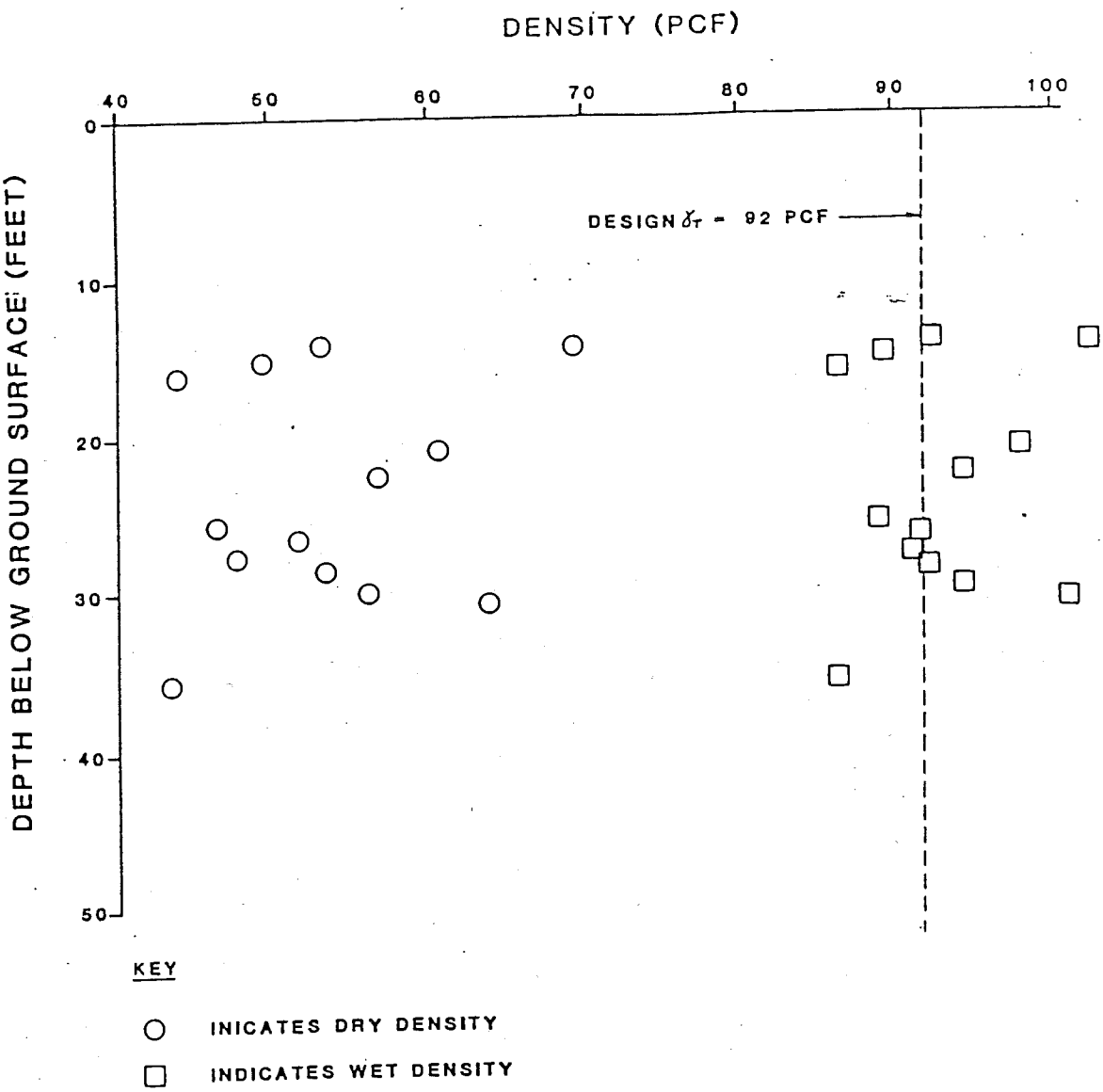
It should be noted that the strength parameters presented in Table D-3-1 are considered representative of the soils as they now exist at the site. The amount and rate of the strength gain due to the load imposed by refuse has been estimated using the results of laboratory testing. However, the actual progress of consolidation should be monitored in the field as construction and landfilling take place. Evaluation of the actual progress may allow the modification of slopes (i.e., the deletion of "benches", thus increasing landfill capacity) and may allow a modification of the recommended landfilling rates.

TABLE D-3-1

DESIGN PARAMETERS - COMPRESSIBLE STRATA

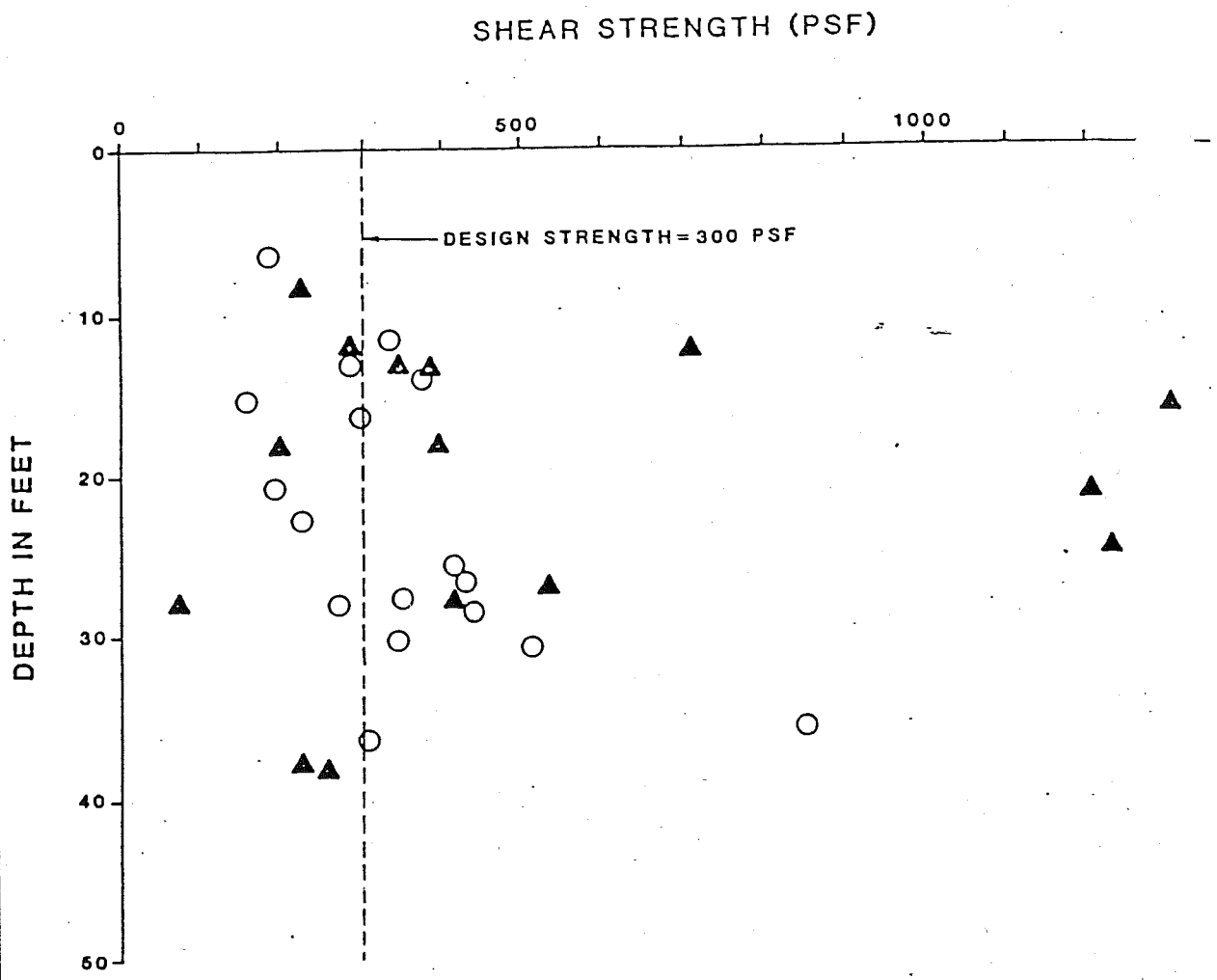
Depth (Ft)	Stratum	Wet Density	Buoyant Unit Wt	Phi-Angle	Cohesion	Pc[3]	C/Pc[4]	Cv[5]	Rr[6]	Cr[6]	Cd[7]
				NORTH PORTION OF WILMINGTON AREA							
- 0	Dark gray & black high plasticity silt & clay with some organics	92.0 pcf	29.5 pcf	0[2]	300 psf	1200 psf	0.22	0.056	0.069	0.195	0.012
-40 (maximum varies)											
				EDGEMOOR AREA							
- 0	Dark grey & black org. silt med. to high plasticity	87.0 pcf	24.5 pcf	0[2]	150 psf	780 psf	0.10	0.046 S.F./day	0.072	0.212	0.014
-25	Dark grey high plasticity silt	89.5 pcf	27.0 pcf	0[2]	300 psf	1300 psf	0.23	0.046 S.F./day	0.076	0.198	0.014
-41	Dark grey silt and clay with lt. grey fine sand laminae	101.5 pcf	39.0 pcf	0[2]	600 psf	5000 psf	0.12	0.135 S.F./day	0.043	0.140	0.014
-Bottom Varies											

NOTES:
1. Design water at the ground surface.
2. 0 degrees for short term condition.
3. Pc = estimated past preconsolidation pressure.
4. Ratio of cohesion to preconsolidation pr[illegible]e used in estimating strength gain following consolit
5. Coefficient of consolidation used to es[illegible] the time rate of consolidation.
6. Coefficients of compressibility to estimate the amount of settlement. Rr for reload; Cr for virgin compression.



NOTE: DENSITIES OF PEAT AND FINE SAND SAMPLES NOT INCLUDED IN THIS FIGURE.

UNIT WEIGHT VS. DEPTH WILMINGTON AREA NSWF-2 CHERRY ISLAND WILMINGTON, DELAWARE	DUFFIELD ASSOCIATES, INC. CONSULTING GEOTECHNICAL ENGINEERS
Drawn: DSH Chk'd: RDC	Date: 1/6/84
Scale: AS SHOWN	W.O.: 410
File No.:	Fig. D-3-1



KEY

○ COHESION FROM UNCONFINED COMPRESSIVE STRENGTH

▲ SHEAR STRENGTH DETERMINED BY FIELD VANE SHEAR (WITH BJERRUM CORRECTION FACTOR)

NOTE: 1. DATA FROM WILMINGTON AREA TEST BORINGS.

2. VANE SHEAR STRENGTHS GREATER THAN 1300 PSF (3 TESTS) NOT INCLUDED IN THIS FIGURE.

SHEAR STRENGTH VS. DEPTH

WILMINGTON AREA

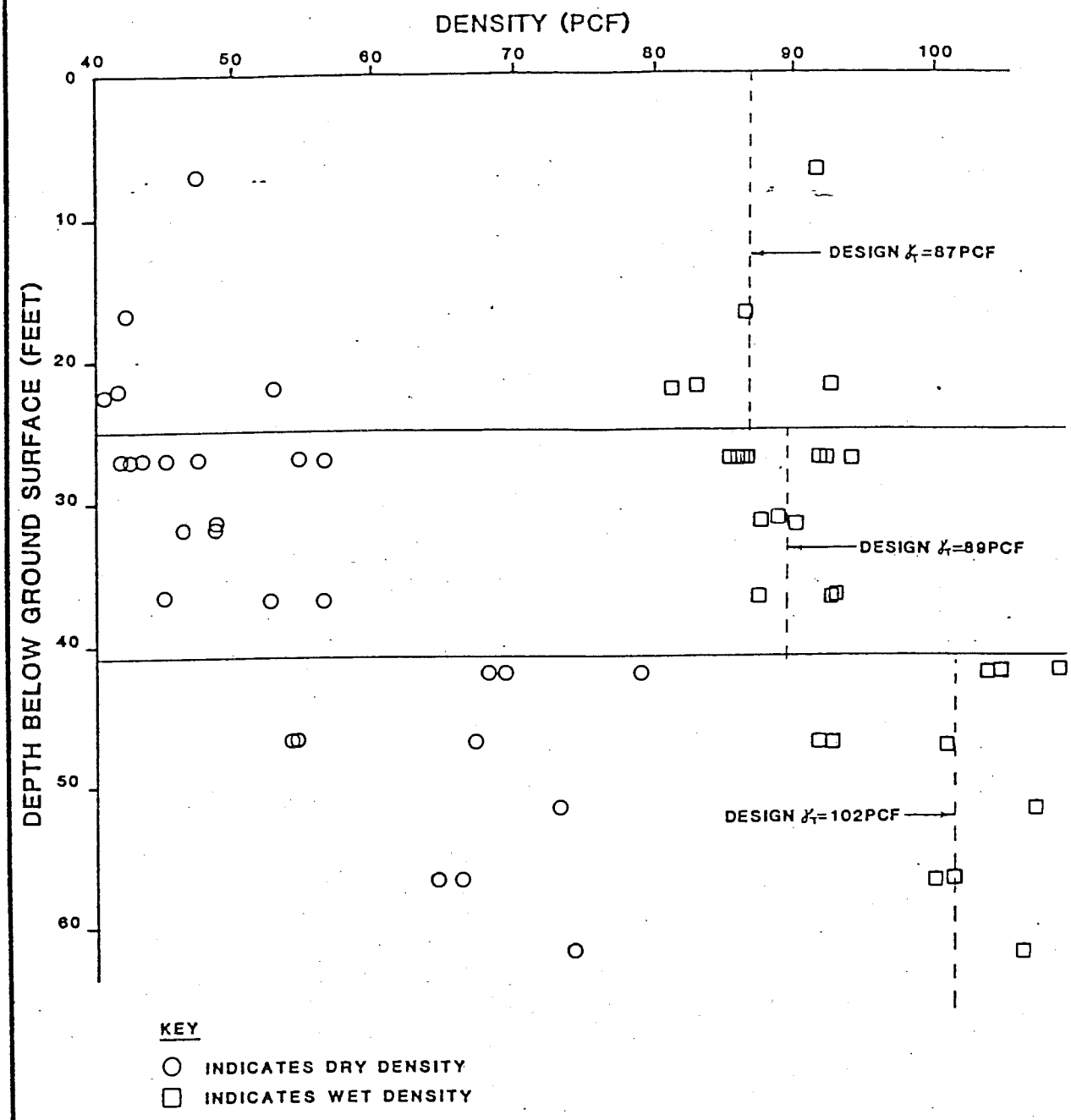
NSWF-2

CHERRY ISLAND

WILMINGTON, DELAWARE

DUFFIELD ASSOCIATES, INC.
CONSULTING GEOTECHNICAL ENGINEERS

Drawn: DSH Chk'd: RDC	Date: 1/6/84
Scale: AS SHOWN	W.O.: 410
File No.:	Fig. D-3-2



UNIT WEIGHT VS. DEPTH

EDGEMOOR AREA

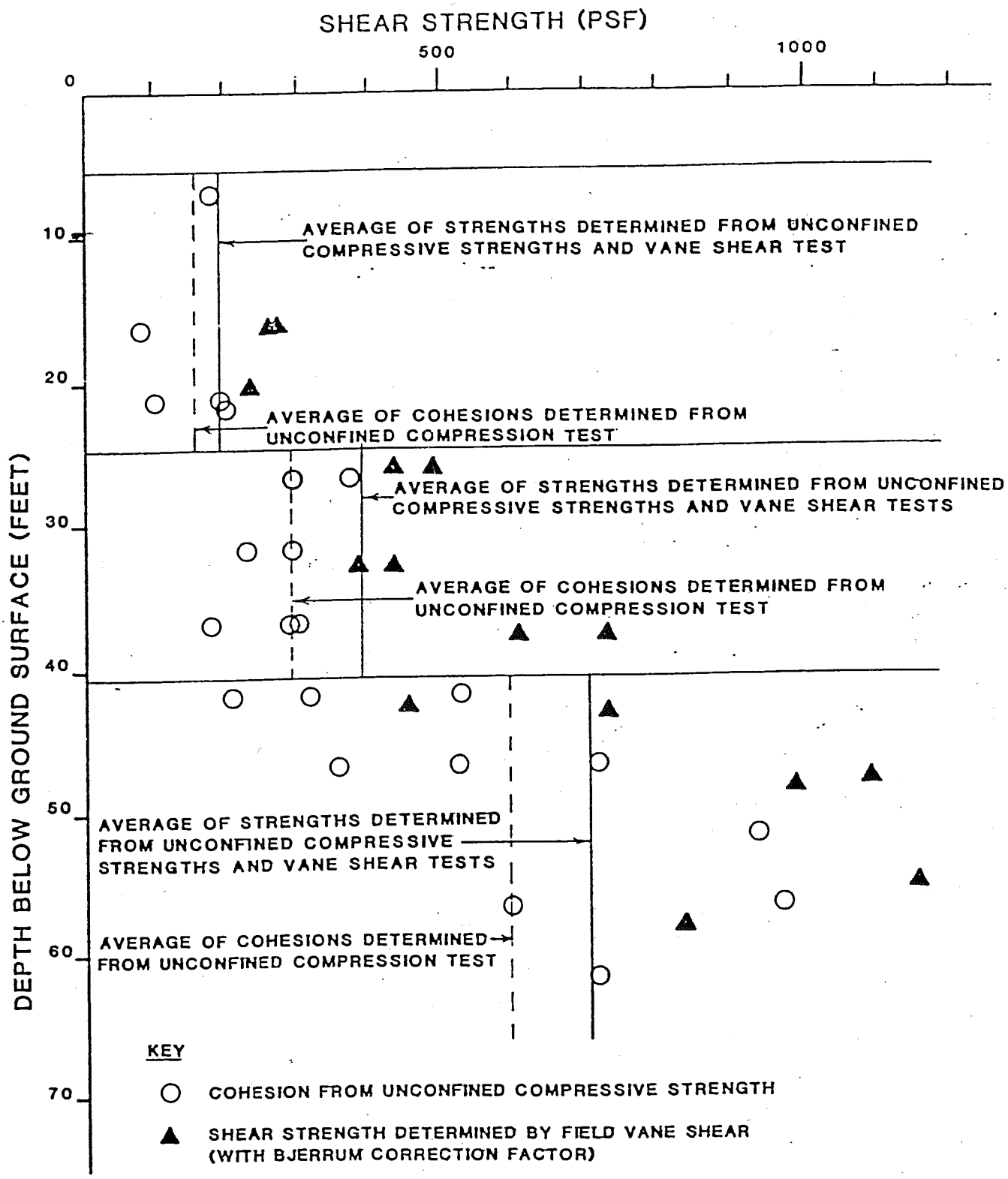
NSWF-2

CHERRY ISLAND

WILMINGTON, DELAWARE

DUFFIELD ASSOCIATES, INC.
CONSULTING GEOTECHNICAL ENGINEERS

Drawn: DMA Chk'd: RDC	Date: 10/25/83
Scale: AS SHOWN	W.O.: 410
File No.:	Fig. D-3-3



SHEAR STRENGTH VS. DEPTH
EDGEMOOR AREA
NSWF-2
CHERRY ISLAND
WILMINGTON, DELAWARE

DUFFIELD ASSOCIATES, INC.
CONSULTING GEOTECHNICAL ENGINE

Drawn: DMA Chk'd: RDC	Date: OCT. 25, 1983
Scale: AS SHOWN	W.O.: 410
File No.:	Fig. D-3-4

TABLE D-1-1

Boring and Piezometer
Construction Details

Test Boring No.	Type	Bottom Elevation(ft.)	Piezometer Elevation(ft.)
G-1	Stratigraphic	-35.6	--
G-2	Stratigraphic	-24.9	--
GP-3	Stratigraphic	-58.1	- 4.75
GP-3A	Non-Sample	+16.7	+17.9
GP-4	Stratigraphic	-76.1	- 8.45
GP-4A	Non-Sample	+14.6	+16.5
GP-5	Stratigraphic	-74.5	- 6.1
GP-5A	Non-Sample	+12.9	+15.6
GP-6	Stratigraphic	-41.1	-10.8
GP-6A	Non-Sample	+ 7.3	+ 7.2
GP-7	Stratigraphic	-79.1	- 5.8
GP-7A	Non-Sample	+ 7.5	+19.0
GP-8	Stratigraphic	-64.0	- 8.8
GP-8A	Non-Sample	+ 9.0	+18.6
GP-9	Stratigraphic	-68.7	- 7.8
GP-9A	Non-Sample	+ 5.3	+18.9
G-10	Stratigraphic	-54.1	--
GP-11	Stratigraphic	-86.0	-25.7
G-12	Stratigraphic	-87.5	--
AB-1	Stratigraphic	+24.1	--
AB-2	Stratigraphic	+24.1	--
AB-3	Stratigraphic	+24.0	--
AB-4	Stratigraphic	+10.5	--
AB-5	Stratigraphic	+ 8.3	--
AB-6	Stratigraphic	+11.9	--
A-1	Stratigraphic	-25.7	--
A-2	Stratigraphic	-31.4	-15.2
A-2A	Non-Sample	- 5.9	- 5.0
A-3	Stratigraphic	-22.9	-12.8
A-3A	Non-Sample	- 3.4	- 0.9
A-4	Stratigraphic	-21.9	- 4.7
A-4A	Non-Sample	+ 4.6	+ 6.2
A-5	Stratigraphic	-23.3	-13.8
A-5A	Non-Sample	+ 0.7	+ 4.6
A-6	Stratigraphic	-23.4	-18.9
A-7	Stratigraphic	-26.3	-25.8

TABLE D-1-2

Summary of Field Vane Shear Data

Test Boring Number	Depth of Van Test (Ft.)	S (Field) (PSF)	Plasticity Index	Correction Factor	S (Design) (PSF)
G-1	13.5	408	25	0.94	384
	28.0	79	24*	0.94	74
G-2	18.5	408	21	0.97	396
	38.0	240	24*	0.94	226
GP-3	20.0	79	24	0.94	74
	35.0	23	26	0.93	21
GP-3A	18.5	340	24	0.94	320
	25.0	634	25	0.94	596
GP-4	18.5	566	29	0.92	521
	28.0	476	6	1.10	524
	38.0	589	6	1.10	648
GP-4A	11.5	385	27	0.92	354
GP-5	23.5	476	7	1.10	524
	33.5	227	38	0.85	193
	43.0	816	6	1.10	898
GP-5A	18.5	272	23	0.96	261
	26.5	54	38	0.85	46
GP-6A	20.5	295	46	0.80	236
GP-7	37.7	861	36	0.86	740
	48.5	915	8	1.09	997
GP-7A	16.5	326	40	0.84	274
	26.5	521	40	0.84	438
GP-8	33.0	462	23	0.95	439
	43.0	553	42	0.83	459
	58.5	816	14	1.04	849
GP-9	33.0	417	24	0.94	392
	43.5	748	19	0.99	741
	55.5	1201	21	0.97	1165
GP-9A	16.5	281	27	0.92	259
	26.5	521	24	0.94	490

Test Boring Number	Depth of Van Test (Ft.)	S (Field) (PSF)	Plasticity Index	Correction Factor	S (Design) (PSF)
G-10	8.5	204	9	1.08	220
	13.0	317	9	1.08	342
	18.0	181	9	1.08	195
	28.0	408	16	1.01	412
	38.5	249	16	1.01	251
GP-11	38.0	589	13	1.04	613
	48.0	1019	9	1.08	1101
G-12	48.0	Not Reported			
A-1	12.0	647	0	1.10	712
	27.5	3535	--	----	3535**
A-2	12.0	299	25	0.94	281
	27.0	568	24	0.94	534
A-2A	15.5	1394	25	0.94	1310
A-3	27.5	1593	25	0.94	1497
	32.5	1892	5	1.10	2081
A-4	24.5	1344	29	0.92	1236
	29.5	1394	17	1.01	1408
A-5A	21.5	2145	21	0.97	1208

* Assumed from data obtained at a comparable elevation.
** Fiberous Peat

NOTES:

(1) S (Design) = S (Field) where S (Field) is field measured shear resistance, is a correction factor related to plasticity index.

(2) determined from Plasticity Index and chart presented by Bjerrum, "Specialty Conference on Performance of Earth and Earth Supported Structures", Vol. 2, 1972.

TABLE D-1-3
NSWF-2
CHERRY ISLAND
SUMMARY

Laboratory Test Results

Test Boring	Sample Depth Ft.	Natural Water Content %	Less Than No. 200 Sieve %	Other
#AB-4	0 - 5.0'	46.0	79.5	
	0 - 5.0'	51.1	--	
#AB-4	5.0' - 10.0'	81.6	--	
	5.0' - 10.0'	81.2	91.3	
#AB-4	10.0' - 15.0'	84.3	96.9	
	10.0' - 15.0'	87.4	--	
#AB-5	0 - 5.0'	77.6	96.0	
	0 - 5.0'	81.3	--	
#AB-5	5.0' - 10.0'	79.5	91.2	
	5.0' - 10.0'	85.7	--	
#AB-5	10.0' - 15.0'	90.6	98.0	
	10.0' - 15.0'	94.4	--	
#AB-6	0 - 5.0'	83.9	96.1	
	0 - 5.0'	86.3	--	
#AB-6	5.0' - 10.0'	95.9	95.0	
	5.0' - 10.0'	96.5	--	
#AB-6	10.0' - 15.0'	100.3	98.6	
	10.0' - 15.0'	90.6	98.1	

TABLE D-1-3
NSWF-2
CHERRY ISLAND
SUMMARY

Laboratory Test Results

Test Boring	Sample Depth Ft.	Natural Water Content %	Less Than No. 200 Sieve %	Other
#C-105	7.0'	50.4	94.2	
	17.0'	66.0	--	
	27.0'	81.9	99.5	
	37.0'	69.8	80.3	
	47.0'	66.9	91.9	
	57.0'	66.4	99.5	
	62.0'	66.7	99.7	
#C-106	7.0'	94.2	96.6	
	17.0'	70.3	97.3	
	27.0'	59.5	98.5	
	37.0'	43.7	42.3	
#C-108	7.0'	45.9	83.1	
	17.0'	62.6	87.3	
	27.0'	71.6	99.4	
#C-102	7.0'	67.1	98.0	
	17.0'	97.8	99.2	
	27.0'	72.6	98.9	
	42.0'	74.8	84.4	

TABLE D-1-3
NSWF-2
CHERRY ISLAND
SUMMARY

Laboratory Test Results

Test Boring	Sample Depth Ft.	Natural Water Content %	Less Than No. 200 Sieve %	Other
#G-1	2.5'	32.0	50.6	
	6.5'	47.7	95.9	
	11.0'	84.1	99.7	
	11.7'	100.3	--	γ_D = 41.7 p.c.f. qu = 662 p.s.f.
	12.0'	105.6	99.2	LL = 86 PI = 25 U.S.C.S. = MH See consolidation and permeability graphs
	16.5'	88.1	99.1	
	26.5'	60.7	98.9	
	31.5'	63.4	99.4	
	36.1'	24.6	--	
	36.7'	22.6	--	γ_D = 104.6 p.c.f
	37.0'	23.0	14.2	
	41.5'	16.6	34.8	
	51.5'	12.2	9.9	
#G-2	2.5'	69.2	98.2	
	11.5'	71.3	94.1	
	16.0'	89.4	92.2	
	16.7'	71.5	--	γ_D = 54.9 p.c.f. qu = 595 p.s.f.
	17.0'	97.1	99.5	LL = 63 PI = 21 U.S.C.S. = MH See consolidation and permeability graphs
	26.5'	47.8	96.8	
	36.5'	21.1	63.9	
	41.5'	20.0	13.8	

TABLE D-1-3
NSWF-2
CHERRY ISLAND
SUMMARY

Laboratory Test Results

Test Boring	Sample Depth Ft.	Natural Water Content %	Less Than No. 200 Sieve %	Other
#GP-3	1.5'	42.3	99.5	
	6.5'	61.4	98.4	
	10.7'	61.7	97.2	γ_D = 60.5 p.c.f. qu = 865 p.s.f.
	11.0'			LL = 68 PI = 21 U.S.C.S. = MH
	12.0'	61.8	99.3	
	12.5'	58.7	98.7	
	13.0'	57.8	97.7	
	14.0'	70.6	98.6	
	16.0'	49.6	94.8	
	16.6'	73.1	98.5	γ_D = 51.6 p.c.f. qu = 509 p.s.f.
	17.0'			LL = 74 PI = 24 U.S.C.S. = MH See consolidation and permeability graphs
	18.5'	74.0	98.2	
	21.5'	74.9	99.0	
	26.7'	77.3	99.2	γ_D = 52.2 p.c.f. qu = 740 p.s.f.
	27.0'			LL = 72 PI = 25 U.S.C.S. = MH
	28.5'	75.0	58.1	
	31.7'	77.4	99.5	γ_D = 52.6 p.c.f. qu = 927 p.s.f.
	32.0'			LL = 85 PI = 26 U.S.C.S. = MH

TABLE D-1-3
NSWF-2
CHERRY ISLAND
SUMMARY

Laboratory Test Results

Test Boring	Sample Depth Ft.	Natural Water Content %	Less Than No. 200 Sieve %	Other
#GP-3	33.5'	67.3	99.2	
	37.0'	69.9	99.4	
	41.5'	94.5	98.9	
	46.5'	38.2	81.7	
	51.5'	71.9	51.3	
	56.5'	153.0	78.4	
	61.5'	19.6	60.3	
	66.5'	31.0	22.6	
	71.5'	14.2	14.1	
	76.5'	9.5	10.9	
	96.5'	37.6	75.7	
#GP-4	2.5'	46.5	95.6	
	11.0'	9.1	6.7	
	11.5'	75.7	98.5	
	16.7'	86.9	91.3	γ_D = 47.5 p.c.f. qu = 506 p.s.f
	17.0'	102.5	--	LL = 80 PI = 27 U.S.C.S. = MH See consolidation and permeability graphs.
	26.5'	82.6	98.7	
	31.5'	77.3	97.0	γ_D = 50.3 p.c.f. qu = 718 p.s.f.
	31.7'	--	--	LL = 38 PI = 6 U.S.C.S. = ML
	41.5'	47.3	95.3	
	51.5'	64.1	98.1	
	60.0'	8.1	11.0	
	70.5'	9.4	18.7	
	80.5'	27.2	26.0	
	90.5'	11.1	12.1	
	95.0'	10.4	16.0	
	105.5'	16.0	33.2	
	110.5'	21.3	62.2	

TABLE D-1-3
NSWF-2
CHERRY ISLAND
SUMMARY

Laboratory Test Results

Test Boring	Sample Depth Ft.	Natural Water Content %	Less Than No. 200 Sieve %	Other
#GP-5	1.5'	52.0	99.6	
	6.5'	73.7	98.9	
	11.5'	73.5	98.7	
	21.7'	81.6	--	γ_D = 51.0 p.c.f. qu = 815 p.s.f.
	21.9'	78.8	99.0	LL = 65 PI = 7 U.S.C.S. = MH
	26.5'	79.9	98.4	
	31.7'	91.2	--	γ_D = 47.6 p.c.f. qu = 830 p.s.f.
	31.9'	91.6	99.5	LL = 103 PI = 38 U.S.C.S. = MH
	41.5'	79.4	99.8	
	51.5'	54.4	98.2	
	61.5'	63.1	99.1	
	66.5'	19.7	24.9	
	76.5'	11.0	10.4	
	81.5'	8.9	9.8	
	86.5'	8.7	22.0	
	96.5'	11.6	16.9	
	101.5'	20.7	15.0	
	111.5'	11.4	6.8	
#GP-5A	16.8'	74.5	--	γ_D = 54.7 p.c.f. qu = 295 p.s.f.
	17.0'	64.5	97.7	LL = 66 PI = 23 U.S.C.S. = MH

TABLE D-1-3
NSWF-2
CHERRY ISLAND
SUMMARY

Laboratory Test Results

Test Boring	Sample Depth Ft.	Natural Water Content %	Less Than No. 200 Sieve %	Other
#GP-6	6.5'	84.9	98.7	
	11.5'	105.9	98.8	
	16.25'	97.7	--	
	16.7'	93.7	--	γ_D = 42.1 p.c.f. qu = 170 p.s.f.
	17.0'	--	--	LL = 85 PI = 21 U.S.C.S. = MH & OH See consolidation and permeability graphs
	21.5'	107.8	99.4	
	26.3'	90.8		γ_D = 45.2 p.c.f.
	26.8'	82.4		γ_D = 47.2 p.c.f.
	27.0'			LL = 80 PI = 46 U.S.C.S. = MH & OH See Triaxial Data
	31.5'	31.1	35.0	
	41.75'	46.3	--	γ_D = 72.0 p.c.f. qu = 400 p.s.f.
	42.0'	48.8	99.6	LL = 56 PI = 23 U.S.C.S. = MH & OH See consolidation and permeability graphs
	46.5'	79.0	96.1	
	56.5'	77.4	90.2	
	66.5'	8.1	9.6	

CHERRY ISLAND

SUMMARY

Laboratory Test Results

Test Boring	Sample Depth Ft.	Natural Water Content %	Less Than No. 200 Sieve %	Other
#GP-7	6.5'	125.6	99.0	
	16.5'	97.7	99.6	
	20.4'	100.3	99.1	
	20.5'	118.6	--	
	20.7'	113.0	99.8	
	20.8'	62.3	--	
	21.7'	--	--	γ_D = 41.4 p.c.f. qu = 207 p.s.f.
	22.0'	--	--	LL = 84 PI = 40 U.S.C.S. = MH & OH See consolidation and permeability graphs
	26.5'	95.1	98.9	
	31.7'	89.7	98.7	γ_D = 46.2 p.c.f. qu = 448 p.s.f.
	32.0'	--	--	LL = 76 PI = 36 U.S.C.S. = MH & OH See consolidation and permeability graphs
	36.5'	84.7	99.7	
	46.75'	50.0	96.5	γ_D = 67.1 p.c.f. qu = 1,042 p.s.f.
	47.0'	47.5	96.5	LL = 38 PI = 8 U.S.C.S. = ML
	56.7'	53.6	95.5	γ_D = 66.0 p.c.f. qu = 1,964 p.s.f.
	57.0'	53.0	96.5	LL = 37 PI = 11 U.S.C.S. = ML
	61.5'	12.1	16.5	
	87.5'	11.9	18.6	

TABLE D-1-3
NSWF-2
CHERRY ISLAND

SUMMARY

Laboratory Test Results

Test Boring	Sample Depth Ft.	Natural Water Content %	Less Than No. 200 Sieve %	Other
#GP-8	11.5'	120.0	96.6	
	21.5'	102.5	99.1	
	25.7'	119.8	--	γ_D = 41.8 p.c.f.
	26.2'	100.0	--	γ_D = 43.5 p.c.f.
	26.7'	101.1	--	γ_D = 42.5 p.c.f.
	27.0'	--	--	LL = 79 PI = 25 U.S.C.S. = MH & OH See Triaxial Data
	31.5'	112.2	99.3	
	35.8'	62.2	99.7	
	36.0'	93.5	--	
	36.7'	94.2	99.7	γ_D = 44.9 p.c.f. qu = 574 p.s.
	37.0'	88.8	99.9	LL = 74 PI = 23 U.S.C.S. = MH & OH See consolidation and permeability data.
	41.5'	85.4	91.1	
	46.75'	69.6	--	γ_D = 54.1 p.c.f. qu = 703 p.s.f.
	47.0'	70.2	96.7	LL = 44 PI = 42 U.S.C.S. = ML & OL
	52.0'	59.4	96.1	
	56.7'	54.8	--	γ_D = 64.5 p.c.f. qu = 1,207 p.s.f.
	57.0'	51.9	97.4	LL = 45 PI = 14 U.S.C.S. = ML
	62.0'	58.5	--	
	71.5'	23.6	85.9	
	98.0'	25.7	97.7	

TABLE D-1-3
NSWF-2
CHERRY ISLAND
SUMMARY

Laboratory Test Results

Test Boring	Sample Depth Ft.	Natural Water Content %	Less Than No. 200 Sieve %	Other
#GP-9	6.5'	140.2	98.6	
	16.5'	141.4	98.2	
	22.2'	98.7	--	γ_D = 40.8 p.c.f. qu = 374 p.s.f.
	22.5'	81.9	99.3	LL = 70 PI = 27 U.S.C.S. = MH & OH
	26.7'	69.0	--	γ_D = 54.6 p.c.f. qu = 498 p.s.f. LL = 68 PI = 24 U.S.C.S. = MH & OH
	27.0'	81.4	99.2	
	31.5'	79.0	97.7	
	36.2'	66.2	--	
	36.7'	65.2	--	γ_D = 56.1 p.c.f. qu = 347 p.s.f.
	37.0'	69.9	99.4	LL = 56 PI = 16 U.S.C.S. = MH & OH See consolidation and permeability graphs
	41.7'	52.4	--	γ_D = 68.0 p.c.f. qu = 1,070 p.s.f. LL = 54 PI = 19 U.S.C.S. = MH
	42.0'	45.5	99.7	
	46.5'	78.8	93.5	
	54.0'	71.2	95.3	LL = 65 PI = 21 U.S.C.S. = MH & OH
	61.5'	28.2	59.0	

TABLE D-1-3
NSWF-2
CHERRY ISLAND
SUMMARY

Laboratory Test Results

Test Boring	Sample Depth Ft.	Natural Water Content %	Less Than No. 200 Sieve %	Other
#G-10	2.5'	89.8	99.2	
	6.45'	92.6	95.8	γ_D = 47.5 p.c.f. qu = 362 p.s.f.
	7.0'	--	--	LL = 42 PI = 9 U.S.C.S. = ML & OL
	16.5'	77.4	99.3	
	26.5'	79.4	97.5	
	36.65'	76.9	86.3	γ_D = 52.4 p.c.f. qu = 614 p.s.f.
	37.0'	--	--	LL = 62 PI = 16 U.S.C.S. = MH & OH
	41.5'	76.7	97.9	
	51.5'	69.2	98.8	
	61.5'	84.7	85.1	
	71.5'	12.5	5.8	
	81.5'	26.9	18.2	

TABLE D-1-3
NSWF-2
CHERRY ISLAND
SUMMARY

Laboratory Test Results

Test Boring	Sample Depth Ft.	Natural Water Content %	Less Than No. 200 Sieve %	Other
#GP-11	6.5'	85.6	98.3	
	16.5'	69.6	--	
	26.6'	66.2	98.4	γ_D = 56.4 p.c.f. qu = 743 p.s.f. LL = 71 PI = 17 U.S.C.S. = MH
	26.9'	79.5	98.4	
	31.5'	68.9	95.9	
	41.7'	39.9	83.5	γ_D = 79.9 p.c.f. qu = 638 p.s.f. LL = 37 PI = 13 U.S.C.S. = ML
	42.0'	45.0	83.5	
	46.5'	43.0	93.7	
	51.7'	46.6	--	γ_D = 73.1 p.c.f. qu = 1,893 p.s.f. LL = 39 PI = 9 U.S.C.S. = ML
	52.0'	64.4	99.9	
	56.5'	46.1	90.3	

TABLE D-1-3
NSWF-2
CHERRY ISLAND

SUMMARY

Laboratory Test Results

Test Boring	Sample Depth Ft.	Natural Water Content %	Less Than No. 200 Sieve %	Other
#G-12	5.5'	75.8	97.7	
	16.5'	85.6	98.4	
	21.75'	75.0	--	γ_D = 52.9 p.c.f. qu = 390 p.s.f.
	22.0'	64.7	96.3	LL = 60 PI = 19 U.S.C.S. = MH & OH
	26.5'	74.5	93.8	
	31.75'	84.8	--	γ_D = 48.7 p.c.f. qu = 571 p.s.f.
	32.0'	87.1	98.8	LL = 68 PI = 27 U.S.C.S. = MH & OH
	36.5'	80.2	96.6	
	46.75'	71.8	--	γ_D = 54.1 p.c.f. qu = 1,432 p.s.f.
	47.0'	72.8	99.4	LL = 72 PI = 25 U.S.C.S. = MH & OH
	51.5'	23.7		
	61.75'	43.1	--	γ_D = 74.0 p.c.f. qu = 1,547 p.s.f.
	62.0'	46.4	--	LL = 40 PI = 15 U.S.C.S. = CL
	66.5'	47.0	73.8	
	76.5'	62.6	95.2	
	86.5'	66.9	--	

TABLE D-1-3
NSWF-2
CHERRY ISLAND
SUMMARY

Laboratory Test Results

Test Boring	Sample Depth Ft.	Natural Water Content %	Less Than No. 200 Sieve %	Other
#A-1	2.5	51.4	62.1	
	5.5	37.7	73.9	
	7.5	79.7	99.2	
	13.6	47.9	--	See consolidation and permeability graphs
	14.3	47.1	--	qu = 745 p.s.f. γ_{dry} = 69.7 p.c.f.
	14.5	43.7	82.2	LL = 21 PI = 0 U.S.C.S. = CL
	16.0	42.1	96.0	
	25.5	137.7	69.5	
	27.0	226.4		γ_{dry} = 20.8 p.c.f. See consolidation and permeability graphs
	29.2	21.4		qu = 543 p.s.f. γ_{dry} = 103.6 p.c.f.
	29.5	21.9	32.6	LL = 19 PI = 0 U.S.C.S. = CL

TABLE D-1-3
NSWF-2
CHERRY ISLAND
SUMMARY

Laboratory Test Results

Test Boring	Sample Depth Ft.	Natural Water Content %	Less Than No. 200 Sieve %	Other
#A-2	2.5	45.4	45.2	
	5.5	74.4	92.1	
	7.5	74.4	93.7	
	12.6	75.0	--	See consolidation data and permeability graphs
	13.2	76.8	--	qu = 572.0 p.s.f γ_{dry} = 53.0 p.c.f
	13.5	63.2	95.5	LL = 60 PI = 25 U.S.C.S. = MH
	15.5	66.0	96.0	
	24.0	171.6	69.4	
	28.7	73.4	--	qu = 881.0 p.s.f. γ_{dry} = 53.2 p.c.f.
	29.0	69.5	96.8	LL = 65 PI = 29 U.S.C.S. = MH

TABLE D-1-3
NSWF-2
CHERRY ISLAND
SUMMARY

Laboratory Test Results

Test Boring	Sample Depth Ft.	Natural Water Content %	Less Than No. 200 Sieve %	Other
#A-3	5.5	61.1	96.2	
	10.5	68.0	99.0	
	15.5	77.2	95.9	
	20.5	75.1	96.8	
	25.7	91.6	--	qu = 825 p.s.f. γ_{dry} = 46.6 p.c.f. LL = 72 PI = 25 U.S.C.S. = MH
	26.0	93.9	94.1	
	30.8	46.3	--	qu = 1030 p.s.f. γ_{dry} = 77.7 p.c.f.
	31.0	20.5	69.1	LL = 22 PI = 5 U.S.C.S. = CL-ML
	35.5	12.6	10.1	

TABLE D-1-3
NSWF-2
CHERRY ISLAND
SUMMARY

Laboratory Test Results

Test Boring	Sample Depth Ft.	Natural Water Content %	Less Than No. 200 Sieve %	Other
#A-4	5.5	63.5	97.3	
	15.5	74.4	97.1	
	16.0	79.9	97.8	LL = 58 PI = 15 U.S.C.S. = MH & OH
	22.8	66.2	--	qu = 452 p.s.f. γ_{dry} = 56.9 p.c.f.
	23.0	59.7	82.3	LL = 58 PI = 29 U.S.C.S. = MH
	27.7	90.3	--	qu = 699 p.s.f. γ_{dry} = 47.9 p.c.f.
	28.0	50.8	97.5	LL = 59 PI = 17 U.S.C.S. = MH
	32.5	162.6	63.8	
	35.8	96.1	--	qu = 1713 p.s.f. γ_{dry} = 43.6 p.c.f.
	36.0	102.8	92.2	LL = 108 PI = 46 U.S.C.S. = MH
	45.4	26.6	48.5	
#A-4A	15.2	80.3	--	qu = 307 p.s.f. γ_{dry} = 49.4 p.c.f.
	15.7	96.3	--	γ_{dry} = 43.8 p.c.f.

TABLE D-1-3
NSWF-2
CHERRY ISLAND
SUMMARY

Laboratory Test Results

Test Boring	Sample Depth Ft.	Natural Water Content %	Less Than No. 200 Sieve %	Other
#A-5	11.5	56.8	87.9	
	15.5	79.8	--	See consolidation data and permeability graphs
	16.7	41.7	83.6	
	17.0	39.3	90.1	LL = 26 PI = 0 U.S.C.S. = ML & OL
	21.5	61.2	95.8	
	26.7	77.1	--	qu = 859 p.s.f. γ_{dry} = 51.9 p.c.f.
	27.0	--	--	LL = 77 PI = 21 U.S.C.S. = MH
	31.5	259.2	25.6	
	41.5	30.0	60.3	

TABLE D-1-3
NSWF-2
CHERRY ISLAND
SUMMARY

Laboratory Test Results

Test Boring	Sample Depth Ft.	Natural Water Content %	Less Than No. 200 Sieve %	Other
#A-6	5.0	58.0	97.2	
	15.0	64.3	97.1	
	25.0	72.3	97.9	
	35.0	58.0	99.8	
	45.0	27.9	62.9	

TABLE D-1-3
NSWF-2
CHERRY ISLAND
SUMMARY

Laboratory Test Results

Test Boring	Sample Depth Ft.	Natural Water Content %	Less Than No. 200 Sieve %	Other
#A-7	2.5	61.7	99.1	
	5.5	71.1	98.7	
	10.5	92.2	98.5	
	20.1	73.2	--	See consolidation data and permeability graphs
	20.7	61.1	--	qu = 394 p.s.f. γ_{dry} = 60.9 p.c.f.
	21.0	58.7	97.8	LL = 43 PI = 10 U.S.C.S. = ML & OL
	25.5	83.4	99.3	
	29.0	72.0	99.2	LL = 69 PI = 26 U.S.C.S. = MH
	30.2	68.3	--	qu = 694 p.s.f. γ_{dry} = 56.0 p.c.f.
	30.7	58.7	--	γ_{dry} = 63.8 p.c.f.
	40.5	63.3	97.4	
	50.5	11.2	10.9	

Definition of Terms:

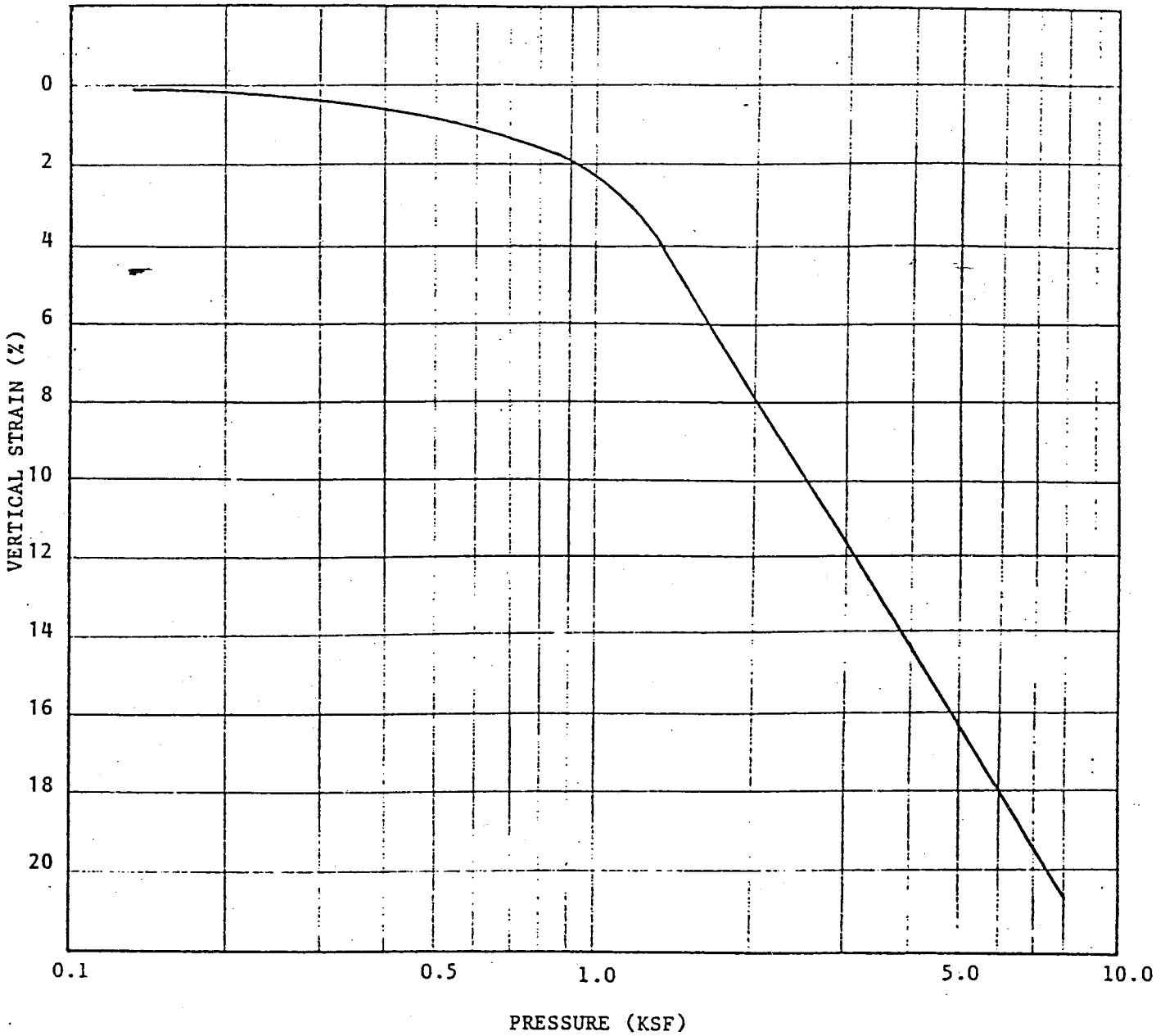
γ_D = Dry Density in Pounds per Cubic Foot

qu = Unconfined Compressive Strength in Pounds per Square Foot

LL = Liquid limit

PI = Plasticity Index

U.S.C.S. = Unified Soils Classification



Test Boring Number G-1 Depth 10.6

Atterberg Limits: LL 86, PI 25, U.S.C.S. Class. MH

Initial Moisture Content 84.1 % Initial Dry Density 41.7 PCF

Est. Existing Overburden Pressure, Po = 0.33 KSF

Est. Preconsolidation Pressure, Pc = 1.1 KSF

Sample Description Dark gray silt, trace fine sand, trace organics

CONSOLIDATION TEST
(A.S.T.M.: D-2435)
For
NSWF-2
Cherry Island
Wilmington, Delaware

DUFFIELD ASSOCIATES, INC.
Consulting Geotechnical Engineers
5400 Limestone Road
Newark, Delaware 19808

W. O. 410	Figure D-1-1	Date: October 21, 1983	Sheet 1 of 19

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Cherry Island

SPRAGUE & HENWOOD, Inc.

SCRANTON, PA.

FOUNDATION TESTING and SOIL SAMPLING RECORD

AME: A.C. Schultes & Sons, Inc. LOCATION: Wilmington, Delaware

OLE NO. AB-1 SURFACE ELEVATION _____ RIG NO. ____ DATE: From 8/31 To 8/31 19 83

BORING LOG		SPOON SAMPLE AND CORE DATA					BLOWS ON CASING
DEPTH FROM—TO	DESCRIPTION OF MATERIAL Based On Samples Recovered Plus Observation Of Material Returned Between Samples	SAMPLE NUMBER	DEPTH FROM—TO	BLOWS PER FT. ON SAMPLES	ROCK CORE RECOV'D	D=DRY U=UNDISTURBED T=TRAP W=WASH R=ROD C=CORE CORE RECOV'D — NO. PCS. REMARKS *	
0.0' 15.0'	Gray river silt	1	0.0' 5.0'			Took samples from	
		2	5.0' 10.0'			Auger Flight	
		3	10.0' 15.0'				

Auger

0-1		51-52	
1-2		52-53	
2-3		53-54	
3-4		54-55	
4-5		55-56	
5-6		56-57	
6-7		57-58	
7-8		58-59	
8-9		59-60	
9-10		60-61	
10-11		61-62	
11-12		62-63	
12-13		63-64	
13-14		64-65	
14-15		65-66	
15-16		66-67	
16-17		67-68	
17-18		68-69	
18-19		69-70	
19-20		70-71	
20-21		71-72	
21-22		72-73	
22-23		73-74	
23-24		74-75	
24-25		75-76	
25-26		76-77	
26-27		77-78	
27-28		78-79	
28-29		79-80	
29-30		80-81	
30-31		81-82	
31-32		82-83	
32-33		83-84	
33-34		84-85	
34-35		85-86	
35-36		86-87	
36-37		87-88	
37-38		88-89	
38-39		89-90	
39-40		90-91	
40-41		91-92	
41-42		92-93	
42-43		93-94	
43-44		94-95	
44-45		95-96	
45-46		96-97	
46-47		97-98	
47-48		98-99	
48-49		99-100	
49-50		100-101	
50-51		101-102	

GROUND WATER

DEPTH	HOUR	DATE

PIPE AND CASING LEFT IN HOLE

SIZE	AMOUNT	REASON

DISTANCE HAMMER DROP _____ INCH
DRIVE HAMMER _____ LBS.
SPOON HAMMER _____ LBS.
CASING SIZE Auger INCH
SPOON SIZE _____ INCH
SIZE OF CORE BIT _____ INCH

NOTE: *Classification of soil has been made by the driller and has not been checked by a soils engineer. Classification of rock has been made by the driller and has not been checked by a geologist.

* Under Remarks mention kind of Bit, loss of sample, loss of Drilling water, soft seamy or broken Rock, Caving, Cavities, unusual Ground water conditions, etc., at depth encountered.

Driller Joseph Dowdy

Helper James Dowdy

Helper William Levering

301

Contract No. 19991
Cherry Island

SPRAGUE & HENWOOD, Inc.
SCRANTON, PA.

FOUNDATION TESTING and SOIL SAMPLING RECORD

NAME: A.C. Schultes & Sons, Inc. LOCATION: Wilmington, Delaware

HOLE NO. AB-2 SURFACE ELEVATION _____ RIG NO. _____ DATE: From 8/31 To 8/31 19 83

BORING LOG		SPOON SAMPLE AND CORE DATA					
DEPTH FROM—TO	DESCRIPTION OF MATERIAL Based On Samples Recovered Plus Observation Of Material Returned Between Samples	SAMPLE NUMBER	DEPTH FROM—TO	BLOWS PER FT. ON SAMPLES	ROCK CORE RECOV'D	D=DRY U=UNDISTURBED T=TRAP W=WASH R=ROD C=CORE CORE RECOV'D — NO. PCS. REMARKS *
0.0' 15.0'	Gray river silt	1	0.0' 5.0'			Took samples from
		2	5.0' 10.0'			Auger Flights
		3	10.0' 15.0'			

BLOWS ON CASING		
0-1		51-52
1-2		52-53
2-3		53-54
3-4		54-55
4-5		55-56
5-6		56-57
6-7		57-58
7-8		58-59
8-9		59-60
9-10		60-61
10-11		61-62
11-12		62-63
12-13		63-64
13-14		64-65
14-15		65-66
15-16		66-67
16-17		67-68
17-18		68-69
18-19		69-70
19-20		70-71
20-21		71-72
21-22		7[illegible]
22-23		7[illegible]
23-24		7[illegible]
24-25		75-76
25-26		76-77
26-27		77-78
27-28		78-79
28-29		79-80
29-30		80-81
30-31		81-82
31-32		82-83
32-33		83-84
33-34		84-85
34-35		85-86
35-36		86-87
36-37		87-88
37-38		88-89
38-39		89-90
39-40		90-91
40-41		91-92
41-42		92-93
42-43		93-94
43-44		94-95
44-45		95-96
45-46		96-97
46-47		97-98
47-48		98-99
48-49		99-100
49-50		100-101
50-51		101

Aug 81

GROUND WATER		
DEPTH	HOUR	DATE

PIPE AND CASING LEFT IN HOLE		
SIZE	AMOUNT	REASON

DISTANCE HAMMER DROP _____ INCH
DRIVE HAMMER _____ LBS.
SPOON HAMMER _____ LBS.
CASING SIZE Auger INCH
SPOON SIZE _____ INCH
SIZE OF CORE BIT _____ INCH

NOTE: *Classification of soil has been made by the driller and has not been checked by a soils engineer. Classification of rock has been made by the driller and has not been checked by a geologist.

* Under Remarks mention kind of Bit, loss of sample, loss of Drilling water, soft seamy or broken Rock, Caving, Cavities, unusual Ground water conditions, etc., at depth encountered.

Driller Joseph Dowdy
Helper James Dowdy
Helper William Levering

301

Cherry Island

SPRAGUE & HENWOOD, Inc.

SCRANTON, PA.

FOUNDATION TESTING and SOIL SAMPLING RECORD

NAME: A.C. Schultes & Sons, Inc. LOCATION: Wilmington, Delaware

HOLE NO. AB-3 SURFACE ELEVATION _____ RIG NO. ____ DATE: From 8/31 To 8/31 19 83

BORING LOG		SPOON SAMPLE AND CORE DATA					
DEPTH FROM—TO	DESCRIPTION OF MATERIAL Based On Samples Recovered Plus Observation Of Material Returned Between Samples	SAMPLE NUMBER	DEPTH FROM—TO	BLOWS PER FT. ON SAMPLES	ROCK CORE RECOV'D	D=DRY U=UNDISTURBED T=TRAP W=WASH R=ROD C=CORE CORE RECOV'D — NO. PCS. REMARKS *
0.0' 15.0'	Gray river silt	1	0.0' 5.0'			Took samples from
		2	5.0' 10.0'			Auger Flights
		3	10.0' 15.0'			

BLOWS ON CASING		
0-1	Auger	51-52
1-2		52-53
2-3		53-54
3-4		54-55
4-5		55-56
5-6		56-57
6-7		57-58
7-8		58-59
8-9		59-60
9-10		60-61
10-11		61-62
11-12		62-63
12-13		63-64
13-14		64-65
14-15		65-66
15-16		66-67
16-17		67-68
17-18		68-69
18-19		69-70
19-20		70-71
20-21		71-72
21-22		72-73
22-23		73-74
23-24		74-75
24-25		75-76
25-26		76-77
26-27		77-78
27-28		78-79
28-29		79-80
29-30		80-81
30-31		81-82
31-32		82-83
32-33		83-84
33-34		84-85
34-35		85-86
35-36		86-87
36-37		87-88
37-38		88-89
38-39		89-90
39-40		90-91
40-41		91-92
41-42		92-93
42-43		93-94
43-44		94-95
44-45		95-96
45-46		96-97
46-47		97-98
47-48		98-99
48-49		99-100
49-50		100-101
50-51		101-102

GROUND WATER

DEPTH	HOUR	DATE

PIPE AND CASING LEFT IN HOLE

SIZE	AMOUNT	REASON

DISTANCE HAMMER DROP _____ INCH
DRIVE HAMMER _____ LBS.
SPOON HAMMER _____ LBS.
CASING SIZE Auger INCH
SPOON SIZE _____ INCH
SIZE OF CORE BIT _____ INCH

NOTE: *Classification of soil has been made by the driller and has not been checked by a soils engineer. Classification of rock has been made by the driller and has not been checked by a geologist.

* Under Remarks mention kind of Bit, loss of sample, loss of Drilling water, soft seamy or broken Rock, Caving, Cavities, unusual Ground water conditions, etc., at depth encountered.

Driller Joseph Dowdy
Helper James Dowdy
Helper William Levering

30t

SPRAGUE & HENWOOD, Inc.
SCRANTON, PA.

Cherry Island
Job Order No. 19531

FOUNDATION TESTING and SOIL SAMPLING RECORD

ME: A.C. Schultes & Sons, Inc. LOCATION: Wilmington, Delaware

LE NO. AB-4 SURFACE ELEVATION _____ RIG NO. _____ DATE: From 7/5 To 7/5 19 83

BORING LOG		SPOON SAMPLE AND CORE DATA					BLOWS ON CASING
DEPTH FROM—TO	DESCRIPTION OF MATERIAL Based On Samples Recovered Plus Observation Of Material Returned Between Samples	SAMPLE NUMBER	DEPTH FROM—TO	BLOWS PER FT. ON SAMPLES	ROCK CORE RECOV'D	D=DRY U=UNDISTURBED T=TRAP W=WASH R=ROD C=CORE CORE RECOV'D — NO. PCS. REMARKS *	AUGERS
0.0' 5.0'	Gray silt	1	0.0' 5.0'			Damp	
		2	5.0' 10.0'			Moist	
		3	10.0' 15.0'			Moist	
						NOTE: Samples taken off Auger Flights	

BLOWS ON CASING	
0-1	51-52
1-2	52-53
2-3	53-54
3-4	54-55
4-5	55-56
5-6	56-57
6-7	57-58
7-8	58-59
8-9	59-60
9-10	60-61
10-11	61-62
11-12	62-63
12-13	63-64
13-14	64-65
14-15	65-66
15-16	66-67
16-17	67-68
17-18	68-69
18-19	69-70
19-20	70-71
20-21	71-72
21-22	72-73
22-23	7
23-24	7
24-25	75-76
25-26	76-77
26-27	77-78
27-28	78-79
28-29	79-80
29-30	80-81
30-31	81-82
31-32	82-83
32-33	83-84
33-34	84-85
34-35	85-86
35-36	86-87
36-37	87-88
37-38	88-89
38-39	89-90
39-40	90-91
40-41	91-92
41-42	92-93
42-43	93-94
43-44	94-95
44-45	95-96
45-46	96-97
46-47	97-98
47-48	98-99
48-49	99-100
49-50	100-101
50-51	10

GROUND WATER

DEPTH	HOUR	DATE
dry	3:00PM	7/5

PIPE AND CASING LEFT IN HOLE

SIZE	AMOUNT	REASON

DISTANCE HAMMER DROP _____ INCH
DRIVE HAMMER _____ LBS.
SPOON HAMMER _____ LBS.
CASING SIZE _____ INCH
SPOON SIZE _____ INCH
SIZE OF CORE BIT _____ INCH

NOTE: *Classification of soil has been made by the driller and has not been checked by a soils engineer. Classification of rock has been made by the driller and has not been checked by a geologist.

* Under Remarks mention kind of Bit, loss of sample, loss of Drilling water, soft seamy or broken Rock, Caving, Cavities, unusual Ground water conditions, etc., at depth encountered.

Driller William Levering J

Helper Ronald Dowdy

Helper _____

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SPRAGUE & HENWOOD, Inc.
SCRANTON, PA.

Cherry Island
Job Order No. 19531

FOUNDATION TESTING and SOIL SAMPLING RECORD

NAME: A.C. Schultes & Sons, Inc. LOCATION: Wilmington, Delaware

HOLE NO. AB-5 SURFACE ELEVATION _____ RIG NO. _____ DATE: From 7/5 To 7/5 19 83

BORING LOG		SPOON SAMPLE AND CORE DATA					
DEPTH FROM—TO	DESCRIPTION OF MATERIAL Based On Samples Recovered Plus Observation Of Material Returned Between Samples	SAMPLE NUMBER	DEPTH FROM—TO	BLOWS PER FT. ON SAMPLES	ROCK CORE RECOV'D	D=DRY U=UNDISTURBED T=TRAP W=WASH R=ROD C=CORE CORE RECOV'D — NO. PCS. REMARKS *
0.0' 5.0'	Gray silt	1	0.0' 5.0'			Moist
		2	5.0' 10.0'			Moist
		3	10.0' 15.0'			Moist
						NOTE: Samples taken off Auger Flights

BLOWS ON CASING	
0-1	51-52
1-2	52-53
2-3	53-54
3-4	54-55
4-5	55-56
5-6	56-57
6-7	57-58
7-8	58-59
8-9	59-60
9-10	60-61
10-11	61-62
11-12	62-63
12-13	63-64
13-14	64-65
14-15	65-66
15-16	66-67
16-17	67-68
17-18	68-69
18-19	69-70
19-20	70-71
20-21	71-72
21-22	72-73
22-23	73-74
23-24	74-75
24-25	75-76
25-26	76-77
26-27	77-78
27-28	78-79
28-29	79-80
29-30	80-81
30-31	81-82
31-32	82-83
32-33	83-84
33-34	84-85
34-35	85-86
35-36	86-87
36-37	87-88
37-38	88-89
38-39	89-90
39-40	90-91
40-41	91-92
41-42	92-93
42-43	93-94
43-44	94-95
44-45	95-96
45-46	96-97
46-47	97-98
47-48	98-99
48-49	99-100
49-50	100-101
50-51	101-102

AUGER

GROUND WATER		
DEPTH	HOUR	DATE
Dry	5:30	7/5

PIPE AND CASING LEFT IN HOLE		
SIZE	AMOUNT	REASON

DISTANCE HAMMER DROP _____ INCH
DRIVE HAMMER _____ LBS.
SPOON HAMMER _____ LBS.
CASING SIZE _____ INCH
SPOON SIZE _____ INCH
SIZE OF CORE BIT _____ INCH

NOTE: *Classification of soil has been made by the driller and has not been checked by a soils engineer. Classification of rock has been made by the driller and has not been checked by a geologist.

* Under Remarks mention kind of Bit, loss of sample, loss of Drilling water, soft seamy or broken Rock, Caving, Cavities, unusual Ground water conditions, etc., at depth encountered.

Driller William Levering Jr.
Helper Ronald Dowdy
Helper _____

- 30:

SPRAGUE & HENWOOD, Inc.
SCRANTON, PA.

Cherry Island
Job No. 19531

FOUNDATION TESTING and SOIL SAMPLING RECORD

ME: A.C. Schultes & Sons, Inc. LOCATION: Wilmington, Delaware

LE NO. AB-6 SURFACE ELEVATION _____ RIG NO. ____ DATE: From 7/6 To 7/6 19 83

BORING LOG		SPOON SAMPLE AND CORE DATA					
DEPTH FROM—TO	DESCRIPTION OF MATERIAL Based On Samples Recovered Plus Observation Of Material Returned Between Samples	SAMPLE NUMBER	DEPTH FROM—TO	BLOWS PER FT. ON SAMPLES	ROCK CORE RECOV'D	D=DRY U=UNDISTURBED T=TRAP W=WASH R=ROD C=CORE CORE RECOV'D — NO. PCS. REMARKS *
0.0' 15.0'	Gray silt	1	0.0' 5.0'			Moist
		2	5.0' 10.0'			Moist
		3	10.0' 15.0'			Moist
						NOTE: Samples taken off Auger Flights

BLOWS ON CASI	
0-1	51-52
1-2	52-53
2-3	53-54
3-4	54-55
4-5	55-56
5-6	56-57
6-7	57-58
7-8	58-59
8-9	59-60
9-10	60-61
10-11	61-62
11-12	62-63
12-13	63-64
13-14	64-65
14-15	65-66
15-16	66-67
16-17	67-68
17-18	68-69
18-19	69-70
19-20	70-71
20-21	71-72
21-22	73
22-23	4
23-24	5
24-25	75-76
25-26	76-77
26-27	77-78
27-28	78-79
28-29	79-80
29-30	80-81
30-31	81-82
31-32	82-83
32-33	83-84
33-34	84-85
34-35	85-86
35-36	86-87
36-37	87-88
37-38	88-89
38-39	89-90
39-40	90-91
40-41	91-92
41-42	92-93
42-43	93-94
43-44	94-95
44-45	95-96
45-46	96-97
46-47	97-98
47-48	98-99
48-49	99-100
49-50	1
50-51	2

ANGELS

GROUND WATER

DEPTH	HOUR	DATE
Dry	12:00	7/6

PIPE AND CASING LEFT IN HOLE

SIZE	AMOUNT	REASON

DISTANCE HAMMER DROP ____ INCH
DRIVE HAMMER ____ LBS.
SPOON HAMMER ____ LBS.
CASING SIZE ____ INCH
SPOON SIZE ____ INCH
SIZE OF CORE BIT ____ INCH

NOTE: *Classification of soil has been made by the driller and has not been checked by a soils engineer. Classification of rock has been made by the driller and has not been checked by a geologist.

* Under Remarks mention kind of Bit, loss of sample, loss of Drilling water, soft seamy or broken Rock, Caving, Cavities, unusual Ground water conditions, etc., at depth encountered.

Driller William Levering Jr.
Helper Ronald Dowdy
Helper

301

Cherry Island

SPRAGUE & HENWOOD, Inc.
SCRANTON, PA.

FOUNDATION TESTING and SOIL SAMPLING RECORD

NAME: A.C. Schultes & Sons, Inc. LOCATION: Wilmington, Delaware

HOLE NO. GP-7 SURFACE ELEVATION _____ RIG NO. ____ DATE: From 8/16 To 8/19 19 83

BORING LOG		SPOON SAMPLE AND CORE DATA					
DEPTH FROM—TO	DESCRIPTION OF MATERIAL Based On Samples Recovered Plus Observation Of Material Returned Between Samples	SAMPLE NUMBER	DEPTH FROM—TO	BLOWS PER 6" ON SAMPLES	Sample D=DRY U=UNDISTURBED T=TRAP W=WASH R=ROD C=CORE ~~RECOV'D~~ RECOV'D	CORE RECOV'D — NO. PCS. REMARKS *
0.0' 47.0'	Gray organic silt	1	5.0' 6.5'	Push	1.5'	
		2	10.0' 11.5'	Push	1.5'	
47.0' 60.0'	Gray sandy silt	3	15.0' 16.5'	Push	1.5'	
		U4	20.0' 22.0'		2.0'	Shelby Tube
60.0' 111.5'	Sand and gravel	5	25.0' 26.5'	Push	1.5'	
		U6	30.0' 32.0'		2.0'	Shelby Tube
111.5' 113.0'	Red clay	7	35.0' 36.5'	Push	1.5'	
			37.3'	- Vane Shear Test		
		8	40.0' 41.5'	Push	1.5'	
		U9	45.0' 47.0'		2.0'	Shelby Tube
			48.5'	- Vane Shear Test		
		10	50.0' 51.5'	1-2 3	1.5'	
		U11	55.0' 57.0'		2.0'	Shelby Tube
		12	60.0' 61.5'	34-41 38	1.5'	
		13	65.5' 67.0'	23-19 12		Used 300 lb. hammer
			Lost sample, drove spoon to 68.0', recovered sample			
			At 70+ recovered wash sample			
			81.0' 82.5'	26-22 23		Used 300 lb. hammer
			Lost sample - recovered wash			
		14	86.0' 87.5'	28-25 20		Used 300 lb. hammer

BLOWS ON CASING	
0-1	51-52
1-2	52-53
2-3	53-54
3-4	54-55
4-5	55-56
5-6	56-57
6-7	57-58
7-8	58-59
8-9	59-60
9-10	60-61
10-11	61-62
11-12	62-63
12-13	63-64
13-14	64-65
14-15	65-66
15-16	66-67
16-17	67-68
17-18	68-69
18-19	69-70
19-20	70-71
20-21	71-72
21-22	72-73
22-23	73-74
23-24	74-75
24-25	75-76
25-26	76-77
26-27	77-78
27-28	78-79
28-29	79-80
29-30	80-81
30-31	81-82
31-32	82-83
32-33	83-84
33-34	84-85
34-35	85-86
35-36	86-87
36-37	87-88
37-38	88-89
38-39	89-90
39-40	90-91
40-41	91-92
41-42	92-93
42-43	93-94
43-44	94-95
44-45	95-96
45-46	96-97
46-47	97-98
47-48	98-99
48-49	99-100
49-50	100-101
50-51	101-102

GROUND WATER

DEPTH	HOUR	DATE
Top of ground		

PIPE AND CASING LEFT IN HOLE

SIZE	AMOUNT	REASON
3/4"	45.0'	Piezometer
		Point

DISTANCE HAMMER DROP 24-30 INCH
DRIVE HAMMER 300 LBS.
SPOON HAMMER 140 LBS.
CASING SIZE _____ INCH
SPOON SIZE 2 INCH
SIZE OF CORE BIT _____ INCH

NOTE: *Classification of soil has been made by the driller and has not been checked by a soils engineer. Classification of rock has been made by the driller and has not been checked by a geologist.

* Under Remarks mention kind of Bit, loss of sample, loss of Drilling water, soft seamy or broken Rock, Caving, Cavities, unusual Ground water conditions, etc., at depth encountered.

Driller Carl Ward

Helper Ronald Dowdy

Helper _____

301

SPRAGUE & HENWOOD, Inc.

SCRANTON, PA.

FOUNDATION TESTING and SOIL SAMPLING RECORD

NAME: A.C. Schultes & Sons, Inc. LOCATION: Wilmington Delaware

HOLE NO. GP-7 SURFACE ELEVATION _____ RIG NO. ____ DATE: From 8/16 To 8/19 19 83

BORING LOG: DEPTH FROM—TO	DESCRIPTION OF MATERIAL Based On Samples Recovered Plus Observation Of Material Returned Between Samples	SAMPLE NUMBER	DEPTH FROM—TO	BLOWS PER 6" ON SAMPLES	Sample D=DRY U=UNDISTURBED T=TRAP W=WASH R=ROD C=CORE / CORE RECOV'D	CORE RECOV'D — NO. PCS. REMARKS *
		15	91.0' 92.5'	10-8 7		Used 300 lb. hammer
			Lost sample- recovered wash			
		16	96.0' 97.5'	32-35 45	0.25'	Used 300lb. hammer
		17	101.0' 102.5'	32-39 45	0.3'	Used 300 lb. hammer
		18	106.0' 107.5'	25-15 13	0.3'	Used 300 lb. hammer
			111.5' 113.0'	Drilled with roller bit		
				hit red clay at 111.5' to 113.0'		
						1/2 Hour delay time
						backfill in Marsh section.

BLOWS ON CASING	
0-1	51-52
1-2	52-53
2-3	53-54
3-4	54-55
4-5	55-56
5-6	56-57
6-7	57-58
7-8	58-59
8-9	59-60
9-10	60-61
10-11	61-62
11-12	62-63
12-13	63-64
13-14	64-65
14-15	65-66
15-16	66-67
16-17	67-68
17-18	68-69
18-19	69-70
19-20	70-71
20-21	71-72
21-22	
22-23	
23-24	
24-25	75-76
25-26	76-77
26-27	77-78
27-28	78-79
28-29	79-80
29-30	80-81
30-31	81-82
31-32	82-83
32-33	83-84
33-34	84-85
34-35	85-86
35-36	86-87
36-37	87-88
37-38	88-89
38-39	89-90
39-40	90-91
40-41	91-92
41-42	92-93
42-43	93-94
43-44	94-95
44-45	95-96
45-46	96-97
46-47	97-98
47-48	98-99
48-49	99-100
49-50	100-101
50-51	

GROUND WATER

DEPTH	HOUR	DATE

PIPE AND CASING LEFT IN HOLE

SIZE	AMOUNT	REASON

DISTANCE HAMMER DROP ____ INCH
DRIVE HAMMER ____ LBS.
SPOON HAMMER ____ LBS.
CASING SIZE ____ INCH
SPOON SIZE ____ INCH
SIZE OF CORE BIT ____ INCH

NOTE: *Classification of soil has been made by the driller and has not been checked by a soils engineer. Classification of rock has been made by the driller and has not been checked by a geologist.

* Under Remarks mention kind of Bit, loss of sample, loss of Drilling water, soft seamy or broken Rock, Caving, Cavities, unusual Ground water conditions, etc., at depth encountered.

Driller Carl Ward

Helper Ronald Dowdy

Helper George Gares

Cherry Island

301

SPRAGUE & HENWOOD, Inc.
SCRANTON, PA.

FOUNDATION TESTING and SOIL SAMPLING RECORD

NAME: A.C. Schultes & Sons, Inc. LOCATION: Wilmington, Delaware

HOLE NO. GP7A SURFACE ELEVATION _____ RIG NO. _____ DATE: From 8/22 To 8/22 19 83

BORING LOG		SPOON SAMPLE AND CORE DATA					
DEPTH FROM—TO	DESCRIPTION OF MATERIAL Based On Samples Recovered Plus Observation Of Material Returned Between Samples	SAMPLE NUMBER	DEPTH FROM—TO	BLOWS PER FT. ON SAMPLES	ROCK CORE RECOV'D	D=DRY U=UNDISTURBED T=TRAP W=WASH R=ROD C=CORE CORE RECOV'D — NO. PCS. REMARKS *
0.0' 26.5'	Gray organic silt		No SampleS Required			
			16.5' - Took Vane Shear Test (Bottom of Vane)			
			26.5' - Took Vane Shear Test (Bottom of Vane)			

BLOWS ON CASING

0-1	SW Casing to 15.0', washed 6" ht to 25.0'	51-52	
1-2		52-53	
2-3		53-54	
3-4		54-55	
4-5		55-56	
5-6		56-57	
6-7		57-58	
7-8		58-59	
8-9		59-60	
9-10		60-61	
10-11		61-62	
11-12		62-63	
12-13		63-64	
13-14		64-65	
14-15		65-66	
15-16		66-67	
16-17		67-68	
17-18		68-69	
18-19		69-70	
19-20		70-71	
20-21		71-72	
21-22		72-73	
22-23		73-74	
23-24		74-75	
24-25		75-76	
25-26		76-77	
26-27		77-78	
27-28		78-79	
28-29		79-80	
29-30		80-81	
30-31		81-82	
31-32		82-83	
32-33		83-84	
33-34		84-85	
34-35		85-86	
35-36		86-87	
36-37		87-88	
37-38		88-89	
38-39		89-90	
39-40		90-91	
40-41		91-92	
41-42		92-93	
42-43		93-94	
43-44		94-95	
44-45		95-96	
45-46		96-97	
46-47		97-98	
47-48		98-99	
48-49		99-100	
49-50		100-101	
50-51		101-102	

GROUND WATER

DEPTH	HOUR	DATE
Top of ground		

PIPE AND CASING LEFT IN HOLE

SIZE	AMOUNT	REASON
3/4"	21.0'	Piezometer Point

DISTANCE HAMMER DROP _____ INCH
DRIVE HAMMER _____ LBS.
SPOON HAMMER _____ LBS.
CASING SIZE SW INCH
SPOON SIZE _____ INCH
SIZE OF CORE BIT _____ INCH

NOTE: *Classification of soil has been made by the driller and has not been checked by a soils engineer. Classification of rock has been made by the driller and has not been checked by a geologist.

* Under Remarks mention kind of Bit, loss of sample, loss of Drilling water, soft seamy or broken Rock, Caving, Cavities, unusual Ground water conditions, etc., at depth encountered.

Driller Carl Ward
Helper Ronald Dowdy
Helper George Gares

301

Contract # 19[illegible]1
Cherry Island

SPRAGUE & HENWOOD, Inc.
SCRANTON, PA.

FOUNDATION TESTING and SOIL SAMPLING RECORD

AME: A.C. Schultes & Sons, Inc. LOCATION: Wilmington, Delaware

OLE NO. GP-8 SURFACE ELEVATION _____ RIG NO. _____ DATE: From 8/23 To 8/25 19 83

BORING LOG		SPOON SAMPLE AND CORE DATA				
DEPTH FROM—TO	DESCRIPTION OF MATERIAL Based On Samples Recovered Plus Observation Of Material Returned Between Samples	SAMPLE NUMBER	DEPTH FROM—TO	BLOWS PER FT. 6" XX ON SAMPLES	Sample ~~CORE~~ RECOV'D	D=DRY U=UNDISTURBED T=TRAP W=WASH R=ROD C=CORE CORE RECOV'D — NO. PCS. REMARKS *
0.0' 40.0'	Gray organic silt	1	5.0' 6.5'	Push	1.5'	
		2	10.0' 11.5'	Push	1.5'	
40.0' 70.0'	Gray silt with sand lenses	3	15.0' 16.5'	Push	1.5'	
		4	20.0' 21.5'	Push	1.5'	
70.0' 73.0'	Clayey silt	U5	25.0' 27.0'		2.0'	Shelby Tube
		6	30.0' 31.5'	Push	1.5'	
73.0' 94.5'	sand and gravel		33.0'	- Vane Shear Test		
		U7	35.0' 37.0'		2.0'	Shelby Tube
94.5' 98.0'	Red clay	8	40.0' 41.5'	6-1 2	1.5'	
			43.0'	- Vane Shear Test		
		U9	45.0' 47.0'		2.0'	Shelby Tube
		10	50.0' 52.0'	Dropped rods and spoon 50.0' to 51.0' 4-2	1.5'	
		U11	55.0' 57.0'		2.0'	Shelby Tube
			58.5'	- Vane Shear Test		
		12	60.0' 62.0'	Pushed 60.0' to 61.0' 6-3	2.0'	
		13	65.0' 66.5'	2-1 3	1.5'	
		14	70.0' 71.5'	3-5 7	1.5'	
		15	80.0' 81.5'	13-15 20	0.7'	Used 300 lb. hammer
		16	86.0' 87.5'	9-15 18	0.0'	Used 300lb. hammer Lost sample

BLOWS ON CASING

0-1		51-52	
1-2		52-53	
2-3	SW Casing to 15.0', NX Casing to 95.0'	53-54	
3-4		54-55	
4-5		55-56	
5-6		56-57	
6-7		57-58	
7-8		58-59	
8-9		59-60	
9-10		60-61	
10-11		61-62	
11-12		62-63	
12-13		63-64	
13-14		64-65	
14-15		65-66	
15-16		66-67	
16-17		67-68	
17-18		68-69	
18-19		69-70	
19-20		70-71	
20-21		71-72	
21-22		72	
22-23		73	
23-24		74	
24-25		75-76	
25-26		76-77	
26-27		77-78	
27-28		78-79	
28-29		79-80	
29-30		80-81	
30-31		81-82	
31-32		82-83	
32-33		83-84	
33-34		84-85	
34-35		85-86	
35-36		86-87	
36-37		87-88	
37-38		88-89	
38-39		89-90	
39-40		90-91	
40-41		91-92	
41-42		92-93	
42-43		93-94	
43-44		94-95	
44-45		95-96	
45-46		96-97	
46-47		97-98	
47-48		98-99	
48-49		99-100	
49-50		100-1[illegible]	
50-51		101-	

GROUND WATER

DEPTH	HOUR	DATE
Top of ground		

PIPE AND CASING LEFT IN HOLE

SIZE	AMOUNT	REASON
3/4"	47.8'	Piezometer Point

DISTANCE HAMMER DROP 24-30 INCH
DRIVE HAMMER 300 LBS.
SPOON HAMMER 140 LBS.
CASING SIZE SW-NX INCH
SPOON SIZE 2 INCH
SIZE OF CORE BIT _____ INCH

NOTE: "Classification of soil has been made by the driller and has not been checked by a soils engineer. Classification of rock has been made by the driller and has not been checked by a geologist.

* Under Remarks mention kind of Bit, loss of sample, loss of Drilling water, soft seamy or broken Rock, Caving, Cavities, unusual Ground water conditions, etc., at depth encountered.

Driller Carl Ward

Helper Ronald Dowdy

Helper ~~George Gares~~

301

SPRAGUE & HENWOOD, Inc.

SCRANTON, PA.

FOUNDATION TESTING and SOIL SAMPLING RECORD

ME: A.C. Schultes & Sons, Inc. LOCATION: Wilmington, Delaware

LE NO. GP-8 SURFACE ELEVATION _____ RIG NO. ____ DATE: From 8/23 To 8/25 19 83

BORING LOG		SPOON SAMPLE AND CORE DATA					BLOWS ON CASING	
DEPTH FROM—TO	DESCRIPTION OF MATERIAL Based On Samples Recovered Plus Observation Of Material Returned Between Samples	SAMPLE NUMBER	DEPTH FROM—TO	BLOWS PER 6" ON SAMPLES	Sample D=DRY U=UNDISTURBED T=TRAP W=WASH R=ROD C=CORE ~~Rock Core~~ RECOV'D	CORE RECOV'D — NO. PCS. REMARKS *	0-1	51-52
							1-2	52-53
							2-3	53-54
							3-4	54-55
							4-5	55-56
		17	91.0 92.5	13-58 15	0.25	'Used 300 lb. hammer	5-6	56-57
							6-7	57-58
		18	96.5 98.0	7-14 17	1.5	Used 300 lb. hammer	7-8	58-59
							8-9	59-60
							9-10	60-61
							10-11	61-62
							11-12	62-63
							12-13	63-64
							13-14	64-65
							14-15	65-66
							15-16	66-67
							16-17	67-68
							17-18	68-69
							18-19	69-70
							19-20	70-71
							20-21	71-72
							21-22	72-73
							22-23	73-74
							23-24	74-75
							24-25	75-76
							25-26	76-77
							26-27	77-78
							27-28	78-79
							28-29	79-80
							29-30	80-81
							30-31	81-82
							31-32	82-83
							32-33	83-84
							33-34	84-85
							34-35	85-86
							35-36	86-87
							36-37	87-88
							37-38	88-89
							38-39	89-90
							39-40	90-91
							40-41	91-92
							41-42	92-93
							42-43	93-94
							43-44	94-95
							44-45	95-96
							45-46	96-97
							46-47	97-98
							47-48	98-99
							48-49	99-100
							49-50	100-101
							50-51	101-102

GROUND WATER		
DEPTH	HOUR	DATE

PIPE AND CASING LEFT IN HOLE		
SIZE	AMOUNT	REASON

DISTANCE HAMMER DROP ____ INCH
DRIVE HAMMER ____ LBS.
SPOON HAMMER ____ LBS.
CASING SIZE ____ INCH
SPOON SIZE ____ INCH
SIZE OF CORE BIT ____ INCH

NOTE: *Classification of soil has been made by the driller and has not been checked by a soils engineer. Classification of rock has been made by the driller and has not been checked by a geologist.

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Driller Carl Ward

Helper Ronald Dowdy

Helper George Gares

Cherry Island

SPRAGUE & HENWOOD, Inc.

SCRANTON, PA.

FOUNDATION TESTING and SOIL SAMPLING RECORD

NAME: A.C. Schultes & Sons, Inc. LOCATION: Wilmington, Delaware

HOLE NO. GP8A SURFACE ELEVATION _____ RIG NO. _____ DATE: From 8/26 To 8/26 19 83

BORING LOG		SPOON SAMPLE AND CORE DATA					BLOWS ON CASING	
DEPTH FROM—TO	DESCRIPTION OF MATERIAL Based On Samples Recovered Plus Observation Of Material Returned Between Samples	SAMPLE NUMBER	DEPTH FROM—TO	BLOWS PER FT. ON SAMPLES	ROCK CORE RECOV'D	D=DRY U=UNDISTURBED T=TRAP W=WASH R=ROD C=CORE; CORE RECOV'D — NO. PCS. REMARKS *	0-1	51-52
0.0' 25.0'	Gray organic silt		No Samples		Required		1 - 2	52-53
							2 - 3	53-54
							3 - 4	54-55
							4 - 5	55-56
							5 - 6	56-57
							6 - 7	57-58
							7 - 8	58-59
							8 - 9	59-60
							9-10	60-61
							10-11	61-62
							11-12	62-63
							12-13	63-64
							13-14	64-65
							14-15	65-66
							15-16	66-67
							16-17	67-68
							17-18	68-69
							18-19	69-70
							19-20	70-71
							20-21	71-72
							21-22	72-[illegible]
							22-23	7[illegible]
							23-24	7[illegible]
							24-25	75-76
							25-26	76-77
							26-27	77-78
							27-28	78-79
							28-29	79-80
							29-30	80-81
							30-31	81-82
							31-32	82-83
							32-33	83-84
							33-34	84-85
							34-35	85-86
							35-36	86-87
							36-37	87-88
							37-38	88-89
							38-39	89-90
							39-40	90-91
							40-41	91-92
							41-42	92-93
							42-43	93-94
							43-44	94-95
							44-45	95-96
							45-46	96-97
							46-47	97-98
							47-48	98-99
							48-49	99-100
							49-50	100-101
							50-51	101

GROUND WATER

DEPTH	HOUR	DATE
Ground surface		

PIPE AND CASING LEFT IN HOLE

SIZE	AMOUNT	REASON
3/4"	16.7'	Piezometer Point

DISTANCE HAMMER DROP _____ INCH
DRIVE HAMMER _____ LBS.
SPOON HAMMER _____ LBS.
CASING SIZE SW INCH
SPOON SIZE _____ INCH
SIZE OF CORE BIT _____ INCH

NOTE: *Classification of soil has been made by the driller and has not been checked by a soils engineer. Classification of rock has been made by the driller and has not been checked by a geologist.

* Under Remarks mention kind of Bit, loss of sample, loss of Drilling water, soft seamy or broken Rock, Caving, Cavities, unusual Ground water conditions, etc., at depth encountered.

Driller Carl Ward
Helper Ronald Dowdy
Helper George Gares

Contract # 19531
Cherry Island

SPRAGUE & HENWOOD, Inc.

SCRANTON, PA.

FOUNDATION TESTING and SOIL SAMPLING RECORD

NAME: A.C. Schultes & Sons, Inc. LOCATION: Wilmington, Delaware

HOLE NO. GP-9 SURFACE ELEVATION _____ RIG NO. _____ DATE: From 8/30 To 9/2 19 83

BORING LOG: DEPTH FROM—TO	DESCRIPTION OF MATERIAL Based On Samples Recovered Plus Observation Of Material Returned Between Samples	SAMPLE NUMBER	DEPTH FROM—TO	BLOWS PER FT. 6" ON SAMPLES	Sample D=DRY U=UNDISTURBED T=TRAP W=WASH R=ROD C=CORE ~~No. Core~~ RECOV'D	CORE RECOV'D — NO. PCS. REMARKS *
0.0' 38.0'	Gray organic silt	1	5.0' 6.5'	Push	1.5'	
		2	10.0' 11.5'	Push	1.5'	
38.0' 60.0'	Gray sandy silt	3	15.0' 16.5'	Push	1.5'	
		U4	20.0' 22.5'		2.5'	Shelby Tube
60.0' 60.5'	Fine silty sand	U5	25.0' 27.0'		2.0'	Shelby Tube
		6	30.0' 31.5'	Push	1.5'	
60.5' 94.0'	Sand and gravel		33.0'	- Vane Shear Test		
		U7	35.0' 37.0'		2.0'	Shelby Tube
94.0' 100.5'	Brown sand and traces of clay	U8	40.0' 42.0'		1.8'	Shelby Tube
			43.5'	- Vane Shear Test		
		9	45.0' 46.5'	3-2 2	1.5'	Tried Shelby tube 50.0' - 52.0', lost sample
		U10	52.0' 54.0'		1.0'	Shelby Tube
			55.5'	- Vane Shear Test		
		11	60.0' 61.5'	3-23 43	1.5'	
		12	66.0' 67.5'	14-16 20	0.3'	Used 300 lb. hammer
		13	76.0' 77.5'	40-55 60	0.4'	Used 300 lb. hammer
	1 Hour delay time- backfill marsh section.	14	86.0' 87.5'	33-43 48	0.4'	Used 300 lb. hammer
		15	92.0' 93.5'	20-14 17	No Rec.	Used 300 lb. hammer Lost Sample
		16	99.0' 100.5'	17-20 23		Lost sample, picked up sample with trap. Used 300 lb. hammer.

BLOWS ON CASIN

0-1	51-52
1-2	52-53
2-3	53-54
3-4	54-55
4-5	55-56
5-6	56-57
6-7	57-58
7-8	58-59
8-9	59-60
9-10	60-61
10-11	61-62
11-12	62-63
12-13	63-64
13-14	64-65
14-15	65-66
15-16	66-67
16-17	67-68
17-18	68-69
18-19	69-70
19-20	70-71
20-21	71-72
21-22	72-73
22-23	73-74
23-24	74-75
24-25	75-76
25-26	76-77
26-27	77-78
27-28	78-79
28-29	79-80
29-30	80-81
30-31	81-82
31-32	82-83
32-33	83-84
33-34	84-85
34-35	85-86
35-36	86-87
36-37	87-88
37-38	88-89
38-39	89-90
39-40	90-91
40-41	91-92
41-42	92-93
42-43	93-94
43-44	94-95
44-45	95-96
45-46	96-97
46-47	97-98
47-48	98-99
48-49	99-100
49-50	100-101
50-51	101-102

SW Casing to 15.0', NX Casing to 95.0', NX Casing to 98.0'

GROUND WATER

DEPTH	HOUR	DATE
Top of ground		

PIPE AND CASING LEFT IN HOLE

SIZE	AMOUNT	REASON
3/4	49.0'	Piezometer Point

DISTANCE HAMMER DROP 24-30 INCH
DRIVE HAMMER 300 LBS.
SPOON HAMMER 140 LBS.
CASING SIZE SW INCH
SPOON SIZE 2 INCH
SIZE OF CORE BIT _____ INCH

NOTE: *Classification of soil has been made by the driller and has not been checked by a soils engineer. Classification of rock has been made by the driller and has not been checked by a geologist.

* Under Remarks mention kind of Bit, loss of sample, loss of Drilling water, soft seamy or broken Rock, Caving, Cavities, unusual Ground water conditions, etc., at depth encountered.

Driller Carl Ward
Helper Ronald Dowdy
Helper George Gares

301

Contract # 19551
Cherry Island

SPRAGUE & HENWOOD, Inc.
SCRANTON, PA.

FOUNDATION TESTING and SOIL SAMPLING RECORD

NAME: A.C. Schultes & Sons, Inc. LOCATION: Wilmington, Delaware

HOLE NO. GP9A SURFACE ELEVATION _____ RIG NO. _____ DATE: From 9/2 To 9/6 19 83

BORING LOG		SPOON SAMPLE AND CORE DATA					BLOWS ON CASING
DEPTH FROM—TO	DESCRIPTION OF MATERIAL Based On Samples Recovered Plus Observation Of Material Returned Between Samples	SAMPLE NUMBER	DEPTH FROM—TO	BLOWS PER FT. ON SAMPLES	ROCK CORE RECOV'D	D=DRY U=UNDISTURBED T=TRAP W=WASH R=ROD C=CORE CORE RECOV'D — NO. PCS. REMARKS *	
0.0' 26.5'	Gray organic silt		No Samples		Required		
			16.5'	- Vane Shear Test			
			26.5'	- Vane Shear Test			

SW Casing to 15.0'

0-1	51-52
1-2	52-53
2-3	53-54
3-4	54-55
4-5	55-56
5-6	56-57
6-7	57-58
7-8	58-59
8-9	59-60
9-10	60-61
10-11	61-62
11-12	62-63
12-13	63-64
13-14	64-65
14-15	65-66
15-16	66-67
16-17	67-68
17-18	68-69
18-19	69-70
19-20	70-71
20-21	71-72
21-22	7[illegible]
22-23	[illegible]
23-24	[illegible]
24-25	75-76
25-26	76-77
26-27	77-78
27-28	78-79
28-29	79-80
29-30	80-81
30-31	81-82
31-32	82-83
32-33	83-84
33-34	84-85
34-35	85-86
35-36	86-87
36-37	87-88
37-38	88-89
38-39	89-90
39-40	90-91
40-41	91-92
41-42	92-93
42-43	93-94
43-44	94-95
44-45	95-96
45-46	96-97
46-47	97-98
47-48	98-99
48-49	99-100
49-50	100-101
50-51	10[illegible]

GROUND WATER

DEPTH	HOUR	DATE
Top of ground		

PIPE AND CASING LEFT IN HOLE

SIZE	AMOUNT	REASON
3/4"	22.4	Piezometer Point

DISTANCE HAMMER DROP _____ INCH
DRIVE HAMMER _____ LBS.
SPOON HAMMER _____ LBS.
CASING SIZE _____ INCH
SPOON SIZE _____ INCH
SIZE OF CORE BIT _____ INCH

NOTE: "Classification of soil has been made by the driller and has not been checked by a soils engineer. Classification of rock has been made by the driller and has not been checked by a geologist.

* Under Remarks mention kind of Bit, loss of sample, loss of Drilling water, soft seamy or broken Rock, Caving, Cavities, unusual Ground water conditions, etc., at depth encountered.

Driller Carl Ward
Helper Ronald Dowdy
Helper George Gares

301

SPRAGUE & HENWOOD, Inc.
SCRANTON, PA.

Cherry Island
Job No. 19531

FOUNDATION TESTING and SOIL SAMPLING RECORD

E: A.C. Schultes & Sons, Inc. LOCATION: Wilmington, Delaware

E NO. G-10 SURFACE ELEVATION _____ RIG NO. ____ DATE: From 7/15 To 7/18 19 83

BORING LOG: DEPTH FROM—TO	DESCRIPTION OF MATERIAL (Based On Samples Recovered Plus Observation Of Material Returned Between Samples)	SAMPLE NUMBER	DEPTH FROM—TO	BLOWS PER 6" ON SAMPLES	ROCK CORE RECOV'D	D=DRY U=UNDISTURBED T=TRAP W=WASH R=ROD C=CORE; CORE RECOV'D — NO. PCS. REMARKS *
0.0' 20.0'	Gray silt with organics	1	1.0' 2.5'	1-0 1	1.0'	Damp, soft
		U1	5.0' 7.0'		2.0'	Pushed Shelby
20.0' 25.0'	Gray silt with sand lenses and organics	V1	8.5'	Vane	Shear	Test
		2	10.0' 11.5'	WOH-WOH WOH	1.5'	Moist, soft
25.0' 30.0'	Gray silt with organics	V2	13.0'	Vane	Shear	Test
		3	15.0' 16.5'	1-0 1	1.5'	Moist, soft
30.0' 32.0'	Brown peat	V3	18.0'	Vane	Shear	Test
		4	20.0' 21.5'	1-1 1	1.5'	Moist, soft
32.0' 61.0'	Gray silt with organics	5	25.0' 26.5'	WOH-WOH-1	1.5'	Moist, soft
		V4	28.0'	Vane	Shear	Test
61.0' 75.0'	Gray silty sand, trace gravel		Attempted Shelby Tube Sample-recovery- 0.7			
		U2	35.0' 37.0'		2.0	Pushed Shelby
75.0' 79.0'	Orange-brown and brown silt, some sand	V5	38.5'	Vane	Shear	Test
		6	40.0' 41.5'	WOH-WOH-2	1.5	Damp, soft
79.0' 81.5'	Orange-brown and gray sand, little silt	7	45.0' 46.5'	WOH-WOH WOH	1.5	Damp, soft
		8	50.0' 51.5'	WOH-WOH WOH	1.5'	Damp, soft
		9	55.0' 56.5'	WOH-2-2	1.5	Damp, soft
		10A	60.0' 61.0'	1-2	1.0'	Damp, soft
		10B	61.0' 61.5'	5	0.25'	Moist, medium dense
		11	65.0' 66.5'	15-15 16	0.75'	Moist, dense

BLOWS ON CASING: 0-1, 1-2, 2-3, 3-4, 4-5, 5-6, 6-7, 7-8, 8-9, 9-10, 10-11, 11-12, 12-13, 13-14, 14-15, 15-16, 16-17, 17-18, 18-19, 19-20, 20-21, 21-22, 22-23, 23-24, 24-25, 25-26, 26-27, 27-28, 28-29, 29-30, 30-31, 31-32, 32-33, 33-34, 34-35, 35-36, 36-37, 37-38, 38-39, 39-40, 40-41, 41-42, 42-43, 43-44, 44-45, 45-46, 46-47, 47-48, 48-49, 49-50, 50-51, 51-52, 52-53, 53-54, 54-55, 55-56, 56-57, 57-58, 58-59, 59-60, 60-61, 61-62, 62-63, 63-64, 64-65, 65-66, 66-67, 67-68, 68-69, 69-70, 70-71, 71-72, 72-73, 73-74, 74-75, 75-76, 76-77, 77-78, 78-79, 79-80, 80-81, 81-82, 82-83, 83-84, 84-85, 85-86, 86-87, 87-88, 88-89, 89-90, 90-91, 91-92, 92-93, 93-94, 94-95, 95-96, 96-97, 97-98, 98-99, 99-100, 100-101, 101-102

Augered to 50.0' w/ Casing to 30.0' - no blows logged

GROUND WATER		
DEPTH	HOUR	DATE
[illegible]	9:00	7/15
[illegible]ter level before [illegible]gers pulled		

PIPE AND CASING LEFT IN HOLE		
SIZE	AMOUNT	REASON

DISTANCE HAMMER DROP 24-30 INCH
DRIVE HAMMER 300 LBS.
SPOON HAMMER 140 LBS.
CASING SIZE 2½ INCH
SPOON SIZE 2 INCH
SIZE OF CORE BIT _____ INCH

NOTE: *Classification of soil has been made by the driller and has not been checked by a soils engineer. Classification of rock has been made by the driller and has not been checked by a geologist.

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Driller William Levering Jr.
Helper Ronald Dowdy
Helper _____

301

SPRAGUE & HENWOOD, Inc.

SCRANTON, PA.

FOUNDATION TESTING and SOIL SAMPLING RECORD

NAME: A.C. Schultes & Sons, Inc. LOCATION: Wilmington, Delaware

HOLE NO. G10 SURFACE ELEVATION _____ RIG NO. ____ DATE: From 7/15 To 7/18 19 83

BORING LOG: DEPTH FROM—TO	DESCRIPTION OF MATERIAL Based On Samples Recovered Plus Observation Of Material Returned Between Samples	SAMPLE NUMBER	DEPTH FROM—TO	BLOWS PER 6" ON SAMPLES	ROCK CORE RECOV'D	D=DRY U=UNDISTURBED T=TRAP W=WASH R=ROD C=CORE; CORE RECOV'D — NO. PCS. REMARKS *
		12	70.0' 71.6'	16-17 13	0.7	Moist, dense
		13	75.0' 76.5'	12-6 8	1.1	Moist, firm second attempt
		14	80.0' 81.5'	9-12 10	1.5	Moist, medium dense

BLOWS ON CASI	
0-1	51-52
1-2	52-53
2-3	53-54
3-4	54-55
4-5	55-56
5-6	56-57
6-7	57-58
7-8	58-59
8-9	59-60
9-10	60-61
10-11	61-62
11-12	62-63
12-13	63-64
13-14	64-65
14-15	65-66
15-16	66-67
16-17	67-68
17-18	68-69
18-19	69-70
19-20	70-71
20-21	71-72
21-22	72-73
22-23	[illegible]
23-24	[illegible]
24-25	75-76
25-26	76-77
26-27	77-78
27-28	78-79
28-29	79-80
29-30	80-81
30-31	81-82
31-32	82-83
32-33	83-84
33-34	84-85
34-35	85-86
35-36	86-87
36-37	87-88
37-38	88-89
38-39	89-90
39-40	90-91
40-41	91-92
41-42	92-93
42-43	93-94
43-44	94-95
44-45	95-96
45-46	96-97
46-47	97-98
47-48	98-99
48-49	99-100
49-50	100-101
50-51	[illegible]

GROUND WATER

DEPTH	HOUR	DATE

PIPE AND CASING LEFT IN HOLE

SIZE	AMOUNT	REASON

DISTANCE HAMMER DROP _____ INCH
DRIVE HAMMER _____ LBS.
SPOON HAMMER _____ LBS.
CASING SIZE _____ INCH
SPOON SIZE _____ INCH
SIZE OF CORE BIT _____ INCH

NOTE: *Classification of soil has been made by the driller and has not been checked by a soils engineer. Classification of rock has been made by the driller and has not been checked by a geologist.

* Under Remarks mention kind of Bit, loss of sample, loss of Drilling water, soft seamy or broken Rock, Caving, Cavities, unusual Ground water conditions, etc., at depth encountered.

Driller William Levering Jr.

Helper Ronald Dowdy

Helper _____

Contract # 19551
Cherry Island

SPRAGUE & HENWOOD, Inc.
SCRANTON, PA.

FOUNDATION TESTING and SOIL SAMPLING RECORD

NAME: A.C. Schultes & Sons, Inc. LOCATION: Wilmington, Delaware

HOLE NO. GP-11 SURFACE ELEVATION _____ RIG NO. _____ DATE: From 9/6 To 9/12 19 83

BORING LOG		SPOON SAMPLE AND CORE DATA					BLOWS ON CASING
DEPTH FROM—TO	DESCRIPTION OF MATERIAL Based On Samples Recovered Plus Observation Of Material Returned Between Samples	SAMPLE NUMBER	DEPTH FROM—TO	BLOWS PER ~~XX~~ 6" ON SAMPLES	Sample ~~ROCK CORE~~ RECOV'D	D=DRY U=UNDISTURBED T=TRAP W=WASH R=ROD C=CORE CORE RECOV'D — NO. PCS. REMARKS *	0-1 / 1-2 / 2-3 / 3-4 / 4-5 / 5-6 / 6-7 / 7-8 / 8-9 / 9-10 / 10-11 / 11-12 / 12-13 / 13-14 / 14-15 / 15-16 / 16-17 / 17-18 / 18-19 / 19-20 / 20-21 / 21-22 / 22-23 / 23-24 / 24-25 / 25-26 / 26-27 / 27-28 / 28-29 / 29-30 / 30-31 / 31-32 / 32-33 / 33-34 / 34-35 / 35-36 / 36-37 / 37-38 / 38-39 / 39-40 / 40-41 / 41-42 / 42-43 / 43-44 / 44-45 / 45-46 / 46-47 / 47-48 / 48-49 / 49-50 / 50-51
0.0' 55.0'	Gray organic silt	1	5.0' 6.5'	Push	1.5'		51-52 / 52-53 / 53-54 / 54-55 / 55-56 / 56-57 / 57-58 / 58-59 / 59-60 / 60-61 / 61-62 / 62-63 / 63-64 / 64-65 / 65-66 / 66-67 / 67-68 / 68-69 / 69-70 / 70-71 / 71-72 / 72-73 / 73-74 / 74-75 / 75-76 / 76-77 / 77-78 / 78-79 / 79-80 / 80-81 / 81-82 / 82-83 / 83-84 / 84-85 / 85-86 / 86-87 / 87-88 / 88-89 / 89-90 / 90-91 / 91-92 / 92-93 / 93-94 / 94-95 / 95-96 / 96-97 / 97-98 / 98-99 / 99-100 / 100-101 / 101-102
		2	10.0' 11.5'	Push	1.5'		
55.0' 62.5'	Gray sandy silt	3	15.0' 16.5'	Push	1.5'		
		4	20.0' 21.5'	Push	1.5'		
62.5' 116.5'	Sand and gravel	U5	25.0' 27.0'		1.8'	Shelby Tube	
		6	30.0' 31.5'	Push	1.5'		
116.5' 120.0'	Red and white clay	7	35.0' 36.5'	Push	1.5'		
			38.0'	- Vane Shear Test			
		U8	40.0' 42.0'		2.0'	Shelby Tube	
		9	45.0' 46.5'	5-3 4	1.5'		
			48.0'	- Vane Shear Test			
		U10	50.0' 52.0'		2.0'	Shelby Tube	
		11	55.0' 56.5'	WOH-5 5	1.5'		
		12	60.0' 61.5'	3-2 4	1.5'		
		13	65.0' 66.5'	20-28 38	0.4'	Used 300 lb. hammer	
		14	76.0' 77.5'	24-28 20		Used 300 lb. hammer Lost sample, recovered wash sample.	
		15	81.0' 82.5'	80-60 65	No Rec.	Used 300 lb. hammer	
		16	86.5' 88.5'	33-38 28-70	No Rec.	Used 300 lb. hammer	
			96.0'			Tried to sample, couldn't get spoon out of casing.	

0' - 15' SW Casing, NX Casing to 95', HX Casing to 114'

GROUND WATER

DEPTH	HOUR	DATE
1.5'	2:00PM	9/12

PIPE AND CASING LEFT IN HOLE

SIZE	AMOUNT	REASON
3/4"	67.7'	Piezometer Point

DISTANCE HAMMER DROP 24-30 INCH
DRIVE HAMMER 300 LBS.
SPOON HAMMER 140 LBS.
CASING SIZE SW-NX INCH
SPOON SIZE 2 INCH
SIZE OF CORE BIT _____ INCH

NOTE: *Classification of soil has been made by the driller and has not been checked by a soils engineer. Classification of rock has been made by the driller and has not been checked by a geologist.

* Under Remarks mention kind of Bit, loss of sample, loss of Drilling water, soft seamy or broken Rock, Caving, Cavities, unusual Ground water conditions, etc., at depth encountered.

Driller Carl Ward
Helper Ronald Dowdy
Helper James Dowdy

301

SPRAGUE & HENWOOD, Inc.

SCRANTON, PA.

FOUNDATION TESTING and SOIL SAMPLING RECORD

AME: A.C. Schultes & Sons, Inc. LOCATION: Wilmington, Delaware

OLE NO. GP-11 SURFACE ELEVATION _____ RIG NO. _____ DATE: From 9/6 To 9/12 19 83

BORING LOG		SPOON SAMPLE AND CORE DATA					BLOWS ON CASING	
DEPTH FROM—TO	DESCRIPTION OF MATERIAL Based On Samples Recovered Plus Observation Of Material Returned Between Samples	SAMPLE NUMBER	DEPTH FROM—TO	BLOWS PER FT. ON SAMPLES	~~% ON CORE~~ RECOV'D	D=DRY U=UNDISTURBED T=TRAP W=WASH R=ROD C=CORE CORE RECOV'D — NO. PCS. REMARKS *	0-1	51-52
			96.0' 120.0'			Drilled ahead of casing with roller bit. Hit red and white clay at 116.5' to 120.0'	1-2	52-53
							2-3	53-54
							3-4	54-55
							4-5	55-56
							5-6	56-57
							6-7	57-58
							7-8	58-59
							8-9	59-60
							9-10	60-61
							10-11	61-62
							11-12	62-63
							12-13	63-64
						48.1' of granular soil backfill.	13-14	64-65
							14-15	65-66
							15-16	66-67
							16-17	67-68
							17-18	68-69
							18-19	69-70
							19-20	70-71
							20-21	71-72
							21-22	72
							22-23	73
							23-24	74
							24-25	75-76
							25-26	76-77
							26-27	77-78
							27-28	78-79
							28-29	79-80
							29-30	80-81
							30-31	81-82
							31-32	82-83
							32-33	83-84
							33-34	84-85
							34-35	85-86
							35-36	86-87
							36-37	87-88
							37-38	88-89
							38-39	89-90
							39-40	90-91
							40-41	91-92
							41-42	92-93
							42-43	93-94
							43-44	94-95
							44-45	95-96
							45-46	96-97
							46-47	97-98
							47-48	98-99
							48-49	99-100
							49-50	100-101
							50-51	101

GROUND WATER

DEPTH	HOUR	DATE

PIPE AND CASING LEFT IN HOLE

SIZE	AMOUNT	REASON

DISTANCE HAMMER DROP _____ INCH
DRIVE HAMMER _____ LBS.
SPOON HAMMER _____ LBS.
CASING SIZE _____ INCH
SPOON SIZE _____ INCH
SIZE OF CORE BIT _____ INCH

NOTE: *Classification of soil has been made by the driller and has not been checked by a soils engineer. Classification of rock has been made by the driller and has not been checked by a geologist.

* Under Remarks mention kind of Bit, loss of sample, loss of Drilling water, soft seamy or broken Rock, Caving, Cavities, unusual Ground water conditions, etc., at depth encountered.

Driller Carl Ward

Helper Ronald Dowdy

Helper James Dowdy

301

Cherry Island

SPRAGUE & HENWOOD, Inc.

SCRANTON, PA.

FOUNDATION TESTING and SOIL SAMPLING RECORD

NAME: A.C. Schultes & Sons, Inc. LOCATION: Wilmington, Delaware

HOLE NO. GP-12 SURFACE ELEVATION _____ RIG NO. _____ DATE: From 9/15 To 9/20 19 83

BORING LOG: DEPTH FROM—TO	DESCRIPTION OF MATERIAL Based On Samples Recovered Plus Observation Of Material Returned Between Samples	SAMPLE NUMBER	DEPTH FROM—TO	BLOWS PER FT. 6" ON SAMPLES	RECOV'D	REMARKS *
0.0' 45.0'	Gray organic silt	1	5.0' 6.5'	Push	1.5'	
		2	10.0' 11.5'	Push	1.5'	
45.0' 50.0'	Gray silt with sand layers	3	15.0' 16.5'	Push	1.5'	
		U4	20.0' 22.0'		1.7'	Shelby Tube
50.0' 51.0'	Sand, some gravel	5	25.0' 26.5'	Push	1.5'	
		U6	30.0' 32.0'		2.0'	Shelby Tube
51.0' 89.0'	Gray sandy silt	7	35.0' 36.5'	Push	1.5'	
		8	40.0' 41.5'	Push-1' 4	1.5'	
89.0' 117.0'	Sand and gravel	U9	45.0' 47.0'		2.0'	Shelby Tube
			48.0'	- Vane Shear Test		
117.0' 120.0'	Gray medium sand	10	50.0' 51.5'	17-12 8	1.2'	
		11	55.0' 56.5'	2-2 4	No Rec.	
		U12	60.0' 62.0'		2.0'	Shelby Tube
		13	65.0' 66.5'	4-8 7	1.5'	
		14	70.0' 71.5'	4-3 5	1.5'	
		15	75.0' 76.5'	2-1 3	1.5'	
		16	80.0' 81.5'	5-5 6	1.5'	
		17	85.0' 86.5'	4-4 6	1.5'	
		18	89.0' 90.5'	17-14 17	1.5'	Used 300 lb. hammer

Sample: D=DRY U=UNDISTURBED T=TRAP W=WASH R=ROD C=CORE

CORE RECOV'D — NO. PCS.

BLOWS ON CASING: 5" Casing to 15.0', NX Casing to 100.0', used mud 100.0' to 120.0'

0-1	51-52
1-2	52-53
2-3	53-54
3-4	54-55
4-5	55-56
5-6	56-57
6-7	57-58
7-8	58-59
8-9	59-60
9-10	60-61
10-11	61-62
11-12	62-63
12-13	63-64
13-14	64-65
14-15	65-66
15-16	66-67
16-17	67-68
17-18	68-69
18-19	69-70
19-20	70-71
20-21	71-72
21-22	72-73
22-23	73-74
23-24	74-75
24-25	75-76
25-26	76-77
26-27	77-78
27-28	78-79
28-29	79-80
29-30	80-81
30-31	81-82
31-32	82-83
32-33	83-84
33-34	84-85
34-35	85-86
35-36	86-87
36-37	87-88
37-38	88-89
38-39	89-90
39-40	90-91
40-41	91-92
41-42	92-93
42-43	93-94
43-44	94-95
44-45	95-96
45-46	96-97
46-47	97-98
47-48	98-99
48-49	99-100
49-50	100-101
50-51	101-102

GROUND WATER

DEPTH	HOUR	DATE
1	8:00 A.M.	9/20

PIPE AND CASING LEFT IN HOLE

SIZE	AMOUNT	REASON

DISTANCE HAMMER DROP 24-30 INCH
DRIVE HAMMER 300 LBS.
SPOON HAMMER 140 LBS.
CASING SIZE SW-NX INCH
SPOON SIZE 2 INCH
SIZE OF CORE BIT _____ INCH

NOTE: *Classification of soil has been made by the driller and has not been checked by a soils engineer. Classification of rock has been made by the driller and has not been checked by a geologist.

* Under Remarks mention kind of Bit, loss of sample, loss of Drilling water, soft seamy or broken Rock, Caving, Cavities, unusual Ground water conditions, etc., at depth encountered.

Driller Carl Ward
Helper Ronald Dowdy
Helper James Dowdy

SPRAGUE & HENWOOD, Inc.

SCRANTON, PA.

FOUNDATION TESTING and SOIL SAMPLING RECORD

NAME: A.C. Schultes & Sons, Inc. LOCATION: Wilmington, Delaware

HOLE NO. GP-12 SURFACE ELEVATION _____ RIG NO. _____ DATE: From 9/15 To 9/20 19 83

BORING LOG		SPOON SAMPLE AND CORE DATA					
DEPTH FROM—TO	DESCRIPTION OF MATERIAL Based On Samples Recovered Plus Observation Of Material Returned Between Samples	SAMPLE NUMBER	DEPTH FROM—TO	BLOWS PER 6" ON SAMPLES	Sample ~~ROCK CORE~~ RECOV'D	D=DRY U=UNDISTURBED T=TRAP W=WASH R=ROD C=CORE CORE RECOV'D — NO. PCS. REMARKS *
		19	102.0 104.0	10-20 17-13	0.3'	Used 300 lb. hammer
		20	114.0 116.0	14-18 25-20	0.2'	Used 300 lb. hammer
		21	117.0 120.0	14-18-24 25-26-27	1.5'	Used 300 lb. hammer

BLOWS ON CASIN	
0-1	51-52
1-2	52-53
2-3	53-54
3-4	54-55
4-5	55-56
5-6	56-57
6-7	57-58
7-8	58-59
8-9	59-60
9-10	60-61
10-11	61-62
11-12	62-63
12-13	63-64
13-14	64-65
14-15	65-66
15-16	66-67
16-17	67-68
17-18	68-69
18-19	69-70
19-20	70-71
20-21	71-72
21-22	7
22-23	7
23-24	
24-25	75-76
25-26	76-77
26-27	77-78
27-28	78-79
28-29	79-80
29-30	80-81
30-31	81-82
31-32	82-83
32-33	83-84
33-34	84-85
34-35	85-86
35-36	86-87
36-37	87-88
37-38	88-89
38-39	89-90
39-40	90-91
40-41	91-92
41-42	92-93
42-43	93-94
43-44	94-95
44-45	95-96
45-46	96-97
46-47	97-98
47-48	98-99
48-49	99-100
49-50	100-
50-51	10

GROUND WATER

DEPTH	HOUR	DATE

PIPE AND CASING LEFT IN HOLE

SIZE	AMOUNT	REASON

DISTANCE HAMMER DROP _____ INCH
DRIVE HAMMER _____ LBS.
SPOON HAMMER _____ LBS.
CASING SIZE _____ INCH
SPOON SIZE _____ INCH
SIZE OF CORE BIT _____ INCH

NOTE: *Classification of soil has been made by the driller and has not been checked by a soils engineer. Classification of rock has been made by the driller and has not been checked by a geologist.

* Under Remarks mention kind of Bit, loss of sample, loss of Drilling water, soft seamy or broken Rock, Caving, Cavities, unusual Ground water conditions, etc., at depth encountered.

Driller Carl Ward
Helper Ronald Dowdy
Helper James Dowdy

WALTON CORPORATION
Drilling Contractor
P. O. BOX 1097, NEWARK, DELAWARE 19711

BORING LOG

NAME Cherry Island PROJECT NO.
Wilmington, DE SUPERVISOR

BORING NO.	DRILLER	DATE
A#1	G. Truver	11-13-83
WEATHER	**SURFACE ELEVATION**	**DATUM**
Cold & Cloudy		

Sample No.	Sample Depth - Feet From	Sample Depth - Feet To	Depth Strata Feet From	Depth Strata Feet To	Driller's Description of Materials	*Blows A		
			0	1.0	Gray Silt w/Tr. Sand & Gravel			
1	1.0	2.5	1.0	3.5	Dk. Gray Silt w/Some Veg. & Tr.	2	3	2
					Sand & Gravel			
2	4.0	5.5	3.5	5.5	Gray Silty F Sand w/Tr. Organic	3	3	2
					& Mica			
3	6.0	7.5	5.5	8.0	Gray Clayey Silt w/Tr. Sand &	2	1	2
					Mica			
4	9.0	10.5	8.0	10.5	Gray Clayey Silt w/Some Sand &	W/H	1	1
					Tr. Mica			
V.S.1	10.5	12.0	10.5		Vane Shear Test			
S#1	12.5	14.5			Gray Clayey Silt w/Tr. Sand &	SHELBY		
					Mica Rec. 24"			
5	14.5	16.0		17.0	Same	W/H	1	2
6	19.0	20.5	17.0	21.5	Gray Clay w/Little Silt & Tr.	W/H	1	2
					Sand,Organics & Mica			
7	24.0	25.5	21.5		Brn. Peat	W/H	1	2
V.S.2	25.5	27.0			Vane Shear Test			
S#2	27.5	29.5		29.0	Same Rec. 22"	SHELBY		
			29.0		Gray F Sand w/Some Silt & Tr. Mica			
8	29.5	31.0		37.5	Same	3	4	3
9	34.0	35.5	32.5	37.0	Brownish Gray Silty F Sand w/Tr.	2	4	5
					Mica			

BLOWS ON CASING B
0- 1
1- 2
2- 3
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*A Number of blows of 140 lb. hammer dropped 30 in. required to drive 2 in. split-spoon sampler for each of three 6 in. increments.

* B Number of blows of 300 lb. hammer dropped 18 in. required to drive ..... in. casing 12 inches.

REMARKS: .....

GROUND WATER

WALTON CORPORATION
Drilling Contractor

P. O. BOX 1097, NEWARK, DELAWARE 19711

BORING LOG

NAME Cherry Island PROJECT NO.

Wilmington, DE SUPERVISOR

BORING NO.	DRILLER	DATE
A#1	G. Truver	11-13-83
WEATHER	**SURFACE ELEVATION**	**DATUM**

Sample No.	Sample Depth - Feet From	Sample Depth - Feet To	Depth Strata Feet From	Depth Strata Feet To	Driller's Description of Materials	*Blows A		
10	39.0	40.5	37.0	40.5	Gray F/C Sand w/Some Gravel &	12	21	23
					& Little Silt & Tr. Mica			

BLOWS ON CASING B
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1- 2
2- 3
3- 4
4- 5
5- 6
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*A Number of blows of 140 lb. hammer dropped 30 in. required to drive 2 in. split-spoon sampler for each of three 6 in. increments.

* B Number of blows of 300 lb. hammer dropped 18 in. required to drive ..... in. casing 12 inches.

REMARKS:

GROUND WATER

WALTON CORPORATION
Drilling Contractor

P. O. BOX 1097, NEWARK, DELAWARE 19711

BORING LOG

NAME Cherry Island PROJECT NO.

Wilmington, DE SUPERVISOR

BORING NO.	DRILLER	DATE
TB A-2	G. Truver	11-29-83
WEATHER	**SURFACE ELEVATION**	**DATUM**
Clear & Breezy		

Sample No.	Sample Depth - Feet From	Sample Depth - Feet To	Depth Strata Feet From	Depth Strata Feet To	Driller's Description of Materials	*Blows A		
1	1.0	2.5	0	1.7	Brn. Silt w/Little Sand & Tr.	2	2	3
			1.7	3.0	Brn. F Sand w/Some Silt & Tr.			
					Gravel			
2	4.0	5.5	3.0	5.5	Dk. Gray Silt w/Tr. Sand,Gravel	1	2	2
					& Mica			
3	6.0	7.5	5.5	8.0	Dk. Gray Silt w/Tr. Sand & Mica	W/H	W/H	1
4	9.0	10.5	8.0	11.0	Dk. Gray Silt w/Tr. Sand,Mica	W/H	W/H	W/H
					& Gravel			
V S 1	10.5	12.0			Vane Shear Test			
S#1	12.0	14.0	11.0		Dk. Gray Silt w/Tr. Sand,Mica &	SHELBY		
					Organics (Rec. 20")			
5	14.0	15.5			Same	W/H	W/H	W/H
6	19.0	20.5		23.0	Same	W/H	W/H	1
7	24.0	25.5	23.0		Peat & Gray Silt w/Tr. Sand &	1	1	2
V S 2	25.5	27.0			Vane Shear Test Mica			
S#2	27.0	29.0		29.0	Same Rec. 24"	SHELBY		
8	29.0	30.5	29.0		Dk. Gray Silt w/Some Organics	W/H	1	2
					& Tr. Mica			
9	34.0	35.5		38.0	Same	1	1	2
10	39.0	40.8	38.0		Gray F/C Sand w/Little Gravel &	11	18	20
					Tr. Silt			
11	44.0	45.5		45.0	Same	12	17	13
			45.0	45.5	Gray F Sand w/Little Silt & Gravel			

*A Number of blows of 140 lb. hammer dropped 30 in. required to drive 2 in. split-spoon sampler for each of three 6 in. increments.

* B Number of blows of 300 lb. hammer dropped 18 in. required to drive ..... in. casing 12 inches.

REMARKS:

GROUND WATER

BLOWS ON CASING B
0- 1
1- 2
2- 3
3- 4
4- 5
5- 6
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WALTON CORPORATION
Drilling Contractor

P. O. BOX 1097, NEWARK, DELAWARE 19711

BORING LOG

NAME: Cherry Island

PROJECT NO.:

Wilmington, DE

SUPERVISOR:

BORING NO.	DRILLER	DATE
TB#A2A	G. Truver	12-1-83
WEATHER	**SURFACE ELEVATION**	**DATUM**
Clear & Chilly		

Sample No.	Sample Depth - Feet From	Sample Depth - Feet To	Depth Strata Feet From	Depth Strata Feet To	Driller's Description of Materials	*Blows A		
			0	14.0	Augered			
V.S.1	14.0	15.5	14.0	15.5	Vane Shear Test			
			15.5	20.0	Augered			
					Piezometer set @ 18.5			

BLOWS ON CASING B
0- 1
1- 2
2- 3
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*A Number of blows of 140 lb. hammer dropped 30 in. required to drive 2 in. split-spoon sampler for each of three 6 in. increments.

* B Number of blows of 300 lb. hammer dropped 18 in. required to drive ..... in. casing 12 inches.

REMARKS:

GROUND WATER

WALTON CORPORATION
Drilling Contractor

P. O. BOX 1097, NEWARK, DELAWARE 19711

BORING LOG

NAME .....Cherry Island..... PROJECT NO. .....

.....Wilmington, DE..... SUPERVISOR .....

BORING NO.	DRILLER	DATE
TB#3	G. Truver	12-2-83
WEATHER	**SURFACE ELEVATION**	**DATUM**
Overcast & Mild		

Sample No.	Sample Depth - Feet From	Sample Depth - Feet To	Depth Strata Feet From	Depth Strata Feet To	Driller's Description of Materials	*Blows A		
1	4.0	5.5	0		Gray Silt & Organics, w/Tr. Sand	2	2	2
					and Mica			
2	9.0	10.5		10.0	Same	2	2	1
			10.0	12.5	Gray Silt w/Tr. Sand & Mica			
3	14.0	15.5	12.5		Dk. Gray Silt & Organics w/Tr.	W/H	W/H	1
					Sand & Mica			
4	19.0	20.5			Same	1	1	2
S#1	24.0	26.0			Same Rec. 22"	SHELBY		
V.S.1	26.0	27.5			Vane Shear Test			
S#2	29.0	31.0		30.5	Dk. Gray Silt & Organics w/Tr	SHELBY		
					Sand & Mica Rec. 24"			
			30.5	32.0	Gray Silt w/Tr. Sand			
V.S.2	31.0	32.5	32.0		Vane Shear Test			
5	34.0	35.5		35.5	Gray F/C Sand & Gravel w/Silt &	6	12	15
					Mica			

*A Number of blows of 140 lb. hammer dropped 30 in. required to drive 2 in. split-spoon sampler for each of three 6 in. increments.

* B Number of blows of 300 lb. hammer dropped 18 in. required to drive ..... in. casing 12 inches.

REMARKS: .....

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GROUND WATER

BLOWS ON CASING B
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WALTON CORPORATION
Drilling Contractor

P. O. BOX 1097, NEWARK, DELAWARE 19711

BORING LOG

NAME .....Cherry Island..... PROJECT NO. .....

..... SUPERVISOR .....

BORING NO.	DRILLER	DATE
A-3A	G. Truver	12-2-83
WEATHER	**SURFACE ELEVATION**	**DATUM**
Cold		

Sample No.	Sample Depth - Feet From	Sample Depth - Feet To	Depth Strata Feet From	Depth Strata Feet To	Driller's Description of Materials	*Blows A		
			0	16.0	Augered			

*A Number of blows of 140 lb. hammer dropped 30 in. required to drive 2 in. split-spoon sampler for each of three 6 in. increments.

*B Number of blows of 300 lb. hammer dropped 18 in. required to drive ..... in. casing 12 inches.

REMARKS: .....

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GROUND WATER

BLOWS ON CASING B
0- 1
1- 2
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WALTON CORPORATION
Drilling Contractor

P. O. BOX 1097, NEWARK, DELAWARE 19711

BORING LOG

NAME Cherry Island PROJECT NO.

Wilmington, DE SUPERVISOR

BORING NO.	DRILLER	DATE
TB#4	G. Truver	12-7-83
WEATHER	**SURFACE ELEVATION**	**DATUM**
Windy & Cold		

Sample No.	Sample Depth - Feet From	Sample Depth - Feet To	Depth Strata Feet From	Depth Strata Feet To	Driller's Description of Materials	*Blows A		
1	4.0	5.5	0		Gray Silt w/Tr. Sand, Organics & Mica	1	1	1
2	9.0	10.5		12.0	Same	1	1	1
3	14.0	15.5	12.0	17.5	Gray Silt w/Little Organics & Tr. Sand & Mica	W/H	2	1
4	19.0	20.5	17.5		Gray Silt w/Tr. Sand, Mica & Organics	W/H	W/H	1
S#1	21.0	23.0			Same 17" Rec.	SHELBY		
VST	23.0	24.5			Vane Shear Test			
S#2	26.0	28.0		28.0	Same 24" Rec.	SHELBY		
5	31.0	32.5	28.0		Brn. Peat	1	1	1
S#3	34.0	36.0		38.0	Same	SHELBY		
6	39.0	40.5	38.0	73.0	Gray Silty F Sand w/Little Mica	W/H	W/H	3
7	44.0	45.5	43.0	45.4	Gray Mica F Sand w/Little Silt	3	5	9
			45.4	45.5	Gray Mica F Sand w/Little Silt & Some Gravel			

*A Number of blows of 140 lb. hammer dropped 30 in. required to drive 2 in. split-spoon sampler for each of three 6 in. increments.

* B Number of blows of 300 lb. hammer dropped 18 in. required to drive ..... in. casing 12 inches.

REMARKS: .....

GROUND WATER

BLOWS ON CASING B
0- 1
1- 2
2- 3
3- 4
4- 5
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WALTON CORPORATION
Drilling Contractor

P. O. BOX 1097, NEWARK, DELAWARE 19711

BORING LOG

NAME Cherry Island
Wilmington, DE

PROJECT NO.

SUPERVISOR

BORING NO.	DRILLER	DATE
A-4A	G. Truver	12-8-83
WEATHER	**SURFACE ELEVATION**	**DATUM**
Cold & Clear		

Sample No.	Sample Depth - Feet From	Sample Depth - Feet To	Depth Strata Feet From	Depth Strata Feet To	Driller's Description of Materials	*Blows A		
			0	14.0	Augered			
S#1	14.0	16.0	14.0	16.0	Dk. Gray Silt	SHELBY		
					Rec. 19"			
			16.0	19.0	Augered			
					Set Piezometer 17.3			

*A Number of blows of 140 lb. hammer dropped 30 in. required to drive 2 in. split-spoon sampler for each of three 6 in. increments.

* B Number of blows of 300 lb. hammer dropped 18 in. required to drive ..... in. casing 12 inches.

REMARKS: .....

GROUND WATER

BLOWS ON CASING B
0- 1
1- 2
2- 3
3- 4
4- 5
5- 6
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WALTON CORPORATION
Drilling Contractor

P. O. BOX 1097, NEWARK, DELAWARE 19711

BORING LOG

NAME Cherry Island PROJECT NO.

Wilmington, DE SUPERVISOR

BORING NO.	DRILLER	DATE
TB#5	G. Truver	12-20-83
WEATHER	**SURFACE ELEVATION**	**DATUM**
Cold & Breezy		

Sample No.	Sample Depth - Feet From	Sample Depth - Feet To	Depth Strata Feet From	Depth Strata Feet To	Driller's Description of Materials	*Blows A		
1	5.0	6.5	0	8.5	Grayish Silt w/Some F Sand & Veg.	2	2	2
					& Tr. Mica			
2	10.0	11.5	8.5		Gray Silt w/Little Veg. & Tr. F	2	1	1
					Sand & Mica			
S#1	15.0	17.0			Same 24" Rec.	SHELBY		
3	20.0	21.5			Same	W/H	W/H	W/H
S#2	25.0	27.0		27.5	Same 21" Rec.	SHELBY		
4	30.0	31.5	27.5	33.0	Brn. Peat	W/H	1	1
5	35.0	36.5	33.0		Dark Gray Silt w/Tr. Peat,Mica	1	1	2
					& Sand			
6	40.0	41.5		40.8	Same			
			40.8	41.0	Gray F Sand w/Little Silt & Tr.	1	5	5
					Mica			
7	43.5	45.0	41.0	45.0	Gray F/M Sand & Gravel	35	29	35
					Piezometer set @ 32.0			

*A Number of blows of 140 lb. hammer dropped 30 in. required to drive 2 in. split-spoon sampler for each of three 6 in. increments.

* B Number of blows of 300 lb. hammer dropped 18 in. required to drive ..... in. casing 12 inches.

REMARKS:

GROUND WATER

BLOWS ON CASING B
0- 1
1- 2
2- 3
3- 4
4- 5
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WALTON CORPORATION
Drilling Contractor

P. O. BOX 1097, NEWARK, DELAWARE 19711

BORING LOG

NAME .....Cherry Island..... PROJECT NO. .....

.....Wilmington, DE..... SUPERVISOR .....

BORING NO.	DRILLER	DATE
TB#5A	G. Truver	12-21-83
WEATHER	**SURFACE ELEVATION**	**DATUM**
Cloudy & Cold		

Sample No.	Sample Depth - Feet From	Sample Depth - Feet To	Depth Strata Feet From	Depth Strata Feet To	Driller's Description of Materials	*Blows A		
			0	20.0	Augered			
V.S.1	20.0	21.5	20.0	21.5	Vane Shear Test			

*A Number of blows of 140 lb. hammer dropped 30 in. required to drive 2 in. split-spoon sampler for each of three 6 in. increments.

* B Number of blows of 300 lb. hammer dropped 18 in. required to drive ..... in. casing 12 inches.

REMARKS: .....

.....

.....

.....

GROUND WATER

BLOWS ON CASING B
0- 1
1- 2
2- 3
3- 4
4- 5
5- 6
6- 7
7- 8
8- 9
9-10
10-11
11-12
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WALTON CORPORATION
Drilling Contractor

P. O. BOX 1097, NEWARK, DELAWARE 19711

BORING LOG

NAME Cherry Island PROJECT NO.

Wilmington, DE SUPERVISOR

BORING NO.	DRILLER	DATE
TB#6	G. Truver	12-19-83
WEATHER	**SURFACE ELEVATION**	**DATUM**
Sunny & Mild		

Sample No.	Sample Depth - Feet From	Sample Depth - Feet To	Depth Strata Feet From	Depth Strata Feet To	Driller's Description of Materials	*Blows A		
1	3.5	5.0			Dk. Brn. Silt, Tr. F Sand, Tr. Mica	2	1	2
2	8.5	10.0			Dk. Brn. & Dk. Gray Silt Tr. F Sand, Tr. Fib. Veg	1	1	2
3	13.5	15.0			Same	W/H	W/H	W/H
4	18.5	20.0			Dk. Gray & Blk. Silt, Tr. F Sand & Mica, Tr. Fib. Veg.	W/H	1	1
5	23.5	25.0			Dk. Gray & Blk. Silt Tr. F Sand & Fib. Veg.	1	1	1
6	28.5	30.0			Dk. Gray Silt Tr. F Sand & Mica	W/H	2	1
7	33.5	35.0			Same	W/H	1	2
8	38.5	40.0		41.5	Dk. Gray Silt w/little Org. & Tr. F Sand & Mica	1	2	2
9	43.5	45.0	41.5	46.0	Gray Misc. F Sand w/Some Silt	4	5	10
10	48.5	50.0	46.0	50.0	Gray Misc. F/M Sand & Gravel w/ Little Silt	25	40	75

*A Number of blows of 140 lb. hammer dropped 30 in. required to drive 2 in. split-spoon sampler for each of three 6 in. increments.

* B Number of blows of 300 lb. hammer dropped 18 in. required to drive ..... in. casing 12 inches.

REMARKS:

GROUND WATER

BLOWS ON CASING B
0- 1
1- 2
2- 3
3- 4
4- 5
5- 6
6- 7
7- 8
8- 9
9-10
10-11
11-12
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WALTON CORPORATION
Drilling Contractor

P. O. BOX 1097, NEWARK, DELAWARE 19711

BORING LOG

NAME Cherry Island PROJECT NO.

Wilmington, DE SUPERVISOR

BORING NO.	DRILLER	DATE
TB#7	G. Truver	12-9-83
WEATHER	**SURFACE ELEVATION**	**DATUM**
Sunny & Mild		

Sample No.	Sample Depth - Feet From	Sample Depth - Feet To	Depth Strata Feet From	Depth Strata Feet To	Driller's Description of Materials	*Blows A		
1	1.0	2.5	0	3.0	Gray Silt & Organics w/Tr. Sand and Mica	2	3	4
2	4.0	5.5	3.0		Gray Silt w/Some Organics & Tr. Sand & Mica	1	1	2
3	9.0	10.5			Same	W/H	W/H	W/H
4	14.0	15.5			Same	W/H	W/H	1
S#1	19.0	21.0		22.0	Same 24" Rec.	SHELBY		
5	24.0	25.5	22.0		Gray Silt & Peat w/Tr. Sand & Mica	W/H	1	1
S#2	29.0	30.5			Same 24" Rec.	SHELBY		
6	34.0	35.5			Same	1	2	3
7	39.0	40.5		41.5	Same	W/H	W/H	1
8	44.0	45.5	41.5	49.0	Gray Silt w/Little Peat & Tr. Sand & Mica	2	2	2
9	49.0	50.5	49.0	53.0	Gray Mica, Sand & Gravel w/Tr. Silt	7	19	26

*A Number of blows of 140 lb. hammer dropped 30 in. required to drive 2 in. split-spoon sampler for each of three 6 in. increments.

* B Number of blows of 300 lb. hammer dropped 18 in. required to drive ..... in. casing 12 inches.

REMARKS:

GROUND WATER

BLOWS ON CASIN
0- 1
1- 2
2- 3
3- 4
4- 5
5- 6
6- 7
7- 8
8- 9
9-10
10-11
11-12
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APPENDIX D-4

DIKE STABILITY

D-4 Dike Stability

An evaluation of the configuration the existing and proposed dikes and landfill configuration was performed utilizing a computer program developed by the U.S. Army Corp of Engineers entitled "Analysis of Slope Stability (the Circular Arc Method)", Program No. 741-F3-R0003. This analysis was performed based on the design parameters summarized in Appendix D-3.

As indicated in Appendix D-3, the soil strengths obtained in this evaluation differ somewhat between the north side of the Wilmington area and the Edgemoor area. The top portion, Figure D-4-1, indicates the results of an analysis performed assuming construction of a 3:1 dike on the soils encountered in the Wilmington area. The resulting factor of safety is 1.15 (a factor of safety of 1.00 indicates impending failure). Based on the results of this analysis, we recommend that the proposed dikes on the Wilmington side of the site be constructed at 3:1 slopes with a geotextile fabric utilized at the base of the embankment to increase the stability of the embankment during construction.

Analysis indicates that placement of 40 feet of refuse at a 3:1 slope against the proposed dikes will result in a factor of safety of approximately 1.0 which is not considered adequate. This analysis was based on the assumption of a strength gain due to consolidation. A slope stability analysis was then performed assuming a 50 foot "bench" between the top of the first 20 feet of refuse and the start of the 3:1 slope of the next 20 foot lift. The resulting factor of safety was approximately 1.37.

We therefore recommend that after the first 20 feet of refuse placement is complete, the beginning of the second 20 foot lift commence at a distance of 50 feet back from the top of the slope. It is recommended, that piezometers and settlement points be

utilized to monitor the progression of consolidation to provide information by which to assess the strength gain over time. This data along with a knowledge of the actual amount of dredge spoil material placed on the south side of the proposed embankment by the COE, may be used to reassess the stability of the landfill slope under 40 feet of refuse. This reassessment may allow a decrease in the bench dimension and thereby increase the landfill capacity in this area.

It is also recommended that a 50 foot bench be constructed along the west side of the Wilmington area after the first 20 feet of refuse has been landfilled in this area. This dimension may be reduced after assessment of the progress of consolidation.

Existing dikes around the perimeter of the Edgemoor site are generally constructed by drag line excavation of dredge spoil piled in a manner to create a dike. The purpose of these dikes is to retain dredge spoil placed on approximately an annual basis. Discussions with COE personnel have indicated several localized failures have occurred in different areas requiring periodic repair. Due to the method of construction of these dikes and the existing configuration (narrow top), they will not be suitable for direct incorporation into the operation of the landfill. To support truck traffic or utility construction, these dikes must be made wider and level and with flatter slopes to support such activities safely. A section of the existing dike was analyzed and is illustrated in the bottom of Figure D-4-1. The location of this section of the northern dike is indicated by Section G-G of Figure 3-1. Our evaluation of placing landfill materials immediately adjacent to the existing dikes of the Edgemoor area indicates a safety factor of approximately 1.1 for a 20 foot lift of refuse. This is not considered satisfactory due to the consequences of failure, particularly along the north and east dikes. A minimum safety

factor of 1.4 is recommended in these areas. To minimize this risk, a setback of 100 feet between the toe of the existing dike and the proposed landfill is recommended.

The evaluation of constructing the proposed dikes over the dredge spoil material in the Edgemoor area was performed assuming five to one slopes and the soil conditions indicated in Figure D-4-2. This figure indicates that with an assumed shear strength of 150 psf in the top 25 feet of the subsurface soils, a minimum factor of safety of 0.85 was obtained, indicating an embankment failure. Review of the lower portion of this figure indicates that the minimum factor of safety becomes approximately 1.10 for an assumed shear strength of 200 psf for the same dike configuration.

Based on our evaluation, it is our opinion that the dikes may be constructed at slopes of 5:1 under the condition assumed. However, the actual shear strengths encountered in the field during dike construction will depend very heavily on the preparatory measures taken to drain water from the site after the proposed December 1983 flooding of this area. Drainage of water from these soils in a timely fashion will be required to raise the shear strength to increase the stability of this area during new dike construction. Failure to increase the shear strength of these soils through drainage may require reducing the slope and thereby increasing the amount of material required for embankment construction.

Based on the results of the stability analysis, we recommend that a geotextile fabric be utilized at the base of the embankment to increase the stability during construction. This geotextile may become critical to the stability of the embankment during construction, depending on the time available for preparing the site prior to construction.

In addition, we recommend that a section of test embankment be constructed in the dredge spoil area to assist in the final design of this embankment. This embankment should be instrumented with piezometers and settlement points to determine the pore water pressure and settlement behavior of the subsurface soils under the embankment load.

Figure D-4-3 illustrates a configuration in which 20 feet of refuse has been landfilled behind the five to one dike. The two configurations illustrated in Figure D-4-3 differ only in that the assumed shear strength for stratum three was 200 in the upper portion and 250 psf in the lower portion, resulting in minimum factors of safety of 0.97 and 1.20 respectively. It is estimated that the soil of stratum three will have attained a shear strength of 250 psf by the time the 20 feet of refuse is in place (it has been assumed that the placement of this refuse will take place in ten foot lifts over a period of four years).

It is evident by comparison of the factors of safety of the two configurations in Figure D-4-3 that the stability of the embankment is heavily dependent upon the shear strength gained from consolidation during the landfilling operation. Assessment of the progress of consolidation will be necessary in estimating the strength gain obtained with time which may impact the landfilling rate in the area of the proposed slopes.

Figure D-4-4 illustrates two configurations analyzed for stability after the placement of a second 20 foot lift of refuse. The upper portion of the figure illustrates a 50 foot bench in the three to one slope of the landfill. The assumed shear strengths for this condition are as indicated in the figure. The factor of safety of this particular condition is 1.02, which is very close to impending failure.

The lower portion of Figure D-4-4 illustrates a 100 foot bench in the landfill slope under the same assumed strength conditions. The resulting factor of safety under this configuration is 1.21.

The evaluation of the conditions indicated in Figure D-4-4 indicates that the failure arc will cut through the stratum identified as number 5 in the figure. It is expected that this stratum, which lies at least 25 feet below the existing ground surface, will be very slow in gaining shear strength due to the distance of this stratum to the ground surface. Therefore we recommend that piezometers be placed in this stratum around the landfill perimeter to monitor the pore water pressures in this area due to the imposed load of the landfilling operation. Again, monitoring of these conditions may impact the landfilling rate and configuration.

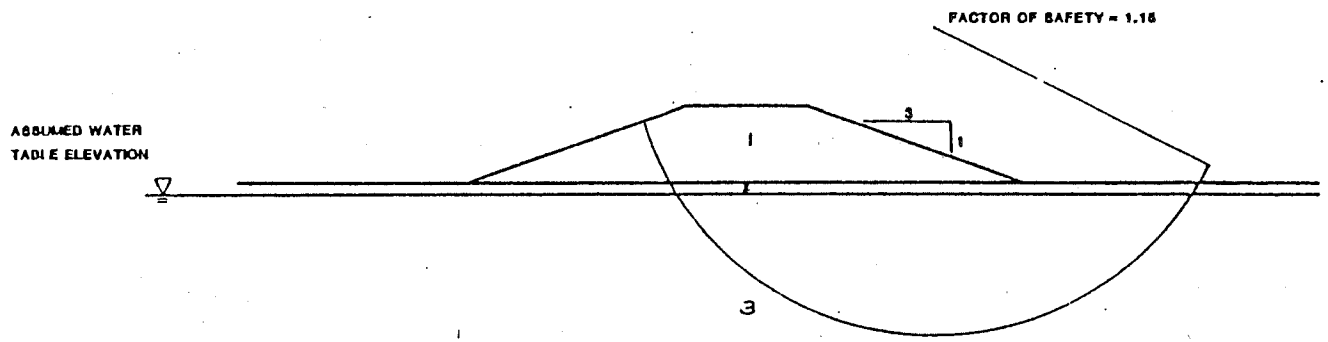
Landfilling inside the northerly and easterly dikes should proceed at a distance of 100 feet into the dredge spoil area from the toe of the existing dikes. Analysis of the slopes in this area was carried out assuming that refuse would be placed directly on the dredge spoil material at a slope of three to one. The upper portion of Figure D-4-5 illustrates this configuration, and the assumed strength conditions. The resulting factor of safety under this condition is 1.09. However, it is our opinion that this small factor of safety may be acceptable due to the proposed 100 foot offset from the existing dike. Review of the analysis indicates that any sloughing due to local shear failures in this area should be contained within the 100 foot setback from the existing dikes.

The lower portion of Figure D-4-5 illustrates a configuration in which a second 20 foot lift of refuse has been placed at a three to one slope and benched 100 feet. The minimal factor of safety under this condition was 1.04. The failure arc for the condition illustrated in the bottom portion of Figure D-4-5 indicates that

the failure arc passes through the stratum of the soil located approximately 25 to 40 feet below the existing ground surface. The strength gain of the lower stratum is expected to be slow due to the relatively long drainage distance for dissipation of excess pore pressure. We recommend the installation of piezometers to determine the pore pressure conditions in this area due to the resulting load imposed by the landfill.

Soil	Unit Wt. (PCF) γ	Cohesion (PSF) C	Phi Angle (Degrees) Φ
1	125	150	20
2	92	300	0
3	30 *	300	0
4	63 *	0	35

* BOUYANT UNIT WEIGHT

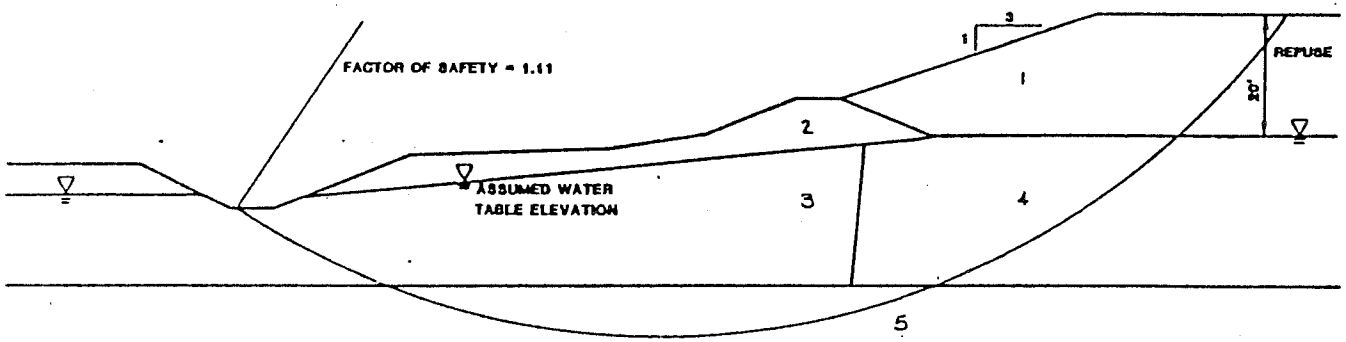


PROPOSED DIKE-SOUTH END OF
NORTHERN WILMINGTON AREA

4

Soil	Unit Wt. (PCF) γ	Cohesion (PSF) C	Phi Angle (Degrees) Φ
1	50	60	2
2	92	300	0
3	30 *	300	0
4	30 *	250	0
5	30 *	300	0
6	40 *	600	0

* BOUYANT UNIT WEIGHT



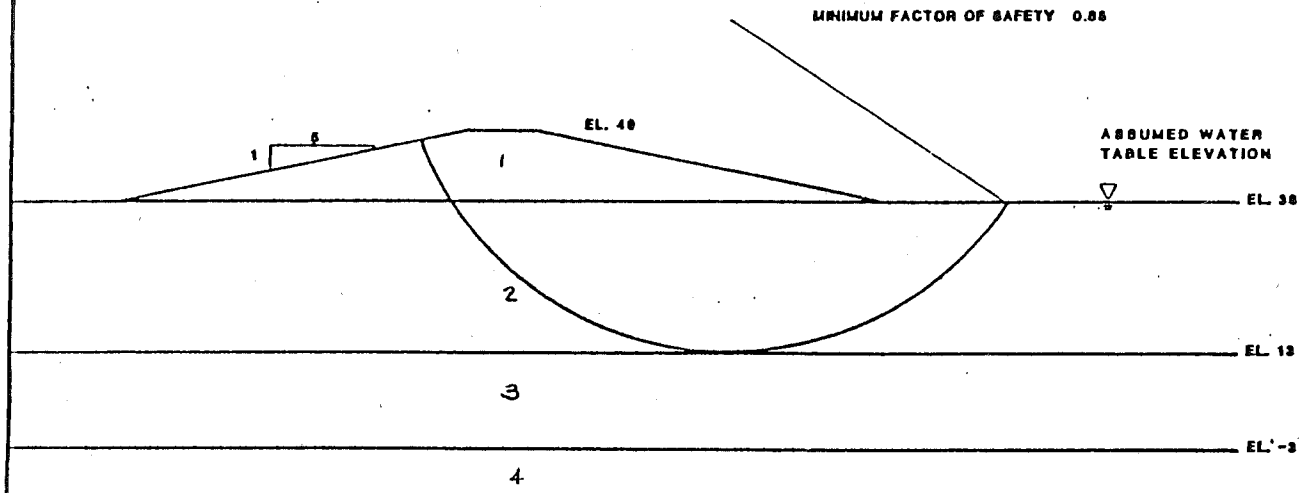
EXISTING DIKE-NORTH SIDE OF EDGEMOOR AREA
20' OF REFUSE TO DIKE
(SEE SECTION G-G OF FIGURE 3-1 FOR LOCATION)

6

SLOPE STABILITY ANALYSIS
NSWF-2
CHERRY ISLAND

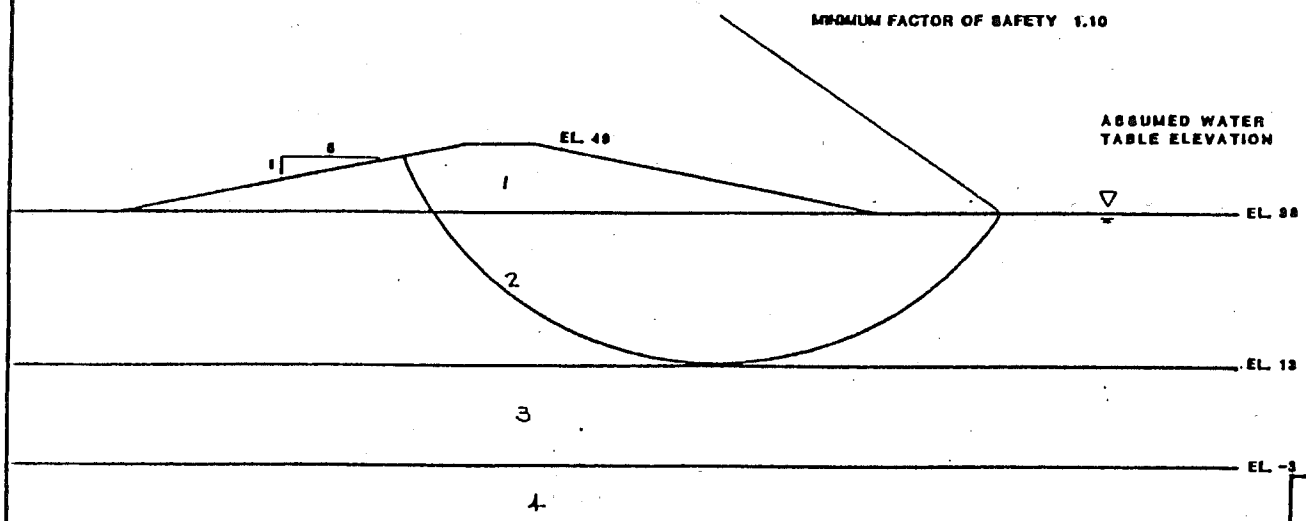
DUFFIELD ASSOCIATES, INC.
CONSULTING GEOTECHNICAL ENGINEERS
WILMINGTON, DELAWARE

DESIGNED BY	RDC	DATE	1/6/84
DRAWN BY	DSH	SCALE	1" 20'
CHECKED BY	JFD	W.O. NO.	410
DRAWING NO.			FIG. D-4-1



Soil	Unit Wt. (PCF) γ	Cohesion (PSF) C	PHI Angle (Degrees) ϕ
1	110	250	20
2	25*	150	0
3	27*	300	0
4	40*	600	0

*BOUYANT UNIT WEIGHT



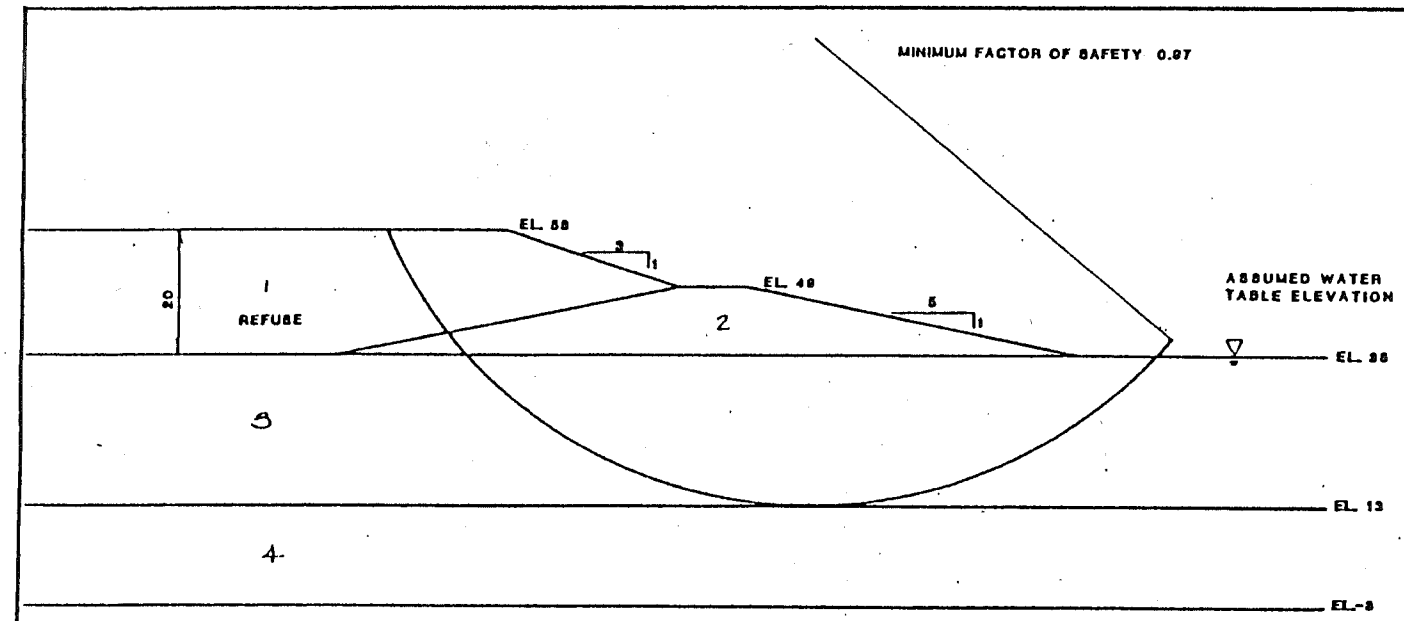
Soil	Unit Wt. (PCF) γ	Cohesion (PSF) C	PHI Angle (Degrees) ϕ
1	110	250	20
2	25*	200	0
3	27*	300	0
4	40*	600	0

* BOUYANT UNIT WEIGHT

SLOPE STABILITY ANALYSIS
INITIAL DIKE CONSTRUCTION
NSWF-2
CHERRY ISLAND

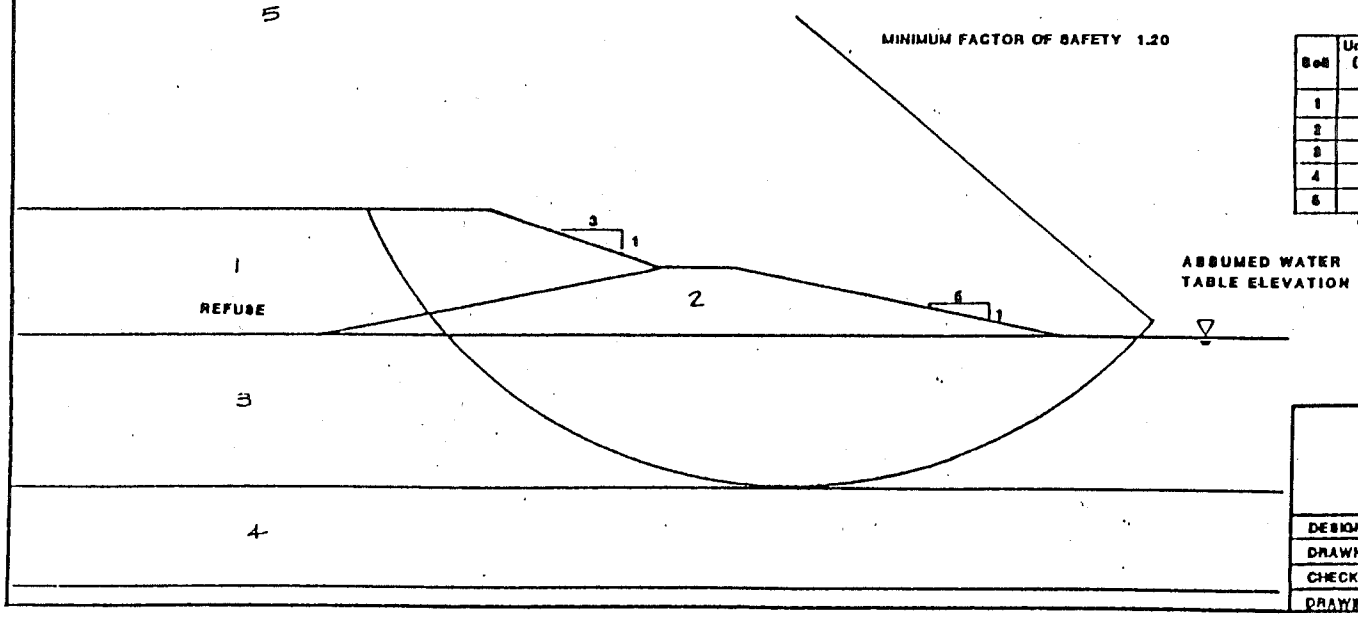
DUFFIELD ASSOCIATES, INC.
CONSULTING GEOTECHNICAL ENGINEERS
WILMINGTON, DELAWARE

DESIGNED BY	RDC	DATE	10/28/83
DRAWN BY	DBH	SCALE	1"= 20'
CHECKED BY	JFD	W.O. NO.	410
DRAWING NO.	B-410-	FIG.	[illegible]



Soil	Unit Wt. (PCF) γ	Cohesion (PSF) C	PHI Angle (Degrees) ϕ
1	60	60	2
2	110	250	20
3	26*	200	0
4	27*	300	0
5	40*	600	0

* BOUYANT UNIT WEIGHT



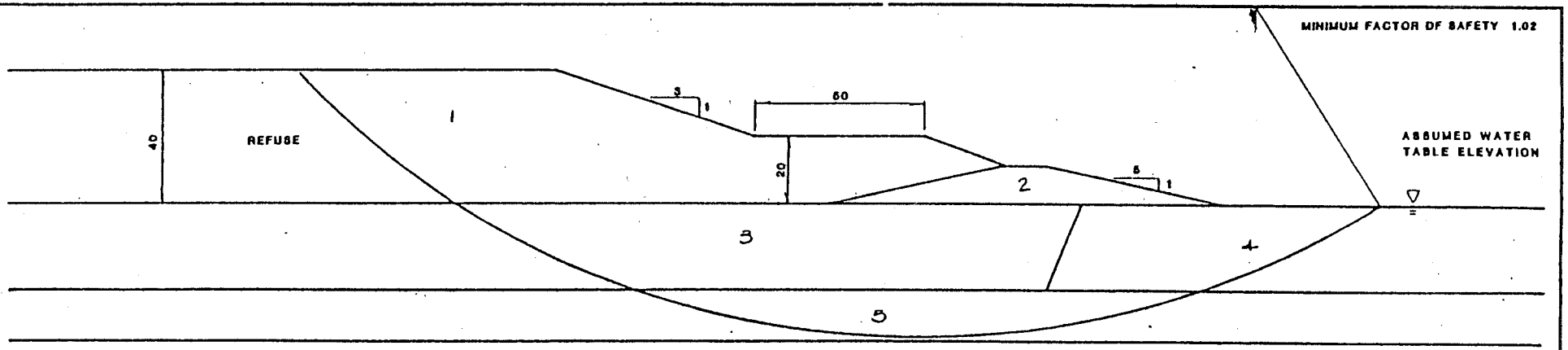
Soil	Unit Wt. (PCF) γ	Cohesion (PSF) C	PHI Angle (Degrees) ϕ
1	60	60	2
2	110	250	20
3	26*	250	0
4	27*	300	0
5	40*	600	0

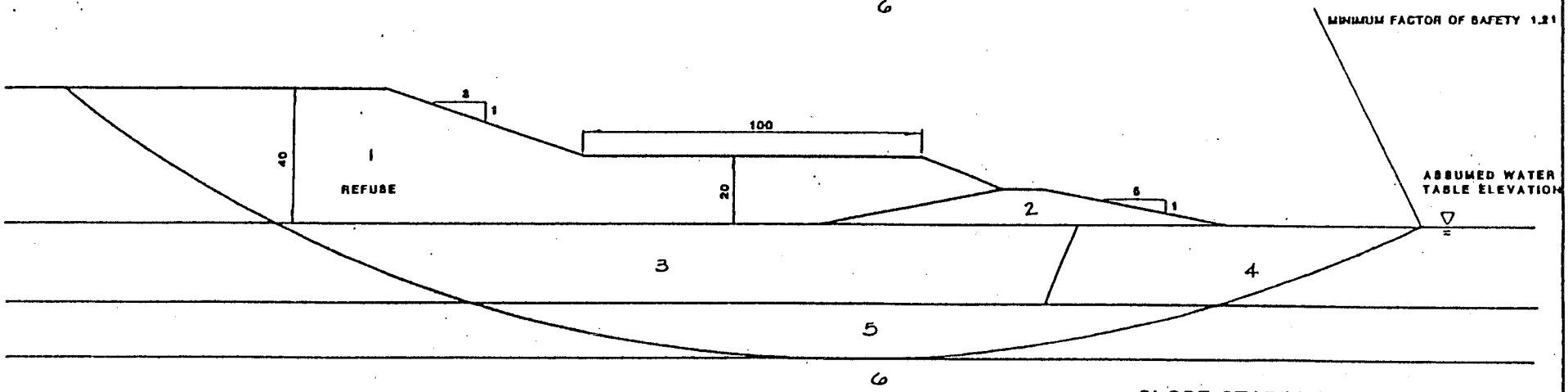
* BOUYANT UNIT WEIGHT

SLOPE STABILITY ANALYSIS
FIRST 20' LIFT OF REFUSE
NSWF-2
CHERRY ISLAND

DUFFIELD ASSOCIATES, INC.
CONSULTING GEOTECHNICAL ENGINEERS
WILMINGTON, DELAWARE

DESIGNED BY	RDG	DATE	10/26/83
DRAWN BY	DSH	SCALE	1" 20'
CHECKED BY	JFD	W.O. NO.	410
DRAWING NO.	B-410-	FIG. D-4-3	





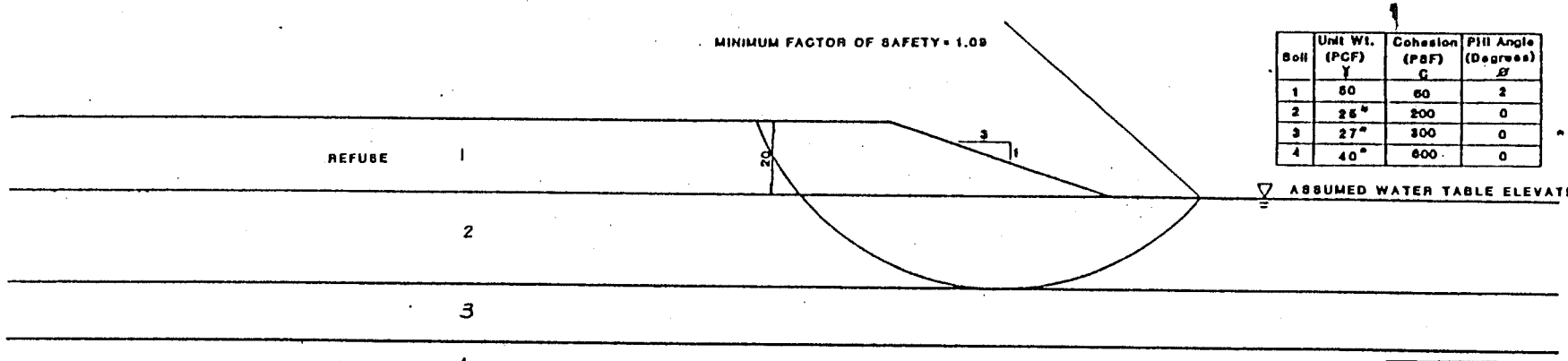
Soil	Unit Wt. (PCF) γ	Cohesion (PSF) C	Phi Angle (Degrees) ϕ
1	50	60	2
2	110	250	20
3	25*	250	0
4	25*	200	0
5	27*	300	0
6	40*	800	0

* BOUYANT UNIT WEIGHT

SLOPE STABILITY ANALYSIS
SECOND 20' LIFT OF REFUSE
NSWF-2
CHERRY ISLAND

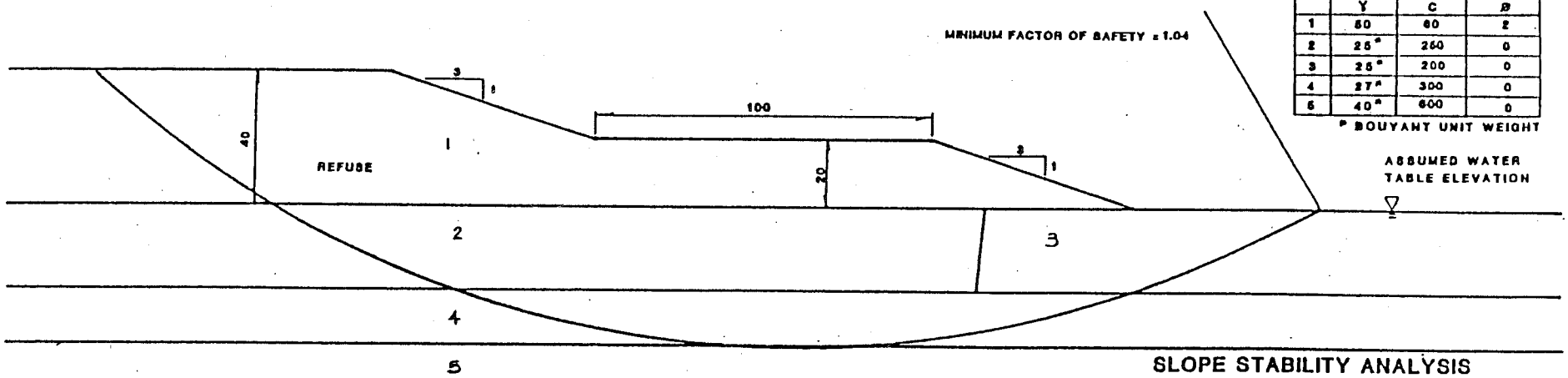
DUFFIELD ASSOCIATES, INC.
CONSULTING GEOTECHNICAL ENGINEERS
WILMINGTON, DELAWARE

DESIGNED BY	RDC	DATE	10/28/83
DRAWN BY	DBH	SCALE	1" 80'
CHECKED BY	JFD	W.O. NO.	410
DRAWING NO.	B-410-	FIG D-4-4	



Soil	Unit Wt. (PCF) γ	Cohesion (PSF) C	Phi Angle (Degrees) Ø
1	50	60	2
2	25*	200	0
3	27*	300	0
4	40*	600	0

* BOUYANT UNIT WEIGHT



Soil	Unit Wt. (PCF) γ	Cohesion (PSF) C	Phi Angle (Degrees) Ø
1	50	60	2
2	25*	250	0
3	25*	200	0
4	27*	300	0
5	40*	600	0

* BOUYANT UNIT WEIGHT

SLOPE STABILITY ANALYSIS
PROPOSED LANDFILLING IN AREA OF EXISTING DIKES
NSWF-2
CHERRY ISLAND

DUFFIELD ASSOCIATES, INC.
CONSULTING GEOTECHNICAL ENGINEERS
WILMINGTON, DELAWARE

DESIGNED BY	RDC	DATE	10/28/83
DRAWN BY	DSH	SCALE	1" = 30'
CHECKED BY	JFD	W.O. NO.	410
DRAWING NO.	B-410-	FIG. D-4-5	

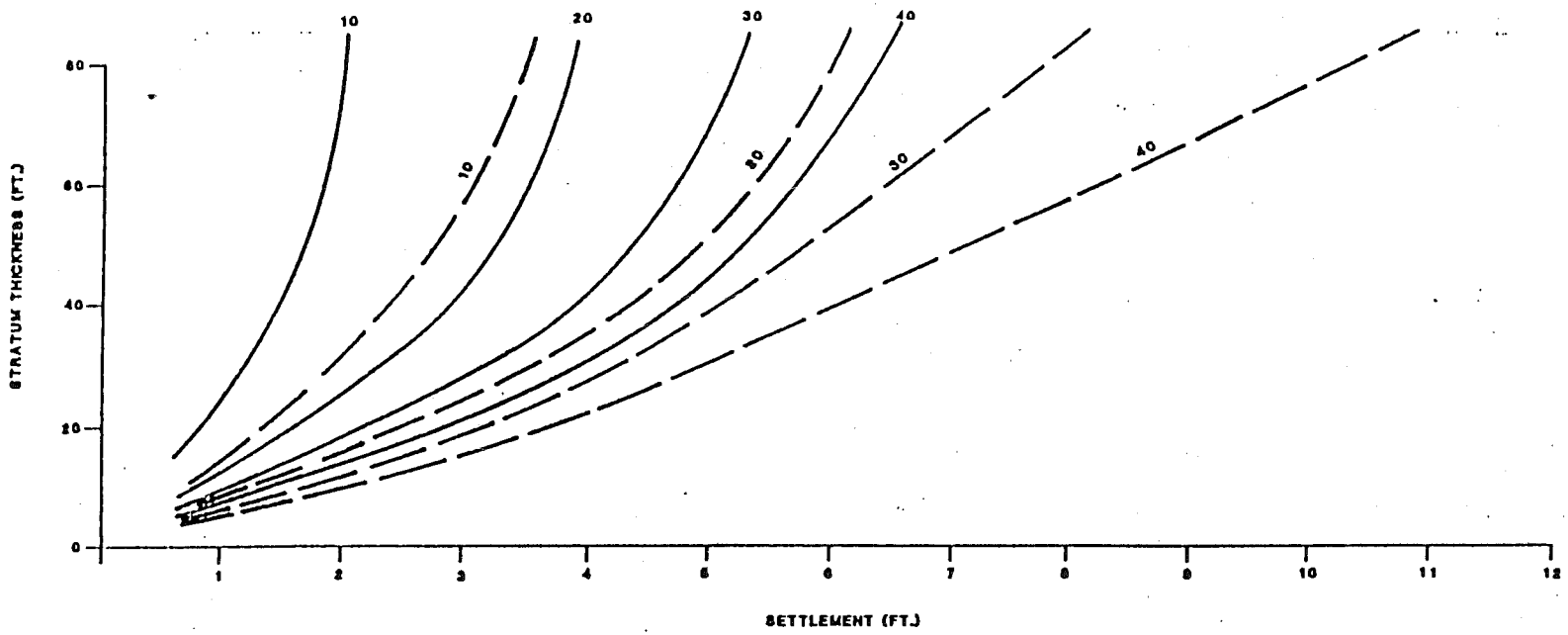
APPENDIX D-5

SETTLEMENT ANALYSIS

D-5 Settlement Analysis

The settlement estimates have been based on two major components, consoidation settlement plus secondary settlement. Consolidation settlement results from the squeezing of water from the soil due to an applied load (e.g. dikes and 40 feet of landfill). Secondary settlement results from the reorientation of soil particles due to an applied load and is assumed to begin at the completion of consolidation. Secondary settlement may be typically ignored in stiff inorganic soils but may represent a significant component of total settlement in soft organic soils such as encountered on the site. The estimated amount and time rate of settlement represent guidelines for design and must be confirmed by on-site monitoring during loading. Settlement will be dependent on the thickness of compressible soils under the load. Since the anticipated landfill will be 40 feet high over a generally flat surface, the settlement profile will tend to "mirror" the slope of the base of compressibles shown on the Structural Concout Map (Figure 3-1).

Utilizing the design parameters, the anticipated landfill loading and the thickness of the compressible soils, Figures D-5-1 and D-5-2 were prepared to aid the design team in estimating the amount and time rates of settlement for various loading conditions around the site.



REFUSE THICKNESS IN FEET

DREDGE SPOIL THICKNESS IN FEET

PRIMARY CONSOLIDATION SUMMARY

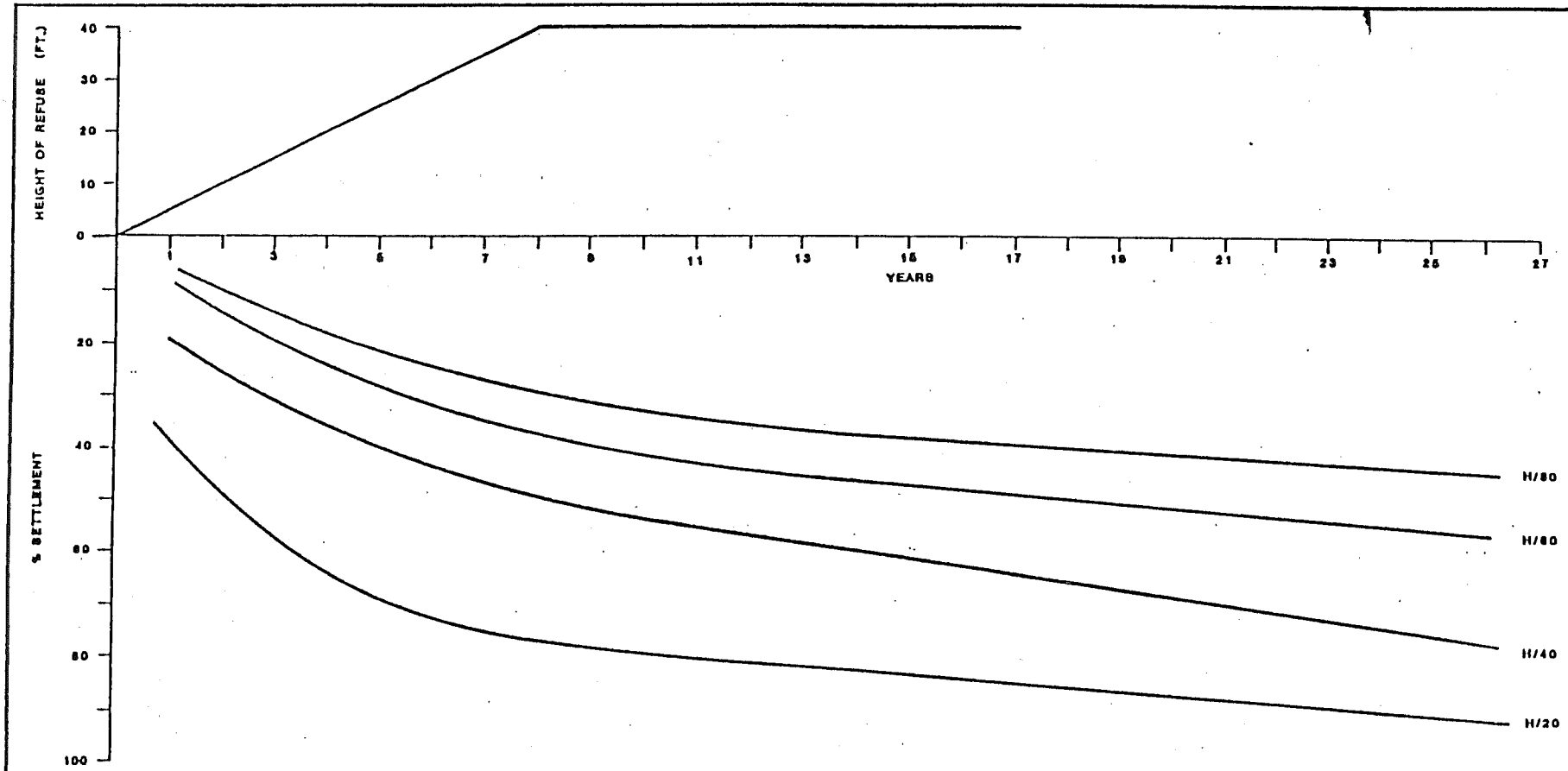
NSWF-2

DUFFIELD ASSOCIATES, INC.

CONSULTING GEOTECHNICAL ENGINEERS

WILMINGTON, DELAWARE

DESIGNED BY	JFD	DATE	10/28/83
DRAWN BY	DSH	SCALE	AS SHOWN
CHECKED BY	JFD	W.O. NO.	410
DRAWING NO.	B-410-		FIG. [illegible]-1



% SETTLEMENT Vs. TIME
GRADUAL RATE LOAD
NSWF-2

H/80 - THICKNESS OF COMPRESSIBLE STRATUM (80 FT.)

NOTE: FIGURE DERIVED FROM NAVDOCS FIGURE DM-7 6-6, GRADUAL LOADING RATE

DUFFIELD ASSOCIATES, INC.
CONSULTING GEOTECHNICAL ENGINEERS
WILMINGTON, DELAWARE

DESIGNED BY	JFD	DATE	10/28/83
DRAWN BY	DSH	SCALE	AS SHOWN
CHECKED BY	JFD	W.O. NO.	410
DRAWING NO.	B-410-		FIG. D-6-2

APPENDIX D-6

SUITABILITY OF ON-SITE SOILS

D-6 Suitability of On-Site Soils

Evaluation of the on-site soils for use as a landfill liner was performed utilizing data obtained from the consolidation tests, and failing head permeability tests. The coefficient of permeability was determined for each of the consolidation tests using the relationshp between the coefficient of permeability, k, and the coefficient of consolidation, Cv. A plot of Cv and k versus the effective pressure are indicated for each of the consolidation tests in Figures D-6-1 through D-6-16. Also indicated on these figures are the estimated existing overburden pressure and a line through the data points derived from a linear regression analysis of the data obtained.

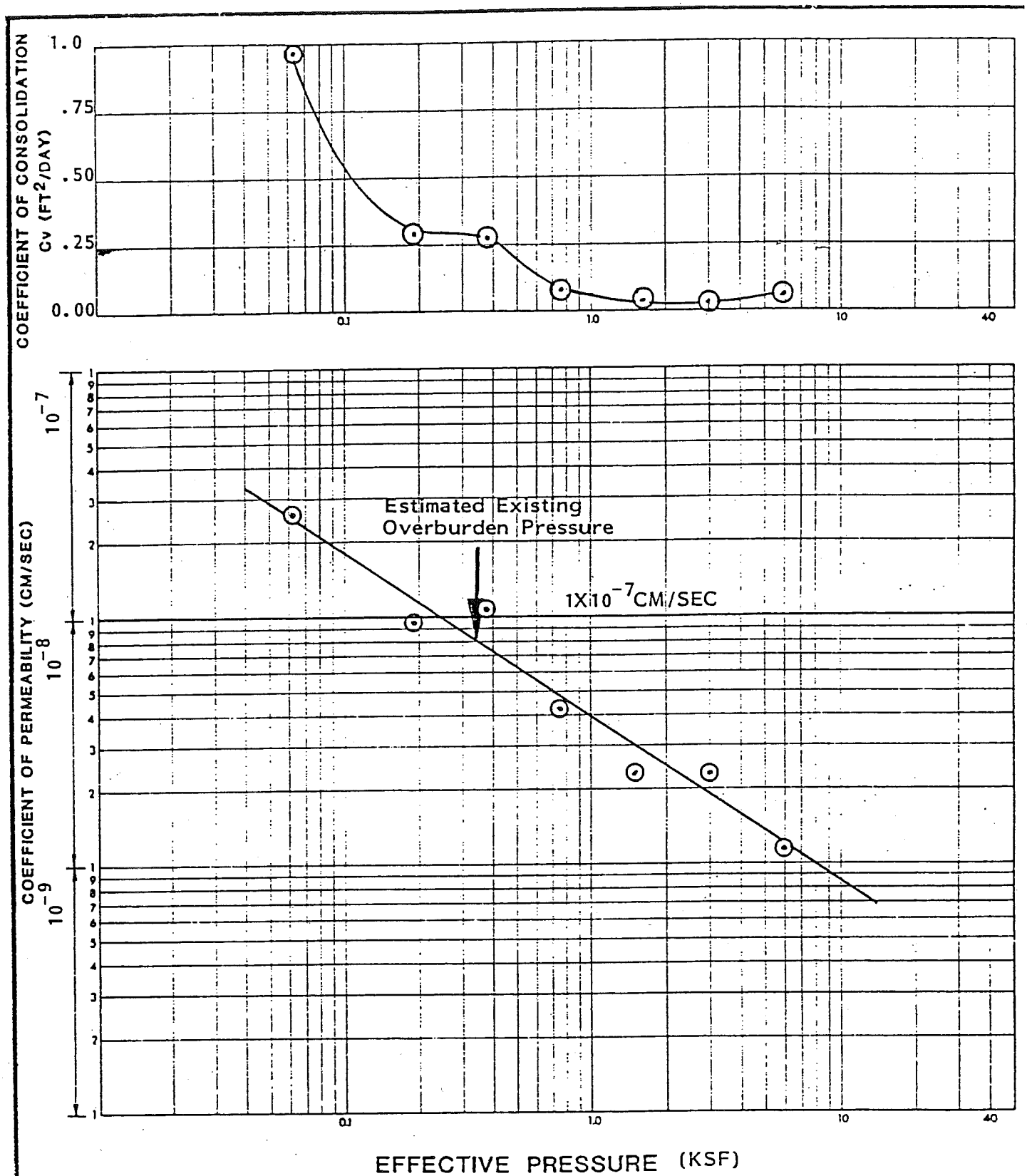
Falling head permeability tests were performed on three of the consolidation samples at various load increments. These permeability tests were performed bya method described in the U.S. Army Corp of Engineers Manual EM 1110-2-1906 dated November 30, 1970. The results of these falling head tests are indicated on the permeability-pressure plots and the data from these tests was included in the linear regression analysis. Review of the permeability versus effective pressure plots for GP-6 (40.1, 41.2 feet), GP-7 (20.5, 20.8 feet), and GP-7 (30.5, 30.9 feet) indicate a good agreement with the data obtained from the consolidation tests.

Examination of the data indicates that the permeability of the subsurface soils at the estimated existing overburden pressures is less than 1×10^{-7} cm/sec. This is the Delaware Department of Natural Resources and Environmental Control's (DNREC) limit for the use of on-site soils as a natural landfill liner.

A plot of the permeability determined from the estimated overburden pressures versus depth is also shown in Figure D-6-17. A similar plot, Figure D-6-18 indicates the permeabilities

estimated from overburden pressures resulting from 25% consolidation under the load of 40 feet of refuse (an effective stress increase of approximately 500 psf). Review of this figure indicates that the estimated permeabilities determined from the linear regression lines are less than 6×10^{-8} cm/sec for the samples obtained in the existing dredge spoil area.

The lowering of the ground water table in the dredge spoil and marsh deposits, and the subsequent consolidation of the materials under the load imposed by the landfill should cause a continued decrease in the permeabilities of these soils with time.

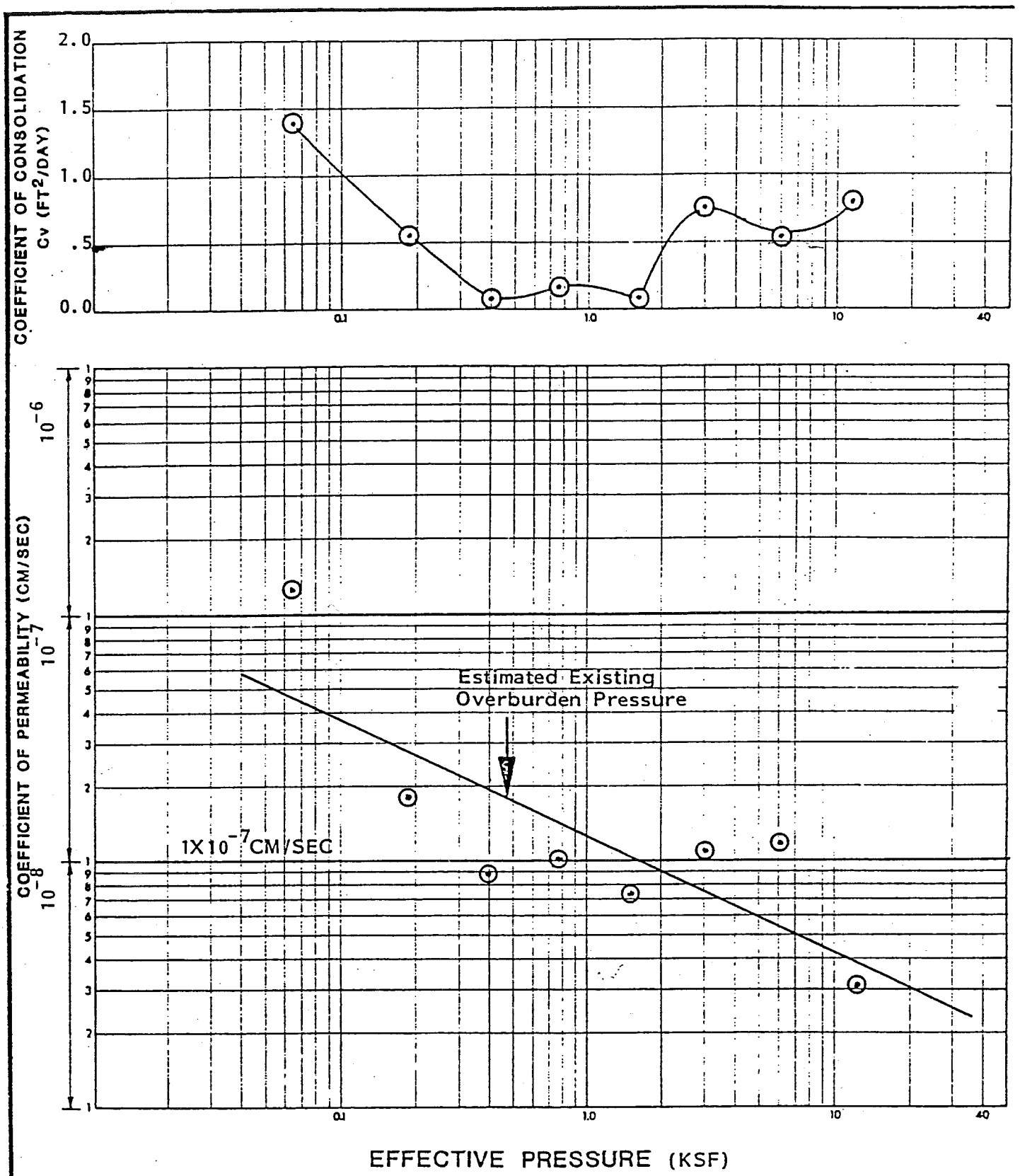


PERMEABILITY RELATED DATA
FROM CONSOLIDATION TEST
TEST BORING: G-1 DEPTH: 10.6

NSWF-2
CHERRY ISLAND
WILMINGTON, DELAWARE

DUFFIELD ASSOCIATES, INC.
CONSULTING GEOTECHNICAL ENGINEERS

Drawn: DSH Chk'd: RDC	Date: October 26, 1983
Scale: AS SHOWN	W.O.: 410
File No.:	Fig. D-6-1



PERMEABILITY RELATED DATA
FROM CONSOLIDATION TEST
TEST BORING: G-2 DEPTH: 15.7

NSWF-2
CHERRY ISLAND
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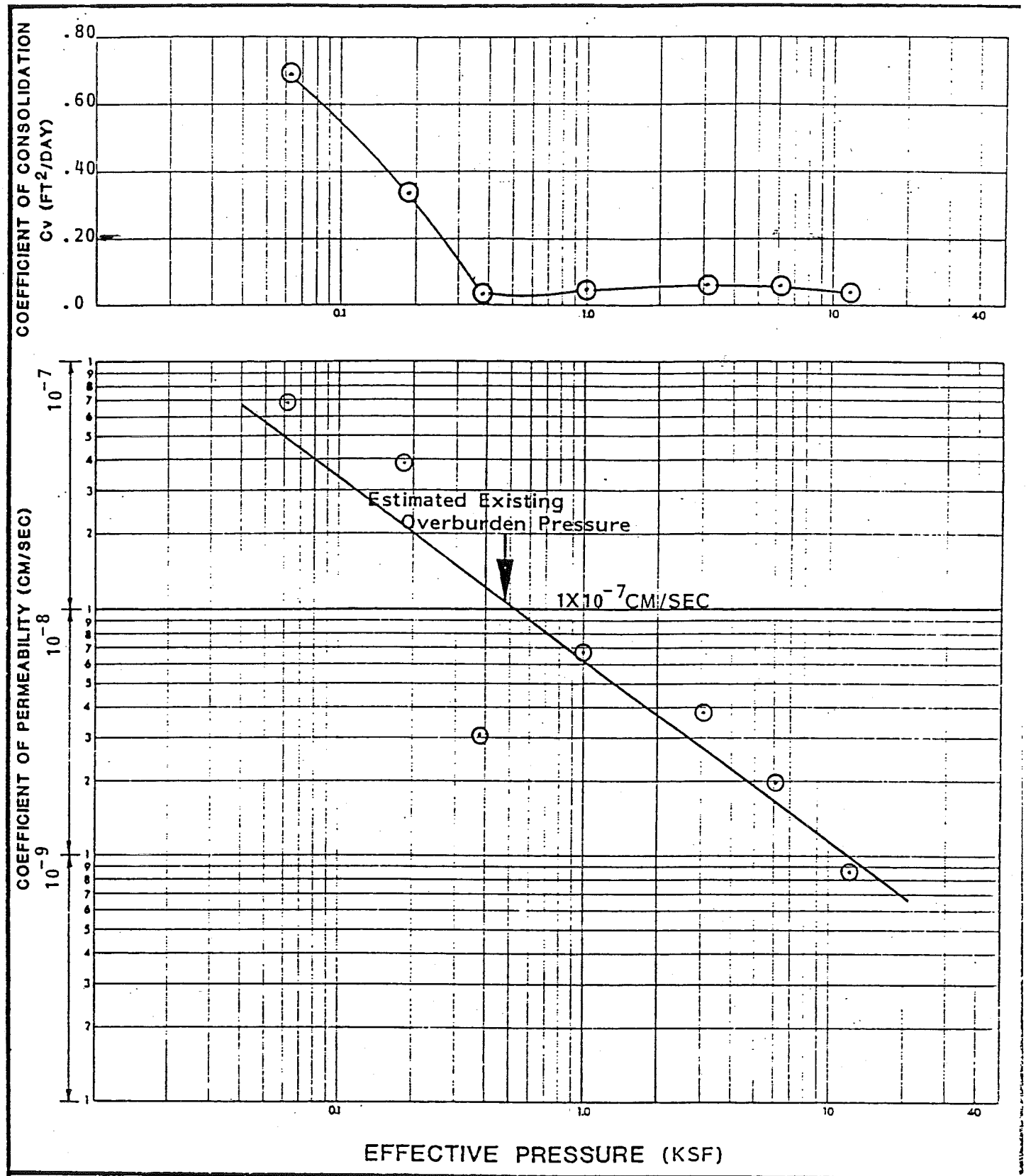
Drawn: DSH Chk'd: RDC	Date: October 26, 1983
Scale: AS SHOWN	W.O.: 410
File No.:	Fig. D-6-2



PERMEABILITY RELATED DATA
FROM CONSOLIDATION TEST
TEST BORING: GP-3 DEPTH: 16.5

NSWF-2
CHERRY ISLAND
WILMINGTON, DELAWARE

DUFFIELD ASSOCIATES, INC.
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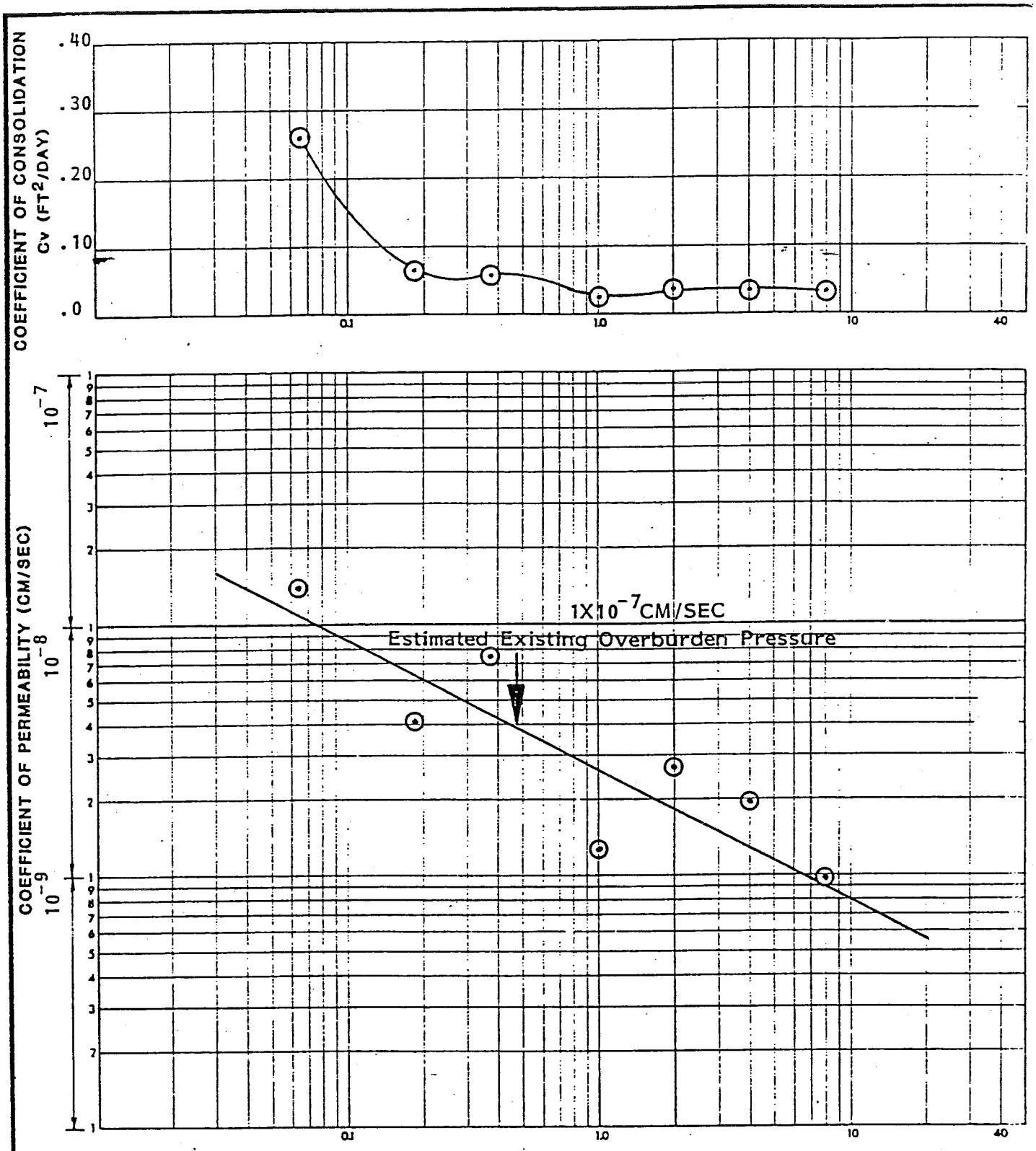
Drawn: DSH Chk'd: RDC	Date: October 26, 1983
Scale: AS SHOWN	W.O.: 410
File No.:	Fig. D-6-3

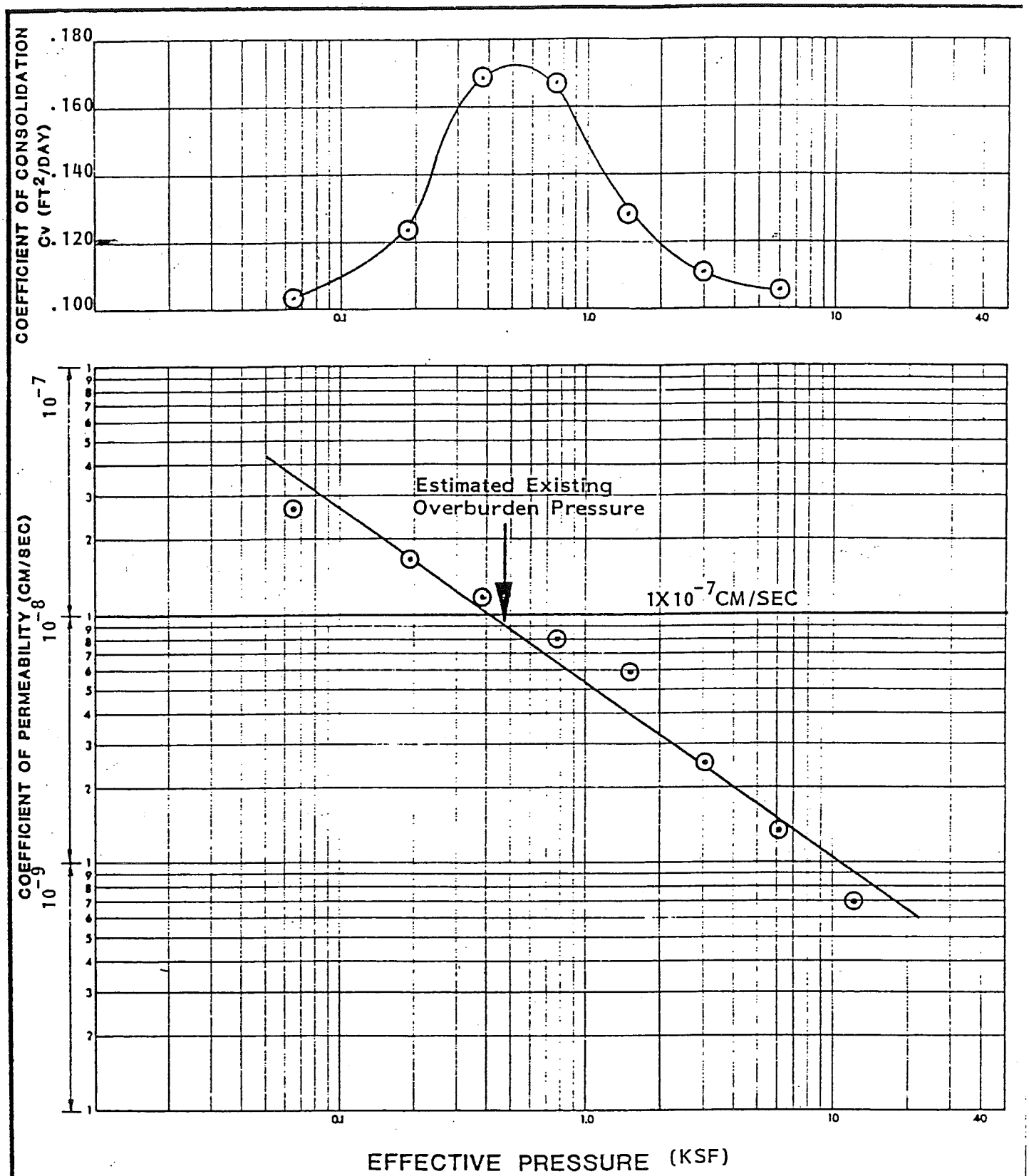


PERMEABILITY RELATED DATA
FROM CONSOLIDATION TEST
TEST BORING: GP-4 DEPTH: 16.1

NSWF-2
CHERRY ISLAND
WILMINGTON, DELAWARE

DUFFIELD ASSOCIATES, INC.
CONSULTING GEOTECHNICAL ENGINEERS

Drawn: DSH Chk'd: RDC	Date: October 26, 1983
Scale: AS SHOWN	W.O.: 410
File No.:	Fig. D-6-4

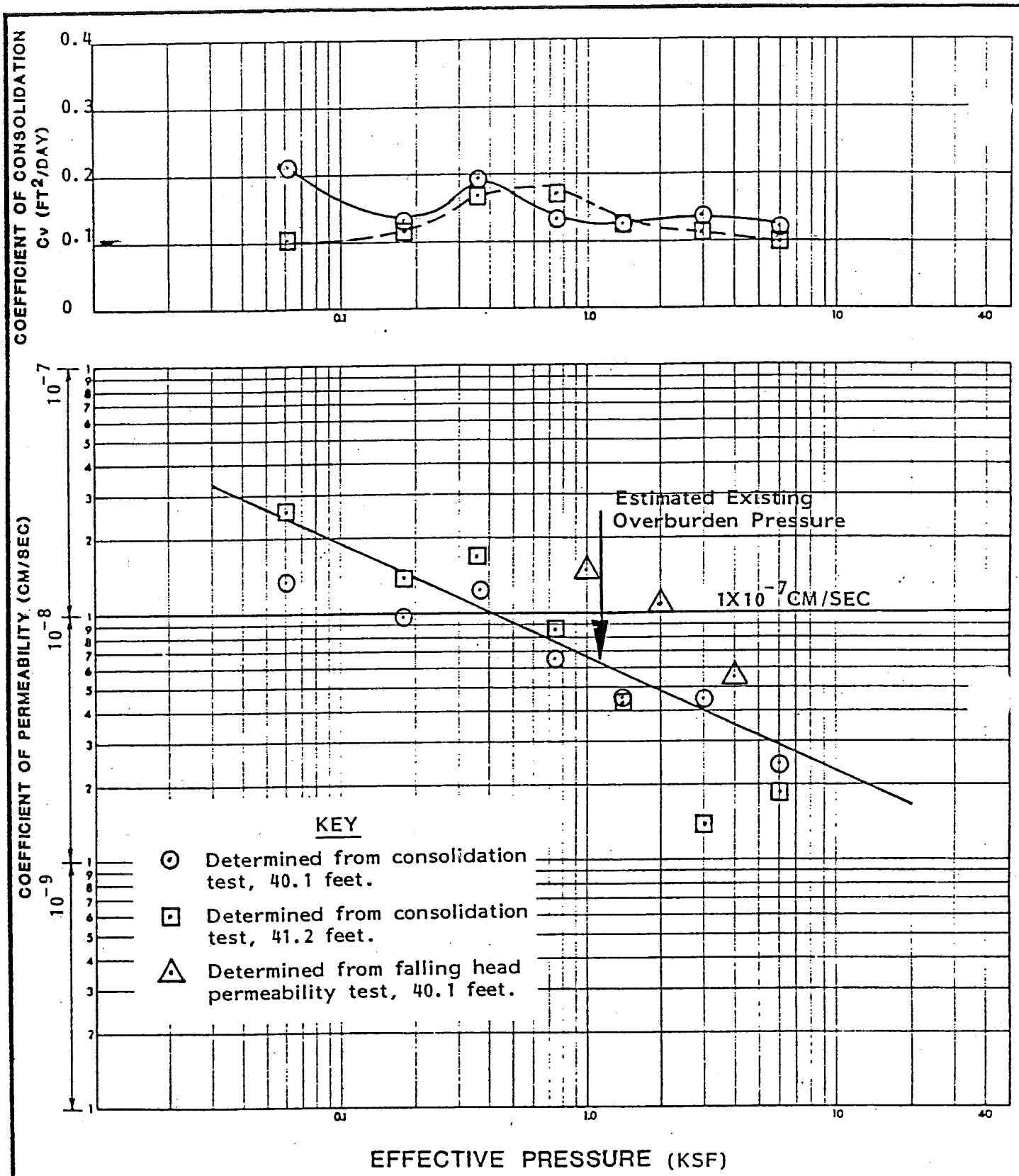


PERMEABILITY RELATED DATA
FROM CONSOLIDATION TEST
TEST BORING: GP-6 DEPTH: 16.1

NSWF-2
CHERRY ISLAND
WILMINGTON, DELAWARE

DUFFIELD ASSOCIATES, INC.
CONSULTING GEOTECHNICAL ENGINEERS

Drawn: DSH Chk'd: RDC	Date: October 26, 1983
Scale: AS SHOWN	W.O.: 410
File No.:	Fig. D-6-5

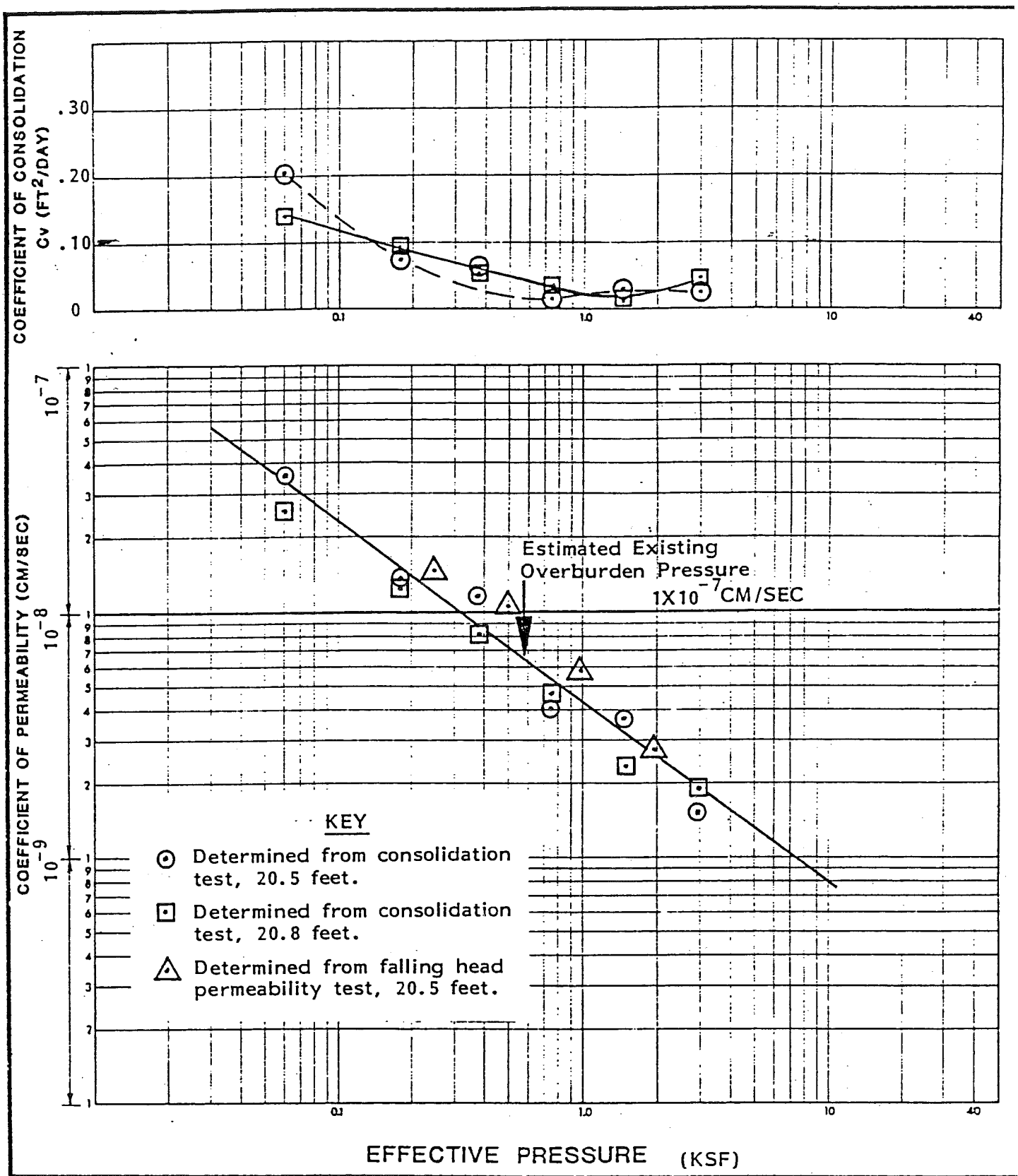


PERMEABILITY RELATED DATA
FROM CONSOLIDATION TEST
TEST BORING: GP-6 DEPTH: 40.1, 41.2

NSWF-2
CHERRY ISLAND
WILMINGTON, DELAWARE

DUFFIELD ASSOCIATES, INC.
CONSULTING GEOTECHNICAL ENGINEER

Drawn: DSH Chk'd: RDC	Date: October 26, 1983
Scale: AS SHOWN	W.O.: 410
File No.:	Fig. D-6-6



PERMEABILITY RELATED DATA
FROM CONSOLIDATION TEST
TEST BORING: GP-7 DEPTH: 20.5, 20.8

NSWF-2
CHERRY ISLAND
WILMINGTON, DELAWARE

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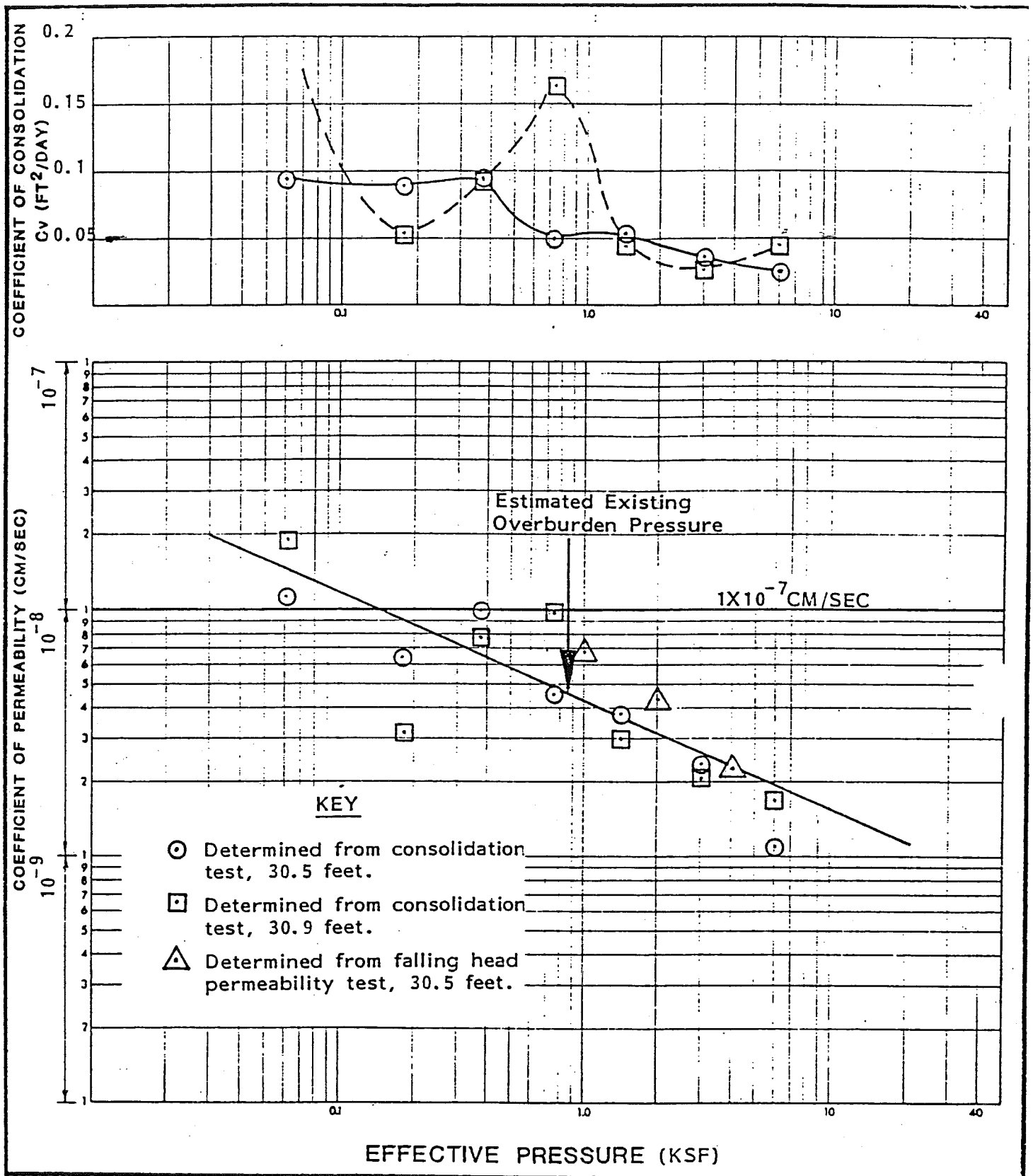
Drawn: DSH Chk'd: RDC	Date: October 26, 1983
Scale: AS SHOWN	W.O.: 410
File No.:	Fig. D-6-7



PERMEABILITY RELATED DATA
FROM CONSOLIDATION TEST
TEST BORING: GP-7 DEPTH: 30.5, 30.9

NSWF-2
CHERRY ISLAND
WILMINGTON, DELAWARE

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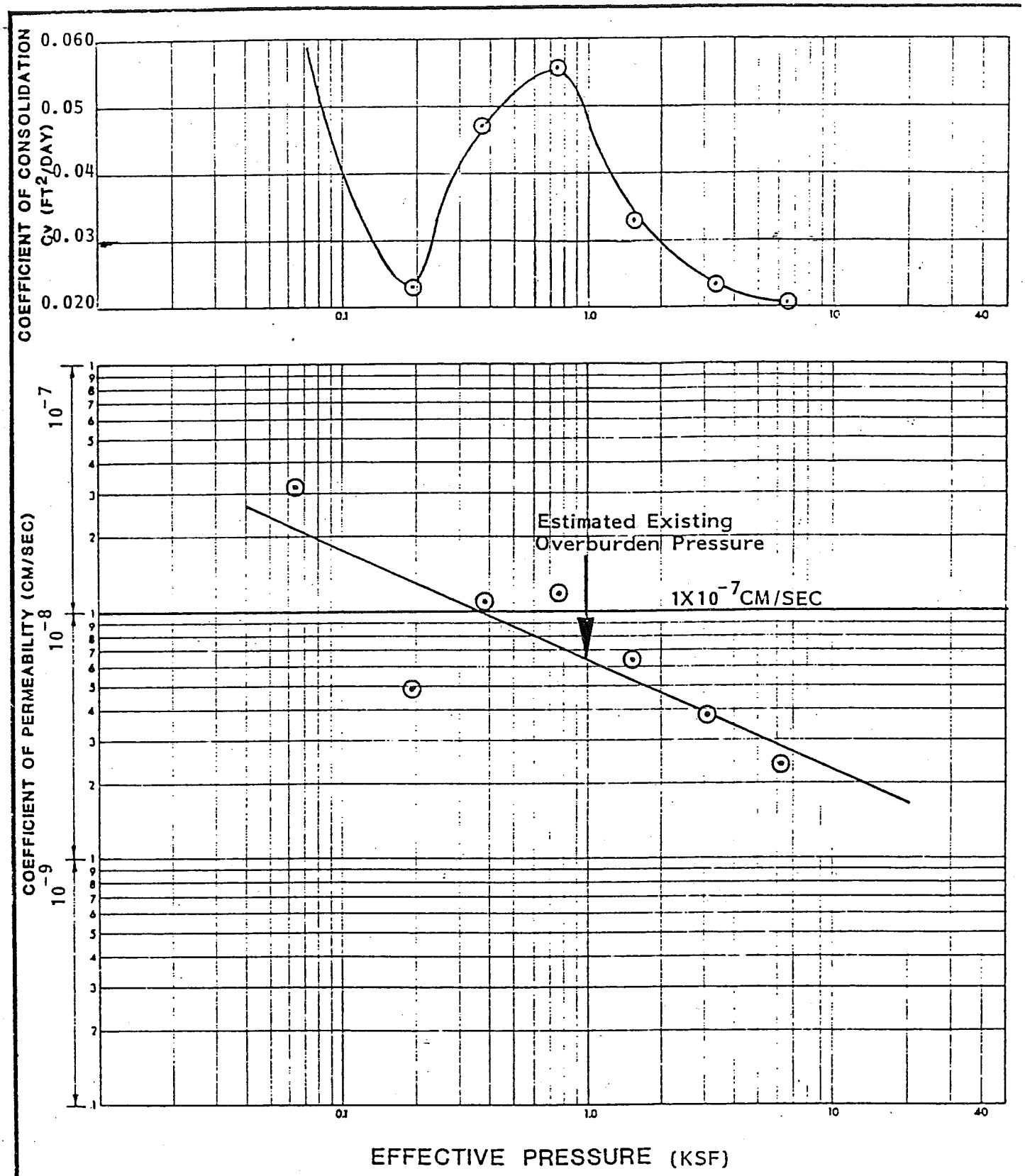
Drawn: DSH Chk'd: RDC	Date: October 26, 1983
Scale: AS SHOWN	W.O.: 410
File No.:	Fig. D-6-8



PERMEABILITY RELATED DATA
FROM CONSOLIDATION TEST
TEST BORING: GP-8 DEPTH: 35.9

NSWF-2
CHERRY ISLAND
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DUFFIELD ASSOCIATES, INC.
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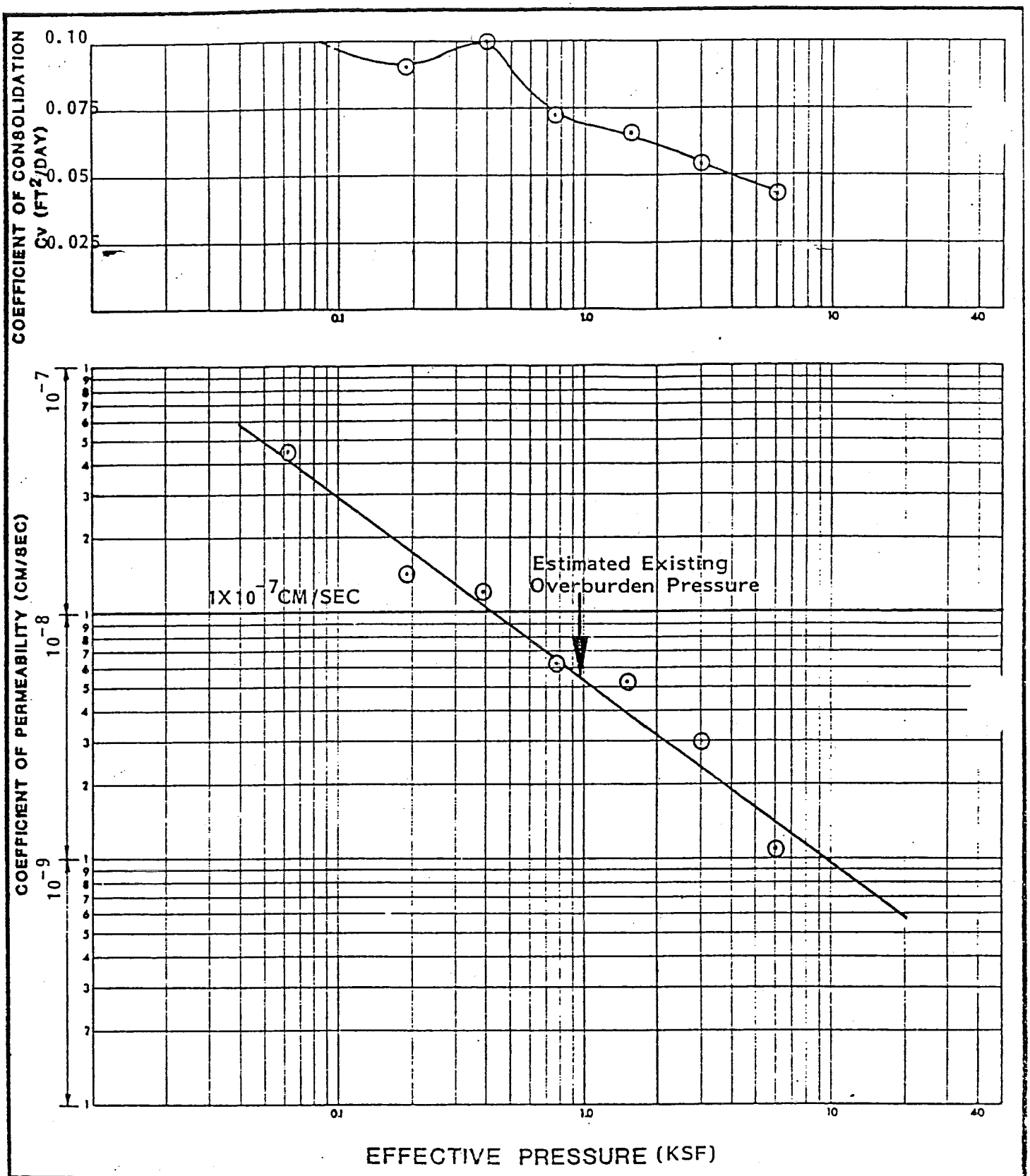
Drawn: DSH Chk'd: RDC	Date: October 26, 1983
Scale: AS SHOWN	W.O.: 410
File No.:	Fig. D-6-9



PERMEABILITY RELATED DATA
FROM CONSOLIDATION TEST

TEST BORING: GP-9 DEPTH: 36.1

NSWF-2
CHERRY ISLAND
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DUFFIELD ASSOCIATES, INC.
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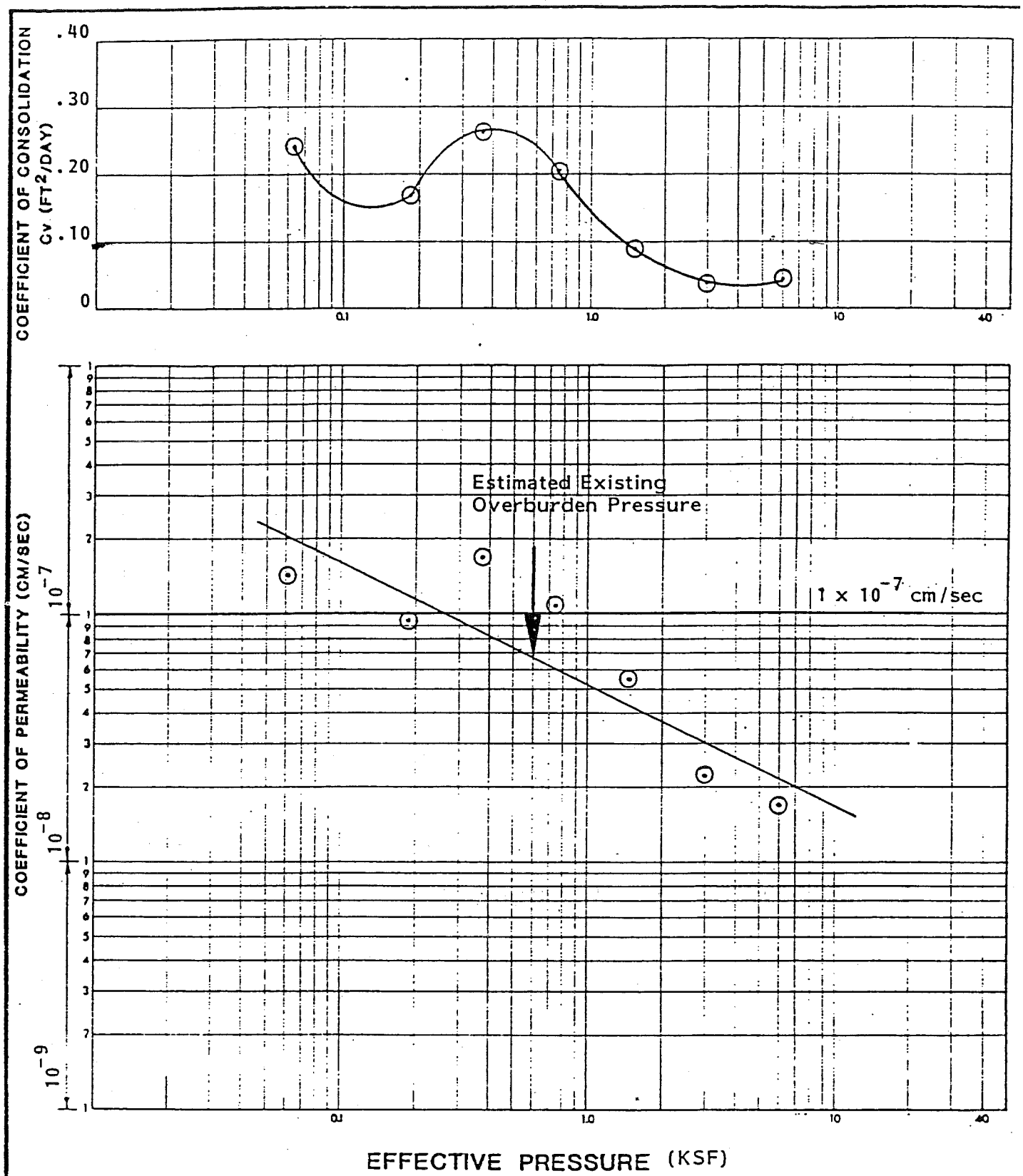
Drawn: DSH Chk'd: RDC	Date: October 26, 1
Scale: AS SHOWN	W.O.: 410
File No.:	Fig. D-6-10

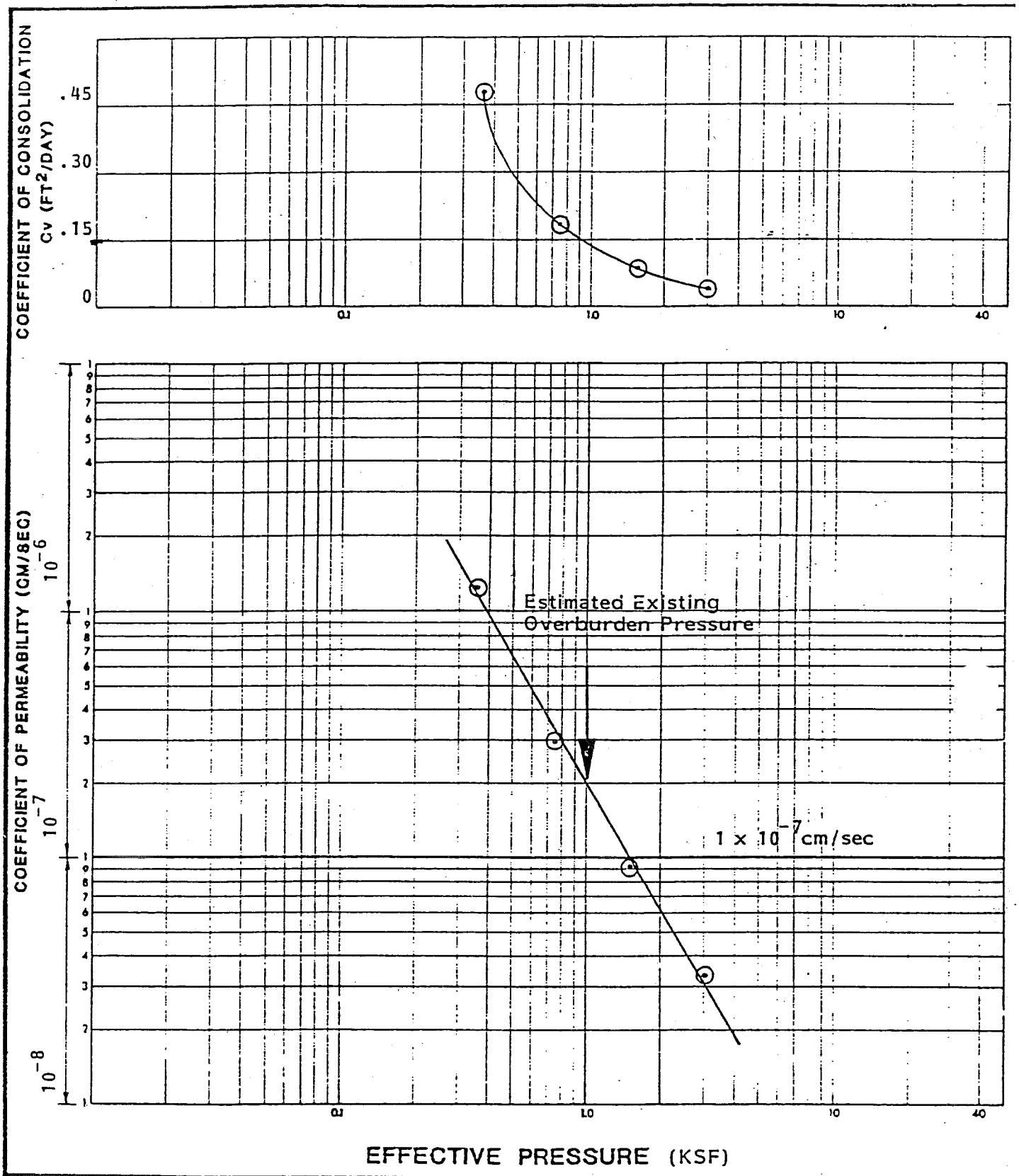


PERMEABILITY RELATED DATA
FROM CONSOLIDATION TEST
TEST BORING: A-1 DEPTH: 13.6

NSWF-2
CHERRY ISLAND
WILMINGTON, DELAWARE

DUFFIELD ASSOCIATES, INC.
CONSULTING GEOTECHNICAL ENGINEERS

Drawn: DSH Chk'd: RDC	Date: 12/22/83
Scale: AS SHOWN	W.O.: 410
File No.:	Fig. D-6-11

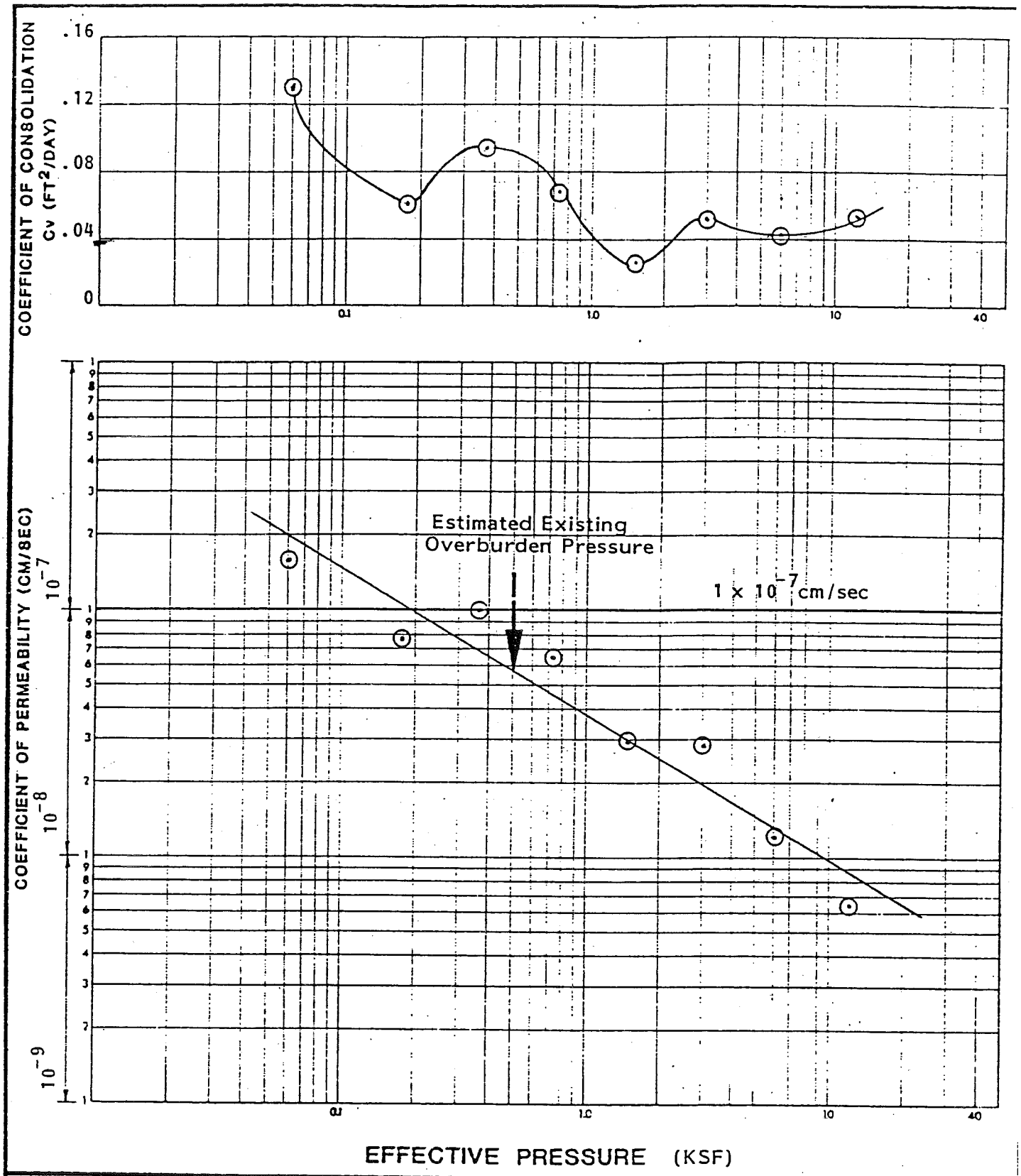


PERMEABILITY RELATED DATA
FROM CONSOLIDATION TEST
TEST BORING: A-1 DEPTH: 27.4

NSWF-2
CHERRY ISLAND
WILMINGTON, DELAWARE

DUFFIELD ASSOCIATES, INC.
CONSULTING GEOTECHNICAL ENGINE

Drawn: DSH Chk'd: RDC	Date: 12/22/83
Scale: AS SHOWN	W.O.: 410
File No.:	Fig. D-6-12



PERMEABILITY RELATED DATA
FROM CONSOLIDATION TEST
TEST BORING: A-2 DEPTH: 12.6

NSWF-2
CHERRY ISLAND
WILMINGTON, DELAWARE

DUFFIELD ASSOCIATES, INC.
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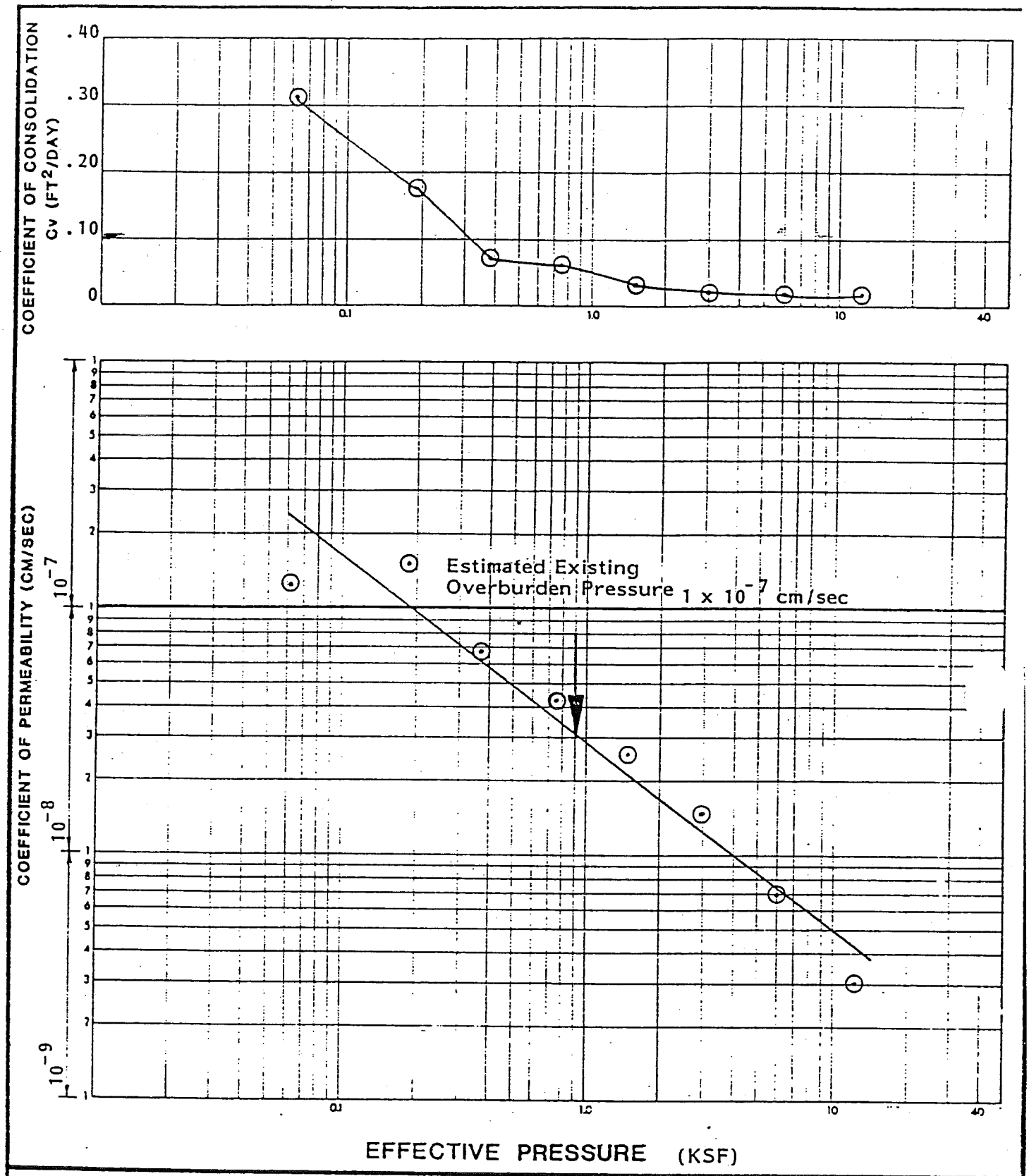
Drawn: DSH Chk'd: RDC	Date: 12/22/83
Scale: AS SHOWN	W.O.: 410
File No.:	Fig. D-6-13



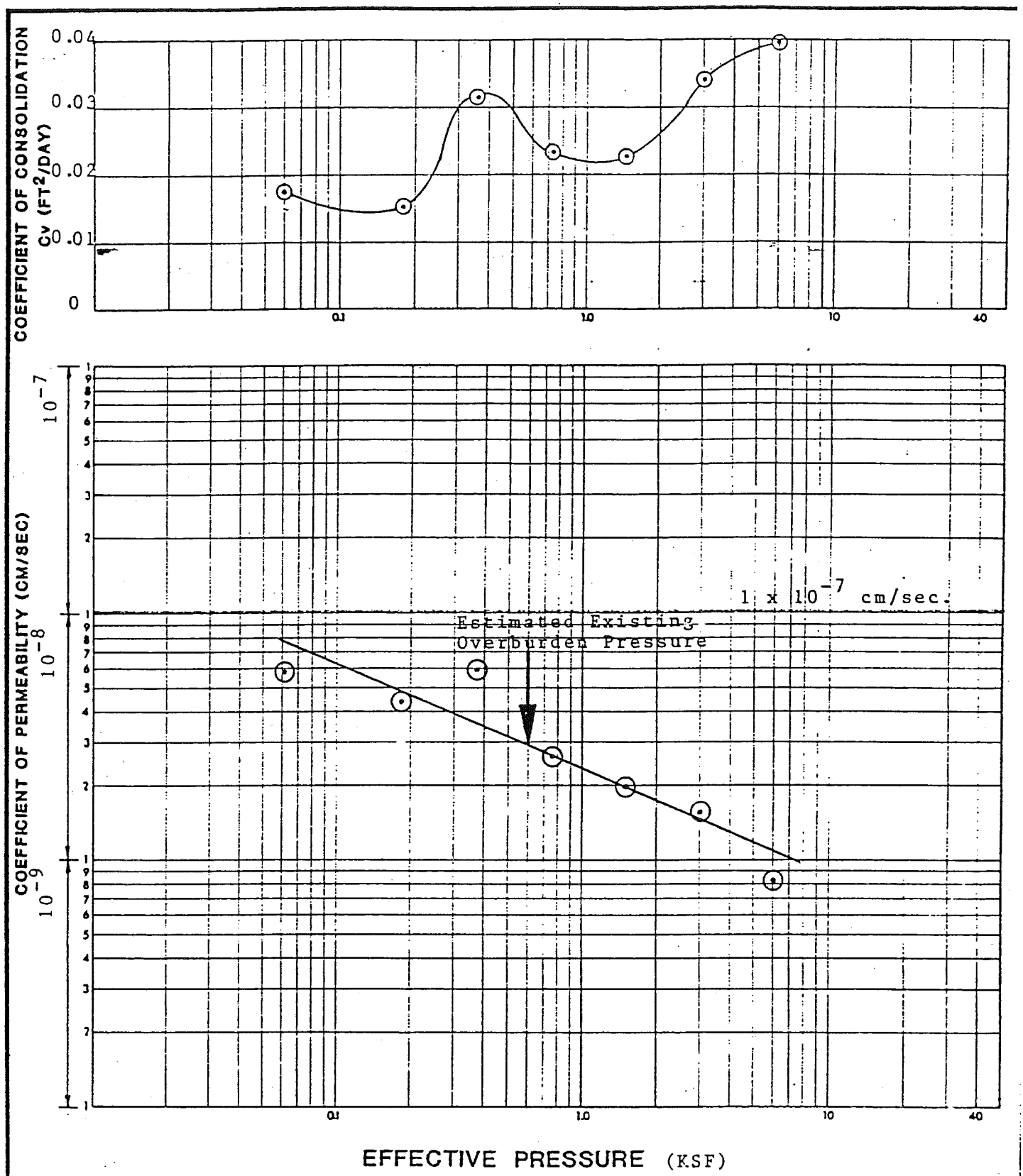
PERMEABILITY RELATED DATA
FROM CONSOLIDATION TEST

TEST BORING: A-3 DEPTH: 25.1

NSWF-2
CHERRY ISLAND
WILMINGTON, DELAWARE

DUFFIELD ASSOCIATES, INC.
CONSULTING GEOTECHNICAL ENGINEE

Drawn: DSH Chk'd: RDC	Date: 12/22/83
Scale: AS SHOWN	W.O.: 410
File No.:	Fig. D-6-14

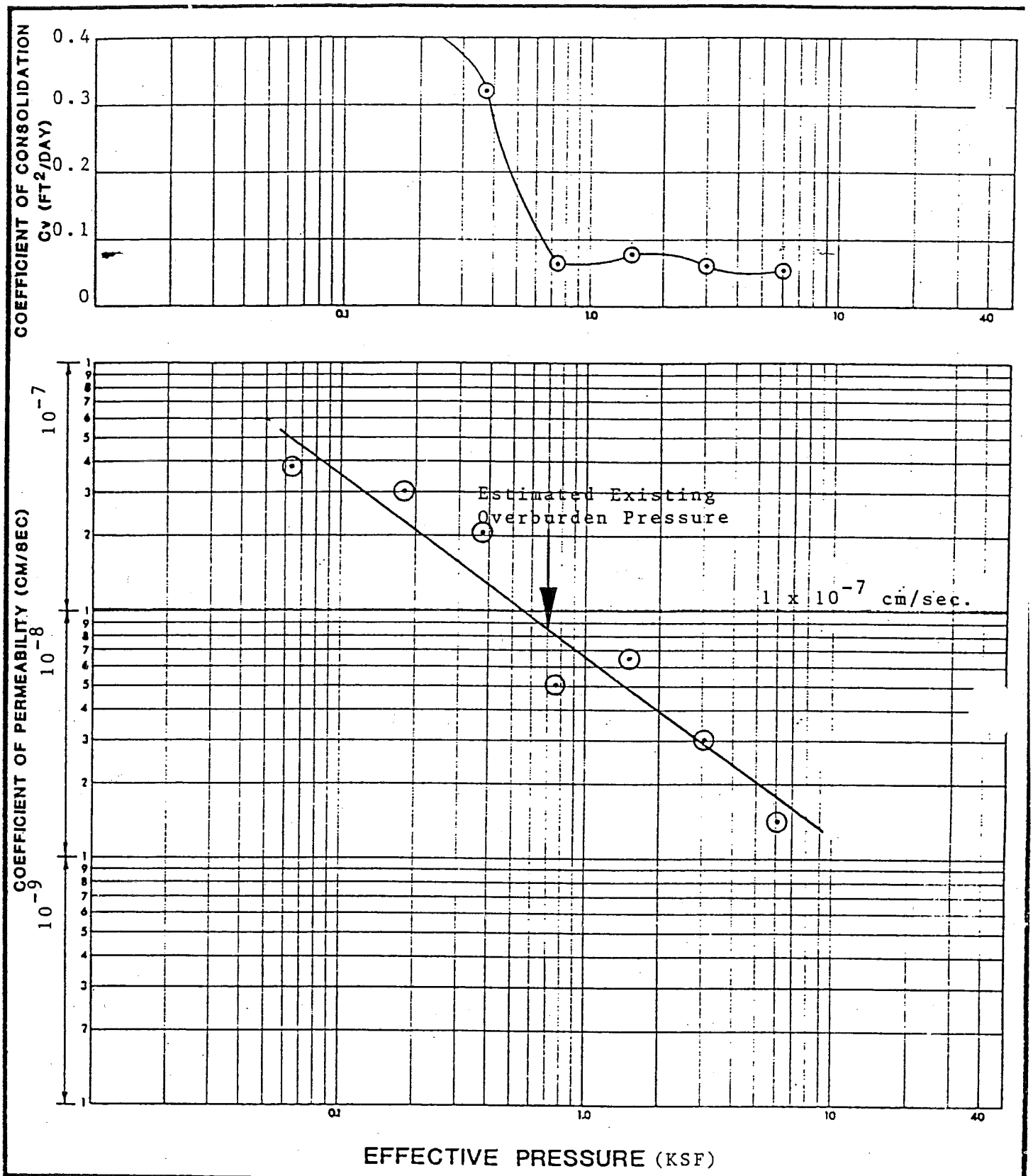


PERMEABILITY RELATED DATA
FROM CONSOLIDATION TEST
TEST BORING: A-5 DEPTH: 15.5

NSWF-2
CHERRY ISLAND
WILMINGTON, DELAWARE

DUFFIELD ASSOCIATES, INC.
CONSULTING GEOTECHNICAL ENGINEERS

Drawn: DSH Chk'd: RDC	Date:
Scale: AS SHOWN	W.O.: 410
File No.:	Fig. D-6-15

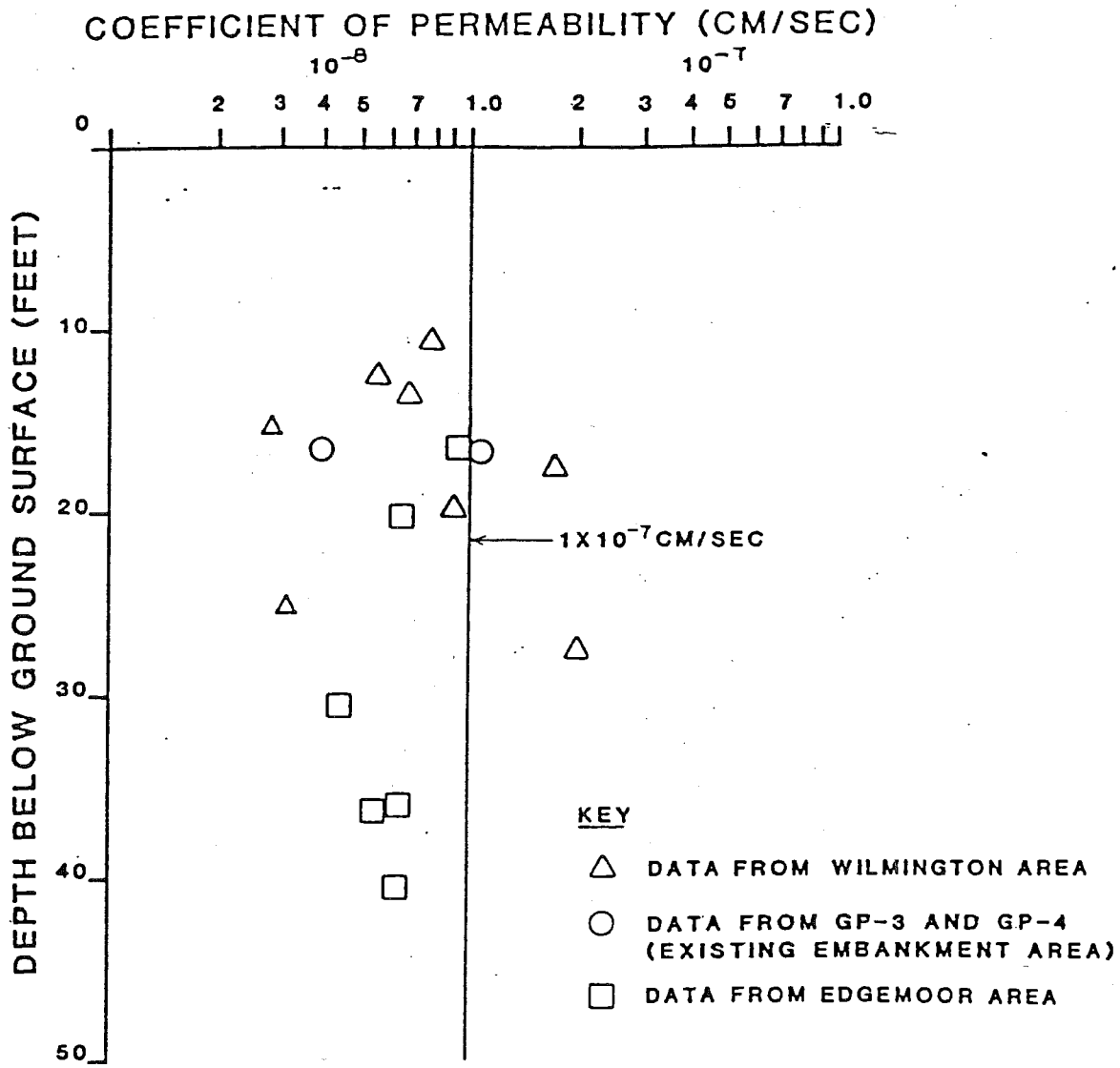


PERMEABILITY RELATED DATA
FROM CONSOLIDATION TEST
TEST BORING: A-7 DEPTH: 20.1

NSWF-2
CHERRY ISLAND
WILMINGTON, DELAWARE

DUFFIELD ASSOCIATES, INC.
CONSULTING GEOTECHNICAL ENGINEERS

Drawn: DSH Chk'd: RDC	Date:
Scale: AS SHOWN	W.O.: 410
File No.:	Fig. D-6-16



NOTE

PERMEABILITIES AT ESTIMATED EXISTING OVERBURDEN PRESSURES DETERMINED FROM PLOTS OF PERMEABILITY VS. PRESSURE LINEAR REGRESSION LINES.

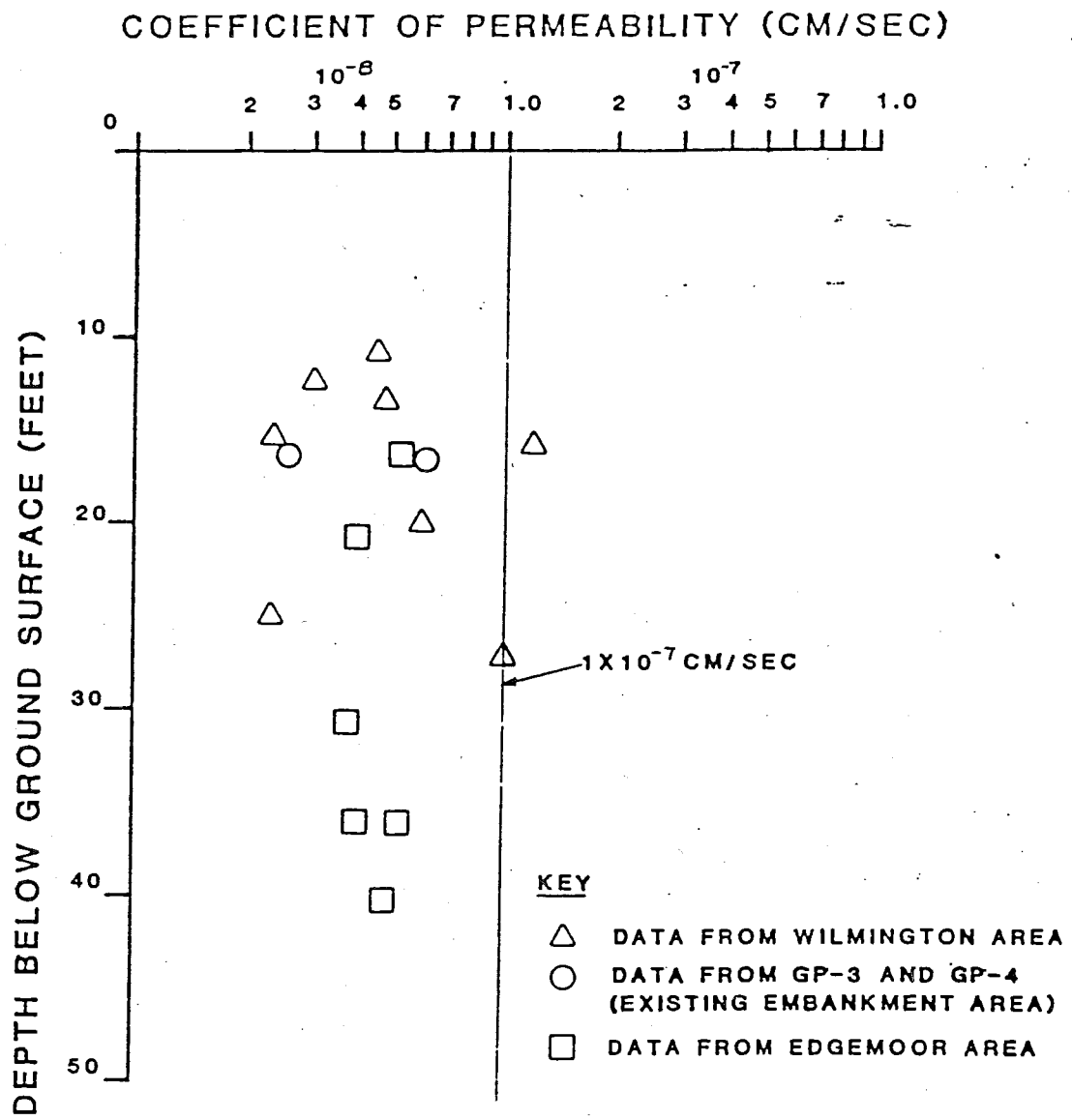
COEFFICIENT OF PERMEABILITY VS. DEPTH AT ESTIMATED EXISTING OVERBURDEN PRESSURE

NSWF-2
CHERRY ISLAND

WILMINGTON, DELAWARE

DUFFIELD ASSOCIATES, INC.
CONSULTING GEOTECHNICAL ENGINEERS

Drawn: DMA Chk'd: RDC	Date: 1/6/84
Scale: AS SHOWN	W.O.: 410
File No.:	Fig. D-6-17



NOTE

PERMEABILITIES DETERMINED FROM PLOTS OF PERMEABILITY VS. PRESSURE LINEAR REGRESSION LINES FROM SUM OF ESTIMATED EXISTING OVERBURDEN PRESSURE AND 25% OF ULTIMATE DESIGN LOAD DUE TO 40 FEET OF REFUSE (500 PSF)

COEFFICIENT OF PERMEABILITY VS. DEPTH AT TIME 25% OF ULTIMATE DESIGN LOAD IS FELT

NSWF-2

CHERRY ISLAND

WILMINGTON, DELAWARE

DUFFIELD ASSOCIATES, INC.
CONSULTING GEOTECHNICAL ENGINEE

Drawn: DMA Chk'd: RDC	Date: 1/6/84
Scale: AS SHOWN	W.O.: 410
File No.:	Fig. D-6-18

APPENDIX D-7

FLY ASH UTILIZATION

D-7 Fly Ash Utilization

Through arrangements with Delmarva Power, fly ash and bottom ash resulting from their operations may be available for use in the landfill construction. Initial discussions with Delmarva personnel have indicated that approximately 60,000 cubic yards of fly ash and 5,000 cubic yards of bottom ash at a moisture content of approximately 25 percent are produced on an annual basis. Preliminary testing was produced on an annual basis. Preliminary testing was performed to aid in evaluating the usefulness of this material either as a sole construction material or as an admixture with the existing dredge spoil materials to aid in improving workability. Samples were obtained from the existing Delmarva stockpiles at the Hay Road site. The field moisture contents of these materials along with a comparison of the in situ moisture content of the dredge spoil obtained in October of 1983 are as follows:

Materials	Moisture Content
Fly Ash	33.6 to 33.8
Bottom Ash	49.2 to 59.0
Dredge Spoil	120.4 to 126.5

In order to evaluate the workability of these materials individually, Standard Proctor tests (ASTM 698 D) were performed. The results of these tests are as follows:

Material	Optimum Moisture Content	Maximum Dry Density
Fly Ash	31%	72 pcf
Bottom Ash	49%	54 pcf
Dredge Spoil	46%	70 pcf

A comparison of the in situ moisture contents and the moisture contents for maximum compaction indicate that the ash materials are generally within the range considered acceptable for maximum compaction. However, the dredge spoil material is significantly above (80 percent) the optimum moisture content for compaction and, therefore, this material will be extremely difficult to work in the field. In this condition, this material may be considered a soft mud.

In order to utilize the dredge spoil materials as a construction material, and thereby achieve a saving over the cost of imported materials, various attempts were made to evaluate methods of improving the workability of the dredge spoil materials. These included admixtures of fly ash with the dredge spoil material, and in addition admixtures of ten percent hydrated lime. Two areas of testing were performed. The first area concerned the effect of the addition of fly ash and lime with the dredge spoil in approximately the optimum range for compaction and, the second series of tests considered the effects of admixtures at approximately the in situ moisture content of the dredge spoil material.

The following summarizes the effect of admixtures on the dredge spoil at approximately the range of optimum moisture content.

Material	Moisture Content	Dry Density
Dredge Spoil	39.1%	72.0 pcf
Dredge Spoil plus 10% lime	33.3%	68.5 pcf
Dredge Spoil plus 10% fly ash	37.8%	77.5 pcf

To evaluate the effects of admixtures at approximately the in situ moisture content, the sample of the dredge spoil was mixed with 10% lime with the following results.

Material	Moisture Content
Before lime admixture	124.8%
After lime admixture	97.8%
One hour after lime admixture	97.0%
Two hours after lime admixture	95.9%
Three hours after lime admixture	94.9%

This data indicates the typical effect of the admixture of lime with a silt material resulting in a rather significant reduction in moisture content with some improvement in the workability of the material through chemical activity and aglomeration of the soil.

To evaluate the change in density with admixture the following tests were performed:

Material	Moisture Content	Dry Density
Dredge Spoil	98.8%	43.9 pcf
Dredge Spoil plus 10% lime	84.7%	48.4 pcf
Dredge Spoil plus 10% fly ash	90.2%	46.8 pcf
Dredge Spoil plus 10% lime plus 10% fly ash	76.5%	52.0 pcf
Bottom Ash	57.9%	54.8 pcf
Bottom Ash plus 10% lime	48.3%	58.9 pcf
Fly Ash	24.7%	70.2 pcf
Fly Ash plus 10% lime	20.8%	69.4 pcf

The above testing illustrates the chemical activity of lime as a pozzolan tending to lower the moisture content of the silt materials, but not having much effect on the addition to the ash materials. The addition of lime in all cases reduces moisture content and improves workability. The addition of fly ash to the dredge spoil reduces the water content. However, due to the similarity in grain size with both soils being essentially silt size, this improvement or reduction in water content is due primarily to the mixing of a drier soil with a wetter soil with no significant improvement in workability. The resulting product is still susceptible to the effects of weather.

While the addition of lime to the dredge spoil appears to offer a reduction in the moisture content, it does not result in a reduction of approximately 80% which would be required to reduce the in situ moisture content to approximately the moisture content for maximum compaction. Therefore, the addition of lime will be somewhat beneficial; however, it soils through ditching, disking, or other means to provide a total program of material handling to result in a moisture content in the range considered for optimal compaction.

The bottom ash texturally approximates a fine sand and is workable over a wider range of moisture contents than is the fly ash. However, due to the relatively small quantity of this material produced on an annual basis, it is unlikely that this material would offer a significant benefit. A mixture of the fly ash and bottom ash in a ratio of one part bottom ash to 12 parts fly ash (the production rate) was performed to aid in evaluating the effect on workability of the fly ash material. This resulted in some improvement in the textural classification of the mixture from 83% silt to 74% silt. However, there is little improvement in the workability of the fly ash. Due to the handling problems

associated with the mixture of the fly ash materials with the on-site silt materials, the cost benefit of this effort will require more detailed evaluation.

Additional testing was performed on both the bottom ash and fly ash to simulate the effects of construction equipment on these materials to establish if crushing of these materials will occur during handling and thereby result in a much finer grained material. The results of these tests were based on the performance of a one point Proctor test and a comparison of the percent finer than a No. 200 sieve test which were performed prior to the Proctor and after the Proctor tests. The results of these tests are as follows:

Description	Bottom Ash	Fly Ash
Before Proctor Water Content	68.3	37.2
Before Proctor Percent less than 200	22.5	83.2
After Proctor Water Content	63.4	36.2
After Proctor Percent less than 200	24.3	84.2

The results of these tests indicate that while some crushing may occur the materials do not tend to be readily broken down by construction equipment and should provide a material which is relatively stable throughout the construction period.

In summary, the addition of fly ash to the dredge spoil materials does not appear to offer any significant advantage. This is due primarily to the grain size of the fly ash being basically that of a silt material. In the presence of moisture such as rain, this material behaves very similar to the dredge spoil materials and in extreme drying and wind conditions tends to dust similar

to the silt material. The only benefit to be achieved appears to be that of mixing a dry material with a wet material to achieve a drier combined material. However, the mechanism to provide uniform mixing with the soft mudlike condition of the dredge spoil with the dry fly ash as produced will create significant handling problems. The bottom ash does offer a relatively granular material which could be of use either singularly or as an admixture with the dredge spoil; however, the quantities produced do not appear to represent a significant volume in the total scheme of construction. The admixture of lime to the dredge spoil material results in the most significant improvement in the reduction of moixture content of the dredge spoil; however, this admixture alone will be insufficient to produce a material in the range of optimum compaction. An on-site program of long-term (one to two years) planning for the utilization of dredge spoil material will be required and must include ditching and disking effects to lower the moisture content which may then be followed by the addition of lime or other admixtures to achieve a product in the range of optimum moisture content for compaction.

A pilot project to assess workability and methods of admixing and ditching on-site will be required to maximize the utilization of the on-site materials. We believe that a test program of this type will be cost effective in view of the many thousands of cubic yards of soil materials which will be required for this landfilling operation.

APPENDIX D-8

TEST BORING LOGS

301

SPRAGUE & HENWOOD, Inc.
SCRANTON, PA.

Job No. 19531

FOUNDATION TESTING and SOIL SAMPLING RECORD

NAME: A.C. Schultes & Sons, Inc. LOCATION: Wilmington, Delaware

HOLE NO. G-1 SURFACE ELEVATION _____ RIG NO. _____ DATE: From 7/7 To 7/8 19 83

BORING LOG		SPOON SAMPLE AND CORE DATA					
DEPTH FROM—TO	DESCRIPTION OF MATERIAL Based On Samples Recovered Plus Observation Of Material Returned Between Samples	SAMPLE NUMBER	DEPTH FROM—TO	BLOWS PER 6" ON SAMPLES	ROCK CORE RECOV'D	D=DRY U=UNDISTURBED T=TRAP W=WASH R=ROD C=CORE CORE RECOV'D — NO. PCS. REMARKS *
0.0' 3.0'	Gray silt, some sand and organics	1	1.0' 2.5'	1-1 2	1.3'	Damp, soft
		2	5.0' 6.5'	2-2 2	1.3'	Damp, soft
3.0' 5.0'	Sand and gravel	U1	10.0' 12.0'		2.0'	Pushed Shelby
		V1	13.5'	Vane	Shear Test	
5.0' 15.0'	Gray silt with sand lenses and organics	3	15.0' 16.5'	WOH-1-1	1.5'	Moist, soft
		4	20.0' 21.5'	WOH-1 1	1.5'	Damp, soft
15.0' 35.0'	Gray silt with organics	5	25.0' 26.5'	WOH-WOH-1	1.5'	Damp, soft
		V2	28.0'	Vane	Shear Test	
35.0' 40.0'	Gray silty sand	6	30.0' 31.5'	WOH-1 3	1.5'	Damp, soft
		U2	35.0' 37.0'		2.0'	Pushed Shelby
40.0' 45.0'	Gray silty sand, trace gravel	7	40.0' 41.5'	5-16 19	1.5'	Moist, medium dense
		8	45.0' 46.5'	15-25 25	1.0'	Moist, dense
45.0' 51.5'	Gray sand with gravel	9	50.0' 51.5'	14-8 7	0.8'	Wet, medium dense

BLOWS ON CASING

0-1		51-52	
1-2		52-53	
2-3		53-54	
3-4		54-55	
4-5		55-56	
5-6		56-57	
6-7		57-58	
7-8		58-59	
8-9		59-60	
9-10		60-61	
10-11		61-62	
11-12		62-63	
12-13		63-64	
13-14		64-65	
14-15		65-66	
15-16		66-67	
16-17		67-68	
17-18		68-69	
18-19		69-70	
19-20		70-71	
20-21		71-72	
21-22		72-73	
22-23		73-74	
23-24		74-75	
24-25		75-76	
25-26		76-77	
26-27		77-78	
27-28		78-79	
28-29		79-80	
29-30		80-81	
30-31		81-82	
31-32		82-83	
32-33		83-84	
33-34		84-85	
34-35		85-86	
35-36		86-87	
36-37		87-88	
37-38		88-89	
38-39		89-90	
39-40		90-91	
40-41		91-92	
41-42		92-93	
42-43		93-94	
43-44		94-95	
44-45		95-96	
45-46		96-97	
46-47		97-98	
47-48		98-99	
48-49		99-100	
49-50		100-101	
50-51		101-102	

GROUND WATER

DEPTH	HOUR	DATE
6.75'	3:00	7/8
Water level before augers pulled.		

PIPE AND CASING LEFT IN HOLE

SIZE	AMOUNT	REASON

DISTANCE HAMMER DROP 30 INCH
DRIVE HAMMER _____ LBS.
SPOON HAMMER 140 LBS.
CASING SIZE _____ INCH
SPOON SIZE 2 INCH
SIZE OF CORE BIT _____ INCH

NOTE: *Classification of soil has been made by the driller and has not been checked by a soils engineer. Classification of rock has been made by the driller and has not been checked by a geologist.

* Under Remarks mention kind of Bit, loss of sample, loss of Drilling water, soft seamy or broken Rock, Caving, Cavities, unusual Ground water conditions, etc.. at depth encountered.

Driller William Levering Jr.
Helper Ronald Dowdy
Helper _____

301

SPRAGUE & HENWOOD, Inc.
SCRANTON, PA.

Cherry Island
Job No. 19531

FOUNDATION TESTING and SOIL SAMPLING RECORD

ME: A.C. Schultes & Sons, Inc. LOCATION: Wilmington, Delaware

LE NO. G-2 SURFACE ELEVATION _____ RIG NO. ____ DATE: From 7/6 To 7/7 19 83

BORING LOG: DEPTH FROM—TO	DESCRIPTION OF MATERIAL Based On Samples Recovered Plus Observation Of Material Returned Between Samples	SAMPLE NUMBER	DEPTH FROM—TO	BLOWS PER 6" SAMPLES	ROCK CORE RECOV'D	D=DRY U=UNDISTURBED T=TRAP W=WASH R=ROD C=CORE; CORE RECOV'D — NO. PCS. REMARKS *
0.0' 3.0'	Brown silt	1	1.0' 2.5'	1-2 2	1.0'	Damp, soft
		2	5.0' 6.5'	1-0 1	0.6'	Damp, soft
3.0' 20.0'	Gray silt with organics	3	10.0' 11.5'	1-2 1	0.8'	Moist, soft
		U-1	15.0' 17.0'		2.0'	Pushed Shelby
20.0' 30.0'	Gray silt with sand lenses	V-1	18.5'	Vane Shear Test		
		4	20.0' 21.5'	1-1 2	1.5'	Damp, soft
30.0' 35.0'	Gray silt and peat	5	25.0' 26.5'	1-1 1	1.5'	Moistt, soft
		6	30.0' 31.5'	WOH-1 WOH-2	1.5'	Damp, soft
35.0' 39.0'	Gray sandy silt	7	35.0' 36.5'	1-4 5	1.5'	Damp, firm
		V-2	38.0'	Vane Shear Test		
39.0' 43.0'	Gray silt sand	8	40.0' 41.5'	7-12 14	1.5'	Moist, medium dense
		9	45.0'			Running sand, sample taken inside Auger Flight with permission of inspector.
43.0' 45.0'	Gray sand, trace gravel					

BLOWS ON CASING (AUGERS)

0-1	51-52
1-2	52-53
2-3	53-54
3-4	54-55
4-5	55-56
5-6	56-57
6-7	57-58
7-8	58-59
8-9	59-60
9-10	60-61
10-11	61-62
11-12	62-63
12-13	63-64
13-14	64-65
14-15	65-66
15-16	66-67
16-17	67-68
17-18	68-69
18-19	69-70
19-20	70-71
20-21	71-72
21-22	72
22-23	73
23-24	74
24-25	75-76
25-26	76-77
26-27	77-78
27-28	78-79
28-29	79-80
29-30	80-81
30-31	81-82
31-32	82-83
32-33	83-84
33-34	84-85
34-35	85-86
35-36	86-87
36-37	87-88
37-38	88-89
38-39	89-90
39-40	90-91
40-41	91-92
41-42	92-93
42-43	93-94
43-44	94-95
44-45	95-96
45-46	96-97
46-47	97-98
47-48	98-99
48-49	99-100
49-50	100-
50-51	101-

GROUND WATER

DEPTH	HOUR	DATE
7'	5:00	7/7
Water level after augers pulled.		
Next day hole collapsed.		

PIPE AND CASING LEFT IN HOLE

SIZE	AMOUNT	REASON

DISTANCE HAMMER DROP 30 INCH
DRIVE HAMMER ____ LBS.
SPOON HAMMER 140 LBS.
CASING SIZE ____ INCH
SPOON SIZE 2 INCH
SIZE OF CORE BIT ____ INCH

NOTE: *Classification of soil has been made by the driller and has not been checked by a soils engineer. Classification of rock has been made by the driller and has not been checked by a geologist.

* Under Remarks mention kind of Bit, loss of sample, loss of Drilling water, soft seamy or broken Rock, Caving, Cavities, unusual Ground water conditions, etc., at depth encountered.

Driller William Levering jr.
Helper Ronald Dowdy
Helper

SPRAGUE & HENWOOD, Inc.
SCRANTON, PA.

Cherry Island
Job No. 19531

FOUNDATION TESTING and SOIL SAMPLING RECORD

NAME: A.C. Schlutes & Sons, Inc. LOCATION: Wilmington, Delaware

HOLE NO. GP-3 SURFACE ELEVATION _____ RIG NO. ____ DATE: From 7/5 To 7/11 19 83

BORING LOG: DEPTH FROM—TO	DESCRIPTION OF MATERIAL Based on Samples Recovered Plus Observation Of Material Returned Between Samples	SAMPLE NUMBER	DEPTH FROM—TO	BLOWS PER 6" ON SAMPLES	ROCK CORE RECOV'D	D=DRY U=UNDISTURBED T=TRAP W=WASH R=ROD C=CORE; CORE RECOV'D — NO. PCS. REMARKS *
0.0' 12.0'	Fill	1	0.0' 1.5'	2-3 5	1.3'	
		2	5.0' 6.5'	1-2 1	1.5'	
12.0' 53.0'	Soft, silty marsh		7.0' 9.0'	Attempted Shelby Tube Sample- No recovery		
		U1	9.0' 11.0'		1.9'	Shelby Tube Sample
53.0' 63.0'	Soft silt	3	11.0' 12.5'	3-3 4	1.5'	
		4	12.5' 14.0'	4-4 5	1.5'	
63.0' 92.5'	Sand, gravel - hard	U2	15.0' 17.0'		2.0'	Shelby Tube Sample
		5	17.0' 18.5'	WOH	1.5'	
92.5' 01.5'	Medium clay, brown to red	V1	20.0'	Vane Shear Test		
		6	20.0' 21.5'	0-2 1	1.5'	
		U3	25.0' 27.0'		2.0'	Shelby Tube Sample
		7	27.0' 28.5'	WOH	1.5'	
		U4	30.0' 32.0'		2.0'	Shelby Tube Sample
		8	32.0' 33.5'	1-2 1	1.5'	
		V2	35.0'	Vane Shear Test		
		9	40.0' 41.5'	1-1 1	1.5'	
		10	45.0' 46.5'	3-4 5	1.5'	
		11	50.0' 51.5'	1-1 2	1.5'	
		12	55.0' 56.5'	2-5 9	1.5'	
		13	60.0' 61.5'	3-6 10	1.5'	

BLOWS ON CASIN	
0-1 10	51-52
1-2 10	52-53
2-3 20	53-54
3-4 25	54-55
4-5 40	55-56
5-6 45	56-57
6-7 50	57-58
7-8 55	58-59
8-9 50	59-60
9-10 52	60-61
10-11 50	61-62
11-12 55	62-63
12-13 60	63-64
13-14 65	64-65
14-15 40	65-66
15-16	66-67
16-17	67-68
17-18	68-69
18-19	69-70
19-20	70-71
20-21	71-72
21-22	72-73
22-23	73-74
23-24	74-75
24-25	75-76
25-26	76-77
26-27	77-78
27-28	78-79
28-29	79-80
29-30	80-81
30-31	81-82
31-32	82-83
32-33	83-84
33-34	84-85
34-35	85-86
35-36	86-87
36-37	87-88
37-38	88-89
38-39	89-90
39-40	90-91
40-41	91-92
41-42	92-93
42-43	93-94
43-44	94-95
44-45	95-96
45-46	96-97
46-47	97-98
47-48	98-99
48-49	99-100
49-50	100-101
50-51	101-102

GROUND WATER

DEPTH	HOUR	DATE

PIPE AND CASING LEFT IN HOLE

SIZE	AMOUNT	REASON
3/4"PVC pipe	45.5'	Piezometer
	1	Piezometer
	casing	

DISTANCE HAMMER DROP 30 INCH
DRIVE HAMMER 300 LBS.
SPOON HAMMER 140 LBS.
CASING SIZE 5 INCH
SPOON SIZE 1 INCH
SIZE OF CORE BIT _____ INCH

NOTE: *Classification of soil has been made by the driller and has not been checked by a soils engineer. Classification of rock has been made by the driller and has not been checked by a geologist.

* Under Remarks mention kind of Bit, loss of sample, loss of Drilling water, soft seamy or broken Rock, Caving, Cavities, unusual Ground water conditions, etc., at depth encountered.

Driller Doug Nelson
Helper George Gares
Helper _____

SPRAGUE & HENWOOD, Inc.

SCRANTON, PA.

FOUNDATION TESTING and SOIL SAMPLING RECORD

NAME: A.C. Schultes & Sons, Inc. LOCATION: Wilmington, Delaware

HOLE NO. GP-3 SURFACE ELEVATION _____ RIG NO. _____ DATE: From 7/5 To 7/11 19 83

BORING LOG		SPOON SAMPLE AND CORE DATA					
DEPTH FROM—TO	DESCRIPTION OF MATERIAL Based On Samples Recovered Plus Observation Of Material Returned Between Samples	SAMPLE NUMBER	DEPTH FROM—TO	BLOWS PER 6" ON SAMPLES	ROCK CORE RECOV'D	D=DRY U=UNDISTURBED T=TRAP W=WASH R=ROD C=CORE CORE RECOV'D — NO. PCS. REMARKS *
		14	65.0 / 66.5	28-50 / 40	1.0	
		15	70.0 / 71.5	50-50 / 48	1.0	
		16	75.0 / 76.5	54-57 / 55	0.8	
		17	80.0 / 81.5	28-58 / 106	No Rec.	Very big gravel
		18	85.0 / 86.5	18-28 / 30	No Rec.	Very big gravel
		19	90.0 / 91.5	100	No Rec.	Took wash samples
		20	95.0 / 96.5	6-7 / 6	No Rec.	
		21	100.0 / 101.5	11-14 / 20	No Rec.	

BLOWS ON CASING	
0-1	51-52
1-2	52-53
2-3	53-54
3-4	54-55
4-5	55-56
5-6	56-57
6-7	57-58
7-8	58-59
8-9	59-60
9-10	60-61
10-11	61-62
11-12	62-63
12-13	63-64
13-14	64-65
14-15	65-66
15-16	66-67
16-17	67-68
17-18	68-69
18-19	69-70
19-20	70-71
20-21	71-72
21-22	72-73
22-23	[illegible]
23-24	[illegible]
24-25	[illegible]
25-26	76-77
26-27	77-78
27-28	78-79
28-29	79-80
29-30	80-81
30-31	81-82
31-32	82-83
32-33	83-84
33-34	84-85
34-35	85-86
35-36	86-87
36-37	87-88
37-38	88-89
38-39	89-90
39-40	90-91
40-41	91-92
41-42	92-93
42-43	93-94
43-44	94-95
44-45	95-96
45-46	96-97
46-47	97-98
47-48	98-99
48-49	99-100
49-50	100-101
50-51	[illegible]

GROUND WATER

DEPTH	HOUR	DATE

PIPE AND CASING LEFT IN HOLE

SIZE	AMOUNT	REASON

DISTANCE HAMMER DROP _____ INCH
DRIVE HAMMER _____ LBS.
SPOON HAMMER _____ LBS.
CASING SIZE _____ INCH
SPOON SIZE _____ INCH
SIZE OF CORE BIT _____ INCH

NOTE: *Classification of soil has been made by the driller and has not been checked by a soils engineer. Classification of rock has been made by the driller and has not been checked by a geologist.

* Under Remarks mention kind of Bit, loss of sample, loss of Drilling water, soft seamy or broken Rock, Caving, Cavities, unusual Ground water conditions, etc., at depth encountered.

Driller Doug Nelson

Helper George Geres

Helper _____

301

SPRAGUE & HENWOOD, Inc.

SCRANTON, PA.

Job No. 19531

FOUNDATION TESTING and SOIL SAMPLING RECORD

ME: A.C. Schultes & Sons, Inc. LOCATION: Wilmington, Delaware

LE NO. GP3A SURFACE ELEVATION _____ RIG NO. ____ DATE: From 7/11 To 7/12 19 83

BORING LOG		SPOON SAMPLE AND CORE DATA					BLOWS ON CASIN
DEPTH FROM—TO	DESCRIPTION OF MATERIAL Based On Samples Recovered Plus Observation Of Material Returned Between Samples	SAMPLE NUMBER	DEPTH FROM—TO	BLOWS PER FT. ON SAMPLES	ROCK CORE RECOV'D	D=DRY U=UNDISTURBED T=TRAP W=WASH R=ROD G=CORE; CORE RECOV'D — NO. PCS. REMARKS *	0-1, 1-2, 2-3, 3-4, 4-5, 5-6, 6-7, 7-8, 8-9, 9-10, 10-11, 11-12, 12-13, 13-14, 14-15, 15-16, 16-17, 17-18, 18-19, 19-20, 20-21, 21-22, 22-23, 23-24, 24-25, 25-26, 26-27, 27-28, 28-29, 29-30, 30-31, 31-32, 32-33, 33-34, 34-35, 35-36, 36-37, 37-38, 38-39, 39-40, 40-41, 41-42, 42-43, 43-44, 44-45, 45-46, 46-47, 47-48, 48-49, 49-50, 50-51
0.0' 9.0'	Fill, marsh					No Samples	51-52, 52-53, 53-54, 54-55, 55-56, 56-57, 57-58, 58-59, 59-60
9.0' 26.9'	Soft silt and marsh	V1	13.5'	Vane Shear Test			60-61, 61-62, 62-63, 63-64, 64-65, 65-66, 66-67, 67-68, 68-69, 69-70, 70-71, 71-72, 72-73, 73-74, 74-75, 75-76, 76-77, 77-78, 78-79, 79-80, 80-81, 81-82, 82-83, 83-84, 84-85, 85-86, 86-87, 87-88, 88-89, 89-90, 90-91, 91-92, 92-93, 93-94, 94-95, 95-96, 96-97, 97-98, 98-99, 99-100, 100-101, 101-102
		V2	25.0'	Vane Shear Test			

Casing to 10.0'

GROUND WATER			PIPE AND CASING LEFT IN HOLE		
DEPTH	HOUR	DATE	SIZE	AMOUNT	REASON
			3/4"PVC pipe	25.7'	Piezometer
				1	Piezometer casing

DISTANCE HAMMER DROP ____ INCH
DRIVE HAMMER 300 LBS.
SPOON HAMMER ____ LBS.
CASING SIZE 6 INCH
SPOON SIZE ____ INCH
SIZE OF CORE BIT ____ INCH

NOTE: *Classification of soil has been made by the driller and has not been checked by a soils engineer. Classification of rock has been made by the driller and has not been checked by a geologist.

* Under Remarks mention kind of Bit, loss of sample, loss of Drilling water, soft seamy or broken Rock, Caving, Cavities, unusual Ground water conditions, etc., at depth encountered.

Driller Doug Nelson

Helper George Gares

Helper _____

SPRAGUE & HENWOOD, Inc.
SCRANTON, PA.

Cherry Island
Job No. 19531

FOUNDATION TESTING and SOIL SAMPLING RECORD

NAME: A.C. Schultes & Sons, Inc. LOCATION: Wilmington, Delaware

HOLE NO. GP-4 SURFACE ELEVATION _____ RIG NO. _____ DATE: From 7/8 To 7/13 19 83

BORING LOG: DEPTH FROM—TO	DESCRIPTION OF MATERIAL Based on Samples Recovered Plus Observation Of Material Returned Between Samples	SAMPLE NUMBER	DEPTH FROM—TO	BLOWS PER 6" ON SAMPLES	ROCK CORE RECOV'D	CORE RECOV'D — NO. PCS. REMARKS *
0.0' 5.0'	Brown silt, trace organics	1	1.0' 2.5'	2-2 4	1.5'	Damp, firm
		2A	5.0' 5.5'	1	0.5'	Damp, soft
5.0' 5.5'	Gray silt with organics	2B	5.5' 6.5'	10-15	1.0'	Damp, medium dense
		3A	10.0' 11.0'	9-4	1.0'	Moist, medium dense
5.5' 11.0'	Gray sand with gravel	3B	11.0' 11.5'	1	0.5'	Damp, soft
		U1	15.0' 17.0'		2.0'	Pushed Shelby
11.0' 35.0'	Gray silt with organics	V1	18.5'	Vane	Shear	Test
		4	20.0' 21.5'	WOH-1-1	1.5'	Damp, soft
35.0' 35.5'	Gray silty sand	5	25.0' 26.5'	WOH-WOH WOH	1.5'	Damp, soft
		V2	28.0'	Vane	Shear	Test
35.5' 40.0'	Gray silt with sand lenses	U2	30.0' 32.0'		2.0'	Pushed Shelby
		6A	35.0' 35.5'	WOH	0.5'	Wet, soft
40.0' 55.0'	Gray silt with sand lenses and organics	6B	35.5' 36.5'	1-1	1.0'	Damp, soft
		V3	38.0'	Vane	Shear	Test
55.0' 58.0'	Pinkish-gray silt with trace of sand	7	40.0' 41.5'	WOH-WOH-2	1.5'	Damp, soft
		8	45.0' 46.5'	2-2 2	1.5'	Damp, soft
58.0' 59.0'	Gray silty sand with gravel	9	50.0' 51.5'	WOH-WOH-3	1.5'	Damp, soft
		10	55.0' 56.5'	4-4 6	1.5'	Damp, form
59.0' 74.0'	Pinkish-gray silty sand with gravel	11	58.5' 60.0'	24-21 30	1.2'	Moist, dense
		12	64.0' 65.5'	13-35 22	1.0'	Wet, dense

D=DRY U=UNDISTURBED T=TRAP W=WASH R=ROD C=CORE

BLOWS ON CASIN

0-1	51-52
1-2	52-53
2-3	53-54
3-4	54-55
4-5	55-56
5-6	56-57
6-7	57-58
7-8	58-59
8-9	59-60
9-10	60-61
10-11	61-62
11-12	62-63
12-13	63-64
13-14	64-65
14-15	65-66
15-16	66-67
16-17	67-68
17-18	68-69
18-19	69-70
19-20	70-71
20-21	71-72
21-22	72-73
22-23	7[illegible]
23-24	7[illegible]
24-25	7[illegible]
25-26	76-77
26-27	77-78
27-28	78-79
28-29	79-80
29-30	80-81
30-31	81-82
31-32	82-83
32-33	83-84
33-34	84-85
34-35	85-86
35-36	86-87
36-37	87-88
37-38	88-89
38-39	89-90
39-40	90-91
40-41	91-92
41-42	92-93
42-43	93-94
43-44	94-95
44-45	95-96
45-46	96-97
46-47	97-98
47-48	98-99
48-49	99-100
49-50	100-101
50-51	101

Augers to 55.0'. BX Casing to 11.0' - No blows required

GROUND WATER

DEPTH	HOUR	DATE
10		7/14

PIPE AND CASING LEFT IN HOLE

SIZE	AMOUNT	REASON
5/4" PVC pipe	43.7'	Piezometer
	1 piezometer casing	

DISTANCE HAMMER DROP 24-30 INCH
DRIVE HAMMER 300 LBS.
SPOON HAMMER 140 LBS.
CASING SIZE BX INCH
SPOON SIZE 2 INCH
SIZE OF CORE BIT _____ INCH

NOTE: *Classification of soil has been made by the driller and has not been checked by a soils engineer. Classification of rock has been made by the driller and has not been checked by a geologist.

* Under Remarks mention kind of Bit, loss of sample, loss of Drilling water, soft seamy or broken Rock, Caving, Cavities, unusual Ground water conditions, etc., at depth encountered.

Driller William Levering J.
Helper Ronald Dowdy
Helper _____

301

SPRAGUE & HENWOOD, Inc.
SCRANTON, PA.

FOUNDATION TESTING and SOIL SAMPLING RECORD

E: A.C. Schultes & Sons, Inc. LOCATION: Wilmington, Delaware

E NO. GP-4 SURFACE ELEVATION _____ RIG NO. _____ DATE: From 7/8 To 7/13 19 83

BORING LOG		SPOON SAMPLE AND CORE DATA					
EPTH DM—TO	DESCRIPTION OF MATERIAL Based On Samples Recovered Plus Observation Of Material Returned Between Samples	SAMPLE NUMBER	DEPTH FROM—TO	BLOWS PER 6" ON SAMPLES	ROCK CORE RECOV'D	D=DRY U=UNDISTURBED T=TRAP W=WASH R=ROD C=CORE CORE RECOV'D — NO. PCS. REMARKS *
4.0' 9.0'	Brown-gray silty sand	13	69.0 70.5	21-24 24	0.9'	Wet, dense
		14	74.0 75.5	11-17 22	1.0'	Wet, dense
9.0' 4.0'	Gray silty sand with gravel	15	79.0 80.5	10-12 15	1.0'	Wet, medium dense
		16	84.0 85.5	9-12 15	0.9'	Wet, medium dense
4.0' 9.0'	Red-brown silty sand	17	89.0 90.5	19-13 12	0.9'	Wet, medium dense
		18	93.5 95.0	33-30 35	0.7'	Damp, dense
9.0' .0.5'	Red and gray clay	19	99.0 100.5	14-9 13	0.3'	Wet, 2nd attempt ~~medium dense~~
		20	104.0 105.5	15-8 10	0.7'	Damp, medium dense
		21	109.0 110.5	11-20 25	1.5'	Damp, stiff

BLOWS ON CASING	
0-1	51-52
1-2	52-53
2-3	53-54
3-4	54-55
4-5	55-56
5-6	56-57
6-7	57-58
7-8	58-59
8-9	59-60
9-10	60-61
10-11	61-62
11-12	62-63
12-13	63-64
13-14	64-65
14-15	65-66
15-16	66-67
16-17	67-68
17-18	68-69
18-19	69-70
19-20	70-71
20-21	71-72
21-22	72-73
22-23	73-74
23-24	74-75
24-25	75-76
25-26	76-77
26-27	77-78
27-28	78-79
28-29	79-80
29-30	80-81
30-31	81-82
31-32	82-83
32-33	83-84
33-34	84-85
34-35	85-86
35-36	86-87
36-37	87-88
37-38	88-89
38-39	89-90
39-40	90-91
40-41	91-92
41-42	92-93
42-43	93-94
43-44	94-95
44-45	95-96
45-46	96-97
46-47	97-98
47-48	98-99
48-49	99-100
49-50	100-101
50-51	101-102

GROUND WATER

DEPTH	HOUR	DATE

PIPE AND CASING LEFT IN HOLE

SIZE	AMOUNT	REASON

DISTANCE HAMMER DROP _____ INCH
DRIVE HAMMER _____ LBS.
SPOON HAMMER _____ LBS.
CASING SIZE _____ INCH
SPOON SIZE _____ INCH
SIZE OF CORE BIT _____ INCH

OTE: *Classification of soil has been made by the driller and has not been checked by a soils engineer. Classification of rock has been made by the driller and has not been checked by a geologist.

* Under Remarks mention kind of Bit, loss of sample, loss of Drilling water, soft seamy or broken Rock, Caving, Cavities, unusual Ground water conditions, etc., at depth encountered.

Driller William Levering Jr.

Helper Ronald Dowdy

Helper _____

SPRAGUE & HENWOOD, Inc.
SCRANTON, PA.

Cherry Island
Job No. 19531

FOUNDATION TESTING and SOIL SAMPLING RECORD

ME: A.C. Schultes & Sons, Inc. LOCATION: Wilmington, Delaware

LE NO. GP4A SURFACE ELEVATION _____ RIG NO. ____ DATE: From 7/14 To 7/14 19 83

BORING LOG		SPOON SAMPLE AND CORE DATA					
DEPTH FROM—TO	DESCRIPTION OF MATERIAL Based on Samples Recovered Plus Observation Of Material Returned Between Samples	SAMPLE NUMBER	DEPTH FROM—TO	BLOWS PER FT. ON SAMPLES	ROCK CORE RECOV'D	D=DRY U=UNDISTURBED T=TRAP W=WASH R=ROD C=CORE CORE RECOV'D — NO. PCS. REMARKS *
0.0' 20.0'	Overburden		Non-Sample		Hole	
		V1	11.5'	Vane Shear Test		

BLOWS ON CASIN

0-1	51-52
1-2	52-53
2-3	53-54
3-4	54-55
4-5	55-56
5-6	56-57
6-7	57-58
7-8	58-59
8-9	59-60
9-10	60-61
10-11	61-62
11-12	62-63
12-13	63-64
13-14	64-65
14-15	65-66
15-16	66-67
16-17	67-68
17-18	68-69
18-19	69-70
19-20	70-71
20-21	71-72
21-22	72-73
22-23	7[illegible]
23-24	[illegible]
24-25	7[illegible]
25-26	76-77
26-27	77-78
27-28	78-79
28-29	79-80
29-30	80-81
30-31	81-82
31-32	82-83
32-33	83-84
33-34	84-85
34-35	85-86
35-36	86-87
36-37	87-88
37-38	88-89
38-39	89-90
39-40	90-91
40-41	91-92
41-42	92-93
42-43	93-94
43-44	94-95
44-45	95-96
45-46	96-97
46-47	97-98
47-48	98-99
48-49	99-100
49-50	100-101
50-51	101

Albers

GROUND WATER

DEPTH	HOUR	DATE
16'		7/14

PIPE AND CASING LEFT IN HOLE

SIZE	AMOUNT	REASON
3/4"PVC pipe	17.3'	Piezometer
	1 Piezometer Casing	

DISTANCE HAMMER DROP ____ INCH
DRIVE HAMMER ____ LBS.
SPOON HAMMER ____ LBS.
CASING SIZE ____ INCH
SPOON SIZE ____ INCH
SIZE OF CORE BIT ____ INCH

NOTE: *Classification of soil has been made by the driller and has not been checked by a soils engineer. Classification of rock has been made by the driller and has not been checked by a geologist.

* Under Remarks mention kind of Bit, loss of sample, loss of Drilling water, soft seamy or broken Rock, Caving, Cavities, unusual Ground water conditions, etc., at depth encountered.

Driller William Levering J
Helper Ronald Dowdy
Helper

SPRAGUE & HENWOOD, Inc.
SCRANTON, PA.

Cherry Island, Pa.
Job No. 19531

FOUNDATION TESTING and SOIL SAMPLING RECORD

ME: A.C.Schultes & Sons, Inc. LOCATION: Wilmington, Delaware

LE NO. GP-5 SURFACE ELEVATION _____ RIG NO. _____ DATE: From 7/12 To 7/18 19 83

BORING LOG: DEPTH FROM—TO	DESCRIPTION OF MATERIAL Based On Samples Recovered Plus Observation Of Material Returned Between Samples	SAMPLE NUMBER	DEPTH FROM—TO	BLOWS PER 6" SAMPLES	ROCK CORE RECOV'D	D=DRY U=UNDISTURBED T=TRAP W=WASH R=ROD C=CORE CORE RECOV'D — NO. PCS. REMARKS *
0.0' 10.0'	Fill, silt	1	0.0' 1.5'	2-3 4	1.5'	
		2	5.0' 6.5'	2-2 2	1.5'	
10.0' 63.0'	Soft silt	3	10.0' 11.5'	1-1 1	1.5'	
		4	15.0' 16.5'	1-1 1	1.5'	
63.0' 115.0'	Sand and gravel	U1	20.0' 22.0'		2.0'	Shelby Tube Sample
		V1	23.5'	Vane	Shear Test	
115.0' 118.5'	Red clay	5	25.0' 26.5'	WOH	1.5'	
		U2	30.0' 32.0'		2.0'	Shelby Tube Sample
		V2	33.5'	Vane	Shear Test	
		6	35.0' 36.5'	WOH	1.5'	
		7	40.0' 41.5'	WOH	1.4'	
		V3	43.5'	Vane	Shear Test	
		8	45.0' 46.5'	1-2 3	1.5'	
		9	50.0' 51.5'	1-1 2	1.5'	
		10	55.0' 56.5'	0-1 0	1.5'	
		11	60.0' 61.5'	1-1 2	1.5'	
		12	65.0' 66.5'	16-38 65	1.0'	
		13	70.0' 71.5'	32-40 42	0.8'	
		14	75.0' 76.5'	31-50 50	1.0'	
		15	80.0' 81.0'	75-75	0.5'	

BLOWS ON CASING

0-1	51-52
1-2	52-53
2-3	53-54
3-4	54-55
4-5	55-56
5-6	56-57
6-7	57-58
7-8	58-59
8-9	59-60
9-10	60-61
10-11	61-62
11-12	62-63
12-13	63-64
13-14	64-65
14-15	65-66
15-16	66-67
16-17	67-68
17-18	68-69
18-19	69-70
19-20	70-71
20-21	71-72
21-22	72-73
22-23	73-74
23-24	74-75
24-25	75-76
25-26	76-77
26-27	77-78
27-28	78-79
28-29	79-80
29-30	80-81
30-31	81-82
31-32	82-83
32-33	83-84
33-34	84-85
34-35	85-86
35-36	86-87
36-37	87-88
37-38	88-89
38-39	89-90
39-40	90-91
40-41	91-92
41-42	92-93
42-43	93-94
43-44	94-95
44-45	95-96
45-46	96-97
46-47	97-98
47-48	98-99
48-49	99-100
49-50	100-101
50-51	101-102

GROUND WATER

DEPTH	HOUR	DATE

PIPE AND CASING LEFT IN HOLE

SIZE	AMOUNT	REASON
3/4" PVC pipe	50.1'	Piezometer
	1 Piezometer casing	

DISTANCE HAMMER DROP 30 INCH
DRIVE HAMMER 300 LBS.
SPOON HAMMER 140 LBS.
CASING SIZE 6 INCH
SPOON SIZE 2 INCH
SIZE OF CORE BIT _____ INCH

NOTE: *Classification of soil has been made by the driller and has not been checked by a soils engineer. Classification of rock has been made by the driller and has not been checked by a geologist.

* Under Remarks mention kind of bit, loss of sample, loss of Drilling water, soft seamy or broken Rock, Caving, Cavities, unusual Ground water conditions, etc., at depth encountered.

Driller Doug Nelson
Helper George Gares
Helper _____

SPRAGUE & HENWOOD, Inc.

SCRANTON, PA.

FOUNDATION TESTING and SOIL SAMPLING RECORD

.ME: A.C. Schultes & Sons, Inc. LOCATION: Wilmington, Delaware

'LE NO. GP-5 SURFACE ELEVATION _____ RIG NO. ____ DATE: From 7/13 To 7/18 19 83

BORING LOG		SPOON SAMPLE AND CORE DATA					BLOWS ON CASIN
DEPTH 'ROM—TO	DESCRIPTION OF MATERIAL Based on Samples Recovered Plus Observation Of Material Returned Between Samples	SAMPLE NUMBER	DEPTH FROM—TO	BLOWS PER 6" SAMPLES	ROCK CORE RECOV'D	D=DRY U=UNDISTURBED T=TRAP W=WASH R=ROD C=CORE CORE RECOV'D — NO. PCS. REMARKS *	0-1 51-52 1-2 52-53 2-3 53-54 3-4 54-55 4-5 55-56 5-6 56-57 6-7 57-58 7-8 58-59 8-9 59-60 9-10 60-61 10-11 61-62 11-12 62-63 12-13 63-64 13-14 64-65 14-15 65-66 15-16 66-67 16-17 67-68 17-18 68-69 18-19 69-70 19-20 70-71 20-21 71-72 21-22 72-73 22-23 7 23-24 24-25 75-76 25-26 76-77 26-27 77-78 27-28 78-79 28-29 79-80 29-30 80-81 30-31 81-82 31-32 82-83 32-33 83-84 33-34 84-85 34-35 85-86 35-36 86-87 36-37 87-88 37-38 88-89 38-39 89-90 39-40 90-91 40-41 91-92 41-42 92-93 42-43 93-94 43-44 94-95 44-45 95-96 45-46 96-97 46-47 97-98 47-48 98-99 48-49 99-100 49-50 100-101 50-51 101
		16	85.0 86.5	21-29 37	1.0	Used 300 lb. hammer	
		17	90.0 91.5	18-17 20	1.0		
		18	95.0 96.5	30-20 21	1.0		
		19	100.0 101.5	13-15 17	0.6		
		20	105.0 106.5	17-17 16	1.0		
		21	110.0 111.5	16-25 24	1.0		
		22	115.5 117.0	34-22 16	1.5		
		23	117.0 118.5	9-22 30	1.5		

GROUND WATER			PIPE AND CASING LEFT IN HOLE		
DEPTH	HOUR	DATE	SIZE	AMOUNT	REASON

DISTANCE HAMMER DROP ____ INCH
DRIVE HAMMER ____ LBS.
SPOON HAMMER ____ LBS.
CASING SIZE ____ INCH
SPOON SIZE ____ INCH
SIZE OF CORE BIT ____ INCH

NOTE: *Classification of soil has been made by the driller and has not been checked by a soils engineer. Classification of rock has been made by the driller and has not been checked by a geologist.

* Under Remarks mention kind of Bit, loss of sample, loss of Drilling water, soft seamy or broken Rock, Caving, Cavities, unusual Ground water conditions, etc., at depth encountered.

Driller Doug Nelson

Helper George Gares

Helper

SPRAGUE & HENWOOD, Inc.
SCRANTON, PA.

Job Order No. 19531

FOUNDATION TESTING and SOIL SAMPLING RECORD

NAME: A.C. Schultes & Sons, Inc. LOCATION: Wilmington, Delaware

HOLE NO. GP5A SURFACE ELEVATION _____ RIG NO. ____ DATE: From 7/18 To 7/19 19 83

BORING LOG		SPOON SAMPLE AND CORE DATA					BLOWS ON CASIN
DEPTH FROM—TO	DESCRIPTION OF MATERIAL Based On Samples Recovered Plus Observation Of Material Returned Between Samples	SAMPLE NUMBER	DEPTH FROM—TO	BLOWS PER FT. ON SAMPLES	ROCK CORE RECOV'D	D=DRY U=UNDISTURBED T=TRAP W=WASH R=ROD C=CORE; CORE RECOV'D — NO. PCS. REMARKS *	
0.0' 10.0'	Fill, silt						
10.0' 30.8'	Soft silt	U-1	15.0' 17.0'		2.0'	Shelby Tube Sample	
		V1	18.5'	Vane	Shear Test		
		V2	28.5'	Vane	Shear Test		

BLOWS ON CASIN: 0-1, 1-2, 2-3, 3-4, 4-5, 5-6, 6-7, 7-8, 8-9, 9-10, 10-11, 11-12, 12-13, 13-14, 14-15, 15-16, 16-17, 17-18, 18-19, 19-20, 20-21, 21-22, 22-23, 23-24, 24-25, 25-26, 26-27, 27-28, 28-29, 29-30, 30-31, 31-32, 32-33, 33-34, 34-35, 35-36, 36-37, 37-38, 38-39, 39-40, 40-41, 41-42, 42-43, 43-44, 44-45, 45-46, 46-47, 47-48, 48-49, 49-50, 50-51, 51-52, 52-53, 53-54, 54-55, 55-56, 56-57, 57-58, 58-59, 59-60, 60-61, 61-62, 62-63, 63-64, 64-65, 65-66, 66-67, 67-68, 68-69, 69-70, 70-71, 71-72, 72-73, 73-74, 74-75, 75-76, 76-77, 77-78, 78-79, 79-80, 80-81, 81-82, 82-83, 83-84, 84-85, 85-86, 86-87, 87-88, 88-89, 89-90, 90-91, 91-92, 92-93, 93-94, 94-95, 95-96, 96-97, 97-98, 98-99, 99-100, 100-101, 101-102

GROUND WATER		
DEPTH	HOUR	DATE

PIPE AND CASING LEFT IN HOLE		
SIZE	AMOUNT	REASON
3/4"PVC Pipe	27.6'	Piezometer
	1	Piezometer
		Casing

DISTANCE HAMMER DROP ____ INCH
DRIVE HAMMER ____ LBS.
SPOON HAMMER ____ LBS.
CASING SIZE ____ INCH
SPOON SIZE ____ INCH
SIZE OF CORE BIT ____ INCH

NOTE: *Classification of soil has been made by the driller and has not been checked by a soils engineer. Classification of rock has been made by the driller and has not been checked by a geologist.

* Under Remarks mention kind of Bit, loss of sample, loss of Drilling water, soft seamy or broken Rock, Caving, Cavities, unusual Ground water conditions, etc., at depth encountered.

Driller Doug Nelson
Helper George Gares
Helper _____

301

Cherry Island

SPRAGUE & HENWOOD, Inc.

SCRANTON, PA.

FOUNDATION TESTING and SOIL SAMPLING RECORD

NAME: A.C. Schultes & Sons, Inc. LOCATION: Wilmington, Delaware

HOLE NO. GP-6 SURFACE ELEVATION _____ RIG NO. _____ DATE: From 8/10 To 8/12 19 83

BORING LOG: DEPTH FROM—TO	DESCRIPTION OF MATERIAL Based On Samples Recovered Plus Observation Of Material Returned Between Samples	SAMPLE NUMBER	DEPTH FROM—TO	BLOWS PER 6" ON SAMPLES	Sample D=DRY U=UNDISTURBED T=TRAP W=WASH R=ROD C=CORE / CORE RECOV'D	CORE RECOV'D — NO. PCS. REMARKS *
0.0' 30.0'	Gray organic silt	1	5.0' 6.5'	Push	1.5'	
		2	10.0' 11.5'	Push	0.5'	
30.0' 35.0'	Gray silt (sandy)	U3	15.0' 17.0'		2.0'	Shelby Tube
		4	20.0' 21.5'	Push	1.5'	
35.0' 50.0'	Gray silt	U5	25.0' 27.0'		2.0'	Shelby Tube
		6	30.0' 31.5'	5-4 4	1.2'	
50.0' 55.5'	Gray silt and peat	7	35.0' 36.5'	2-1 1	1.5'	
55.5' 60.0'	Clayey silt	U8	40.0' 42.0'		2.0'	Shelby Tube
		9	45.0' 46.5'	Push	1.5'	
60.0' 75.5'	Sand and gravel	10	50.0' 51.5'	2-3 4	1.5'	
		11	55.0' 56.5'	5-6 8	1.5'	
		12	60.0' 61.5'	10-21 55	1.5'	
		13	66.0' 67.5'	21-35 36	0.6'	Used 300 lb. hammer
		14	71.0' 72.5'	18-25 20	0.25'	Used 300 lb. hammer
			75.5'	Refusal 100 blows		Used 300 lb. hammer

BLOWS ON CASIN

0-1	51-52
1-2	52-53
2-3	53-54
3-4	54-55
4-5	55-56
5-6	56-57
6-7	57-58
7-8	58-59
8-9	59-60
9-10	60-61
10-11	61-62
11-12	62-63
12-13	63-64
13-14	64-65
14-15	65-66
15-16	66-67
16-17	67-68
17-18	68-69
18-19	69-70
19-20	70-71
20-21	71-72
21-22	72-73
22-23	[illegible]
23-24	[illegible]
24-25	[illegible]
25-26	76-77
26-27	77-78
27-28	78-79
28-29	79-80
29-30	80-81
30-31	81-82
31-32	82-83
32-33	83-84
33-34	84-85
34-35	85-86
35-36	86-87
36-37	87-88
37-38	88-89
38-39	89-90
39-40	90-91
40-41	91-92
41-42	92-93
42-43	93-94
43-44	94-95
44-45	95-96
45-46	96-97
46-47	97-98
47-48	98-99
48-49	99-100
49-50	100-101
50-51	[illegible]

GROUND WATER

DEPTH	HOUR	DATE
Top of ground		

PIPE AND CASING LEFT IN HOLE

SIZE	AMOUNT	REASON
3/4"	42.2'	Piezometer Point

DISTANCE HAMMER DROP 24-30 INCH
DRIVE HAMMER 300 LBS.
SPOON HAMMER 140 LBS.
CASING SIZE _____ INCH
SPOON SIZE 2 INCH
SIZE OF CORE BIT _____ INCH

NOTE: *Classification of soil has been made by the driller and has not been checked by a soils engineer. Classification of rock has been made by the driller and has not been checked by a geologist.

* Under Remarks mention kind of Bit, loss of sample, loss of Drilling water, soft seamy or broken Rock, Caving, Cavities, unusual Ground water conditions, etc., at depth encountered.

Driller Carl Ward

Helper Ronald Dowdy

Helper George Gares

Contract # 19991
Cherry Island

SPRAGUE & HENWOOD, Inc.
SCRANTON, PA.

FOUNDATION TESTING and SOIL SAMPLING RECORD

NAME: A.C. Schultes & Sons, Inc. LOCATION: Wilmington, Delaware

HOLE NO. GP-6A SURFACE ELEVATION _____ RIG NO. _____ DATE: From 8/15 To 8/15 19 83

BORING LOG		SPOON SAMPLE AND CORE DATA					BLOWS ON CASI
DEPTH FROM—TO	DESCRIPTION OF MATERIAL Based On Samples Recovered Plus Observation Of Material Returned Between Samples	SAMPLE NUMBER	DEPTH FROM—TO	BLOWS PER FT. ON SAMPLES	ROCK CORE RECOV'D	D=DRY U=UNDISTURBED T=TRAP W=WASH R=ROD C=CORE CORE RECOV'D — NO. PCS. REMARKS *	
0.0' 30.0'	Gray organic silt		No Samples Required				
			20.5' — Took Vane Shear Test (Bottom of Vane)				

0-1	51-52
1-2	52-53
2-3	53-54
3-4	54-55
4-5	55-56
5-6	56-57
6-7	57-58
7-8	58-59
8-9	59-60
9-10	60-61
10-11	61-62
11-12	62-63
12-13	63-64
13-14	64-65
14-15	65-66
15-16	66-67
16-17	67-68
17-18	68-69
18-19	69-70
19-20	70-71
20-21	71-72
21-22	72-73
22-23	73-74
23-24	74-75
24-25	75-76
25-26	76-77
26-27	77-78
27-28	78-79
28-29	79-80
29-30	80-81
30-31	81-82
31-32	82-83
32-33	83-84
33-34	84-85
34-35	85-86
35-36	86-87
36-37	87-88
37-38	88-89
38-39	89-90
39-40	90-91
40-41	91-92
41-42	92-93
42-43	93-94
43-44	94-95
44-45	95-96
45-46	96-97
46-47	97-98
47-48	98-99
48-49	99-100
49-50	100-101
50-51	101-102

GROUND WATER

DEPTH	HOUR	DATE
Top of	Ground	

PIPE AND CASING LEFT IN HOLE

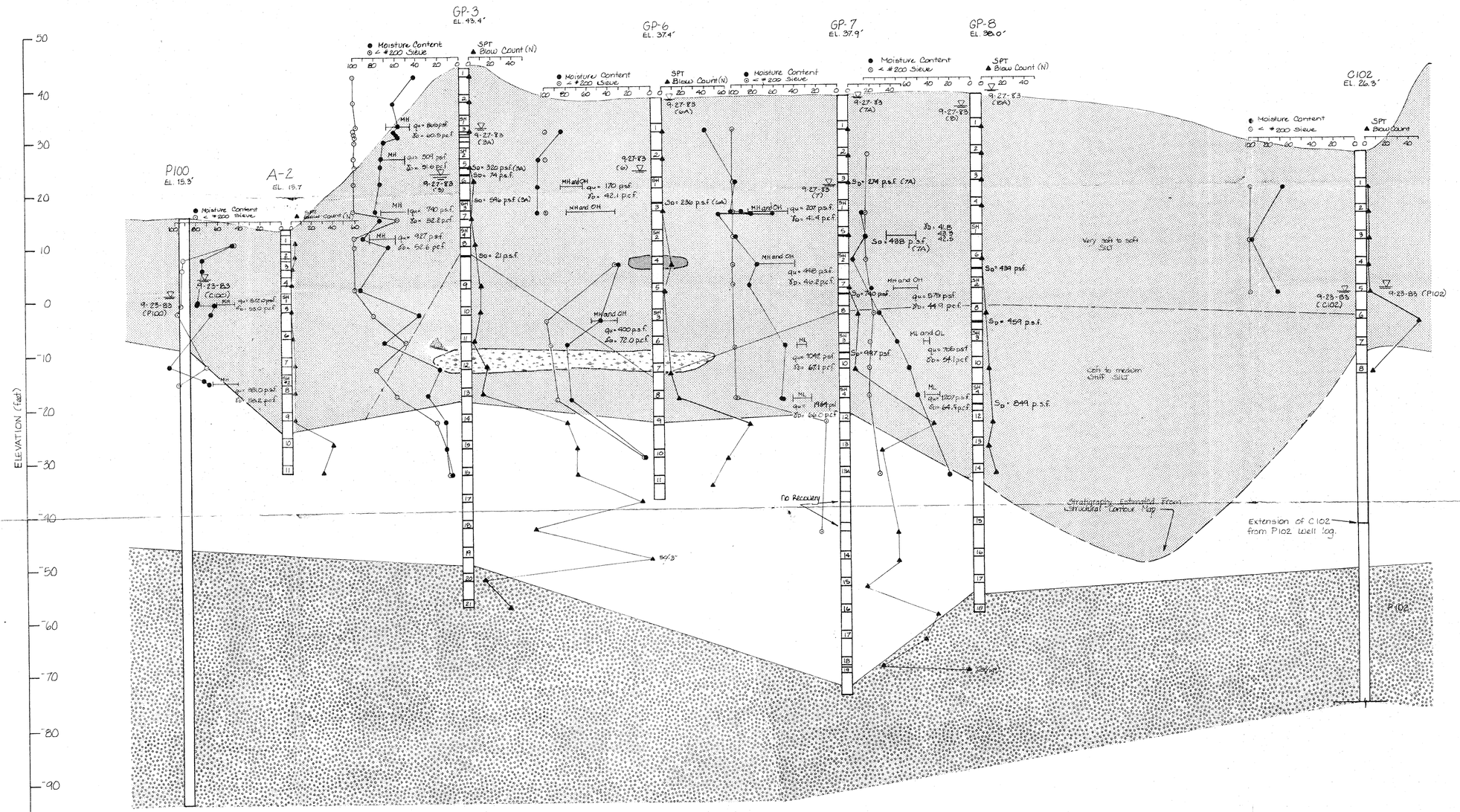
SIZE	AMOUNT	REASON
3/4"	29.6'	Piezometer Point

DISTANCE HAMMER DROP _____ INCH
DRIVE HAMMER _____ LBS.
SPOON HAMMER _____ LBS.
CASING SIZE _____ INCH
SPOON SIZE _____ INCH
SIZE OF CORE BIT _____ INCH

NOTE: *Classification of soil has been made by the driller and has not been checked by a soils engineer. Classification of rock has been made by the driller and has not been checked by a geologist.

* Under Remarks mention kind of Bit, loss of sample, loss of Drilling water, soft seamy or broken Rock, Caving, Cavities, unusual Ground water conditions, etc., at depth encountered.

Driller Carl Ward
Helper Ronald Dowdy
Helper George Gares



SECTION E-E

Scale:
Horz: 1" = 200'
Vert: 1" = 10'

DATA COMPILED BY DUFFIELD ASSOCIATES

General Key

SPT Blow Count (N)	Standard Penetration Test (ASTM D-1586) Blow Count (N) Defined as the number of 30 inch drops required for a 140 lb hammer to drive a 2 inch O.D. Sampler 12 inches
7	Indicates Standard Penetration Test Sample
SH	Indicates Shelby Tube Sample
MH	USCS Classification
Liquid Limit — Natural Moisture Content — Plastic Limit	
▼	Groundwater Elevation and Date
q_u	Unconfined Shear Strength
γ_D	Dry Density
S_D	Shear Strength By Field Vane Test (with Bjerrum Correction)

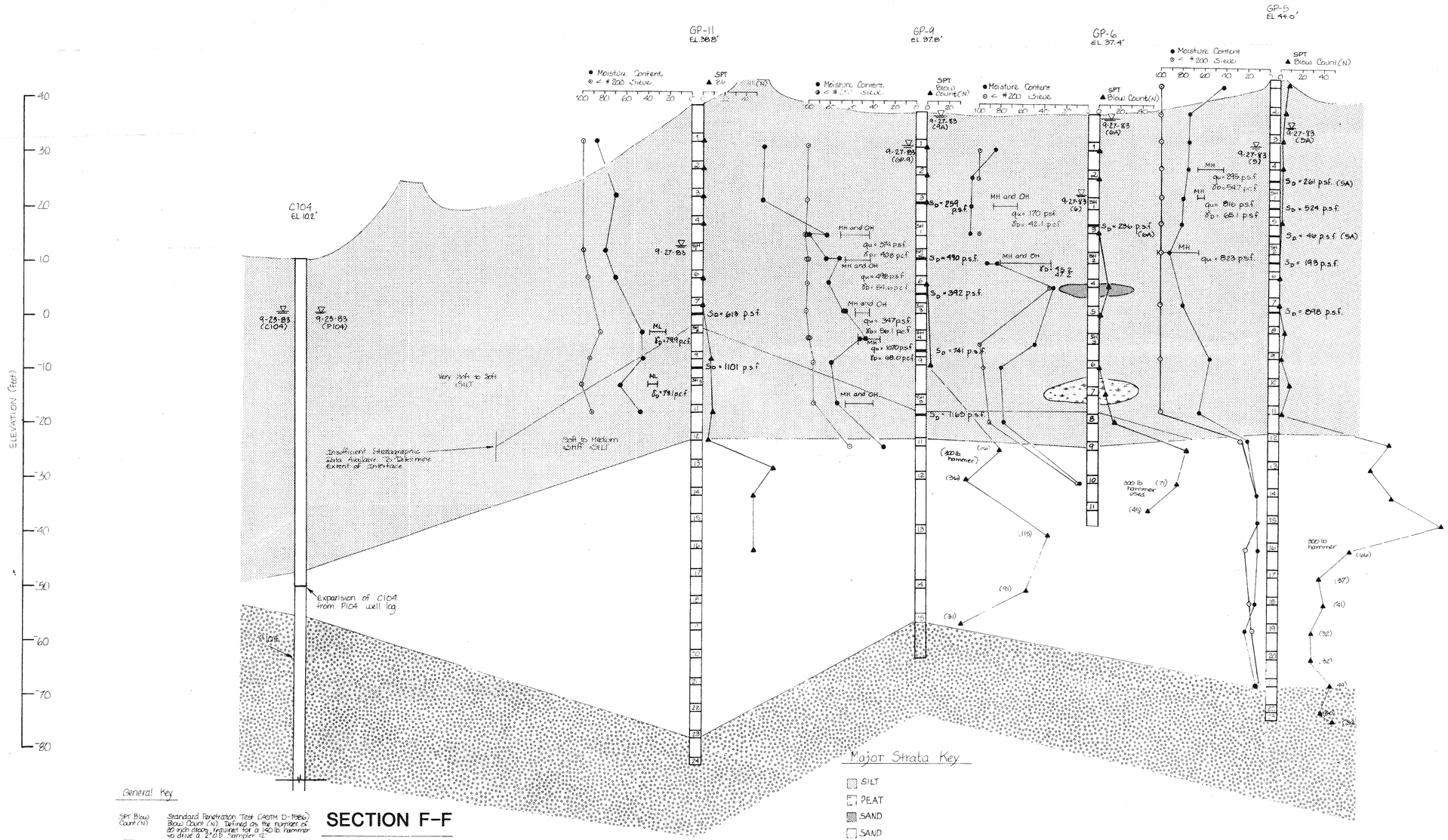
Major Strata Key

- SILT
- PEAT
- SAND
- SAND
- SILT/CLAY

NOTES:

1. See text for more detailed description of subsurface soils.
2. See boring location plan for section locations.
3. Strata profiles are based on straight line interpolation between test borings and the driller's estimate of conditions between samples. Actual soil conditions between test borings are unknown.
4. The Standard Penetration Test "N" value is determined over a specific interval. Lines between "N" values are shown for comparison purposes only.

FIGURE 3-3
GEOTECHNICAL CROSS SECTION E-E
CHERRY ISLAND



SECTION F-F

Scale:
Horz.: 1" = 200'
Vert.: 1" = 10'

DATA COMPILED BY DUFFIELD ASSOCIATES

General Key

SPT Blow Count (N)	Standard Penetration Test (ASTM D-1586) Blow Count (N) Defined as the number of 30 inch drops required for a 140 lb. hammer to drive a 2" O.D. "sampler 12"
7	Indicates Standard Penetration Test Sample.
5H	Indicates Shelby Tube Sample.
MH — Liquid Limit — Natural Moisture Content — Plastic Limit	USCS Classification
▼	Groundwater Elevation and Date.
qu	Unconfined Shear Strength
δd	Dry Density
Sv	Shear Strength by Field Vane Test (with Bjerrum Correction)

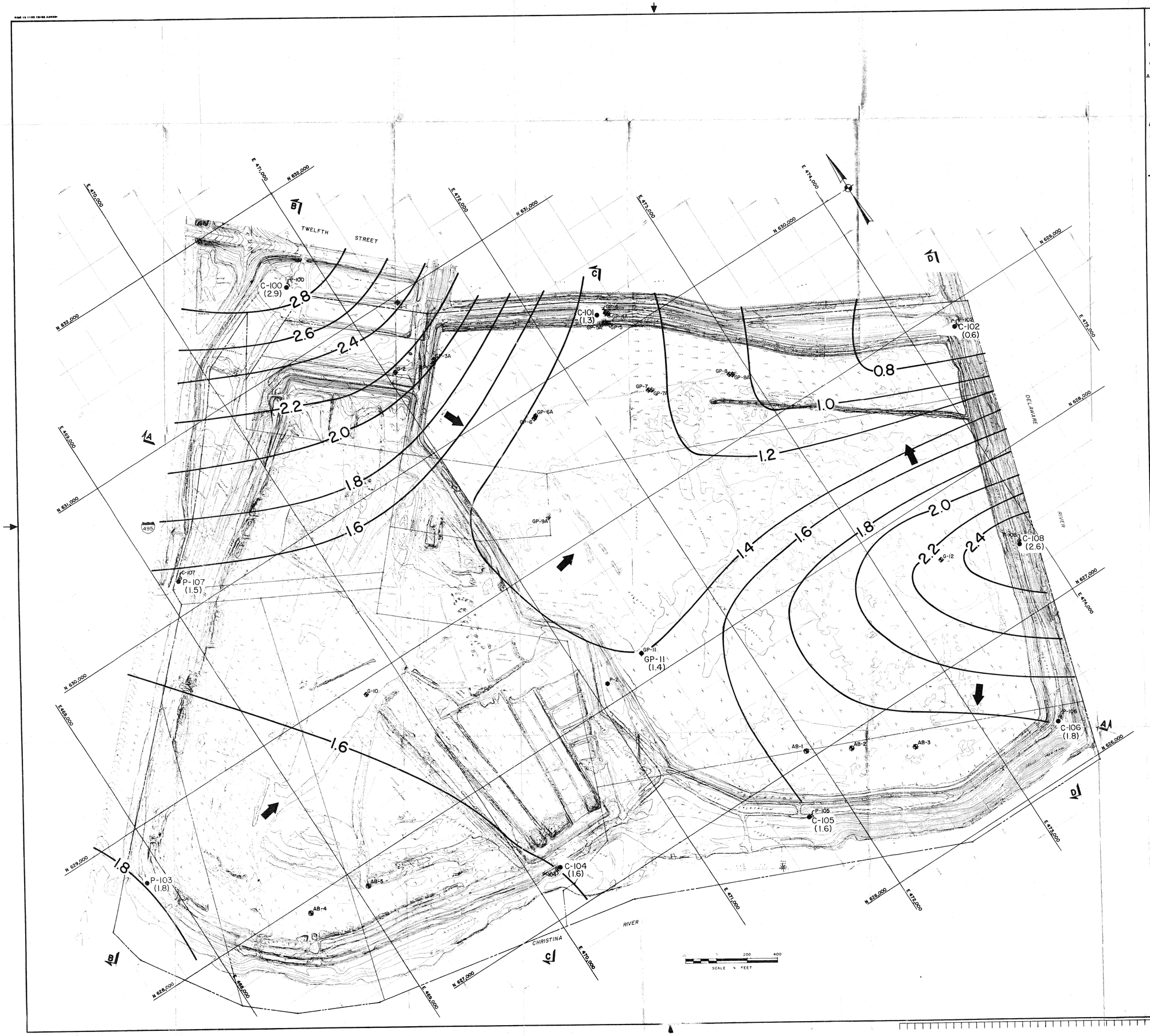
Major Strata Key

- SILT
- PEAT
- SAND
- SAND
- SILT/CLAY

Notes:

1. See text for more detailed description of subsurface soils.
2. See boring location plan for section locations.
3. Strata profiles are based on straight line interpolation between test borings and the driller's estimate of conditions between samples. Actual soil conditions between test borings are unknown.
4. The Standard Penetration Test "N" value is determined over a specific interval. Lines between "N" values are shown for comparison purposes only.

FIGURE 3-4
GEOTECHNICAL CROSS SECTION F-F
CHERRY ISLAND



LEGEND

- G-1 GEOTECHNICAL BORING
- GP-7 GEOTECHNICAL BORING WITH DEEP PIEZOMETER
- GP-7A GEOTECHNICAL BORING WITH SHALLOW PIEZOMETER
- AB-3 AUGER BORING
- RECENT DEPOSIT MONITORING WELL
- COLUMBIA FORMATION MONITORING WELL
- POTOMAC FORMATION MONITORING WELL
- A A GEOLOGIC CROSS-SECTION
- P-2 POTOMAC FORMATION MONITORING WELL (DRILLED IN SEPT. 1981)
- (2.6) GROUNDWATER ELEVATION (SEPTEMBER 23, 1983)
- 1.0 POTENTIOMETRIC SURFACE CONTOUR (EL. IN FEET)
- GROUNWATER FLOW DIRECTION

NO.	DATE	MADE	CHKD.	DESCRIPTION	APPVD.

REVISIONS

DELAWARE SOLID WASTE AUTHORITY

WILMINGTON, DELAWARE — CHERRY ISLAND

NORTHERN SOLID WASTE FACILITY

POTENTIOMETRIC SURFACE MAP

COLUMBIA FORMATION

TERRAQUA RESOURCES CORPORATION
Engineers and Consultants

King of Prussia, Pa.
Hunt Valley, Md.
Reading, Pa.

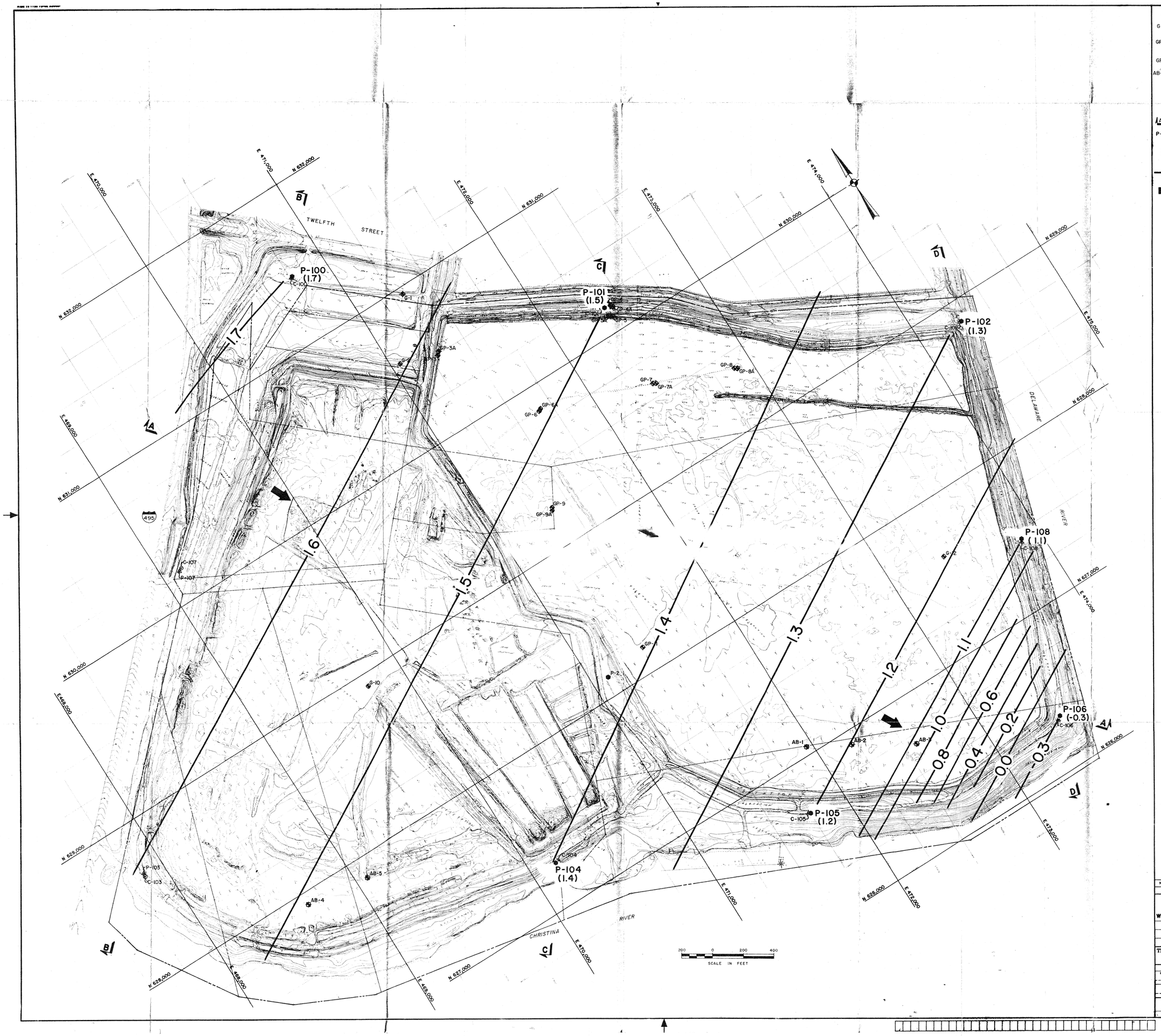
DRAFTING: MADE / CHECKED — ENGINEERING INTERFACES: 1. 2. 3. 4.

APPROVED

ENGINEER APPROVAL — DEPT. — DATE

FIGURE 2-7

W.O. — DRAWING NUMBER — REV



LEGEND

- G-1 GEOTECHNICAL BORING
- GP-7 GEOTECHNICAL BORING WITH DEEP PIEZOMETER
- GP-7A GEOTECHNICAL BORING WITH SHALLOW PIEZOMETER
- AB-3 AUGER BORING
- RECENT DEPOSIT MONITORING WELL
- COLUMBIA FORMATION MONITORING WELL
- POTOMAC FORMATION MONITORING WELL
- A A' GEOLOGIC CROSS-SECTION
- P-2 POTOMAC FORMATION MONITORING WELL (DRILLED IN SEPT. 1981)
- (1.6) GROUNDWATER ELEVATION (SEPTEMBER 23, 1983)
- 1.6 POTENTIOMETRIC SURFACE CONTOUR (EL. IN FEET)
- GROUNDWATER FLOW DIRECTION

NO.	DATE	MADE	CHKD.	DESCRIPTION	APPVD.
				REVISIONS	

DELAWARE SOLID WASTE AUTHORITY

WILMINGTON, DELAWARE — CHERRY ISLAND

NORTHERN SOLID WASTE FACILITY

POTENTIOMETRIC SURFACE MAP

POTOMAC FORMATION

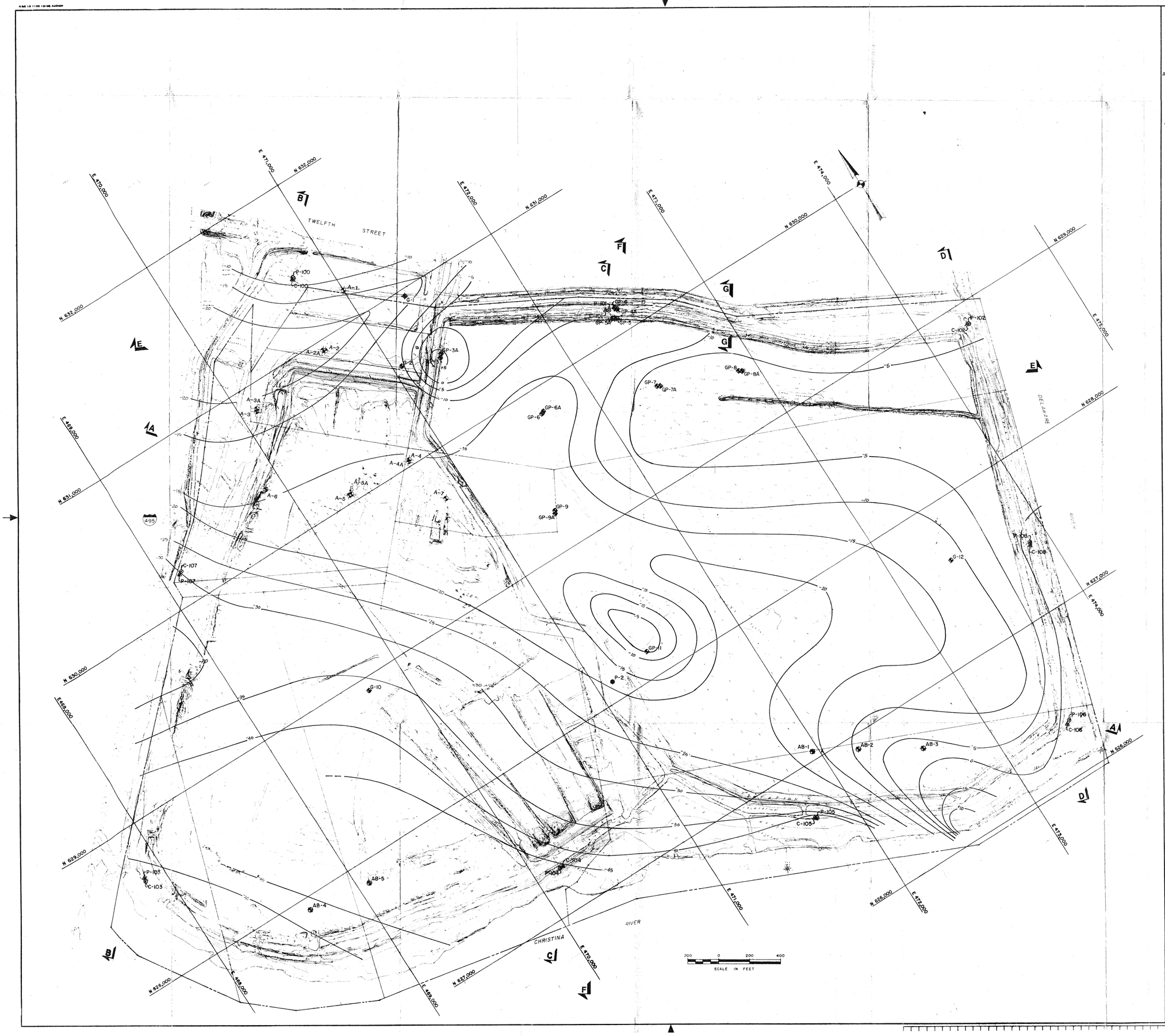
TERRAQUA RESOURCES CORPORATION
Engineers and Consultants

King of Prussia, Pa.
Heat Valley, Md.
Reading, Pa.

DRAFTING		ENGINEERING INTERFACES			
MADE	CHECKED	1.	2.	3.	4.
APPROVED					
		ENGINEER APPROVAL	DATE		

FIGURE 2-8

W.O. — DRAWING NUMBER — REV



LEGEND

G-1	GEOTECHNICAL BORING
GP-7	GEOTECHNICAL BORING WITH DEEP PIEZOMETER
GP-7A	GEOTECHNICAL BORING WITH SHALLOW PIEZOMETER
AB-3	AUGER BORING
	RECENT DEPOSIT MONITORING WELL
	COLUMBIA FORMATION MONITORING WELL
	POTOMAC FORMATION MONITORING WELL
A A	GEOLOGIC CROSS-SECTION
P-2	POTOMAC FORMATION MONITORING WELL (DRILLED IN SEPT. 1981)

NO.	DATE	MADE	CHKD.	DESCRIPTION	APPVD.

REVISIONS

DELAWARE SOLID WASTE AUTHORITY

WILMINGTON, DELAWARE — CHERRY ISLAND

NORTHERN SOLID WASTE FACILITY

STRUCTURAL CONTOUR MAP

BASE OF LOW SHEAR STRENGTH SOILS

TERRAQUA RESOURCES CORPORATION
Engineers and Consultants
King of Prussia, Pa.
West Valley, Md.
Reading, Pa.

DRAFTING		ENGINEERING INTERFACES			
MADE	CHECKED	1.	2.	3.	4.
APPROVED					
		ENGINEER APPROVAL		DEPT.	DATE

FIGURE 3-2

W.O. — DRAWING NUMBER — REV.