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Appendix B: Environmental Analysis

Appendix C: U.S. Fish and Wildlife Service Coordination

Appendix D: Engineering Technical

Appendix E: Economic Analysis

Appendix F: Real Estate Plan

Appendix G: Cultural Resources

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Appendix B

Environmental Analysis

AN EVALUATION AND ASSESSMENT OF THE BENTHIC MACROINVERTEBRATE RESOURCES OF THE PROPOSED SAND BORROW AREAS FOR LOWER CAPE MAY MEADOWS, NEW JERSEY

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FOREWORD

This report, entitled *An Evaluation and Assessment of the Benthic Macroinvertebrate Resources of the Proposed Sand Borrow Areas for Lower Cape May Meadows, New Jersey* was prepared by Versar, Inc., for Beth Brandreth, Environmental Resources Branch, U.S. Army Corps of Engineers, Philadelphia District, under Contract No. DACW61-95-D-0011.

EXECUTIVE SUMMARY

The U.S. Army Corps of Engineers (USACOE), Philadelphia District, has identified two potential borrow areas as sources of sand for shoreline replenishment activities for lower Cape May Meadows, New Jersey. Dredging sand for use in shoreline replenishment has potential environmental effects on macroinvertebrate resources in the dredged area. The USACOE intends to minimize the effects of dredging by selecting the borrow area with the greatest capacity to recover. To evaluate the impact on benthic resources, benthic macroinvertebrate communities and the abundance of commercially and recreationally important species in the borrow areas were compared with: (1) each other; (2) similar habitat adjacent to the borrow areas (reference sites); and (3) similar habitat within the lower Delaware Bay and nearby coastline (regional comparison).

A stratified random design was used to select 25 stations for benthic macroinvertebrate sampling within the borrow areas. Benthic samples were collected from the borrow areas and four reference sites with a Young-modified Van Veen grab-sampler to provide data on benthic community condition and sediment characteristics. Data from 7 studies conducted for the USACOE and U.S. Environmental Protection Agency (EPA) were used to represent similar habitats in the lower Delaware Bay and nearby coastline. Only samples collected with the same kind of gear from high salinity (polyhaline to marine), sand habitats were included in the comparison.

Analysis of variance of log-transformed data was used to compare measures of benthic community condition including diversity, abundance, and biomass. Large individuals (greater than 2 cm length) and species of commercial or recreational importance were also evaluated. Benthic community comparisons were conducted separately for reference and regional comparisons.

The data suggest that neither potential borrow site supports a unique or rare macroinvertebrate community that would preclude either site from being selected as a borrow source for shoreline replenishment activities. The taxa collected in the borrow areas were similar to each other, the reference sites, and to taxa collected from other studies in the region. In general, macroinvertebrate community attributes were similar between Borrow P1 and P2 and to the reference sites. Most of the significant differences between the borrow areas were attributed to the high abundance of two polychaete taxa in Borrow P1; however, these differences would not preclude selection of either site as a source for shoreline replenishment activities.

If supporting and maintaining a viable surf clam harvest is of special concern, then Borrow P2 may be the more appropriate source for dredge material. This site had a higher (not significant) number of small juvenile clams but both size and biomass data indicate that these juveniles may not be reaching harvestable size. Over 39% of the surf clams in Borrow P1 were greater than 2 cm length, suggesting that individual clams at this site may have a greater potential of reaching harvestable size than at Borrow P2. It is noted, however, that these

results are based on grab data; a clam survey would be a more appropriate method for estimating adult populations of surf clams.

Size data suggests that Borrow P1 also supports a greater proportion of large taxa than P2, even though the number of taxa with larger organisms is not significantly higher. The presence of a greater proportion of large organisms may indicate a more mature benthic community in Borrow P1 that may require a longer time frame to recover from dredging operations.

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1.0 INTRODUCTION

The U.S. Army Corps of Engineers (USACOE), Philadelphia District, is conducting a feasibility study to consider solutions to shoreline erosion and environmental restoration in the lower Cape May Meadows, located at the southern tip of New Jersey. This area is environmentally sensitive because it contains both fresh and brackish water wetlands. The USACOE is examining the use of beach replenishment as a means to protect the Cape May Meadows shoreline from erosion caused by storms as a critical component of the feasibility study. To offset erosion, the USACOE often employs shoreline replenishment, or the addition of sand dredged from a suitable borrow area, to affected shorelines. The USACOE has identified two potential borrow areas offshore of Cape May Meadows, New Jersey (Figure 1-1).

Dredging sand for shoreline replenishment can adversely affect macrobenthic resources. An immediate effect is the removal of existing benthic communities. Furthermore, altering the composition of the substrate may prevent recolonization by the original benthic community. Initial recolonization of disturbed areas is often dominated by opportunistic taxa that are uncharacteristic of mature benthic communities.

The purpose of this study was to describe the macroinvertebrate communities in the potential borrow areas and assist the USACOE in identifying which of the proposed borrow areas is the most appropriate source of sand for shoreline replenishment. The USACOE can minimize the effects of dredging by selecting a borrow area with the least potential impact on benthic resources. To evaluate this impact, benthic macroinvertebrate communities and the abundance of commercially and recreationally important species in the borrow areas were described and compared to: (1) each other; (2) similar habitat in an area adjacent to the borrow areas (reference area); and (3) similar habitats within the lower Delaware Bay.

This report includes six chapters and four appendices. Chapter 2.0 presents the sampling design, methods of sample collection, sample processing, and data analysis. Chapter 3.0 compares the benthic macroinvertebrate communities among the borrows, reference areas, and other regional studies. Chapter 4.0 describes the potential effects of dredging and placing of dredged sand on benthic communities. Chapter 5.0 presents conclusions and chapter 6.0 lists cited references. Appendix A is the scope of work. Appendix B contains the spatial coordinates for individual stations in each habitat of the borrow area. Appendix C contains the sediment grain-size distribution curves for each station. Appendix D contains station-specific abundance and biomass data. Appendix E provides a taxonomic list of all infaunal taxa collected and mean abundance for each area. Appendix F provides sampling location maps for the studies included in the regional comparisons.

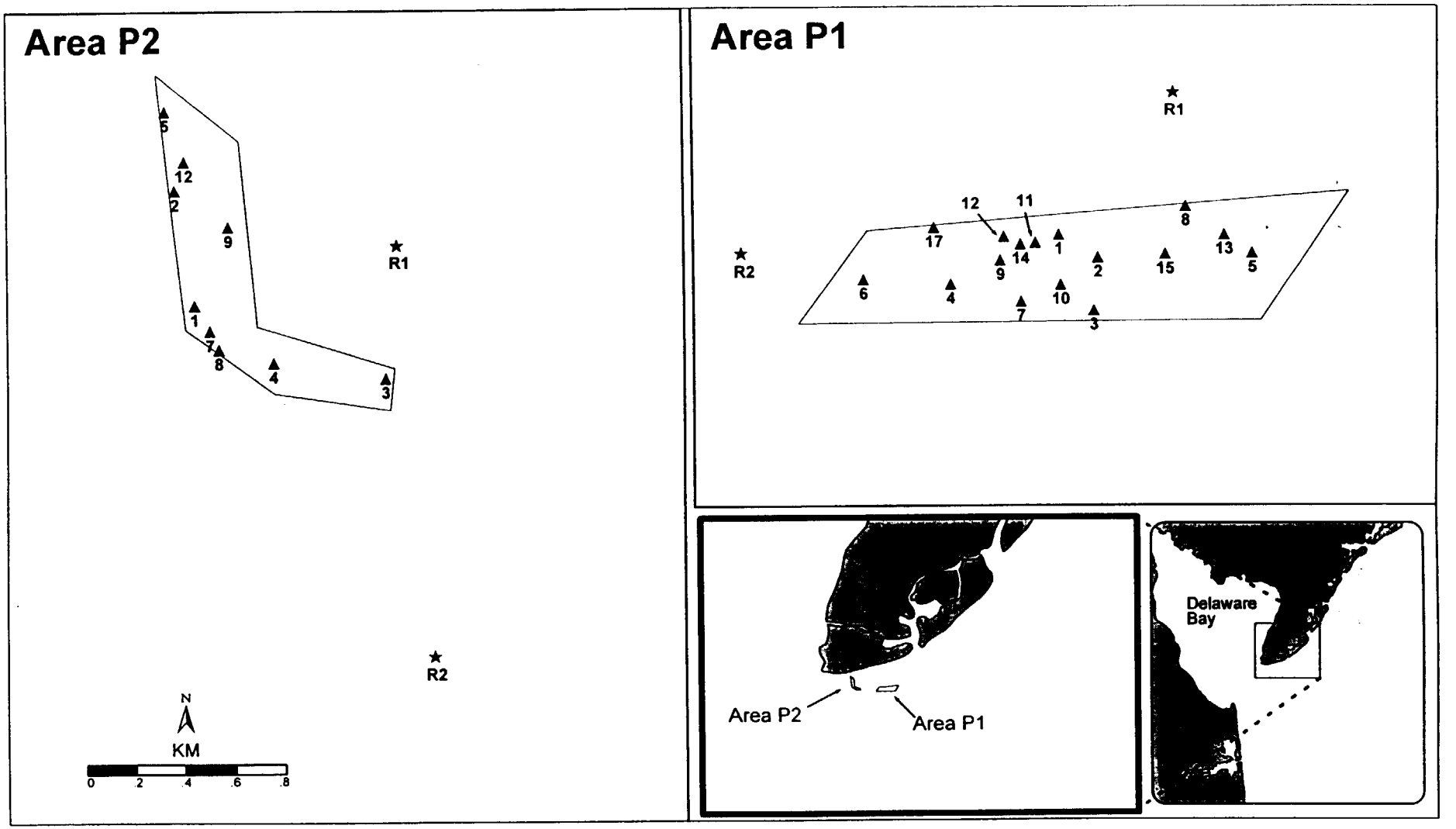

Figure 1-1. Station locations at the proposed borrow areas and reference sites in lower Cape May Meadows, New Jersey

2.0 METHODS

2.1 SAMPLING DESIGN

A stratified random design was used to select 25 stations for benthic macroinvertebrate sampling among the two borrow areas. Random selection of station locations allows statistically valid statements to be made about the benthic community condition within each area because each potential sampling site has an equal probability of being sampled. Twenty five stations were allocated to the borrow areas (Figure 1-1). The number of stations designated to each borrow area was proportional to the size of the area (Borrow area P1 has an area of approximately 250 acres and P2 has an area of approximately 150 acres). Sixteen stations were allocated to borrow area P1 and 9 stations to borrow area P2. Two reference stations were positioned near each borrow area with similar depth and sediment characteristics (a total of 4 stations). Sampling was conducted on September 23 and 24, 1996. Appendix B lists the location coordinates for stations in the borrow and reference areas.

2.2 SAMPLE COLLECTION METHODS

2.2.1 Station Positioning

Stations were located using a Trimble NT200D Differential Global Positioning System (DGPS) which is accurate to within 15 meters. After positioning the vessel on station, a portable computer linked directly to the DGPS recorded position coordinates at the rate of one record per second for three minutes. The 180 position records were averaged to obtain coordinates for a sampling station.

2.2.2 Sample Collection

Benthic and sediment samples were collected with a 0.044-m^2 stainless steel, Young-modified Van Veen grab sampler. Samples collected for benthic macroinvertebrates were sieved using a 0.5-mm screen and preserved in a 10% solution of buffered formaldehyde stained with rose bengal. Sediment samples for analysis of grain-size and total organic content (TOC) were obtained from a second grab and were frozen until laboratory processing. Water quality was not measured due to equipment failure. Several grab samples of surface water were collected and salinity was measured in the laboratory. Depth was recorded from the vessel's electronic depth meter (accurate to ± 0.3 meters depending on bottom type).

2.3 SAMPLE PROCESSING

2.3.1 Grain-size and Total Organic Content

Grain-size analysis was performed according to ASTM Method D422-63. Sieve sizes ranged from 4.25 mm (U.S. Standard Sieve No. 4) to 63 μm (U.S. Standard Sieve No. 230). TOC was measured by weight loss upon ignition at 500° C for 4 hours in a muffle furnace. Appendix C contains grain-size curves for each station. Appendix D contains TOC values for each station.

2.3.2 Benthic Macroinvertebrates

Benthic organisms were sorted from debris using a dissecting microscope, identified to the lowest practical taxonomic category, and counted. Organisms longer than 2 cm were also counted separately. Organisms were grouped according to the lowest taxonomic level to determine ash-free dry weight biomass. Ash-free dry weight provides a more accurate measure of carbon available to higher trophic levels as compared to dry weight. Ash-free dry weight biomass was determined by drying each taxon at 60°C to a constant weight and ashing in a muffle furnace at 500°C for 4 hours. Appendix D contains station-specific abundance and biomass data.

2.4 DATA ANALYSIS

To assist USACOE in identifying the borrow area with the least potential impact on benthic resources, benthic community conditions were compared between (1) the two proposed borrow areas and the reference sites and (2) the borrow areas and data from previous studies in the lower Delaware Bay and nearby ocean shoreline sites with similar salinity and sediment characteristics (regional studies). The areas were evaluated based on three benthic community attributes: (1) abundance, (2) biomass, and (3) diversity. In addition, abundances of commercially or recreationally important species and abundances of large organisms (those with a size greater than 2 cm) were compared among the borrow areas and reference sites.

Seven studies conducted for the USACOE and U.S. Environmental Protection Agency (EPA) were included in the regional comparison. For these comparisons, only data collected with the 0.044-m^2 stainless steel, Young-modified Van Veen grab sampler were included. In addition, only stations with similar salinity (polyhaline to marine), silt/clay characteristics (less than 40% silt/clay), and depth (greater than 3 m) were included. USACOE studies contained in the regional comparison include Cape May Villas (Chaillou 1995a), MS-19 (Chaillou and Weisberg 1995), Roosevelt Inlet (Kelley and Scott 1996), Bethany Beach and South Bethany (Kelley et al. 1996), Brigantine Inlet to Great Egg Harbor Inlet (Brigantine I) (Chaillou 1995b), and Townsends Inlet to Cape May Inlet (Brigantine II) (Chaillou and Scott 1996). Station maps

for these studies are presented in Appendix F. The condition of the lower Delaware Bay was also represented by data from the U.S. EPA's Environmental Monitoring and Assessment Program (EMAP) (Strobel et al. 1995). These studies used the same sampling and processing methods as described above with the following exceptions: (1) EMAP measured shell-free dry weight biomass instead of ash-free dry weight; (2) MS-19 measured wet-weight biomass instead of ash-free dry weight; and (3) EMAP measured total organic carbon using CHN analysis instead of loss on ignition.

Analysis of variance (ANOVA) was used to compare benthic community attributes between the borrow areas and reference sites, and the borrow areas and regional areas. Mean values for selected benthic macroinvertebrate attributes were calculated by sampling area. One-way ANOVAs were conducted to determine if differences were statistically significant ($p < 0.05$). Data for each parameter were log-transformed before analysis to meet requirements for normality. Duncan's Multiple Range Test was performed to determine statistical differences between class variables.

Abundance, biomass, number of taxa, percentage of organisms with opportunistic life histories, and percentage of organisms with individuals greater than 2 cm were compared to assess differences in benthic community condition. In addition, sediment characteristics were compared between borrow areas and reference areas.

3.0 RESULTS

3.1 SEDIMENT CHARACTERISTICS

Sediments in both borrow areas and the reference sites were classified as sand with mean silt/clay values between 1.7 and 2.8% (Table 3-1). No significant difference between the borrow areas and the reference sites were detected for percent silt/clay.

Table 3-1. Means of sediment characteristics for the borrow areas and reference sites. Standard error of estimate in parenthesis. Means with the same letter are not significantly different as indicated by Duncan's Multiple Range Test.

Characteristic	Borrow P1	Borrow P2	Reference
Silt-clay (% < 63μ)	1.82[a] (0.17)	2.77[a] (1.53)	1.70[a] (0.47)
Total Organic Content (%)	0.47[a] (0.04)	0.32[a] (0.04)	0.44[a] (0.07)

Examination of the sediment grain curves, however, led to the detection of some subtle differences at specific stations within the borrow areas. For example, only one station in Borrow P1 (Station 6) had a silt-clay percentage less than 1%, whereas 4 stations in Borrow P2 had silt-clay percentages less than 1% (Stations 3, 4, 7, and 8; Appendix C). Additionally, these 4 stations were among 8 that had 75% of the sediment particles fall within the fine to medium sand category (Table 3-2). The other 21 stations had a larger percentage of coarse to very coarse sand particles (Appendix C).

Table 3-2. Sieve sizes used for sediment particle distribution analyses and the Wentworth sediment size classifications

Sieve Number	Sieve Size	Wentworth Size Category
4	4.75-mm	Pebble
10	2.00-mm	Granule
20	850-μm	Very Coarse Sand
40	850-μm	Coarse Sand
60	850-μm	Medium Sand
140	850-μm	Fine Sand
200	850-μm	Undefined
230	850-μm	Very Fine Sand
	850-μm	Silt-Clay

TOC was relatively low and was within expected ranges for sandy sediments. Mean TOC at Borrow P1 was 0.47%, at Borrow P2 was 0.32%, and at the reference sites was 0.44% (Table 3-1). TOC was not significantly different between the three sampling areas.

3.2 DESCRIPTION OF BENTHIC COMMUNITY

A total of 112 distinct infauna taxa were identified from the three sampling regions (Appendix E). Borrow P1 had 77, Borrow P2 had 76, and the reference sites had 68 distinct taxa. The total number of taxa and the mean number of taxa were within expected ranges for euhaline environments. Five of the top taxa from each sampling area were common among all three sampling areas (Table 3-3). Borrow P1 had 5 taxa that were not among the top abundant taxa in Borrow P2 (i.e., Nemertinea, Oligochaeta, *Turbonilla interrupta, Mysella planulata*, and *Tellina agilis*). Borrow P2 also had five dominant taxa that were not dominant in Borrow P1; two of which, *Donax variabilis* and *Parahaustorius longimerus*, were not even collected at Borrow P1 or the reference sites (Table 3-3). A list of taxa considered to be epifauna and were excluded from all analyses is presented in Table 3-4.

Table 3-3. Mean abundances (#/m^2) of the 10 most abundant infaunal taxa collected during macroinvertebrate sampling at the borrow areas and reference sites

Taxa	Borrow P1	Borrow P2	Reference
Nemertinea			
Nemertinea	106.5	35.4	198.9
Annelida : Polychaeta			
Amastigos caperatus	15.6	197.0	715.9
Caulleriella sp. B (Blake)	474.4	300.5	380.7
Paraprionosyllis longicirrata	72.4	598.5	318.2
Polycirrus eximius	5843.7	1123.7	278.4
Polygordius spp.	10994.3	1214.6	3846.6
Tharyx sp. A (Morris)	7.1	356.1	62.5
Annelida : Oligochaeta			
Oligochaeta	315.3	126.3	289.8
Mollusca : Gastropoda			
Turbonilla interrupta	166.2	5.1	0
Mollusca : Bivalvia			
Donax variabilis	0	199.5	0
Mysella planulata	119.3	48.0	17.1
Petricola pholadiformis	61.1	515.2	198.9
Spisula solidissima	169.0	275.3	170.5
Tellina agilis	208.8	131.3	198.9
Arthropoda : Amphipoda			
Parahaustorius longimerus	0	166.7	0

Table 3-4. Mean abundances (#/m^2) of epifaunal taxa collected during macroinvertebrate sampling at the borrow areas and reference sites.

Taxa	Borrow P1	Borrow P2	Reference
Annelida : Polychaeta			
Polynoidae	8.5	0	0
Sabellaria vulgaris	122.2	138.9	187.5
Mollusca : Gastropoda			
Crepidula maculosa	49.7	48.0	11.4
Crepidula plana	96.6	48.0	39.8
Crepidula spp.	56.8	65.7	51.1
Doridella obscura	59.7	22.7	17.1
Mollusca : Bivalvia			
Mytilus edulis	1.4	2.5	5.7
Arthropoda : Mysidacea			
Neomysis americana	0	2.5	0
Arthropoda : Isopoda			
Edotea triloba	5.7	0	0
Arthropoda : Amphipoda			
Batea catharinensis	4.3	25.3	5.7
Cerapus tubularis	0	5.1	0
Corophium spp.	0	7.6	0
Corophium tuberculatum	1.4	0	0
Microprotopus raneyi	51.1	2.5	11.4
Stenothoe minuta	0	10.1	0
Arthropoda : Decapoda			
Cancer irroratus	0	2.5	0
Crangon septemspinosa	7.1	0	0
Libinia spp.	1.4	0	0
Pagurus longicarpus	0	0	5.7
Pagurus spp.	54.0	22.7	28.4
Echinodermata : Echinoidea			
Echinoidea	2.8	0	0
Chordata : Ascidiacea			
Ascidiacea	69.6	2.5	392.0

3.3 MEASURES OF BENTHIC COMMUNITY CONDITION

3.3.1 Biodiversity

The mean number of taxa at each borrow area was within expected ranges for a euhaline environment. Borrow P2 had a lower mean number of taxa but was not significantly different than Borrow P1 or the reference sites (Table 3-5). The Shannon-Wiener Index and Simpson's Diversity Index calculated for each borrow area suggests that individuals within each taxa at Borrow P2 were more evenly distributed than at Borrow P1 (Table 3-5). Borrow P1 also had significantly lower mean diversity indices than the reference sites. The significantly lower diversity indices for Borrow P1 were most likely caused by the high abundance of two polychaete taxa (*Polycirrus eximius* and *Polygordius* spp., Table 3-3).

3.3.2 Abundance

Mean abundance of macroinvertebrates among the borrow areas was variable, with means differing by a factor of three; however, abundances were not significantly different between the borrow areas or between the borrow areas and the reference sites (Tables 3-5). The major contributors to the higher abundance in Borrow P1 were the polychaetes *Polycirrus eximius* and *Polygordius* spp. (Table 3-3). This was reflected in the mean abundance by major group. (i.e. amphipods, bivalves, and polychaetes); total mean polychaete abundance was significantly higher at Borrow P1 than at P2 (Table 3-5).

3.3.3 Biomass

Total mean biomass was significantly lower at Borrow P2 than at Borrow P1 and the reference sites (Table 3-5). Bivalves were the major group contributing to the significantly lower biomass at Borrow P2. Mean bivalve biomass was significantly lower at Borrow P2 than at P1. Bivalve biomass was so low at this borrow site that the mean biomass of amphipods and polychaetes was greater than the mean bivalve biomass. This is unusual because bivalves are typically the major contributors to biomass in euhaline environments. Mean polychaete biomass was also significantly lower at Borrow P2 than at P1 but was not significantly lower than the reference sites (Table 3-5).

The dominant taxon contributing to the bivalve biomass at all three sampling areas was the commercially valuable, surf clam, *Spisula solidissima*. Biomass of this species was significantly lower at Borrow P2 than at P1 (see Table 3-7).

Table 3-5. Means of benthic attributes for the borrow areas and reference sites. Standard error in parenthesis. Means with the same letter are not significantly different as indicated by Duncan's Multiple Range Test.

Attribute	Borrow P1	Borrow P2	Reference
Number of Taxa (#/Sample)	27.4[a] (1.6)	21.8[a] (3.8)	27.5[a] (4.4)
Shannon-Wiener Index	2.12[b] (0.17)	2.99[a] (0.18)	3.24[a] (0.29)
Simpson's Diversity Index	0.59[b] (0.04)	0.81[a] (0.03)	0.79[a] (0.06)
Total Abundance (#/m^2)	19,430[a] (4,081)	6,462[a] (2,141)	8,233[a] (3,415)
Amphipod Abundance (#/m^2)	65[a] (14)	513[a] (224)	358[a] (208)
Bivalve Abundance (#/m^2)	668[a] (92)	1,311[a] (366)	670[a] (190)
Polychaete Abundance (#/m^2)	17,972[a] (4,020)	4,237[b] (1,886)	6,483[a,b] (3,310)
Biomass (g/m^2) (ash-free)	12.2[a] (2.8)	1.7[b] (0.5)	23.5[a] (13.9)
Amphipod Biomass (g/m^2) (ash-free)	0.005[a] (0.002)	0.211[a] (0.125)	0.049[a] (0.031)
Bivalve Biomass (g/m^2) (ash-free)	9.87[a] (2.59)	0.19[b] (0.05)	7.09[a,b] (6.72)
Polychaete Biomass (g/m^2) (ash-free)	1.60[a] (0.31)	0.38[b] (0.13)	0.61[a,b] (0.30)
Number of samples	16	9	4

3.4 LARGE ORGANISMS

In general, benthic communities possessing large individuals of many taxa suggest a long-lived, established benthic community. Such communities usually require a long period of time to recover from a disturbance (Warwick 1986; Dauer 1993).

The total number of taxa with individuals greater than 2 cm length was similar among the borrow areas and reference sites (Table 3-6). Since the total number of taxa can be

dependant on the number of samples, a more preferable means of examination is by mean number of taxa with individuals greater than 2 cm length. Borrow P1 had the highest mean number of taxa but was not significantly greater than Borrow P2 (Table 3-6). Borrow P1 also had the greater percentage of organisms with lengths greater than 2 cm than both Borrow P2 and the reference sites (Table 3-6). Borrow P2 had no bivalves with lengths greater than 2 cm; specifically, no individual *Spisula solidissima* in Borrow P2 had a length greater than 2 cm (Table 3-6).

Table 3-6. Percentage of organisms longer than 2 cm collected in the borrow areas and reference sites (zeros indicate species less than 2 cm were not collected; no value indicates species was not collected). Mean number of taxa with the same letter are not significantly different as indicated by Duncan's Multiple Range Test.

Taxon	Borrow P1	Borrow P2	Reference
Nemertinea			
Nemertinea	0.63	9.26	0
Annelida : Polychaeta			
Ancistrosyllis hartmanae	1.04		0
Diopatra cuprea		11.11	
Dispio uncinata		16.67	
Drilonereis longa	12.50		25.00
Glycera americana			25.00
Glycera dibranchiata	43.75	0	0
Hemipodus roseus	11.98	0	25.00
Hypereteone foliosa	6.25		
Magelona spp.		5.56	
Nephtys picta	18.75		
Notocirrus spiniferus	6.25	11.11	25.00
Notomastus luridus	12.50		
Onuphis eremita		11.11	
Owenia fusiformis	0.69		0
Phyllodoce arenae	6.25	0	30.00
Polydora socialis	0	5.56	0
Polygordius spp.	0	0	10.00
Sigalion arenicola		11.11	
Mollusca : Gastropoda			
Nassarius trivittatus	0	11.11	0
Polinices duplicatus	0		25.00

Table 3-6. Cont'd

Taxon	Borrow P1	Borrow P2	Reference
Mollusca : Bivalvia			
Ensis directus	40.63		
Pandora gouldiana	0		25.00
Spisula solidissima	39.22	0	20.45
Arthropoda : Decapoda			
Callianassa setimanus	0	11.11	
Total Number of Taxa	13	10	9
Mean Number of Taxa (Standard Error)	2.7[a] (0.4)	1.3[a] (0.2)	2.5[a] (0.6)

3.5 SPECIES OF COMMERCIAL OR RECREATIONAL IMPORTANCE

The only species considered commercially or recreationally important that was collected from the borrow areas and reference sites was the surf clam, *Spisula solidissima*. Borrow P2 had the greater abundance of surf clam (though not significantly), but the biomass of this species was extremely low and was significantly lower than Borrow P1 and the reference sites (Table 3-7). In Borrow P1, 39% of the surf clams collected had lengths greater than 2 cm (Table 3-6). No individuals greater than 2 cm length were collected in Borrow P2. This suggests that although juvenile surf clams settled and survived in Borrow P2, they may not be reaching older life stages.

Table 3-7. Mean abundance (#/m^2) and mean biomass (g/m^2) of the commercially and recreationally important species *Spisula solidissima* in the borrow areas and reference sites. Standard error in parenthesis. Means with the same letter are not significantly different as indicated by Duncan's Multiple Range Test.

Attribute	Borrow P1	Borrow P2	Reference
Abundance	169.0[a] (28.7)	275.3[a] (100.2)	170.5[a] (83.2)
Biomass	9.15[a] (2.61)	0.07[b] (0.02)	6.82[a,b] (6.8)

3.6 REGIONAL COMPARISONS

The macrobenthic assemblages present in the borrow areas of this study were similar to the assemblages found in the regional studies included in this analysis (Chaillou 1995a; Kelley and Scott 1996; Chaillou 1995b; Chaillou and Scott 1996; Kelley et al. 1996; Chaillou and Weisberg 1995). The majority of the taxa present in the borrow areas have been collected from at least some of the other regional studies indicating that neither borrow site contains a unique or rare benthic assemblage. Means for the specific attributes examined from all regional studies varied widely (Table 3-8). ANOVA analysis results for the regional comparisons indicated that the two potential borrow areas at Cape May Meadows supports a macroinvertebrate community with similar attributes to other sites in the vicinity (Table 3-8). For the most part, individual attributes from Borrow P1 and P2 were typically not significantly different from the other regional studies. One major difference detected by the regional comparison was in the bivalve biomass at Borrow P2; P2 had significantly lower bivalve biomass than 4 of the 5 applicable regional studies (Table 3-8).

Table 3-8. Means of benthic macroinvertebrate attributes for the borrow areas and regional studies. Studies that are not statistical different from the borrow areas as indicated by the Duncan's Multiple Range test are presented in parentheses. Borrow P1 is denoted by (a) and Borrow P2 is denoted by (b). (Chaillou 1995a; Kelley and Scott 1996; Chaillou 1995b; Chaillou and Scott 1996; Kelley et al. 1996; Chaillou and Weisberg 1995)

Attribute	Borrow P1	Borrow P2	Cape May Villas	Roosevelt Inlet	Brigantine I	Brigantine II	Bethany Beach	MS19B	Lower Delaware Bay (EMAP)
Number of Taxa (#/Sample)	27.4	21.8	22.1 (a,b)	21.5 (a,b)	8.8 (b)	14.9 (a,b)	18.7 (a,b)	32.4	32.6
Shannon-Wiener Index	2.12	2.99	2.55 (a,b)	2.91 (b)	1.91 (a)	2.26 (a)	2.91 (b)	3.23 (b)	3.00 (b)
Simpson's Diversity Index	0.59	0.81	0.64 (a)	0.77 (b)	0.60 (a)	0.64 (a)	0.78 (b)	0.82 (b)	0.73 (b)
Total Abundance (#/m^2)	19,430	6,462	13,829 (a,b)	5,375 (a,b)	1,484 (b)	4,988 (a,b)	4,907 (a,b)	5,278	6,170
Total Biomass (g/m^2)	12.6	1.7	4.0 (b)	3.7 (b)	78.0	2.8 (b)	7.8 (a)	N/A	N/A
Amphipod Abundance (#/m^2)	65	512	7,339 (b)	54 (a)	1,106 (b)	2,666 (b)	293 (a,b)	618 (a)	606 (a)
Amphipod Biomass (g/m^2)	0.005	0.21	0.60 (b)	0.01 (a,b)	0.07 (a,b)	0.15 (a,b)	0.06 (a,b)	N/A	N/A
Bivalve Abundance (#/m^2)	668	1,311	668 (a,b)	618 (a,b)	175	133	1,789 (a,b)	1,424	602
Bivalve Biomass (g/m^2)	9.87	0.19	2.07	2.65	77.2	1.98 (b)	6.79 (a)	N/A	N/A
Polychaete Abundance (#/m^2)	17,973	4,237	4,141 (a,b)	2,679 (a,b)	170 (b)	1,598 (b)	2,328 (b)	2,117	4,005
Polychaete Biomass (g/m^2)	1.60	0.38	0.86 (b)	0.57 (b)	0.12 (b)	0.30 (b)	0.39 (b)	N/A	N/A

4.0 ASSESSMENT OF POTENTIAL EFFECTS ON THE BENTHIC COMMUNITY

Dredging of sediments for shoreline replenishment activities has immediate localized effects on the benthic macroinvertebrate community in the affected area. The most direct effect is the removal of the existing natural and established benthic community. Survival of organisms in the vicinity of dredging operations varies widely and is dependent on the hydraulics of the site. Mechanical disturbance of the substrate may generate suspended sediments and increase turbidity in the immediate vicinity of the dredging operation (Naqvi and Pullen 1982). Reduced penetration of light through the water can affect settlement of larvae by delaying their final descent and subjecting them to increased predation (Thorson 1964). Depth and tidal currents influence the spread of sediments and turbidity.

The modification of the habitat by altering the sediment substrate is another potential affect in the immediate area after dredging operations. Removing the original substrate by dredging may uncover sediments of different composition that may be unsuitable for the existing benthic community. For example, changing from a coarse sand sediment to a muddy sediment will significantly change the composition of the benthic assemblage at a site (Maurer et al. 1978). The effect of changing from muddy-sand to mud would be less severe (Maurer et al. 1978).

In addition to the physically disruptive effects of dredging, a long-term environmental concern is the recolonization of the dredged area. The benthic community is initially decimated but recolonization can be fairly rapid taking typically three months to a year for a complete recovery (Saloman et al. 1982; Van Dolah et al. 1984; Hirsch et al. 1978). Timing of dredging operations before major recruitment periods can increase the rate of initial recovery. The disturbed area is initially recolonized by larval recruitment and horizontal migration from adjacent, unaffected areas (Van Dolah et al. 1984; Oliver et al. 1977). Rapid faunal recovery may be promoted by the immigration of benthic organisms via transport from slumping sediment walls of the borrow pit (Van Dolah et al. 1984).

Initial recolonization is dominated by opportunistic taxa whose reproductive capacity is large and environmental requirements are often flexible enough to allow them to occupy disturbed areas (Boesch and Rosenberg 1981; McCall 1977). With additional time (several months to several years) and if optimal environmental conditions exist, the initial surface-dwelling opportunistic taxa will be replaced by benthic taxa that represent a more mature community.

5.0 CONCLUSIONS

The data suggest that neither borrow area supports a unique or rare macroinvertebrate community that would preclude either site from being selected as a borrow source for shoreline replenishment activities. Macroinvertebrate community attributes were similar between Borrow P1 and P2 and to the reference sites. Significant differences between the borrow areas were detected in the Shannon-Wiener Index, Simpson's Diversity Index, and polychaete abundance. These differences were attributed to the high abundance of two polychaete taxa (*Polycirrus eximius* and *Polygordius* spp) in Borrow P1. These differences would not preclude selection of either site as a source for shoreline replenishment activities.

The taxa collected in the borrow areas were similar to each other, the reference sites, and to the regional areas. An exception was the dominate presence of the bivalve *Donax variabilis* and the amphipod *Parahauystorius longimerus* at Borrow P2. However, these two species are generally ubiquitous in euhaline systems and in the Delaware region. Therefore, the large presence of these species in Borrow P2 and not in P1 should not prevent selection of P2 as the sediment source for shoreline replenishment activities.

If supporting and maintaining a viable surf clam harvest is of special concern, than Borrow P2 may be the more appropriate source for dredge material. This site had a higher (not significant) number of small juvenile surf clams, but size and biomass data indicate that these juveniles may not reach harvestable size. Over 39% of the surf clams in Borrow P1 were greater than 2 cm length, suggesting that individual clams at this site may have a greater potential of reaching harvestable size. It must be noted, however, that these results are based on grab data; a clam survey would be a more appropriate method for estimating adult populations of surf clams.

Size data also suggests that Borrow P1 supports a greater proportion of large taxa than P2, even though the number of taxa with larger organisms is not significantly higher. The presence of a greater proportion of large organisms may indicate that Borrow P1 will require a longer time frame to recover from dredging operations (Warwick 1986; Dauer 1993).

Sediments in the borrow areas and reference sites were not significantly different based on comparisons of silt-clay content and total organic content; however, the sediments in Borrow P1 appear more homogenous based on the size of the silt-clay standard error for the sampling stations. Additionally, several sites in Borrow P2 had a greater proportion of finer sands than other sites in the borrow areas.

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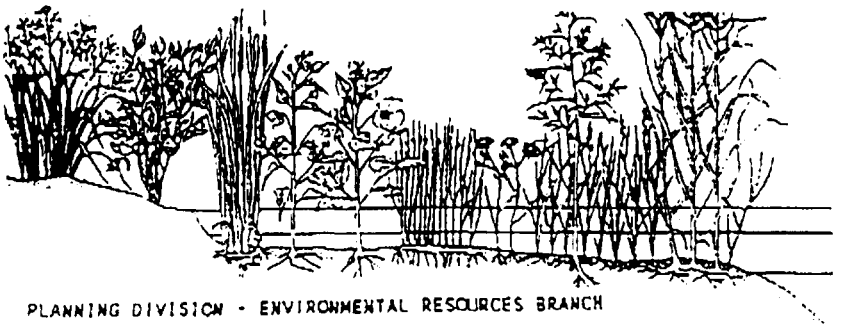
APPENDIX A

Scope of Work

US Army Corps
of Engineers
Philadelphia District



PLANNING DIVISION - ENVIRONMENTAL RESOURCES BRANCH

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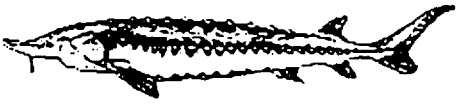

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Here is the SOW for the CAPE MAY Benthic. Call me w/ questions. I'll pass it on to Contracting.

Beth

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Lower Cape May Meadows Feasibility Study
Cape May County, New Jersey,
Benthic Assessment of Sand Borrow Areas

SCOPE OF WORK

Project Name: Benthic Animal-Sediment Assessment of Potential Beachfill Borrow Sources for the Lower Cape May Meadows, New Jersey Feasibility Study.

Corps District and Contact: Philadelphia District Corps of Engineers, Wanamaker Building, 100 Penn Square East, Philadelphia, PA 19107-3390. Project Biologist: Beth Brandreth, Environmental Resources Branch, (215) 656-6558.

Contractor: Versar, Inc, 9200 Rumsey Road, Columbia, Maryland 21045-1934. POC: William Burton, (410) 964-9200.

Project Description: The lower Cape May Meadows study are is located at the southern tip of New Jersey on the Atlantic Ocean side of the Cape May Peninsula (Figure 1). The study limits are from the western end of Cape May City to the eastern end of Cape May Point. Lower Cape May Meadows is approximately 1.3 miles long, encompasses about 350 acres, and contains both fresh water and brackish water wetlands. The purpose of the Feasibility study is to investigate Federal interest in shore protection and environmental restoration in this area and to consider potential solutions. This study includes substantial data acquisition and analysis to define existing coastal processes and conditions along the section of coast. The State of New Jersey is the non-Federal sponsor for the project.

A critical component of this feasibility study is the evaluation and selection of offshore sand borrow sources for beach nourishment. Several issues have been identified during the Reconnaissance Study that need to be addressed such as the potential disruption of commercial/recreational and ecological important benthic communities within the borrow source, and the generation of baseline benthic data for these areas in order to determine potential impacts to these benthic habitats. This study will determine the species composition, relative abundance, and distribution of the benthic resources in the potential offshore borrow areas that may be impacted by this project.

Two potential borrow sources, Borrow Areas P1 and P2, have been identified. Their locations are shown in Figure 2. Appendix B contains a listing of the areas and their coordinates.

Please note that no sampling is to be done in the cross hatched areas shown on Figure 2. The area labeled M1 is currently

an active borrow area and area M2 has the potential to contain un-exploded ordinance from and old gunnery located along the coast.

Data and Information: The Corps will provide upon contractor's request readily available district project information.

State Agency Coordination: The Contractor must obtain any required collector's permits from the state of New Jersey before proceeding with the field survey efforts.

Purpose: The purpose of the study is to determine the species composition, relative abundance, and distribution of the benthic communities within the proposed borrow areas. This data will be compared with other benthic data that are available for the project area to determine the quality and stability of the potentially impacted benthic communities. The study will also compare the benthic communities between the alternative borrow areas, and/or in adjacent areas.

Electronic Position To Locate Work Areas

The Contractor shall establish and record sample positions with a Trimble NT200D global positioning system unit with built-in differential capability. The Contractor will take 180 position fixes with a precision of thousandths of a minute (1 per second) using differential corrections and an on-board lap-top computer. These 180 fixes will be averaged in order to report station position.

Benthic Macroinvertebrates

1. Sampling.

Borrow Areas. The cumulative area being considered for borrow (400 acres) shall be divided into twenty-five (25) cells of approximately the same size (approx. 16 acres each). A benthic sampling station shall be randomly placed within each cell. At each randomly selected sampling station, one sample shall be collected using a 0.4 m^2, stainless steel, Young-modified Van Veen (or equivalent) Grab Sampler. In addition, two (2) control samples shall be taken outside the boundary of each of the two proposed borrow areas (for a total of 4 control samples) in areas that exhibit similar depth and substrate characteristics (no control samples are to be taken within the cross hatched areas on Figure 2). Each "grab" will be at least 50% full and show no evidence of surface washout.

Benthic macroinvertebrates will be sieved in the field using 500 u mesh and preserved (isopropanol, ethanol, or 5% buffered formalin) for laboratory processing. No samples will be composite, all will be handled individually.

2. Grain Size Analysis. A sediment core sample for substrate particle size and organic content analysis will be collected at each sample station using the same equipment. This sample will be placed in its entirety in a container from which excess water will be decanted following a short period of settling, frozen, and then transported to the laboratory for analysis. In the laboratory, sediment samples will be analyzed for grain size using ASTM D2487. Classification will be taken down to the U.S. Standard Sieve No. 200; the hydrometer portion of the ASTM test will not be run. A grain size curve will be prepared for each sample tested. Samples will be measured for total organic carbon (TOC) as measured by loss on ignition.

3. Laboratory Analysis. Macroinvertebrates will be sorted from sample residue, identified, enumerated, and weighed. The top ten taxa as measured by numerical count and/or biomass will be identified to species; others will be grouped by class or phylum. Length of all specimens relative to 2 cms (i.e. < or > 2 cms) will be recorded.

Noting that benthic macroinvertebrate community composition is strongly correlated with the nature of substrate conditions, the substrate particle size and organic content, these data will be examined for each sampling station. If, in the opinion of the Contractor, these data are similar for all measurements made at all borrow area sample stations, then the biological data will be grouped for the purpose of data analysis. If two or more distinct groups of substrate condition data are recognized, the biological data will be grouped similarly. In effect, this is data stratification on the basis of substrate conditions.

Each of the top ten species (as measured by numerical count and/or biomass) shall be counted and dry-weighted separately. Each group shall be weighted to within 0.001 grams. Biomass determinations shall be completed on each sample within the same day to avoid sample degradation.

4. Physical Data Collection. In the field, date and time of collection, latitude and longitude coordinates (either by dual-range positioning or DGPS) for all samples will be recorded. In addition, the following parameters will be measured at the surface and as close to the substrate as possible: depth, pH, water temperature, turbidity, dissolved oxygen, and salinity. Elevation will also be reported relative to tide state. The time of the

latest high and low tide at the nearest tide station will also be reported.

5. Benthic Invertebrate Data Analysis. A detailed report will be prepared, discussing the results of the benthic animal assessment. The report will describe, in detail, all methods that were used and the data obtained. Maps will be included to show the project area and sample locations. Data will be compiled on the ARC/INFO DOS operated Geographic Information System (GIS), or Auto Cadd v.11 DXF. The horizontal grid will be based on the NAD 83, New Jersey State Plan Coordinate System. Data will be delivered on a high density 3 1/2 inch disk.

For benthic macroinvertebrate data, the identity and number of individuals for the top ten species (as measured by numerical count and/or biomass) will be reported in terms of mean numbers per square meter of ocean bottom. The identity and number of all individuals with length > 2 cms will be reported by species. Biomass data will be reported by taxon as mean value per square meter of ocean bottom. Data collected by the Young-modified Van Veen Grab Sampler will be reported on tables and\or graphs and fully summarized. Data collected from this study will be compared to data that has been collected in other similar studies in the area (ie., Townsends Inlet and Brigantine Inlet, etc.).

Biological data will be discussed in terms of species composition and population density which may be impacted through burial by beach nourishment activities, suffocation by turbidity, or excavation by dredging. Taxonomic groups will be described in terms of their accessibility and desirability as a food source for water birds and shorebirds, fish, blue crabs (*Callinectes sapidus*), horseshoe crabs (*Limulus polyphemus*) and other commercial, recreational or ecological species of importance, as well as whether the benthic communities found indicate a healthy or stressed environment. This information shall be presented in a type-written scientific report including sections describing the objective, methods, results, discussion, and conclusions. The results and analyses shall include but not be limited to graphical, tabular, and chart presentations of the data and findings. The conclusions section shall evaluate the potential recovery of the benthic community based on the species found, as well as compare the results of this study with other similar benthic studies done in the area. Original data sheets shall be provided in the appendices of the report.

The report shall be publishable and present the data, analysis, and discussions of this study.

A. Data Presentation

1. The following information shall be presented in the

report: size distribution of organisms, dry weight biomass of major taxonomic groups, taxonomic distribution, and sediment grain size analysis at each station. Additional information regarding recreational/commercial species and opportunistic species found shall be presented.

2. All data shall be presented in, but not be limited to, graphical and tabular forms.

B. Data Analysis

1. Data analysis shall include but not be limited to abundance and/or densities (i.e. biomass/unit area, numbers of organisms/unit area etc.). The following measurements will also be applied: Shannon-Weiner Diversity Index, Simpson's Dominance Index, and species richness.

2. Results shall be presented in graphical or tabular form to provide easy comparisons between stations, as well as with the results of other benthic studies in the project area.

C. Report Text

1. The report shall include written discussions of, but not be limited to, the following sections:

- purpose/objective of the study
- summary of findings
- methods
- results
- comparisons with other areas
- discussion
- conclusions

D. Appendices

1. All figures, tables, maps, and charts shall be presented in the appendices, as appropriate.

2. Appendices shall include original (dated) data sheets.

3. Appendices shall also include a copy of the names of all subcontractors and their addresses.

E. Miscellaneous

1. If the report has been written by someone other than the contract principal investigator, the cover and title page of the publishable report shall bear the inscription: <u>Prepared Under</u>

the Supervision of (Name), Principal Investigator. The principal investigator is required to sign the original document. In addition, the principal investigator must at least prepare a forward describing the overall research context of the report, the significance of the work and any other related background circumstances relating to the manner in which the work was undertaken.

2. The TITLE PAGE of the report shall include the date (month and year) the report was submitted, the project name, the author organization and/or client, and contract number.

3. A TABLE OF CONTENTS, including a list of all Figures and Tables shall be presented in the report.

4. PAGE SIZE AND FORMAT. The report shall be produced on 8 1/2 X 11" paper, single-spaced, with double spacing between paragraphs. Figures shall be 8 1/2 X 11" or folded 11 x 17" format sheet size. All text pages (including appendices) shall be consecutively numbered. Text print quality must be at least letter quality.

5. All references shall be properly cited in a bibliography at the end of the report text.

Submittal and Schedules:

A. Field sampling shall commence on or after September 9, 1996 and shall be completed no later than October 11, 1996.

B. The Contractor shall provide 3 copies of the draft report, to the Philadelphia District U.S. Army Corps of Engineers by January 10, 1997.

C. The Corps will provide comments to the contractor within 30 calendar days of receipt of the draft report. The contractor is responsible for incorporating any changes to the draft document.

D. The Contractor shall provide 5 bound copies and 1 unbound, reproducible original copy of the final report to the Philadelphia District Corps of Engineers by February 23, 1997.

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New Jersey Shore Protection

Lower Cape May Meadows - Cape May Point

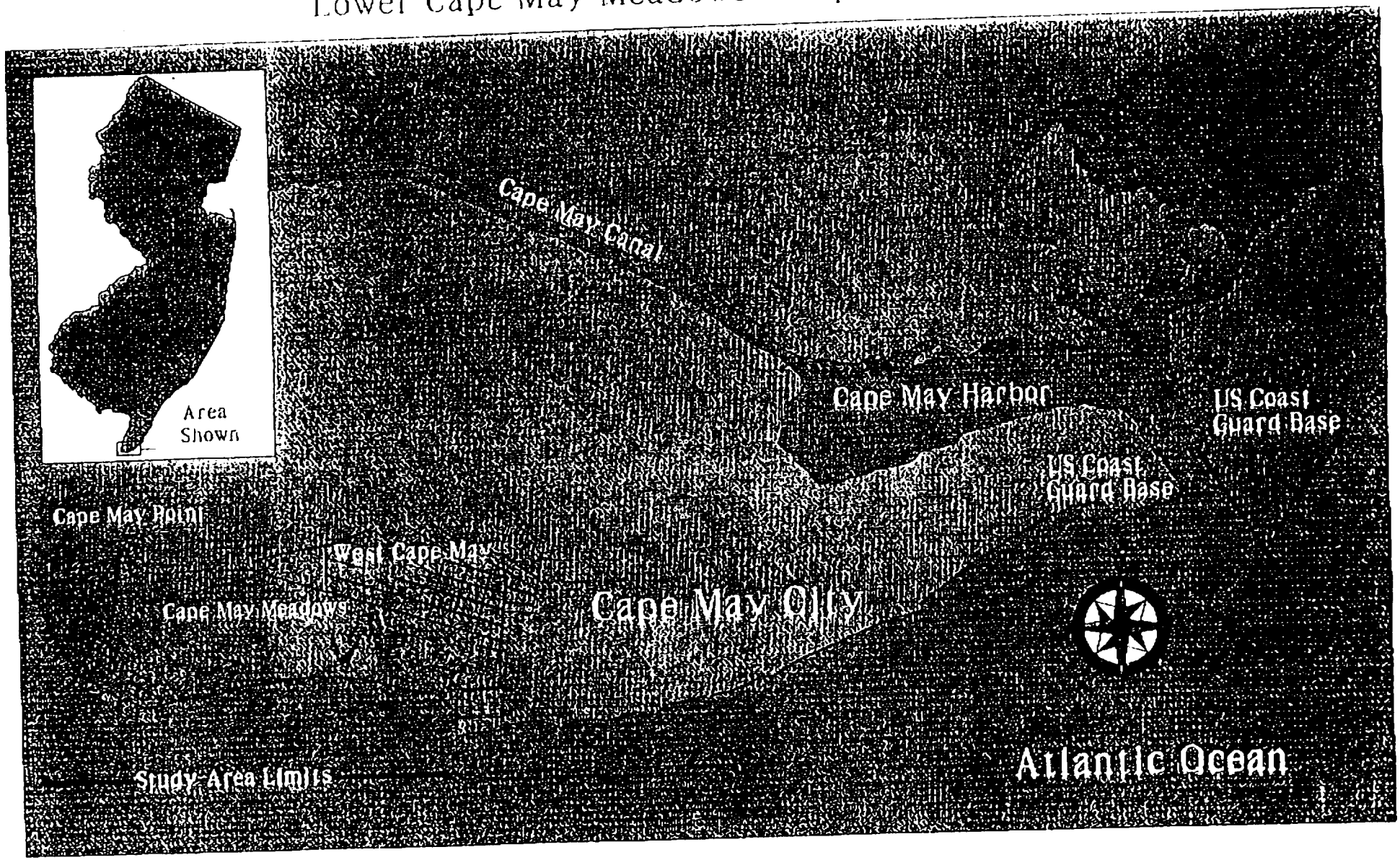
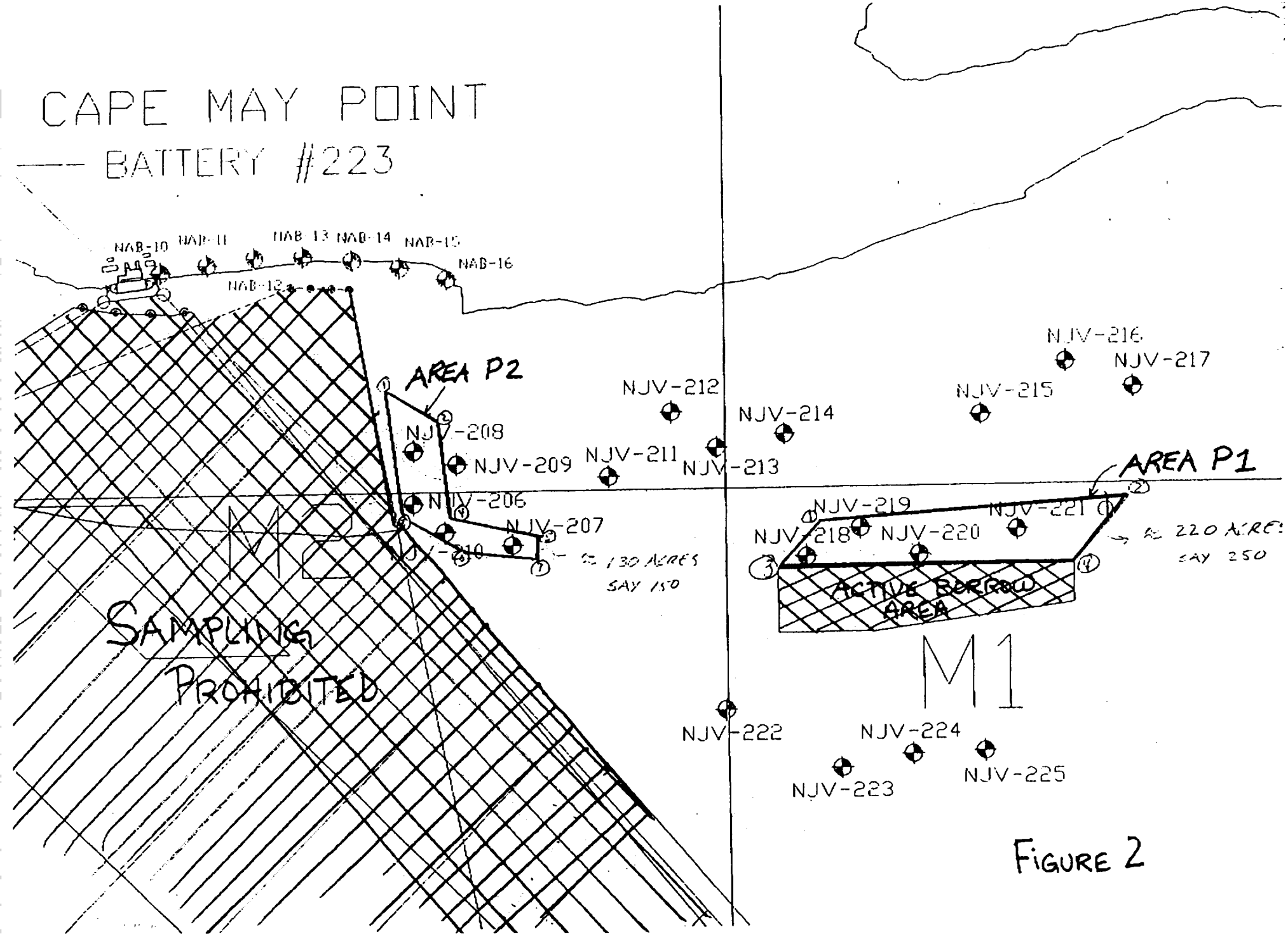


FIGURE 1


CAPE MAY POINT
BATTERY #223
NAB-10
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NAB-15
NAB-16
AREA P2
NJV-208
NJV-209
NJV-206
NJV-207
NJV-210
≈ 130 ACRES
SAY 150
NJV-212
NJV-214
NJV-211
NJV-213
NJV-216
NJV-217
NJV-215
AREA P1
NJV-219
NJV-218
NJV-220
NJV-221
≈ 220 ACRES
SAY 250
ACTIVE BORROW AREA
M1
SAMPLING PROHIBITED
NJV-222
NJV-224
NJV-223
NJV-225

FIGURE 2

APPENDIX A: SUGGESTED EQUIPMENT LIST (may be modified as necessary)

A. Sampling Device

-0.4 square meter Young-modified Van Veen grab sampler

B. 0.5 mm (500 micron) sieve (circular with 12" or greater sides)

C. 1.0 mm (1000 micron) sieve (circular with 12" or greater sides)

D. Wash bottles with squirt nozzles and water pitchers or beakers for sample washdown

E. Forceps and eyedropper

F. Plastic sample jars (pint or quart jars with lids)

G. Labels, grease pencil, waterproof paper, pen or pencil

H. 50% solution of buffered and stained (rose bengal) formalin for sample preservation: 1 quart = approx. 10 samples

I. One 3-4 foot diameter wash tub (optional)

J. Funnel

K. White tray for sample sorting

L. Spatulas or small scoops

M. Small twist tie plastic bags for sediment samples

N. Munsell color chart

O. Boat equipped with suitable surveying/positioning equipment. This equipment is subject to Corps approval.

APPENDIX B BORROW AREA COORDINATES

Area P1 (coordinates are in NAD 83)
Approximately 250 acres

1.	-74.9107	38.9135
	-74°54'38.52"	38°54'48.60"
2.	-74.8888	38.9149
	-74°53'19.68"	38°54'53.64"
3..	-74.9139	38.9102
	-74°54'50.04"	38°54'36.72"
4.	-74.8928	38.9103
	-74°53'34.08"	38°54'37.08"

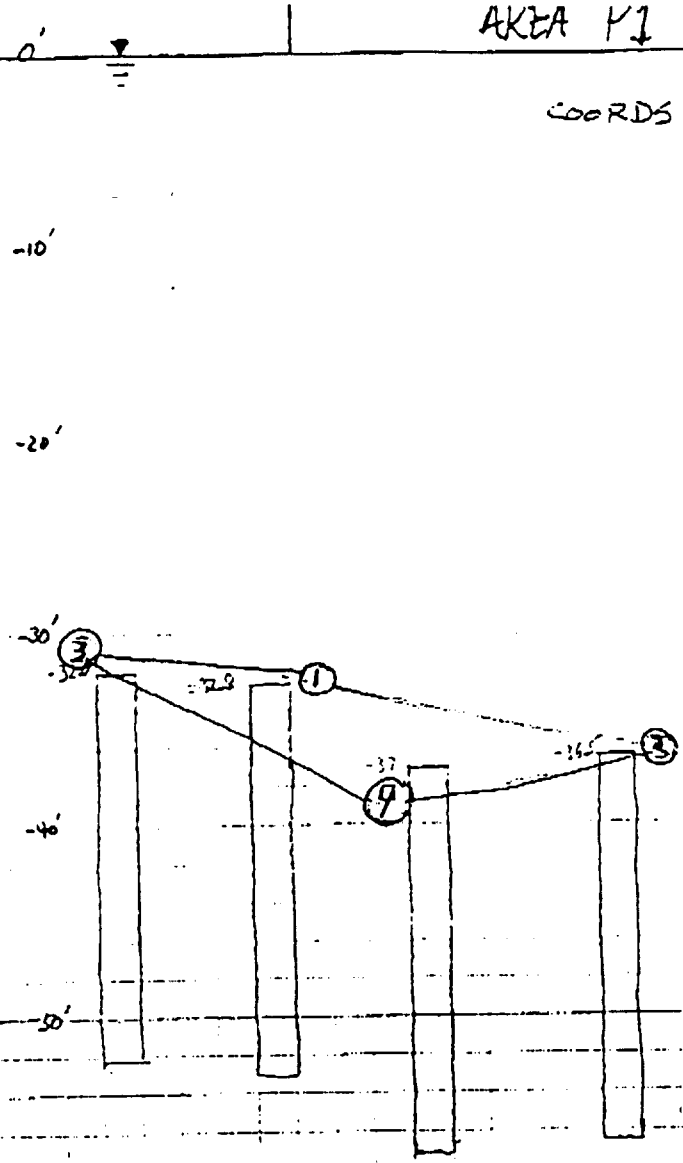
Area P2 (coordinates are in NAD 83)
Approximately 150 acres

1.	-74.9419	38.9232
	-74°56'30.84"	38°55'23.52"
2.	-74.9381	38.9208
	-74°56'17.16"	38°55'14.88"
3.	-74.9406	38.9141
	-74°56'26.16"	38°54'50.76"
4.	-74.9373	38.9142
	-74°56'14.28"	38°54'51.12"

5.	-74.9309	38.9127
	-74°55'51.24"	38°54'45.72"
6.	-74.9365	38.9118
	-74°56'11.40"	38°54'42.48"
7.	-74.9311	38.9112
	-74°55'51.96"	38°54'40.32"

AREA F1

COORDS ARE IN NAD 83



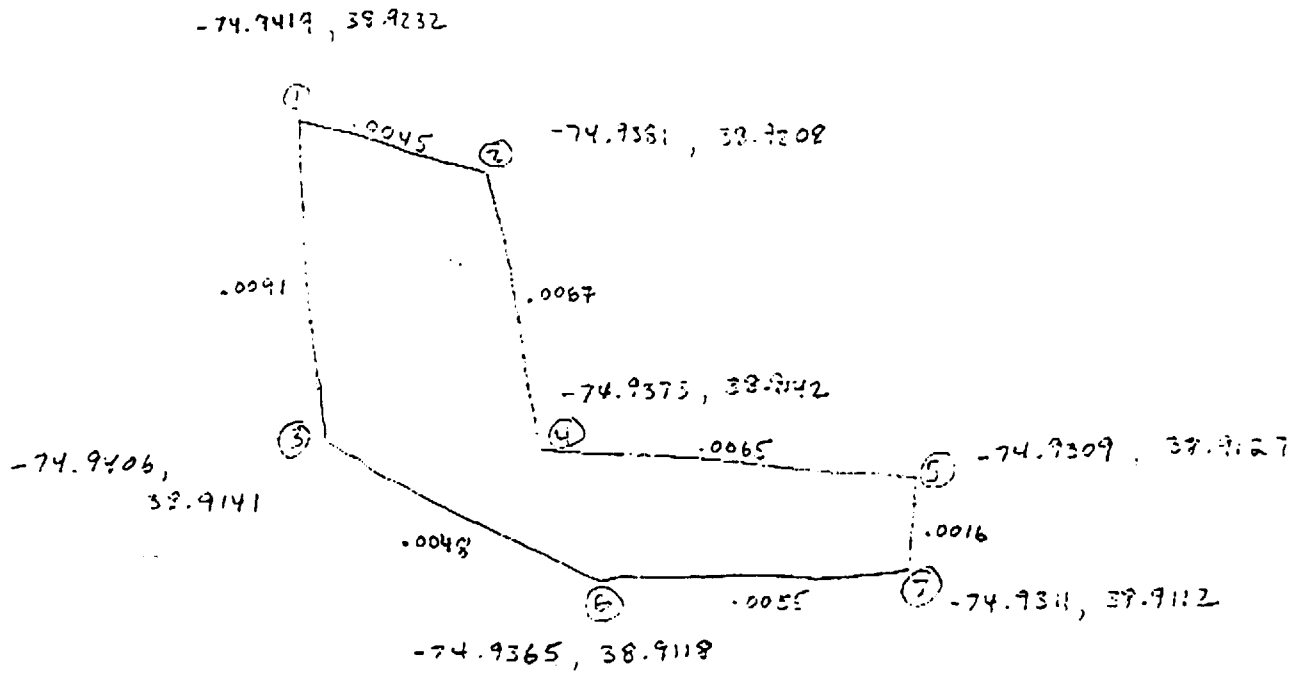
~ 220 ACRES

1	-74.9107 -74°54'38.52"	38.9135 38°54'48.60"	
2	-74.8888 -74°53'19.68"	38.9149 38°54'53.64"	
3	-74.9139 -74°54'50.04"	38.9102 38°54'36.72"	
4	-74.8928 -74°53'34.08"	38.9103 38°54'37.08"	

22-141 50 SHEETS
22-142 100 SHEETS
22-144 200 SHEETS
AMPAD

AREA P2

Coords are in NAD 23



100-130 ACRES

1	-74° 56' 30.84",	38° 55' 23.52"
2	-74° 56' 17.16",	38° 55' 14.88"
3	-74° 56' 26.16"	38° 54' 50.76"
4	-74° 56' 14.28")	38° 54' 51.12"
5	-74° 55' 51.24",	38° 54' 45.72"
6	-74° 56' 11.40",	38° 54' 42.48"
7	-74° 55' 51.96",	38° 54' 40.32"

22-141 50 SHEETS
22-142 100 SHEETS
22-144 200 SHEETS
AMPAD

APPENDIX B

Latitude/Longitude Coordinates for Individual Station Locations

Appendix Table B-1. Latitude/longitude coordinates for individual sampling locations

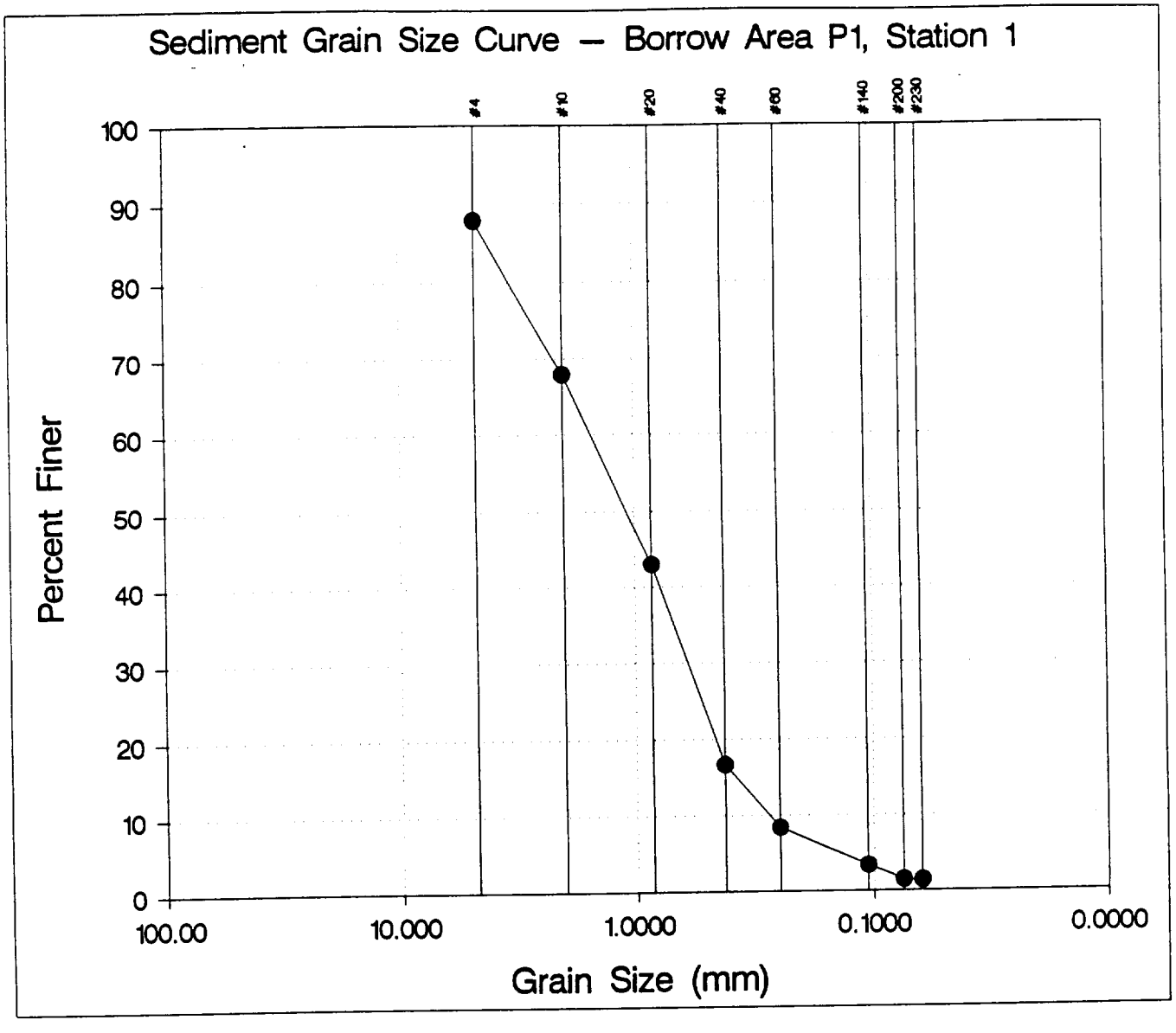
Station	Latitude		Longitude	
Borrow Area P1				
1	38 °	54.801'	74 °	54.115
2	38 °	54.752'	74 °	54.008
3	38 °	54.639'	74 °	54.020
4	38 °	54.696'	74 °	54.414
5	38 °	54.761'	74 °	53.590
6	38 °	54.706'	74 °	54.653
7	38 °	54.659'	74 °	54.220
8	38 °	54.861'	74 °	53.771
9	38 °	54.747'	74 °	54.277
10	38 °	54.695'	74 °	54.111
11	38 °	54.784'	74 °	54.179
12	38 °	54.798'	74 °	54.267
13	38 °	54.801'	74 °	53.666
14	38 °	54.781'	74 °	54.220
15	38 °	54.759'	74 °	53.827
17	38 °	54.817'	74 °	54.458
Borrow Area P2				
1	38 °	54.897'	74 °	56.410
2	38 °	55.142'	74 °	56.500'
3	38 °	54.741'	74 °	55.880
4	38 °	54.774'	74 °	56.193
5	38 °	55.312'	74 °	56.544'
7	38 °	54.843'	74 °	56.369
8	38 °	54.802'	74 °	56.392'
9	38 °	55.065'	74 °	56.317
12	38 °	55.204'	74 °	56.436

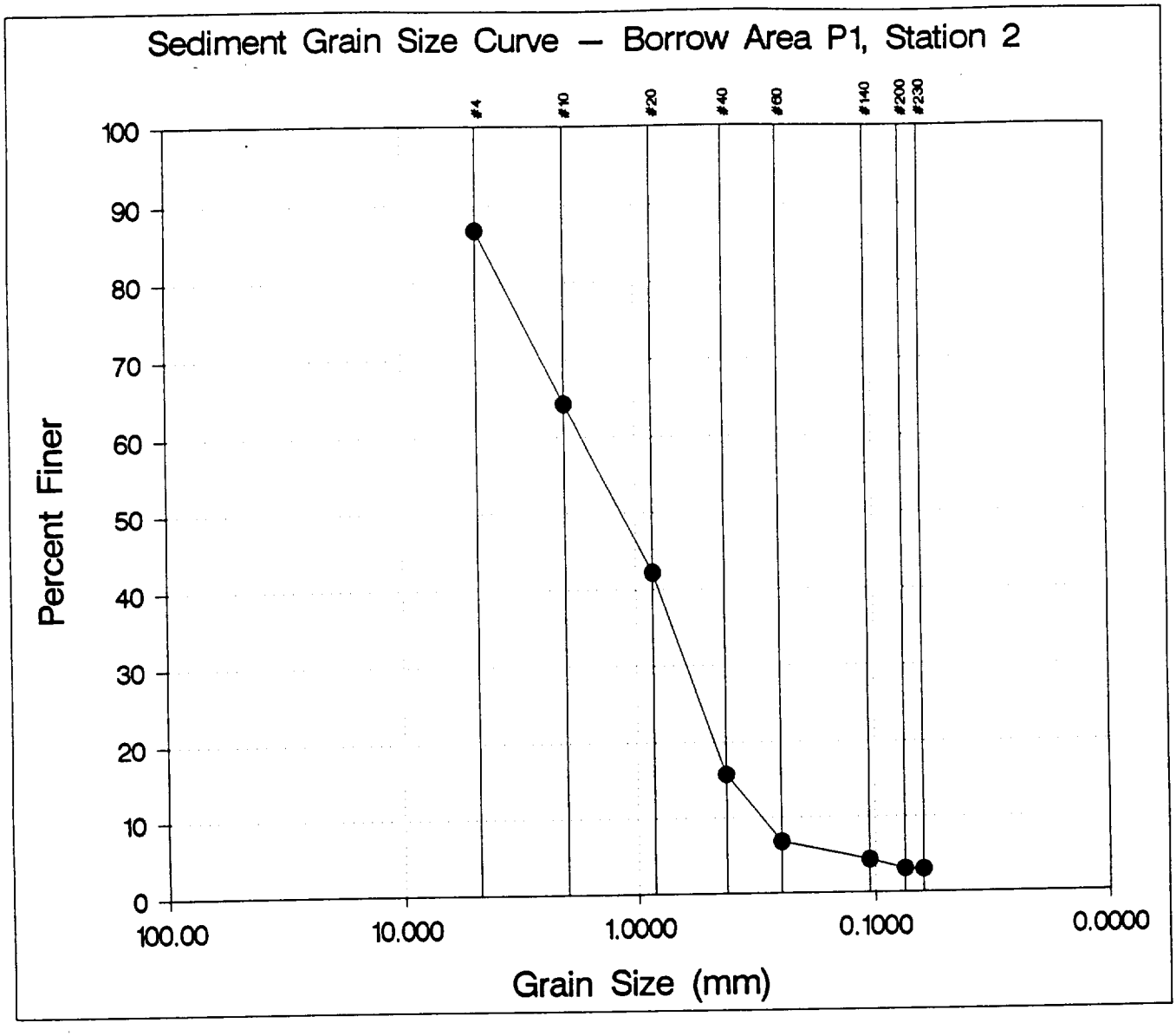
Appendix Table B-1. (Continued)

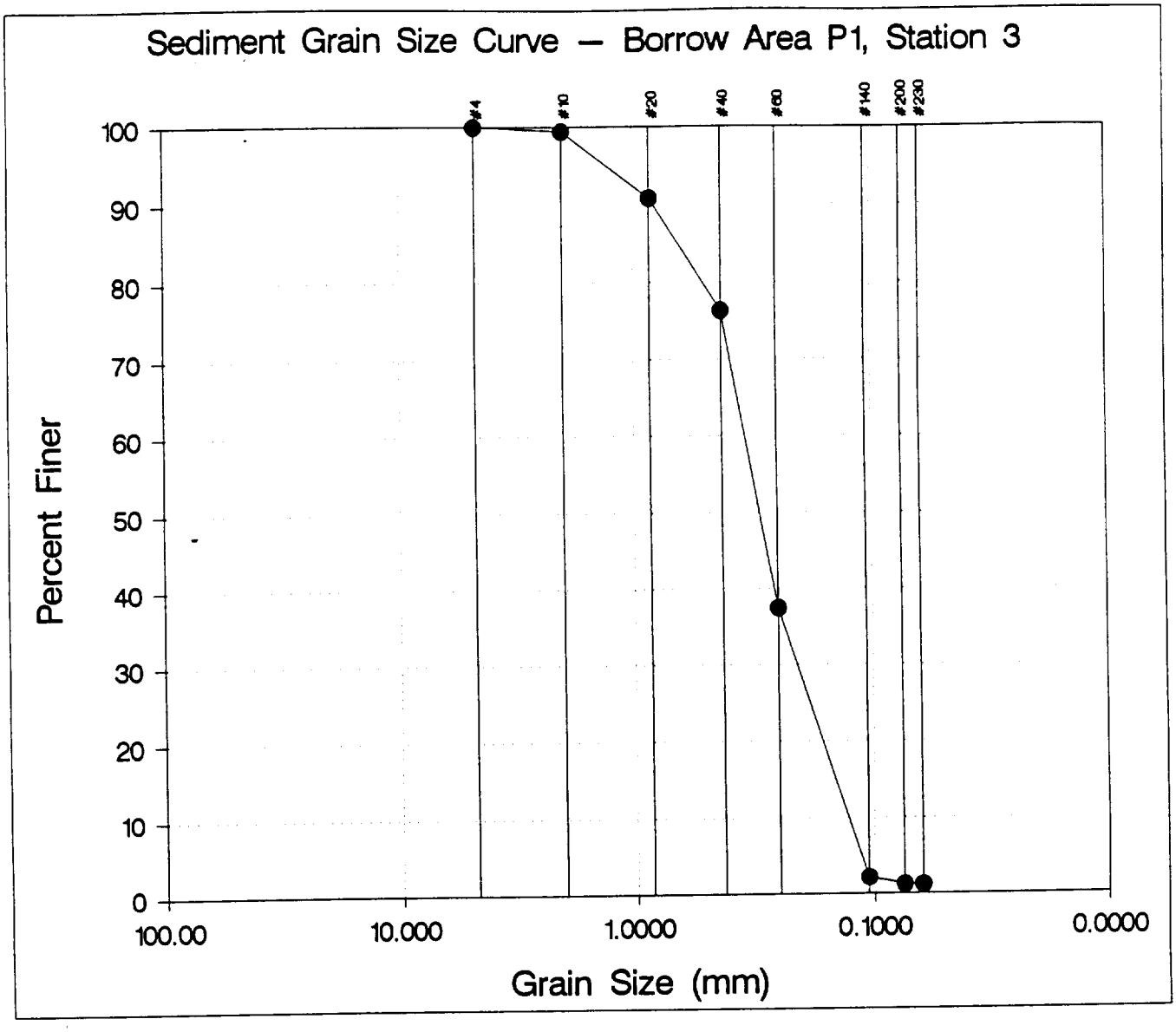
Station	Latitude		Longitude	
Reference Area				
RP1	38 °	54.765'	74 °	54.991
RP1	38 °	55.106'	74 °	53.802
RP2	38 °	55.025'	74 °	55.846'
RP2	38 °	54.146'	74 °	55.746'

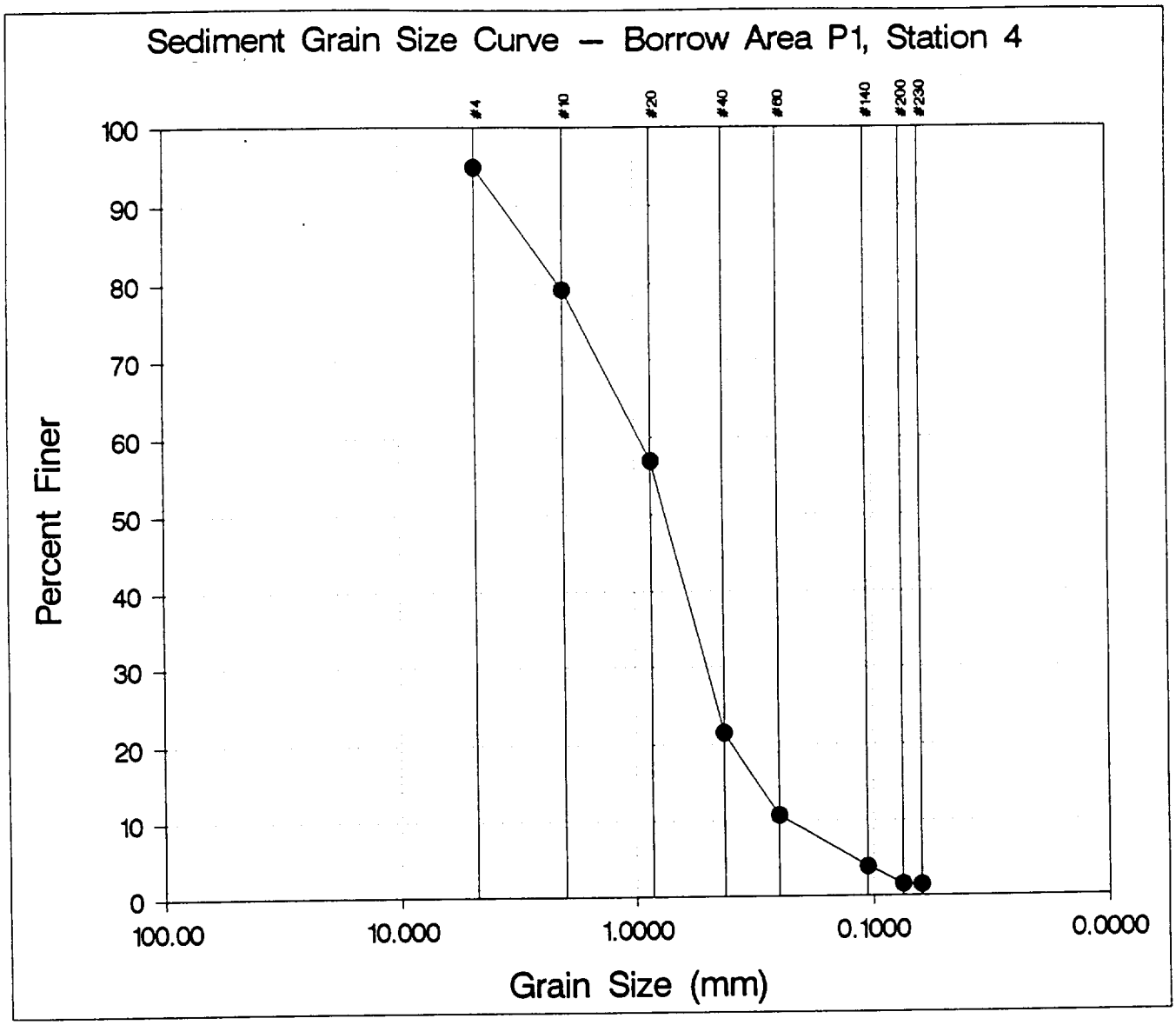
APPENDIX C

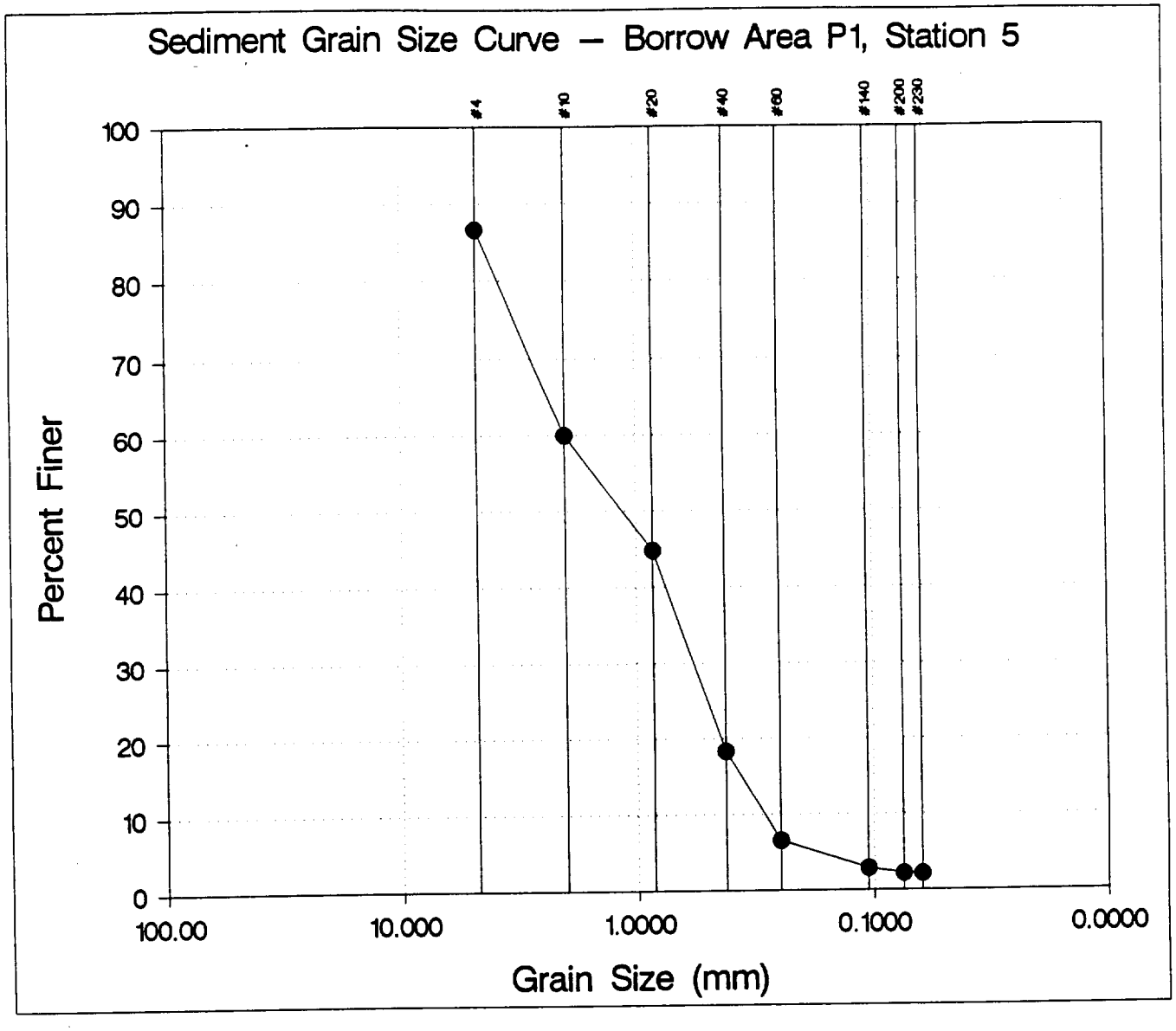
Sediment Grain Size Curves

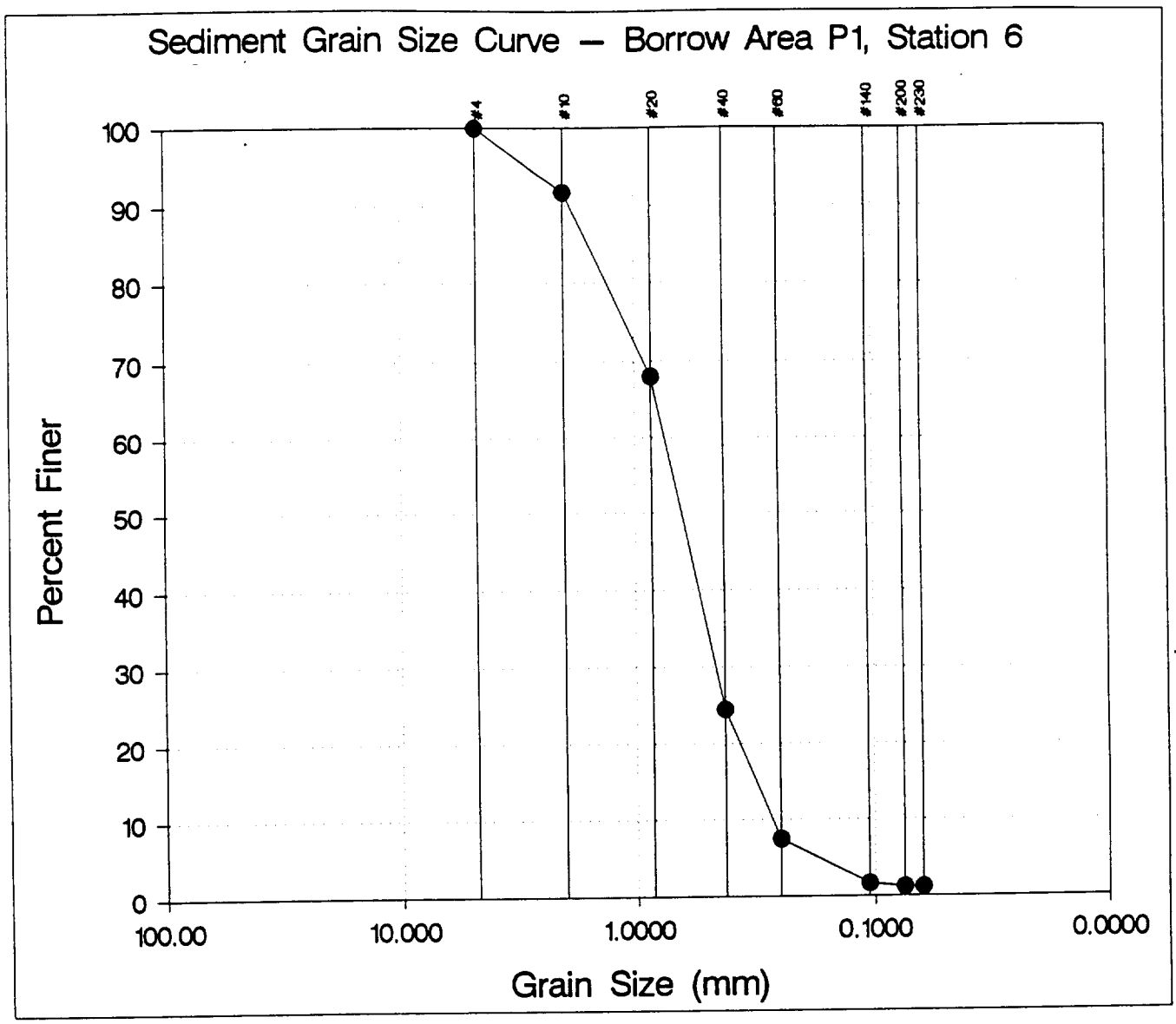

Sediment Grain Size Curve — Borrow Area P1, Station 1
#4
#10
#20
#40
#60
#140
#200
#230
100
90
80
70
60
50
40
30
20
10
0
Percent Finer
100.00
10.000
1.0000
0.1000
0.0000
Grain Size (mm)

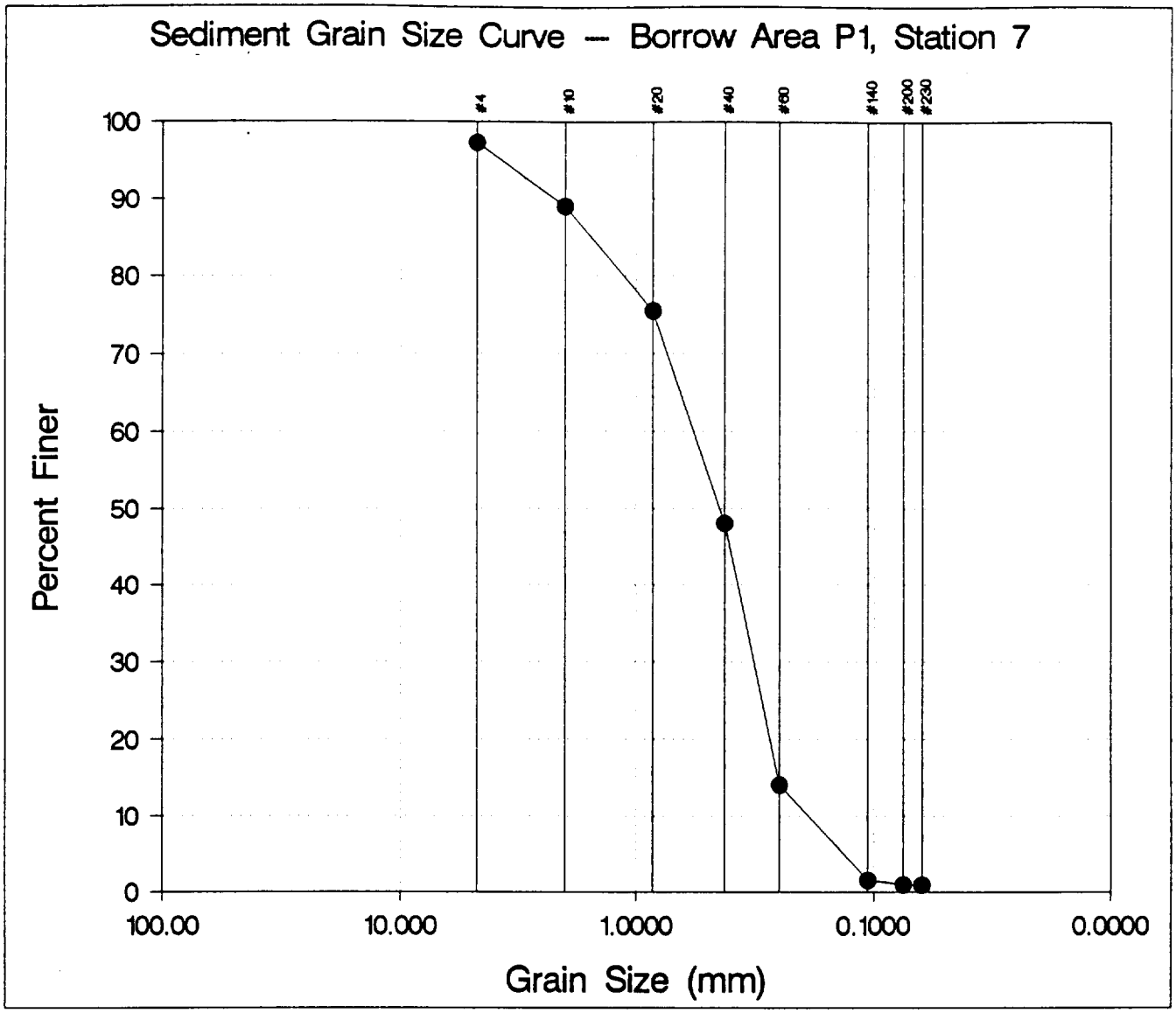

Sediment Grain Size Curve — Borrow Area P1, Station 2
#4
#10
#20
#40
#60
#140
#200
#230
100
90
80
70
60
50
40
30
20
10
0
Percent Finer
100.00
10.000
1.0000
0.1000
0.0000
Grain Size (mm)

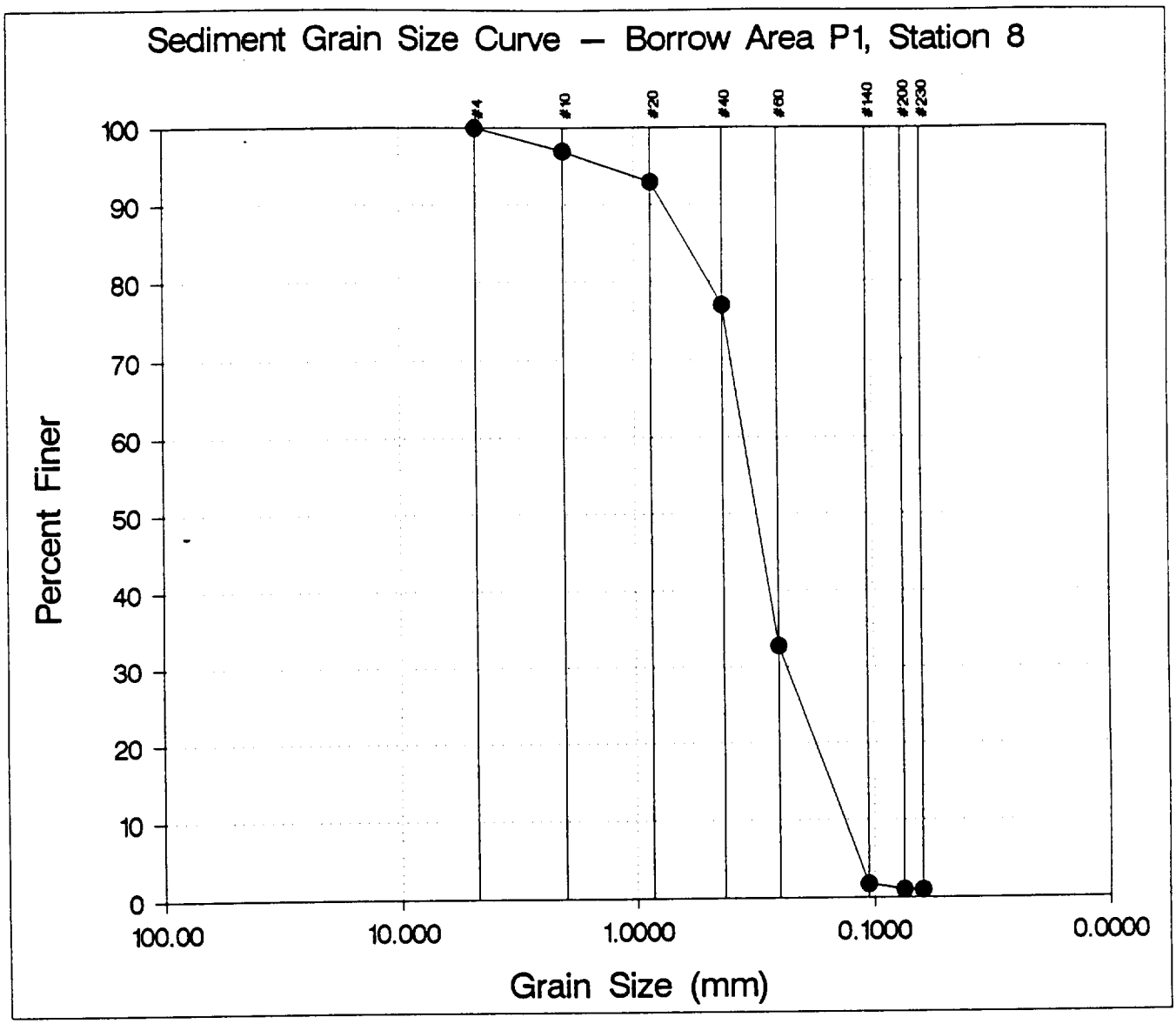

Sediment Grain Size Curve — Borrow Area P1, Station 3
#4
#10
#20
#40
#60
#140
#200
#230
100
90
80
70
60
50
40
30
20
10
0
Percent Finer
100.00
10.000
1.0000
0.1000
0.0000
Grain Size (mm)

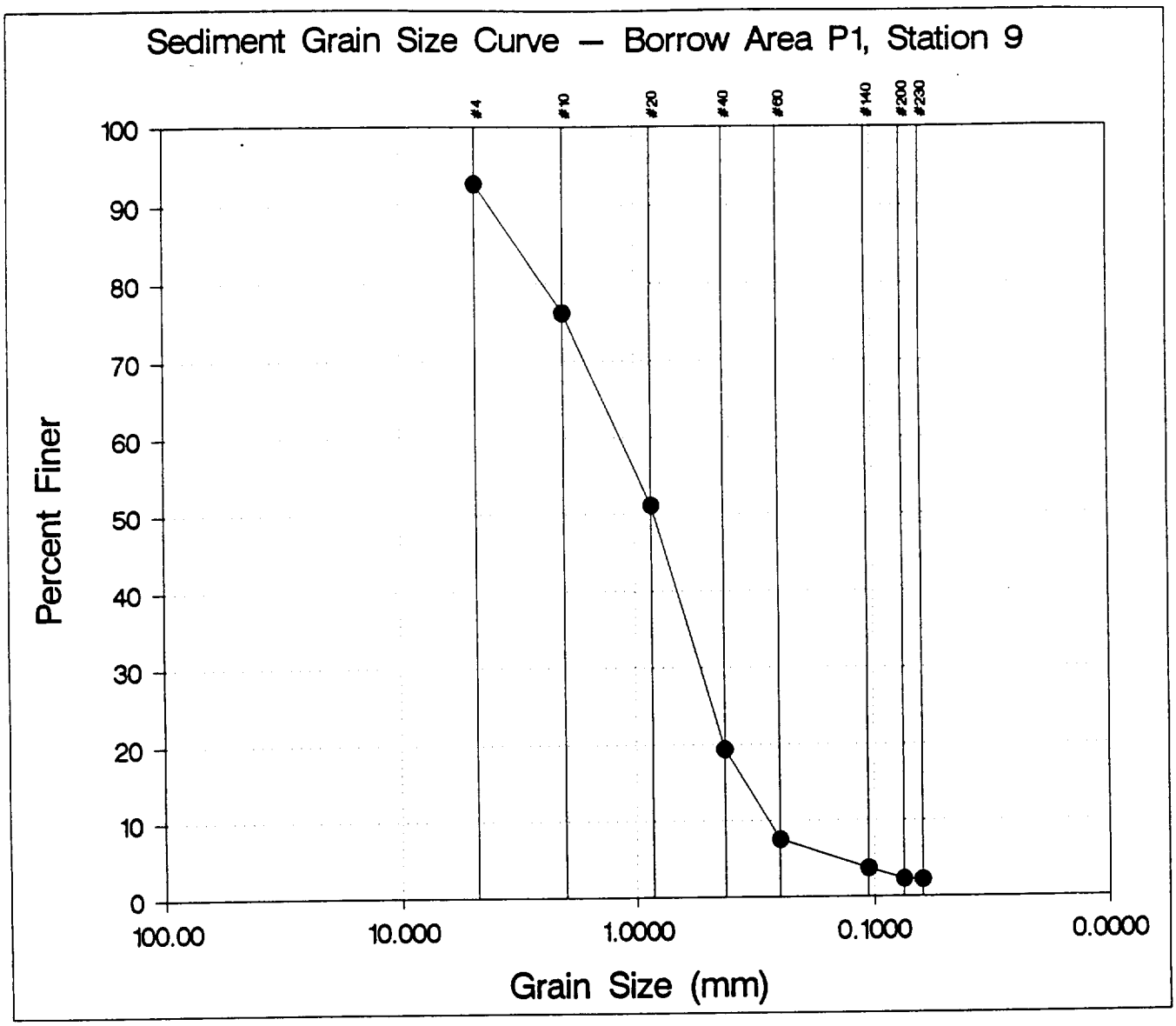

Sediment Grain Size Curve — Borrow Area P1, Station 4
#4
#10
#20
#40
#60
#140
#200
#230
100
90
80
70
60
50
40
30
20
10
0
Percent Finer
100.00
10.000
1.0000
0.1000
0.0000
Grain Size (mm)

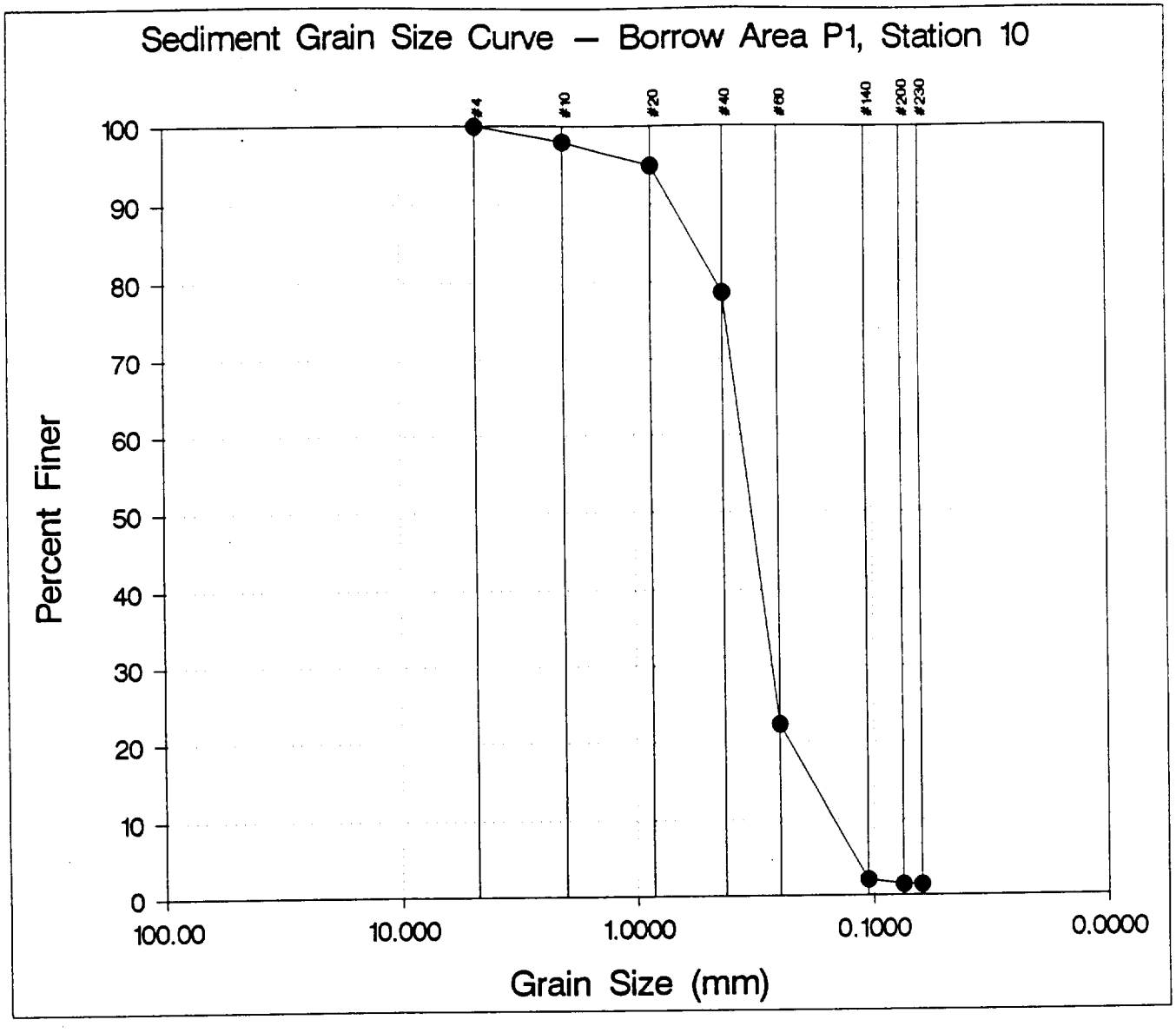

Sediment Grain Size Curve — Borrow Area P1, Station 5
#4
#10
#20
#40
#60
#140
#200
#230
100
90
80
70
60
50
40
30
20
10
0
Percent Finer
100.00
10.000
1.0000
0.1000
0.0000
Grain Size (mm)

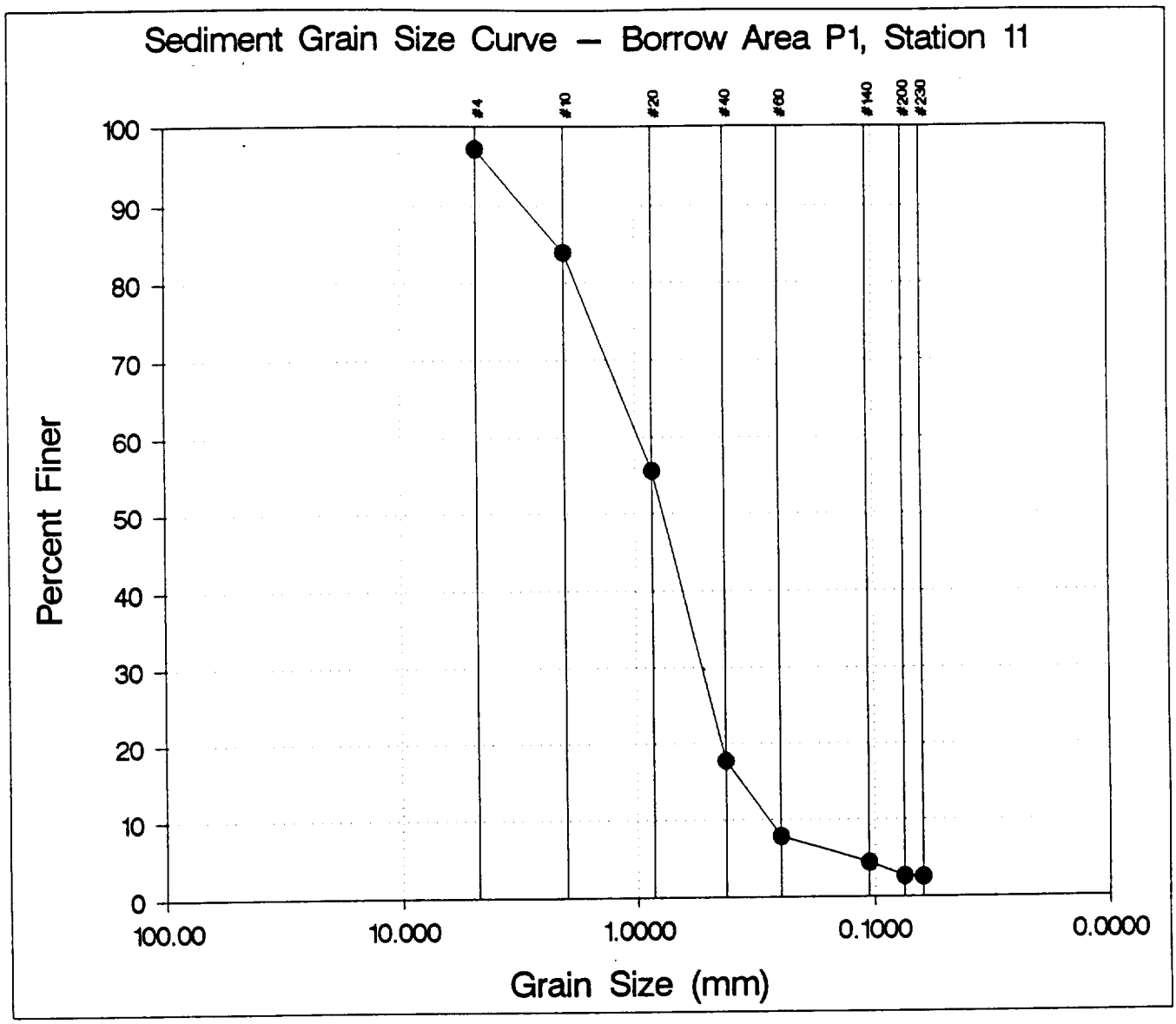

Sediment Grain Size Curve — Borrow Area P1, Station 6
#4
#10
#20
#40
#60
#140
#200
#230
100
90
80
70
60
50
40
30
20
10
0
Percent Finer
100.00
10.000
1.0000
0.1000
0.0000
Grain Size (mm)

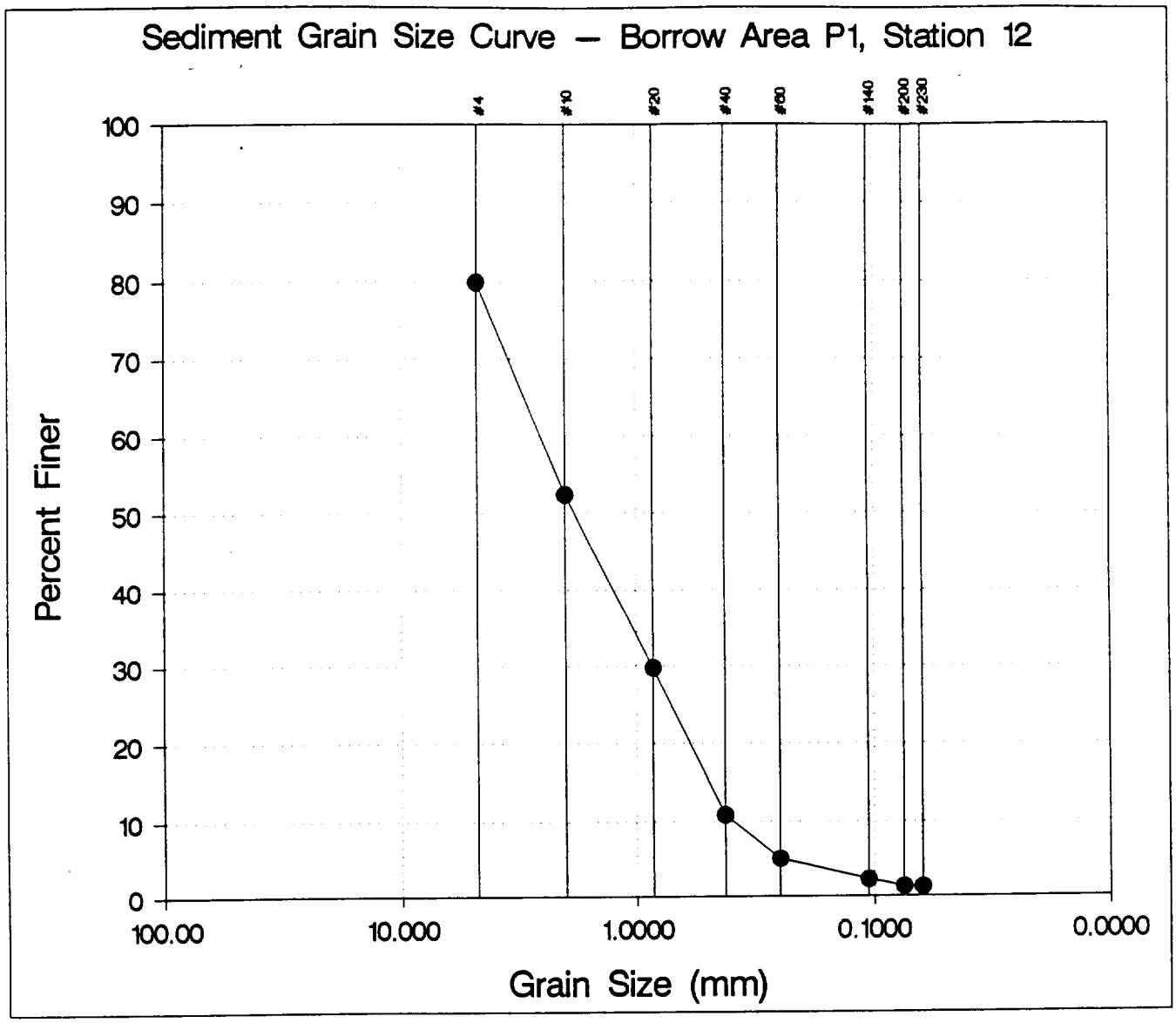

Sediment Grain Size Curve — Borrow Area P1, Station 7
#4
#10
#20
#40
#60
#140
#200
#230
100
90
80
70
60
50
40
30
20
10
0
Percent Finer
100.00
10.000
1.0000
0.1000
0.0000
Grain Size (mm)

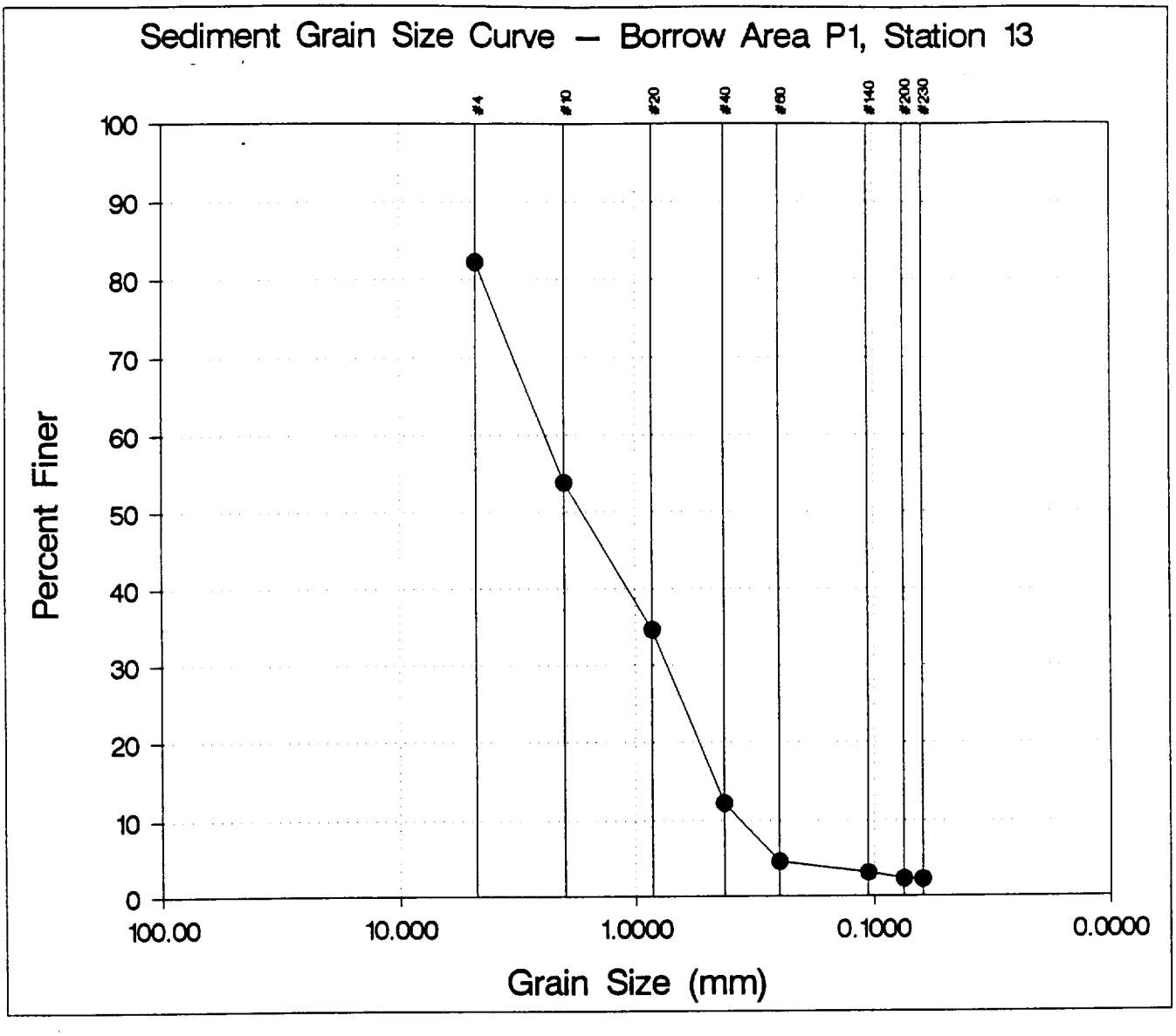

Sediment Grain Size Curve – Borrow Area P1, Station 8
#4
#10
#20
#40
#60
#140
#200
#230
100
90
80
70
60
50
40
30
20
10
0
Percent Finer
100.00
10.000
1.0000
0.1000
0.0000
Grain Size (mm)

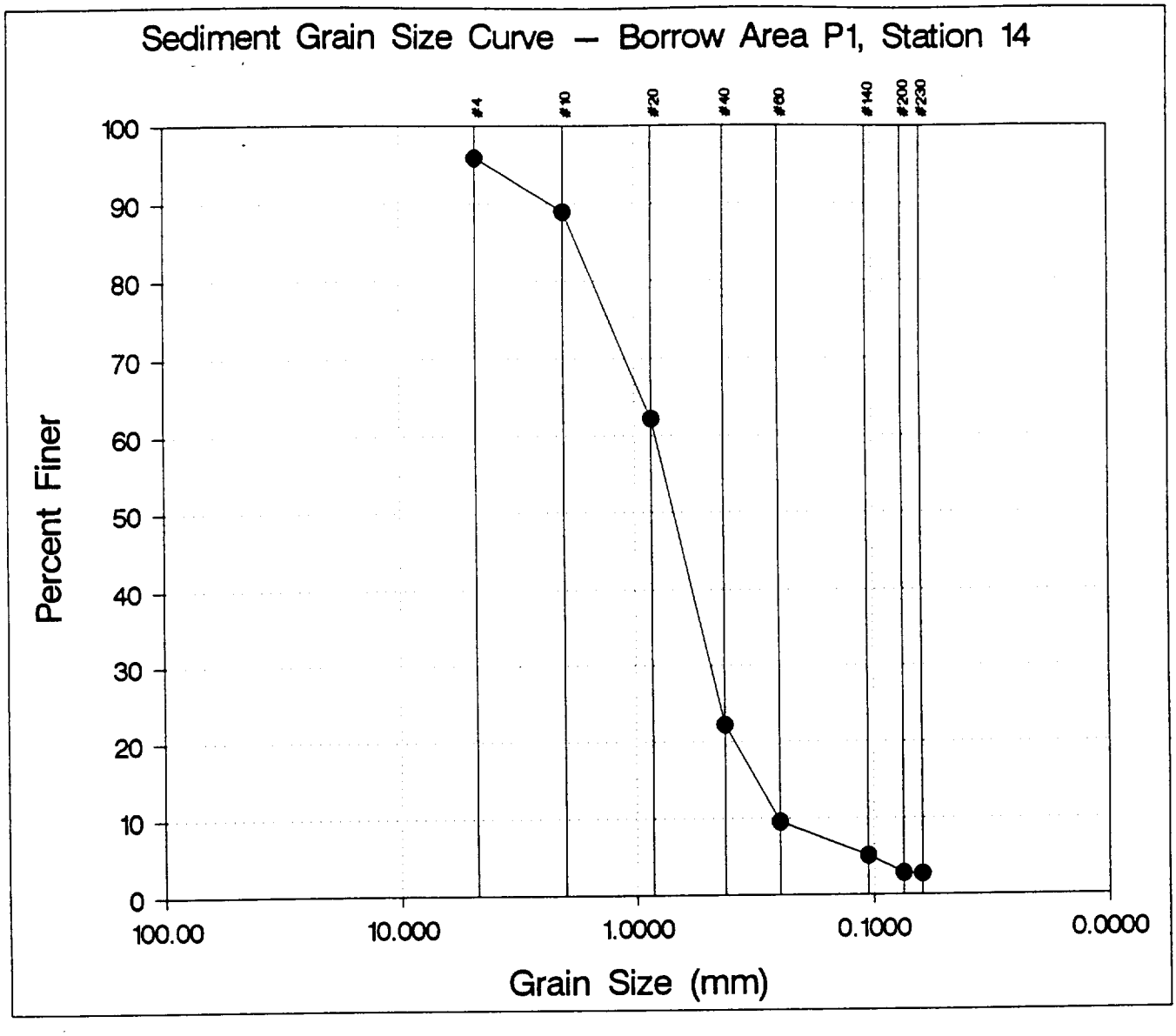

Sediment Grain Size Curve — Borrow Area P1, Station 9
#4
#10
#20
#40
#60
#140
#200
#230
100
90
80
70
60
50
40
30
20
10
0
Percent Finer
100.00
10.000
1.0000
0.1000
0.0000
Grain Size (mm)

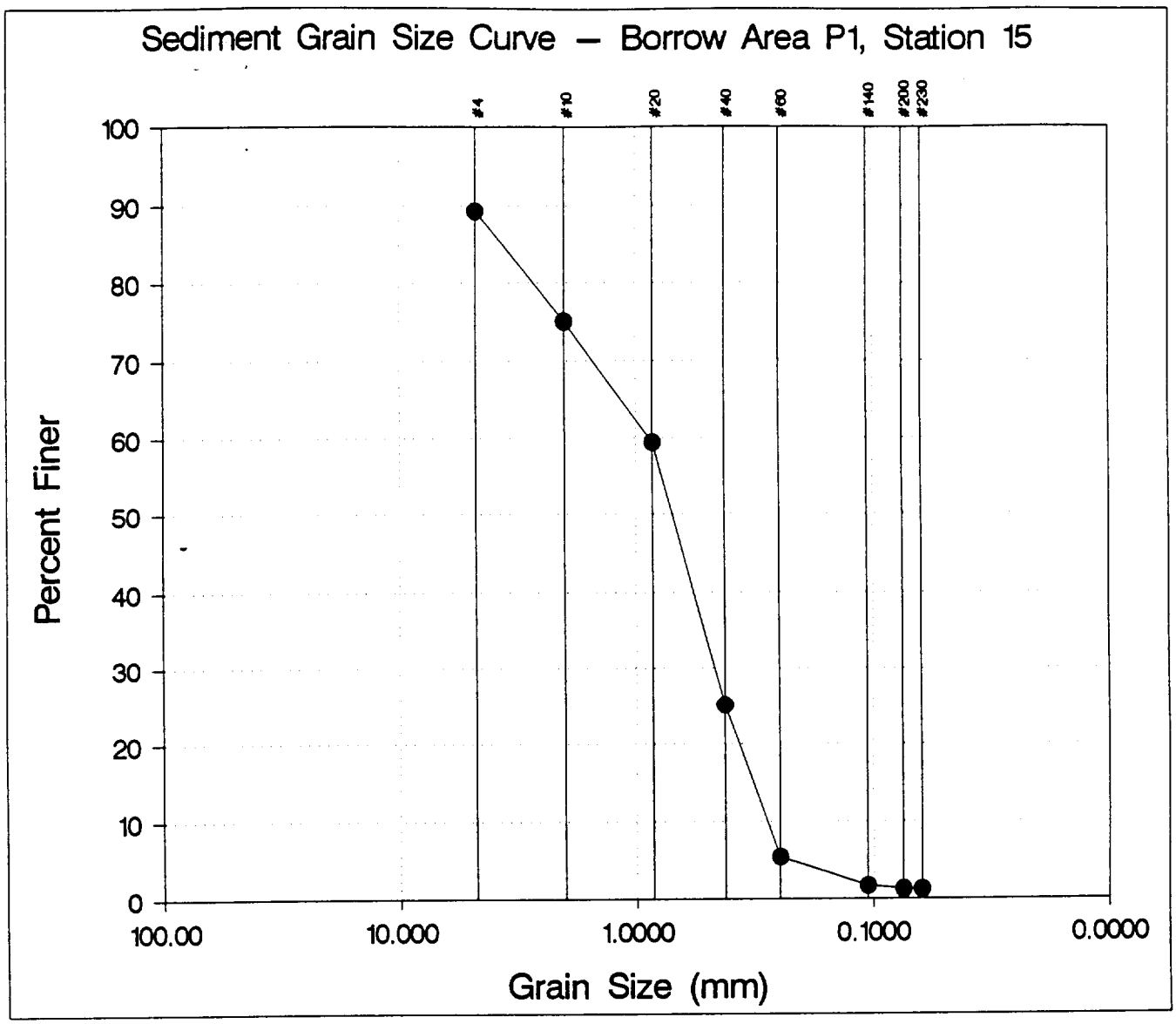

Sediment Grain Size Curve — Borrow Area P1, Station 10
#4
#10
#20
#40
#60
#140
#200
#230
100
90
80
70
60
50
40
30
20
10
0
Percent Finer
100.00
10.000
1.0000
0.1000
0.0000
Grain Size (mm)

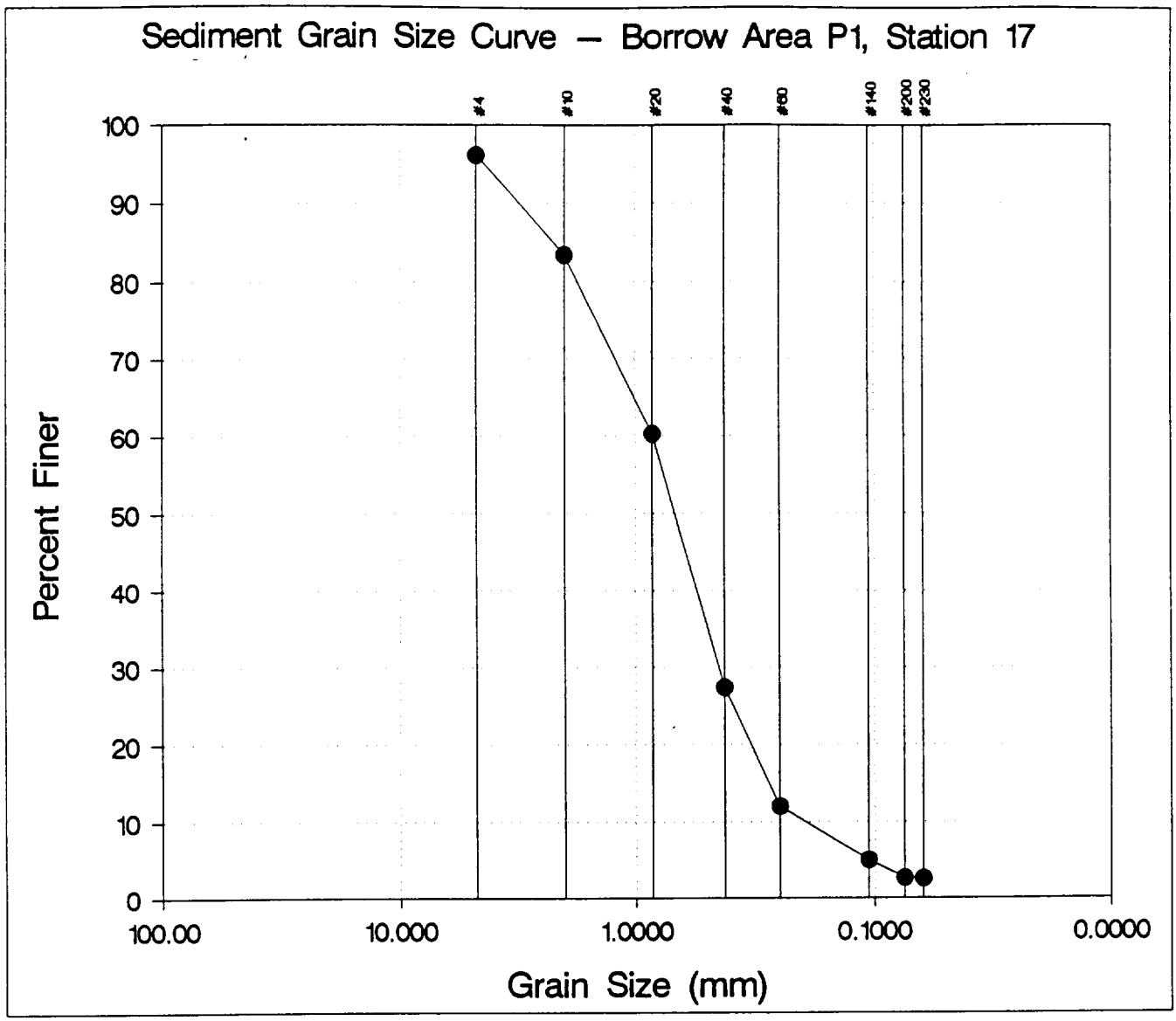

Sediment Grain Size Curve — Borrow Area P1, Station 11
#4
#10
#20
#40
#60
#140
#200
#230
100
90
80
70
60
50
40
30
20
10
0
Percent Finer
100.00
10.000
1.0000
0.1000
0.0000
Grain Size (mm)


Sediment Grain Size Curve — Borrow Area P1, Station 12
#4
#10
#20
#40
#60
#140
#200
#230
100
90
80
70
60
50
40
30
20
10
0
Percent Finer
100.00
10.000
1.0000
0.1000
0.0000
Grain Size (mm)


Sediment Grain Size Curve — Borrow Area P1, Station 13
#4
#10
#20
#40
#60
#140
#200
#230
100
90
80
70
60
50
40
30
20
10
0
Percent Finer
100.00
10.000
1.0000
0.1000
0.0000
Grain Size (mm)


Sediment Grain Size Curve — Borrow Area P1, Station 14
#4
#10
#20
#40
#60
#140
#200
#230
100
90
80
70
60
50
40
30
20
10
0
Percent Finer
100.00
10.000
1.0000
0.1000
0.0000
Grain Size (mm)


Sediment Grain Size Curve — Borrow Area P1, Station 15
#4
#10
#20
#40
#60
#140
#200
#230
100
90
80
70
60
50
40
30
20
10
0
Percent Finer
100.00
10.000
1.0000
0.1000
0.0000
Grain Size (mm)


Sediment Grain Size Curve — Borrow Area P1, Station 17
#4
#10
#20
#40
#60
#140
#200
#230
100
90
80
70
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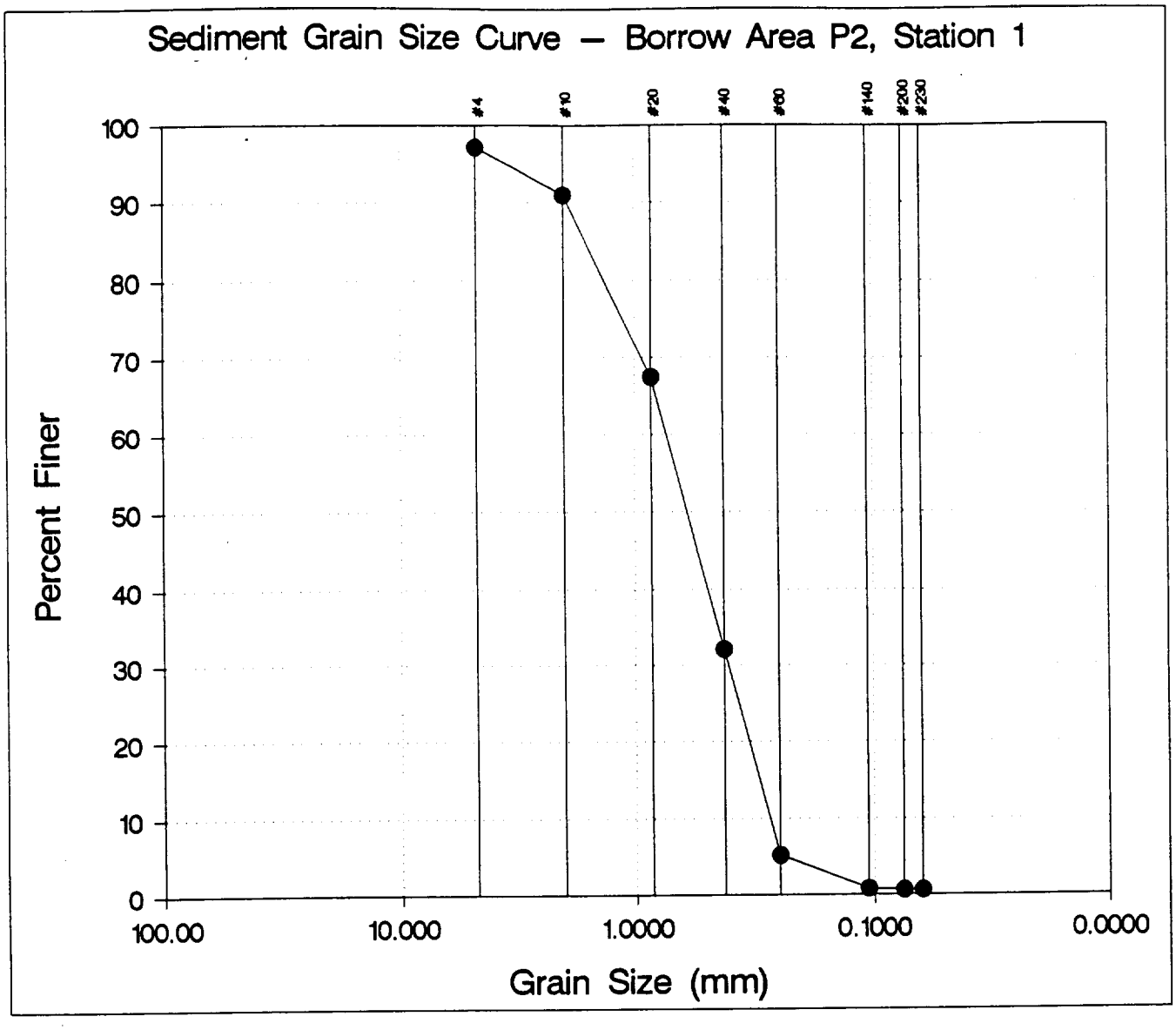
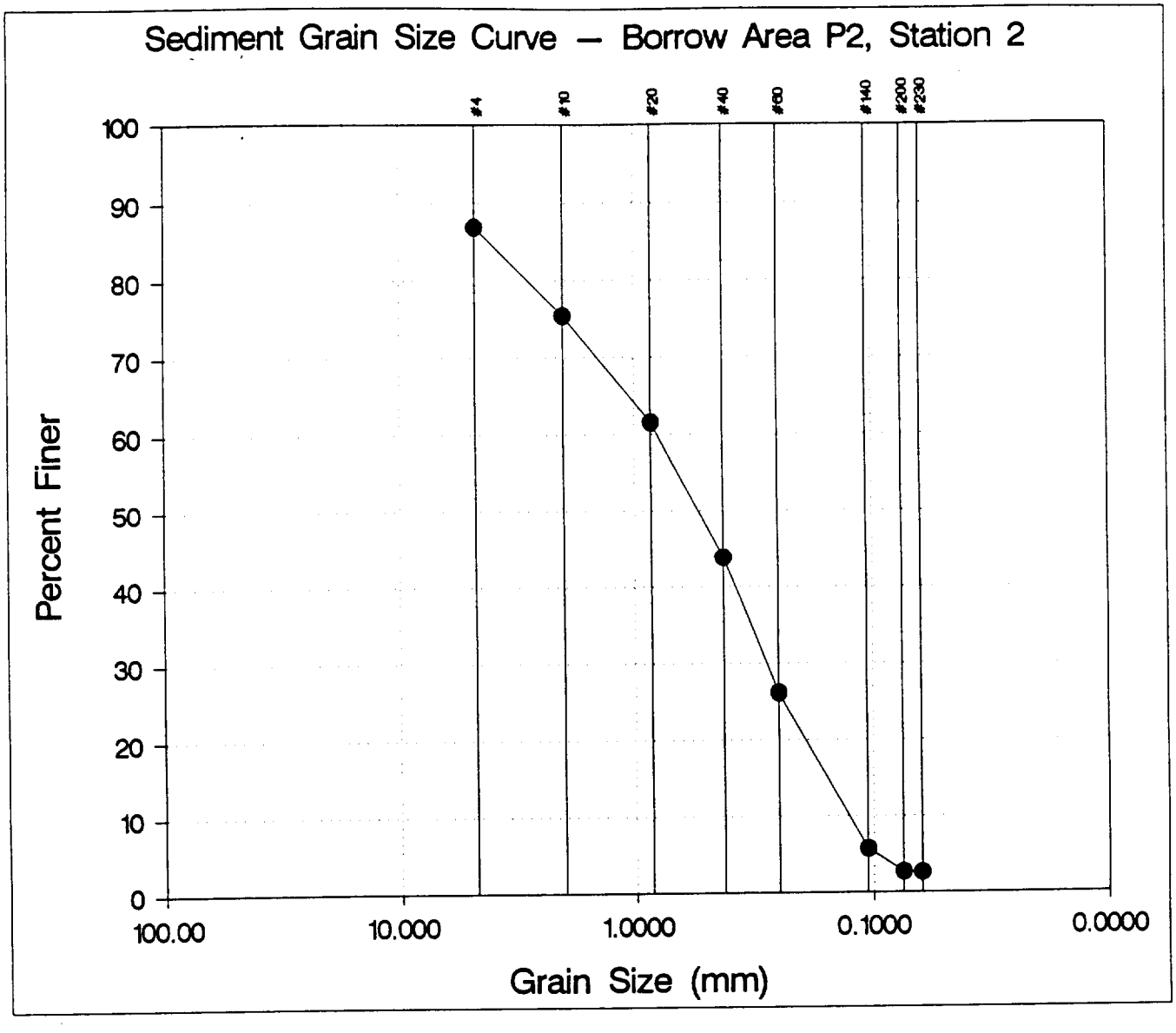
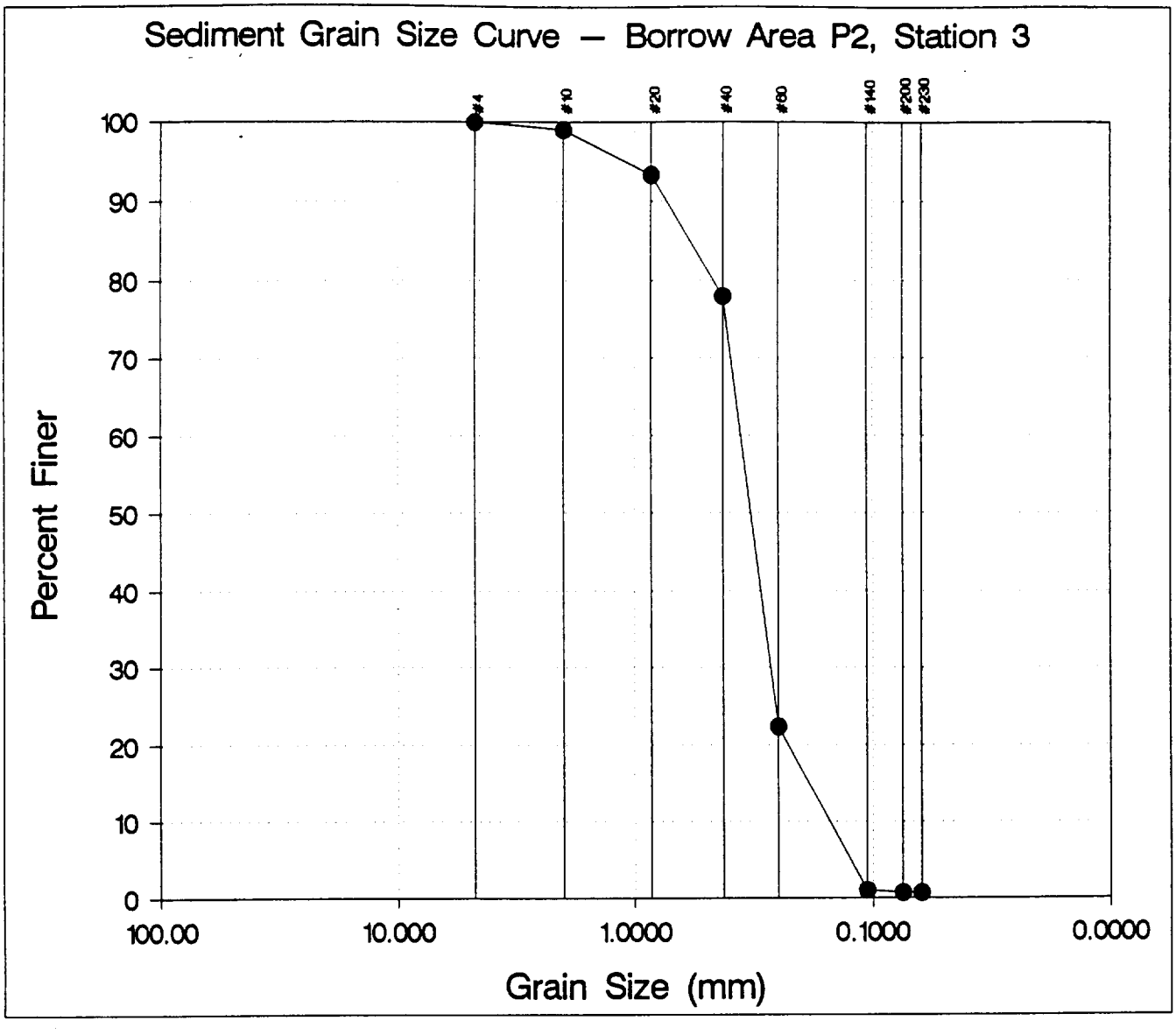
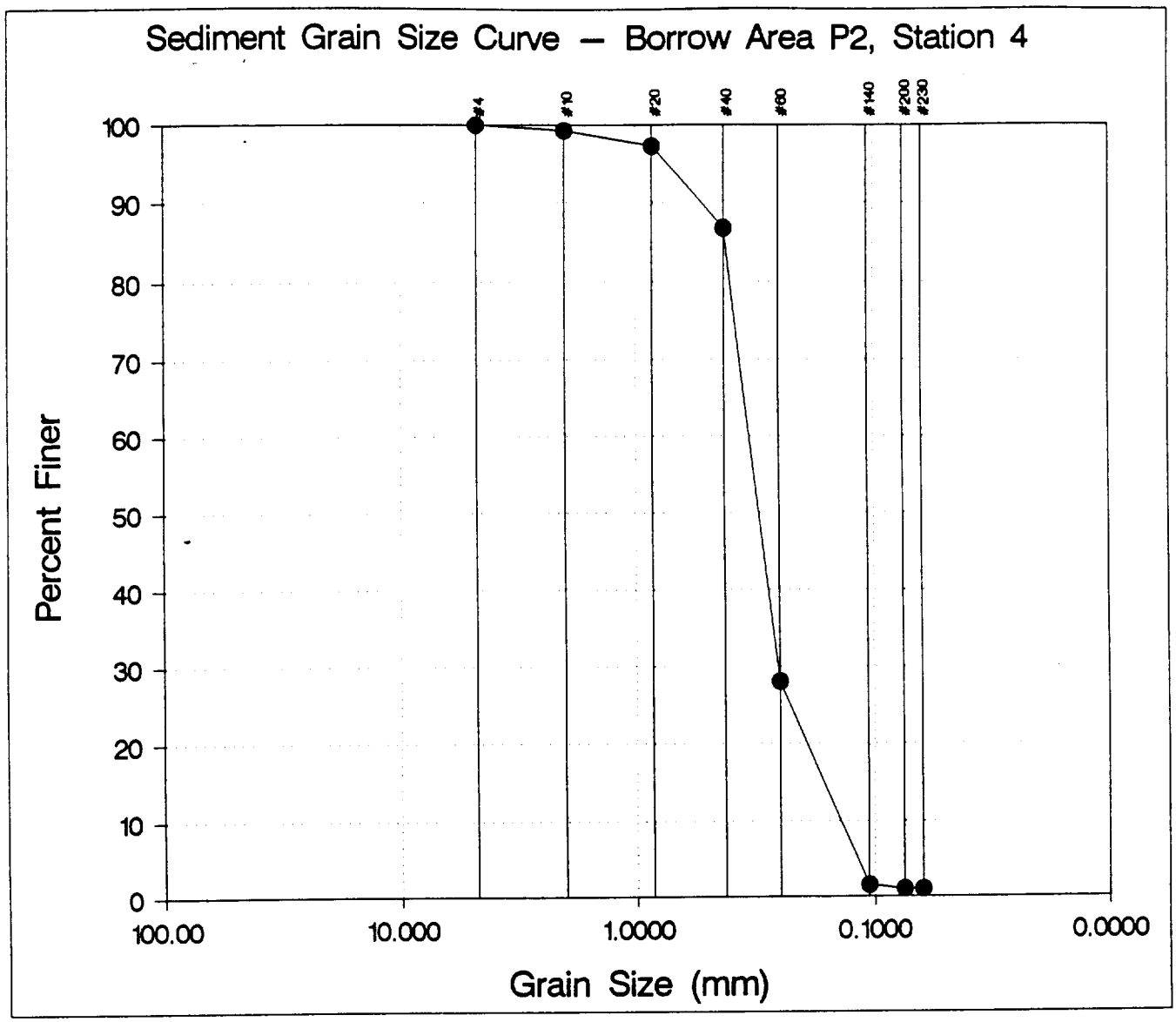
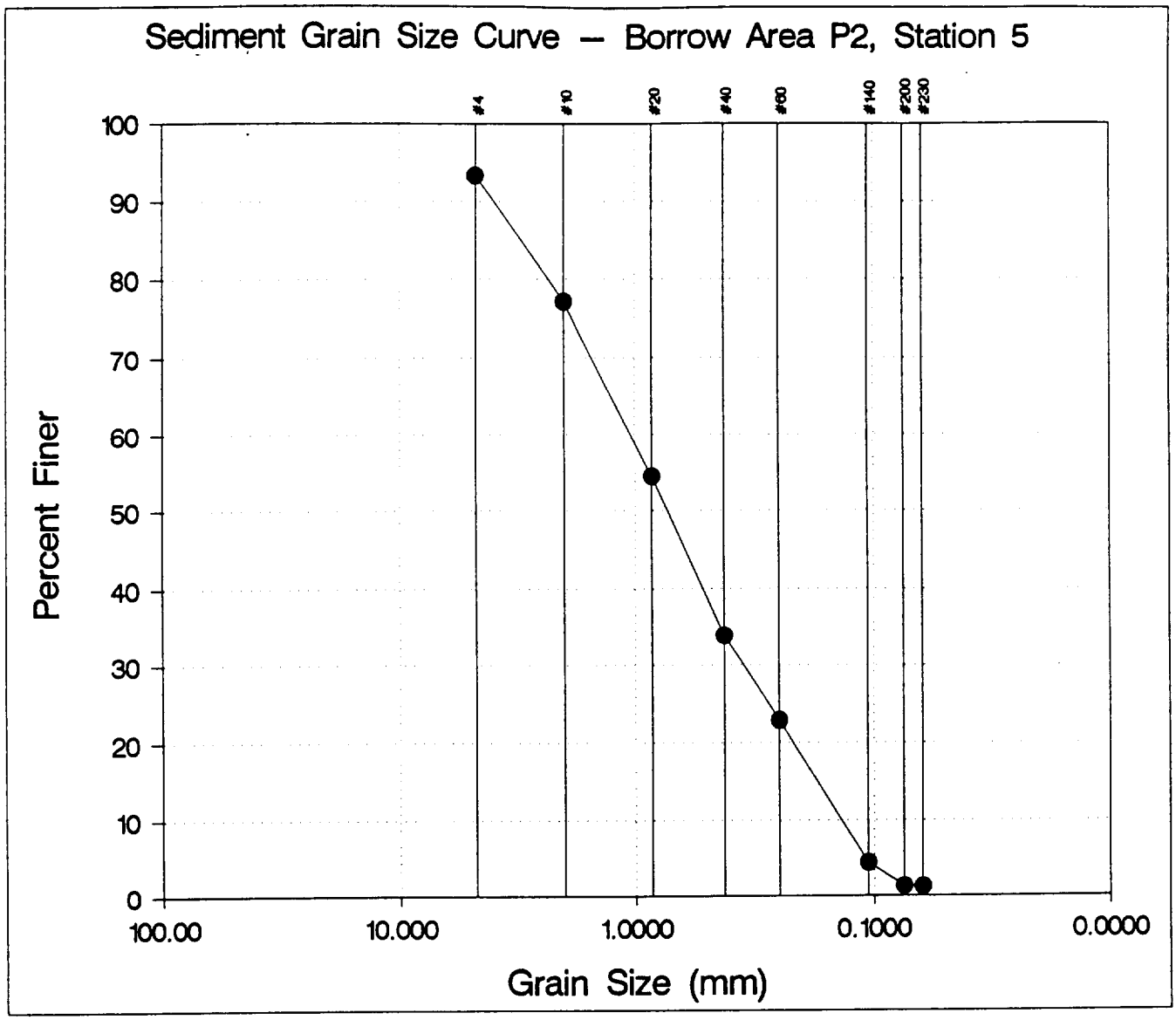
30
20
10
0
Percent Finer
100.00
10.000
1.0000
0.1000
0.0000
Grain Size (mm)

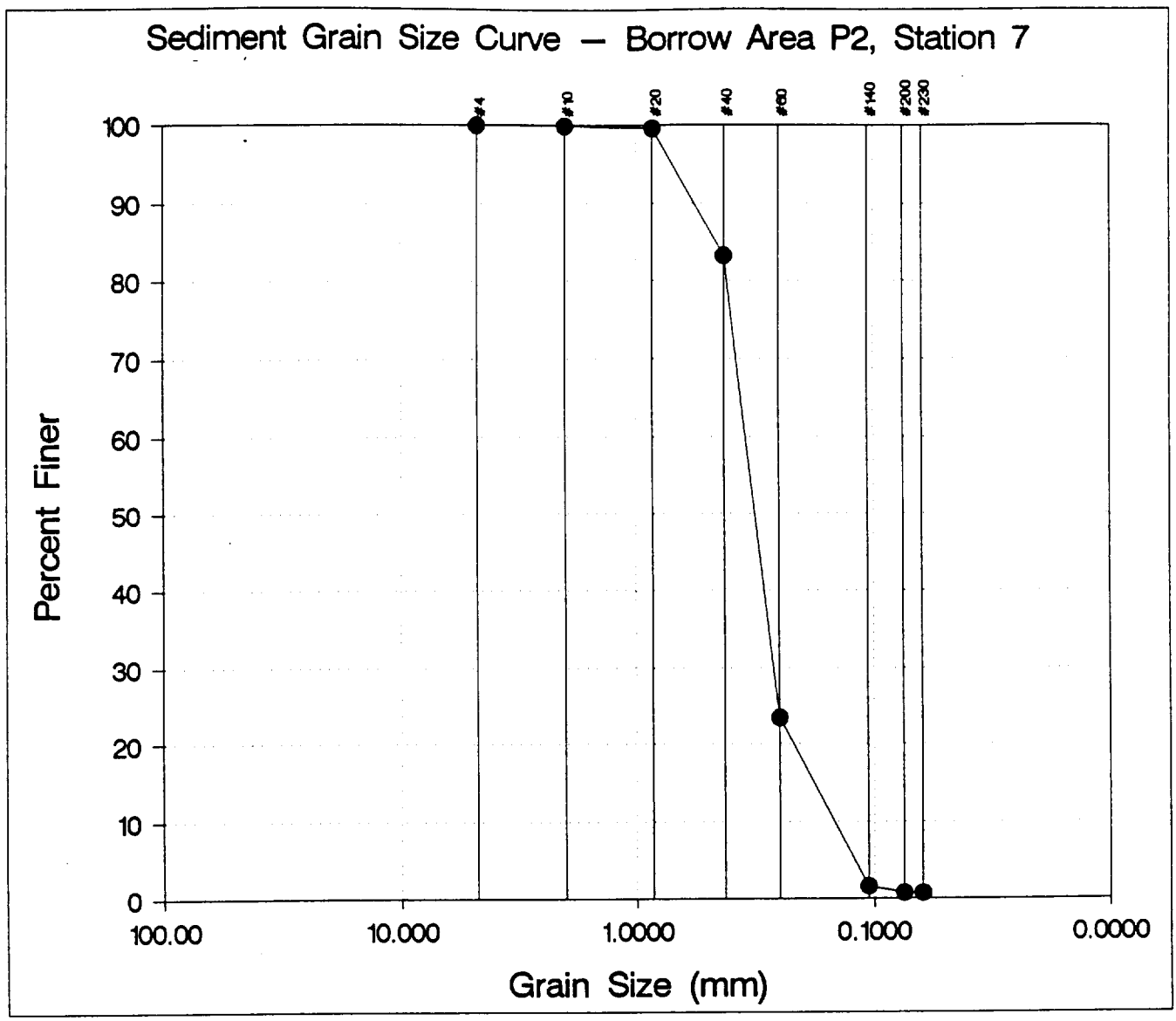

Sediment Grain Size Curve – Borrow Area P2, Station 1
#4
#10
#20
#40
#60
#140
#200
#230
100
90
80
70
60
50
40
30
20
10
0
Percent Finer
100.00
10.000
1.0000
0.1000
0.0000
Grain Size (mm)

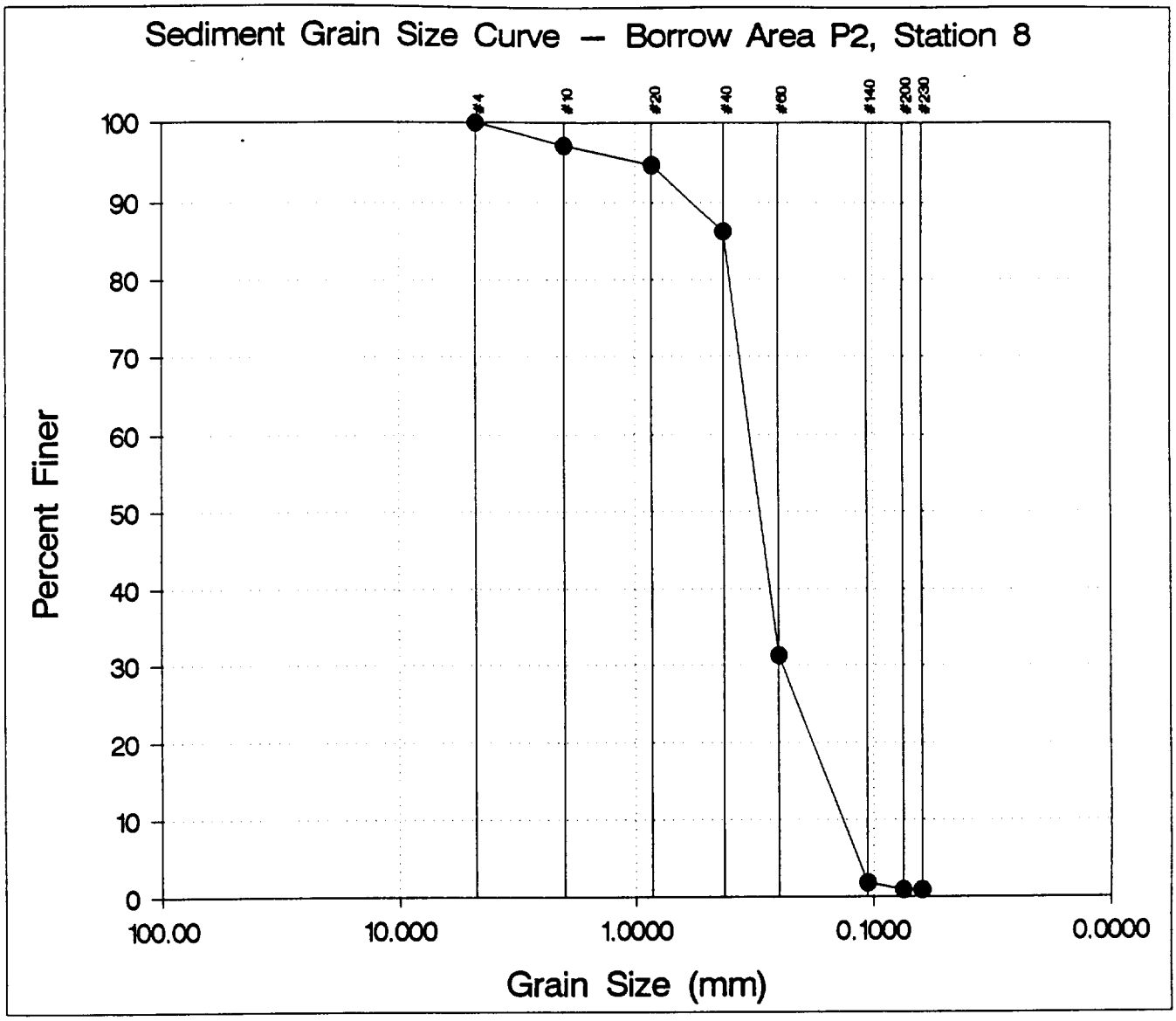

Sediment Grain Size Curve — Borrow Area P2, Station 2
#4
#10
#20
#40
#60
#140
#200
#230
100
90
80
70
60
50
40
30
20
10
0
Percent Finer
100.00
10.000
1.0000
0.1000
0.0000
Grain Size (mm)

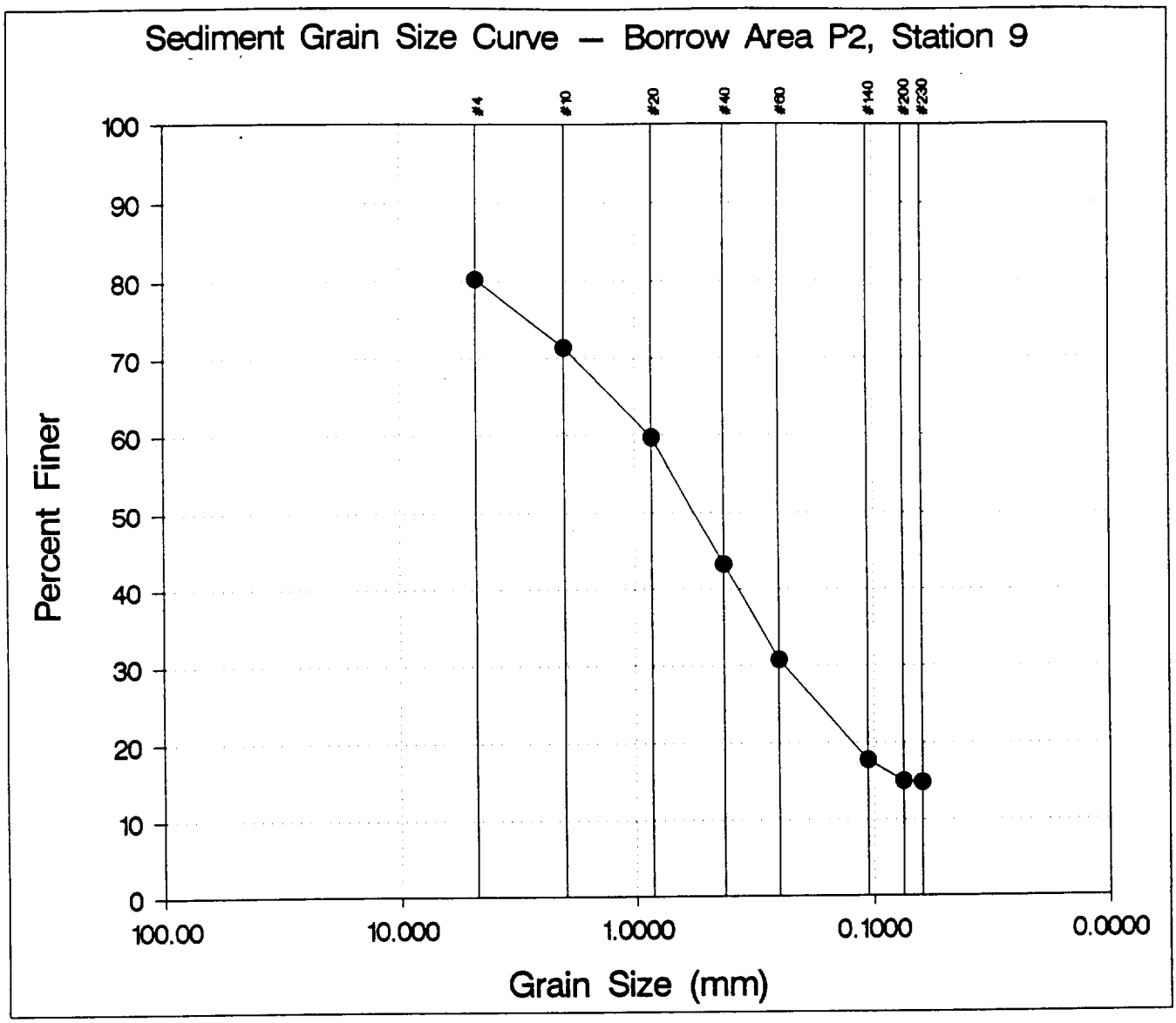

Sediment Grain Size Curve — Borrow Area P2, Station 3
#4
#10
#20
#40
#60
#140
#200
#230
100
90
80
70
60
50
40
30
20
10
0
Percent Finer
100.00
10.000
1.0000
0.1000
0.0000
Grain Size (mm)

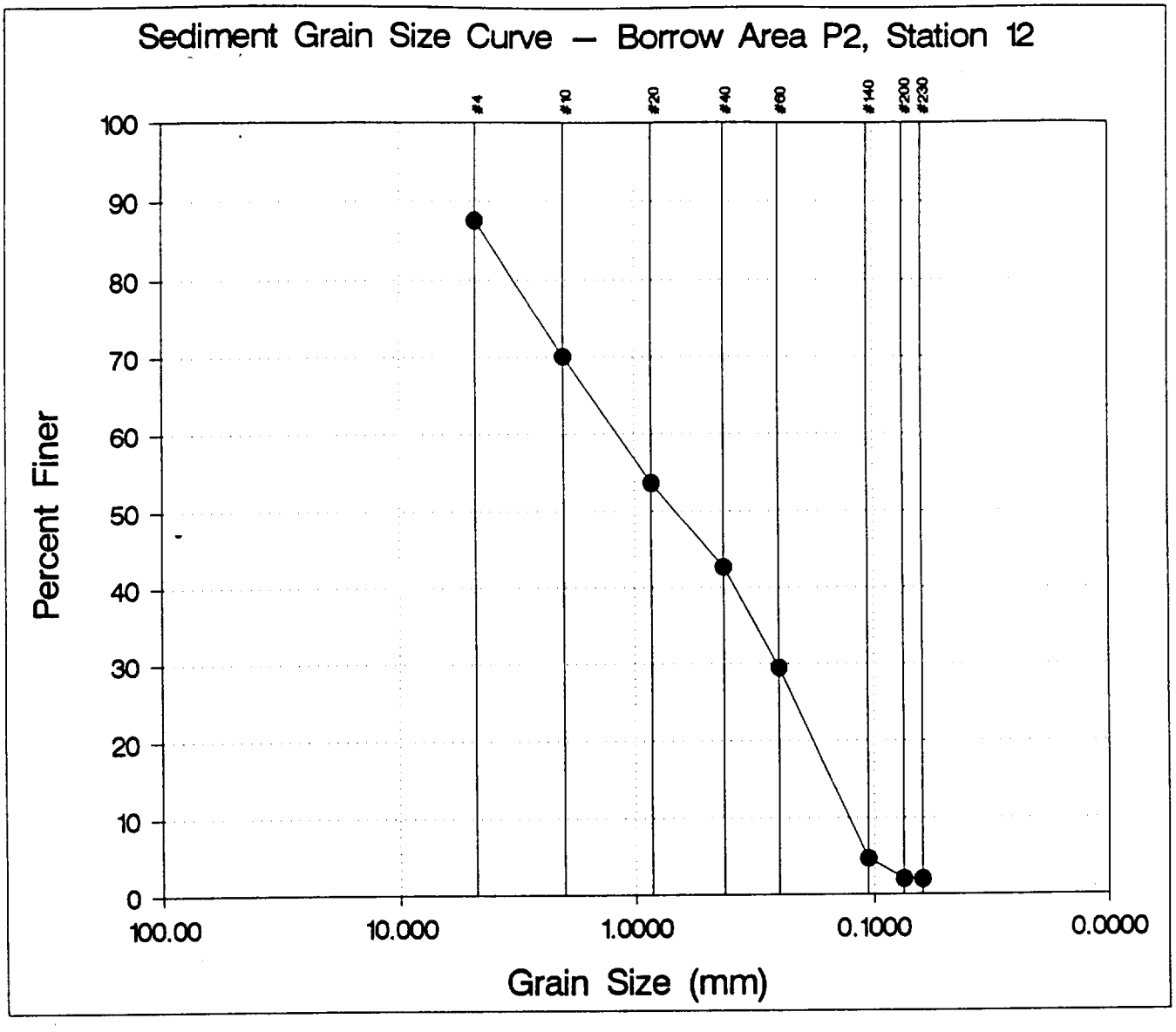

Sediment Grain Size Curve — Borrow Area P2, Station 4
#4
#10
#20
#40
#60
#140
#200
#230
100
90
80
70
60
50
40
30
20
10
0
Percent Finer
100.00
10.000
1.0000
0.1000
0.0000
Grain Size (mm)

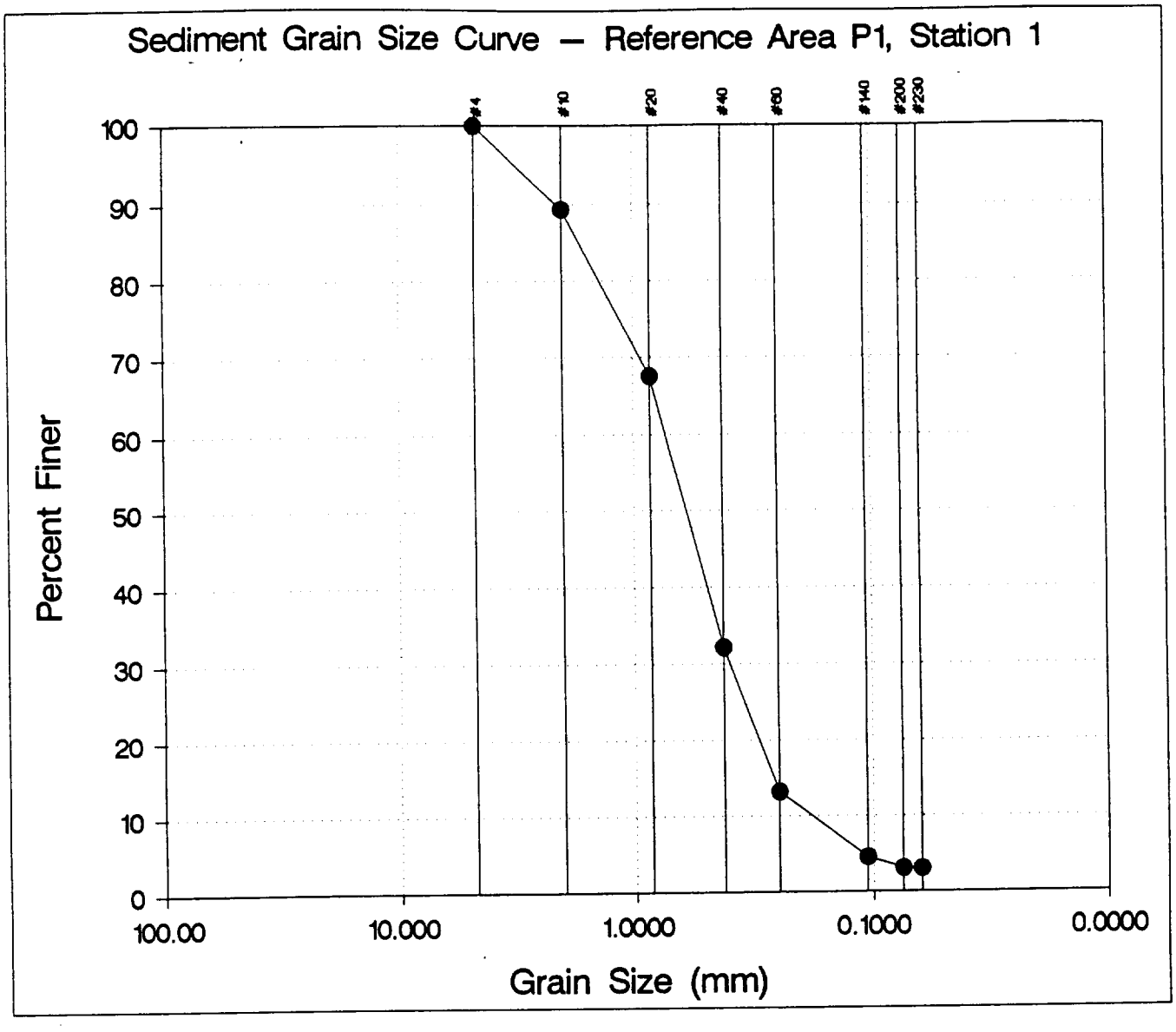

Sediment Grain Size Curve — Borrow Area P2, Station 5
#4
#10
#20
#40
#60
#140
#200
#230
100
90
80
70
60
50
40
30
20
10
0
Percent Finer
100.00
10.000
1.0000
0.1000
0.0000
Grain Size (mm)

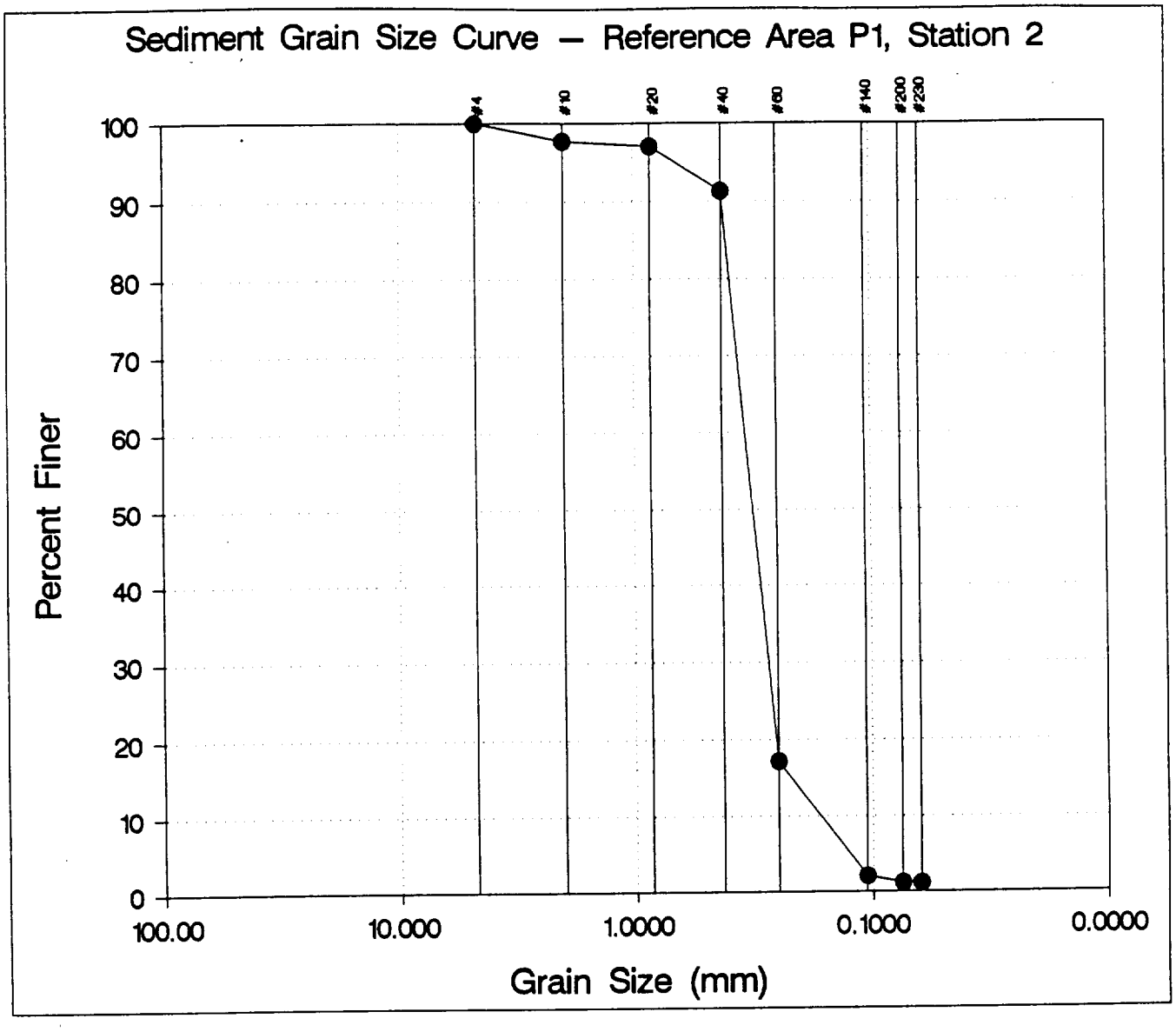

Sediment Grain Size Curve — Borrow Area P2, Station 7
#4
#10
#20
#40
#60
#140
#200
#230
100
90
80
70
60
50
40
30
20
10
0
Percent Finer
100.00
10.000
1.0000
0.1000
0.0000
Grain Size (mm)

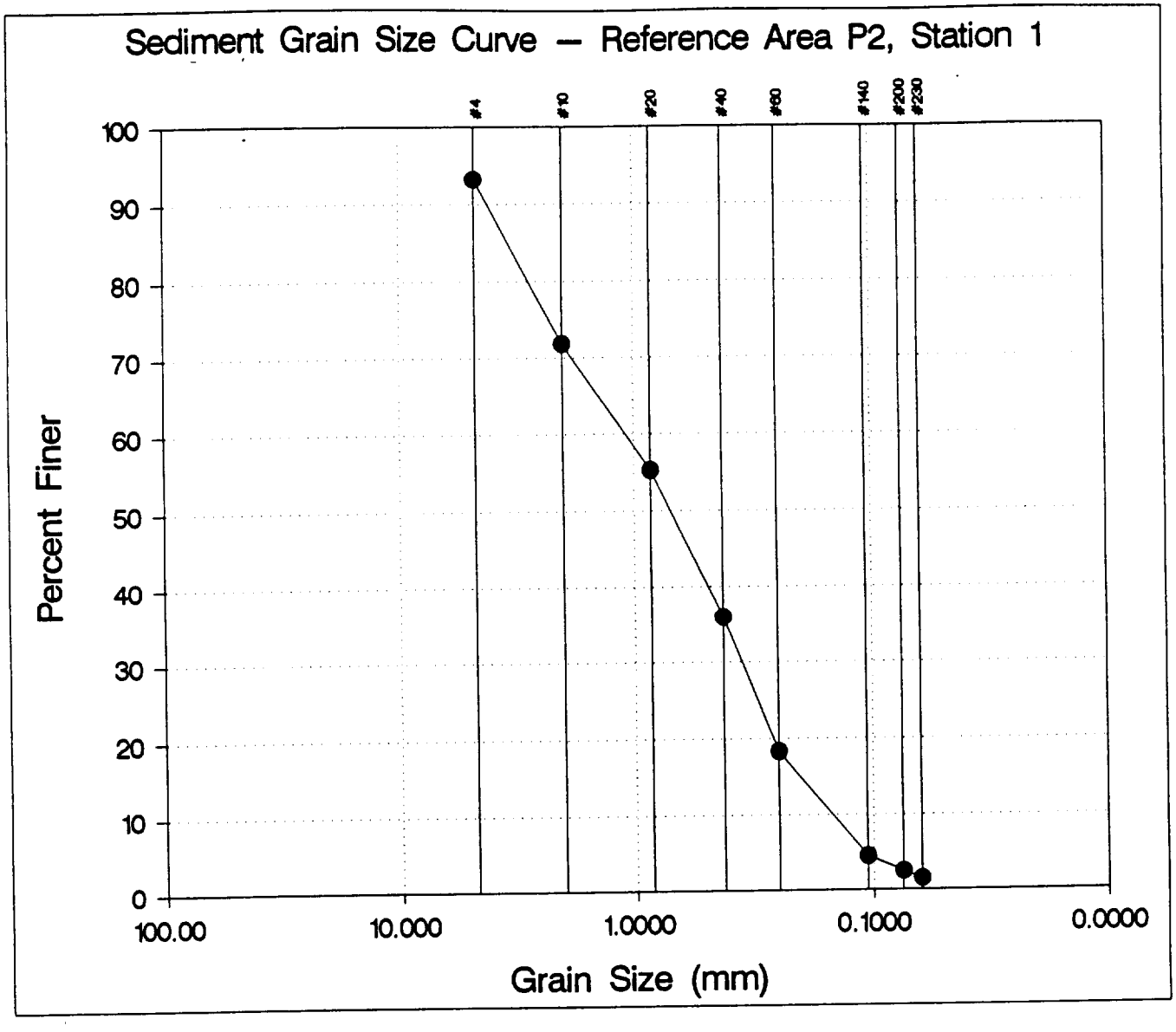

Sediment Grain Size Curve — Borrow Area P2, Station 8
#4
#10
#20
#40
#60
#140
#200
#230
100
90
80
70
60
50
40
30
20
10
0
Percent Finer
100.00
10.000
1.0000
0.1000
0.0000
Grain Size (mm)

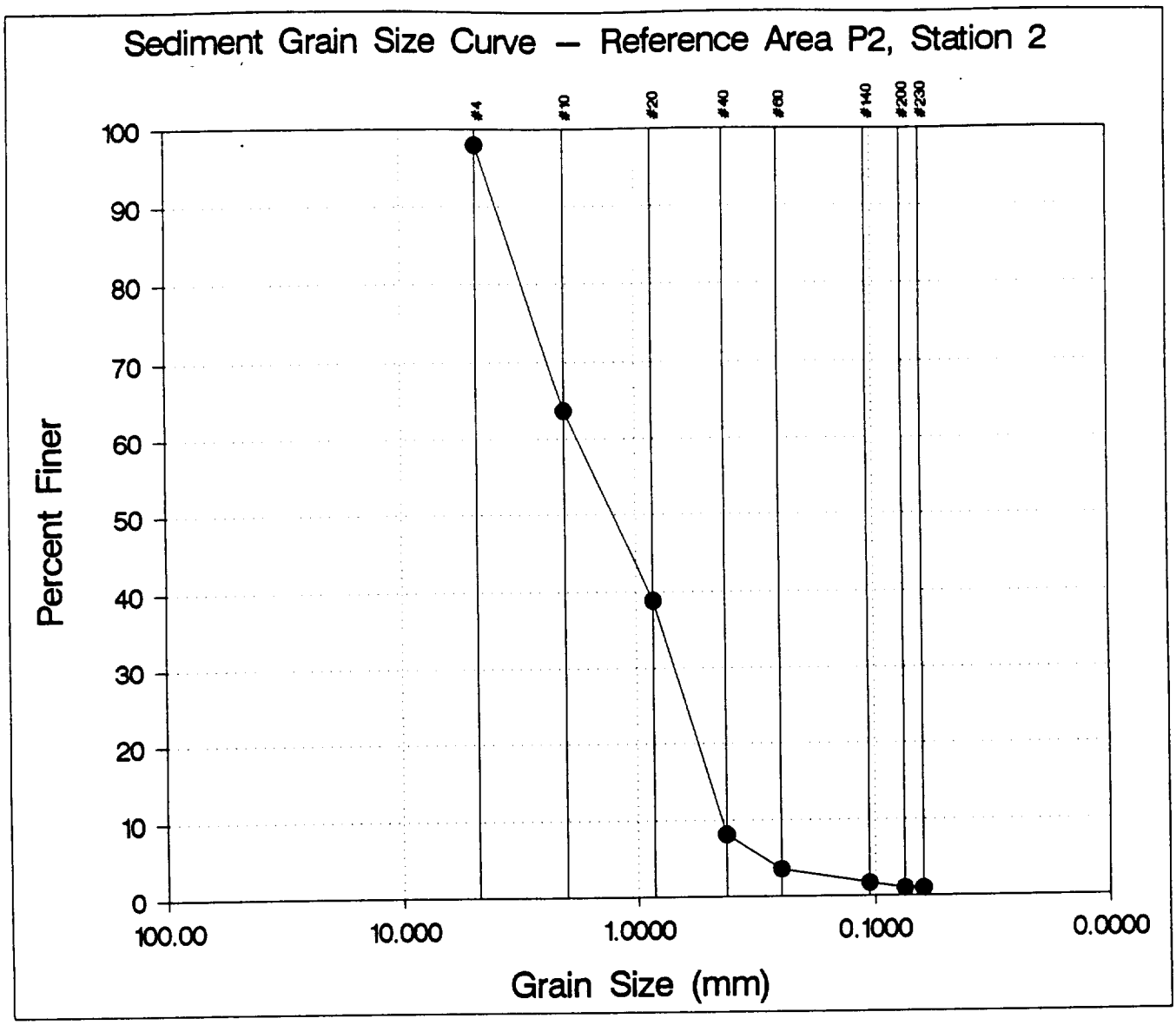

Sediment Grain Size Curve — Borrow Area P2, Station 9
#4
#10
#20
#40
#60
#140
#200
#230
100
90
80
70
60
50
40
30
20
10
0
Percent Finer
100.00
10.000
1.0000
0.1000
0.0000
Grain Size (mm)


Sediment Grain Size Curve — Borrow Area P2, Station 12
#4
#10
#20
#40
#60
#140
#200
#230
100
90
80
70
60
50
40
30
20
10
0
Percent Finer
100.00
10.000
1.0000
0.1000
0.0000
Grain Size (mm)


Sediment Grain Size Curve — Reference Area P1, Station 1
#4
#10
#20
#40
#60
#140
#200
#230
100
90
80
70
60
50
40
30
20
10
0
Percent Finer
100.00
10.000
1.0000
0.1000
0.0000
Grain Size (mm)


Sediment Grain Size Curve — Reference Area P1, Station 2
#4
#10
#20
#40
#60
#140
#200
#230
100
90
80
70
60
50
40
30
20
10
0
Percent Finer
100.00
10.000
1.0000
0.1000
0.0000
Grain Size (mm)


Sediment Grain Size Curve — Reference Area P2, Station 1
#4
#10
#20
#40
#60
#140
#200
#230
100
90
80
70
60
50
40
30
20
10
0
Percent Finer
100.00
10.000
1.0000
0.1000
0.0000
Grain Size (mm)


Sediment Grain Size Curve — Reference Area P2, Station 2
#4
#10
#20
#40
#60
#140
#200
#230
100
90
80
70
60
50
40
30
20
10
0
Percent Finer
100.00
10.000
1.0000
0.1000
0.0000
Grain Size (mm)

APPENDIX D

Station-Specific Sediment, Abundance, and Biomass Data

Benthic Macroinvertebrate Abundance and Biomass (Ash-Free Dry Weight) Data
Cape May, New Jersey

BORROW AREA : P1 | STATION : 1 | SAMPLING GEAR : Young-Modified Van Veen
SAMPLED AREA : 0.044 sq.m | SAMPLING DATE : September 24, 1996
SEDIMENT SILT-CLAY (%) : 1.40 | TOTAL ORGANIC CONTENT (%) : 0.50

BENTHOS	Abundance (#/m2) Total	Abundance (#/m2) >= 2cm	Biomass (g/m2) Total
Annelida : Oligochaeta			
Oligochaeta	159		0.00114
Annelida : Polychaeta			
Amastigos caperatus	68		0.00455
Aricidea catherinae	205		0.01364
Brania wellfleetensis	68		0.00455
Caulleriella sp. B Blake	2273		0.05000
Eumida sanguinea	23		0.00227
Microphthalmus similis	23		0.00227
Neanthes arenaceodentata	45		0.00227
Notomastus spp.	136		0.00455
Owenia fusiformis	205	23	0.05682
Parapionosyllis longicirrata	45		0.00114
Parougia caeca	23		0.00114
Polycirrus eximius	5909		0.89318
Polygordius spp.	29977		0.70000
Spiophanes bombyx	45		0.00455
Tharyx sp. A Morris	23		0.00114
Arthropoda : Amphipoda			
Ampelisca vadorum	23		0.00682
Liljeborgia sp. A Morris	23		0.00114
Arthropoda : Decapoda			
Pagurus spp.	45		0.01136
Upogebia affinis	23		0.01364
Mollusca : Bivalvia			
Ensis directus	23	23	4.80908
Lyonsia spp.	45		0.00455

Continued . . .

Benthic Macroinvertebrate Abundance and Biomass (Ash-Free Dry Weight) Data
Cape May, New Jersey

(Borrow Area: P1, Station: 1 - Contd.)

BENTHOS	Abundance (#/m2) Total	Abundance (#/m2) >= 2cm	Biomass (g/m2) Total
Nucula annulata	23		0.00114
Spisula solidissima	45		0.18636
Tellina agilis	205		0.17727
Mollusca : Gastropoda			
Crepidula maculosa	136		0.13636
Crepidula spp.	91		0.00909
Nassarius trivittatus	45		0.53182
Turbonilla interrupta	114		0.02273
Nemertinea			
Nemertinea	45		0.00114
Total	40114	45	7.65566
Number of Taxa	29		

Benthic Macroinvertebrate Abundance and Biomass (Ash-Free Dry Weight) Data
Cape May, New Jersey

BORROW AREA : P1
SAMPLED AREA : 0.044 sq.m
SEDIMENT SILT-CLAY (%) : 3.08

STATION : 2

SAMPLING GEAR : Young-Modified Van Veen
SAMPLING DATE : September 24, 1996
TOTAL ORGANIC CONTENT (%) : 0.34

BENTHOS	Abundance (#/m2) Total	Abundance (#/m2) >= 2cm	Biomass (g/m2) Total
Annelida : Oligochaeta			
Oligochaeta	159		0.00114
Annelida : Polychaeta			
Amastigos caperatus	23		0.00227
Aricidea catherinae	68		0.01364
Brania wellfleetensis	23		0.00227
Caulleriella sp. B Blake	682		0.01818
Eumida sanguinea	45		0.00114
Glycera dibranchiata	45	45	0.52273
Hemipodus roseus	23		0.00682
Hypereteone foliosa	23		0.04773
Mediomastus ambiseta	45		0.00227
Microphthalmus similis	23		0.00227
Notomastus spp.	23		0.00682
Owenia fusiformis	68		0.01136
Paranaitis speciosa	23		0.00114
Parapionosyllis longicirrata	68		0.00114
Parougia caeca	23		0.00227
Pisione remota	23		0.00227
Polycirrus eximius	10568		1.61590
Polydora socialis	23		0.00455
Polygordius spp.	27795		0.85909
Polynoidae	23		0.00455
Sabellaria vulgaris	136		0.04091
Arthropoda : Amphipoda			
Unciola spp.	91		0.00455

Continued . . .

Benthic Macroinvertebrate Abundance and Biomass (Ash-Free Dry Weight) Data
Cape May, New Jersey

(Borrow Area: P1, Station: 2 - Contd.)

BENTHOS	Abundance (#/m2) Total	Abundance (#/m2) >= 2cm	Biomass (g/m2) Total
Arthropoda : Decapoda			
Callianassa setimanus	23		0.00227
Pagurus spp.	68		0.00455
Pinnixa spp.	45		0.00682
Upogebia affinis	23		0.00455
Chordata : Ascidiacea			
Ascidiacea	182		0.00455
Cnidaria : Anthozoa			
Anthozoa	23		0.03636
Echinodermata : Ophiuroidea			
Ophiuroidea	23		0.00114
Mollusca : Bivalvia			
Lyonsia spp.	114		0.02045
Mysella planulata	23		0.00455
Pandora gouldiana	45		0.03182
Petricola pholadiformis	23		0.00114
Spisula solidissima	23	23	1.92045
Tellina agilis	45		0.07500
Mollusca : Gastropoda			
Astyris lunata	68		0.05455
Crepidula maculosa	91		0.10000
Crepidula spp.	205		0.00455
Doridella obscura	23		0.00114
Epitonium spp.	23		0.00114
Nassarius trivittatus	23		0.07045
Turbonilla interrupta	341		0.09773
Nemertinea			
Nemertinea	295		0.01818

Continued . . .

Benthic Macroinvertebrate Abundance and Biomass (Ash-Free Dry Weight) Data
Cape May, New Jersey

(Borrow Area: P1, Station: 2 - Contd.)

BENTHOS	Abundance (#/m2) Total	Abundance (#/m2) ≥ 2cm	Biomass (g/m2) Total
Platyhelminthes : Turbellaria			
Turbellaria	23		0.02045
Total	41773	68	5.65680
Number of Taxa	45		

Benthic Macroinvertebrate Abundance and Biomass (Ash-Free Dry Weight) Data
Cape May, New Jersey

BORROW AREA : P1
SAMPLED AREA : 0.044 sq.m
SEDIMENT SILT-CLAY (%) : 1.20

STATION : 3

SAMPLING GEAR : Young-Modified Van Veen
SAMPLING DATE : September 24, 1996
TOTAL ORGANIC CONTENT (%) : 0.34

BENTHOS	Abundance (#/m2) Total	Abundance (#/m2) >= 2cm	Biomass (g/m2) Total
Annelida : Oligochaeta			
Oligochaeta	23		0.00114
Annelida : Polychaeta			
Aricidea catherinae	68		0.01364
Brania wellfleetensis	23		0.00227
Caulleriella sp. B Blake	136		0.01818
Hemipodus roseus	23		0.01591
Notomastus spp.	23		0.00114
Parapionosyllis longicirrata	45		0.00114
Polygordius spp.	2568		0.06136
Spiophanes bombyx	182		0.02727
Syllidae	23		0.00227
Arthropoda : Decapoda			
Pagurus spp.	23		0.01136
Arthropoda : Isopoda			
Ancinus depressus	182		0.30227
Cnidaria : Anthozoa			
Anthozoa	23		0.03636
Echinodermata : Echinoidea			
Echinoidea	23		0.01364
Mollusca : Bivalvia			
Petricola pholadiformis	23		0.00114
Spisula solidissima	227	23	3.58408
Tellina agilis	659		0.24091
Mollusca : Gastropoda			
Astyris lunata	23		0.00227
Nassarius trivittatus	23		0.75682

Continued . . .

Benthic Macroinvertebrate Abundance and Biomass (Ash-Free Dry Weight) Data
Cape May, New Jersey

(Borrow Area: P1, Station: 3 - Contd.)

BENTHOS	Abundance (#/m2) Total	Abundance (#/m2) >= 2cm	Biomass (g/m2) Total
Nemertinea			
Nemertinea	23		0.00227
Total	4341	23	5.09544
Number of Taxa	19		

Benthic Macroinvertebrate Abundance and Biomass (Ash-Free Dry Weight) Data
Cape May, New Jersey

BORROW AREA : P1
SAMPLED AREA : 0.044 sq.m
SEDIMENT SILT-CLAY (%) : 1.48

STATION : 4

SAMPLING GEAR : Young-Modified Van Veen
SAMPLING DATE : September 24, 1996
TOTAL ORGANIC CONTENT (%) : 0.58

BENTHOS	Abundance (#/m2) Total	Abundance (#/m2) >= 2cm	Biomass (g/m2) Total
Annelida : Oligochaeta			
Oligochaeta	636		0.00682
Annelida : Polychaeta			
Amastigos caperatus	23		0.00227
Ancistrosyllis spp.	23		0.00682
Aricidea catherinae	23		0.00114
Bhawania heteroseta	23		0.00682
Caulleriella sp. B Blake	250		0.00227
Hemipodus roseus	91		0.07500
Maldanidae	23		0.00455
Mediomastus ambiseta	45		0.00455
Microphthalmus similis	23		0.00227
Neanthes arenaceodentata	23		0.00227
Owenia fusiformis	23		0.00455
Parapionosyllis longicirrata	159		0.00114
Polycirrus eximius	1159		0.18864
Polygordius spp.	13318		0.29318
Spiophanes bombyx	45		0.00227
Arthropoda : Amphipoda			
Microprotopus raneyi	45		0.00114
Unciola spp.	23		0.00114
Arthropoda : Decapoda			
Pagurus spp.	23		0.00455
Arthropoda : Isopoda			
Ancinus depressus	23		0.12727
Arthropoda : Tanaidacea			
Tanaissus psammophilus	23		0.00114

Continued . . .

Benthic Macroinvertebrate Abundance and Biomass (Ash-Free Dry Weight) Data
Cape May, New Jersey

(Borrow Area: P1, Station: 4 - Contd.)

BENTHOS	Abundance (#/m2) Total	Abundance (#/m2) >= 2cm	Biomass (g/m2) Total
Chordata : Ascidiacea			
Ascidiacea	23		0.00227
Chordata : Cephalochordata			
Branchiostoma caribaeum	45		0.01364
Mollusca : Bivalvia			
Ensis directus	23	23	0.51363
Lyonsia arenosa	136		0.13182
Mysella planulata	250		0.00455
Petricola pholadiformis	23		0.00114
Spisula solidissima	273	68	11.58633
Tellina agilis	159		0.02955
Mollusca : Gastropoda			
Crepidula spp.	45		0.00455
Polinices duplicatus	23		2.91817
Turbonilla interrupta	68		0.04545
Nemertinea			
Nemertinea	159		0.13182
Sipuncula			
Sipuncula	23		0.00114
Total	17273	91	16.12381
Number of Taxa	34		

Benthic Macroinvertebrate Abundance and Biomass (Ash-Free Dry Weight) Data
Cape May, New Jersey

BORROW AREA : P1 STATION : 5 SAMPLING GEAR : Young-Modified Van Veen
SAMPLED AREA : 0.044 sq.m SAMPLING DATE : September 24, 1996
SEDIMENT SILT-CLAY (%) : 2.18 TOTAL ORGANIC CONTENT (%) : 0.66

BENTHOS	Abundance (#/m2)	Biomass (g/m2)
	Total >= 2cm	Total
Annelida : Oligochaeta		
Oligochaeta	591	0.01136
Annelida : Polychaeta		
Amastigos caperatus	23	0.00114
Aricidea catherinae	45	0.00455
Caulleriella sp. B Blake	23	0.00227
Dorvilleidae sp. A Hilbig	23	0.00114
Eumida sanguinea	91	0.00114
Hemipodus roseus	45	0.01818
Maldanidae	23	0.00227
Microphthalmus similis	91	0.00227
Neanthes arenaceodentata	68	0.00114
Nereididae	23	0.00227
Orbiniidae	91	0.00114
Owenia fusiformis	23	0.01136
Parapionosyllis longicirrata	182	0.00114
Parougia caeca	45	0.00114
Phyllodoce arenae	23	0.00227
Polycirrus eximius	10205	2.23863
Polydora socialis	23	0.00227
Polygordius spp.	42863	1.19318
Sabellaria vulgaris	45	0.00227
Spiophanes bombyx	114	0.02500
Syllidae	23	0.00227
Arthropoda : Amphipoda		
Batea catharinensis	23	0.00114
Liljeborgia sp. A Morris	23	0.00114

Continued . . .

Benthic Macroinvertebrate Abundance and Biomass (Ash-Free Dry Weight) Data
Cape May, New Jersey

(Borrow Area: P1, Station: 5 - Contd.)

BENTHOS	Abundance (#/m2) Total	Abundance (#/m2) >= 2cm	Biomass (g/m2) Total
Microprotopus raneyi	568		0.00909
Unciola spp.	114		0.00455
Arthropoda : Cumacea			
Oxyurostylis smithi	23		0.00682
Arthropoda : Decapoda			
Crangon septemspinosa	68	23	0.58863
Pagurus spp.	91		0.00455
Arthropoda : Isopoda			
Edotea triloba	23		0.00114
Chordata : Ascidiacea			
Ascidiacea	227		0.00227
Mollusca : Bivalvia			
Ensis directus	23	23	0.65682
Lyonsia spp.	136		0.00682
Mysella planulata	136		0.00227
Petricola pholadiformis	91		0.00227
Spisula solidissima	136	91	15.57040
Tellina agilis	45		0.08636
Veneridae	23		0.00455
Mollusca : Gastropoda			
Astyris lunata	23		0.02045
Crepidula spp.	114		0.01818
Doridella obscura	182		0.01136
Turbonilla interrupta	250		0.07500
Nemertinea			
Nemertinea	250		0.00455
Platyhelminthes : Turbellaria			
Turbellaria	23		0.00227
Total	57273	136	20.60902
Number of Taxa	43		

Benthic Macroinvertebrate Abundance and Biomass (Ash-Free Dry Weight) Data
Cape May, New Jersey

BORROW AREA : P1 STATION : 6 SAMPLING GEAR : Young-Modified Van Veen
SAMPLED AREA : 0.044 sq.m SAMPLING DATE : September 24, 1996
SEDIMENT SILT-CLAY (%) : 1.23 TOTAL ORGANIC CONTENT (%) : 0.56

BENTHOS	Abundance (#/m2) Total	Abundance (#/m2) >= 2cm	Biomass (g/m2) Total
Annelida : Oligochaeta			
Oligochaeta	114		0.00227
Annelida : Polychaeta			
Ampharetidae	23		0.00114
Aricidea catherinae	23		0.00114
Glycera dibranchiata	23	23	0.26364
Hemipodus roseus	45		0.02045
Nephtys picta	23	23	0.11136
Parapionosyllis longicirrata	182		0.00227
Parougia caeca	45		0.00227
Polycirrus eximius	2295		0.65909
Polygordius spp.	159		0.00227
Arthropoda : Isopoda			
Ancinus depressus	68		0.18636
Chordata : Ascidiacea			
Ascidiacea	23		0.00114
Mollusca : Bivalvia			
Lyonsia spp.	23		0.00455
Mysella planulata	182		0.00682
Pandora gouldiana	23		0.02273
Petricola pholadiformis	68		0.00114
Spisula solidissima	250	91	7.95679
Tellina agilis	159		0.03182
Mollusca : Gastropoda			
Crepidula maculosa	23		0.01818
Crepidula spp.	45		0.00227
Doridella obscura	45		0.00114

Continued . . .

Benthic Macroinvertebrate Abundance and Biomass (Ash-Free Dry Weight) Data
Cape May, New Jersey

(Borrow Area: P1, Station: 6 - Contd.)

BENTHOS	Abundance (#/m2) Total	Abundance (#/m2) >= 2cm	Biomass (g/m2) Total
Turbonilla interrupta	68		0.00455
Nemertinea			
Nemertinea	23		0.01364
Platyhelminthes : Turbellaria			
Turbellaria	23		0.00455
Total	3955	136	9.32156
Number of Taxa	24		

Benthic Macroinvertebrate Abundance and Biomass (Ash-Free Dry Weight) Data
Cape May, New Jersey

BORROW AREA : P1 STATION : 7 SAMPLING GEAR : Young-Modified Van Veen
SAMPLED AREA : 0.044 sq.m SAMPLING DATE : September 24, 1996
SEDIMENT SILT-CLAY (%) : 0.98 TOTAL ORGANIC CONTENT (%) : 0.27

BENTHOS	Abundance (#/m2) Total	Abundance (#/m2) >= 2cm	Biomass (g/m2) Total
Annelida : Oligochaeta			
Oligochaeta	386		0.00227
Annelida : Polychaeta			
Ancistrosyllis hartmanae	136	23	0.01364
Glycera dibranchiata	23	23	0.18636
Hemipodus roseus	68		0.03636
Mediomastus ambiseta	23		0.00114
Orbiniidae	23		0.00114
Owenia fusiformis	45		0.00455
Phyllodoce arenae	45		0.00909
Polygordius spp.	45		0.00114
Spiophanes bombyx	45		0.00227
Tharyx sp. A Morris	23		0.00114
Arthropoda : Amphipoda			
Microprotopus raneyi	45		0.00114
Unciola spp.	45		0.00114
Arthropoda : Decapoda			
Pagurus spp.	68		0.01591
Arthropoda : Isopoda			
Ancinus depressus	23		0.01136
Chiridotea coeca	23		0.00227
Chordata : Ascidiacea			
Ascidiacea	114		0.00114
Mollusca : Bivalvia			
Ensis directus	23	23	0.27045
Petricola pholadiformis	45		0.00114
Spisula solidissima	182	45	7.86588

Continued . . .

Benthic Macroinvertebrate Abundance and Biomass (Ash-Free Dry Weight) Data
Cape May, New Jersey

(Borrow Area: P1, Station: 7 - Contd.)

BENTHOS	Abundance (#/m2) Total	Abundance (#/m2) >= 2cm	Biomass (g/m2) Total
Tellina agilis	250		0.15909
Mollusca : Gastropoda			
Crepidula spp.	23		0.00114
Nemertinea			
Nemertinea	114		0.03636
Total	1818	114	8.62611
Number of Taxa	23		

Benthic Macroinvertebrate Abundance and Biomass (Ash-Free Dry Weight) Data
Cape May, New Jersey

BORROW AREA : P1 STATION : 8 SAMPLING GEAR : Young-Modified Van Veen
SAMPLED AREA : 0.044 sq.m SAMPLING DATE : September 24, 1996
SEDIMENT SILT-CLAY (%) : 1.05 TOTAL ORGANIC CONTENT (%) : 0.27

BENTHOS	Abundance (#/m2) Total	Abundance (#/m2) >= 2cm	Biomass (g/m2) Total
Annelida : Oligochaeta			
Oligochaeta	23		0.00114
Annelida : Polychaeta			
Amastigos caperatus	45		0.00909
Ancistrosyllis spp.	45		0.00455
Aricidea catherinae	45		0.00909
Caulleriella sp. B Blake	364		0.03409
Glycera spp.	23		0.00455
Maldanidae	23		0.00227
Nephtys picta	23		0.03636
Owenia fusiformis	23		0.00114
Parapionosyllis longicirrata	23		0.00114
Parougia caeca	23		0.00114
Polycirrus eximius	205		0.00909
Polygordius spp.	886		0.02727
Spiophanes bombyx	91		0.00227
Arthropoda : Amphipoda			
Acanthohaustorius spp.	23		0.00455
Bathyporeia parkeri	23		0.00455
Arthropoda : Decapoda			
Crangon septemspinosa	23		0.00455
Pagurus spp.	23		0.00114
Arthropoda : Isopoda			
Ancinus depressus	23		0.20454
Chiridotea tuftsi	45		0.00455
Mollusca : Bivalvia			
Spisula solidissima	91		0.00227

Continued . . .

Benthic Macroinvertebrate Abundance and Biomass (Ash-Free Dry Weight) Data
Cape May, New Jersey

(Borrow Area: P1, Station: 8 - Contd.)

BENTHOS	Abundance (#/m2) Total	Abundance (#/m2) >= 2cm	Biomass (g/m2) Total
Tellina agilis	68		0.00682
Platyhelminthes : Turbellaria			
Turbellaria	23		0.00114
Total	2182		0.37727
Number of Taxa	23		

Benthic Macroinvertebrate Abundance and Biomass (Ash-Free Dry Weight) Data
Cape May, New Jersey

BORROW AREA : P1 STATION : 9 SAMPLING GEAR : Young-Modified Van Veen
SAMPLED AREA : 0.044 sq.m SAMPLING DATE : September 24, 1996
SEDIMENT SILT-CLAY (%) : 2.25 TOTAL ORGANIC CONTENT (%) : 0.55

BENTHOS	Abundance (#/m2) Total	Abundance (#/m2) >= 2cm	Biomass (g/m2) Total
Annelida : Oligochaeta			
Oligochaeta	409		0.00227
Annelida : Polychaeta			
Ampharetidae	68		0.00114
Brania wellfleetensis	23		0.00114
Caulleriella sp. B Blake	45		0.00114
Eumida sanguinea	68		0.00455
Glycera dibranchiata	45	45	0.64318
Hemipodus roseus	136	23	0.06136
Neanthes arenaceodentata	23		0.00114
Parapionosyllis longicirrata	23		0.00114
Polycirrus eximius	8477		1.25000
Polydora cornuta	23		0.00114
Polydora socialis	23		0.00227
Polygordius spp.	1409		0.04545
Polynoidae	23		0.00114
Sabellaria vulgaris	545		0.02273
Spiophanes bombyx	23		0.00227
Arthropoda : Amphipoda			
Batea catharinensis	23		0.00114
Microprotopus raneyi	23		0.00114
Unciola spp.	114		0.00227
Chordata : Ascidiacea			
Ascidiacea	205		0.00114
Mollusca : Bivalvia			
Anadara transversa	45		0.04773
Ensis directus	23	23	0.45909

Continued . . .

Benthic Macroinvertebrate Abundance and Biomass (Ash-Free Dry Weight) Data
Cape May, New Jersey

(Borrow Area: P1, Station: 9 - Contd.)

BENTHOS	Abundance (#/m2) Total	Abundance (#/m2) >= 2cm	Biomass (g/m2) Total
Lyonsia spp.	45		0.00227
Mysella planulata	91		0.00114
Nucula annulata	23		0.00114
Petricola pholadiformis	273		0.00114
Spisula solidissima	295	273	37.90442
Tellina agilis	227		0.07045
Mollusca : Gastropoda			
Astyris lunata	159		0.15454
Crepidula maculosa	205		0.11136
Crepidula plana	955		0.16591
Crepidula spp.	159		0.00455
Doridella obscura	45		0.00455
Nassarius trivittatus	23		0.59773
Polinices duplicatus	23		1.57272
Turbonilla interrupta	273		0.05000
Nemertinea			
Nemertinea	159		0.00682
Total	14750	364	43.20327
Number of Taxa	36		

Benthic Macroinvertebrate Abundance and Biomass (Ash-Free Dry Weight) Data
Cape May, New Jersey

BORROW AREA : P1 STATION : 10 SAMPLING GEAR : Young-Modified Van Veen
SAMPLED AREA : 0.044 sq.m SAMPLING DATE : September 24, 1996
SEDIMENT SILT-CLAY (%) : 1.44 TOTAL ORGANIC CONTENT (%) : 0.32

BENTHOS	Abundance (#/m2) Total	Abundance (#/m2) >= 2cm	Biomass (g/m2) Total
Annelida : Polychaeta			
Amastigos caperatus	23		0.00227
Ancistrosyllis spp.	23		0.00227
Aricidea catherinae	114		0.01591
Brania wellfleetensis	23		0.00227
Caulleriella sp. B Blake	91		0.00455
Glycera dibranchiata	23	23	0.02273
Glycera spp.	45		0.02727
Hypereteone foliosa	23	23	0.06591
Microphthalmus similis	68		0.00227
Parapionosyllis longicirrata	23		0.00455
Parougia caeca	159		0.00909
Phyllodoce arenae	23		0.01136
Polycirrus eximius	91		0.01818
Polygordius spp.	1045		0.02955
Sabellaria vulgaris	23		0.03864
Spiophanes bombyx	23		0.00455
Arthropoda : Amphipoda			
Acanthohaustorius millsi	45		0.00114
Arthropoda : Decapoda			
Pagurus spp.	205		0.05455
Arthropoda : Isopoda			
Chiridotea tuftsi	91		0.01591
Cnidaria : Anthozoa			
Anthozoa	23		0.02273
Echinodermata : Echinoidea			
Echinoidea	23		0.00227

Continued . . .

Benthic Macroinvertebrate Abundance and Biomass (Ash-Free Dry Weight) Data
Cape May, New Jersey

(Borrow Area: P1, Station: 10 - Contd.)

BENTHOS	Abundance (#/m2) Total	Abundance (#/m2) >= 2cm	Biomass (g/m2) Total
Mollusca : Bivalvia			
Pandora gouldiana	114		0.81136
Spisula solidissima	227	23	1.50681
Tellina agilis	477		0.19773
Mollusca : Gastropoda			
Turbonilla interrupta	23		0.00455
Nemertinea			
Nemertinea	23		0.00682
Total	3068	68	2.88522
Number of Taxa	25		

Benthic Macroinvertebrate Abundance and Biomass (Ash-Free Dry Weight) Data
Cape May, New Jersey

BORROW AREA : P1 STATION : 11 SAMPLING GEAR : Young-Modified Van Veen
SAMPLED AREA : 0.044 sq.m SAMPLING DATE : September 24, 1996
SEDIMENT SILT-CLAY (%) : 2.58 TOTAL ORGANIC CONTENT (%) : 0.53

BENTHOS	Abundance (#/m2) Total	Abundance (#/m2) >= 2cm	Biomass (g/m2) Total
Annelida : Oligochaeta			
Oligochaeta	205		0.00114
Annelida : Polychaeta			
Ampharetidae	23		0.00455
Ancistrosyllis hartmanae	23		0.00227
Aricidea catherinae	68		0.00114
Caulleriella sp. B Blake	136		0.00114
Eumida sanguinea	23		0.00114
Glycera dibranchiata	23	23	1.91136
Hemipodus roseus	91	23	0.05455
Microphthalmus fragilis	23		0.00227
Nephtys picta	23	23	0.34318
Notocirrus spiniferus	23	23	0.45682
Notomastus luridus	23		0.01364
Owenia fusiformis	91		0.00909
Parapionosyllis longicirrata	45		0.00114
Parougia caeca	68		0.00114
Pisione remota	23		0.00114
Polycirrus eximius	6568		0.90682
Polygordius spp.	6455		0.23864
Polynoidae	23		0.00114
Proceraea cornuta	45		0.00114
Sabellaria vulgaris	409		0.01591
Spiophanes bombyx	68		0.00114
Arthropoda : Amphipoda			
Batea catharinensis	23		0.00114
Paracaprella tenuis	23		0.00114

Continued . . .

Benthic Macroinvertebrate Abundance and Biomass (Ash-Free Dry Weight) Data
Cape May, New Jersey

(Borrow Area: P1, Station: 11 - Contd.)

BENTHOS	Abundance (#/m2) Total	Abundance (#/m2) >= 2cm	Biomass (g/m2) Total
Unciola serrata	159		0.02727
Arthropoda : Decapoda			
Xanthidae	23		0.01364
Chordata : Ascidiacea			
Ascidiacea	68		0.00114
Mollusca : Bivalvia			
Barnea truncata	68		0.00227
Lyonsia spp.	23		0.01364
Pandora gouldiana	68		0.07955
Petricola pholadiformis	45		0.00114
Spisula solidissima	159	91	10.70451
Tellina agilis	68		0.00114
Mollusca : Gastropoda			
Astyris lunata	114		0.09773
Crepidula spp.	45		0.00114
Doridella obscura	182		0.00227
Nassarius trivittatus	23		0.55000
Turbonilla interrupta	318		0.09091
Nemertinea			
Nemertinea	182		0.02045
Total	16068	182	15.57950
Number of Taxa	39		

Benthic Macroinvertebrate Abundance and Biomass (Ash-Free Dry Weight) Data
Cape May, New Jersey

BORROW AREA : P1 STATION : 12 SAMPLING GEAR : Young-Modified Van Veen
SAMPLED AREA : 0.044 sq.m SAMPLING DATE : September 24, 1996
SEDIMENT SILT-CLAY (%) : 1.31 TOTAL ORGANIC CONTENT (%) : 0.42

BENTHOS	Abundance (#/m2) Total	Abundance (#/m2) >= 2cm	Biomass (g/m2) Total
Annelida : Oligochaeta			
Oligochaeta	432		0.00682
Annelida : Polychaeta			
Amastigos caperatus	23		0.00114
Ancistrosyllis hartmanae	23		0.00114
Aricidea catherinae	45		0.00114
Brania wellfleetensis	68		0.00114
Caulleriella sp. B Blake	1091		0.02500
Drilonereis longa	23	23	0.06818
Eumida sanguinea	91		0.00114
Hemipodus roseus	23		0.00909
Mediomastus ambiseta	45		0.00227
Microphthalmus similis	23		0.00114
Nephtys picta	23	23	0.10227
Nereididae	23		0.00114
Owenia fusiformis	23		0.00114
Parapionosyllis longicirrata	68		0.00114
Polycirrus eximius	3864		0.67273
Polydora socialis	23		0.00114
Polygordius spp.	19136		0.46363
Polynoidae	45		0.00114
Proceraea cornuta	23		0.00114
Sabellaria vulgaris	477		0.02727
Spiophanes bombyx	91		0.00227
Streblospio benedicti	23		0.00114
Tharyx sp. A Morris	68		0.00114

Continued . . .

Benthic Macroinvertebrate Abundance and Biomass (Ash-Free Dry Weight) Data
Cape May, New Jersey

(Borrow Area: P1, Station: 12 - Contd.)

BENTHOS	Abundance (#/m2) Total	Abundance (#/m2) >= 2cm	Biomass (g/m2) Total
Arthropoda : Amphipoda			
Unciola spp.	68		0.00455
Arthropoda : Decapoda			
Callianassa setimanus	45		0.00227
Pagurus spp.	45		0.00682
Pinnixa spp.	23		0.01818
Chordata : Ascidiacea			
Ascidiacea	23		0.00114
Mollusca : Bivalvia			
Lyonsia spp.	45		0.00227
Mysella planulata	136		0.00455
Nucula annulata	23		0.00114
Pandora gouldiana	45		0.03864
Petricola pholadiformis	68		0.00114
Spisula solidissima	91		6.33862
Tellina agilis	477		0.20454
Mollusca : Gastropoda			
Astyris lunata	68		0.05909
Crepidula maculosa	205		0.06818
Crepidula plana	341		0.06136
Crepidula spp.	114		0.00682
Doridella obscura	273		0.00114
Nassarius trivittatus	45		0.98863
Turbonilla interrupta	273		0.04773
Nemertinea			
Nemertinea	45		0.00227
Total	28227	45	9.25452
Number of Taxa	43		

Benthic Macroinvertebrate Abundance and Biomass (Ash-Free Dry Weight) Data
Cape May, New Jersey

BORROW AREA : P1
SAMPLED AREA : 0.044 sq.m
SEDIMENT SILT-CLAY (%) : 2.28

STATION : 13

SAMPLING GEAR : Young-Modified Van Veen
SAMPLING DATE : September 24, 1996
TOTAL ORGANIC CONTENT (%) : 0.56

BENTHOS	Abundance (#/m2) Total >= 2cm	Biomass (g/m2) Total
Annelida : Oligochaeta		
Oligochaeta	591	0.00682
Annelida : Polychaeta		
Aricidea catherinae	45	0.00114
Brania wellfleetensis	91	0.00227
Caulleriella sp. B Blake	182	0.00682
Eumida sanguinea	45	0.00114
Mediomastus ambiseta	227	0.00455
Neanthes arenaceodentata	227	0.01136
Notomastus spp.	159	0.01364
Owenia fusiformis	23	0.00455
Phyllodoce arenae	23	0.00682
Polycirrus eximius	21000	2.79317
Polygordius spp.	10636	0.23182
Sabellaria vulgaris	23	0.10227
Spiochaetopterus costarum	23	0.00114
Arthropoda : Amphipoda		
Corophium tuberculatum	23	0.00114
Unciola spp.	68	0.00227
Arthropoda : Decapoda		
Libinia spp.	23	0.00114
Pagurus spp.	91	0.02727
Pinnixa spp.	23	0.00455
Upogebia affinis	23	0.00114
Arthropoda : Isopoda		
Edotea triloba	45	0.00227

Continued . . .

Benthic Macroinvertebrate Abundance and Biomass (Ash-Free Dry Weight) Data
Cape May, New Jersey

(Borrow Area: P1, Station: 13 - Contd.)

BENTHOS	Abundance (#/m2) Total	Abundance (#/m2) >= 2cm	Biomass (g/m2) Total
Mollusca : Bivalvia			
Ensis directus	23	23	0.16818
Lyonsia spp.	91		0.01364
Mysella planulata	1091		0.02727
Petricola pholadiformis	23		0.00114
Spisula solidissima	23	23	2.85226
Tellina agilis	136		0.00227
Mollusca : Gastropoda			
Astyris lunata	45		0.02500
Crepidula maculosa	23		0.00114
Crepidula plana	68		0.00455
Doridella obscura	45		0.00114
Turbonilla interrupta	136		0.02500
Nemertinea			
Nemertinea	23		0.00114
Total	35318	45	6.34998
Number of Taxa	33		

Benthic Macroinvertebrate Abundance and Biomass (Ash-Free Dry Weight) Data
Cape May, New Jersey

BORROW AREA : P1 STATION : 14 SAMPLING GEAR : Young-Modified Van Veen
SAMPLED AREA : 0.044 sq.m SAMPLING DATE : September 24, 1996
SEDIMENT SILT-CLAY (%) : 2.80 TOTAL ORGANIC CONTENT (%) : 0.83

BENTHOS	Abundance (#/m2) Total	Abundance (#/m2) >= 2cm	Biomass (g/m2) Total
Annelida : Oligochaeta			
Oligochaeta	386		0.00227
Annelida : Polychaeta			
Ampharetidae	45		0.00114
Ancistrosyllis hartmanae	250		0.03636
Caulleriella sp. B Blake	136		0.00114
Drilonereis longa	23		0.00227
Eumida sanguinea	45		0.00455
Glycera dibranchiata	23	23	0.20454
Hemipodus roseus	136	68	0.09318
Lepidonotus sublevis	23		0.00227
Microphthalmus similis	23		0.00227
Neanthes arenaceodentata	23		0.00114
Notomastus luridus	23	23	0.00114
Orbiniidae	45		0.00114
Owenia fusiformis	114		0.02273
Parapionosyllis longicirrata	23		0.00114
Parougia caeca	114		0.00114
Polycirrus eximius	11341		0.99545
Polydora socialis	23		0.00114
Polygordius spp.	4750		0.16136
Sabellaria vulgaris	182		0.00909
Spiophanes bombyx	45		0.00227
Arthropoda : Amphipoda			
Microprotopus raneyi	136		0.00682
Unciola spp.	159		0.00455

Continued . . .

Benthic Macroinvertebrate Abundance and Biomass (Ash-Free Dry Weight) Data
Cape May, New Jersey

(Borrow Area: P1, Station: 14 - Contd.)

BENTHOS	Abundance (#/m2) Total	Abundance (#/m2) >= 2cm	Biomass (g/m2) Total
Arthropoda : Decapoda			
Crangon septemspinosa	23	23	0.20000
Pagurus spp.	114		0.01364
Arthropoda : Isopoda			
Edotea triloba	23		0.00114
Chordata : Ascidiacea			
Ascidiacea	159		0.00114
Echinodermata : Holothuroidea			
Leptosynapta tenuis	23		0.00909
Mollusca : Bivalvia			
Ensis directus	45	23	0.38864
Lyonsia spp.	159		0.00682
Mytilus edulis	23		0.00114
Pandora gouldiana	114		0.12727
Petricola pholadiformis	227		0.00114
Spisula solidissima	409	318	27.23855
Tellina agilis	250		0.03409
Mollusca : Gastropoda			
Astyris lunata	45		0.02727
Crepidula maculosa	45		0.01136
Crepidula plana	182		0.03409
Doridella obscura	136		0.00682
Nassarius trivittatus	68		0.25682
Turbonilla interrupta	500		0.08864
Nemertinea			
Nemertinea	227	23	0.16136
Total	20841	500	30.16809
Number of Taxa	42		

Benthic Macroinvertebrate Abundance and Biomass (Ash-Free Dry Weight) Data
Cape May, New Jersey

BORROW AREA : P1 STATION : 15 SAMPLING GEAR : Young-Modified Van Veen
SAMPLED AREA : 0.044 sq.m SAMPLING DATE : September 24, 1996
SEDIMENT SILT-CLAY (%) : 1.26 TOTAL ORGANIC CONTENT (%) : 0.30

BENTHOS	Abundance (#/m2) Total	Abundance (#/m2) >= 2cm	Biomass (g/m2) Total
Annelida : Oligochaeta			
Oligochaeta	841		0.00909
Annelida : Polychaeta			
Ampharete arctica	23		0.00682
Ancistrosyllis hartmanae	45		0.00227
Aricidea catherinae	68		0.01136
Brania wellfleetensis	23		0.00682
Caulleriella sp. B Blake	23		0.00455
Eumida sanguinea	159		0.00455
Hypereteone foliosa	23		0.02273
Microphthalmus fragilis	23		0.00114
Microphthalmus similis	159		0.00114
Neanthes arenaceodentata	45		0.00455
Notomastus luridus	23	23	0.00114
Owenia fusiformis	91		0.02955
Parapionosyllis longicirrata	182		0.00114
Phyllodoce arenae	45	45	0.04318
Polycirrus eximius	8227		1.38636
Polydora socialis	23		0.00114
Polygordius spp.	9545		0.30000
Polynoidae	23		0.00455
Sabellaria vulgaris	114		0.01136
Spiophanes bombyx	68		0.01364
Arthropoda : Decapoda			
Pagurus spp.	23		0.00682
Arthropoda : Isopoda			
Ancinus depressus	136		0.11818

Continued . . .

Benthic Macroinvertebrate Abundance and Biomass (Ash-Free Dry Weight) Data
Cape May, New Jersey

(Borrow Area: P1, Station: 15 - Contd.)

BENTHOS	Abundance (#/m2) Total	Abundance (#/m2) >= 2cm	Biomass (g/m2) Total
Chiridotea coeca	23		0.00909
Chordata : Ascidiacea			
Ascidiacea	91		0.00455
Mollusca : Bivalvia			
Anadara transversa	23		1.31818
Lyonsia spp.	45		0.00227
Pandora gouldiana	23		0.08182
Petricola pholadiformis	45		0.00455
Spisula solidissima	250	68	10.72042
Tellina agilis	45		0.03864
Mollusca : Gastropoda			
Astyris lunata	23		0.00455
Crepidula maculosa	68		0.14773
Crepidula spp.	45		0.00682
Turbonilla interrupta	136		0.02727
Nemertinea			
Nemertinea	136		0.00909
Total	20886	136	14.36700
Number of Taxa	36		

Benthic Macroinvertebrate Abundance and Biomass (Ash-Free Dry Weight) Data
Cape May, New Jersey

BORROW AREA : P1 STATION : 17 SAMPLING GEAR : Young-Modified Van Veen
SAMPLED AREA : 0.044 sq.m SAMPLING DATE : September 24, 1996
SEDIMENT SILT-CLAY (%) : 2.61 TOTAL ORGANIC CONTENT (%) : 0.50

BENTHOS	Abundance (#/m2) Total	Abundance (#/m2) >= 2cm	Biomass (g/m2) Total
Annelida : Oligochaeta			
Oligochaeta	91		0.00114
Annelida : Polychaeta			
Amastigos caperatus	23		0.00114
Ampharetidae	23		0.00114
Ancistrosyllis spp.	23		0.00227
Aricidea catherinae	68		0.00114
Brania wellfleetensis	227		0.00909
Caulleriella sp. B Blake	2159		0.10682
Drilonereis longa	23	23	0.02500
Eumida sanguinea	23		0.00114
Hemipodus roseus	23	23	0.01818
Neanthes arenaceodentata	45		0.01136
Parapionosyllis longicirrata	91		0.00114
Polycirrus eximius	3591		0.76363
Polydora socialis	23		0.00114
Polygordius spp.	5318		0.11136
Proceraea cornuta	23		0.00114
Spiochaetopterus costarum	68		0.00114
Spiophanes bombyx	114		0.00455
Arthropoda : Amphipoda			
Unciola spp.	23		0.00114
Arthropoda : Cumacea			
Oxyurostylis smithi	45		0.00114
Arthropoda : Decapoda			
Pagurus spp.	45		0.00227
Upogebia affinis	45		0.00227

Continued . . .

Benthic Macroinvertebrate Abundance and Biomass (Ash-Free Dry Weight) Data
Cape May, New Jersey

(Borrow Area: P1, Station: 17 - Contd.)

BENTHOS	Abundance (#/m2) Total	Abundance (#/m2) >= 2cm	Biomass (g/m2) Total
Mollusca : Bivalvia			
Mercenaria mercenaria	23		0.00227
Pandora gouldiana	23		0.01591
Petricola pholadiformis	23		0.00114
Spisula solidissima	23		0.41136
Tellina agilis	68		0.09545
Mollusca : Gastropoda			
Crepidula spp.	23		0.00114
Doridella obscura	23		0.00227
Turbonilla interrupta	159		0.02500
Total	12477	45	1.62386
Number of Taxa	30		

Benthic Macroinvertebrate Abundance and Biomass (Ash-Free Dry Weight) Data
Cape May, New Jersey

BORROW AREA : P2 STATION : 1 SAMPLING GEAR : Young-Modified Van Veen
SAMPLED AREA : 0.044 sq.m SAMPLING DATE : September 23, 1996
SEDIMENT SILT-CLAY (%) : 0.65 TOTAL ORGANIC CONTENT (%) : 0.20

BENTHOS	Abundance (#/m2) Total	Abundance (#/m2) >= 2cm	Biomass (g/m2) Total
Annelida : Oligochaeta			
Oligochaeta	250		0.00227
Annelida : Polychaeta			
Amastigos caperatus	23		0.00455
Dispio uncinata	23	23	0.06818
Hemipodus roseus	136		0.02500
Paraonis fulgens	91		0.01364
Parapionosyllis longicirrata	23		0.00114
Parougia caeca	23		0.00227
Polygordius spp.	136		0.01136
Syllidae	23		0.00455
Mollusca : Bivalvia			
Spisula solidissima	159		0.04545
Nemertinea			
Nemertinea	23		0.02273
Total	909	23	0.20114
Number of Taxa	11		

Benthic Macroinvertebrate Abundance and Biomass (Ash-Free Dry Weight) Data
Cape May, New Jersey

BORROW AREA : P2 STATION : 2 SAMPLING GEAR : Young-Modified Van Veen
SAMPLED AREA : 0.044 sq.m SAMPLING DATE : September 23, 1996
SEDIMENT SILT-CLAY (%) : 2.63 TOTAL ORGANIC CONTENT (%) : 0.43

BENTHOS	Abundance (#/m2) Total	Abundance (#/m2) >= 2cm	Biomass (g/m2) Total
Annelida : Oligochaeta			
Oligochaeta	114		0.00455
Annelida : Polychaeta			
Amastigos caperatus	250		0.00682
Brania wellfleetensis	23		0.00114
Caulleriella sp. B Blake	45		0.00455
Cirriformia grandis	45		0.00909
Clymenella torquata	45		0.00114
Eumida sanguinea	23		0.00227
Hydroides dianthus	68		0.04773
Leitoscoloplos spp.	45		0.00114
Mediomastus ambiseta	114		0.00227
Neanthes arenaceodentata	136		0.01136
Neanthes succinea	45		0.03409
Parapionosyllis longicirrata	136		0.00227
Phyllodoce arenae	91		0.02500
Polycirrus eximius	4455		0.51363
Polydora cornuta	23		0.00455
Polydora socialis	45	23	0.05000
Polygordius spp.	2136		0.05682
Sabellaria vulgaris	318		0.21818
Streblospio benedicti	23		0.00682
Tharyx sp. A Morris	91		0.01136
Arthropoda : Amphipoda			
Ampelisca spp.	23		0.00114
Eobrolgus spinosus	23		0.00114
Melita nitida	23		0.00114

Continued . . .

Benthic Macroinvertebrate Abundance and Biomass (Ash-Free Dry Weight) Data
Cape May, New Jersey

(Borrow Area: P2, Station: 2 - Contd.)

BENTHOS	Abundance (#/m2) Total	Abundance (#/m2) >= 2cm	Biomass (g/m2) Total
Unciola spp.	182		0.01136
Arthropoda : Decapoda			
Callianassa setimanus	23	23	0.16818
Pagurus spp.	68		0.01136
Pinnixa spp.	23		0.01818
Upogebia affinis	23		0.00909
Mollusca : Bivalvia			
Aligena elevata	68		0.00682
Barnea truncata	23		0.00455
Mysella planulata	68		0.00227
Nucula annulata	68		0.15454
Petricola pholadiformis	2364		0.30000
Tellina agilis	159		0.05455
Mollusca : Gastropoda			
Astyris lunata	91		0.07955
Crepidula maculosa	114		0.27045
Crepidula plana	45		0.00114
Crepidula spp.	182		0.00114
Nassarius trivittatus	114		3.22272
Turbonilla interrupta	23		0.00455
Nemertinea			
Nemertinea	68		0.00682
Platyhelminthes : Turbellaria			
Turbellaria	23		0.00455
Total	12068	45	5.34998
Number of Taxa	42		

Benthic Macroinvertebrate Abundance and Biomass (Ash-Free Dry Weight) Data
Cape May, New Jersey

BORROW AREA : P2 | STATION : 3 | SAMPLING GEAR : Young-Modified Van Veen
SAMPLED AREA : 0.044 sq.m | SAMPLING DATE : September 23, 1996
SEDIMENT SILT-CLAY (%) : 0.73 | TOTAL ORGANIC CONTENT (%) : 0.28

BENTHOS	Abundance (#/m2) Total	Abundance (#/m2) >= 2cm	Biomass (g/m2) Total
Annelida : Polychaeta			
Dispio uncinata	23		0.03409
Paraonis fulgens	23		0.00227
Parougia caeca	68		0.00114
Polygordius spp.	45		0.00455
Arthropoda : Amphipoda			
Acanthohaustorius millsi	68		0.01818
Acanthohaustorius similis	23		0.00909
Protohaustorius wigleyi	91		0.02955
Arthropoda : Isopoda			
Chiridotea coeca	364		0.08636
Arthropoda : Tanaidacea			
Tanaissus psammophilus	68		0.00114
Chordata : Ascidiacea			
Ascidiacea	23		0.13409
Mollusca : Bivalvia			
Donax variabilis	68		0.00455
Mysella planulata	23		0.00114
Nucula annulata	23		0.00455
Pandora spp.	23		0.01136
Spisula solidissima	795		0.18182
Tellina agilis	45		0.14091
Mollusca : Gastropoda			
Nassarius trivittatus	23	23	2.48863

Continued . . .

Benthic Macroinvertebrate Abundance and Biomass (Ash-Free Dry Weight) Data
Cape May, New Jersey

(Borrow Area: P2, Station: 3 - Contd.)

BENTHOS	Abundance (#/m2) Total	Abundance (#/m2) >= 2cm	Biomass (g/m2) Total
Nemertinea			
Nemertinea	23		0.00114
Total	1818	23	3.15454
Number of Taxa	18		

Benthic Macroinvertebrate Abundance and Biomass (Ash-Free Dry Weight) Data
Cape May, New Jersey

BORROW AREA : P2
SAMPLED AREA : 0.044 sq.m
SEDIMENT SILT-CLAY (%) : 1.05

STATION : 4

SAMPLING GEAR : Young-Modified Van Veen
SAMPLING DATE : September 23, 1996
TOTAL ORGANIC CONTENT (%) : 0.20

BENTHOS	Abundance (#/m2) Total	Abundance (#/m2) >= 2cm	Biomass (g/m2) Total
Annelida : Polychaeta			
Dispio uncinata	68		0.00909
Magelona spp.	45	23	0.04318
Onuphis eremita	23	23	0.02727
Polygordius spp.	45		0.00114
Arthropoda : Amphipoda			
Acanthohaustorius millsi	23		0.00682
Acanthohaustorius spp.	23		0.00227
Bathyporeia parkeri	23		0.00114
Parahaustorius longimerus	68		0.01818
Protohaustorius spp.	45		0.00114
Arthropoda : Cumacea			
Mancocuma stellifera	23		0.00114
Arthropoda : Isopoda			
Chiridotea coeca	45		0.00227
Arthropoda : Tanaidacea			
Tanaissus psammophilus	68		0.00114
Mollusca : Bivalvia			
Donax variabilis	136		0.00909
Spisula solidissima	182		0.03182
Tellina agilis	91		0.08864
Nemertinea			
Nemertinea	45		0.00227
Total	955	45	0.24659
Number of Taxa	15		

Benthic Macroinvertebrate Abundance and Biomass (Ash-Free Dry Weight) Data
Cape May, New Jersey

BORROW AREA : P2 STATION : 5 SAMPLING GEAR : Young-Modified Van Veen
SAMPLED AREA : 0.044 sq.m SAMPLING DATE : September 23, 1996
SEDIMENT SILT-CLAY (%) : 1.29 TOTAL ORGANIC CONTENT (%) : 0.45

BENTHOS	Abundance (#/m2) Total	Abundance (#/m2) >= 2cm	Biomass (g/m2) Total
Annelida : Oligochaeta			
Oligochaeta	500		0.01818
Annelida : Polychaeta			
Amastigos caperatus	1477		0.09091
Aricidea catherinae	23		0.00227
Brania wellfleetensis	136		0.00682
Caulleriella sp. B Blake	1955		0.06591
Hydroides dianthus	45		0.00114
Leitoscoloplos spp.	45		0.00114
Mediomastus ambiseta	773		0.01818
Microphthalmus similis	45		0.00114
Neanthes arenaceodentata	114		0.00682
Notocirrus spiniferus	23	23	0.12045
Orbiniidae	23		0.00455
Parapionosyllis longicirrata	91		0.00455
Parougia caeca	68		0.00227
Polycirrus eximius	341		0.06818
Polydora socialis	91		0.01818
Polygordius spp.	2818		0.06818
Sabellaria vulgaris	68		0.03182
Spiophanes bombyx	23		0.00455
Syllides verrilli	23		0.00227
Tharyx sp. A Morris	2205		0.30000
Arthropoda : Amphipoda			
Melita nitida	23		0.00227
Unciola serrata	159		0.05000

Continued . . .

Benthic Macroinvertebrate Abundance and Biomass (Ash-Free Dry Weight) Data
Cape May, New Jersey

(Borrow Area: P2, Station: 5 - Contd.)

BENTHOS	Abundance (#/m2) Total	Abundance (#/m2) >= 2cm	Biomass (g/m2) Total
Arthropoda : Decapoda			
Callianassa setimanus	68		0.02273
Pagurus spp.	23		0.01136
Mollusca : Bivalvia			
Mysella planulata	68		0.00114
Petricola pholadiformis	182		0.01136
Spisula solidissima	91		0.16136
Tellina agilis	136		0.02727
Mollusca : Gastropoda			
Astyris lunata	23		0.01136
Crepidula maculosa	23		0.05455
Crepidula spp.	45		0.00682
Nassarius trivittatus	23		0.88409
Nemertinea			
Nemertinea	68	23	0.06818
Total	11818	45	2.14999
Number of Taxa	33		

Benthic Macroinvertebrate Abundance and Biomass (Ash-Free Dry Weight) Data
Cape May, New Jersey

BORROW AREA : P2
SAMPLED AREA : 0.044 sq.m
SEDIMENT SILT-CLAY (%) : 0.76

STATION : 7

SAMPLING GEAR : Young-Modified Van Veen
SAMPLING DATE : September 23, 1996
TOTAL ORGANIC CONTENT (%) : 0.23

BENTHOS	Abundance (#/m2) Total >= 2cm	Biomass (g/m2) Total
Annelida : Polychaeta		
Polygordius spp.	23	0.00114
Arthropoda : Amphipoda		
Parahaustorius longimerus	841	1.14545
Parahaustorius spp.	91	0.00114
Arthropoda : Isopoda		
Chiridotea coeca	250	0.04091
Mollusca : Bivalvia		
Donax variabilis	1227	0.08636
Spisula solidissima	182	0.08636
Total	2614	1.36136
Number of Taxa	5	

Benthic Macroinvertebrate Abundance and Biomass (Ash-Free Dry Weight) Data
Cape May, New Jersey

BORROW AREA : P2 STATION : 8 SAMPLING GEAR : Young-Modified Van Veen
SAMPLED AREA : 0.044 sq.m SAMPLING DATE : September 23, 1996
SEDIMENT SILT-CLAY (%) : 0.93 TOTAL ORGANIC CONTENT (%) : 0.26

BENTHOS	Abundance (#/m2) Total	Abundance (#/m2) >= 2cm	Biomass (g/m2) Total
Annelida : Oligochaeta			
Oligochaeta	23		0.00114
Annelida : Polychaeta			
Dispio uncinata	91	45	0.09318
Magelona spp.	23		0.02273
Polygordius spp.	45		0.00227
Sigalion arenicola	23	23	0.14091
Arthropoda : Amphipoda			
Acanthohaustorius millsi	23		0.00682
Parahaustorius holmesi	23		0.06364
Parahaustorius longimerus	591		0.32954
Parahaustorius spp.	114		0.00909
Arthropoda : Isopoda			
Ancinus depressus	45		0.07955
Chiridotea coeca	114		0.04545
Arthropoda : Mysidacea			
Neomysis americana	23		0.00114
Arthropoda : Tanaidacea			
Tanaissus psammophilus	23		0.00114
Mollusca : Bivalvia			
Donax variabilis	364		0.02045
Pandora spp.	23		0.00114
Spisula solidissima	773		0.04545
Tellina agilis	45		0.05000

Continued . . .

Benthic Macroinvertebrate Abundance and Biomass (Ash-Free Dry Weight) Data
Cape May, New Jersey

(Borrow Area: P2, Station: 8 - Contd.)

BENTHOS	Abundance (#/m2) Total	Abundance (#/m2) >= 2cm	Biomass (g/m2) Total
Nemertinea			
Nemertinea	23		0.00455
Total	2386	68	0.91818
Number of Taxa	17		

Benthic Macroinvertebrate Abundance and Biomass (Ash-Free Dry Weight) Data
Cape May, New Jersey

BORROW AREA : P2
SAMPLED AREA : 0.044 sq.m
SEDIMENT SILT-CLAY (%) : 14.91

STATION : 9

SAMPLING GEAR : Young-Modified Van Veen
SAMPLING DATE : September 23, 1996
TOTAL ORGANIC CONTENT (%) : 0.51

BENTHOS	Abundance (#/m2) Total	Abundance (#/m2) >= 2cm	Biomass (g/m2) Total
Annelida : Oligochaeta			
Oligochaeta	159		0.00114
Annelida : Polychaeta			
Brania wellfleetensis	23		0.00227
Caulleriella sp. B Blake	136		0.00682
Cirriformia grandis	23		0.00114
Diopatra cuprea	23	23	0.35227
Eumida sanguinea	91		0.00682
Hydroides protulicola	23		0.00227
Lepidonotus sublevis	23		0.01364
Maldanidae	295		0.00114
Mediomastus ambiseta	68		0.00455
Microphthalmus similis	45		0.00114
Neanthes arenaceodentata	45		0.00455
Parapionosyllis longicirrata	5114		0.02045
Parougia caeca	68		0.00114
Polycirrus eximius	5091		0.55454
Polydora cornuta	45		0.00114
Polygordius spp.	4227		0.08409
Sabellaria vulgaris	273		0.05909
Sphaerodoropsis spp.	23		0.00114
Tharyx sp. A Morris	23		0.00114
Arthropoda : Amphipoda			
Cerapus tubularis	23		0.00455
Corophium spp.	68		0.00114
Luconacia incerta	45		0.00114

Continued . . .

Benthic Macroinvertebrate Abundance and Biomass (Ash-Free Dry Weight) Data
Cape May, New Jersey

(Borrow Area: P2, Station: 9 - Contd.)

BENTHOS	Abundance (#/m2) Total	Abundance (#/m2) >= 2cm	Biomass (g/m2) Total
Arthropoda : Cumacea			
Mancocuma stellifera	23		0.00114
Arthropoda : Isopoda			
Ancinus depressus	68		0.32273
Chiridotea coeca	68		0.05227
Mollusca : Bivalvia			
Barnea truncata	1000		0.02045
Mysella planulata	273		0.00682
Mytilus edulis	23		0.00227
Nucula annulata	23		0.00227
Petricola pholadiformis	1864		0.05227
Spisula solidissima	273		0.00227
Mollusca : Gastropoda			
Astyris lunata	45		0.03864
Crepidula maculosa	23		0.01364
Crepidula plana	182		0.05000
Doridella obscura	23		0.00114
Turbonilla interrupta	23		0.00114
Nemertinea			
Nemertinea	23		0.00227
Total	19886	23	1.69659
Number of Taxa	38		

Benthic Macroinvertebrate Abundance and Biomass (Ash-Free Dry Weight) Data
Cape May, New Jersey

BORROW AREA : P2 STATION : 12 SAMPLING GEAR : Young-Modified Van Veen
SAMPLED AREA : 0.044 sq.m SAMPLING DATE : September 23, 1996
SEDIMENT SILT-CLAY (%) : 2.01 TOTAL ORGANIC CONTENT (%) : 0.27

BENTHOS	Abundance (#/m2) Total	Abundance (#/m2) >= 2cm	Biomass (g/m2) Total
Annelida : Oligochaeta			
Oligochaeta	91		0.00455
Annelida : Polychaeta			
Amastigos caperatus	23		0.00227
Ampharetidae	23		0.00114
Brania wellfleetensis	23		0.00114
Caulleriella sp. B Blake	568		0.01591
Glycera dibranchiata	23		0.02045
Hydroides dianthus	23		0.00227
Leitoscoloplos spp.	23		0.00227
Lepidonotus sublevis	68		0.03636
Neanthes arenaceodentata	23		0.00455
Parapionosyllis longicirrata	23		0.00227
Phyllodoce arenae	91		0.02727
Polycirrus eximius	227		0.02955
Polydora socialis	23		0.00227
Polygordius spp.	1455		0.04318
Proceraea cornuta	23		0.00455
Sabellaria vulgaris	591		0.30227
Streblospio benedicti	45		0.00455
Tharyx sp. A Morris	886		0.09545
Arthropoda : Amphipoda			
Ampelisca spp.	68		0.00114
Batea catharinensis	227		0.00682
Cerapus tubularis	23		0.00227
Eobrolgus spinosus	23		0.00114
Melita nitida	818		0.03864

Continued . . .

Benthic Macroinvertebrate Abundance and Biomass (Ash-Free Dry Weight) Data
Cape May, New Jersey

(Borrow Area: P2, Station: 12 - Contd.)

BENTHOS	Abundance (#/m2) Total	Abundance (#/m2) >= 2cm	Biomass (g/m2) Total
Microprotopus raneyi	23		0.00227
Paracaprella tenuis	68		0.00227
Parametopella cypris	45		0.00227
Stenothoe minuta	91		0.00227
Unciola serrata	1068		0.14318
Arthropoda : Cumacea			
Oxyurostylis smithi	23		0.00455
Arthropoda : Decapoda			
Cancer irroratus	23	23	8.23634
Pagurus spp.	114		0.01591
Upogebia affinis	23		0.01136
Xanthidae	45		0.03864
Mollusca : Bivalvia			
Lyonsia spp.	23		0.00455
Petricola pholadiformis	227		0.01818
Spisula solidissima	23		0.03182
Tellina agilis	705		0.05455
Mollusca : Gastropoda			
Astyris lunata	364		0.29318
Crepidula maculosa	273		0.16818
Crepidula plana	205		0.02727
Crepidula spp.	364		0.01136
Doridella obscura	182		0.00227
Nassarius trivittatus	23		0.04318
Nemertinea			
Nemertinea	45	23	0.13864
Total	9364	45	9.90451
Number of Taxa	44		

Benthic Macroinvertebrate Abundance and Biomass (Ash-Free Dry Weight) Data
Cape May, New Jersey

BORROW AREA : Reference P1 STATION : 1 SAMPLING GEAR : Young-Modified Van Veen
SAMPLED AREA : 0.044 sq.m SAMPLING DATE : September 24, 1996
SEDIMENT SILT-CLAY (%) : 3.07 TOTAL ORGANIC CONTENT (%) : 0.50

BENTHOS	Abundance (#/m2) Total	Abundance (#/m2) >= 2cm	Biomass (g/m2) Total
Annelida : Oligochaeta			
Oligochaeta	545		0.00682
Annelida : Polychaeta			
Amastigos caperatus	1818		0.07727
Aricidea catherinae	114		0.02500
Brania wellfleetensis	45		0.00909
Caulleriella sp. B Blake	795		0.03409
Drilonereis longa	45	45	0.18864
Glycera americana	45	45	0.06136
Hemipodus roseus	23		0.01364
Hydroides spp.	23		0.00114
Leitoscoloplos spp.	23		0.00114
Mediomastus ambiseta	432		0.01136
Microphthalmus similis	23		0.00114
Notocirrus spiniferus	23	23	0.60227
Parapionosyllis longicirrata	250		0.00114
Parougia caeca	227		0.00455
Phyllodoce arenae	23	23	0.02955
Polycirrus eximius	273		0.15227
Polygordius spp.	5818		0.14545
Sabellaria vulgaris	23		0.02955
Streblospio benedicti	23		0.00114
Tharyx sp. A Morris	23		0.00227
Arthropoda : Isopoda			
Ancinus depressus	45		0.16591
Mollusca : Bivalvia			
Mysella planulata	23		0.00114

Continued . . .

Benthic Macroinvertebrate Abundance and Biomass (Ash-Free Dry Weight) Data
Cape May, New Jersey

(Borrow Area: Reference P1, Station: 1 - Contd.)

BENTHOS	Abundance (#/m2) Total	Abundance (#/m2) >= 2cm	Biomass (g/m2) Total
Petricola pholadiformis	45		0.00114
Spisula solidissima	68		0.04773
Tellina agilis	45		0.00227
Mollusca : Gastropoda			
Crepidula spp.	68		0.01136
Nassarius trivittatus	23		1.05909
Nemertinea			
Nemertinea	91		0.01136
Total	11023	136	2.69885
Number of Taxa	29		

Benthic Macroinvertebrate Abundance and Biomass (Ash-Free Dry Weight) Data
Cape May, New Jersey

BORROW AREA : Reference P1
SAMPLED AREA : 0.044 sq.m
SEDIMENT SILT-CLAY (%) : 1.15

STATION : 2

SAMPLING GEAR : Young-Modified Van Veen
SAMPLING DATE : September 24, 1996
TOTAL ORGANIC CONTENT (%) : 0.23

BENTHOS	Abundance (#/m2) Total	Abundance (#/m2) >= 2cm	Biomass (g/m2) Total
Annelida : Polychaeta			
Aricidea cerrutti	23		0.00114
Brania wellfleetensis	45		0.00114
Caulleriella sp. B Blake	91		0.00682
Orbiniidae	23		0.00227
Parougia caeca	114		0.00114
Polygordius spp.	205		0.00909
Streptosyllis pettiboneae	23		0.00114
Arthropoda : Amphipoda			
Acanthohaustorius millsi	341		0.07500
Acanthohaustorius similis	23		0.00114
Bathyporeia parkeri	23		0.00114
Microprotopus raneyi	23		0.00114
Protohaustorius wigleyi	273		0.05227
Arthropoda : Decapoda			
Pagurus spp.	23		0.00682
Arthropoda : Isopoda			
Ancinus depressus	23		0.32273
Chiridotea tuftsi	68		0.00909
Arthropoda : Tanaidacea			
Tanaissus psammophilus	227		0.00455
Mollusca : Bivalvia			
Pandora gouldiana	23	23	0.89318
Spisula solidissima	364		0.07273
Tellina agilis	227		0.06591
Mollusca : Gastropoda			
Polinices duplicatus	23	23	59.73390

Continued . . .

Benthic Macroinvertebrate Abundance and Biomass (Ash-Free Dry Weight) Data
Cape May, New Jersey

(Borrow Area: Reference P1, Station: 2 - Contd.)

BENTHOS	Abundance (#/m2) Total	Abundance (#/m2) >= 2cm	Biomass (g/m2) Total
Nemertinea			
Nemertinea	68		0.00909
Platyhelminthes : Turbellaria			
Turbellaria	23		0.00455
Total	2273	45	61.27594
Number of Taxa	22		

Benthic Macroinvertebrate Abundance and Biomass (Ash-Free Dry Weight) Data
Cape May, New Jersey

BORROW AREA : Reference P2
SAMPLED AREA : 0.044 sq.m
SEDIMENT SILT-CLAY (%) : 1.53

STATION : 1

SAMPLING GEAR : Young-Modified Van Veen
SAMPLING DATE : September 23, 1996
TOTAL ORGANIC CONTENT (%) : 0.54

BENTHOS	Abundance (#/m2) Total	Abundance (#/m2) >= 2cm	Biomass (g/m2) Total
Annelida : Oligochaeta			
Oligochaeta	227		0.00682
Annelida : Polychaeta			
Amastigos caperatus	1045		0.03182
Ancistrosyllis hartmanae	23		0.04773
Aricidea catherinae	23		0.00114
Brania wellfleetensis	568		0.03182
Caulleriella sp. B Blake	636		0.03182
Clymenella torquata	23		0.00455
Eumida sanguinea	68		0.02273
Glycera dibranchiata	23		0.01136
Hydroides dianthus	114		0.02500
Hypereteone heteropoda	23		0.00227
Leitoscoloplos spp.	23		0.00455
Mediomastus ambiseta	91		0.00909
Neanthes arenaceodentata	23		0.00227
Parapionosyllis longicirrata	568		0.00909
Parougia caeca	159		0.00682
Phyllodoce arenae	114	23	0.01591
Polycirrus eximius	841		0.20454
Polydora socialis	250		0.00909
Polygordius spp.	9023		0.27500
Proceraea cornuta	45		0.00114
Sabellaria vulgaris	705		0.08409
Sabellidae	45		0.00227
Sthenelais spp.	23		0.03182
Streblospio benedicti	45		0.00227

Continued . . .

Benthic Macroinvertebrate Abundance and Biomass (Ash-Free Dry Weight) Data
Cape May, New Jersey

(Borrow Area: Reference P2, Station: 1 - Contd.)

BENTHOS	Abundance (#/m2) Total	Abundance (#/m2) >= 2cm	Biomass (g/m2) Total
Tharyx sp. A Morris	227		0.01591
Arthropoda : Amphipoda			
Batea catharinensis	23		0.00909
Eobrolgus spinosus	159		0.01818
Lysianopsis alba	23		0.00455
Melita nitida	159		0.01591
Microprotopus raneyi	23		0.00455
Unciola serrata	432		0.02955
Arthropoda : Cumacea			
Oxyurostylis smithi	45		0.01136
Arthropoda : Decapoda			
Hexapanopeus angustifrons	45		0.18409
Pagurus longicarpus	23	23	0.21364
Pagurus spp.	91		0.01591
Pinnixa spp.	23		0.00909
Upogebia affinis	23		0.00682
Hemichordata			
Saccoglossus kowalevskii	45		0.06136
Mollusca : Bivalvia			
Barnea truncata	159		0.00909
Petricola pholadiformis	477		0.01364
Tellina agilis	455		0.01591
Mollusca : Gastropoda			
Astyris lunata	159		0.09318
Crepidula maculosa	45		0.04318
Crepidula plana	159		0.03636
Crepidula spp.	136		0.00682
Doridella obscura	68		0.00455
Polinices duplicatus	23		1.07954

Continued . . .

Benthic Macroinvertebrate Abundance and Biomass (Ash-Free Dry Weight) Data
Cape May, New Jersey

(Borrow Area: Reference P2, Station: 1 - Contd.)

BENTHOS	Abundance (#/m2) Total	Abundance (#/m2) >= 2cm	Biomass (g/m2) Total
Nemertinea			
Nemertinea	159		0.01364
Total	17909	45	2.79090
Number of Taxa	47		

Benthic Macroinvertebrate Abundance and Biomass (Ash-Free Dry Weight) Data
Cape May, New Jersey

BORROW AREA : Reference P2
SAMPLED AREA : 0.044 sq.m
SEDIMENT SILT-CLAY (%) : 1.03

STATION : 2

SAMPLING GEAR : Young-Modified Van Veen
SAMPLING DATE : September 23, 1996
TOTAL ORGANIC CONTENT (%) : 0.50

BENTHOS	Abundance (#/m2) Total	Abundance (#/m2) >= 2cm	Biomass (g/m2) Total
Annelida : Oligochaeta			
Oligochaeta	386		0.01591
Annelida : Polychaeta			
Ancistrosyllis hartmanae	23		0.00114
Aphelochaeta spp.	23		0.00114
Aricidea cerrutti	23		0.00114
Hemipodus roseus	23	23	0.04773
Microphthalmus similis	23		0.00114
Ophelia denticulata	182		0.02500
Ophryotrocha spp.	23		0.00114
Owenia fusiformis	45		0.00455
Parapionosyllis longicirrata	455		0.00227
Parougia caeca	91		0.00682
Pisione remota	91		0.01364
Polygordius spp.	341	136	0.15909
Sabellaria vulgaris	23		0.00455
Arthropoda : Isopoda			
Chiridotea coeca	23		0.01364
Chordata : Ascidiacea			
Ascidiacea	1568		0.02045
Cnidaria : Anthozoa			
Anthozoa	114		0.03182
Mollusca : Bivalvia			
Cyclocardia borealis	68		0.04773
Lyonsia spp.	23		0.00114
Mysella planulata	45		0.00114
Mytilus edulis	23		0.00114

Continued . . .

Benthic Macroinvertebrate Abundance and Biomass (Ash-Free Dry Weight) Data
Cape May, New Jersey

(Borrow Area: Reference P2, Station: 2 - Contd.)

BENTHOS	Abundance (#/m2) Total	Abundance (#/m2) >= 2cm	Biomass (g/m2) Total
Pandora gouldiana	68		0.02500
Petricola pholadiformis	273		0.00909
Spisula solidissima	250	205	27.15446
Tellina agilis	68		0.00455
Nemertinea			
Nemertinea	477		0.10682
Total	4750	364	27.70218
Number of Taxa	26		

APPENDIX E

Mean Abundance of Infaunal Taxa for Each Borrow Area and Reference Site

Mean Abundance (#/m2) w/o Epifauna Species

Species Group	Species Name	P1	P2	Reference
Cnidaria : Anthozoa	Anthozoa	4.26		28.41
Platyhelminthes : Turbellaria	Turbellaria	5.68	2.53	5.68
Nemertinea	Nemertinea	106.53	35.35	198.86
Annelida : Polychaeta	Amastigos caperatus	15.62	196.97	715.91
	Ampharete arctica	1.42		
	Ampharetidae	11.36	2.53	
	Ancistrosyllis hartmanae	29.83		11.36
	Ancistrosyllis spp.	7.10		
	Aphelochaeta spp.			5.68
	Aricidea catherinae	55.40	2.53	34.09
	Aricidea cerrutti			11.36
	Bhawania heteroseta	1.42		
	Brania wellfleetensis	35.51	22.73	164.77
	Caulleriella sp. B Blake	474.43	300.50	380.68
	Cirriformia grandis		7.58	
	Clymenella torquata		5.05	5.68
	Diopatra cuprea		2.53	
	Dispio uncinata		22.73	
	Dorvilleidae sp. A Hilbig	1.42		
	Drilonereis longa	4.26		11.36
	Eumida sanguinea	38.35	12.63	17.05
	Glycera americana			11.36
	Glycera dibranchiata	12.78	2.53	5.68
	Glycera spp.	4.26		
	Hemipodus roseus	44.03	15.15	11.36
	Hydroides dianthus		15.15	28.41
	Hydroides protulicola		2.53	
	Hydroides spp.			5.68
	Hypereteone foliosa	4.26		
	Hypereteone heteropoda			5.68
	Leitoscoloplos spp.		12.63	11.36
	Lepidonotus sublevis	1.42	10.10	
	Magelona spp.		7.58	
	Maldanidae	4.26	32.83	
	Mediomastus ambiseta	24.15	106.06	130.68
	Microphthalmus fragilis	2.84		
	Microphthalmus similis	26.99	10.10	11.36
	Neanthes arenaceodentata	31.25	35.35	5.68
	Neanthes succinea		5.05	
	Nephtys picta	5.68		
	Nereididae	2.84		
	Notocirrus spiniferus	1.42	2.53	5.68
	Notomastus luridus	4.26		
	Notomastus spp.	21.31		
	Onuphis eremita		2.53	
	Ophelia denticulata			45.45
	Ophryotrocha spp.			5.68
	Orbiniidae	9.94	2.53	5.68

Mean Abundance (#/m2) w/o Epifauna Species

Species Group	Species Name	P1	P2	Reference
Annelida : Polychaeta	Owenia fusiformis	45.45		11.36
	Paranaitis speciosa	1.42		
	Paraonis fulgens		12.63	
	Parapionosyllis longicirrata	72.44	598.48	318.18
	Parougia caeca	31.25	25.25	147.73
	Phyllodoce arenae	9.94	20.20	34.09
	Pisione remota	2.84		22.73
	Polycirrus eximius	5843.73	1123.73	278.41
	Polydora cornuta	1.42	7.58	
	Polydora socialis	9.94	17.68	62.50
	Polygordius spp.	10994.28	1214.64	3846.58
	Proceraea cornuta	5.68	2.53	11.36
	Sabellidae			11.36
	Sigalion arenicola		2.53	
	Sphaerodoropsis spp.		2.53	
	Spiochaetopterus costarum	5.68		
	Spiophanes bombyx	59.66	2.53	
	Sthenelais spp.			5.68
	Streblospio benedicti	1.42	7.58	17.05
	Streptosyllis pettiboneae			5.68
	Syllidae	2.84	2.53	
	Syllides verrilli		2.53	
	Tharyx sp. A Morris	7.10	356.06	62.50
Annelida : Oligochaeta	Oligochaeta	315.34	126.26	289.77
Mollusca : Gastropoda	Astyris lunata	35.51	58.08	39.77
	Epitonium spp.	1.42		
	Nassarius trivittatus	15.62	20.20	5.68
	Polinices duplicatus	2.84		11.36
	Turbonilla interrupta	166.19	5.05	
Mollusca : Bivalvia	Aligena elevata		7.58	
	Anadara transversa	4.26		
	Barnea truncata	4.26	113.64	39.77
	Cyclocardia borealis			17.05
	Donax variabilis		199.49	
	Ensis directus	11.36		
	Lyonsia arenosa	8.52		
	Lyonsia spp.	45.45	2.53	5.68
	Mercenaria mercenaria	1.42		
	Mysella planulata	119.32	47.98	17.05
	Nucula annulata	4.26	12.63	
	Pandora gouldiana	28.41		22.73
	Pandora spp.		5.05	
	Petricola pholadiformis	61.08	515.15	198.86
	Spisula solidissima	169.03	275.25	170.45
	Tellina agilis	208.81	131.31	198.86
	Veneridae	1.42		
Arthropoda : Cumacea	Mancocuma stellifera		5.05	

Mean Abundance (#/m2) w/o Epifauna Species

Species Group	Species Name	P1	P2	Reference
Arthropoda : Cumacea	Oxyurostylis smithi	4.26	2.53	11.36
Arthropoda : Tanaidacea	Tanaissus psammophilus	1.42	17.68	56.82
Arthropoda : Isopoda	Ancinus depressus	28.41	12.63	17.05
	Chiridotea coeca	2.84	93.43	5.68
	Chiridotea tuftsi	8.52		17.05
Arthropoda : Amphipoda	Acanthohaustorius millsi	2.84	12.63	85.23
	Acanthohaustorius similis		2.53	5.68
	Acanthohaustorius spp.	1.42	2.53	
	Ampelisca spp.		10.10	
	Ampelisca vadorum	1.42		
	Bathyporeia parkeri	1.42	2.53	5.68
	Eobrolgus spinosus		5.05	39.77
	Liljeborgia sp. A Morris	2.84		
	Luconacia incerta		5.05	
	Lysianopsis alba			5.68
	Melita nitida		95.96	39.77
	Paracaprella tenuis	1.42	7.58	
	Parahaustorius holmesi		2.53	
	Parahaustorius longimerus		166.67	
	Parahaustorius spp.		22.73	
	Parametopella cypris		5.05	
	Protohaustorius spp.		5.05	
	Protohaustorius wigleyi		10.10	68.18
	Unciola serrata	9.94	136.36	107.95
	Unciola spp.	44.03	20.20	
Arthropoda : Decapoda	Callianassa setimanus	4.26	10.10	
	Hexapanopeus angustifrons			11.36
	Pinnixa spp.	5.68	2.53	5.68
	Upogebia affinis	7.10	5.05	5.68
	Xanthidae	1.42	5.05	
Sipuncula	Sipuncula	1.42		
Echinodermata : Ophiuroidea	Ophiuroidea	1.42		
Echinodermata : Holothuroidea	Leptosynapta tenuis	1.42		
Hemichordata	Saccoglossus kowalevskii			11.36
Chordata : Cephalochordata	Branchiostoma caribaeum	2.84		

APPENDIX F

Sampling Locations
Regional Studies

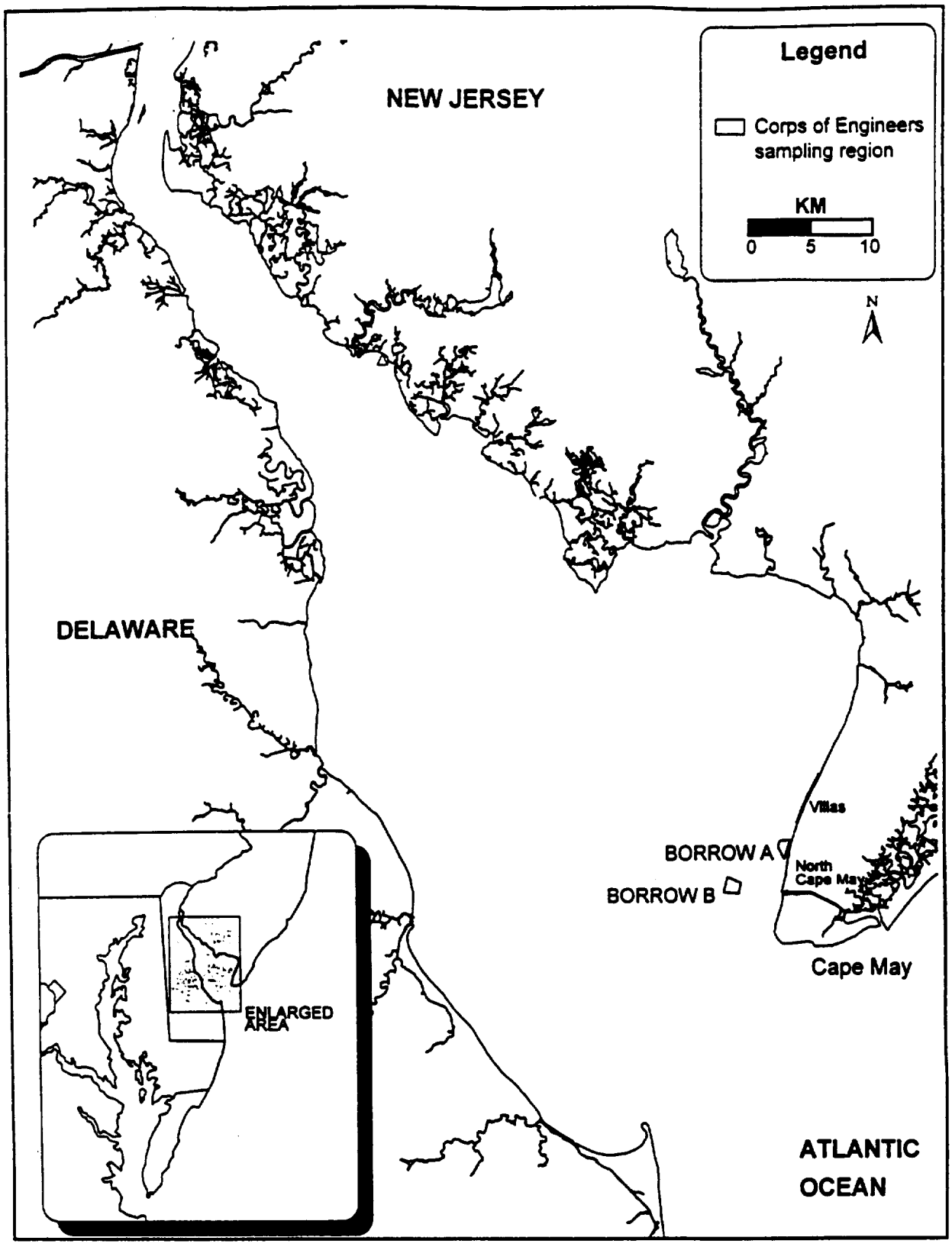


Figure F-1. Location of sampling areas included in the regional analysis near Cape May villas (from Chaillou 1995)

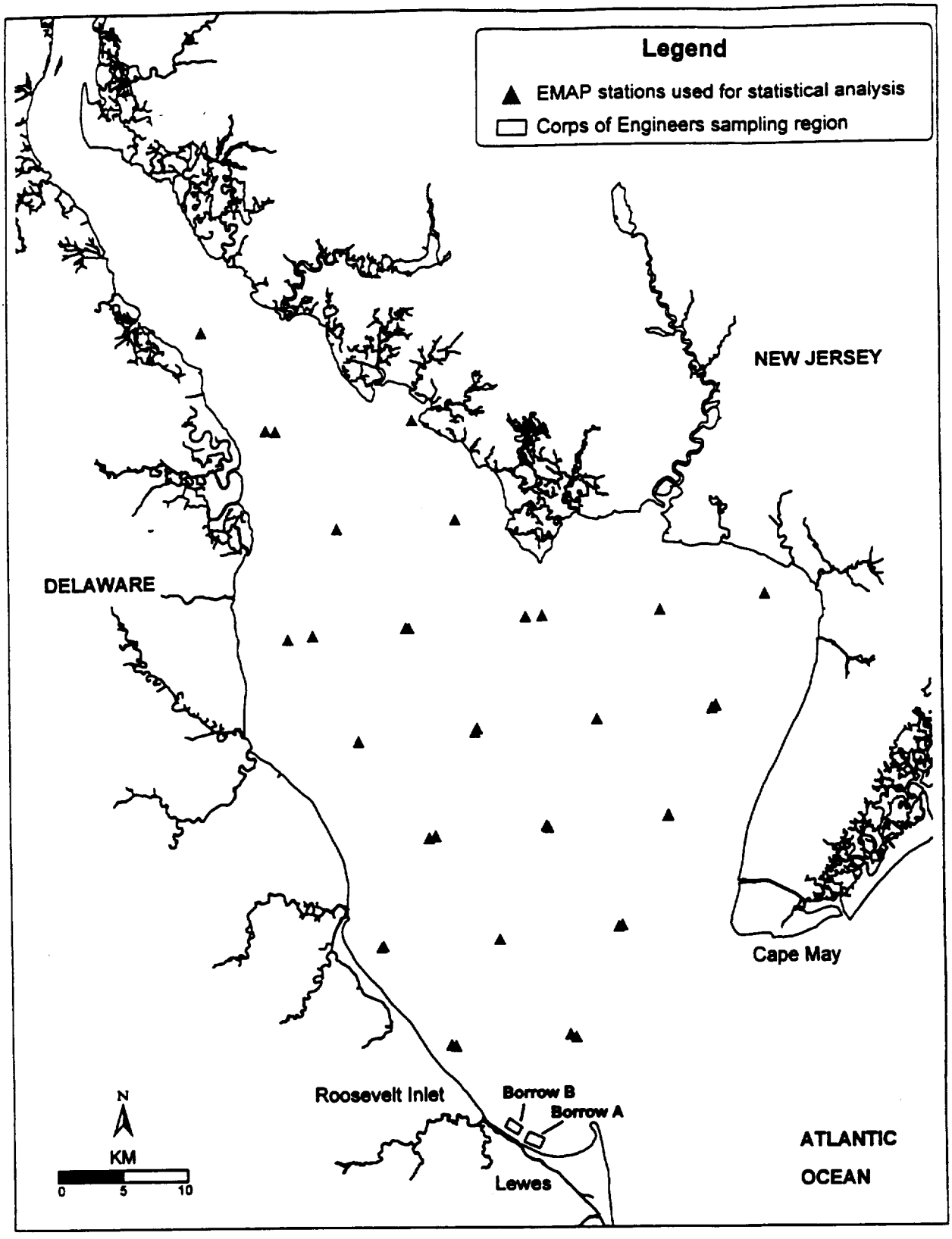


Figure F-2. Location of sampling sites included in the regional analysis near Roosevelt Inlet (USACOE) and the lower Delaware Bay (USEPA's EMAP) (from Kelley and Scott 1996)

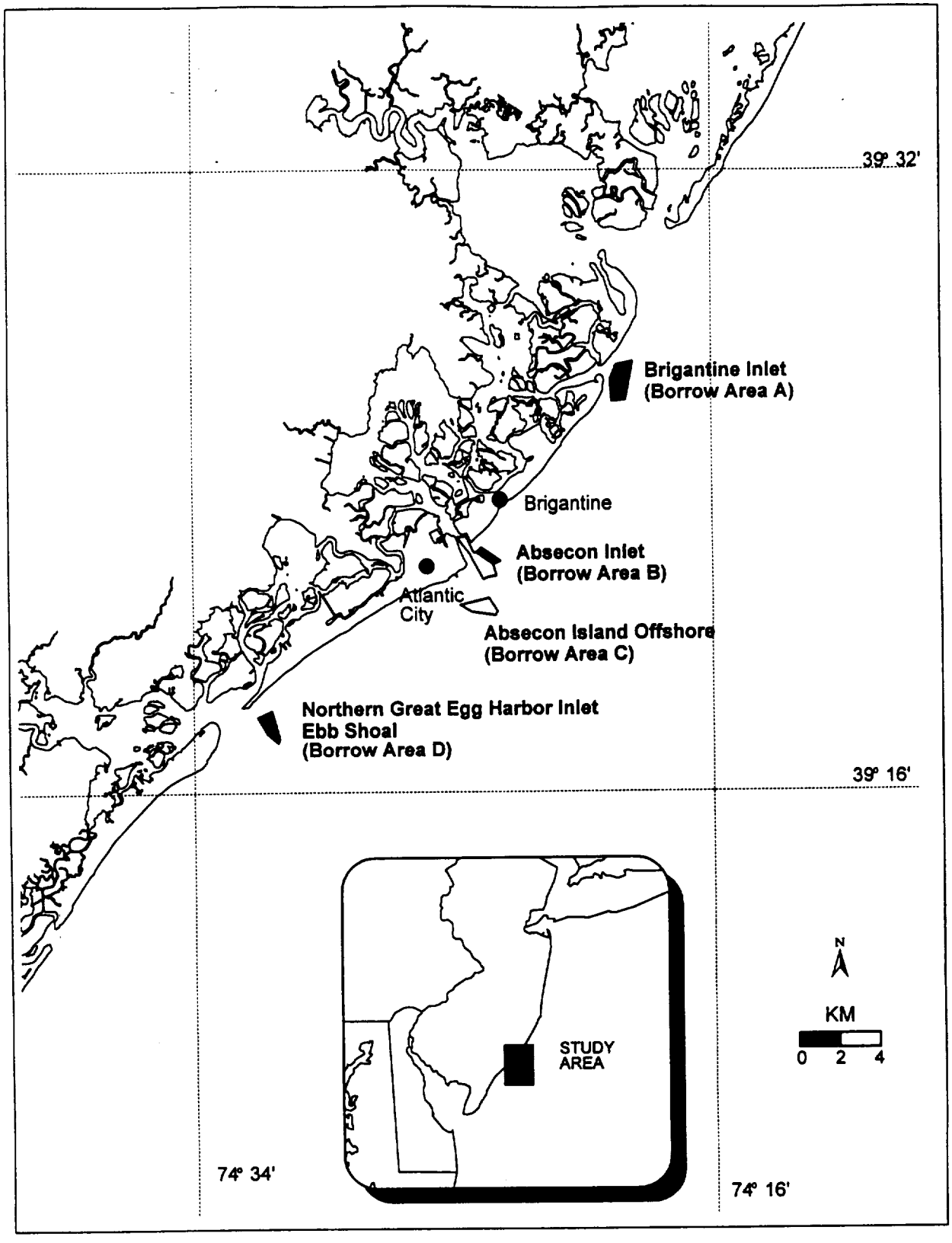


Figure F-3. Location of sampling areas included in the regional analysis near Brigantine Inlet, NJ (Brigantine I; from Chaillou 1995)

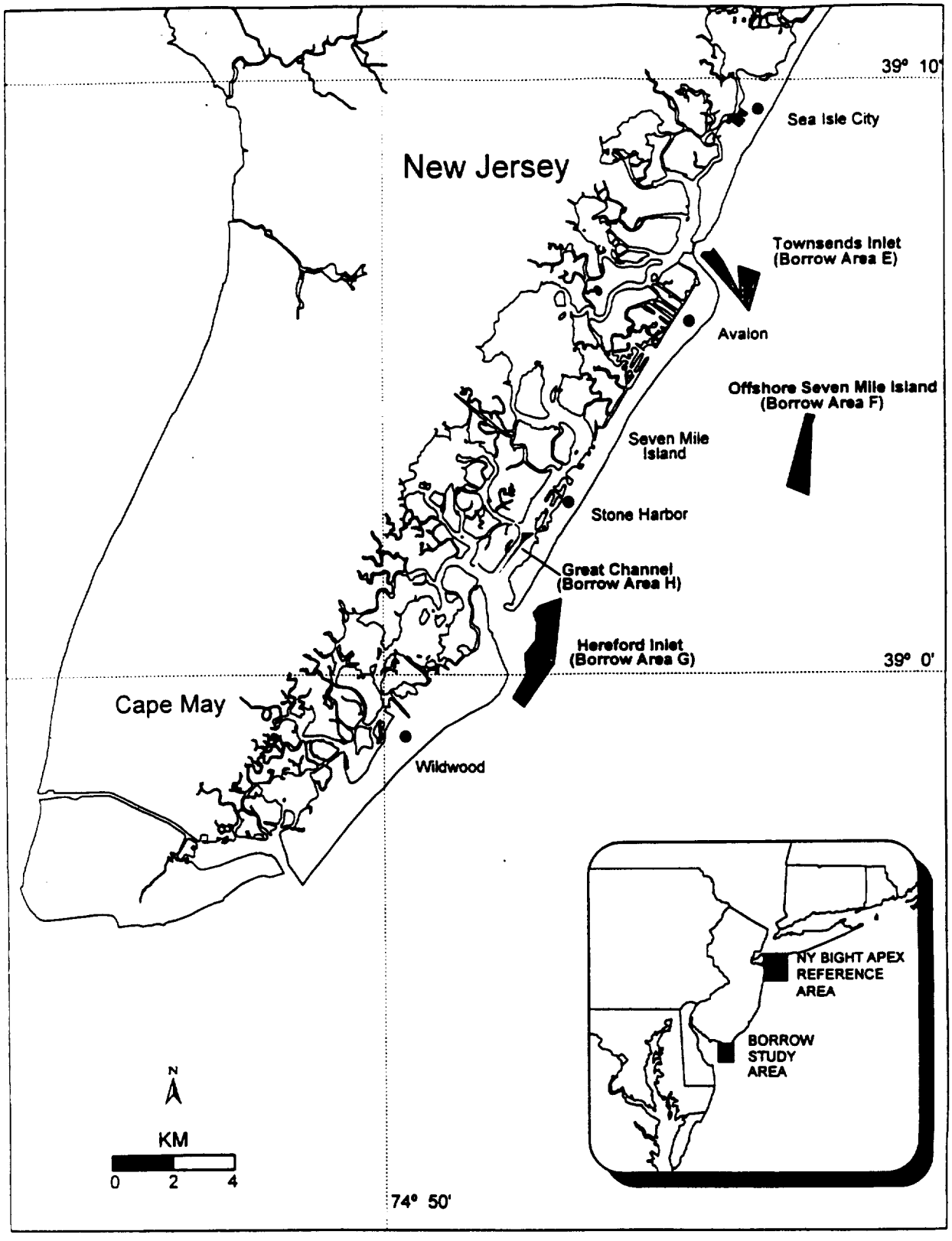


Figure F-41. Location of sampling areas included in the regional analysis near the southeast coast of Cape May County, NJ (Brigantine II; from Chaillou and Scott 1996)

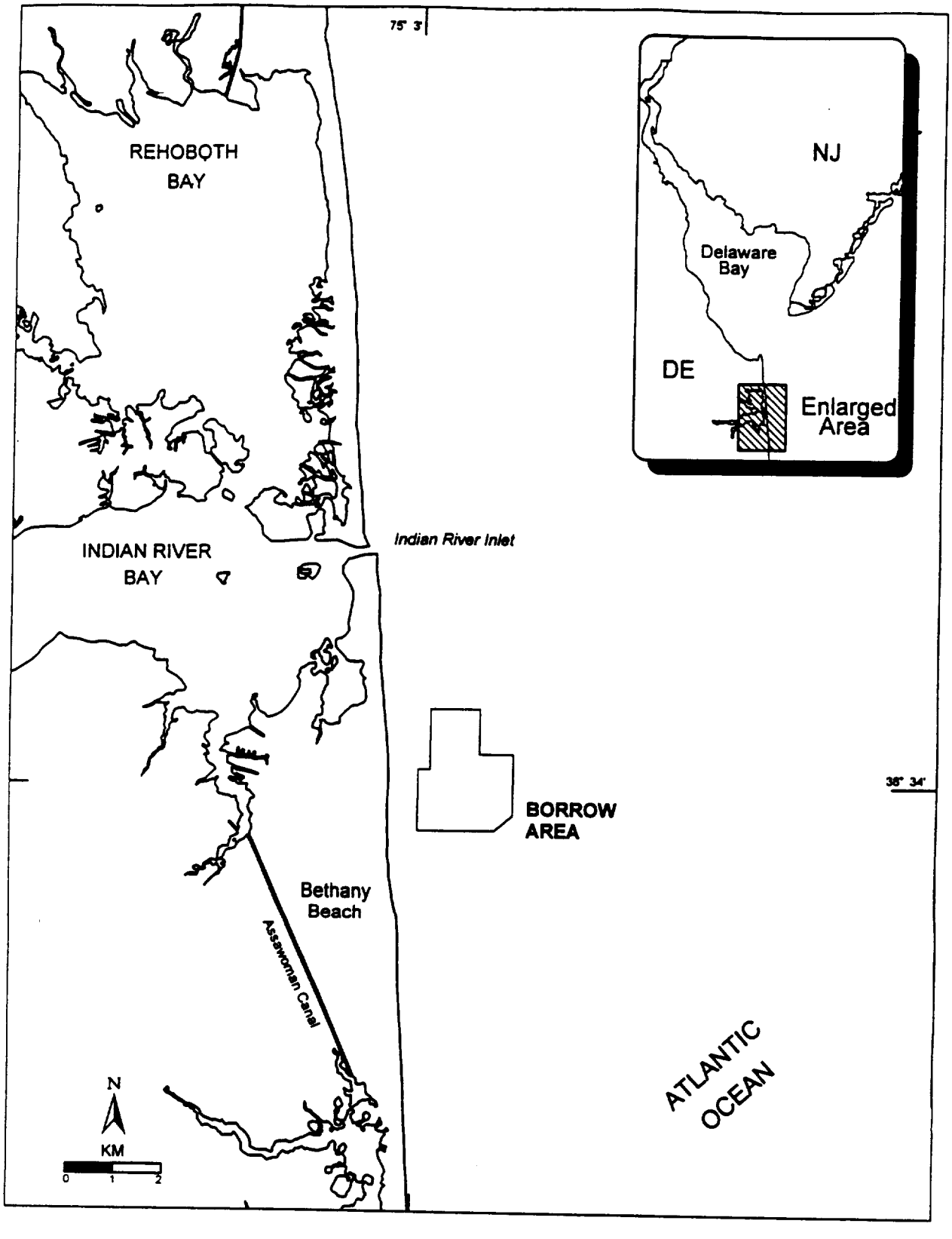


Figure F-5. Location of sampling areas included in the regional analysis near Bethany Beach, Delaware (from Kelley et al. 1996)

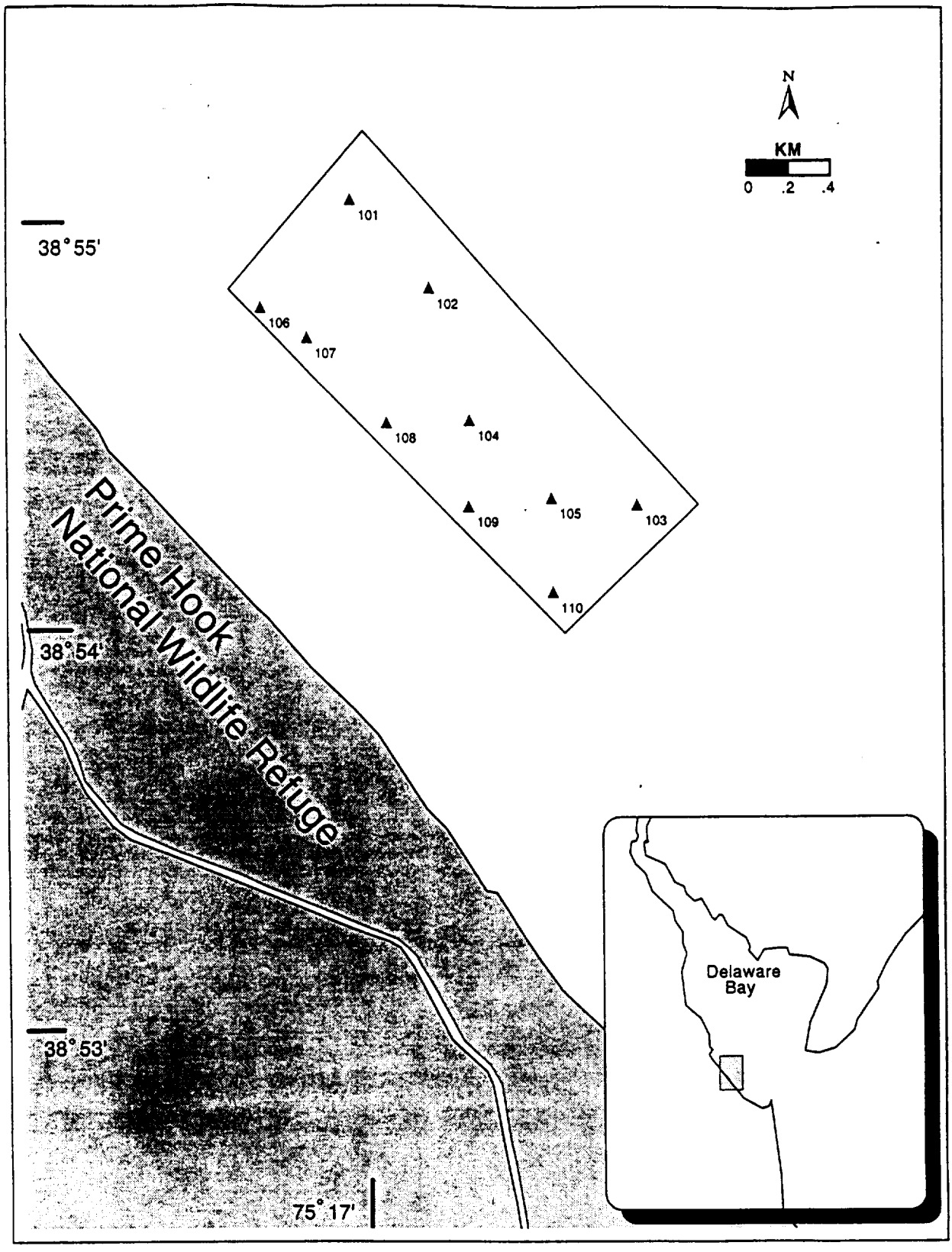


Figure F-6. Location of sampling areas included in the regional analysis from Site MS19B in Delaware Bay (from Chaillou and Weisberg 1995)

HEP TEAM COMPOSITION

Project Lower Cape May Meadows

Designated HEP Team Members

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Eric Schrading	U.S. Fish & Wildlife Service	927 N. Main Street Building D Pleasantville, NJ 08232

IDENTIFICATION OF CRITICAL AND UNIQUE HABITAT

Project Lower Cape May Meadows

Habitat Type	Acres Present
WETLANDS (list each classification separately)	
Emergent wetlands (Nature Conservancy)	44
REPTILE AND AMPHIBIAN NATURAL AREAS	
Forest (State Park and Nature Conservancy)	75
Open Water (State Park and Nature Conservancy)	49
Old Field (Nature Conservancy)	24
SPECIAL WILDLIFE AREAS	
Wintering (indicate species)	
Forest (Pied-billed grebe, northern harrier, red-shouldered hawk, etc.)	75
Colony Nest sites (indicate species)	
Migrating Areas	
Forest (State Park and Nature Conservancy)	75
Old Field (Nature Conservancy)	24
Beach (State Park and Nature Conservancy)	65

IDENTIFICATION OF CRITICAL AND UNIQUE HABITAT

Project: Lower Cape May Meadows

Species	Habitat Type	Acres Present
FEDERAL ENDANGERED AND THREATENED SPECIES		
Bald Eagle	Forest, Field	75,24
Peregrine Falcon	Forest, Field	75,24
Piping Plover	Beach	65
Kemp's Green Sea Turtle	Water (Ocean)	
Kemp's Hawksbill Sea Turtle	Water (Ocean)	
Kemp's Loggerhead Sea Turtle	Water (Ocean)	
Kemp's Ridley Sea Turtle	Water (Ocean)	
Kemp's Leatherback Sea Turtle	Water (Ocean)	
STATE ENDANGERED SPECIES		
Coopers Hawk	Forest, Field	75,24
Northern Harrier	Forest, Field	75,24
Upland Sandpiper	Field	24
Roseate Tern	Beach	65
Least Tern	Beach	65
Skimmer	Beach	65
Short-eared Owl	Wetland	44
Cliff Swallow	Open Water, Field,	49,24,
	Wetland	44
Short-billed Marsh Wren	Wetland	44
Pied-billed Grebe	Open Water	49
Southern Gray Tree Frog		
Keen Myotis	Wetland, Field	44,24
Small-footed Myotis	Wetland, Field	44,24
Silver-haired Bat	Forest	75
Hoary Bat	Forest	75
S. Flying Squirrel	Forest	75
Rice Rat	Wetland, Field	44,24
S. bog Lemming	Wetland	75
Meadow Jumping Mouse	Wetland, Field	75
Least Shrew	Wetland, Forest	44,24
Starnose Mole	Wetland	44

STATE THREATENED SPECIES

Red-headed Woodpecker	Forest	75
Barred Owl	Forest	75
Merlin	Wetland, Field	44,24
Osprey	Open Water, Wetlands	49,44
Red-shouldered Hawk	Forest	75
Yellow-crowned Night Heron	Open Water	49
Great Blue Heron	Open Water	49
Bobolink	Fields, Wetlands, Phragmites	24,44, 95
Savannah Sparrow	Dune, Wetlands	65,44
Grasshopper Sparrow	Field	24

STATE ENDANGERED OR RARE PLANTS

Owl-leaved Rush		
Long's Rush		
Butterfly Pea	Dry open woods & thickets	
Whorled Marsh-pennywort		
Mistflower	Moist woods & thickets	
Narrow-leaved Wild Crab Apple		

**** **PLEASE NOTE: In order to simplify the HEP, and make the results more accurate for the Feasibility Study, several of the evaluation species identified in the Reconnaissance Study were deleted from the final evaluation. These species included: the semi-palmated sandpiper, the river otter, the great egret, and the great horned owl. The deletion of these species allowed each cover type to be evaluated by the same number of species (two) making it more accurate when comparisons were made between the different cover types.**

The initial measurements for these species can still be found on the data sheets.

HSI DETERMINATION TERRESTRIAL/WETLANDS TERRESTRIAL COVER TYPES

Project Lower Cape May Meadows **Date** 1/1194
Target Year 1994
Land Use/Cover Type Phragmites
Compartment Number 4 **Area** _____ **Mitigation Category** ___
Site Description Nature Conserv, eastern side of site along Sunset Blvd.

Evaluation Species	Life Requisite		Requisite Rankings FWS	COE	SP	NC	Avg	HSI
Marsh	Food		.1	.1	.1	.1	.1	.1
Wren	Cover&Repro	1	.5	.5	.5	.5	.5	
		2	1.0	1.0	1.0	1.0	1.0	

Limiting Factors Lack of standing water due to density of phragmites

Muskrat	Breeding		.5	.5	.5	.5	.5	0.0
	Food		1.0	1.0	1.0	1.0	1.0	
	Cover		0.0	0.0	0.0	0.0	0.0	
	Water	1	.5	.5	.5	.5	.5	
		2	1.0	1.0	1.0	1.0	1.0	
		3	1.0	1.0	1.0	1.0	1.0	

Limiting Factors Lack of cover due to dominance of phragmites at waters edge

Limiting Factors _____

HSI DETERMINATION TERRESTRIAL/WETLANDS TERRESTRIAL COVER TYPES

Project Lower Cape May Meadows **Date** 1/11/94
Target Year 1994
Land Use/Cover Type Phragmites
Compartment Number 3 **Area** _____ **Mitigation Category** ___
Site Description Nature Conservancy, near dune eastern end of site

Evaluation Species	Life Requisite		Requisite Rankings FWS	COE	SP	NC	Avg	HSI
Marsh Wren	Food		.3	.3	.3	.3	.3	.3
	Cover&Repro	1	1.0	1.0	1.0	1.0	1.0	
		2	1.0	1.0	1.0	1.0	1.0	

Limiting Factors Lack of open (standing) water due to density of phragmites

Muskrat	Breeding		.75	.75	.75	.75	.75	.5
	Food		1.0	1.0	1.0	1.0	1.0	
	Cover		.5	.5	.5	.5	.5	
	Water	1	.5	.5	.5	.5	.5	
		2	1.0	1.0	1.0	1.0	1.0	
		3	1.0	1.0	1.0	1.0	1.0	

Limiting Factors Lack of cover due to dominance of phragmites at waters edge

Limiting Factors _____

HSI DETERMINATION TERRESTRIAL/WETLANDS TERRESTRIAL COVER TYPES

Project Lower Cape May Meadows **Date** 1/11/94
Target Year 1994
Land Use/Cover Type Phragmites
Compartment Number 2 **Area** _____ **Mitigation Category** ___
Site Description State Park, along yellow trail

Evaluation Species	Life Requisite		Requisite Rankings FWS	COE	SP	NC	Avg	HSI
Marsh	Food		.7	.7	.7	.7	.7	.5
Wren	Cover&Repro	1	.5	.5	.5	.5	.5	
		2	1.0	1.0	1.0	1.0	1.0	

Limiting Factors Height of canopy cover

Muskrat	Breeding		.75	.75	.75	.75	.75	.5
	Food		1.0	1.0	1.0	1.0	1.0	
	Cover		0.0	0.0	0.0	0.0	0.0	
	Water	1	.5	.5	.5	.5	.5	
		2	1.0	1.0	1.0	1.0	1.0	
		3	1.0	1.0	1.0	1.0	1.0	

Limiting Factors Lack of cover due to dominance of phragmites at waters edge

Limiting Factors _____

HSI DETERMINATION TERRESTRIAL/WETLANDS TERRESTRIAL COVER TYPES

Project Lower Cape May Meadows **Date** 1/11/94
Target Year 1994
Land Use/Cover Type Phragmites
Compartment Number 1 **Area** _____ **Mitigation Category** ___
Site Description State Park, area surrounding Lighthouse Pond

Evaluation Species	Life Requisite		Requisite Rankings FWS	COE	SP	NC	Avg	HSI
Marsh Wren	Food		.3	.3	.3	.3	.3	.3
	Cover&Repro	1	.5	.5	.5	.5	.5	
		2	1.0	1.0	1.0	1.0	1.0	

Limiting Factors Lack of standing water due to density of phragmites

Muskrat	Breeding		.5	.5	.5	.5	.5	0.0
	Food		1.0	1.0	1.0	1.0	1.0	
	Cover		0.0	0.0	0.0	0.0	0.0	
	Water	1	.5	.5	.5	.5	.5	
		2	1.0	1.0	1.0	1.0	1.0	
		3	1.0	1.0	1.0	1.0	1.0	

Limiting Factors Lack of cover due to dominance of phragmites at waters edge

Limiting Factors _____

HSI DETERMINATION TERRESTRIAL/WETLANDS TERRESTRIAL COVER TYPES

Project Lower Cape May Meadows **Date** 1/11/94
Target Year 1994
Land Use/Cover Type Beach
Compartment Number 3 **Area** _____ **Mitigation Category** ___
Site Description Nature Conservancy towards jetty

Evaluation Species	Life Requisite		Requisite Rankings FWS	COE	SP	NC	Avg	HSI
Least Tern	Food	1	1.0	1.0	1.0	1.0	1.0	1.0
		2	1.0	1.0	1.0	1.0	1.0	
	Reproduction	1	1.0	1.0	1.0	1.0	1.0	
		2	1.0	1.0	1.0	1.0	1.0	

Limiting Factors _____

Sanderling	Substrate		1.0	1.0	1.0	1.0	1.0	.8
	Wave Action		1.0	1.0	1.0	1.0	1.0	
	Disturbance		.5	.5	.5	.5	.5	

Limiting Factors Human disturbance

Limiting Factors _____

HSI DETERMINATION TERRESTRIAL/WETLANDS TERRESTRIAL COVER TYPES

Project Lower Cape May Meadows **Date** 1/11/94
Target Year 1994
Land Use/Cover Type Beach
Compartment Number 2 **Area** _____ **Mitigation Category** ___
Site Description Nature Conservancy, north of dune

Evaluation Species	Life Requisite		Requisite Rankings FWS	COE	State Park	NC	Avg	HSI
Least Tern	Food	1	1.0	1.0	1.0	1.0	1.0	.8
		2	1.0	1.0	1.0	1.0	1.0	
	Reproduction	1	1.0	1.0	1.0	1.0	1.0	
		2	.8	1.8	1.8	1.8	1.8	

Limiting Factors _____

Sanderling	Substrate		1.0	1.0	1.0	1.0	1.0	.6
	Wave Action		0.0	0.0	0.0	0.0	0.0	
	Disturbance		.75	.75	.75	.75	.75	

Limiting Factors Lack of wave action

Limiting Factors _____

HSI DETERMINATION TERRESTRIAL/WETLANDS TERRESTRIAL COVER TYPES

Project Lower Cape May Meadows **Date** 1/11/94
Target Year 1994
Land Use/Cover Type Beach
Compartment Number 1 **Area** _____ **Mitigation Category** ___
Site Description State Park, ocean side of dune

Evaluation Species	Life Requisite		Requisite Rankings FWS	COE	SP	NC	Avg	HSI
Least Tern	Food	1	1.0	1.0	1.0	1.0	1.0	.8
		2	1.0	1.0	1.0	1.0	1.0	
	Reproduction	1	1.0	1.0	1.0	1.0	1.0	
		2	.8	.8	.8	.8	.8	

Limiting Factors _____

Sanderling	Substrate		1.0	1.0	1.0	1.0	1.0	.8
	Wave Action		1.0	1.0	1.0	1.0	1.0	
	Disturbance		.5	.5	.5	.5	.5	

Limiting Factors Human disturbance

_____								

Limiting Factors _____

HSI DETERMINATION TERRESTRIAL/WETLANDS TERRESTRIAL COVER TYPES

Project Lower Cape May Meadows **Date** 4/11/94
Target Year 1994
Land Use/Cover Type Emergent Wetlands
Compartment Number 4 **Area** _____ **Mitigation Category** ___
Site Description Nature Conservancy, along edge of western path

Evaluation Species	Life Requisite		Requisite Rankings FWS	COE	SP	NC	Avg	HSI
Green Heron	Breeding		1.0	1.0	1.0	1.0	1.0	.5
	Food	1	.5	.5	.5	.5	.5	
		2	.75	.75	.75	.75	.75	
		3	.5	.5	.5	.5	.5	
	Water		.5	.5	.5	.5	.5	

Limiting Factors Substrate water surface covered by emergent vegetation and amount of permanent water

Semi-palmated Sandpiper	Substrate		.75	.75	.75	.75	.75	.5
	Water		1.0	1.0	1.0	1.0	1.0	
	Vegetation		0.0	0.0	0.0	0.0	0.0	
	Cover		0.0	0.0	0.0	0.0	0.0	
	Disturbance		.5	.5	.5	.5	.5	

Limiting Factors Height of vegetation and percent cover

Clapper Rail	Habitat	1	.6	.6	.6	.6	.6	.8
		2	.9	.9	.9	.9	.9	
		3	1.0	1.0	1.0	1.0	1.0	

Limiting Factors _____

HSI DETERMINATION TERRESTRIAL/WETLANDS TERRESTRIAL COVER TYPES

Project Lower Cape May Meadows **Date** 4/11/94
Target Year 1994
Land Use/Cover Type Emergent Wetlands
Compartment Number 3 **Area** _____ **Mitigation Category** ___
Site Description Nature Conserv., west of paths, north of sample site # 2

Evaluation Species	Life Requisite		Requisite Rankings FWS	COE	SP	NC	Avg	HSI
Green Heron	Breeding		1.0	1.0	1.0	1.0	1.0	.6
	Food	1	.5	.5	.5	.5	.5	
		2	.75	.75	.75	.75	.75	
		3	.5	.5	.5	.5	.5	
	Water		1.0	1.0	1.0	1.0	1.0	

Limiting Factors Substrate and amount of water surface covered by emergent vegetation

Semi-palmated Sandpiper	Substrate		.75	.75	.75	.75	.75	.4
	Water		.5	.5	.5	.5	.5	
	Vegetation		0.0	0.0	0.0	0.0	0.0	
	Cover		0.0	0.0	0.0	0.0	0.0	
	Disturbance		.75	.75	.75	.75	.75	

Limiting Factors Height of vegetation and percent cover

Clapper Rail	Habitat	1	.2	.2	.2	.2	.2	.6
		2	1.0	1.0	1.0	1.0	1.0	
		3	1.0	1.0	1.0	1.0	1.0	

Limiting Factors Amount of exposed flats and channels

HSI DETERMINATION TERRESTRIAL/WETLANDS TERRESTRIAL COVER TYPES

Project Lower Cape May Meadows **Date** 4/11/94
Target Year 1994
Land Use/Cover Type Emergent Wetlands
Compartment Number 2 **Area** _____ **Mitigation Category** ___
Site Description Nature Conservancy, west of paths near dune

Evaluation Species	Life Requisite		Requisite Rankings FWS	COE	SP	NC	Avg	HSI
Green Heron	Breeding		1.0	1.0	1.0	1.0	1.0	.5
	Food	1	.75	.75	.75	.75	.75	
		2	1.0	1.0	1.0	1.0	1.0	
		3	.5	.5	.5	.5	.5	
	Water		.5	.5	.5	.5	.5	

Limiting Factors Percent of water surface covered by emergent vegetation and the amount of permanent water

Semi-palmated Sandpiper	Substrate		.75	.75	.75	.75	.75	.4
	Water		.5	.5	.5	.5	.5	
	Vegetation		0.0	0.0	0.0	0.0	0.0	
	Cover		0.0	0.0	0.0	0.0	0.0	
	Disturbance		.75	.75	.75	.75	.75	

Limiting Factors Height of vegetation and percent cover

Clapper Rail	Habitat	1	.3	.3	.3	.3	.3	.7
		2	1.0	1.0	1.0	1.0	1.0	
		3	1.0	1.0	1.0	1.0	1.0	

Limiting Factors Amount of exposed flats and channels

HSI DETERMINATION TERRESTRIAL/WETLANDS TERRESTRIAL COVER TYPES

Project Lower Cape May Meadows **Date** 4/11/94
Target Year 1994
Land Use/Cover Type Emergent Wetlands
Compartment Number 1 **Area** _____ **Mitigation Category** ___
Site Description Nature Conservancy, between two paths near dune

Evaluation Species	Life Requisite		Requisite Rankings FWS	COE	SP	NC	Avg	HSI
Green Heron	Breeding		1.0	1.0	1.0	1.0	1.0	.5
	Food	1	.75	.75	.75	.75	.75	
		2	1.0	1.0	1.0	1.0	1.0	
		3	.5	.5	.5	.5	.5	
	Water		.5	.5	.5	.5	.5	

Limiting Factors Percent of water surface covered by emergent vegetation and the amount of permanent water

Semi-palmated Sandpiper	Substrate		.75	.75	.75	.75	.75	.6
	Water		.5	.5	.5	.5	.5	
	Vegetation		.5	.5	.5	.5	.5	
	Cover		.75	.75	.75	.75	.75	
	Disturbance		.5	.5	.5	.5	.5	

Limiting Factors Vegetation height, water depth and human disturbance

Clapper Rail	Habitat	1	1.0	1.0	1.0	1.0	1.0	.9
		2	.8	.8	.8	.8	.8	
		3	1.0	1.0	1.0	1.0	1.0	

Limiting Factors _____

Project Lower Cape May Meadows **Compartment No.** 5 **Date** 11/30/93

Evaluation Species	Life Requisite	Requisite Rankings FWS	COE	SP	NC	Avg	HSI
Spring Peeper	Breeding	1.0	1.0	1.0	1.0	1.0	0.0
	Cover 1	1.0	1.0	1.0	1.0	1.0	
	2	.5	.5	.5	.5	.5	
	3	.5	.5	.5	.5	.5	
	Spec Condition	0.0	0.0	0.0	0.0	0.0	

Limiting Factors Salinity, soil moisture

Limiting Factors

Limiting Factors

HSI DETERMINATION TERRESTRIAL/WETLANDS TERRESTRIAL COVER TYPES

Project Lower Cape May Meadows **Date** 11/30/93
Target Year 1994
Land Use/Cover Type Open Water
Compartment Number 5 **Area** _____ **Mitigation Category** ___
Site Description Nature Conservancy, eastern section near dune

Evaluation Species	Life Requisite		Requisite Rankings FWS	COE	SP	NC	Avg	HSI
Black Duck	Food	1	.7	.7	.7	.7	.7	.5
		2	.5	.5	.5	.5	.5	
		3	1.0	1.0	1.0	1.0	1.0	
		4	.5	.5	.5	.5	.5	
		5	.3	.3	.3	.3	.3	
		6	.5	.5	.5	.5	.5	
	Water		.5	.5	.5	.5	.5	

Limiting Factors Amount of permanent water present during winter

River Otter	Water/Food	1	.5	.5	.5	.5	.5	.3
		2	0.0	0.0	0.0	0.0	0.0	
	Cover	1	1.0	1.0	1.0	1.0	1.0	
		2	1.0	1.0	1.0	1.0	1.0	

Limiting Factors Lack of water not frozen during winter

Great Egret	Food	1	.5	.5	.5	.5	.5	.5
		2	1.0	1.0	1.0	1.0	1.0	
		3	1.0	1.0	1.0	1.0	1.0	
		4	1.0	1.0	1.0	1.0	1.0	

Limiting Factors _____

Project Lower Cape May Meadows **Compartment No.** 4 **Date** 11/30/93

Evaluation Species	Life Requisite	Requisite Rankings FWS	COE	SP	NC	Avg	HSI
Spring Peeper	Breeding	1.0	1.0	1.0	1.0	1.0	0.0
	Cover 1	.5	.5	.5	.5	.5	
	2	0.0	0.0	0.0	0.0	0.0	
	3	.5	.5	.5	.5	.5	
	Spec Condition	0.0	0.0	0.0	0.0	0.0	

Limiting Factors Salinity, tree canopy cover

Limiting Factors

Limiting Factors

HSI DETERMINATION TERRESTRIAL/WETLANDS TERRESTRIAL COVER TYPES

Project Lower Cape May Meadows **Date** 11/30/93
Target Year 1994
Land Use/Cover Type Open Water
Compartment Number 4 **Area** _____ **Mitigation Category** ___
Site Description Nature Conservancy, between paths

Evaluation Species	Life Requisite		Requisite Rankings FWS	COE	SP	NC	Avg	HSI
Black Duck	Food	1	.7	.7	.7	.7	.7	.5
		2	.5	.5	.5	.5	.5	
		3	1.0	1.0	1.0	1.0	1.0	
		4	.5	.5	.5	.5	.5	
		5	.8	.8	.8	.8	.8	
		6	.5	.5	.5	.5	.5	
	Water		.5	.5	.5	.5	.5	

Limiting Factors Amount of available water during winter

River Otter	Water/Food	1	.5	.5	.5	.5	.5	.3
		2	0.0	0.0	0.0	0.0	0.0	
	Cover	1	.5	.5	.5	.5	.5	
		2	.5	.5	.5	.5	.5	

Limiting Factors Lack of water not frozen during winter

Great Egret	Food	1	.5	.5	.5	.5	.5	.5
		2	1.0	1.0	1.0	1.0	1.0	
		3	1.0	1.0	1.0	1.0	1.0	
		4	1.0	1.0	1.0	1.0	1.0	

Limiting Factors _____

Project Lower Cape May Meadows **Compartment No.** 3 **Date** 11/30/93

Evaluation Species	Life Requisite	Requisite Rankings FWS	COE	SP	NC	Avg	HSI
Spring Peeper	Breeding	1.0	1.0	1.0	1.0	1.0	0.0
	Cover 1	1.0	1.0	1.0	1.0	1.0	
	2	1.0	1.0	1.0	1.0	1.0	
	3	.5	.5	.5	.5	.5	
	Spec Condition	0.0	0.0	0.0	0.0	0.0	

Limiting Factors Salinity, soil moisture

Limiting Factors

Limiting Factors

HSI DETERMINATION TERRESTRIAL/WETLANDS TERRESTRIAL COVER TYPES

Project Lower Cape May Meadows **Date** 11/30/93
Target Year 1994
Land Use/Cover Type Open Water
Compartment Number 3 **Area** _____ **Mitigation Category** ___
Site Description State Park, small puddles along edge of path

Evaluation Species	Life Requisite		Requisite Rankings FWS	COE	SP	NC	Avg	HSI
Black Duck	Food	1	1.0	1.0	1.0	1.0	1.0	.5
		2	.5	.5	.5	.5	.5	
		3	1.0	1.0	1.0	1.0	1.0	
		4	.5	.5	.5	.5	.5	
		5	.3	.3	.3	.3	.3	
		6	.5	.5	.5	.5	.5	
	Water		.5	.5	.5	.5	.5	

Limiting Factors Amount of permanent water present during winter

River Otter	Water/Food	1	.5	.5	.5	.5	.5	.3
		2	0.0	0.0	0.0	0.0	0.0	
	Cover	1	.5	.5	.5	.5	.5	
		2	1.0	1.0	1.0	1.0	1.0	

Limiting Factors Lack of water not frozen during winter

Great Egret	Food	1	.5	.5	.5	.5	.5	.5
		2	1.0	1.0	1.0	1.0	1.0	
		3	1.0	1.0	1.0	1.0	1.0	
		4	1.0	1.0	1.0	1.0	1.0	

Limiting Factors Salinity

Project Lower Cape May Meadows Compartment No. 2 Date 11/30/93

Evaluation Species	Life Requisite	Requisite Rankings FWS	COE	SP	NC	Avg	HSI
Spring Peeper	Breeding	1.0	1.0	1.0	1.0	1.0	0.0
	Cover 1	1.0	1.0	1.0	1.0	1.0	
	2	.5	.5	.5	.5	.5	
	3	1.0	1.0	1.0	1.0	1.0	
	Spec Condition	0.0	0.0	0.0	0.0	0.0	

Limiting Factors Salinity, tree canopy cover

Limiting Factors

Limiting Factors

HSI DETERMINATION TERRESTRIAL/WETLANDS TERRESTRIAL COVER TYPES

Project Lower Cape May Meadows **Date** 11/30/93
Target Year 1994
Land Use/Cover Type Open Water
Compartment Number 2 **Area** _____ **Mitigation Category** ___
Site Description State Park, cattail pond on eastern side of site

Evaluation Species	Life Requisite		Requisite Rankings FWS	COF	SP	NC	Avg	HSI
Black Duck	Food	1	1.0	1.0	1.0	1.0	1.0	.5
		2	.5	.5	.5	.5	.5	
		3	1.0	1.0	1.0	1.0	1.0	
		4	.5	.5	.5	.5	.5	
		5	.3	.3	.3	.3	.3	
		6	.5	.5	.5	.5	.5	
	Water		.5	.5	.5	.5	.5	

Limiting Factors Amount of permanent water present during winter

River Otter	Water/Food	1	.5	.5	.5	.5	.5	.3
		2	0.0	0.0	0.0	0.0	0.0	
	Cover	1	1.0	1.0	1.0	1.0	1.0	
		2	1.0	1.0	1.0	1.0	1.0	

Limiting Factors Lack of water not frozen during winter, water quality

Great Egret	Food	1	.5	.5	.5	.5	.5	.5
		2	1.0	1.0	1.0	1.0	1.0	
		3	1.0	1.0	1.0	1.0	1.0	
		4	.75	.75	.75	.75	.75	

Limiting Factors Salinity of water

Project Lower Cape May Meadows **Compartment No.** 1 **Date** 11/30/93

Evaluation Species	Life Requisite	Requisite Rankings FWS	COE	SP	NC	Avg	HSI
Spring Peeper	Breeding	1.0	1.0	1.0	1.0	1.0	0.0
	Cover 1	.5	.5	.5	.5	.5	
	2	1.0	1.0	1.0	1.0	1.0	
	3	.5	.5	.5	.5	.5	
	Spec Condition	0.0	0.0	0.0	0.0	0.0	

Limiting Factors Salinity, Amount of leaf litter and soil moisture

Limiting Factors

Limiting Factors

HSI DETERMINATION TERRESTRIAL/WETLANDS TERRESTRIAL COVER TYPES

Project Lower Cape May Meadows **Date** 11/30/93
Target Year 1994
Land Use/Cover Type Open Water
Compartment Number 1 **Area** _____ **Mitigation Category** ___
Site Description State Park, Shallow Pond next to dune

Evaluation Species	Life Requisite		Requisite Rankings FWS	COE	SP	NC	Avg	HSI
Black Duck	Food	1	1.0	1.0	1.0	1.0	1.0	.7
		2	.5	.5	.5	.5	.5	
		3	1.0	1.0	1.0	1.0	1.0	
		4	.5	.5	.5	.5	.5	
		5	.8	.8	.8	.8	.8	
		6	.5	.5	.5	.5	.5	
	Water		1.0	1.0	1.0	1.0	1.0	

Limiting Factors Exposed flats, amount of wetlands with open water, density of snails

River Otter	Water/Food	1	1.0	1.0	1.0	1.0	1.0	.5
		2	1.0	1.0	1.0	1.0	1.0	
	Cover	1	.5	.5	.5	.5	.5	
		2	.5	.5	.5	.5	.5	

Limiting Factors Lack of adequate cover, human disturbance

Great Egret	Food	1	1.0	1.0	1.0	1.0	1.0	.5
		2	1.0	1.0	1.0	1.0	0.0	
		3	1.0	1.0	1.0	1.0	1.0	
		4	.5	.5	.5	.5	.5	

Limiting Factors Amount of shallow water habitat

HSI DETERMINATION TERRESTRIAL/WETLANDS TERRESTRIAL COVER TYPES

Project Lower Cape May Meadows **Date** 3/15/94
Target Year 1994
Land Use/Cover Type Forest
Compartment Number 4 **Area** _____ **Mitigation Category** ___
Site Description Nature Conservancy, western property line

Evaluation Species	Life Requisite		Requisite Rankings FWS	COE	SP	NC	Avg	HSI
Sharp-Shinned Hawk	Food/Cover	1	1.0	1.0	1.0	1.0	1.0	.9
		2	.7	.7	.7	.7	.7	

Limiting Factors Percent ground cover

Wood Thrush	Reproduction	1	.5	.5	.5	.5	.5	.2
		2	.5	.5	.5	.5	.5	
	Cover	1	0.0	0.0	0.0	0.0	0.0	
		2	.4	.4	.4	.4	.4	
	Food	1	.5	.5	.5	.5	.5	
		2	1.0	1.0	1.0	1.0	1.0	

Limiting Factors Size of forest and tree height

Great Horned Owl	Cover	1	.2	.2	.2	.2	.2	.4
		2	0.0	0.0	0.0	0.0	0.0	
		3	1.0	1.0	1.0	1.0	1.0	
	Food	1	1.0	1.0	1.0	1.0	1.0	
		2	1.0	1.0	1.0	1.0	1.0	

Limiting Factors Number of trees with a DBH of 15" or more

HSI DETERMINATION TERRESTRIAL/WETLANDS TERRESTRIAL COVER TYPES

Project Lower Cape May Meadows **Date** 3/15/94
Target Year 1994
Land Use/Cover Type Forest
Compartment Number 3 **Area** _____ **Mitigation Category** ___
Site Description State Park, eastern side of site near old bean field

Evaluation Species	Life Requisite		Requisite Rankings FWS	COE	SP	NC	Avg	HSI
Sharp-Shinned Hawk	Food/Cover	1	1.0	1.0	1.0	1.0	1.0	.5
		2	0.0	0.0	0.0	0.0	0.0	

Limiting Factors Percent of ground cover

Wood Thrush	Reproduction	1	1.0	1.0	1.0	1.0	1.0	.5
		2	.9	.9	.9	.9	.9	
	Cover	1	.1	.1	.1	.1	.1	
		2	.9	.9	.9	.9	.9	
	Food	1	1.0	1.0	1.0	1.0	1.0	
		2	1.0	1.0	1.0	1.0	1.0	

Limiting Factors Size of forest

Great Horned Owl	Cover	1	.6	.6	.6	.6	.6	.5
		2	0.0	0.0	0.0	0.0	0.0	
		3	1.0	1.0	1.0	1.0	1.0	
	Food	1	.7	.7	.7	.7	.7	
		2	1.0	1.0	1.0	1.0	1.0	

Limiting Factors Number of trees with a DBH of 15" or more

HSI DETERMINATION TERRESTRIAL/WETLANDS TERRESTRIAL COVER TYPES

Project Lower Cape May Meadows **Date** 3/15/94
Target Year 1994
Land Use/Cover Type Forest
Compartment Number 2 **Area** _____ **Mitigation Category** ___
Site Description State Park, area known as weatherby woods

Evaluation Species	Life Requisite		Requisite Rankings FWS	COE	SP	NC	Avg	HSI
Sharp-Shinned Hawk	Food/Cover	1	1.0	1.0	1.0	1.0	1.0	.5
		2	0.0	0.0	0.0	0.0	0.0	

Limiting Factors Percent of ground cover

Wood Thrush	Reproduction	1	.5	.5	.5	.5	.5	.5
		2	.8	.8	.8	.8	.8	
	Cover	1	.1	.1	.1	.1	.1	
		2	.9	.9	.9	.9	.9	
	Food	1	1.0	1.0	1.0	1.0	1.0	
		2	1.0	1.0	1.0	1.0	1.0	

Limiting Factors Size of forest

Great Horned Owl	Cover	1	.8	.8	.8	.8	.8	.7
		2	.2	.2	.2	.2	.2	
		3	1.0	1.0	1.0	1.0	1.0	
	Food	1	.3	.3	.3	.3	.3	
		2	1.0	1.0	1.0	1.0	1.0	

Limiting Factors Number of trees with a DBH of 15" or more

HSI DETERMINATION TERRESTRIAL/WETLANDS TERRESTRIAL COVER TYPES

Project Lower Cape May Meadows **Date** 3/15/94
Target Year 1994
Land Use/Cover Type Forest
Compartment Number 1 **Area** _____ **Mitigation Category** ___
Site Description State Park, western side of property along Redtrail

Evaluation Species	Life Requisite		Requisite Rankings FWS	COE	SP	NC	Avg	HSI
Sharp-Shinned Hawk	Food/Cover	1	1.0	1.0	1.0	1.0	1.0	1.0
		2	.9	.9	.9	.9	.9	

Limiting Factors _____

Wood Thrush	Reproduction	1	.5	.5	.5	.5	.5	.2
		2	.9	.9	.9	.9	.9	
	Cover	1	0.0	0.0	0.0	0.0	0.0	
		2	.4	.4	.4	.4	.4	
	Food	1	.8	.8	.8	.8	.8	
		2	1.0	1.0	1.0	1.0	1.0	

Limiting Factors Size of forest

Great Horned Owl	Cover	1	.2	.2	.2	.2	.2	.4
		2	0.0	0.0	0.0	0.0	0.0	
		3	1.0	1.0	1.0	1.0	1.0	
	Food	1	.5	.5	.5	.5	.5	
		2	1.0	1.0	1.0	1.0	1.0	

Limiting Factors Number of trees with a DBH of 15" or more

HSI DETERMINATION TERRESTRIAL/WETLANDS TERRESTRIAL COVER TYPES

Project Lower Cape May Meadows **Date** 11/23/93
Target Year 1994
Land Use/Cover Type Old Field
Compartment Number 3 **Area** _____ **Mitigation Category** ___
Site Description Nature Conserv., east of paths, surrounded by phragmites

Evaluation Species	Life Requisite	Requisite Rankings FWS	COE	SP	NC	Avg	HSI
American Kestrel	Breeding/Cover	1.0	1.0	1.0	1.0	1.0	.7
	Food 1	1.0	1.0	1.0	1.0	1.0	
	2	.0	.0	.0	.0	.0	
	3	1.0	1.0	1.0	1.0	1.0	

Limiting Factors Height of herbaceous ground cover

Field Sparrow	Cover 1	.4	.4	.4	.4	.4	.5
	2	1.0	1.0	1.0	1.0	1.0	
	3	.5	.5	.5	.5	.5	
	4	0.0	0.0	0.0	0.0	0.0	

Limiting Factors Height of herbaceous canopy

Limiting Factors _____

HSI DETERMINATION TERRESTRIAL/WETLANDS TERRESTRIAL COVER TYPES

Project Lower Cape May Meadows **Date** 11/23/93
Target Year 1994
Land Use/Cover Type Old Field
Compartment Number 2 **Area** _____ **Mitigation Category** ___
Site Description Nature Conservancy, between the two paths

Evaluation Species	Life Requisite	Requisite Rankings FWS	COE	SP	NC	Avg	HSI
American Kestrel	Breeding/Cover	1.0	1.0	1.0	1.0	1.0	.7
	Food 1	1.0	1.0	1.0	1.0	1.0	
	2	.2	.2	.2	.2	.2	
	3	1.0	1.0	1.0	1.0	1.0	

Limiting Factors Height of herbaceous ground cover

Field Sparrow	Cover 1	1.0	1.0	1.0	1.0	1.0	.8
	2	1.0	1.0	1.0	1.0	1.0	
	3	1.0	1.0	1.0	1.0	1.0	
	4	0.0	0.0	0.0	0.0	0.0	

Limiting Factors Height of herbaceous canopy

Limiting Factors _____

HSI DETERMINATION TERRESTRIAL/WETLANDS TERRESTRIAL COVER TYPES

Project Lower Cape May Meadows **Date** 11/23/93
Target Year 1994
Land Use/Cover Type Old Field
Compartment Number 1 **Area** _____ **Mitigation Category** ___
Site Description Nature conservancy, west of parking lot

Evaluation Species	Life Requisite	Requisite Rankings FWS	COE	SP	NC	Avg	HSI
American Kestrel	Breeding/Cover	1.0	1.0	1.0	1.0	1.0	.8
	Food 1	1.0	1.0	1.0	1.0	1.0	
	2	.5	.5	.5	.5	.5	
	3	1.0	1.0	1.0	1.0	1.0	

Limiting Factors Height of herbaceous ground cover

Field Sparrow	Cover 1	0.0	0.0	0.0	0.0	0.0	.6
	2	.2	.2	.2	.2	.2	
	3	1.0	1.0	1.0	1.0	1.0	
	4	1.0	1.0	1.0	1.0	1.0	

Limiting Factors Lack of shrub crown cover

Limiting Factors _____

FWS - U.S. Fish and Wildlife Service
COE - U.S. Army Corps of Engineers
SP- New Jersey Department of Environmental Protection and Energy, Division of Parks and Forestry.
NC - The Nature Conservancy

MEAN SPECIES HSI PER COVER TYPE

Project Lower Cape May Meadows **Date** _____

Alternative Existing Conditions **Target Year** 1994

Land Use/Cover Type Old Field

Sample Sites			**Evaluation Species**			
			American Kestrel	Field Sparrow		
1 Area 12.14	HSI		0.8	0.6		
	HU		9.712	7.284		
2 Area 7.0	HSI		0.7	0.8		
	HU		4.9	5.6		
3 Area 4.75	HSI		0.7	0.5		
	HU		3.325	2.375		
4 Area	HSI					
	HU					
5 Area	HSI					
	HU					
6 Area	HSI					
	HU					
7 Area	HSI					
	HU					
Total Area 23.89						
Total HU			17.94	15.26		
Mean HSI			.8	.6		

MEAN SPECIES HSI PER COVER TYPE

Project Lower Cape May Meadows **Date** _____

Alternative Existing Conditions **Target Year** 1994

Land Use/Cover Type Phragmites

Sample Sites		**Evaluation Species**			
		Marsh Wren	Muskrat		
1	HSI	0.3	0.0		
Area 11.18	HU	3.354	0.0		
2	HSI	0.5	0.5		
Area 36.75	HU	18.375	18.375		
3	HSI	0.3	0.5		
Area 1.03	HU	.309	.515		
4	HSI	0.1	0.0		
Area 5.3	HU	.53	0.0		
5	HSI				
Area	HU				
6	HSI				
Area	HU				
7	HSI				
Area	HU				
Total Area 54.26					
Total HU		22.57	18.89		
Mean HSI		.4	.3		

MEAN SPECIES HSI PER COVER TYPE

Project Lower Cape May Meadows **Date** _____

Alternative Existing Conditions **Target Year** 1994

Land Use/Cover Type Beach

Sample Sites		**Evaluation Species**			
		Least Tern	Sanderling		
1	HSI	0.8	0.8		
Area 30.3	HU	24.24	24.24		
2	HSI	0.8	0.6		
Area 6.57	HU	5.256	3.942		
3	HSI	1.0	0.8		
Area 27.45	HU	27.45	21.96		
4	HSI				
Area	HU				
5	HSI				
Area	HU				
6	HSI				
Area	HU				
7	HSI				
Area	HU				
Total Area 64.32					
Total HU		56.95	50.14		
Mean HSI		.9	.8		

MEAN SPECIES HSI PER COVER TYPE

Project Lower Cape May Meadows **Date** _____

Alternative Existing Conditions **Target Year** 1994

Land Use/Cover Type Emergent Wetlands

Sample Sites			**Evaluation Species**			
			Green Heron	Semi-Palmated Sandpiper	Clapper Rail	
1		HSI	0.5	0.6	0.9	
Area	8.3	HU	4.15	4.98	7.47	
2		HSI	0.5	0.4	0.7	
Area	10.73	HU	5.37	4.292	7.511	
3		HSI	0.6	0.4	0.6	
Area	2.8	HU	1.68	1.12	1.68	
4		HSI	0.5	0.5	0.8	
Area	2.6	HU	1.3	1.3	2.08	
5		HSI				
Area		HU				
6		HSI				
Area		HU				
7		HSI				
Area		HU				
Total Area	24.43					
Total HU			12.5	11.7	18.7	
Mean HSI			.5	.5	.8	

MEAN SPECIES HSI PER COVER TYPE

Project Lower Cape May Meadows **Date** _____

Alternative Existing Conditions **Target Year** 1994

Land Use/Cover Type Open Water

Sample Sites		**Evaluation Species**			
		Black Duck	River Otter	Great Egret	Spring Peeper
1	HSI	0.7	0.5	0.5	0.0
Area 8.35	HU	5.845	4.175	4.175	0.0
2	HSI	0.5	0.3	0.5	0.0
Area 1.66	HU	.83	.498	.83	0.0
3	HSI	0.5	0.3	0.5	0.0
Area .54	HU	0.27	.162	0.27	0.0
4	HSI	0.5	0.3	0.5	0.0
Area 6.0	HU	3.0	1.8	3.0	0.0
5	HSI	0.5	0.3	0.5	0.0
Area 1.08	HU	.54	.324	.54	0.0
6	HSI				
Area	HU				
7	HSI				
Area	HU				
Total Area 17.63					
Total HU		10.49	6.96	8.82	0.0
Mean HSI		.6	.4	.5	0.0

MEAN SPECIES HSI PER COVER TYPE

Project Lower Cape May Meadows **Date** _____

Alternative Existing Conditions **Target Year** 1994

Land Use/Cover Type Forest

Sample Sites		**Evaluation Species**			
		Sharp-Shinned Hawk	Wood Thrush	Great Horned Owl	
1 Area 10.8	HSI	1.0	0.2	0.4	
	HU	10.8	2.16	4.32	
2 Area 28.7	HSI	0.5	0.5	0.7	
	HU	14.35	14.35	20.09	
3 Area 9.4	HSI	0.5	0.5	0.5	
	HU	4.7	4.7	4.7	
4 Area 3.1	HSI	0.9	0.2	0.4	
	HU	2.79	.62	1.24	
5 Area _____	HSI				
	HU				
6 Area _____	HSI				
	HU				
7 Area _____	HSI				
	HU				
Total Area 52.0					
Total HU		32.64	21.83	30.35	
Mean HSI		.6	.4	.6	

PAM-HEP HSI MODEL

Species: Clapper Rail (*Rallus longirostris*)

Project: Lower Cape May Meadows

Cover Types: Emergent wetlands, Tidal Marshes

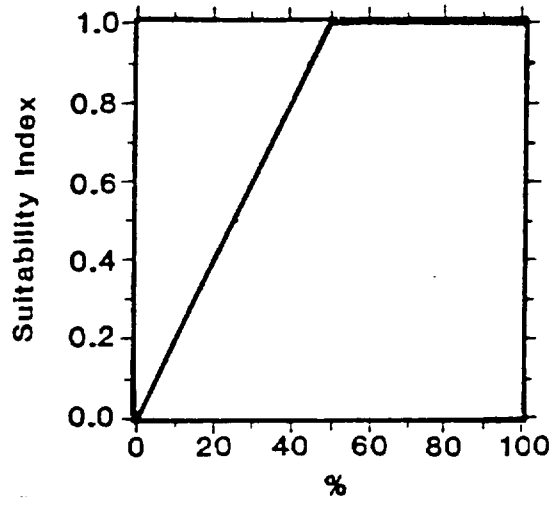
Life History: The Clapper Rail lives and nests at high spring and storm tides in tidal marshes and it usually breeds in salt marshes. They can be seen feeding at lowtide from mudflats and marsh creeks. The Clapper Rails can be seen nesting in a dense clump of vegetation on the highest place available in the open salt marshes.

Life Requisite Factors:

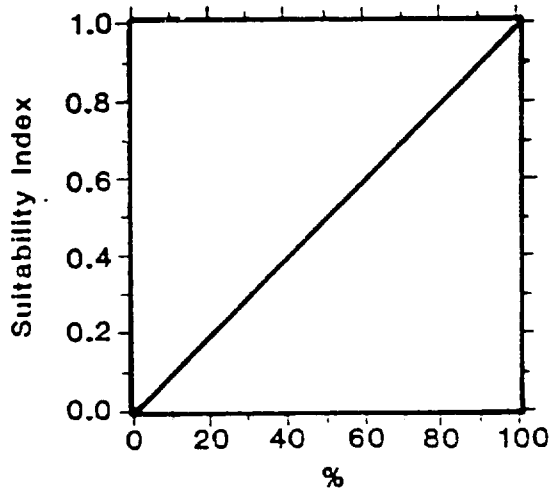
Factor	Condition	Value
Habitat	1. Percentage of shoreline of persistent wetlands bordered by mud flats or exposed channels.	
	0%	0.0
	25%	0.5
	50-100%	1.0
	2. Percent of area covered by persistent wetlands.	
	0%	0.0
	50%	0.5
	100%	1.0
	3. Percent of emergent wetland within 49 ft. of exposed mud flats.	
	0%	0.0
	15%	0.6
	25%	1.0

$$HSI = (SIv_1 * SIv_2 * SIv_3)^{1/3}$$

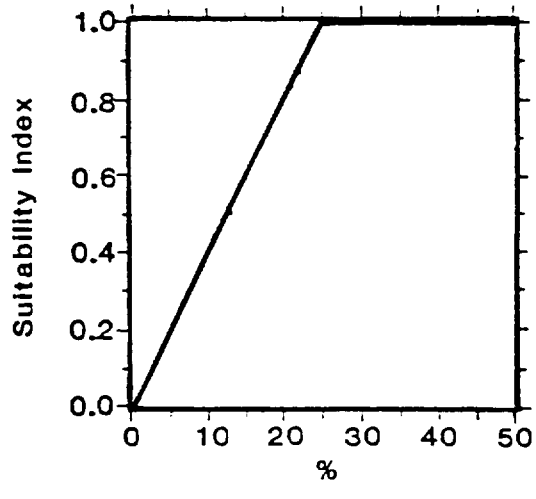
Habitat	Variable		Suitability Graph
E	V_1	Percentage of shoreline of persistent emergent and scrub/shrub mangrove wetlands that is bordered by flats or exposed channels.	



Habitat	Variable		Suitability Graph
E	V_2	Percentage of area covered by persistent emergent and/or scrub/shrub mangrove wetlands.	



E	V_3	Percentage of emergent and scrub/shrub mangrove wetland within 15 m (49.2 ft) of exposed mud flats.	



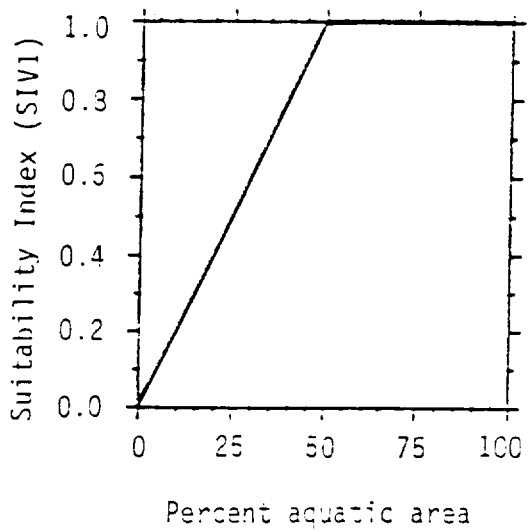
$$HSI = \left(SI_{V_1} \cdot SI_{V_2} \cdot SI_{V_3}\right)^{1/3}$$

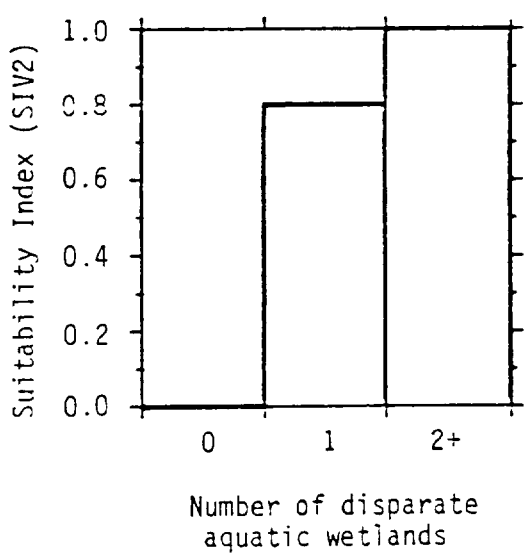
Date:

Least Tern

Sample Size

Food Component



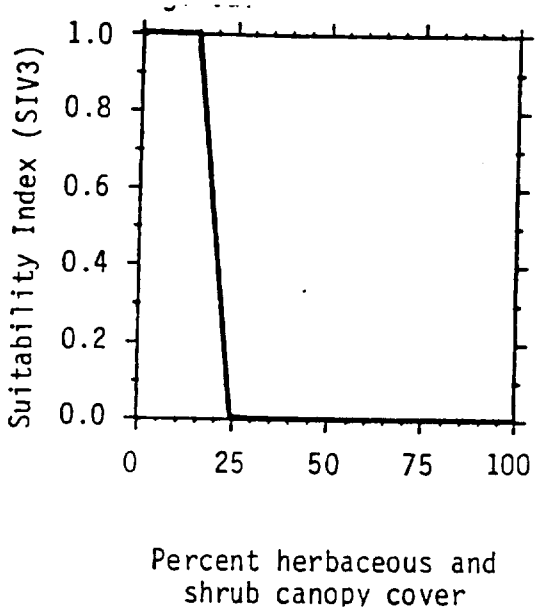


$$SIF = \frac{2(SIV1) + SIV2}{3}$$

Least Tern Cont.

Sample Sites

Reproductive Component

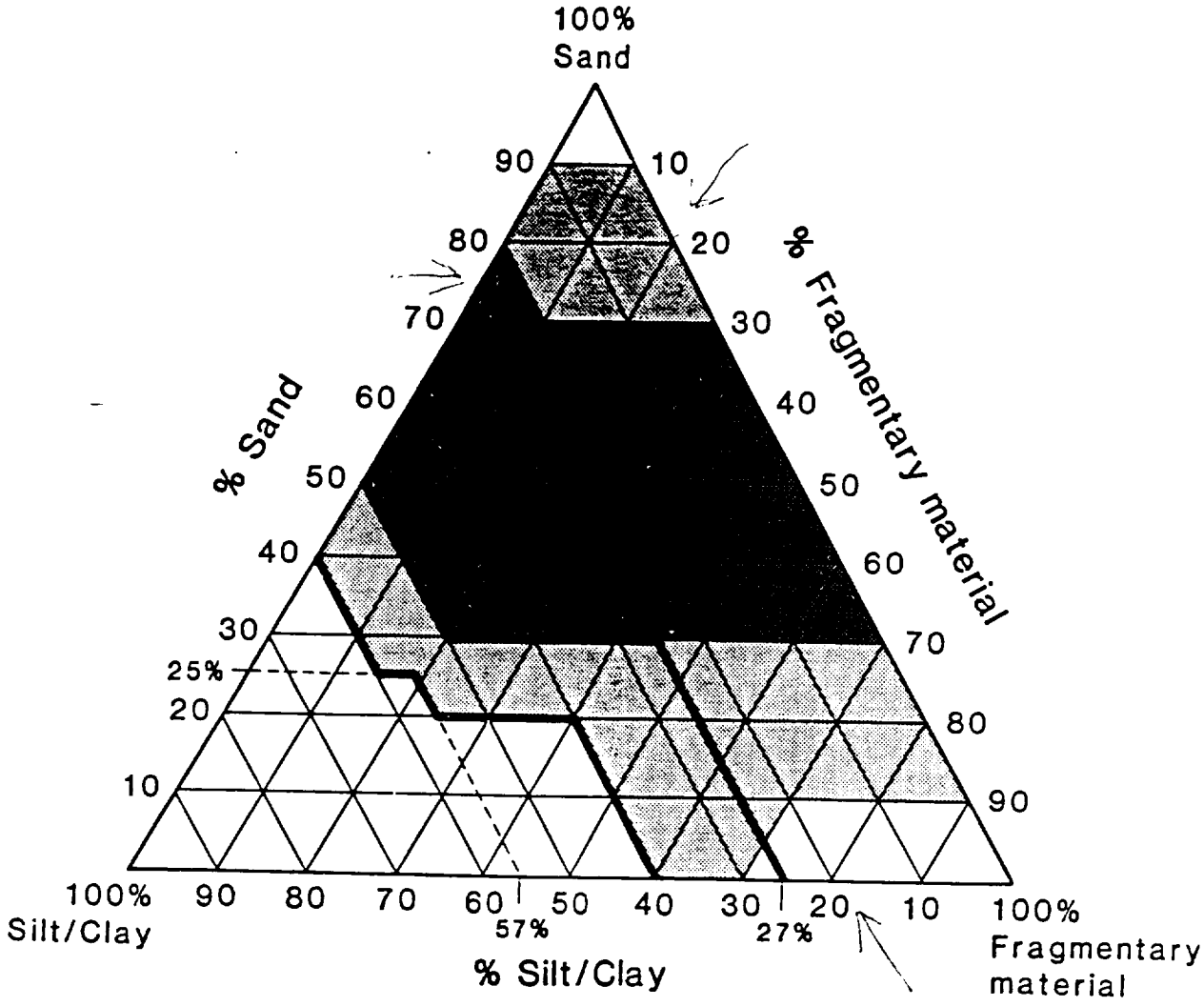


SIV5 = Quality of Substrate

SIR = Lower of SIV3 or SIV5

HSI OVERALL

HSI = Lower of SIR or SIF



QUALITY OF NESTING SUBSTRATE

- excellent, SIV5 = 1.0
- good, SIV5 = 0.8
- poor, SIV5 = 0.2

Figure 6. The relationship between substrate composition and the suitability index value for least tern reproduction.

PAM-HEP HSI MODEL

Species: Spring Peeper (*Hyla crucifer*)

Project: Lower Cape May Meadows

Cover Types: Deciduous forest, Forested wetlands, Open water, Scrub-shrub wetlands

Life History: The Spring Peeper is a small tree frog that inhabits ponds, marshes and other damp areas in the U.S. It can be found in woodland ponds outside of the breeding season.

Life Requisite Factors:

Factor	Condition	Value
Breeding	1. Permanent or semi-permanent water bodies per acre	
	None	0.0
	One per acre	0.5
	Greater than one per acre	1.0
Cover	1. Leaf litter	
	None	0.0
	Sparse, less than or equal to 1 in. deep	0.5
	Abundant, greater than 1. in deep	1.0
	2. Tree canopy closure	
	Less than 30%	0.0
	Greater than 60%	0.5
	30 - 60%	1.0
	3. Soil moisture	
	Dry-crumbles when compressed	0.0
	Wet-drips when compressed	0.5
	Moist-forms cast when compressed	1.0
Special Conditions	1. Water salinity	
	Less than 1ppt	1.0
	Greater than 1ppt	0.0

HSI DETERMINATION: HSI is equal to the lowest value of breeding, special conditions or average cover parameters.

PAM-HEP HSI MODEL

Species: Marsh wren (*Cistothorus palustris*)

Project: **Lower Cape May Meadows**

Cover types: Estuarine Emergent Macrophyte

Life History: (see attached)

Life Requisite Factors:

Factor	Condition	Value
Food	% of wetland covered by standing water (exclusive of emergent vegetation, consider average summer conditions or mean high tide)	% cover/100
Cover & Repro.	1. % canopy cover at 2.5'	
	0-10%	0.0
	10-30%, 80-100%	0.5
	30-80%	1.0
	2. % of veg. cover which is composed of broadleafed herbaceous plants (i.e. *Typha* spp., *Phragmites*, broadleafed *Carex* spp.).	
	0-35%	0.0
	35-60%	0.5
	60-100%	1.0

HSI Determination: Repro. = R1 X R2, HSI = lowest life req. val.

References:

U.S. Fish & Wilflife Service, April 1980. Long-billed marsh wren draft HSI model.

Prepared: Dave Jenkins - Sr. Zoologist, N.J. Div. Fish, Game & Wildlife, Endangered & Nongame Species Prog. 9/85.

PAM-HEP HSI MODEL

Species: Sanderling (Calidris alba)

Project: Lower Cape May Meadows

Cover Type: Beach habitat

Life History: Sanderlings nests are often seen in the barrens near the sea around the north pole. Sanderlings can be seen on virtually on any beach. Their nests are usually placed on a low ridge or terrace of the dry upland tundra, mainly on sandflats.

Life Requisite Factors:

Factor	Condition	Values
Habitat	1. Substrate	
	Sand	1.0
	Mud	0.5
	Rocks	0.0
	2. Wave Action	
	High energy beach	1.0
	No wave action	0.0
	3. Disturbance	
	None	1.0
	Passive	0.5
	Active	0.0

$$HSI = \frac{(1) + (2) + (3)}{3}$$

Based on conversations with Kathy Clark and Doug Helmers

PAM HEP HSI MODEL

Species: Field Sparrow (Spizella pusilla)

Project: **Lower Cape May Meadows**

Cover Types: Herbaceous Rangeland
Scrub-Brush Rangeland

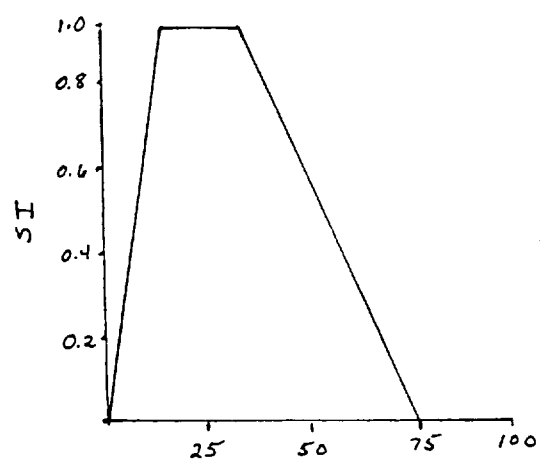
Life History Synopsis: Optimal habitat for this bird is found in old field areas with low to moderate density of shrubs and dense, moderately tall grasses. They use shrubs for perch sites and often for nest sites. Shrubs are a necessary component; however, 75 percent or more canopy cover of shrubs is too dense. They usually nest in low shrubs, and use higher ones for songperch sites. Overall shrub suitability is a function of both shrub density and height distribution.

Grasses are used much more than forbes as nest sites; optimal grass density is fund from 50% to 90%. Optimal height of herbaceous vegetation from May-June is 6-13 inches to allow access to nests. Food is obtained by foraging around in the grass and on the ground, therefore, slightly open ground cover allows easier foraging.

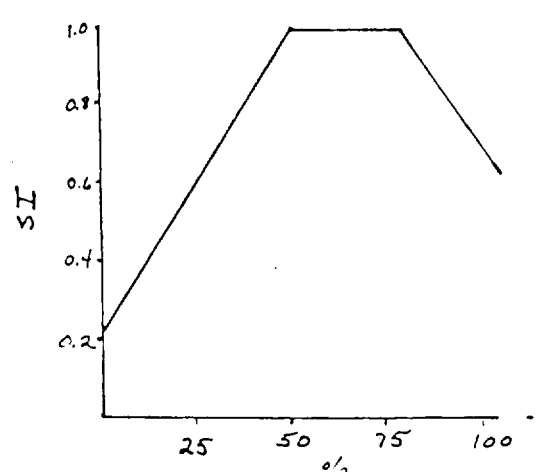
Life Requisite Factor:

Cover

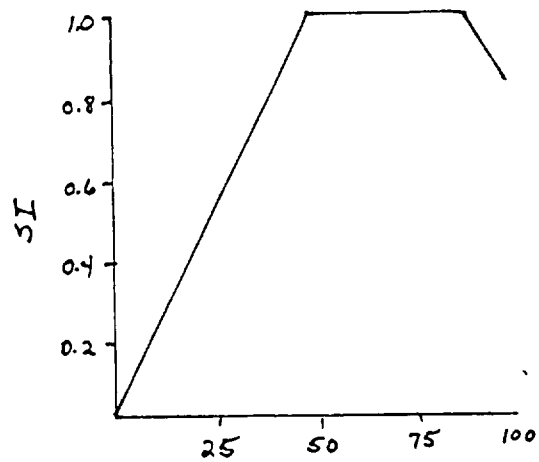
1 Percent shrub crown cover.



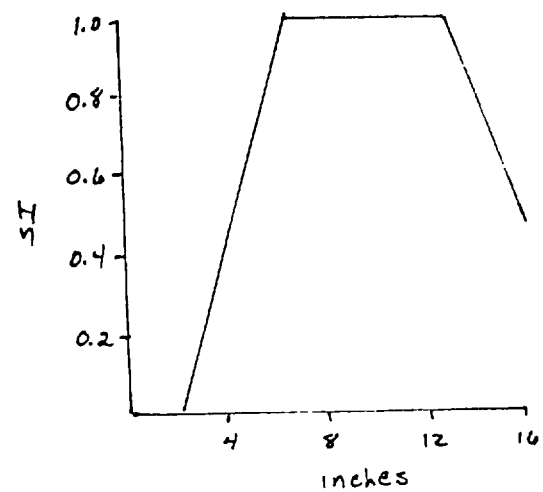
2 Percent of total shrubs that are less than 1.5 m (4.9 ft) tall.



3 Percent canopy cover of grasses.



4 Average height of herbaceous canopy (average spring conditions).



HSI Determination: HSI equals the average value of 1-4.

Reference: WELUT HSI Model, September 183.

Developed by: Dennis F. Brown, U.S. Fish and Wildlife Service, State College, Pennsylvania.

Model Relationships

PAM-HEP HSI MODEL

Species: American kestrel (*Falco sparverius*)

Project: **Lower Cape May Meadows**

Cover Types: Agricultural land, Herbaceous rangeland, Shrub and brush rangeland, Mixed rangeland, Scrub-shrub wetland

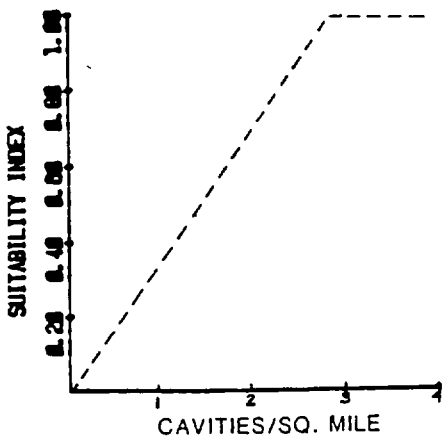
Life History: A generalized predator of invertebrate and small vertebrate prey, the kestrel is a cavity nester of open and semi-open areas. Percent and average height of herbaceous ground cover are important relative to the interaction of prey availability with prey vulnerability. While arthropods are important prey by frequency, vertebrate prey may be more important by total biomass. Although kestrels will hover in search of prey, they will confine hunting activity to adjacent areas with perches. Suitable nesting cavities can be limiting.

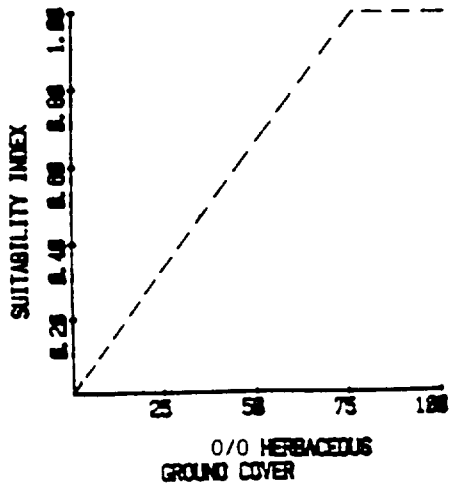
Life Requisite Factors:

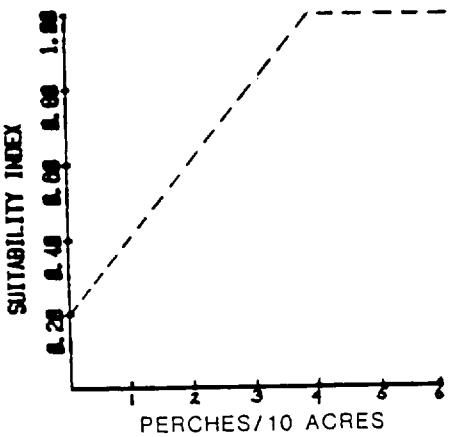
Factor	Condition	Value
Breeding/Cover	1. Nest cavities per square mile	
	None	0.0
	1-2	0.5
	Greater than 2	1.0
Food	1. % herbaceous ground cover	
	0%	0.0
	25-50%	0.5
	50-100%	1.0
	2. Average height of herbaceous ground cover	
	0" or greater than 10"	0.0
	1-2" or 8-10"	0.5
	3-7"	1.0
	3. Perches per 10 acres	
	0	0.2
	1-2	0.5
	Greater than 2	1.0

HSI DETERMINATION: HSI is equal to the lowest value of breeding or average food parameters.

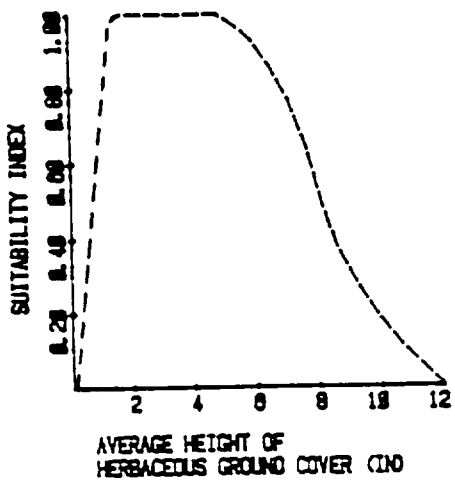
AMERICAN KESTREL







*SNAG, ROCK, UTILITY WIRES, TREE, SHRUB, ETC.



PAM HEP-HSI MODEL

Species: Black Duck (*Anas rubripes*)

Project: **Lower Cape May Meadows**

Cover Types: Emergent Wetlands, Forested Wetlands, Open Water, Scrub-Shrub Wetlands

Life History:

Black ducks are herbivores during summer and fall but make heavy use of invertebrates from winter into spring. Daily foraging radius for flighted birds is up to 25 mi.

Breeding habitat is varied from open coastal marshes to woodland beaver ponds. The majority of nests are on upland sites adjacent to these areas. Nest sites will often be stumps, clumps of vegetation or muskrat houses.

Brood cover consists of beaver ponds or other small impounded areas, loosestrife bogs, brush lined streams and high elevation marshes.

Wintering areas consist of open marshes with adequate food and water as well as small wood lined streams.

Life Requisite Factors (Wintering):

Factor		Condition	Value
Food	1.	< 20% of subtidal open water areas ≤ 1 m deep at low tide.	0.1
		≥ 20% to < 40% of subtidal open water areas ≤ 1 m deep at low tide.	0.5
		≥ 80% of subtidal open water areas ≤ 1 m deep at low tide.	0.7
		≥ 60% to < 80% of subtidal open water areas ≤ 1 m deep at low tide.	1.0
Food	2.	10% to < 20% of total open-water area that becomes exposed tide banks, bars, stream beds and tidal flats at low tide.	0.5
		> 60% of total open-water area that becomes exposed tide banks, bars, stream beds and tidal flats at low tide.	0.8
		> 20% to ≤ 60% of total open-water area that becomes exposed tide banks, bars, stream beds and tidal flats at low tide.	1.0
	3.	≥ 10% to < 20% of subtidal open water (≤ 1 m deep at low tide) that supports rooted vascular plants.	0.5
		≥ 20% of subtidal open water (≤ 1 m deep at low tide) that supports rooted vascular plants.	1.0

Factor	Condition	Value
	4. 10% to < 20% and > 30% to 90% of estuarine emergent and forested wetlands occupied by creeks, ponds and impoundments.	0.5
	≥ 20% to ≤ 30% of estuarine emergent and forested wetlands occupied by creeks, ponds and impoundments	1.0
	5. 20% to 40% of substrate samples from ponds or impoundments are occupied by Ruppia and/or Potamogeton.	0.3
	> 40% to < 80% of substrate samples from ponds or impoundments are occupied by Ruppia and/or Potamogeton.	0.8
	≥ 80% of substrate samples from ponds or impoundments are occupied by Ruppia and/or Potamogeton.	1.0
	6. 10% to < 25% of emergent marsh supports ≥ 750 snails/m².	0.5
	≥ 25% of emergent marsh supports ≥ 750 snails/m².	1.0
	NOTE: Presence of any one condition singularly meets entire food requirement. Presence of two or more conditions are treated cumulatively and final food value is adjusted upward accordingly.	
Cover	Cover is not a limiting factor.	
Water (Winter)	1. No water present	0.0
	Water is frozen for periods longer than one week	0.5
	Permanent and open water present	1.0

HSI Determination: HSI is equal to the lowest average value of any listed life requisite factor.

References:

U.S. Fish and Wildlife Service. Sept. 1984. Habitat Suitability Index Models: American Black Duck (Wintering). 16 pp.

Developed: Oct. 2, 1985, by Lee Widjeskog, Sr. Wildlife Biol. N.J. Div. Fish, Game and Wildlife

Revised: 10/85

PAM HEP HSI MODEL

Species: Sharp-shinned Hawk (Accipter Striatus)

Project: **Lower Cape May Meadows**

Cover Types: Coniferous forests

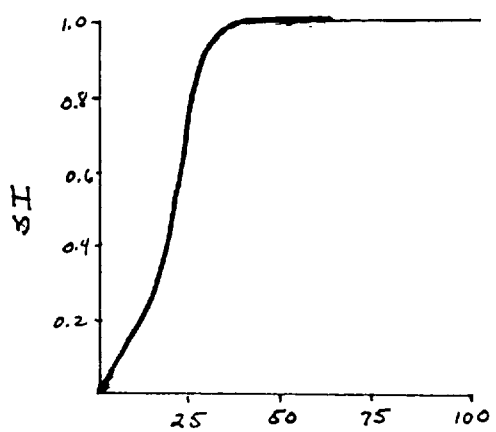
Life History Synopsis:

Sharp-shinned hawks primarily inhabit coniferous forests. Nesting sites in one study were located atop large evergreens in cool, moist conifer stand with sparse ground cover.

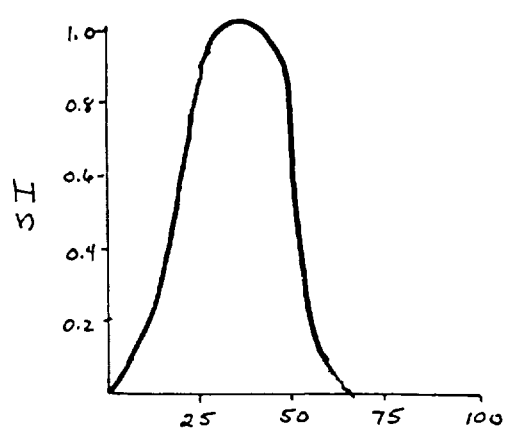
Sharp-shinned hawks feed primarily on birds (90-97%) taking warblers, sparrows, and thrushes in equal numbers. They hunt from perches capturing their prey in flight. Mammals. reptiles, and insects are also eaten in low numbers. A breeding pair occupies about 10 acres of forest.

Life Requisite Requirements:

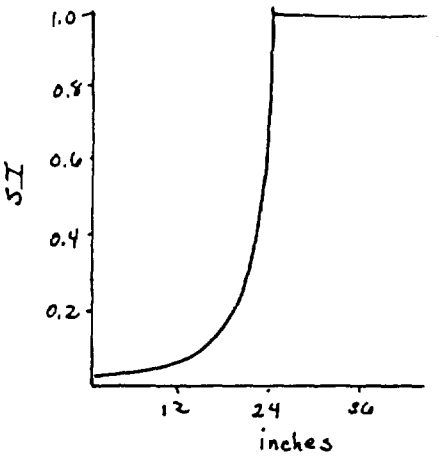
Food/Cover 1. Percent Canopy cover



2. Percent ground cover



3. Average dbh of conifers



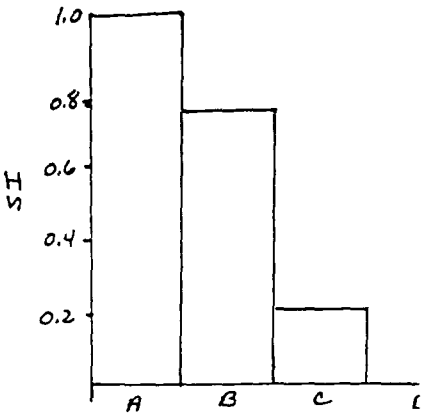
4. Level of logging activity

A- No logging within ½ mile

B- High grading or timber stand improvement

C- Clearcutting within ½ mile

D- Clearcutting less than ¼ mile



HSI Determination: HSI is equal to $\frac{2(1)+(2)+2(3)+(4)}{6}$

References: WELUT 1980 Model

Prepared by: Richard W. McCoy 1987 USFWS State College, PA

FINAL

PAM HEP HSI Model

Species: Green Heron (Butorides virescens)

Project: **Lower Cape May Meadows**

Cover Types: Paulstrine scrub-shrub/emergent, Estuarine emergent

Life History: Green herons are wading birds that inhabit a wide range of aquatic environments. They are somewhat adaptable and general in their habitat preferences.

Breeding cover is provided by woody material capable of supporting a nest in proximity of suitable feeding areas. Optimum breeding habitat is provided with suitable clumps of deciduous shrubs/trees within 0.25 miles. There must be some breeding cover within 1.0 mile.

Herons forage in openings, among emergent vegetation, and along soft, muddy borders of shallow water. Good feeding areas require a muddy or sandy bottom, water less than 10" deep, and a moderate amount of vegetation cover.

Cover is not generally limiting and is provided by the breeding and food requirements.

Green herons require water. Permanent water provides the optimum value while semi-permanent will receive some utilization.

Life Requisite Factors:

Factor	Condition	Value
Breeding	1. Clumps of deciduous shrubs/trees 1.0 miles or more distant.	0.0
	Clumps of deciduous shrubs/trees 0.75 miles distant.	0.5
	Clumps of deciduous shrubs/trees 0.25 miles or less distant.	1.0
Food	1. Littoral substrate rocky.	0.0
	Littoral substrate sandy.	0.5
	Littoral substrate muddy.	1.0
	2. 0% of water less than 10"	0.0
	50% of water less than 10"	0.5
	100% of water less than 10"	1.0
	NOTE: Consider average summer conditions.	
	3. 0% or 100% of water surface covered by emergent vegetation, woody vegetation, logs, or trees.	0.0
	0-25% or 75-100% of water surface	0.5

Assume productivity is sufficient unless their is evidence or previous knowledge to believe otherwise. If marsh, pond, river, etc. is biologically dead; food value = 0. Consult HSI for aquatic prey species (fish).

	covered by emergent vegetation, woody vegetation, logs, or trees.	
	25% to 75% of water surface covered by emergent vegetation, woody vegetation, logs, or trees.	1.0

Food SI is the average of 2, 3, and 4.

Cover	Is not a limiting factor.	
Water	1. No permanent water.	0.0
	Semi-permanent water.	0.5
	Permanent water.	1.0

HSI Determination: HSI is equal to the lowest life requisite value.

References: WELUT HSI Model, April 1980.
PAM HEP HSI Model, Exton Bypass, October 1982.

Prepared: April 13, 1982, by J. H. Palmer, Pennsylvania Game Commission.

Reviewed and approved as suitable for application to Manasquan Reservoir Project. Dave Jenkins, Senior Zoologist, N.J. Division of Fish, Game and Wildlife, Endangered and Nongame Specie Program, Sept., 1985

PAM HEP-HSI MODEL

Species: Muskrat (*Ondatra zibethicus*)

Project: **Lower Cape May Meadows**

Cover Types: Estuarine Wetlands
Emergent Wetlands (persistent and non-persistent)
Riverine Wetlands (less than 5 ft. deep)
Lacustrine Wetlands (less than 5 ft. deep)
Riparian Banks (containing herbaceous and woody vegetation)

Life History:

Muskrats are typically found in areas with permanent, slow moving or tidal water, emergent vegetation and suitable bank den sites. Home range averages 200 feet in diameter in marshes. Up to 1000 ft. of shoreline will be used in stream environments. Faster flowing or semi-permanent streams are utilized to a limited degree.

Muskrat productivity in most streams, lakes and marshes appears to be related to the availability of suitable areas and soil for bank burrows. Where suitable bank denning sites are not available but other requirements are adequately met, muskrats use houses constructed of vegetation for nursery sites.

Primary food sources for the species consist of leaves, stems and rootstock of emergent vegetation. Rootstock is especially important as a source of winter nutrition. Productive muskrat marshes consist of 5 to 70 percent emergent vegetation. Herbaceous bank vegetation and riparian shrub thickets are utilized as food sources along streams. Cover is generally provided by the same vegetation which provides food and can be supplemented by logs, trees and shrubs.

Life Requisite Factors:

Factor		Condition	Val
Breeding (Bank burrows)	1.	Bank soil consists of gravel or rock	0.0
		Bank soil consists of sand or clay	0.2
		Bank soil consists of loam or silt-loam	0.5
		Bank soil sandy clay-loam, sandy loam or loamy sand	1.0
	2.	Bank eroding away	0.0
		Bank 50 percent stable	0.5
		Bank 100 percent stable	1.0

NOTE: A minimum bank slope of 10 percent is required for muskrat burrows. In considering bank stability, do not include muskrat-induced erosion.

$$\text{Breeding SI} = \frac{1+2}{2}$$

NOTE: 0.0 SI for Variable 1 or 2 is limiting and resulting Breeding SI will be 0.0

Factor	Condition	Valu
Breeding (Lodges)	Value is equal to the average of food and cover SI values present in Marsh Habitat	
Marsh Habitat:		
Food	1. Less than 5 percent of water surface area in emergent herbaceous canopy cover	0.0
	35 percent of water surface area in emergent herbaceous canopy cover	0.5
	67 percent or more of water surface area in emergent herbaceous canopy cover	1.0
Cover	1. None of surface covered with logs, trees, woody shrubs or emergent canopy cover (including material overhanging from shore)	0.0
	15 percent of water surface covered with logs, trees, woody shrubs or emergent canopy cover; or more than 75 percent of surface covered	0.5
	30-50 percent of water surface covered with logs trees, woody shrubs or emergent canopy cover	1.0
Lake & Stream Habitat:		
Food	1. No herbaceous vegetation on banks	0.0
	30 percent of bank surface covered with herbaceous vegetation	0.5
	60 percent or more of bank covered with herbaceous vegetation	1.0
	2. Stands of emergent vegetation more than 500 ft. average distance	0.0
	Stands of emergent vegetation 400 ft. average distance	0.5
	Stands of emergent vegetation 300 ft. or less average distance	1.0
	Food SI $= \frac{1+2}{2}$	
	NOTE: 0.0 SI for Variable 1 is limiting and resulting Food SI is 0.0. 0.0 SI values for Variable 2 is not limiting and is averaged in.	
Cover	Value identical to food value in stream and lake habitats. Values not recorded.	
Marsh, Lake & Stream Habitats:		
Water	1. No water	0.0
	Semi-permanent water	0.5
	Permanent water	1.0
	2. Water salinity exceeds 30 ppt for more than one week per year. Plant species associated with these conditions include salt grass (*Distichlis spicita*) and cordgrass (*Spartina patens*).	0.0

Factor	Condition	Value
Water (cont.)	Water salinity does not exceed 30 ppt for more than one week per year. Indicative plant species include cordgrass (Spartina patens), smooth cordgrass (Spartina alterniflora), big cordgrass (Spartina cynosuroides) and common reed (Phragmites communis) in association.	1.0
	3. Current 36 inches per second or greater (strong)	0.1
	Current 20 inches per second (mild)	0.5
	Current 6 inches or less per second (weak)	1.0

$$\text{Water SI} = \frac{1+2+3}{3}$$

NOTE: 0.0 SI for Variable 1 or 2 is limiting. Resulting Water SI will be 0.0

HSI Determination: HSI is equal to lowest average life requisite value.

References:

PA Game Commission. Feb. 20, 1985. PAM HEP HSI Model, Muskrat. Generic model for marsh and stream habitats in Pa. 6 pp.

Perry, H. R. 1982. Muskrats. Pages 282-325 in J. A. Chapman and G. A. Feldhamer, ed., Wild Mammals of North America. Johns Hopkins University Press. Baltimore, Md. pp. 1147.

U.S. Fish and Wildlife Service. June 1984. Habitat Suitability Index Models: Muskrat. 27 pp.

U.S. Fish and Wildlife Service. June 1978. Draft HSI, Muskrat-Riparian Zone, Ecoregion 2213. pp. IV-I-9 through IV-I-15.

U.S. Fish and Wildlife Service. April 1980. Review Copy HSI Model for Muskrat. 14 pp.

Developed: Sept. 20, 1985, by R.Eriksen, Principal Wildlife Biol., N.J. Div. of Fish, Game and Wildlife.

Revised: 10/85

PAM HEP HSI MODEL

Species: Wood thrush (*Hylacichla mustelina*)

Project: Lower Cape May Meadows

Cover Type: Deciduous Forest

Life History Synopsis:

The wood thrush occurs in cool, damp woodlands. It seems to prefer deciduous forests with an abundance of sapling growth and large trees. They forage on the forest floor for both vegetable and animal matter. Water may be necessary for use in nest building (mud). Their nests are built in shrubs or small trees less than 20 feet above ground. They are strongly associated with tracts of undisturbed woodlands greater than 40 acres.

Life Requisite Factors:

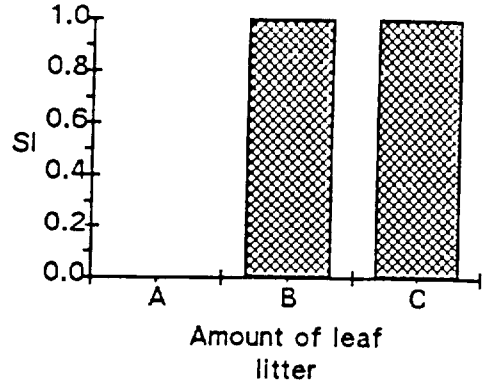
Factor	Condition	Value
Reproduction	1. Shrub crown closure <10% or >90%	0.0
	Shrub crown closure 10-30% or 70-90%	0.5
	Shrub crown closure 30-70%	1.0
	2. Average height of shrubs <5' or >20'	0.0
	Average height of shrubs 5-7' or 14-20'	0.5
	Average height of shrubs 7-14'	1.0
Cover	3. Size of woodland <20 acres	0.0
	Size of woodland 20-50 acres	0.5
	Size of woodland >50 acres	1.0
	4. Average tree height <30'	0.0
	Average tree height 30-50'	0.5
	Average tree height >50'	1.0
Food	5. No leaf litter	0.0
	Some leaf litter present or abundant	1.0
	6. Soil dry -- crumbles when compressed or wet, drips when compressed	0.0
	Soil moist -- forms a cast	1.0

HSI Determination: HSI is equal to lowest average value for any factor.

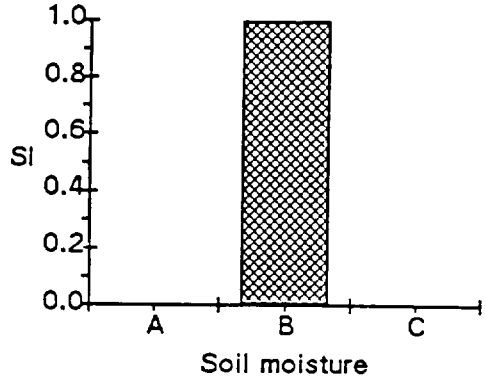
Reference: WELUT HSI Model, June, 1978.

Suitability Graphs

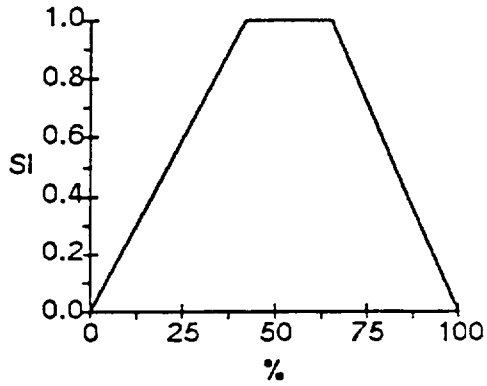
1. Amount of leaf litter
   A = None
   B = Sparse, not more than 1" deep
   C = Abundant, more than 1" deep

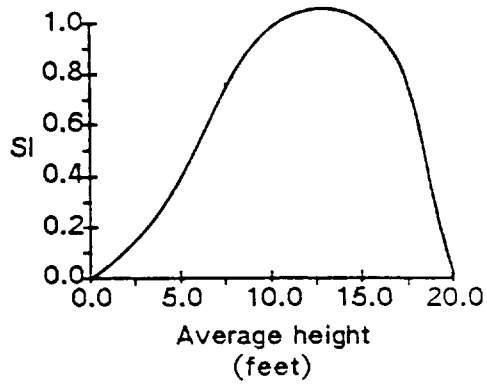


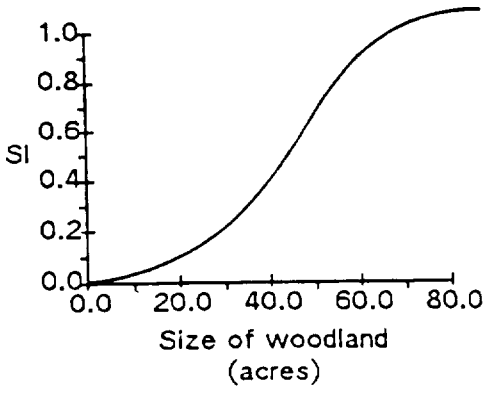
2. Soil moisture
   A = Dry - when compressed, soil crumbles and does not form a cast
   B = Moist - when compressed, soil forms a cast and is moldable
   C = Wet - when compressed, soil drips water

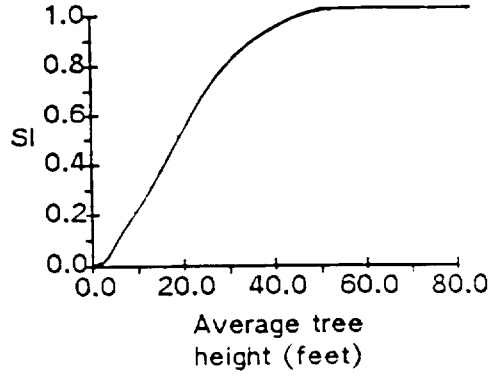


Suitability Graphs









Habitat Suitability Index:
Wood Thrush in Upland Hardwood
Ecoregion 2215

Food Value (X_1) = $(I_1 \times I_2 \times I_3)^{1/3}$

where I_1 = Suitability Index (SI) of amount of leaf litter
I_2 = SI of soil moisture
I_3 = SI of shrub crown closure

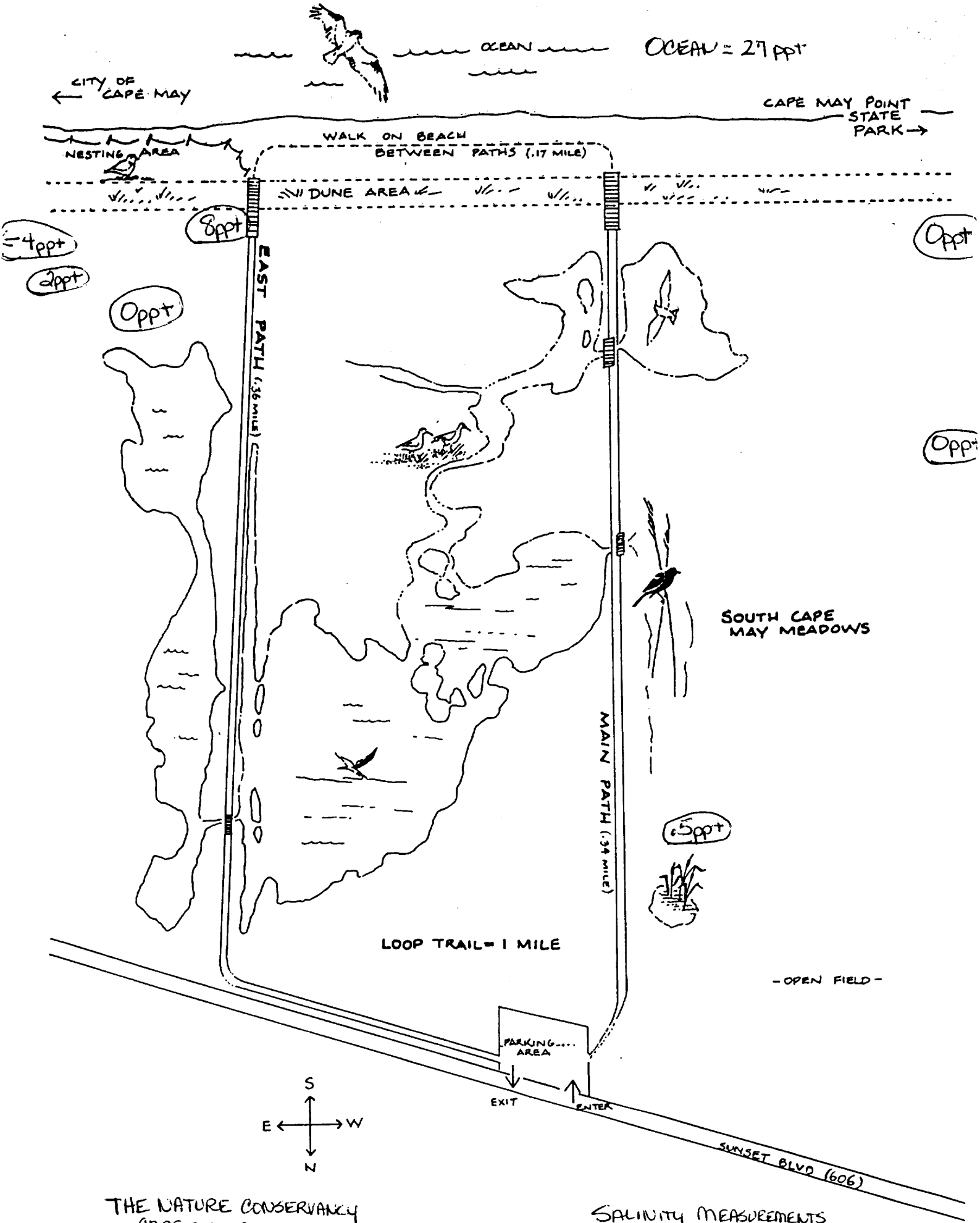
Cover Value (X_2) = $(I_3 \times I_5 \times I_6)^{1/3}$

where I_3 = SI of shrub crown closure
I_5 = SI of size of woodland
I_6 = SI of average tree height

Reproductive Value (X_3) = $(I_3 \times I_4)^{1/2}$

where I_3 = SI of shrub crown closure
I_4 = SI of average height of shrubs

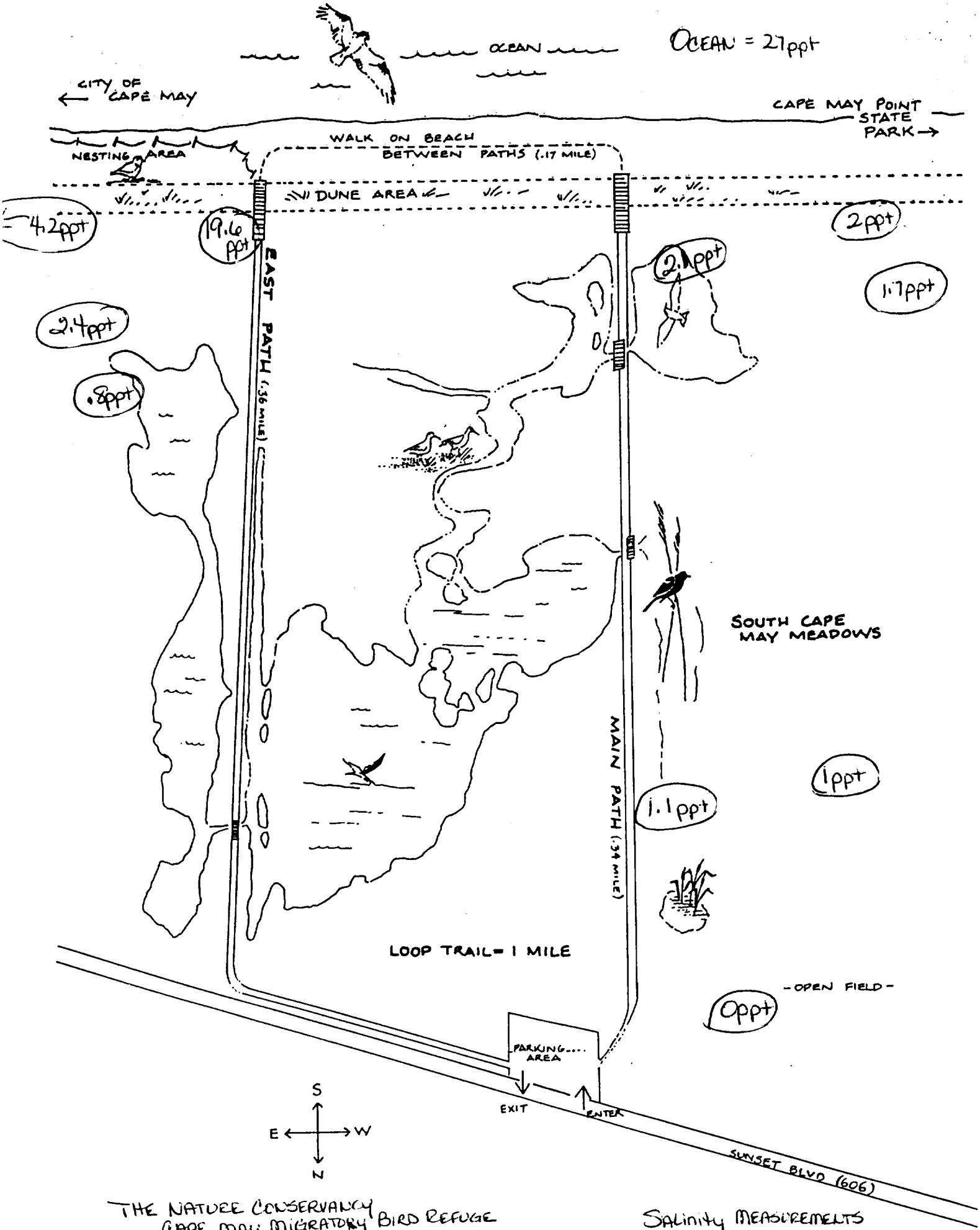
HSI Determination: The Habitat Suitability Index is the lowest X_n value.



THE NATURE CONSERVANCY
CAPE MAY MIGRATORY BIRD REFUGE

SALINITY MEASUREMENTS
April 14, 1982

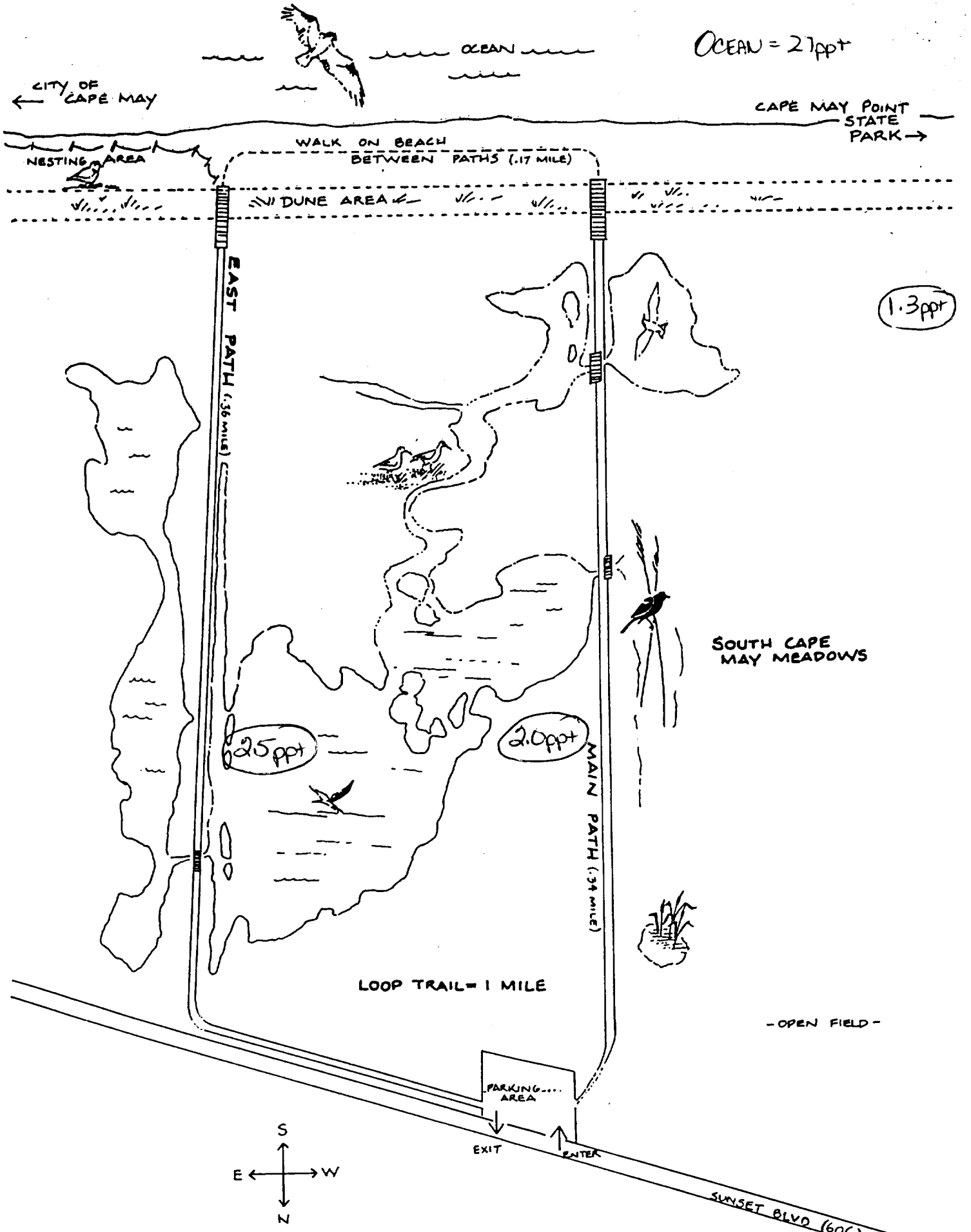
* APPROXIMATE SAMPLE LOCATIONS



THE NATURE CONSERVANCY
CAPE MAY MIGRATORY BIRD REFUGE

* APPROXIMATE SAMPLE LOCATIONS

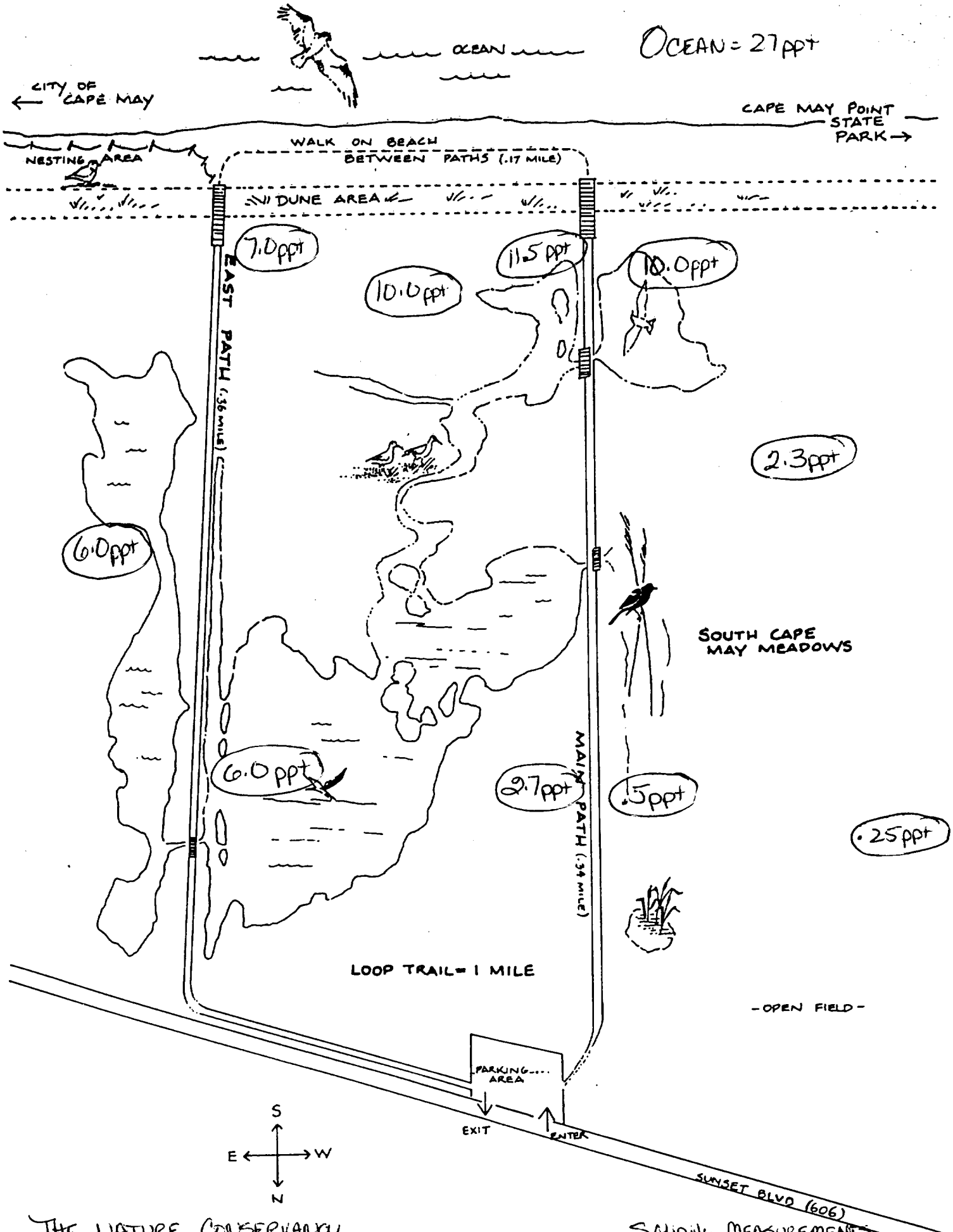
SALINITY MEASUREMENTS
MAY 5, 1982



THE NATURE CONSERVANCY
CAPE MAY MIGRATORY BIRD REFUGE

* APPROXIMATE SAMPLE LOCATIONS

SALINITY MEASUREMENTS
JUNE 22, 1988



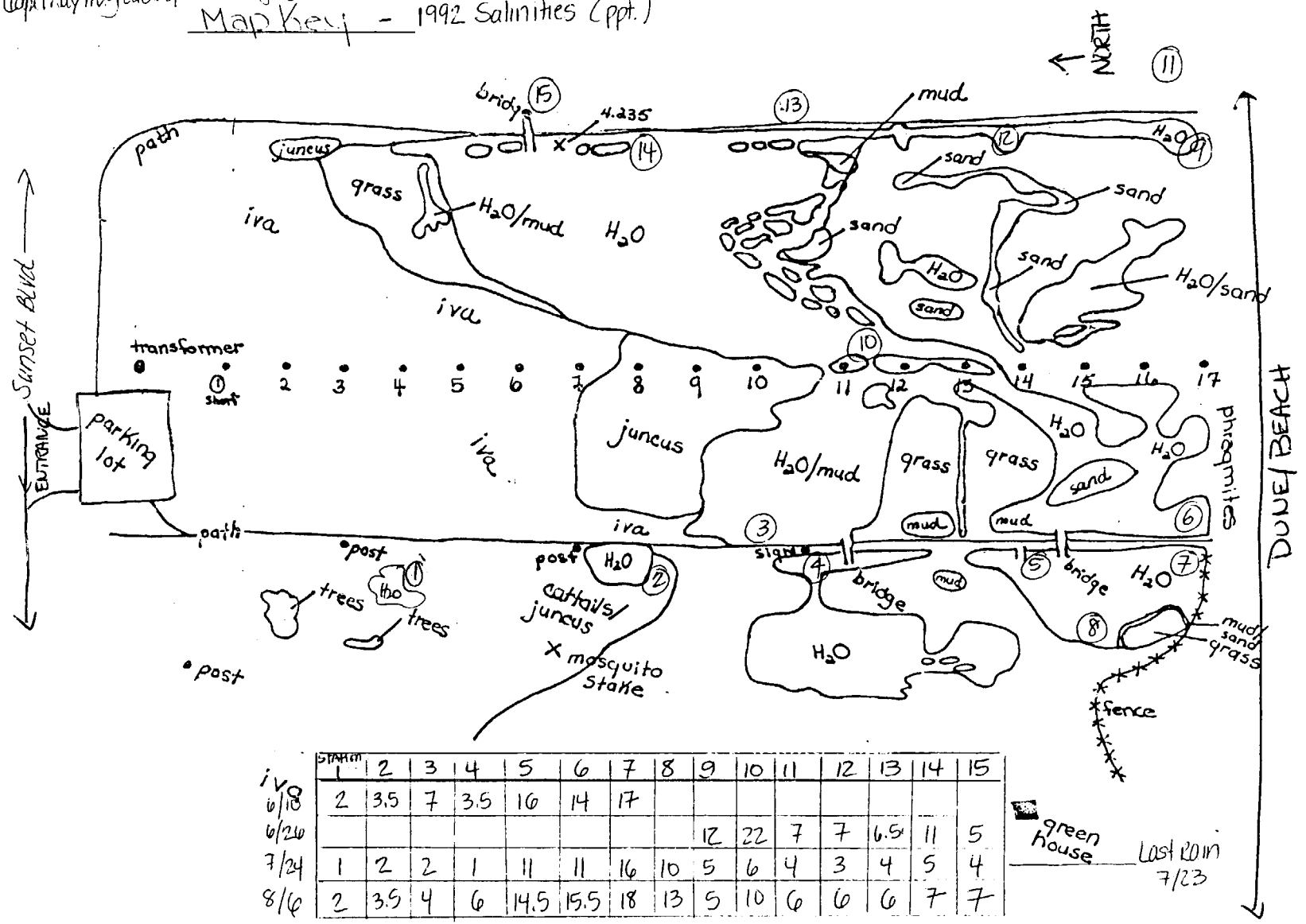
THE NATURE CONSERVANCY
CAPE MAY MIGRATORY BIRD REFUGE

SALINITY MEASUREMENTS
August 9, 1988

* APPROXIMATE SAMPLE LOCATIONS

The Nature Conservancy
Cape May Migratory Bird Refuge

Map Key - 1992 Salinities (ppt.)



	Station 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
iva 6/18	2	3.5	7	3.5	16	14	17								
6/26									12	22	7	7	6.5	11	5
7/24	1	2	2	1	11	11	16	10	5	6	4	3	4	5	4
8/6	2	3.5	4	6	14.5	15.5	18	13	5	10	6	6	6	7	7

green house

Last rain 7/23

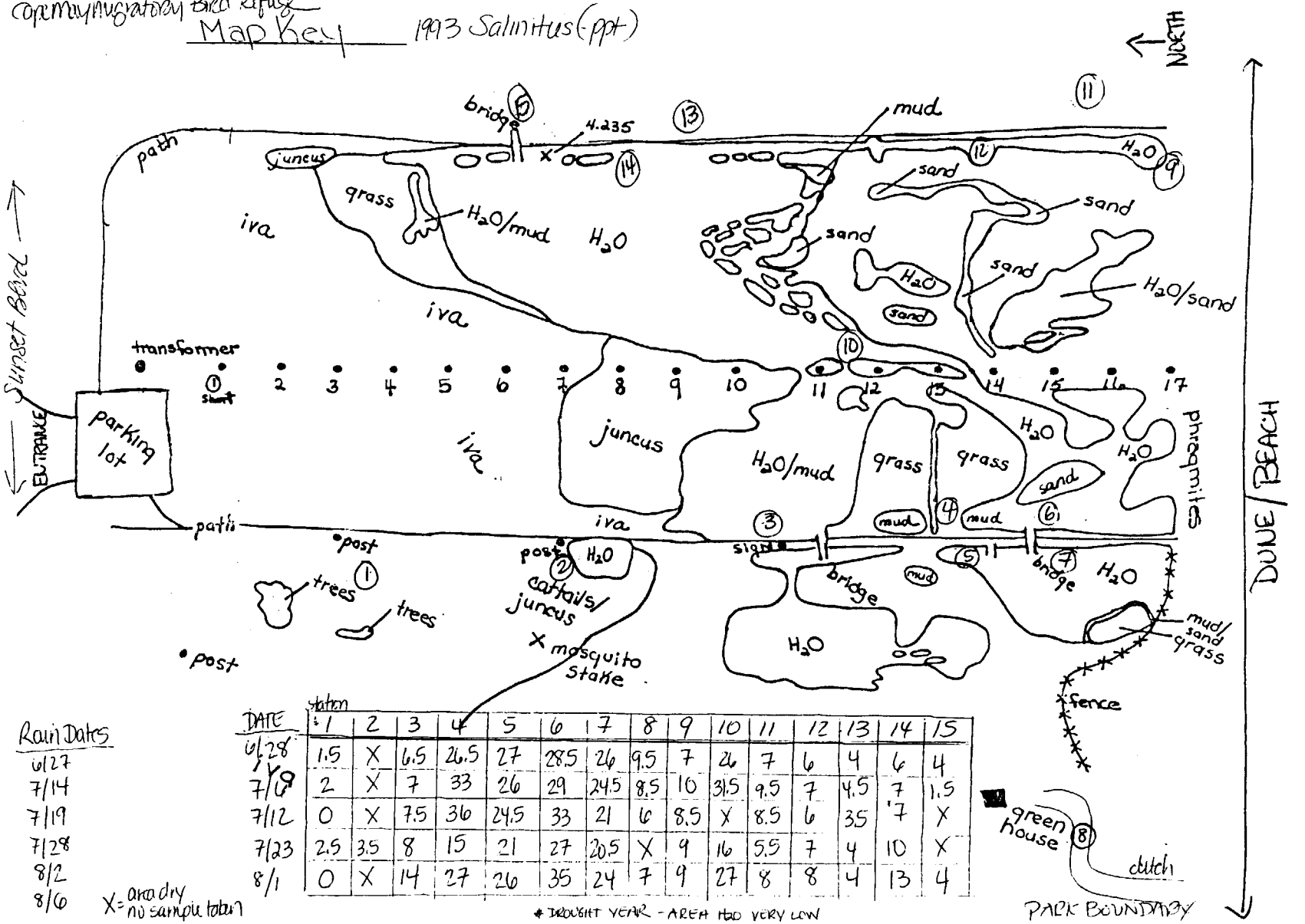
TO CAPE MAY POINT STATE PARK

SOURCE: LIZ JOHNSON
NATURE CONSERVANCY

The Nature Conservancy
Cape May Migratory Bird Refuge

Map Key

1993 Salinitus (ppt)



DATE	station 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
6/28	1.5	X	6.5	26.5	27	28.5	26	9.5	7	26	7	6	4	6	4
7/6	2	X	7	33	26	29	24.5	8.5	10	31.5	9.5	7	4.5	7	1.5
7/12	0	X	7.5	36	24.5	33	21	6	8.5	X	8.5	6	3.5	7	X
7/23	2.5	3.5	8	15	21	27	20.5	X	9	16	5.5	7	4	10	X
8/1	0	X	14	27	26	35	24	7	9	27	8	8	4	13	4

Rain Dates
6/27
7/14
7/19
7/28
8/2
8/6

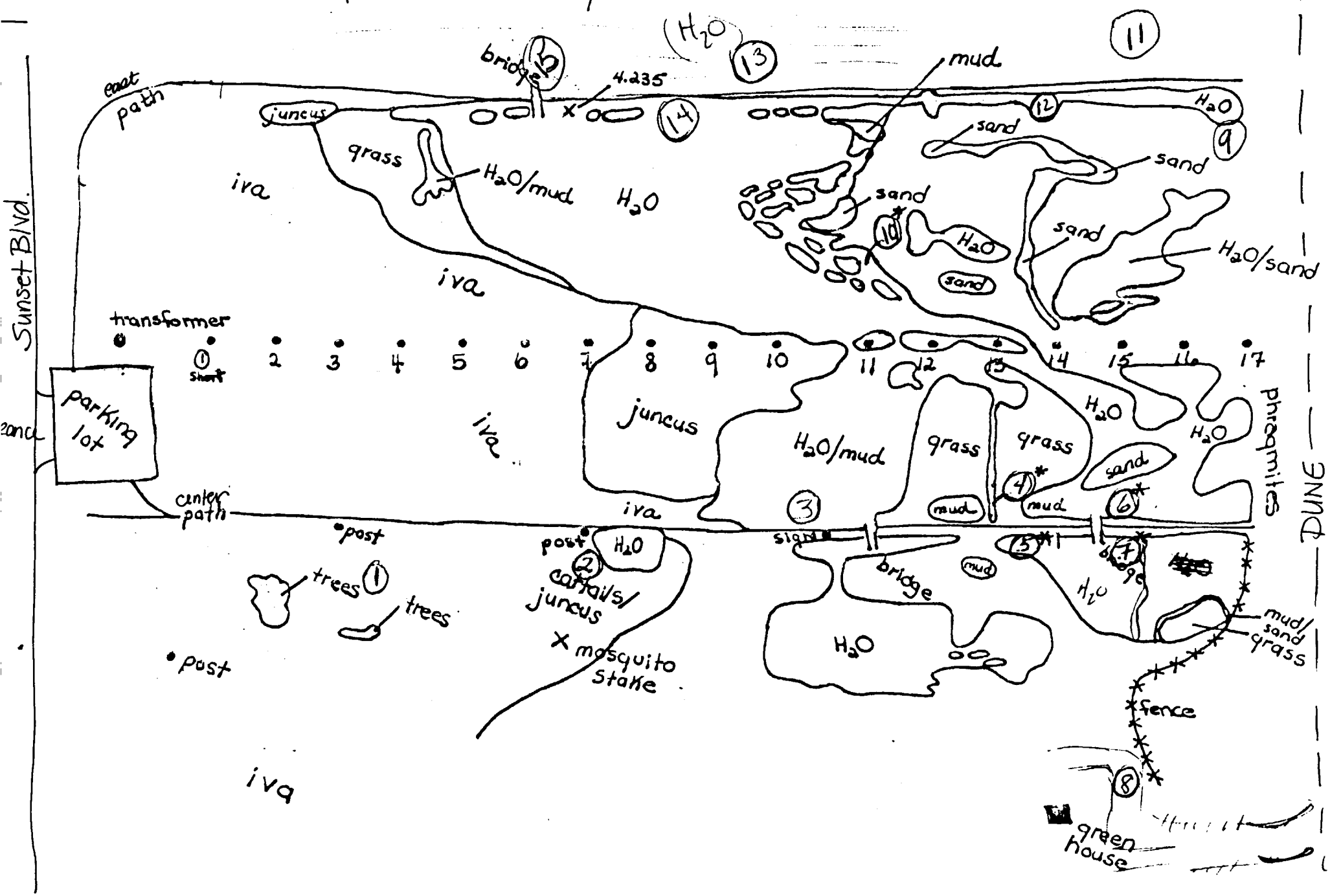
X = area dry no sample taken

* DROUGHT YEAR - AREA HAD VERY LOW

SOURCE: LIZ JOHNSON, NATURE CONSERVANCY

Map Key

Salinity Samples - 1993



Salinity Samples - 1993
(ppt)

Location of Sample

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
6/28	1.5	X	6.5	26.5	27	28.5	26	9.5	7	26	7	6	4	6	4
7/6	2	X	7	33	26	29	24.5	8.5	10	31.5	9.5	7	4.5	7	1.5
7/12	0	X	7.5	36	24.5	33	21	6	8.5	X	8.5	6	3.5	7	X
7/23	2.5	3.5	8	15	21	27	20.5	X	9	16	5.5	7	4	10	X
8/1	0	X	14	27	26	35	24	7	9	27	8	8	4	13	4
8/10															

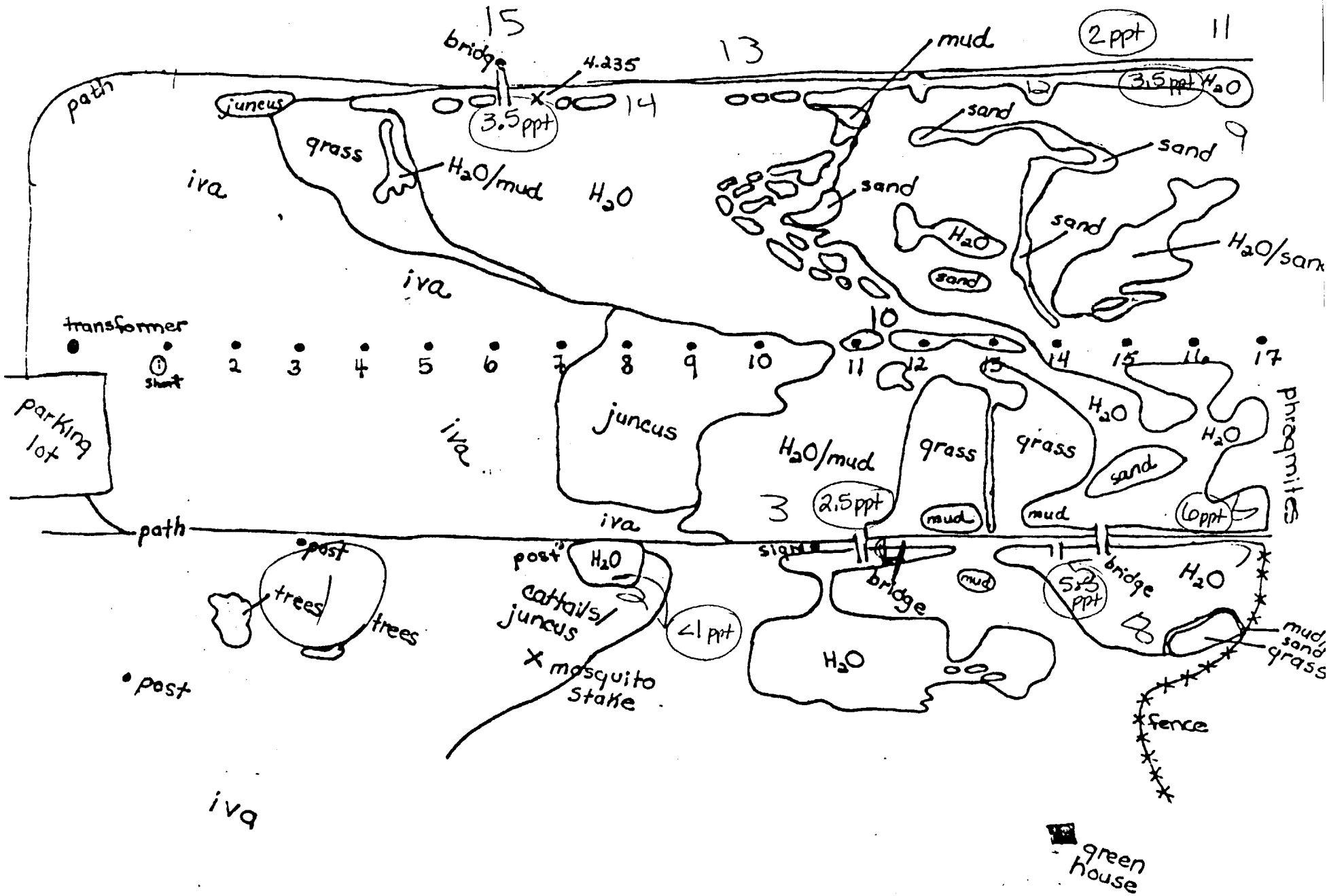
X = area dry, no sample taken.

Salinities >10 are highlighted

Rain:

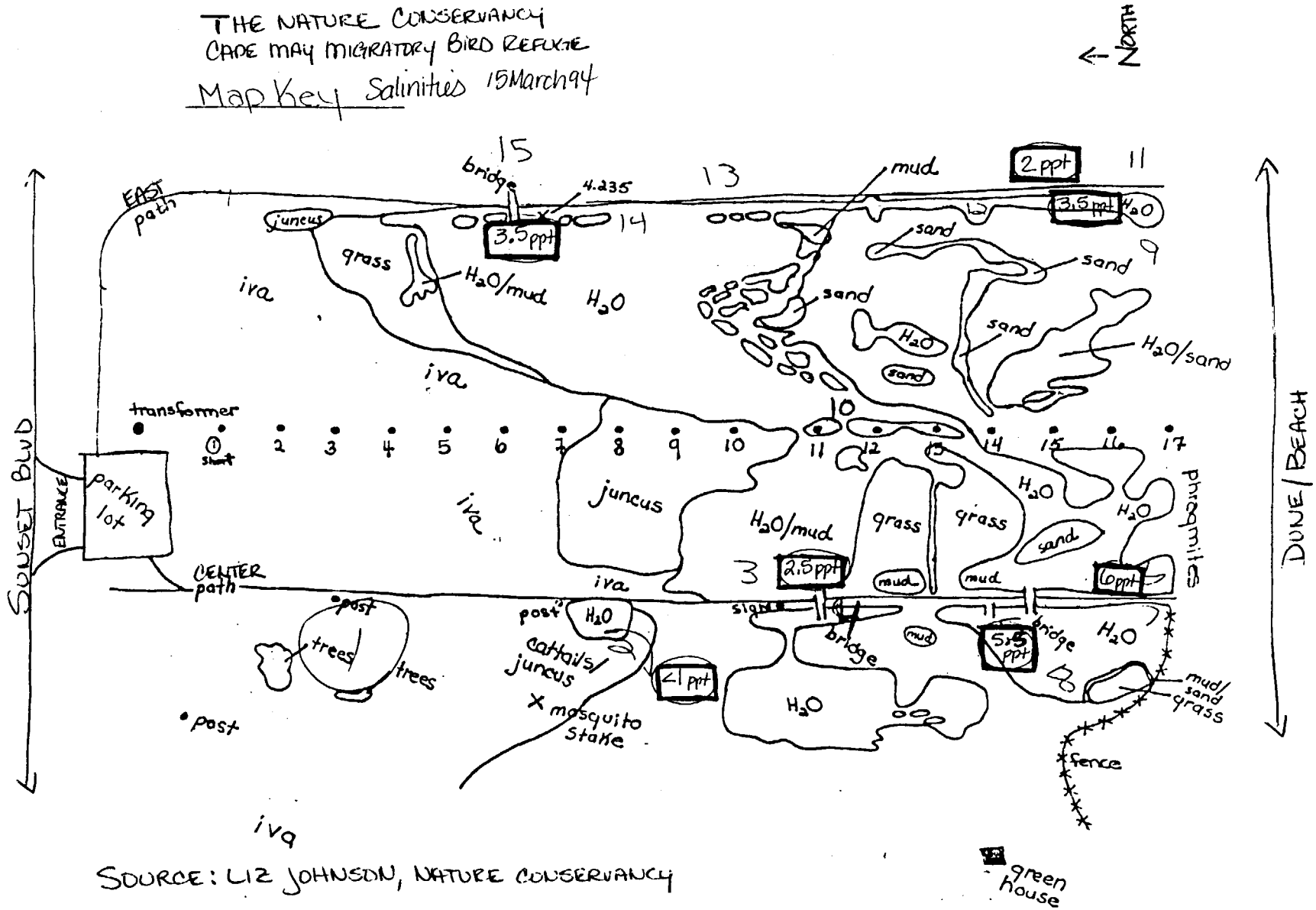
6/27
7/14
7/19
7/28
8/2
8/6

Map Key Salinities 15March94



THE NATURE CONSERVANCY
CAPE MAY MIGRATORY BIRD REFUGE

Map Key Salinities 15March94



SOURCE: LIZ JOHNSON, NATURE CONSERVANCY

TO CAPE MAY POINT STATE PARK

RARE, THREATENED AND ENDANGERED PLANT SURVEY

Lower Cape May Meadows

Cape May, New Jersey

Fall 1995 - Spring 1996

U.S. Army Corps of Engineers
Philadelphia District
Environmental Resources Branch
Wanamaker Building
100 Penn Square East
Philadelphia, PA 19107-3390

RFP No. DACW61-95-D-0011

Prepared by:

Biohabitats, Inc.
15 West Aylesbury Road
Timonium, Maryland 21093
(410) 337-3659

Biohabitats Project No. 95025.02

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2.0	Field Methodology	1
3.0	Results	8
4.0	Discussion	11
5.0	Recommendations	18

Appendix A - RTE Plant Community Location Map
Appendix B - Plant Location Spreadsheet
Appendix C - Plant Descriptions and Habitat Reference

Figures

Figure 1 Land Use/Cover Type Map
Figure 2 Site Map Delineating Study Areas
Figure 2a Transect Sampling Locations
Figure 3 Rare, Threatened and Endangered Plant Field Worksheet

References

1.0 Introduction

Recognizing the need to protect biodiversity and habitat, the U.S. Army Corps of Engineers, Philadelphia District (ACOE), has initiated the planning of restoration efforts at Lower Cape May Meadows in Cape May, New Jersey. Lower Cape May Meadows consists of the Cape May Point State Park and the Nature Conservancy's Migratory Bird Refuge. Both parcels are threatened by beach erosion and salt water intrusion from dune breaching during storm events.

As part of the planning phase of the restoration project, the ACOE initiated a rare, threatened and endangered (RTE) species plant survey of Lower Cape May Meadows. The findings of the Fall 1995 and the Spring 1996 survey, typical habitat requirements, sources of negative impacts, site changes during the study period and suggestions for restoration are contained herein.

2.0 Field Methodology

On October 21 and 22, 1995, Biohabitats, Inc. conducted the first phase of a preliminary RTE plant survey of the Cape May Point State Park and Nature Conservancy Migratory Bird Refuge. The purpose of the study is to locate and confirm the existence of previously identified RTE communities within the study area. The second phase of the project was conducted on June 19, 20 and 21st of 1996.

The RTE plant survey focused on areas and habitats where populations of RTE species had previously been identified by others. Therefore, the survey consisted of a focused search in known locations and similar habitats. After these areas had been searched, a general quadrant search was employed. However, areas thick with ***Phragmites australis*** (common reed) were not investigated due to the thick monoculture created by the presence of the reed, the lack of habitat requirements and the shear difficulty in investigating these areas. The perimeters around all common reed stands were investigated.

Biohabitats used the Land Use Cover Type Map (figure 1) provided in the Lower Cape May Meadows 1994 Reconnaissance Study (ACOE) to perform an initial vegetation biotype analysis of the study area. Based on this map and the most recent site topography and aerial photographs, Biohabitats developed a strategy for vegetation sampling. Once in the field, the reconnaissance teams walked the study area in its entirety in order to verify the existing vegetative strata and separate study areas based on cover type, vegetation density, and biotype. After the initial field assessment, the study site was divided into three distinct areas based on similarities in the existing vegetative cover. Area 1 consists of the Lower Cape May State Park site in its entirety while Areas 2 and 3 consist of the Lower Cape May Migratory Bird Refuge. Each of the three areas are shown on the overall project site map (figure 2).

The vegetative cover in Areas 1 and 3 consist of aggressive stands of common reed and small pockets of palustrine forest. Area 2 is dominated by maritime meadow on the northwest portion of the property, while the remaining portion consists of emergent wetland marsh. Based on the initial field reconnaissance which revealed little plant diversity among the stands of common reed in Areas 1 and 3, the field teams implemented a strategy based on known location and habitat requirements.

Lower Cape May Meadows 1994
Land Use / Cover Type Mapping

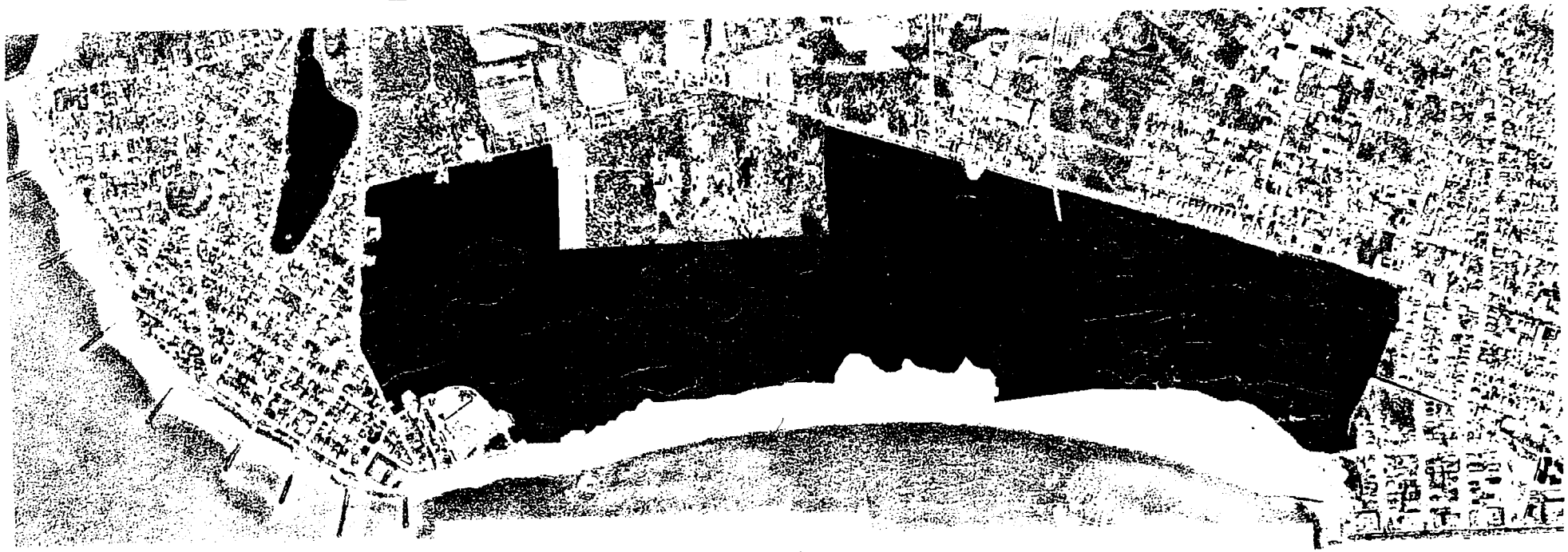


Figure 1

PHRAGMITES

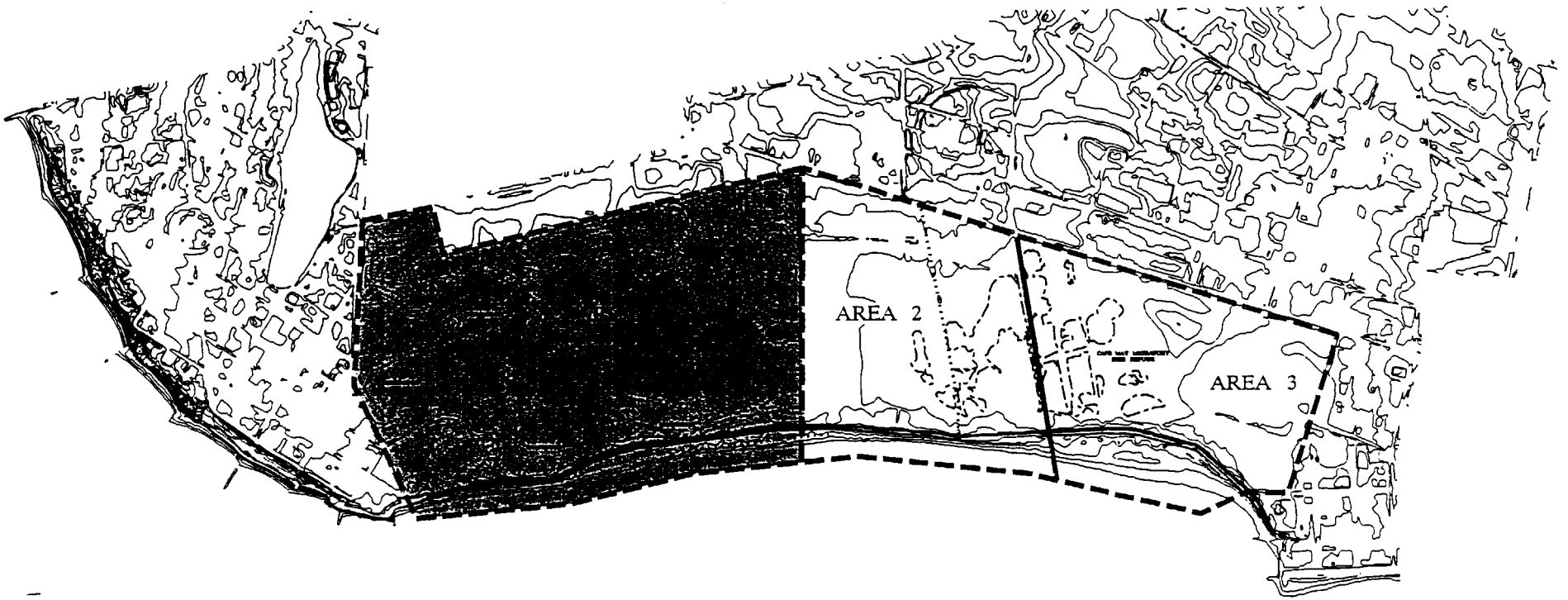
EMERGENT WETLANDS

WATER

FOREST

BEACH

FIELD



Legend:

Property Boundary
Walking Path
Pond
Cape May State Park

SCALE: 1 in. = 1,000 ft.

0 250 500 1,000

Project Site Map

Lower Cape May Meadows
Rare, Threatened, and
Endangered Species
Inventory
Cape May, New Jersey

Figure 2.

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Versar INC.

More specifically in these areas, the team used 8 1/2 by 11 inch maps provided by the State of New Jersey and the Nature Conservancy to focus on areas and habitats where populations of the RTE species had previously been known to exist. The spring survey was supplemented by the data that had been collected in the fall. In addition to previously known habitat locations all paths and perimeter pond areas were examined for the presence of RTE species.

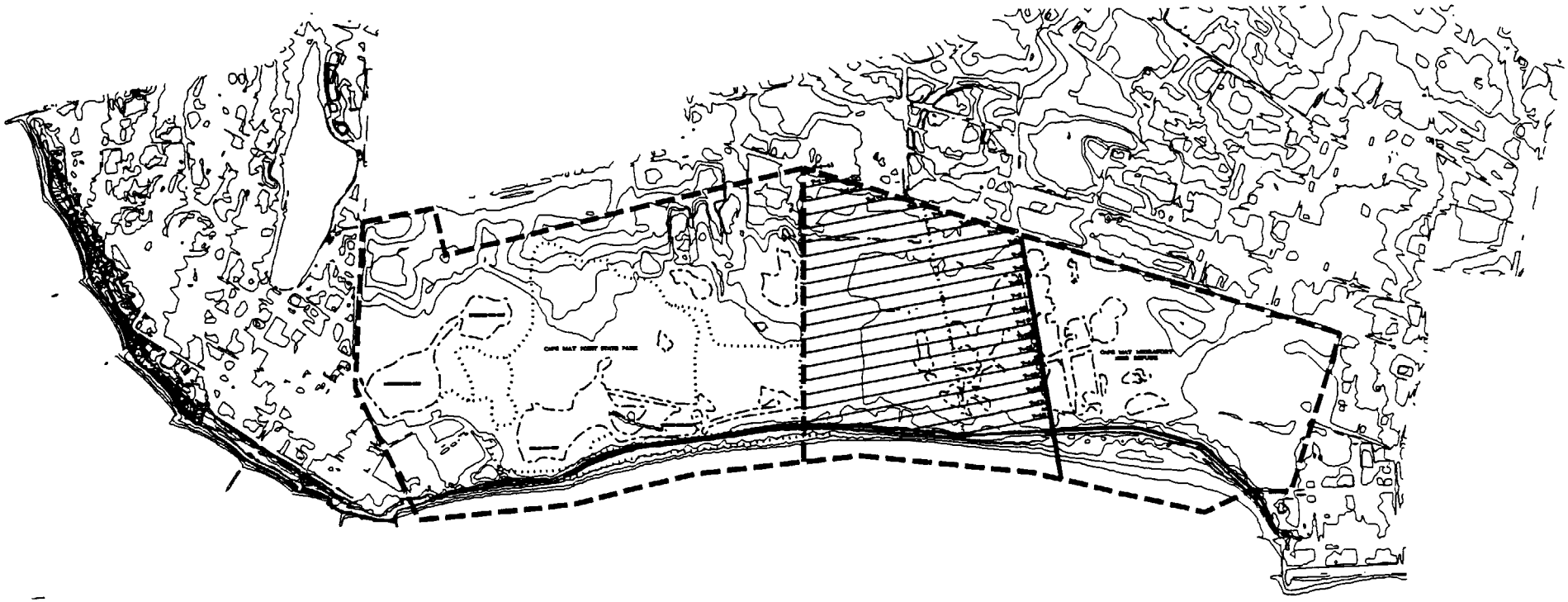
Forested areas in the study site were broken down by habitat and cover type. Those areas having the most desirable habitat features for each plant community were thoroughly searched. Particular attention was paid to the woodland edges, low ground areas and canopy openings. Aerial photographs provided by the Cape May State Park were used to stratify the forest for pine tree groupings or individual pine tree specimens. These areas were located and investigated in the field for the presence of *Pinus serotina* (pond pine).

A quadrant based sampling technique was implemented in Area 2. The cover type in this area consisted of maritime meadow, shrub scrub species and emergent wetland. After field verifying the accuracy of the land use/cover map, the aerial photos, and the topography, Biohabitats used a standard grid system to assure unbiased sample points. The team set up field transects from east to west across the entire area. The transects extended from the northern property boundary southward across the site at 110 foot intervals. At total of 21 transects were established and surveyed. Each transect was established at a ninety degree angle to the existing footpath. The field crews used a compass to backsight onto the transect start point to ensure accuracy of the transect search. (figure 2a)

Once a plant was identified in the field, the field form shown in figure 3 was completed for each individual species located. This form was modeled after the State of New Jersey, Natural Heritage Rare Species Form which was developed by the Office of Natural Lands Management to report personal sitings of rare plant species. The latitude and longitude of each plant or plant community was determined using a hand-held Magellan Global Positioning System (GPS). The locations of all plant communities confirmed during the study are shown on the enclosed RTE Map (Appendix A). Additional information including the longitude and latitude of each RTE is contained in Appendix B.

A reference summary for the key identification features, habitat and soil requirements of the seven RTE plants that were the focus of this study is contained in Appendix C. These plants were initially identified in the Cape May Point Natural Area Management Plan of 1986 and were again cited in the Lower Cape May Meadows Reconnaissance Study of August 1994. In addition to these seven species, one additional RTE species was located during the site work. Reference summaries for these species are also shown in Appendix C. Vegetative keys used during the field work included Gray's Manual of Botany and the Flora of West Virginia. These keys are accepted as the most modern and accurate guides to plants of eastern North America. A list of other reference materials used to complete the RTE study is included in the back of this document.

After completing the field investigation, Biohabitats met with State Park and Nature Conservancy personnel in order to review historic records and use their on-site knowledge to obtain the last-known siting and location of each plant community. After reviewing the initial survey results and assessing the



Legend:

Property Boundary
Walking Path
Pond
Transect Line

SCALE: 1 in. = 1,000 ft.

0 250 500 1,000

Transect Sampling Locations

Lower Cape May Meadows
Rare, Threatened, and Endangered Species Inventory
Cape May, New Jersey

Figure 2a.

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Field Survey Form Figure 3.

PLANT NAME:

LOCATION:

GPS LOCATION:

IDENTIFICATION: How was this species identified in the field?

NUMBER OF INDIVIDUALS OBSERVED:

1-10 11-50 51-100 100-1000 1001-10000 10000+

INDIVIDUAL PLANTS INCLUDED: Single stems Clumps Entire clumps Patches

LIFE STAGES PRESENT:

Vegetative In bud Flower Fruit Seed Seedling

QUALITY/VIGOR OF PLANT COMMUNITY: Poor Fair Good Excellent

GENERAL HEALTH OF PLANT COMMUNITY:

ARE THERE ANY INVASIVES OR FACTORS NEGATIVELY IMPACTING THE PLANT COMMUNITY?

WAS PLANT IN STANDING WATER: Yes No

GENERAL COMMENTS:

historic records, the field personnel went back to each area as a quality control method to reinvestigate for the presence of RTE species.

In summary, the field reconnaissance was conducted using the following methodology when common reed was the dominant vegetative strata or when an area was forested:

1) Assessing mapped vegetative strata, initial field verification;

2) Investigating known locations and similar habitats;

3) Investigating all other habitats, and;

4) Investigating historic records and personnel experience locations.

Field reconnaissance was conducted using the transect methodology when the vegetative strata consisted of maritime meadow or wetland vegetation. All transects were set at 110 foot spacings and were perpendicular to the existing footpath. RTE species and GPS locations were recorded during the Fall and Spring surveys. Only the latest recorded GPS locations of all RTE's have been provided in Appendix B.

The Fall and Spring survey focused on the following plant species:

Plant Species	Status
• awl-leaved rush (*Juncus coriaceus*)	Endangered[1]
• butterfly pea (*Clitoria mariana*)	Endangered
• pond pine (*Pinus serotina*)	Imperiled[2]
• narrow-leaved wild crabapple (*Pyrus angustifolia*)	Imperiled
• whorled marsh-pennywort (*Hydrocotyle verticillata*)	Imperiled
• blue boneset (*Eupatorium coelestinum*)	Rare[3]
• Long's rush (*Juncus longii*)	No longer tracked

* Information Source - State of New Jersey - List of Endangered Plant Species and Plant Species of Concern; January 1992.

[1] Endangered - species whose prospects for survival within the state are in immediate danger due to lack of habitat, predation, competition, disease or exploitation. Restricted habitats found in +/- 3% of the State; even with intensive searching, sizeable occurrences are unlikely to be discovered.

[2] Imperiled - Critically imperiled in the state of N.J.; between 6 and 20 occurrences or few remaining acres. Elements are often restricted to very specialized conditions or habitats. Found in +/- 10% of the State area.

[3] Rare in State - Between 21 and 50 occurrences. May become imperiled if additional populations are destroyed.

Additional plant species that were included in the Fall and Spring reconnaissance included:

Plant Species	Status
• dodder (*Cuscuta indecora*)	Endangered
• fog fruit (*Phyla* (*Lippia*) *lanceolata*)	Endangered
• silvery beardgrass (*Andropogon ternarius*)	Imperiled
• bearded skeleton grass (*Gymnopogon ambiguus*)	Rare
• marsh rattlesnake master (*Eryngium aquaticum*)	Rare
• spring or early ladies'-tresses (*Spiranthes vernalis*)	No longer tracked

These plants were not the focus of the study, however they were included because of the probability of finding these plants in the local habitat. Several of these species were known to previously exist in the study area. All possible habitats and formerly mapped locations were checked for the presence of these species. Grasses were not in flower during the spring survey. Therefore, no positive identification was made for these plants.

3.0 Results

The following plant species were **confirmed** within the study area:

Cape May Point State Park

- narrow-leaved wild crabapple (*Pyrus angustifolia*)
- whorled marsh-pennywort (*Hydrocotyle verticillata*)
- blue boneset (*Eupatorium coelestinum*)

Cape May Point - Nature Conservancy Migratory Bird Refuge

- narrow-leaved wild crabapple *(Pyrus angustifolia)*
- whorled marsh-pennywort (*Hydrocotyle verticillata)*
- blue boneset *(Eupatorium coelestinum)*
- dodder *(Cuscuta indecora)*

A summary of the populations identified and confirmed within the study area is contained on the following pages. The size and health of the populations are as observed in the field during the Spring field survey. The letter legend corresponds to the general community locations as shown on the Lower Cape May Meadows RTE Plant Species Survey Map included in Appendix A. The habitat discussion refers to site specific conditions at the location where each species was observed in the study area.

Py Narrow-leaved wild crabapple (*Pyrus angustifolia*) Imperiled

Two mature trees were identified on a berm adjacent to the Blue Trail near the East Pond in the State Park. The trees were approximately 4 meters in height and were severely stressed, with few leaves present and no apparent new growth during the fall survey. During the spring survey no growth was observed and the trees appeared not to leaf-out. No vegetative buds were observed and the trees are assumed to be dead. One other viable tree was located on the woodland edge near Sunset Boulevard during the Spring survey. This tree is approximately 30 meters from utility pole #3 360 SP3J 2-50. This tree is approximately 2-3 meters in height and is showing severe canopy dieback. Positive identification was difficult because of the lack of fruit or flowers.

Habitat: Mixed hardwood/pine edge and thicket area between common reed stand and the trail. Soil was moist and contained some surface hydrology. The location of the two trees near the blue trail corresponded to a previously mapped location. No other crab apple specimens were located in previously known locations. The tree near the power pole was not previously mapped. This tree is growing on the edge of thicket and common reed. Soil was saturated at time of observation.

H Whorled marsh-pennywort (*Hydrocotyle verticillata*) Imperiled

Several large unmapped contiguous communities (over a thousand individuals), were identified in Area 1 immediately adjacent to the boardwalk along the Red trail and near the main trailhead entrance to the boardwalk. A second smaller population was located near the lower ponds adjacent to the beach. A third community was located within the canal located in Area 2. No plants of this species were observed in Area 3.

Habitat: Areas where the common reed had been mowed, in full or partial sunlight, and on the margins of standing water. In most cases this plant was flourishing in moist areas, along drainage swales or low spots near the boardwalk path. This plant was not observed along the drier margins of the site.

E Blue boneset (*Eupatorium coelstinum*) Rare

Blue boneset was found throughout Area 1 in the State Park along the boardwalk edges, and in Area 2 of the Nature Conservancy. It is estimated that a population of several hundred individuals exists along wetland/upland margins in the northeast section of the Nature Conservancy. Populations throughout the State Park tended to be smaller, ranging in size from 10-50 individuals present. General health was good to excellent. The species was not previously mapped.

Habitat: Found in drier margins of the site; areas where the common reed had been mowed, clearings for paths, and the open fields. Soils were moist, however no surface hydrology was present. Areas tended to be in full to partial sunlight. Some individuals were noted on the fringes of forest and shrub areas where the herbaceous understory was sparse and the canopy was open.

C Dodder (*Cuscuta indecora*) Endangered

Dodder was found in two previously mapped areas along the right and left side of the walking path on the Nature Conservancy site. The plants were located approximately 200 feet south of the observation platform and just before crossing the small footbridge. No standing water was present, however, the pond edge was within three feet of the plant location. The stems on this plant seemed sparse but healthy.

Habitat: Area between the footpath and shallow ponds. Host plants were bayberry shrubs and herbaceous material. Soils were moist.

4.0 Discussion

The flora of the Lower Cape May Meadows study area is unique in its diversity and comprises several successional communities. Botanically, the Cape May region is known as the geographic merging point for a number of northern and southern species. For example, both the northern bayberry and southern waxmyrtle are found growing throughout the site.

In terms of habitat, behind the beach dunes of the Cape May State Park are coastal ponds and marsh areas dominated by common reed grass. These areas have varying degrees of brackishness. In slightly higher areas just near the water's edge where the soil tends to dry out during the summer months, freshwater plant communities including numerous species of juncus and carex can be found. These areas grade into viney brambles of poison ivy, Japanese knotweed, yam-leaved clematis and greenbrier thickets. Beyond the viney brambles and thickets, small pockets of woodland forest are found. These small groves of hardwoods consisting of pitch pine, red cedar oaks and sassafras are found on the higher ground away from the beach and seasonal saltwater intrusion.

Likewise, a similar community exists directly behind the dunes of the Nature Conservancy's Migratory Bird Refuge. The ponds on this site tend to be more brackish and support less diversity in the vegetative strata. These areas transition into emergent wetland thick with a variety of halophytes and shrubs dominated by bayberry. Eventually the grade rises enough to support a maritime meadow on drier ground with an abundant diversity of floristic plant material. Some of the typical species observed include rabbit clover, bindweed, sweet everlasting, jointweed, parrot feather, purple and yellow vetch, early goldenrod, seaside goldenrod, blue-eyed grass, and sheep sorrel.

The woodlands on the Nature Conservancy site consist of pines, cedars, hickory, oak, persimmon, sour gum and large sassafras trees. The infrequent pockets of trees occur on higher grounds away from the beach or on a few isolated islands on either side of the meadow areas.

Continuous beach erosion has brought about a change in the flora of the Cape May Meadows study area. Once dominated by fresh water plant communities, the areas directly behind the primary dunes are inundated at least once a year with several feet of salt water. As a result of this inundation, fresh water plant communities and low lands have been replaced with brackish marsh areas. The wetland areas most susceptible to frequent salt water intrusion can be identified by the presence of common reed. While the common reed does not prefer this type of brackish environment, it survives because it is one of the few plants that can tolerate the varying levels of soil salinity and inundation. In fact, in freshwater habitats, many other species will successfully out-compete the common reed grass. [Marks, Lapin and Randall, 1994].

The freshwater habitat of the Lower Cape May Meadows area has been dramatically altered by the dynamic ocean environment. The trees and shrubs that survive are the most hardy and tolerant to salt water intrusion, or are located on higher grounds that are safe from the damaging inundation. Species such as the butterfly pea, pond pine and narrow-leafed crabapple no longer exist or are struggling to survive because the gradual disturbances to the freshwater habitat caused by the changing environmental

conditions. The restoration of the these disturbed areas will not be successful until the source of nutrient loads has been remedied. In this case, the effect of the Atlantic Ocean breaching the beach dunes during severe storms. If the beach erosion continues, the freshwater habitat and brackish wetlands will be replaced by a saltwater community.

The construction and replanting of the primary dune on the State Park site was the most notable cause for differences in the vegetation surveys completed in the Fall and Spring. The new dune stopped the ocean inundation throughout the winter months. Near the new dune, new populations of hydrocotle and bindweed were observed during the spring survey. The populations of hydrocotyle on the Nature Conservancy site have also increased in size. This is assumed to be from the lack of heavy leaf canopy at the time the spring survey was completed. After a full summer of canopy growth, the populations of hydrocotyle along the canal on the Nature Conservancy site may once again be shaded out and show a decline in vigor.

In the meadow area two potential negative impacts were observed. High populations of vetch threaten the abundant plant diversity of meadow species and a high number of mimosa seedlings indicate the meadow is in an active transition.

Vetch is an aggressive plant that will outcompete other species found on the site to form a monoculture. This situation was observed in an isolated open meadow located on the northern portion of the Nature Conservancy site. The presence of the mimosa tree suggests a natural transition from meadow to pioneer forest is occurring. Both of these conditions will alter the vegetative strata and will cause a decline in the RTE's recorded on this site.

The discussion that follows provides more detail on the habitat for each of the species in the RTE survey and the existing environmental conditions.

> Whorled marsh pennywort was located throughout the State Park along path borders and the edges of common reed and scrub shrub stands. It is also located within a canal that runs between the State Park and the Nature Conservancy property. The lack of larger populations on the Nature Conservancy site is probably related to salt water intrusion as evidenced by the presence of halophytes in the areas where the Pennywort was not present. However, there was a stronger population present during the Spring survey than there was during the Fall investigation. Additional communities of the hydrocotyle were observed in the Spring near the pond edges closest to the beach front. Again the increased populations are probably related reduced salt water intrusion.
>
> Blue boneset was found throughout both sites in open, full sun areas, or in areas that had been mowed. Blue boneset was not found in areas dominated by halophytes. The plant was observed growing on sites that were slightly higher in elevation and were not exposed to the brackish conditions. Where common reed had been cut back near the pathways, strong stands of this plant material were present. The largest threat to this community is probably the natural succession of the meadow, the fluctuating water levels, and competition for the common reed. With the

construction of the new dunes, the habitat along the paths should be protected, however, regular maintenance with weed-whips along the boardwalk is also a potential threat to this species.

Populations of awl-leaved rush were not found where originally mapped. A potential new population was identified west of Lighthouse Pond along the border between the forest and common reed. A field investigation with the State Park personnel failed to locate this plant species in this area. The last know siting was in Summer 1995. The area previously identified by the fall survey was overtaken with common reed.

Likewise, populations of butterfly pea were not located in any of the previously mapped locations. These areas were inundated with water and thick stands of the common reed grass were present. Discussions with the Park personnel and the historic records confirmed that this species had not been observed in the park for the past five years. An increase in soil salinity and soil saturation is the likely reason for this plant's demise.

Four healthy stands of dodder species were observed near the path on the Nature Conservancy site. There are approximately eight native and three introduced species of dodder in the United States. Each species is similar in habitat and hence is difficult to identify. Since the plant was not in flower during the Fall and Spring surveys, Biohabitats was unable to positively identify the species present. Records obtained from the Nature Conservancy show that species *indecora* has been known to exist. While the plant is considered a parasitic nuisance in some areas of the midwest, the plants observed showed no aggressive tendencies. This is possibly due to the brackish site conditions.

The genus *Cuscuta* as a whole is commonly referred as Love Vine or strangle weed according to Gray's Manual of Botany. The species *indoreca* was not referred to by a common name other than "dodder" in any of the sources or books checked.

The search for *Pinus serotina* proved to be the most difficult and time consuming during both the Fall and Spring survey. The forested areas were thick with greenbrier, poison ivy and thicket. The known habitat locations near the pond edges are choked with common reed and access was difficult in most situations. No trees of this species were identified. The ideal habitat of low, moist ground was present. However, this species is only marginally hardy in this area. Based on the changing site conditions it is not unreasonable to assume that trees of this species may have succumbed to stress.

Other plants including the silvery beardgrass, bearded skeleton grass, marsh rattlesnake master were not observed during the Spring or Fall Survey. Each of these species were known to previously exist in the survey area. During the field work the critical flower parts necessary for positive identification were not present. The field team did expect to find early ladies tresses based on the observation of plant communities such as blue eyed grass and allium that bloom during the same period. However, no communities of the early ladies tresses were observed. Habitat for this plant is typically fields, damp meadows, moist thickets and grassy swamps.

5.0 Recommendations

The best protection for the greatest number of plant species is to protect the habitats in which they thrive. The freshwater habitat of the Lower Cape May area is unique and is threatened by the frequent inundation from the ocean's salty water.

Protection of this unique habitat is not limited to the erosion control along the beach, but should include a comprehensive plan for restoration that addresses wildlife habitat improvement, invasive species control and native species replacement.

Priority items directly related to the restoration and enhancement of the freshwater flora of the Lower Cape May area that must be included in the comprehensive restoration plan would include:

1. An investigation into methods to protect RTE species and improve and protect the freshwater habitat conditions. In addition, this plan should develop a specific methodology to increase populations of RTE's through propagation.

2. Determine if the maritime meadow is to be remain. If this is the desired case, a best management plan is necessary in order to preserve the existing vegetative cover. This management plan must address the spread of invasive species and the natural succession of the meadow.

3. The final restoration plan for the site must address the removal, eradication and management of common reed. Protection of the known RTE species and sensitive wildlife habitat should be a primary component of the common reed eradication plan.

Appendix A - Plant Community Location Map

Appendix B - Plant Location Spreadsheet

Cape May Meadows
Rare, Threatened and Endangered
Plant Survey

	Plant Name	GPS Location		Number of Individuals Observed	Quality/Vigor	Comments
1.	Blue Boneset	38 55.98 N	74 57.49 W	1 - 10	Good	Both sides of boardwalk, 100 ft from trailhead.
2.	Whorled Marsh Pennywort	38 56.00 N	74 57.50 W	1 - 10	Good	Stand is crowded by path. Located on both sides of boardwalk.
3.	Whorled Marsh Pennywort	38 56.02 N	74 57.49 W	101 - 1,000	Good	Intersection of Red, Blue and Yellow trails. All around boardwalk.
4.	Blue Boneset	38 56.06 N	74 57.49 W	11 - 50	Good	Right side of boardwalk. Competition from phragmites.
5.	Whorled Marsh Pennywort	38 56.06 N	74 57.49 W	11 - 50	Good	Right side of path. Competition from phragmites.
6.	Whorled Marsh Pennywort	38 56.05 N	74 57.48 W	1,001 - 10,000	Excellent	Nicest stand observed. Vigorous community both sides of boardwalk.

	Plant Name	GPS Location		Number of Individuals Observed	Quality/Vigor	Comments
7.	Whorled Marsh Pennywort	38 56.05 N	74 57.57 W	101 - 1,000	Excellent	Growing on both sides of a small drainage swale. No individuals were observed in the standing water.
8.	Whorled Marsh Pennywort	38 56.04 N	74 57.54 W	101 - 1,000	Good	Community located on both sides of the boardwalk 50 feet from end of red trail at the duck blind.
9.	Whorled Marsh Pennywort	38 56.04 N	74 57.51 W	101 - 1,000	Good	Community located on both sides of the red trail.
10.	Whorled Marsh Pennywort	38 56.05 N	74 57.54 W	11 - 50	Good	Nice community, not as aggressive as others. Community located along woodland edge and appears to be shade intolerant.

	Plant Name	GPS Location		Number of Individuals Observed	Quality/Vigor	Comments
11.	Blue Boneset	38 56.08 N	74 57.52 W	11 - 50	Good	Small plants. Mixed in with phragmites and pennywort. Area is moist.
12.	Whorled Marsh Pennywort	38 56.10 N	74 57.54 W	1,001 - 10,000	Excellent	Community size is 4 feet wide by 100 feet long along both sides of boardwalk; very full and consistent. No competition from phragmites.
13.	Whorled Marsh Pennywort	38 56.06 N	74 57.50 W	101 - 1,000	Fair	
14.	Wild Crabapple	38 56.10 N	74 57.49 W	2	Dead	Plants were located during fall survey. During the Spring survey these trees lacked leaves and new growth.

	Plant Name	GPS Location		Number of Individuals Observed	Quality/Vigor	Comments
15.	Whorled Marsh Pennywort	38 56.11 N	74 57.48 W	11 - 50		Communities were not located during the spring survey. Area is dominated by phragmites.
16.	Blue Boneset	38 56.14 N	74 57.49 W	11 - 50		Communities were not located during the spring survey. Area is dominated by phragmites.
17.	Blue Boneset	38 55.49 N	74 57.04 W	11 - 50		Could not locate this community during the Spring survey. Phragmites is the dominant vegetation in area.
18.	Blue Boneset	38 56.27 N	74 56.79 W	11 - 50	Poor	West side of Transect 2 near the woodland edge. Community located in grassy area with solidago, juncus and baccharis.

	Plant Name	GPS Location		Number of Individuals Observed	Quality/Vigor	Comments
19.	Blue Boneset	38 56.28 N	74 56.68 W	101 - 1,000	Fair	Transect 2 near the footpath. Open meadow condition.
20.	Blue Boneset	38 56.32 N	74 56.63 W	11 - 50	Good	Small clump. Open meadow with solidago and juncus communites nearby. Rose and thistle also present.
21.	Blue Boneset	38 56.32 N	74 56.58 W	11 - 50	Good	Transect 5 and 6.
22.	Blue Boneset	38 56.24 N	74 56.66 W	101 - 1,000	Good	Nice plant community. Room to spread. Juncus and solidago located in adjacent communites. Mimosa seedlings also present.
23.	Blue Boneset	38 56.20 N	74 56.65 W	11 - 50	Good	Near shrub edge 200 feet from from footpath. Heavy competition from grasses.

	Plant Name	GPS Location		Number of Individuals Observed	Quality/Vigor	Comments
24.	Blue Boneset	38 56.21 N	74 56.17 W	11 - 50	Good	Transects 7 and 8. Near the pond edge. Nice Community. Potential for community to spread.
25.	Blue Boneset	38 56.19 N	74 56.65 W	11 - 50	Good	Transitional meadow. Community located on the fringe of wet zone.
26.	Blue Boneset	38 56.17 N	74 56.66 W	11 - 50	Fair	Growing on one foot strip between pond and path.
27.	Blue Boneset	38 56.12 N	74 57.17 W	101 - 1,000	Good	Transect 9 and 10 near cattail marsh. Occurs between a very wet zone dominated by elocharis. Dryer zones are dominated by baccharis.

	Plant Name	GPS Location		Number of Individuals Observed	Quality/Vigor	Comments
28.	Blue Boneset	38 56.07 N	74 56.75 W	1 - 10	Poor	Transect 8 in open field. Smaller community exists near baccharis.
29.	Whorled Marsh Pennywort	38 56.13 N 38 56.02 N	74 56.91 W 74 56.91 W	51 - 100 101 - 1,000	Poor	Community seems to be shade intolerant. Small groups of this plant occur sporadically along canal length and is more vigorous in areas where the canopy gaps appear.
30.	Whorled Marsh Pennywort	38 55.95 N 38 56.13 N 38 56.02 N	74 56.77 W 74 56.91 W 74 56.91 W	101 - 1,000 11 -50	Poor	Very few present in each grouping observed. Communities are located next to woodland edge and appear shade intolerant.

	Plant Name	GPS Location		Number of Individuals Observed	Quality/Vigor	Comments
31.	Dodder	38 56.10 N 38 56.09 N	74 56.94 W 74 56.66 W	1 - 5	Good	Small community along both sides of path. Located with Baccharus on one foot strip between footpath and pond. Host plant is wax myrtle.
32.	Narrow - leaved crabapple	38 56.16 N	74 56.70 W	1	Poor	Tree is leaning and in a state of decline. Crown dieback is obvious. Tree species should be verified when in flower.
33.	Whorled Marsh Pennywort	38 55.80 N 38 55.81 N	74 57.45 W 74 57.20 W	51 - 100	Poor	New communities located along the southern edge of the pond not observed during the fall survey. Continue monitoring for vigor and abundance improvements.

Appendix C - Plant Descriptions and Habitat Reference

Juncus coriaceus **Awl-leaved rush**

Junaceaes
Perennial; solid round stem; height 3-10 dm.; leaves basal except the bracts; inflorescence 2-4 cm. long ; capsule 3-4 mm., globose-ovoid, shining, chestnut brown; occasionally with a slender beak up to 1mm. long; seeds 0.6-0.8mm. long; blooms in June-Sept.

Found: Swamps; salt marshes; wet woods

Soils: Wet ground

Clitoria marina **Butterfly pea**

Leguninosae
Perennial; herb; trailing or climbing, 1 m. or more in height; flowers of two kinds, early ones showy and late ones small; flowers pale blue, 5-6 cm. long, calyx is tubular with five ovate teeth 10 mm. long; leaves pinnately compound with usually three leaflets and stipels 2-4 mm. long; leaflets broadly lanceolate, obtuse, 2.5-6 cm. long by 8-25 mm. wide; legumes stalked above the calyx 2.5-5 cm. long by 6 mm. wide and pointed; blooms in June-August

Found: Frequently in coastal areas

Soils: Dry soils

Pinus serotina **Pond Pine**

Pinaceae
evergreen; small canopy tree, less than 20 m. with horizontal or drooping branches forming an open crown; bark reddish-brown 1-2 cm thick with small scaly plates and shallow fissures; twigs orange-black; leaves in threes, dark green and flexible, 12-25 cm. long; staminate cones 1.5-3.5 cm. long; female cones 4-6 cm. long; seeds triangular 3 mm. long with wings 18 mm. long

Found: Near coast, not abundant; not found in uplands or mountains

Soils: Poorly drained soils or peaty swamps

Pyrus angustifolia **Narrow-leaved wild crabapple**

Rosaceae
Trees up to 8m tall; flowering branchlets and leaves glabrous; leaves of fertile often spinescent branchlets oblong or narrowly elliptic, round-tipped, tapering to base, entire, crenate-dentate or serrate, often evergreen; pedicles glaborous; calyx glabrous outside; tomentose within; petals roseate, fading to white; apple 2-3.5 cm in diameter, yellowish green, sepals often deciduous

Found: Woodland edges and thickets.

Soil: Moist sandy soil

Hydrocotyle verticillata **Whorled marsh-pennywort**

Umbelliferae
Creeping weakly erect marsh plant with greenish-white inflorescence, simple or with 2-several erect branches, usually overtopped by the leaves, appearing all summer; Flowers are 1/16 inch wide, 5 parted, in clusters of 1-5. Leaves are doubly scalloped with a deep basal notch. Fruit depressed much broader than long, 1-2.5 mm high, 2-4 mm broad. Plant creeps with runners arising from leaf axils.

Found: Damp woods, meadows, shores, low grounds and moist edges.

Soil: Moist, wet peaty or sandy soils of watersides

Eupatorium coelestinum **Blue Boneset**

Compositae
Perennial; stem rising from a cord-like rhizome, with slender superficial stolons, pubescent, 0.3-1 m high; leaves triangular-ovate or subcordate, petioled, often with auxillary fasciles; corymbs compact and terminal or terminating on the upper branches; involucre many-flowered; flowers powder blue. Blooms late summer to mid autumn.

Found: Low open meadows, damp thickets or clearings, borders of streams.

Soil: Moist, humus rich soil that does not dry out completely.

Juncus longii **Long's rush**

Juncaceae
perennial; two or three stems 4-10 dm. long, arising from a cordlike stolon up to 2 dm; leaves rigid, deep green and narrow; cyme 1-11 cm. long; flowers 2.5-3.5 mm. long; petals olive brown with white margins; seeds fusiform, yellowish 8-12 ribbed; blooms May-Sept.

Found: Salt Brackish water, wet ground of bogs, ponds and marshes

Soil: Damp sand or peaty soils of watersides or meadows

Cuscuta indecora **Dodder**

Convolvulaceae
Perennial; leafless, parasitic vine; flowers 5 or more, 2-2.5 mm long, fleshy, papillose, shorter than the slender pedicles, forming open panicles, calyx much shorter than corolla-tube, the lobes are triangular or acute. Corolla bell-shaped, the lobes shorter, the lobes shorter than the tube. Anthers are large, often purplish. Blooms July-Aug.

Eight native and three introduced species are pests of agricultural fields, open meadows and tree crops. Dodders lack chlorophyll; the seeds germinate in soil, but the roots cease to function as soon as the seedling becomes attached to the host, adhering by suckers. Profuse clusters of tiny 1/8 inch whitish bell-shaped flowers are usually produced in summer and fall. Corolla is 5-lobed; and stems are yellow-orange.

Found: Damp soils and sandy openings on various host plants. Some species are parasitic on crops.

Soil: Found on a variety of plants in moist low ground.

References

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Versar INC.
ESM Operations

August 28, 1997

Beth Brandreth
Environmental Resources Branch
U.S. Army Corps of Engineers
Wanamaker Building
100 Penn Square East
Philadelphia, PA 19107-3390

RE: Lower Cape May Meadows Sediment and Water Quality Results

Dear Beth:

The sediment and surface water testing results for samples we collected at Cape May Meadows during the spring and summer of 1997 have been completed and are summarized in Tables 1 and 2. Sediment and surface water samples were taken in Lake Lilly, Lighthouse Pond West, Lighthouse Pond East, Shallow Pond West, and one of the Nature Conservancy's ponds in the western portion of the meadows. Spring collections were taken on May 1 while the summer samples were collected on July 31. Station locations are indicated in Figure 1. Both the sediment and water samples were tested for phosphorus, ammonia, and the various forms of nitrogen (i.e., nitrate, nitrite, and TKN). Sampling at two sediment and surface water stations at the Nature Conservancy pond was added to the summer survey.

Based on the data results we have made the following observations:

Sediments

- Nitrate and nitrite forms of nitrogen were not detected in any of the sediment samples in either the spring or summer seasons,
- Substantially higher sediment concentrations of phosphorus, ammonia, and TKN occurred in the spring samples at Lake Lilly, Lighthouse Pond West, and Lighthouse Pond East relative to Shallow Pond West,
- Substantially lower sediment concentrations of phosphorus, ammonia, and TKN were observed in the summer collections at all the ponds,
- Sediment nutrient concentrations during the summer at the Nature Conservancy pond were low and similar to levels observed in Shallow Pond West; higher levels occurred at Lake Lilly and Lighthouse Ponds East and West.
- Sediments in Shallow Pond West and the Nature Conservancy pond had higher percent solids relative to the other ponds,

Surface Water

- Springtime surface water salinities were low in all ponds ranging from 0.3 to 0.7 ppt,

9200 RUMSEY ROAD • COLUMBIA, MARYLAND 21045-1934 • TELEPHONE: (410) 964-9200 • FAX (410) 964-5156

- Nitrate and Nitrite forms of nitrogen were not detected in any of the surface water samples in either the spring or summer seasons,

- Summertime surface water salinities were higher at the Nature Conservancy pond, Shallow Pond West, and Lighthouse Pond East ranging from 2.0 to 4.1 ppt, while Lake Lilly was essentially fresh,

- Low summertime dissolved oxygen was observed at Lighthouse Pond West and Shallow Pond East, while DO levels in the other ponds were relatively good,

- Surface water concentrations of nutrients in Lake Lilly and the other ponds during spring were extremely low (mostly below detection limits)

- Summertime water column phosphorus concentration in Lake Lilly was orders of magnitude lower than all the other ponds sampled.

Although the summer concentration of phosphorus in Lake Lilly was among the lowest of all the ponds sampled, all the ponds would be classified as eutrophic based on EPA's 1983[1] trophic classification of lakes. EPA suggests that lakes containing phosphorus concentrations >0.02 mg/L are eutrophic. However, this criteria may not applicable to coastal marsh ecosystems which are naturally nutrient enriched.

I hope this survey information meets your needs and expectations. I have also included copies of the laboratory analysis certificates which are attached for your review.

Sincerely,

William H. Burton
(Program Manager)

WHB:whb/sg
Enclosures
F:\DATA\WPSHARED\DEPT.74\PHILA97\CAPEMAY\11478-R.WPD

cc: File: 3353-013

[1] EPA 1983. Technical Guidance Manual for Performing Wast Load Allocations. Book 4 Lakes and Impoundments. Chapter 2 Nutrient/Eutrophication Impacts. U.S. Environmental Protection Agency Washington, D.C.

Table 1 Sediment and water quality at Lower Cape May Meadows during Spring 1997.

Parameter	Lake Lily			Lighthouse Pond West		Lighthouse Pond East		Shallow Pond West		
Station	01	02	03	07	08	09	10	04	05	06
SEDIMENT (mg/kg)										
Percent Solids (%)	8	7	7	6	5	5	6	61	50	52
Total Phosphorus	300	370	360	420	500	560	430	46	58	56
Ammonia	300	240	230	100	160	220	250	8.2	<4.0	7.7
Nitrate	<6.3	8.86	<7.1	<8.3	<10	<10	<8.3	<0.82	<1.0	<0.96
Nitrite	<0.50	<0.57	<0.57	<0.67	<0.80	<0.80	<0.67	<0.066	<0.080	<0.077
TKN	13000	14000	15000	20000	20000	20000	15000	440	820	1000
WATER QUALITY (mg/L)										
Total Phosphorus	<0.050	<0.050		<0.050		<0.050		<0.050		
Ammonia	0.3	<0.10		<0.10		<0.10		<0.10	<0.10	
Nitrate	<0.050	<0.050		<0.050		<0.050		<0.050	<0.050	
Nitrite	<0.010	<0.010		<0.010		<0.010		<0.010	<0.010	
TKN	0.9	0.9		1.2		1.9		2	1.5	
Total Coliform (cln/100 ml)	17	80		13		ND		240	34	
Fecal Coliform (cln/100 ml)	4	50		4		ND		22	11	
Temp (°C)	17.24	16.91	17.36	15.93	16.15	16.31		15.66	15.96	15.96
pH	9.64	9.58	9.62	9.67	9.68	9.53		8.41	8.20	8.19
Conductivity (mS/cm)	0.673	0.686	0.686	1.029	1.007	1.221		1.241	1.273	1.259
Salinity (ppt)	0.3	0.4	0.4	0.5	0.5	0.6		0.7	0.7	0.7
%Saturation DO	119.6	119.1	115.0	107.2	104.3	101.4		103.7	101.4	103.2
DO (mg/L)	11.47	11.50	11.00	10.56	10.22	9.90		10.27	9.97	10.15
Turbidity (NTU)	37.4	35.3	35.4	33.0	31.0	36.1		37.3	33.9	40.1

ND - Not detected

Table 2 Sediment and water quality at Lower Cape May Meadows during Summer 1997.

Parameter	Lake Lily		Lighthouse Pond West		Lighthouse Pond East		Shallow Pond West		Nature Conservancy	
Station	**01**	**02**	**07**	**08**	**09**	**10**	**04**	**05**	**11**	**12**
SEDIMENT (mg/kg)										
Percent Solids (%)	7	10	12	7	8	18	82	40	72	50
Total Phosphorus	<36	28	<21	76	31	32	<3.0	<6.3	<3.5	<5
Ammonia	300	220	150	230	300	83	3.7	28	15	44
Nitrate	<7.0	<5.1	<4.2	<7.3	<6.0	<2.7	<0.61	<1.3	<0.67	<0.92
Nitrite	<0.57	<0.40	<0.33	<0.57	<0.50	<0.22	<0.049	<0.1	<0.056	<0.08
TKN	2600	1500	1800	2900	4100	1300	36	640	190	770
WATER QUALITY (mg/L)										
Total Phosphorus	0.0756	0.0441		0.100		0.204	0.221	0.332		0.351
Ammonia	0.10	<0.10		0.20		0.20	0.10	0.20		0.20
Nitrate	<0.05	<0.05		<0.05		<0.05	<0.05	<0.05		<0.05
Nitrite	<0.01	<0.01		<0.01		<0.01	<0.01	<0.01		<0.01
TKN	1.7	1.4		1.6		4.0	4.3	4.7		25
Total Coliform (cln/100 ml)	30	30		8		50	1600	50		1600
Fecal Coliform (cln/100 ml)	11	8		4		50	240	50		500
Temp (°C)	25.54	24.84	24.03	23.14	22.78	22.26	21.49	21.3	26.28	26.02
pH	9.19	9.34	7.56	7.72	9.4	9.36	9.1	9.1	8.6	8.62
Conductivity (mS/cm)	0.937	0.972	2.04	2.05	3.7	3.78	7.33	3.72	3.79	4.09
Salinity (ppt)	0.5	0.5	1.1	1.1	2	2.1	4.1	2	2.1	2.2
%Saturation DO	62.8	70	10.4	40.1	41.2	47.1	0	13.7	84.5	82.4
DO (mg/L)	5.12	5.78	0.87	3.4	3.5	4.04	0	1.2	6.3	6.58
Turbidity (NTU)	4.0	1.5	5.4	3.8	--	25.7	32.8	22.4	--	24.7

ND - Not detected

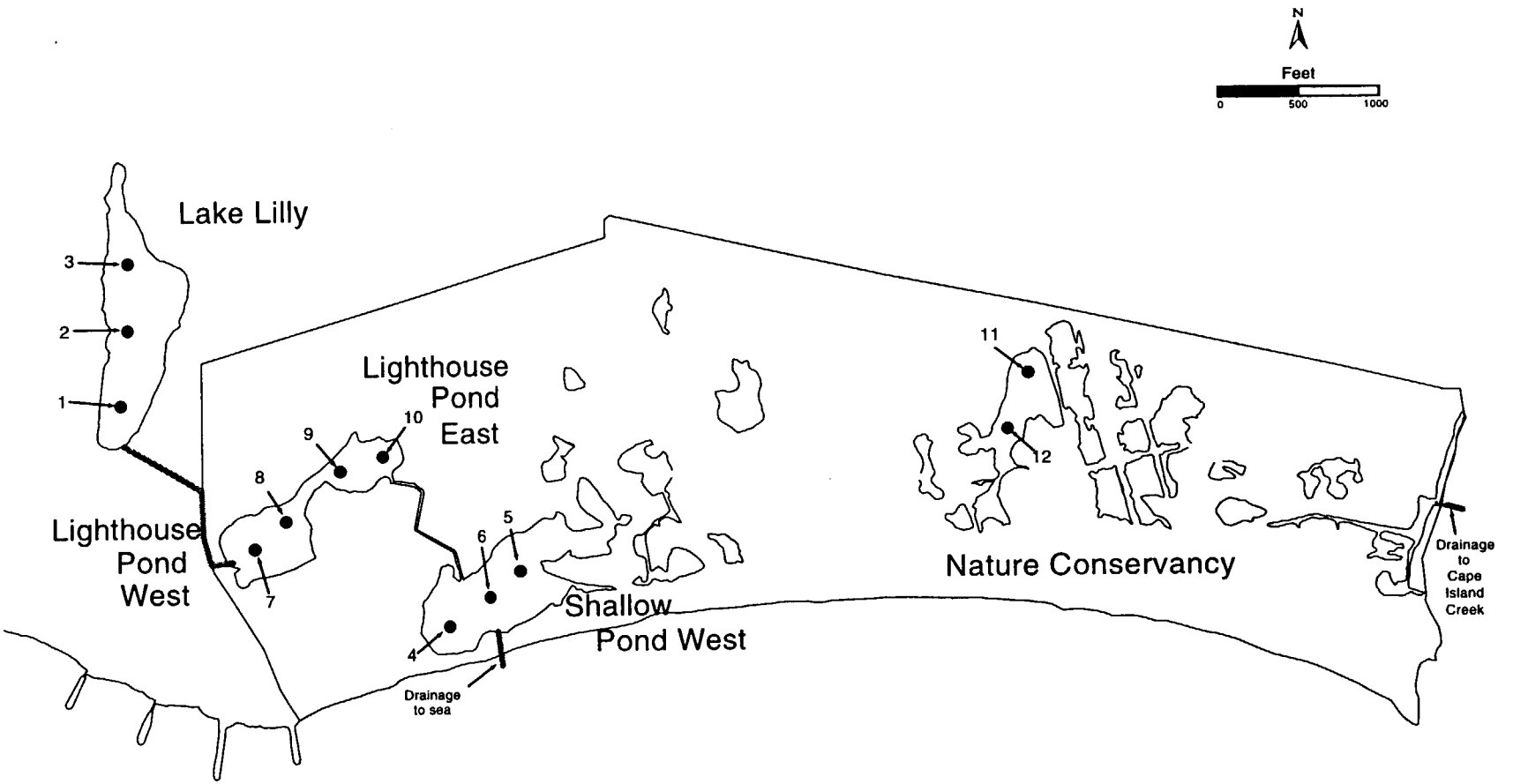

Figure 1. Station locations for sediment and surface water sampling conducted at Cape May Meadows in the spring and summer of 1997.

Versar INC.

SUMMER SAMPLING

LABORATORY ANALYSIS CERTIFICATES

KEMRON Environmental Services
109 Starlite Park
Marietta, Ohio 45750
Phone: (614) 373-4071

Versar, Inc.
9200 Rumsey Road
Columbia, MD 21045-1934

Attention: William Burton

PO Number:
Account Number: VERSAR-MD-331

Login #: L9708012
Report Date: 08/21/97
Work ID: 3333-013/PACOE CAPE MAY SEDIM.
Date Received: 08/01/97

SAMPLE IDENTIFICATION

Sample Number	Sample Description	Sample Number	Sample Description
L9708012-01	LL-01-07-31-97	L9708012-02	LL-02-07-31-97
L9708012-03	SPW-04-07-31-97	L9708012-04	SPW-05-07-31-97
L9708012-05	LPW-07-07-31-97	L9708012-06	LPW-08-07-31-97
L9708012-07	LPE-09-07-31-97	L9708012-08	LPE-10-07-31-97
L9708012-09	NL-11-07-31-97	L9708012-10	NL-12-07-31-97

All results on solids/sludges are reported on a dry weight basis, where applicable, unless otherwise specified. This report shall not be reproduced, except in full, without the written approval of KEMRON.

NYSDOH ELAP ID: 10861

Certified By
Deanna Hesson

KEMRON
ENVIRONMENTAL SERVICES

Login #L9708012
August 21, 1997 09:27 am

KEMRON ENVIRONMENTAL SERVICES

Lab Sample ID: L9708012-01
Client Sample ID: LL-01-07-31-97
Site/Work ID: 3333-013/PACOE CAPE MAY SEDIM.

Matrix: Soil
Collected: 07/31/97 940

% Solid: 7
COC Info: N/A

ANALYTE	UNITS	RESULT	QUALIFIER	RDL	ANALYST	ANALYSIS DATE	METHOD	DIL TYPE
Nitrogen, Ammonia.....	mg/kg	300		29	DIH	08/13/97	350.1	N/A
Nitrogen, Nitrite.....	mg/kg		ND	0.57	MAR	08/08/97	354.1	N/A
Percent Solids.....	% wt.	7.0		1.0	CLH	08/13/97	D2216-90	N/A
Phosphorus, Total.....	mg/kg		ND	36	RJS	08/12/97	365.2	N/A
Nitrogen, Nitrate.....	mg/kg		ND, (A)	7.0			300M	N/A
Nitrogen, Total Kjeldahl.....	mg/kg	2600	(A)	560			351.2	N/A

Login #L9708012
August 21, 1997 09:27 am

KEMRON ENVIRONMENTAL SERVICES

Lab Sample ID: L9708012-02
Client Sample ID: LL-02-07-31-97
Site/Work ID: 3333-013/PACOE CAPE MAY SEDIM.

Matrix: Soil
Collected: 07/31/97 950

% Solid: 10
COC Info: N/A

ANALYTE	UNITS	RESULT	QUALIFIER	RDL	ANALYST	ANALYSIS DATE	METHOD	DIL TYPE
Nitrogen, Ammonia.....	mg/kg	220		20	DIH	08/13/97	350.1	N/A
Nitrogen, Nitrite.....	mg/kg		ND	0.40	MAR	08/08/97	354.1	N/A
Percent Solids.....	% wt.	10		1.0	CLH	08/13/97	D2216-90	N/A
Phosphorus, Total.....	mg/kg	28		25	RJS	08/12/97	365.2	N/A
Nitrogen, Nitrate.....	mg/kg		ND, (A)	5.1			300M	N/A
Nitrogen, Total Kjeldahl.....	mg/kg	1500	(A)	400			351.2	N/A

Login #L9708012
August 21, 1997 09:27 am

KEMRON ENVIRONMENTAL SERVICES

Lab Sample ID: L9708012-03
Client Sample ID: SPW-04-07-31-97
Site/Work ID: 3333-013/PACOE CAPE MAY SEDIM.

Matrix: Soil
Collected: 07/31/97 730

% Solid: 82
COC Info: N/A

ANALYTE	UNITS	RESULT	QUALIFIER	RDL	ANALYST	ANALYSIS DATE	METHOD	DIL TYPE
Nitrogen, Ammonia.....	mg/kg	3.7		2.4	DIH	08/13/97	350.1	N/A
Nitrogen, Nitrite.....	mg/kg		ND	0.049	MAR	08/08/97	354.1	N/A
Percent Solids.....	% wt.	82		1.0	CLH	08/13/97	D2216-90	N/A
Phosphorus, Total.....	mg/kg		ND	3.0	RJS	08/12/97	365.2	N/A
Nitrogen, Nitrate.....	mg/kg		ND, (A)	0.61			300M	N/A
Nitrogen, Total Kjeldahl.....	mg/kg	36	(A)	4.9			351.2	N/A

Login #L9708012
August 21, 1997 09:27 am

KEMRON ENVIRONMENTAL SERVICES

Lab Sample ID: L9708012-04
Client Sample ID: SPW-05-07-31-97
Site/Work ID: 3333-013/PACOE CAPE MAY SEDIM.

Matrix: Soil
Collected: 07/31/97 750

% Solid: 40
COC Info: N/A

ANALYTE	UNITS	RESULT	QUALIFIER	RDL	ANALYST	ANALYSIS DATE	METHOD	DIL TYPE
Nitrogen, Ammonia.....	mg/kg	28		5.0	DIH	08/13/97	350.1	N/A
Nitrogen, Nitrite.....	mg/kg		ND	0.10	MAR	08/08/97	354.1	N/A
Percent Solids.....	% wt.	40		1.0	CLH	08/13/97	D2216-90	N/A
Phosphorus, Total.....	mg/kg		ND	6.3	RJS	08/12/97	365.2	N/A
Nitrogen, Nitrate.....	mg/kg		ND, (A)	1.3			300M	N/A
Nitrogen, Total Kjeldahl.....	mg/kg	640	(A)	98			351.2	N/A

Login #L9708012
August 21, 1997 09:27 am

KEMRON ENVIRONMENTAL SERVICES

Lab Sample ID: L9708012-05
Client Sample ID: LPW-07-07-31-97
Site/Work ID: 3333-013/PACOE CAPE MAY SEDIM.

Matrix: Soil
Collected: 07/31/97 830

% Solid: 12
COC Info: N/A

ANALYTE	UNITS	RESULT	QUALIFIER	RDL	ANALYST	ANALYSIS DATE	METHOD	DIL TYP
Nitrogen, Ammonia.....	mg/kg	150		17	DIH	08/13/97	350.1	N/
Nitrogen, Nitrite.....	mg/kg		ND	0.33	MAR	08/08/97	354.1	N/
Percent Solids.....	% wt.	12		1.0	CLH	08/13/97	D2216-90	N/
Phosphorus, Total.....	mg/kg		ND	21	RJS	08/12/97	365.2	N/
Nitrogen, Nitrate.....	mg/kg		ND, (A)	4.2			300M	N/
Nitrogen, Total Kjeldahl.....	mg/kg	1800	(A)	330			351.2	N/

Login #L9708012
August 21, 1997 09:27 am

KEMRON ENVIRONMENTAL SERVICES

Lab Sample ID: L9708012-06
Client Sample ID: LPW-08-07-31-97
Site/Work ID: 3333-013/PACOE CAPE MAY SEDIM.

Matrix: Soil
Collected: 07/31/97 845

% Solid: 7
COC Info: N/A

ANALYTE	UNITS	RESULT	QUALIFIER	RDL	ANALYST	ANALYSIS DATE	METHOD	DIL TYPE
Nitrogen, Ammonia.....	mg/kg	230		29	DIH	08/13/97	350.1	N/A
Nitrogen, Nitrite.....	mg/kg		ND	0.57	MAR	08/08/97	354.1	N/A
Percent Solids.....	% wt.	7.0		1.0	CLH	08/13/97	D2216-90	N/A
Phosphorus, Total.....	mg/kg	76		36	RJS	08/12/97	365.2	N/A
Nitrogen, Nitrate.....	mg/kg		ND, (A)	7.3			300M	N/A
Nitrogen, Total Kjeldahl.....	mg/kg	2900	(A)	570			351.2	N/A

Login #L9708012
August 21, 1997 09:27 am

KEMRON ENVIRONMENTAL SERVICES

Lab Sample ID: L9708012-07
Client Sample ID: LPE-09-07-31-97
Site/Work ID: 3333-013/PACOE CAPE MAY SEDIM.

Matrix: Soil
Collected: 07/31/97 850

% Solid: 8
COC Info: N/A

ANALYTE	UNITS	RESULT	QUALIFIER	RDL	ANALYST	ANALYSIS DATE	METHOD	DIL TYP
Nitrogen, Ammonia.....	mg/kg	300		25	DIH	08/13/97	350.1	N/
Nitrogen, Nitrite.....	mg/kg		ND	0.50	MAR	08/08/97	354.1	N/
Percent Solids.....	% wt.	8.0		1.0	CLH	08/13/97	D2216-90	N/
Phosphorus, Total.....	mg/kg		ND	31	RJS	08/12/97	365.2	N/
Nitrogen, Nitrate.....	mg/kg		ND, (A)	6.0			300M	N/
Nitrogen, Total Kjeldahl.....	mg/kg	4100	(A)	500			351.2	N/

Login #L9708012
August 21, 1997 09:27 am

KEMRON ENVIRONMENTAL SERVICES

Lab Sample ID: L9708012-08
Client Sample ID: LPE-10-07-31-97
Site/Work ID: 3333-013/PACOE CAPE MAY SEDIM.

Matrix: Soil
Collected: 07/31/97 900

% Solid: 18
COC Info: N/A

ANALYTE	UNITS	RESULT	QUALIFIER	RDL	ANALYST	ANALYSIS DATE	METHOD	DIL TYPE
Nitrogen, Ammonia.....	mg/kg	83		11	DIH	08/13/97	350.1	N/A
Nitrogen, Nitrite.....	mg/kg		ND	0.22	MAR	08/08/97	354.1	N/A
Percent Solids.....	% wt.	18		1.0	CLH	08/13/97	D2216-90	N/A
Phosphorus, Total.....	mg/kg	32		14	RJS	08/12/97	365.2	N/A
Nitrogen, Nitrate.....	mg/kg		ND, (A)	2.7			300M	N/A
Nitrogen, Total Kjeldahl.....	mg/kg	1300	(A)	220			351.2	N/A

Login #L9708012
August 21, 1997 09:27 am

KEMRON ENVIRONMENTAL SERVICES

Lab Sample ID: L9708012-09
Client Sample ID: NL-11-07-31-97
Site/Work ID: 3333-013/PACOE CAPE MAY SEDIM.

Matrix: Soil
Collected: 07/31/97 1035

% Solid: 72
COC Info: N/A

ANALYTE	UNITS	RESULT	QUALIFIER	RDL	ANALYST	ANALYSIS DATE	METHOD	DIL TYP
Nitrogen, Ammonia.....	mg/kg	15		2.8	DIH	08/13/97	350.1	N/.
Nitrogen, Nitrite.....	mg/kg		ND	0.056	MAR	08/08/97	354.1	N/.
Percent Solids.....	% wt.	72		1.0	CLH	08/13/97	D2216-90	N/.
Phosphorus, Total.....	mg/kg		ND	3.5	RJS	08/12/97	365.2	N/.
Nitrogen, Nitrate.....	mg/kg		ND, (A)	0.67			300M	N/.
Nitrogen, Total Kjeldahl.....	mg/kg	190	(A)	54			351.2	N/.

Login #L9708012
August 21, 1997 09:27 am

KEMRON ENVIRONMENTAL SERVICES

Lab Sample ID: L9708012-10
Client Sample ID: NL-12-07-31-97
Site/Work ID: 3333-013/PACOE CAPE MAY SEDIM.

Matrix: Soil
Collected: 07/31/97 1030

% Solid: 50
COC Info: N/A

ANALYTE	UNITS	RESULT	QUALIFIER	RDL	ANALYST	ANALYSIS DATE	METHOD	DIL TYPE
Nitrogen, Ammonia.....	mg/kg	44		4.0	DIH	08/13/97	350.1	N/A
Nitrogen, Nitrite.....	mg/kg		ND	0.08	MAR	08/08/97	354.1	N/A
Percent Solids.....	% wt.	50		1.0	CLH	08/13/97	D2216-90	N/A
Phosphorus, Total.....	mg/kg		ND	5.0	RJS	08/12/97	365.2	N/A
Nitrogen, Nitrate.....	mg/kg		ND, (A)	0.92			300M	N/A
Nitrogen, Total Kjeldahl.....	mg/kg	770	(A)	150			351.2	N/A

KEMRON ANALYST LIST

Ohio Valley Laboratory

07/28/97

AJS - - Ashlee J. Scott
ALC - - Ann L. Clark
BWH - - Ben W. Haynes
CEB - - Chad E. Barnes
CLH - - Chris L. Hurst
CMS - - Crystal M. Stevens
DJH - - Deanna J. Hesson
DJP - - Douglas J. Poling
DLP - - Dorothy L. Payne
DST - - Dennis S. Tepe
ECL - - Eric C. Lawson
EDG - - Eric D. Gerkin
FEH - - Fay E. Harmon
FRM - - Fred R. Montgomery
GWH - - George W. Hutchison
HV - - Hema Vilasagar
JKM - - June K. Morris
JLI - - Janice L. Inghram
JLW - - Jessica L. Wright
JMM - - Jim M. Monk
JWR - - John W. Richards
JYH - - Ji Y. Hu
KHA - - Kim H. Archer
KMM - - Kevin M. McDonald
KPO - - Kevin P. Overstreet
KRA - - Kathy R. Albertson
LMW - - Lisa M. Wagner
MAR - - MaryAnn Roach
MBJ - - Matthew B. Jarrell
MDA - - Mike D. Albertson
MDC - - Michael D. Cochran
MES - - Mary E. Schiling
MFB - - Mike F. Barrow
MLS - - Michael L. Schimmel
MMB - - Maren M. Beery
MSW - - Mike S. Wetz
RDC - - Rebecca D. Cutlip
REB - - Russell E. Burton
REF - - Ron E. Fertile
REK - - Robert E. Kyer
RJS - - Rick J. Santos
RSS - - Regina S. Simmons
RWC - - Rodney W. Campbell
SCW - - Stephen C. West
SJM - - Shawn J. Marshall
SLT - - Stephanie L. Tepe
SPL - - Steve P. Learn
TLD - - Teresa L. Davis
VC - - Vicki Collier
WCD - - Wade C. Dawson

INORGANIC QA/QC

Kemron
ENVIRONMENTAL SERVICES

KEMRON ENVIRONMENTAL SERVICES
OHIO VALLEY LABORATORY
QUALITY CONTROL SUMMARY

WORKGROUP: wg27460
METHOD: 354 1
MATRIX: Soil
UNITS: mg Kg

RUN DATE: 8 8 97
ANALYST: mar
DUPLICATE: 08 012-03
SPIKE: 08-012-03

ANALYTE	RDL	Blank	CONCENTRATION PPM T-LCS	LCS	REP1	REP2	SAMPLE RESULT	T-MS	MS	PERCENT RECOVERY LCS	LCS LCL	LCS UCL	MS	MS LCL	MS UCL	PERCENT RPD REP RPD	RPD UCL
Nitrite	0 04	ND	0 40	0 326	ND	ND	0 00	0 40	0 299	81 50	75 00	125 00	73 88	75 00	125 00	NA	20 00

NOTES & DEFINITIONS
RDL = REPORTING DETECTION LIMIT
DL = DILUTED OUT
NA = NOT APPLICABLE
ND = DETECTED

LCS = LABORATORY CONTROL SAMPLE
T-LCS = TRUE VALUE OF LCS
REP1 = UNSPIKED SAMPLE REPLICATE 1
REP2 = UNSPIKED SAMPLE REPLICATE 2
SAMPLE RESULT = CONCENTRATION OF UNSPIKED MATRIX
T-MS = TRUE VALUE OF MATRIX SPIKE
MS = MATRIX SPIKE
LCL = LOWER CONTROL LIMIT
UCL = UPPER CONTROL LIMIT

REP RPD = RELATIVE PERCENT DIFFERENCE OF SAMPLE REPLICATES

KEMRON ENVIRONMENTAL SERVICES
OHIO VALLEY LABORATORY
QUALITY CONTROL SUMMARY

WORKGROUP: wg27603
METHOD: 365.2
MATRIX: soil
UNITS: mg/kg

RUN DATE: 8/12/97
ANALYST: rjs
DUPLICATE: 08-012-03
SPIKE: 08-012-03

			CONCENTRATION PPM							PERCENT RECOVERY						PERCENT RPD	
ANALYTE	RDL	Blank	T-LCS	LCS	REP1	REP2	SAMPLE RESULT	T-MS	MS	LCS	LCS LCL	LCS UCL	MS	MS LCL	MS UCL	REP RPD	RPD UCL
Phosphorus	2.50	ND	50.00	47.80	ND	ND	DL	20.00	DL	95.6	75.0	125.0	DL	75.0	125.0	NA	20.00

NOTES & DEFINITIONS :
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ND = NOT REQUIRED

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T-MS = TRUE VALUE OF MATRIX SPIKE
MS = MATRIX SPIKE
LCL = LOWER CONTROL LIMIT
UCL = UPPER CONTROL LIMIT

REP RPD = RELATIVE PERCENT DIFFERENCE OF SAMPLE REPLICATES

KEMRON ENVIRONMENTAL SERVICES
OHIO VALLEY LABORATORY
QUALITY CONTROL SUMMARY

WORKGROUP: wg27670
METHOD: 350 1
MATRIX: Soil
UNITS: mg/Kg

RUN DATE: 8/11/97
ANALYST: djp
DUPLICATE: 08-012-03
SPIKE: 08-012-09

ANALYTE	RDL	Blank	CONCENTRATION PPM T-LCS	LCS	REP1	REP2	SAMPLE RESULT	T-MS	MS	PERCENT RECOVERY LCS	LCS LCL	LCS UCL	MS	MS LCL	MS UCL	PERCENT RPD REP RPD	RPD UCL
Ammonia - Soil	2 00	2 00	40 00	41 88	3 00	5 00	10 56	20 00	29 12	104 70	81.00	119 00	92 80	75 00	125 00	50 00	20 00

NOTES & DEFINITIONS .
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UCL = UPPER CONTROL LIMIT

REP RPD = RELATIVE PERCENT DIFFERENCE OF SAMPLE REPLICATES

KEMRON
ENVIRONMENTAL SERVICES

84759

CHAIN-OF-CUSTODY RECORD

Page 1 of 1

Project Contact: Versar, Inc / Fredrick Kelley

Turn Around Requirements:

Project No.: 3353-013

Project Name: PACOE: Cape May Sediment

Sampler (print): Fredrick S. Kelley

Signature: Fredrick S. Kelley

Sample I.D. No.	Comp*	Grab	Date	Time	Protocol CWA	Protocol SW846	NUMBER OF SAMPLES	Hold	NO_2, NH_3, TP	NO_3, TKN	ADDITIONAL REQUIREMENTS
LL-01-07-31-97		✓	7/31/97	09:40			2		1	1	
LL-02-07-31-97		✓		09:50			2		1	1	
SPW-04-07-31-97		✓		07:30			2		1	1	
SPW-05-07-31-97		✓		07:50			2		1	1	
LPW-07-07-31-97		✓		08:30			2		1	1	
LPW-08-07-31-97		✓		08:45			2		1	1	
LPE-09-07-31-97		✓		08:50			2		1	1	
LPE-10-07-31-97		✓		09:00			2		1	1	
NL-11-07-31-97		✓		10:35			2		1	1	
NL-12-07-31-97		✓		10:30			2		1	1	

Relinquished by: (Signature)	Date	Time	Received by: (Signature)	Relinquished by: (Signature)	Date	Time	Received by: (Signature)
Fredrick Kelley	7/31/97	1600					

Relinquished by: (Signature)	Date	Time	Received for Laboratory by: (Signature)	Date	Time	Remarks:
			Angelia P. Scott	8/1/97	1034	use times as listed on COC (LPW may say 8:37) Cooler Temp 6 / COC Sealed

*Homogenize all composite samples prior to analysis

White – Lab Yellow – Office Pink – Field

WORK ORDER #: L908C42 Client: Versar - ND SAMPLE #: 1-10 PAGE: 1

SAMPLE #	TESTS	REASON	REMOVED BY (ADT)	REMOVED FROM	MOVED TO	RELIQ. BY	RET'D BY (ADT)	RET'D TO	REC'D BY	REASON
1-10	NO3/TKN	Subcontract analyses	RWS 8-1-97 @1415	Legen	Gel	RWS	—	—	—	—
1-6 8+10	NO2	Ana	MAR 8-5-97 @1230	Walkin	wet 08-13-97	RWS	CLH/08-13-97/0956	Archive	DRG	Archive
1-10	PCT-S	AN	CLH/08-13-97/0930	~~Walkin~~ * CLH	Wet	DRG				

Removed portion for PCT-S. 5x's were never removed from Wet lab. CLH/08-13-97/0836

KCO Cooler # _____

Number of Coolers 2

PROJECT: 3353-013/PACOE Cape May Sediments — WQ Date received: 8-1-97

USE OTHER SIDE OF THIS FORM TO NOTE DETAILS CONCERNING CHECK-IN PROBLEMS.

A. PRELIMINARY EXAMINATION PHASE: Date cooler was opened: _____

by (print) Angelina R. Scott (sign) Angelina R. Scott

1. Did cooler come with a shipping slip (air bill, etc.)? ..... YES NO

   If YES, enter carrier name & air bill number here: Fed Ex 146 0900 604 950 9464 413

2. Were custody seals on outside of cooler? ..... YES NO

   How many & where: 2/Front, seal date: 8-1, seal name: Kopinran

3. Were custody seals unbroken and intact at the date and time of arrival? ..... YES NO
4. Did you screen samples for radioactivity using the Geiger Counter ..... YES NO
5. Were custody papers sealed in a plastic bag & taped inside to the lid? ..... YES NO
6. Were custody papers filled out properly (ink, signed, etc.)? ..... YES NO
7. Did you sign custody papers in the appropriate place? ..... YES NO
8. Was project identifiable from custody papers? If YES, enter project name at the top of this form. YES NO
9. If required, was enough ice used? ..... Type of ice: wet ..... YES NO
10. Have designated person initial here to acknowledge receipt of cooler: AS (date) 8-1-97

B. LOG-IN PHASE: Date samples were logged-in: 8-1-97

by (print) Angelina R. Scott (sign) Angelina R. Scott

11. Describe type of packing in cooler: Bubble wrap baggies.
12. Were all bottles sealed in separate plastic bags? ..... YES NO
13. Did all bottles arrive unbroken & were labels in good condition? ..... YES NO
14. Were all bottle labels complete (ID, date, time, signature, preservative, etc.)? ..... YES NO
15. Did all bottle labels agree with custody papers? ..... YES NO
16. Were correct containers used for the tests indicated? ..... YES NO
17. Were correct preservatives added to samples? ..... YES NO
18. Was a sufficient amount of sample sent for tests indicated? ..... YES NO
19. Were bubbles absent in VOA samples? If NO, list by CA#: _____ YES NO
20. Was the project manager called and status discussed? If YES, give details on the back of this form. YES NO

21. Who was called ? _____ By whom ? _____ (date) _____

COOLER CHECK SHEET

CLIENT: Versar

DATE: 8/

COOLER # KL-194	COOLER # KL-370	COOLER #
INDEX # 146 0900 604	INDEX # 950 9464 413	INDEX #
SEALED Y N	SEALED Y N	SEALED Y N
TEMP 4.0 C	TEMP 6.0 C	TEMP ____ C
TEMP IN RANGE (4C +/-2) Y N	TEMP IN RANGE (4C +/-2) Y N	TEMP IN RANGE (4C +/-2) Y N
SAMPLES INTACT Y N	SAMPLES INTACT Y N	SAMPLES INTACT Y N
LABELS LEGIBLE Y N	LABELS LEGIBLE Y N	LABELS LEGIBLE Y N
LABELS MATCH COC Y N	LABELS MATCH COC Y N	LABELS MATCH COC Y N
pH IN RANGE (as appropriate) Y N	pH IN RANGE (as appropriate) Y N	pH IN RANGE (as appropriate) Y N
WET ICE / BLUE ICE	WET ICE / BLUE ICE	WET ICE / BLUE ICE
Radiation Checked Y N	Radiation Checked Y N	Radiation Checked Y N
All N notations require comment where applicable	All N notations require comment where applicable	All N notations require comment where applicable
CoC 88043	CoC 54759	

Revised 6/1/97
NO. 3

KEMRON Environmental Services
109 Starlite Park
Marietta, Ohio 45750
Phone: (614) 373-4071

Versar, Inc.
9200 Rumsey Road
Columbia, MD 21045-1934

Attention: William Burton

PO Number:
Account Number: VERSAR-MD-331

Login #: L9708011
Report Date: 08/15/97
Work ID: 3353-013/PACOE CAPE MAY WQ
Date Received: 08/01/97

SAMPLE IDENTIFICATION

Sample Number	Sample Description	Sample Number	Sample Description
L9708011-01	LL-01-07-31-97	L9708011-02	LL-02-07-31-97
L9708011-03	SPW-04-07-31-97	L9708011-04	SPW-05-07-31-97
L9708011-05	LPW-08-07-31-97	L9708011-06	LPE-10-07-31-97
L9708011-07	NL-12-07-31-97		

All results on solids/sludges are reported on a dry weight basis, where applicable, unless otherwise specified. The report shall not be reproduced, except in full, without the written approval of KEMRON.

Certified By
Deanna Hesson

KEMRON
ENVIRONMENTAL SERVICES

Login #L9708011
August 15, 1997 08:59 am

KEMRON ENVIRONMENTAL SERVICES

Lab Sample ID: L9708011-01
Client Sample ID: LL-01-07-31-97
Site/Work ID: 3353-013/PACOE CAPE MAY WQ

Matrix: Water
Collected: 07/31/97 940

COC Info: N/A

ANALYTE	UNITS	RESULT	QUALIFIER	RDL	ANALYST	ANALYSIS DATE	METHOD	DIL TYP
Nitrogen, Ammonia.....	mg/L	0.10		0.10	DIH	08/13/97	350.1	N/
Nitrogen, Nitrite.....	mg/L		ND	0.01	MAR	08/04/97	354.1	N/
Nitrogen, Nitrate.....	mg/L		ND	0.05	DIH	08/04/97	353.2	N/
Nitrogen, Total Kjeldahl.....	mg/L	1.7		0.10	JWR	08/08/97	351.2	N/

Login #L9708011
August 15, 1997 08:59 am

KEMRON ENVIRONMENTAL SERVICES

Lab Sample ID: L9708011-02
Client Sample ID: LL-02-07-31-97
Site/Work ID: 3353-013/PACOE CAPE MAY WQ

Matrix: Water
Collected: 07/31/97 950

COC Info: N/A

ANALYTE	UNITS	RESULT	QUALIFIER	RDL	ANALYST	ANALYSIS DATE	METHOD	DIL TYPE
Nitrogen, Ammonia.....	mg/L		ND	0.10	DIH	08/13/97	350.1	N/A
Nitrogen, Nitrite.....	mg/L		ND	0.01	MAR	08/04/97	354.1	N/A
Nitrogen, Nitrate.....	mg/L		ND	0.05	DIH	08/04/97	353.2	N/A
Nitrogen, Total Kjeldahl.....	mg/L	1.4		0.10	JWR	08/08/97	351.2	N/A

Login #L9708011
August 15, 1997 08:59 am

KEMRON ENVIRONMENTAL SERVICES

Lab Sample ID: L9708011-03
Client Sample ID: SPW-04-07-31-97
Site/Work ID: 3353-013/PACOE CAPE MAY WQ

Matrix: Water
Collected: 07/31/97 730

COC Info: N/A

ANALYTE	UNITS	RESULT	QUALIFIER	RDL	ANALYST	ANALYSIS DATE	METHOD	DIL TYPE
Nitrogen, Ammonia.....	mg/L	0.10		0.10	DIH	08/13/97	350.1	N/A
Nitrogen, Nitrite.....	mg/L		ND	0.01	MAR	08/04/97	354.1	N/A
Nitrogen, Nitrate.....	mg/L		ND	0.05	DIH	08/04/97	353.2	N/A
Nitrogen, Total Kjeldahl.....	mg/L	4.3		0.40	JWR	08/08/97	351.2	N/A

Login #L9708011
August 15, 1997 08:59 am

KEMRON ENVIRONMENTAL SERVICES

Lab Sample ID: L9708011-04
Client Sample ID: SPW-05-07-31-97
Site/Work ID: 3353-013/PACOE CAPE MAY WQ

Matrix: Water
Collected: 07/31/97 750

COC Info: N/A

ANALYTE	UNITS	RESULT	QUALIFIER	RDL	ANALYST	ANALYSIS DATE	METHOD	DIL TYPE
Nitrogen, Ammonia.....	mg/L	0.20		0.10	DIH	08/13/97	350.1	N/A
Nitrogen, Nitrite.....	mg/L		ND	0.01	MAR	08/04/97	354.1	N/A
Nitrogen, Nitrate.....	mg/L		ND	0.05	DIH	08/04/97	353.2	N/A
Nitrogen, Total Kjeldahl.....	mg/L	4.7		0.50	JWR	08/08/97	351.2	N/A

Login #L9708011
August 15, 1997 08:59 am

KEMRON ENVIRONMENTAL SERVICES

Lab Sample ID: L9708011-05
Client Sample ID: LPW-08-07-31-97
Site/Work ID: 3353-013/PACOE CAPE MAY WQ

Matrix: Water
Collected: 07/31/97 845

COC Info: N/A

ANALYTE	UNITS	RESULT	QUALIFIER	RDL	ANALYST	ANALYSIS DATE	METHOD	DIL TYP
Nitrogen, Ammonia.....	mg/L	0.20		0.10	DIH	08/13/97	350.1	N/
Nitrogen, Nitrite.....	mg/L		ND	0.01	MAR	08/04/97	354.1	N/
Nitrogen, Nitrate.....	mg/L		ND	0.05	DIH	08/04/97	353.2	N/
Nitrogen, Total Kjeldahl.....	mg/L	1.6		0.10	JWR	08/08/97	351.2	N/

Login #L9708011
August 15, 1997 08:59 am

KEMRON ENVIRONMENTAL SERVICES

Lab Sample ID: L9708011-06
Client Sample ID: LPE-10-07-31-97
Site/Work ID: 3353-013/PACOE CAPE MAY WQ

Matrix: Water
Collected: 07/31/97 900

COC Info: N/A

ANALYTE	UNITS	RESULT	QUALIFIER	RDL	ANALYST	ANALYSIS DATE	METHOD	DIL TYPE
Nitrogen, Ammonia.....	mg/L	0.20		0.10	DIH	08/13/97	350.1	N/A
Nitrogen, Nitrite.....	mg/L		ND	0.01	MAR	08/04/97	354.1	N/A
Nitrogen, Nitrate.....	mg/L		ND	0.05	DIH	08/04/97	353.2	N/A
Nitrogen, Total Kjeldahl.....	mg/L	4.0		0.40	JWR	08/08/97	351.2	N/A

Login #L9708011
August 15, 1997 08:59 am

KEMRON ENVIRONMENTAL SERVICES

Lab Sample ID: L9708011-07
Client Sample ID: NL-12-07-31-97
Site/Work ID: 3353-013/PACOE CAPE MAY WQ

Matrix: Water
Collected: 07/31/97 1030

COC Info: N/A

ANALYTE	UNITS	RESULT	QUALIFIER	RDL	ANALYST	ANALYSIS DATE	METHOD	DIL TYPE
Nitrogen, Ammonia.....	mg/L	0.20		0.10	DIH	08/13/97	350.1	N/A
Nitrogen, Nitrite.....	mg/L		ND	0.01	MAR	08/04/97	354.1	N/A
Nitrogen, Nitrate.....	mg/L		ND	0.05	DIH	08/04/97	353.2	N/A
Nitrogen, Total Kjeldahl.....	mg/L	25		2.0	JWR	08/08/97	351.2	N/A

KEMRON Environmental Services, Inc.
LIST OF VALID DATA QUALIFIERS (qual)
April 23, 1997

Qualifier	Description
(A)	See the report narrative
(B)	See the report narrative
(C)	See the report narrative
÷	Correlation coefficient for the MSA is less than 0.995
<	Less than
>	Greater than
B	Present in the method blank
C	Confirmed by GC/MS
*	Surrogate or spike compound out of range
CG	Confluent growth
D	The analyte was quantified at a secondary dilution factor
DL	Surrogate or spike was diluted out
E	Estimated concentration due to sample matrix interference
F	Present below nominal reporting limit (AFCEE only)
FL	Free liquid
I	Semiquantitative result, out of instrument calibration range
J	Present below nominal reporting limit
L	Sample reporting limits elevated due to matrix interference
M	Duplicate injection precision not met
N	Tentatively Identified Compound (TIC)
NA	Not applicable
ND	Not detected at or above the reporting limit
NF	Not found
NFL	No free liquid
NI	Non-ignitable
NR	Analyte is not required to be analyzed
NS	Not spiked
P	Concentrations > 25% difference between the two GC columns
QNS	Quantity not sufficient to perform analysis
R	Analyte exceeds regulatory limit
RA	Reanalysis confirms reported results
RE	Reanalysis confirms sample matrix interference
S	Analyzed by method of standard addition
SMI	Sample matrix interference on surrogate
SP	Reported results are for spike compounds only
TNTC	Too numerous to count
U	Analyzed for but not detected
W	Post-digestion spike for furnace AA out of control limits
X	Can not be resolved from isomer. See below.

Special Notes for Organic Analytes

1. Acrolein and acrylonitrile by method 624 are semiquantitative screens only.
2. 1,2-Diphenylhydrazine is unstable and is reported as azobenzene.
3. N-nitrosodiphenylamine cannot be separated from diphenylamine.
4. 3-Methyphenol and 4-Methyphenol are unresolvable compounds.
5. m-Xylene and p-Xylene are unresolvable compounds.

KEMRON ANALYST LIST

Ohio Valley Laboratory

07/28/97

AJS - - Ashlee J. Scott
ALC - - Ann L. Clark
BWH - - Ben W. Haynes
CEB - - Chad E. Barnes
CLH - - Chris L. Hurst
CMS - - Crystal M. Stevens
DIH - - Deanna I. Hesson
DJP - - Douglas J. Poling
DLP - - Dorothy L. Payne
DST - - Dennis S. Tepe
ECL - - Eric C. Lawson
EDG - - Eric D. Gerkin
FEH - - Fay E. Harmon
FRM - - Fred R. Montgomery
GWH - - George W. Hutchison
HV - - Hema Vilasagar
JKM - - June K. Morris
JLI - - Janice L. Inghram
JLW - - Jessica L. Wright
JMM - - Jim M. Monk
JWR - - John W. Richards
JYH - - Ji Y. Hu
KHA - - Kim H. Archer
KMM - - Kevin M. McDonald
KPO - - Kevin P. Overstreet
KRA - - Kathy R. Albertson
LMW - - Lisa M. Wagner
MAR - - MaryAnn Roach
MBJ - - Matthew B. Jarrell
MDA - - Mike D. Albertson
MDC - - Michael D. Cochran
MES - - Mary E. Schiling
MFB - - Mike F. Barrow
MLS - - Michael L. Schimmel
MMB - - Maren M. Beery
MSW - - Mike S. Wetz
RDC - - Rebecca D. Cutlip
REB - - Russell E. Burton
REF - - Ron E. Fertile
REK - - Robert E. Kyer
RJS - - Rick J. Santos
RSS - - Regina S. Simmons
RWC - - Rodney W. Campbell
SCW - - Stephen C. West
SJM - - Shawn J. Marshall
SLT - - Stephanie L. Tepe
SPL - - Steve P. Learn
TLD - - Teresa L. Davis
VC - - Vicki Collier
WCD - - Wade C. Dawson

INORGANIC QA/QC

Kemron
ENVIRONMENTAL SERVICES

KEMRON ENVIRONMENTAL SERVICES
OHIO VALLEY LABORATORY
QUALITY CONTROL SUMMARY

WORKGROUP: wg27111
METHOD: 353 2
MATRIX: Water
UNITS: mg/L

RUN DATE: 8/4/97
ANALYST: dlh
DUPLICATE: 07-443-01
SPIKE: 07-443-01

ANALYTE	RDL	Blank	CONCENTRATION PPM T-LCS	LCS	REP1	REP2	SAMPLE RESULT	T-MS	MS	PERCENT RECOVERY LCS	LCS LCL	LCS UCL	MS	MS LCL	MS UCL	PERCENT RPD REP RPD	RPD UCL
Nitrate	0 05	ND	1 000	1.100	0.070	0 060	0 065	0 500	0 587	110.00	81.00	120 00	104 40	75 00	125 00	15 38	17 00

NOTES & DEFINITIONS :
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MS = MATRIX SPIKE
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UCL = UPPER CONTROL LIMIT

REP RPD = RELATIVE PERCENT DIFFERENCE OF SAMPLE REPLICATES

KEMRON ENVIRONMENTAL SERVICES
OHIO VALLEY LABORATORY
QUALITY CONTROL SUMMARY

WORKGROUP:	wg27143	RUN DATE:	8/1/97
METHOD:	354 1	ANALYST:	mar
MATRIX:	Water	DUPLICATE:	701101 00
UNITS:	mg/L	SPIKE:	701101 00

			CONCENTRATION PPM							PERCENT RECOVERY						PERCENT RPD	
ANALYTE	RDL	Blank	T-LCS	LCS	REP1	REP2	SAMPLE RESULT	T-MS	MS	LCS	LCS LCL	LCS UCL	MS	MS LCL	MS UCL	REP RPD	RPD UCL
Nitrite	0 01	ND	0 10	0 104	ND	ND	ND	0 10	0 091	104 00	93 00	111 00	90 59	75 00	125 00	NA	6 30

NOTES & DEFINITIONS :

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MS = MATRIX SPIKE
LCL = LOWER CONTROL LIMIT
UCL = UPPER CONTROL LIMIT

REP RPD = RELATIVE PERCENT DIFFERENCE OF SAMPLE REPLICATES

KEMRON ENVIRONMENTAL SERVICES
OHIO VALLEY LABORATORY
QUALITY CONTROL SUMMARY

WORKGROUP: wg27510
METHOD: 351 2
MATRIX: Water
UNITS: mg/L

RUN DATE: 8/8/97
ANALYST: jwr
DUPLICATE: 08-153-10
SPIKE: 08-153-10

			CONCENTRATION PPM							PERCENT RECOVERY						PERCENT RPD	
ANALYTE	RDL	Blank	T-LCS	LCS	REP1	REP2	SAMPLE RESULT	T-MS	MS	LCS	LCS LCL	LCS UCL	MS	MS LCL	MS UCL	REP RPD	RPD UCL
TKN	0 10	ND	1 00	1 065	0 33	0 35	0 33	0 50	0 967	106 50	75 00	125 00	126 56	75 00	125 00	5 88	20 00

NOTES & DEFINITIONS
RDL = REPORTING DETECTION LIMIT
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SAMPLE RESULT = CONCENTRATION OF UNSPIKED MATRIX
T-MS = TRUE VALUE OF MATRIX SPIKE
MS = MATRIX SPIKE
LCL = LOWER CONTROL LIMIT
UCL = UPPER CONTROL LIMIT

REP RPD = RELATIVE PERCENT DIFFERENCE OF SAMPLE REPLICATES

KEMRON ENVIRONMENTAL SERVICES
OHIO VALLEY LABORATORY
QUALITY CONTROL SUMMARY

WORKGROUP: wg27671
METHOD: 350 1
MATRIX: Water
UNITS: mg/L

RUN DATE: 8/13/97
ANALYST: djp
DUPLICATE: 08-011-01
SPIKE: 08-011-02

ANALYTE	RDL	Blank	CONCENTRATION PPM							PERCENT RECOVERY						PERCENT RPD	
			T-LCS	LCS	REP1	REP2	SAMPLE RESULT	T-MS	MS	LCS	LCS LCL	LCS UCL	MS	MS LCL	MS UCL	REP RPD	RPD UCL
Ammonia-Dist.	0 10	ND	2.000	1 710	0.150	0.160	0 100	1 000	1.177	85.50	75.00	113 00	107 70	75 00	125 00	6 45	20 00

NOTES & DEFINITIONS :
RDL = REPORTING DETECTION LIMIT
DL = DILUTED OUT
NA = NOT APPLICABLE
ND = NOT DETECTED
NR = NOT REQUIRED

LCS = LABORATORY CONTROL SAMPLE
T- LCS = TRUE VALUE OF LCS
REP1 = UNSPIKED SAMPLE REPLICATE 1
REP2 = UNSPIKED SAMPLE REPLICATE 2
SAMPLE RESULT = CONCENTRATION OF UNSPIKED MATRIX
T-MS = TRUE VALUE OF MATRIX SPIKE
MS = MATRIX SPIKE
LCL = LOWER CONTROL LIMIT
UCL = UPPER CONTROL LIMIT

REP RPD = RELATIVE PERCENT DIFFERENCE OF SAMPLE REPLICATES

KEMRON
ENVIRONMENTAL SERVICES

88043

CHAIN-OF-CUSTODY RECORD

Project Contact: (410) 740-6110
Versar Inc - Frederick Kelley

Turn Around Requirements:

Project No.: 3353-013

Project Name: PACOE : Cape May WQ

Sampler (print): Frederick S. Kelley

Signature: Frederick S Kelley

Sample I.D. No.	Comp*	Grab	Date	Time	Protocol CWA	Protocol SW846	NUMBER OF SAMPLES	Hold	Nitrate - Nitrite	NH_3	TKN	ADDITIONAL REQUIREMENTS
LL-01-07-31-97		✓	7/31/97	9:40			3		1	1	1	
LL-02-07-31-97		✓		9:50			3		1	1	1	
SPW-04-07-31-97		✓		7:30			3		1	1	1	
SPW-05-07-31-97		✓		7:50			3		1	1	1	
LPW-08-07-31-97		✓		8:45			3		1	1	1	
LPE-10-07-31-97		✓		0900			3		1	1	1	
NL-12-07-31-97		✓		10:30			3		1	1	1	

Relinquished by: (Signature)	Date	Time	Received by: (Signature)	Relinquished by: (Signature)	Date	Time	Received by: (Signature)
Paul Kelley	7/31/97	1600					

Relinquished by: (Signature)	Date	Time	Received for Laboratory by: (Signature)	Date	Time	Remarks:
			Angelia B Scott	8/1/97	1034	Cooler Temp 4.0 / Sx sealed intact

White – Lab Yellow – Office Pink – Field

*Homogenize all composite samples prior to analysis

INORGANIC DATA REPORTING SHEET
Prepared for:
Versar, Inc.
By:
Envirosystems, Inc.

Project: PACOE Reservoirs

Site Location: Cape May, NJ

				Parameter
				Phosphorus
			Method:	325.5
			Analysis Date	8/11/97
			Units:	mg/L
Client ID	Lab ID	Date Samp.	Date Rec.	
LL-01-07-31-97	97071617	7/31/97	7/31/97	0.0756
LL-01-07-31-97	97071617 MS			0.618
LL-01-07-31-97	97071617 DUP			0.0698
LL-02-07-31-97	97071618	7/31/97	7/31/97	0.0441 J
SPW-04-07-31-97	97071619	7/31/97	7/31/97	0.221
SPW-05-07-31-97	97071620	7/31/97	7/31/97	0.332
LPW-08-07-31-97	97071621	7/31/97	7/31/97	0.100
LPE-10-07-31-97	97071622	7/31/97	7/31/97	0.204
NC-12-07-31-97	97071623	7/31/97	7/31/97	0.351
Lab Blank				<0.050
Blank Spike (LCS)				0.547
Blank Spike Recovery				109.4%
Matrix Spike Recovery				123.6%

J - Estimated Value Below the Detection Limit.

BLUE MARSH LABORATORY, INC.

85 Benjamin Franklin Highway
Douglassville, PA 19518
Phone (610) 327-8196
FAX (610) 327-6864

Certifications:
NJ DEPE Cert #77925
PA DEP Cert #06-409

Client Information:		Lot No:	1843
Versar, Inc. 9200 Rumsey Road Columbia, MD 21045-1934		Number of Samples:	7
		Date Submitted:	01-Aug-97
Attn: Fred Kelley		Sample Matrix:	Water

Sample Information:

Project: PHILLY CORPS
PACOE RESERVOIRS: CAPE MAY WQ
Project No: 3353-013
Date Sampled: 07/31/97
Sampled by: Frederick S. Kelley

Lab ID:	Sample ID:	Total Coliform	Fecal Coliform
9708-6372	LL-01-07-31-97	30.	11.
9708-6373	LL-02-07-31-97	30.	8.
9708-6374	SPW-04-07-31-97	1600.	240.
9708-6375	SPW-05-07-31-97	50.	50.
9708-6376	LPW-08-07-31-97	8.	4.
9708-6377	LPE-10-07-31-97	50.	50.
9708-6378	NC-12-07-31-97	1600.	500.
EPA Method Used:		SM 9221B	SM 9221E
Practical Quantitation Limit:		2./100. ml	2./100. ml

All results are expressed in colonies/100. ml.

Reviewed and Approved by:

Michael J. McKenna, Laboratory Director

This report is intended to be reproduced in its entirety only. The results in this report apply to only the sample(s) submitted and analyzed.

Versar INC.

SPRING SAMPLING

LABORATORY ANALYSIS CERTIFICATES

KEMRON Environmental Services
109 Starlite Park
Marietta, Ohio 45750

Phone: (614) 373-4071

Versar, Inc.
9200 Rumsey Road
Columbia, MD 21045-1934

Attn: William Burton

Login #: 97-05-031
Date Received: 05/02/97
Date Completed: 05/21/97
Date Reported: 05/21/97 14:40
Work ID: LOWER CAPE MAY

Client Code: VERSAR-MD-331

SAMPLE IDENTIFICATION

Sample Number	Sample Description	Sample Number	Sample Description
01	LL-01-05-01-97	02	LL-02-05-01-97
03	LL-03-05-01-97	04	SPW-04-05-01-97
05	SPW-05-05-01-97	06	SPW-06-05-01-97
07	LPW-07-05-01-97	08	LPW-08-05-01-97
09	LPE-09-05-01-97	10	LPE-10-05-01-97

All results for soils/sludges are reported on a dry weight basis, where applicable, unless otherwise specified. This report shall not be reproduced, except in full, without the prior written approval of KEMRON.

Certified by
Deanna Hesson

KEMRON ENVIRONMENTAL SERVICES
RESULTS BY SAMPLE

This is to certify that the following samples were analyzed using good laboratory practices to show the following results.

SAMPLE ID: **01** **LL-01-05-01-97** Collected: **05/01/97 1230** Category: **Soil**

TEST DESCRIPTION	RESULT	REPORTING LIMIT	UNITS	DATE ANALYZED	BY	METHOD
Nitrogen, Ammonia	300	25	mg/kg	05/07/97	DIH	350.1
Nitrogen, Nitrite	ND	0.50	mg/kg	05/06/97	SCM	354.1
Percent Solids	8	1	% wt.	05/05/97	SCM	D2216-90
Phosphorus, Total	300	31	mg/kg	05/12/97	RJS	365.2
Nitrogen, Nitrate	ND, (A)	6.3	mg/kg			300M
Nitrogen, Total Kjeldahl	13000(A)	50	mg/kg			351.2

SAMPLE ID: **02** **LL-02-05-01-97** Collected: **05/01/97 1240** Category: **Soil**

TEST DESCRIPTION	RESULT	REPORTING LIMIT	UNITS	DATE ANALYZED	BY	METHOD
Nitrogen, Ammonia	240	29	mg/kg	05/07/97	DIH	350.1
Nitrogen, Nitrite	ND	0.57	mg/kg	05/06/97	SCM	354.1
Percent Solids	7	1	% wt.	05/05/97	SCM	D2216-90
Phosphorus, Total	370	36	mg/kg	05/12/97	RJS	365.2
Nitrogen, Nitrate	8.86(A)	7.1	mg/kg			300M
Nitrogen, Total Kjeldahl	14000(A)	57	mg/kg			351.2

SAMPLE ID: **03** **LL-03-05-01-97** Collected: **05/01/97 1235** Category: **Soil**

TEST DESCRIPTION	RESULT	REPORTING LIMIT	UNITS	DATE ANALYZED	BY	METHOD
Nitrogen, Ammonia	230	29	mg/kg	05/07/97	DIH	350.1
Nitrogen, Nitrite	ND	0.57	mg/kg	05/06/97	SCM	354.1
Percent Solids	7	1	% wt.	05/05/97	SCM	D2216-90
Phosphorus, Total	360	36	mg/kg	05/12/97	RJS	365.2
Nitrogen, Nitrate	ND, (A)	7.1	mg/kg			300M
Nitrogen, Total Kjeldahl	15000(A)	57	mg/kg			351.2

SAMPLE ID: **04** **SPW-04-05-01-97** Collected: **05/01/97 1110** Category: **Soil**

TEST DESCRIPTION	RESULT	REPORTING LIMIT	UNITS	DATE ANALYZED	BY	METHOD
Nitrogen, Ammonia	8.2	3.3	mg/kg	05/07/97	DIH	350.1
Nitrogen, Nitrite	ND	0.066	mg/kg	05/06/97	SCM	354.1
Percent Solids	61	1	% wt.	05/05/97	SCM	D2216-90
Phosphorus, Total	46	4.1	mg/kg	05/12/97	RJS	365.2
Nitrogen, Nitrate	ND, (A)	0.82	mg/kg			300M
Nitrogen, Total Kjeldahl	440(A)	6.6	mg/kg			351.2

SAMPLE ID: **05** **SPW-05-05-01-97** Collected: **05/01/97 1125** Category: **Soil**

TEST DESCRIPTION	RESULT	REPORTING LIMIT	UNITS	DATE ANALYZED	BY	METHOD
Nitrogen, Ammonia	ND	4.0	mg/kg	05/07/97	DIH	350.1

NOTES AND DEFINITIONS:

ND = Not detected at or above the reporting limit
(A) = See the report narrative

SAMPLE ID: **05** **SPW-05-05-01-97** Collected: **05/01/97 1125** Category: **Soil**

TEST DESCRIPTION	RESULT	REPORTING LIMIT	UNITS	DATE ANALYZED	BY	METHOD
Nitrogen, Nitrite	ND	0.080	mg/kg	05/06/97	SCM	354.1
Percent Solids	50	1	% wt.	05/05/97	SCM	D2216-90
Phosphorus, Total	58	5.0	mg/kg	05/12/97	RJS	365.2
Nitrogen, Nitrate	ND, (A)	1.0	mg/kg			300M
Nitrogen, Total Kjeldahl	820(A)	8.0	mg/kg			351.2

SAMPLE ID: **06** **SPW-06-05-01-97** Collected: **05/01/97 1130** Category: **Soil**

TEST DESCRIPTION	RESULT	REPORTING LIMIT	UNITS	DATE ANALYZED	BY	METHOD
Nitrogen, Ammonia	7.7	3.8	mg/kg	05/07/97	DIH	350.1
Nitrogen, Nitrite	ND	0.077	mg/kg	05/06/97	SCM	354.1
Percent Solids	52	1	% wt.	05/05/97	SCM	D2216-90
Phosphorus, Total	56	4.8	mg/kg	05/12/97	RJS	365.2
Nitrogen, Nitrate	ND, (A)	0.96	mg/kg			300M
Nitrogen, Total Kjeldahl	1000(A)	7.7	mg/kg			351.2

SAMPLE ID: **07** **LPW-07-05-01-97** Collected: **05/01/97 1000** Category: **Soil**

TEST DESCRIPTION	RESULT	REPORTING LIMIT	UNITS	DATE ANALYZED	BY	METHOD
Nitrogen, Ammonia	100	33	mg/kg	05/07/97	DIH	350.1
Nitrogen, Nitrite	ND	0.67	mg/kg	05/06/97	SCM	354.1
Percent Solids	6	1	% wt.	05/05/97	SCM	D2216-90
Phosphorus, Total	420	42	mg/kg	05/12/97	RJS	365.2
Nitrogen, Nitrate	ND, (A)	8.3	mg/kg			300M
Nitrogen, Total Kjeldahl	20000(A)	67	mg/kg			351.2

SAMPLE ID: **08** **LPW-08-05-01-97** Collected: **05/01/97 1010** Category: **Soil**

TEST DESCRIPTION	RESULT	REPORTING LIMIT	UNITS	DATE ANALYZED	BY	METHOD
Nitrogen, Ammonia	160	40	mg/kg	05/07/97	DIH	350.1
Nitrogen, Nitrite	ND	0.80	mg/kg	05/06/97	SCM	354.1
Percent Solids	5	1	% wt.	05/05/97	SCM	D2216-90
Phosphorus, Total	500	50	mg/kg	05/12/97	RJS	365.2
Nitrogen, Nitrate	ND, (A)	10	mg/kg			300M
Nitrogen, Total Kjeldahl	20000(A)	80	mg/kg			351.2

SAMPLE ID: **09** **LPE-09-05-01-97** Collected: **05/01/97 1015** Category: **Soil**

TEST DESCRIPTION	RESULT	REPORTING LIMIT	UNITS	DATE ANALYZED	BY	METHOD
Nitrogen, Ammonia	220	40	mg/kg	05/07/97	DIH	350.1
Nitrogen, Nitrite	ND	0.80	mg/kg	05/06/97	SCM	354.1
Percent Solids	5	1	% wt.	05/05/97	SCM	D2216-90
Phosphorus, Total	560	50	mg/kg	05/12/97	RJS	365.2
Nitrogen, Nitrate	ND, (A)	10	mg/kg			300M
Nitrogen, Total Kjeldahl	20000(A)	80	mg/kg			351.2

NOTES AND DEFINITIONS:

ND = Not detected at or above the reporting limit
(A) = See the report narrative

KEMRON ENVIRONMENTAL SERVICES
RESULTS BY SAMPLE

SAMPLE ID: **10** **LPE-10-05-01-97** Collected: **05/01/97 1020** Category: **Soil**

TEST DESCRIPTION	RESULT	REPORTING LIMIT	UNITS	DATE ANALYZED	BY	METHOD
Nitrogen, Ammonia	250	33	mg/kg	05/07/97	DIH	350.1
Nitrogen, Nitrite	ND	0.67	mg/kg	05/06/97	SCM	354.1
Percent Solids	6	1	% wt.	05/05/97	SCM	D2216-90
Phosphorus, Total	430	42	mg/kg	05/12/97	RJS	365.2
Nitrogen, Nitrate	ND, (A)	8.3	mg/kg			300M
Nitrogen, Total Kjeldahl	15000 (A)	67	mg/kg			351.2

NOTES AND DEFINITIONS:

ND = Not detected at or above the reporting limit
(A) = See the report narrative

Order #97-05-031
May 21, 1997 14:40

KEMRON ENVIRONMENTAL SERVICES
REPORT NARRATIVE

(NITRATE, TOTAL KJELDAHL NITROGEN) A = Analysis performed by General Engineering Laboratories.

KEMRON ANALYST LIST

Ohio Valley Laboratory

05/07/97

AJS - - Ashlee J. Scott
ALC - - Ann L. Clark
BWH - - Ben W. Haynes
CEB - - Chad E. Barnes
CMS - - Crystal M. Stevens
DIH - - Deanna I. Hesson
DJP - - Douglas J. Poling
DLP - - Dorothy L. Payne
DST - - Dennis S. Tepe
ECL - - Eric C. Lawson
EDG - - Eric D. Gerkin
ENH - - E. Nick Hamner
FEH - - Fay E. Harmon
FRM - - Fred R. Montgomery
GWH - - George W. Hutchison
HV - - Hema Vilasagar
JEC - - Jesse E. Chapman
JKM - - June K. Morris
JLI - - Janice L. Inghram
JMM - - Jim M. Monk
JWR - - John W. Richards
JYH - - Ji Y. Hu
KHA - - Kim H. Archer
KMM - - Kevin M. McDonald
KPO - - Kevin P. Overstreet
KRA - - Kathy R. Albertson
LMW - - Lisa M. Wagner
MBJ - - Matthew B. Jarrell
MDA - - Mike D. Albertson
MDC - - Michael D. Cochran
MES - - Mary E. Schiling
MLS - - Michael L. Schimmel
MMB - - Maren M. Beery
RDC - - Rebecca D. Cutlip
REB - - Russell E. Burton
REF - - Ron E. Fertile
REK - - Robert E. Kyer
RJS - - Rick J. Santos
RWC - - Rodney W. Campbell
SCM - - Susan C. Moellendick
SCW - - Stephen C. West
SLT - - Stephanie L. Tepe
SPL - - Steve P. Learn
TLD - - Teresa L. Davis
VC - - Vicki Collier
WCD - - Wade C. Dawson

INORGANIC QA/QC

Kemron
ENVIRONMENTAL SERVICES

KEMRON ENVIRONMENTAL SERVICES
OHIO VALLEY LABORATORY
QUALITY CONTROL SUMMARY

WORKGROUP:	wg22747	RUN DATE:	5/12/97
METHOD:	365.2	ANALYST:	rjs
MATRIX:	soil	DUPLICATE:	05-031-10
UNITS:	mg/kg	SPIKE:	05-031-10

			CONCENTRATION PPM							PERCENT RECOVERY						PERCENT RPD	
ANALYTE	RDL	Blank	T-LCS	LCS	REP1	REP2	SAMPLE RESULT	T-MS	MS	LCS	LCS LCL	LCS UCL	MS	MS LCL	MS UCL	REP RPD	RPD UCL
Phosphorus	2.50	ND	50.00	46.21	26.00	27.00	25.73	20.00	45.89	92.4	75.0	125.0	100.8	75.0	125.0	3.77	20.00

NOTES & DEFINITIONS :
RDL = REPORTING DETECTION LIMIT
DL = DILUTED OUT
NA = NOT APPLICABLE
ND = NOT DETECTED
ND = NOT REQUIRED

LCS = LABORATORY CONTROL SAMPLE
T- LCS = TRUE VALUE OF LCS
REP1 = UNSPIKED SAMPLE REPLICATE 1
REP2 = UNSPIKED SAMPLE REPLICATE 2
SAMPLE RESULT = CONCENTRATION OF UNSPIKED MATRIX
T-MS = TRUE VALUE OF MATRIX SPIKE
MS = MATRIX SPIKE
LCL = LOWER CONTROL LIMIT
UCL = UPPER CONTROL LIMIT

REP RPD = RELATIVE PERCENT DIFFERENCE OF SAMPLE REPLICATES

KEMRON ENVIRONMENTAL SERVICES
OHIO VALLEY LABORATORY
QUALITY CONTROL SUMMARY

WORKGROUP: wg22585
METHOD: 350.1
MATRIX: Soil
UNITS: mg/Kg

RUN DATE: 5/7/97
ANALYST: dih
DUPLICATE: 05-031-02
SPIKE: 05-031-02

			CONCENTRATION PPM							PERCENT RECOVERY						PERCENT RPD	
ANALYTE	RDL	Blank	T-LCS	LCS	REP1	REP2	SAMPLE RESULT	T-MS	MS	LCS	LCS LCL	LCS UCL	MS	MS LCL	MS UCL	REP RPD	RPD UCL
Ammonia - Soil	2.00	ND	40.00	40.30	17.00	16.00	16.98	20.00	35.25	100.75	81.00	119.00	91.35	75.00	125.00	6.06	20.00

NOTES & DEFINITIONS :
RDL = REPORTING DETECTION LIMIT
DL = DILUTED OUT
NA = NOT APPLICABLE
ND = NOT DETECTED

LCS = LABORATORY CONTROL SAMPLE
T- LCS = TRUE VALUE OF LCS
REP1 = UNSPIKED SAMPLE REPLICATE 1
REP2 = UNSPIKED SAMPLE REPLICATE 2
SAMPLE RESULT = CONCENTRATION OF UNSPIKED MATRIX
T-MS = TRUE VALUE OF MATRIX SPIKE
MS = MATRIX SPIKE
LCL = LOWER CONTROL LIMIT
UCL = UPPER CONTROL LIMIT

REP RPD = RELATIVE PERCENT DIFFERENCE OF SAMPLE REPLICATES

KEMRON ENVIRONMENTAL SERVICES
OHIO VALLEY LABORATORY
QUALITY CONTROL SUMMARY

WORKGROUP:	wg22546	RUN DATE:	5/6/97
METHOD:	354 1	ANALYST:	scm
MATRIX:	water	DUPLICATE:	05-031-10
UNITS:	mg/l	SPIKE:	05-031-08

			CONCENTRATION PPM							PERCENT RECOVERY						PERCENT RPD	
ANALYTE	RDL	Blank	T-LCS	LCS	REP1	REP2	SAMPLE RESULT	T-MS	MS	LCS	LCS LCL	LCS UCL	MS	MS LCL	MS UCL	REP RPD	RPD UCL
Nitrite	0.04	ND	0.40	0.388	ND	ND	0.02	0.400	0.41	97.0	81.5	105.6	98.7	75.0	125.0	NA	2.50

NOTES & DEFINITIONS :
RDL = REPORTING DETECTION LIMIT
DL = DILUTED OUT
NA = NOT APPLICABLE
ND = NOT DETECTED

LCS = LABORATORY CONTROL SAMPLE
T- LCS = TRUE VALUE OF LCS
REP1 = UNSPIKED SAMPLE REPLICATE 1
REP2 = UNSPIKED SAMPLE REPLICATE 2
SAMPLE RESULT = CONCENTRATION OF UNSPIKED MATRIX
T-MS = TRUE VALUE OF MATRIX SPIKE
MS = MATRIX SPIKE
LCL = LOWER CONTROL LIMIT
UCL = UPPER CONTROL LIMIT

REP RPD = RELATIVE PERCENT DIFFERENCE OF SAMPLE REPLICATES

KEMRON
ENVIRONMENTAL SERVICES

86021

CHAIN-OF-CUSTODY RECORD

Sediment

Page _____ of _____.

Project Contact: William Burton (410) 740-6086

Turn Around Requirements: 10-14 days

Project No.:

Project Name: Lower Cape May

Sampler (print): Frederick S. Kelley

Signature: Frederick S. Kelley

Sample I.D. No.	Comp*	Grab	Date	Time	Protocol CWA	Protocol SW846	NUMBER OF SAMPLES	Hold	NO_2, NH_3	T-Phos, TKN, NO_3	ADDITIONAL REQUIREMENTS
LL-01-05-01-97		1	5-1-97	12:30					1	1	
LL-02-05-01-97		1		12:40					1	1	(*)
LL-03-05-01-97		1		12:35					1	1	(*)
SPW-04-05-01-97		1		11:10					1	1	
SPW-05-05-01-97		1		11:25					1	1	
SPW-06-05-01-97		1		11:30					1	1	(*)
LPW-07-05-01-97		1		10:00					1	1	
LPW-08-05-01-97		1		10:10					1	1	
LPE-09-05-01-97		1		10:15					1	1	
LPE-10-05-01-97		1		10:20					1	1	

(*) (1) Jar rec'd broken

Relinquished by: (Signature)	Date	Time	Received by: (Signature)	Relinquished by: (Signature)	Date	Time	Received by: (Signature)
Fred Kelley	5/1/97	1536					

Relinquished by: (Signature)	Date	Time	Received for Laboratory by: (Signature)	Date	Time	Remarks:
			Glenda Gregory	5/2/97	930	C of C Sealed Cooler Temp 10.0

*Homogenize all composite samples prior to analysis

White – Lab Yellow – Office Pink – Field

WORK ORDER #: L9705031 Client: Vers- MD SAMPLE #: 01-10 PAGE: 1

AMPLE	TESTS	REASON	REMOVED BY (ADT)	REMOVED FROM	MOVED TO	RELIQ. BY	RET'D BY (ADT)	RET'D TO	REC'D BY	REASON
1-10	NO3/ TKN	Subbed Out	Big 5/6/97@1500	Log-In	Gen. Eng. Lab	JKW	—	—	—	—
1-10	NO_2, PCT-S	ANAL	scm/5/5/0940/97	WALK IN	WET L.	Big	scm/5/5/1100/97 SM 5/5	WALK IN ~~ARCHIVE~~	CS	WALK IN ~~ARCHIVE~~ SM 5/5
1-10	PHOS NH_3	TEST	RJS/05/06/97/0806	Walk-In	Wet Lab	Big	RJS/05/06/97/1150	Archive	Big	Archive
1-10	PHOS	Reanalyze	RJS/05/12/97/0814	Archive	Wet Lab	Big	RJS/05/12/97/1630	Archive	Big	Archive

KEMRON ENVIRONMENTAL SERVICES
RESULTS BY SAMPLE

This is to certify that the following samples were analyzed using good laboratory practices to show the following results.

SAMPLE ID: **01** **LL-01-05-01-97** Collected: **05/01/97 1230** Category: **Water**

TEST DESCRIPTION	RESULT	REPORTING LIMIT	UNITS	DATE ANALYZED	BY	METHOD
Nitrogen, Ammonia	0.30	0.10	mg/L	05/07/97	DIH	350.1
Nitrogen, Nitrate	ND	0.050	mg/L	05/09/97	REB	353.2
Nitrogen, Nitrite	ND, (A)	0.010	mg/L	05/02/97	SCM	354.1
Nitrogen, Total Kjeldahl	0.90	0.10	mg/L	05/09/97	REB	351.2

SAMPLE ID: **02** **LL-02-05-01-97** Collected: **05/01/97 1240** Category: **Water**

TEST DESCRIPTION	RESULT	REPORTING LIMIT	UNITS	DATE ANALYZED	BY	METHOD
Nitrogen, Ammonia	ND	0.10	mg/L	05/07/97	DIH	350.1
Nitrogen, Nitrate	ND	0.050	mg/L	05/09/97	REB	353.2
Nitrogen, Nitrite	ND, (A)	0.010	mg/L	05/02/97	SCM	354.1
Nitrogen, Total Kjeldahl	0.90	0.10	mg/L	05/09/97	REB	351.2

SAMPLE ID: **03** **SPW-04-05-01-97** Collected: **05/01/97 1110** Category: **Water**

TEST DESCRIPTION	RESULT	REPORTING LIMIT	UNITS	DATE ANALYZED	BY	METHOD
Nitrogen, Ammonia	ND	0.10	mg/L	05/07/97	DIH	350.1
Nitrogen, Nitrate	ND	0.050	mg/L	05/09/97	REB	353.2
Nitrogen, Nitrite	ND, (A)	0.010	mg/L	05/02/97	SCM	354.1
Nitrogen, Total Kjeldahl	2.0	0.10	mg/L	05/09/97	REB	351.2

SAMPLE ID: **04** **SPW-05-05-01-97** Collected: **05/01/97 1125** Category: **Water**

TEST DESCRIPTION	RESULT	REPORTING LIMIT	UNITS	DATE ANALYZED	BY	METHOD
Nitrogen, Ammonia	ND	0.10	mg/L	05/07/97	DIH	350.1
Nitrogen, Nitrate	ND	0.050	mg/L	05/09/97	REB	353.2
Nitrogen, Nitrite	ND, (A)	0.010	mg/L	05/02/97	SCM	354.1
Nitrogen, Total Kjeldahl	1.5	0.10	mg/L	05/09/97	REB	351.2

SAMPLE ID: **05** **LPW-07-05-01-97** Collected: **05/01/97 1000** Category: **Water**

TEST DESCRIPTION	RESULT	REPORTING LIMIT	UNITS	DATE ANALYZED	BY	METHOD
Nitrogen, Ammonia	ND	0.10	mg/L	05/07/97	DIH	350.1
Nitrogen, Nitrate	ND	0.050	mg/L	05/09/97	REB	353.2
Nitrogen, Nitrite	ND, (A)	0.010	mg/L	05/02/97	SCM	354.1
Nitrogen, Total Kjeldahl	1.2	0.10	mg/L	05/09/97	REB	351.2

NOTES AND DEFINITIONS:

ND = Not detected at or above the reporting limit
(A) = See the report narrative

KEMRON ENVIRONMENTAL SERVICES
RESULTS BY SAMPLE

SAMPLE ID: **06** **LPE-09-05-01-97** Collected: **05/01/97 1015** Category: **Water**

TEST DESCRIPTION	RESULT	REPORTING LIMIT	UNITS	DATE ANALYZED	BY	METHOD
Nitrogen, Ammonia	ND	0.10	mg/L	05/07/97	DIH	350.1
Nitrogen, Nitrate	ND	0.050	mg/L	05/09/97	REB	353.2
Nitrogen, Nitrite	ND, (A)	0.010	mg/L	05/02/97	SCM	354.1
Nitrogen, Total Kjeldahl	1.9	0.10	mg/L	05/09/97	REB	351.2

NOTES AND DEFINITIONS:

ND = Not detected at or above the reporting limit
(A) = See the report narrative

Order #97-05-028
May 12, 1997 16:38

KEMRON ENVIRONMENTAL SERVICES
REPORT COMMENTS

(NITRITE) A = The LCS associated with this batch was above the statistically determined limits of 82-106%. These limits are extremely tight. All other associated Quality control samples were acceptable. We do not feel the validity of the reported results have been affected.

KEMRON ANALYST LIST

Ohio Valley Laboratory

05/07/97

AJS - - Ashlee J. Scott
ALC - - Ann L. Clark
BWH - - Ben W. Haynes
CEB - - Chad E. Barnes
CMS - - Crystal M. Stevens
DIH - - Deanna I. Hesson
DJP - - Douglas J. Poling
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DST - - Dennis S. Tepe
ECL - - Eric C. Lawson
EDG - - Eric D. Gerkin
ENH - - E. Nick Hamner
FEH - - Fay E. Harmon
FRM - - Fred R. Montgomery
GWH - - George W. Hutchison
HV - - Hema Vilasagar
JEC - - Jesse E. Chapman
JKM - - June K. Morris
JLI - - Janice L. Inghram
JMM - - Jim M. Monk
JWR - - John W. Richards
JYH - - Ji Y. Hu
KHA - - Kim H. Archer
KMM - - Kevin M. McDonald
KPO - - Kevin P. Overstreet
KRA - - Kathy R. Albertson
LMW - - Lisa M. Wagner
MBJ - - Matthew B. Jarrell
MDA - - Mike D. Albertson
MDC - - Michael D. Cochran
MES - - Mary E. Schiling
MLS - - Michael L. Schimmel
MMB - - Maren M. Beery
RDC - - Rebecca D. Cutlip
REB - - Russell E. Burton
REF - - Ron E. Fertile
REK - - Robert E. Kyer
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RWC - - Rodney W. Campbell
SCM - - Susan C. Moellendick
SCW - - Stephen C. West
SLT - - Stephanie L. Tepe
SPL - - Steve P. Learn
TLD - - Teresa L. Davis
VC - - Vicki Collier
WCD - - Wade C. Dawson

INORGANIC QA/QC

KEMRON
ENVIRONMENTAL SERVIC

KEMRON ENVIRONMENTAL SERVICES
OHIO VALLEY LABORATORY
QUALITY CONTROL SUMMARY

WORKGROUP: wg22678
METHOD: 353 2
MATRIX: Water
UNITS: mg/L

RUN DATE: 5/9/97
ANALYST: reb
DUPLICATE: 05-095-01
SPIKE: 05-095-01

			CONCENTRATION PPM							PERCENT RECOVERY						PERCENT RPD	
ANALYTE	RDL	Blank	T-LCS	LCS	REP1	REP2	SAMPLE RESULT	T-MS	MS	LCS	LCS LCL	LCS UCL	MS	MS LCL	MS UCL	REP RPD	RPD UCL
Nitrate	0.05	ND	1.000	0.971	1.400	1.400	1.375	0.500	1.860	97.10	90.30	114.30	97.00	75.00	125.00	0.00	17.20

NOTES & DEFINITIONS :
RDL = REPORTING DETECTION LIMIT
DL = DILUTED OUT
NA = NOT APPLICABLE
ND = NOT DETECTED

LCS = LABORATORY CONTROL SAMPLE
T- LCS = TRUE VALUE OF LCS
REP1 = UNSPIKED SAMPLE REPLICATE 1
REP2 = UNSPIKED SAMPLE REPLICATE 2
SAMPLE RESULT = CONCENTRATION OF UNSPIKED MATRIX
T-MS = TRUE VALUE OF MATRIX SPIKE
MS = MATRIX SPIKE
LCL = LOWER CONTROL LIMIT
UCL = UPPER CONTROL LIMIT

REP RPD = RELATIVE PERCENT DIFFERENCE OF SAMPLE REPLICATES

KEMRON ENVIRONMENTAL SERVICES
OHIO VALLEY LABORATORY
QUALITY CONTROL SUMMARY

WORKGROUP:	wg22674	RUN DATE:	5/9/97
METHOD:	351.2	ANALYST:	reb
MATRIX:	water	DUPLICATE:	05-095-01
UNITS:	mg/l	SPIKE:	05-095-01

			CONCENTRATION PPM							PERCENT RECOVERY						PERCENT RPD	
ANALYTE	RDL	Blank	T-LCS	LCS	REP1	REP2	SAMPLE RESULT	T-MS	MS	LCS	LCS LCL	LCS UCL	MS	MS LCL	MS UCL	REP RPD	RPD UCL
TKN	0.10	ND	1.00	0.929	3.80	3.98	3.79	0.50	4.32	92.9	75.0	125.0	106.0	75.0	125.0	4.63	20.00

NOTES & DEFINITIONS

RDL = REPORTING DETECTION LIMIT
DL = DILUTED OUT
NA = NOT APPLICABLE
ND = NOT DETECTED

LCS = LABORATORY CONTROL SAMPLE
T- LCS = TRUE VALUE OF LCS
REP1 = UNSPIKED SAMPLE REPLICATE 1
REP2 = UNSPIKED SAMPLE REPLICATE 2
SAMPLE RESULT = CONCENTRATION OF UNSPIKED MATRIX
T-MS = TRUE VALUE OF MATRIX SPIKE
MS = MATRIX SPIKE
LCL = LOWER CONTROL LIMIT
UCL = UPPER CONTROL LIMIT

REP RPD = RELATIVE PERCENT DIFFERENCE OF SAMPLE REPLICATES

KEMRON ENVIRONMENTAL SERVICES
OHIO VALLEY LABORATORY
QUALITY CONTROL SUMMARY

WORKGROUP:	wg22584	RUN DATE:	5/7/97
METHOD:	350.1	ANALYST:	dih
MATRIX:	Water	DUPLICATE:	05-017-01
UNITS:	mg/L	SPIKE:	05-020-01

			CONCENTRATION PPM							PERCENT RECOVERY						PERCENT RPD	
ANALYTE	RDL	Blank	T-LCS	LCS	REP1	REP2	SAMPLE RESULT	T-MS	MS	LCS	LCS LCL	LCS UCL	MS	MS LCL	MS UCL	REP RPD	RPD UCL
Ammonia-Dist	0.10	ND	2.000	1.700	10.000	9.700	DL	1.000	DL	85.00	75.00	108.70	DL	75.00	120.22	3.05	20.00

NOTES & DEFINITIONS :

RDL = REPORTING DETECTION LIMIT
DL = DILUTED OUT
NA = NOT APPLICABLE
ND = NOT DETECTED
NR = NOT REQUIRED

LCS = LABORATORY CONTROL SAMPLE
T- LCS = TRUE VALUE OF LCS
REP1 = UNSPIKED SAMPLE REPLICATE 1
REP2 = UNSPIKED SAMPLE REPLICATE 2
SAMPLE RESULT = CONCENTRATION OF UNSPIKED MATRIX
T-MS = TRUE VALUE OF MATRIX SPIKE
MS = MATRIX SPIKE
LCL = LOWER CONTROL LIMIT
UCL = UPPER CONTROL LIMIT

REP RPD = RELATIVE PERCENT DIFFERENCE OF SAMPLE REPLICATES

KEMRON ENVIRONMENTAL SERVICES
OHIO VALLEY LABORATORY
QUALITY CONTROL SUMMARY

WORKGROUP: wg22437
METHOD: 354 1
MATRIX: water
UNITS: mg/l

RUN DATE: 5/2/97
ANALYST: scm

ANALYTE	RDL	Blank	CONCENTRATION PPM T-LCS	LCS	REP1	REP2	SAMPLE RESULT	T-MS	MS	PERCENT RECOVERY LCS	LCS LCL	LCS UCL	MS	MS LCL	MS UCL	PERCENT RPD REP RPD	RPD UCL
Nitrite	0 01	ND	0 10	0 108	ND	ND	ND	0 100	0 09	108 0	81.5	105 6	92 0	75 0	125.0	NA	2 50

NOTES & DEFINITIONS :
RDL = REPORTING DETECTION LIMIT
DL = DILUTED OUT
NA = NOT APPLICABLE
ND = DETECTED

LCS = LABORATORY CONTROL SAMPLE
T- LCS = TRUE VALUE OF LCS
REP1 = UNSPIKED SAMPLE REPLICATE 1
REP2 = UNSPIKED SAMPLE REPLICATE 2
SAMPLE RESULT = CONCENTRATION OF UNSPIKED MATRIX
T-MS = TRUE VALUE OF MATRIX SPIKE
MS = MATRIX SPIKE
LCL = LOWER CONTROL LIMIT
UCL = UPPER CONTROL LIMIT

REP RPD = RELATIVE PERCENT DIFFERENCE OF SAMPLE REPLICATES

KEMRON
ENVIRONMENTAL SERVICES

86020

CHAIN-OF-CUSTODY RECORD

Water

Page _____ of _____.

Project Contact: William Burton

Turn Around Requirements: 10-14 days

Project No.:

Project Name: PACOE - Lower Cape May

Sampler (print): Frederick S. Kelley

Signature: Frederick S. Kelley

Sample I.D. No.	Comp*	Grab	Date	Time	Protocol CWA	Protocol SW846	NUMBER OF SAMPLES	Hold	NO_2, NO_3	NH_3	TKN	ADDITIONAL REQUIREMENTS
LL-01-05-01-97		✓	5-1-97	12:30					1	1	1	
LL-02-05-01-97		✓		12:40					1	1	1	
SPW-04-05-01-97		✓		11:10					1	1	1	
SPW-05-05-01-97		✓		11:25					1	1	1	
LPW-07-05-01-97		✓		10:00					1	1	1	
LPE-09-05-01-97		✓		10:15					1	1	1	

Relinquished by: (Signature)	Date	Time	Received by: (Signature)	Relinquished by: (Signature)	Date	Time	Received by: (Signature)
Frederick Kelley	5/1/97	1536					

Relinquished by: (Signature)	Date	Time	Received for Laboratory by: (Signature)	Date	Time	Remarks:
			Berta Gregory	5/2/97	930	C of C Sealed Sp intact/cooler Temp 3.0

*Homogenize all composite samples prior to analysis

White – Lab Yellow – Office Pink – Field

WORK ORDER #: L9705028 Client: Ver-mD SAMPLE #: 01-6 PAGE: 1

SAMPLE	TESTS	REASON	REMOVED BY (ADT)	REMOVED FROM	MOVED TO	RELIQ. BY	RET'D BY (ADT)	RET'D TO	REC'D BY	REASON
1-06	NO_2	ANAL.	SCM/5/2/1400/97	LOG IN	WET L.	Blg	SCM/5/2/1430/97	WALK IN	JKW	STORAGE
21-06	NH_3	Test	RAS/05/06/97/0807	Walk-In	Wet Lab	Blg	RAS/05/06/97/1150	Archive	Blg	archive
1-6	TKN	ANAL.	REB/05/08/0855	WALK IN	WET. Lab.	Blg	REB/05/08/0355	ARCHIVE	Blg	archive
1-6	NO3	ANAL	REB/05/09/0850	WALK IN	WET LAB	CLS	REB/05/09/1620	ARCHIVE	CLS	archive

INORGANICS DATA REPORTING SHEET
Prepared for:
Versar, Inc.
By:
Envirosystems, Inc.

				Parameter
				Total Phosphorus
			Method:	365.3
			Analysis Date	5/6/97
			Units:	mg/L
Client ID	Lab ID	Date Samp.	Date Rec.	
LL-01-05-01-97	97050737	5/1/97	5/2/97	<0.050
LL-02-05-01-97	97050738	5/1/97	5/2/97	<0.050
LL-02-05-01-97	97050738 MS			0.552
LL-02-05-01-97	97050738 DUP			<0.050
SPW-04-05-01-97	97050739	5/1/97	5/2/97	<0.050
SPW-05-05-01-97	97050740	5/1/97	5/2/97	<0.050
LPW-07-05-01-97	97050741	5/1/97	5/2/97	<0.050
LPE-09-05-01-97	97050742	5/1/97	5/2/97	<0.050
Lab Blank				<0.050
Blank Spike (LCS)				0.512
Spike Recovery MS/LCS				110%/102%

BLUE MARSH LABORATORY, INC.

85 Benjamin Franklin Highway
Douglassville, PA 19518
Phone (610) 327-8196
FAX (610) 327-6864

Certifications:
NJ DEPE Cert #77925
PA DEP Cert #06-409

Client Information:

Versar, Inc.
9200 Rumsey Road
Columbia, MD 21045-1934

Attn: William Burton

Lot No: 1027

Number of Samples: 6

Date Submitted: 02-May-97

Sample Matrix: Water

Sample Information:

Project: PHILLY CORPS
PACOE RESERVOIRS: LOWER CAPE MAY
Project No: 3353-001
Date Sampled: 05/01/97
Sampled by: Frederick S. Kelley

Lab ID:	Sample ID:	Total Coliform	Fecal Coliform
9705-3441	LL-01-05-01-97	17.	4.
9705-3442	LL-02-05-01-97	80.	50.
9705-3443	SPW-04-05-01-97	240.	22.
9705-3444	SPW-05-05-01-97	34.	11.
9705-3445	LPW-07-05-01-97	13.	4.
9705-3446	LPE-09-05-01-97	ND	ND
EPA Method Used:		SM 9221B	SM 9221E
Practical Quantitation Limit:		2./100. ml	2./100. ml

All results are expressed in colonies/100. ml.

ND = The compound indicated was not detected at or above the practical quantitation limit (P.Q.L.) listed for the method performed.

This report has been reviewed and approved by the person signed below.
The report is accurate to the best of our knowledge.

Sincerely,

Michael J. McKenna/FOS.

Michael J. McKenna
Laboratory Director

This report is intended to be reproduced in its entirety only. The results in this report apply to only the sample(s) submitted and analyzed.

COMMON REED REMOVAL WETLAND VEGETATION MANAGEMENT AND MARSH EDGE RESTORATION PLANS

Prepared for

Beth Brandreth
U.S. Army Corps of Engineers
Philadelphia District
Philadelphia, PA 19107-3390

Prepared by

Steve Harriott
Versar, Inc.
9200 Rumsey Road
Columbia, MD 21045

Contract No. DACW61-95-D-0011
Delivery Order No. 0031

Prepared Under the Supervision of
Principal Investigator

William H. Burton

May 1997

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1.0 INTRODUCTION/BACKGROUND

The U.S. Army Corps of Engineers (USACOE) has initiated an environmental study to investigate means for enhancing wetland habitat in conjunction with storm damage/dune restoration efforts planned for lower Cape May, New Jersey. The beach protection/nourishment project area is located at the southern tip of New Jersey between Cape May City and Cape May Point. Adjacent to the beach/dune restoration area is Lower Cape May Meadows, a 1.3 mile long, 350 acre area of undeveloped marsh and uplands consisting of State and Nature Conservancy owned land. The habitat within the marsh consists of a variety of cover types including beaches, dunes, brackish and freshwater marshes, open water, palustrine forested wetlands, and uplands. Lower Cape May Meadows suffers from severe long-term and storm induced erosion, which has lead to habitat degradation due to storm surges, dune erosion, salt water intrusion, and flooding from the surrounding communities of Cape May Point and West Cape May.

The USACOE is investigating several means to repair the storm damaged Atlantic coast shoreline between Cape May City and Cape May Point, including beach nourishment and dune reconstruction. As part of the shoreline protection project, the USACOE is investigating ways to improve the habitat value of the existing wetlands. The current plan is to manage the southern half of the Meadows as a freshwater marsh and a portion of the northern half as a saltwater marsh.

An important aspect of improving the habitat value of Lower Cape May Meadows is the development of a wetland vegetation management plan. Large sections of Cape May Meadows are currently colonized by common reed (*Phragmites australis*), a nuisance freshwater wetland plant known to be of poor habitat value to wildlife, and in some cases, a fire hazard. Because of its adaptivity to areas with anthropogenic disturbances, its tolerance of a wide variety of environmental conditions, and its ability to propagate either vegetatively (as individual plants fall over, they can send out new propagules and roots from nodes along the stem) or by seed, removal of common reed can be very difficult. To succeed, common reed removal projects must be approached systematically and with persistence. Therefore, a comprehensive plan needs to be developed to control and reduce stands of common reed and to establish and maintain wetland vegetation of higher value to wildlife. This plan also needs to be consistent the Nature Conservancy's management activities which includes *Phragmites* control through periodic application of herbicides.

In addition to the wetland management plan, the USACOE is planning to restore storm damaged wetlands behind the seaward dunes. Most of the existing dune system along the Lower Cape May Meadows shoreline is very narrow, steep, and insubstantial (vertical is approximately 17.5 feet NGVD, and about 10 feet wide); large sections are frequently washed away by storms (personal communication from Bob Moore, USACOE to Steve Harriott, Versar, Columbia, MD). In October 1991 an unusually large storm destroyed about 2,000 feet of dune and caused severe flooding. Severe storms also occurred in 1992, 1993, and 1994

(USACOE 1996). After the storms, the damaged sections of dune were subsequently re-built and re-planted with beach grasses by the state. During storm events the dune is overtopped by the waves and flood surges, and sand and salt water are washed into the herbaceous freshwater marshes behind the dune.

Over time, the dune overwashing has damaged the freshwater wetlands in two general ways, from filling in of the marsh edges with sand (creating upland conditions), and from altering the freshwater conditions to brackish conditions in some areas. The change in salinity in parts of the marshes has likely had detrimental effects on both freshwater vegetation and wildlife. The increased salinity in some areas of the wetlands has also apparently been exacerbated during dry summers (such as the summer of 1993). One amphibian that used to occur throughout the freshwater marshes, spring peeper, has not been heard or observed there recently for several years, apparently owing to the increasing salinity from the saltwater overtopping (USACOE 1996).

2.0 COMMON REED REMOVAL PLAN

The purpose of this plan is to provide recommendations for permanently removing as much common reed (*Phragmites australis*) as possible from the approximately 350-acre Cape May Meadows site. Based on our mapping of vegetation and land cover, about 101 acres (about 29%) of Cape May Meadows are currently colonized by common reed. The 101 acres of common reed comprises 46.4 acres of wetlands on the Nature Conservancy portion (194 acres total), and 54.8 acres of wetlands within the State Park portion (158 acres total). Other vegetation and land cover that currently exists within the Cape May Meadows site include forest, field, emergent wetland, sand/beach, and open water.

2.1 COMMON REED MAPPING

Current common reed cover was mapped through interpretation of a set of 1996 black and white vertical low-altitude aerial photographs (USACOE 1996a). In addition, the mapping was confirmed with 1997 low-altitude (approximately 100 feet above ground level) oblique color aerial photographs (TNC 1997), and field-truthing. A transparent mylar overlay was placed over the 1996 photographs, and areas possessing a dense cover of common reed were mapped onto the overlay. The common reed mapping was subsequently digitized into a GIS, and common reed areas were quantified. Results are presented in Fig. 2-1, and discussed in Section 2.4.

2.2 COMMON REED REMOVAL TECHNIQUES

Several methods have been applied in common reed removal projects, including chemical treatment with herbicide, controlled burning, physical removal by excavation, inundation of the roots with sea water (as appropriate in restored tidal situations), or a combination of these. Burning of common reed is generally not a successful removal technique by itself; it does not harm underground propagules, may actually stimulate denser growth by releasing essential nutrients back to the soil, and re-exposes the underground propagules back to sunlight (personal communication, Dr. Gary Pierce, Southern Tier Consulting, Inc. to S. Harriott, Versar, Inc.). Physical removal is impractical over large areas of wetlands, and it rarely removes all of the underground propagules, which easily become re-established in a new disturbed situation.

2.2.1 Herbicide Treatment

Proper treatment with appropriate herbicide and exposure of common reed areas to regular tidal sea water fluctuation are the most successful removal techniques for common

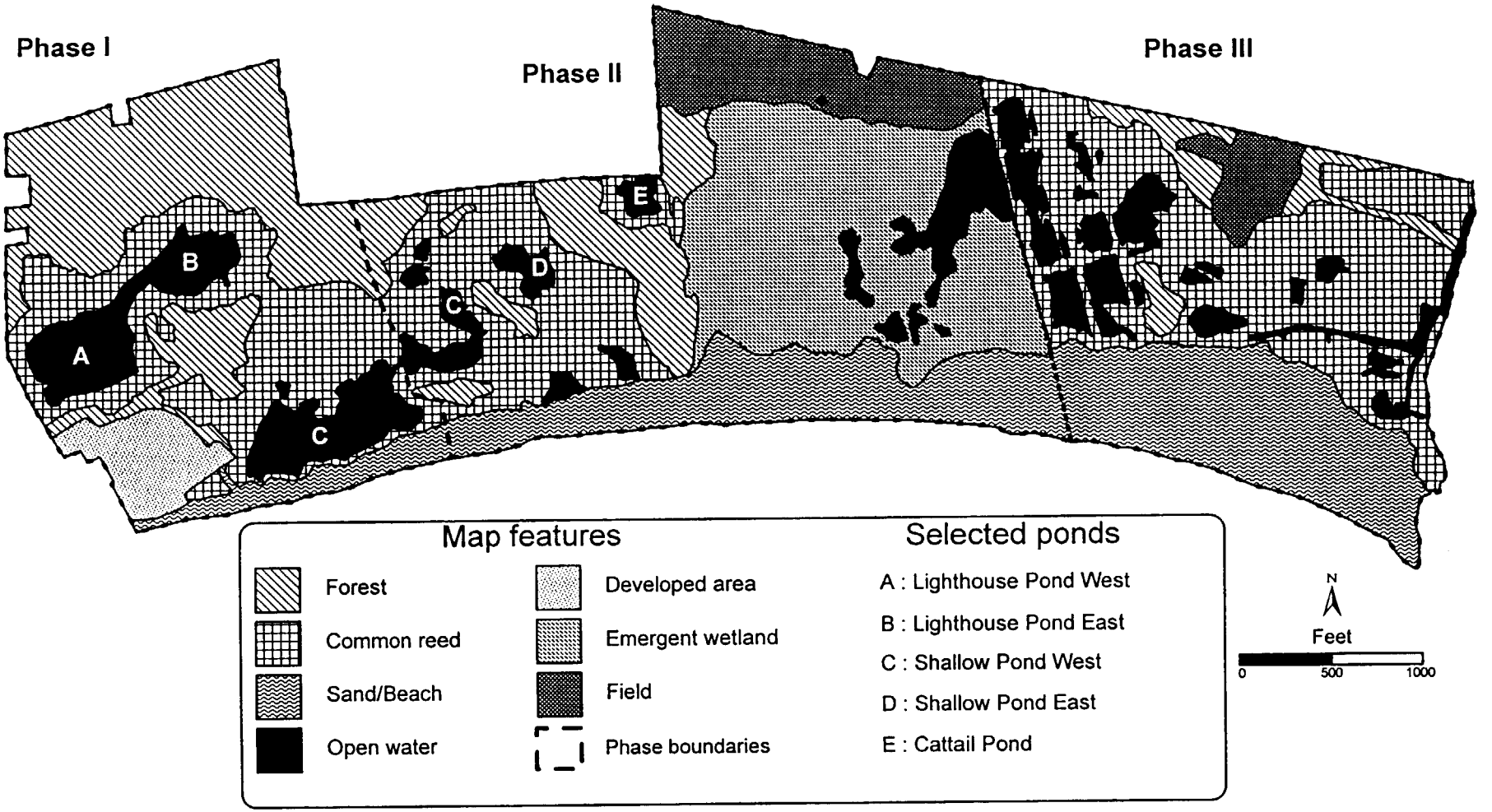

Figure 2-1. Vegetation and land cover mapping of the Lower Cape May Meadows site, Cape May County, New Jersey. Map was created from photointerpretation of 1996 vertical, low-altitude, black and white aerial photography (USACOE 1996a), and was verified and corrected by use of oblique, super-low altitude color aerial photography (TNC 1997). Three phases, corresponding to common reed removal, are also depicted (refer to text for explanation of phases).

reed (note also that flooding of common reed with fresh water is not a successful removal technique by itself, unless the plant is to be totally inundated over the winter months) (personal communication, Dr. Gary Pierce, Southern Tier, Inc., to S. Harriott, Versar). These techniques are further enhanced if common reed removal areas are re-planted with appropriate wetland vegetation to assist in shading out further common reed growth.

Several methods are available for application of herbicide on common reed; the success of each is dependent on the size of the project. All use of herbicides at the site should comply with the "no-spray" areas as mapped in this report (refer to Section 2.3). Owing either to their lack of common reed or to their ecological sensitivity, "no spray" areas should not be sprayed with herbicide (the prescription in some of these areas may be individual hand application by "painting" - see below).

Aerial application by helicopter has been successfully used on large, remote, or un-traversable sites where hand application is infeasible or impractical (helicopters are preferable to small planes owing to greater maneuverability). Because of the large aerial extent of the Lower Cape May Meadows site, it would be most efficient to divide the site into separate treatment areas and to utilize aerial application of herbicide over several growing seasons. The aerial application would be used over a majority of each of the segments. It is estimated that each aerial application could be accomplished in a segment within an 8-hour day.

Hand application of herbicide with backpack-type sprayers is effective for treatment of relatively small areas. Hand application is typically used in areas where aerial application is not feasible. It can be used in small areas as a follow up treatment where aerial spraying occurred, but additional treatment is needed. Because of its labor-intensive nature, treatment of large areas (larger than about 10 acres) with this method is not desirable, and is not recommended. On an even finer scale, common reed problem areas can also be treated by "painting" herbicide onto individual common reed plants with a paint brush. This technique may be particularly useful in areas containing vulnerable threatened and endangered plants, as previously identified (USACOE 1996b). Backback sprayers and hand-painting have been employed by The Nature Conservancy (TNC) on small areas of their part of the property, with a reasonable degree of success (personal communication, Jay Laubengeyer, TNC, to S. Harriott, Versar). TNC has not used aerial application of herbicides to date at the Lower Cape May Meadows site.

Details on site-specific plans for site herbicide use are provided in Section 2.4.

2.2.2 Conversion to Saltwater Wetlands

Wetlands at the Lower Cape May Meadows site are all currently primarily freshwater. The Corps believes that while the conversion of the affected freshwater wetlands to salt water wetlands at the site would be ecologically valuable (especially directly adjacent to the existing freshwater wetlands), their development should be limited to a relatively small area.

In this part of coastal southern New Jersey, freshwater wetlands that are directly adjacent to the ocean environment are increasingly uncommon, owing to development pressures and other anthropogenic disturbances. These freshwater wetlands provide critical habitat for a large variety of wildlife, especially migratory shorebirds and waterfowl (as well as a diverse flora). Additionally, tidal saltwater wetlands are the most abundant wetland type in southern New Jersey. For these reasons, it may be most reasonable to maintain the majority of the site as freshwater wetlands. A small section of the eastern-most part of the site, however, could be converted to tidal saltwater wetlands.

The Corps is considering several options for creating a comparatively small tidally-influenced saltwater wetland in the eastern-most part of the site (within the Nature Conservancy portion) near West Cape May. Lower Cape May Meadows drains to Cape Island Creek through a 5-foot diameter pipe, and Cape Island Creek drains to Cape May Harbor. Two potential scenarios are being considered; these are depicted in Fig. 2-2.

2.3 ESTABLISHMENT OF "NO-SPRAY" AREAS

Based on interpretation of a series of 1996 low-altitude vertical black and white aerial photographs (USACOE 1996a) "no-spray zones" were created by mapping these areas directly onto transparent mylar overlays of the photographs. The "no-spray" areas consist of sections that do not currently possess common reed, including forested areas, emergent wetlands, upland field, open water, sand/beach, and developed areas. The "no-spray" zones should be excluded from all aerial herbicide application. "No-spray zone" vegetation and land cover types are shown in Fig. 2-1 as all non-common reed parcels.

It must be noted that several areas proposed to be treated to the south of Lighthouse Pond East, Lighthouse Pond West, and Shallow Pond West contain small populations of four state-listed rare, threatened, and endangered plant species[1]. The location of these plants were mapped in the Fall of 1995 and the Spring of 1996 (USACOE 1996b); all are adjacent to the walking paths in this area. It appears that the best protection for these populations during the herbicide treatments may be to provide temporary covers (such as impermeable tarps, staked down). The covers should then be removed within several days after treatments. It is important to note that all of these species of plants of concern are state-listed only (not federal-listed) and are apparently at the edges of their natural ranges in the geographic region of the site. According to several regional plant keys (Brown and Brown 1984; Strausbaugh and Core 1977; Gleason and Cronquist 1963), populations of each of these species are evidently secure in other parts of their natural ranges. Measures should be taken to protect these plants during treatments; however, even if a few plants were to be killed due to the treatments, the overall ecological benefits of the treatments would greatly outweigh these

[1] These species include blue boneset (*Eupatorium coelestinum*), collared dodder (*Cuscuta indecora*), whorled marsh pennywort (*Hydrocotyle verticillata*), and wild crab apple (*Pyrus angustifolia*).

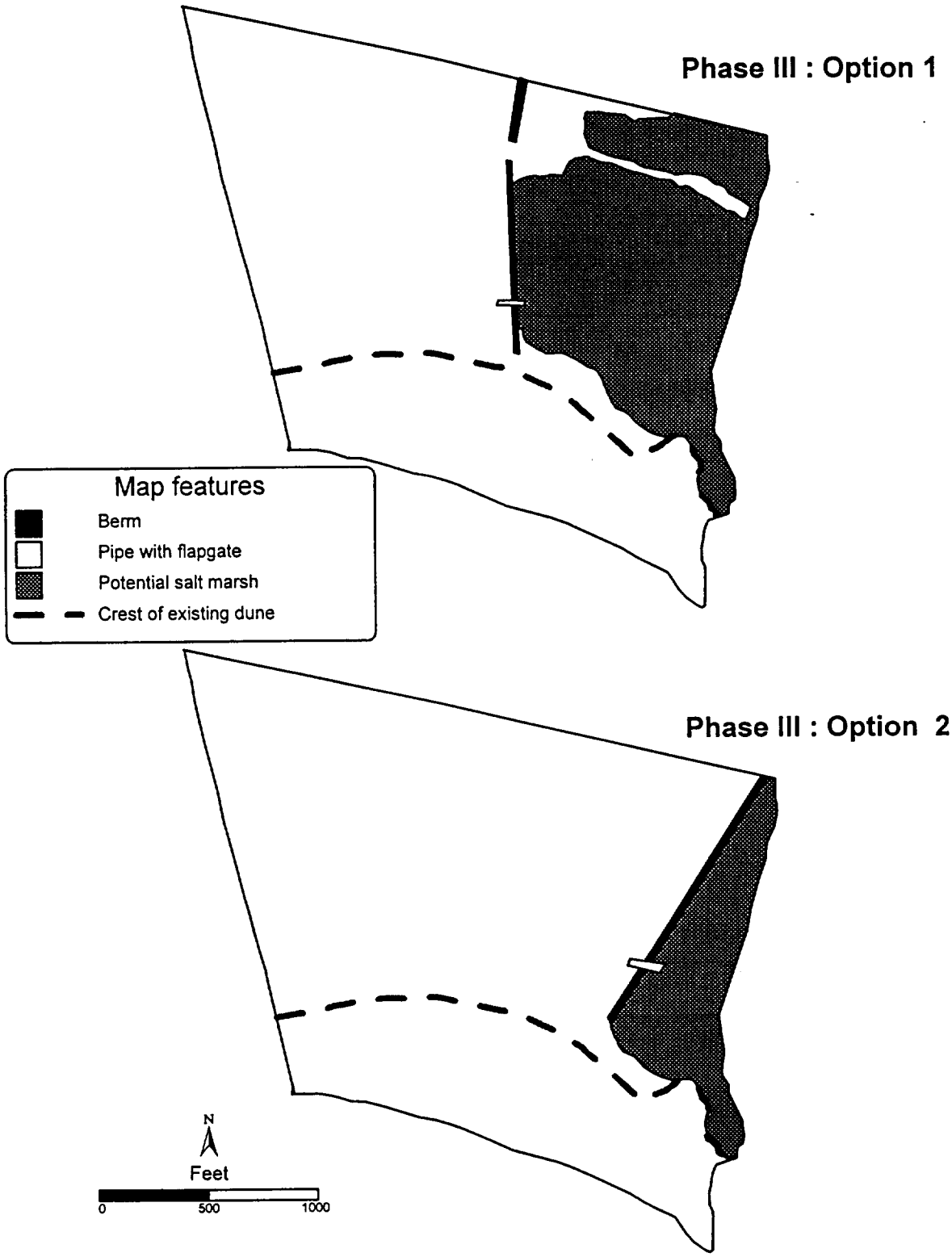

Figure 2-2. Two potential options for creation of saltwater wetlands by construction of berms within the easternmost section of the Lower Cape May Meadows site, Cape May County, New Jersey. As mapped, Option 1 could create about 27.9 acres of saltwater wetlands, while Option 2 could create about 10.6 acres of saltwater wetlands (both options would convert current common reed wetlands).

small losses. The mapped rare, threatened and endangered plants on the Nature Conservancy portion of the site are within emergent wetlands; this area is within a "no-spray" zone, and will not be treated.

2.4 SITE-SPECIFIC MANAGEMENT PLAN

Based on interpretation of the 1996 vertical aerial photographs, and with verification from the TNC 1997 color oblique photographs, there is currently a total of approximately 29.4 acres of common reed in Phase I, 25.4 acres in Phase II, and 46.4 acres in Phase III. Much of the common reed-dominated areas consist of large, dense monotypic stands without other species of vegetation.

At Lower Cape May Meadows, we recommend a program of herbicide application to the common reed over at least two growing seasons by aerial treatment (helicopter), controlled burns at the end of herbicide treatment to remove dead above-ground growth (in areas where it is safe to do so), and immediate re-planting of appropriate wetland vegetation to assist in shading out remaining common reed. This should be followed by hand application of herbicide in problem areas, and follow-up treatments, as necessary. Additionally, an option will be available to restore tidal salt water flow into a part of the eastern-most area of the Nature Conservancy portion of the property. Since this is typically such an effective means of common reed eradication, only selective hand application will be prescribed for the saltwater-flooded area (i.e., no aerial application will be prescribed).

We recommend use of a commercially available herbicide containing glyphosate (such as Rodeo®) that is relatively safe and USEPA approved to use in aquatic environments. Our method involves herbicide application in each treated area two times in one year, once in late August after most of the plants are flowering, and then again in early October to further weaken the plants (this time period is when maximum transport of sugars, and thus glyphosate, to the rhizomes is occurring for over-wintering). After the second herbicide application, controlled burns should be executed (where possible) in late winter/early spring to remove the standing dead stems, and appropriate native wetland vegetation should be planted immediately after. Small remaining areas of common reed should then be sprayed with herbicide by hand with backpack-type sprayers (or other means) over the next growing season, as necessary.

The Delaware Department of Natural Resources and Environmental Control has reported success in aerial application using Bell 47G helicopters equipped with Simple spraying systems and size 3 and 5 Raindrop nozzles. They also utilize Through Valve Booms when low herbicide drift is mandatory (personal communication, Mr. Rob Hossler, Delaware Department of Natural Resources and Environmental Control, to S. Harriott, Versar, Inc.). Care should be taken at all times to prevent overspray into "no-spray" zones (Fig. 2-1); herbicides such as Rodeo® are non-selective and will kill virtually any live vegetation they come into contact with. At no time should the herbicide be applied directly into open water or other "no-spray"

zones, during windy conditions, or when rain is forecast in the next 48 hours. All label directions should be followed when using herbicides.

Because it is such a large site, we have divided the Cape May Meadows common reed management into three separate phases, each corresponding to a distinct geographic area of the site (Fig. 2-1). Phase I would involve treatment of the area most visible to the public, including Lighthouse Ponds East and West and part of Shallow Pond West. This area extends from Lighthouse Avenue, then east to the eastern end of the main part of Shallow Pond West. Phase II would provide treatment from the western end of the smaller part of Shallow Pond West to the main north-south dirt access road in the Nature Conservancy property (properties would only be treated upon prior approval by TNC and the State Park). Phase III would provide treatment from the north-south access road east to the eastern end of the Nature Conservancy property in West Cape May.

Each of the three phases is described below.

2.4.1 Phase I

A large portion of the northwestern part of Phase I is a forested "no-spray" area. One other small forested "no-spray" area exists to the immediate east of Shallow Pond West. These areas need to be protected from all herbicide spraying. Two large parcels of common reed exist in Phase I, separated by a forested area.

The first common reed parcel is around the periphery of Lighthouse Ponds West and East. The common reed would best be treated by aerial treatment with a helicopter flying around the perimeter of the pond(s). The common reed in this parcel ranges from about 50 feet wide at its narrowest point to about 400 feet at its widest point. Several passes would probably be required by the helicopter to treat the entire area at its widest points (a narrow overlap of each of the passes is required for adequate treatment).

The second common reed parcel is essentially oriented in an east-west direction to the north of Shallow Pond West. This band of common reed is approximately 600 feet wide at its widest point and 200 feet at its narrowest point. Several narrowly-overlapping east to west flight lines could be used to treat this parcel. The outer 25 feet of common reed adjacent to all forested areas should be hand treated with backpack-type sprayers to help prevent overspray.

Based on an approximate $79.00 per acre cost for aerial application[2] (personal communication, Mr. Rob Hossler, Delaware Department of Natural Resources and Environmental Control, to S. Harriott, Versar, Inc.), it would cost $2,323.00 per treatment for the 29.4 acres of common reed within the Phase I area (Table 2-1). Initial backpack application for sensitive areas (peripheries of forest) would cost about $2,800, based on 7 man-days of labor plus materials[3]. Several subsequent follow-up spot treatments with backpack-type sprayers would cost about $2,800, based on 7 man-days of labor plus materials.

2.4.2 Phase II

Most of the common reed currently existing in the Phase II area is located in the eastern-most part, to the north and east of Shallow Pond East and Cattail Pond. Other scattered, small areas of common reed are located throughout.

The common reed in the vicinity of Shallow Pond East and Cattail Pond is approximately 500 wide at its widest point south of Cattail Pond and 100 feet wide at its narrowest point northeast of Cattail Pond. This parcel of common reed is more broken up by forested areas and open water than in Phase I. Because of the size of the common reed parcel, it would be most prudent to also aerial spray this parcel by helicopter, but much more caution should to be exercised to avoid the "no-spray" areas within the parcel. The outer 25 feet of common reed adjacent to all forested areas should be hand treated with backback-type sprayers to help prevent overspray. In addition, one small area of the common reed around the southeast periphery of Cattail Pond is directly adjacent to sensitive emergent wetlands. Aerial application should cease at least 25 feet from the edge of the emergent wetland. The rest of the common reed from this point to the edge of the emergent wetland should be hand treated with backpack-type sprayers.

Other small, scattered areas of common reed exist in the Phase II area, but are not included on Fig. 2-1 due to scale. Owing to the ecological sensitivity of the central and easternmost parts of Phase II (many of the plants of special concern at Lower Cape May Meadows exist here), these areas must be treated either with backpack-type sprayers or "painted" by hand.

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[2] Includes helicopter costs and herbicide and surfactant costs, at an applied rate of about 4 pints of herbicide per acre treated. The $79.00 per acre cost is conservative. Some field teams in Delaware have achieved a $60.00 per acre cost, but this was in 1993. Additionally, nominal one-time deployment costs could apply for use of the helicopter (personal communication, Mr. Rob Hossler, Delaware Department of Natural Resources and Environmental Control, to S. Harriott, Versar, Inc.).

[3] Outer 50-foot peripheries could be treated for approximately twice the backpack application costs listed for all phases.

Table 2-1. Estimated costs (1997 Dollars) for two herbicide treatments (note from text that at least two treatments are recommended), re-planting of common reed areas, and conversion to saltwater wetlands (Phase III area) at the Lower Cape May Meadows site. Note from the text that areas converted to saltwater wetlands under Phase III Options 1 and 2 would not be aerial-treated with herbicide. Basis for costs are explained in the text.

	Phase I **(treat 29.4 acres)**	**Phase II** **(treat 25.4 acres)**	**Phase III**** **(Option 1: treat 18.5 acres + 27.9 acres saltwater flooding)** **(Option 2: treat 35.8 acres + 10.6 acres saltwater flooding)**
Aerial Herbicide Application	$4,646	$4,014	Option 1: $2,923 Option 2: $5,656
Hand Spraying/ Backpack	$2,800	$2,800	$4,200
Follow-up Hand Treatments	$2,800	$2,800	$5,640
Plant Costs	$308,700	$266,700	$487,200
Saltwater Wetland Conversion Costs	N/A	N/A	Option 1: $117,600 Option 2: $137,600
TOTAL COSTS*	$318,946	$276,314	Option 1:$617,563 Option 2:$640,296

*Does not include some costs for materials.
**Either of the two Options under Phase III would yield a total of 46.4 acres of restored wetlands.

Based on an approximate $79.00 per acre cost for aerial application by helicopter, it would cost $2,007.00 per treatment for the 25.4 acres of common reed within the Phase II area (Table 2-1). Initial backpack application for areas around the periphery of the forests and other sensitive areas would cost about $2,800, based on 7 man-days of labor plus materials. Several subsequent follow-up spot treatments with backpack-type sprayers would cost about $2,800, based on 7 man-days of labor plus materials.

2.4.3 Phase III

The Phase III area contains the largest percentage cover of common reed of the three phases and has two options (Fig. 2-2). Much of this area is also covered by open water. One small upland field exists in the northcentral part, and several very small, scattered forested parcels exist throughout. The outer 25 feet of common reed adjacent to all of forested areas and the upland field should be hand treated with backback-type sprayers to help prevent overspray.

As discussed in Section 2.2.2, part of the easternmost portion of Phase III could be flooded with salt water, through construction of a dike. Although common reed will persist in somewhat brackish conditions, it will not ultimately survive in the highly saline environment that ocean water would provide. It is estimated that once the area is flooded in a fully tidal regime with salt water, only minor spraying with backback-type sprayers would be necessary to rid the area of common reed.

If the saltwater wetlands are created (under either Option 1 or Option 2), based on approximately $79.00 per acre for aerial application, it would cost $1,462 per treatment under Option 1 and $2,828 per treatment under Option 2 for treatment of common reed within the Phase III area (Table 2-1). Initial backpack application for areas around sensitive areas would cost about $4,200, based on 10.5 man-days of labor plus materials. Several subsequent follow-up spot treatments with backpack-type sprayers would cost about $5,640, based on 14 man-days of labor plus materials.

2.5 PLANTING PLANS

Based on Versar's recent investigation of undisturbed freshwater marshes in the vicinity of Lower Cape May Meadows, appropriate wetlands species and densities to plant at the site are presented in Table 2-2. Planting on 2-foot centers, we recommend a density of approximately 21,000 herbaceous plants per acre (depending on species, localized conditions, objectives, and other criteria). At this density, replanting of the Phase I area would require 617,400 plants, Phase II would require 533,400 plants, and Phase III would require 974,400 plants. All plants used must be native to southern New Jersey wetlands, and must be commercially available from local plant nurseries. Plants should be installed in the Spring, after the second herbicide treatment has taken place and the dead standing crop of common reed has been burned off during the previous winter.

2.6 CONVERSION TO SALT WATER WETLANDS

Both Options 1 and 2 would involve construction of berms in the marsh, and would use the existing salt water canal to flood areas within the constructed berms (Fig. 2-2). Option 1 would require construction of a 10-foot-wide, 3-foot-tall berm in two sections that total 1,150 feet with a 20-inch outfall pipe outfitted with a flapgate (to let fresh water in and keep salt water from going out). Approximately 27.9 acres of saltwater wetland could be created

by implementing Option 1. Option 2 would also require construction of a 10-foot-wide, 3-foot-tall berm (on an angle to the ocean shoreline), approximately 1,350 feet in length, and with a 20-inch pipe outfitted with a flapgate. Approximately 10.6 acres of saltwater wetland could be created by implementing Option 2. The crest elevation and location of the berms in both scenarios would be set so that the downstream storage volume is large enough to hold the volume of inflow from the salt water canal based on a 50-year storm.

Table 2-2. Twenty native wetlands plant species recommended for use in freshwater wetlands Phase I, II, and III common reed removal areas, and for marsh edge restoration re-planting. All listed species are native to wetlands in the vicinity of the site. Refer to Table 2-1 and 3-1 for approximate costs of the plants by Phase/Option.

Scientific Name	Common Name
Decodon verticillatus	Water Willow
Distichlis spicata	Marsh Spike Grass
Dulichium arundinaceum	Three Way Sedge
Eupatorium perfoliatum	Thoroughwort Boneset
Juncus effusus	Common Rush
Juncus roemerianus	Black Needlerush
Leersia oryzoides	Rice Cut Grass
Lobelia cardinalis	Cardinal Flower
Nuphar lutea	Spatterdock
Panicum virgatum	Switchgrass
Peltandra virginica	Arrow Arum
Polygonum hydropiperoides	Swamp Smartweed
Potamogeton pectinatus	Sago Pondweed
Sabatia stellaris	Sea Pink
Sagittaria latifolia	Duck Potato
Scirpus tabernaemontani	Great Bulrush
Solidago uliginosa	Swamp Goldenrod
Sparganium americanum	American Burreed
Spartina patens	Salt Hay
Vallisneria americana	Water Celery

3.0 SEAWARD MARSH EDGE RESTORATION PLAN

The primary purpose of this task is to present options for restoring herbaceous wetlands along the edges of the existing freshwater marsh, and creating new herbaceous wetlands at the Lower Cape May Meadows site if the dune is restored. The Corps is presenting three options for restoration of freshwater marsh edges at Lower Cape May Meadows. Each of the three options involve moving different quantities of sand seaward onto a much more substantial dune than currently exists. One option removes only overwashed sand from the seaward edges of the marshes. Each of the other two options includes removal of the overwashed sand, as well as moving the existing dune seaward. Each of the areas would be brought to a final elevation identical to existing adjacent wetlands. In each of the options, the restored marsh would be immediately planted with a variety of native herbaceous plants to help check the invasion of common reed into these areas. Sand excavated and moved from the restoration project would be used for constructing the proposed new dune.

3.1 MAPPING AND QUANTIFICATION

A reconnaissance site visit was made in March 1997 to provide an overview of localized conditions around the affected marsh edges. Versar subsequently used recent (1996), vertical, low-altitude, black and white aerial photography for mapping purposes in this part of the study. Transparent mylar overlays were created for the photographs, and affected marsh edge areas, the existing dune, and the non-wetted portion of the beach at low tide were mapped directly onto them. The overlay of these three areas was then digitized into a GIS system, allowing for accurate quantification of the excavation areas (Fig. 3-1).

The mapped areas were categorized as three separate units, including: (1) an area of the marsh edges that could be excavated to restore those areas of the marsh; (2) an area where the existing the dune could be moved seaward, and (3) an area where a portion of the non-wetted beach could be moved seaward to the approximate edge of low tide. Plans detailing three potential options (corresponding to the three mapped areas) for marsh edge restoration and wetland creation are presented below.

3.2 SITE-SPECIFIC SEAWARD MARSH EDGE RESTORATION

3.2.1 Option 1: Excavation Behind Dune

This option would restore the existing freshwater marshes to their more recent historical size by excavation of overwash sand from their edges. It would also be the least expensive of the three options to implement.

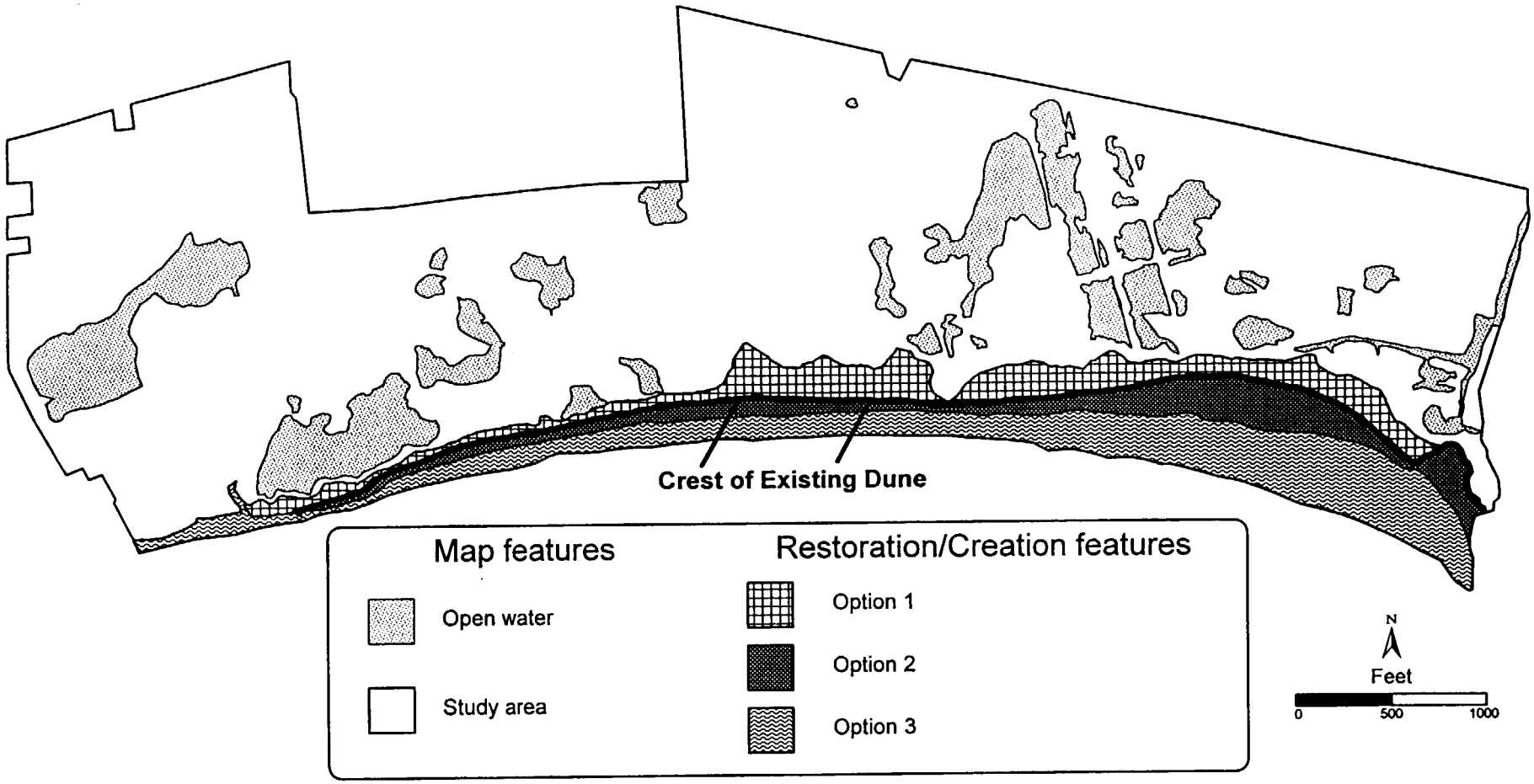

Figure 3-1. Three potential options for restoration and creation of freshwater wetlands at the Lower Cape May Meadows site, Cape May County, New Jersey. Map was created from photointerpretation of 1996 vertical, low-altitude, black and white aerial photography (USACOE 1996a). Refer to text for sizes of the three options.

The concept behind Option 1 would be to excavate the sand from the outer edges of the affected marshes to create a uniform depth identical to that of the existing adjacent marsh. Additionally, all recent monitoring well data should be checked to confirm the approximate average ground water level in the adjacent marshes. The purpose of this step is to ensure that final grade of the excavated areas is approximately at the level of high groundwater.

The largest (widest) areas of deposited overwash sand on the marsh side of the dune is near the western part of the Nature Conservancy portion of the site (see Fig. 3-1). According to the mapping in Fig. 3-1, the total area of the marshes that could be re-claimed by excavation of the overwash areas behind the existing dune is approximately 17.42 acres (Table 3-1).

Table 3-1. Excavation and approximate cost breakdown versus wetlands restored/created for Marsh Edge Restoration Plan Options 1, 2, and 3 at the Lower Cape May Meadows site

Option	Excavation quantity (cubic yards)	Sand excavation and moving costs[a] (1997 $)	Plant Material costs[b] (1997 $)	Organic substrate costs[c] (1997 $)	Total Costs[d] (1997 $)	Acres of wetlands restored (R) or created (C) [Total areas]
1	103,037	515,185	182,910	187,350	885,445	R: 17.42
2	262,420	1,312,100	338,520	346,740	1,997,360	R: 17.42 C: 14.82 [32.24]
3	515,094	2,575,470	473,130	644,020	3,692,620	R: 17.42 C: 27.64 [45.06]
TOTAL	**880,551**	**4,402,755**	**994,560**	**1,178,110**	**6,575,425**	**59.88**

[a] Costs based on $5.00 total per cubic yard of sand excavated or moved.
[b] Planting costs based on $0.50 per plant, each planted on 2-foot centers. These costs total about $10,500 per acre. Labor costs for planting are not included in this estimate, but would be on the order of approximately $5,040 per acre, based on a crew of four persons averaging $30 per hour, each installing at least 1,000 plants per 8-hour day. This figure is conservative, and is likely to vary, depending on actual labor wages and site conditions.
[c] Assumes 8 inches of organic substrate added throughout, at a delivered cost of $10.00 per cubic yard (includes placement of the material).
[d] Does not include labor costs for planting.

Once at the proper grade, a determination would have to be made whether sufficient organic substrate exists for wetland plant growth. It should also be determined whether salts have accumulated within this substrate. If either insufficient organic substrate exists or salts are found to be excessive in the substrate, organics may need to be added. If this is the case, an additional 6 to 8 inches of material should be excavated below adjacent wetland grade. The graded area should then be backfilled with suitable organic material.

From review of topographical maps of the site we estimated that there is approximately a 3-foot vertical difference from the middle of the back dune area to the existing wetlands. We estimate that if a uniform average of 3 feet of sand is removed over the entire back dune area, approximately 84,302 cubic yards of sand would have to excavated and moved onto the new dune. An additional 8 inches of grading would add 18,735 cubic yards of sand to be excavated. The total of 103,037 cubic yards of sand excavated from the marshes would then be used as a partial source of material to create the new, more substantial dune proposed by the Corps.

After excavation, native wetland plants can be installed in the hydrologically-restored marsh (refer to plant list, Table 2-2). Since the re-planted areas would be herbaceous marsh, the plants can be installed on approximately 2-foot centers (generally the mitigation standard for herbaceous wetlands). Approximate costs for planting this area are provided in Table 3-1.

It should be noted that the excavation and planting for Option 1 could also be staged or split into several east-west sections if needed. Such a split may be advantageous if the required plant material is not all concurrently available, or if it is reasonable due to fiscal constraints.

3.2.2 Option 2: Front Side of Dune Pushed Seaward

This option would only be performed in conjunction with Option 1. In addition to restoring the marsh edges in Option 1, Option 2 would create about 14.82 acres of new marsh. In addition to the sand excavation from the marsh edges, Option 2 would also involve pushing the front (seaward) side of the existing dune further seaward (Figure 3-1).

After the existing dune is pushed seaward, the area would be lowered to the wetland grade determined in Option 1. It should be noted that the substrate under the excavated portion of this part of the beach is likely to be pure sand, containing highly saline residues, requiring addition of organic substrate. As in the Option 1, this would be accomplished by grading approximately 8 inches below the adjacent wetland grade and backfilling this amount of organic substrate.

From review of topographical maps of the site we estimated that there is approximately a 3-foot vertical difference from the middle of the back dune area to the existing wetlands, and an approximately 6-foot vertical difference from the middle of the front dune area. We

then estimated if a uniform average of 3 feet of sand is removed over the entire back dune area and 6 feet of sand is removed from the front dune area, a total of approximately 227,746 cubic yards of sand would have to excavated and moved onto the new dune. An additional 8 inches of grading would add 34,674 cubic yards of sand to be excavated in this option. The 262,420 total cubic yards of sand resulting from this option would then be used as a partial source of material to create the new, more substantial dune proposed by the Corps.

After excavation and pushing the sand seaward, the entire Option 2 zone would be planted with native wetland plants. The proposed species for planting the Option 2 zone are presented in Table 2-2. Approximate costs for planting this area are also provided in Table 3-1.

As in Option 1, the combined excavation and planting for Option 1 and Option 2 could be further staged or split into several east-west sections if needed.

3.2.3 Option 3: Portion of Non-wetted Beach Pushed Seaward

This option would only be performed in conjunction with Option 1 and Option 2. In addition to the excavation, moving of sand, and re-planting in the first two options, Option 3 would involve moving a portion of the non-wetted beach seaward to the wetted edge. The area under the portion of the beach pushed forward would then be excavated and lowered to the wetland grade determined in Option 1. This would create an additional 27.64 acres of marsh, in addition to that created in Option 2, and that restored in Option 1.

From review of topographical maps of the site we estimated that since there is approximately a 3-foot vertical difference from the middle of the back dune area to the existing wetlands, an approximately 6-foot vertical difference from the middle of the front dune area to the wetlands, and an approximately 5-foot vertical difference from the beach area to the wetlands, a total of approximately 450,692 cubic yards of sand would have to excavated and moved onto the new dune.

As explained in Option 2, it is anticipated that the entire area of Option 3 would need to be over-excavated by approximately 6 to 8 inches and then backfilled with organic substrate. An additional 8 inches of grading would add 64,402 cubic yards of sand to be excavated in this option. The 515,094 total cubic yards of sand resulting from this option would then be used as a partial source of material to create the new, more substantial dune proposed by the Corps.

After excavation is complete, the Option 3 area would be planted with native wetland plants. The proposed species for planting the Option 3 zone are presented in Table 2-1. Approximate costs for planting this area are provided in Table 3-1.

As in Options 1 and 2, the combined excavation and planting for Options 1, 2, and 3 could be further staged or split into several east-west sections if needed.

4.0 CONCLUSIONS

Once fully established, common reed is very difficult to eradicate. Currently, the most successful means for removal of common reed is treatment with herbicide, preferably one containing glyphosate. Owing to the large areas to be treated at the Lower Cape May Meadows site, aerial application of herbicide, followed by hand application around sensitive areas and re-planting, is the most efficient means of common reed removal. To make the task more manageable, we divided the work into three potential phases corresponding to geographic areas of the site. We also provided an option to create saltwater wetlands in a small portion of the site as another potentially effective means for common reed removal.

Because of the difficulty in permanently removing common reed parcels when significant established stands remain at a project, we recommend that all three of the proposed removal phases be implemented. The three phases of work should be scheduled as close together as possible during the first years of implementation to minimize re-colonization of common reed. If saltwater wetlands are created in the easternmost portion of the site, these areas may only require selective hand spraying (not aerial spraying) of herbicide. Finally, long-term removal of common reed would best be facilitated through bi-annual inspections and spot hand treatment of small problem areas. This will help to prevent any major invasions of common reed back to the site.

Any of the three options for seaward marsh edge restoration would restore existing or historical wetlands in a site that has been proven to be of critical value to wildlife, especially migratory birds. The technical approach to implementing the three options is essentially the same; the difference is primarily in scope. The Corps estimates that the sand excavation/sand moving activities required for either of the three options would be relatively routine. Essentially, the same large earth-moving equipment would be utilized under all three of the options. However, the restoration work could also be staged into several east-west sections, no matter which of the three options are chosen. All of the sand excavated and moved would only be transported a short distance to the new reinforced dune being created by the Corps. Some of the sand moving costs for creating the new reinforced dune would be defrayed by implementing the marsh edge restoration.

The principal difference regarding implementation of the three restoration/creation options is cost of sand moving and grading. The cost to move and excavate the sand is about 2.5 times greater for Option 2 versus Option 1, and about 2 times greater for Option 3 versus Option 2. However, slightly less than twice the amount of wetlands would result from implementing Option 2 versus Option 1 (17.42 acres versus 32.24 acres), at 2.5 times greater cost. Similarly, about 2.6 times greater wetland area would result from Option 3 versus Option 1, at about 4 times more cost.

Because the benefits versus cost appear to be maximized under Option 1, we recommend implementation of only this option. Excavation costs to create Option 2 and 3 appear to be prohibitive for the amount of wetland that could be created.

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LOWER CAPE MAY MEADOWS
WETLANDS HYDROLOGIC MODEL

Prepared for

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FOREWORD

This report, entitled "Lower Cape May Meadows Wetlands Hydrologic Model" was prepared by Versar, Inc., for Ms. Beth Brandreth, Environmental Resources Branch, U.S. Army Corps of Engineers, Philadelphia District, under contract No. DACW61-95-D-0011. The results presented in this report should be interpreted with caution as there was no data on flows between ponds or changes in water surface elevation over time following storm events or dry periods through which the model could be calibrated or verified. Results are most useful in relative comparisons between scenarios, rather than for evaluating absolute values of water surface elevations.

1.0 INTRODUCTION

1.1 BACKGROUND

The proposed project is an environmental initiative study designed to investigate means to enhance the wetland habitat in conjunction with storm damage reduction and dune restoration efforts planned by the USACOE for Lower Cape May Meadows, New Jersey. The beach protection/nourishment project area is located at the southern tip of New Jersey between Cape May City and Cape May Point. Adjacent to the beach/dune restoration area is Lower Cape May Meadows, a 1.3 mile long, 350 acre area of undeveloped marsh and uplands consisting of State and Nature Conservancy owned property. The habitat within the Meadows consists of a variety of cover types including beaches, dunes, brackish and freshwater marshes, open water, and uplands. Lower Cape May Meadows suffers from severe long-term storm induced erosion, which has led to habitat degradation due to storm surges, dune erosion, and salt water intrusion.

1.2 NEED FOR STUDY

The Corps is investigating several means to repair the storm damaged Atlantic coast shoreline between Cape May City and Cape May Point, including beach nourishment, wetland restoration and dune reconstruction. As part of the shoreline protection project, the Corps is interested in investigating ways to improve the habitat value of the existing wetlands. Much of the wetland habitat has been taken over by the nuisance herbaceous marsh plant, common reed (*Phragmites australis*), which is known to be of poor habitat value to wildlife. Sand has also overtopped many areas of the existing dunes during storm surges and has filled in the edges of the wetlands in these places. Some of these areas of former marsh are no longer wetlands. The current plan is to manage most of the meadow as a freshwater marsh and a small portion in the eastern section as a saltwater marsh. Runoff in the western portion of the project area flows from the township of Cape May Point into Lake Lily (a natural lake which serves as a retention pond adjacent to a residential community) which in turn flows into Lighthouse Pond West (via a storm drain) and then into the Shallow Pond West before exiting the system through a weir designed to shunt excess freshwater through a pipeline into the Atlantic Ocean near the ruins of an old bunker. The control elevation of the weir is 3.5 ft National Geodetic Vertical Datum (NGVD). If the pond level exceeds elevation 5.0 ft, the freshwater will flow overland towards the Nature Conservancy property.

1.3 RESTORATION PLANS

There are several freshwater ponds in the meadows which are hydrologically isolated from the main ponds, receiving freshwater only from rainfall events or groundwater seepage.

One potential improvement to the freshwater marshes would be to physically connect some of the isolated ponds to the main ponds by constructing natural channels between them. Increasing the freshwater inputs into these isolated ponds will improve the water quality within the ponds and promote the desired maintenance of the area as a freshwater marsh. In the current configuration of freshwater flows, excess freshwater is discharged to the ocean near the old bunker from Shallow Pond West and is not available to the eastern portion of the Meadows. This drainage structure was installed in 1995 to prevent flooding induced by blockage of the existing drainage channel to the Nature Conservancy property caused by dune overwash.

Before any changes to the flow patterns can be implemented, the system needs to be modeled to evaluate the ramifications of altering the hydrology within the marsh. Extensive surveys of pond elevation and the marsh topography have been conducted by the Corps, so the data exists through which a simple box model can be developed for various flow alteration scenarios. The models can incorporate effects of runoff due to rainfall events and can be used to ensure that flood protection for the township of Cape May Point and West Cape May is maintained, and to evaluate whether the proposed flow alterations can achieve the desired water quality improvements and promotion of freshwater marsh ecosystems. To manage the eastern section of the project site as a saltmarsh ecosystem, connections between the eastern ponds to tidal creeks leading from Cape Island Creek need to be improved or developed. However, as with the flow alterations for the remainder of the project site, modeling the hydrology of the system needs to be conducted prior to implementing the physical changes.

The Corps has the following goals for the wetlands and pond areas of Cape May Meadows that could affect local hydrology: 1) maintain and restore freshwater wetland habitat; 2) reduce the flow of avian organic matter to the meadows by dredging Lake Lily; 3) provide adequate storm water drainage from the ponds; 4) aid in control of water-level management; and 5) manage water levels so that ponds do not completely dry up during periods of low water. A hydrologic model of the area was used to describe existing hydrology and evaluate changes in hydrology which might occur to achieve the above goals. The hydrologic model was created as a simple compartmental box model which accounts for runoff and drainage flows from Cape May Point through Lake Lily and the pond system of the meadows.

2.0 METHODS

The Corps provided the following information on the physical characteristics and known hydrology of the Cape May Meadows wetlands area: 1) elevation, surface area and volume of each pond and groups of ponds; 2) existing connections between ponds, including pipe sizes and maximum flow rates where known; 3) a qualitative description of possible new connections between pond areas; 4) existing outflow rating functions through the system; 5) rating functions of possible new inflow/outflow structures which may be considered; 6) size of design-storms to be considered for runoff estimation; 7) drainage areas to Cape May Meadows; and 8) soil types and maps from which percentage impervious areas in the Cape May Point area and other drainage areas could be estimated.

2.1 DRAINAGE PATTERNS

Water flow through Cape May Meadows begins at Cape May Point and flows generally eastward toward Cape May proper (Figure 1). Water flow was assumed to start at Lake Lily which drains a small portion of Cape May Point through storm drains and a larger portion via direct overland flow and groundwater flow following rain events. Drainage from Lake Lily occurs via a storm drain under Lighthouse Road to Lighthouse Pond West. Drainage within Cape May Meadows historically occurred from the higher elevation ponds (about 3.5 feet NGVD) at the west end toward the lower elevation ponds (about 1.5 feet NGVD) at the eastern end. At the eastern end, water drains via Cape Island Creek to a 5-foot diameter concrete pipe at Broadway Ave. Ponds were previously connected via a series of drainage canals which subsequently became filled-in from beach erosion and overtopping. Due to drainage problems caused by blockage of these canals, the city of Cape May Point installed a drainage system from Shallow Pond West out to the ocean near the concrete bunker. Ponds were aggregated into three major groups by common ground and pond water level elevations; these groupings are shown in Figure 1 and Table 2-1. The aggregated elevation/volume relationships of Lake Lily and the 3 hydrologic segments are listed in Table 2-2.

The drainage rate from Lake Lily to Lighthouse Pond West is a function of headwater (inlet) and tailwater (outlet) elevations and the size and roughness of the pipe; this function was provided by the Corps and is listed in Appendix Table 1. The drainage system from Shallow Pond West out to the ocean includes a one-way valve to prevent ocean water at high tides from entering the ponds; the drainage rate is a function of headwater and tailwater elevations as listed in Appendix Table 2. The pipe from Cape Island Creek drains as a function of the headwater and tailwater elevations as shown in Appendix Table 3. Overland flow between segments during storm events was estimated by the functions shown in Appendix Table 4.

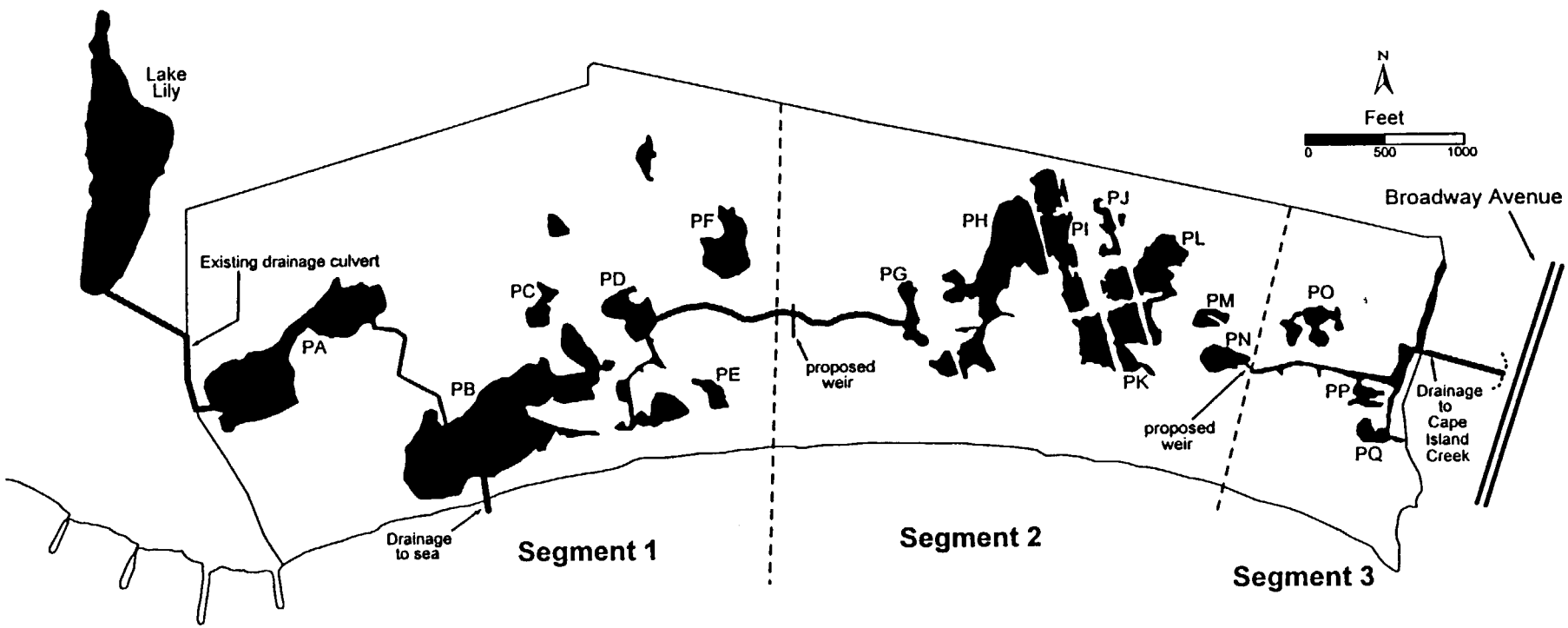

Figure 1. Map showing groupings of ponds and connections between hydrologic segments included in the Cape May Meadows wetlands hydrologic model. Pond sizes and locations based on aerial survey made on March 7, 1993.

Table 2-1. Hydrologic Segments for the Cape May Meadows Hydrologic Model, showing ponds included in each segment, cross-section lines used for volume calculations, water surface elevations (WSEL) , and areas and volumes. Data based on survey made 7 March 1993 but with initial WSEL's adjusted following construction and operation of the bunker outflow control structure.

Pond/Segment Group	Base WSEL (ft NGVD)	Maximum WSEL (ft NGVD)	Maximum Area, Acres	Maximum Volume, Acre-ft
Lake Lily	3.5	6.0	14.4	27.4
Hydrologic Segment 1				
Pond PA: Lighthouse Ponds East and West; lines IL-1,2,3,4	3.5	6.0	20.3	39.1
Pond PB: Shallow Pond West; lines IL-7,8	3.5	6.0	19.1	40.9
Pond PD: Shallow Pond East; lines IL-10,12	3.5	6.0	6.3	8.8
Pond PE: line IL-13	3.5	6.0	1.04	1.66
Hydrologic Segment 2				
Pond PG: line IL-16	2.4	2.5	0.99	0.8
Pond PH: lines IL-17,18,19,20	2.2	2.5	7.2	6.9
Pond PI: lines IL-21,22,23	2.2	2.5	5.3	6.6
Pond PJ: lines IL-21,22,23	2.2	2.5	0.69	0.54
Pond PK: lines IL-22,23	2.2	2.5	2.7	3.0
Pond PL: lines IL-22,23	2.2	2.5	2.6	2.67
Pond PM: line IL-24	2.2	2.2	0.5	0.32
Pond PN: lines IL-23,25	2.2	2.2	1.1	1.41
Hydrologic Segment 3				
Pond PO: line IL-26	1.0	1.0	1.3	0.25
Pond PP: line IL-27	1.0	1.0	0.5	0.27
Pond PQ: lines IL-26,27,28	1.0	1.0	2.2	2.85

Table 2-2. Elevation-capacity of hydrologic segments of Cape May Meadows hydrologic model. These elevation-capacity values are for the year 2000 projected shoreline. Options such as moving the shoreline out and increasing storage capacity of the Meadows are not reflected in the table.

Elevation (ft, NGVD)	Volume (acre-ft)	Elevation (ft, NGVD)	Volume (acre-ft)
Lake Lily		Hydrologic Segment 2	
3.1	0.0	1.0	0.0
3.5	5.8	1.5	2.5
4.0	13.0	2.0	11.2
4.5	20.2	2.5	20.5
5.0	27.4	3.0	44.0
6.0	41.8	4.0	111.9
Hydrologic Segment 1		5.0	196.4
1.0	0.0	Hydrologic Segment 3	
1.5	3.7	-0.3	0.0
2.0	7.7	0.0	0.6
2.5	18.8	0.5	1.6
3.0	30.8	1.0	3.2
3.5	43.6	1.4	4.8
4.0	57.1	2.0	21.1
4.5	71.4	3.0	50.5
5.0	90.5	4.0	89.3
5.2	99.8	5.0	134.8
5.5	120.4		
6.0	165.8		

2.2 MODEL DESCRIPTION

The information described above was used to create a simple box model of water flow from Lake Lily through the aggregated pond segments of Cape May Meadows (represented schematically in Figure 2). The model consists of a spreadsheet containing information on the volume and elevation of each pond system or hydrologic segment and the rating functions which determines the flow rates between segments and out of the meadows system to the ocean, either via the bunker outflow system or Cape Island Creek. The model was structured to simulate existing flow patterns from Lake Lily through the bunker outflow structure. With these existing flow patterns, water only moves from segment 1 to 2 and from 2 to 3 under flood conditions when the elevation exceeds the highest level between those segments. Between segments 1 and 2, the high ground level is approximately 5.5 ft, NGVD and between segments 2 and 3, the highest ground elevation is approximately 3.0 ft.

A proposed wetlands restoration project would return drainage through the eastern pond areas and out through the Cape Island Creek. Segment 3 would be restored as a salt marsh with an average WSEL of 1.0 ft, NGVD; a berm is constructed between segments 2 and 3 to elevation 4.0 ft, NGVD. For the purposes of simulating restored flows between hydrologic segments, new canals were assumed to be constructed connecting the closest ponds within each segment as shown in Figure 1. The new canals would be located further back from the dune line than the original canals, to prevent them from being filled in from overwash during a large ocean storm. Flow between segments 1 and 2 and 2 and 3 is assumed to be controlled by weir structures, with the rating functions as shown in Appendix Table 5.

The bunker outflow structure was assumed to be closed in the proposed flow restoration model, diverting all drainage through the eastern ponds to provide more freshwater through the wetland areas. During flood events, water was also allowed to move between segments according to the overland flow rating function whenever the elevation exceeded the highest level between the segments. No attempt was made to identify additional connections which might be necessary within pond segments; in the model, water is assumed to move freely between ponds within a segment. Model time steps were set to 0.5 hours during flood conditions and to 2 hours during dry or average summer conditions.

2.3 MODEL INPUTS AND OUTPUTS

Inputs to the model includes initial water level elevations, runoff to each hydrologic segment (only during flood periods) and evaporation rate (except during flood periods). Other model conditions can also be specified, including the total simulation time, the time step and the tidal elevation range. Any of these values can easily be changed to determine the effect on water flows. Segment elevation-volume relationships and outflow functions can also be changed to simulate possible changes to the system and the resulting effect on the hydrology of the system. The model calculates flows between segments and volume and elevation of each segment at each time step. Graphical model output is provided as the change in water

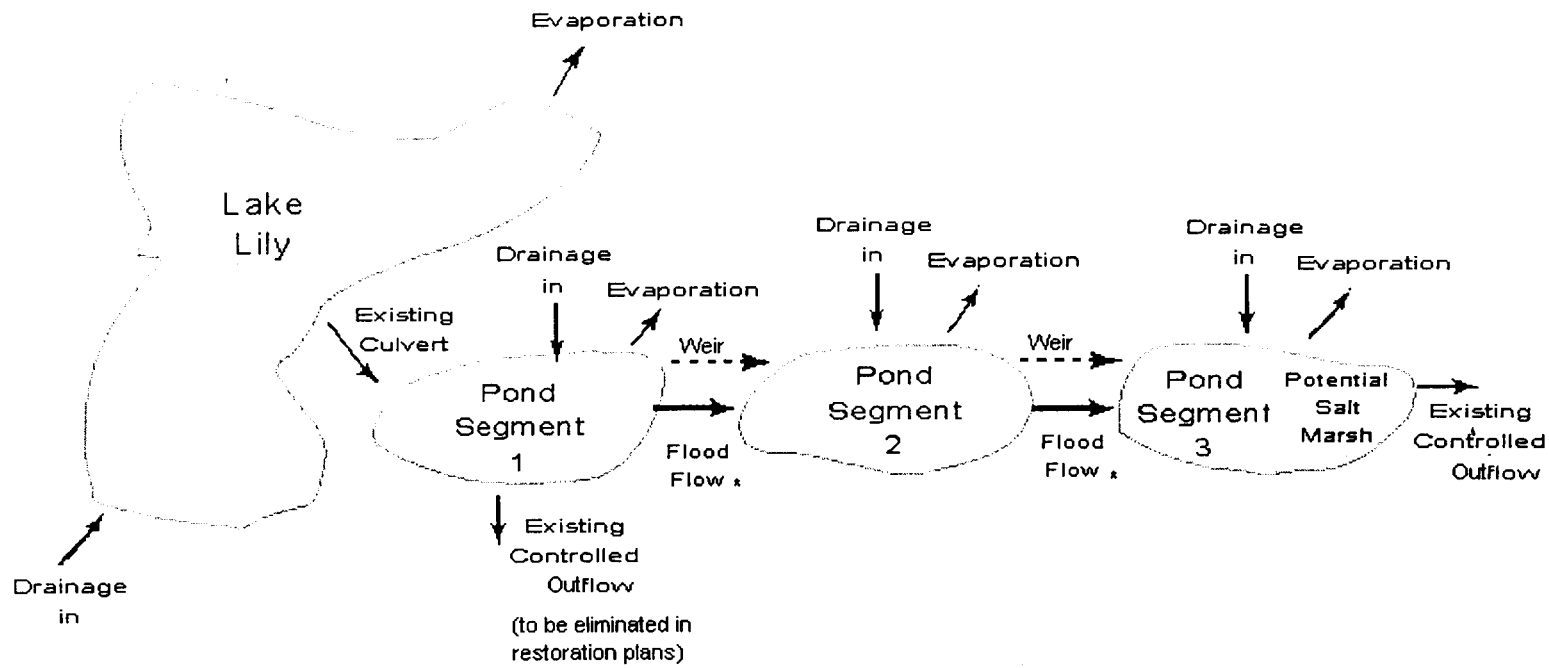

Figure 2. Schematic of Cape May Meadows hydrologic model showing pond segments, existing and potential connections (dashed lines) between segments and inflows and outflows included in the model. Drainage runoff is included only during flood conditions and evaporative losses are included only during dry and average conditions. *Flood flow from segments 1 and 2 occurs when WSEL exceeds 5.5 ft and 3.0 ft (NGVD), respectively.

surface elevation in each hydrologic segment over time, although flows and volumes are also calculated and tabulated within the model.

2.4 RUNOFF AND EVAPORATION

Drainage areas to Lake Lily and the pond segments were provided by the Corps (Appendix Table 6). All of the rainfall directly over the open water and marsh areas was included in the volume of water entering each segment (areas listed as ponds and marsh in Appendix Table 6). Runoff from the remaining land area was calculated using the curve number method described in TR-55 (USDA, 1986). The amount of pervious and impervious area within each drainage area was estimated from areal photographs and drawings of the area which showed roads and houses. The 10-year and 50-year 24-hour rainfall events for this area (5 inches and 7 inches, respectively, for TR-55 storm type III) were used as flood events to be simulated. The time of concentration for each drainage area was estimated using the methods in TR-55 to obtain a flood hydrograph for input to the model. Since there are no defined stream channels leading to the pond systems, runoff was assumed to enter the pond systems at intervals during the 24-hour rainfall period as calculated by TR-55 for each drainage area assuming channel travel time of zero. The rainfall which did not enter the ponds was assumed to be stored in depressions, surface soils or enter the groundwater and not enter the pond systems during the time of the flood simulation. During the dry periods, no runoff or groundwater flow was assumed to enter the pond systems. Evaporation rate (for dry periods only) was estimated from the average evapotranspiration rate for the area (55% of average annual rainfall). This rate was assumed to occur primarily during 100 days during the summer months and was applied to all of the ponds and pervious land area within the meadows.

2.5 SIMULATION SCENARIOS

A variety of simulations were made of the existing system (draining through the bunker outflow structure) and the proposed restored wetland hydrologic system, over a range of hydrologic conditions. These include flood conditions (10-year and 50-year design storms for the area) within wet and dry antecedent (prior to the storm) conditions to represent what might happen with a severe rain event during previously wet periods. For the 50-year design storm under the wetland restoration scenario, flows out of segments 1 and 2 were assumed to be controlled with the weir height set to 2.5 ft, NGVD to allow for greater water storage under these extreme conditions (Appendix Table 5). For the 10-year design storm simulation under the wetland restoration scenario, flows from these segments were assumed to be controlled at a higher elevation of 3.5 ft, NGVD (Appendix Table 5). These simulations were run for 3 days. Drought conditions were simulated, in which no rain events occurred for a period of about 21 days. Average summer conditions were also simulated, using typical rainfall events for 21 days in July (Appendix Table 7). Both the drought and average summer condition simulations were run with dry antecedent ground moisture conditions; the weir height which controls outflow from segments 1 and 2 was assumed to be set to 2.5 ft, NGVD.

3.0 RESULTS

3.1 FLOOD CONDITIONS

Antecedent conditions determine how much runoff occurs during storm events based on ground conditions before the storm. If the ground is relatively dry prior to a storm event, more rainfall will infiltrate the ground and there will be less runoff than if the ground is relatively wet or saturated before a storm event. Figures 3 through 6 show the water surface elevations (WSEL) for Lake Lily and pond segments 1 through 3, for the 50-year rainfall event under wet antecedent conditions (a worst-case scenario). Figures 7 through 10 show the WSEL's for each model segment for the 10-year event, also for wet antecedent conditions. Table 3 lists the initial, peak, and final water surface elevations for each segment and each scenario.

These results show the filling of Lake Lily and all of the pond segments during the 24-hour rain event, followed by a gradual decline over the 80-hour simulation period as Lake Lily drains into segment 1. Results indicate that low-lying areas around Lake Lily would flood during the 10- and 50-year events, under existing flow conditions as well as with the wetland flow restoration project (with project); flooding will occur in some areas at elevations above about 4.7 feet. Flow out of Lake Lily is controlled primarily by the culvert draining it to Lighthouse Pond, so there is not much difference between current and with project conditions (Figure 3). There is a slightly more rapid decline in elevation following the storm event with project conditions, since there is a more rapid decline in segment 1 elevation, which permits more water to flow out of Lake Lily. Segment 1 declines more rapidly (Figure 4) because water can move out of it through the restored canal to segment 2, in addition to flowing out at the bunker control structure. Segment 1 floods for a short period of time under current conditions, reaching elevation 5.4 feet; flooding occurs above elevation 5.3 feet. With project conditions, however, segment 1 never exceeds 5.0 feet even under the most severe flood event simulated. Segment 2 initially has more water following flow restoration than under current conditions since it receives water from segment 1 (Figure 5). After about 2 days, however, water levels for the with project condition decrease below current conditions as water moves to segment 3. Water levels in segment 3 are continuously higher (with the peak height about 0.2 feet higher) with project conditions than with current conditions since more water is entering from segment 2 (Figure 6). These results suggest there could be flooding in some low-lying areas under both current conditions and flow restoration following severe storm events. There is a more gradual decline in water levels with project conditions as compared to existing conditions due to greater flows through the system when water flow is restored to the Meadows system. The decline in water levels fluctuates for both scenarios due to the tidal effect on the discharge rating function.

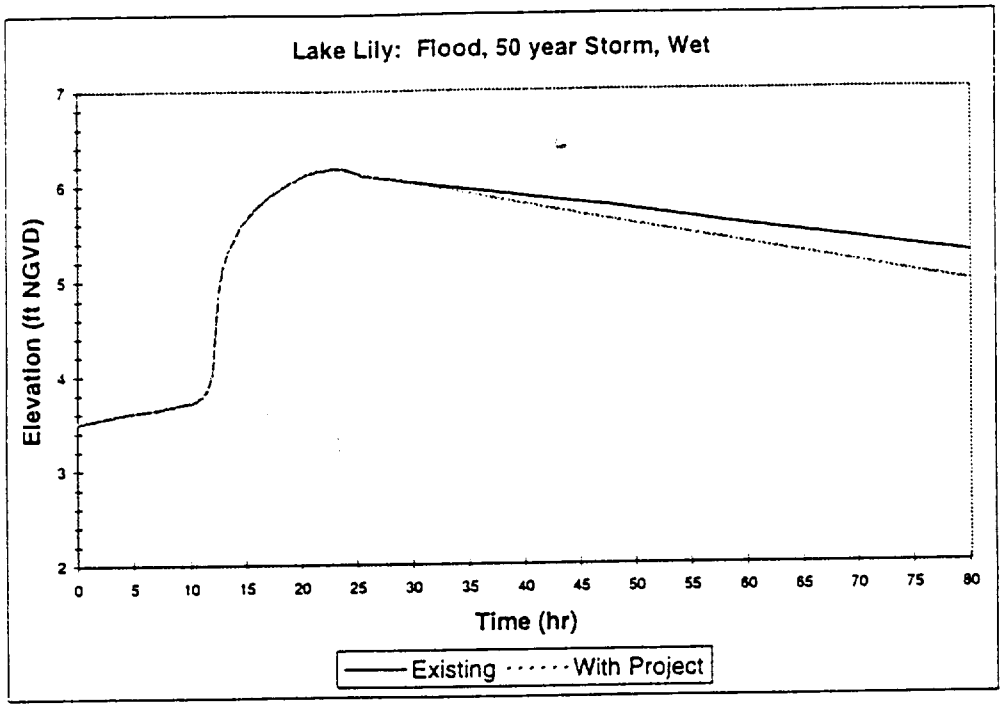

Figure 3. Comparison of water surface elevations (WSEL) simulated in Lake Lily under existing hydrologic conditions in Cape May Meadows and after a wetland flow restoration scenario (with project). Simulation conditions followed a 50-year, 24-hour design storm event of 7 inches under wet antecedent conditions.

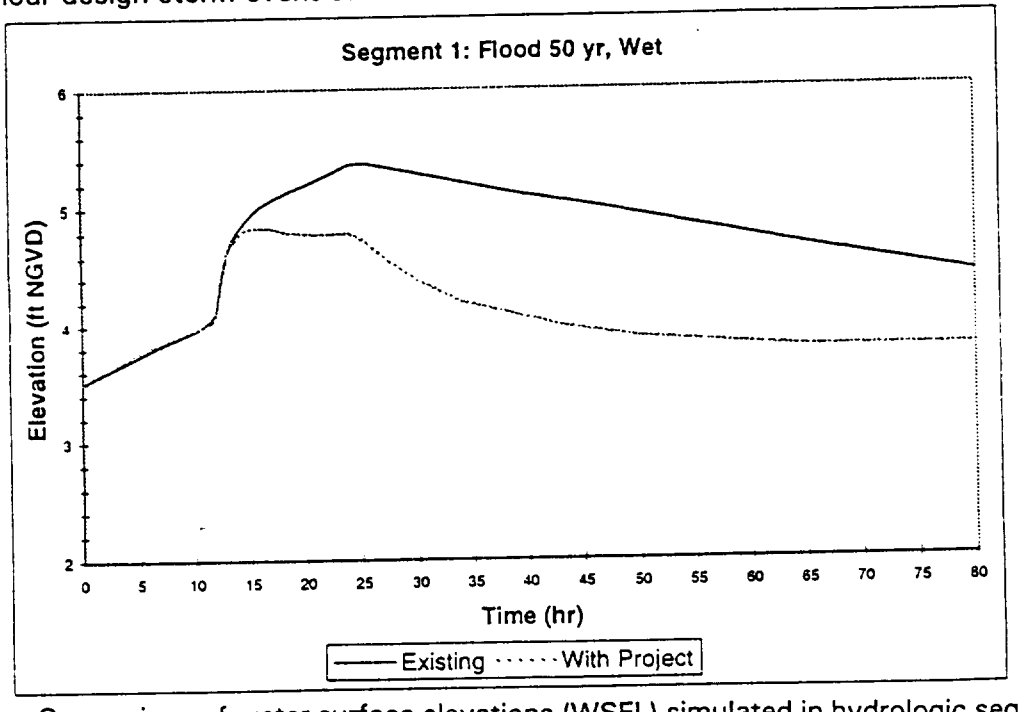

Figure 4. Comparison of water surface elevations (WSEL) simulated in hydrologic segment 1 under existing hydrologic conditions in Cape May Meadows and after a wetland flow restoration scenario (with project). Simulation conditions followed a 50-year, 24-hour design storm event of 7 inches under wet antecedent conditions.

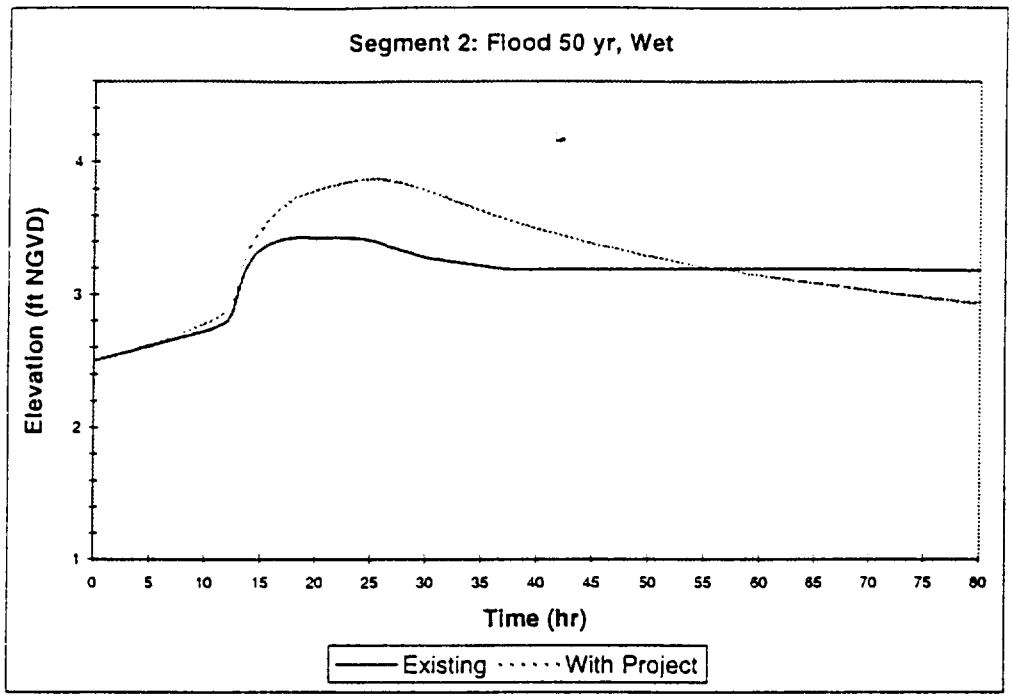

Figure 5. Comparison of water surface elevations (WSEL) simulated in hydrologic segment 2 under existing hydrologic conditions in Cape May Meadows and after a wetland flow restoration scenario (with project). Simulation conditions followed a 50-year, 24-hour design storm event of 7 inches under wet antecedent conditions.

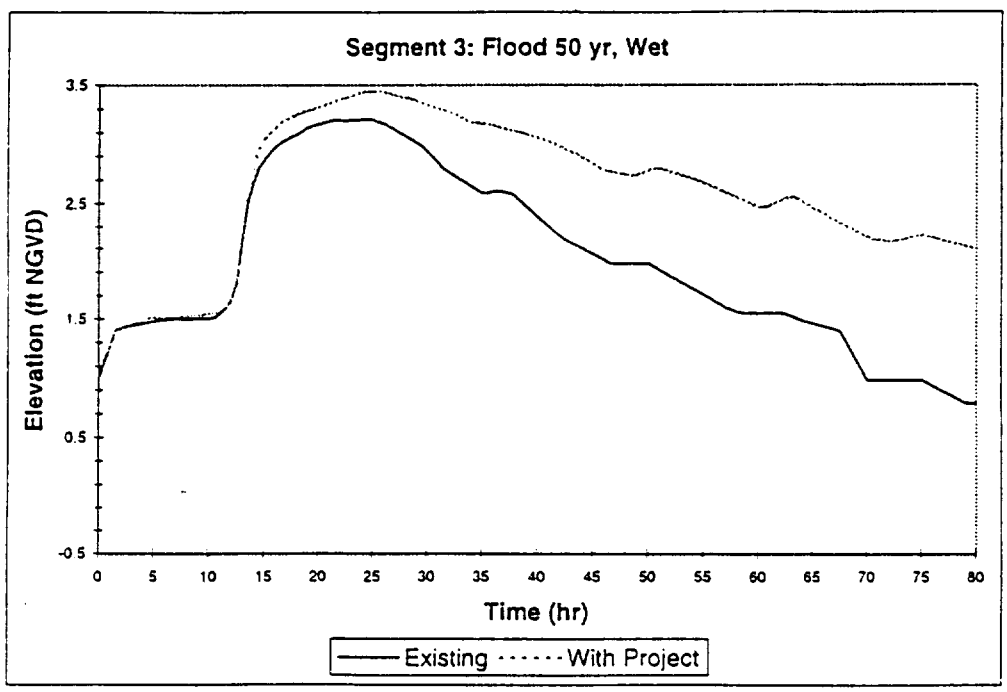

Figure 6. Comparison of water surface elevations (WSEL) simulated in hydrologic segment 3 under existing hydrologic conditions in Cape May Meadows and after a wetland flow restoration scenario (with project). Simulation conditions followed a 50-year, 24-hour design storm event of 7 inches under wet antecedent conditions.

Results for both the 50-year and 10-year design storms are very similar in the general pattern of elevation change over time in Lake Lily and segment 3 (see Figures 7 and 10). However, results for the 10-year storms show the effect of the higher weir settings at the outflows of segments 1 and 2 (Figures 8 and 9). Water levels in both these segments show a 1-foot higher starting elevation with project conditions but otherwise water levels show a similar response to flood inflows and subsequent drainage patterns. More water is retained in segments 1 and 2 since the weir settings are higher.

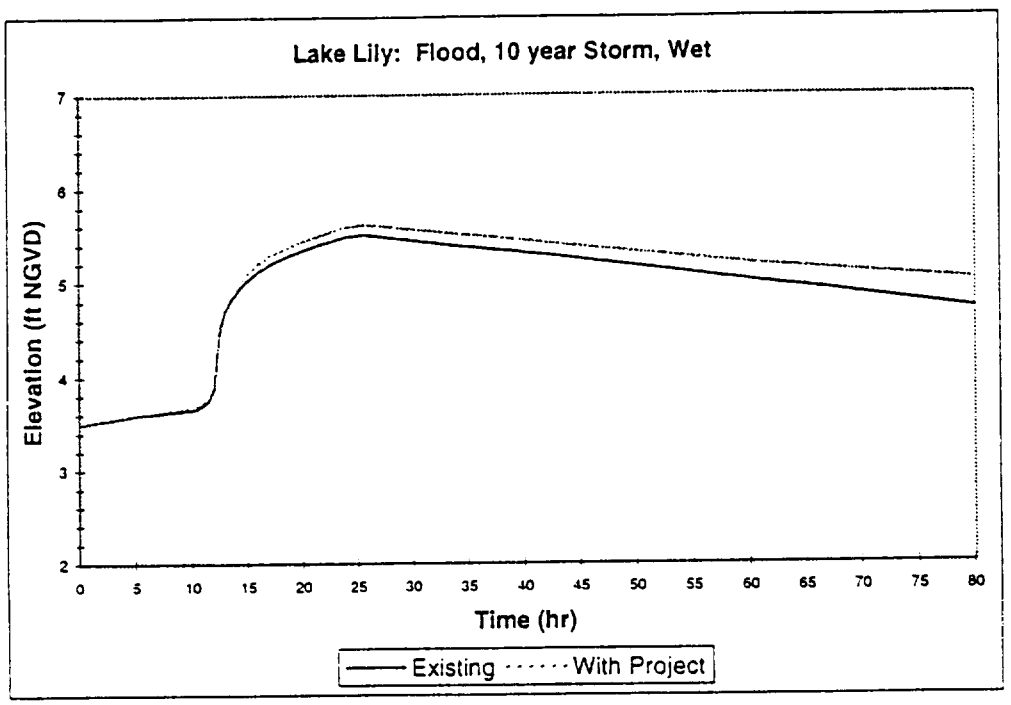

Figure 7. Water surface elevations (WSEL) simulated in Lake Lily under existing conditions compared to a wetland flow restoration scenario (with project). Simulation conditions followed a 10-year, 24-hour design storm event of 5 inches under wet antecedent conditions.

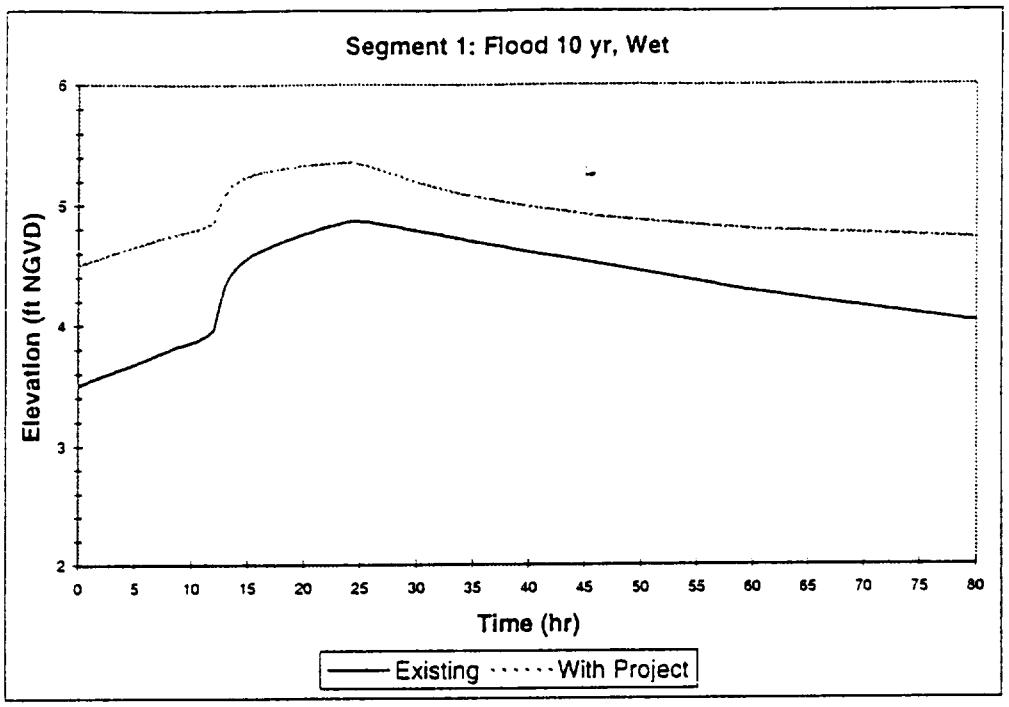

Figure 8. Water surface elevations (WSEL) simulated in Cape May Meadows hydrologic segment 1 under existing conditions compared to a wetland flow restoration scenario (with project). Simulation conditions followed a 10-year, 24-hour design storm event of 5 inches under wet antecedent conditions.

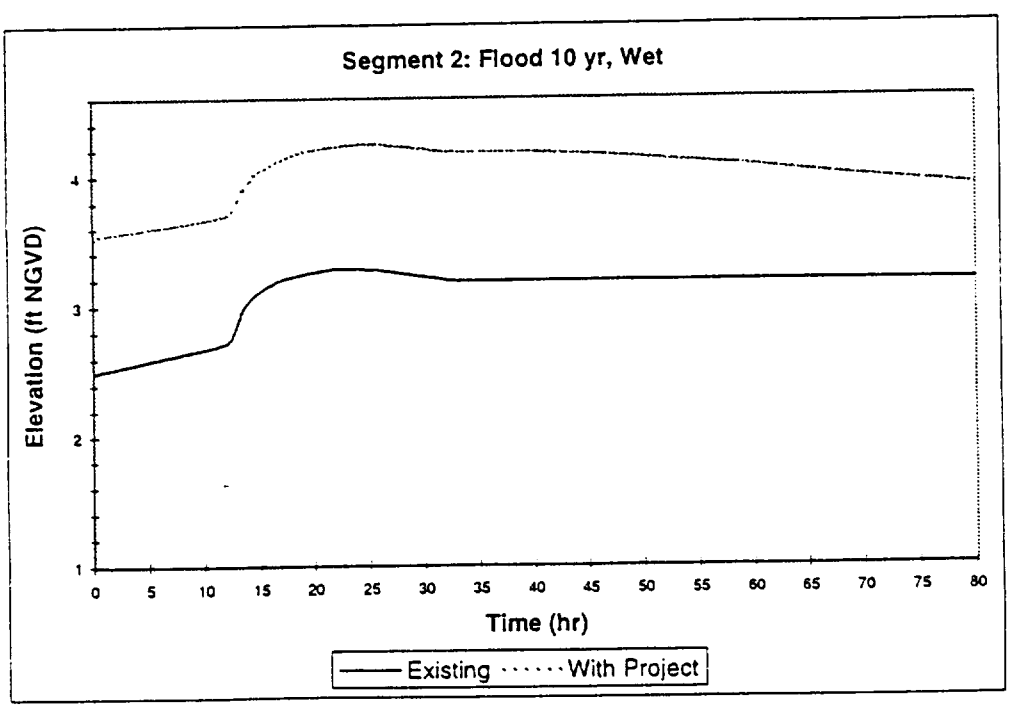

Figure 9. Water surface elevations (WSEL) simulated in Cape May Meadows hydrologic segment 2 under existing conditions compared to a wetland flow restoration scenario (with project). Simulation conditions followed a 10-year, 24-hour design storm event of 5 inches under wet antecedent conditions.

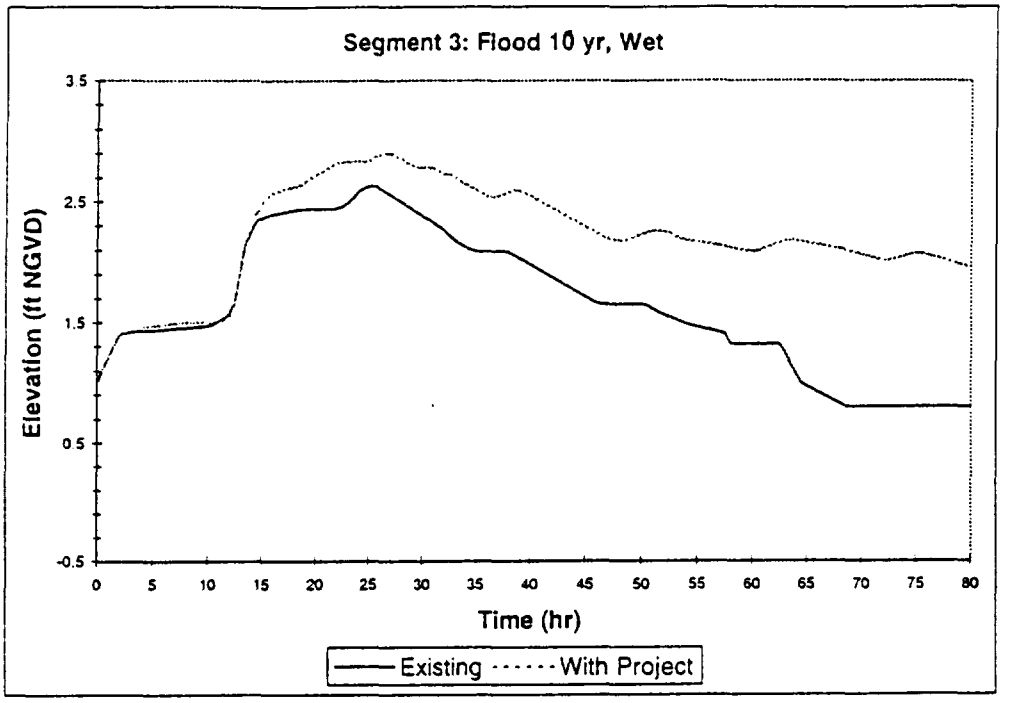

Figure 10. Water surface elevations (WSEL) simulated in Cape May Meadows hydrologic segment 3 under existing conditions compared to a wetland flow restoration scenario (with project). Simulation conditions followed a 10-year, 24-hour design storm event of 5 inches under wet antecedent conditions.

3.2 DROUGHT CONDITIONS

Drought conditions were simulated with changes in water surface elevation from the same starting point as in flood conditions. No rainfall or groundwater inflow was assumed to occur. Water losses were due to evaporation and drainage through the existing and proposed structures using the same rating functions as in the flood case. Results for Lake Lily show a gradual decrease in water level, controlled by the evaporation rate (Figure 11). There is only a slightly greater water level with project conditions, due to a more gradual decrease in water level downstream in segment 1. In segment 1, water levels decrease more gradually with project conditions than under existing conditions since there would no longer be any flow out of the bunker control structure (Figure 12). After 5 days, however, the water level changes are identical and controlled by the evaporation rate. In segment 2, water levels decrease more rapidly in the first day at the same rate under both scenarios due to evaporation (Figure 13). Segment 3 is not included in this simulation since there is no flow from segment 2. However, with project conditions, segment 3 is a salt marsh with water levels maintained by tidal flow providing more water and better flushing than under current conditions.

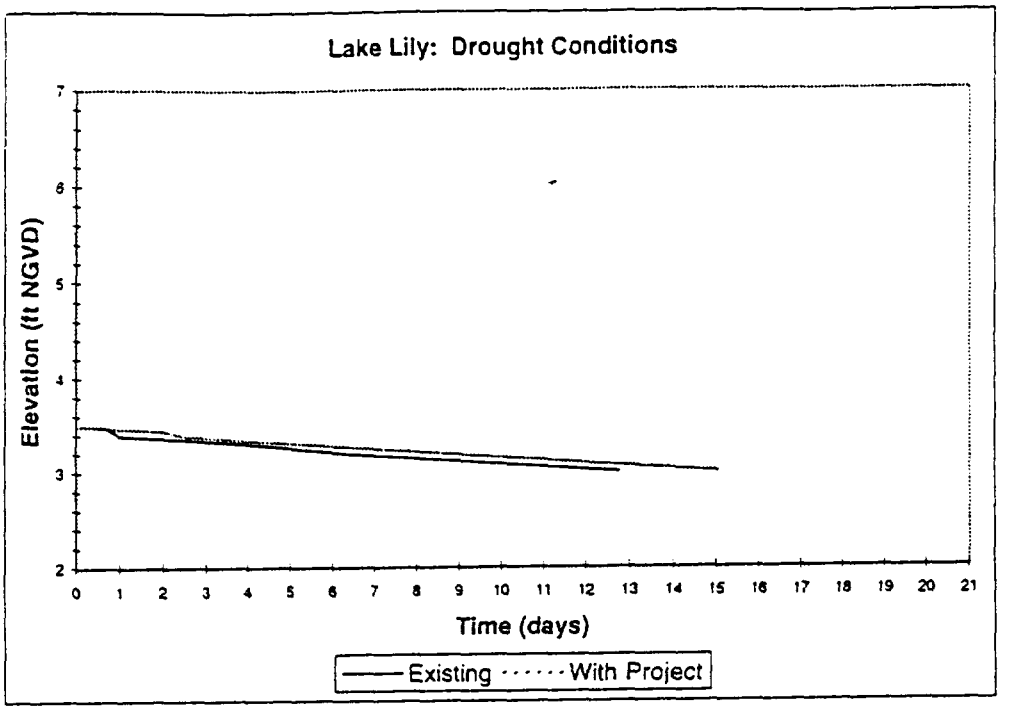

Figure 11. Water surface elevations (WSEL) simulated in Lake Lily under drought conditions with no rainfall. Existing hydrologic conditions in Cape May Meadows are compared to a wetland flow restoration scenario (with project).

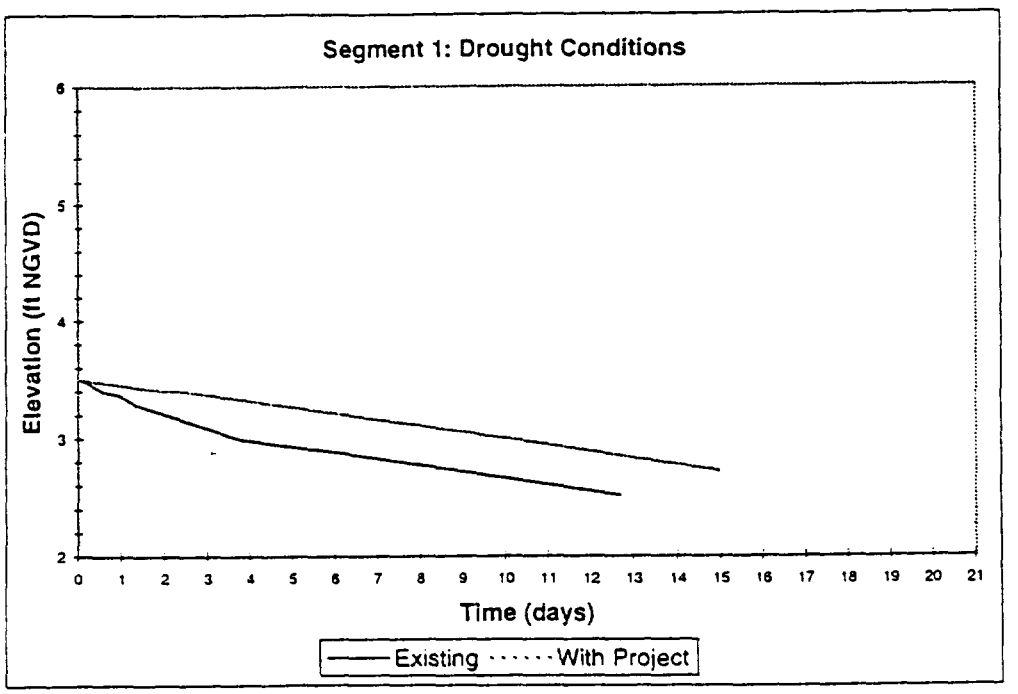

Figure 12. Water surface elevations (WSEL) simulated in hydrologic segment 1 under drought conditions with no rainfall. Existing hydrologic conditions in Cape May Meadows are compared to a wetland flow restoration scenario (with project).

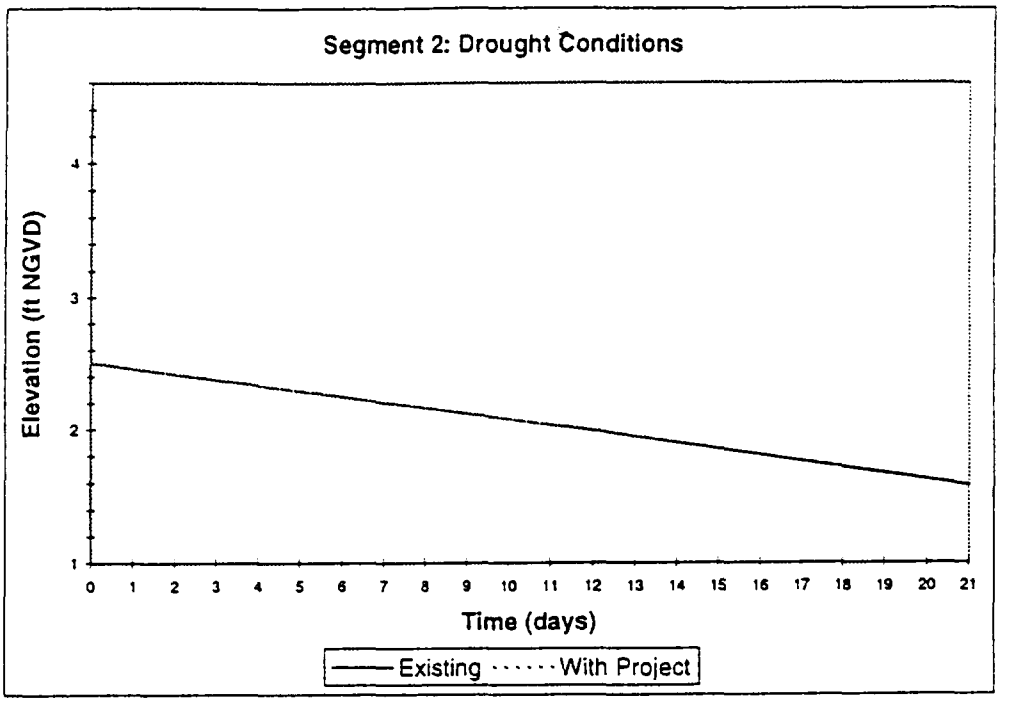

Figure 13. Water surface elevations (WSEL) simulated in hydrologic segment 2 under drought conditions with no rainfall. Existing hydrologic conditions in Cape May Meadows are compared to a wetland flow restoration scenario (with project).

3.3 AVERAGE SUMMER CONDITIONS

Average summer conditions were simulated with changes in water surface elevation from the same starting point as in drought and flood conditions. Rainfall over a 21 day period from July 1988 was used to represent typical summer conditions. This rainfall was entered as a direct input into the local pond areas but no runoff occurred due to dry antecedent conditions and the small amount of rainfall which occurred was not large enough to result in any runoff. No groundwater inflow was assumed to occur. Water losses were due to evaporation and drainage through the existing and proposed structures using the same rating functions as in the previous cases.

Results for Lake Lily show a gradual change in water level as water is lost by evaporation, with slight increases due to rain events at day 6 and day 16; there is no difference between scenarios since changes downstream of Lake Lily do not affect its water level (Figure 14). In segment 1, water levels under current conditions decrease more rapidly than under wetland restoration for the first 5 days, due to drainage through the bunker outflow structure under current conditions. There is a greater response to the small rain events at days 6 and 16 than in Lake Lily (Figure 15). This is caused by the greater area that can

intercept rainfall. In segment 2, changes in water levels are similar to those for segment 1, but with a much smaller difference between scenarios since water level changes are mainly caused by evaporative losses and rainfall input and is not affected by changes in drainage patterns (Figure 16). Segment 3 is not included in this simulation since there is no flow from segment 2. However, with project conditions, segment 3 is a salt marsh with water levels maintained by tidal flow providing more water and better flushing than under current conditions.

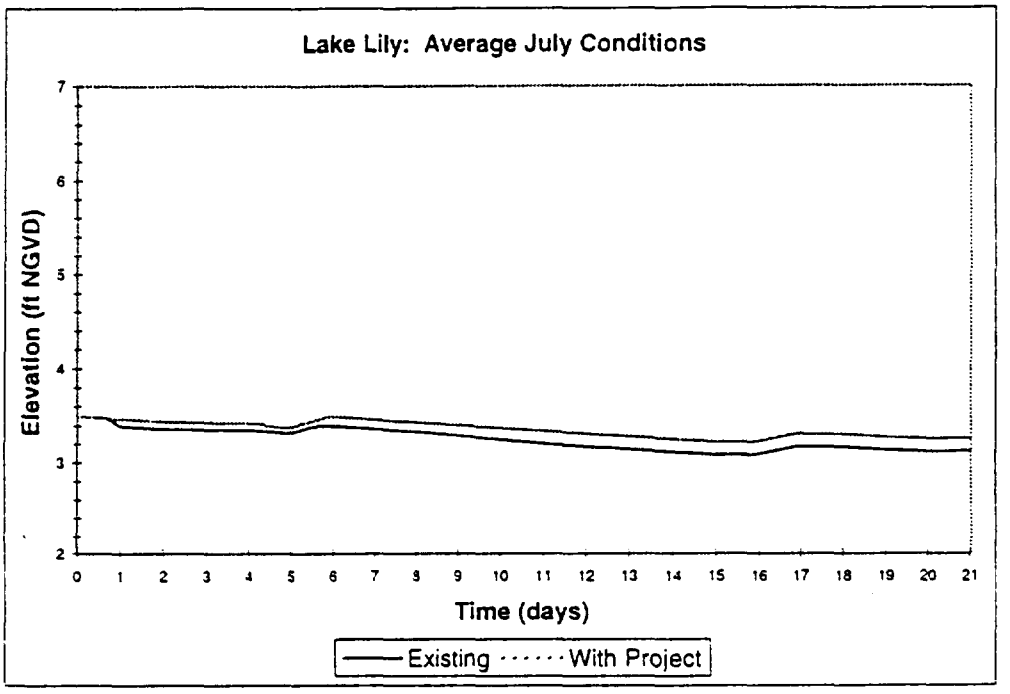

Figure 14. Water surface elevations (WSEL) simulated in Lake Lily under average summer conditions. Existing conditions compared to a Cape May Meadows wetland flow restoration scenario (with project).

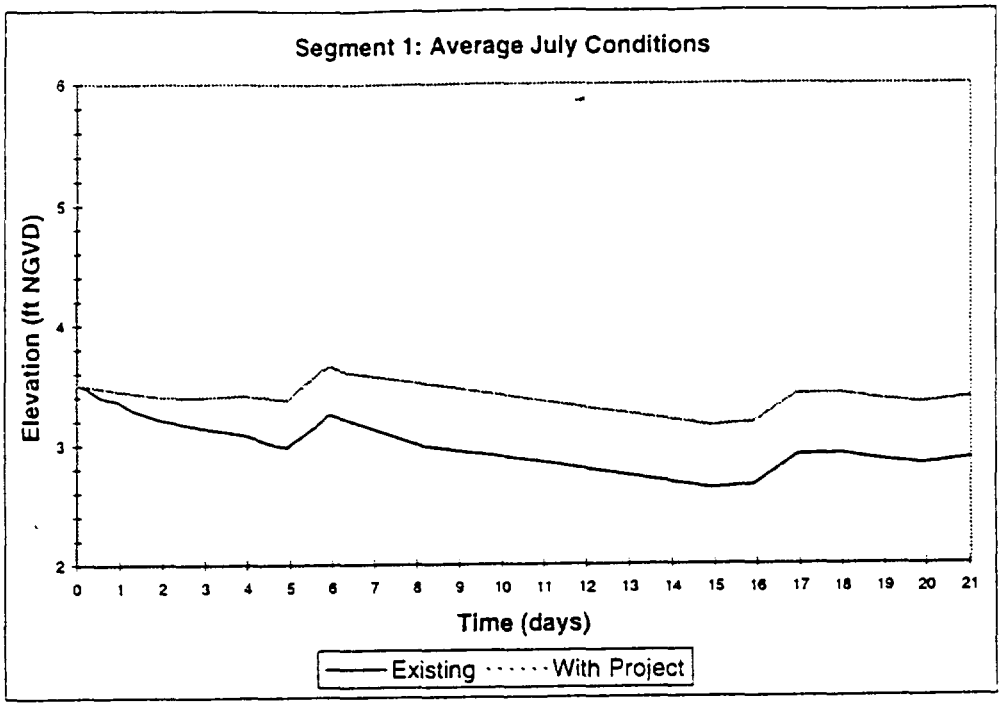

Figure 15. Water surface elevations (WSEL) simulated in hydrologic segment 1 under average summer conditions. Existing conditions compared to a Cape May Meadows wetland flow restoration scenario (with project).

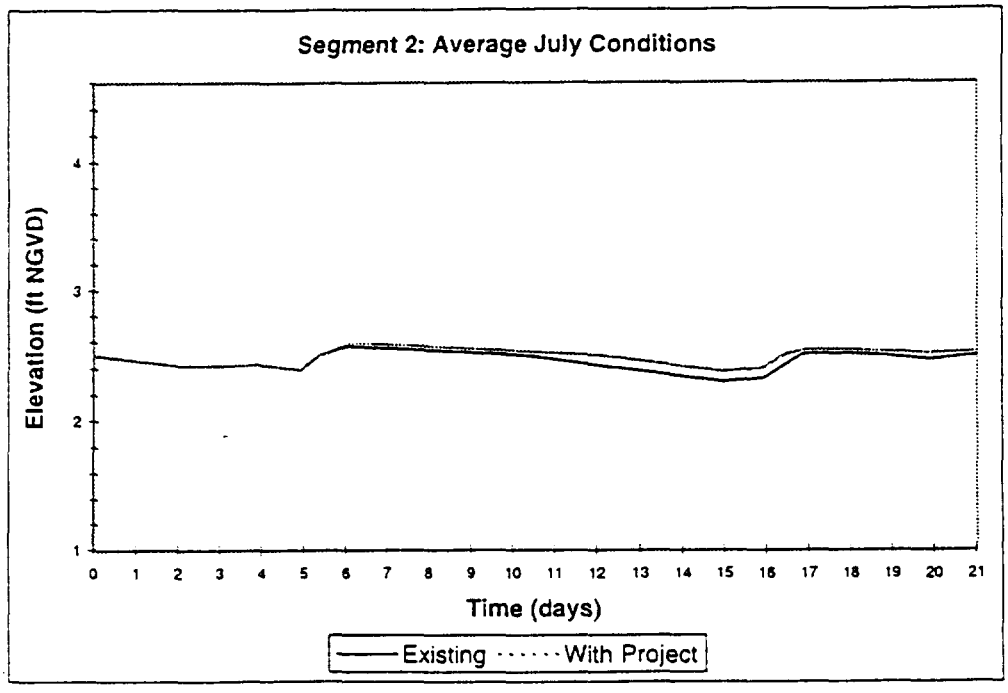

Figure 16. Water surface elevations (WSEL) simulated in hydrologic segment 2 under average summer conditions. Existing conditions compared to a Cape May Meadows wetland flow restoration scenario (with project).

4.0 DISCUSSION AND SUMMARY

Results of hydrologic modeling in lower Cape May Meadows from Lake Lily east to Cape Island Creek shows that restoration of freshwater flows throughout the marsh is a feasible project which would not jeopardize flood control at Cape May Point. The flow restoration project would divert water currently discharged from Shallow Pond West near the old bunker into the middle and eastern portion of the meadows area. This diversion would not increase the flood potential at Lake Lily even with a 50-year, 24-hour design storm but modeling results confirm the existing flood potential at Lake Lily for this type of storm. Flow restoration through Cape May Meadows shows a decrease in water levels during flood events at the western edge of the meadows and a slight increase in water levels in the middle and eastern edge of the meadows during these events. The magnitude of these water level changes depends on the severity of the flood event. There is no change in flood potential with restoration of salt marsh at the eastern edge of the meadows, although severe tidal flooding was not simulated in this study. Simulations of drought conditions and average summer conditions indicates that water level control at the eastern edge of the meadows could provide for greater water level stability under these conditions, particularly at the eastern edge. Restoration of salt marsh at the eastern-most portion of the meadows would provide more water and greater flushing than at present under low freshwater flow conditions.

5.0 REFERENCES

Roberson ,J.A., J.J. Cassidy, and M. H. Chaudhry. 1988. Hydraulic Engineering. Houghton Mifflin Company, Boston. 662 p.

United States Department of Agriculture (USDA), Soil Conservation Service, 1986. Urban Hydrology for Small Watersheds. Technical Release 55.

APPENDIX

Table 1. Rating table for drainage (cfs) from shallow pond east to ocean via bunker outflow structure. Inlet at 3.5 ft NGVD, exit at 1.9 ft NGVD.

Tailwater Elevation (ft NGVD)	-10	1.9	2.4	2.9	3.4	3.9	4.4	4.9
Headwater Elevation (ft NGVD)								
0	0	0	0	0	0	0	0	0
2.5	0	0	0	0	0	0	0	0
3	0.89	0.89	0.89	0.89	0	0	0	0
3.3	1.99	1.99	1.99	1.99	0	0	0	0
3.55	3.42	3.42	3.42	3.42	1.99	0	0	0
3.8	5.07	5.07	5.07	5.07	5.07	0	0	0
4.05	6.82	6.82	6.82	6.82	6.82	0	0	0
4.29	8.49	8.49	8.49	8.49	8.49	5.87	0	0
4.5	9.92	9.92	9.92	9.92	9.92	8.3	0	0
4.69	10.81	10.81	10.81	10.81	10.81	10.17	5.62	0
4.87	11.06	11.06	11.06	11.06	11.06	10.17	7.95	0
5.12	13.3	13.3	13.3	13.3	13.3	11.74	10.17	5.37
5.64	15.21	15.21	15.21	15.21	15.21	13.13	13.13	9.3

Table 2. Rating table for drainage (cfs) from Lake Lilly to Lighthouse Pond West								
Tailwater Elevation (ft NGVD)	2	3	3.4	3.8	4.2	4.6	5	5.4
Headwater Elevation (ft (NGVD)								
3	0	0	0	0	0	0	0	0
3.2	0.1	0	0	0	0	0	0	0
3.4	0.4	1.69	0	0	0	0	0	0
3.6	0.9	1.69	1.64	0	0	0	0	0
3.8	1.56	1.69	1.64	0	0	0	0	0
4	2.31	2.94	2.32	1.59	0	0	0	0
4.2	3.1	2.94	3.32	1.59	0	0	0	0
4.4	3.86	3.36	2.84	2.25	1.54	0	0	0
4.6	4.92	3.74	3.28	2.75	1.54	0	0	0
4.8	4.92	3.74	3.28	2.75	2.17	1.48	0	0
5	5.25	4.09	3.67	3.18	2.66	1.48	0	0
5.2	5.25	4.09	3.67	3.55	2.66	2.1	1.43	0
5.4	5.25	4.4	4.02	3.55	3.07	2.57	2.02	0
5.6	5.62	4.7	4.34	3.89	3.44	2.97	2.02	1.37
5.8	5.62	4.7	4.34	3.89	3.77	2.97	2.47	1.94
6	5.96	4.98	4.64	4.2	3.77	3.32	2.85	2.37
6.2	5.96	4.98	4.64	4.5	4.07	3.63	3.19	2.37

Table 3. Rating Table for Drainage (cfs) at Broadway Street Culvert from Segment III to Ocean. Culvert equipped with flap gate that prevents backflow.

Tailwater Elevation (ft NGVD)	≤-0.2	0.8	1	1.2	1.4	1.6	1.8	2	2.2	2.4	2.6	2.8	3	3.2	3.4
Headwater Elevation (ft NGVD)															
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.8	1.88	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1	7.89	7.89	0	0	0	0	0	0	0	0	0	0	0	0	0
1.2	7.89	7.89	7.89	0	0	0	0	0	0	0	0	0	0	0	0
1.4	7.89	7.89	7.89	7.89	0	0	0	0	0	0	0	0	0	0	0
1.6	17.64	17.64	17.64	17.64	7.89	0	0	0	0	0	0	0	0	0	0
1.8	17.64	17.64	17.64	17.64	17.64	7.89	0	0	0	0	0	0	0	0	0
2	17.64	17.64	17.64	17.64	17.64	17.64	7.89	0	0	0	0	0	0	0	0
2.2	30.36	30.36	17.64	17.64	17.64	17.64	17.64	7.89	0	0	0	0	0	0	0
2.4	30.36	30.36	30.36	30.36	30.36	30.36	17.64	7.89	7.89	0	0	0	0	0	0
2.6	30.36	30.36	30.36	30.36	30.36	30.36	30.36	17.64	17.64	7.89	0	0	0	0	0
2.8	45.04	45.04	45.04	45.04	45.04	45.04	45.04	30.36	30.36	17.64	7.89	0	0	0	0
3	45.04	45.04	45.04	45.04	45.04	45.04	45.04	45.04	45.04	45.04	17.64	17.64	0	0	0
3.2	60.52	60.52	60.52	60.52	60.52	60.52	60.52	60.52	60.52	45.04	45.04	33.49	7.89	0	0
3.4	60.52	60.52	60.52	60.52	60.52	60.52	60.52	60.52	60.52	60.52	60.52	47.37	30.36	7.89	0
3.6	60.52	60.52	60.52	60.52	60.52	60.52	60.52	60.52	60.52	60.52	60.52	60.52	60.52	60.52	17.64

Table 4. Overland rating functions for the Cape May Meadows Hydrologic Model

Lake Lily			Segment 1			Segment 2 Overland Rating		
Elevation (ft-NGVD)	Discharge (cfs)	Velocity (ft/sec)	Elevation (ft-NGVD)	Discharge (cfs)	Velocity (ft/sec)	Elevation (ft-NGVD)	Discharge (cfs)	Velocity (ft/sec)
0	0	0	0	0	0	0	0	0
6.12	5	0.44	5.42	10	0.07	3.19	10	0.08
6.18	10	0.58	5.53	20	0.09	3.28	20	0.1
6.23	15	0.68	5.62	30	0.1	3.36	30	0.12
6.27	20	0.76	5.7	40	0.11	3.43	40	0.13
6.31	25	0.83	5.77	50	0.12	3.49	50	0.15
6.35	30	0.89	5.96	80	0.15	3.65	80	0.18
6.42	40	1	6.07	100	0.16	3.75	100	0.19
6.48	50	1.09	6.31	150	0.19	3.95	150	0.23
6.53	60	1.18	6.52	200	0.22	4.13	200	0.25
6.63	80	1.32	6.71	250	0.24	4.29	250	0.28
6.73	100	1.44	6.88	300	0.26	4.44	300	0.3
6.93	150	1.69	7.03	350	0.27	4.58	350	0.32
7.11	200	1.91	7.18	400	0.29	4.71	400	0.33
7.27	250	2.07	7.48	500	0.31	4.96	500	0.37

Table 5. Rating functions for control weirs between hydrologic segments in the Cape May Meadows Hydrologic Model			
Segment 1: rating with project weir height at 3.5 ft (NGVD)		**Segment 2: rating with project weir height at 2.5 ft (NGVD); berm built 1 foot higher than existing**	
Elevation (ft-NGVD)	**Discharge (cfs)**	**Elevation (ft-NGVD)**	**Discharge (cfs)**
0	0	0	0
3.5	0	2.5	0
3.6	1.1	2.6	1.1
3.7	3	2.7	3
3.8	5.6	2.8	5.6
3.9	8.6	2.9	8.6
4	12	3	12
4.2	20	3.1	15.8
4.4	29	3.2	20
4.5	34	3.3	24
4.6	39	3.4	29
4.8	50	3.5	34
5	63	3.6	39
5.2	75	3.7	45
5.42	101	3.8	50
5.53	118	3.9	56
5.62	135	4	62
5.7	151	4.19	85
5.77	166	4.28	101
5.96	211	4.36	116
6.07	240	4.43	131
6.31	310	4.49	145
6.52	378	4.65	187
6.71	446	4.75	215
6.88	511	4.95	280
7.03	576	5.13	345
7.18	640	5.29	408
7.48	770	5.44	481

Table 6. Drainage areas and values used to calculate runoff volumes into the Cape May Meadows hydrologic model.

Drainage Area Name	Total Area Acres	Ponds and Marsh Acres	Pervious Area Acres	Impervious Area Acres	Open Land Acres	Farmland Acres	Comp* CN I	Comp* CN II	Comp* CN III
A (Lake Lilly	113.1	14.4	53.8	44.9	0	0	57	66	77
B	52.7	0	27.7	25	0	0	58	67	78
C	36.4	5.3	0	3.7	28.6	0	25	39	58
D	44.1	5	0	0	35	4.1	18	34	53
G	40.2	37.5	0	0	2.7	0	15	30	50
H	27.1	12.1	0	0	15	0	15	30	50
I	9.2	2.3	0	0	6.9	0	15	30	50
Total segment 1	209.7								
L	29.6	1	0	0	28.6	0	15	30	50
M	35	7	1.8	0.3	25.9	0	16	31	51
N	144.2	20.1	26.3	20.7	59	18.1	35	49	65
O	24.6	10.3	4.7	2	7.6	0	29	42	60
Total segment 2	233.4								
J**	32.2	0	0	0	32.0	0	15	30	50
P (segment 3)	205.1	44	85.4	54	21.7	0	47	58	71

* Composite Curve Number for antecedent conditions I, II, or III.
** Under existing conditions, runoff from area J drains to segment 2 when the estimated storage of Cattail Pond is exhausted (only under the 50-year flood condition). With the restoration project condition, runoff from area J drains to segment 1 via proposed drainage ditch.

Table 7. Rainfall used for simulation of average summer conditions in the Cape May Meadows hydrologic model

July 1988		Direct Rainfall onto Ponds and Marshes (acre-ft)			
Day	Inches of Rain	Lake Lily	Segment 1	Segment 2	Segment 3
1	0	0.00	0.00	0.00	0.00
2	0	0.00	0.00	0.00	0.00
3	0.25	0.30	1.30	0.80	0.92
4	0.32	0.38	1.66	1.02	1.17
5	0	0.00	0.00	0.00	0.00
6	1.8	2.16	9.33	5.76	6.60
7	0	0.00	0.00	0.00	0.00
8	0	0.00	0.00	0.00	0.00
9	0	0.00	0.00	0.00	0.00
10	0	0.00	0.00	0.00	0.00
11	0	0.00	0.00	0.00	0.00
12	0	0.00	0.00	0.00	0.00
13	0	0.00	0.00	0.00	0.00
14	0	0.00	0.00	0.00	0.00
15	0	0.00	0.00	0.00	0.00
16	0.4	0.48	2.07	1.28	1.47
17	1.41	1.69	7.31	4.51	5.17
18	0.31	0.37	1.61	0.99	1.14
19	0	0.00	0.00	0.00	0.00
20	0.12	0.14	0.62	0.38	0.44
21	0.45	0.54	2.33	1.44	1.65

Appendix C

US Fish and Wildlife Service Coordination

United States Department of the Interior

FISH AND WILDLIFE SERVICE

Ecological Services
927 North Main Street (Bldg. D1)
Pleasantville, New Jersey 08232

Tel: 609-646-9310
FAX: 609-646-0352

IN REPLY REFER TO:

FP-94/024

September 7, 1994

Robert L. Callegari, Chief
Planning Division
U.S. Army Corps of Engineers
Wanamaker Building
100 Penn Square East
Philadelphia, Pennsylvania 19107-3396
ATTN: Environmental Resources Branch

Dear Mr. Callegari:

This is the U.S. Fish and Wildlife Service's (Service) planning aid letter for the Lower Cape May Meadows - Cape May Point Reconnaissance Study (Reconnaissance Study), Cape May County, New Jersey. This letter is provided in accordance with the Fiscal Year-1993 scope-of-work agreement between the Service and the Philadelphia District, Corps of Engineers (Corps) and includes the Service's comments on a draft of the Corps' Lower Cape May Meadows - Cape May Point Reconnaissance Study Report (Report) (U.S. Army Corps of Engineers, 1994) that was received by the New Jersey Field Office on July 25, 1994. Specifically, the Service has reviewed the section of the Report that addresses the Pennsylvania Modified Habitat Evaluation Procedures (PAM HEP) (Palmer, et al., 1985) study that was conducted during the fall and winter of 1993 and the winter and spring of 1994 by an interagency team, which included Service participation.

The Service encourages the use of habitat assessment techniques early in the planning process to assist the Corps in developing plans that allow for fish and wildlife habitat protection and enhancement.

Authority

This response is provided pursuant to the Endangered Species Act of 1973 (87 Stat. 884, as amended; 16 U.S.C. 1531 *et seq.*) to ensure the protection of endangered and threatened species and is provided as technical assistance regarding other fish and wildlife concerns. This letter is not the document required of the Secretary of the Interior pursuant to Section 2(b) of the Fish and Wildlife Coordination Act (48 Stat. 401; 16 U.S.C. 661 *et seq.*). Planning aid is valid only for the described conditions and must be revised if significant environmental changes or changes in the proposed project take place prior to initiation.

Study Area Description

The Lower Cape May Meadows study area (study area) is within a nationally significant corridor along the East Coast for migratory bird species. The study area is located between Cape May City and Cape May Point in southern New Jersey at the tip of the Cape May peninsula, which separates the Atlantic Ocean from Delaware Bay. Because of the study area's geographic location, migratory bird species concentrate in this area prior to crossing Delaware Bay during the fall southern migration and after crossing Delaware Bay during the spring northern migration. In addition to the geographic location of the study area, the large variety of vegetative cover types present (beach and dune, upland forest, upland field - scrub / shrub, open water ponds, emergent marsh, and Phragmites wetlands) provide habitat requirements for a large number of bird species.

Identified Problems and Reconnaissance Study Purpose

Lower Cape May Meadows suffers from both severe long-term and short-term storm-induced beach erosion. The high rate of beach erosion is primarily caused by an interruption of sand flow by the Cape May Inlet jetties (U.S. Army Corps of Engineers, 1994). Beach erosion in the study area has led to the loss and degradation of fish and wildlife habitat and has caused flooding in surrounding communities.

The purpose of the Corps' Reconnaissance Study is to establish justification for environmental protection and / or restoration and to assess the degree to which the Cape May jetties have affected beach erosion in the study area (U.S. Army Corps of Engineers, 1994).

Proposed Project Description

The Report (U.S. Army Corps of Engineers, 1994) briefly describes the Corps' proposed plan to nourish ocean beaches on the study area to reduce beach erosion, saltwater intrusion, and dune breaching. According to the proposed plan, the Corps would place 436,500 cubic yards of sand on the existing Lower Cape May Meadows beach and dune system between Cape May Point and Cape May City.

Service Mitigation Policy

The Service's Mitigation Policy (Federal Register, Vol. 46, No. 15, Jan. 23, 1981) contains guidance to assist in developing consistent and effective recommendations to protect and conserve valuable fish and wildlife resources and to allow federal and private developers to anticipate Service recommendations and incorporate mitigation measures into the early stages of project planning. The Mitigation Policy defines four Resource Categories, and establishes the Service's mitigation goal for each.

The Service classifies the open water ponds, upland forest, upland field - scrub / shrub, beach and dune, and emergent marsh cover types of the study area as Resource Category 2, which means that the areas provide high quality habitat for evaluation species and are relatively scarce or becoming scarce on a national basis or in the ecoregion. The Service's mitigation goal for Resource Category 2 areas is no net loss of in-kind habitat value. The Service classifies the Phragmites-dominated sites within the study area as Resource Category 3, which means that the habitat is of high to medium value for evaluation species. The Service's mitigation goal for Resource Category 3 habitat is no net loss of habitat value while minimizing loss of in-kind habitat value.

Federally-listed Species

Enclosed are current summaries of the federally-listed and candidate species in New Jersey for your information. Documented nesting sites for the federally-listed threatened piping plover (*Charadrius melodus*) are located within the study area. Piping plovers nest on sandy beaches above the high tide line on mainland coastal beaches, sand flats, and barrier island coastal beaches. The nesting sites are typically located on gently sloping foredunes, blowout areas behind primary dunes, washover areas cut into or between dunes, ends of sandspits, and on sites with deposits of suitable dredged or pumped sand.

Food for adult plovers and chicks consists of invertebrates such as marine worms, fly larvae, beetles, crustaceans, and mollusks. Feeding areas include intertidal portions of ocean beaches, ocean washover areas, mudflats, sandflats, wrack lines (organic ocean material left by high tide), shorelines of coastal ponds, lagoons, and salt marshes.

Development along the coastal shoreline for residential and commercial uses, and the subsequent stabilization of the once shifting and dynamic beach ecosystem via seawalls, breakwaters, jetties, and groins have resulted in the destruction and alteration of natural beaches to such an extent along the Atlantic coast that many beaches are no longer suitable habitat for the piping plover.

Federally-listed species are afforded protection under the Endangered Species Act pursuant to Section 7(a)(2), which requires every federal agency, in consultation with the Service, to insure that any action it authorizes, funds, or carries out is not likely to jeopardize the continued existence of any listed species or result in the destruction or adverse modification of critical habitat. An assessment of potential direct, indirect, and cumulative impacts is required for all federal actions that may affect listed species. Therefore, if any activities are proposed that may directly or indirectly affect the piping plover or other federally-listed species under the jurisdiction of the Service, further Section 7 consultation with the Service will be required. Beach nourishment or stabilization activities that may affect current known nesting areas of the piping plover or create additional nesting areas for the piping plover will require further Section 7 consultation with the Service.

Except for the piping plover and an occasional transient bald eagle (*Haliaeetus leucocephalus*) or peregrine falcon (*Falco peregrinus*), no other federally-listed or proposed threatened or endangered flora or fauna under Service jurisdiction are known to occur in the vicinity of the study area.

Principal responsibility for federally-listed marine species, including whales and marine turtles, is vested with the National Marine Fisheries Service (NMFS). Therefore, the NMFS must be contacted to fulfill consultation requirements pursuant to Section 7(a)(2) of the Endangered Species Act:

National Marine Fisheries Service
Habitat and Protected Resources Division
Sandy Hook Laboratory
Highlands, New Jersey 07732
(908/872-3023)

Federal Candidate and State-listed Species

Candidate species are species under consideration by the Service for possible inclusion on the List of Endangered and Threatened Wildlife and Plants. Although these species receive no substantive or procedural protection under the Endangered Species Act, the Service encourages federal agencies and other planners to consider candidate species in the project planning process.

The precious underwing (*Catocala pretiosa*), a Category 2 candidate species, has been identified as occurring within the study area. The precious underwing is generally known to inhabit forested wetlands and may be present in wetlands on and adjacent to the study area. The Service recommends that this species be considered in project planning.

The lest tern (*Sterna antillarum*), a State-listed endangered species is known to inhabit the study area and was selected as an evaluation species in the subject PAM HEP study. Additional information on the least tern may be obtained from the New Jersey Natural Heritage Program (NHP), which provides the most up-to-date information on candidate and State-listed species in the State. The NHP may be contacted at the following address:

Mr. Thomas Breden
Natural Heritage Program
Division of Parks and Forestry
CN 404
Trenton, New Jersey 08625
(609/984-0097)

Further information on State-listed wildlife species in New Jersey may be obtained from the following office:

Mr. Larry Niles
Endangered and Nongame Species Program
Division of Fish, Game and Wildlife
CN 400
Trenton, New Jersey 08625
(609/292-9400)

Habitat Assessment Study Objectives

The major resource objective of the habitat assessment portion of the Corps' Reconnaissance Study was the evaluation of the effect of habitat loss, caused by coastal erosion, on fish and wildlife resources. Special emphasis was placed on the evaluation of existing habitat and on future with and without project habitat conditions for migratory bird and wetland-dependent species.

PAM HEP Compared to HEP

The PAM HEP (Palmer, et al., 1985) is a "condensed" version of the Service's 1980 HEP (U.S. Fish and Wildlife Service, 1980). Both methods multiply area by a habitat suitability index (HSI) for a given evaluation species to produce Habitat Units (HUs) for relative comparisons of different areas or of the same area over time. However, the PAM HEP requires less rigorous sampling and interpretation of data than HEP. Thus, PAM HEP is less reproducible than HEP and places more emphasis on the skills and professional judgement of the PAM HEP study team biologists. In general, PAM HEP uses less complex species HSI models with fewer variables than does HEP, which increases the need for model assumptions that must be agreed upon by study team members.

PAM HEP Study Overview

The PAM HEP study was conducted via an interagency team. Team members included:

Elizabeth Brandreth	(U.S. Army Corps of Engineers)
Steven Allen	(U.S. Army Corps of Engineers)
Thomas McDowell	(U.S. Fish and Wildlife Service)
Peter Benjamin	(U.S. Fish and Wildlife Service)
Elizabeth Johnson	(The Nature Conservancy)
Dean Cramer	(New Jersey Department of Environmental Protection Division of Parks and Forestry)

The study area was mapped on the basis of vegetative cover types. Six cover types were identified by the study team: open water ponds; upland forest; upland field - scrub / shrub; beach and dune; Phragmites wetlands; and, emergent marsh.

Evaluation species were selected based upon the PAM HEP study team's assessment of the resource values of the study area. Because the study area provides valuable habitat to migratory birds and offers diverse habitat for wetland-dependent species, species selected by the study team reflected these resource values. Thirteen avian species dependent upon cover types found on the study area were selected as evaluation species: sharp-shinned hawk (*Accipiter striatus*); American black duck (*Anus rubripes*); great horned owl (*Bubo virginianus*); green heron (*Butorides striatus*); sanderling (*Calidris alba*); semi-palmated sandpiper (*Calidris pusilla*); great egret (*Casmerodius albus*); marsh wren (*Cistothorus palustris*); American kestrel (*Falco sparverius*); wood thrush (*Hylocichla mustelina*); clapper rail (*Rallus longirostris*); field sparrow (*Spizella pusilla*); and, least tern (*Sterna antillarum*). In addition, muskrat (*Ondatra zibethicus*), river otter (*Lutra canadensis*), and spring peeper (*Hyla crucifer*) were selected because of their dependence on wetlands.

Species selection included guilding techniques to allow extrapolation of study data to other species that have similar habitat requirements. A guild is defined as a group of species that share a common resource. For example, Habitat Suitability Index (HSI) value for the black duck can be used to indicate the value of the study area for other dabbling ducks, such as mallard (*Anas platyrhynchos*), which also feed on macroinvertebrates and aquatic vegetation.

Service Review and Recommendations Regarding the PAM HEP Study

Overall, the PAM HEP portion of the Report contains an accurate explanation of the PAM HEP study and provides appropriate determinations of existing resource values of the study area. However, the PAM HEP report could be improved through incorporation of the recommendations outlined below.

The study team's selection of evaluation species was a critical initial step in the PAM HEP study because selection was based on the study team's determination of wildlife resource management objectives for the study area. These resource management objectives were determined by evaluating the important fish and wildlife resources, or resource issues (e.g., loss of wetlands) in the study area. The Service recommends that the connection between resource objectives, as established by the study team, and the selection of evaluation species be explained in detail within the text (page 41).

The Report should include a single, detailed explanation of how future and past cover type determinations were made. Presently, the method of future and past cover type determinations is briefly mentioned in both the Field Assessment and Data Analysis sections of the Report. Because the prediction

of cover types at different points in time is critical to interpreting the study results, the methods used should be explained separately from other issues. The Service recommends including a section entitled, "Methods Used to Determine Past and Future Cover Types."

The Report does not include sufficient detail regarding the assumptions made by the PAM HEP study team during field data collection. An explanation of the assumptions made by the study team is necessary for the methods to be reproducible and for the limitations of the study (i.e., level of detail) to be fully understood. Because sampling was conducted in the late fall and winter months, assumptions were made regarding certain variables in species HSI models (e.g., it was not possible to measure summer dissolved oxygen levels in ponds). Additionally, some species HSI models, such as black duck and clapper rail, were designed for tidal wetlands, which were not present in the study area. The presence of only non-tidal wetlands required a study team consensus on how variables that were dependent on tides (such as mudflats) would be evaluated. A more complete explanation of the potential effects of the above-referenced study team decisions on the final HSI values is recommended.

Finally, the representation of data in the tables entitled, "Comparison of Past, Present, and Future Area," and "HUs by Land Use / Cover Types" includes HUs that are added across different species to give the "total number of HUs." Adding HUs across species is not a proper representation of the data because HUs are species-specific and can only give meaningful results when added or averaged for a given species. In addition to double-counting acreage, the current representation (addition of HUs across evaluation species) directly links the number of HUs lost or gained to the number of evaluation species in the study (i.e., the greater the number of evaluation species chosen, the greater the number of HUs lost or gained), which is misleading. The data tables and discussions in the Report should address changes in HUs for individual evaluation species only.

Service Conclusions and Recommendations Regarding the Results of the Reconnaissance Study

The comparison of with and without project alternatives presented in the draft Report indicates that the study area will substantially lose fish and wildlife habitat of high value without beach nourishment or other forms of protection. The predicted losses in habitat and habitat value would result from land lost to coastal erosion and the continued increase in the percentage of the study area dominated by monotypic stands of Phragmites, which generally have low habitat value for fish and wildlife.

The Service recommends that the Corps continue to study the feasibility of engineered solutions to the coastal erosion threat to the Lower Cape May Meadows area. A more thorough, reproducible, and scientifically defendable HEP study is recommended for the feasibility stage of the planning process to more precisely establish the baseline habitat values of the study area and to establish future fish and wildlife habitat values both with and without the proposed project.

The above comments on the draft Reconnaissance Study Report are intended to assist the Corps in its planning process. The Service looks forward to working with the Philadelphia District as this study continues. Should you have any questions regarding these comments, please contact Thomas McDowell of my staff.

Sincerely,

Clifford G. Day
Supervisor

References

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U.S. Army Corps of Engineers. 1994. Lower Cape May Meadows - Cape May Point Reconnaissance Study (Draft). Philadelphia District, Philadelphia, Pennsylvania.

U.S. Fish and Wildlife Service. 1980. Habitat Evaluation Procedures (HEP) ESM 102. Division of Ecological Services. U.S. Fish and Wildlife Service, Department of the Interior, Washington, D.C.

DRAFT

FISH AND WILDLIFE COORDINATION ACT
SECTION 2(b) REPORT

ASSESSMENT OF THE LOWER CAPE MAY MEADOWS - CAPE MAY POINT FEASIBILITY STUDY, CAPE MAY COUNTY, NEW JERSEY

Prepared by:

U.S. Fish and Wildlife Service
Ecological Services, Region 5
New Jersey Field Office
Pleasantville, New Jersey 08232

November 1997

United States Department of the Interior

FISH AND WILDLIFE SERVICE

Ecological Services
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Pleasantville, New Jersey 08232

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IN REPLY REFER TO:

FP-97/55

November 13, 1997

Lt. Colonel Robert B. Keyser
District Engineer, Philadelphia District
U.S. Army Corps of Engineers
Wanamaker Building
100 Penn Square East
Philadelphia, Pennsylvania 19107-3390

Dear Lt. Colonel Keyser:

This is the draft report of the U.S. Fish and Wildlife Service (Service) on anticipated impacts to fish and wildlife resources from the U.S. Army Corps of Engineers (Corps) proposed Lower Cape May Meadows - Cape May Point Project (Meadows Project), Cape May County, New Jersey. This report was prepared pursuant to Section 2(b) of the Fish and Wildlife Coordination Act (FWCA) (48 Stat. 401; as amended; 16 U.S.C. 661 *et seq.*).

This draft report is provided in accordance with our Fiscal Year-1997 scope-of-work agreement and is based on plans and information provided in the Corps August 1997 Lower Cape May Meadows - Cape May Point Feasibility Study, Alternative Formulation Briefing Submittal. The Service previously provided the Corps with a Planning Aid Letter (PAL) dated September 7, 1994 that included information on federally listed and State-listed threatened and endangered species relevant to the Meadows Project and comments regarding the Habitat Evaluation Procedures study conducted during the reconnaissance phase of the Meadows Project.

The Lower Cape May Meadows project represents a unique opportunity to protect and enhance fish and wildlife habitat in an area that is especially critical to migratory birds. The Lower Cape May Meadows is an internationally significant coastal wetland complex that provides a critical stopover for these migratory birds. Migratory birds are a federal trust resource responsibility of the Service. Even with the current degradation of the Lower Cape May Meadows due to common reed (*Phragmites australis*) invasion and frequent inundation by storm events, the project area provides critical habitat for fish and wildlife resources. Continuing erosion of the Lower Cape May Meadows compromises both the quantity and quality of fish and wildlife habitat within this unique area. The Service ardently supports fish and wildlife restoration projects, particularly in areas subject to continuing degradation (e.g., erosion of the shoreline, common reed expansion, salt water inundation).

The federally listed (threatened) piping plover (*Charadrius melodus*) nests within the Lower Cape May Meadows area. Lower Cape May Meadows was one of the most productive piping plovers nesting areas in southern New Jersey in 1996 and 1997. Despite continuing erosion, which has reduced the beach width of the Meadows Project area, piping plovers continue to use this area. Piping plovers nest on sandy beaches above the high tide line on mainland coastal beaches, sand flats, and barrier island coastal beaches. Potential and historic nesting areas change over time as a result of coastal storms and littoral drift affecting beach erosion and accretion. Consequently, some documented piping plover nesting areas may become unsuitable over time, while new nesting areas may be formed as a result of accretion or the proposed beach nourishment.

The lead federal agency for a project has the responsibility under Section 7(c) of the Endangered Species Act (87 Stat. 884, as amended; 16 U.S.C. 1531 *et seq.*) to prepare a Biological Assessment, if the proposal is a major construction project that requires an Environmental Impact Statement and if the proposal may affect a federally listed species. Therefore, the Corps must prepare a Biological Assessment to address potential project-related impacts to the piping plover. The assessment should contain information concerning the piping plover within the action area and an analysis of any potential effect of the proposed action on this species. The Biological Assessment may be incorporated in the Corps National Environmental Policy Act (83 Stat. 852; 42 U.S.C. 4321 *et seq.*) document.

Other than the piping plover and an occasional transient peregrine falcon (*Falco peregrinus*) or bald eagle (*Haliaeetus leucocephalus*), no other federally listed or proposed endangered or threatened flora or fauna under Service jurisdiction are known to occur within the project area.

The federally listed endangered Kemp's Ridley turtle (*Lepidochelys kempii*), hawksbill turtle (*Eretmochelys imbricata*), leatherback turtle (*Dermochelys coriacea*) and the federally listed threatened green turtle (*Chelonia midas*) and loggerhead turtle (*Caretta caretta*) occur in the Atlantic Ocean immediately adjacent to the proposed project area. Except for nesting habitat for sea turtles, principal responsibility for marine turtles and marine mammals is under the jurisdiction of the National Marine Fisheries Service.

A draft copy of this report was forwarded to the New Jersey Division of Fish, Game and Wildlife (NJDFGW) for concurrence. A copy of the Service's letter to the NJDFGW is included in Appendix A. The Service is currently awaiting NJDFGW's response.

Additional information regarding this draft report can be provided by John Staples or Eric Schrading of my staff. The Service would appreciate any written comments on this report within 30 days.

Sincerely,

Clifford G. Day
Supervisor

Enclosure

DRAFT

FISH AND WILDLIFE COORDINATION ACT
SECTION 2(b) REPORT

ASSESSMENT OF THE LOWER CAPE MAY MEADOWS - CAPE MAY POINT FEASIBILITY STUDY, CAPE MAY COUNTY, NEW JERSEY

Prepared for:

U.S. Army Corps of Engineers
Philadelphia District
Philadelphia, Pennsylvania 19107-3390

Prepared by:

U.S. Fish and Wildlife Service
Ecological Services, Region 5
New Jersey Field Office
Pleasantville, New Jersey 08232

Preparer: Eric P. Schrading
Assistant Project Leader: John C. Staples
Project Leader: Clifford G. Day

November 1997

EXECUTIVE SUMMARY

The U.S. Army Corps of Engineers, Philadelphia District (Corps) initiated the New Jersey Shore Protection Study, incorporating the Lower Cape May Meadows - Cape May Point Project (Meadows Project), under the authority of resolutions adopted by the Committee on Public Works and Transportation of the U.S. House of Representatives and the Committee on Environment and Public Works of the U.S. Senate in December 1987. The project area is approximately 1.3 miles in length along the Atlantic Ocean coast, within the Borough of Cape May Point and the Borough of West Cape May, Cape May County, New Jersey.

Erosion has resulted in a reduction of approximately 115 acres of valuable fish and wildlife habitat since the construction of the Cape May Harbor jetties in 1911. An estimated additional 205 acres of habitat will be lost by 2050 if existing conditions continue. Additionally, habitat quality within the remaining Lower Cape May Meadows will continue to degrade without corrective measures, due to invasion of salt water into freshwater wetlands. Continual inundation by salt water will eliminate the remaining freshwater wetland plants, including several rare and State-listed plants, and will provide an opportunity for the continued expansion of common reed (*Phragmites australis*) within the Lower Cape May Meadows.

The Meadows Project is designed to protect and restore valuable beach and freshwater wetland habitat, improve water quality and hydrology within the subject wetland / upland complex, and eliminate invasive plant species (i.e., common reed). The Meadows Project also provides incidental benefits to the Borough of Cape May Point by providing shore protection from storm damage. Specifically, the project involves the construction of a berm and dune, in addition to dune grass plantings and installation of sand fence for dune stability. Renourishment is proposed every 3 to 4 years to compensate for expected losses of 15 feet per year due to erosion. The Corps is also considering reclaiming 7 acres of overwash area to emergent wetlands; restoring 25 acres of salt marsh; eliminating 95 acres of common reed by herbicide and burn treatment; replanting native, beneficial emergent and scrub / shrub wetland vegetation; reconnecting the hydrologic link between internal ponds; establishing 2 water control structures; and, excavating 6 new fish reservoirs within existing ponds. The Corps is also considering moving the shoreline waterward, reclaiming 35 acres of emergent wetlands.

The U.S. Fish and Wildlife Service (Service) considers the proposed ecosystem restoration as a beneficial project that would restore and enhance beach and dune habitat and improve the adjacent wetland / upland complex of Lower Cape May Meadows for fish and wildlife resources. Therefore, the Service fully supports the Corps proposed Lower Cape May Meadows project. Restoration and / or enhancement of 352 acres of valuable migratory bird habitat would improve this critical stopover location on the Cape May Peninsula. However, water level management and monitoring would be required to ensure that the goals and objectives of the proposed project are achieved and maintained.

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Figure 1. Lower Cape May Meadows Project Area 2

APPENDICES

Appendix A. Coordination with the New Jersey Division of Fish, Game and Wildlife

Appendix B. Guidelines for Managing Recreational Activities in Piping Plover Breeding Habitat on the U.S. Atlantic Coast to Avoid Take Under Section 9 of the Endangered Species Act

Appendix C. Federally Listed and State-Listed Endangered and Threatened Species in New Jersey

Appendix D. Suggested Plantings, Transplants, or Revegetation for Lower Cape May Meadows

I. INTRODUCTION

This constitutes the U.S. Fish and Wildlife Service's (Service) draft Fish and Wildlife Coordination Act, Section 2(b) report describing the fish and wildlife resources and supporting ecosystems in the area of the U.S. Army Corps of Engineers (Corps) proposed Lower Cape May Meadows - Cape May Point Project (Meadows Project). This report is provided in accordance with a Fiscal Year-1997 scope-of-work agreement between the Service and the Corps Philadelphia District. The information presented in this report: documents the fish and wildlife resources in the project area; identifies potential beneficial and adverse impacts to those resources; and, provides recommendations to minimize adverse impacts and maximize beneficial impacts. The project area is approximately 1.3 miles in length, and includes Cape May Point State Park (State Park) and The Nature Conservancy's Cape May Migratory Bird Refuge (TNC Refuge). The project area is within the Borough of Cape May Point and the Borough of West Cape May, Cape May County, New Jersey (Figure 1).

The New Jersey Shore Protection Study, which incorporates the Meadows Project, was authorized by resolutions adopted by the Committee on Public Works and Transportation of the U.S. House of Representatives and the Committee on Environment and Public Works of the U.S. Senate in December 1987. The authorization calls for defining coastal area problems associated with erosion and identifying potential solutions; identifying costs, environmental, and social impacts of potential solutions; and, presenting an optimized National Economic Development (NED) Plan. However, unlike traditional civil works water resource projects, ecosystem protection and restoration projects need not exhibit net NED benefits.

The Service requests that no part of this report be used out of context and if reproduced, the report should appear in its entirety. Furthermore, any data, opinions, figures, recommendations, or conclusions that are excerpted from the report should be properly cited and include the page number from which the information was taken. This report should be cited as follows:

Schrading, E.P. 1997. Assessment of the Lower Cape May Meadows - Cape May Point Feasibility Study, Cape May County, New Jersey. Draft Fish and Wildlife Coordination Act Section 2(b) Report. U.S. Department of the Interior, Fish and Wildlife Service, New Jersey Field Office. Pleasantville, New Jersey. 22 pp. + appendices.

Questions or comments regarding this report are welcomed by the Service. Written inquiries should be addressed to:

Supervisor
U.S. Fish and Wildlife Service
New Jersey Field Office, Ecological Services
927 North Main Street, Building D-1
Pleasantville, New Jersey 08232

II. PROJECT DESCRIPTION

The objectives of the Meadows Project are to:

(1) protect and restore beach and freshwater wetland habitat;

(2) improve water quality within the project area;

(3) eliminate / control nuisance plant species; and,

(4) increase availability of freshwater within the project area.

The proposed restoration project also has secondary objectives of reducing storm damage vulnerability and ocean inundation via the Lower Cape May Meadows (Meadows) to the Boroughs of Cape May Point and West Cape May. The proposed project was developed based on comments and input from the landowners of the Meadows (i.e., New Jersey Division of Parks and Forestry and The Nature Conservancy), in addition to the Service and the Borough of Cape May Point.

The proposed project involves a complex array of alternatives that would enhance or restore habitat within the Meadows. Most of the alternatives involve work landward of the existing dune, in the wetland / upland complex of the Meadows, and are dependent on berm and dune creation. Most of the alternatives can be accomplished independently or can be initiated in combination with other alternatives. However, restoration and enhancement within the Meadows would not be practical if the remaining freshwater wetland complex is not protected from the ocean by a suitable berm and dune. Therefore, creation of a berm and dune is critical to the restoration of the Meadows complex. The Corps proposes to construct a 157-foot-wide berm, as measured from the waterward toe of the dune to the mean high water line. The berm would have a top elevation of +8 feet National Geodetic Vertical Datum (NGVD). In addition, the Corps proposes a dune with a top elevation of 18 feet NGVD and a top width of 25 feet. Dune side slopes would be 1V:5H (i.e., 1 vertical on 5 horizontal) waterward and 1V:3H landward. The proposed berm and dune construction would provide an additional 10 acres of beach and dune habitat to the existing 64 acres adjacent to the Meadows. The proposed berm and dune construction would extend along the Meadows and beach areas of Cape May Point. Storms impacting Cape May Point flood the residential areas adjacent to the Meadows. These flood waters follow existing contours into the Meadows, thus inundating the Meadows with salt water. Thus, beach nourishment along Cape May Point is critical to protecting the Meadows from inundation damage. Dune areas would be planted with dune grass (likely American beach grass (*Ammophila breviligulata*)) and sand fence would be installed along the dunes for stability. Renourishment would occur every 3 to 4 years to compensate for expected losses of 15 feet per year due to erosion (U.S. Army Corps of Engineers, 1997a).

The Corps has identified two offshore borrow areas in the Atlantic Ocean: Borrow Area P1 (250 acres) and Borrow Area P2 (150 acres) (Figure 1). The Corps proposes to use Borrow Area P2 because of its proximity to the Meadows and because Borrow Area P1 lacks an adequate supply of suitable material (U.S. Army Corps of Engineers, 1997a). In addition, Borrow Area P2 has a average grain size (0.75 mm) closer to the existing average grain size at the Meadows (0.21 mm) and at Cape May Point (0.42 mm).

The Corps is also proposing three alternatives to restore previously eroded or overwashed areas. The first alternative involves conversion of 7 acres of overwash area to emergent wetlands in an area immediately behind an existing dune. The other two alternatives involve moving the existing shoreline waterward to reclaim 35 or 60 acres of habitat that was terrestrial and is now subtidal. These second two alternatives would maintain the proposed beach acreage of 74 acres and convert the reclaimed area to freshwater emergent marsh landward of the proposed dune.

The Corps is also proposing to eliminate or control invasive plant species, specifically common reed by herbicide and burning treatments. An herbicide (e.g., glyphosate) would be applied in the fall aerially, followed by a winter or spring burn of the common reed areas. A second herbicide treatment would likely be applied the following fall. Maintenance would be required to ensure that common reed does not recolonize these areas. Following elimination of common reed, the Corps proposes to plant beneficial freshwater emergent plants to revegetate areas formerly colonized by common reed. The Corps is also considering restoring 25 acres of salt marsh on the extreme eastern portion of the Meadows. This area was originally the headwaters of Cape Island Creek; however, due to residential development, a 2,000-foot-long pipe under various houses is the only connection between Cape Island Creek and the Meadows. This area is dominated by common reed due to restricted water movement from a closed flap gate on the pipe. The Corps is proposing to restore tidal flushing to the 25 acre area to enhance wetlands in the area and provide increased wetland diversity in the Meadows. Tidal inundation throughout the proposed 25-acre site would eliminate common reed and would promote conditions for establishment of salt marsh vegetation such as *Spartina alterniflora* and *Spartina patens*. The proposed salt marsh restoration would be separated from the adjacent freshwater wetlands by constructing a dike and providing a hydrologic connection via a water-control structure.

The Corps proposes to improve water quality and increase the availability of freshwater by reconnecting the hydrologic connection between ponds within the Meadows. Currently internal ponds in the Meadows are not connected resulting in stagnant water, which encourages eutrophication. The Corps proposes to provide a hydrologic linkage between most of the ponds to improve water quality and restore hydrologic flow through the Meadows. Associated with this proposal is construction of two water-control structures between the State Park and TNC Refuge and between the freshwater wetlands and the proposed salt marsh. Water-control structures are essential to controlling the spread of common reed and providing habitat enhancement opportunities for a variety of migratory birds. The Corps is also considering creation of six fish reservoirs within four ponds in the Meadows. The fish reservoirs would not be deeper than 36 inches and would be approximately 0.1 acre in size. The

purpose of the fish reservoirs is to provide refuge for fish and other aquatic organisms during dry seasons (e.g., late summer). By creating fish reservoirs, abundance of fish within the Meadows may be sufficient to consume enough mosquito (*Culicidae*) larvae to reduce the need for the Cape May County Mosquito Control Commission to apply pesticides in the Meadows.

Of the proposed alternatives described above, the current recommended plan includes: construction of a berm and dune waterward of the existing shoreline, reclaiming 35 acres of terrestrial habitat; control of common reed throughout the Meadows via herbicide and burning treatment; tidal inundation of 25 acres of common reed-dominated wetlands on the eastern portion of the Meadows with conversion to salt marsh; reconnection of the hydrologic link between ponds; construction of 6 new fish reservoirs; and, installation of two water-control structures to allow internal water management (Brandreth, pers. comm., 1997). The proposed project is based on extensive coordination among the Corps, the Service, the New Jersey Division of Parks and Forestry (NJDPF) (Cramer, pers. comm., 1997), and The Nature Conservancy (Laubengeyer, pers. comm., 1997).

III. METHODS AND PROCEDURES

The information and findings presented in this report are based on review of the August 1997 New Jersey Shore Protection Study, Lower Cape May Meadows - Cape May Point Feasibility Study, Alternative Formulation Briefing Submittal (U.S. Army Corps of Engineers, 1997a) and review of additional information made available to the Service by the Corps. The content of this report is also based on review of Service files and library material; coordination with the NJDPF, The Nature Conservancy, New Jersey Division of Fish, Game and Wildlife's (NJDFGW) Bureau of Marine Fisheries, Bureau of Shellfisheries, and Endangered and Nongame Species Program (ENSP); and, site visits conducted by Service biologists in October and December 1993, April 1994, and August, September, and October 1997.

IV. PHYSICAL CHARACTERISTICS

The Meadows Project area is 1.3 miles long bordered with a relatively narrow beach, man-made dunes, and shallow subtidal waters along the Atlantic Ocean. The Meadows project area is 333 acres and is divided between the Park (149 acres) managed by the NJDPF and the Refuge (184 acres) owned by The Nature Conservancy. The Meadows is in the Boroughs of Cape May Point and West Cape May, Cape May County, New Jersey. The ground in the Meadows slopes down from west to east, with an average elevation of 5 feet-NGVD in the Park to 1.5 feet-NGVD in the Refuge. Currently, the Meadows is comprised of the following cover types: forest (72 acres), field (23 acres), palustrine emergent wetlands (38 acres), common reed-dominated wetlands (95 acres), palustrine

open water (41 acres), and beach / dune (64 acres). Forest and field cover types are landwardmost on the Meadows (Figure 1). The erosion rate of the Meadows is 15 feet / year and by 2050 an estimated 205 acres of habitat will be lost. The entire Meadows is protected in perpetuity by the State of New Jersey and The Nature Conservancy. Areas surrounding the Meadows include moderate to high density residential development and some agricultural land. Groin fields occur along the coast on the eastern and western sides of the Meadows and may be partly responsible for sand starvation of beaches in the Meadows.

Hydrology within the Meadows is palustrine and generally follows the topography from west to east, despite the lack of hydrologic connections between internal ponds. Lake Lily located in the Borough of Cape May Point is a freshwater lake fed by groundwater and storm runoff and is surrounded by 113 acres of residential development. Lake Lily is hydrologically connected with the western portion of the Meadows by a 1,200-foot-long 18-inch-diameter pipe, which runs to Lighthouse Pond West. Shallow Pond West within the Park is connected to the Atlantic Ocean via an outfall structure. This outfall structure was installed after the March 1992 northeaster, which inundated Lighthouse Avenue in the Borough of Cape May Point for months. The outfall structure, with an invert of 3.5 feet-NGVD was installed to prevent flooding of Lighthouse Avenue. The eastern portion of the project is the former headwaters of Cape Island Creek. Currently little to no hydrologic connection occurs between the Meadows and Cape Island Creek and between the internal ponds within the Meadows. Storm events such as northeasters and hurricanes severely impact the quality of the habitat within the Meadows. Salt water inundation and erosion result in habitat loss and reduce the quality of palustrine wetlands. Storm events may (depending on frequency and duration) destroy freshwater wetland vegetation not tolerant of salinity. In addition, the periodic disturbance from storm events coupled with the loss of freshwater wetland vegetation, provide opportunities for common reed to continue to spread and colonize the Meadows.

V. FISH AND WILDLIFE RESOURCES

The Service's September 7, 1994 Planning Aid Letter (PAL) identifies federally listed and State-listed threatened and endangered species relevant to the Meadows Project. Additionally, the Corps (1997a) identifies numerous fish and wildlife resources including finfish, shorebirds, wading birds, waterfowl, raptors, and other terrestrial wildlife that occur in the project area. The project area provides valuable open water, intertidal beach, freshwater wetlands, and upland areas for a variety of finfish, migratory birds, and other wildlife. Furthermore, the project area serves as a critical migratory stopover for raptors, shorebirds, and neotropical birds.

The Corps assessed the status of benthic organisms for each proposed sand borrow site. The studies were initiated to establish a baseline for the benthic macroinvertebrate assemblages within the proposed borrow sites and to identify the presence of commercial and / or recreationally important benthic

macroinvertebrates. Borrow Area P1 and P2 had species diversity (mean = 27.4 and 21.8, respectively) similar to reference sites (Scott, 1997). Borrow Area P1 had higher macroinvertebrate abundance (19,430) than P2 (6,462), but differences were not significant. Surf clams (*Spisula solidissima*) were more abundant in Borrow Area P2 than P1 (though not significantly), but the biomass of this species was extremely low in P2 and was significantly lower than P1. Borrow Area P1 had significantly higher polychaete abundance than P2 and Borrow Area P2 had a significantly higher Shannon-Wiener Index and Simpson's Diversity Index than P1. However, Scott (1997) concluded that the differences were attributable to the high abundance of two polychaete taxa (*Polycirrus eximius* and *Polygordius* spp.) in Borrow Area P1. Scott (1997) summarized that the differences between borrow areas P1 and P2 would not preclude the selection of either site as a source for borrow material.

The shallow-water areas, particularly shoals adjacent to the Meadows support a productive commercial and recreational fishery. The internal ponds of the Meadow also support finfish including; mummichog (*Fundulus heteroclitus*), banded killifish (*F. diaphanus*), sheepshead minnow (*Cyprinodon variegatus*), tidewater silversides (*Menidia beryllina*), and mosquitofish (*Gambusia affinis*). Finfish and other aquatic organisms occurring in ponds in the Meadow provide important food resources for wading birds such as the great blue heron (*Ardea herodias*), snowy egret (*Egretta thula*), little blue heron (*Egretta caerulea*), great egret (*Casmerodius albus*), glossy ibis (*Plegadis falcinellus*), black-crowned night heron (*Nycticorax nycticorax*), and yellow-crowned night heron (*Nycticorax violaceus*) (New Jersey Division of Fish, Game and Wildlife, 1994). While wading birds feed regularly in the Meadows, the nearest nesting colony is north of Cape May Canal, more than 2 miles from the Meadows (Andrews, 1990).

The Meadows provides important habitat for waterfowl and shorebirds, particularly during spring and fall migration. Waterfowl including blue-winged teal (*Anas discors*), green-winged teal (*Anas crecca*), American widgeon (*Anas americana*), lesser scaup (*Aythya affinis*), black duck (*Anas rubripes*), and mallard (*Anas platyrhynchos*) are commonly seen in the ponds of the Meadows (New Jersey Division of Fish, Game and Wildlife, 1994). Coastal wetlands are particularly important overwintering habitat for black ducks. Shorebirds also use habitat within the Meadows during spring and fall migration. Red knot (*Calidris canutus*), ruddy turnstone (*Arenaria interpres*), sanderling (*Calidris alba*), and semipalmated sandpiper (*Calidris pusilla*) are common shorebirds of the Meadows (New Jersey Division of Fish, Game and Wildlife, 1994).

Migratory raptors concentrate along the southern tip of New Jersey prior to crossing the Delaware Bay. In the fall, regular observations by the Cape May Bird Observatory record an average of 60,000 raptors a year. Common migrating raptors include Cooper's hawk (*Accipiter cooperii*), sharp-shinned hawk (*A. striatus*), broad-winged hawk (*Buteo platypterus*), red-shouldered hawk (*B. lineatus*), red-tailed hawk (*B. jamaicensis*), northern harrier (*Circus cyaneus*), American kestrel (*Falco sparverius*), and merlin (*F. columbarius*). The barn owl (*Tyto alba*), long-eared owl (*Asio otus*), short-eared owl, and northern saw-whet owl (*Aegolius acadicus*) undertake similar migrations (Dunne and Sutton, 1986).

A variety of other wildlife species inhabit the Meadows area, including cottontail rabbit (*Sylvilagus floridanus*), muskrat (*Ondatra zibethicus*), raccoon (*Procyon lotor*), diamondback terrapin (*Malaclemys terrapin*), Fowler's toad (*Bufo woodhousii*), and spring peeper (*Hyla crucifer*) (New Jersey Division of Fish, Game and Wildlife, 1994). The spring peeper was once very common within both the Park and the Refuge; however, no spring peepers have been observed or heard in the Meadows in the last several years. Saltwater intrusion is believed to be the cause of their disappearance (U.S. Army Corps of Engineers, 1997a).

The Meadows have been designated by the U.S. Environmental Protection Agency (EPA) as a "priority" wetland because the area provides significant habitat for migratory birds and is threatened by development in adjacent communities. The adjacent Cape Island Creek wetlands have been designated by the Service as "priority" wetlands, pursuant to the Emergency Wetlands Resources Act of 1986 (100 Stat. 3582), because of their national ecological significance. In addition, the wetlands in the Meadows are internationally significant in being distinguished in the Ramsar List of Wetlands of International Importance and as part of the Western Hemisphere Shorebird Reserve Network (sponsored by World Wildlife Fund, the International Association of Fish and Wildlife Agencies, and the Academy of Natural Sciences of Philadelphia), the Delaware Estuary Program (sponsored by EPA), and the Coastal Ecosystem Program (sponsored by the Service).

VI. ENDANGERED AND THREATENED SPECIES

A review of Service records indicates that the Meadows supported the most productive piping plover (*Charadrius melodus*) nesting area in 1996 and 1997 in southern New Jersey. The piping plover is a federally listed (threatened) species and regularly nests on beaches adjacent to the Meadows. Piping plovers nest on sandy beaches above the high tide line on mainland coastal beaches, sand flats, and barrier island coastal beaches. The nesting sites are typically located on gently sloping foredunes, blowout areas behind primary dunes, washover areas cut into or between dunes, ends of sandspits, and on sites with deposits of suitable dredged or pumped sand.

Food for adult plovers and chicks consists of invertebrates such as marine worms, fly larvae, beetles, crustaceans, and mollusks. Feeding areas include intertidal portions of ocean beaches, ocean washover areas, mudflats, sandflats, wrack lines (organic ocean material left by high tide), shorelines of coastal ponds, lagoons, and salt marshes.

Development along the coastal shoreline for residential and commercial uses, and the subsequent stabilization of the once-shifting and dynamic beach ecosystem via seawalls, breakwaters, jetties, and groins have resulted in the deterioration and alteration of natural beaches. The above activities have occurred to such an extent along the Atlantic coast that many beaches no longer provide suitable habitat for the piping plover.

The Service expects that piping plovers will continue to nest on the beaches within the project area between now and the initiation of project construction. Potential and historic nesting areas change over time as a result of coastal storms and littoral drift, which affect beach erosion and accretion. Consequently, some current piping plover nesting areas may become unsuitable over time, while new nesting areas may be formed as a result of accretion or the proposed beach nourishment.

Project-related activities could adversely affect the piping plover. The lead federal agency for a project has the responsibility under Section 7(c) of the Endangered Species Act of 1973 (87 Stat. 884, as amended; 16 U.S.C. 1531 *et seq.*) to prepare a Biological Assessment if the project is a construction project that requires an Environmental Impact Statement (EIS) and the project may affect listed species. Therefore, the Corps must prepare a Biological Assessment to address potential project-related adverse impacts to the piping plover.

The Biological Assessment should contain information concerning listed or proposed species, which may be present in the action area, and an analysis of any potential effects of the proposed action on such species. The following may be considered for inclusion in a Biological Assessment of the proposed project, although actual contents are at the discretion of the federal authorizing agency:

(1) results of field surveys to determine if listed species are present or occur seasonally;

(2) views of recognized experts on the species;

(3) literature review;

(4) analysis of direct, indirect, and cumulative effects of the action on the species; and,

(5) analysis of alternative actions.

Specifically, the Biological Assessment should include potential adverse impacts on piping plovers associated with proposed beach nourishment and renourishment activities for the project life (i.e., 50 years). Biological Assessments may be consolidated with procedures for interagency cooperation required by other statutes such as the Fish and Wildlife Coordination Act or the National Environmental Policy Act of 1969, as amended (83 Stat. 852; 42 U.S.C. 4321 *et seq.*). However, satisfying the requirements of these other statutes does not in itself relieve a federal agency of its obligation to comply with the Biological Assessment procedures of the Endangered Species Act. The results of a Biological Assessment may be incorporated in the EIS. If the Biological Assessment indicates that no listed or proposed species are present or will be affected, and the Service <u>concurs</u> in writing with the assessment, then no formal consultation pursuant to Section 7 will be required.

To ensure the continued protection of the piping plover over the life of the project, the Service recommends that the Corps reinitiate consultation:

- at least 135 days (90 days for formal consultation, 45 days for issuance of a Biological Opinion) prior to beginning any beach nourishment associated with the Meadows Project; and,

- at least 135 days prior to any beach maintenance activities (e.g., beach renourishment) for the life of the project (i.e., 50 years).

To reduce impacts associated with proposed beach nourishment and renourishment activities, the Service suggests the following project modifications.

1. Avoid all work in the project area between April 1 and August 15 in order to avoid potential adverse impacts on nesting piping plovers. This seasonal restriction would be applicable to maintenance work that may be necessary in subsequent years. Associated work includes, but is not limited to: the placement, movement, or maintenance of pipelines; stockpiling of construction materials and equipment; and, the pumping, placement, or distribution of sand.

2. Establish protective zones in accordance with the Service's "Guidelines for Managing Recreational Activities in Piping Plover Breeding Habitat on the U.S. Atlantic Coast to Avoid Take Under Section 9 of the Endangered Species Act" (Guidelines), dated April 15, 1994 (Appendix B). Protective zones for piping plover nests shall take precedence over all recreational activities (e.g., vehicle access, sunbathing, kite-flying, swimming, walking). In addition, other measures identified in the Guidelines shall be instituted, such as prohibiting dogs in the vicinity of protective zones or ensuring that all dogs are leashed. Establishment of the protective zones must be coordinated with the ENSP.

3. Maintain multiple access passages between the proposed beach and the existing freshwater wetlands and feeding areas (e.g., poorly vegetated areas) landward of the proposed dune to preserve freshwater wetland feeding areas for piping plovers (Jenkins, pers. comm., 1997). Access passages over the dunes are areas gently-sloping, wide, unvegetated corridors over the dunes that provide access to relatively unvegetated flats adjacent to wetlands. The Service and ENSP would provide additional assistance in the maintenance or creation of these areas.

Other than the piping plover and an occasional transient bald eagle (*Haliaeetus leucocephalus*) or peregrine falcon (*Falco peregrinus*), no other federally listed or proposed threatened or endangered flora or fauna under Service jurisdiction are known to occur in the vicinity of the project.

The federally listed Kemp's Ridley turtle (*Lepidochelys kempii*), green turtle (*Chelonia mydas*), hawksbill turtle (*Eretmochelys imbricata*), leatherback turtle (*Dermochelys coriacea*), and loggerhead turtle (*Caretta caretta*) are known to occur in the vicinity of the project. Except for nesting habitat for sea turtles, principal responsibility for marine turtles and marine mammals is under the jurisdiction of the National Marine Fisheries Service (NMFS). The Service understands that the Corps has contacted the NMFS regarding potential impacts to federally listed species, under NMFS jurisdiction, that may result from dredging projects and would comply with conditions identified in the NMFS Biological Opinion regarding listed species.

Nesting populations of the State-listed endangered least tern (*Sterna antillarum*) occur within the project area. The State-listed black skimmer (*Rynchops niger*) has also nested within the project area and on adjacent beaches. The State-listed threatened American bittern (*Botaurus lentiginosus*) occurs within wetlands adjacent to the Meadows (New Jersey Division of Fish, Game and Wildlife, 1994). The State-listed endangered southern gray treefrog (*Hyla chrysoscelis*) and eastern tiger salamander (*Ambystoma tigrinum*) occur within southern Cape May and may have occurred in the Meadows; however, it is unlikely that these species currently exist in the Meadows due to saltwater intrusion. Several birds-of-prey occur in the vicinity of the project area including the State-listed endangered Cooper's hawk (*Accipiter cooperii*), and the State-listed threatened northern goshawk (*Accipiter gentilis*), osprey (*Pandion haliaetus*), and barred owl (*Strix varia*). The State-listed endangered sedge wren (*Cistothorus platensis*) also occurs in the vicinity of the Meadows and inhabits freshwater emergent and scrub / shrub wetlands (New Jersey Division of Fish, Game and Wildlife, 1994). Provided construction does not occur between April 1 and August 15, it is unlikely that the proposed Meadows Project would adversely affect the abovementioned State-listed species; however, it is likely that the Meadows Project would enhance habitat for several State-listed species including the least tern, black skimmer, and sedge wren. A summary of federally listed and State-listed species in New Jersey is included as Appendix C.

The Meadows also supports several State-listed endangered plants including the butterfly pea (*Clitoria mariana*), awl-leaved rush (*Juncus coriaceus*), and fog fruit (*Phyla lanceolata*) (New Jersey Division of Parks and Forestry, 1986). Additionally, several rare plants also occur in the Meadows including the narrow-leaved wild crab apple (*Pyrus angustifolia*), whorled marsh-pennywort (*Hydrocotyle verticillata*), and blue boneset (*Eupatorium coelestinum*) (Biohabitats, Incorporated, 1995). Additionally, a follow-up plant survey by Biohabitats, Incorporated (1996) identified dodder (*Cuscuta indecora*), which is considered rare in New Jersey. The proposed common reed control of spraying herbicides (e.g., glyphosate-based herbicides) and burning could adversely affect State-listed and rare plants. Therefore, the Service recommends that the Corps identify the location of all State-listed and rare plants within the Meadows and take appropriate measures to protect these areas from activities intended to control common reed to ensure that adverse impacts on rare species are avoided. The Service also recommends that the Corps contact the New Jersey Natural Heritage Program and ENSP regarding the protection of State-listed and rare species.

VII. IDENTIFICATION OF BENEFICIAL AND ADVERSE IMPACTS, AND MITIGATIVE MEASURES

A. BENEFICIAL AND ADVERSE IMPACTS

Restoration efforts have the potential to recreate, restore, and protect valuable areas for use by fish and wildlife resources. Additionally, enhancement activities within the Meadows such as common reed control, hydrologic improvements, and revegetation would significantly improve the Meadows for fish and wildlife resources. However, restoration efforts that include extraction of materials from offshore borrow areas and related beach nourishment operations may result in adverse impacts to benthic organisms, finfish, and wildlife. In particular, beach nourishment activities result in the conversion of shallow water cover types to beach and dune cover types. Enhancement activities may also result in temporary adverse impacts on freshwater wetlands within the Meadows.

1. Extraction from Borrow Areas

Dredging borrow areas results in the removal of sediment and organisms from the borrow areas and adversely impacts water quality. Beach nourishment at the Meadows would adversely impact approximately 150 acres of benthic habitat, resulting in mortality of benthic organisms. Long-term impacts on borrow areas include potential changes in circulation patterns and the pattern of sediment deposition. Extraction from borrow areas may create bottom depressions with reduced flushing, which can create anoxic conditions slowing the recovery of benthic populations. However, most benthic organisms within the Delaware Bay's dynamic ecosystem have adapted to periodic changes in habitat that occur as a result of northeasters, hurricanes, and other storms. As a result, benthic organisms typically recolonize an area quickly, provided the habitat is still suitable. Saloman *et al.* (1982) concluded that benthic organisms recover from dredging events in approximately 1 year, with minor sedimentological changes, and a small decline in diversity and abundance within the benthic community. The Corps has also determined that recolonization of the proposed borrow areas would occur within 1 to 2 years of dredging (U.S. Army Corps of Engineers, 1997a). However, disturbances within the borrow areas every 3 to 4 years for the life of the project (i.e., 50 years) would likely limit recolonization, thereby maintaining low infaunal abundance and low species diversity.

The type of equipment used and the time of year extraction occurs may greatly influence the nature and extent of adverse impacts related to dredging. For example, dredging with a hydraulic dredge may reduce short-term adverse impacts on water quality, but may impact eggs, young fish, and other slow-moving organisms unable to avoid entrainment. The timing of dredging is also important in that if initiated concurrently with a period of low biological activity (November-January), adverse impacts on fish and wildlife resources could be minimized.

2. Beach Nourishment

The proposed beach nourishment and subsequent renourishment will bury infaunal organisms and result in mortality within the shallow nearshore (littoral) zone. Most of the organisms inhabiting the extremely dynamic nearshore and intertidal zones are highly mobile and adapt quickly to significant changes in abiotic factors. However, the proposed project would likely reduce infaunal abundance and species diversity despite the resiliency of the intertidal benthic fauna. Reilly and Bellis (1983) determined that recovery of macrofauna is rapid after beach nourishment activities cease; however, the recolonized community may differ considerably from the original community. Differences in grain size from the original beach and sand provided for beach nourishment may also affect the rate of recolonization and community diversity. Borrow Area P2 has an average grain size (0.75 mm) similar to the existing average grain size at the Meadows (0.21 mm) and at Cape May Point (0.42 mm) (U.S. Army Corps of Engineers, 1997a).

Beach nourishment activities may also adversely affect the piping plover or other shorebirds, particularly if such activities occur during the nesting season. Conversely, beach nourishment may create suitable nesting habitat in areas that currently do not support shorebird nesting. Piping plovers and other beach nesting birds, such as black skimmers, least terns, and common terns may benefit from such activities.

The proposed project would reclaim 35 acres of terrestrial habitat waterward of the existing shoreline. Obviously, this would eliminate 35 acres of shallow water habitat adjacent to the Meadows. However, this area was formerly beach habitat prior to construction of updrift jetties and groins (U.S. Army Corps of Engineers, 1997a). Shallow water habitat would be created waterward of the proposed berm and dune construction, therefore, no net loss in shallow water habitat is predicted.

3. Ecosystem Restoration

The proposed project is critical to protecting freshwater wetlands within the Meadows. Without protection of the Meadows via berm and dune construction, the Meadows would eventually lose 205 acres of habitat and continue to be inundated by salt water during storm events. Inundation would eliminate freshwater wetland emergent plants and promote the continued spread of common reed within the Meadows.

Ecosystem restoration at the Meadows would create an additional 10 acres of dune, upland beach, and intertidal habitat that is continuing to decline along the Meadows. The currently proposed Meadows Project would also create 31 acres of freshwater emergent wetlands and 4 acres of freshwater ponds landward of the proposed dune. In addition, the proposed restoration may create additional habitat for federally listed and State-listed species, including the piping plover.

a. Habitat evaluation procedures

A Habitat Evaluation Procedures (HEP) study was initiated by the Corps, the Service, the NJDPF and The Nature Conservancy in fall 1993, spring 1994, and summer 1997 to provide a qualitative and quantitative assessment of fish and wildlife habitat on the Meadows and to determine the potential benefits of ecosystem restoration (U.S. Army Corps of Engineers, 1994).

Habitat quality for selected evaluation species is documented with an index referred to as the "Habitat Suitability Index" (HSI). Each evaluation species' HSI Model is applied to the project area(s) to evaluate the life requisite factors (primarily food, water, and breeding and escape cover). Each component is given a numerical rating (using a 0 to 1 scale in increments of 0.1) that determines the life requisite value (Suitability Index). The overall relationship of the suitability indices are calculated mathematically to yield the HSI value for an individual species at a given site and point in time. "Habitat Units" (HU) identify the relative habitat value of an area for a given species by incorporating the quality (i.e., HSI) and quantity (i.e., acres) of the habitat into a product value. HUs are created using the following expression: HSI x acres = HU.

Twelve evaluation species were selected to represent the guild of species that use the different cover types within the Meadows. The sharp-shinned hawk (*Accipiter striatus*) and wood thrush (*Hylocichla mustelina*) represent forested areas. The American kestrel (*Falco sparverius*) and the field sparrow (*Spizella pusilla*) represent the field. The green heron (*Butorides virescens*) and clapper rail (*Rallus longirostris*) represent emergent wetlands. The sanderling (*Calidris alba*) and the least tern represent the beach. The marsh wren (*Cistothorus palustris*) and the muskrat (*Ondatra zibethicus*) represent wetlands dominated by common reed. The black duck and the spring peeper represent open water areas within the Meadows.

As of 1997, the Meadows provided 57.6 HUs for sharp-shinned hawk, 36 HUs for wood thrush, 18.4 HUs for American kestrel, 13.8 HUs for field sparrow, 22.8 HUs for green heron, 30.4 HUs for clapper rail, 51.2 HUs for sanderling, 64 HUs for least tern, 38 HUs for marsh wren, 28.5 HUs for muskrat, 32.8 HUs for black duck, and 24.6 HUs for spring peeper.

The Corps selected ecosystem restoration plan (including beach nourishment, common reed control, salt marsh creation, and hydrologic modifications) would protect the existing Meadows habitat and the HUs provided within the Meadows. In addition, the proposed plan would create an additional 108.4 HUs for green heron, 117.2 HUs for clapper rail, 8 HUs for sanderling, 10 HUs for least tern, 5 HUs for black duck, and 4.8 HUs for spring peeper by year 2050 compared to the baseline HUs in 1997. These HU gains would be significantly higher when compared to HU values for the project area at year 2050 if no project activities occur. Without any project activities within the Meadows, the current

erosion rate of 15 feet / year is assumed to continue, which would eliminate 205 acres of terrestrial habitat from the Meadows. Therefore, the HU gains for the evaluation species are significantly higher when the with-project HUs are compared to the without-project HUs for year 2050 (i.e., 426.8 HUs among all evaluation species).

Since common reed would be eliminated (to the maximum extent practicable) this cover type would no longer exist within the meadows and the representative species for this cover type (i.e., marsh wren and muskrat) would technically lose HUs (38 HUs and 28.5 HUs, respectively). However, marsh wren and muskrat also inhabit freshwater emergent wetlands and the same if not more HUs would still exist within the Meadows for marsh wren and muskrat with the proposed project.

The Corps has not completed the cost:benefit analysis for the Meadows Project to date. The Service recommends that the Corps analyze each HEP evaluation species independently in the cost:benefit analysis for the Meadows Project. There is no biological basis for adding HUs of different species, although they may appear to be the same units. As such, analyzing HEP evaluation species independently, rather than adding all the HUs in the cost:benefit analysis, is the only valid cost:benefit analysis that can be conducted using HEP data.

b. Common reed control

Common reed control would involve spraying herbicides (e.g., glyphosate-based herbicides) and burning, potentially multiple times. These activities would eliminate common reed and some beneficial emergent vegetation. Glyphosate-based herbicides are regularly used by the Service on National Wildlife Refuges and provided EPA guidelines are followed, impacts on fish and wildlife resources are minimal. Glyphosate is a water-soluble chemical with a short half-life and has no significant impact on macroinvertebrates, fish, or wildlife. Glyphosate is also approved for use in wetland and other aquatic areas. Common reed control will have temporary impacts; however, with follow-up revegetation (e.g., plantings) of beneficial emergent vegetation and water-level control, habitat within impacted areas would be improved and the spread of common reed (and the need for follow-up herbicide treatment) would be reduced. As noted above, the Service recommends surveying for rare plant species (after coordination with the State Natural Heritage Program and ENSP) to avoid adverse impacts to such species during control of common reed.

Reintroducing tidal inundation to 25 acres on the eastern portion of the Meadows would eliminate common reed in this area and provide increased diversity of wetlands within the Meadows. The subject area is the headwaters of Cape Island Creek and was traditionally salt marsh prior to development. To avoid flooding of adjacent developed areas, a self-regulating tide gate would be installed allowing twice-daily tidal inundation to the salt marsh, that would limit the entry of water during extreme tides. Restoring salt marsh in this area would replace 25 acres

of freshwater wetlands with 25 acres of salt marsh; however, the existing freshwater wetlands are saturated with common reed and have low habitat value for fish and wildlife resources. Therefore, the proposed wetland conversion would improve the habitat value of the subject 25-acre area.

c. Freshwater pond enhancement

Connecting the freshwater ponds within the Meadows would involve excavating channels between the ponds. Many of these channels previously existed prior to being filled by sediment or overwash. Excavation would require disturbance of less than 1 acre of common-reed dominated wetlands. In addition two water-control structures would be created between the Park and Refuge and between the freshwater marsh and salt marsh. The water-control structures would provide the ability to manage water levels within the Meadows based on management objectives. Control of water levels is also important in controlling the spread of common reed. Six fish reservoirs would also be constructed within existing freshwater ponds. Reservoirs would be no deeper than 36 inches and would be on average 0.1 acre, ranging from 0.01 to 0.25 acre. Creation of fish reservoirs provides a refuge for obligate aquatic species during dry periods. The construction of fish reservoirs is consistent with Open Marsh Water Management and provides habitat for mosquito-eating fish (even during dry periods) to allow biological control of mosquitos. Currently, the Cape May County Mosquito Control Commission sprays the Meadows regularly during the summer to exterminate mosquitos. Construction of fish reservoirs would reduce or eliminate the need to spray insecticides on the Meadows. All of the hydrologic impacts (e.g., channels, water-control structures, fish reservoirs) would result in minor, temporary adverse impacts on the Meadows, but would provide significant long-term improvements to habitat quality within the Meadows.

B. MITIGATIVE MEASURES

1. Extraction from Borrow Areas

The Corps is currently proposing to deepen the Delaware River Channel as identified in the Delaware River Main Channel Deepening Project (U.S. Army Corps of Engineers, 1997b). The Corps proposes to stockpile sand in two areas in the Delaware Bay resulting in the burial of 730 acres of subtidal habitat. As an alternative to sand stockpiling, the Service recommends that the Corps consider linking federal projects that involve beach nourishment (e.g., Meadows) with the Delaware River Main Channel Deepening Project. Direct beach nourishment would eliminate double handling of dredged material and would eliminate or minimize adverse impacts on 730 acres of subtidal habitat.

The Water Resources Development Act (33 U.S.C. 2201 *et seq.*; 100 Stat. 4082) (WRDA) directs the Corps to place a greater emphasis on the use of dredged material for beneficial uses, including beach nourishment. Section 207 of WRDA of 1996 specifically allows the Corps to select a disposal method other than the least cost option, if the incremental costs are reasonable in relation to the environmental benefits. As stated above, the Service recommends that the Corps use the material from the Delaware River Main Channel Deepening Project for direct beneficial uses (e.g., Meadows) consistent with Section 207 of the WRDA of 1996.

If use of borrow material from the Delaware Main Channel Deepening Project is not feasible, the Service concurs with the Corps selection of Borrow Area P2 to provide borrow material. However, prior to use of this site, the Service recommends additional sampling to better quantify adverse impacts. Specifically, Scott (1997) sampled the proposed borrow area with a Young-modified Van Veen grab-sampler, which is inappropriate for sampling adult surf clams. Therefore, the Service recommends that the Corps conduct a clam survey using appropriate methodology to estimate the adult population of surf clams in the proposed borrow areas.

In order to minimize repeated impacts on benthic organisms within the borrow area, the Service recommends conducting each renourishment dredging phase in a limited portion of the borrow area and alternate locations for each subsequent renourishment cycle. This concept of rotational dredging minimizes frequent, repeated disturbance of a particular area, thereby allowing recolonization of benthic organisms to occur over a longer period of time.

In order to avoid anoxic conditions in the borrow area, the Service recommends that the Corps avoid the creation of excessively deep, poorly flushed borrow sites. The Service also recommends that dredging occur during a period of low biological activity (November to January) to minimize impacts on benthic organisms, and to use a hydraulic dredge with a pipeline delivery system to minimize turbidity and minimize impacts on benthic invertebrates.

Finfish such as striped bass (*Morone saxatilis*) and bluefish (*Pomatomus saltatrix*) frequent shoals immediately offshore of the Meadows such as the Eph Shoal adjacent to Borrow Area P2. Dredging activities within these shoals could adversely impact use of these shoals by recreationally valuable finfish (McClain, pers. comm., 1997). Therefore, the Service recommends that the Corps coordinate with the New Jersey Division of Fish, Game and Wildlife, Bureau of Marine Fisheries and the Cape May Charter Boat Association to identify potential impacts on recreational fisheries and minimize adverse impacts on such fisheries.

2. Beach Nourishment

Revegetation and fencing are proposed to stabilize the constructed dune. Dune stabilization plans should account for beach nesting birds (including piping plovers) and diamondback terrapins (*Malaclemys terrapin*), which travel over and use dune areas. Specifically, the Service recommends minimizing dune

plantings to the extent possible without compromising dune stabilization. The Service also recommends a broken configuration of sand fencing using a zig-zag pattern parallel to the shore or a Y-type design perpendicular to the shore to avoid or reduce any barriers to wildlife movement to and from the shoreline.

3. Ecosystem Restoration

The proposed water-control structures would allow for the management of water levels within the Meadows to maintain water in the Meadows during dry periods, maintain beneficial emergent wetland plants, and discourage the spread of common reed. However, detailed water level management has not been addressed by the Corps. Therefore, the Service recommends that the Corps coordinate with the Service, NJDPF, ENSP, and The Nature Conservancy to develop a water level management plan to identify appropriate water level objectives to maximize benefits for fish and wildlife resources within the Meadows. Modification of the existing outfall structure in Shallow Pond West should also be considered in the water level management plan. Currently, the invert elevation of the existing outfall structure is +3.5 feet NGVD. Increasing the invert elevation of the existing outfall structure should be considered in the water level management plan to provide adequate saturation of freshwater emergent wetlands.

The proposed project provides an opportunity to significantly increase the habitat value of the Meadows for a variety of fish and wildlife resources. However, no monitoring program has been developed to ensure that the goals and objectives of the Meadows Project are obtained. Therefore, the Service recommends that the Corps coordinate with the Service, NJDPF, ENSP and The Nature Conservancy to develop a monitoring program to gather information on long-term beneficial (and adverse) impacts of the proposed project on fish and wildlife resources, including beach nesting birds. The monitoring program should also incorporate remedial actions that would take place if proposed goals and objectives are not attained. Monitoring should include the: spread of common reed, survival of planted emergent wetland vegetation, effectiveness of hydrologic connections between internal ponds, effectiveness of water level management, and recolonization of salt marsh vegetation in the 25-acre area on the eastern portion of the Meadows. Actual monitoring could be conducted by NJDPF and The Nature Conservancy staff.

The Service provided a list of suggested plantings, transplants, or revegetation for the Meadows to the Corps in September 1997 (Appendix D). As planned, revegetation of freshwater emergent wetlands would occur following common reed eradication. The Service recommends that the Corps use all or some of the suggested plantings to revegetate the freshwater wetlands within the Meadows following common reed control. Several scrub / shrub species are included in the list of suggested plantings. These species could be planted along the landward toe of the proposed dune, provided that access between the beach and the wetlands is maintained for piping plovers.

VIII. CONCLUSIONS AND RECOMMENDATIONS

The Service strongly supports the Corps proposed ecosystem restoration at the Meadows and view the proposed project as beneficial to fish and wildlife by restoring and enhancing beach and dune areas that support valuable fish and wildlife habitats. Additionally, the proposed project would restore critical freshwater wetland areas within the Meadows, providing valuable habitat for a variety of fish and wildlife resources including the 12 HEP evaluation species and the species guilds that they represent. The proposed project has the potential to provide additional habitat for federally listed and State-listed threatened and endangered species (e.g., piping plover). However, water level management and monitoring would be required to fully achieve and maintain the proposed project's goals and objectives for fish and wildlife.

It is the view of the Service that potential project-related adverse impacts to fish and wildlife could be minimized and project-related beneficial impacts could be maximized by incorporating the following recommendations into the final project design.

1. Prepare a Biological Assessment to address potential project-related adverse impacts to the piping plover.

2. Reinitiate consultation with the Service to ensure the continued protection of the piping plover:

   - at least 135 days (90 days for formal consultation, 45 days for issuance of a Biological Opinion) prior to beginning any initial beach nourishment associated with the Meadows Project; and,

   - at least 135 days prior to any beach maintenance activities (e.g., beach renourishment) for the life of the project (i.e., 50 years).

3. Incorporate the following project modifications to minimize impacts on piping plovers:

   a. Avoid all work in the project area between April 1 and August 15 in order to avoid potential adverse impacts on nesting piping plovers. This seasonal restriction would be applicable to maintenance work that may be necessary in subsequent years. Associated work includes, but is not limited to: the placement, movement, or maintenance of pipelines; stockpiling of construction materials and equipment; and, the pumping, placement, or distribution of sand.

b. Establish protective zones in accordance with the Service's "Guidelines for Managing Recreational Activities in Piping Plover Breeding Habitat on the U.S. Atlantic Coast to Avoid Take Under Section 9 of the Endangered Species Act" (Guidelines), dated April 15, 1994 (Appendix B). Protective zones for piping plover nests shall take precedence over all recreational activities (e.g., vehicle access, sunbathing, kite-flying, swimming, walking). In addition, other measures identified in the Guidelines shall be instituted, such as prohibiting dogs in the vicinity of protective zones or ensuring that all dogs are leashed. Establishment of the protective zones must be coordinated with ENSP.

c. Maintain multiple access passages between the proposed beach and the existing freshwater wetlands and feeding areas (e.g., poorly vegetated areas) landward of the proposed dune to preserve freshwater wetland feeding areas for piping plovers.

4. Identify the location of all State-listed and rare plants within the Meadows and take appropriate measures to protect these areas from common reed control activities to ensure that adverse impacts on these species are avoided. Additionally, contact the New Jersey Natural Heritage Program and ENSP regarding the protection of State-listed plant species.

5. Analyze each HEP evaluation species independently in the cost:benefit analysis for the Meadows Project

6. Use the material from the Delaware River Main Channel Deepening Project for direct beneficial uses (e.g., Meadows) consistent with Section 207 of the WRDA of 1996.

7. Conduct a clam survey using appropriate methodology to estimate the adult population of surf clams in the proposed borrow areas.

8. Conduct each renourishment dredging phase in a limited portion of the borrow area and alternate locations for each subsequent renourishment cycle (i.e., rotational dredging).

9. Avoid the creation of excessively deep, poorly flushed borrow sites; dredge during a period of low biological activity (November to January); and, use a hydraulic dredge with a pipeline delivery system to minimize impacts on benthic invertebrates.

10. Coordinate with the New Jersey Division of Fish, Game and Wildlife, Bureau of Marine Fisheries and the Cape May Charter Boat Association to minimize adverse impacts on recreational fisheries from dredging activities.

11. Dune plantings should be minimized and sand fencing should be in a broken configuration using a zig-zag pattern parallel to the shore or a Y-type design perpendicular to the shore to avoid or reduce restrictions on wildlife movement between the dunes and the shore.

12. Coordinate with the Service, NJDPF, ENSP. and The Nature Conservancy to develop a water level management plan to identify appropriate water level objectives to maximize benefits for fish and wildlife resources within the Meadows.

13. Coordinate with the Service, NJDPF, ENSP and The Nature Conservancy to develop a monitoring program to gather information on long-term beneficial (and adverse) impacts of the proposed project on fish and wildlife resources, including beach nesting birds. The monitoring program should also incorporate remedial actions that would take place if proposed goals and objectives are not attained.

14. Revegetate the freshwater wetlands within the Meadows following common reed control using the suggested plantings listed in Appendix D.

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B. PERSONAL COMMUNICATIONS

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APPENDICES

APPENDIX A

Coordination with the
New Jersey Division of Fish, Game and Wildlife

United States Department of the Interior

FISH AND WILDLIFE SERVICE

Ecological Services
927 North Main Street (Bldg. D1)
Pleasantville, New Jersey 08232

Tel: 609-646-9310
FAX: 609-646-0352

IN REPLY REFER TO:

FP-97/55

November 13, 1997

Robert McDowell, Director
New Jersey Division of Fish, Game and Wildlife
CN 400
Trenton, New Jersey 08625-0400

Dear Mr. McDowell:

Enclosed is the U.S. Fish and Wildlife Service's (Service) draft Fish and Wildlife Coordination Act report entitled, "Assessment of the Lower Cape May Meadows - Cape May Point Feasibility Study, Cape May County, New Jersey." This constitutes the Service's report on fish and wildlife impacts that can be expected to result from the U.S. Army Corps of Engineers (Corps) proposed plan to construct a berm and dune, and enhance and restore wetland habitat within Lower Cape May Meadows, Cape May County, New Jersey. This report has been prepared pursuant to Section 2(b) of the Fish and Wildlife Coordination Act (48 Stat. 401; as amended; 16 U.S.C. 661 *et seq.*) and is for inclusion in the Corps Draft Feasibility Report and Environmental Impact Statement.

The Service's report contains an assessment of the proposed plan and recommendations for protection and enhancement of fish and wildlife resources. Please provide a letter of comment including indication of concurrence, or lack thereof, within 20 days from the date of this letter. If there are any questions concerning this report, please contact John Staples or Eric Schrading of my staff.

Thank you for your assistance in this matter.

Sincerely,

Clifford G. Day
Supervisor

Enclosure

PRINTED ON RECYCLED PAPER

APPENDIX B

Guidelines for Managing Recreational Activities
in Piping Plover Breeding Habitat on
the U.S. Atlantic Coast to Avoid Take Under
Section 9 of the Endangered Species Act

United States Department of the Interior

FISH AND WILDLIFE SERVICE
300 Westgate Center Drive
Hadley, MA 01035-9589

TAKE PRIDE IN AMERICA

In Reply Refer To:
FWS/Region 5/ES-TE

APR 21 1994

Mr. John H. Spencer
Bureau of Natural Resources
Department of Environmental Protection
79 Elm Street
Hartford, Connecticut 06106-5127

Dear Mr. Spencer:

Enclosed are the U.S. Fish and Wildlife Service's Guidelines for Managing Recreational Activities in Piping Plover Breeding Habitat on the U.S. Atlantic Coast to Avoid Take Under Section 9 of the Endangered Species Act. This is the final version of the draft guidelines sent to you for review and comment on March 18, 1994.

These guidelines, based on the best available biological information, provide a flexible approach to protecting piping plovers, while minimizing impacts on beach recreation on non-Federal lands. Management techniques recommended in these guidelines will generally facilitate pedestrian access to the shoreline throughout the plover's breeding cycle. Recommended management options that include intensive monitoring will, in most cases, also allow use of motorized vehicles except when flightless chicks are present.

Please contact Anne Hecht at 508-443-4325 or Paul Nickerson at 413-253-8615 if you have questions about these guidelines or other aspects of the piping plover recovery effort.

Sincerely,

Ronald E. Lambertson

Regional Director

Enclosure

GUIDELINES FOR MANAGING RECREATIONAL ACTIVITIES IN PIPING PLOVER BREEDING HABITAT ON THE U.S. ATLANTIC COAST TO AVOID TAKE UNDER SECTION 9 OF THE ENDANGERED SPECIES ACT

Northeast Region, U.S. Fish and Wildlife Service
April 15, 1994

The following information is provided as guidance to beach managers and property owners seeking to avoid potential violations of Section 9 of the Endangered Species Act (16 U.S.C. 1538) and its implementing regulations (50 CFR Part 17) that could occur as the result of recreational activities on beaches used by breeding piping plovers along the Atlantic Coast. These guidelines were developed by the Northeast Region, U.S. Fish and Wildlife Service (Service), with assistance from the U.S. Atlantic Coast Piping Plover Recovery Team. The guidelines are advisory, and failure to implement them does not, of itself, constitute a violation of the law. Rather, they represent the Service's best professional advice to beach managers and landowners regarding the management options that will prevent direct mortality, harm, or harassment of piping plovers and their eggs due to recreational activities.

Some land managers have endangered species protection obligations under Section 7 of the Endangered Species Act (see section I below) or under Executive Orders 11644 and 11989[1] that go beyond adherence to these guidelines. Nothing in this document should be construed as lack of endorsement of additional piping plover protection measures implemented by these land managers or those who are voluntarily undertaking stronger plover protection measures.

This document contains four sections: (I) a brief synopsis of the legal requirements that afford protection to nesting piping plovers; (II) a brief summary of the life history of piping plovers and potential threats due to recreational activities during the breeding cycle; (III) guidelines for protecting piping plovers from recreational activities on Atlantic Coast beaches; and (IV) literature cited.

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[1] Executive Order 11644, Use of Off-Road Vehicles on the Public Lands and Executive Order 11989, Off-Road Vehicles on Public Lands pertain to lands under custody of the Secretaries of Agriculture, Defense, and Interior (except for Indian lands) and certain lands under the custody of the Tennessee Valley Authority.

I. LEGAL CONSIDERATIONS

Section 9 of the Endangered Species Act (ESA) prohibits any person subject to the jurisdiction of the United States from harassing, harming, pursuing, hunting, shooting, wounding, killing, trapping, capturing, or collecting listed wildlife species. It is also unlawful to attempt such acts, solicit another to commit such acts, or cause such acts to be committed. A "person" is defined in Section 3 to mean "an individual, corporation, partnership, trust, association, or any other private entity; or any officer, employee, agent, department, or instrumentality of the Federal Government, of any State, municipality, or political subdivision of a State, or of any foreign government; any State, municipality, or political subdivision of a State; or any other entity subject to the jurisdiction of the United States." Regulations implementing the ESA (50 CFR 17.3) further define "harm" to include significant habitat modification or degradation that results in the killing or injury of wildlife by significantly impairing essential behavioral patterns including breeding, feeding, or sheltering. "Harass" means an intentional or negligent act or omission which creates the likelihood of injury to wildlife by annoying it to such an extent as to significantly disrupt normal behavioral patterns which include, but are not limited to, breeding, feeding, or sheltering. Penalties for violations of Section 9 are provided in Section 11 of the ESA; for threatened species, these penalties include fines of up to $25,000, imprisonment for not more than six months, or both.

Section 10 of the ESA and related regulations provide for permits that may be granted to authorize acts prohibited under Section 9, for scientific purposes or to enhance the propagation or survival of a listed species. States that have Cooperative Agreements under Section 6 of the ESA, may provide written authorization for take that occurs in the course of implementing conservation programs. For example, State agencies have authorized certain biologists to construct predator exclosures for piping plovers. It is also legal for employees or designated agents of certain Federal or State agencies to take listed species without a permit, if the action is necessary to aid sick, injured, or orphaned animals or to salvage or dispose of a dead specimen.

Section 10 also allows permits to be issued for take that is "incidental to, and not the purpose of, carrying out an otherwise lawful activity" if the Service determines that certain conditions have been met. An applicant for an incidental take permit must prepare a conservation plan that specifies the impacts of the take, steps the applicant will take to minimize and mitigate the impacts, funding that will be available to implement these steps, alternative actions to the take that the applicant considered, and the reasons why such alternatives are not being utilized.

Section 7 of the ESA may be pertinent to beach managers and landowners in situations that have a Federal nexus. Section 7 requires Federal agencies to consult with the Service (or National Marine Fisheries Service for marine species) prior to authorizing, funding, or carrying out activities that may affect listed species. Section 7 also requires that these agencies use their authorities to further the conservation of listed species. Section 7 obligations have caused Federal land management agencies to implement piping plover protection measures that go beyond those required to avoid take, for example by conducting research on threats to piping plovers. Other examples of Federal activities that may affect piping plovers along the Atlantic Coast, thereby triggering Section 7 consultation, include permits for beach nourishment or disposal of dredged material (U.S. Army Corps of Engineers) and funding of beach restoration projects (Federal Emergency Management Authority).

Piping plovers, as well as other migratory birds such as least terns, common terns, American oystercatchers, laughing gulls, herring gulls, and great black-backed gulls, their nests, and eggs are also protected under the Migratory Bird Treaty Act of 1918 (16 U.S.C. 703-712). Prohibited acts include pursuing, hunting, shooting, wounding, killing, trapping, capturing, collecting, or attempting such conduct. Violators may be fined up to $5000 and/or imprisoned for up to six months.

Almost all States within the breeding range of the Atlantic Coast piping plover population list the species as State threatened or endangered (Northeast Nongame Technical Committee 1993). Various laws and regulations may protect State-listed species from take, but the Service has not ascertained the adequacy of the guidelines presented in this document to meet the requirements of any State law.

II. LIFE HISTORY AND THREATS FROM HUMAN DISTURBANCE

Piping plovers are small, sand-colored shorebirds that nest on sandy, coastal beaches from South Carolina to Newfoundland. Since 1986, the Atlantic Coast population has been protected as a threatened species under provisions of the U.S. Endangered Species Act of 1973 (U.S. Fish and Wildlife Service 1985). The U.S. portion of the population was estimated at 875 pairs in 1993 (U.S. Fish and Wildlife Service 1993). Many characteristics of piping plovers contribute to their susceptibility to take due to human beach activities.

LIFE HISTORY

Piping plovers begin returning to their Atlantic Coast nesting beaches in mid-March (Coutu et al. 1990, Cross 1990, Goldin 1990, MacIvor 1990, Hake 1993). Males establish and defend territories and court females (Cairns 1982). Eggs may be present on the beach from mid-April through late July. Clutch size is generally four eggs, and the incubation period[2] usually lasts for 27-28 days. Piping plovers fledge only a single brood per season, but may renest several times if previous nests are lost. Chicks are precocial[3] (Wilcox 1959, Cairns 1982). They may move hundreds of yards from the nest site during their first week of life (see Table 1, Summary of Chick Mobility Data). Chicks remain together with one or both parents until they fledge (are able to fly) at 25 to 35 days of age. Depending on date of hatching, flightless chicks may be present from mid-May until late August, although most fledge by the end of July (Patterson 1988, Goldin 1990, MacIvor 1990, Howard et al. 1993).

Piping plover nests are situated above the high tide line on coastal beaches, sand flats at the ends of sandspits and barrier islands, gently sloping foredunes, blowout areas behind primary dunes, and washover areas cut into or between dunes. They may also nest on areas where suitable dredge material has been deposited. Nest sites are shallow scraped depressions in substrates ranging from fine grained sand to mixtures of sand and pebbles, shells or cobble (Bent 1929, Burger 1987a, Cairns 1982, Patterson 1988, Flemming et al. 1990, MacIvor 1990,

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[2] "Incubation" refers to adult birds sitting on eggs, to maintain them at a favorable temperature for embryo development.

[3] "Precocial" birds are mobile and capable of foraging for themselves within several hours of hatching.

Strauss 1990). Nests are usually found in areas with little or no vegetation although, on occasion, piping plovers will nest under stands of American beachgrass (Ammophila breviligulata) or other vegetation (Patterson 1988, Flemming et al. 1990, MacIvor 1990). Plover nests may be very difficult to detect, especially during the 6-7 day egg-laying phase when the birds generally do not incubate (Goldin 1994).

Plover foods consist of invertebrates such as marine worms, fly larvae, beetles, crustaceans or mollusks (Bent 1929, Cairns 1977, Nicholls 1989). Feeding areas include intertidal portions of ocean beaches, washover areas, mudflats, sandflats, wrack lines[4], and shorelines of coastal ponds, lagoons or salt marshes (Gibbs 1986, Coutu et al. 1990, Hoopes et al. 1992, Loegering 1992, Goldin 1993). Studies have shown that the relative importance of various feeding habitat types may vary by site (Gibbs 1986, Coutu et al. 1990, McConnaughey et al. 1990, Loegering 1992, Goldin 1993, Hoopes 1993) and by stage in the breeding cycle (Cross 1990). Adults and chicks on a given site may use different feeding habitats in varying proportion (Goldin et al. 1990). Feeding activities of chicks may be particularly important to their survival. Cairns (1977) found that piping plover chicks typically tripled their weight during the first two weeks post-hatching; chicks that failed to achieve at least 60% of this weight gain by day 12 were unlikely to survive. During courtship, nesting, and brood rearing, feeding territories are generally contiguous to nesting territories (Cairns 1977), although instances where brood-rearing areas are widely separated from nesting territories are not uncommon (see Table 1). Feeding activities of both adults and chicks may occur during all hours of the day and night (Burger 1993) and at all stages in the tidal cycle (Goldin 1993, Hoopes 1993).

THREATS FROM NONMOTORIZED BEACH ACTIVITIES

Sandy beaches that provide nesting habitat for piping plovers are also attractive recreational habitats for people and their pets. Nonmotorized recreational activities can be a source of both direct mortality and harassment of piping plovers. Pedestrians on beaches may crush

[4] Wrack is organic material including seaweed, seashells, driftwood and other materials deposited on beaches by tidal action.

eggs (Burger 1987b, Hill 1988, Shaffer and Laporte 1992, Cape Cod National Seashore 1993, Collazo et al. 1994). Unleashed dogs may chase plovers (McConnaughey et al. 1990), destroy nests (Hoopes et al. 1992), and kill chicks (Cairns and McLaren 1980).

Pedestrians may flush incubating plovers from nests (see Table 2, Summary of Data on Distances at Which Plovers React to Disturbance), exposing eggs to avian predators or causing excessive cooling or heating of eggs. Repeated exposure of shorebird eggs on hot days may cause overheating, killing the embryos (Bergstrom 1991). Excessive cooling may kill embryos or retard their development, delaying hatching dates (Welty 1982). Pedestrians can also displace unfledged chicks (Strauss 1990, Burger 1991, Hoopes et al. 1992, Loegering 1992, Goldin 1993). Fireworks are highly disturbing to piping plovers (Howard et al. 1993). Plovers are particularly intolerant of kites, compared with pedestrians, dogs, and vehicles; biologists believe this may be because plovers perceive kites as potential avian predators (Hoopes et al. 1992).

THREATS FROM MOTOR VEHICLES

Unrestricted use of motorized vehicles on beaches is a serious threat to piping plovers and their habitats. Vehicles can crush eggs (Wilcox 1959; Tull 1984; Burger 1987b; Patterson et al. 1991; United States of America v. Breezy Point Cooperative, Inc., U.S. District Court, Eastern District of New York, Civil Action No. CV-90-2542, 1991; Shaffer and Laporte 1992), adults, and chicks. In Massachusetts and New York, biologists documented 14 incidents in which 18 chicks and 2 adults were killed by vehicles between 1989 and 1993 (Melvin et al. 1994). Goldin (1993) compiled records of 34 chick mortalities (30 on the Atlantic Coast and 4 on the Northern Great Plains) due to vehicles. Many biologists that monitor and manage piping plovers believe that many more chicks are killed by vehicles than are found and reported (Melvin et al. 1994). Beaches used by vehicles during nesting and brood-rearing periods generally have fewer breeding plovers than available nesting and feeding habitat can support. In contrast, plover abundance and productivity has increased on beaches where vehicle restrictions during chick-rearing periods have been combined with protection of nests from predators (Goldin 1993; S. Melvin, pers. comm., 1993).

Typical behaviors of piping plover chicks increase their vulnerability to vehicles. Chicks frequently move between the upper berm or foredune and feeding habitats in the wrack line

and intertidal zone. These movements place chicks in the paths of vehicles driving along the berm or through the intertidal zone. Chicks stand in, walk, and run along tire ruts, and sometimes have difficulty crossing deep ruts or climbing out of them (Eddings et al. 1990, Strauss 1990, Howard et al. 1993). Chicks sometimes stand motionless or crouch as vehicles pass by, or do not move quickly enough to get out of the way (Tull 1984, Hoopes et al. 1992, Goldin 1993). Wire fencing placed around nests to deter predators (Rimmer and Deblinger 1990, Melvin et al. 1992) is ineffective in protecting chicks from vehicles because chicks typically leave the nest within a day after hatching and move extensively along the beach to feed (see Table 1).

Vehicles may also significantly degrade piping plover habitat or disrupt normal behavior patterns. They may harm or harass plovers by crushing wrack into the sand and making it unavailable as cover or a foraging substrate, by creating ruts that may trap or impede movements of chicks, and by preventing plovers from using habitat that is otherwise suitable (MacIvor 1990, Strauss 1990, Hoopes et al. 1992, Goldin 1993).

III. GUIDELINES FOR PROTECTING PIPING PLOVERS FROM RECREATIONAL DISTURBANCE

The Service recommends the following protection measures to prevent direct mortality or harassment of piping plovers, their eggs, and chicks.

MANAGEMENT OF NONMOTORIZED RECREATIONAL USES

On beaches where pedestrians, joggers, sun-bathers, picnickers, fishermen, boaters, horseback riders, or other recreational users are present in numbers that could harm or disturb incubating plovers, their eggs, or chicks, areas of at least 50 meter-radius around nests above the high tide line should be delineated with warning signs and symbolic fencing[5]. Only persons engaged in rare species monitoring, management, or research activities should enter posted areas. These areas should remain fenced as long as viable eggs or unfledged chicks are present. Fencing is intended to prevent accidental crushing of nests and repeated flushing of

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[5] "Symbolic fencing" refers to one or two strands of light-weight string, tied between posts to delineate areas where pedestrians and vehicles should not enter.

incubating adults, and to provide an area where chicks can rest and seek shelter when large numbers of people are on the beach.

Available data indicate that a 50 meter buffer distance around nests will be adequate to prevent harassment of the majority of incubating piping plovers. However, fencing around nests should be expanded in cases where the standard 50 meter-radius is inadequate to protect incubating adults or unfledged chicks from harm or disturbance. Data from various sites distributed across the plover's Atlantic Coast range indicates that larger buffers may be needed in some locations (see Table 2). This may include situations where plovers are especially intolerant of human presence, or where a 50 meter-radius area provides insufficient escape cover or alternative foraging opportunities for plover chicks.[6]

In cases where the nest is located less than 50 meters above the high tide line, fencing should be situated at the high tide line, and a qualified biologist should monitor responses of the birds to passersby, documenting his/her observations in clearly recorded field notes. Providing that birds are not exhibiting signs of disturbance, this smaller buffer may be maintained in such cases.

On portions of beaches that receive heavy human use, areas where territorial plovers are observed should be symbolically fenced to prevent disruption of territorial displays and courtship. Since nests can be difficult to locate, especially during egg-laying, this will also prevent accidental crushing of undetected nests. If nests are discovered outside fenced areas, fencing should be extended to create a sufficient buffer to prevent disturbance to incubating adults, eggs, or unfledged chicks.

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[6] For example, on the basis of data from an intensive three year study that showed that plovers on Assateague Island in Maryland flush from nests at greater distances than those elsewhere (Loegering 1992), the Assateague Island National Seashore established 200 meter buffers zones around most nest sites and primary foraging areas (Assateague Island National Seashore 1993). Following a precipitous drop in numbers of nesting plover pairs in Delaware in the late 1980's, that State adopted a Piping Plover Management Plan that provided 100 yard buffers around nests on State park lands and included intertidal areas (Delaware Department of Natural Resources and Environmental Control 1990).

Pets should be leashed and under control of their owners at all times from April 1 to August 31 on beaches where piping plovers are present or have traditionally nested. Pets should be prohibited on these beaches from April 1 through August 31 if, based on observations and experience, pet owners fail to keep pets leashed and under control.

Kite flying should be prohibited within 200 meters of nesting or territorial adult or unfledged juvenile piping plovers between April 1 and August 31.

Fireworks should be prohibited on beaches where plovers nest from April 1 until all chicks are fledged.

MOTOR VEHICLE MANAGEMENT

The Service recommends the following minimum protection measures to prevent direct mortality or harassment of piping plovers, their eggs, and chicks on beaches where vehicles are permitted. Since restrictions to protect unfledged chicks often impede vehicle access along a barrier spit, a number of management options affecting the timing and size of vehicle closures are presented here. Some of these options are contingent on implementation of intensive plover monitoring and management plans by qualified biologists. It is recommended that landowners seek concurrence with such monitoring plans from either the Service or the State wildlife agency.

Protection of Nests

All suitable piping plover nesting habitat should be identified by a qualified biologist and delineated with posts and warning signs or symbolic fencing on or before April 1 each year. All vehicular access into or through posted nesting habitat should be prohibited. However, prior to hatching, vehicles may pass by such areas along designated vehicle corridors established along the outside edge of plover nesting habitat. Vehicles may also park outside delineated nesting habitat, if beach width and configuration and tidal conditions allow. Vehicle corridors or parking areas should be moved, constricted, or temporarily closed if territorial, courting, or nesting plovers are disturbed by passing or parked vehicles, or if disturbance is anticipated because of unusual tides or expected increases in vehicle use during weekends, holidays, or special events.

If data from several years of plover monitoring suggests that significantly more habitat is available than the local plover population can occupy, some suitable habitat may be left unposted if the following conditions are met:

1. The Service OR a State wildlife agency that is party to an agreement under Section 6 of the ESA provides written concurrence with a plan that:

   A. Estimates the number of pairs likely to nest on the site based on the past monitoring and regional population trends.

   AND

   B. Delineates the habitat that will be posted or fenced prior to April 1 to assure a high probability that territorial plovers will select protected areas in which to court and nest. Sites where nesting or courting plovers were observed during the last three seasons as well as other habitat deemed most likely to be pioneered by plovers should be included in the posted and/or fenced area.

   AND

   C. Provides for monitoring of piping plovers on the beach by a qualified biologist(s). Generally, the frequency of monitoring should be not less than twice per week prior to May 1 and not less than three times per week thereafter. Monitoring should occur daily whenever moderate to large numbers of vehicles are on the beach. Monitors should document locations of territorial or courting plovers, nest locations, and observations of any reactions of incubating birds to pedestrian or vehicular disturbance.

AND

2. All unposted sites are posted immediately upon detection of territorial plovers.

Protection of Chicks

Sections of beaches where unfledged piping plover chicks are present should be temporarily closed to all vehicles not deemed essential. (See the provisions for essential vehicles below.) Areas where vehicles are prohibited should include all dune, beach, and intertidal habitat within the chicks' foraging range, to be determined by either of the following methods:

1. The vehicle free area should extend 1000 meters on each side of a line drawn through the nest site and perpendicular to the long axis of the beach. The resulting 2000 meter-wide area of protected habitat for plover chicks should extend from the ocean-side low water line to the bay-side low water line or to the farthest extent of dune habitat if no bay-side intertidal habitat exists. However, vehicles may be allowed to pass through portions of the protected area that are considered inaccessible to plover chicks because of steep topography, dense vegetation, or other naturally-occurring obstacles.

OR

2. The Service OR a State wildlife agency that is party to an agreement under Section 6 of the ESA provides written concurrence with a plan that:

A. Provides for monitoring of all broods during the chick-rearing phase of the breeding season and specifies the frequency of monitoring.

AND

B. Specifies the minimum size of vehicle-free areas to be established in the vicinity of unfledged broods based on the mobility of broods observed on the site in past years and on the frequency of monitoring. Unless substantial data from past years show that broods on a site stay very close to their nest locations, vehicle-free areas should extend at least 200 meters on each side of the nest site during the first week following hatching. The size and location of the protected area should be adjusted in response to the observed mobility of the brood, but in no case should it be reduced to less than 100 meters on each

side of the brood. In some cases, highly mobile broods may require protected areas up to 1000 meters, even where they are intensively monitored. Protected areas should extend from the ocean-side low water line to the bay-side low water line or to the farthest extent of dune habitat if no bay-side intertidal habitat exists. However, vehicles may be allowed to pass through portions of the protected area that are considered inaccessible to plover chicks because of steep topography, dense vegetation, or other naturally-occurring obstacles. In a few cases, where several years of data documents that piping plovers on a particular site feed in only certain habitat types, the Service or the State wildlife management agency may provide written concurrence that vehicles pose no danger to plovers in other specified habitats on that site.

Timing of Vehicle Restrictions in Chick Habitat

Restrictions on use of vehicles in areas where unfledged plover chicks are present should begin on or before the date that hatching begins and continue until chicks have fledged. For purposes of vehicle management, plover chicks are considered fledged at 35 days of age or when observed in sustained flight for at least 15 meters, whichever occurs first.

When piping plover nests are found before the last egg is laid, restrictions on vehicles should begin on the 26th day after the last egg is laid. This assumes an average incubation period of 27 days, and provides a 1 day margin of error.

When plover nests are found after the last egg has been laid, making it impossible to predict hatch date, restrictions on vehicles should begin on a date determined by one of the following scenarios:

1) With intensive monitoring: If the nest is monitored at least twice per day, at dawn and dusk (before 0600 hrs and after 1900 hrs) by a qualified biologist, vehicle use may continue until hatching begins. Nests should be monitored at dawn and dusk to minimize the time that hatching may go undetected if it occurs after dark. Whenever possible, nests should be monitored from a distance with spotting scope or binoculars to minimize disturbance to incubating plovers.

OR

2) Without intensive monitoring: Restrictions should begin on May 15 (the earliest probable hatch date). If the nest is discovered after May 15, then restrictions should start immediately.

If hatching occurs earlier than expected, or chicks are discovered from an unreported nest, restrictions on vehicles should begin immediately.

If ruts are present that are deep enough to restrict movements of plover chicks, then restrictions on vehicles should begin at least 5 days prior to the anticipated hatching date of plover nests. If a plover nest is found with a complete clutch, precluding estimation of hatching date, and deep ruts have been created that could reasonably be expected to impede chick movements, then restrictions on vehicles should begin immediately.

Essential Vehicles

Because it is impossible to completely eliminate the possibility that a vehicle will accidently crush an unfledged plover chicks, use of vehicles in the vicinity of broods should be avoided whenever possible. However, the Service recognizes that life-threatening situations on the beach may require emergency vehicle response. Furthermore, some "essential vehicles" may be required to provide for safety of pedestrian recreationists, law enforcement, maintenance of public property; or access to private dwellings not otherwise accessible. On large beaches, maintaining the frequency of plover monitoring required to minimize the size and duration of vehicle closures may necessitate the use of vehicles by plover monitors.

Essential vehicles should only travel on sections of beaches where unfledged plover chicks are present if such travel is absolutely necessary and no other reasonable travel routes are available. All steps should be taken to minimize number of trips by essential vehicles through chick habitat areas. Homeowners should consider other means of access, eg. by foot, water, or shuttle services, during periods when chicks are present.

The following procedures should be followed to minimize the probability that chicks will be crushed by essential (non-emergency) vehicles:

1. Essential vehicles should travel through chick habitat areas only during daylight hours, and should be guided by a qualified monitor who has first determined the location of all unfledged plover chicks.

2. Speed of vehicles should not exceed five miles per hour.

3. Use of open 4-wheel motorized all-terrain vehicles (ATVs) or non-motorized all-terrain bicycles is recommended whenever possible for monitoring and law enforcement because of the improved visibility afforded operators.

4. A log should be maintained by the beach manager of the date, time, vehicle number and operator, and purpose of each trip through areas where unfledged chicks are present. Personnel monitoring plovers should maintain and regularly update a log of the numbers and locations of unfledged plover chicks on each beach. Drivers of essential vehicles should review the log each day to determine the most recent number and location of unfledged chicks.

Essential vehicles should avoid driving on the wrack line, and travel should be infrequent enough to avoid creating deep ruts that could impede chick movements. If essential vehicles are creating ruts that could impede chick movements, use of essential vehicles should be further reduced and, if necessary, restricted to emergency vehicles only.

SITE-SPECIFIC MANAGEMENT GUIDANCE

The guidelines provided in this document are based on an extensive review of the scientific literature and are intended to cover the vast majority of situations likely to be encountered on piping plover nesting sites along the U.S. Atlantic Coast. However, the Service recognizes that site-specific conditions may lead to anomalous situations in which departures from this guidance may be safely implemented. The Service recommends that landowners who believe such situations exist on their lands contact either the Service or the State wildlife agency and, if appropriate, arrange for an on-site review. Written documentation of agreements regarding departures from this guidance is recommended.

In some unusual circumstances, Service or State biologists may recognize situations where this guidance provides insufficient protection for piping plovers or their nests. In such a case, the Service or the State wildlife agency may provide written notice to the landowner describing additional measures recommended to prevent take of piping plovers on that site.

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Table 1. Summary of Chick Mobility Data

Source	Location	Data
Patterson 1988 (p.40)	Maryland and Virginia	18 of 38 broods moved to feeding areas more than 100 meters from their nests; 5 broods moved more than 600 meters (distance measured parallel to wrackline).
Cross 1989 (p.23)	Virginia	At three sites, observers relocated broods at mean distances from their nests of 153 m +/-97m (44 observations, 14 broods), 32 m +/-7 m (8 observations, 3 broods), and 492 m +/-281 m (12 observations, 4 broods).
Coutu et al. 1990 (p.12)	North Carolina	Observations of 11 broods averaged 212 m from their nests; 3 broods moved 400-725 m from nest sites.
Strauss 1990 (p.33)	Massachusetts	10 chicks moved more than 200 m during first 5 days post-hatch while 19 chicks moved less than 200 meters during same interval.
Loegering 1992 (p.72)	Maryland	Distances broods moved from nests during first 5 days post-hatch averaged 195 m in Bay habitat (n=10), 141 m in Interior habitat (n=36), and 131 m in Ocean habitat (n=41). By 21 days, average movement in each habitat had, respectively, increased to 850 m (n=1), 464 m (n=10), and 187 m (n=69). One brood moved more than 1000 m from its nest.
Melvin et al. 1994	Massachusetts and New York	In 14 incidents in which 18 chicks were killed by vehicles, chicks were run over $\leq$ 10 m to $\leq$ 900 m from their nests. In 7 of these instances, mortality occurred $\geq$ 200 m from the nest.

Table 2. Summary of Data on Distances at which Piping Plovers React to Disturbance

Source	Location	Data
Flushing of Incubating Birds by Pedestrians		
Flemming et al. 1988 (p.326)	Nova Scotia	Adults usually flushed from the nests at distances <40 m; however, great variation existed and reaction distances as great as 210 m were observed.
Cross 1990 (p.47)	Virginia	Mean flushing distances in each of two years were 47 m (n=181, range = 5 m to 300 m) and 25 m (n=214, range = 2 m to 100 m).
Loegering 1992 (p.61)	Maryland	Flushing distances averaged 78 m (n=43); range was 20 m to 174 m. Recommended use of 225 m disturbance buffers on his site.
Cross and Terwilliger 1993	Virginia	Mean flushing distance for all years on all sites (Virginia plover sites, 1986-91) was 63 m (n=201, SD=31, range = 7 m to 200 m). Differences among years were not significant, but differences among sites were.
Hoopes 1993 (p.72)	Massachusetts	Mean flushing distance for incubating plovers was 24 m (n=31).
Disturbance to Non-incubating Birds		
Hoopes 1993 (p.89)	Massachusetts	Mean response distance (all ages, all behaviors) was 23 m for pedestrian disturbances (range = 10 m to 60 m), 40 m for vehicles (range = 30 m to 70 m), 46 m for dogs/pets (range = 20 m to 100 m), and 85 m for kites (range = 60 m to 120 m).
Goldin 1993 (p.74)	New York	Average flushing distance for adult and juvenile plovers was 18.7 m for pedestrian disturbances (n=585), 19.5 m for joggers (n=183), and 20.4 m for vehicles (n=111). Pedestrians caused chicks to flush at an average distance of 20.7 m (n=175), joggers at 32.3 m (n=37), and vehicles at 19.3 m (n=7). Tolerance of individual birds varied; one chick moved 260 m in direct response to 20 disturbances in 1 hour.

APPENDIX C

Federally Listed and State-Listed Endangered
and Threatened Species in New Jersey

FEDERALLY LISTED ENDANGERED AND THREATENED SPECIES IN NEW JERSEY

An **ENDANGERED** species is any species that is in danger of extinction throughout all or a significant portion of its range.

A **THREATENED** species is any species that is likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range.

	COMMON NAME	SCIENTIFIC NAME	STATUS
FISHES	**Shortnose sturgeon***	*Acipenser brevirostrum*	E
REPTILES	**Bog turtle**	*Clemmys muhlenbergii*	T
	Atlantic Ridley turtle*	*Lepidochelys kempii*	E
	Green turtle*	*Chelonia mydas*	T
	Hawksbill turtle*	*Eretmochelys imbricata*	E
	Leatherback turtle*	*Dermochelys coriacea*	E
	Loggerhead turtle*	*Caretta caretta*	T
BIRDS	**American peregrine falcon**	*Falco peregrinus anatum*	E
	Bald eagle	*Haliaeetus leucocephalus*	T
	Piping plover	*Charadrius melodus*	T
	Roseate tern	*Sterna dougallii dougallii*	E
MAMMALS	**Eastern cougar**	*Felis concolor couguar*	E+
	Indiana bat	*Myotis sodalis*	E
	Gray wolf	*Canis lupus*	E+
	Delmarva fox squirrel	*Sciurus niger cinereus*	E+
	Blue whale*	*Balaenoptera musculus*	E
	Finback whale*	*Balaenoptera physalus*	E
	Humpback whale*	*Megaptera novaeangliae*	E
	Right whale*	*Balaena glacialis*	E
	Sei whale*	*Balaenoptera borealis*	E
	Sperm whale*	*Physeter macrocephalus*	E

Revised 11/97

	COMMON NAME	SCIENTIFIC NAME	STATUS
INVERTEBRATES	**Dwarf wedgemussel**	*Alasmidonta heterodon*	E
	Northeastern beach tiger beetle	*Cicindela dorsalis dorsalis*	T
	Mitchell saytr butterfly	*Neonympha m. mitchellii*	E+
	American burying beetle	*Nicrophorus americanus*	E+
PLANTS	**Small whorled pogonia**	*Isotria medeoloides*	E
	Swamp pink	*Helonias bullata*	T
	Eastern prairie fringed orchid	*Platanthera leucophaea*	T+
	Knieskern's beaked-rush	*Rhynchospora knieskernii*	T
	American chaffseed	*Schwalbea americana*	E
	Sensitive joint-vetch	*Aeschynomene virginica*	T
	Sea-beach pigweed	*Amaranthus pumilus*	T+

STATUS:			
E	endangered species	PE	proposed endangered
T	threatened species	PT	proposed threatened
+	presumed extirpated		

* Except for sea turtle nesting habitat, principal responsibility for these species is vested with the National Marine Fisheries Service.

Note: for a complete listing of Endangered and Threatened Wildlife and Plants, refer to 50 CFR 17.11 and 17.12.

For further information, please contact:

U.S. Fish and Wildlife Service
New Jersey Field Office
927 N. Main Street, Building D
Pleasantville, New Jersey 08232
Phone: (609) 646-9310
Fax: (609) 646-0352

FEDERAL CANDIDATE SPECIES IN NEW JERSEY

CANDIDATE SPECIES are species that appear to warrant consideration for addition to the federal List of Endangered and Threatened Wildlife and Plants. Although these species receive no substantive or procedural protection under the Endangered Species Act, the U.S. Fish and Wildlife Service encourages federal agencies and other planners to give consideration to these species in the environmental planning process.

SPECIES	SCIENTIFIC NAME
Bog asphodel	*Narthecium americanum*

Note: For complete listings of taxa under review as candidate species, refer to Federal Register Vol. 62, No. 182, September 19, 1997 (Endangered and Threatened Wildlife and Plants; Review of Plant and Animal Taxa that are Candidates for Listing as Endangered or Threatened Species).

Revised 10/97

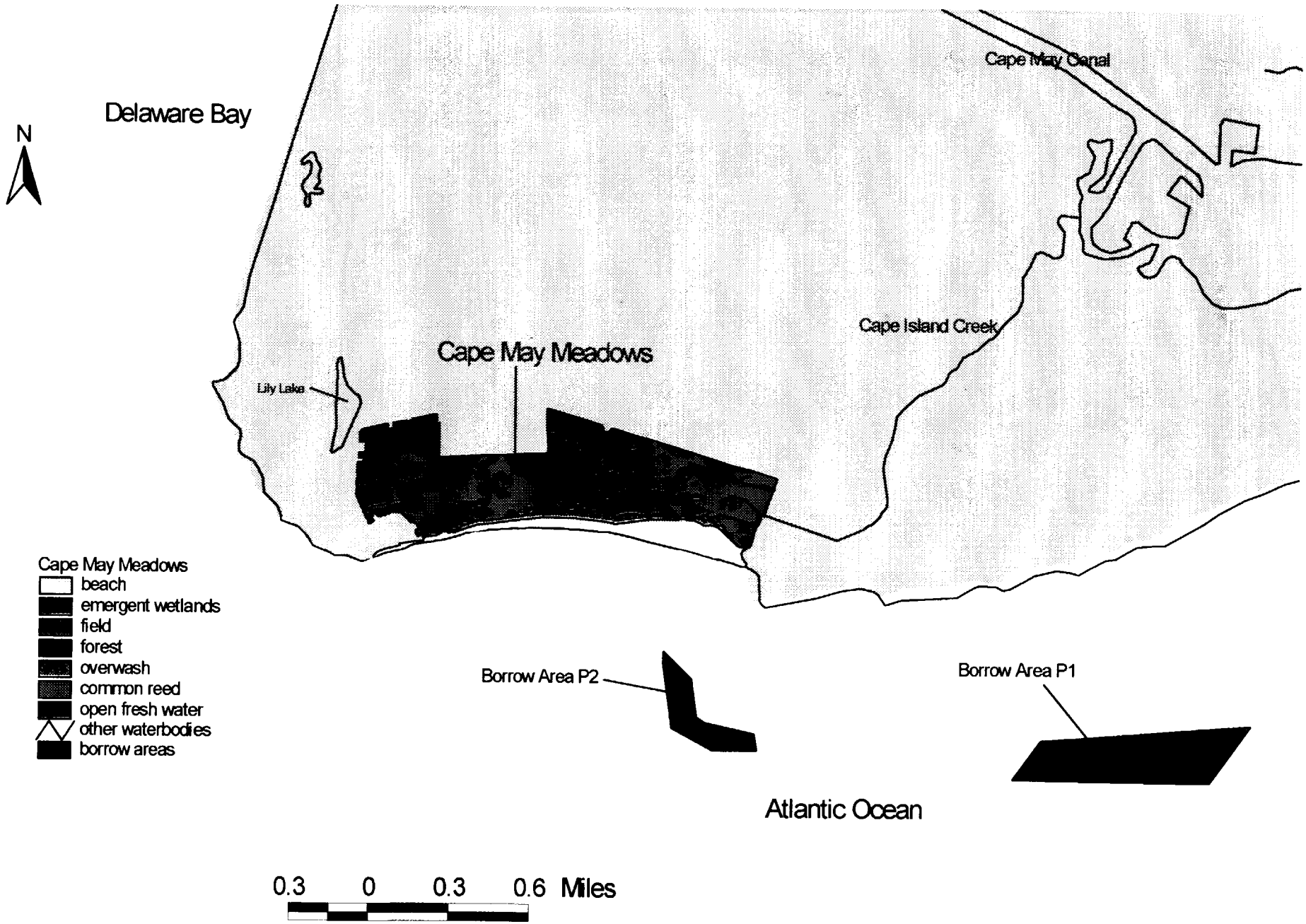


Figure 1. Lower Cape May Meadows Project Area.

ENDANGERED AND THREATENED WILDLIFE OF NEW JERSEY

Endangered Species are those whose prospects for survival in New Jersey are in immediate danger because of a loss or change in habitat, over-exploitation, predation, competition, disease, disturbance or contamination. Assistance is needed to prevent future extinction in New Jersey.

Threatened Species are those who may become endangered if conditions surrounding them begin to or continue to deteriorate.

BIRDS

Endangered

Pied-billed Grebe,* *Podilymbus podiceps*
Bald Eagle, *Haliaeetus leucocephalus***
Northern Harrier,* *Circus cyaneus*
Cooper's Hawk, *Accipiter cooperii*
Red-shouldered Hawk, *Buteo lineatus* (Breeding)
Peregrine Falcon, *Falco peregrinus***
Piping Plover, *Charadrius melodus***
Upland Sandpiper, *Bartramia longicauda*
Roseate Tern, *Sterna dougallii*
Least Tern, *Sterna antillarum*
Black Skimmer, *Rynchops niger*
Short-eared Owl,* *Asio flammeus*
Sedge Wren, *Cistothorus platensis*
Loggerhead Shrike, *Lanius ludovicianus*
Vesper Sparrow, *Pooecetes gramineus*
Henslow's Sparrow, *Ammodramus henslowii*

Threatened

American Bittern*, *Botaurus lentiginosos*
Great Blue Heron*, *Ardea herodias*
Little Blue Heron, *Egretta caerulea**
Yellow-crowned Night Heron, *Nyctanassa violaceus*
Osprey, *Pandion haliaetus*
Northern Goshawk, *Accipiter gentilis*
Red-shouldered Hawk, *Buteo lineatus* (Non-breeding)
Black Rail, *Laterallus jamaicensis*
Long-eared Owl, *Asio otus*
Barred Owl, *Strix varia*
Red-headed Woodpecker, *Melanerpes erythrocephalus*
Cliff Swallow,* *Hirundo pyrrhonota*
Savannah Sparrow, *Passerculus sandwichensis*
Ipswich Sparrow, *Passerculus sandwichensis princeps*
Grasshopper Sparrow, *Ammodramus savannarum*
Bobolink, *Dolichonyx oryzivorus*

*Only breeding population considered endangered or threatened
**Federally endangered or threatened

REPTILES

Endangered

Bog Turtle, *Clemmys muhlenbergi*
Atlantic Hawksbill, *Eretmochelys imbricata***
Atlantic Loggerhead, *Caretta caretta***
Atlantic Ridley, *Lepidochelys kempi***
Atlantic Leatherback, *Dermochelys coriacea***
Corn Snake, *Elaphe g. guttata*
Timber Rattlesnake, *Crotalus h. horridus*

Threatened

Wood Turtle, *Clemmys insculpta*
Atlantic Green Turtle, *Chelonia mydas***
Northern Pine Snake, *Pituophis m. melanoleucus*

**Federally endangered or threatened

ENDANGERED AND NONGAME SPECIES PROGRAM

NEW JERSEY DEPARTMENT OF ENVIRONMENTAL PROTECTION AND ENERGY
DIVISION OF FISH, GAME AND WILDLIFE

AMPHIBIANS

Endangered

Tremblay's Salamander, *Ambystoma tremblayi*
Blue-spotted Salamander, *Ambystoma laterale*
Eastern Tiger Salamander, *Ambystoma t. tigrinum*
Pine Barrens Treefrog, *Hyla andersonii*
Southern Gray Treefrog, *Hyla chrysoscelis*

Threatened

Long-tailed Salamander, *Eurycea longicauda*
Eastern Mud Salamander, *Pseudotriton montanus*

MAMMALS

Endangered

Bobcat, *Lynx rufus*
Eastern Woodrat, *Neotoma floridana*
Sperm Whale *Physeter, macrocephalus* **
Fin Whale, *Balaenoptera physalus* **
Sei Whale, *Balaenoptera borealis* **
Blue Whale, *Balaenoptera musculus* **
Humpback Whale, *Megaptera novaeangliae* **
Black Right Whale, *Balaena glacialis* **

INVERTEBRATES

Endangered

Mitchell's Satyr (butterfly), *Neonympha m. mitchellii* **
Northeastern Beach Tiger Beetle, *Cicindela d. dorsalis*
American Burying Beetle, *Nicrophorus americanus* **
Dwarf Wedge Mussel, *Alasmidonta heterodon* **

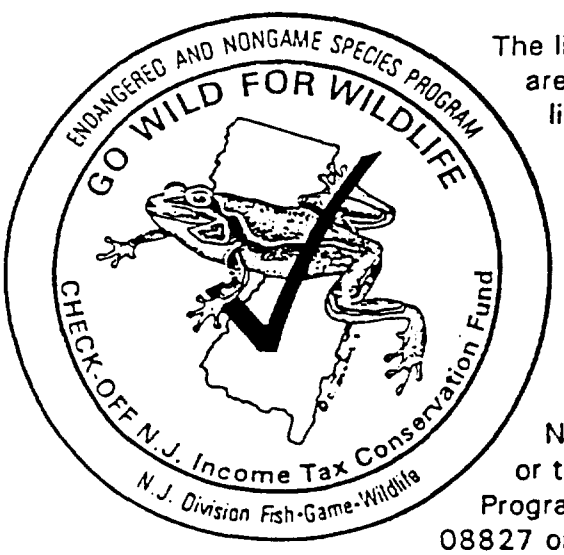
**Federally endangered

FISH

Endangered

Shortnose Sturgeon, *Acipenser brevirostrum* **

List revisions: March 29, 1979
January 17, 1984
May 6, 1985
July 20, 1987
June 3, 1991



The lists of New Jersey's endangered and nongame wildlife species are maintained by the DEP&E's Division of Fish, Game and Wildlife's, Endangered and Nongame Species Program. These lists are used to determine protection and management actions necessary to insure the survival of the State's endangered and nongame wildlife. This work is made possible only through voluntary contributions received through the Wildlife Check-off on the New Jersey State Tax Form. The Wildlife Check-off is the only major funding source for the protection and management of the State's endangered and nongame wildlife resource. For more information about the Endangered and Nongame Species Program or to report a sighting of endangered or threatened wildlife contact: Endangered and Nongame Species Program, Northern District Office, Box 383 R.D. 1, Hampton, N.J. 08827 or call (908) 735-8975.

AMPHIBIANS

Endangered

Tremblay's Salamander, *Ambystoma tremblayi*
Blue-spotted Salamander, *Ambystoma laterale*
Eastern Tiger Salamander, *Ambystoma t. tigrinum*
Pine Barrens Treefrog, *Hyla andersonii*
Southern Gray Treefrog, *Hyla chrysoscelis*

Threatened

Long-tailed Salamander, *Eurycea longicauda*
Eastern Mud Salamander, *Pseudotriton montanus*

MAMMALS

Endangered

Bobcat, *Lynx rufus*
Eastern Woodrat, *Neotoma floridana*
Sperm Whale *Physeter, macrocephalus* **
Fin Whale, *Balaenoptera physalus* **
Sei Whale, *Balaenoptera borealis* **
Blue Whale, *Balaenoptera musculus* **
Humpback Whale, *Megaptera novaeangliae* **
Black Right Whale, *Balaena glacialis* **

INVERTEBRATES

Endangered

Mitchell's Satyr (butterfly), *Neonympha m. mitchellii* **
Northeastern Beach Tiger Beetle, *Cicindela d. dorsalis*
American Burying Beetle, *Nicrophorus americanus* **
Dwarf Wedge Mussel, *Alasmidonta heterodon* **

**Federally endangered

FISH

Endangered

Shortnose Sturgeon, *Acipenser brevirostrum* **

List revisions: March 29, 1979
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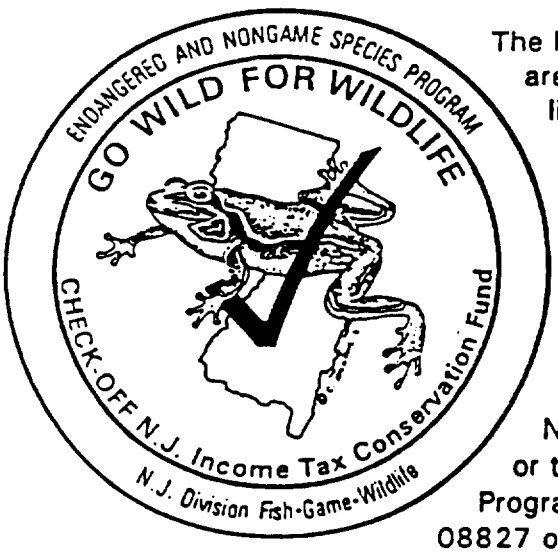

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APPENDIX D

Suggested Plantings, Transplants, or Revegetation
for Lower Cape May Meadows

Suggested Plantings, Transplants, or Revegetation for Lower Cape May Meadows

Suggested plantings are based on food or cover value to wildlife, in particular waterfowl, shorebirds, and neotropical birds that use Lower Cape May Meadows.

Estuarine emergent wetlands*

Saltmarsh cordgrass (*Spartina alterniflora*) e (90% of low marsh)
Saltmeadow cordgrass (*Spartina patens*) e (50%+ of high marsh)
Saltgrass (*Distichlis spicata*) e (20% of high marsh)
Sea pink (*Sabatia stellaris*) e (<10% of high marsh)
Saltwort (*Salicornia* spp.) e (10-20% of high marsh)

Estuarine / Palustrine Interface

(Wetland / upland complex between palustrine and estuarine wetlands)

Marsh goldenrod (*Solidago sempervirens*) e
Marsh elder (*Iva frutescens*) e
Bayberry (*Myrica pensylvanica*) e
Wax myrtle (*Myrica cerifera*) e
Smartweed (*Polygonum* spp.) e
Widgeongrass (*Ruppia maritima*)
Saltmarsh (Walters) millet (*Echinochloa walteri*)
Saltmarsh bulrush (*Scirpus robustus*)

Palustrine open water

(Ponds - 1-3 feet water depth)

Pondweed (*Potamogeton* spp.)
Wild celery (*Vallisneria americana*)
Bushy pondweed (*Najas flexilis*)
Duckweed (*Lemna* spp.)
Arrowhead (*Sagittaria* spp.)
Arrow arum (*Peltandra virginica*)

Palustrine open water / emergent interface

(Pond edge)

Narrow-leaved cattail (*Typha angustifolia*) e
Cattail (*Typha latifolia*) e
Bulrush (*Scirpus* spp.) e
Buttonbush (*Cephalanthus occidentalis*)
Smartweeds (*Polygonum* spp.)
Wild rice (*Zizania aquatica*)
Bur-reed (*Sparganium* spp.)
Soft-stem bulrush (*Scirpus validus*)
Arrow arum (*Peltandra virginica*)
Pickerelweed (*Pontederia cordata*)
Big arrowhead (*Sagittaria latifolia*)
Spatterdock (*Nuphar luteum*)

Palustrine emergent wetlands

Smartweeds (*Polygonum* spp.)
Wild millet (*Echinochloa* spp.) e
Rice cutgrass (*Leersia oryzoides*)
Spike rush (*Eleocharis* spp.) e
Widgeongrass (*Ruppia maritima*)
Bulrush (*Scirpus* spp.)
Woolgrass (*Scirpus cyperinus*)
Lowland broomsedge (*Andropogon glomeratus*)
Sedge (*Carex lurida, lupulina, or lonchocarpa*)

Adjacent Uplands

(Only bayberry and waxmyrtle would need to be planted, other species would voluntarily colonize)

Bayberry (*Myrica pensylvanica*) e
Wax myrtle (*Myrica cerifera*) e
Sumac (*Rhus* spp.) e
Poison Ivy (*Rhus radicans*) e
Rose (*Rosa* spp.) e
Greenbrier (*Smilax* spp.) e
Elderberry (*Sambucus canadensis*)
Wild raisin (*Viburnum nudum*)

Rare or special concern plants

(These rare plants which exist in Lower Cape May Meadows would be protected and provided areas in which to expand their population. If these plants are available, additional plantings or propagation of wild stock could be considered; however, local genetics should be maintained and not mixed with plants from unknown sources. Further coordination with the New Jersey State Heritage Program would be required.)

Butterfly pea (*Clitoria maniana*) e
Awl-leaved rush (*Juncus coriaceus*) e
Swamp Pine (*Pinus serotina*) e
Whorled marsh-pennywort (*Hydrocotyle verticillata*) e
Blue boneset (*Eupatorium coelestinum*) e
Wild crab apple (*Pyrus angustifolia*) e
Long's rush (*Juncus longii*) e
Rattlesnake master (*Eryngium aquaticum*) e
Early Ladies'-tresses (*Spiranthes vernalis*) e
Bearded skeleton grass (*Gymnopogon ambiguus*) e
Fog fruit (*Phyla lanceolata*) e

* Planting will probably not be required as most of these saltmarsh species will voluntarily colonize created estuarine wetlands from Cape Island Creek (provided hydrology is appropriate).

e Currently exist within the Lower Cape May Meadows

SOURCE:

Martin, A.C., H.S. Zim, and A.L. Nelson. 1951. American wildlife and plants: A guide to wildlife food habits. Dover Publications, Incorporated, New York, New York. 500 pp.

Payne, N.F. 1992. Techniques for wildlife habitat management of wetlands. McGraw Hill, Incorporated, New York, New York. 549 pp.

Tiner, R.W., Jr. 1985. Wetlands of New Jersey. U.S. Department of the Interior, Fish and Wildlife Service, Hadley, Massachusetts. 117 pp.

APPENDIX D

ENGINEERING TECHNICAL APPENDIX

NEW JERSEY SHORE PROTECTION STUDY
NEW JERSEY

LOWER CAPE MAY MEADOWS - CAPE MAY POINT
FEASIBILITY STUDY

APPENDIX D
ENGINEERING TECHNICAL APPENDIX

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SECTION 16: Cost Estimates

SECTION 17: Schedule for Design and Construction

SECTION 18: Special Studies

SECTION 1

GENERAL

This Engineering Technical Appendix was prepared in accordance with ER 1110-2-1150, Engineering and Design for Civil Works Projects. Information in this appendix supplements data in the Feasibility Study to satisfy criteria in ER 1110-2-1150.

SECTION 2

HYDRAULICS AND HYDROLOGY
COASTAL PROCESSES

HYDRAULIC TECHNICAL APPENDIX

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A.HCP.1 COASTAL PROCESSES

A.HCP.1.1 INTRODUCTION

A number of coastal hydraulic processes which affect the Cape May Meadows and Cape May Point study area were investigated. The following paragraphs summarize these critical elements which include historic and existing wind, wave, water level and sediment conditions for the study area.

A.HCP.1.2 WAVES.

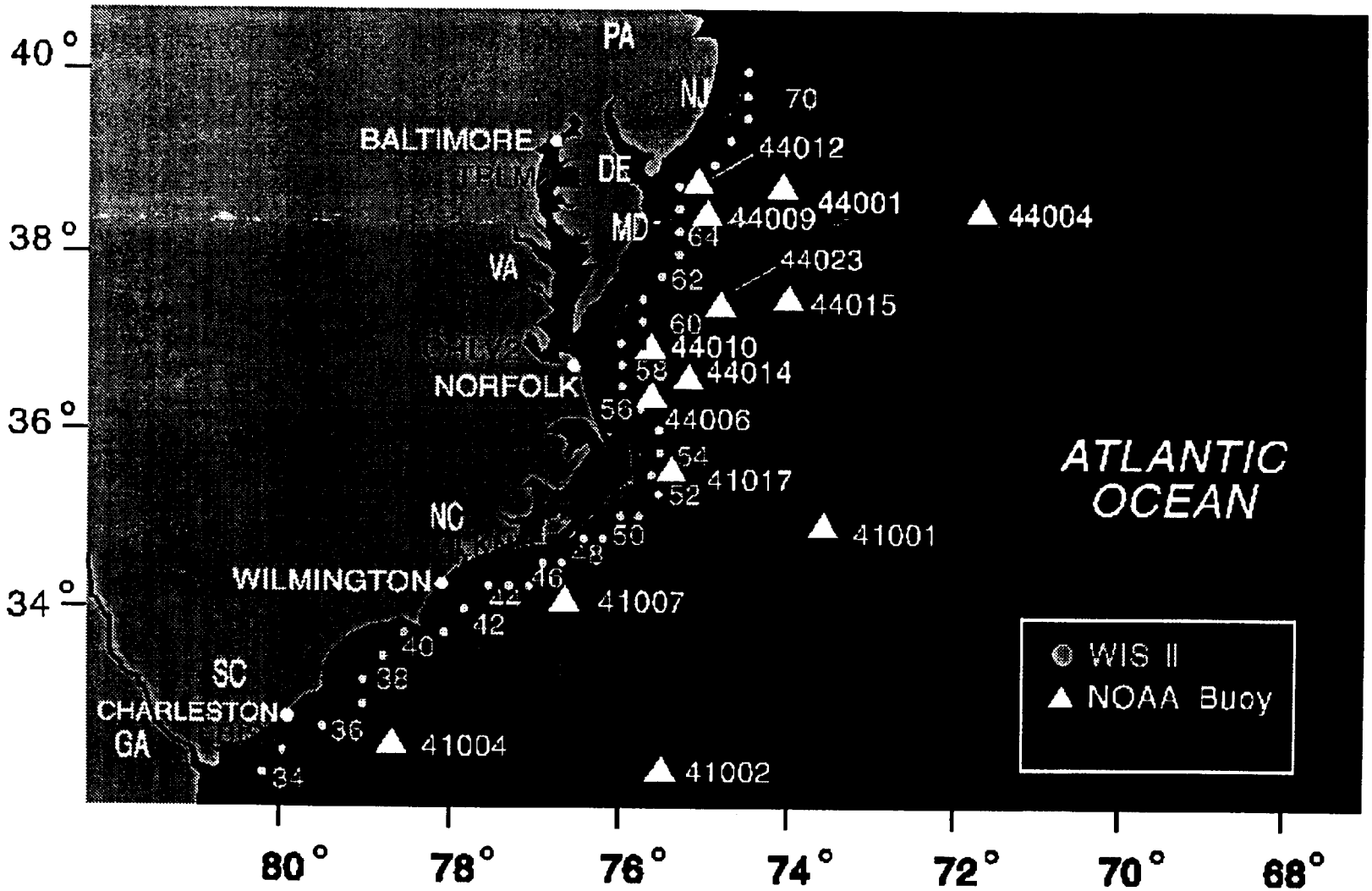
The most recent analysis of general wave statistics for the study area shoreline is presented in a report entitled "Hindcast Wave Information for the U. S. Atlantic Coast" (Wave Information Study (WIS) Report 30) prepared by Hubertz, et al., 1993. The WIS data is also available digitally through the Coastal Engineering Data Retrieval System (CEDRS) developed by the U.S. Army Engineer Coastal Engineering Research Center. WIS Report 30 and information in CEDRS provides wave data for 108 locations along the U. S. Atlantic coast, and supersedes WIS Report 2 (Corson, et al. 1981), WIS Report 6 (Corson, et al. 1982) and WIS Report 9 (Jensen 1983). The wave information for each location is derived from wind fields developed in a previous hindcast covering the period 1956 through 1975 and the present version of the WIS wave model, WISWAVE 2.0 (Hubertz 1992). Wave heights are universally higher for the current hindcast than for the original hindcast since the values more closely correspond to maximum measured (buoy) values.

Hindcast results are available as time series every 3-hr for the 20-yr period and as tabular summary statistics. WIS Report 30 contains tables presenting the distribution of spectral wave height, peak period and peak mean direction by month for the 20-yr period; the number of occurrences by 1-m height and 2-sec period categories for eight different direction bands and a final table for all directions; the distribution of wind in 2.5-m/sec and 45-deg speed and direction categories on a monthly basis; and finally summary tables of mean and maximum wave heights by month for each of the 20 years hindcast. These tables also include the peak period and peak mean wave direction associated with the maximum wave height occurrence.

The WIS output results are a verified source of information for wind and wave climate along the U.S. Atlantic Coast and have been used to gain a basic understanding of the wind and wave climate at the study area. The wave statistics pertinent to the study area are those derived for Station 67 of WIS Report 30 (Figure A.HCP.1.1). The location of Station 67 is Latitude 39.00 N, Longitude 74.50 W, in a water depth of approximately 60 ft. Monthly mean wave heights at Station 67 for the entire 20-yr hindcast range from 2.3 ft in August to 4.2 ft in December and January. The maximum wave height (H_{mo}) at Station 67 for the 20-yr period is reported as 23.6 ft, with an associated peak period of 14 sec and a peak direction of 97 deg on 7 March 1962. The maximum wind speed for Station 67 for the 20-yr hindcast is reported as 89 ft/sec at 20 deg on 7 March 1962.

Mid Atlantic Map - WIS Phase II and NOAA Buoys

WIS Phase II - Mid Atlantic Region



Atlantic WIS

U.S. ARMY ENGINEER DISTRICT, PHILADELPHIA
CORPS OF ENGINEERS
PHILADELPHIA, PENNSYLVANIA

LOWER CAPE MAY MEADOWS-CAPE MAY POINT
FEASIBILITY STUDY

WIS Station Map

FIGURE A.HCP.1.1

2

The actual wave spectrum experienced at any particular time along the project shoreline may show considerable local variation. This variability is largely due to the interaction of incident waves with: tidal currents at the entrance to Delaware Bay, shoal morphology, local shoreline alignment, nearshore bathymetry, and presence of shoreline stabilization structures. Therefore, the hindcast wave statistics should be viewed as a very general representation of the wave climate of the study area offshore. Inshore of the 60 ft depth, the effects enumerated above will modify the incident waves such that significant alongshore differences may exist with respect to breaking wave height and angle relative to the shoreline. Computer programs which transform offshore waves over varying bathymetry must be used to further investigate wave conditions closer to the shoreline.

A.HCP.1.3 WIND AND CLIMATE.

The site closest to the study area for which long-term systematic wind and climatic data are available is Atlantic City. Weather data were recorded at the Absecon Lighthouse from about 1902 to 1958. In 1943, systematic weather observations were initiated at the U. S. Naval Air Station located about 10 miles northwest of the Absecon Light. Records have been made continuously at the Air Station site (presently, National Aviation Facilities Experimental Center, Pomona) to the present. In 1958, the weather observation site in Atlantic City proper was relocated from Absecon Light about 1.1 miles northwest to the Atlantic City State Marina. The station was then moved several hundred yards to the Atlantic City Coast Guard Facility. The following paragraphs are quoted from the 1992 Annual Summary of Local Climatological Data, and are considered to be fully representative of conditions along the study area.

"Atlantic City is located on Absecon Island on the southeast coast of New Jersey. Surrounding terrain, composed of tidal marshes and beach sand, is flat and lies slightly above sea level. The climate is principally continental in character. However, the moderating influence of the Atlantic Ocean is apparent throughout the year, being more marked in the city than at the airport. As a result, summers are relatively cooler and winters milder than elsewhere at the same latitude."

"Land and sea breezes, local circulations resulting from the differential heating and cooling of the land and sea, often prevail. These winds occur when moderate or intense storms are not present in the area, thus enabling the local circulation to overcome the general wind pattern. During the warm season sea breezes in the late morning and afternoon hours prevent excessive heating. Frequently, the temperature at Atlantic City during the afternoon hours in the summer averages several degrees lower than at the airport and the airport averages several degrees lower than the localities farther inland. On occasions, sea breezes have lowered the temperature as much as 15 to 20 degrees within a half hour. However, the major effect of the sea breeze at the airport is preventing the temperature from rising above the 80's. Because the change in ocean temperature lags behind the air temperature from season to season, the weather tends to remain comparatively mild late into the fall, but on the other hand, warming is retarded in the spring. Normal ocean temperatures range from an average near 37 degrees in January to near 72 degrees in

August."

"Precipitation is moderate and well distributed throughout the year, with June the driest month and August the wettest. Tropical storms or hurricanes occasionally bring excessive rainfall to the area. The bulk of winter precipitation results from storms which move northeastward along, or in close proximity to, the east coast of the United States. Snowfall is considerably less than elsewhere at the same latitude and does not remain long on the ground. Precipitation, often beginning as snow, will frequently become mixed with or change to rain while continuing as snow over more interior sections. In addition, ice storms and resultant glaze are relatively infrequent."

As referenced in the 1992 Annual Summary from the US Coast Guard Facility, the prevailing winds are from the south and of moderate velocity (14 to 28 miles per hour), and winds from the northeast have the greatest average velocity (between 19 and 20 miles per hour). The wind data from this period also show that winds in excess of 28 miles per hour occur from the northeast more than twice as frequently as from any other direction.

The maximum five-minute average velocity at Atlantic City was recorded during the hurricane of September 1944, with a value of 82 miles per hour from the north. This storm also caused the largest recorded storm surge along the Atlantic coast of New Jersey. The fastest mile windspeed recorded at the Atlantic City Marina site over the 1960 to 1992 period was recorded during Hurricane Doria in August 1971. The fastest mile wind speed was 63 miles per hour from the southeast. The wind records generally reflect the fact that the most extreme, but infrequent, winds accompany hurricanes during the August to October period. Less extreme but more frequent high winds occur during the November to March period accompanying northeasters.

A.HCP.1.4 TIDES.

The tides affecting the study area are classified as semi-diurnal with two nearly equal high tides and two nearly equal low tides per day. The average tidal period is actually 12 hours and 25 minutes, such that two full tidal periods require 24 hours and 50 minutes. Thus, tide height extremes (highs and lows) appear to occur almost one hour (average is 50 minutes) later each day. The mean tide range at the Cape May Municipal pier is reported as 4.3 feet in the Tide Tables published annually by the National Oceanic and Atmospheric Administration (NOAA). The spring tide range is reported as 5.2 feet.

The NOS (National Ocean Service) tide gage nearest to the study area shoreline is Breakwater Harbor, Delaware. The mean and spring tide ranges for the gage are 4.2 and 4.9 feet respectively.

A.HCP.1.5 STORMS.

Storms of two basic types present a significant threat to New Jersey's coastal zone. Hurricanes are the most severe storms affecting the Atlantic Coast. Extratropical storms with winds from easterly quadrants, particularly the northeast, also cause extensive damage to beaches and structures along the coast.

Tropical storms and hurricanes, spawned over the warm low latitude waters of the Atlantic Ocean, are probably the best known and most feared storms. Hurricanes, characterized by winds of seventy-five miles per hour or greater and heavy rain, plague the Gulf and Atlantic seaboards in the late summer and autumn. Historically, the Hurricane of 1944 and Hurricane Gloria are ranked first and fifth, respectively, in terms of maximum stage at the Atlantic City gage.

Extratropical storms, often called "northeasters", present a particular problem to the Atlantic seaboard. Such storms may develop as strong, low pressure areas over land and move slowly offshore. The winds, though not of hurricane force, blow onshore from a northeasterly or easterly direction for sustained periods of time and over very long fetches. The damage by these storms may ultimately exceed the destruction from a hurricane. The March 1962 Northeaster ranks second only to the 1944 hurricane in terms of maximum stage. The northeasters which occurred in November 1950 and December 1992 rank third and fourth in the stage frequency analysis for the Atlantic City gage.

The intensity and damage-producing potential of coastal storms are related to certain meteorological factors such as winds, storm track, and amount and duration of precipitation. However, the major causes of coastal damage tend to be related to storm surge, storm duration, and wave action. Storm surge and wave setup will be discussed in the storm erosion and inundation analysis included in a later section.

A.HCP.1.6 SEA LEVEL RISE.

Sea level rise is a contributing factor to long term coastal erosion and increased potential for coastal inundation. Because of the enormous variability and uncertainty of the climatic factors that affect sea level rise, predicting future trends with any certainty is difficult. There exists many varying scenarios of future sea level rise. Corps of Engineers guidance ER-1105-2-100 section 5-25 recommends that The National Research Council (NRC) study on sea level rise, Responding to Changes in Sea Level: Engineering Implications, 1987 be used until more definitive data become available. Corps of Engineer's policy calls for consideration of designs which are most appropriate for a range of possible future rates of rise. Strategies, such as beach fills which can be augmented in the future as more definitive information becomes available, should receive preference over those that would be optimal for a particular rate of rise but unsuccessful for other possible outcomes. Potential sea level rise should be considered in every coastal study, with the degree of consideration dependent on the quality of the historical record for the study site. Based on historical tide gage records between 1912 and 1986 at Atlantic City and

Ventnor, New Jersey, sea level has been rising at an approximate average rate of 0.013 feet per year (Hicks and Hickman 1988). In consideration of the length and quality of the tide record at Atlantic City, the ocean stage frequency analysis incorporates the effects of the local sea level rise. Over the proposed fifty year project life, it is assumed that mean sea level will rise by 0.65 feet.

A.HCP.1.7 STORM CRITERIA

Under contract to the Philadelphia District, Offshore&Coastal Technologies Inc- East Coast (OCTI-E) developed storm water level, wave height, period and direction criteria for the project area for the 2-, 5-, 10-, 20-, 50-, 100-, 200-, and 500-year events. Storm wind, wave and water level data to be used for erosion and inundation modeling were generated using historic data and hindcasting techniques. This section describes the techniques used and the results for the Cape May Meadows study area.

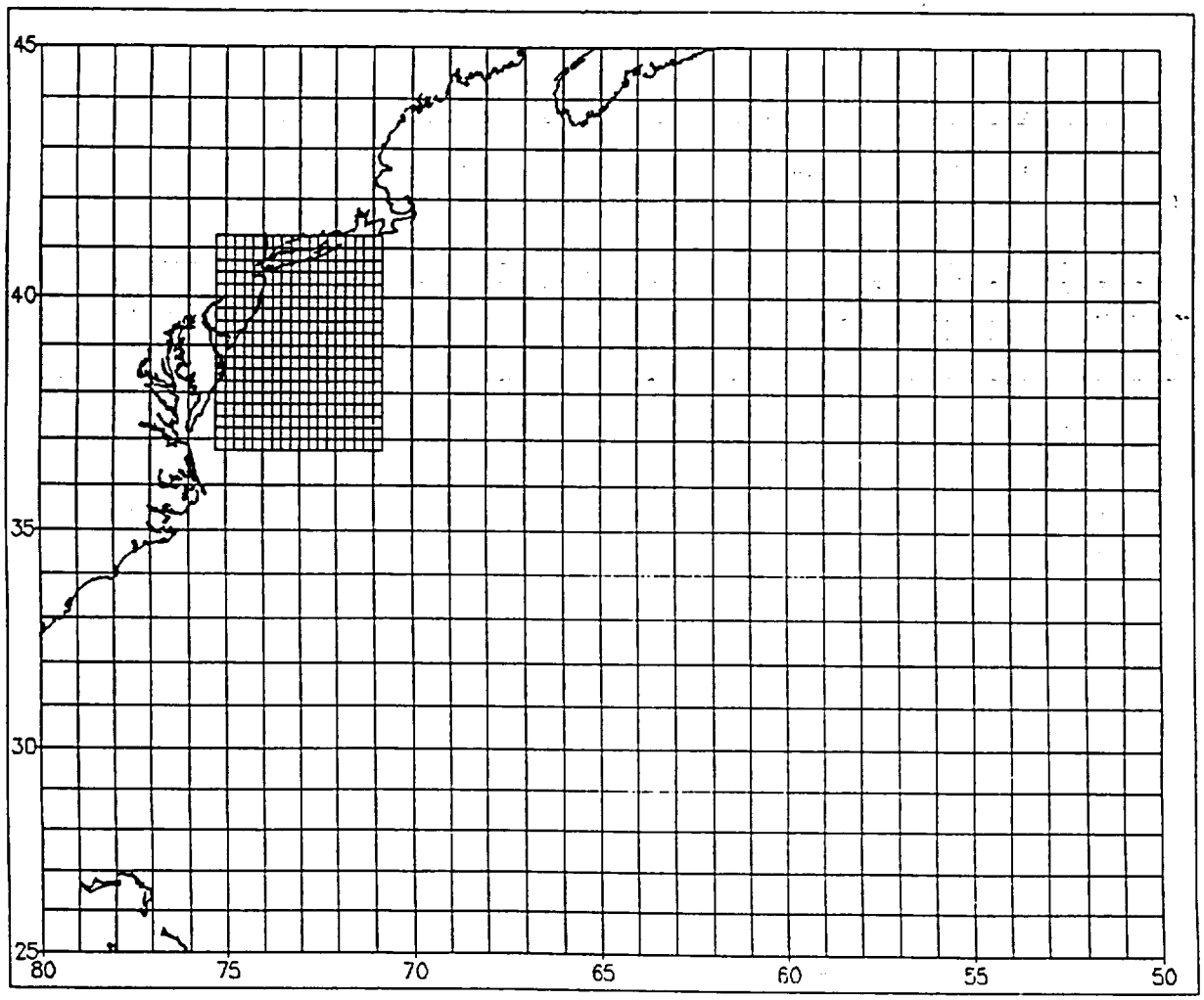
Historic storm data were generated using a series of numerical models, applied to the two storm populations: hurricanes and northeasters. First, the wind fields were specified during each storm at a high temporal (hourly for tropical storms, six-hourly for northeasters) and spatial resolution. The wave field over the northern and mid-Atlantic Ocean area and the eastern Delaware Bay was simulated to provide data for the coastal areas of southern New Jersey and Delaware. Fully discrete directional spectra were modeled using a numerical spectral model that has had considerable prior validation in deep and shallow areas around the world. The present study includes the effects of swell propagation from the Atlantic Ocean by appropriate nesting of wave model grids.

The specification of water levels and currents for the area of interest was performed using a two-dimensional storm surge and current model. The model included the effect of shallow water and land boundaries, the effects of surface wind stresses, Coriolis forcing, and the important contribution of astronomical tide.

The modeling grids are illustrated in Figures A.HCP.1.2 and A.HCP.1.3, indicating that the entire study included a large portion of the Atlantic Ocean and significant detail in Delaware Bay and the adjacent oceanfront shorelines of southern New Jersey and Delaware.

A.HCP.1.7.1 HISTORIC STORM SELECTION

A total of 30 of the most severe storms to have impacted the Delaware Bay and the New Jersey coast were selected for the hindcasting study from a 102-year period of record: 15 hurricanes and 15 northeasters. Storm selection was based on the potential for wind, wave and storm surge-generation by the events. Coastal erosion and inundation are primarily a function of water level; however, waves are a significant consideration. Some events will generate high waves on the Delaware Bay, such as storms with strong northwesterly winds; however, the storm tides on the Delaware Bay and waves on the New Jersey coast will be relatively insignificant. The primary emphasis of the storm



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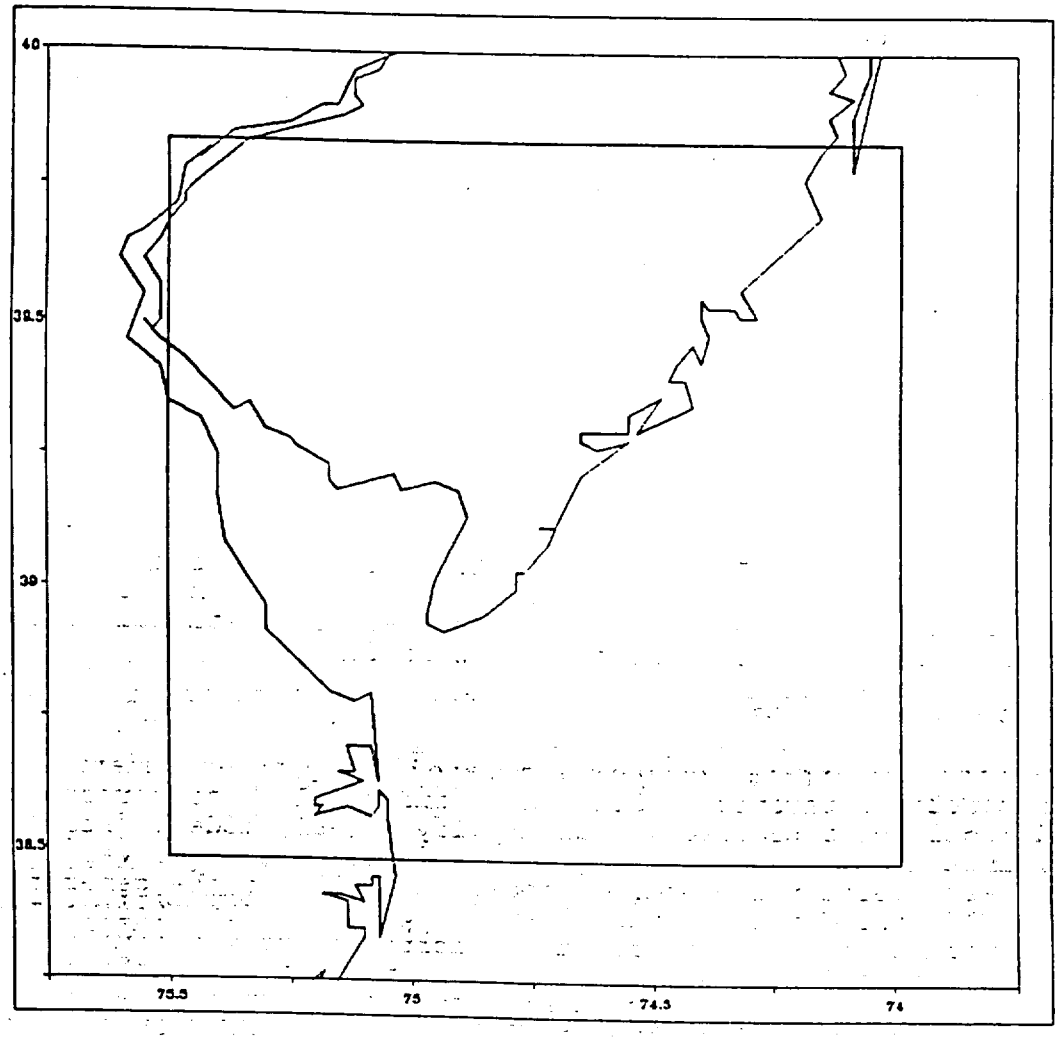
Large Scale Grid for Hindcast Analysis

FIGURE A.HCP.1.2



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Small Scale Grid for Hindcast Analysis

FIGURE A.HCP.1.3

selection phase was to define an extreme storm population for the Delaware Bay. For this study, the population of storms were considered applicable to the New Jersey Atlantic Coast area due to the large size of northeasters that govern the majority of historic extreme storms in the area and due to the sparsity of hurricanes in the historic storm population.

Screening of historic hurricanes was performed using the NOAA database to determine the most severe events based upon track and intensity. This screening, which yielded a list of storms that passed within 100 miles of the study area, was refined by assessing documented or reported storm severity (storm damages along the Delaware Bay and Atlantic Ocean coastlines and measured oceanographic data). A set of 15 storms was finalized as shown in Table A.HCP.1.1.

Table A.HCP.1.1
Hurricanes Used
In Hindcast

Oct 1891	Aug 1954 (Carol)
Aug 1899	Sep 1954 (Edna)
Sep 1903	Sep 1958 (Daisy)
Aug 1924	Sep 1960 (Donna)
Sep 1933	Sep 1967 (Doria)
Sep 1936	Aug 1976 (Belle)
Sep 1944	Sep 1985 (Gloria)
Aug 1953	

Northeasters were selected based upon a review of historic weather maps, reputed storm damages and tide records. Several types of extra tropical storms have historically affected the New Jersey and Delaware area, originating in the Bahamas, southern Florida, or arriving from the Appalachia. The storm selection process resulted in the storm list provided in Table A.HCP.1.2.

Table A.HCP.1.2
Northeasters Used
In Hindcast

Nov 1950	Oct 1977
Oct 1953	Feb 1978
Mar 1962	Oct 1980
Jan 1964	Mar 1984
Jan 1966	Oct 1991
Dec 1973	Jan 1992
Nov 1974	Dec 1992
Mar 1977	

Note that for this study, 11 of the top recorded annual maximum water levels on record at Atlantic City, NJ, are included in the hindcast storm population.

A.HCP.1.7.2 STORM WIND FIELDS

Historic wind fields were simulated using three numerical wind field models: a parametric hurricane wind model, a geostrophic wind field model and a planetary boundary layer (PBL) model. For hurricanes and tropical storms, a parametric wind model was used. The model was a relatively detailed model that allowed the generation of wind fields based upon temporally-varying storm parameters. The method used to derive wind fields in northeasters was similar to that used for tropical storms except for the application of the parametric tropical storm model. The standard approach to specification of wind fields in non-tropical regimes relies on direct analysis of surface observations in a process called kinematic analysis to develop the most accurate wind fields possible. Isobars on historic surface weather charts were digitized at the best available resolution (generally 4 mb), with maps mostly available at 6-hourly time increments. Digital information was gridded on a one-degree increment. After application of the geostrophic and PBL wind models, ship observations and buoy data, as available, were blended into the resulting surface wind fields along with smaller-scale weather systems affecting the New Jersey and Delaware coastal and offshore areas. Wind fields were validated against all available marine buoy and C-MAN station data.

A.HCP.1.7.3 STORM WAVE FIELDS

Hindcasted storm wave conditions for this study were simulated using a second generation discrete directional spectral wave model that is applicable in all water depths. The model was developed by Dr. D.T. Resio and includes a nonlinear wave-wave interaction source term and shallow water wave transformations. The model is a FORTRAN code which simulates wave growth, dissipation and propagation in deep or shallow water. Spectra are represented as fully two-dimensional spectra in discretized frequency and direction bands. Propagation effects and source/sink mechanisms are computed in terms of variations of energy levels in each of these frequency-direction elements. All wave parameters such as significant wave height, frequency of the spectral peak, mean wave direction, etc. are computed from these discrete elements.

The New Jersey coast application of the model includes the propagation of energy toward shore from the deep water of the Atlantic Ocean to the shallow shelf waters and into the Delaware Bay. The model includes source terms describing wave shoaling, refraction, wind effects, wave-wave interactions and bottom interaction effects. The wave model was implemented to simulate waves on three nested grids, depicted in Figures A.HCP.1.2 and A.HCP.1.3. The series of grids assures that distant swell as well as locally-generated wind waves are included in the results. The final (finest resolution) grid spacing used a one nautical mile resolution so that conditions very near to the coast could be produced to the best accuracy possible.

Near shore wave time series for the hindcasted events were determined as follows:

1. Scale all energy bins of the hindcasted directional spectra of the offshore wave time series by the square of the required wave height scale factor (wave height is proportional to the square-root of wave energy).

2. Propagate each hourly spectrum on an approximately 1500-foot grid resolution using model STWAVE along the oceanfront to the nearshore. Archive the time series of zero-moment wave height, peak wave period and mean wave direction at the grid cell at coordinates 38-55N and 74-55W. These time series were then used to generate a wave height time series file and a wave angle time series file for each storm event.

The extreme wave heights estimated using hindcast results were compared to Wave Information Study (WIS) wave hindcast results produced by CERC at Station 67, the offshore hindcast reporting location that is closest to the study area. The WIS data are generally higher than the recently-hindcast results up until the 50- year event. The difference in the results reflects basic differences in the studies:

--The recent hindcast includes storm of all types (tropical and extra tropical) from a longer period of record, i.e. hurricanes since 1890 and northeasters since 1950, whereas WIS includes storms from a 20-year period between 1956 and 1975.

--The recent hindcast accounts for detailed local bathymetric conditions whereas WIS bathymetry used a simplified shelf configuration (straight and parallel contours).

--The recent hindcast includes near shore storm winds whereas WIS data was propagated from a WIS phase II station without near shore wave generation by winds.

A.HCP.1.7.4 STORM SURGES

Water level and current hindcasting were performed using a depth-integrated finite difference model. This model included the effect of shallow water and land boundaries on the flow field. The results of the storm simulations reflect the astronomical tidal and storm wind-and pressure-induced water level changes and currents during each event. These components of water level and current must be added to other sources of ambient currents, wave setup, coastal currents, etc. to determine total conditions at a given location. The model used in this study solves momentum and continuity equations using an explicit differencing scheme. The momentum equations contain advection, surface slope, Coriolis, wind stress, bottom stress and inverse barometer terms. The effects of sea

level rise are included in the calculation of water levels and effects on waves by applying the storm driving forces over recently collected bathymetry and beach profile surveys. This data is referenced to NGVD 1929 vertical datum.

The computational grid for the hindcast was a 1-minute grid covering the Atlantic Ocean and Delaware Bay area extending from 73 to 75.5 degrees West Longitude and from 37.0 to 40.0 degrees North Latitude. Only results within the wave model grid three were recorded as output from the model for further archiving and post-processing.

A.HCP.1.7.5 FREQUENCY DESIGN CRITERIA

Peak waves and water level information were produced for the Cape May Meadows study area offshore of The Meadows at coordinates 38 degrees 55 minutes North Latitude/74 degrees 55 minutes West Longitude. The location, outside the major influences of near shore tidal shoals, had a water depth of approximately 26 feet MLLW.

An analysis of storm peak waves and water levels was performed in order to formulate extreme design criteria for the project. A best-fit Gumbel distribution was developed using all of the data. Extremes were calculated for return periods of 2, 5, 10, 20, 50, 100, 200 and 500 years.

The approach for formulating a distribution of the most extreme events was performed using the hindcast results, which include a large percentage of the most severe water level and wave events that historically have occurred at the study area. This method utilized the actual historical record, supplemented by numerically-modeled details, to generate the extreme value distribution. A curve was fitted to the hindcasted sample distribution of actual storms and then this curve was extrapolated to longer time intervals than that covered by the sample.

The basic input data to the extremal analysis are the maximum values of each particular scalar variate (water level and wave height) from each storm. The maxima are arranged in ascending order and a cumulative distribution function is determined. Since an annual series is not used, but rather a set of 30 storm peaks that have occurred over a known period of history, the time scale in the recurrence interval estimates is converted to allow for the appropriate mean interval between storms.

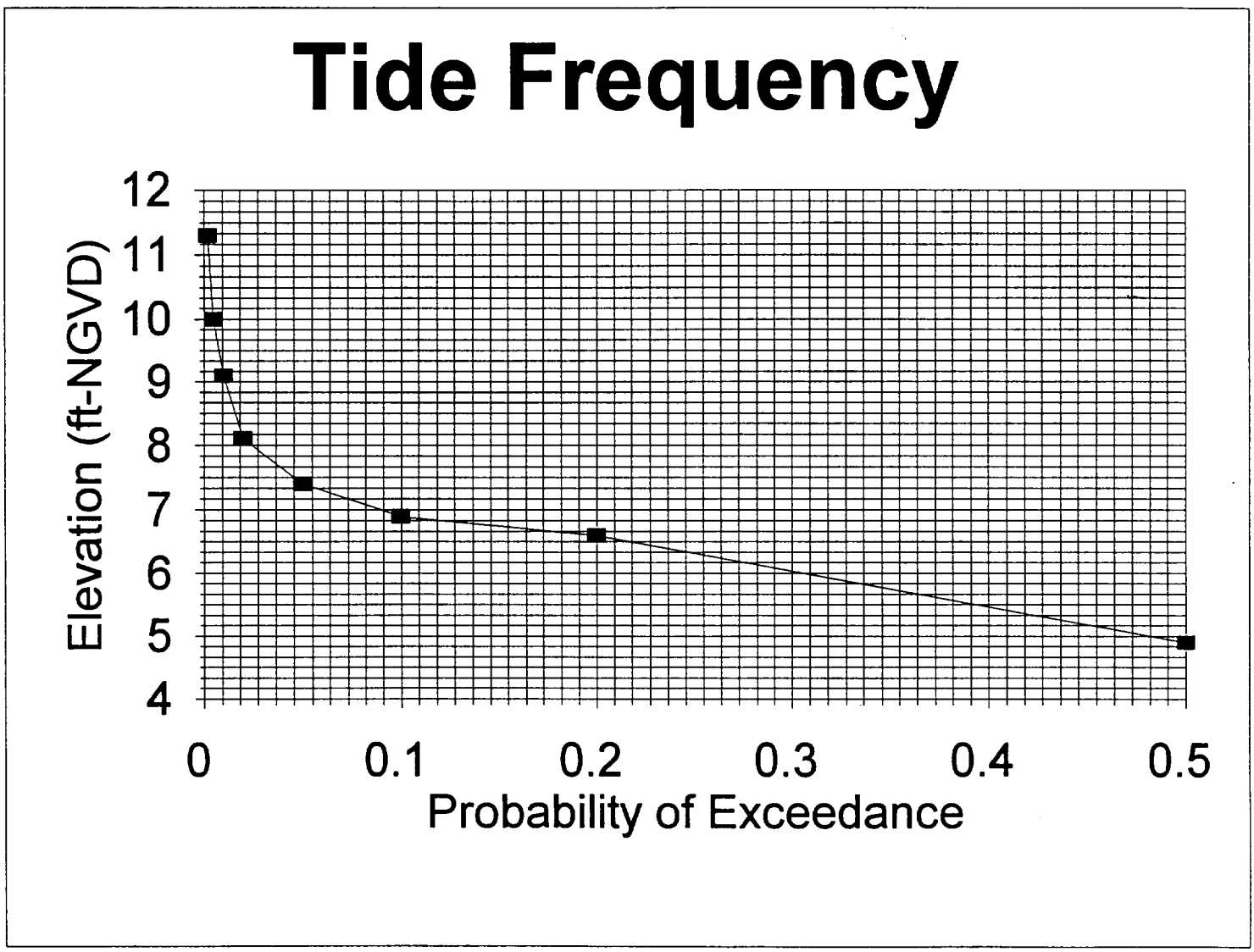
In this analysis, an estimate of values for 8 recurrence intervals are given. The Gumbel distribution (Fisher-Tippett Type I) is used. Extrapolation to higher recurrence intervals is more uncertain and it is generally recognized that this should not be extended to recurrence intervals greater than 2-3 times the length of the period over which the population is drawn (in this case the period is 102 years). Therefore, extrapolation to the 200- and 500-year events will contain the most uncertainty. The wave height and water level frequency data are provided as Table A.HCP.1.3 and the elevation-frequency data are plotted on Figure A.HCP.1.4.

Table A.HCP.1.3
Frequency Wave and Water Level
(at 38-55N, 74-55W)

Event (Year)	Probability of Exceedance	Water Surface Elevation (ft-NGVD)	Sig Wave Ht (feet)
2	0.500	4.9	13.1
5	0.200	6.6	14.4
10	0.100	6.9	16.7
20	0.050	7.4	19.4
50	0.020	8.1	22.6
100	0.010	9.1	24.9
200	0.005	10.0	27.2
500	0.002	11.3	30.5

Note: Elevations referenced to NAVD88 datum are obtained by subtracting 1.27 feet from the NGVD29 elevations

The nearest long term tide gage is at Atlantic City recently relocated at the Trump Taj Mahal Pier. It has been in operation since July 1911 with two years of missing record, 1922, and 1970. As a point of comparison with the ocean stage frequency curve for Cape May Meadows, Table A.HCP.1.4 presents the 20 highest observed stages adjusted for sea level rise at Atlantic City.



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Ocean Stillwater Elevation-Frequency Curve

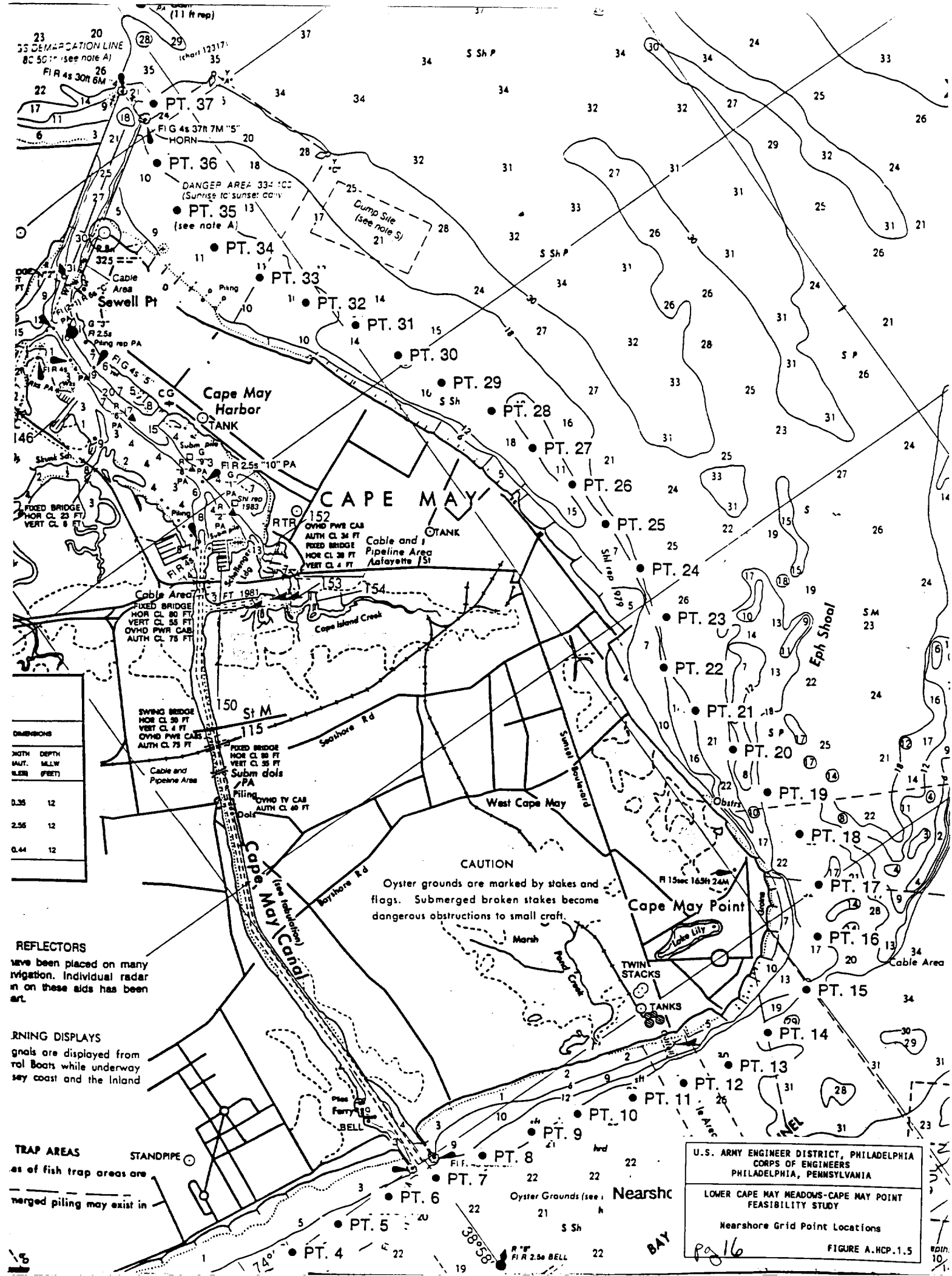
FIGURE A.HCP.1.4

Table A.HCP.1.4
20 Highest Stages
Atlantic City, N.J. 1912-1992

YEAR	DATE	RANK	NGVD
1944	14 SEP 1944	1	8.19
1962	7 MAR 1962	2	7.56
1950	25 NOV 1950	3	7.51
1992	11 DEC 1992	4	7.40
1985	27 SEP 1985	5	7.37
1976	9 AUG 1976	6	7.37
1991	31 OCT 1991	7	7.21
1984	29 MAR 1984	8	6.81
1980	25 OCT 1980	9	6.69
1953	23 OCT 1953	10	6.57
1989	19 OCT 1989	11	6.48
1977	14 OCT 1977	12	6.45
1947	1 NOV 1947	13	6.45
1972	22 DEC 1972	14	6.43
1960	12 SEP 1960	15	6.38
1961	22 OCT 1961	16	6.37
1932	10 NOV 1932	17	6.34
1935	6 SEP 1935	18	6.31
1920	5 FEB 1920	19	6.30
1966	23 JAN 1966	20	6.21

A.HCP.1.8 LONGSHORE SEDIMENT TRANSPORT

Andrews, Miller & Assoc., Inc. under contract to the Philadelphia District prepared an assessment of the longshore transport potential in the vicinity of Cape May Meadows and Cape May Point. The analysis was based on a near shore wave and current hindcast for the period 1987-1992 prepared by OCTI-E acting as a subcontractor for Andrew Miller Inc. The meteorological and oceanographic numerical modelling approaches used are the same as that described in the section above, except for the use of a fine scale grid model (0.25 nautical miles) nested inside the larger grid. The limits of the finer grid for the Atlantic Ocean and Delaware Bay area extended from 74 to 75 degrees West Longitude and from 38.0 to 39.0 degrees North Latitude. The finer grid provides the necessary definition of nearshore waves and currents for use in a sediment assessment. The location of the grid points nearest to shore are shown on Figure A.HCP.1.5 with additional information provided on Table A.HCP.1.5.


PT. 37
PT. 36
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PT. 15
PT. 14
PT. 13
PT. 12
PT. 11
PT. 10
PT. 9
PT. 8
PT. 7
PT. 6
PT. 5
PT. 4
Dump Site (see note S)
Sewell Pt
Cape May Harbor
CAPE MAY
Cape May Canal
West Cape May
Cape May Point
Eph Shoal
Sunset Boulevard
Seashore Rd
Cape Island Creek
Pond Creek
Marsh
Lake Lily
TWIN STACKS
TANKS
STANDPIPE
Cable Area
Cable and Pipeline Area
Lafayette St
FIXED BRIDGE HOR CL 23 FT VERT CL 6 FT
FIXED BRIDGE HOR CL 80 FT VERT CL 55 FT OVHD PWR CAB AUTH CL 75 FT
SWING BRIDGE HOR CL 50 FT VERT CL 4 FT OVHD PWR CAB AUTH CL 75 FT
FIXED BRIDGE HOR CL 80 FT VERT CL 55 FT
OVHD TV CAB AUTH CL 60 FT
OVHD PWR CAB AUTH CL 34 FT
FIXED BRIDGE HOR CL 38 FT VERT CL 4 FT
Fl R 2.5s "10" PA
Fl G 4s 37ft 7M "5" HORN
Fl R 4s 30ft 6M
Fl R 2.5s BELL
Oyster Grounds (see
Nearshc
CAUTION
Oyster grounds are marked by stakes and flags. Submerged broken stakes become dangerous obstructions to small craft.
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Nearshore Grid Point Locations
FIGURE A.HCP.1.5

Table A.HCP.1.5
Nearshore Point Data

Nearshore Point	Latitude	Longitude	Depth (ft,MLW)
1	38-59.50	74-57.50	15
2	38-59.25	74-57.75	15
3	38-59.00	74-58.00	15
4	38-58.75	74-58.00	15
5	38-58.50	74-58.00	13
6	38-58.25	74-58.25	14
7	38-58.00	74-58.50	15
8	38-57.75	74-58.50	18
9	38-57.50	74-58.50	21
10	38-57.25	74-58.50	22
11	38-57.00	74-58.50	23
12	38-56.75	74-58.50	25
13	38-56.50	74-58.50	26
14	38-56.25	74-58.25	24
15	38-56.00	74-58.00	13
16	38-55.75	74-57.75	19
17	38-55.50	74-57.50	14
18	38-55.50	74-57.25	15
19	38-55.50	74-57.00	12
20	38-55.50	74-56.75	12
21	38-55.50	74-56.50	12
22	38-55.50	74-56.25	14
23	38-55.50	74-56.00	20
24	38-55.50	74-55.75	23
25	38-55.50	74-55.50	22
26	38-55.50	74-55.25	22
27	38-55.50	74-55.00	21
28	38-55.50	74-54.75	19
29	38-55.50	74-54.50	18
30	38-55.50	74-54.25	17
31	38-55.50	74-54.00	16
32	38-55.75	74-53.75	15
33	38-56.00	74-53.50	15
34	38-56.25	74-53.25	15
35	38-56.50	74-53.00	14
36	38-56.50	74-52.75	12
37	38-56.50	74-52.50	10

A.HCP.1.8.1 WAVE-INDUCED NEARSHORE LONGSHORE TRANSPORT

The wave data generated at each of the 37 near shore locations was analyzed to determine long shore transport potential due to waves. Wave-driven transport potential was calculated using the CERC energy flux method- with long shore energy flux and transport rate expressions taken from the Shore Protection Manual (SPM Equations 4-39 and 4-49). This procedure calculates the breaking wave height and angle with respect to the local shoreline orientation as scaled off the bathymetric chart at each of the 37 locations. Snell's Law was used with the assumption of straight and parallel bottom contours and conservation of wave energy flux directed onshore. The rates were calculated for each onshore wave condition and cumulated for each year of the 6-year normal condition hindcast.

Based on the methodology discussed above, the near shore long shore sediment transport potential was calculated for each of the thirty-seven (37) nearshore grid points which are spaced 0.25 nmi along the study area from Cape May Canal to Cape May Inlet. The results of the calculations consist of potential long shore sediment transport to the left (-) and to the right (+) (conventional reference with observer standing onshore and looking offshore), net transport and gross transport for each of the thirty-seven (37) near shore grid points for the years 1987-1992. The six (6) year average of the net potential long shore transport for each point is presented as Table A.HCP.1.6.

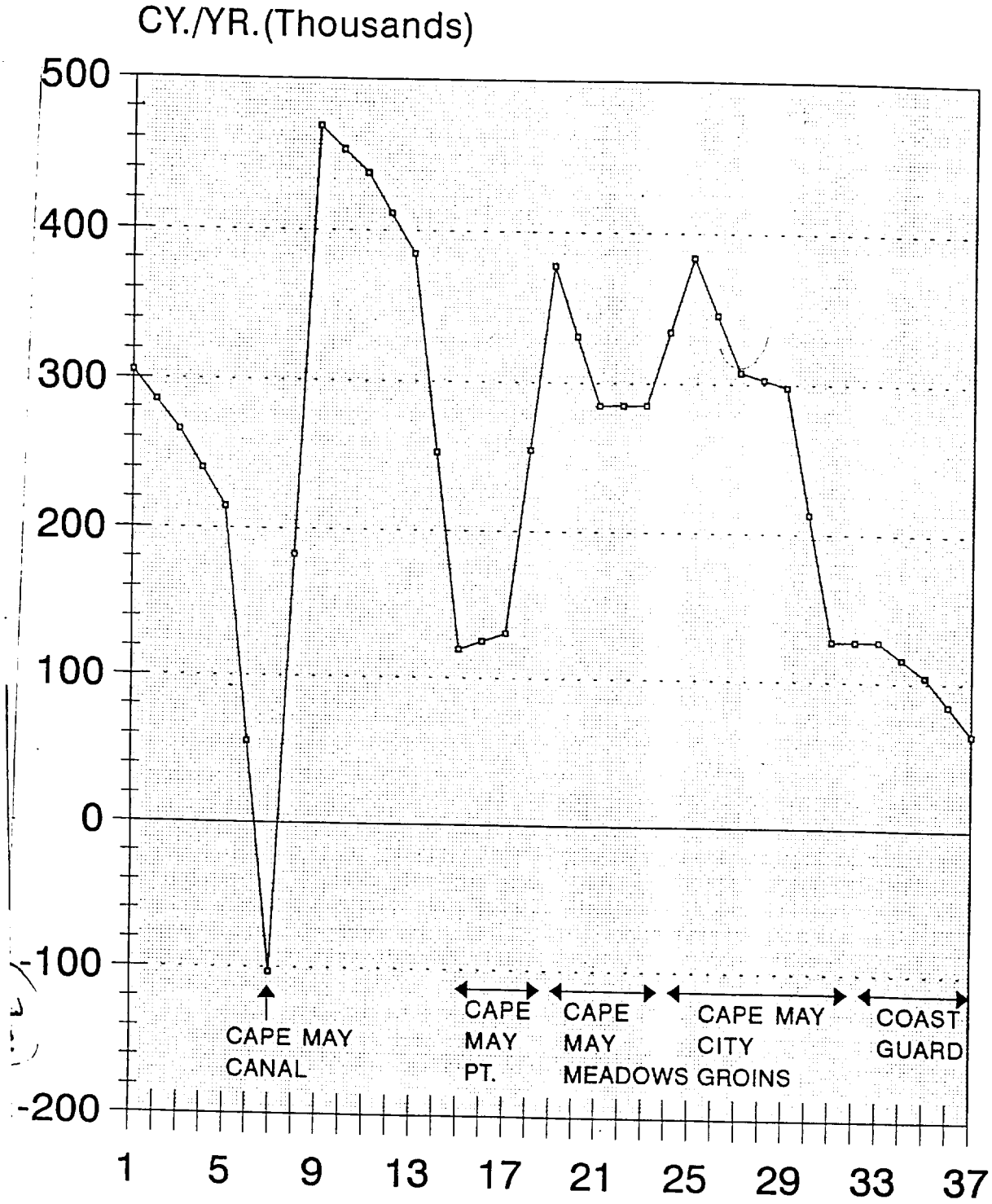
Table A.HCP.1.6
Potential Wave-Induced Net
Longshore Sediment Transport

Nearshore Grid Point	QNet (Cy/Yr)	Nearshore Grid Point	QNet (Cy/Yr)
1	304850	20	331000
2	285306	21	284500
3	265762	22	284667
4	240000	23	284833
5	214238	24	334250
6	55611	25	383667
7	-103017	26	345667
8	182852	27	307667
9	468720	28	302750
10	453317	29	297833
11	437913	30	212750
12	411240	31	127667
13	384567	32	127750
14	252283	33	127833
15	120000	34	116167
16	125500	35	104500
17	131000	36	84833
18	254250	37	65167
19	377500		
Average	242848		
Min Val	-103017		
Max Value	468720		
Standard Dev	127530		

As shown in Table A.HCP.1.6, the calculated value of the potential net long shore sediment transport averaged over the study area from Cape May Inlet to Cape May Point is 242,848 cubic yards per year (east to west), which compares very closely to the value of 250,000 cubic yards per year net transport to the east computed by Caldwell (Corps, 1980). Variations in the wave-induced potential net long shore transport rate along the study area shoreline are shown in Figure A.HCP.1.6.

Proceeding west from the Cape May Inlet jetties, the net long shore transport rate averages about 104,000 cubic yards per year (to the west) along the Coast Guard shoreline and then increases to an average of about 289,000 cubic yards per year (to the west) along the Cape May City shoreline. The lower net transport rate along the Coast Guard shoreline is probably attributable to sheltering by the jetties and shoreline orientation differences with the Cape May shoreline.

CAPE MAY, NEW JERSEY
WAVE-INDUCED LONGSHORE SEDIMENT TRANSPORT



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Potential Wave-Induced
Longshore Sediment Transport

FIGURE A.HCP.1.6

Along the Cape May Meadows shoreline, the average net transport rate is about 313,000 cubic yards per year (to the west) and then decreases to an average of about 158,000 cubic yards per year along the Cape May Point groin field. This decrease in transport is a result of the shoreline orientation change along the point which would reduce the transport potential of waves from the east to southeast directions. From the west groin at Cape May, the transport rate increases to an average of about 370,000 cubic yards per year due to shoreline orientation changes which would increase the transport potential of waves from the south to southwest.

At Cape May Canal, there is a reversal in the net transport direction to 100,000 cubic yards per year to the east. From west of the entrance to the canal, the net transport is to the west at an average of about 228,000 cubic yards per year.

A.HCP.1.8.2 CURRENT-INDUCED LONGSHORE TRANSPORT

The hindcast tidal current data for each near shore grid point was analyzed to determine long shore transport potential due to currents. Bed load sediment transport potential due to storm and tidal driven current was calculated using a relationship developed by Dixon and Westfall (Morris and Wiggert, 1972) which is based upon a large range of laboratory and field conditions. The relationship is a function of median grain size (here, assumed to be 0.2 mm) and the flow velocity.

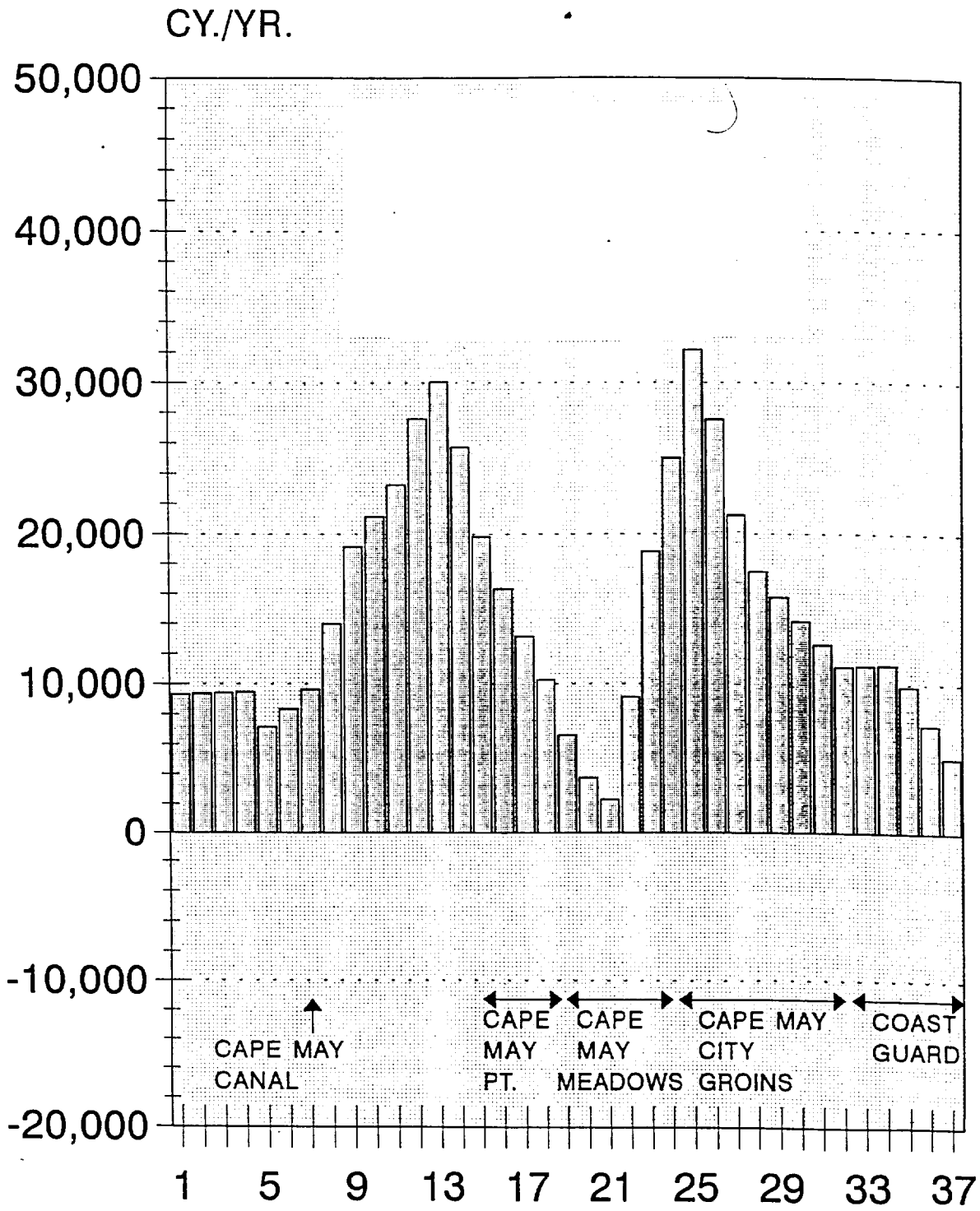
The results of the calculations consist of potential current induced long shore sediment transport to the left (-) and to the right (+) (conventional reference with observer standing onshore and looking offshore), net transport and gross transport for each of the thirty-seven (37) near shore grid points for the years 1987-1992. The six (6) year average of the net potential long shore transport for each point is presented as Table A.HCP.1.7.

Table A.HCP.1.7
Potential Current-Induced Net
Longshore Sediment Transport

Nearshore Grid Point	QNet (Cy/Yr)	Nearshore Grid Point	QNet (Cy/Yr)
1	9329	20	3745
2	9383	21	2279
3	9437	22	9166
4	9492	23	18813
5	7171	24	25022
6	8365	25	32157
7	9658	26	27556
8	13987	27	21217
9	19148	28	17466
10	21136	29	15765
11	23234	30	14141
12	27609	31	12597
13	30033	32	11134
14	25737	33	11197
15	19818	34	11260
16	16316	35	9864
17	13137	36	7288
18	10286	37	5089
19	6621		
Average	14747		
Minimum Value	2279		
Maximum Value	32157		
Median	12597		
Standard Dev	7658		

As shown in Table A.HCP.1.7, the calculated potential current-induced long shore sediment transport averaged over the study area is 14,747 cubic yards per year. Variations in the current-induced long shore transport along the shoreline are shown in Figure A.HCP.1.7. Analysis of Figure A.HCP.1.7 indicates that there are peaks in the current-induced transport offshore of the 3rd Avenue terminal groin and in the vicinity of the west groin at Cape May Point. Figure A.HCP.1.7 also indicates a minimum current-induced transport offshore of The Meadows area.

CAPE MAY, NEW JERSEY
CURRENT-INDUCED LONGSHORE SEDIMENT TRANSPORT



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LOWER CAPE MAY MEADOWS-CAPE MAY POINT
FEASIBILITY STUDY

Potential Current-Induced
Longshore Sediment Transport

FIGURE A.HCP.1.7

A.HCP.1.8.3 LIMITATIONS OF THE ANALYSIS

The potential wave-induced long shore sediment transport rates, although in general agreement with previous estimates, were developed at points 0.25 nmi offshore and 0.25 nmi along shore using generalized shoreline orientation as input with none of the effects of the existing structures along the shoreline taken into account and assuming wave transformation by straight and parallel contours throughout the area. Potential current-induced longshore sediment transport is based on bed load transport and does not account for the potential increased long shore transport due to currents acting on sediment mobilized by wave turbulence and suspension.

A.HCP.1.8.4 TIDAL CURRENT DATA COLLECTION

A field effort was undertaken to obtain tidal current data consisting of velocity, direction, and depth across four (4) profiles perpendicular to the shoreline. Data collection at locations across each profile and at various depths defines the horizontal and vertical tidal current distribution. Current measurements were taken at three stations along each of the four profiles, as shown in Figure A.HCP.1.8, and at a minimum of three depths. Each station was referenced to the New Jersey State Plane Coordinate System. The first location along each profile was as close to shore as possible without entering the surf zone. Successive measurements were then taken at greater distances from shore as determined by changes in bathymetry. The tidal measurements were obtained during the optimum conditions of spring tide with minimum wind and wave interference over the period 26-28 July 1994.

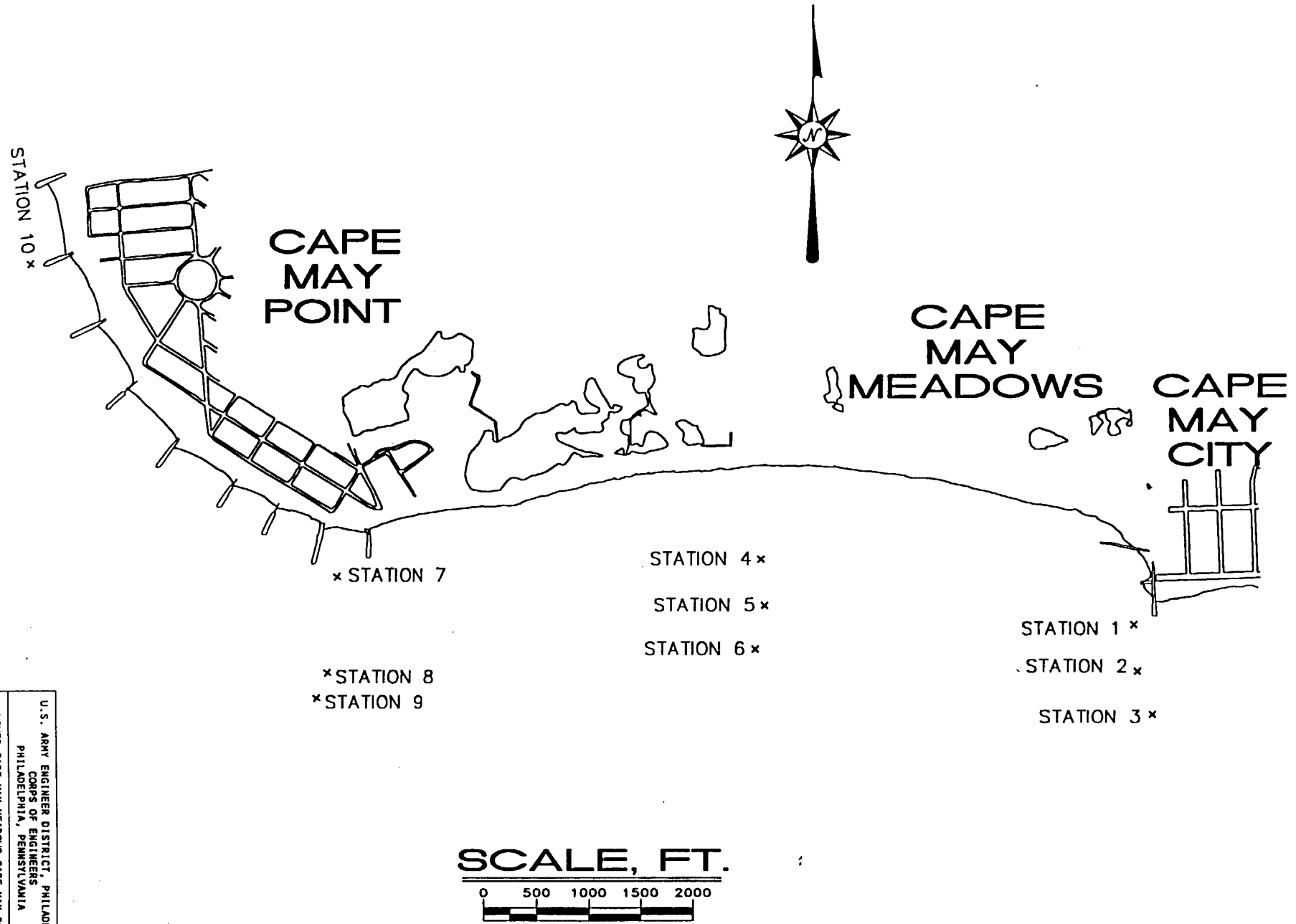
A.HCP.1.8.5 TIDAL CURRENT DATA EVALUATION

Analysis of the current velocity data indicates that the maximum current velocities occur about 2.5 hours prior to the maximum high tide or low tide elevation. In general, the slack current occurred about 40 minutes after the high tide elevation occurs. Tidal current measurements were made at three depths at each of the 12 stations. These depths were generally -2 feet, -6 feet, and -13 feet relative to the water surface. Analysis of the data shows the typical vertical distribution of current velocity with the higher velocities at the surface (-2 feet) and decreasing velocity with depth. Evaluation of the data indicates that the vertical distribution of the current velocity is generally distributed in accordance with the one-seventh-power law which gives the tidal current velocity at any depth (UTz) as:

$$UTz = UTz\ (z/d)^{**}(1/7)$$

where:

UTz = surface current
z = distance above the bottom measured positive upward
d = water depth



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Tidal Current Measurement Stations

FIGURE A.HCP.1.8

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Since one of the primary objectives of the study was an evaluation of the impacts of the tidal currents on sediment transport, the near bottom current velocity was calculated for each measurement at each of the 12 stations. This data is most useful in evaluating sediment transport potential. Representative current plots over a tide cycle for three stations is provided as Figure A.HCP.1.9.

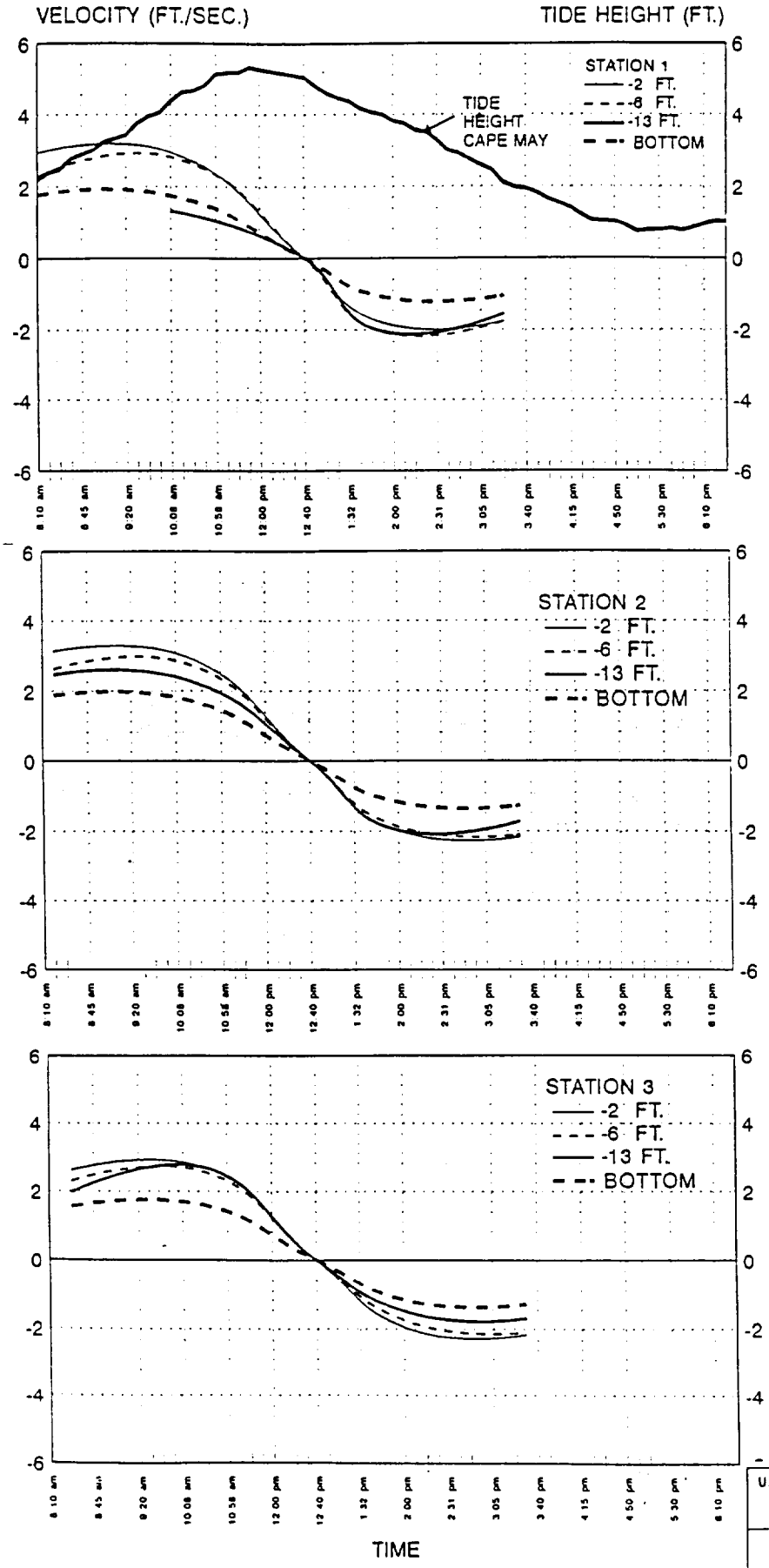
A summary of the calculated maximum bottom currents based on the surface currents measured on 27 and 28 July 1994 at the various locations is shown in Table A.HCP.1.8.

Table A.HCP.1.8
Maximum Calculated Bottom Current
Speed and Direction
(feet/sec)

	27 July 1994				28 July 1994			
	Flood		Ebb		Flood		Ebb	
Sta	Speed	Dir	Speed	Dir	Speed	Dir	Speed	Dir
1	1.86	126°	-1.14	280°	0.6*	100°	NA	NA
2	1.93	120°	-1.31	300°	1.61*	95^	NA	NA
3	1.67	98°	-1.33	280°	1.8*	100°	NA	NA
4	1.65	109°	-1.23	318°	1.53	110°	NA	NA
5	1.49	117°	-1.28	304°	1.50	125°	NA	NA
6	1.63*	120°	-1.09	295°	1.40	115°	NA	NA
7	2.74*	124°	-0.87	290°	2.38	126°	NA	NA
8	1.78*	123°	-1.87	303°	1.69	108°	-1.65*	316^
9	0.94*	125°	-1.89	302°	1.65	125°	-1.86*	305^
10	NA	NA	-2.82	355°	0.61	200°	-1.70*	10°
11	1.63*	165°	-2.26	10°	1.81	175°	-1.80*	10°
12	1.43*	163°	-2.26	355°	1.48	190°	3.06*	16

*Based on Maximum Current Measured (possibly not the maximum current during the ebb/flood cycle)

CAPE MAY, NEW JERSEY
TIDAL CURRENT MEASUREMENTS: 27 JULY 1994



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Typical Tidal Current Measurements

FIGURE A.HCP.1.9

The data in Table A.HCP.1.8 indicates that the maximum flood current velocities exceed the maximum ebb current velocities at Stations 1-7. Station 7 which is located just offshore of the second groin compartment at Cape May Point, showed a significant flood current dominance. A near shore tidal channel has been identified previously in this location. For Stations 8-12, the data indicates that in general the maximum ebb current velocities exceed the maximum flood current velocities.

Analysis of the data does not show a general trend in the horizontal distribution of current velocities at each of the profile locations. However, the data does indicate a significant increase in the flood current velocity from offshore to inshore between Stations 7-9 at Cape May Point and a decrease in ebb current velocities from offshore to inshore at the same stations.

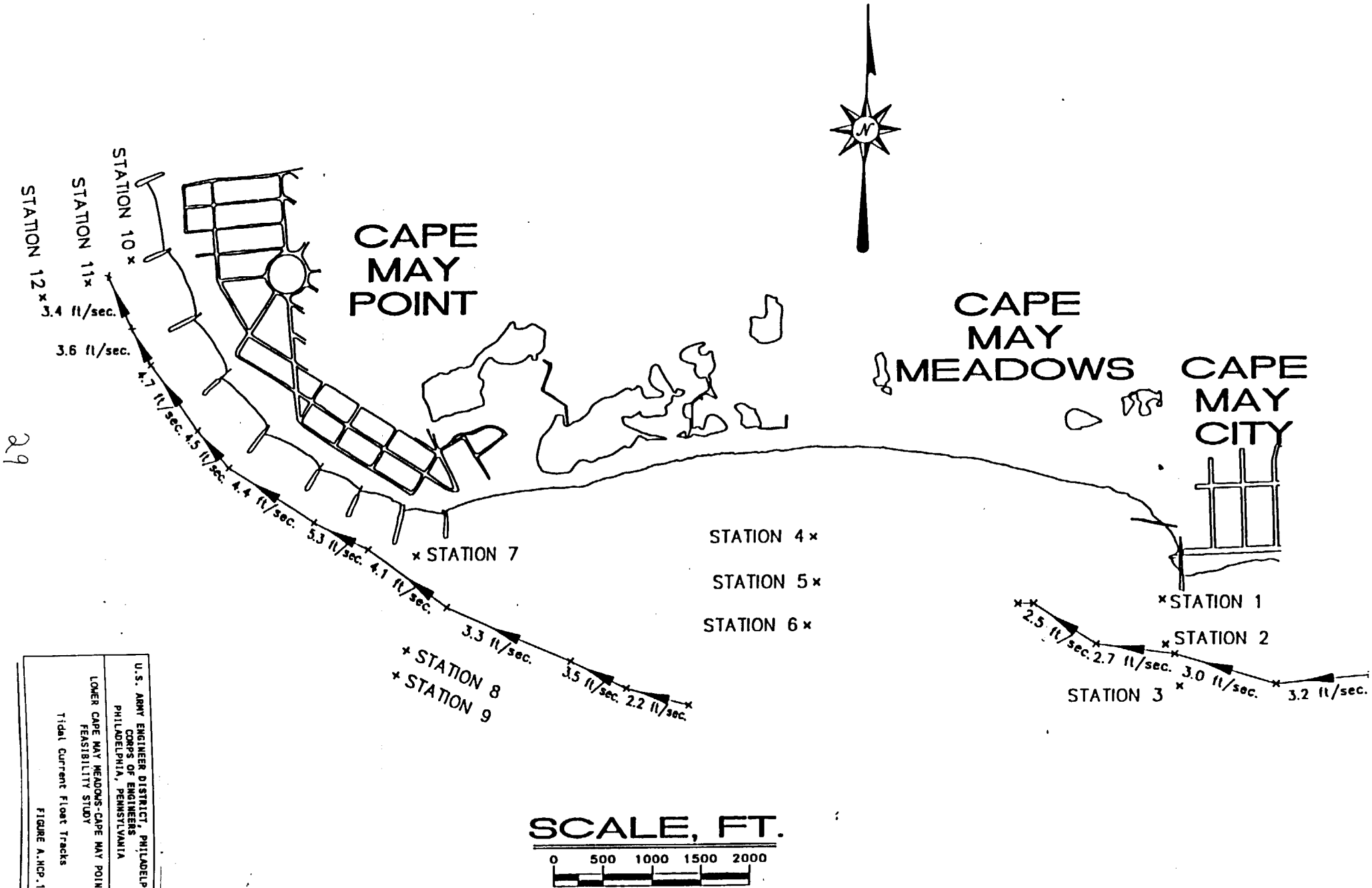
A.HCP.1.8.6 TIDAL CURRENT FLOAT DEPLOYMENT

In order to observe the pattern of the flow field, tidal current floats were deployed on 29 July 1994. The floats were of the drag type and consisted of 2x2' plywood sheets painted fluorescent red with a cable and umbrella suspended under the float for drag. This type of float is not subject to winds and generally provides a reasonable simulation of the current movement. Floats were deployed in the 3rd Avenue terminal groin and Cape May Point areas during flood tide. The results of the float tracking are presented in Figure A.HCP.1.10. In the 3rd Street area, the floats moved in a general shore parallel direction from east of the terminal groin to the terminal groin and then moved shoreward somewhat. The average velocity of the floats was about 3 feet per sec which is comparable to the surface current velocities measured at stations 1-3.

In the Cape May Point area, the floats moved in a shore ward direction from the release point at a velocity of about 3 feet per second and accelerated to over 4 feet per second when they were located just offshore of the first and second groin compartments. This accelerated velocity compares very closely to the surface current velocities measured at Station 7. From this point, the float velocity increased to an average of greater than 4.5 feet per second and the floats maintained a general shore parallel direction throughout the rest of the Cape May Point area. Offshore of the westernmost groin compartments, the float velocity decreased to about 3.5 feet per second. The results of the float tracking, like the tidal current measurements, indicate the presence of a flood current channel along the Cape May Point area.

A.HCP.1.8.7 PREVIOUS INVESTIGATIONS

Based on an analysis of shoreline change data between 1949-1978, the U.S. Army Coastal Engineering Research Center (CERC) concluded that all the beaches in the study area suffer from a lack of sand due to the Cape May Inlet jetties which act as a littoral barrier to sand moving down coast. This deficit of sand has resulted in significant erosion of up to 20 feet per year at the Coast Guard Training Center. Erosion of this beach has been a principal source of littoral drift for the Cape May City area between Windsor and Third



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FEASIBILITY STUDY

Tidal Current Float Tracks

FIGURE A.NCP.1.10

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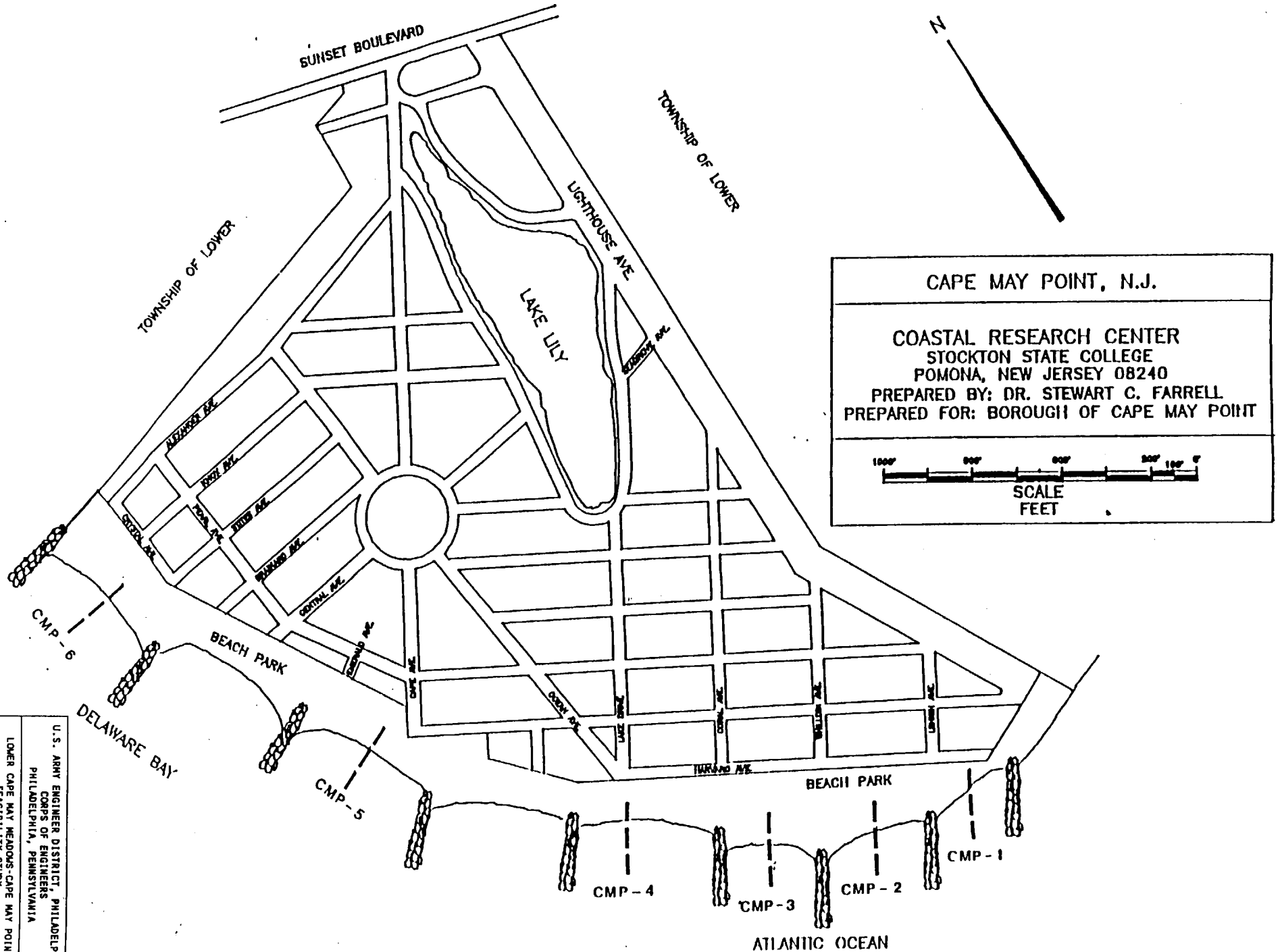
Avenues. Further west, the terminal groin at 3rd Avenue in Cape May City also acts as a littoral barrier to the shoreline to the west where shoreline erosion rates have averaged 20 to 30 feet per year. Previous analyses of profiles along the study area shoreline by the Corps of Engineers indicated a definite steepening of the profile slopes both above and below mean low water in the Cape May Point area. These steeper profiles were attributed to the erosive tide-induced currents in the deep channelized area offshore between Cape May Point and Prissy Wicks Shoal. It was concluded that the continuous effects of the tidal forces in producing these currents keep the beach and offshore slopes in this reach comparatively steep.

Previous investigations of tidal currents from Wildwood to Cape May Point were conducted by the Corps of Engineers using drift floats during the period of November 1947 to December 1948. These observations indicated a definite reversal of currents in the area of observation with the change of tide in Delaware Bay. Typical current velocities measured during this time period averaged on the order of 3 feet per second maximum for both flood and ebb currents. During the Delaware Bay and River's ebb tide, a pattern of currents was believed to be set up that opposes the wave direction. Since currents attain velocities of over 3 feet per second under normal tide conditions, it is possible that the net transport of sediment to the west is reduced as the incoming waves and ebb currents meet. However, during flood flows these same currents combine with the normal wave action to possibly increase the sediment transport to the west. No conclusions were reached based on this data regarding the significance of the tidal currents in the sediment transport process. At Cape May Point, Stockton College identified the location of a major tidal channel about 450 feet offshore of the instrument location at Profile CMP-1 located in the eastern most groin cell as shown in Figure A.HCP.1.11. This channel runs offshore through Profile CMP-4. Flood and ebb tidal currents were reported to move swiftly through this channel and acted to transport sand at its margin into shoals located east and west of Cape May Point in the mouth of Delaware Bay. Stockton College's monitoring efforts indicated that storm events produce intense wave turbulence along the shoreline of the groin compartment and this turbulence acts to move sand in suspension out of the groin cell. At Profile CMP-2, where the majority of a beach fill was placed between May-July, 1991, Stockton College reported that the October 1991 storm removed essentially all of the sand placed in the berm and dune. Little if any of the lost sand was observed to have accumulated in the shallow sub-tidal zone between the groins; the normal onshore migration of sand after the storm did not occur. The probable reason for this situation was identified to be near shore tidal currents which removed the sand from the system. Stockton College concluded that wave turbulence and tidal eddies carry larger quantities of sand away from the Borough than should leave by wave transport alone along the shoreline.



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LOWER CAPE MAY MEADOWS-CAPE MAY POINT
FEASIBILITY STUDY

Cape May Point Profile Locations

FIGURE A.HCP.1.11

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A.HCP.1.8.8 RELATIVE IMPORTANCE OF THE VARIOUS SEDIMENT TRANSPORT PROCESSES

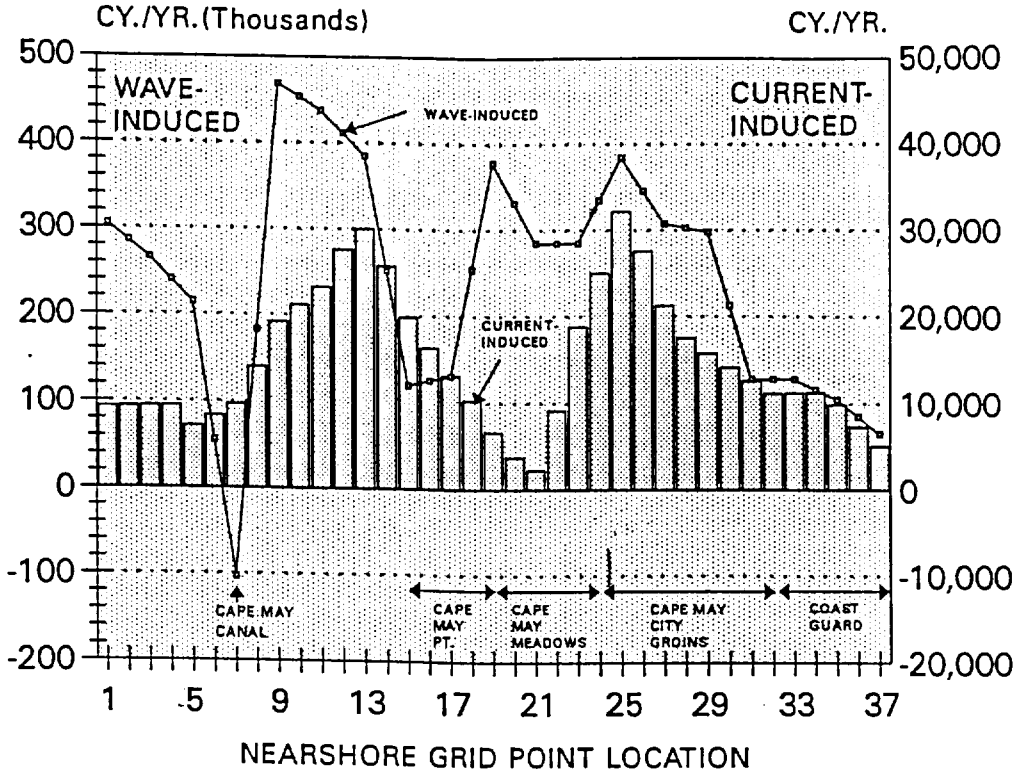
In order to gain insight into the relative importance of each of the potential sediment transport processes, the potential wave-induced and potential current-induced bed load net transport rates (averaged between 1987-1992) along the study area were plotted together in Figure A.HCP.1.12a and the available historical shoreline changes were plotted in Figure A.HCP.1.12b. Analysis of Figure A.HCP.1.12a indicates that the potential wave-induced long shore sediment transport exceeds the potential current-induced bed load sediment transport at the near shore grid points (0.25 nmi offshore and at 0.25 nmi along shore) throughout the study area by a factor of 10 to 20.

Considered independently, the data indicates that the potential wave-induced sediment transport is dominant throughout the study area since without wave-induced suspension of sediment, tidal currents would have to entrain sediment from the bottom and transport it as bed load. Under these circumstances, current-induced transport is clearly not dominant. However, in areas where long shore sediment transport is induced by wave breaking and turbulence in the vicinity of relatively strong tidal currents, the currents could augment the transport of this sediment out of the near shore littoral system and thus play a more significant role.

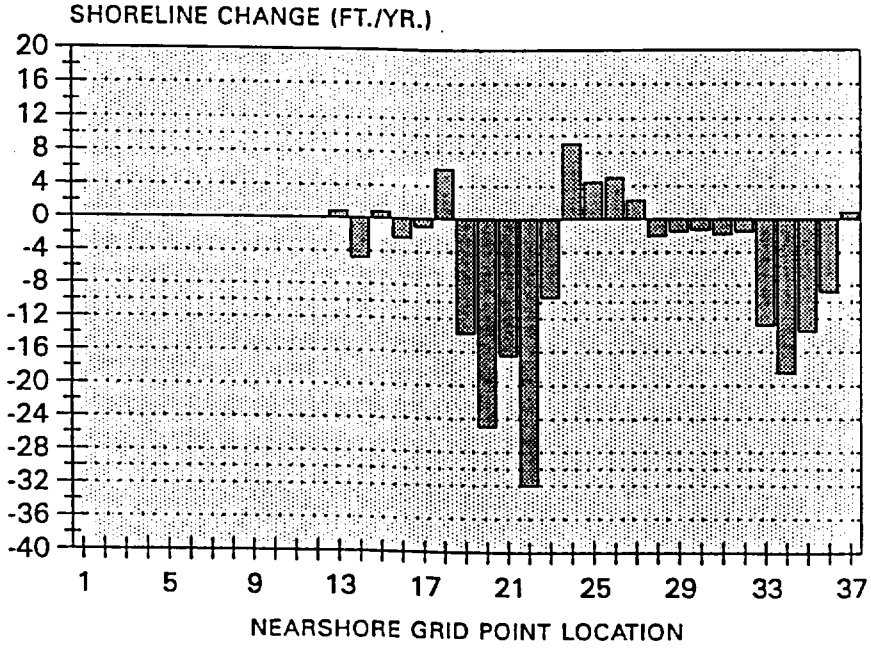
In the presence of net westerly wave-induced long shore sediment transport, the flood currents could potentially increase the overall long shore sediment transport to the west. Conversely, the ebb currents could possibly reduce the net westerly transport as the opposing tidal currents and waves meet.

The computed potential current-induced transport and previous investigations identified two potential areas where tidal currents may be more important. They are in the vicinity of the 3rd Avenue terminal groin in Cape May City and along the groin field at Cape May Point. Peaks in the potential current-induced sediment transport are generally located in both of these areas as shown in Figure A.HCP.1.12a. Tidal current measurements made on 27-28 July 1994 also showed peak flood current velocities at these general locations (Stations 1 and 7). In addition, results of the float tracking on 29 July 1994 indicated a relatively strong flood current offshore of the 3rd Avenue terminal groin and indicated a significant acceleration of flood current velocities in the vicinity of the Cape May Point groins. At the 3rd Avenue groin, net westerly moving long shore sediment transport that bypasses the groin could be subject to transportation by the tidal currents in that area. Flood currents would tend to transport this material either offshore or towards Cape May Point and essentially past the eroding Cape May Meadows shoreline which is located significantly land ward.

Along the shoreline at Cape May Point, primarily between the first two (2) groin compartments, Stockton College reported that a tidal channel offshore of this location is transporting sediment suspended by wave turbulence out of this area. Tidal current measurements at Station 7 on 28 July 1994 and the float tracking confirm the presence of



Potential Wave-Induced vs. Current-Induced Sediment Transport



Historical Shoreline Change Rates: 1949-1978

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LOWER CAPE MAY MEADOWS-CAPE MAY POINT
FEASIBILITY STUDY

Potential Wave vs Current Induced
Sediment Transport and Historic
Shoreline Change Rates: 1949-1978

FIGURES A.HCP.1.12a/b

a channel in this area.

As further analysis, the computed sediment transport rates are compared with the a flood historical changes along the study area shoreline for the period 1949-1978 shown in Figure A.HCP.1.12b. Although the potential long shore sediment transport rates shown in Figure A.HCP.1.12a are based on the 1987-1992 period, they should provide representative rates for qualitative comparison with the historical erosion rates. Comparison of Figure A.HCP.1.12a and A.HCP.1.12b indicates a reduced net wave-induced and current-induced long shore transport rate along the Coast Guard shoreline in an area that experienced high erosion rates between 1949-1978. The reduced wave-induced sediment transport in this area is probably due to the sheltering provided by the Cape May Inlet jetties and the shoreline orientation of this area as compared to the shoreline to the west. Although both the wave-induced and current-induced long shore transport rates are lower than the average in this reach, the total lack of sand supply from up drift resulted in the high erosion rates between 1949-1978.

From the east end to the west end of the Cape May City groin field the wave-induced and current- induced long shore transport rates increase to an average of about 289,000 cubic yards per year and 20,000 cubic yards per year, respectively. However, this area showed net accretion during the 1949-1978 period as shown in Figure A.HCP.1.12b. This accretion is attributed to the sand eroded from the Coast Guard shoreline and the eastern action of the Cape May groin field.

Along the Cape May Meadows shoreline, wave-induced transport rates remain high averaging about 313,000 cubic yards per year as compared to a decrease in the current-induced transport rate to about 5,000 cubic yards per year. The lack of sand supply due to the 3rd Avenue terminal groin combined with the high rate of potential wave-induced sediment transport are assumed responsible for the high erosion rates in this area during 1949-1978.

Along Cape May Point, the wave-induced long shore transport rates decrease to an average of about 158,000 cubic yards per year as compared to an increase in current-induced transport to an average of about 13,000 cubic yards per year. The wave-induced transport reduction is attributed to the shoreline orientation shift from East to West to Southeast to Northwest. However, the general stability of this reach between 1949-1978 is attributed to the groins along the point.

West of Cape May Point, both the wave-induced and current-induced transport rates increased to an average of about 370,000 cubic yards per year and 20,000 cubic yards per year, respectively. However, shoreline change data was not available for comparison.

A.HCP.1.8.9 CONCLUSIONS

Based on the computed potential transport rates and the preceding evaluations, it is concluded that wave-induced long shore sediment transport is generally dominant in the Cape May area with the net direction of transport from the east to the west at an average rate of about 245,000 cubic yards per year. This conclusion is based on the analysis of sediment transport by tidal currents as bed load transport. In this mode, the tidal currents would have to scour the near shore bottom and entrain and transport sediment. The analyses conducted during this study indicate that this mode of current-induced sediment transport is not significant. However, it is probable that tidal currents also play a role by transporting sediment set in suspension by wave breaking and turbulence. Increases in long shore sediment transport due to this process are probable in the area and are considered to be potentially more important in at least two locations: 1) offshore of the 3rd Avenue terminal groin and offshore of this groin field at Cape May Point.

A.HCP.2 HISTORIC SHORELINE CHANGE ANALYSIS

A.HCP.2.1 SUMMARY OF HISTORIC SHORELINE CONDITIONS

A historic shoreline analysis was conducted for the ocean shorelines of Lower Township Cape May (Meadows) and Cape May Point. This analysis documents past behavior and "background" conditions of the shoreline and determines long-term erosion rates where applicable in the study area.

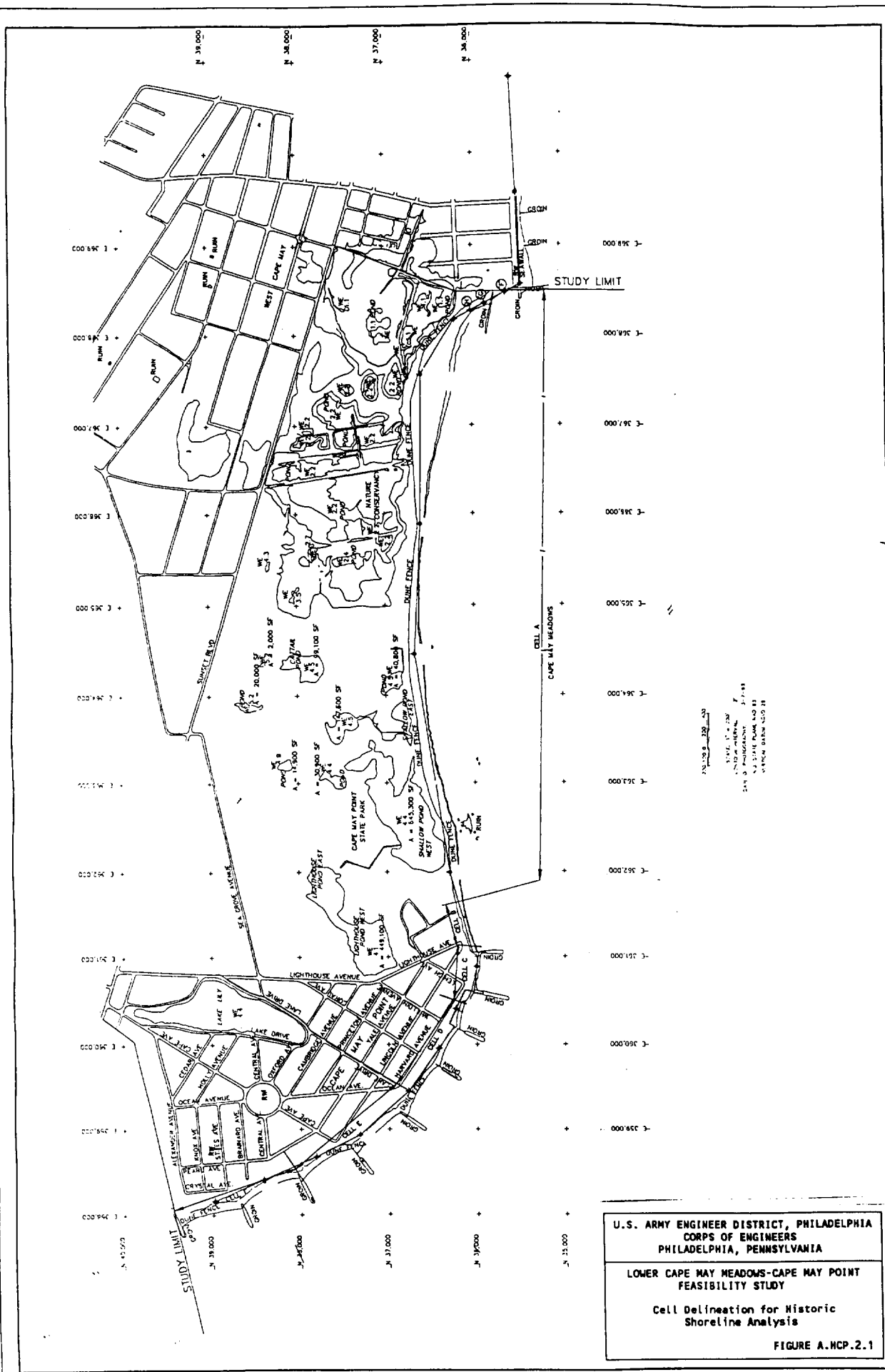
A.HCP.2.2 CELL DELINEATIONS.

In order to adequately quantify and analyze the erosion potential for the study area, the spatial variability along the ocean shoreline must be considered. Consequently, the ocean shoreline of the study area was subdivided into a number of "cells" based on general similarity of shoreline alignment, beach width, historic shoreline behavior, location of significant shoreline structures (revetments, groins, bulkheads, etc.), and development category of land and structures landward of the shoreline. The ocean shoreline cells and their respective limits are presented in Table A.HCP.2.1 and Figure A.HCP.2.1.

Table A.HCP.2.1
Cell Delineation for
Long Term Erosion

Cell ID	Length (Ft)	Limits
A*	7450	Third Avenue groin in Cape May City to Lighthouse Avenue groin in Cape May Point
C	470	First Groin Cell in Cape May Point i.e. Lighthouse Avenue groin to Lehigh Avenue groin
D	1660	Lehigh Avenue groin to Lake Drive
E	1420	Lake Drive to Central Avenue
F	1490	Central Avenue to Alexander Avenue

*Determination of inundation profiles required cell A be subdivided into cell A and cell B.



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FEASIBILITY STUDY

Cell Delineation for Historic
Shoreline Analysis

FIGURE A.MCP.2.1

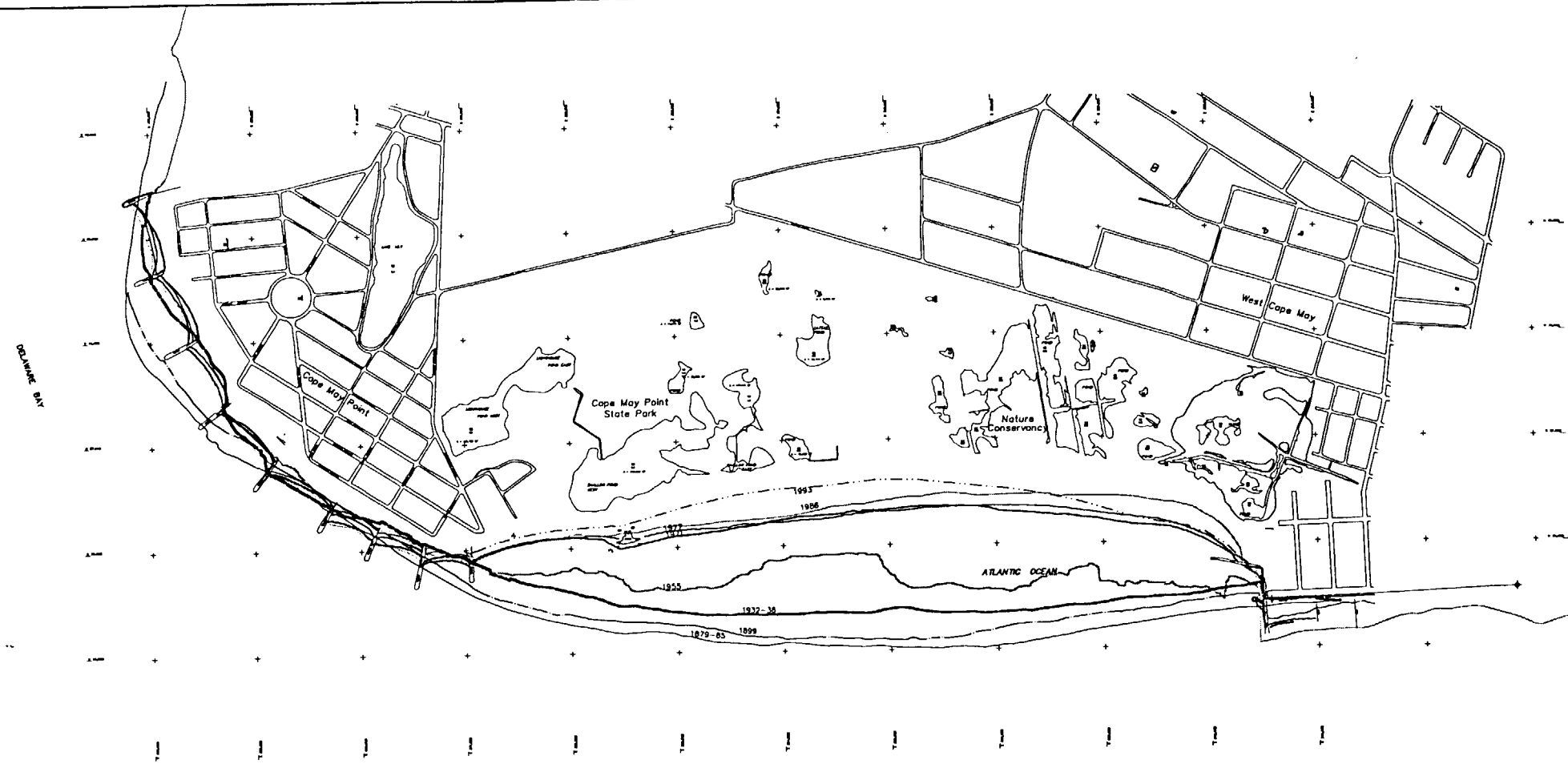
A.HCP.2.3 DATA SOURCES.

The historic shoreline analysis relied on four principal types of information: aerial photography, onshore/offshore beach profiles, digital shoreline change maps, and previous reports. In the period of 1953 through 1955 a groin was constructed at Third Avenue, the boundary between Cape May City and Lower Township. This groin significantly affected the behavior of the shoreline in the study area. This groin accelerated in time but not in magnitude the erosion ultimately caused by the Cold Spring Inlet jetties acting as a complete littoral barrier. For the purposes of this analysis only the information for the period after 1955 was considered because it incorporates into the erosion assessment the combined effects of wave climate and the inevitable deficit of sand attributable to the jetties.

The aerial photography used for the study area was from two periods, 1949-1978 and 1953-1993. The period of 1949-1978 was compiled by the Coastal Engineering Research Center (CERC) in 1980. The period of 1953-1993 was compiled specifically for this study. Most of the aerial photography is vertical black-and-white at a contact scale of 1 inch equals 400 feet.

A total of six beach profile lines in Lower Township Cape May and Cape May Point have been monitored by the Corps of Engineers periodically since 1965. Because the lines established in 1965 could not be recovered new lines were set to better document existing conditions. In 1993 five (5) new monitoring lines where added to Cell A. The new lines were in close proximity to the 1965 lines and they gave a better indication of current conditions. In Cells C through F the beach profile lines used for the analysis were those established by the Coastal Research Center of Stockton State College. The profile lines typically extend from the landward side of the existing dune or revetment seaward out to a depth of 30 feet below mean low water.

Historic shorelines of the study area were digitally mapped as part of the New Jersey Historical Shoreline Map Series (Farrell and Leatherman, 1989). These maps include shorelines from 1879-85, 1899, 1932-36, 1955, 1971, 1977, and 1986. A digital shoreline from 1993 was subsequently added. These eight shorelines are plotted together on Figure A.HCP.2.2. The shoreline maps provide a beneficial overview of shoreline conditions through time. However, it can be difficult to evaluate and differentiate natural shoreline evolution from the effects of development and coastal protection projects (such as beach fills and coastal structures). A list of known beach fill nourishment projects for the years 1940 to 1993 is provided in Table A.HCP.2.2.



1879-1885
1899
1932-1938
1955
1971
1977
1986
1993

200 100 0 200 400

SCALE: 1" = 200'
CONTOUR INTERVAL: 5'
DATE OF PHOTOGRAPHY: 3-7-83
N.J. STATE PLANE NAD 83
VERTICAL DATUM NGVD 29

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Historic Shorelines

FIGURES A.NCP.2.2

Table A.HCP.2.2
History of Beachfills

Location	Volume Placed (CuYd)	Date Completed	Responsible Agency
Cape May Point	156,700	1962	ACOE
Cape May Park to Lighthouse Ave	15,000	9 Mar 1967	NJDEP
Cape May Point	2,500	1967	ACOE
Lighthouse Ave to Alexander Ave	253,900	12 May 1969	NJDEP
Cape May State Park	87,000	1986	NJDEP
Cape May Point	50,000	1991	NJDEP
Cape May State Park and Cape May Point	98,000	1992-93	NJDEP
Cape May Point (Lehigh Ave groin)	22,000	1993	NJDEP

The reports and documents pertinent to the study area shoreline, which were reviewed for this analysis, included the following:

-- Historical Shorelines of New Jersey, 1835-1986, NJDEP-Division of Coastal Resources.

-- Cape May Inlet to Lower Township, Phase I - General Design Memorandum.

-- Cape May Inlet to Lower Township, New Jersey, Shoreline Changes Drawing, Dated June 1972.

All of the above listed sources of information pertinent to the study area were compiled and reviewed in order to develop a qualitative, and where possible, a quantitative understanding of historic behavior of the ocean shoreline. In order to adequately quantify and analyze the erosion hazard for the study area, the spatial variability along the ocean shoreline must be considered. Since the shoreline of Cape May Meadows is fairly short and the various methods of analysis did not show any one area being significantly different from the others, a single erosion rate was chosen to represent the behavior of the shoreline.

After reviewing all the information available for the study area the data selected for further analysis were the aerial photography from 1953-1993. This was chosen because the period coincides with the post-construction period of the Third Avenue groin. This best represents the current and likely future conditions of the shoreline in the study area. The Third Avenue groin was constructed in response to the accelerated erosion caused by the Cold Spring Inlet jetties. This groin advanced in time, but not in magnitude the inevitable erosion resulting from the jetties acting as a complete littoral barrier.

The long-term erosion rate for Cell A is approximately 15 feet per year. Cells C through F consist of a series of 8 groin compartments. Because of these groins, the shorelines in Cells C through F have shown variability over the last 40 years that range from 3 feet of erosion per year to 3 feet of accretion per year. Therefore it was concluded that Cells C through F do not have any significant long-term erosion.

A.HCP.3 HISTORICAL BATHYMETRY ANALYSIS

An analysis of historic offshore bathymetric data was conducted in addition to the analysis of shoreline change described in Section A.HCP.2. The bathymetry analysis was considered necessary in view of the large recession which has occurred along The Meadows shoreline. This recession has created a situation in which the formerly low-elevation upland of Cape May Meadows has been progressively converted into nearshore open-ocean bottom as the shoreline retreated. Additionally, hydrographic surveys obtained by the Philadelphia District since 1993 in the vicinity of The Meadows and Point have revealed significant scour "holes" adjacent to the easternmost groins at Cape May Point.

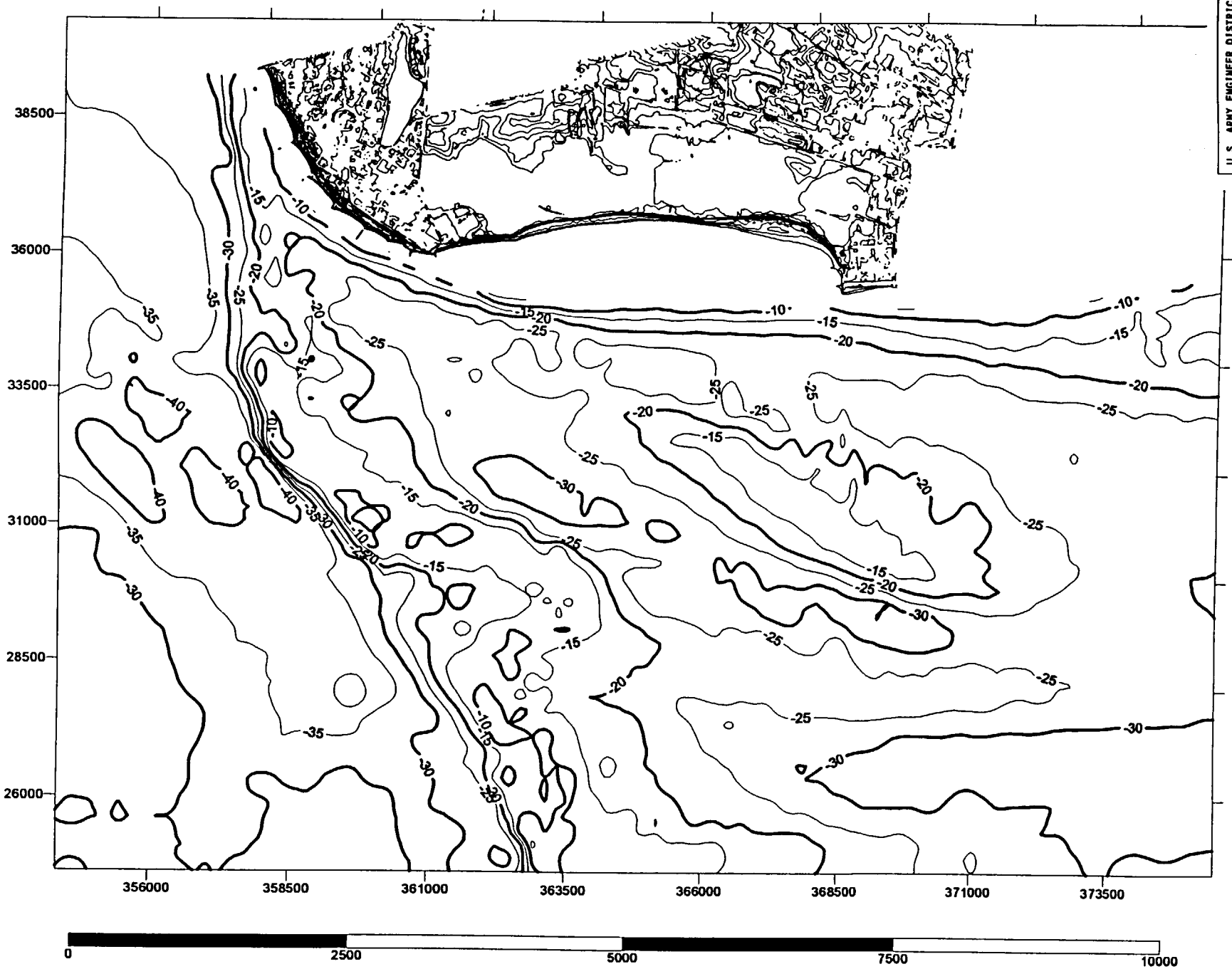
The principal sources of data for this analysis consist of hydrographic surveys obtained by the National Ocean Service, and its predecessor, the US Coast and Geodetic Survey, in 1937 and 1972. The bathymetric data were available as digital files of soundings (depth below MLW) at specific points (latitude, longitude pairs) in the Atlantic Ocean and Delaware Bay offshore of the Cape May Meadows/Point study area. The data from each survey date were manipulated within AutoCAD to create a "tin" (triangulated irregular network), which is an imaginary surface mathematically fitted to the irregularly spaced

points in each survey data file. Contour plots of depth for the 1937 and 1972 surveys are shown on Figures A.HCP.3.1. and A.HCP.3.2, respectively.

To evaluate the depth changes between the two survey dates, the 1937 and 1972 "tins" were superimposed within AutoCAD, and the difference in depth between the tins was calculated. The result of this comparison is a plot which displays areas of "cut" (equivalent to "scour") and "fill" (equivalent to "shoaling"). A plot of the 1937 to 1972 depth changes offshore of the study area is shown in Figure A.HCP.3.3, with a 5-foot contour interval. The most significant feature revealed by the depth change plot is the shoaling which has occurred at location "A". This location corresponds to the bottom feature historically known as "Eph Shoal" which has migrated northwestward approximately 3,000 feet in the 35 year interval between the two surveys. In addition to this specific location, the figure also displays the spatial extent of "scour and shoal" changes in the zone which extends approximately 2 miles in the offshore direction along approximately 4 miles of shoreline.

Section A.HCP.1 of this report previously documented the modeled and observed tidal current regime in the nearshore zone immediately offshore of the Cape May Meadows and Point study area. Both efforts clearly demonstrate that normal and storm condition "tidal" currents regularly exceed 1 meter per second, and that the predominant direction of sediment transport driven by these currents is westward, toward the entrance of Delaware Bay. These findings are entirely consistent with the historic bathymetric changes revealed by the comparison of the 1937 and 1972 NOS surveys. It is inferred that the "scour and shoaling" changes in the area offshore of Cape May Meadows and Point are largely, if not entirely, the product of the tidal circulation between

Cape May Meadows and Point
Contour Map of 1937 Bathymetric Data



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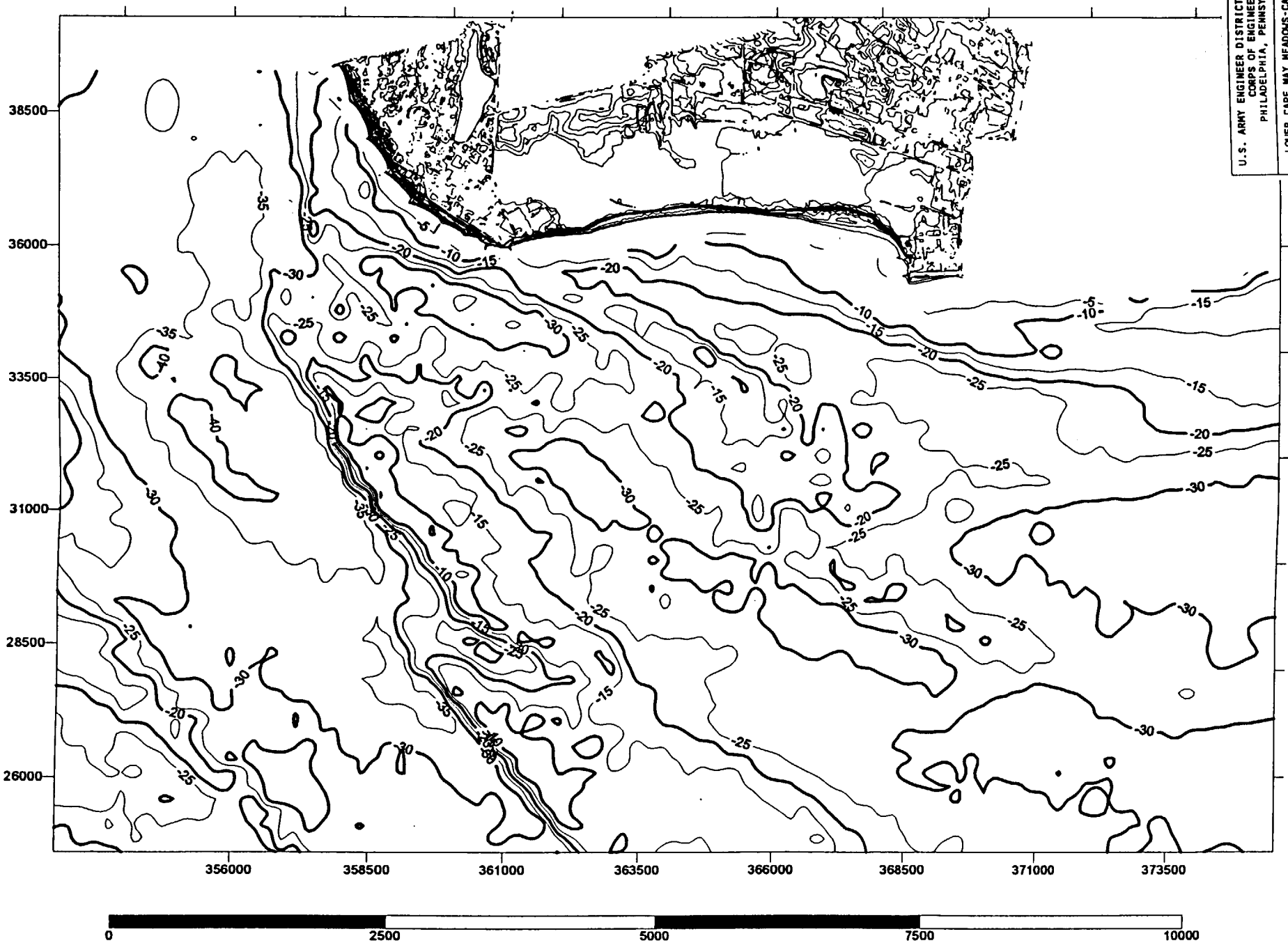
1937 Bathymetric Contours

FIGURE A.HCP.3.1

43

Cape May Meadows and Point
Contour Map of 1972 Bathymetric Data



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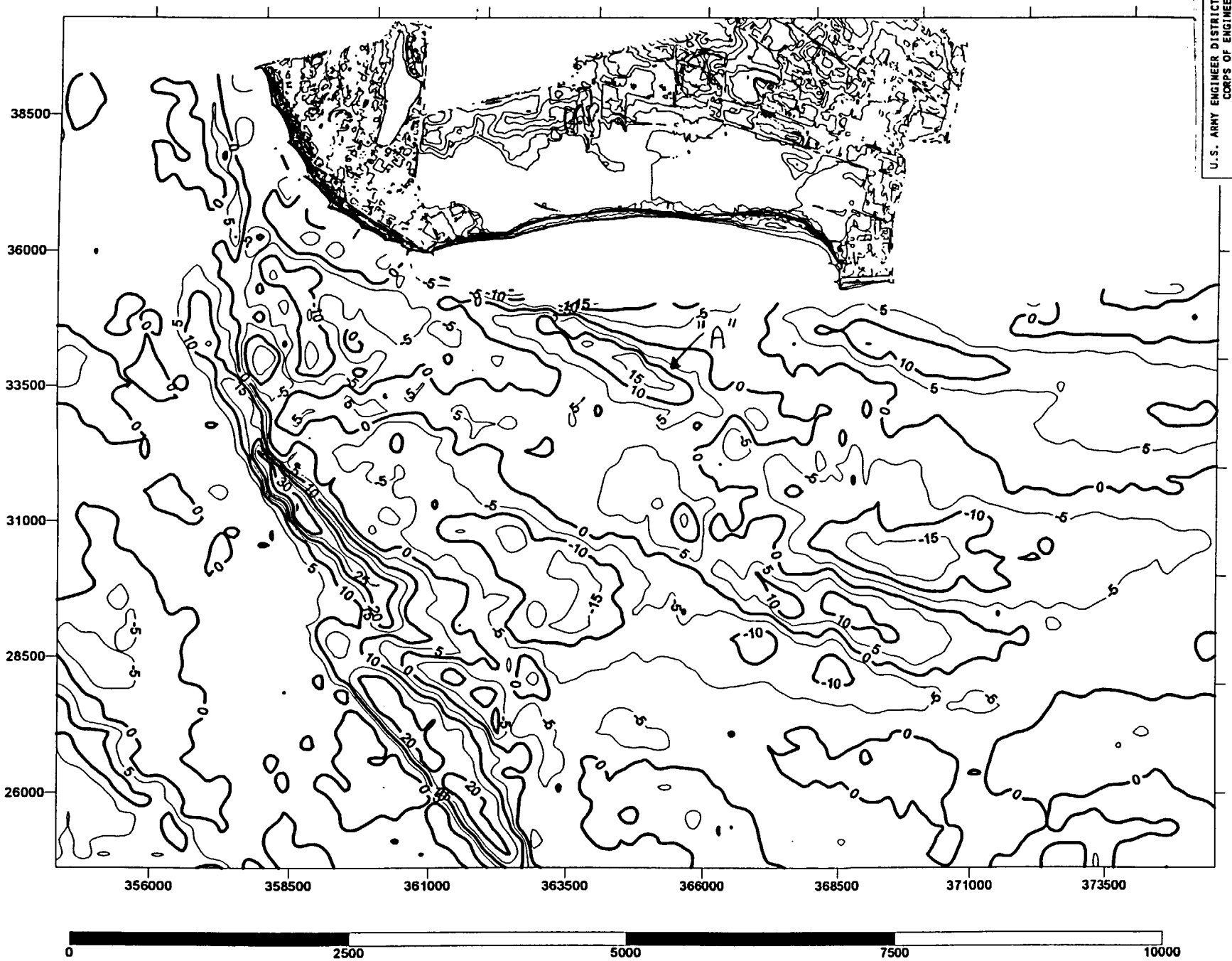
1972 Bathymetric Contours

FIGURE A.HCP.3.2

Cape May Meadows and Point
Contour Map of Depth Changes Between 1937 and 1972



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1937 to 1972 Depth Changes

FIGURE A.HCP.3.3

the Atlantic Ocean and Delaware Bay, and not related to man-made changes at the shoreline of the study area.

As a result of the initial findings from the comparison of 1937 and 1972 surveys, a more detailed set of hydrographic surveys was obtained on several dates in 1995 and 1996 in the zone extending approximately one-half mile from the study area shoreline. These surveys revealed that localized scour at the eastern end of the Cape May Point groin field has attained depths in excess of 60 feet at the easternmost groin (groin # 1), and approaching 50 feet at the adjacent groin # 2. The depth of scour at these locations, coupled with the hindcast and observed current velocities documented in the sediment transport analysis, suggests that at least the eastern end of the Cape May Point groin field is at risk in terms of structural integrity and ability to maintain the Cape May Point shoreline.

A.HWO WITHOUT PROJECT HYDRAULIC ANALYSIS

A.HWO.1 STORM-INDUCED INUNDATION AND EROSION ANALYSES

Storm inundation and erosion analyses were conducted for the study area shorelines to determine the potential for damage caused by the waves and elevated water levels which accompany storms. Storm-induced erosion and coastal flooding are first evaluated for the without project condition, which is a projection of conditions existing in the base year of 2000. Similar analyses will then be conducted for the with project conditions.

A.HWO.2 FACTORS INFLUENCING STORM EFFECTS

A brief summary of the mechanisms which result in erosion and inundation from coastal storms is provided in this section. The major causes of damage and loss of life are storm surge, storm duration, and wave action.

Under storm conditions, there is typically a net increase in the ocean water level which is superimposed on the normal astronomic tide height fluctuations. The increase in water level caused by the storm is referred to as "storm surge." The effect of storm surge on the coast depends on the interaction between the normal astronomic tide and storm-produced water level rise. For example, if the time of normal high tide coincides with the maximum surge, the overall effect will be greater. If the surge occurs at low or falling tide, the impact will likely be lessened. The term "stage" as applied in this analysis pertains to the total water elevation, including both tide and storm surge components, relative to a reference datum, NGVD used herein. (Elevations referenced to the NAVD88 datum are obtained by subtracting 1.27 feet from the NGVD29 elevations.) The term "surge" is defined as the difference between the observed stage and the stage that is predicted to occur due to normal tidal forces, and is thus a good indicator of the magnitude of storm intensity. Slowly moving "northeasters" may continue to build a surge that lasts through several high tides. Such a condition occurred during the devastating March 1962 storm which lasted for five high tides.

In addition to storm surge, a rise in water level in the near shore can occur due to wave setup. Although short period surface waves are responsible for minimal transport in the direction of wave propagation in open water, they may cause significant transport near shore upon breaking. Water is propelled landward due to breaking waves rather rapidly, but water returned seaward under the influence of gravity is slower. This difference in transport rates in the onshore/offshore direction results in a pileup of water near shore referred to as wave setup. Wave setup was computed and included in this storm analysis.

There is typically also an increase in absolute wave height and wave steepness (the ratio of wave height to wave length). When these factors combine under storm conditions, the higher, steeper waves and elevated ocean stage cause a seaward transport of material from the beach profile. The net movement of material is from the foreshore seaward toward the surf zone. This offshore transport creates a wider, flatter nearshore zone over which the

incident waves break and dissipate energy. The beach profile evolves in this manner toward an equilibrium configuration with the storm conditions.

A.HWO.3 MODELING STORM-INDUCED EROSION

Analyses of storm-related erosion for coastal sites require either a long period of record over which the important storm parameters as well as the resultant storm erosion are quantified, or a model which is capable of realistically simulating erosion effects of a particular set of storm parameters acting on a given beach configuration. There are very few locations for which the necessary period of prototype information is available to perform an empirical analysis of storm-induced erosion. This is primarily due to the difficulty of directly measuring many important beach geometry and storm parameters before, during, and immediately after a storm. Thus, a systematic evaluation of erosion under a range of possible starting conditions requires that a numerical model approach be adopted for the study area.

The USACE has developed, adopted, and released the numerical storm-erosion model SBEACH (Storm Induced BEAch CHange) for use in field offices (Rosati, et al., 1993). SBEACH is available via a user interface available for the personal computer, or through the Coastal Modeling System (CMS) (Cialone et al., 1992). Comprehensive descriptions of development, testing, and application of the model are contained in Reports 1 and 2 of the SBEACH series (Larson and Kraus 1989; Larson, Kraus, and Byrnes 1990)

A.HWO.4 SBEACH METHODOLOGY

SBEACH is a geomorphic-based two-dimensional model which simulates beach profile change, including the formation and movement of major morphologic features such as longshore bars, troughs, and berms, under varying storm waves and water levels (Rosati, et al. 1993). SBEACH has significant capabilities that make it useful for quantitative and qualitative investigation of short-term beach profile response to storms. Since SBEACH is based on cross-shore processes, caution should be used when using the model in the vicinity of inlets, structures, and areas with strong longshore gradient in transport processes.

Input parameters include varying water levels as produced by storm surge and tide, varying wave heights and periods, and median grain size in the fine-to-medium sand range. The initial beach profile can be input as either an idealized dune and berm configuration or surveyed total profile configuration. SBEACH Version 3.0 allows for variable cross-shore grid spacing, simulates water-level setup due to wind, provides an estimate of dune overwash and includes advanced procedures for calculating the wave breaking index and breaker decay. Also the wave model has been upgraded to provide a more realistic simulation of beach change under random waves.

Shoreward boundary conditions that may be specified include a vertical structure (that can fail due to either excessive scour or instability caused by wave action/water elevation) or a

beach with a dune of arbitrary configuration. Output results from SBEACH include calculated profiles, cross-shore parameters, a log for each SBEACH run, and a report file.

A.HWO.4.1 MODEL PARAMETERS

Various model parameters required to run SBEACH are included in the input configuration file. The configuration file is separated into five sections: A - Model Setup; B - Waves/Water Elevation/Wind; C - Beach; D - Beachfill; and E - Seawall/Revetment. Section A (Model Setup) deals with the initial and measured profiles, grid arrangement, output parameters, and calibration parameters. Section B facilitates entry of information about waves, water elevations, and winds. Section C allows entry of basic information related to beach profile data, and Section D allows for definition of a beachfill placed on the initial profile. An example configuration file for typical dune cell D is provided as Table A.HWO.4.1.

In Section E, the location and failure criteria for a seawall or revetment can be entered. Unlike other storm erosion models, SBEACH can account for the presence of a vertical structure such as a seawall or bulkhead. A stone revetment, approximately 650 linear feet, is located in Cell C. The revetment extends from the first groin in Cape May Point to approximately one third the way between the second and third groins. A gabion mattress revetment in Cell B was completed in the Spring of 1996 by the State of New Jersey. It has a length of 450 feet fronting the State Park buildings. The remaining cells in the study area are fronted with dunes.

A.HWO.4.2 WATER ELEVATION

The water level is the most important or first-order forcing parameter controlling storm-induced beach profile change, normally exerting greater control over profile change during storms than either waves or wind. Water level consists of contributions from the tide, storm surge, wave- and wind-induced setup, and wave runup; the latter three are computed within SBEACH. Input data in this case is tide and storm surge data. The combined time series of tide and surge is referred to as the "hydrograph of total water level." The shape of the hydrograph is characterized by its duration (time when erosive wave conditions and higher than normal water elevation occur) and by its peak elevation.

A.HWO.4.3 WAVE HEIGHT, PERIOD, AND ANGLE

Elevated water level accompanying storms allows waves to attack portions of the profile that are out of equilibrium with wave action because the area of the beach is not normally inundated. Significant wave height and peak period are combined in an empirical equation within SBEACH to determine if the beach will erode or accrete for a time step. In beach erosion modeling, a storm is defined by the combination of these parameters (water level and waves) that produce offshore transport.

Table A.HWO.4.1
Example Configuration File

```
A.1  RUN TITLE: TITLE
     Cape May Meadows / Point   Cell D   Line "CMP 2"
A.2  INPUT UNITS (SI=1, AMERICAN CUST.=2): UNITS
     2
A.3  TOTAL NUMBER OF CALCULATION CELLS AND POSITION OF LANDWARD BOUNDARY
     RELATIVE TO INITIAL PROFILE: NDX, XSTART
     639     -2470.00
A.4  GRID TYPE (CONSTANT=0, VARIABLE=1): IDX
     1
A.5  COMMENT: IF GRID TYPE IS VARIABLE, CONTINUE TO A.8
A.6  CONSTANT GRID CELL WIDTH: DXC

A.7  COMMENT: IF GRID TYPE IS CONSTANT CONTINUE TO A.10
A.8  NUMBER OF DIFFERENT GRID CELL REGIONS: NGRID
     3
A.9  GRID CELL WIDTHS AND NUMBER OF CELLS IN EACH REGION FROM LANDWARD
     TO SEAWARD BOUNDARY: (DXV(I), NDXV(I), I=1,NGRID)
     10, 200, 5, 404, 50, 35
A.10 NUMBER OF TIME STEPS AND VALUE OF TIME STEP IN MINUTES: NDT,DT
     960         2.00
A.11 NUMBER OF TIME STEP(S) INTERMEDIATE OUTPUT IS WANTED: NWR
     -1
A.12 TIME STEPS OF INTERMEDIATE OUTPUT: (WRI(I), I=1,NWR)
     5
A.13 IS A MEASURED PROFILE AVAILABLE FOR COMPARISON? (NO=0, YES=1): ICOMP
     0
A.14 THREE PROFILE ELEVATION CONTOURS (MAXIMUM HORIZONTAL RECESSION OF EACH
     WILL BE DETERMINED): ELV1, ELV2, ELV3
        5.00      0.00     -5.00
A.15 THREE PROFILE EROSION DEPTHS AND REFERENCE ELEVATION (DISTANCE FROM
     POSITION OF REFERENCE ELEVATION ON INITIAL PROFILE TO POSITION OF
     LANDWARD MOST OCCURRENCE OF EACH EROSION DEPTH WILL BE DETERMINED
      EDP1, EDP2, EDP3, REFELV
        0.10      0.50      1.50     0.00
A.16 TRANSPORT RATE COEFFICIENT (m^4/N): K
     1.2e-6
A.17 COEFFICIENT FOR SLOPE-DEPENDENT TERM (m^2/s): EPS
     0.003000
A.18 TRANSPORT RATE DECAY COEFFICIENT MULTIPLIER: LAMM
     0.500000
A.19 WATER TEMPERATURE IN DEGREES C: TEMPC
       10.00

                        WAVES/WATER ELEVATION/WIND
B.1  WAVE TYPE (MONOCHROMATIC=1, IRREGULAR=2): WVTYPE
     2
B.2  WAVE HEIGHT AND PERIOD INPUT (CONSTANT=0, VARIABLE=1): IWAVE
     1
B.3  COMMENT: IF WAVE HEIGHT AND PERIOD ARE VARIABLE, CONTINUE TO B.6

B.4  CONSTANT WAVE HEIGHT AND PERIOD: HIN, T
B.5  COMMENT: IF WAVE HEIGHT AND PERIOD ARE CONSTANT, CONTINUE TO B.7
B.6  TIME STEP OF VARIABLE WAVE HEIGHT AND PERIOD INPUT IN MINUTES: DTWAV
       60.00
B.7  WAVE ANGLE INPUT (CONSTANT=0, VARIABLE=1): IANG
     0
B.8  COMMENT: IF WAVE ANGLE IS VARIABLE, CONTINUE TO B.11
B.9  CONSTANT WAVE ANGLE: ZIN
        0.00
B.10 COMMENT: IF WAVE ANGLE IS CONSTANT, CONTINUE TO B.12

B.11 TIME STEP OF VARIABLE WAVE ANGLE INPUT IN MINUTES: DTAN G
B.12 WATER DEPTH OF INPUT WAVES (DEEPWATER=0): DMEAS
       24.00
B.13 IS RANDOMIZATION OF WAVE HEIGHT DESIRED? (NO=0, YES=1): IRAND
     0
B.14 COMMENT: IF RANDOMIZATION OF WAVE HEIGHT IS NOT DESIRED, CONTINUE TO B.16

B.15 SEED VALUE FOR RANDOMIZER AND PERCENT OF VARIABILITY: ISEED, RPERC
B.16 TOTAL WATER ELEVATION INPUT (CONSTANT=0, VARIABLE=1): IELEV
     1
```

Table A.HWO.4.1
(continued)

```
B.17 COMMENT: IF WATER ELEVATION IS VARIABLE CONTINUE TO B.20

B.18 CONSTANT TOTAL WATER ELEVATION: TELEV
B.19 COMMENT: IF WATER ELEVATION IS CONSTANT, CONTINUE TO B.21
B.20 TIME STEP OF VARIABLE TOTAL WATER ELEVATION INPUT IN MINUTES: DTELV
        60.00
B.21 WIND SPEED AND ANGLE INPUT (CONSTANT=0, VARIABLE=1): IWIND
     0
B.22 COMMENT: IF WIND SPEED AND ANGLE ARE VARIABLE, CONTINUE TO B.25
B.23 CONSTANT WIND SPEED AND ANGLE: W,ZWIND
        0.00      0.00
B.24 COMMENT: IF WIND SPEED AND ANGLE ARE CONSTANT, CONTINUE TO C.
B.25 TIME STEP OF VARIABLE WIND SPEED AND ANGLE INPUT IN MINUTES: DTWND

                              BEACH
C.1  TYPE OF INPUT PROFILE (ARBITRARY=1, SCHEMATIZED=2): TPIN
     1
C.2  COMMENT: IF PROFILE TYPE IS ARBITRARY CONTINUE TO C.4
C.3  LOCATION AND ELEVATION OF LANDWARD BOUNDARY, LANDWARD BASE OF DUNE,
     LANDWARD CREST OF DUNE, SEAWARD CREST OF DUNE, START OF BERM,
     END OF BERM, AND FORESHORE: XLAND,DLAND,XLBDUNE,DLBDUNE,XLCDUNE,DLCDUNE,
     XSCDUNE,DSCDUNE,XBERMS,DBERMS,XBERME,DBERME,XFORS,DFORS

C.4  DEPTH CORRESPONDING TO LANDWARD END OF SURF ZONE: DFS
        1.00
C.5  EFFECTIVE GRAIN SIZE DIAMETER IN MILLIMETERS: D50
        0.42
C.6  MAXIMUM PROFILE SLOPE PRIOR TO AVALANCHING IN DEGREES: BMAX
       40.00

                             BEACH FILL
D.1  IS A BEACH FILL PRESENT? (NO=0, YES=1): IBCHFILL
     0
D.2  COMMENT: IF NO BEACH FILL, CONTINUE TO E.
D.3  POSITION OF START AND END OF BEACH FILL RELATIVE
     TO INITIAL PROFILE: XBFS, XBFE

D.4  NUMBER OF REPRESENTATIVE POINTS BETWEEN START
     AND END OF BEACH FILL: NFILL

D.5  LOCATION AND ELEVATION OF REPRESENTATIVE POINTS RELATIVE TO THE
     INITIAL PROFILE: (XF(I), EFILL(I), I=1,NFILL)

                           SEAWALL/REVETMENT
E.1  IS A SEAWALL PRESENT? (NO=0, YES=1): ISWALL
     0
E.2  COMMENT: IF NO SEAWALL, CONTINUE TO F.
E.3  LOCATION OF SEAWALL RELATIVE TO INITIAL PROFILE: XSWALL

E.4  IS SEAWALL ALLOWED TO FAIL? (NO=0, YES =1): ISWFAIL

E.5  COMMENT: IF NO SEAWALL FAILURE, CONTINUE TO F.
E.6  PROFILE ELEVATION AT SEAWALL WHICH CAUSES FAILURE, TOTAL WATER ELEVATION
     AT SEAWALL WHICH CAUSES FAILURE, AND WAVE HEIGHT AT SEAWALL WHICH CAUSES
     FAILURE: PEFAIL, WEFAIL,HFAIL

                              COMMENTS
                                END
```

The modified version of SBEACH used in this analysis allows for the input of random wave data, that is, waves with variable height, period, and direction or angle.

A.HWO.4.4 FREQUENCY STORM HYDROGRAPHS

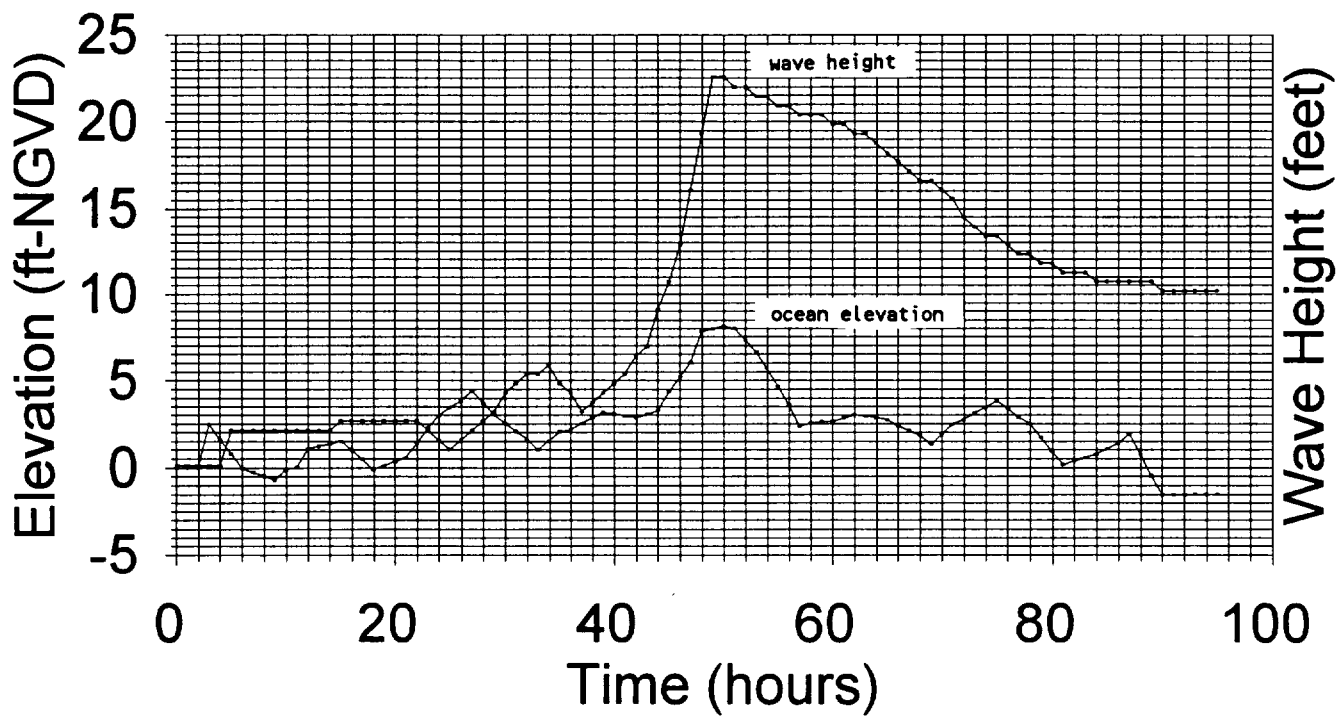
The OCTI hindcast and statistical analysis described in section A.HCP.1 provided the frequency peak values of wave height and water level elevation. However, SBEACH requires a storm hydrograph of wave and water level. These hydrographs, (at a 1 hour time interval) were developed by adopting the November 1950 northeaster as a template and scaling the waves and elevations of that historic storm to match the water levels and significant wave heights of the 2, 5, 10, 20, 50, 100, 200 and 500 year values. For all events the wave hydrograph was shifted in time such that the peak significant wave height occurred at the same time as the peak water level. The frequency storms hydrographs are applicable to all cells. The 50 year wave and water level hydrographs are provided as Figure A.HWO.4.1 as a representative example.

A.HWO.4.5 PROFILE DATA

The study area was separated into 6 cells reflecting uniformity of beach/dune configuration, longterm erosion potential, expected storm induced shoreline response and back dune topography. For each delineated cell, one profile line was selected representing the "average" conditions for that cell. Each profile line is horizontally referenced to a baseline which runs parallel to the shore. For most cells the baseline is set at the dune crests. Storm erosion and inundation were both computed relative to the designated baseline and the results presented later are provided relative to that baseline. The hydraulic baseline is the same as the economic baseline. Figure A.HWO.4.2 provides a plan view of the study area, cell delineation, baseline orientation and profile line locations. Pertinent information for each profile line is provided in Table A.HWO.4.2. Beach profile data was developed from the offshore survey data collected in March 1996 and onshore survey data collected in September 1993. Each profile was extended landward over 1000 ft, using digital photogrammetric data, to allow for erosion and inundation computations. Based on the long-term erosion analysis described in section A.HCP.2, the developed input profiles represent the predicted beach in the base year and throughout the project life. The profile lines for the Cape May Point cells of C through F reflect critical condition, defined as the beach/dune configuration at which the locals will mobilize for remedial work. Even though cell A has a substantial long term erosion rate the shape of the profile line for cell A is not adjusted.

Water Elev and Wave Height

Hydrograph



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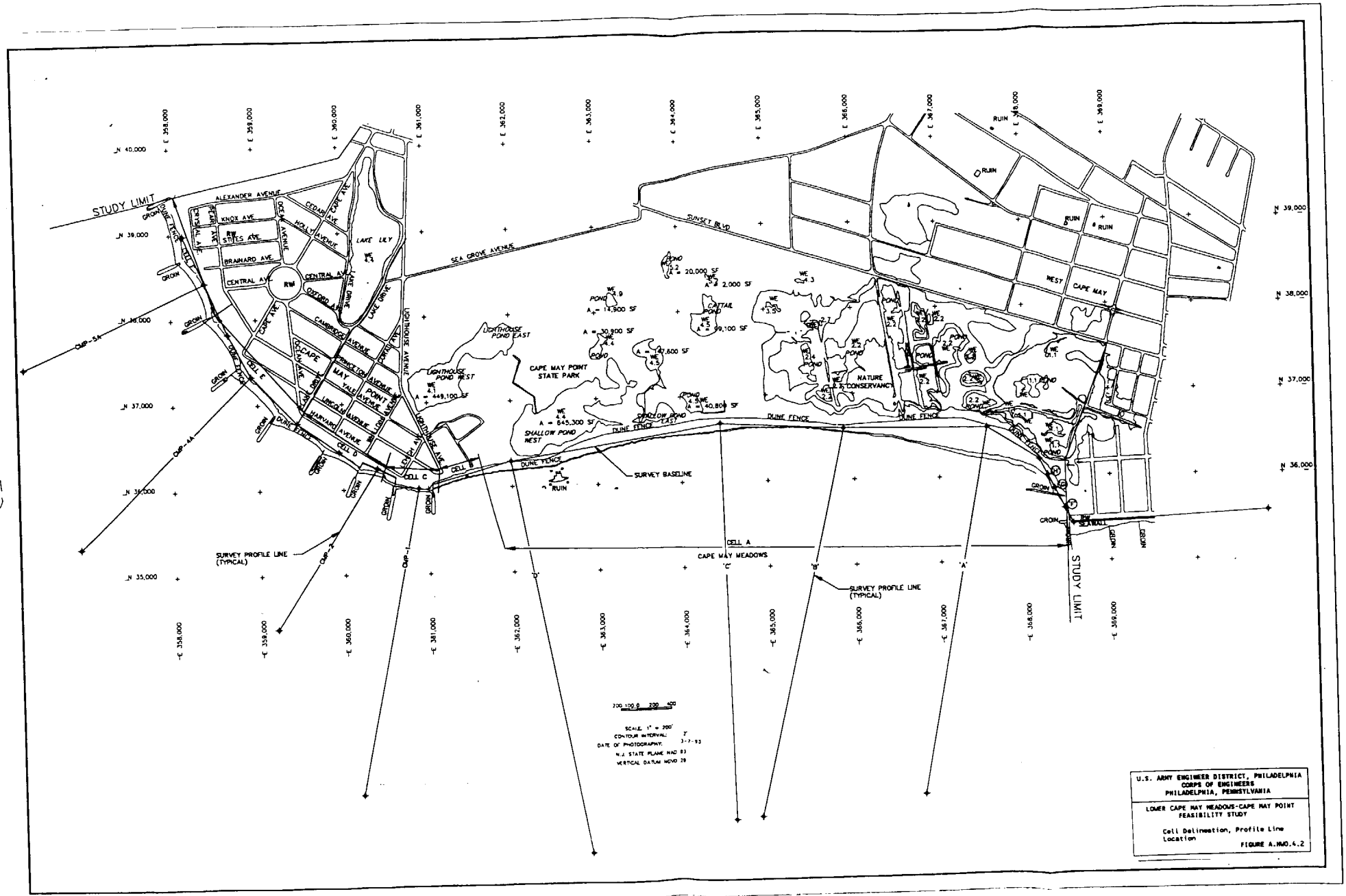
LOWER CAPE MAY MEADOWS-CAPE MAY POINT
FEASIBILITY STUDY

50 Yr Wave Height and Water Level
Hydrograph

FIGURE A.HW04.1


STUDY LIMIT
ALEXANDER AVENUE
KNOX AVE
STILES AVE
BRAINARD AVE
CENTRAL AVE
LAKE LILY
SEA GROVE AVENUE
SUNSET BLVD
LIGHTHOUSE AVENUE
LIGHTHOUSE POND EAST
LIGHTHOUSE POND WEST
CAPE MAY POINT STATE PARK
SHALLOW POND WEST
SHALLOW POND EAST
NATURE CONSERVANCY
DUNE FENCE
SURVEY BASELINE
SURVEY PROFILE LINE (TYPICAL)
CELL A
CELL B
CELL C
CELL D
CELL E
CAPE MAY MEADOWS
GROIN
SEAWALL
RUIN
WEST CAPE MAY
SCALE 1" = 200'
CONTOUR INTERVAL: 1'
DATE OF PHOTOGRAPHY: 3-7-93
N.J. STATE PLANE NAD 83
VERTICAL DATUM NGVD 29
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LOWER CAPE MAY MEADOWS-CAPE MAY POINT
FEASIBILITY STUDY
Cell Delineation, Profile Line Location
FIGURE A.MWO.4.2

Table A.HWO.4.2
Profile Line Data

Cell	Limits of Cell	Length of Cell (ft)	Profile Line	Dune Crest Elev (NGVD)	Grain Size D50 (mm)
A	Terminal groin of Cape May City to start of State Park buildings	7000	C	17.8	0.21
B	State Park buildings to Lighthouse Ave groin	450	D	16.3	0.21
C	Lighthouse Ave groin to 150 ft past Lehigh Ave groin	470	CMP-1	15.5	0.42
D	Lehigh Ave groin past Whilden Ave to Lake Drive	1660	CMP-2	16.9	0.42
E	Lake Drive past Cape Ave groin to Central Ave groin	1420	CMP-4A	22.7	0.42
F	Central Ave groin past Brainard groin to Alexander groin	1490	CMP-5A	22.2	0.42

Notes:

1) All lines were surveyed March 1996.
2) For Cells A and B, the SBEACH calibration parameters were set as:
   K=0.0000023; eps=0.003; Lamm=0.5
   For all other cells the parameters were set as:
   K=0.0000012; eps=0.003; Lamm=0.5

Historically as the beach retreated and the dune overwashed, the State of NJ rebuilt the dune at its new landward location. The longterm continuation of this practice is expected. While the line itself will retreat landward it's shape is assumed unchanged since the depth of closure is considered to move landward. This assumption is supported by the past 40 years of shoreline retreat accompanied by substantial (over 20 feet) near shore deepening as documented in section A.HCP.3 Cell B is protected by a revetment completed in the Spring of 1996 by the State of New Jersey. The profile line for this cell is reflective of base year conditions in light of the State's commitment to stabilize this threatened section of the shoreline. The profile lines for all cells, applicable at the base year are provided as Figures A.HWO.4.3 to A.HWO.4.8.

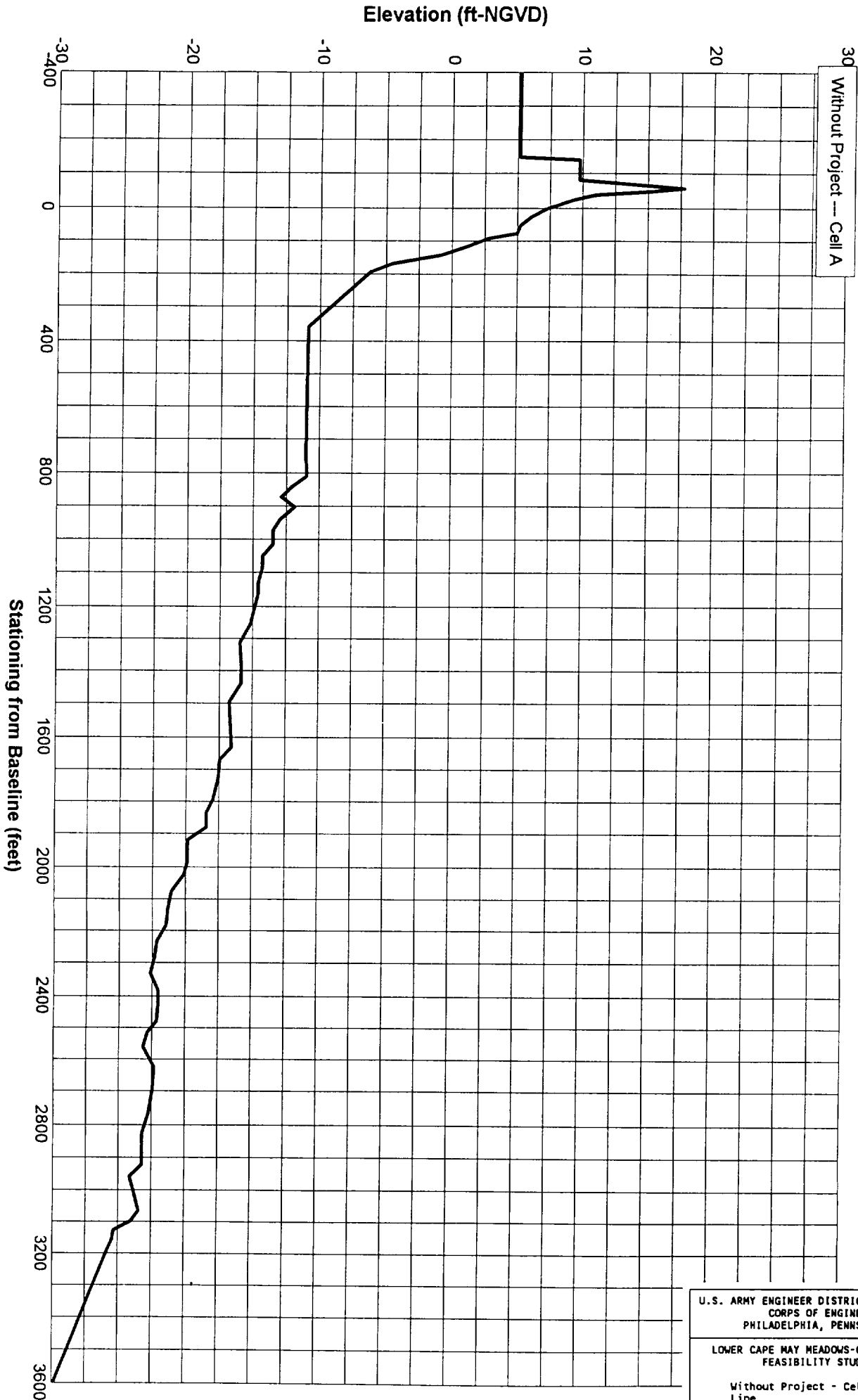
A.HWO.4.6 SBEACH CALIBRATION

Calibration refers to the procedure of reproducing with SBEACH the change in profile shape produced by an actual storm. Due to the empirical foundation of SBEACH and the natural variability that occurs along the beach during storms, the model should be calibrated using data from beach profiles surveyed before and after storms at the project coast or a similar coast. The calibration procedure involves iterative adjustments of controlling simulation parameters until agreement is obtained between measured and simulated profiles.

In a report titled "Townsends Inlet to Cape May Inlet Feasibility Study - Without Project Storm Erosion and Inundation Analysis" dated 10 July 1995, by Offshore & Coastal Technologies, Inc (OCTI) a calibration and verification analysis was performed using pre and post storm profiles of Atlantic Coast beaches within the Philadelphia District. The calibration was performed using data from Dewey Beach, DE for the December 1992 storm. This data was considered the most appropriate for calibration because it includes site specific wave measurements for the storm period and water level data obtained from the NOAA primary tide gaging station at Breakwater Harbor, DE, located approximately 8 miles from Dewey Beach. Four profiles were chosen for analysis and through a sensitivity analysis reasonable overall comparisons with measured survey data especially for the berm and the dune portions of the profiles were obtained with the following parameters:

K=0.0000012
eps=0.003
LAMM=0.10
BMAX=60

The data from Ocean City NJ for the same December 1992 storm was used for the verification, since the oceanographic data is considered to be of a lower overall quality than the data used at Dewey Beach. The wave data for Ocean City, NJ area was produced using a numerical hindcast model as opposed to site specific wave measurements. (Andrews Miller, 1993) Spectral wave hindcast models have typically exhibited approximately 15% error when compared to measurements. The water level



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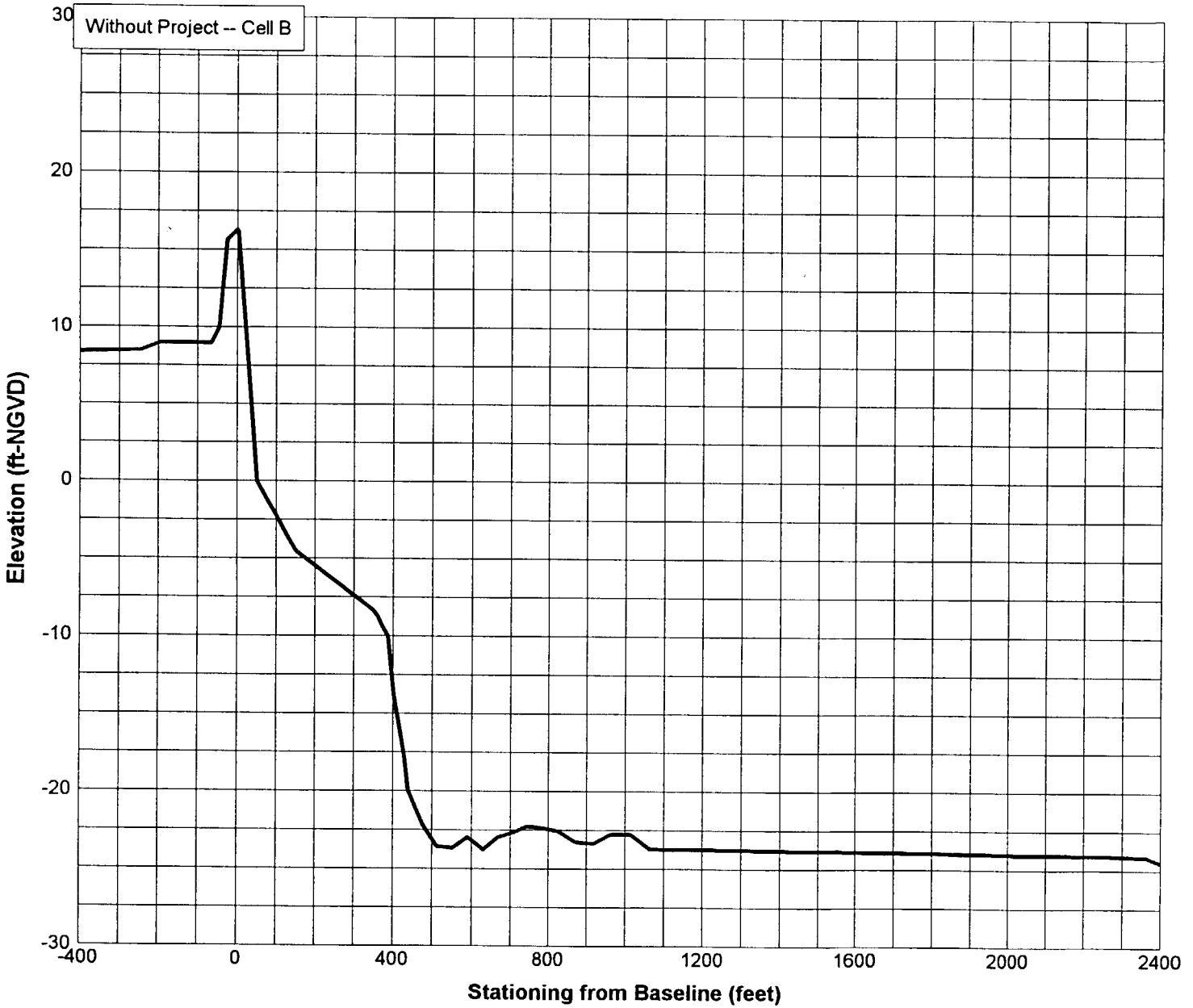
LOWER CAPE MAY MEADOWS-CAPE MAY POINT
FEASIBILITY STUDY

Without Project - Cell A Profile Line

FIGURE A.HWO.4.3



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PHILADELPHIA, PENNSYLVANIA

LOWER CAPE MAY MEADOWS-CAPE MAY POINT
FEASIBILITY STUDY

Without Project - Cell B Profile
Line

FIGURE A.HWQ.4.4

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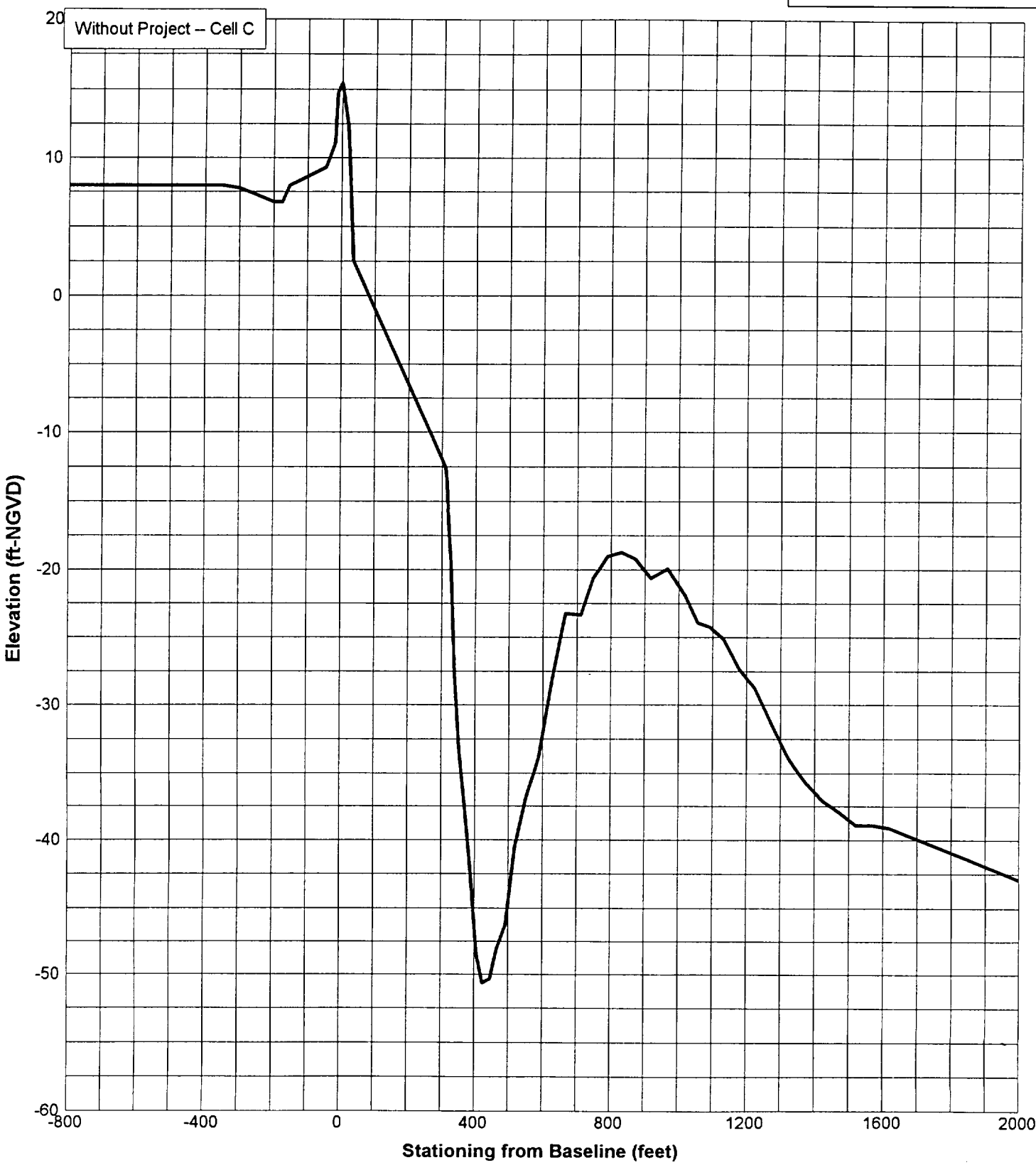
LOWER CAPE MAY MEADOWS-CAPE MAY POINT
FEASIBILITY STUDY

Without Project - Cell C Profile Line

FIGURE A.HWO.4.5



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LOWER CAPE MAY MEADOWS-CAPE MAY POINT
FEASIBILITY STUDY

Without Project - Cell D Profile
Line

FIGURE A.HWO.4.6

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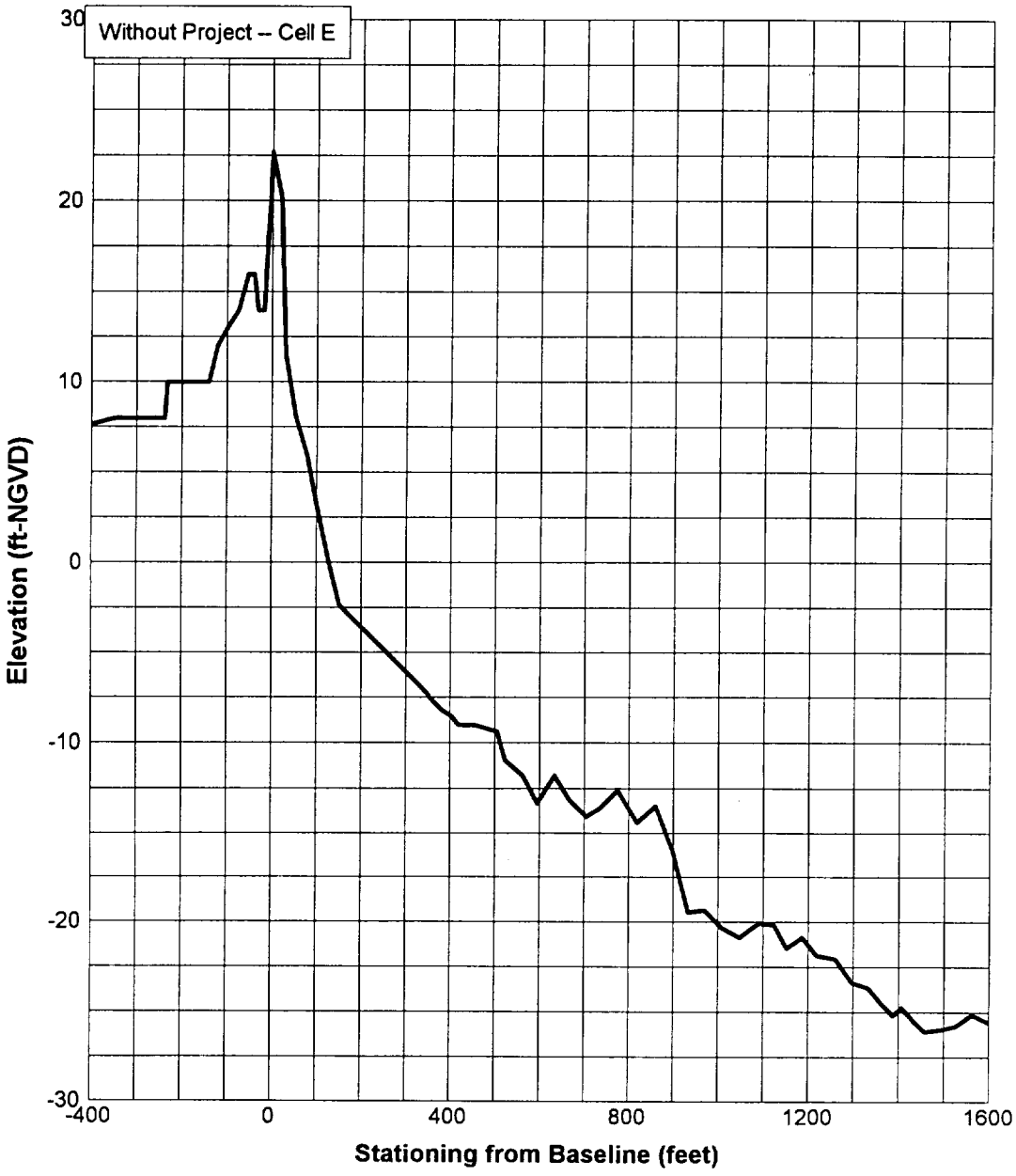

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LOWER CAPE MAY MEADOWS-CAPE MAY POINT
FEASIBILITY STUDY

Without Project - Cell E Profile Line

FIGURE A.HWO.4.7

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LOWER CAPE MAY MEADOWS-CAPE MAY POINT
FEASIBILITY STUDY

Without Project - Cell F Profile
Line

FIGURE A.HWO.4.8

data was considered to be of equivalent quality to that used at Dewey Beach because it was acquired from a NOAA primary tide gaging station at Atlantic City, NJ which is also approximately 8-10 miles from the Ocean City area. Four profiles were selected at random from the Ocean City data set and used to perform the validation assessment. Use of the final parameters from the Dewey Beach data set provided acceptable results but an improved match between the observed and predicted beach profiles for the upper beach and dune was obtained by increasing the value of k from 0.0000012 to 0.0000025. The increased in k is justified by the differences in median grain size between Ocean City at 0.24 mm and Dewey Beach at 0.33mm.

The results of the calibration and verification of the Dewey Beach and Ocean City data sets were used to select the values of the SBEACH calibration parameters for Cape May Meadows and Cape May Point. For all cells the values of eps, LAMM and BMAX were set at 0.003 and 0.5 and 40 respectively. (Version 3.0 with its improved beach transformation routines under random waves recommends a LAMM value of 0.5.) Cells A and B with a median grain size of 0.21mm was assigned a K value of 0.0000023, while all other cells with a median grain size of 0.42 mm were assigned a K value of 0.0000012.

A.HWO.5 STORM INUNDATION EVALUATION

The project area consisting of the towns of Cape May Point and West Cape May are subject to inundation from two separate mechanisms: 1) Static flooding due to damaging ocean induced water surface elevations in The Meadows and 2) dynamic attack, the result of wave runup overtopping the dunes and protective structures or superelevated ocean stages exceeding the dune crests causing them to breach. All of West Cape May and the majority of the structures in Cape May Point are subject to static flooding from The Meadows . In Cape May Point only those structures closest to the dune are exposed to dynamic flooding. Static Meadow's flooding occurs in two ways: 1) dunes fronting The Meadows are breached and the ocean elevation obtains in the interior or 2) wave runup volumes overtopping the dunes drain to The Meadows where it ponds to damaging elevations. (Cells A, B, C, D and E drain to The Meadows .) When the water elevation in The Meadows reaches elevation 5 ft-NGVD water flows across Lighthouse Ave and Sunset Boulevard, flooding Cape May Point and West Cape May respectively. This type of flooding has occurred several times since 1989. Based on High Water Marks in Cape May Point the maximum interior water surface elevation reached during the October 1991 storm was 6.8 ft-NGVD and 7.5 ft-NGVD for both the January and December 1992 storms.

The SBEACH program was applied to assess the effect of frequency storms on the beach/dune configuration, as represented by the profile line for each of the 6 cells. The storms analyzed are the 2yr, 5yr, 10yr, 20yr, 50yr, 100yr, 200yr and 500yr events. Model output includes a post-storm profile plot, and several report and post-processing files. Simulation results from each particular combination of profile geometry and storm characteristics yield predicted profile transformation through time and nearshore water levels due to surge and wave setup. The output for each run was generated at 15 minute

intervals consisting of end of period beach profile, total water level including wave setup near the dune crest and offshore water level wave height and peak period. These parameters served as input to a computer program which solves a regression equation predictive of the average overtopping flow rate for the period. The regression equation is based on work done by the Delft Hydraulics Laboratory (1983) which prepared a series of small and large scale laboratory tests directed at evaluating wave runup and overtopping on eroded beach/dune profiles during severe storms. The equation is provided below:

$$Qm = A*(e**B)$$

$$\text{where } A = (0.1*Hm*Lo) / (Tm*((\cot S)**0.5)$$

$$B = Fc*((\cot S)**0.5) / ((Hm*Lo)**0.5)$$

Qm = mean wave overtopping discharge per unit width

Hm = mean deepwater wave height, which is the significant wave height multiplied by 0.625

Lo = deep water wavelength which equals g*(Tm**2) / 2*pi

Tm = mean deepwater wave period which equals the peak wave period multiplied by 0.9

S = structure slope

Fc = height of structure above still water i.e. freeboard

For each frequency storm event the cumulative overtopping volume of each cell was obtained by integrating the unit discharge hydrograph of overtopping flows and then multiplying by the length of the cell. The storm volumes of each cell were then added to obtain the total overtopping volume draining to The Meadows . The volumes obtained in this manner were adjusted to match documented overtopping volumes. The need for the adjustment arises because of the approximate nature of the regression equation and because of the use of the full cell length in calculating overtopping volumes. In reality during any instance of wave overtopping only a small portion of the cell length is overtopped. But because it is difficult to specify at any time the fraction of the cell's length overtopped, the full cell length is used and a subsequent adjustment is made. However, since the adjustment factor will be applied to both with and without project

conditions a consistent comparison of the effectiveness of various plans of improvement in reducing overtopping volumes is possible.

The adjustment factor was calculated in the following manner. The most recent topographic map was used to generate an interior elevation capacity curve provided as Table A.HWO.5.1.

Table A.HWO.5.1 Without Project Interior Elevation-Capacity Year 2000	
Elevation (ft-NGVD)	Capacity (Acre-ft)
2	20
4	170
6	650
8	1530
10	2700
12	4110

Interviews with long term residents of the area indicate that an ocean induced flood event occurs approximately once every 4 years. In the case of West Cape May ponded water in The Meadows overflows Sunset Boulevard while in the case of Cape May Point the low spots of Lighthouse Avenue are exceeded. A water surface elevation of 5.5 ft-NGVD, which corresponds to approximately 0.5 ft of water over these 2 roads was assigned to the 0.25 exceedance probability. The adjustment factor is the ratio of the volume at elevation 5.5 ft-NGVD to the calculated total overtopping volume. This factor is then applied to the calculated total overtopping volume of all frequency events. A breach is assumed to occur when the total water surface elevation at the shoreline for any time step is equal to or greater than the corresponding dune crest elevation. When a breach occurs the interior water surface elevation is set equal to the ocean frequency still water elevation. Without project performance is summarized in Table A.HWO.5.2.

Table A.HWO.5.2
Without Project Performance

Cell	2 yr	5 yr	10 yr	20 yr	50 yr	100 yr	200 yr	500 yr
Meadows	OT	OT	BR	BR	BR	BR	BR	BR
CM Point	--	OT	BR	BR	BR	BR	BR	BR

Note: OT -- dune is overtopped
BR -- dune is breached

The overtopping volumes for the without project condition are shown in Table A.HWO.5.3.

Table A.HWO.5.3
Without Project Overtopping
Volumes (acre-ft)

Cell	2 yr	5 yr	10 yr	20 yr	50 yr	100 yr	200 yr	500 yr
Meadows	270	460	BR	BR	BR	BR	BR	BR
CM Point	--	135	BR	BR	BR	BR	BR	BR

Note: 270 -- overtopping volume in acre-ft
BR -- dune is breached, interior WSEL is set equal to peak ocean stillwater elevation.

The without project condition reflects the longterm erosion of The Meadows beachfront which reduces the storage capacity of the interior to contain overtopping volumes. The retreat of The Meadows beach has been analyzed in 10 year blocks. Starting at the year 2000 and ending at the year 2050, elevation-area and elevation-capacity tables were determined for each end of decade taking into account the effects of 15 ft/yr of long term erosion on the topography of The Meadows . These data are provided as Tables A.HWO.5.4 and A.HWO.5.5 respectively.

Table A.HWO.5.4
Without Project
Interior Elevation-Area (acres)

Elevation (ft-NGVD)	Year 2000	2010	2020	2030	2040	2050
1.4	29.5	28.3	27.1	26.0	24.8	23.6
2	29.5	28.3	27.1	26.0	24.8	23.6
4	120.7	110.8	100.9	91.1	81.2	71.3
6	363.3	342.0	320.8	299.5	278.3	257.0
8	517.0	494.6	472.3	449.9	427.6	405.2
10	643.4	620.7	598.0	575.2	552.5	529.8
12	769.8	746.7	723.6	700.6	677.5	654.4

Note: The elevation-area data reflects all area behind the dune line including the towns of West Cape May and Cape May Point.

Table A.HWO.5.5
Without Project
Interior Elevation-Capacity (acre-ft)

Elevation ft-NGVD)	Year 2000	2010	2020	2030	2040	2050
1.4	0	0	0	0	0	0
2	18	17	16	16	15	14
4	170	155	145	130	120	110
6	650	610	565	520	475	430
8	1530	1440	1360	1270	1180	1090
10	2700	2560	2430	2290	2160	2030
12	4110	3930	3750	3570	3390	3220

Note: The elevation-capacity data reflects all volume behind the dune line including the towns of West Cape May and Cape May Point.

Consideration of overtopping and breaching performance of all cells which drain to The Meadows was the basis for determining the frequency static interior water levels by decade. When a breach occurs the interior water surface elevation was set equal to the peak ocean stillwater elevation. For the overtopping events the interior water surface elevations were determined by applying the overtopping volumes, assumed constant with time, to the elevation capacity curves decreasing with time. The interior elevation-frequency relationship for The Meadows , which is applicable to all structures of West Cape May and to those structures of Cape May Point distant from the dunes is provided as Table A.HWO.5.6.

Table A.HWO.5.6
Without Project
Frequency Water Surface Elevation
By Decade (ft-NGVD)

	Year					
Event	2000	2010	2020	2030	2040	2050
2 yr	4.4	4.5	4.6	4.7	4.9	5.0
5 yr	5.8	5.9	6.1	6.2	6.3	6.5
10 yr	6.9	6.9	6.9	6.9	6.9	6.9
20 yr	7.4	7.4	7.4	7.4	7.4	7.4
50 yr	8.1	8.1	8.1	8.1	8.1	8.1
100 yr	9.1	9.1	9.1	9.1	9.1	9.1
200 yr	10.0	10.0	10.0	10.0	10.0	10.0
500 yr	11.3	11.3	11.3	11.3	11.3	11.3

The interior frequency water surface elevations correspond to acres of The Meadows inundated by salt water. However, the unit of account to quantify the environmental effects of salt water inundation is acres not inundated rather than acres inundated because of the effect of long term erosion. If one uses acres inundated one finds that the acres inundated decrease with time suggesting an improved condition. But of course there are fewer acres inundated because there are fewer acres, due to their loss from long term erosion. The acres not inundated for each end of decade were determined by first converting the frequency water surface elevations to acres of The Meadows inundated by salt water and then subtracting this value from the total acres of The Meadows remaining at that time. The elevation-area curve for The Meadows by decade is provided in Table A.HWO.5.7. The frequency-acres of The Meadows not inundated by end of decade is provided as Table A.HWO.5.8.

Table A.HWO.5.7
Without Project
Elevation-Area of Meadows (acre)

Elevation (ft-NGVD)	Year 2000	2010	2020	2030	2040	2050
1.4	29.5	28.3	27.1	26.0	24.8	23.6
2	29.5	28.3	27.1	26.0	24.8	23.6
4	117.8	107.9	98.0	88.2	78.3	68.4
6	263.4	242.1	220.9	199.6	178.4	157.1
8	294.1	271.7	249.4	227.0	204.7	182.3
10	312.1	289.4	266.7	243.9	221.2	198.5
12	330.1	307.0	283.9	260.9	237.8	214.7

Note 1: The elevation-area data pertains only to The Meadows .
Note 2:

Year	Acres of Meadows Remaining	Year	Acres of Meadows Remaining
2000	333	2030	264
2010	310	2040	241
2020	287	2050	218

□

Table A.HWO.5.8 Without Project Frequency Acres not Inundated by Salt Water By Decade (ft-NGVD)						
	Year					
Event	2000	2010	2020	2030	2040	2050
1 yr	333	310	287	264	241	218
2 yr	186	169	152	137	118	105
5 yr	84	75	65	62	60	58
10 yr	56	56	56	56	56	56
20 yr	48	48	48	48	48	48
50 yr	38	38	38	38	38	38
100 yr	29	29	29	29	29	29
200 yr	21	21	21	21	21	21
500 yr	9	9	9	9	9	9

A.HWO.6 WAVE ATTACK

Coastal structures can be exposed to forces in addition to stillwater flooding which are attributed to the direct impact of waves and high velocity runup. This phenomenon will be considered the wave attack for the purpose of this analysis. Reducing wave attack with a proposed project such as a beach fill would reduce the severity of coastal storm damage and also improve the integrity of stone revetment which limits wave and erosion damage. The wave attack analysis applies only to those structures of Cape May Point nearest the dunes.

A.HWO.6.1 CRITERIA FOR DAMAGE

To evaluate the added potential for structural damage, the boundaries of the wave attack must be delineated, and the critical damage wave height identified. Return periods of 2, 5, 10, 20, 50, 100, 200, and 500 years associated with the inundation-frequency curve were evaluated for each cell. The analysis estimates the location of a wave attack line and the associated zones of high energy stages. The wave attack line is the most landward position of the swash zone where the force due to waves and high velocity flow exceeds

the force required to damage typical coastal structures. Any structure located landward of this line is subject to the equivalent of stillwater flooding because the dynamic forces are not sufficient to cause the accelerated damages incurred seaward of the wave attack line.

At Cape May Point for those structures falling within the first two blocks landward of the dunes, the water surface inundation profile is controlled by the dynamics of wave overtopping. For those events which do not breach the dunes, the inundation water surface elevations were determined by adding 1 ft or 2 ft of water to the ground elevations of the profile line landward of the dune crest based on whether the wave runup exceeded the dune crest by less than or more than 3 feet respectively. However, if either of these elevations were less than the static frequency water surface elevation for the event the static water level from the Meadow controlled. For those frequency events which breach the dune, the inundation profile reflects a depth of water, estimated to be 4 feet, which rushes landward as the dune collapses. This depth, augmented by the nonbreaking wave height that can be carried by this depth was added to the ground elevations landward of the dune. When greater, the static frequency water surface elevation of The Meadows was used.

Table A.HWO.6.1 provides the computed total water level inundation profile for all cells. The effects of stage plus setup, wave amplitude, wave runup at structures or crest location were incorporated into the total water level. The total water level information for each cell in the study area was compiled, and the values used as input to the economic model which ultimately computes damages associated with storm related inundation.

A.HWO.7 STORM EROSION SIMULATIONS

The SBEACH model was applied to predict storm-induced erosion for the study area. All representative storm events were run against the pre-storm profiles for each cell. Simulation results from each particular combination of profile geometry and storm characteristics yield predicted profile retreat. In this analysis, profile retreat for any given storm event was measured landward from the designated baseline to the location of 0.1 ft of vertical erosion. Figures A.HWO.7.1 to A.HWO.7.8 illustrate, for Cell D, pre and post SBEACH storm profiles reflecting retreat due to erosion for the eight frequency storms.

Cells B and C reflect the fact that each cell is protected by a stone revetment. In order for storm erosion to affect the community landward of the revetments the structures must fail. SBEACH simulates failure through a number of mechanisms including storm induced scour at the toe of the structure, direct wave attack, or inundation. Failure criteria for the stone revetments were developed based on a synthesis of available data, including design and construction information, existing condition typical cross-sections, and field inspection of the structures. The appropriate failure criteria was input to the SBEACH configuration file. Model simulations typically resulted in the undermining of the toe of the revetment by scour at the 20 yr storm and greater for both Cell B and Cell C.

Table A.HWO.6.1
Without Project
Inundation Profiles
(2,5,10,20,50,100,200,500 Years)

**********CELL B**********

STORM EROSION,WAVE IMPACT,WAVE DAMAGE ELEVATION,
ZONES 1 & 2

0.0	0	0.0	0.	0.
0.0	0	0.0	0.	0.
0.0	0	0.0	0.	0.
15.0	0	0.0	0.	0.
45.0	0	0.0	0.	0.
80.0	0	0.0	0.	0.
160.0	40	0.0	0.	0.
180.0	20	0.0	0.	0.

INUNDATION PROFILE: DISTANCE FROM BASELINE AND
TOTAL WATERLEVEL

0	17.2	26	10.3	50	10.3	65	9.5
195	9.5	245	9.0	415	9.0	445	9.0
525	9.5	605	9.0	635	8.0	795	5.0
0	17.2	26	10.3	50	10.3	65	9.5
195	9.5	245	9.0	415	9.0	445	9.0
525	9.5	605	9.0	635	8.0	795	5.7
0	17.2	26	10.3	50	10.3	65	9.5
195	9.5	245	9.0	415	9.0	445	9.0
525	9.5	605	9.0	635	8.0	795	7.7
0	9.6	20	17.0	48	9.5	70	9.5
195	9.5	245	9.0	415	9.0	445	9.0
525	9.5	605	9.0	635	8.4	795	8.4
0	10.6	80	14.3	97	9.5	130	9.5
195	9.5	245	9.2	415	9.2	445	9.2
525	9.5	605	9.2	635	9.2	795	9.2
0	11.7	140	13.1	152	9.6	190	9.6
195	9.6	245	9.6	415	9.6	445	9.6
525	9.6	605	9.6	635	9.6	795	9.6
0	15.1	20	14.9	170	13.3	220	13.3
240	13.0	245	13.0	415	13.0	445	12.8
525	12.6	605	11.0	635	10.3	795	10.3
0	17.1	190	15.2	210	14.3	240	13.0
242	13.0	245	13.0	415	13.0	445	12.8
525	12.6	605	11.3	635	11.3	795	11.3

**********CELL C**********

STORM EROSION,WAVE IMPACT,WAVE DAMAGE ELEVATION,
ZONES 1 & 2

0.0	0	0.0	0.	0.
0.0	0	0.0	0.	0.
0.0	0	0.0	0.	0.
45.0	0	0.0	0.	0.
60.0	0	0.0	0.	0.
120.0	80	0.0	0.	0.
145.0	55	0.0	0.	0.
165.0	35	0.0	0.	0.

INUNDATION PROFILE: DISTANCE FROM BASELINE AND
TOTAL WATERLEVEL

0	16.3	24	9.8	50	9.8	200	8.5
350	8.5	460	8.5				
0	16.3	24	9.8	50	9.8	200	8.5
350	8.5	460	8.5				
0	16.3	24	9.8	50	9.8	200	8.5
350	8.5	460	8.5				
0	9.7	80	14.0	99	8.8	130	8.8
350	8.5	460	8.5				
0	10.6	100	12.1	112	9.2	150	9.2
350	9.2	460	9.2				
0	11.7	155	13.2	175	13.2	205	13.2
350	12.6	460	12.6				
0	13.0	175	13.2	195	13.2	225	13.2
350	12.6	460	12.6				
0	17.4	175	13.7	195	13.7	225	13.7
350	13.1	460	13.1				

Table A.HWO.6.1
(continued)

**********CELL D**********

STORM EROSION,WAVE IMPACT,WAVE DAMAGE ELEVATION,
ZONES 1 & 2

5.0	0.0	0.0	0.	0.
15.0	0.0	0.0	0.	0.
50.0	150	0.0	0.	0.
55.0	145	0.0	0.	0.
60.0	140	0.0	0.	0.
65.0	135	0.0	0.	0.
70.0	130	0.0	0.	0.
75.0	125	0.0	0.	0.

INUNDATION PROFILE: DISTANCE FROM BASELINE AND
TOTAL WATERLEVEL

0	0.0	100	0.0	200	0.0	300	0.0
470	0.0	570	0.0				
0	10.5	15	14.4	42	7.5	65	7.5
470	7.5	570	7.5				
0	11.2	55	12.1	75	12.1	105	12.1
470	11.5	570	11.5				
0	11.9	55	12.1	75	12.1	105	12.1
470	11.5	570	11.5				
0	12.1	65	12.1	85	12.1	115	12.1
470	11.5	570	11.5				
0	13.9	65	12.1	85	12.1	115	12.1
470	11.5	570	11.5				
0	15.0	65	12.6	85	12.6	115	12.6
470	12.1	570	12.1				
0	16.6	65	14.1	85	14.1	115	14.1
470	13.6	570	13.6				

**********CELL E**********

STORM EROSION,WAVE IMPACT,WAVE DAMAGE ELEVATION,
ZONES 1 & 2

0.0	0	0.0	0.	0.
0.0	0	0.0	0.	0.
0.0	0	0.0	0.	0.
5.0	0	0.0	0.	0.
55.0	0	0.0	0.	0.
70.0	0	0.0	0.	0.
90.0	210	0.0	0.	0.
95.0	205	0.0	0.	0.

INUNDATION PROFILE: DISTANCE FROM BASELINE AND
TOTAL WATERLEVEL

0	0.0	100	0.0	200	0.0	300	0.0
400	0.0	500	0.0	510	0.0		
0	23.4	50	17.0	74	10.5	150	10.5
350	8.5	500	7.5	510	7.5		
0	22.0	50	17.0	74	10.5	150	10.5
350	8.5	500	7.7	510	7.7		
0	21.1	50	17.0	74	10.5	150	10.5
350	8.5	500	8.4	510	8.4		
0	13.7	75	17.9	96	12.5	125	12.5
350	9.2	500	9.2	510	9.2		
0	15.1	110	17.2	135	10.5	160	10.5
350	9.6	500	9.6	510	9.6		
0	15.8	115	15.8	138	14.5	165	14.5
350	12.1	500	11.0	510	11.0		
0	16.1	115	16.0	139	14.5	165	14.5
350	13.6	500	11.3	510	11.3		

Table A.HWO.6.1
(continued)

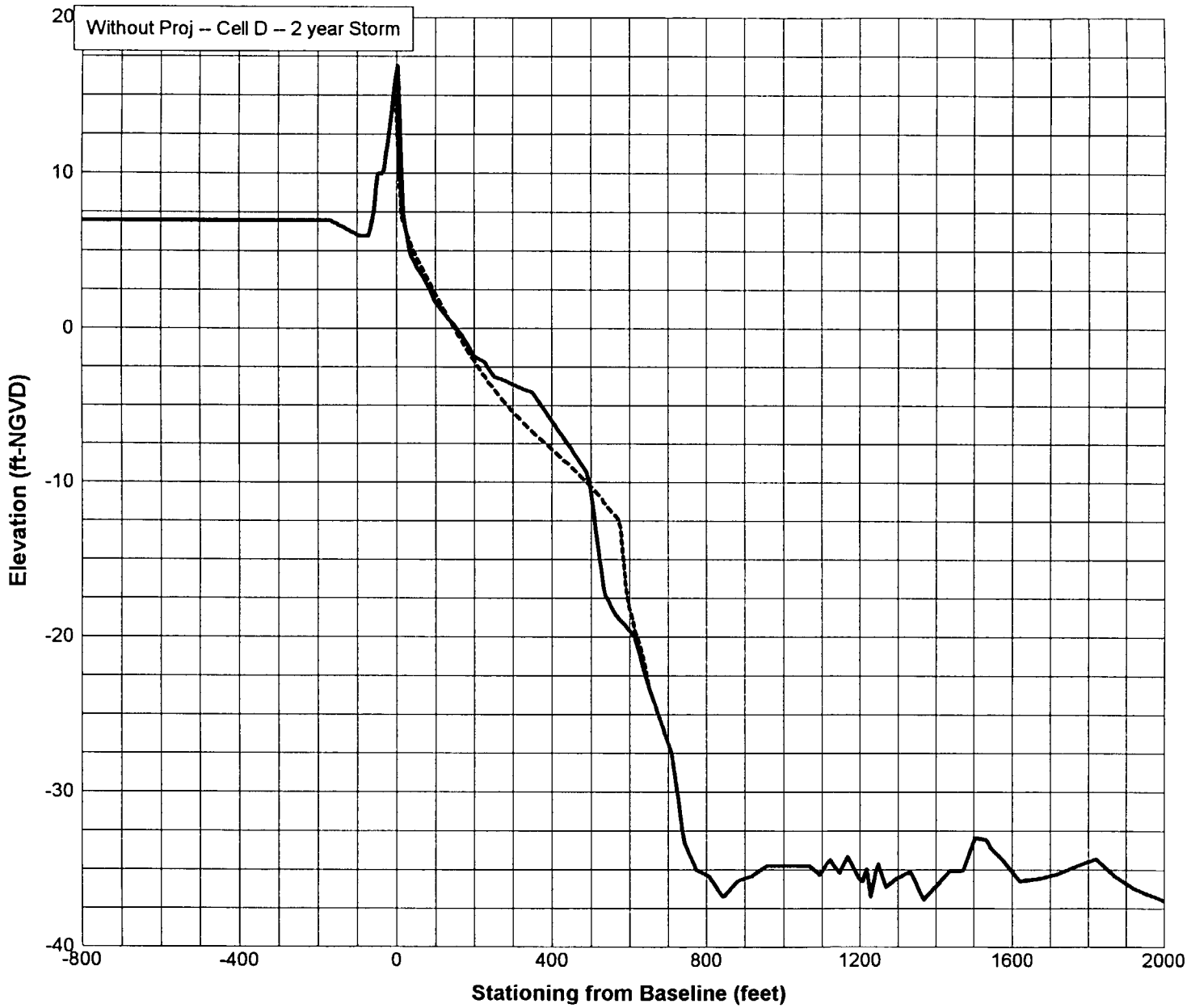
**********CELL F**********

STORM EROSION,WAVE IMPACT,WAVE DAMAGE ELEVATION,
ZONES 1 & 2

0.0	0	0.0	0.	0.
10.0	0	0.0	0.	0.
15.0	0	0.0	0.	0.
45.0	0	0.0	0.	0.
55.0	195	0.0	0.	0.
65.0	185	0.0	0.	0.
70.0	180	0.0	0.	0.
80.0	170	0.0	0.	0.

INUNDATION PROFILE: DISTANCE FROM BASELINE AND
TOTAL WATERLEVEL

0	0.0	100	0.0	150	0.0	200	0.0
350	0.0	460	0.0				
0	12.1	10	23.0	54	12.0	68	10.5
350	10.5	460	10.5				
0	12.6	15	22.4	61	11.2	68	10.5
350	10.5	460	10.5				
0	13.4	100	14.9	116	10.5	150	10.5
350	10.5	460	10.5				
0	14.4	200	14.6	220	14.6	250	14.6
350	14.6	460	14.6				
0	15.6	250	15.0	270	14.6	300	14.6
350	14.6	460	14.6				
0	15.8	250	15.3	270	14.6	300	14.6
350	14.6	460	14.6				
0	16.8	250	15.4	270	14.6	300	14.6
350	14.6	460	14.6				



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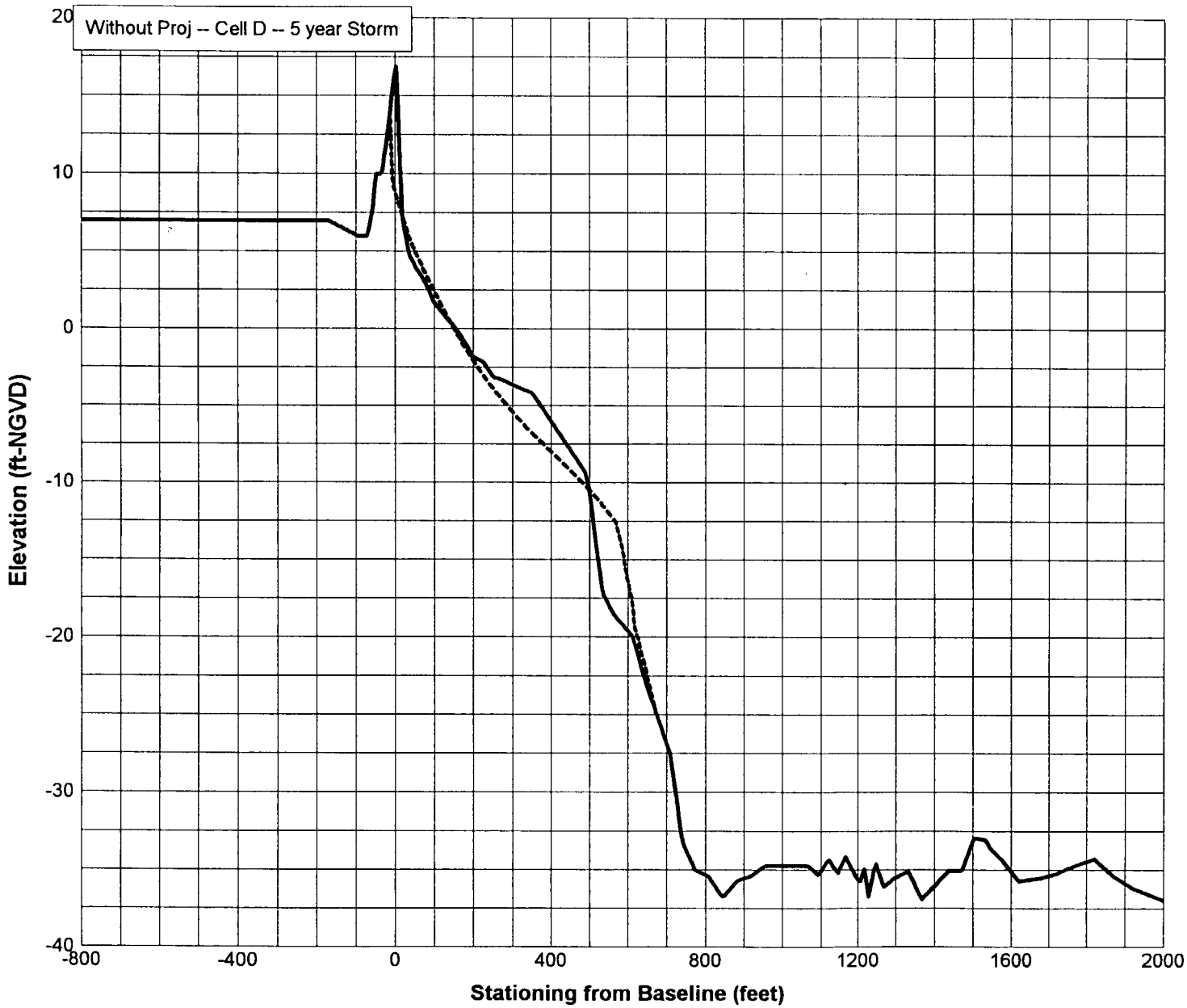
LOWER CAPE MAY MEADOWS-CAPE MAY POINT
FEASIBILITY STUDY

Without Project - Cell D - 2 Yr
Erosion

FIGURE A.HWQ.7.1

74



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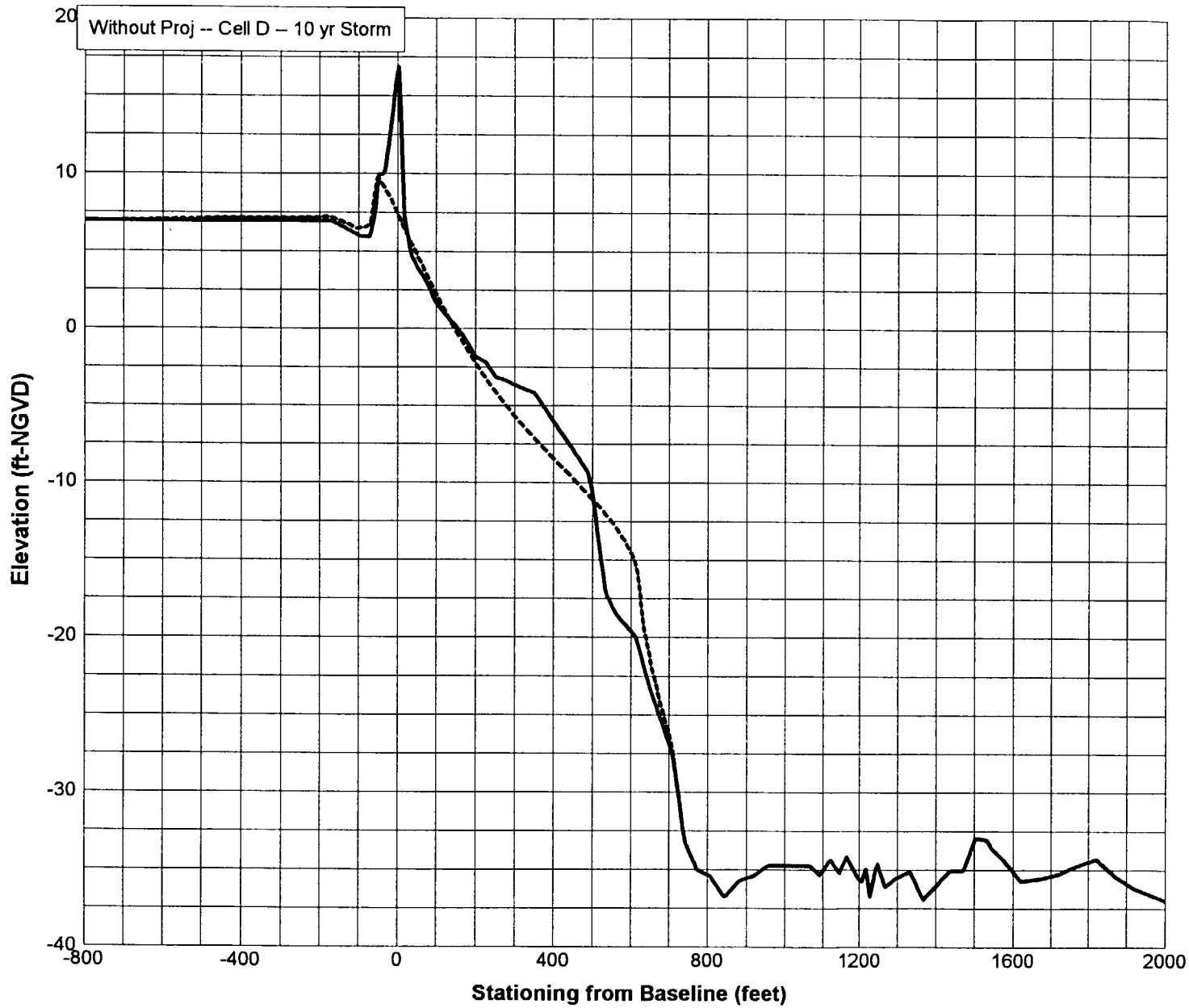
LOWER CAPE MAY MEADOWS-CAPE MAY POINT
FEASIBILITY STUDY

Without Project - Cell D - 5 Yr
Erosion

FIGURE A.HWO.7.2

75



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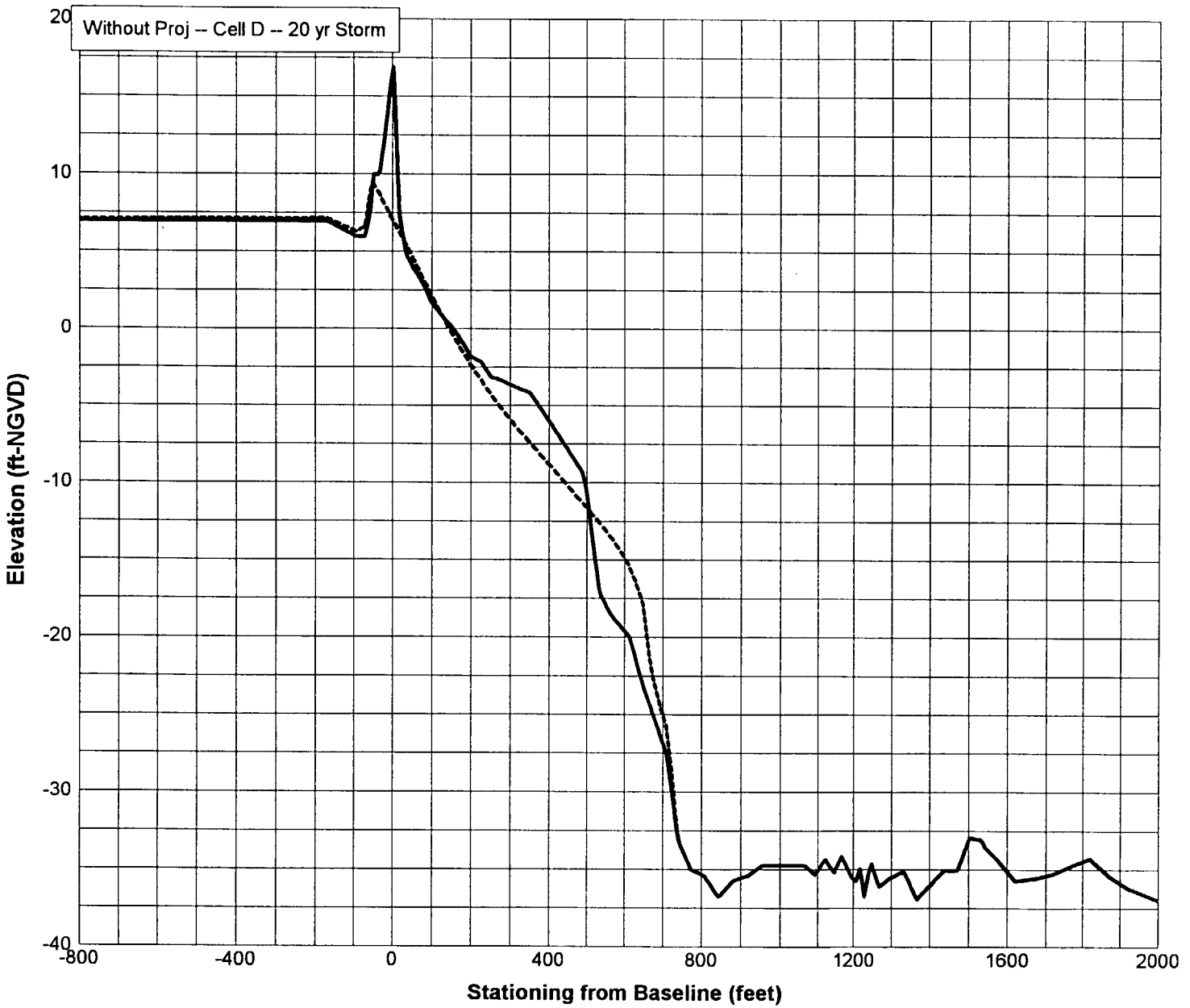
LOWER CAPE MAY MEADOWS-CAPE MAY POINT
FEASIBILITY STUDY

Without Project - Cell D - 10 Yr
Erosion

FIGURE A.HWO.7.3

76



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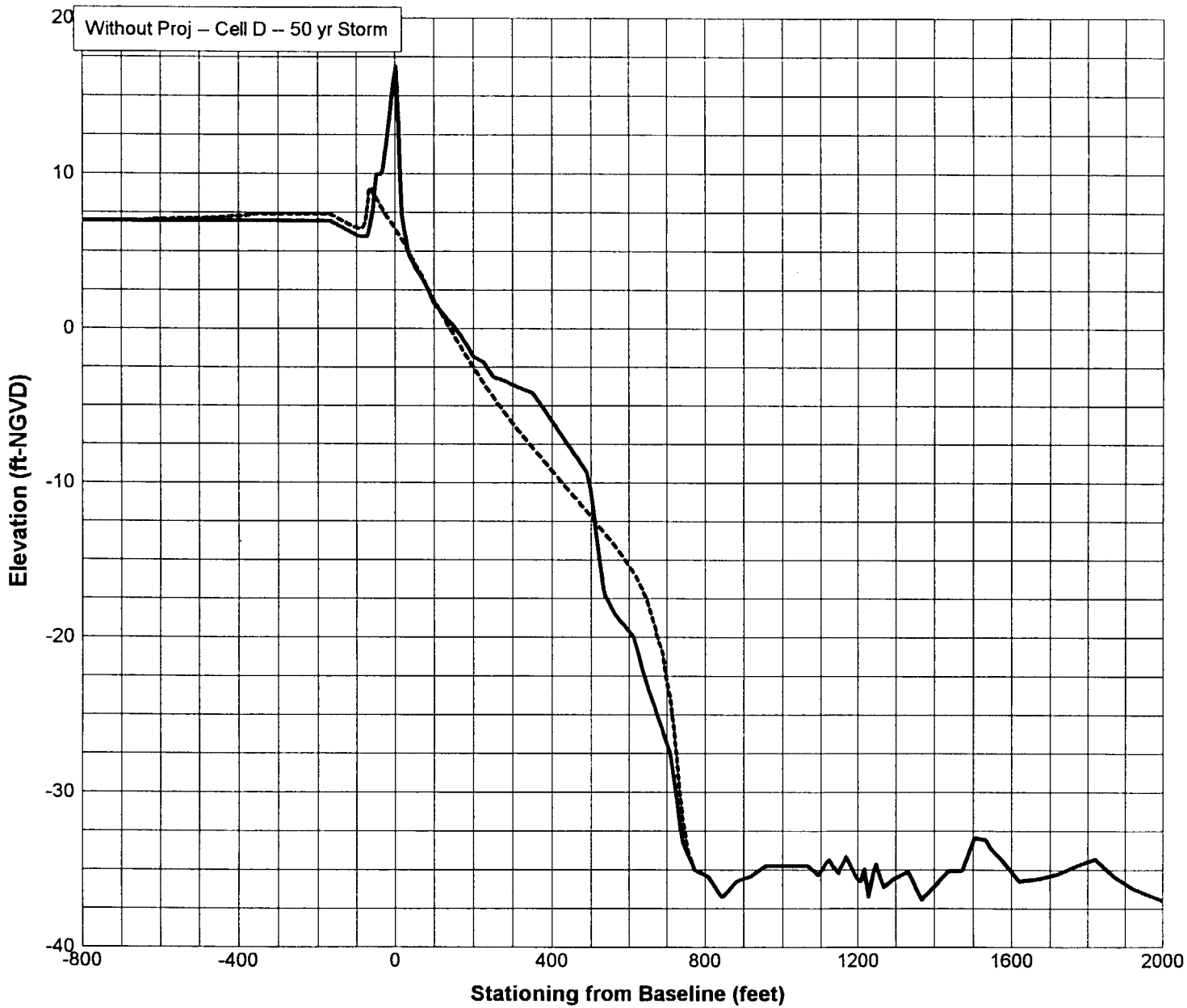
LOWER CAPE MAY MEADOWS-CAPE MAY POINT
FEASIBILITY STUDY

Without Project - Cell D - 20 Yr
Erosion

FIGURE A.HWO.7.4

77



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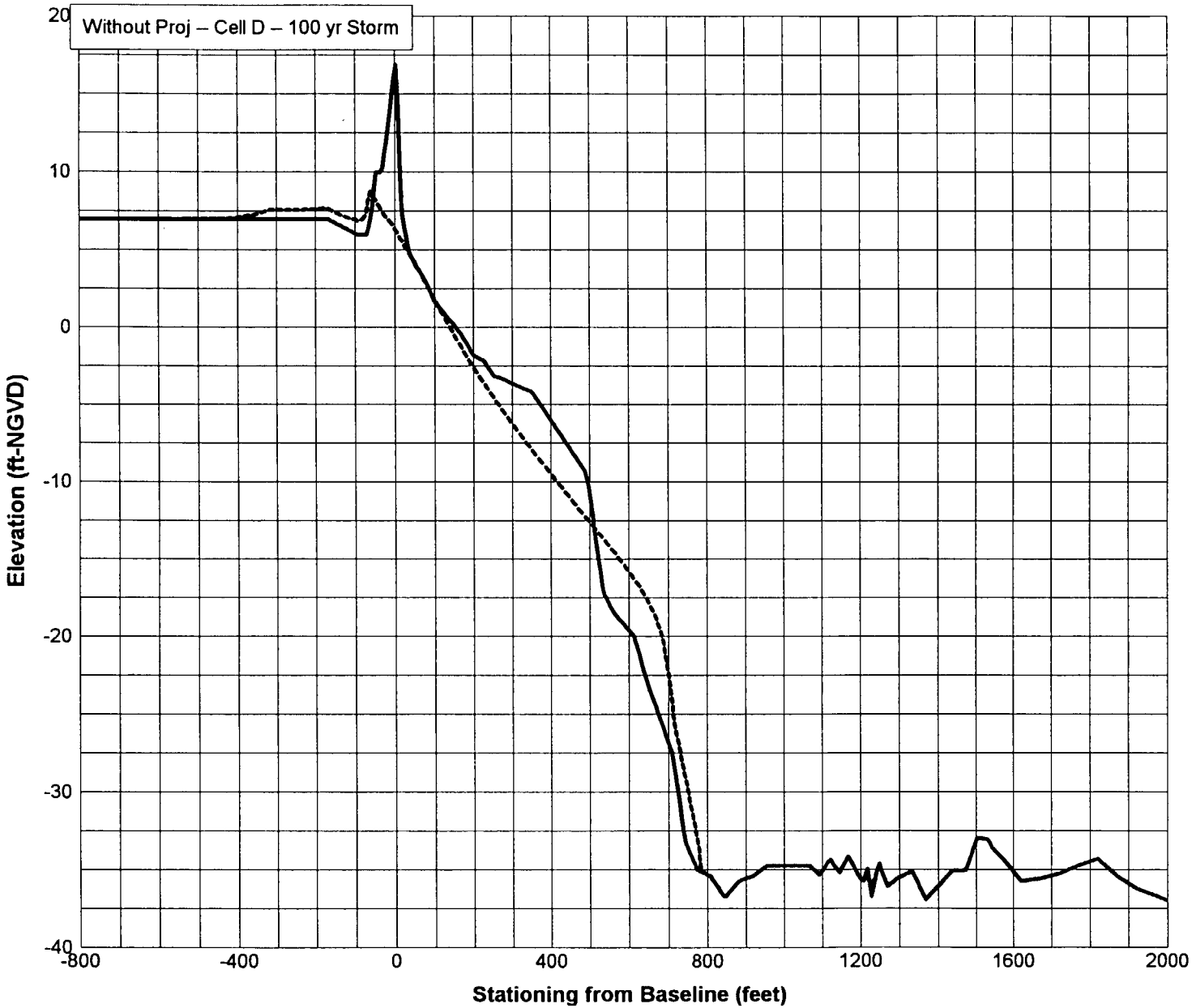
LOWER CAPE MAY MEADOWS-CAPE MAY POINT
FEASIBILITY STUDY

Without Project - Cell D - 50 Yr
Erosion

FIGURE A.HWO.7.5

78



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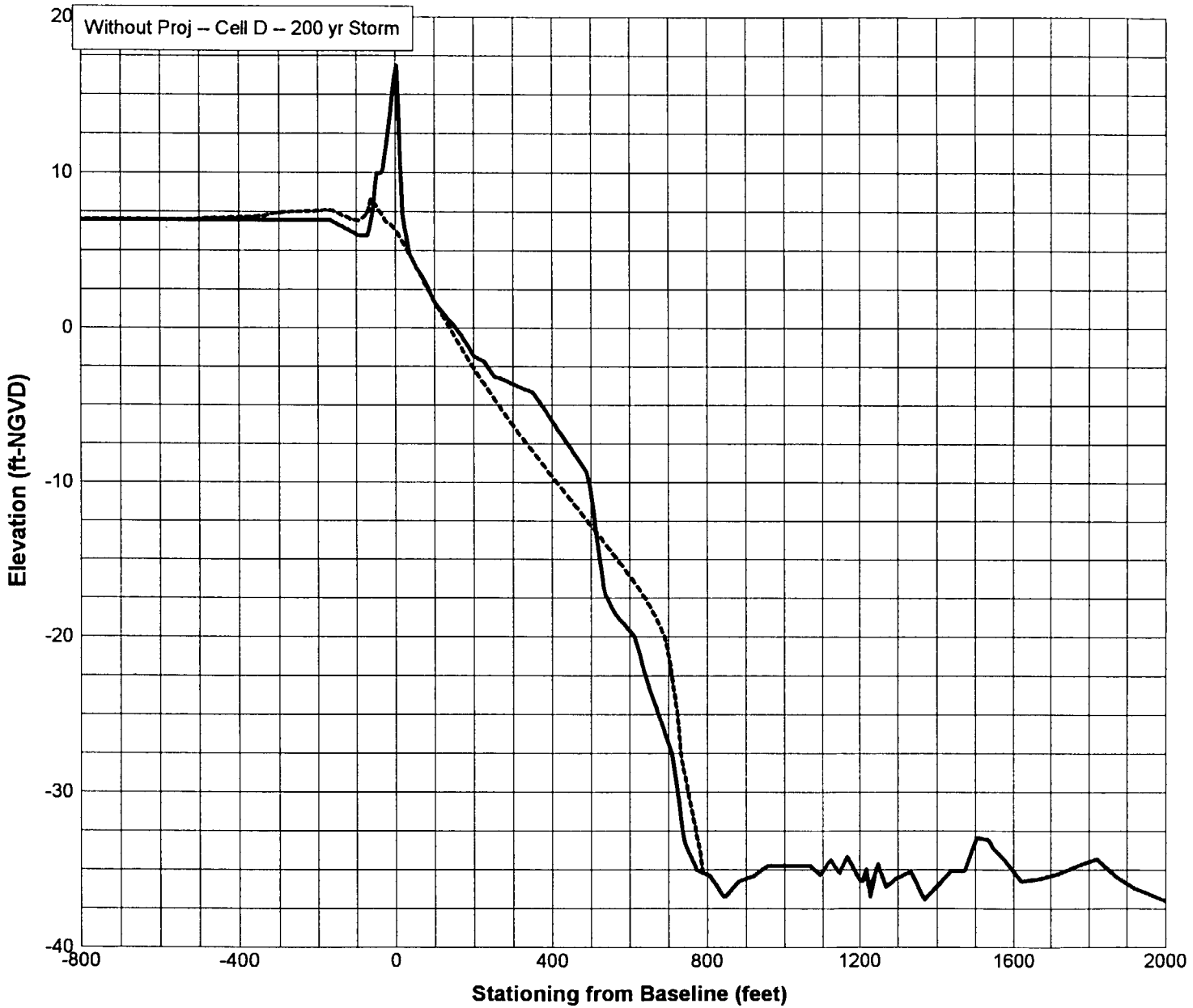
LOWER CAPE MAY MEADOWS-CAPE MAY POINT
FEASIBILITY STUDY

Without Project - Cell D - 100 Yr
Erosion

FIGURE A.HWO.7.6

79



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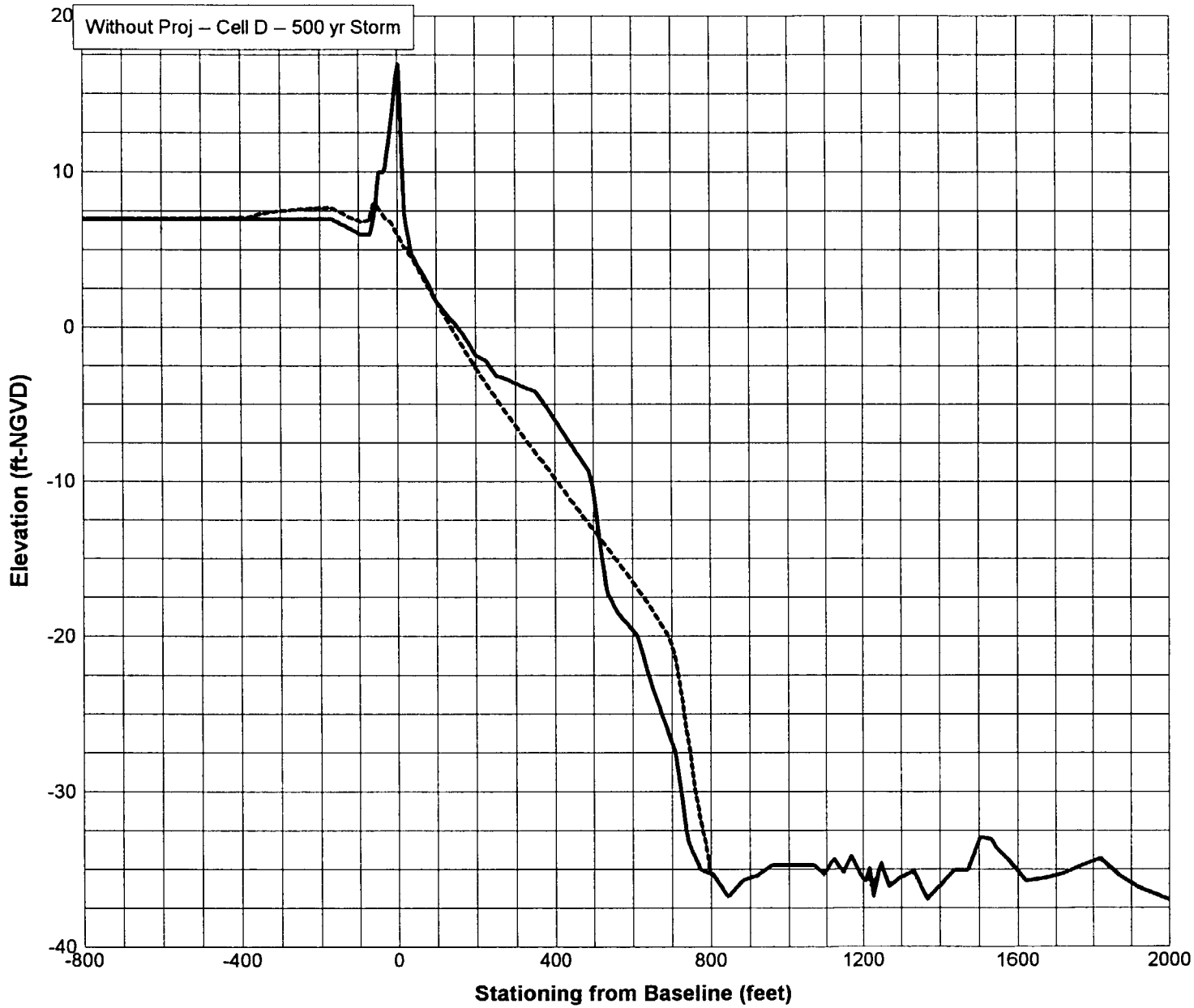
LOWER CAPE MAY MEADOWS-CAPE MAY POINT
FEASIBILITY STUDY

Without Project - Cell D - 200 Yr
Erosion

FIGURE A.HWO.7.7

80



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LOWER CAPE MAY MEADOWS-CAPE MAY POINT
FEASIBILITY STUDY

Without Project - Cell D - 500 Yr
Erosion

FIGURE A.HWQ.7.8

The limits of without project erosion, as measured from the baseline for all cells and for all frequency storms is provided as Table A.HWO.7.1.

Table A.HWO.7.1
Without Project
Erosion Distances (Feet)
(Measured from Baseline)

Cell	2yr	5yr	10yr	20yr	50yr	100yr	200yr	500yr
A	60	70	90	135	150	155	160	165
B	0	0	0	15	45	80	160	180
C	0	0	0	45	60	120	145	165
D	5	15	50	55	60	65	70	75
E	0	0	0	5	55	70	90	95
F	0	10	15	45	55	65	70	80

NOTES:

1. Distances are measured positive landward from the baseline.
2. Cell B was analyzed as a stone revetment.
   Cell C was analyzed as a stone revetment.
3. The baseline is set along the top of the frontal dune except for Cell A and B which recovered the baseline used in the Reconnaissance Study. Since the completion of the Reconnaissance Study the dune has eroded landward.
4. Distance to first structure in the cell:

Cell	Distance from Baseline (ft)
A	No structures in the cell
B	90
C	40
D	90
E	80
F	80

A.HWO.8 FLUVIAL HYDROLOGY OF STUDY AREA

A.HWO.8.1 PRECIPITATION

The viability of The Meadows ecosystem is ultimately dependent upon the amount and distribution of rain throughout the year. Accurate information of the area's precipitation is provided by a NOAA climatological and hourly precipitation station located at Cape May at coordinates 38-57N, 74-56W. The station has been in continuous operation since 1949. Data from this station was used to prepare the following summary tables.

Average annual rainfall is 40.7 inches per year, but the annual rainfall is highly variable ranging from a low of 29.2 inches in 1968 to a high of 54.9 inches in 1958. Annual rain totals for the period of record are provided in Table A.HWO.8.1.

Table A.HWO.8.1
Cape May Meadows
Annual Rainfall

Year	Total Annual Rainfall(in)	Year	Total Annual Rainfall(in)
1949	35.7	1971	44.2
1950	34.8	1972	52.7
1951	30.5*	1973	43.6
1952	40.7**	1974	33.7
1953	47.7	1975	46.2
1954	40.3	1976	37.5
1955	36.7	1977	37.2
1956	48.1	1978	41.6
1957	34.1	1979	52.5
1958	54.9	1980	36.2
1959	40.4	1981	35.0
1960	38.4	1982	37.3
1961	45.3	1983	47.5
1962	38.5	1984	43.8
1963	35.6	1985	44.3
1964	36.1	1986	32.1
1965	30.4	1987	33.0
1966	40.5	1988	37.3
1967	46.4	1989	52.0
1968	29.2	1990	40.9
1969	40.3	1991	40.2
1970	37.0	1992	38.7
		1993	41.3

* Data for December is missing.

** Data for January and February are missing.

The average monthly precipitation is fairly uniform over the year ranging from a low of 3.0 inches for February to high of 4.2 inches for August. A monthly rain summary is provided as Table A.HWO.8.2.

Table A.HWO.8.2
Cape May Meadows
Monthly Rain Summary
(1949-1993)

	Maximum (inches)	Minimum (inches)	Average (inches)
Jan	7.30	0.40	3.26
Feb	6.01	0.94	3.01
Mar	8.39	1.36	3.99
Apr	8.25	0.57	3.42
May	8.02	0.18	3.33
Jun	7.47	0.13	3.01
Jul	10.52	0.52	3.41
Aug	11.62	0.56	4.23
Sep	7.52	0.17	3.18
Oct	7.13	0.25	3.11
Nov	9.20	0.69	3.46
Dec	10.40	0.50	3.36

However, there is a great deal of variability in the monthly rain totals from year to year as indicated by the large difference between the monthly maximum and minimum totals. A distribution of monthly rain totals for the 45 year period of record is provided in Table A.HWO.8.3. A further characterization of the period of record rainfall is provided by Table A.HWO.8.4 which is a breakdown by month of the daily rain totals.

For any particular rain event it is impossible to predict with any certainty the percent of rain which runs off directly, the percent intercepted by vegetation and the percent reaching the groundwater table. However, the USGS as part of the study entitled "Ground-Water Hydrology and Simulation of Saltwater Encroachment, Shallow Aquifer System of Southern Cape May County, New Jersey" Water-Resources Investigations Report 91-4191 has estimated that on an annual basis 55% of the rain is accounted for as evapotranspiration, leaving 45% of the rain as direct runoff or groundwater recharge. Of this rainfall it is difficult to predict the percentage which runs off directly into The Meadows and that portion which reaches The Meadows as ground water. However, considering the low relief of the basin and the absorptive capacity of the soils (The majority of the soils throughout the basin are classified as SCS hydrologic soil group B - defined as soils having moderate infiltration rates when thoroughly wetted.) it is likely that for the majority of rain events a large percentage will reach The Meadows as ground-water.

Table A.HWO.8.3
Monthly Rain Totals
For Period 1949-1993

Monthly Rain Total(in)	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Missing Years	3	2	0	1	0	0	0	1	1	2	3	2
0.0-0.5	1	0	0	0	3	3	0	0	2	1	0	0
0.5-1.0	1	1	0	2	1	2	6	2	3	3	2	3
1.0-1.5	3	4	2	3	1	4	3	3	4	2	5	4
1.5-2.0	1	5	4	4	6	5	4	2	0	6	5	3
2.0-2.5	3	2	5	1	4	6	5	7	9	5	4	3
2.5-3.0	11	9	3	9	5	7	3	5	5	8	2	8
3.0-3.5	9	9	3	7	5	4	5	3	2	6	7	3
3.5-4.0	4	6	8	5	5	1	5	2	2	1	1	7
4.0-4.5	2	4	6	3	5	4	3	3	5	4	3	4
4.5-5.0	1	0	2	3	2	3	0	4	5	2	4	1
5.0-5.5	2	0	3	2	3	2	4	4	2	0	3	1
5.5-6.0	1	2	3	1	2	1	1	1	1	2	3	1
6.0-6.5	1	1	1	2	0	0	2	2	2	2	2	2
6.5-7.0	1	0	1	1	1	1	1	1	1	0	0	1

Table A.HWO.8.3
(continued)

Monthly Rain Total(in)	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
7.0-7.5	1	0	3	0	1	2	1	1	0	1	0	1
7.5-8.0	0	0	0	0	0	0	0	1	1	0	0	0
8.0-8.5	0	0	1	1	1	0	0	0	0	0	0	0
8.5-9.0	0	0	0	0	0	0	1	0	0	0	0	0
9.0-9.5	0	0	0	0	0	0	0	0	0	0	1	0
9.5-10.0	0	0	0	0	0	0	0	0	0	0	0	0
10.0-10.5	0	0	0	0	0	0	0	1	0	0	0	1
10.5-11.0	0	0	0	0	0	0	1	0	0	0	0	0
11.0-11.5	0	0	0	0	0	0	0	1	0	0	0	0
11.5-12.0	0	0	0	0	0	0	0	1	0	0	0	0

Table A.HWO.8.4
Cape May Meadows
24 Hour Rainfall Distribution For Period 1949-1993

Daily Rain (inches)	Number of Days											
	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
0.0	995	888	1048	980	1069	1075	1104	1103	1126	1143	1041	1092
0.0-0.2	116	128	106	135	111	109	101	89	85	81	91	89
0.2-0.4	66	84	77	68	78	56	63	55	56	60	63	65
0.4-0.6	40	35	58	56	49	39	38	50	37	36	50	43
0.6-0.8	30	27	26	26	27	17	20	21	22	14	24	34
0.8-1.0	21	23	26	21	25	17	17	15	13	16	17	22
1.0-2.0	32	24	41	27	28	29	33	37	29	37	36	35
2.0-3.0	0	0	6	3	3	5	8	12	8	4	6	2
3.0-4.0	0	0	1	0	1	1	2	4	2	2	2	0
4.0-5.0	0	0	0	0	0	1	0	2	0	0	0	0
5.0-6.0	0	0	0	0	0	0	0	0	0	0	0	0
6.0-7.0	0	0	0	0	0	0	0	0	1	0	0	1
7.0-8.0	0	0	0	0	0	0	0	0	0	0	0	0
8.0-9.0	0	0	0	0	0	0	0	1	0	0	0	0

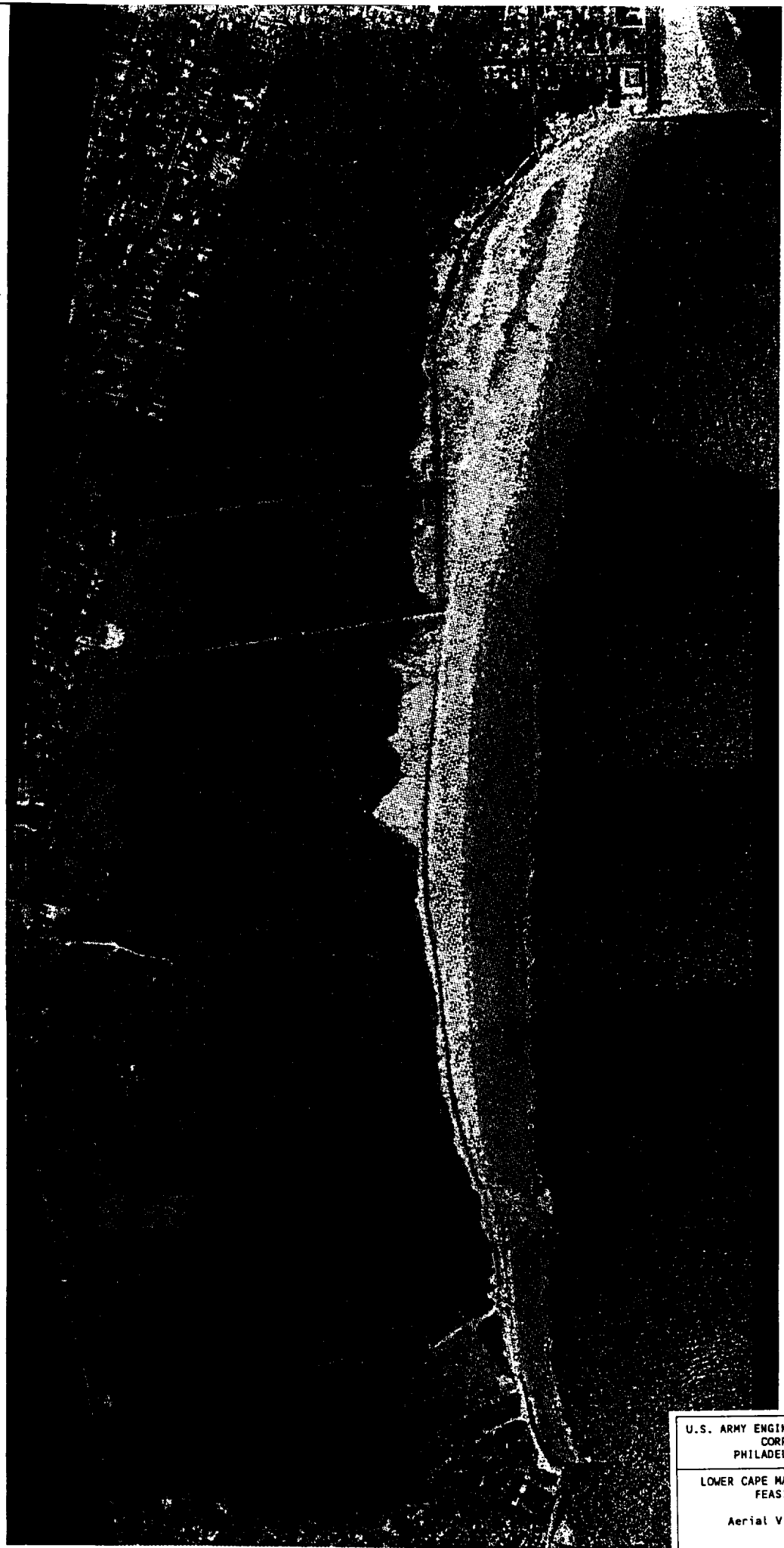
Table A.HWO.8.4
(continued)

Total Rainfall (inches)	139.3	131.1	184.3	147.0	153.4	138.4	153.8	195.6	147.9	140.8	161.1	157.5
Total # of Days	1300	1202	1389	1316	1391	1349	1386	1389	1379	1393	1330	1383
Average Daily Rainfall (inches)	0.11	0.11	0.13	0.11	0.11	0.10	0.11	0.14	0.11	0.10	0.12	0.11

A.HWO.8.2 THE MEADOWS

The Lower Cape May Meadows area is predicted to have an area of 333 acres at the year 2000. It is bounded by Broadway Ave on the east, Lighthouse Ave on the west and Sunset Boulevard and Seagrove Ave on the North and the Atlantic Ocean on the South. An aerial view of the site is provided as Figure A.HWO.8.1. Ownership of The Meadows is divided between the State Park at 153 acres and the Nature Conservancy at 180 acres (Year 2000). Interior drainage patterns within The Meadows follow a general West to East direction proceeding from the State Park at an average ground elevation of 5 ft-NGVD towards the Nature Conservancy property with an average ground elevation of 1.5 ft-NGVD. (Elevations referenced to NAVD88 datum are obtained by subtracting 1.27 feet from the NGVD29 elevations.) Flow velocities are extremely low due to the small hydraulic gradient and the low relief of the area. At the downstream end of the Conservancy's property the outflow from The Meadows enters Cape Island Creek as an open channel which quickly transitions into a 5 ft diameter concrete pipe at Broadway Avenue. The pipe extends for 2000 ft emptying into the tidally influenced channel of Cape Island Creek which continues for 8000 feet discharging into Cape May Harbor. A plan view of the site is provided as Figure A.HWO.8.2. The topography of the site is provided on Figure A.HWO.8.3. Also included on this figure is a subbasin delineation. Incremental and cumulative drainage areas are provided for various points throughout The Meadows. The 832 acre drainage area (year 2000) at the downstream limit of The Meadows, is divided between 499 acres of residential development and 333 acres of natural preserve.

The topographic map of 1993 is lacking in bathymetric information. This data gap was rectified with a series of 29 cross sections surveyed in May 1996 with Differential Global Positioning Surveying (DGPS). The purpose of these lines was to define the pond and channel bottoms, and to provide the information necessary to formulate improvements to the flow patterns. The location and extent of these cross-section lines is shown on Figure A.HWO.8.4. An average pond elevation for each line was determined and is noted. Locations of adverse channel slopes are apparent. A representative interior survey line is provided as Figure A.HWO.8.5. With both the topography and bathymetry defined, desired pond depths can be optimally obtained by comparing the costs of raising the water surface with control structures versus lowering the pond bottoms by excavation or some combination of the two.



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LOWER CAPE MAY MEADOWS-CAPE MAY POINT
FEASIBILITY STUDY

Aerial View of Cape May Meadows

FIGURE A.HWO.8.1

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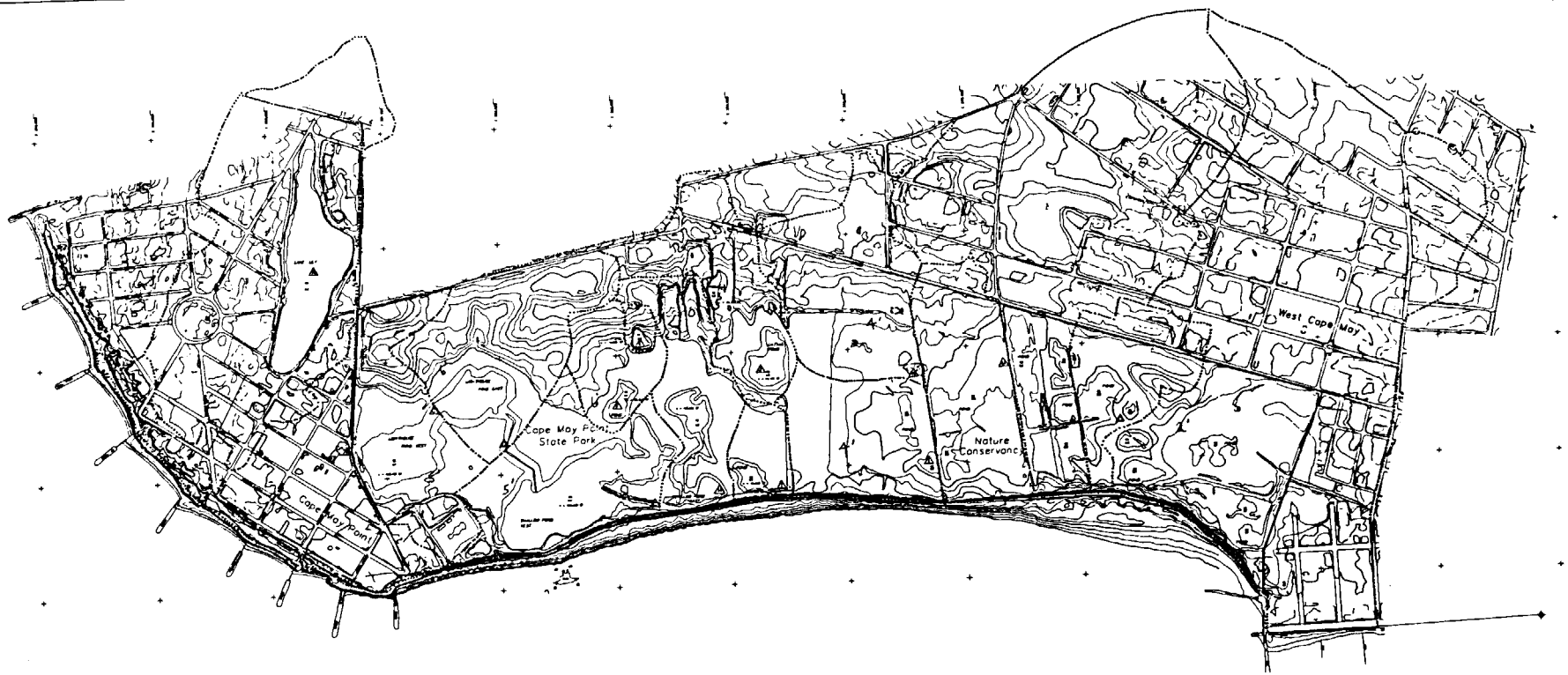
LOWER CAPE MAY MEADOWS-CAPE MAY POINT
FEASIBILITY STUDY

Plan View - Cape May Point to Cape May Harbor

FIGURE A.NWO.8.2



DRAINAGE POINT	INCREMENTAL DRAINAGE AREA (ACRES)	TOTAL DRAINAGE AREA (ACRES)
A	113.1	113.1
B	52.7	165.8
C	36.4	202.2
D	44.1	246.3
E	2.3	
F	14.1	
G	40.2	302.8
H	27.1	329.9
I	6.2	336.1
J	32.3	
K	41.4	
L	99.9	442.3
M	30.9	
N	144.3	621.5
O	24.6	646.1
P	206.1	891.2

DRAINAGE SUBBASIN

200 100 0 200 400

SCALE 1" = 200'
CONTOUR INTERVAL 2'
DATE OF PHOTOGRAPHY 3-7-93
N.J. STATE PLANE NAD 83
VERTICAL DATUM NGVD 29

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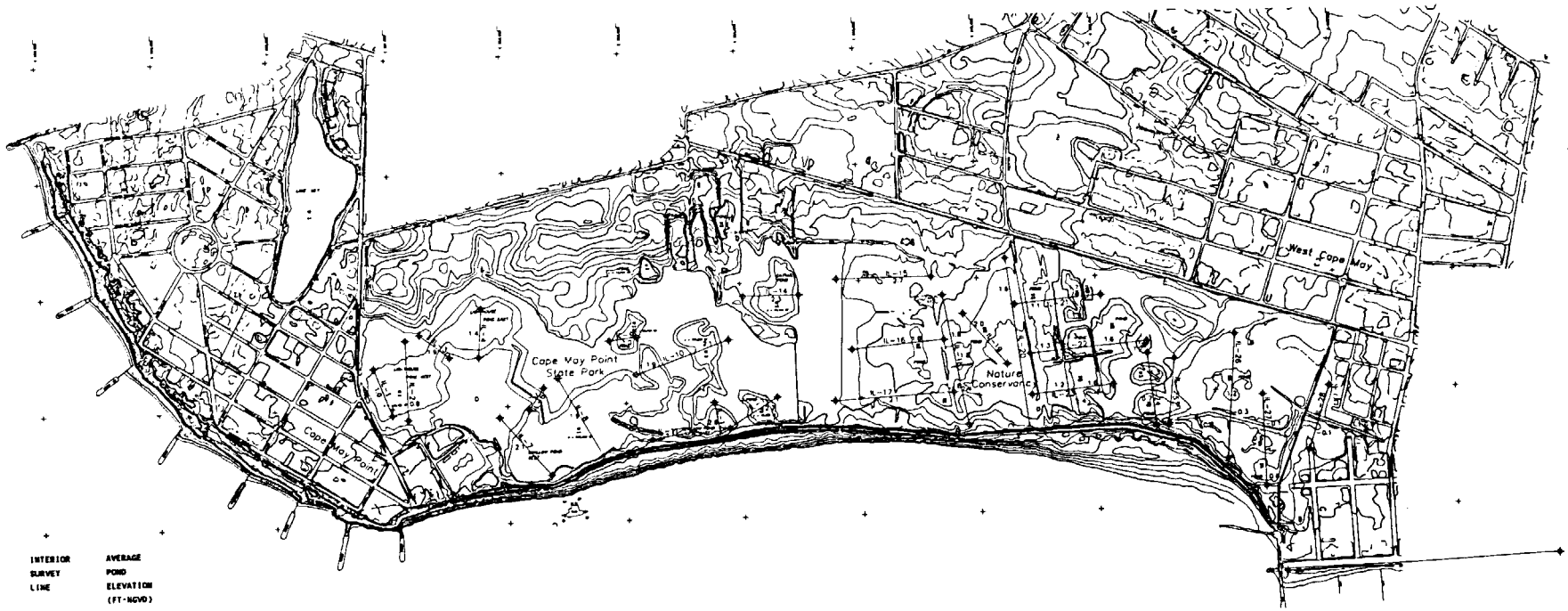
LOWER CAPE MAY MEADOWS-CAPE MAY POINT
FEASIBILITY STUDY

Site Topography and Subbasin Delineation

FIGURE A.HWO.8.3



INTERIOR SURVEY LINE	AVERAGE POND ELEVATION (FT-NGVD)
IL-1	1.0
IL-2	0.8
IL-3	1.9
IL-4	1.4
IL-6	3.3
IL-7	2.1
IL-8	1.9
IL-9	3.0
IL-10	2.1; 1.9
IL-11	--
IL-12	2.8
IL-13	2.7
IL-14	2.3
IL-15	2.7
IL-16	1.6
IL-17	2.1
IL-18	1.8; 1.8; 2.4
IL-19	2.0
IL-20	1.6
IL-21	1.9; 1.7; 1.1
IL-22	1.6; 1.3; 0.8; 1.3
IL-23	1.4; 1.6; 1.2
IL-24	1.2; 1.3; 0.7
IL-25	1.2
IL-26	1.2; -0.3
IL-27	-0.1; 0.6; 0.6
IL-28	-0.1
IL-29	0.6

200 100 0 200 400

SCALE 1" = 200'
CONTOUR INTERVAL 2'
DATE OF PHOTOGRAPHY 3-7-83
N.J. STATE PLANE NAD 83
VERTICAL DATUM NGVD 29

1.6 — AVERAGE POND ELEVATION
IL-16 — WETLANDS SURVEY LINE

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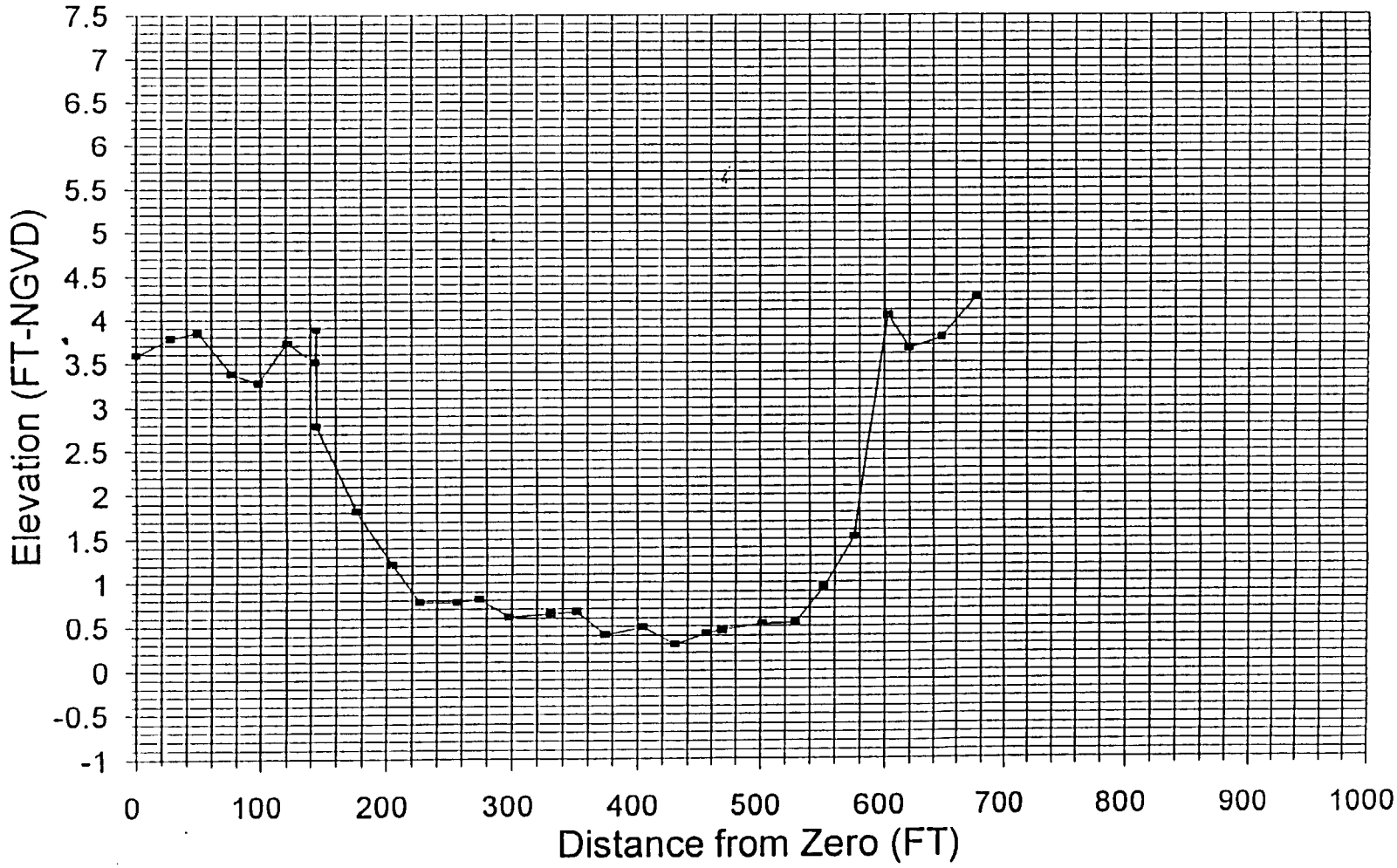
LOWER CAPE MAY MEADOWS-CAPE MAY POINT
FEASIBILITY STUDY

Interior Cross-section Location

FIGURE A.MWO.8.4

Cape May Meadows IL-2



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LOWER CAPE MAY MEADOWS-CAPE MAY POINT
FEASIBILITY STUDY

Representative Interior Cross-section Line

FIGURE A.HWO.8.5

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A.HWO.8.2.1 DRAINAGE STRUCTURES

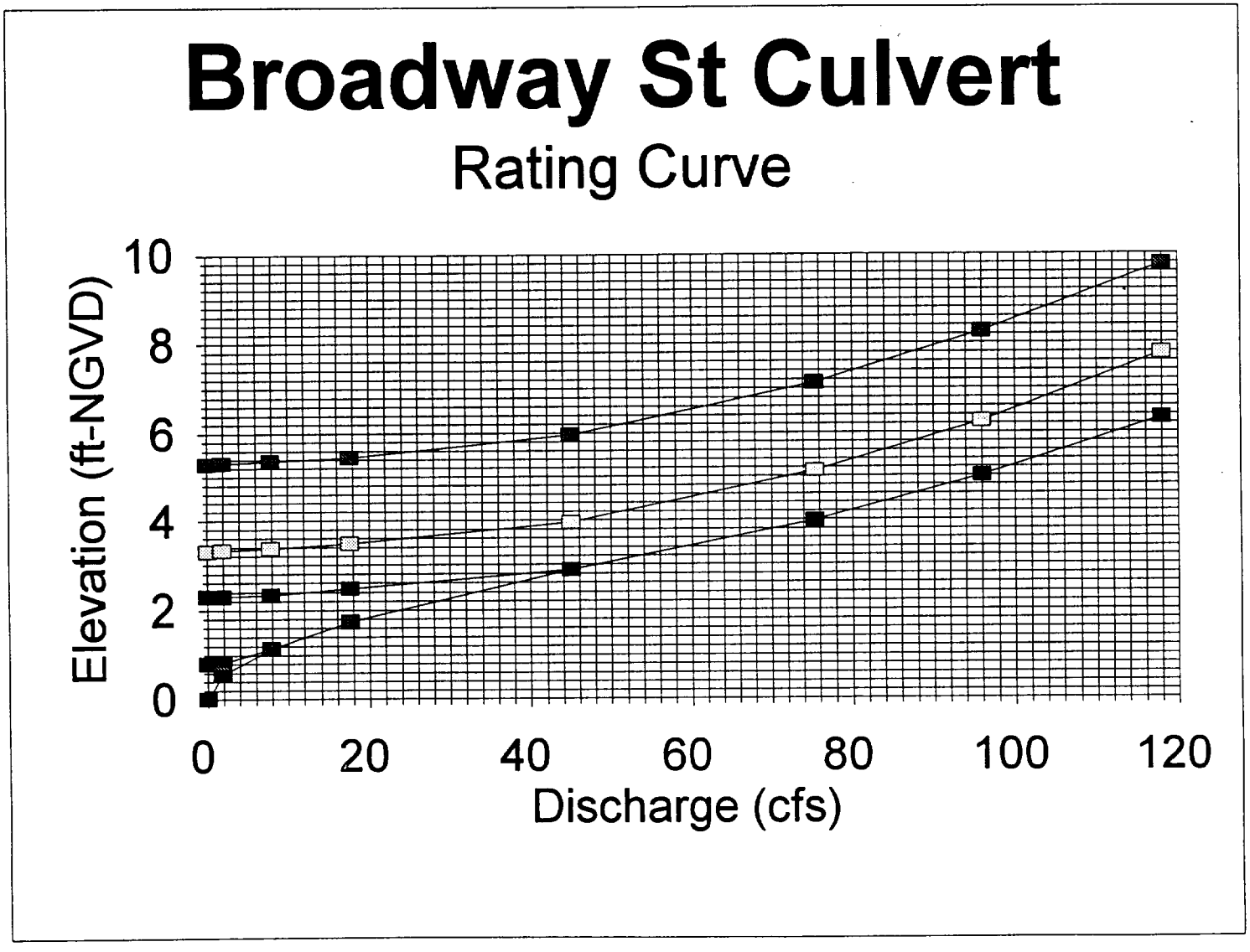
There are three notable drainage structures relevant to an understanding of the drainage patterns of The Meadows: Broadway Street Culvert, Drainage East and Drainage West.

Broadway Street Culvert:

The Meadows ends as a small open channel approximately 10 ft wide, and 700 feet long which terminates as a 5 ft diameter concrete pipe at Broadway Avenue. This pipe extends approximately 2000 ft ending at West Perry Street (a continuation of Sunset Blvd). The outfall is fitted with a flap gate. This pipe was installed by the County of Cape May in 1987 and replaces a corrugated metal pipe which had deteriorated. The inverts of the pipe at the entrance and exit are 0.0 and -2.2 ft-NGVD respectively. The tidal range at West Perry St is -1.6 to +2.5 ft-NGVD. A pipe and flap gate has existed at this location since 1927, but in the years immediately prior to 1987 the tide was bypassing the flapgate, and salt water was reaching the lower reaches of the Nature Conservancy property. Since 1987, the flap gate has worked as designed and the Meadows is a freshwater ecosystem except for those occasions of dune overtopping. Interviews with locals indicate that the maximum rain induced rise of water surface in the lower reaches of The Meadows is 1 ft. With a normal water surface elevation of 1.0 ft-NGVD in the lower portion of The Meadows this is consistent with the recent survey of the fluvial high water mark of 1.8 ft-NGVD. An outlet spoked rating curve for the pipe has been generated and is provided as Figure A.HWO.8.6. Residents have complained of odor problems during hot summer months on occasions of limited rainfall. The problem arises because the ground is not properly graded resulting in pockets of ponded water which stagnate. Some locals have suggested periodic lifting of the flap gate to allow a tidal flushing during extended periods of zero rainfall.

Drainage East:

During the March 1992 northeaster, the dune fronting The Meadows breached, resulting in the blockage of the main drainage ditch. This blockage interfered with the normal drainage from Cape May Point and resulted in the inundation of a portion of Lighthouse Ave for months. To rectify this problem Cape May Point installed an outfall structure from Shallow Pond West to the ocean in the vicinity of the abandoned military bunker. This structure consists of a 300 foot long 2 foot diameter ductile iron pipe through the dune, with a concrete inlet drop structure. The inlet is screened, 3 feet long, 1.5 ft high with an invert of 3.5 ft-NGVD. There is a 1.0 ft drop to the pipe which then slopes uniformly to the exit at an elevation of 1.9 ft-NGVD. The outfall is fitted with a backflow preventer. Between a headwater of 3.5 to 5.0 ft-NGVD for a normal ocean range the capacity of this outfall is approximately 10 cfs. A capacity rating for this structure is provided as Figure A.HWO.8.7. Historically, rain induced surcharges of Lighthouse Pond as reported by the locals have not exceeded 1 foot.



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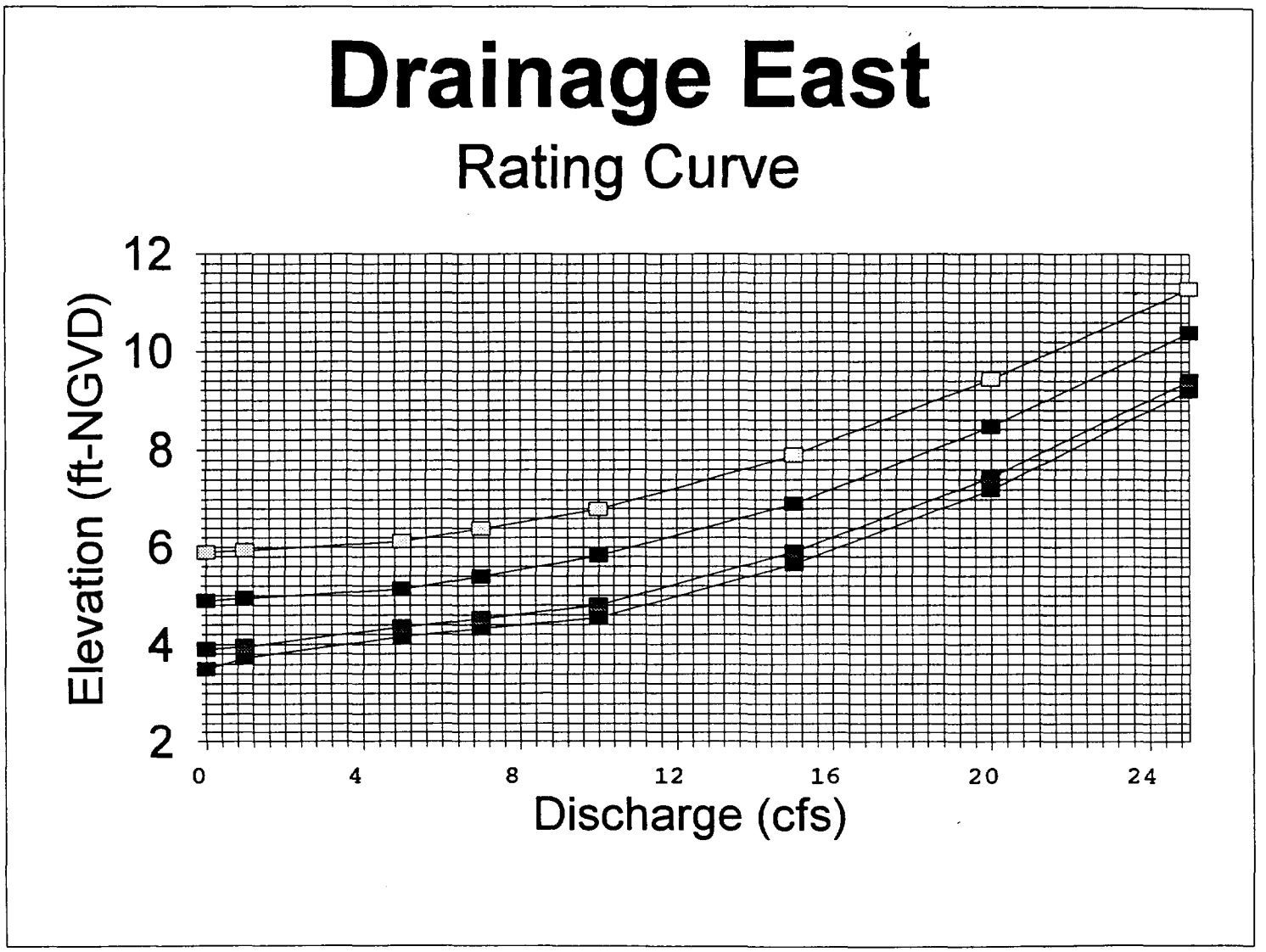
LOWER CAPE MAY MEADOWS-CAPE MAY POINT
FEASIBILITY STUDY

Rating Curve of Broadway St Culvert

FIGURE A.HWO.8.6



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LOWER CAPE MAY MEADOWS-CAPE MAY POINT
FEASIBILITY STUDY

Rating Curve of Drainage East

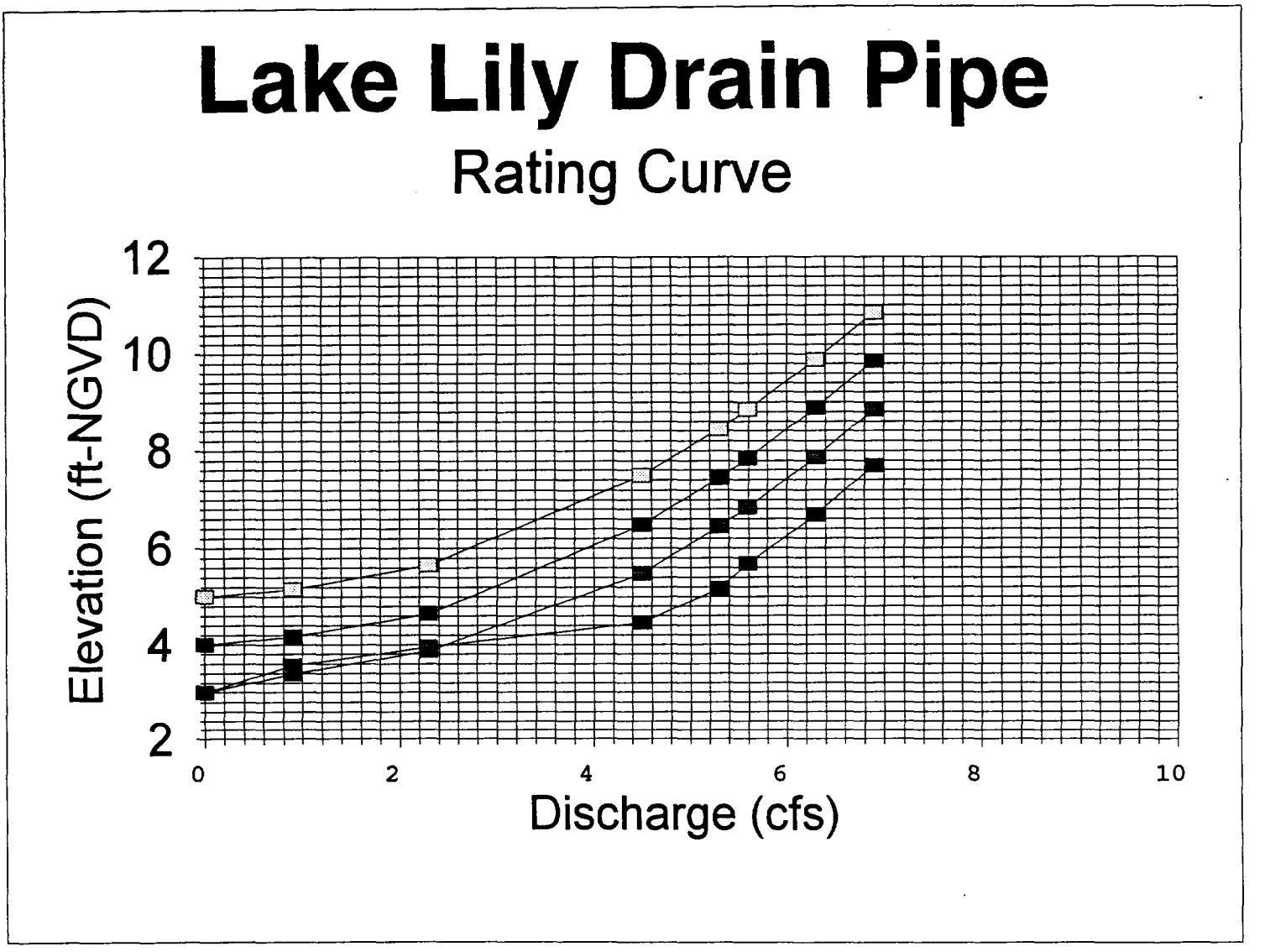
FIGURE A.HWO.8.7

Drainage West:

Lake Lily located in the middle of Cape May Point is a fresh water lake fed by groundwater and storm runoff from the surrounding 113 acres of residential development. Lake Lily drains to Lighthouse Pond West through a 1200 ft long 18 inch cast iron pipe. A spoked rating curve is provided as Figure A.HWO.8.8. This pipe has a limited capacity of approximately 3 cfs for a normal range of headwaters and tailwaters. The borough is in the process of preparing plans and specifications for a drainage improvement called "Drainage West". This plan calls for the installation of a 15 cfs capacity pump at the Northern end of the lake with a connection to an existing but abandoned pipe under Sunset Blvd draining to the Delaware Bay. The plan calls for the activation of the pump whenever the elevation of Lake Lily exceeds 4.5 ft-NGVD. At elevations greater than 4.5 ft-NGVD, surrounding storm drains are filled with standing water and nuisance ponding occurs on some street intersections. The runoff pumped to the bay will be fresh water lost to The Meadows ecosystem. However, on an annual basis the loss is conservatively estimated to be 7 percent of the annual runoff. This estimate is based on the fact that the volume between the normal lake elevation of 3.5 ft-NGVD and the pump trigger elevation of 4.5 ft-NGVD is 15 acre-ft. This requires 1.6 inches of runoff from the surrounding 113 acres of drainage area. Yet examination of precipitation data in Table A.HWO.8.4 indicates that over the period of record, a total of 133.7 inches of rain or 7% out of a period of record total of 1850.2 inches occurred after the 1.6 inch threshold was reached. The analysis was also performed for the growing season of May to September, and for the period of record only 10.6% of the rainfall exceeds the 1.6 inch threshold. The actual percentage of freshwater diverted is smaller because the analysis was based on rainfall, not the direct runoff which fills Lake Lily. The analysis also does not consider the fact that when the level of Lake Lily is greater than 4.5 ft-NGVD only 83% of the volume above that elevation will be pumped with the remainder draining to Lighthouse Pond West. Based on this operating plan Drainage West will be used infrequently and will not seriously diminish the annual freshwater runoff volume from Cape May Point to The Meadows. However, there are indications that this plan will not be implemented by the base year due to funding problems and hence Drainage West was excluded from the hydrologic analysis.

A.HWO.8.3 HYDROLOGIC MODELING

A hydrologic model of The Meadows' watershed has been developed. The model was used to assess the advisability of and limits to water level adjustment of the ponds. Raising of the water levels during the hot summer months has environmental benefits by reducing the risk of the ponds drying out during an extended period of hot and dry weather. However higher initial pond elevations also increase the risk of flood damage from an intense rainfall event, in conjunction with the elevated pond water levels. The hydrologic model was used to assess the effect of the initial pond elevations on the risk of obtaining damaging water levels during a severe rain event.



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LOWER CAPE MAY MEADOWS-CAPE MAY POINT
FEASIBILITY STUDY

Rating Curve of Lake Lilly Drain Pipe

FIGURE A.HWO.8.8

The drainage area has been divided into 16 subbasins and The Meadows has been divided into 3 hydrologic segments as shown on Figure A.HWO.8.3. Flow generally starts at Cape May Point and flows east through The Meadows to the Cape Island Creek culvert. However, there is substantial lateral inflow to The Meadows from the northern subbasins. The runoff response of each subbasin was quantified with the Soil Conservation Service (SCS) dimensionless unit hydrograph and loss rate function. Time of concentration and curve numbers for each basin are provided in Table A.HWO.8.5.

The time of concentration is the sum of shallow and concentrated flow travel time only, since there are no defined open channels. Antecedent Moisture Condition III (AMC III) was selected since it produces the greatest volume of runoff and provides the most conservative assessment of flooding impacts due to changes in pond starting water levels. The percent imperviousness of each subbasin was accounted for and for those subbasins with large bodies of water the curve number was weighted to reflect zero losses from the open water portion.

For each precipitation event the runoff hydrographs of each subbasin were determined and routed through the storage of The Meadows. The Meadows was divided into 3 hydrologic segments based on common ground elevations and the historic water level response of individual ponds acting as a unit. The limits of the 3 hydrologic segments are shown in Figure A.HWO.8.3. The elevation-capacity data for each segment and also for Lake Lily is provided as Table A.HWO.8.6.

Table A.HWO.8.5
Without Project
Subbasin Parameters for
Hydrologic Model

Sub-basin	Drainage Area (acres)	Time of Concentration (hours)	Curve Number* AMC III
A	113.1	0.42	77
B	52.7	0.62	78
C	36.4	0.76	58
D	44.1	0.93	53
E	2.2	0.10	50
F	14.1	0.46	50
G	35.5	0.82	50
H	25.4	0.41	50
I	7.9	0.14	50
J	32.2	1.06	50
K	41.4	0.96	55
L	26.3	0.76	50
M	32.9	0.87	51
N	143.0	1.67	65
O	24.1	0.61	60
P	200.9	1.28	71

Note 1: The curve numbers are a composite weighting of pervious and impervious areas.

Note 2: Subbasin drainage areas reflect the predicted year 2000 shoreline

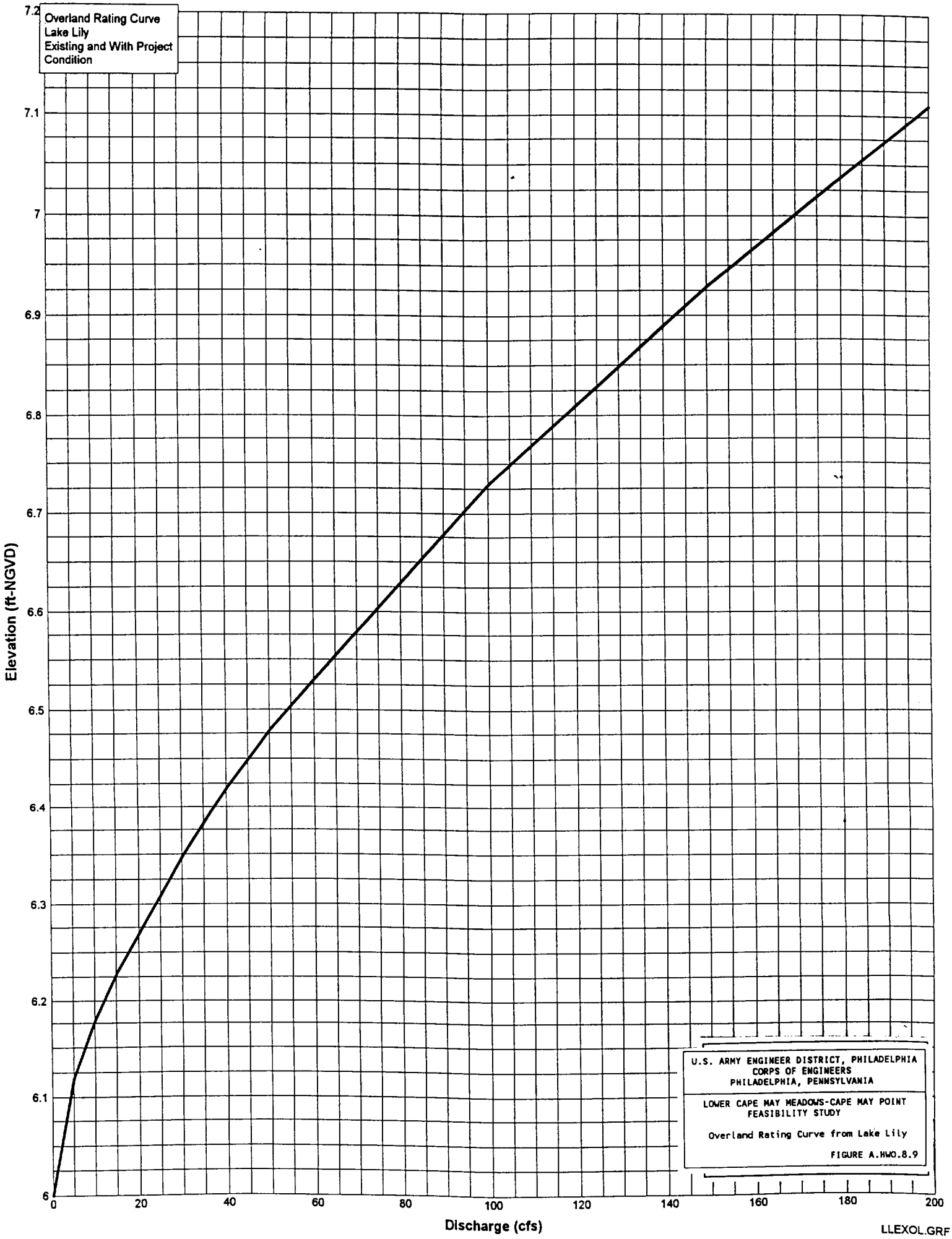
Table A.HWO.8.6
Interior Hydrologic Segments
Elevation-Capacity

	Storage Volume (acre-ft)			
Elevation (ft-NGVD)	Lake Lily	Hydrologic Segment 1	Hydrologic Segment 2	Hydrologic Segment 3
-0.3	NA	NA	NA	0.0
0.0	NA	NA	NA	1
0.5	NA	NA	NA	2
1.0	NA	0.0	0.0	3
1.5	NA	4	3	5
2.0	NA	8	11	21
2.5	NA	19	21	39
3.0	0.0*	31	39	56
3.5	6	44	70	78
4.0	13	57	102	99
4.5	20	71	142	124
5.0	27	91	182	149
5.5	35	120	---	---
6.0	42	166	---	---

Note: Storage capacity is based on year 2000 shoreline.
*The upstream invert of the pipe draining Lake Lily is elevation 3.0 ft-NGVD.

The inflow hydrographs were modified by the storage effects of each segment. Outflow from one segment to the next downstream segment was allowed. The outflow relationship for each segment was specified as a rating curve. The outflow from Lake Lily into segment 1 is approximately 3 cfs for a range of headwaters and tailwaters. When Lake Lily exceeds elevation 6.0 ft-NGVD it spills and flow towards The Meadows. An overland rating curve for Lake Lily is provided as Figure A.HWO.8.9. Segment 1 drains in two directions, directly to the ocean through drainage east and into hydrologic segment 2. The rating function for drainage east is provided as Figure A.HWO.8.7. Flow enters segment 2 as overland flow when the water level in segment 1 exceeds elevation 5.2 which is the ground elevation separating the two hydrologic segments. This overland flow rating curve is provided as Figure A.HWO.8.10. Segment 2 discharges into segment 3 when it's water level exceeds elevation 3.0 ft-NGVD, which is the elevation of the divide between the two segments. The rating curve is provided as Figure A.HWO.8.11. Segment 3 drains through the Broadway Ave culvert; its rating curve was previously provided as Figure A.HWO.8.6. The effect of daily tidal fluctuations of Cape Island Creek on the outfall of this culvert at West Perry Street is reflected in the rating.

For without project condition the 10 and 50 year rain events were analyzed. The 24 hour rain totals of 5.5 and 7.0 inches respectively were temporally distributed with an SCS type III distribution. The runoff volumes and peak flows for the hydrologic segments are provided in Table A.HWO.8.7. Water level hydrographs for Lake Lily and the three hydrologic segments were calculated under the assumption that the starting elevations for hydrologic segments 1, 2 and 3 were 3.5, 2.5 and 1.0 ft-NGVD respectively. Peak interior water surface elevations for the 10 and 50 year events are provided in Table A.HWO.8.8. Drainage West was not considered to be part of the base condition because of uncertainty of installation by the base year. In addition, its exclusion provides a conservative estimate of water levels in The Meadows and Lake Lily.


Overland Rating Curve
Lake Lily
Existing and With Project
Condition
Elevation (ft-NGVD)
7.2
7.1
7
6.9
6.8
6.7
6.6
6.5
6.4
6.3
6.2
6.1
6
0
20
40
60
80
100
120
140
160
180
200
Discharge (cfs)
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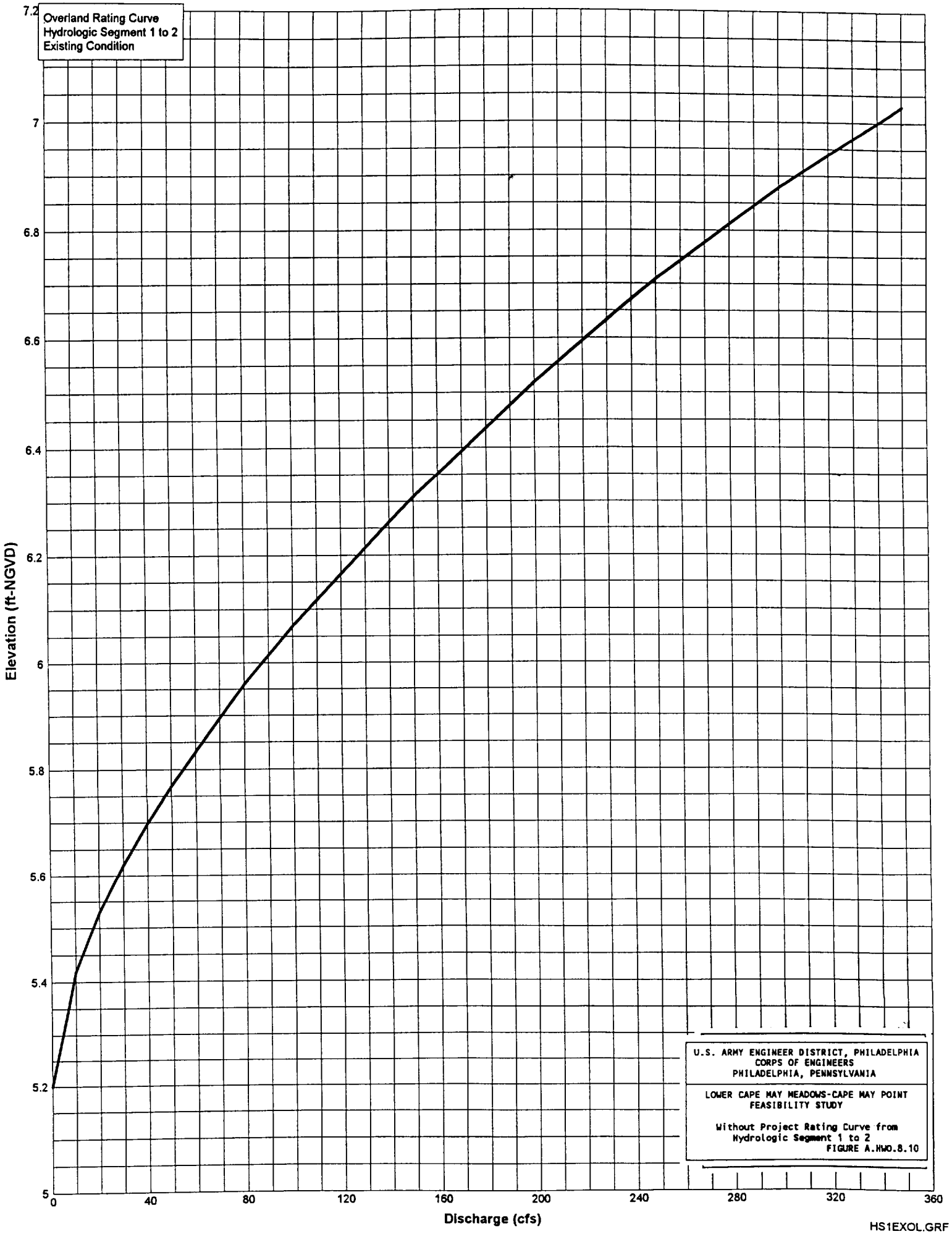
LOWER CAPE MAY MEADOWS-CAPE MAY POINT
FEASIBILITY STUDY
Overland Rating Curve from Lake Lily
FIGURE A.HWO.8.9
LLEXOL.GRF


Overland Rating Curve
Hydrologic Segment 1 to 2
Existing Condition
Elevation (ft-NGVD)
7.2
7
6.8
6.6
6.4
6.2
6
5.8
5.6
5.4
5.2
5
0
40
80
120
160
200
240
280
320
360
Discharge (cfs)
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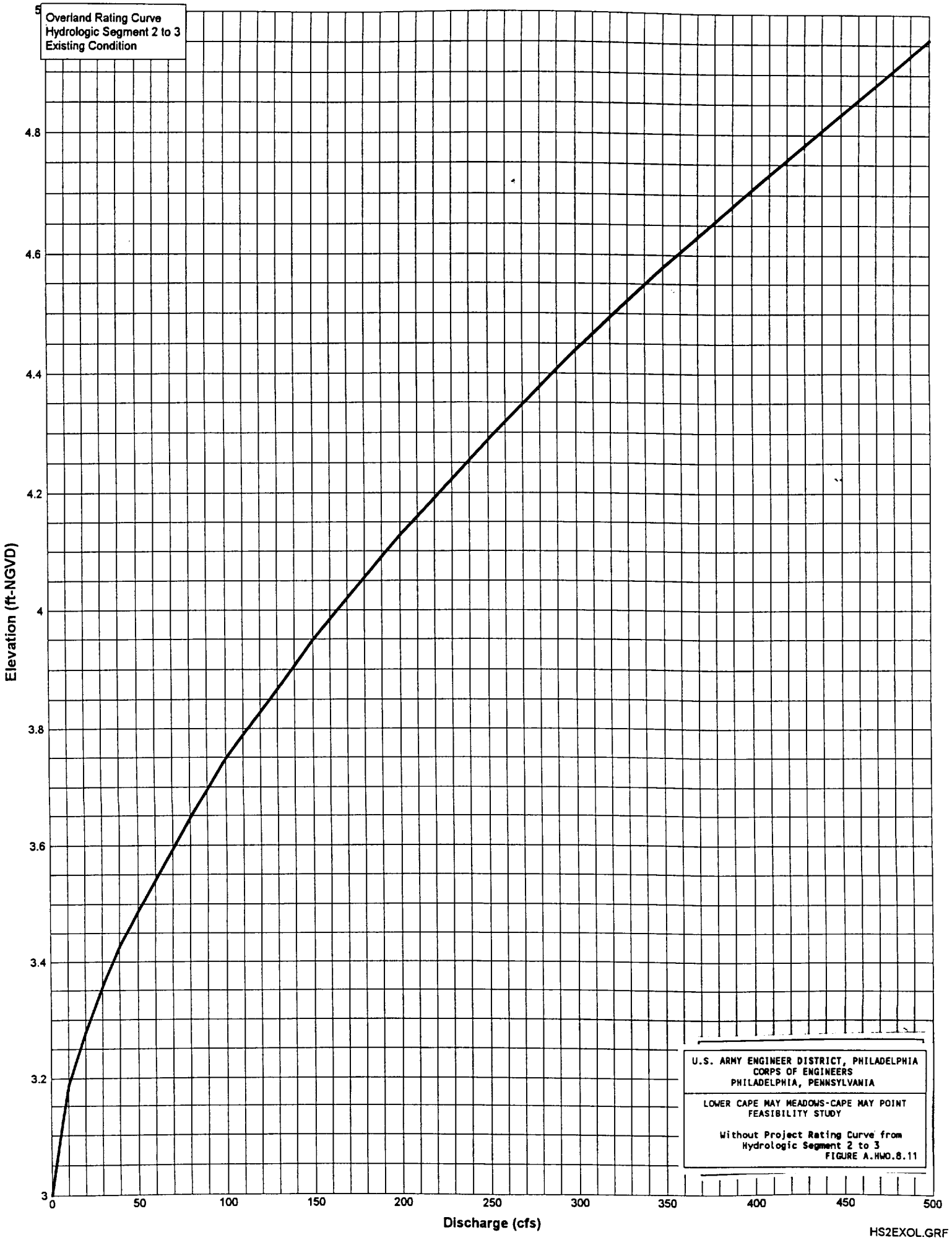
LOWER CAPE MAY MEADOWS-CAPE MAY POINT
FEASIBILITY STUDY
Without Project Rating Curve from
Hydrologic Segment 1 to 2
FIGURE A.HWO.8.10
HS1EXOL.GRF


Overland Rating Curve
Hydrologic Segment 2 to 3
Existing Condition
Elevation (ft-NGVD)
5
4.8
4.6
4.4
4.2
4
3.8
3.6
3.4
3.2
3
0
50
100
150
200
250
300
350
400
450
500
Discharge (cfs)
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LOWER CAPE MAY MEADOWS-CAPE MAY POINT
FEASIBILITY STUDY
Without Project Rating Curve from
Hydrologic Segment 2 to 3
FIGURE A.HWO.8.11

HS2EXOL.GRF

Table A.HWO.8.7
Without Project Hydrologic Modeling Results

Hydrologic Segment	Rain Event	Runoff Vol(in)	Runoff Vol(ac-ft)	Peak Runoff (cfs)
Lake Lily	10 yr	3.1	28.8	209
	50 yr	4.4	41.2	284
HS1	10 yr	1.6	28.5	141
	50 yr	2.5	45.5	225
HS2	10 yr	1.5	37.0	130
	50 yr	2.4	60.8	227
HS3	10 yr	2.5	41.9	160
	50 yr	3.7	62.3	244

Runoff is based on Antecedent Moisture Condition III.
Lake Lily consists of subbasin: A
HS1 consists of subbasins: B,C,D,E,F,G,H,I
HS2 consists of subbasins: J,K,L,M,N,O
HS3 consists of subbasins: P
Results correspond to the predicted 2000 year shoreline.
Runoff is incremental not cumulative.

Table A.HWO.8.8
Without Project
Interior Water Surface Elevations
for the 10 and 50 Year Rain Events

Segment	Elevation (ft-NGVD)	
	10 Year	50 Year
Lake Lily	5.5	6.2
Hydrologic Segment 1	4.9	5.4
Hydrologic Segment 2	3.3	3.4
Hydrologic Segment 3	2.6	3.2

Note: Results are based on a 24 hour storm under antecedent moisture condition III and initial pond elevations of:

Lake Lily and HS1 --- 3.5 ft-NGVD
HS2 --- 2.5 ft-NGVD
HS3 --- 1.0 ft-NGVD

Results correspond to the predicted year 2000 shoreline.

A.HWP WITH PROJECT HYDROLOGY AND HYDRAULICS

A.HWP.1 ANALYSIS APPROACH

The loss of habitat at Cape May Meadows is due to two causes: loss of acres from long term erosion and degradation of the habitat from frequent saltwater inundation of the weakened dune/berm system. The saltwater inundation incidentally causes flooding to the surrounding communities of West Cape May and Cape May Point. Plans of improvement consist of two broad categories here defined as exterior and interior. The exterior plans of improvement involve consideration of dune/berm strengthening while the interior plans of improvement involve the elimination and management of low value vegetation such as Phragmites and the restoration of flow between ponds blocked by past dune overwash. To ensure a manageable formulation matrix the exterior and interior plans were decoupled with the exterior plans of improvement considered first. Changes to the interior were considered after the exterior plan of improvement was selected. Plans of dune/berm improvement were initially formulated solely on environmental benefits although incidental NED benefits were determined. After the environmental plan was identified, consideration was given to enlarging the design based on the elimination of residual structural damage.

The order of the exterior plan formulation is outlined below:

1) Prevention of the loss of habitat due to long term erosion of The Meadows.
2) Optimization of a barrier to saltwater inundation based primarily on environmental benefits with secondary consideration given to structural damage reduction.
3) Consideration of alternate shoreline positions to restore acres of wetland eroded.
4) Consideration of various methods of reducing the cost of continuing construction, i.e. nourishment.

A.HWP.2 PREVENTION OF HABITAT LOSS DUE TO LONG TERM EROSION

As documented in the Without Project Hydrology and Hydraulics Appendix, the without project average annual acres not inundated are 144.5 acres. This value incorporates the loss of The Meadows through time due to the long term erosion rate of 15 ft/yr. Stabilizing the shoreline of The Meadows' cell at the base year through an offsetting program of periodic nourishment results in average annual acres not inundated of 179.2 acres. This value was determined by assuming the year 2000 elevation-capacity curve is applicable over the period 2000-2050, and the breaching and overtopping characteristics of Cell A are the same as without project condition at year 2000. The without project results for the year 2000 are reproduced as Table A.HWP.2.1. The relatively small increase in the average annual acres not inundated by saltwater indicates the need to reduce the frequency and magnitude of overtopping volumes through dune/berm strengthening.

Table A.HWP.2.1 With Project Frequency WSEL and Acres not Inundated by Salt Water for Stabilized Shoreline		
Event	WSEL (ft-NGVD)	Acres
2 yr	4.4	186
5 yr	5.8	84
10 yr	6.9	56
20 yr	7.4	48
50 yr	8.1	38
100 yr	9.1	29
200 yr	10.0	21
500 yr	11.3	9

Note 1: The results are based on the prevention of loss of acres from long term erosion. The dune/berm is not strengthened and overtopping and breaching characteristics of both The Meadows and Cape May Point cells are the same as without project, year 2000 condition.

Note 2: Elevations referenced to the NAVD88 datum are obtained by subtracting 1.27 feet from the NGVD29 elevations.

A.HWP.3 BARRIER TO SALTWATER INUNDATION

Inundation of The Meadows can be reduced/eliminated with a vertical barrier. A seawall and bulkhead were eliminated because of their obvious high cost and environmental incompatibility with shorebirds such as endangered piping plovers. The only viable vertical barrier is a dune/berm. Since berm width and dune height interact in complex ways in the reduction of wave overtopping and breaching, a sensitivity analysis consisting of 12 combinations of dunes and berms was run. Four dunes at elevations of 16,18,21 and 24 ft-NGVD were combined with three berms at widths of 110, 160 and 210 ft (measured from the landward side of the dune at elevation 8.0). Each trial template was placed on the base year dune of all cells which drain to The Meadows. These cells are A,B,C,D,E. The landward side of the existing dune at

elevation 8.0 was the match point for the trial templates. Table A.HWP.3.1 provides the dimensions for each of the 12 trials. The nourishment quantity was considered the same for all trials, hence it was not a factor in selecting amongst them.

Table A.HWP.3.1
Dimensions of 12 Trial Templates

Trial	Dune Crest Elevation (ft-NGVD)	Berm Width(ft) From Landward Toe of Dune (at el=8.0)	Berm Width(ft) From Ocean Toe of Dune (at el=8.0)
1	24	210	100
2	18	160	85
3	18	110	35
4	18	210	135
5	24	110	10
6	24	160	50
7	21	210	115
8	21	110	20
9	21	160	70
10	16	110	50
11	16	160	100
12	16	210	150

The 12 trial templates were placed on the Cape May Point cells since overtopping volumes from these cells drain to The Meadows . Placing the templates on just The Meadows cell would not provide a means to assess the incremental effectiveness of each in preventing

inundation of The Meadows because of the large volumes of saltwater reaching The Meadows via the Cape May Point cells. A level of protection for the Cape May Point cells independent of The Meadows was considered in a later phase of the optimization. The interior static frequency water surface elevations for each of the 12 designs were determined and were combined with the elevation-area curve of The Meadows for the year 2000 (Table A.HWO.5.4) to calculate the frequency acres not inundated. The frequency interior water surface elevations and acres not inundated are provided in Tables A.HWP.3.2 and A.HWP.3.3. At this stage of the analysis the damage from dynamic wave overtopping and breaching was not considered. These data were provided to Economics Branch which determined the annualized structural dollar damage and the acres not inundated by salt water. Combined with initial quantity and cost estimates it became apparent that the most effective trial templates were those with intermediate crest elevations of 18 or 21 ft-NGVD and relatively small berm widths of 20 and 50 feet. The next phase of study considered the performance of four dune/berm configurations applied to The Meadows and the Cape May Point Cells in various combinations. The 20 resultant designs are shown in Table A.HWP.3.4. The without project template for the Cape May Point cells was also included in order to determine the incremental environmental and monetary benefits of the various templates in reducing the overtopping and breaching volumes from Cape May Point.

Table A.HWP.3.2
Preliminary Analysis of Dune/Berm Templates
Frequency Interior Water Surface Elevation (ft-NGVD)

Event	Trial 1	Trial 2	Trial 3	Trial 4	Trial 5	Trial 6	Trial 7	Trial 8	Trial 9	Trial 10	Trial 11	Trial 12
2yr	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
5yr	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
10yr	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	6.3	1.0	1.0
20yr	1.0	1.0	7.3	1.0	1.0	1.0	1.0	1.0	1.0	7.4	6.9	1.0
50yr	1.0	8.1	8.1	7.3	1.0	1.0	1.0	7.9	1.0	8.1	8.1	8.1
100yr	1.0	9.1	9.1	9.1	8.9	1.0	1.0	9.1	8.9	9.1	9.1	9.1
200yr	1.0	10.0	10.0	10.0	10.0	8.4	10.0	10.0	10.0	10.0	10.0	10.0
500yr	11.3	11.3	11.3	11.3	11.3	11.3	11.3	11.3	11.3	11.3	11.3	11.3

Note: A water surface elevation of 1.0 indicates that there is no saltwater inundation. Some of the ponds have normal non-damaging freshwater elevations greater than 1.0 ft-NGVD.

Table A.HWP.3.3
Preliminary Analysis of Dune/Berm Templates
Frequency Interior Acres Not Inundated By Saltwater

Event	Trial 1	Trial 2	Trial 3	Trial 4	Trial 5	Trial 6	Trial 7	Trial 8	Trial 9	Trial 10	Trial 11	Trial 12
2yr	333	333	333	333	333	333	333	333	333	333	333	333
5yr	333	333	333	333	333	333	333	333	333	333	333	333
10yr	333	333	333	333	333	333	333	333	333	65	333	333
20yr	333	333	50	333	333	333	333	333	333	48	56	333
50yr	333	38	38	50	333	333	333	40	333	38	38	38
100yr	333	29	29	29	31	333	333	29	31	29	29	29
200yr	333	21	21	21	21	35	21	21	21	21	21	21
500yr	9	9	9	9	9	9	9	9	9	9	9	9

Note: Water surface elevations and acres not inundated based on year 2000 shoreline.

Table A.HWP.3.4
Description of 20 Designs
(dune height-berm width)

Design	Meadows	Cape May Point
1	21-50	21-50
2	21-50	without project
3	21-20	21-20
4	21-20	without project
5	21-50	21-20
6	21-20	21-50
7	18-50	18-50
8	18-50	without project
9	18-50	21-50
10	18-50	21-20
11	21-50	18-50
12	21-20	18-50
13	21-50	18-20
14	21-20	18-20
15	18-50	18-20
16	18-20	18-20
17	18-20	without project
18	18-20	21-50
19	18-20	21-20
20	18-20	18-50

NOTE 1) 21-50 is a dune with a crest elevation of 21 ft-NGVD, 25 ft wide, with landward slope of 1 on 3 and an ocean slope of 1 on 5. The berm is at elevation 8.0 ft-NGVD with a width of 50 ft measured from the ocean toe of the dune. The beach slopes at 1 on 25 from the berm to MLW and then replicates the natural offshore bathemetry shifted oceanward.

NOTE 2) Measured from the landward side of the dune, the berm widths at elevation 8.0 ft-NGVD for the three templates are:

Template	Berm Width (feet)
18-20	125
18-50	155
21-20	150
21-50	180

Design performance for the four templates of 21-50, 21-20, 18-50 and 18-20 is summarized in Table A.HWP.3.5. The overtopping volumes for each design are shown in Table A.HWP.3.6. Combined with the elevation-capacity curve for the year 2000, interior water surface elevations for overtopping events were determined. When a breach occurred the interior water surface elevation was set equal to the maximum ocean stillwater elevation.

Table A.HWP.3.5
With Project
Design Performance

Cell	Plan	2 yr	5 yr	10 yr	20 yr	50 yr	100 yr	200 yr	500 yr
Meadows									
	W/O	OT	OT	BR	BR	BR	BR	BR	BR
	21-50	--	--	--	--	--	--	OT	BR
	21-20	--	--	--	--	--	OT	OT	BR
	18-50	--	--	--	--	--	OT	BR	BR
	18-20	--	--	--	--	OT	BR	BR	BR
CM Point									
	W/O	--	OT	BR	BR	BR	BR	BR	BR
	21-50	--	--	--	--	--	--	OT	BR
	21-20	--	--	--	--	--	--	OT	BR
	18-50	--	--	--	--	--	OT	BR	BR
	18-20	--	--	--	--	OT	OT	BR	BR

Note: OT -- dune is overtopped
BR -- dune is breached

Table A.HWP.3.6
Design Overtopping Volumes (acre-ft)

Cell	Plan	2 yr	5 yr	10 yr	20 yr	50 yr	100 yr	200 yr	500 yr
Meadows									
	W/O	270	460	BR	BR	BR	BR	BR	BR
	21-50	--	--	--	--	--	--	1240	BR
	21-20	--	--	--	--	--	795	1465	BR
	18-50	--	--	--	--	--	1355	BR	BR
	18-20	--	--	--	--	1075	BR	BR	BR
CM Point									
	W/O	--	135	BR	BR	BR	BR	BR	BR
	21-50	--	--	--	--	--	--	140	BR
	21-20	--	--	--	--	--	--	200	BR
	18-50	--	--	--	--	--	155	BR	BR
	18-20	--	--	--	--	135	685	BR	BR

Note: OT -- dune is overtopped
BR -- dune is breached

The frequency interior water surface elevations and acres not inundated for each design are shown in Tables A.HWP.3.7 and A.HWP.3.8 respectively. During this phase of study COSTDAM control files were developed for the Cape May Point cells for the four design templates of 21-50, 21-20, 18-50 and 18-20 in order to assess the efficacy of the designs in reducing structural damage from dynamic wave overtopping and breaching. Inundation profiles of cells B, C, D and E for the four designs are provided on Tables A.HWP.3.9, A.HWP.3.10, A.HWP.3.11 and A.HWP.3.12. When combined with the reduced damages associated with the residual static flooding, a total accounting of all monetary benefits was obtained. Consideration of both environmental and monetary benefits as described in the Plan Formulation section was the basis for selecting design 16, 18-20 on both The Meadows and Point cells, as the optimal dune/berm configuration. The beach width of design 16 was evaluated relative to the habitat requirements of piping plovers and was found satisfactory. Increases or decreases in the berm width are considered unwarranted.

Table A.HWP.3.7
Refined Analysis of Dune/Berm Templates
Frequency Interior Water Surface Elevations (ft-NGVD)

Event	Dsgn 1	Dsgn 2	Dsgn 3	Dsgn 4	Dsgn 5	Dsgn 6	Dsgn 7	Dsgn 8	Dsgn 9	Dsgn 10	Dsgn 11	Dsgn 12	Dsgn 13	Dsgn 14	Dsgn 15	Dsgn 16	Dsgn 17	Dsgn 18	Dsgn 19	Dsgn 20
2yr	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
5yr	1.0	3.6	1.0	3.6	1.0	1.0	1.0	3.6	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	3.6	1.0	1.0	1.0
10yr	1.0	6.9	1.0	6.9	1.0	1.0	1.0	6.9	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	6.9	1.0	1.0	1.0
20yr	1.0	7.4	1.0	7.4	1.0	1.0	1.0	7.4	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	7.4	1.0	1.0	1.0
50yr	1.0	8.1	1.0	8.1	1.0	1.0	1.0	8.1	1.0	1.0	1.0	1.0	3.5	3.5	3.5	7.3	8.1	7.0	7.0	7.0
100yr	1.0	9.1	6.3	9.1	1.0	6.3	7.9	9.1	7.6	7.6	3.8	6.7	6.1	7.9	8.9	9.1	9.1	9.1	9.1	9.1
200yr	7.7	10.0	8.2	10.0	7.8	8.1	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
500yr	11.3	11.3	11.3	11.3	11.3	11.3	11.3	11.3	11.3	11.3	11.3	11.3	11.3	11.3	11.3	11.3	11.3	11.3	11.3	11.3

Note: A water surface elevation of 1.0 indicates that there is no saltwater inundation. Some of the ponds have normal non-damaging freshwater elevations greater than 1.0 ft-NGVD.

Table A.HWP.3.8
Refined Analysis of Dune/Berm Templates
Frequency Interior Acres Not Inundated By Saltwater

Event	Dsgn 1	Dsgn 2	Dsgn 3	Dsgn 4	Dsgn 5	Dsgn 6	Dsgn 7	Dsgn 8	Dsgn 9	Dsgn 10	Dsgn 11	Dsgn 12	Dsgn 13	Dsgn 14	Dsgn 15	Dsgn 16	Dsgn 17	Dsgn 18	Dsgn 19	Dsgn 20
2yr	333	333	333	333	333	333	333	333	333	333	333	333	333	333	333	333	333	333	333	333
5yr	333	233	333	233	333	333	333	233	333	333	333	333	333	333	333	333	233	333	333	333
10yr	333	56	333	56	333	333	333	56	333	333	333	333	333	333	333	333	56	333	333	333
20yr	333	48	333	48	333	333	333	48	333	333	333	333	333	333	333	333	48	333	333	333
50yr	333	38	333	38	333	333	333	38	333	333	333	333	237	237	237	50	38	54	54	54
100yr	333	29	65	29	333	65	40	29	45	45	224	59	68	40	31	29	29	29	29	29
200yr	44	21	37	21	42	38	21	21	21	21	21	21	21	21	21	21	21	21	21	21
500yr	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9

Note: Water surface elevation and acres not inundated are based on the year 2000 shoreline.

Table A.HWP.3.9
Design 1, 21-50
Inundation Profiles
(2,5,10,20,50,100,200,500 Years)

**********CELL B**********

STORM EROSION,WAVE IMPACT,WAVE DAMAGE ELEVATION,
ZONES 1 & 2

-385.0	0	0.0	0.	0.
-320.0	0	0.0	0.	0.
-300.0	0	0.0	0.	0.
-65.0	0	0.0	0.	0.
-65.0	0	0.0	0.	0.
-65.0	0	0.0	0.	0.
-65.0	0	0.0	0.	0.
-65.0	0	0.0	0.	0.

INUNDATION PROFILE: DISTANCE FROM BASELINE AND
TOTAL WATERLEVEL

0	0.0	26	0.0	50	0.0	65	0.0
195	0.0	245	0.0	415	0.0	445	0.0
525	0.0	605	0.0	635	0.0	795	0.0
0	0.0	26	0.0	50	0.0	65	0.0
195	0.0	245	0.0	415	0.0	445	0.0
525	0.0	605	0.0	635	0.0	795	0.0
0	0.0	26	0.0	50	0.0	65	0.0
195	0.0	245	0.0	415	0.0	445	0.0
525	0.0	605	0.0	635	0.0	795	0.0
0	0.0	20	0.0	48	0.0	70	0.0
195	0.0	245	0.0	415	0.0	445	0.0
525	0.0	605	0.0	635	0.0	795	0.0
0	0.0	80	0.0	97	0.0	130	0.0
195	0.0	245	0.0	415	0.0	445	0.0
525	0.0	605	0.0	635	0.0	795	0.0
0	0.0	140	0.0	152	0.0	190	0.0
195	0.0	245	0.0	415	0.0	445	0.0
525	0.0	605	0.0	635	0.0	795	0.0
0	7.7	20	7.7	170	7.7	220	7.7
240	7.7	245	7.7	415	7.7	445	7.7
325	7.7	605	7.7	635	7.7	795	7.7
0	11.3	190	11.3	210	11.3	240	11.3
242	11.3	245	11.3	415	11.3	445	11.3
525	11.3	605	11.3	635	11.3	795	11.3

**********CELL C**********

STORM EROSION,WAVE IMPACT,WAVE DAMAGE ELEVATION,
ZONES 1 & 2

-400.0	0	0.0	0.	0.
-330.0	0	0.0	0.	0.
-75.0	0	0.0	0.	0.
-70.0	0	0.0	0.	0.
-60.0	0	0.0	0.	0.
-50.0	0	0.0	0.	0.
-35.0	0	0.0	0.	0.
0.0	300	0.0	0.	0.

INUNDATION PROFILE: DISTANCE FROM BASELINE AND
TOTAL WATERLEVEL

0	0.0	24	0.0	50	0.0	200	0.0
350	0.0	460	0.0				
0	0.0	24	0.0	50	0.0	200	0.0
350	0.0	460	0.0				
0	0.0	24	0.0	50	0.0	200	0.0
350	0.0	460	0.0				
0	0.0	80	0.0	99	0.0	130	0.0
350	0.0	460	0.0				
0	0.0	100	0.0	112	0.0	150	0.0
350	0.0	460	0.0				
0	0.0	155	0.0	175	0.0	205	0.0
350	0.0	460	0.0				
0	7.7	175	7.7	195	7.7	225	7.7
350	7.7	460	7.7				
0	16.0	175	20.1	195	13.6	225	12.9
350	12.9	460	12.9				

Table A.HWP.3.9
(continued)

**********CELL D**********

STORM EROSION,WAVE IMPACT,WAVE DAMAGE ELEVATION,
ZONES 1 & 2

-460.0	0.0	0.0	0.	0.
-385.0	0.0	0.0	0.	0.
-50.0	0.0	0.0	0.	0.
-40.0	0.0	0.0	0.	0.
-30.0	0.0	0.0	0.	0.
-10.0	0.0	0.0	0.	0.
-5.0	0.0	0.0	0.	0.
5.0	0.0	0.0	0.	0.

INUNDATION PROFILE: DISTANCE FROM BASELINE AND
TOTAL WATERLEVEL

0	0.0	100	0.0	200	0.0	300	0.0
470	0.0	570	0.0				
0	0.0	15	0.0	42	0.0	65	0.0
470	0.0	570	0.0				
0	0.0	55	0.0	75	0.0	105	0.0
470	0.0	570	0.0				
0	0.0	55	0.0	75	0.0	105	0.0
470	0.0	570	0.0				
0	0.0	65	0.0	85	0.0	115	0.0
470	0.0	570	0.0				
0	0.0	65	0.0	85	0.0	115	0.0
470	0.0	570	0.0				
0	7.7	65	7.7	85	7.7	115	7.7
470	7.7	570	7.7				
0	17.4	20	22.0	40	16.0	70	11.3
470	11.3	570	11.3				

**********CELL E**********

STORM EROSION,WAVE IMPACT,WAVE DAMAGE ELEVATION,
ZONES 1 & 2

-330.0	0	0.0	0.	0.
-270.0	0	0.0	0.	0.
-30.0	0	0.0	0.	0.
-25.0	0	0.0	0.	0.
-15.0	0	0.0	0.	0.
0.0	0	0.0	0.	0.
5.0	0	0.0	0.	0.
15.0	0	0.0	0.	0.

INUNDATION PROFILE: DISTANCE FROM BASELINE AND
TOTAL WATERLEVEL

0	0.0	100	0.0	200	0.0	300	0.0
400	0.0	500	0.0	510	0.0		
0	0.0	50	0.0	74	0.0	150	0.0
350	0.0	500	0.0	510	0.0		
0	0.0	50	0.0	74	0.0	150	0.0
350	0.0	500	0.0	510	0.0		
0	0.0	50	0.0	74	0.0	150	0.0
350	0.0	500	0.0	510	0.0		
0	0.0	75	0.0	96	0.0	125	0.0
350	0.0	500	0.0	510	0.0		
0	0.0	110	0.0	135	0.0	160	0.0
350	0.0	500	0.0	510	0.0		
0	7.7	115	7.7	138	7.7	165	7.7
350	7.7	500	7.7	510	7.7		
0	17.4	30	22.0	50	19.1	80	14.8
350	11.3	500	11.3	510	11.3		

Table A.HWP.3.10
Design 3, 21-20
Inundation Profiles
(2,5,10,20,50,100,200,500 Years)

**********CELL B**********

STORM EROSION,WAVE IMPACT,WAVE DAMAGE ELEVATION,
ZONES 1 & 2

-355.0	0	0.0	0.	0.
-290.0	0	0.0	0.	0.
-270.0	0	0.0	0.	0.
-65.0	0	0.0	0.	0.
-65.0	0	0.0	0.	0.
-65.0	0	0.0	0.	0.
-65.0	0	0.0	0.	0.
-65.0	0	0.0	0.	0.

INUNDATION PROFILE: DISTANCE FROM BASELINE AND
TOTAL WATERLEVEL

0	0.0	26	0.0	50	0.0	65	0.0
195	0.0	245	0.0	415	0.0	445	0.0
525	0.0	605	0.0	635	0.0	795	0.0
0	0.0	26	0.0	50	0.0	65	0.0
195	0.0	245	0.0	415	0.0	445	0.0
525	0.0	605	0.0	635	0.0	795	0.0
0	0.0	26	0.0	50	0.0	65	0.0
195	0.0	245	0.0	415	0.0	445	0.0
525	0.0	605	0.0	635	0.0	795	0.0
0	0.0	20	0.0	48	0.0	70	0.0
195	0.0	245	0.0	415	0.0	445	0.0
525	0.0	605	0.0	635	0.0	795	0.0
0	0.0	80	0.0	97	0.0	130	0.0
195	0.0	245	0.0	415	0.0	445	0.0
525	0.0	605	0.0	635	0.0	795	0.0
0	6.3	140	6.3	152	6.3	190	6.3
195	6.3	245	6.3	415	6.3	445	6.3
525	6.3	605	6.3	635	6.3	795	6.3
0	8.2	20	8.2	170	8.2	220	8.2
240	8.2	245	8.2	415	8.2	445	8.2
525	8.2	605	8.2	635	8.2	795	8.2
0	11.3	190	11.3	210	11.3	240	11.3
242	11.3	245	11.3	415	11.3	445	11.3
525	11.3	605	11.3	635	11.3	795	11.3

**********CELL C**********

STORM EROSION,WAVE IMPACT,WAVE DAMAGE ELEVATION,
ZONES 1 & 2

-370.0	0	0.0	0.	0.
-300.0	0	0.0	0.	0.
-75.0	0	0.0	0.	0.
-65.0	0	0.0	0.	0.
-55.0	0	0.0	0.	0.
-50.0	0	0.0	0.	0.
-30.0	0	0.0	0.	0.
5.0	295	0.0	0.	0.

INUNDATION PROFILE: DISTANCE FROM BASELINE AND
TOTAL WATERLEVEL

0	0.0	24	0.0	50	0.0	200	0.0
350	0.0	460	0.0				
0	0.0	24	0.0	50	0.0	200	0.0
350	0.0	460	0.0				
0	0.0	24	0.0	50	0.0	200	0.0
350	0.0	460	0.0				
0	0.0	80	0.0	99	0.0	130	0.0
350	0.0	460	0.0				
0	0.0	100	0.0	112	0.0	150	0.0
350	0.0	460	0.0				
0	0.0	155	0.0	175	0.0	205	0.0
350	0.0	460	0.0				
0	8.2	175	8.2	195	8.2	225	8.2
350	8.2	460	8.2				
0	16.0	175	20.1	195	13.6	225	12.9
350	12.9	460	12.9				

Table A.HWP.3.10
(continued)

**********CELL D**********

STORM EROSION,WAVE IMPACT,WAVE DAMAGE ELEVATION,
ZONES 1 & 2

-430.0	0.0	0.0	0.	0.
-355.0	0.0	0.0	0.	0.
-50.0	0.0	0.0	0.	0.
-40.0	0.0	0.0	0.	0.
-25.0	0.0	0.0	0.	0.
-10.0	0.0	0.0	0.	0.
0.0	0.0	0.0	0.	0.
5.0	0.0	0.0	0.	0.

INUNDATION PROFILE: DISTANCE FROM BASELINE AND
TOTAL WATERLEVEL

0	0.0	100	0.0	200	0.0	300	0.0
470	0.0	570	0.0				
0	0.0	15	0.0	42	0.0	65	0.0
470	0.0	570	0.0				
0	0.0	55	0.0	75	0.0	105	0.0
470	0.0	570	0.0				
0	0.0	55	0.0	75	0.0	105	0.0
470	0.0	570	0.0				
0	0.0	65	0.0	85	0.0	115	0.0
470	0.0	570	0.0				
0	6.3	65	6.3	85	6.3	115	6.3
470	6.3	570	6.3				
0	8.2	65	8.2	85	8.2	115	8.2
470	8.2	570	8.2				
0	17.4	20	22.0	40	16.0	70	11.3
470	11.3	570	11.3				

**********CELL E**********

STORM EROSION,WAVE IMPACT,WAVE DAMAGE ELEVATION,
ZONES 1 & 2

-300.0	0	0.0	0.	0.
-240.0	0	0.0	0.	0.
-25.0	0	0.0	0.	0.
-20.0	0	0.0	0.	0.
-15.0	0	0.0	0.	0.
0.0	0	0.0	0.	0.
5.0	0	0.0	0.	0.
45.0	255	0.0	0.	0.

INUNDATION PROFILE: DISTANCE FROM BASELINE AND
TOTAL WATERLEVEL

0	0.0	100	0.0	200	0.0	300	0.0
400	0.0	500	0.0	510	0.0		
0	0.0	50	0.0	74	0.0	150	0.0
350	0.0	500	0.0	510	0.0		
0	0.0	50	0.0	74	0.0	150	0.0
350	0.0	500	0.0	510	0.0		
0	0.0	50	0.0	74	0.0	150	0.0
350	0.0	500	0.0	510	0.0		
0	0.0	75	0.0	96	0.0	125	0.0
350	0.0	500	0.0	510	0.0		
0	0.0	110	0.0	135	0.0	160	0.0
350	0.0	500	0.0	510	0.0		
0	8.2	115	8.2	138	8.2	165	8.2
350	8.2	500	8.2	510	8.2		
0	16.0	115	17.0	139	16.6	165	16.1
350	14.1	500	13.1	510	13.1		

Table A.HWP.3.11
Design 7, 18-50
Inundation Profiles
(2,5,10,20,50,100,200,500 Years)

**********CELL B**********

STORM EROSION,WAVE IMPACT,WAVE DAMAGE ELEVATION,
ZONES 1 & 2

-355.0	0	0.0	0.	0.
-290.0	0	0.0	0.	0.
-270.0	0	0.0	0.	0.
-65.0	0	0.0	0.	0.
-65.0	0	0.0	0.	0.
-65.0	0	0.0	0.	0.
-65.0	0	0.0	0.	0.
-65.0	0	0.0	0.	0.

INUNDATION PROFILE: DISTANCE FROM BASELINE AND
TOTAL WATERLEVEL

0	0.0	26	0.0	50	0.0	65	0.0
195	0.0	245	0.0	415	0.0	445	0.0
525	0.0	605	0.0	635	0.0	795	0.0
0	0.0	26	0.0	50	0.0	65	0.0
195	0.0	245	0.0	415	0.0	445	0.0
525	0.0	605	0.0	635	0.0	795	0.0
0	0.0	26	0.0	50	0.0	65	0.0
195	0.0	245	0.0	415	0.0	445	0.0
525	0.0	605	0.0	635	0.0	795	0.0
0	0.0	20	0.0	48	0.0	70	0.0
195	0.0	245	0.0	415	0.0	445	0.0
525	0.0	605	0.0	635	0.0	795	0.0
0	0.0	80	0.0	97	0.0	130	0.0
195	0.0	245	0.0	415	0.0	445	0.0
525	0.0	605	0.0	635	0.0	795	0.0
0	7.9	140	7.9	152	7.9	190	7.9
195	7.9	245	7.9	415	7.9	445	7.9
525	7.9	605	7.9	635	7.9	795	7.9
0	10.0	20	10.0	170	10.0	220	10.0
240	10.0	245	10.0	415	10.0	445	10.0
525	10.0	605	10.0	635	10.0	795	10.0
0	16.0	20	18.5	40	15.4	70	11.3
195	11.3	245	11.3	415	11.3	445	11.3
525	11.3	605	11.3	635	11.3	795	11.3

**********CELL C**********

STORM EROSION,WAVE IMPACT,WAVE DAMAGE ELEVATION,
ZONES 1 & 2

-380.0	0	0.0	0.	0.
-310.0	0	0.0	0.	0.
-50.0	0	0.0	0.	0.
-50.0	0	0.0	0.	0.
-50.0	0	0.0	0.	0.
-25.0	0	0.0	0.	0.
5.0	295	0.0	0.	0.
10.0	290	0.0	0.	0.

INUNDATION PROFILE: DISTANCE FROM BASELINE AND
TOTAL WATERLEVEL

0	0.0	24	0.0	50	0.0	200	0.0
350	0.0	460	0.0				
0	0.0	24	0.0	50	0.0	200	0.0
350	0.0	460	0.0				
0	0.0	24	0.0	50	0.0	200	0.0
350	0.0	460	0.0				
0	0.0	80	0.0	99	0.0	130	0.0
350	0.0	460	0.0				
0	0.0	100	0.0	112	0.0	150	0.0
350	0.0	460	0.0				
0	7.9	155	7.9	175	7.9	205	7.9
350	7.9	460	7.9				
0	14.7	175	17.8	195	14.0	225	12.9
350	12.9	460	12.9				
0	16.0	175	20.1	195	13.6	225	12.9
350	12.9	460	12.9				

Table A.HWP.3.11
(continued)

**********CELL D**********

STORM EROSION,WAVE IMPACT,WAVE DAMAGE ELEVATION,
ZONES 1 & 2

-440.0	0.0	0.0	0.	0.
-365.0	0.0	0.0	0.	0.
-25.0	0.0	0.0	0.	0.
-15.0	0.0	0.0	0.	0.
-5.0	0.0	0.0	0.	0.
0.0	0.0	0.0	0.	0.
30.0	270.0	0.0	0.	0.
35.0	265.0	0.0	0.	0.

INUNDATION PROFILE: DISTANCE FROM BASELINE AND
TOTAL WATERLEVEL

0	0.0	100	0.0	200	0.0	300	0.0
470	0.0	570	0.0				
0	0.0	15	0.0	42	0.0	65	0.0
470	0.0	570	0.0				
0	0.0	55	0.0	75	0.0	105	0.0
470	0.0	570	0.0				
0	0.0	55	0.0	75	0.0	105	0.0
470	0.0	570	0.0				
0	0.0	65	0.0	85	0.0	115	0.0
470	0.0	570	0.0				
0	7.9	65	7.9	85	7.9	115	7.9
470	7.9	570	7.9				
0	14.7	65	18.0	85	16.0	115	13.1
470	13.1	570	13.1				
0	16.0	65	20.2	85	17.4	115	13.1
470	13.1	570	13.1				

**********CELL E**********

STORM EROSION,WAVE IMPACT,WAVE DAMAGE ELEVATION,
ZONES 1 & 2

-310.0	0	0.0	0.	0.
-250.0	0	0.0	0.	0.
-5.0	0	0.0	0.	0.
0.0	0	0.0	0.	0.
5.0	0	0.0	0.	0.
15.0	0	0.0	0.	0.
60.0	0	0.0	0.	0.
65.0	235	0.0	0.	0.

INUNDATION PROFILE: DISTANCE FROM BASELINE AND
TOTAL WATERLEVEL

0	0.0	100	0.0	200	0.0	300	0.0
400	0.0	500	0.0	510	0.0		
0	0.0	50	0.0	74	0.0	150	0.0
350	0.0	500	0.0	510	0.0		
0	0.0	50	0.0	74	0.0	150	0.0
350	0.0	500	0.0	510	0.0		
0	0.0	50	0.0	74	0.0	150	0.0
350	0.0	500	0.0	510	0.0		
0	0.0	75	0.0	96	0.0	125	0.0
350	0.0	500	0.0	510	0.0		
0	7.9	110	7.9	135	7.9	160	7.9
350	7.9	500	7.9	510	7.9		
0	14.7	75	18.2	95	15.0	125	13.0
350	10.0	500	10.0	510	10.0		
0	16.0	115	17.0	139	16.6	165	16.1
350	14.1	500	13.1	510	13.1		

Table A.HWP.3.12
Design 16, 18-20
Inundation Profiles
(2,5,10,20,50,100,200,500 Years)

**********CELL B**********

STORM EROSION,WAVE IMPACT,WAVE DAMAGE ELEVATION,
ZONES 1 & 2

-355.0	0	0.0	0.	0.
-290.0	0	0.0	0.	0.
-270.0	0	0.0	0.	0.
-65.0	0	0.0	0.	0.
-65.0	0	0.0	0.	0.
-65.0	0	0.0	0.	0.
-65.0	0	0.0	0.	0.
-65.0	0	0.0	0.	0.

INUNDATION PROFILE: DISTANCE FROM BASELINE AND
TOTAL WATERLEVEL

0	0.0	26	0.0	50	0.0	65	0.0
195	0.0	245	0.0	415	0.0	445	0.0
525	0.0	605	0.0	635	0.0	795	0.0
0	0.0	26	0.0	50	0.0	65	0.0
195	0.0	245	0.0	415	0.0	445	0.0
525	0.0	605	0.0	635	0.0	795	0.0
0	0.0	26	0.0	50	0.0	65	0.0
195	0.0	245	0.0	415	0.0	445	0.0
525	0.0	605	0.0	635	0.0	795	0.0
0	0.0	20	0.0	48	0.0	70	0.0
195	0.0	245	0.0	415	0.0	445	0.0
525	0.0	605	0.0	635	0.0	795	0.0
0	7.3	80	7.3	97	7.3	130	7.3
195	7.3	245	7.3	415	7.3	445	7.3
525	7.3	605	7.3	635	7.3	795	7.3
0	9.1	140	9.1	152	9.1	190	9.1
195	9.1	245	9.1	415	9.1	445	9.1
525	9.1	605	9.1	635	9.1	795	9.1
0	10.0	20	10.0	170	10.0	220	10.0
240	10.0	245	10.0	415	10.0	445	10.0
525	10.0	605	10.0	635	10.0	795	10.0
0	16.0	20	18.5	40	15.4	70	11.3
195	11.3	245	11.3	415	11.3	445	11.3
525	11.3	605	11.3	635	11.3	795	11.3

**********CELL C**********

STORM EROSION,WAVE IMPACT,WAVE DAMAGE ELEVATION,
ZONES 1 & 2

-350.0	0	0.0	0.	0.
-280.0	0	0.0	0.	0.
-50.0	0	0.0	0.	0.
-50.0	0	0.0	0.	0.
-50.0	0	0.0	0.	0.
-25.0	0	0.0	0.	0.
10.0	290	0.0	0.	0.
15.0	285	0.0	0.	0.

INUNDATION PROFILE: DISTANCE FROM BASELINE AND
TOTAL WATERLEVEL

0	0.0	24	0.0	50	0.0	200	0.0
350	0.0	460	0.0				
0	0.0	24	0.0	50	0.0	200	0.0
350	0.0	460	0.0				
0	0.0	24	0.0	50	0.0	200	0.0
350	0.0	460	0.0				
0	0.0	80	0.0	99	0.0	130	0.0
350	0.0	460	0.0				
0	7.3	100	7.3	112	7.3	150	7.3
350	7.3	460	7.3				
0	9.1	155	9.1	175	9.1	205	9.1
350	9.1	460	9.1				
0	14.7	175	17.8	195	14.0	225	12.9
350	12.9	460	12.9				
0	16.0	175	20.1	195	13.6	225	12.9
350	12.9	460	12.9				

Table A.HWP.3.12
(continued)

**********CELL D**********

STORM EROSION,WAVE IMPACT,WAVE DAMAGE ELEVATION,
ZONES 1 & 2

-410.0	0.0	0.0	0.	0.
-335.0	0.0	0.0	0.	0.
-25.0	0.0	0.0	0.	0.
-15.0	0.0	0.0	0.	0.
-5.0	0.0	0.0	0.	0.
0.0	0.0	0.0	0.	0.
30.0	270.0	0.0	0.	0.
35.0	265.0	0.0	0.	0.

INUNDATION PROFILE: DISTANCE FROM BASELINE AND
TOTAL WATERLEVEL

0	0.0	100	0.0	200	0.0	300	0.0
470	0.0	570	0.0				
0	0.0	15	0.0	42	0.0	65	0.0
470	0.0	570	0.0				
0	0.0	55	0.0	75	0.0	105	0.0
470	0.0	570	0.0				
0	0.0	55	0.0	75	0.0	105	0.0
470	0.0	570	0.0				
0	7.3	65	7.3	85	7.3	115	7.3
470	7.3	570	7.3				
0	9.1	65	9.1	85	9.1	115	9.1
470	9.1	570	9.1				
0	14.7	65	18.0	85	16.0	115	13.1
470	13.1	570	13.1				
0	16.0	65	20.2	85	17.4	115	13.1
470	13.1	570	13.1				

**********CELL E**********

STORM EROSION,WAVE IMPACT,WAVE DAMAGE ELEVATION,
ZONES 1 & 2

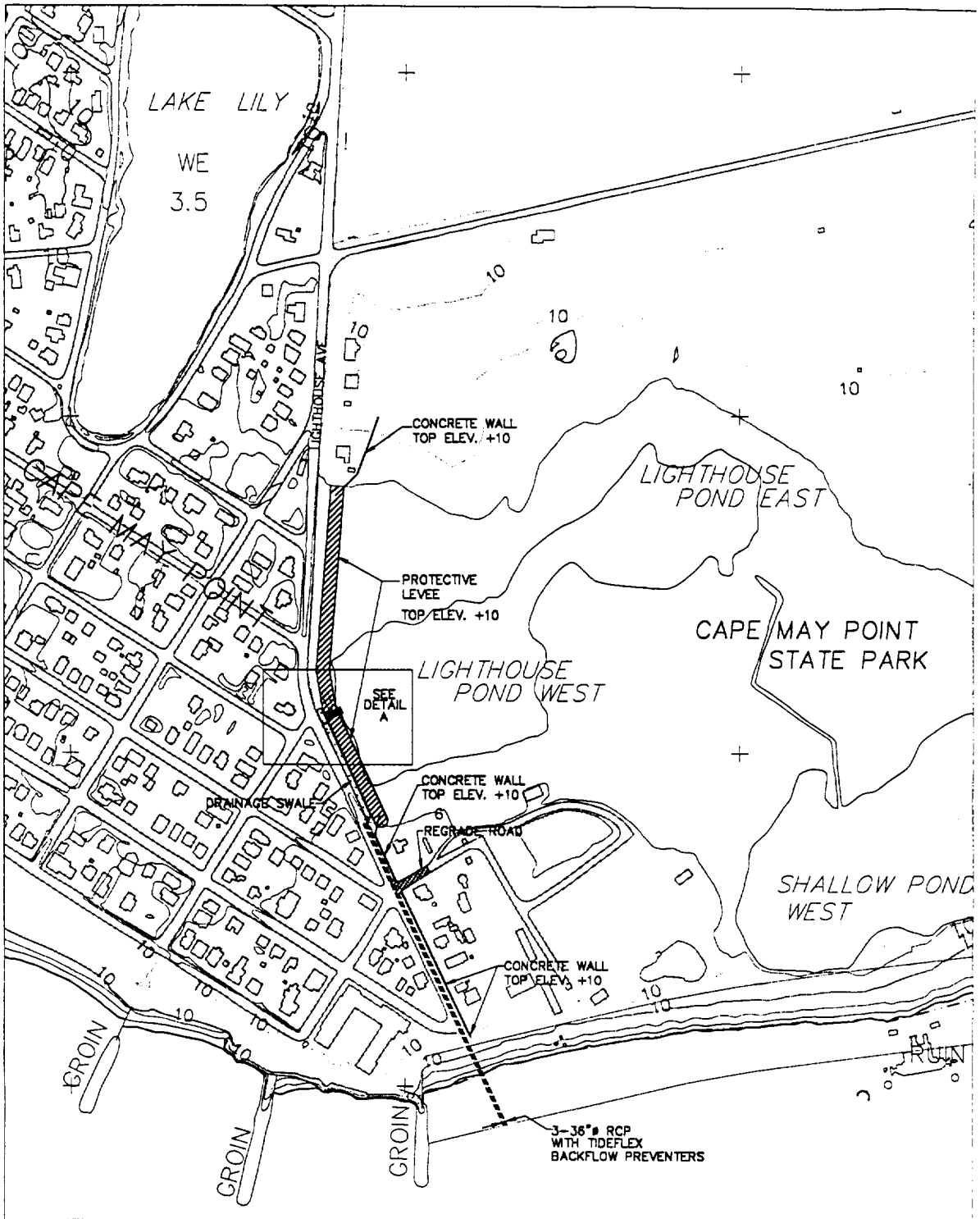
-280.0	0	0.0	0.	0.
-220.0	0	0.0	0.	0.
-5.0	0	0.0	0.	0.
0.0	0	0.0	0.	0.
5.0	0	0.0	0.	0.
15.0	0	0.0	0.	0.
60.0	0	0.0	0.	0.
65.0	235	0.0	0.	0.

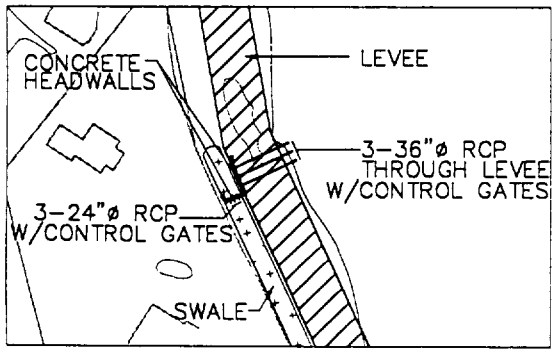
INUNDATION PROFILE: DISTANCE FROM BASELINE AND
TOTAL WATERLEVEL

0	0.0	100	0.0	200	0.0	300	0.0
400	0.0	500	0.0	510	0.0		
0	0.0	50	0.0	74	0.0	150	0.0
350	0.0	500	0.0	510	0.0		
0	0.0	50	0.0	74	0.0	150	0.0
350	0.0	500	0.0	510	0.0		
0	0.0	50	0.0	74	0.0	150	0.0
350	0.0	500	0.0	510	0.0		
0	7.3	75	7.3	96	7.3	125	7.3
350	7.3	500	7.3	510	7.3		
0	9.1	110	9.1	135	9.1	160	9.1
350	9.1	500	9.1	510	9.1		
0	14.7	75	18.2	95	15.0	125	13.0
350	10.0	500	10.0	510	10.0		
0	16.0	115	17.0	139	16.6	165	16.1
350	14.1	500	13.1	510	13.1		

A.HWP.3.1 OPTIMIZATION OF FLANKING PROTECTION FOR THE MEADOWS

Design 16, (18-20 on both the Meadows and Cape May Point) was identified as the optimal level of protection based on both environmental and monetary benefits. However, given the expense of the Cape May Point dune/berm, consideration was given to eliminating the Cape May Point beach fill component and replacing it with an alternate method of protecting The Meadows from salt water inundation. Without a dune/berm along the Cape May Point ocean frontage, salt water from the over topped and breached Cape May Point dunes will drain to The Meadows along Lighthouse Avenue. To prevent this a dike along Lighthouse Avenue was considered. It will be located on the east side of Lighthouse Avenue set to minimize encroachment to the wetlands of the State Park. The dike will prevent any salt water which over tops the existing dunes of Cape May Point from reaching The Meadows. The dike consists of an earthen levee and a concrete wall at a crest elevation of 10.0 ft-NGVD which provides the same level of environmental protection to The Meadows as Design 16. Provisions for controlled entry and egress to the State Park and private residences along Lighthouse Avenue will be provided. There will be three 3 foot diameter gated concrete pipes through the levee draining fresh water from Cape May Point, including Lake Lily to Lighthouse Pond West. The upstream end of the pipes will be connected to a concrete diversion structure, which is designed to allow rain water to drain to The Meadows and to divert salt water from over topping events back to the ocean. Construction of the dike will trap salt water in Cape May Point and prevent it from reaching The Meadows where it drains to the ocean through drainage east and the Cape Island Creek culvert. Therefore the dike also requires the installation of three 3 foot diameter concrete pipes under Lighthouse Avenue extending from a swale near the diversion structure to the ocean at the western most end of the State Park. The combined flow area of the three pipes is the same as the combined flow area of drainage east and Cape Island Creek pipes and will drain salt water from over topping and breach events to the ocean. The diversion structure is gated such that during rain events fresh water passes through the dike to The Meadows while the gates draining to the ocean are closed. In anticipation of an ocean storm and salt water inflow the locals will manually switch the gate settings such that flow to The Meadows is prevented and the gates to the ocean are open for the eventual draining of the ponded salt water when the ocean stages return to normal. The details of the dike and the appurtenant structures are found on Figure A.HWP.3.1.1.





DETAIL A

200 100 0 200 400

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LOWER CAPE MAY MEADOWS-CAPE MAY POINT
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Plan View of Dike along the
Western Edge of the Meadows

FIGURE A.HWP.3.1.1

Construction of the dike changes the with project frequency water surface elevations for the interior. With the dike in place the frequency water levels for The Meadows and West Cape May are not the same as Cape May Point water surface elevations. With a dune/berm of 18-20 on the Meadows and a dike with a crest elevation of 10.0 ft-NGVD along the western edge of the Meadows the elevation-area-storage of The Meadows changes. The modified elevation-area-storage data is shown in Table A.HWP.3.1.1

Table A.HWP.3.1.1.
Elevation-Area-Storage
of the Meadows and West
Cape May Only

Elevation (ft-NGVD)	Area (acres)	Volume (acre-ft)
1.4	29.5	0
2.0	29.5	18
4.0	120.7	170
6.0	323.1	610
8.0	432.8	1370
10.0	509.4	2310
12.0	586.0	3400

Note 1: The area and volume includes the Meadows and West Cape May.
Note 2: The above table is based on the dike at elevation 10.0 ft-NGVD which isolates Meadows/West Cape May storage from Cape May Point Storage.
Note 3: The Meadows shoreline is at the Year 2000 location.

Frequency over topping volumes and water surface elevations and acres not inundated which are applicable to The Meadows and West Cape May are shown in Table A.HWP.3.1.2 These results are based on an 18-20 dune/berm template along The Meadows ocean front.

Table A.HWP.3.1.2
With Project
Frequency Interior Water Surface Elevations
and Acres not Inundated for the Meadows

Event	Meadows Over topping Volume (acre-ft)	Water Surface Elevation (ft-NGVD)	Acres not Inundated
2	---	1.0	333
5	---	1.0	333
10	---	1.0	333
20	---	1.0	333
50	1075	7.2	51
100	BR	9.1	29
200	BR	10.0	21
500	BR	11.3	9

Note 1: BR is a dune breach
Note 2: The Meadows shoreline is at the year 2000 location.
Note 3: The 18-20 dune/berm template is along the Meadows ocean front and there is a dike at elevation 10.0 ft-NGVD along Lighthouse Avenue.

As can be seen with a comparison to Tables A.HWP.3.7 and A.HWP.3.8 replacement of the dune/berm of Cape May Point with a dike along Lighthouse Avenues does not affect the environmental protection to The Meadows nor the structural protection to West Cape May. These results are identical to Design 16 except for the 50 year event where the water surface elevation is 7.3 ft-NGVD and the acres not inundated are 50 acres. The interior water surface elevations also apply to West Cape May.

The main disadvantage of the dike is the induced higher water surface elevations it causes for Cape May Point. Under both existing condition and Design 16 any salt water which over tops the dunes at Cape May Point drains to the Meadows, where because of the large storage

volume available, ponds to relatively low elevations. However, with the dike in place this is not possible and the salt water over topping the dunes at Cape May Point must pond at the Point. The elevation-area-storage for Cape May Point is shown on Table A.HWP.3.1.3.

Table A.HWP.3.1.3
Elevation-Area-Storage
of Cape May Point Only

Elevation (ft-NGVD)	Area (acres)	Volume (acre-ft)
5.0	4.9	0
6.0	40.2	60
8.0	84.2	180
10.0	134.0	400

Note 1: The area and volume includes Cape May Point only.

While the dike prevents salt water from reaching The Meadows it does not stop the saltwater inundation of Cape May Point which continues unabated because of the inadequacy of the existing dunes. Frequency over topping volumes of Cape May Point and the resultant water surface elevations are provided on Table A.HWP.3.1.4. The existing condition water surface elevations are provided for ease of comparison.

Table A.HWP.3.1.4
Frequency Water Surface Elevations
at Cape May Point

Event	Over topping Volumes from Cape May Point Dunes (acre-ft)	Water Surface Elevations (ft-NGVD)	Existing Condition Water Surface Elevations (ft-NGVD)
2 yr	---	---	4.4
5 yr	135	7.3	5.8
10 yr	155 (BR)	7.6	6.9
20 yr	200 (BR)	8.2	7.4
50 yr	260 (BR)	8.7	8.1
100 yr	BR	9.1	9.1
200 yr	BR	10.0	10.0
500 yr	BR	11.3	11.3

Note 1: The results are based on the existing condition dunes of Cape May Point and a dike along Lighthouse Avenue which prevents salt water in Cape May Point from reaching The Meadows.

Note 2: The over topping volumes are those volumes which over top before the breach. With both the Meadows/West Cape May/Cape May Point storage capacity available, the salt water which over tops before the breach ponds to an elevation less than the still water elevation which obtains after the breach. However, the dike along Lighthouse Avenue truncates a great deal of storage capacity and the volume of salt water which over tops the Point dunes must pond in the limited storage capacity at Cape May Point. The elevation to which they pond may be greater than the ocean still water level. After the breach occurs the higher water level in Cape May Point drains out to the ocean until the ocean still water level is reached.

The above results were provided to Economics Branch for evaluation. Consideration of costs and benefits indicated that a dune/berm of 18-20 along Cape May Point is preferable to a dike along Lighthouse Avenue for the prevention of salt water flanking of the 18-20 dune/berm along The Meadows.

A.HWP.4 RESTORATION OF ERODED ACRES

The above analysis identified template 18-20 as the optimal design. Consideration was given to moving The Meadows' dune line ocean ward as a means of restoring acres lost to long term erosion. In 1955 the area of The Meadows was 467 acres and is expected to be 333 acres in the year 2000. The three locations labeled S1, S2 and S3 are shown on Figure A.HWP.4.1. Compared to the year 2000 shoreline they correspond to an incremental increase of 30, 65 and 95 acres respectively. The elevation-area and the elevation-capacity curves for these three shoreline configurations are shown in Tables A.HWP.4.1 and A.HWP.4.2 respectively.

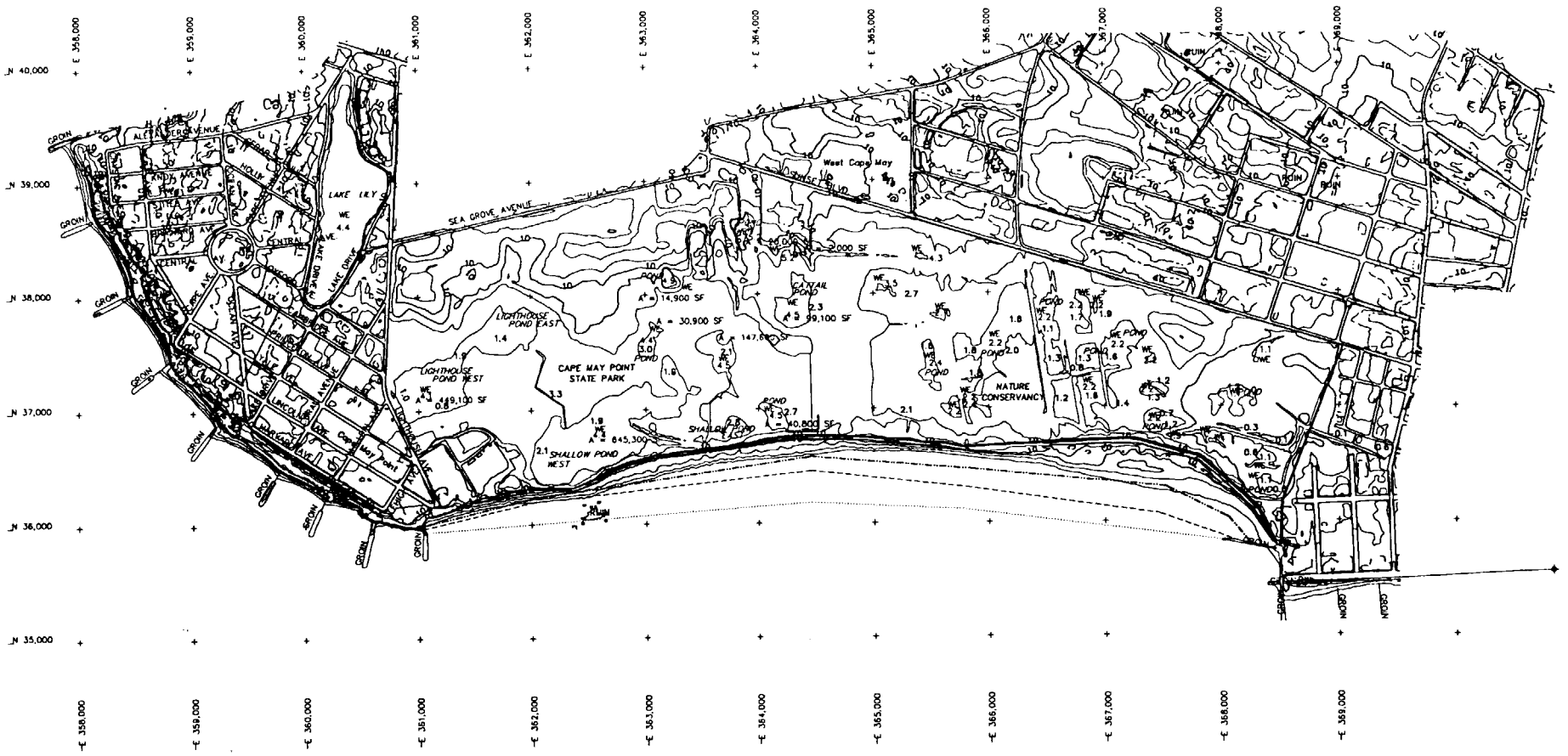
Table A.HWP.4.1
With Project
Extended Meadows' Shoreline
Elevation-Area of The Meadows(acres)

Elevation (ft-NGVD)	Year 2000	Year 2000 Shoreline Position S1	Year 2000 Shoreline Position S2	Year 2000 Shoreline Position S3
2	29.5	37.7	43.3	46.3
4	117.8	144.5	162.3	178.7
6	263.4	299.6	324.6	359.6
8	294.1	329.2	354.1	389.1
10	312.1	348.0	373.0	408.0
12	330.1	365.1	390.1	425.1

Table A.HWP.4.2
With Project
Extended Meadows' Shoreline
Interior Elevation-Capacity (acre-ft)

Elevation (ft-NGVD)	Year 2000	Year 2000 Shoreline Position S1	Year 2000 Shoreline Position S2	Year 2000 Shoreline Position S3
2	18	23	26	28
4	170	210	230	255
6	650	755	820	900
8	1530	1710	1830	1970
10	2700	2940	3110	3320
12	4110	4420	4640	4920

Note: The elevation-capacity curves reflect the storage of not only The Meadows but also the surrounding towns of West Cape May and Cape May Point.



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LOWER CAPE MAY MEADOWS-CAPE MAY POINT
FEASIBILITY STUDY

Alternate Shoreline Locations

FIGURE A.HWP.4.1

Frequency interior water surface elevations and acres not inundated are shown on Tables A.HWP.4.3 and A.HWP.4.4 respectively.

Table A.HWP.4.3
With Project
Extended Meadows' Shoreline
Frequency Interior Elevation
(ft-NGVD)

Event	Design 16	Design 16 Shoreline Position S1	Design 16 Shoreline Position S2	Design 16 Shoreline Position S3
2 yr	1.0	1.0	1.0	1.0
5 yr	1.0	1.0	1.0	1.0
10 yr	1.0	1.0	1.0	1.0
20 yr	1.0	1.0	1.0	1.0
50 yr	7.3	7.0	6.8	6.6
100 yr	9.1	9.1	9.1	9.1
200 yr	10.0	10.0	10.0	10.0
500 yr	11.3	11.3	11.3	11.3

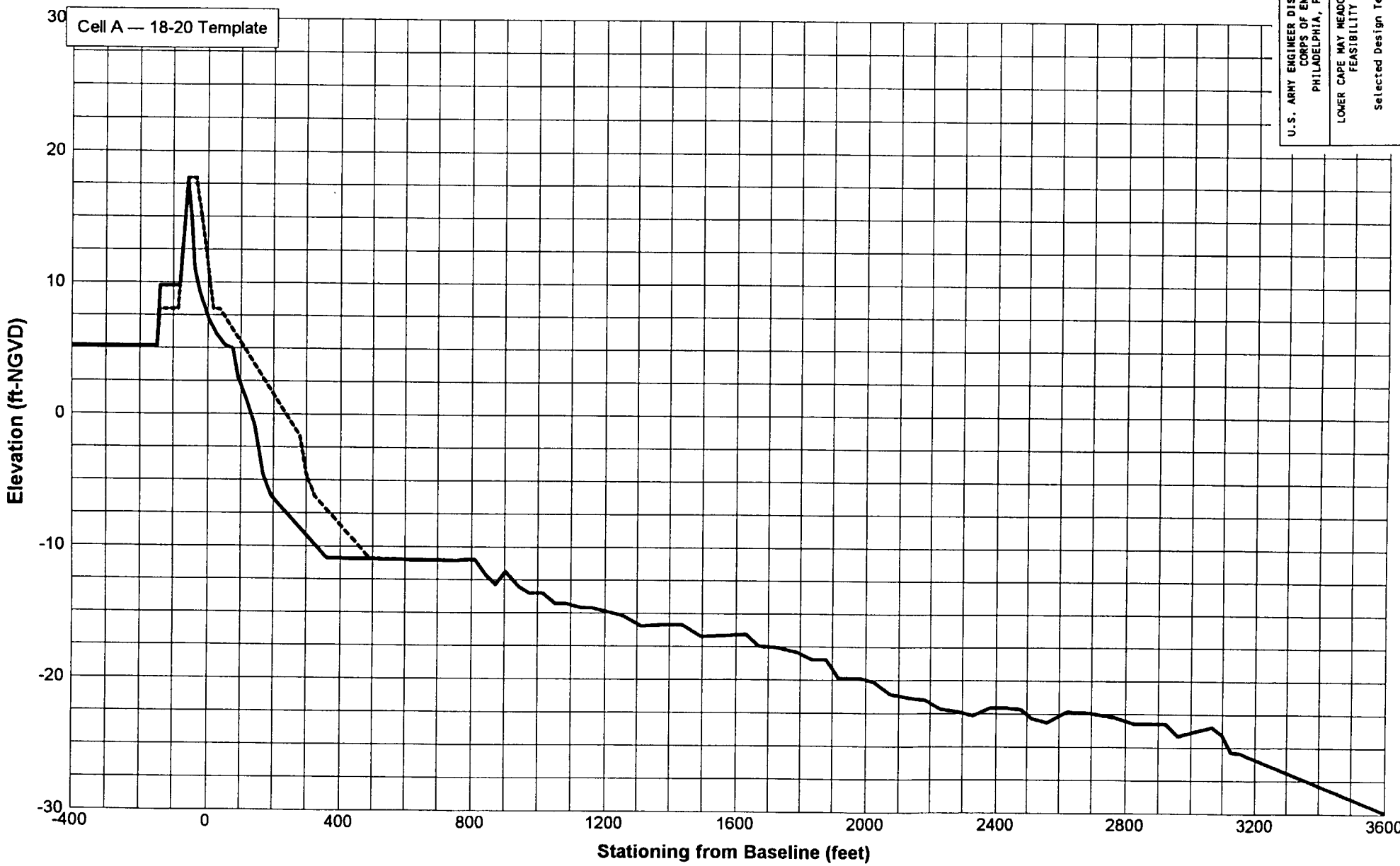
Design 16 is template 18-20 on both The Meadows and Cape May Point cells which drain to The Meadows.

Table A.HWP.4.4
With Project
Extended Meadows' Shoreline
Frequency Interior Acres not Inundated by Salt Water

Event	Design 16	Design 16 Shoreline Position S1	Design 16 Shoreline Position S2	Design 16 Shoreline Position S3
2 yr	333	368	393	428
5 yr	333	368	393	428
10 yr	333	368	393	428
20 yr	333	368	393	428
50 yr	50	54	57	60
100 yr	29	29	29	29
200 yr	21	21	21	21
500 yr	9	9	9	9

Design 16 is template 18-20 on both The Meadows and Cape May Point.

Average annual environmental and monetary benefits were determined for the three shoreline positions and compared to the costs. The large incremental cost to move the shoreline oceanward is not expected to be offset by the increase in environmental and monetary benefits, hence template 18-20 at the year 2000 shoreline is considered to be the selected plan for this submittal. (Seven acres of The Meadows are covered with sand from past overwash events. This sand will be excavated and the land regraded as wetlands and scrub/shrub habitat.) Figures A.HWP.4.2 to A.HWP.4.6 show the selected design template over plotted on the without project profile lines for cells, A, B, C, D and E.



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FEASIBILITY STUDY

Selected Design Template on Cell A

FIGURE A.HMP.4.2

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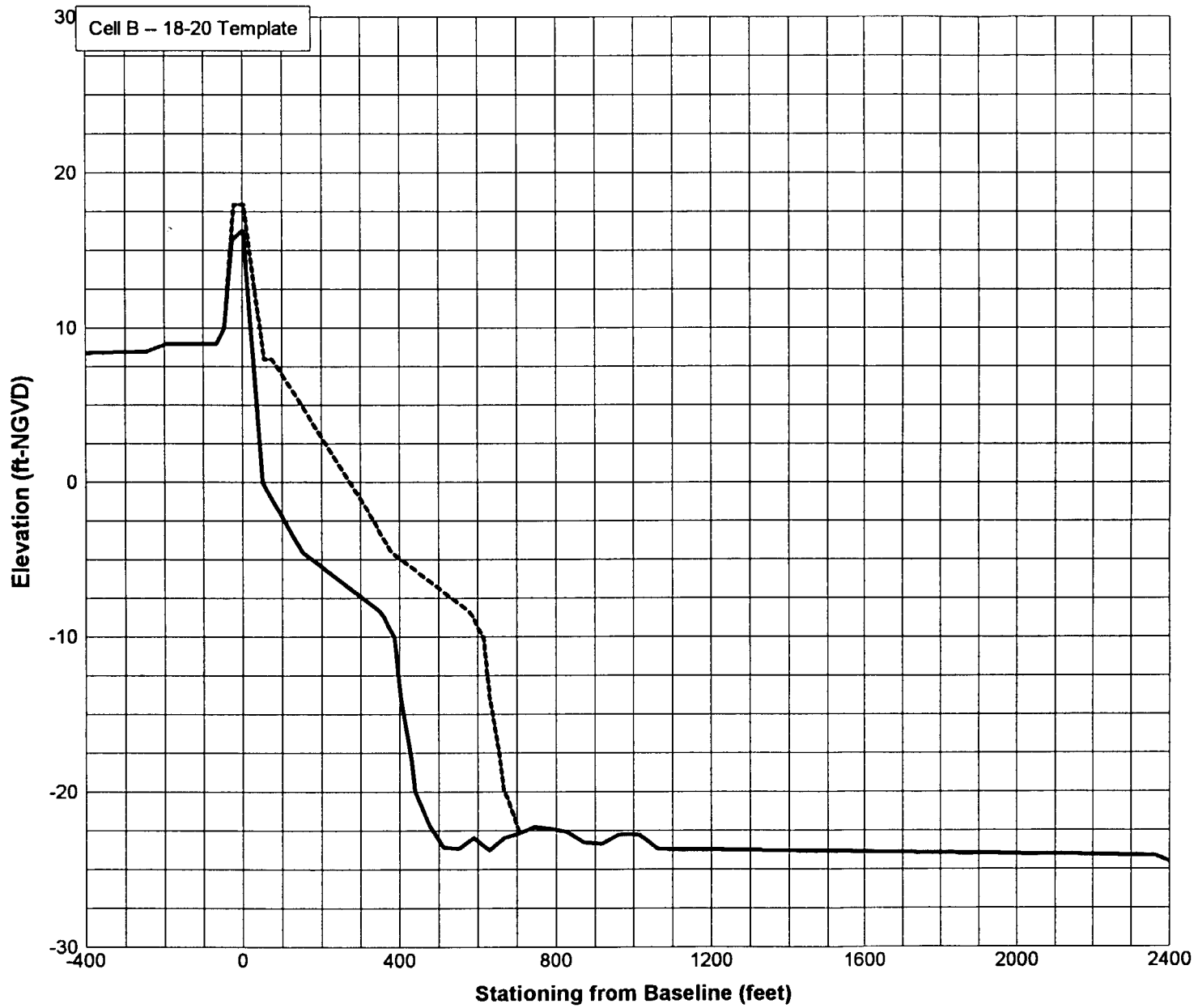

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LOWER CAPE MAY MEADOWS-CAPE MAY POINT
FEASIBILITY STUDY

Selected Design Template on Cell B

FIGURE A.HWP.4.3

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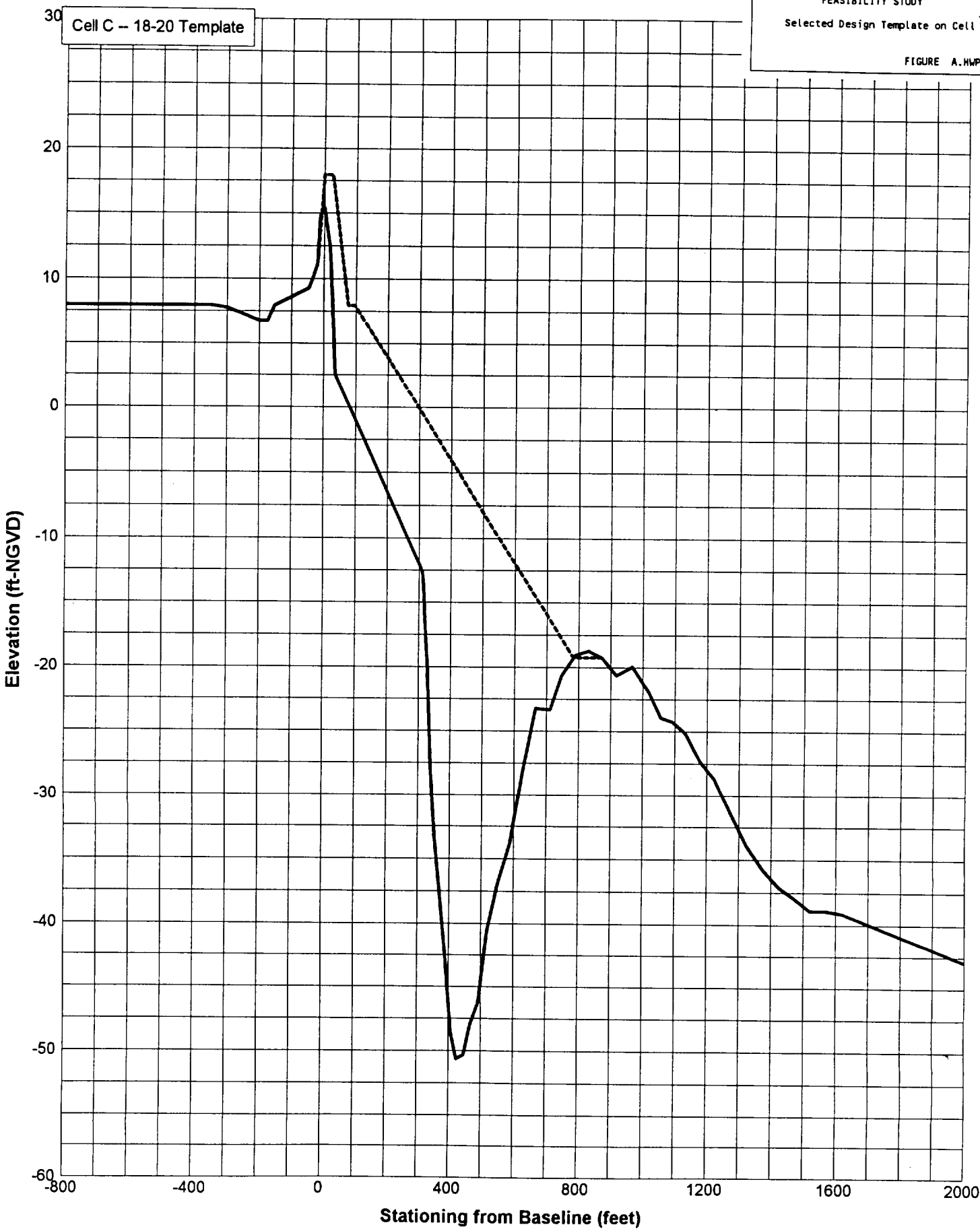
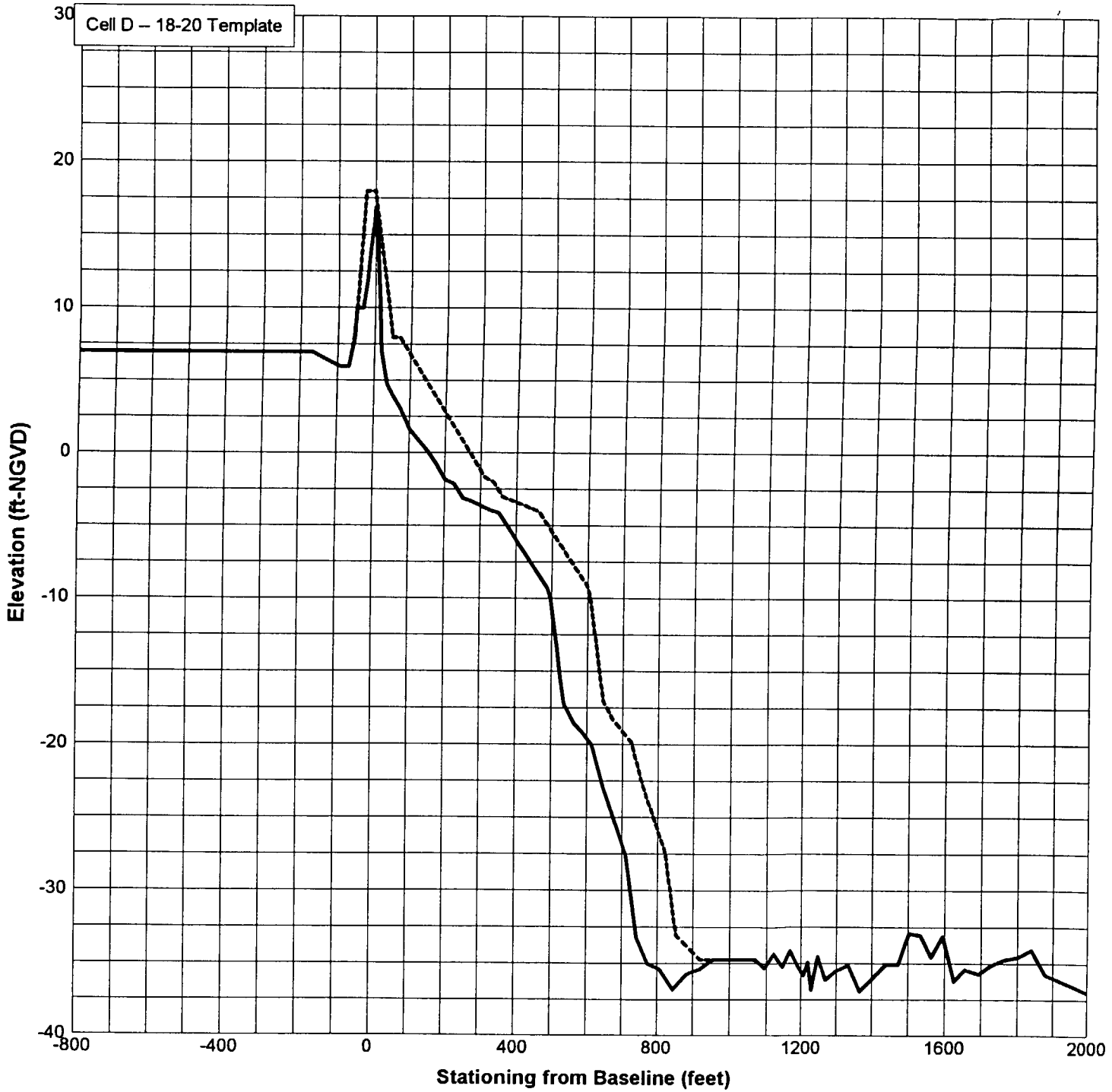
LOWER CAPE MAY MEADOWS-CAPE MAY POINT
FEASIBILITY STUDY

Selected Design Template on Cell C

FIGURE A.HWP.4.4





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FEASIBILITY STUDY

Selected Design Template on Cell D

FIGURE A.HWP.4.5

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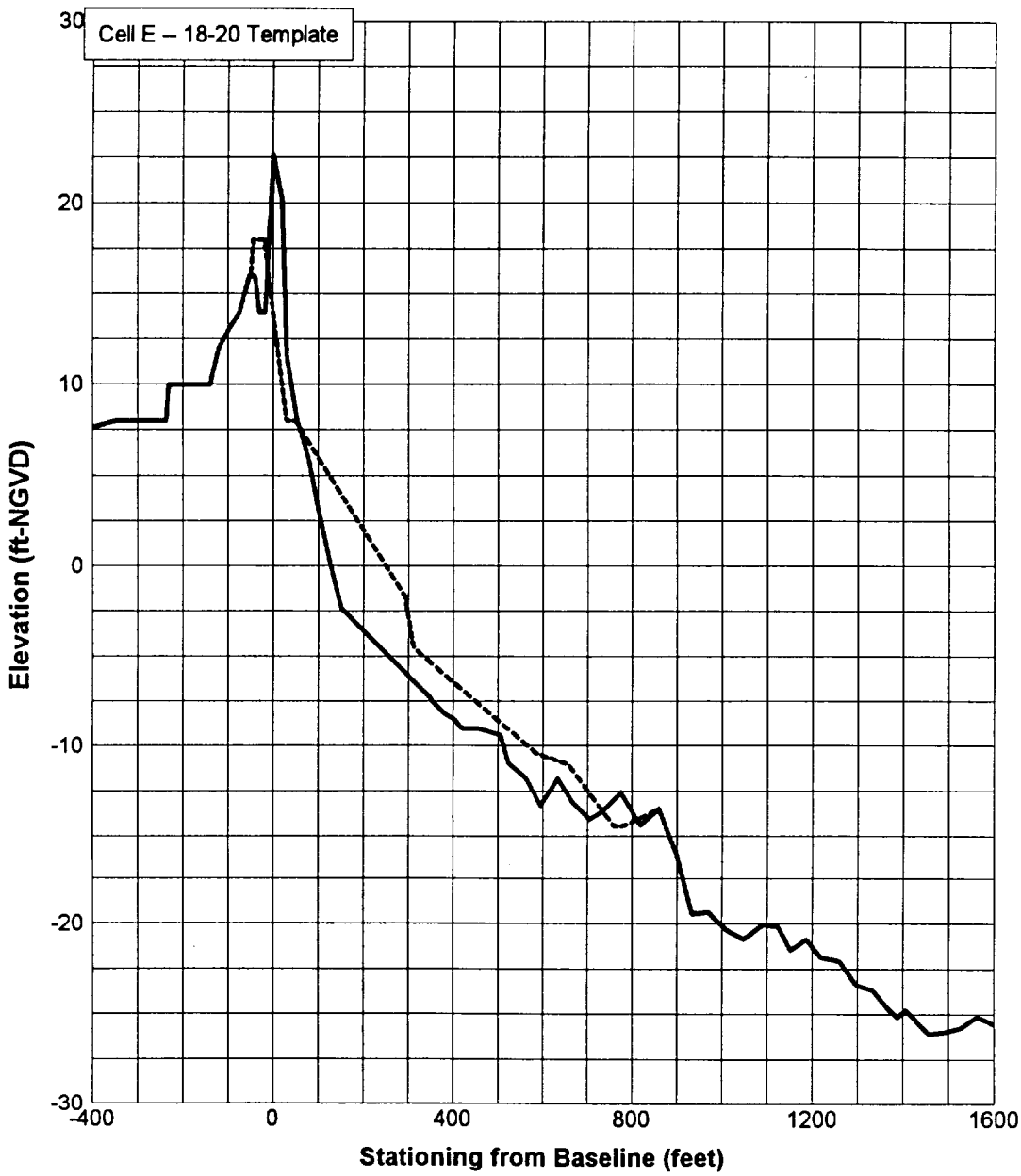

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LOWER CAPE MAY MEADOWS-CAPE MAY POINT
FEASIBILITY STUDY

Selected Design Template on Cell E

FIGURE A.HWP.4.6

A.HWP.5 CONSIDERATION OF ADDITIONAL PROTECTION

Design template 18-20 on both The Meadows and the Cape May Point cell at the year 2000 shoreline has been provisionally identified as the optimal design. With the selected plan there is still residual damage to the towns of West Cape May and Cape May Point due to the elevated stages of The Meadows at the 50 year event and beyond. Additional protection for these towns can be effected if small levees are built to contain the elevated Meadows WSEL. However, the annualized residual damages for both towns is too low to support construction of a levee and this idea was not pursued further.

Consideration was also given to structural reinforcement of The Meadows dune. Various methods are available to reinforce the dune but the only method analyzed was geotextile tubes, since it is the least expensive method and if it is unjustified all other methods will also be unjustified. Examination of the SBEACH output indicates that for design 18-20 it is the 50 year event which first substantially affects the dune. The benefits which accrue to the placement of geotextiles tubes are structural damage reduction and reduction of major rehabilitation costs. With geotextile tubes The Meadows' dune will not be eroded and hence there will be a reduction in the overtopping volume of the 50 and 100 year events. This results in a small reduction in the 50 and 100 year interior water surface and a commensurate reduction in structural damage, however overtopping will continue unabated from the Cape May Point cells. There will no reduction of the 200 and 500 year water surface elevations since the Cape May Point cells will continue to breach. The annualized reduction in structural damage from a reduction in interior water levels is negligible. A geotextile tube core in The Meadows dune will provide a cost savings through the elimination of dune reconstruction after a major event. The 500 year event erodes the dune from elevation 18 to an average elevation of 12 ft-NGVD. The eroded area of the dune is 280 square feet, which corresponds to 76, 700 cubic yards assuming that the erosion applies to the 7400 ft cell length of The Meadows . Conservatively applying this volume to the 50 year event and annualizing, the volume of sand displaced is 1,530 cubic yards per year. Converting this average annual volume of displaced sand to present value is the maximum allowable cost of geotextile tube installation. It is obvious that the cost of replacing sand after a major event (i.e. 50 year or greater) would be less than the installation of 7400 feet of geotextile tubes. Geotextile tubes may be useful as insurance for maintaining a specified dune crest under severe storm conditions but such a use can not be economically justified.

A.HWP.6 CONTINUING CONSTRUCTION

The size and location of the line of protection has been identified. But such a plan will require periodic nourishment. Consideration was given to the following means to reduce the nourishment requirements, but they were rejected for performance and cost considerations. A more detailed discussion can be found in the Plan Formulation section.

---- Mechanical sand bypassing from Cape May City and placement along Meadows ocean front

---- Notch terminal groin of Cape May City to allow for increased natural downdrift to The Meadows .

---- offshore detached breakwaters

---- beach dewatering

---- offshore submerged feeder berm

The nourishment cycle was selected as 4 years in order to effect a cost savings by synchronizing The Meadows nourishment with the 2 year cycle of the adjacent Cape May City beachfill. Nourishment quantities were calculated separately for The Meadows and those Cape May Point cells which drain to The Meadows. For all cells the nourishment quantity consists of 2 components: a buffer protecting the design template and major rehabilitation of the design template. The buffer in turn consists of two components: a quantity of sand to offset long term erosion and a quantity of sand sized to compensate for episodic storm erosion such that there is a 50% chance that the cumulative sand eroded over a 4 year period will not exceed the placed episodic component. Major Rehabilitation reflects on an average annual basis the quantity of sand lost from the design template due to frequency storm events assuming the buffer is not in place. This quantity was calculated as the area under the SBEACH determined erosion volume-frequency curve. For the Meadow's Cell any sand indicated to have been displaced to an average depth of water greater than 5 ft is assumed to be unrecoverable because of the tidal currents. For the Cape May Point Cells an identical procedure was used to estimate the average annual rehabilitation quantity. Any sand indicated by SBEACH to have been displaced beyond the tips of the existing groins were assumed lost to the tidal currents. This assumption is supported by the results of groin monitoring by Stockton State College as documented in section A.HCP.1.8.7. Table A.HWP.6.1 shows the nourishment quantities by location and by category.

Table A.HWP.6.1 Nourishment Quantities --- 4 year Cycle (cu yd/ft-yr)		
	Meadows	Cape May Point*
Buffer:		
Long term	15	0
Episodic	1.3	3.9
Average Annual frequency erosion (Major Rehabilitation)	1.6	4.6
Cell Length(ft)	7400	3550
4 Year Nourishment Quantity(cu yd)	530000	121000

*cells which drain to The Meadows

The historic average annual fill placed by the State of New Jersey at Cape May Point over the period 1967 to 1997 is 2.2 cu yd/ft-yr which compares favorably to the value of 4.6 cu yd/ft-yr considering that the value of 4.6 includes storm events which have not occurred over this historic period. The proposed nourishment quantities for The Meadows is estimated to be 17.9 cu yd/ft-yr which corresponds favorably to an actual fill rate of 13.5 cu yd/ft-yr for the 19400 foot long Cape May City beachfill project (with groins) over the period April 1993 to April 1997.

The above analysis pertained to cells, A,B,C,D and E which drain to The Meadows. Cell F, consisting of the two most westward groin compartments does not drain to The Meadows. However, there is without project damage and an assessment was made of the economic viability of a beachfill project. The without project dune is large, with a peak crest elevation of 24 ft-NGVD and a width, at elevation 21 ft-NGVD greater than the design template width of 25 ft. However, there is a minimal berm. An analysis was performed to determine the structural damage reduction for two designs: berm widths of 20 and 50 ft at elevation 8.0 ft-NGVD. SBEACH was run for the 2, 5, 10, 20, 50, 100, 200 and 500 year storms. The design performance of the 20 and 50 ft berms is summarized in Table A.HWP.6.2.

Table A.HWP.6.2
Cell F
With Project Design Performance

Plan	2 yr	5 yr	10 yr	20 yr	50 yr	100 yr	200 yr	500 yr
W/O	--	--	--	--	BR	BR	BR	BR
Berm-50ft	--	--	--	--	--	--	OT	BR
Berm-20ft	--	--	--	--	--	--	OT	BR

Note: OT -- dune is overtopped
BR -- dune is breached

Using the same methodology as above, a periodic nourishment estimate was prepared and is summarized in Table A.HWP.6.3. A Federal project for Cell F was found to be economically unjustified.

Table A.HWP.6.3
Cell F Nourishment Quantities
4 year Cycle
(cu yd/ft-yr)

	Cell F
Buffer:	
Long term	0
Episodic	2.3
Average Annual frequency erosion (Major Rehabilitation)	3.0
Cell Length(ft)	1490
4 Year Nourishment Quantity(cu yd)	31700

A.HWP.7 INTERIOR PLAN ANALYSIS

The exterior plan formulation determined that the most cost effective means to protect the environmental value of The Meadows is to provide a strengthened dune system for both The Meadows and Cape May Point. The proposed interior improvement of The Meadows is discussed below.

The major improvement to The Meadows is the elimination of Phragmites through herbicidal spraying followed by a control burn to eliminate the biomass. In addition 7 acres of Meadows' wetland which were overwashed with sand are to be excavated and regraded as wetlands and scrub/shrub habitat. Hydrologic Segments 1 and 2 are to remain fresh water, while hydrologic segment 3 is be converted into a salt marsh, by replacing the standard flap gate on the Broadway Street culvert with a self-regulating tide gate (SRT). The tide gate will be field adjusted to provide daily inundation of segment 3 to a maximum elevation of 1.5 ft-NGVD. The controls on the SRT will be selected to automatically close the gate when the water level at the gate exceeds a critical threshold, also to be field determined. However, due to frequent sand overwash events which have filled in various ditches, drainage work is required to improve the flow circulation and thereby the water quality. The selected improvements consist of excavating adverse slopes between the ponds, reconnecting ponds within hydrologic segments and connecting the hydrologic segments with drainage channels. Generally the refurbished and new drainage channels will have a bottom width of 20 feet. The drainage channels between the hydrologic segments will be controlled by 10 foot wide sharp crested weirs with removable flashboards. This allows flexibility in setting the water level in the ponds while allowing water to flow downstream at non-damaging elevations. The water control structure between hydrologic segments 1 and 2 will have a crest elevation range between 3.0 and 4.5 ft-NGVD, while the control structure between hydrologic segments 2 and 3 will have a range between 2.0 and 3.5 ft-NGVD. A small berm with a crest elevation of 4.0 ft-NGVD will be placed at the boundary between segments 2 and 3 in order to detain in segment 2 the increased with project outflows from segment 1. The berm results in the water being slowly released over the weir into segment 3 instead of flowing uncontrolled overland. In order to increase the availability of fresh water a shield will be placed over the intake for the drainage east. This will prevent the loss of water to the ocean, making it available to the eastern portion of The Meadows. Although it is highly unlikely that the proposed main drainage channels will become blocked from sand overwash due to their distance from the dune line, the shield for drainage east is designed for easy removal, if necessary to provide drainage relief for the town of Cape May Point. The interior improvements are shown on Figure A.HWP.7.1

The improvements have been analyzed with the hydrologic model described in section A.HWO.8.3. The results show that over a range of initial pond water levels there is not a substantial increased risk of fluvial flooding. The proposed improvements (shield over drainage east, drainage ditches, with weirs between hydrologic segments, a berm between segments 2 and 3 and the conversion of hydrologic segment 3 into a salt marsh) were incorporated into the hydrologic model and two conditions were analyzed: the 10 year storm with the pond starting water surface elevations at the maximum levels of 4.5 and 3.5 ft-NGVD for segments 1 and 2 respectively and the 50 year storm with the pond levels at the normal settings of 3.5 and 2.5 ft-

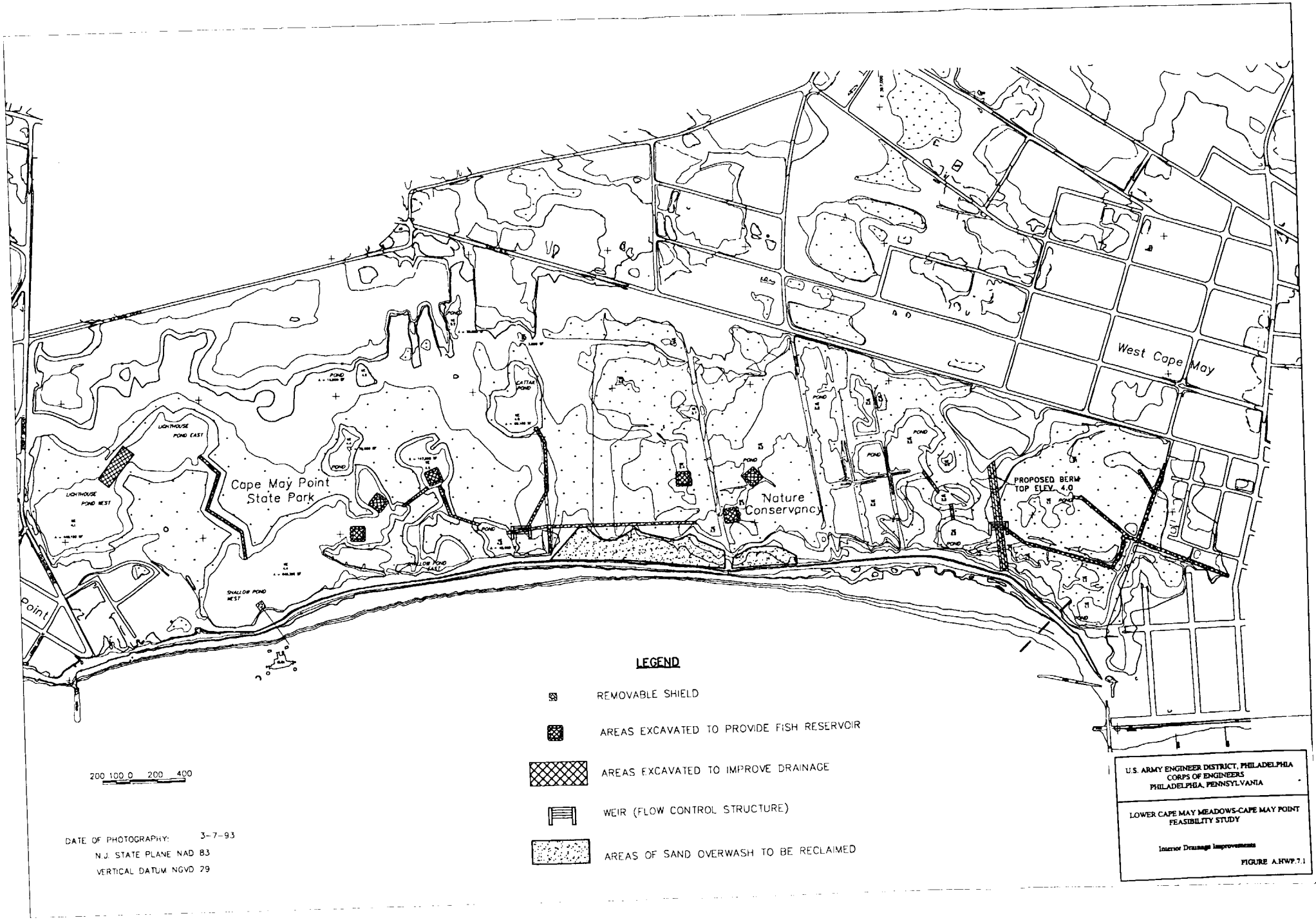
NGVD for segments 1 and 2. The calculated water surface elevations are not the 10 and 50 year interior frequency water surface elevations. Rather they are the estimated water surface elevations when the 10 and 50 year 24 hour rain storms occur with the assumed starting elevations of Lake Lily and the ponds in The Meadows. With and without project interior water surface elevations for the 10 and 50 year rain events are provided in Table A.HWP.7.1. The stage-hydrographs for both the 10 and 50 year events for the 3 segments and Lake Lily are over plotted on the without project results as Figures A.HWP.7.2 through A.HWP.7.9. Not unexpectedly, there is no difference in water level for Lake Lily for the 50 year event due to the fact that the capacity of the 18 inch drain pipe which connects it with The Meadows is relatively invariant to the tailwater in hydrologic segment 1. And for the 10 year event the increased with project water levels for Lake Lily and hydrologic segments 1 and 2 are due solely to the assumption of higher initial starting water levels. For the 50 year event the water level in hydrologic segment 1 is lower than without project condition, and is due to the release capacity of the weir. The water level in segment 2 for the 50 year event is higher than without project condition, but this is acceptable because the water level is non-damaging; the paths within the Nature Conservancy property will be temporarily inundated. The water levels in segment 3 are slightly higher than the existing water levels for both the10 and 50 year events, but in both cases the maximum water surface elevations are non-damaging. These results indicate that if the weir crests are set at the normal elevations there is in any given year only a 2 percent chance of exceeding in each segment the calculated non-damaging elevations. And if the pond water levels are set at their maximum level, there is in any year only a 10 percent chance that the non-damaging calculated water levels will be exceeded.

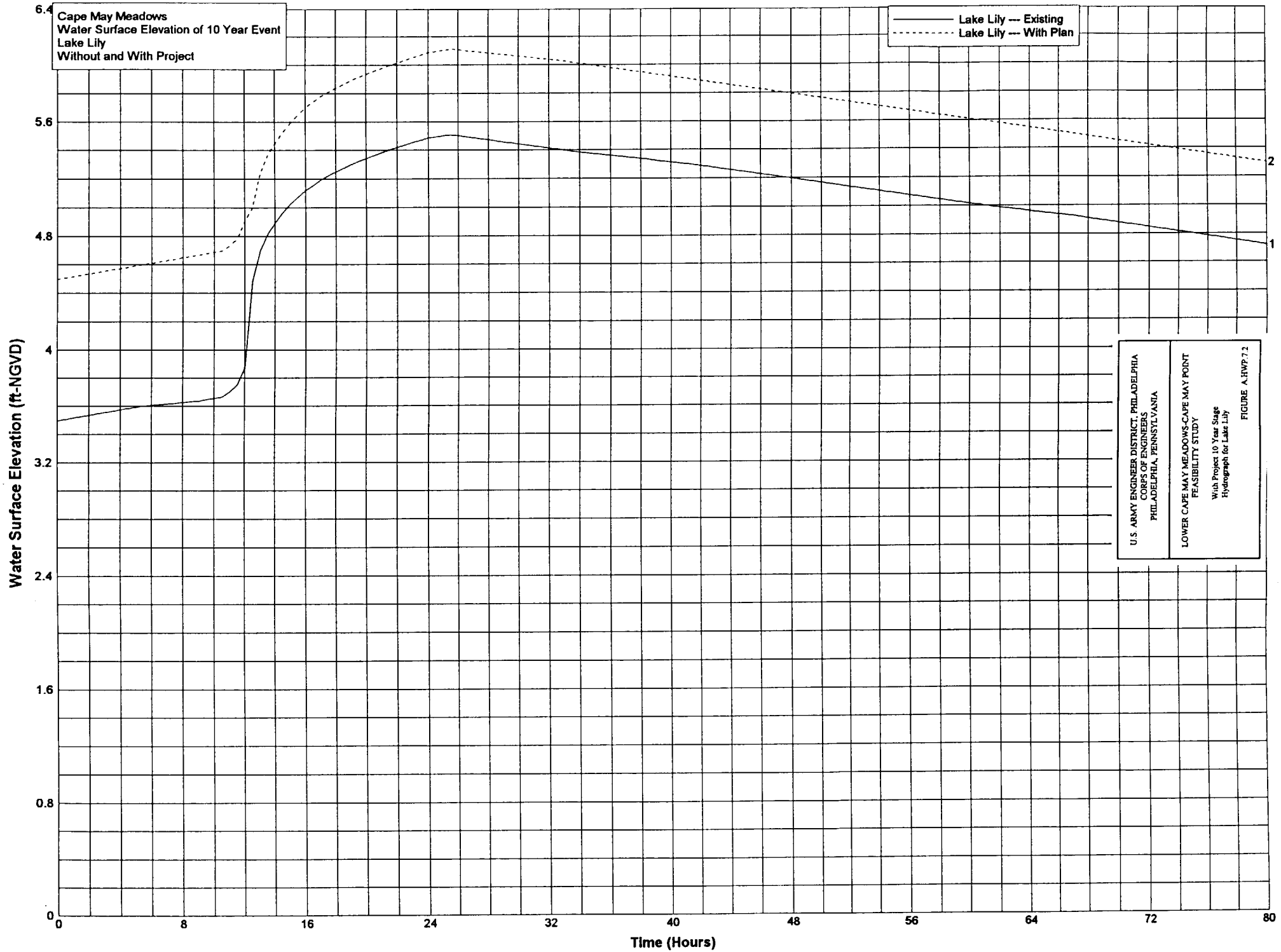
Table A.HWP.7.1
With and Without Project
Interior Water Surface Elevations
for the 10 and 50 Year Rain Events

Segment	Elevation (ft-NGVD)			
	10 Year		50 Year	
	Without Project	With Project	Without Project	With Project
Lake Lily	5.5	6.1	6.2	6.2
Hydrologic Segment 1	4.9	5.4	5.4	4.8
Hydrologic Segment 2	3.3	4.2	3.4	3.9
Hydrologic Segment 3	2.6	2.9	3.2	3.4

Note: Results are based on a 24 hour storm under antecedent moisture condition 3 and initial pond elevations of:

	10 Year		50 year	
	W/O	W	W/O	W
Lake Lily and HS1	3.5	4.5	3.5	3.5
HS2	2.5	3.5	2.5	2.5
HS3	1.0	1.0	1.0	1.0


Cape May Point State Park
Nature Conservancy
West Cape May
Point
LIGHTHOUSE POND EAST
LIGHTHOUSE POND WEST
SHALLOW POND WEST
CATTAIL POND
PROPOSED BERM TOP ELEV. 4.0
POND
LEGEND
REMOVABLE SHIELD
AREAS EXCAVATED TO PROVIDE FISH RESERVOIR
AREAS EXCAVATED TO IMPROVE DRAINAGE
WEIR (FLOW CONTROL STRUCTURE)
AREAS OF SAND OVERWASH TO BE RECLAIMED
200 100 0 200 400
DATE OF PHOTOGRAPHY: 3-7-93
N.J. STATE PLANE NAD 83
VERTICAL DATUM NGVD 29
U.S. ARMY ENGINEER DISTRICT, PHILADELPHIA
CORPS OF ENGINEERS
PHILADELPHIA, PENNSYLVANIA
LOWER CAPE MAY MEADOWS-CAPE MAY POINT
FEASIBILITY STUDY
Interior Drainage Improvements
FIGURE A.HWP.7.1


Cape May Meadows
Water Surface Elevation of 10 Year Event
Lake Lily
Without and With Project
Lake Lily --- Existing
Lake Lily --- With Plan
Water Surface Elevation (ft-NGVD)
6.4
5.6
4.8
4
3.2
2.4
1.6
0.8
0
0
8
16
24
32
40
48
56
64
72
80
Time (Hours)
2
1
U.S. ARMY ENGINEER DISTRICT, PHILADELPHIA
CORPS OF ENGINEERS
PHILADELPHIA, PENNSYLVANIA
LOWER CAPE MAY MEADOWS-CAPE MAY POINT
FEASIBILITY STUDY
With Project 10 Year Stage
Hydrograph for Lake Lily
FIGURE A.HWP.7.2

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Cape May Meadows
Water Surface Elevation of 10 Year Event
Hydrologic Segment 1
Without and With Project
Segment 1 --- Existing
Segment 1 --- With Plan
Water Surface Elevation (ft-NGVD)
Time (Hours)
6.4
5.6
4.8
4
3.2
2.4
1.6
0.8
0
0
8
16
24
32
40
48
56
64
72
80
4
3
U.S. ARMY ENGINEER DISTRICT, PHILADELPHIA
CORPS OF ENGINEERS
PHILADELPHIA, PENNSYLVANIA
LOWER CAPE MAY MEADOWS-CAPE MAY POINT
FEASIBILITY STUDY
With Project 10 Year Stage
Hydrograph for Hydrologic Segment 1
FIGURE A.HWP.7.3

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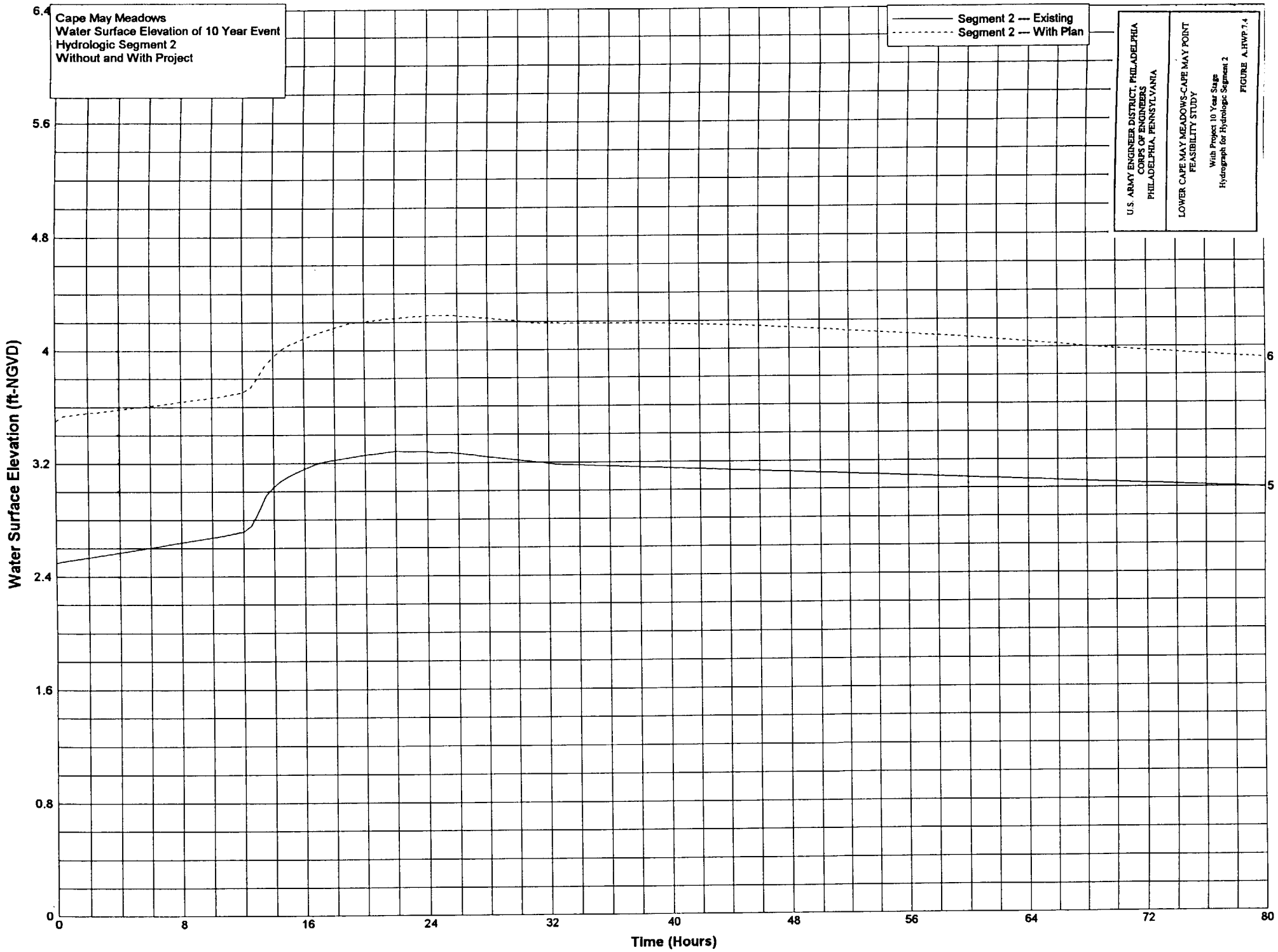
Cape May Meadows
Water Surface Elevation of 10 Year Event
Hydrologic Segment 2
Without and With Project
Segment 2 --- Existing
Segment 2 --- With Plan
Water Surface Elevation (ft-NGVD)
6.4
5.6
4.8
4
3.2
2.4
1.6
0.8
0
0
8
16
24
32
40
48
56
64
72
80
Time (Hours)
6
5
U.S. ARMY ENGINEER DISTRICT, PHILADELPHIA
CORPS OF ENGINEERS
PHILADELPHIA, PENNSYLVANIA
LOWER CAPE MAY MEADOWS-CAPE MAY POINT
FEASIBILITY STUDY
With Project 10 Year Stage
Hydrograph for Hydrologic Segment 2
FIGURE A.HWP.7.4

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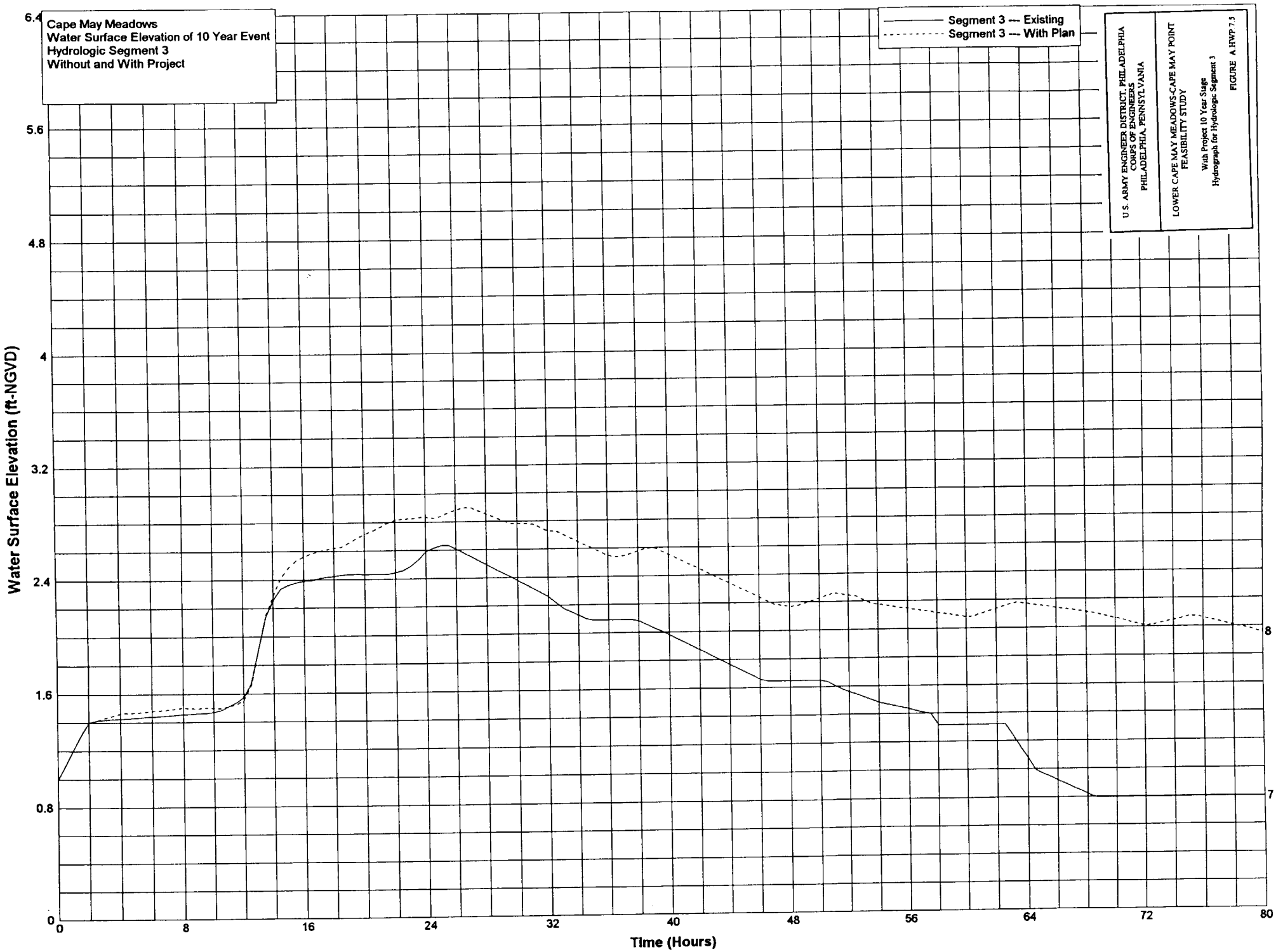
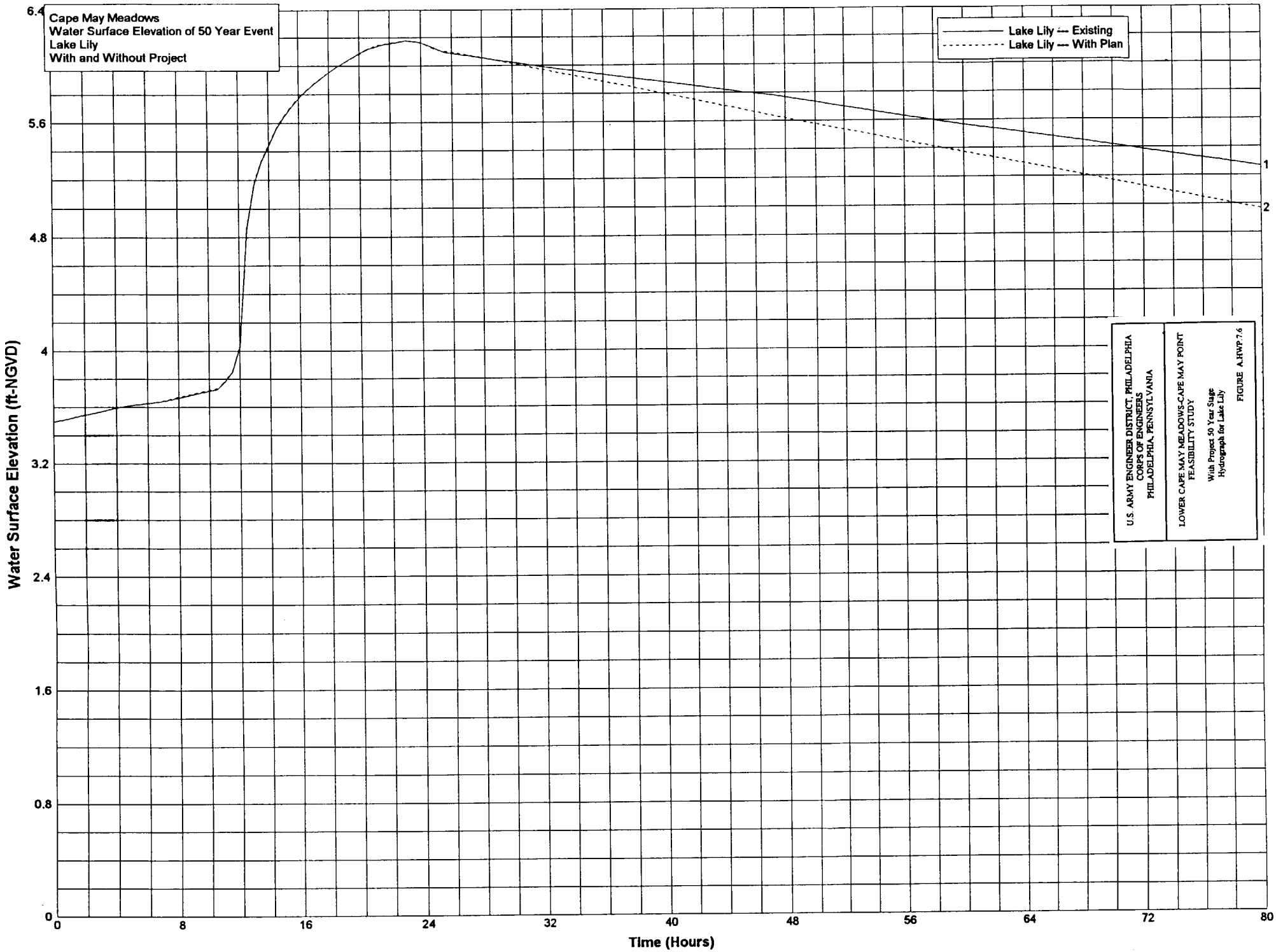

Cape May Meadows
Water Surface Elevation of 10 Year Event
Hydrologic Segment 3
Without and With Project
Segment 3 --- Existing
Segment 3 --- With Plan
U.S. ARMY ENGINEER DISTRICT, PHILADELPHIA
CORPS OF ENGINEERS
PHILADELPHIA, PENNSYLVANIA
LOWER CAPE MAY MEADOWS-CAPE MAY POINT
FEASIBILITY STUDY
With Project 10 Year Stage
Hydrograph for Hydrologic Segment 3
FIGURE A.HWP 7.5
Water Surface Elevation (ft-NGVD)
6.4
5.6
4.8
4
3.2
2.4
1.6
0.8
0
0
8
16
24
32
40
48
56
64
72
80
Time (Hours)
8
7

147


Cape May Meadows
Water Surface Elevation of 50 Year Event
Lake Lily
With and Without Project
Lake Lily --- Existing
Lake Lily --- With Plan
Water Surface Elevation (ft-NGVD)
6.4
5.6
4.8
4
3.2
2.4
1.6
0.8
0
0
8
16
24
32
40
48
56
64
72
80
Time (Hours)
1
2
U.S. ARMY ENGINEER DISTRICT, PHILADELPHIA
CORPS OF ENGINEERS
PHILADELPHIA, PENNSYLVANIA
LOWER CAPE MAY MEADOWS-CAPE MAY POINT
FEASIBILITY STUDY
With Project 50 Year Stage
Hydrograph for Lake Lily
FIGURE A.HWP.7.6

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Cape May Meadows
Water Surface Elevation of 50 Year Event
Hydrologic Segment 1
With and Without Project
Segment 1 — Existing
Segment 1 — With Plan
Water Surface Elevation (ft-NGVD)
Time (Hours)
6.4
5.6
4.8
4
3.2
2.4
1.6
0.8
0
0
8
16
24
32
40
48
56
64
72
80
3
4
U.S. ARMY ENGINEER DISTRICT, PHILADELPHIA
CORPS OF ENGINEERS
PHILADELPHIA, PENNSYLVANIA
LOWER CAPE MAY MEADOWS-CAPE MAY POINT
FEASIBILITY STUDY
With Project 50 Year Stage
Hydrograph for Hydrologic Segment 1
FIGURE A.HWP.7.7

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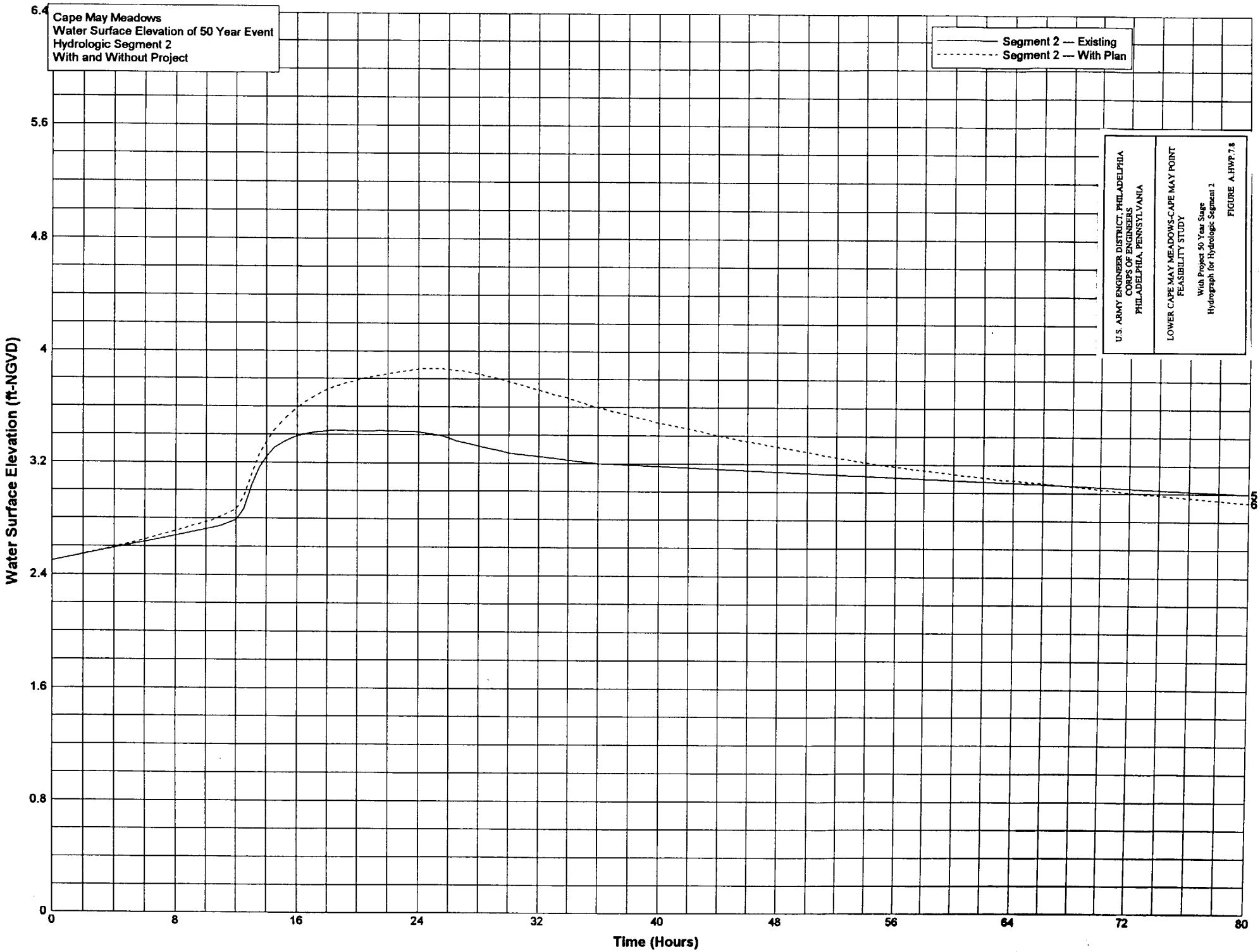
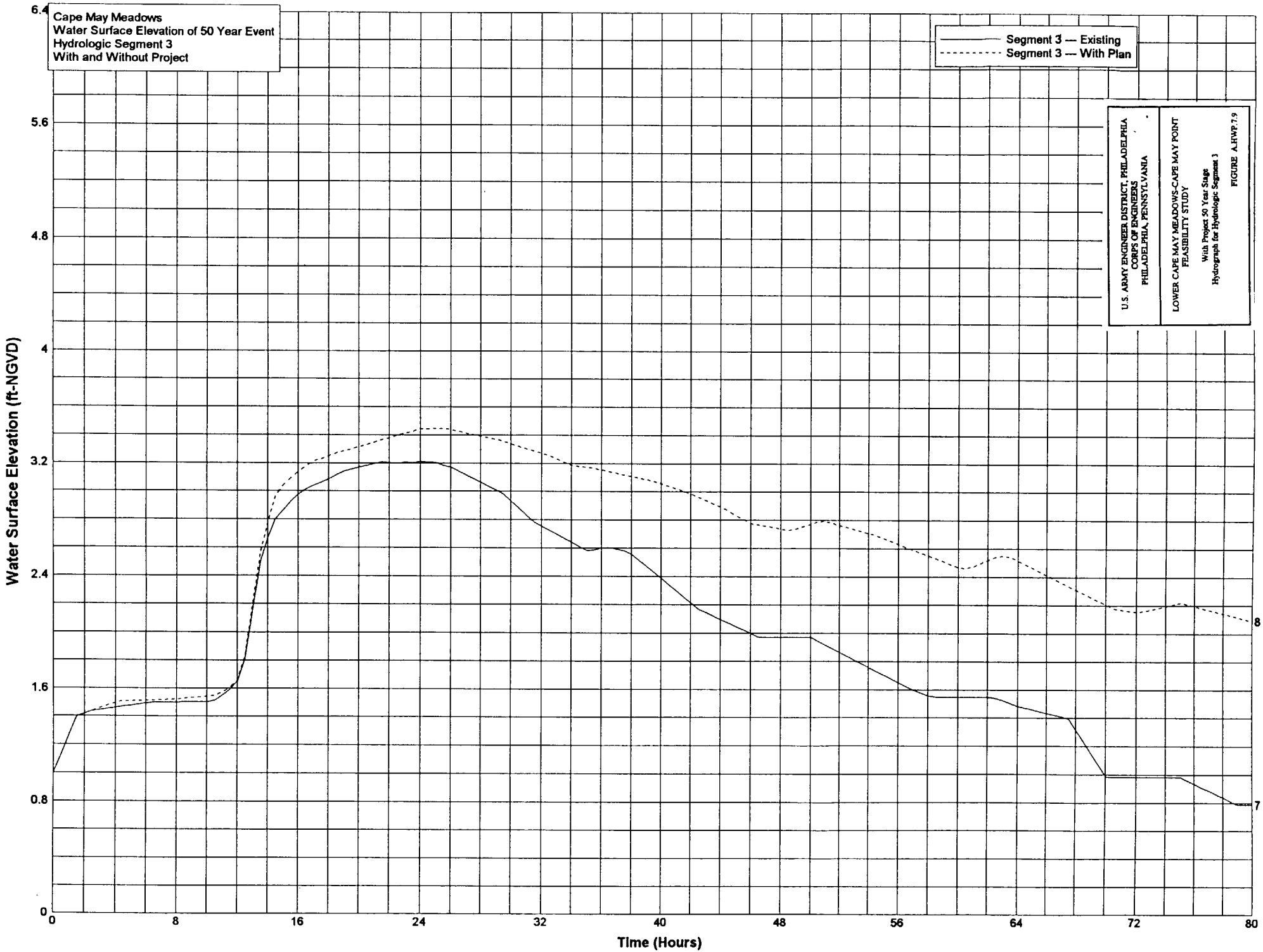

Cape May Meadows
Water Surface Elevation of 50 Year Event
Hydrologic Segment 2
With and Without Project
Segment 2 — Existing
Segment 2 — With Plan
Water Surface Elevation (ft-NGVD)
Time (Hours)
6.4
5.6
4.8
4
3.2
2.4
1.6
0.8
0
0
8
16
24
32
40
48
56
64
72
80
5
6
U.S. ARMY ENGINEER DISTRICT, PHILADELPHIA
CORPS OF ENGINEERS
PHILADELPHIA, PENNSYLVANIA
LOWER CAPE MAY MEADOWS-CAPE MAY POINT
FEASIBILITY STUDY
With Project 50 Year Stage
Hydrograph for Hydrologic Segment 2
FIGURE A.HWP.7.8

150


Cape May Meadows
Water Surface Elevation of 50 Year Event
Hydrologic Segment 3
With and Without Project
Segment 3 — Existing
Segment 3 — With Plan
Water Surface Elevation (ft-NGVD)
6.4
5.6
4.8
4
3.2
2.4
1.6
0.8
0
0
8
16
24
32
40
48
56
64
72
80
Time (Hours)
8
7
U.S. ARMY ENGINEER DISTRICT, PHILADELPHIA
CORPS OF ENGINEERS
PHILADELPHIA, PENNSYLVANIA
LOWER CAPE MAY MEADOWS-CAPE MAY POINT
FEASIBILITY STUDY
With Project 50 Year Stage
Hydrograph for Hydrologic Segment 3
FIGURE A.HWP.7.9

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SECTION 3

SURVEYING AND MAPPING REQUIREMENTS

Survey data used for the Feasibility Study was originally collected in 1994 and was updated in 1996. The spacing between the survey lines varies from 500 to 2500 feet. This included the recovery of one benchmark in the Meadows due to continued erosion.

Data collected for the study mapping effort include the following: aerial photography, first floor elevations of all structures in the first block fronting the ocean in Cape May Point, elevations and locations of all shore protection structures, street and street names, spot elevations and contours at 2' intervals throughout the study area. Computer programs used to read and store the mapping include AutoCAD and Map and Imaging Processing System (MIPS), which is a program used for Geographic Information Systems (GIS). Additional surveying collected during the Feasibility phase of the study included cross sections of various existing ponds and other drainage features within the interior of the Meadows habitat area.

Mapping developed for this Feasibility Study in 1993, is sufficient for the plans and specifications phase, but new survey data will be required. Beach Profile surveys every 200 feet starting from the terminal groin in the city of Cape May to the last groin in Cell E in Cape May Point to beyond the depth of closure will be necessary to accurately determine quantities in developing the plans and specifications. These beach profiles should also include profiles of all groins in the study area. Hydrographic surveys of the area in Cape May Point where the existing scourholes adjacent to the 2 groins in Cell C are located will also be required.

SECTION 4

GEOTECHNICAL INVESTIGATION

Geotechnical Appendix
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Section 1
Vibrocore Logs

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- 2.2 Positioning System
- 2.3 Navigational Data Acquisition and Logging System
- 2.4 Vibracore
- 2.5 Echosounder
- 2.6 Personnel

3.0 DATA PRESENTATION
- 3.1 Summary of Events
- 3.2 Table 1 - List of Core Locations
- 3.3 Core Logs
- 3.4 Penetration Graphs

1.0 INTRODUCTION

The U.S. Army Engineer District, Philadelphia contracted Alpine Ocean Seismic Survey, Inc. (Contract Number: DACW61-96-C-0026) to obtain sixty-nine (69) twenty (20) foot core samples in Delaware Bay and offshore New Jersey Coast. The sixty-nine (69) cores were collected during the field work period of 19-31 May 1996.

Field work included: precise positioning of the coring vessel using DGPS; obtaining continuous core samples with an Alpine Pneumatic Vibracore; obtaining penetrometer records (rate of penetration of coring tube into the sediment); and the recording of water depths at each coring location. The field work was conducted aboard Alpine's vessel "R/V Atlantic Twin". A representative of the Corps of Engineers was aboard during the duration of operations. Core samples were delivered to the Corps upon completion of the project.

2.0 EQUIPMENT

2.1 Survey Vessel

The R\V Atlantic Twin, a 90-foot steel catamaran hull research vessel with a 7-feet draft, was used as the platform for the vibracoring operations. The vessel has ample deck space, anchoring system, hydraulic crane, deck winches and A-frame capability for vibracore operations. The navigation equipment, with associated computer, printer and display unit were mounted in the pilot house. The vessel has sleeping facilities to accommodate crew and vibracore staff during the survey period.

2.2 Positioning System

A Trimble 4000 Differential GPS Navigation System was used throughout this operation. The DGPS system consists of an 8-channel satellite receiver connected to an HF data link receiver which obtains differential correction signals from the United States Coast Guard GPS transmitter at Cape Henlopen, Delaware.

2.3 Navigational Data Acquisition and Logging System

The WGS-84 Geographic position obtained by the GPS navigation system were converted into New Jersey State Grid coordinate positions, using a computer and Sextant navigation software, version 9.44. The system consists of the following components:

1) 486 DX 33Mhz Computer w/3.5" logging disk.

2) Color Video Monitor (Helmsman Display).

3) Printer.

4) Sextant closure box and software.

2.4 Vibracore

A model 271 B Alpine Pneumatic Vibracore configured to take cores 20 feet in length was used on this project. The model 271B is a self-contained, free standing pneumatic vibracore unit. The unit consists of an air-driven vibratory hammer assembly, an aluminum H-beam which acts as the vertical guide for the vibrator, a set of four steel support pads and legs which hold the beam upright on the sea bottom, a steel coring pipe, a cutting edge, a core retainer, a clear PVC core liner and a penetrometer which records time and depth of penetration of the core pipe into the sea bottom. An air hose array provides passage of compressed air from the compressor on deck to drive the vibracore. A jet pump was installed aboard the vessel to provide high pressure water for jetting operations.

2.5 Echoscounder

An Innerspace 448 echosounder obtained water depths at each core site. The echosounder was calibrated each day by the "bar check" method. Water depths were reduced to MLW using tide tables for the Breakwater Harbor, Delaware and the Sandy Hook, New Jersey tide gauges.

2.6 Personnel

The following key personnel were aboard the vessel:

Alpine Party Chief:	John Maker
Captain:	Darren McClave
Vibracore Operator:	Nick Price
Corps Representative:	Harold Schwanger

3.0 DATA PRESENTATION

3.1 Summary of Events

5/18

Mobilize vessel at USCG Station, Cape May
Corp of Engineers representative on board

5/19

08:45 - Attempted Core NJV-203 - washout
09:12 - Obtained Core NJV-203 R2
10:47 - Obtained Core NJV-203 R3

11:24 - Obtained Core NJV-205
13:10 - Abandoned attempt at NJV-204 due tidal currents
14:05 - Obtained Core NJV-206
14:56 - Obtained Core NJV-208
16:04 - Obtained Core NJV-209
16:54 - Obtained Core NJV-210
18:30 - Abandoned attempt at NJV-207 due currents

5/20

07:55 - Obtained Core NJV-212
09:03 - Obtained Core NJV-211 R1
11:27 - Obtained Core NJV-211 R2
13:52 - Obtained Core NJV-207
14:35 - Obtained Core NJV-213
15:59 - Obtained Core NJV-214
16:50 - Obtained Core NJV-218
17:34 - Obtained Core NJV-219

5/21

09:43 - Obtained Core NJV-221
11:03 - Obtained Core NJV-220
12:03 - Obtained Core NJV-225
12:48 - Obtained Core NJV-224
14:37 - Obtained Core NJV-223
15:29 - Obtained Core NJV-222
16:20 - Obtained Core NJV-215
17:18 - Obtained Core NJV-216

5/22

09:47 - Obtained Core NJV-217
11:52 - Obtained Core NJV-204
13:29 - Obtained Core NJV-246
14:20 - Obtained Core NJV-245
15:00 - Pulley on anchor A-Frame broke loose
15:45 - Returning to dock for repairs

5/23

09:59 - Obtained Core NJV-244
10:32 - Obtained Core NJV-243
10:57 - Obtained Core NJV-242
11:54 - Obtained Core NJV-249
12:23 - Obtained Core NJV-248
13:16 - Obtained Core NJV-247
15:16 - Obtained Core NJV-294
16:18 - Obtained Core NJV-293

17:10 - Crane problem - return to dock for repair

5/24

12:00 - Crane repaired, enroute to work area
14:35 - Obtained Core NJV-291
15:09 - Obtained Core NJV-292
16:15 - Crane problem - return to dock for repair

5/25

11:10 - Obtained Core NJV-297
11:45 - Obtained Core NJV-299
12:13 - Obtained Core NJV-301 R1
12:33 - Obtained Core NJV-301 R2
13:20 - Obtained Core NJV-300 R1
13:37 - Obtained Core NJV-300 R2
14:18 - Obtained Core NJV-298
15:17 - Obtained Core NJV-296
17:16 - Obtained Core NJV-295

5/26

10:52 - Obtained Core DRV-37
12:11 - Obtained Core DRV-36
14:02 - Obtained Core DRV-35
14:43 - Obtained Core DRV-34
15:49 - Obtained Core DRV-33 R3 - Problem retaining fine material
16:55 - Obtained Core DRV-32 R3 - Problem retaining fine material
17:15 - Weather building - return to dock

5/27

10:52 - Obtained Core NJV-290
11:14 - Obtained Core NJV-289
13:16 - Obtained Core DRV-31 R1
13:40 - Obtained Core DRV-31 R2
14:08 - Obtained Core DRV-30
14:30 - Weather building - return to dock

5/28

Weathered-in - Perform maintenance on vessel & equipment

5/29

05:30 - Enroute to Delaware Coast for KAV core sites
10:19 - Attempt Core KAV-52 R1 - Refusal at 8.9' due buried wood
10:35 - Attempt Core KAV-52 R2 - Refusal at 9.4' due buried wood
11:07 - Attempt Core KAV-53 - too shallow, retry at high tide
11:40 - Obtained Core KAV-49

13:18 - Obtained Core KAV-44
13:42 - Obtained Core KAV-42
14:15 - Obtained Core KAV-46
15:05 - Obtained Core KAV-55
15:34 - Obtained Core KAV-56 R1
15:57 - Obtained Core KAV-56 R2
16:16 - Obtained Core KAV-57
16:39 - Obtained Core KAV-58
17:02 - Obtained Core KAV-59 R1
17:18 - Obtained Core KAV-59 R2
17:39 - Obtained Core KAV-54
18:06 - Attempt Core KAV-52 R3 - Refusal at 8.4' due buried wood
18:26 - Obtained Core KAV-52 R4 - Moved 50m offshore
18:41 - Obtained Core KAV-53 R1
18:58 - Obtained Core KAV-53 R2

5/30

09:50 - Enroute to Townsend Area
13:45 - Obtained Core NJV-233
15:09 - Obtained Core NJV-234
15:41 - Obtained Core NJV-230 R1
16:01 - Obtained Core NJV-230 R2
16:32 - Obtained Core NJV-231
16:57 - Obtained Core NJV-232
17:15 - Complete sampling - enroute to Atlantic City

5/31

Unload core samples - deliver to Philadelphia

TABLE 1

3.2 LIST OF CORES AND LOCATIONS

NUMBER	GRS-80	NJ TM NAD 83	MLLW
DRV-30	39° 04' 42.772"N 75° 10' 59.579"W	298164.2 E 90041.2 N	46.5
DRV-31 R1	39° 04' 21.508"N 75° 10' 44.708"W	299320.8 E 87881.0 N	44.3
DRV-31 R2	39° 04' 21.416"N 75° 10' 44.800"W	299313.5 E 87871.7 N	44.4
DRV-32 R1	39° 03' 59.903"N 75° 10' 29.694"W	300488.7 E 85686.2 N	47.2
DRV-32 R2	39° 03' 59.949"N 75° 10' 29.935"W	300469.7 E 85691.0 N	47.1
DRV-32 R3	39° 03' 59.959"N 75° 10' 29.777"W	300482.2 E 85692.0 N	47.0
DRV-33 R1	39° 03' 43.396"N 75° 10' 23.249"W	300984.7 E 84012.4 N	45.9
DRV-33 R2	39° 03' 43.423"N 75° 10' 23.298"W	300980.8 E 84015.1 N	45.9
DRV-33 R3	39° 03' 43.480"N 75° 10' 23.422"W	300971.1 E 84021.0 N	45.8
DRV-34	39° 03' 34.530"N 75° 10' 14.058"W	301703.0 E 83110.0 N	46.2
DRV-35	39° 03' 22.938"N 75° 10' 11.268"W	301914.5 E 81935.5 N	46.4
DRV-36	39° 03' 14.150"N 75° 10' 09.960"W	302011.1 E 81045.6 N	44.1
DRV-37	39° 02' 56.364"N 75° 10' 02.715"W	302574.2 E 79240.0 N	42.7
KAV-42	38° 50' 43.963"N 75° 10' 52.088"W	298120.5 E 5171.1 N	13.9
KAV-44	38° 50' 29.589"N 75° 10' 39.711"W	299089.0 E 3709.5 N	14.4
KAV-46	38° 49' 41.736"N 75° 10' 58.024"W	297603.8 E -1121.0 N	14.1
KAV-49	38° 49' 44.689"N 75° 09' 58.649"W	302304.8 R -857.0 N	13.2
KAV-52 R1	38° 47' 57.206"N 75° 09' 35.737"W	304039.5 E -11744.3 N	14.3
KAV-52 R2	38° 47' 57.562"N 75° 09' 35.970"W	304021.3 E -11708.2 N	14.3
KAV-52 R3	38° 47' 57.313"N 75° 09' 34.834"W	304110.3 E -11734.0 N	12.0
KAV-52 R4	38° 47' 56.979"N 75° 09' 33.935"W	304182.0 E -11768.3 N	16.6
KAV-53 R1	38° 47' 56.325"N 75° 09' 47.626"W	303097.6 E -11826.7 N	12.3
KAV-53 R2	38° 47' 56.325"N 75° 09' 47.626"W	303097.2 E -11838.5 N	12.2
KAV-54	38° 47' 48.291"N 75° 09' 06.972"W	306310.4 E -12662.6 N	17.7
KAV-55	38° 47' 35.679"N 75° 08' 53.202"W	307391.5 E -13946.3 N	12.2
KAV-56 R1	38° 47' 23.923"N 75° 08' 50.861"W	307568.5 E -15137.0 N	10.4
KAV-56 R2	38° 47' 23.907"N 75° 08' 50.943"W	307562.0 E -15138.6 N	10.4
KAV-57	38° 47' 29.330"N 75° 09' 02.510"W	306650.0 E -14583.4 N	12.2
KAV-58	38° 47' 33.541"N 75° 09' 18.824"W	305361.3 E -14148.2 N	12.0
KAV-59 R1	38° 47' 37.744"N 75° 09' 08.810"W	306157.2 E -13728.6 N	13.2
KAV-59 R2	38° 47' 37.924"N 75° 09' 08.592"W	306174.6 E -13710.5 N	13.2
NJV-203 R2	38° 55' 09.270"N 74° 59' 51.888"W	350501.0 E 31676.2 N	27.8
NJV-203 R3	38° 55' 09.298"N 74° 59' 51.737"W	350512.9 E 31678.4 N	27.0
NJV-204	38° 55' 05.125"N 74° 59' 36.312"W	351729.8 E 31249.6 N	32.2
NJV-205	38° 55' 23.131"N 75° 00' 03.223"W	349612.8 E 33082.9 N	27.0
NJV-206	38° 54' 55.151"N 74° 56' 23.246"W	366984.4 E 30162.4 N	26.5
NJV-207	38° 54' 43.337"N 74° 55' 58.272"W	368952.7 E 28957.7 N	29.2
NJV-208	38° 55' 07.627"N 74° 56' 23.541"W	366967.2 E 31429.7 N	26.7
NJV-209	38° 55' 05.615"N 74° 56' 12.848"W	367811.4 E 31217.1 N	26.0
NJV-210	38° 54' 47.233"N 74° 56' 15.459"W	367596.1 E 29358.4 N	27.4
NJV-211 R1	38° 55' 01.643"N 74° 55' 33.353"W	370931.1 E 30800.5 N	37.0
NJV-211 R2	38° 55' 00.804"N 74° 55' 33.075"W	370952.4 E 30716.0 N	36.7
NJV-212	38° 55' 17.685"N 74° 55' 17.258"W	372210.7 E 32417.6 N	15.8
NJV-213	38° 55' 08.187"N 74° 55' 05.393"W	373144.0 E 31452.3 N	28.7
NJV-214	38° 55' 11.512"N 74° 54' 48.002"W	374520.1 E 31782.5 N	26.9

NUMBER	GRS 80	NJ TM NAD 83	MLLW
NJV-215	38° 55' 16.079"N 74° 53' 57.081"W	378546.7 E 32226.6 N	29.3
NJV-216	38° 55' 29.001"N 74° 53' 35.408"W	380265.5 E 33587.2 N	24.6
NJV-217	38° 55' 22.367"N 74° 53' 17.820"W	381652.4 E 32849.4 N	32.0
NJV-218	38° 54' 39.858"N 74° 54' 42.630"W	374930.2 E 28578.1 N	30.7
NJV-219	38° 54' 47.038"N 74° 54' 28.496"W	376050.7 E 29299.5 N	31.7
NJV-220	38° 54' 39.532"N 74° 54' 13.689"W	377217.7 E 28534.8 N	36.7
NJV-221	38° 54' 46.089"N 74° 53' 48.810"W	379187.2 E 29189.6 N	36.3
NJV-222	38° 54' 00.751"N 74° 55' 03.284"W	373279.5 E 24628.9 N	29.7
NJV-223	38° 53' 45.354"N 74° 54' 33.721"W	375609.7 E 23060.6 N	27.9
NJV-224	38° 53' 48.729"N 74° 54' 15.707"W	377035.4 E 23395.7 N	31.1
NJV-225	38° 53' 49.439"N 74° 53' 57.241"W	378495.7 E 23461.1 N	31.5
NJV-230 R1	39° 07' 11.383"N 74° 42' 08.050"W	434745.2 E 104411.7 N	12.3
NJV-230 R2	39° 07' 12.233"N 74° 42' 08.371"W	434720.1 E 104497.8 N	12.4
NJV-231	39° 06' 37.443"N 74° 41' 53.954"W	435848.6 E 100975.4 N	12.8
NJV-232	39° 06' 17.370"N 74° 41' 53.020"W	435917.8 E 98944.3 N	13.2
NJV-233	39° 06' 39.582"N 74° 41' 40.932"W	436876.9 E 101187.1 N	16.4
NJV-234	39° 06' 59.872"N 74° 41' 55.096"W	435765.0 E 103242.3 N	12.0
NJV-242	38° 58' 37.426"N 75° 00' 48.814"W	346120.4 E 52760.4 N	24.5
NJV-243	38° 58' 30.718"N 75° 00' 29.939"W	347607.2 E 52073.3 N	19.3
NJV-244	38° 58' 15.447"N 75° 00' 15.292"W	348755.4 E 50531.9 N	12.3
NJV-245	38° 58' 08.911"N 75° 00' 39.606"W	346831.4 E 49871.3 N	23.2
NJV-246	38° 58' 07.110"N 75° 00' 59.847"W	345231.7 E 49698.2 N	30.0
NJV-247	39° 00' 08.172"N 74° 57' 53.764"W	359991.4 E 61867.2 N	21.2
NJV-248	39° 00' 00.522"N 74° 57' 42.817"W	360851.7 E 61088.8 N	20.4
NJV-249	38° 59' 44.619"N 74° 57' 39.996"W	361066.2 E 59478.7 N	16.2
NJV-289	38° 56' 48.426"N 75° 05' 06.013"W	325737.9 E 41854.9 N	40.1
NJV-290	38° 56' 53.898"N 75° 05' 00.207"W	326200.2 E 42405.6 N	44.4
NJV-291	38° 57' 39.012"N 75° 02' 35.786"W	337637.3 E 46899.4 N	42.9
NJV-292	38° 58' 27.374"N 75° 02' 29.872"W	338133.5 E 51789.6 N	41.2
NJV-293	38° 57' 50.491"N 75° 59' 47.699"W	350920.9 E 47983.0 N	25.4
NJV-294	38° 58' 02.646"N 74° 59' 17.790"W	353289.9 E 49202.0 N	26.0
NJV-295	39° 00' 35.819"N 75° 02' 24.286"W	338651.8 E 64782.2 N	53.1
NJV-296	39° 05' 00.124"N 75° 55' 15.428"W	372627.8 E 91344.5 N	15.3
NJV-297	39° 05' 30.273"N 74° 56' 05.812"W	368669.4 E 94413.5 N	11.8
NJV-298	39° 06' 06.029"N 74° 54' 30.077"W	376233.9 E 97996.1 N	12.1
NJV-299	39° 06' 30.417"N 74° 55' 08.841"W	373189.4 E 100477.5 N	11.0
NJV-300 R1	39° 07' 09.201"N 74° 54' 11.833"W	377700.5 E 104381.2 N	10.6
NJV-300 R2	39° 07' 09.103"N 74° 54' 12.270"W	377666.0 E 104371.4 N	10.6
NJV-301 R1	39° 07' 18.190"N 74° 55' 11.809"W	372977.8 E 105312.0 N	10.4
NJV-301 R2	39° 07' 18.044"N 74° 55' 11.809"W	372952.6 E 105297.4 N	10.4

3.3 CORE LOGS

ALPINE OCEAN SEISMIC SURVEY, INC.
70 Oak Street Norwood, New Jersey 07648
Tel. (201) 768-8000 Fax: (201) 768-5750

CORE LOG

Core No. NJ1203 Run No. 2 Date: 5/19/96 Area: Cape May

Grid Position: Easting 350501.0 Northing 31676.2

Geographic Position: Lat. 35°55'09.27" Long. 74°59'51.888"

Water Depth	Vibration Time	Core Depth
Uncorrected: 28.0	Stop: 0915	Penetration: 19.55'
Tide: 0.224	Start: 0912	Recovery: 6.1'
= Corrected: 27.776	= Elapsed: 3 min	

Depth	Core Description	Depth	Core Description
0	Gravel, Silt, Shell		
1		21	
2		22	
3		23	
4		24	
5		25	
6	" "	26	
7		27	
8		28	
9		29	
10		30	
11		31	
12		32	
13		33	
14		34	
15		35	
16		36	
17		37	
18		38	
19		39	
20		40	

1 0 1 3 1 5 10 17 8 7 4 12 1 14 9 11 7 14 12 8

Comments:

ALPINE OCEAN SEISMIC SURVEY, INC.
70 Oak Street Norwood, New Jersey 07648
Tel. (201) 768-8000 Fax: (201) 768-5750

CORE LOG

Core No. NJV203 Run No. 3 Date: 5/19/96 Area: Cape May

Grid Position: Easting 3505512.9 Northing 316784

Geographic Position: Lat. 38°55'09.298" Long. 74°59'51.737"

Water Depth	Vibration Time	Core Depth
Uncorrected: 27.6	Stop: 1057	Penetration: 19.5'
Tide: 0.576	Start: 1047	Recovery: 10.7'
= Corrected: 27.024	= Elapsed: 10 min.	

Depth	Core Description	Depth	Core Description
0	Jet		
1		21	
2		22	
3		23	
4		24	
5		25	
6	Jet to 6.0'	26	
157 7	Shelly Gravel, Silt	27	
19 8	Clay	28	
22 9		29	
43 10		30	
31 11		31	
12 12	" "	32	
17 13		33	
14 14		34	
16 15		35	
20 16		36	
13 17	Clay	37	
25 18		38	
32 19		39	
17 20		40	

Comments:

ALPINE OCEAN SEISMIC SURVEY, INC.
70 Oak Street Norwood, New Jersey 07648
Tel. (201) 768-8000 Fax: (201) 768-5750

CORE LOG

Core No. NJV204 Run No. 1 Date: 5/22/96 Area: Cape May

Grid Position: Easting 351729.8 Northing 312949.6

Geographic Position: Lat. 38°55'05.125" Long. 74°59'36.312"

Water Depth	Vibration Time	Core Depth
Uncorrected: 32.6	Stop: 1154	Penetration: 18.9'
Tide: 0.367	Start: 1152	Recovery: 19.4'
= Corrected: 32.233	= Elapsed: 2 min.	

Depth	Core Description	Depth	Core Description
0			
1	Mixed Sand	21	
2		22	
3	Fine/Medium Sand	23	
4		24	
5		25	
6		26	
7		27	
8	Fine Silt with Sand	28	
9		29	
10		30	
11		31	
12		32	
13		33	
14		34	
15		35	
16		36	
17		37	
18		38	
19		39	
20		40	

Comments:

ALPINE OCEAN SEISMIC SURVEY, INC.
70 Oak Street Norwood, New Jersey 07648
Tel. (201) 768-8000 Fax: (201) 768-5750

CORE LOG

Core No. NSV705 Run No. 1 Date: 5/19/96 Area: Cape May

Grid Position: Easting 344612.8 Northing 33082.9

Geographic Position: Lat. 38°55'23.131" Long. 75°.00'03.223"

Water Depth	Vibration Time	Core Depth
Uncorrected: 27.7	Stop: 1124	Penetration: 19.75'
Tide: 0.725	Start: 1121	Recovery: 20.3'
= Corrected: 26.975	= Elapsed: 3 min	

Depth	Core Description	Depth	Core Description
0	Grey Sand / Gravel		
1		21	
2		22	
3		23	
4		24	
5	Grey Sand / Silt / Gravel	25	
6		26	
7		27	
8		28	
9		29	
10	Grey Sand / Gravel	30	
11		31	
12	Clay	32	
13		33	
14		34	
15	Clay	35	
16		36	
17		37	
18		38	
19		39	
20	Clay	40	

Comments:

ALPINE OCEAN SEISMIC SURVEY, INC.
70 Oak Street Norwood, New Jersey 07648
Tel. (201) 768-8000 Fax: (201) 768-5750

CORE LOG

Core No. NJV206 Run No. 1 Date: 5/19/96 Area: Cape May

Grid Position: Easting 366984.4 Northing 30162.4

Geographic Position: Lat. 38°54'55.151" Long. 74°56'23.246"

Water Depth	Vibration Time	Core Depth
Uncorrected: 28.0	Stop: 1405	Penetration: 19.5'
Tide: 1.477	Start: 1359	Recovery: 19.9'
= Corrected: 26.523	= Elapsed: 6 min.	

Depth	Core Description	Depth	Core Description
0	Coarse Grey Sand/Shell		
1		21	
2		22	
3		23	
4		24	
5	Coarse Grey Sand/Shell	25	
6		26	
7		27	
8		28	
9		29	
10	Coarse Grey Sand/Silt	30	
11		31	
12	Brown Sand/Silt	32	
13		33	
14		34	
15	Brown Sand/Silt	35	
16		36	
17		37	
18	Medium Grey Sand	38	
19		39	
20		40	

Comments: Medium Grey Sand

ALPINE OCEAN SEISMIC SURVEY, INC.
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Tel. (201) 768-8000 Fax: (201) 768-5750

CORE LOG

Core No. NJSU207 Run No. 1 Date: 5/20/96 Area: Cape May

Grid Position: Easting 368952.7 Northing 28957.7

Geographic Position: Lat. 38°54'43.337" Long. 74°55'58.272"

Water Depth	Vibration Time	Core Depth
Uncorrected: 30.5	Stop: 1352	Penetration: 19.0'
Tide: 1.253	Start: 1344	Recovery: 18.0'
= Corrected: 29.247	= Elapsed: 8 min.	

Depth	Core Description	Depth	Core Description
0			
1 1		21	
1 2	Fine Sand	22	
2 3	Trace of medium Sand	23	
1 4		24	
2 5		25	
2 6		26	
4 7		27	
3 8	Medium Sand/Silt	28	
14 9		29	
17 10		30	
15 11		31	
32 12		32	
37 13	Medium Sand	33	
27 14		34	
21 15		35	
22 16		36	
61 17		37	
57 18		38	
112 19		39	
20		40	

Comments:

ALPINE OCEAN SEISMIC SURVEY, INC.
70 Oak Street Norwood, New Jersey 07648
Tel. (201) 768-8000 Fax: (201) 768-5750

CORE LOG

Core No. NJV208 Run No. 1 Date: 5/19/96 Area: Cape May

Grid Position: Easting 366967.2 Northing 31424.7

Geographic Position: Lat. 38°55'07.627" Long. 74°56'23.541"

Water Depth	Vibration Time	Core Depth
Uncorrected: 28.2	Stop: 1456	Penetration: 19.0'
Tide: 1.55	Start: 1451	Recovery: 17.3'
= Corrected: 26.65	= Elapsed: 5 min.	

	Depth	Core Description	Depth	Core Description
	0	Coarse Brown Sand		
1	1		21	
1	2	Coarse Brown Sand	22	
2	3	Coarse Grey Sand	23	
15	4		24	
8	5	Coarse Grey Sand	25	
14	6		26	
4	7		27	
5	8		28	
3	9		29	
3	10	Clay	30	
2	11		31	
3	12		32	
3	13		33	
4	14		34	
5	15	Clay	35	
6	16		36	
15	17		37	
42	18	Grey Sand/Clay	38	
91	19		39	
	20		40	

Comments:

ALPINE OCEAN SEISMIC SURVEY, INC.
70 Oak Street Norwood, New Jersey 07648
Tel. (201) 768-8000 Fax: (201) 768-5750

CORE LOG

Core No. 15V209 Run No. 1 Date: 5/19/96 Area: Cape May

Grid Position: Easting 367811.4 Northing 31217.1

Geographic Position: Lat. 38°55'05.615" Long. 74°56'12.848"

Water Depth	Vibration Time	Core Depth
Uncorrected: 27.4	Stop: 1604	Penetration: 15.02'
Tide: 1.370	Start: 1553	Recovery: 20.3'
= Corrected: 26.03	= Elapsed: 11 min	

Depth	Core Description	Depth	Core Description
0	Grey Sand/Silt		
1		21	
2		22	
3		23	
4		24	
5	Grey Sand/Silt	25	
6		26	
7		27	
8		28	
9		29	
10	Grey Clay	30	
11		31	
12		32	
13		33	
14		34	
15		35	
16		36	
17		37	
18		38	
19		39	
20	Grey Clay	40	

Comments:

ALPINE OCEAN SEISMIC SURVEY, INC.
70 Oak Street Norwood, New Jersey 07648
Tel. (201) 768-8000 Fax: (201) 768-5750

CORE LOG

Core No. NJV210 Run No. 1 Date: 5/19/96 Area: Cape May

Grid Position: Easting 367596.1 Northing 29358.4

Geographic Position: Lat. 38°54'47.233" Long. 74°56'15.459"

Water Depth	Vibration Time	Core Depth
Uncorrected: 27.4	Stop: 1654	Penetration: 19.9'
Tide: 1.137	Start: 1648	Recovery: 15.9'
= Corrected: 26.263	= Elapsed: 6 min.	

Depth	Core Description	Depth	Core Description
0	Medium Brown Sand		
1		21	
2		22	
3		23	
4		24	
5	Medium Dark Grey Sand	25	
6		26	
7		27	
8		28	
9		29	
10	Coarse Sand Trace of Silt	30	
11		31	
12		32	
13		33	
14		34	
15		35	
16	Fine Sand/Silty	36	
17		37	
18		38	
19		39	
20		40	

Comments:

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CORE LOG

Core No. NSV-211 Run No. 1 Date: 5/20/96 Area: Cape May

Grid Position: Easting 370931.1 Northing 308000.5

Geographic Position: Lat. 38°55'01.643" Long. 74°55'33.353"

Water Depth	Vibration Time	Core Depth
Uncorrected: 37.2	Stop: 0903	Penetration: ~~7'~~ N/A
Tide: 0.203	Start: 0859	Recovery: 13.4'
= Corrected: 36.997	= Elapsed: 4 min	

Depth	Core Description	Depth	Core Description
0			
1	Medium/Coarse Grey Sand	21	
2		22	
3		23	
4		24	
5	Large Coarse Sand	25	
6		26	
7		27	
8		28	
9		29	
10	Fine Silt/Sand and Clay	30	
11		31	
12		32	
13	Coarse Sand	33	
14		34	
15		35	
16		36	
17		37	
18		38	
19		39	
20		40	

Comments:

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CORE LOG

Core No. NJ5V211 Run No. 2 Date: 5/20/96 Area: Cape May

Grid Position: Easting 370952.4 Northing 307160

Geographic Position: Lat. 38°55'00.804" Long. 74°55'33.075"

Water Depth	Vibration Time	Core Depth
Uncorrected: 37.2	Stop: 1127	Penetration: 20.0'
Tide: 0.493	Start: 1118	Recovery: 21.4'
= Corrected: 36.707	= Elapsed: 9 min.	

Depth	Core Description	Depth	Core Description
0			
1		21	
2		22	
3		23	
4		24	
5		25	
6		26	
7		27	
8		28	
9		29	
10		30	
11		31	
12	SET TO 12.0'	32	
13	COARSE TO MEDIUM	33	
14	SAND	34	
15		35	
16		36	
17		37	
18		38	
19		39	
20		40	

Comments:

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CORE LOG

Core No. NJ5V212 Run No. 1 Date: 5/20/96 Area: Cape May

Grid Position: Easting 3722610.7 Northing 324717.6

Geographic Position: Lat. 38°55'17.685" Long. 74°55'17.258"

Water Depth		Vibration Time		Core Depth	
Uncorrected:	16.2	Stop:	0757	Penetration:	17.1'
Tide:	0.363	Start:	0753	Recovery:	17.4'
= Corrected:	15.837	= Elapsed:	4 min.		

Depth	Core Description	Depth	Core Description
0	Fine Sand		
1 1		21	
1 2		22	
4 3		23	
1 4		24	
3 5	Fine Grey Sand	25	
4 6		26	
4 7		27	
6 8		28	
4 9		29	
5 10		30	
5 11		31	
8 12		32	
14 13		33	
14 14		34	
16 15	Fine Sand/Silt	35	
23 16		36	
97 17		37	
18		38	
19		39	
20		40	

Comments:

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CORE LOG

Core No. NJV213 Run No. 1 Date: 5/20/96 Area: Cape May

Grid Position: Easting 373144.0 Northing 31452.3

Geographic Position: Lat. 38°55'08.187" Long. 74°55'05.393"

Water Depth	Vibration Time	Core Depth
Uncorrected: 30.2	Stop: 1435	Penetration: 19.4'
Tide: 1.492	Start: 1432	Recovery: 20.3'
= Corrected: 28.708	= Elapsed: 3 min	

Depth	Core Description	Depth	Core Description
0			
	Sand trace of Silt		
1		21	
2		22	
3		23	
4		24	
5	Sandy Silt	25	
6		26	
7		27	
8		28	
9		29	
10	Silty Clay	30	
11		31	
12		32	
13		33	
14		34	
15	Silty Clay	35	
16		36	
17		37	
18		38	
19		39	
20	Organic Silt	40	

Comments:

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CORE LOG

Core No. NJV214 Run No. 1 Date: 5/20/96 Area: Cape May

Grid Position: Easting 3745201 Northing 31782.5

Geographic Position: Lat. 38°55'11.512" Long. 74°54'48.002"

Water Depth	Vibration Time	Core Depth
Uncorrected: 28.4	Stop: 1559	Penetration: 19.3'
Tide: 1.501	Start: 1551	Recovery: 20.0'
= Corrected: 26.899	= Elapsed: 8 min.	

Depth	Core Description	Depth	Core Description
0	Silt		
1		21	
2		22	
3		23	
4		24	
5	Fine Sand/Silt	25	
6		26	
7		27	
8		28	
9		29	
10	Fine Sand trace of Silt	30	
11		31	
12		32	
13		33	
14	Fine + Some Medium Sand trace	34	
15	Of Gravel	35	
16		36	
17		37	
18		38	
19		39	
20		40	

Comments:

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CORE LOG

Core No. NJV215 Run No. 1 Date: 5/21/96 Area: Cape May

Grid Position: Easting 378546.7 Northing 32226.6

Geographic Position: Lat. 38°55'16.079" Long. 74°53'57.081"

Water Depth	Vibration Time	Core Depth
Uncorrected: 30.8	Stop: 1623	Penetration: 18.5'
Tide: 1.533	Start: 1620	Recovery: 20.1'
= Corrected: 29.265	= Elapsed: 3 min.	

Depth	Core Description	Depth	Core Description
0			
1		21	
2		22	
3	Fine/Medium Sand/Silt	23	
4		24	
5		25	
6	Fine/Medium Sand/Silt	26	
7		27	
8		28	
9		29	
10		30	
11	Sand/Silt	31	
12		32	
13		33	
14	Fine/Medium Sand Trace of Silt	34	
15		35	
16		36	
17		37	
18		38	
19		39	
20		40	

Comments:

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CORE LOG

Core No. NJV216 Run No. 1 Date: 5/21/96 Area: Cape May

Grid Position: Easting 380265.5 Northing 33587.2

Geographic Position: Lat. 38°55'29.001" Long. 74°53'35.408"

Water Depth	Vibration Time	Core Depth
Uncorrected: 26.0	Stop: 1718	Penetration: 19.3'
Tide: 1.415	Start: 1715	Recovery: 19.2'
= Corrected: 24.585	= Elapsed: 3 min	

Depth	Core Description	Depth	Core Description
0	Mixed Sand		
1		21	
2		22	
3		23	
4		24	
5	Mixed Sand	25	
6		26	
7		27	
8	Mixed Sand	28	
9		29	
10		30	
11		31	
12		32	
13		33	
14	Mixed Sand	34	
15		35	
16		36	
17	Mixed Sand	37	
18		38	
19	" "	39	
20		40	

Comments:

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CORE LOG

Core No. NJV217 Run No. 1 Date: 5/22/96 Area: Cape May

Grid Position: Easting 381652.4 Northing 32849.4

Geographic Position: Lat. 38°55'22.367" Long. 74°53'17.820

Water Depth	Vibration Time	Core Depth
Uncorrected: 32.4	Stop: 0945	Penetration: 18.7'
Tide: 0.376	Start: 0942	Recovery: 20.0'
= Corrected: 32.024	= Elapsed: 3min	

Depth	Core Description	Depth	Core Description
0			
1	Fine/Medium Sand	21	
2		22	
3		23	
4	Clay	24	
5		25	
6		26	
7		27	
8	Clay	28	
9		29	
10		30	
11		31	
12	Clay	32	
13		33	
14		34	
15		35	
16		36	
17	Clay	37	
18		38	
19		39	
20		40	

Comments:

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CORE LOG

Core No. NJV218 Run No. 1 Date: 5/20/96 Area: Cape May

Grid Position: Easting 374930.2 Northing 28578.1

Geographic Position: Lat. 38°54'39.858" Long. 74°54'42.630"

Water Depth	Vibration Time	Core Depth
Uncorrected: 32.0	Stop: 1650	Penetration: 19.65'
Tide: 1.317	Start: 1647	Recovery: 20.3'
= Corrected: 30.683	= Elapsed: 3 min.	

Depth	Core Description	Depth	Core Description
0	Fine to Medium Sand		
1	Trace of Silt and Shells	21	
2		22	
3	Fine/Medium Sand	23	
4		24	
5	Trace of Gravel	25	
6		26	
7		27	
8		28	
9		29	
10		30	
11	Fine/Medium Sand	31	
12		32	
13		33	
14		34	
15		35	
16	Fine Sand	36	
17		37	
18		38	
19		39	
20		40	

Comments:

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CORE LOG

Core No. NSV219 Run No. 1 Date: 5/20/96 Area: Cape May

Grid Position: Easting 376050.7 Northing 29299.5

Geographic Position: Lat. 38°54'47.038" Long. 74°54'28.496"

Water Depth	Vibration Time	Core Depth
Uncorrected: 32.8	Stop: 1734	Penetration: 16.4'
Tide: 1.135	Start: 1723	Recovery: 16.1'
= Corrected: 31.665	= Elapsed: 11 min.	

Depth	Core Description	Depth	Core Description
0	Mixed Sand / Gravel		
1		21	
2		22	
3		23	
4		24	
5	Medium to Fine Sand	25	
6		26	
7		27	
8		28	
9		29	
10	Medium to Fine Sand	30	
11		31	
12		32	
13		33	
14		34	
15		35	
16	Medium to Fine Sand	36	
17		37	
18		38	
19		39	
20		40	

Comments:

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CORE LOG

Core No. NJV220 Run No. 1 Date: 5/21/96 Area: Cape May

Grid Position: Easting 377217.7 Northing 28534.8

Geographic Position: Lat. 38°54'39.532" Long. 74°54'13.689

Water Depth	Vibration Time	Core Depth
Uncorrected: 37.0	Stop: 1103	Penetration: 18.3'
Tide: 0.311	Start: 1100	Recovery: 19.5'
= Corrected: 36.689	= Elapsed: 3 min.	

Depth	Core Description	Depth	Core Description
0			
1	Fine Sand/Silt	21	
2	" "	22	
3		23	
4		24	
5		25	
6		26	
7		27	
8	Fine Sand	28	
9		29	
10		30	
11		31	
12		32	
13		33	
14		34	
15	" "	35	
16	Fine/Medium	36	
17	Sand	37	
18		38	
19		39	
20	" "	40	

Comments:

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CORE LOG

Core No. NJV221 Run No. 1 Date: 5/21/96 Area: Cape May

Grid Position: Easting 379187.2 Northing 29189.6

Geographic Position: Lat. 38°54'46.089" Long. 74°53'48.810"

Water Depth		Vibration Time		Core Depth	
Uncorrected:	36.5	Stop:	0943	Penetration:	19.1'
Tide:	0.214	Start:	0938	Recovery:	19.9'
= Corrected:	36.286	= Elapsed:	5 min.		

Depth	Core Description	Depth	Core Description
0	" "		
1		21	
2		22	
3		23	
4	Mix of Fine to Coarse Sand with Trace of Gravel.	24	
5		25	
6		26	
7		27	
8		28	
9		29	
10		30	
11		31	
12		32	
13		33	
14		34	
15		35	
16		36	
17		37	
18		38	
19		39	
20	" "	40	

Comments:

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CORE LOG

Core No. NJV222 Run No. 1 Date: 5/21/96 Area: Cape May

Grid Position: Easting 373279.5 Northing 24628.9

Geographic Position: Lat. 38°54'00.751" Long. 74°55'03.284

Water Depth	Vibration Time	Core Depth
Uncorrected: 31.2	Stop: 1529	Penetration: 19.5'
Tide: 1.497	Start: 1527	Recovery: 16.9'
= Corrected: 29.703	= Elapsed: 2min	

Depth	Core Description	Depth	Core Description
0			
1		21	
2	Mixed Sand trace of Shells	22	
3		23	
4		24	
5		25	
6		26	
7		27	
8	Fine Sand/Silt	28	
9		29	
10		30	
11		31	
12		32	
13		33	
14		34	
15		35	
16		36	
17	" "	37	
18		38	
19		39	
20		40	

Comments:

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CORE LOG

Core No. NJ1/223 Run No. 1 Date: 5/21/96 Area: Cape May

Grid Position: Easting 375609.7 Northing 23060.6

Geographic Position: Lat. 38°53'45.354" Long. 74°54'33.721"

Water Depth	Vibration Time	Core Depth
Uncorrected: 29.2	Stop: 1437	Penetration: 19.0'
Tide: 1.323	Start: 1435	Recovery: 19.0'
= Corrected: 27.877	= Elapsed: 2 min.	

Depth	Core Description	Depth	Core Description
0			
1		21	
2	Medium / Coarse Sand Trace of Shell	22	
3		23	
4		24	
5		25	
6		26	
7		27	
8	Fine Sand	28	
9		29	
10		30	
11		31	
12		32	
13	Sand / Silt	33	
14		34	
15		35	
16		36	
17	Medium / Coarse Sand	37	
18		38	
19		39	
20		40	

Comments:

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CORE LOG

Core No. NJV224 Run No. 1 Date: 5/21/96 Area: Cape May

Grid Position: Easting 377035.4 Northing 23395.7

Geographic Position: Lat. 38°53'48.729" Long. 74°54'15.707"

Water Depth	Vibration Time	Core Depth
Uncorrected: 31.8	Stop: 1249	Penetration: 18.4'
Tide: 0.747	Start: 1248	Recovery: 17.0'
= Corrected: 31.053	= Elapsed: 1 min.	

Depth	Core Description	Depth	Core Description
0			
1	Well Graded Sand	21	
2	with trace of Shells	22	
3		23	
4		24	
5		25	
6		26	
7		27	
8		28	
9	Well Graded Mixed SAND	29	
10		30	
11		31	
12		32	
13		33	
14		34	
15		35	
16		36	
17		37	
18		38	
19		39	
20		40	

Comments:

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CORE LOG

Core No. NJV225 Run No. 1 Date: 5/21/96 Area: Cape May

Grid Position: Easting 378495.7 Northing 234601.1

Geographic Position: Lat. 38°53'49.439" Long. 74°53'57.241"

Water Depth	Vibration Time	Core Depth
Uncorrected: 32.0	Stop: 1203	Penetration: 18.0'
Tide: 0.518	Start: 1200	Recovery: 17.8'
= Corrected: 31.482	= Elapsed: 3 min	

Depth	Core Description	Depth	Core Description
0	" "	21	
1		22	
2		23	
3		24	
4		25	
5		26	
6	Well Mixed Sand	27	
7	TRACE of Shell	28	
8		29	
9		30	
10		31	
11		32	
12		33	
13		34	
14		35	
15		36	
16		37	
17		38	
18		39	
19		40	
20	" "		

Comments:

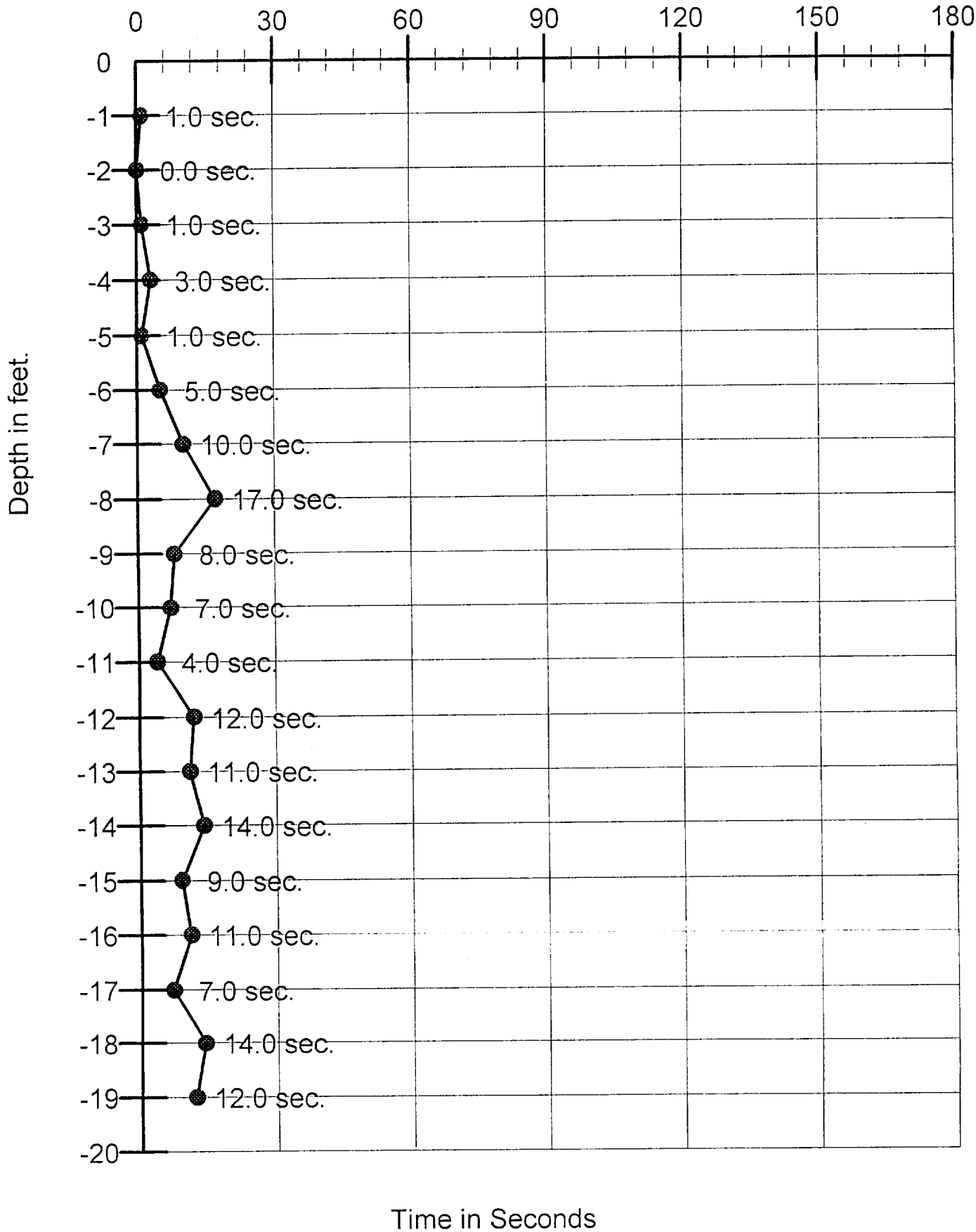
3.4 PENETRATION GRAPHS

PENETRATION GRAPH

Core No: NJV 203 Run#: 2 Location: East: 350501.0 ft. North: 31676.2 ft.

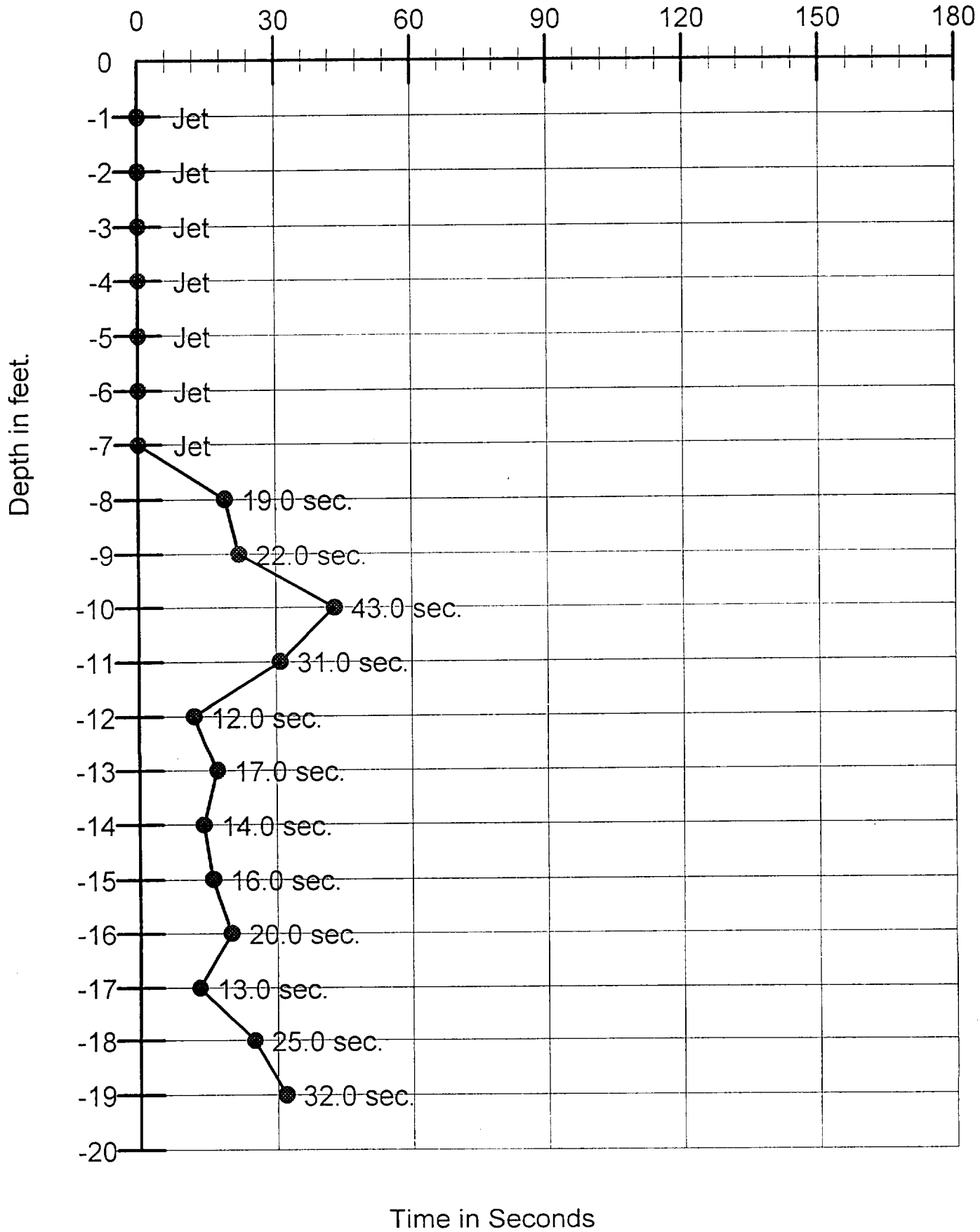
Date: 5/19/96 Start Time: 09:15 AM Stop Time: 09:12 AM Jet to:

W.D. Raw: 28.0 ft. W.D.Corrected: 27.8 ft. Total Penetration: 19.5 ft. Total Recovery: 6.1 ft.



PENETRATION GRAPH

Core No: NJV 203 Run#: 3 Location: East: 350512.9 ft. North: 31678.4 ft.
Date: 5/19/96 Start Time: 10:47 A Stop Time: 10:57 A Jet to: 6.0 ft.
W.D. Raw: 27.6 ft. W.D.Corrected: 27.0 ft. Total Penetration: 19.5 ft. Total Recovery: 10.7 ft.

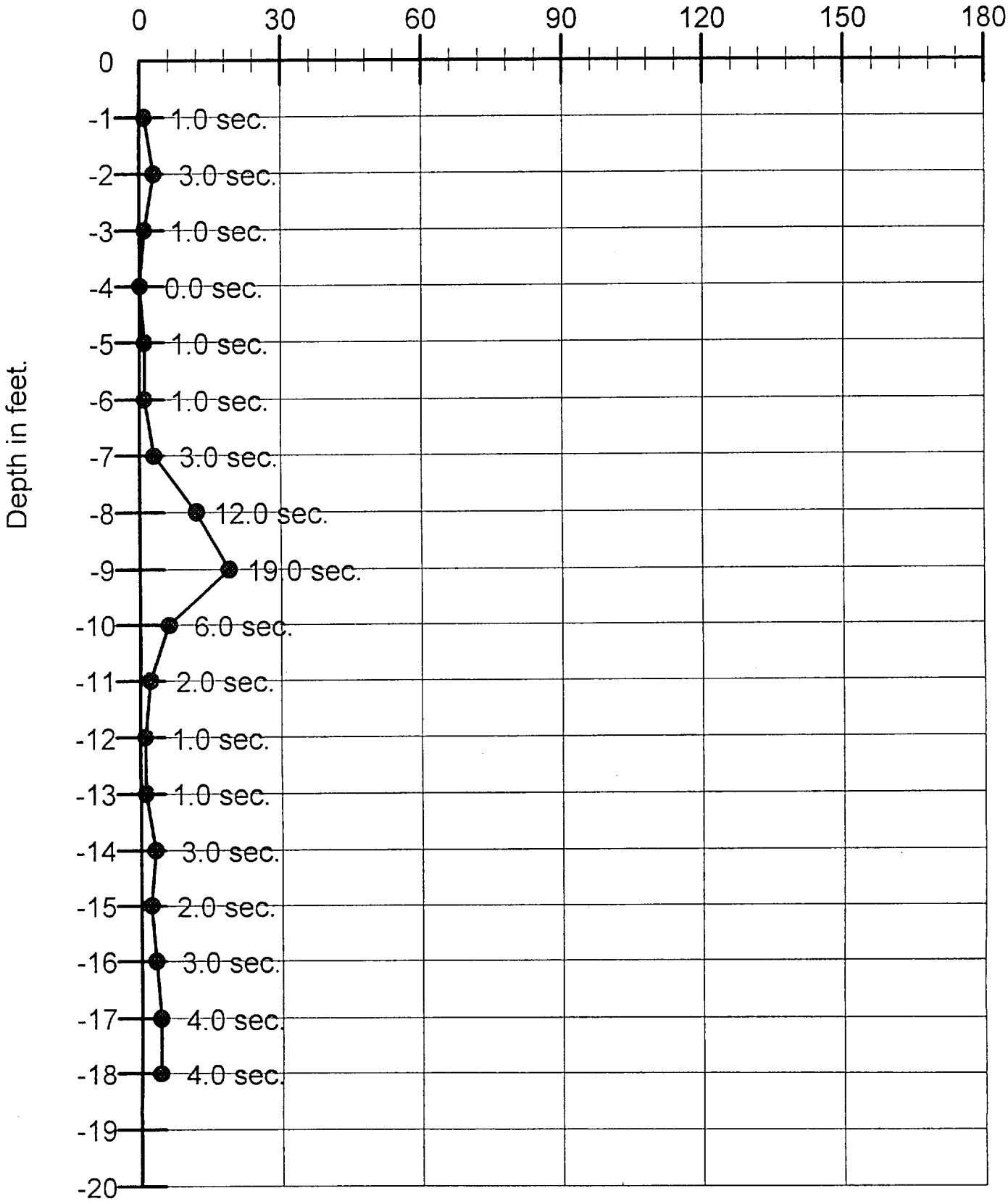


PENETRATION GRAPH

Core No: NJV 204 Run#: 1 Location: East: 251729.8 ft. North: 31249.6 ft.

Date: 5/22/96 Start Time: 11:52 A Stop Time: 11:54 A Jet to:

W.D. Raw: 32.6 ft. W.D.Corrected: 32.2 ft. Total Penetration: 18.9 ft. Total Recovery: 19.4 ft.

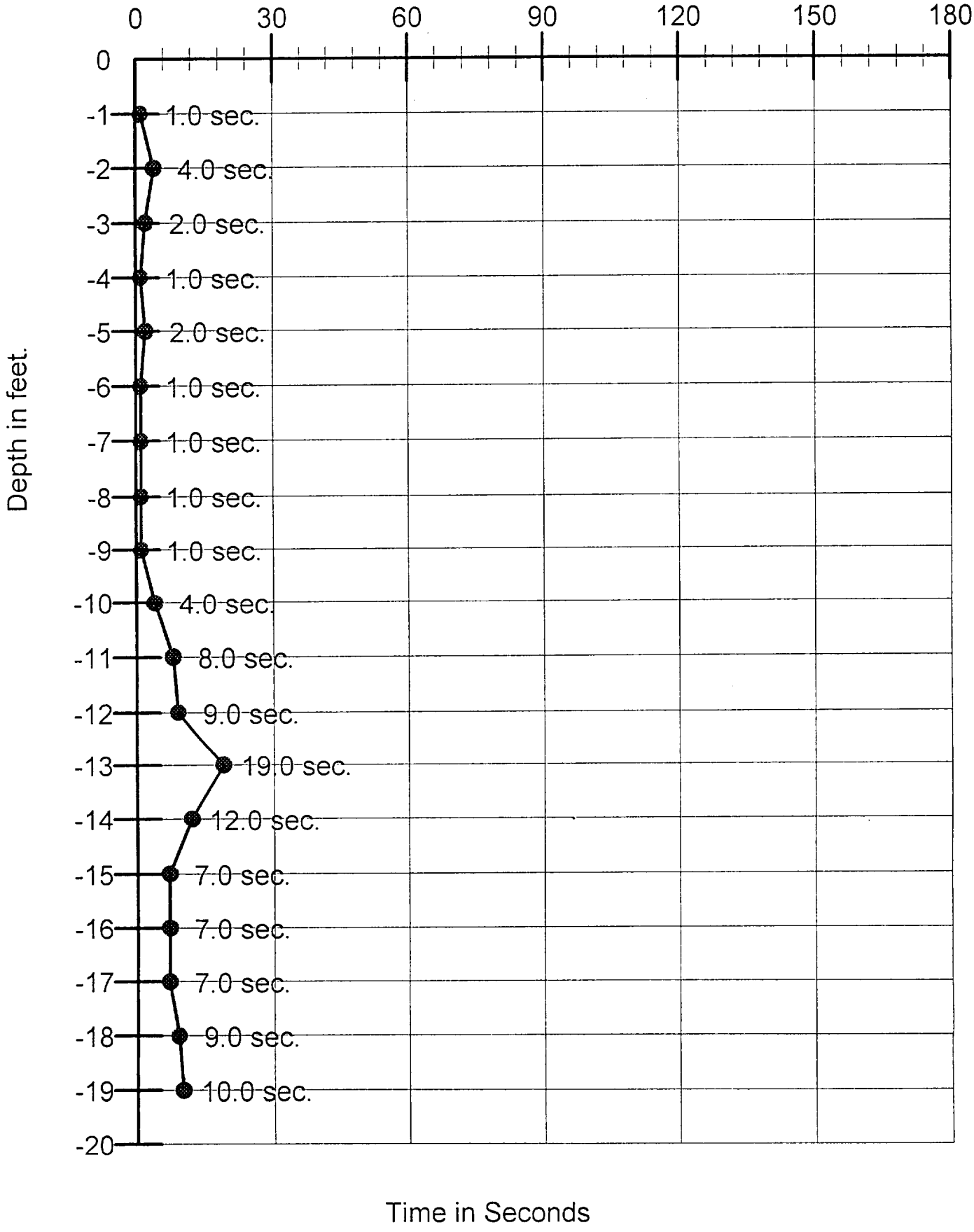


PENETRATION GRAPH

Core No: NJV 205 Run#: 1 Location: East: 349612.8 ft. North: 33082.9 ft.

Date: 5/19/96 Start Time: 11:21 A Stop Time: 11:24 A Jet to:

W.D. Raw: 27.7 ft. W.D.Corrected: 27.0 ft. Total Penetration: 19.7 ft. Total Recovery: 20.3 ft.

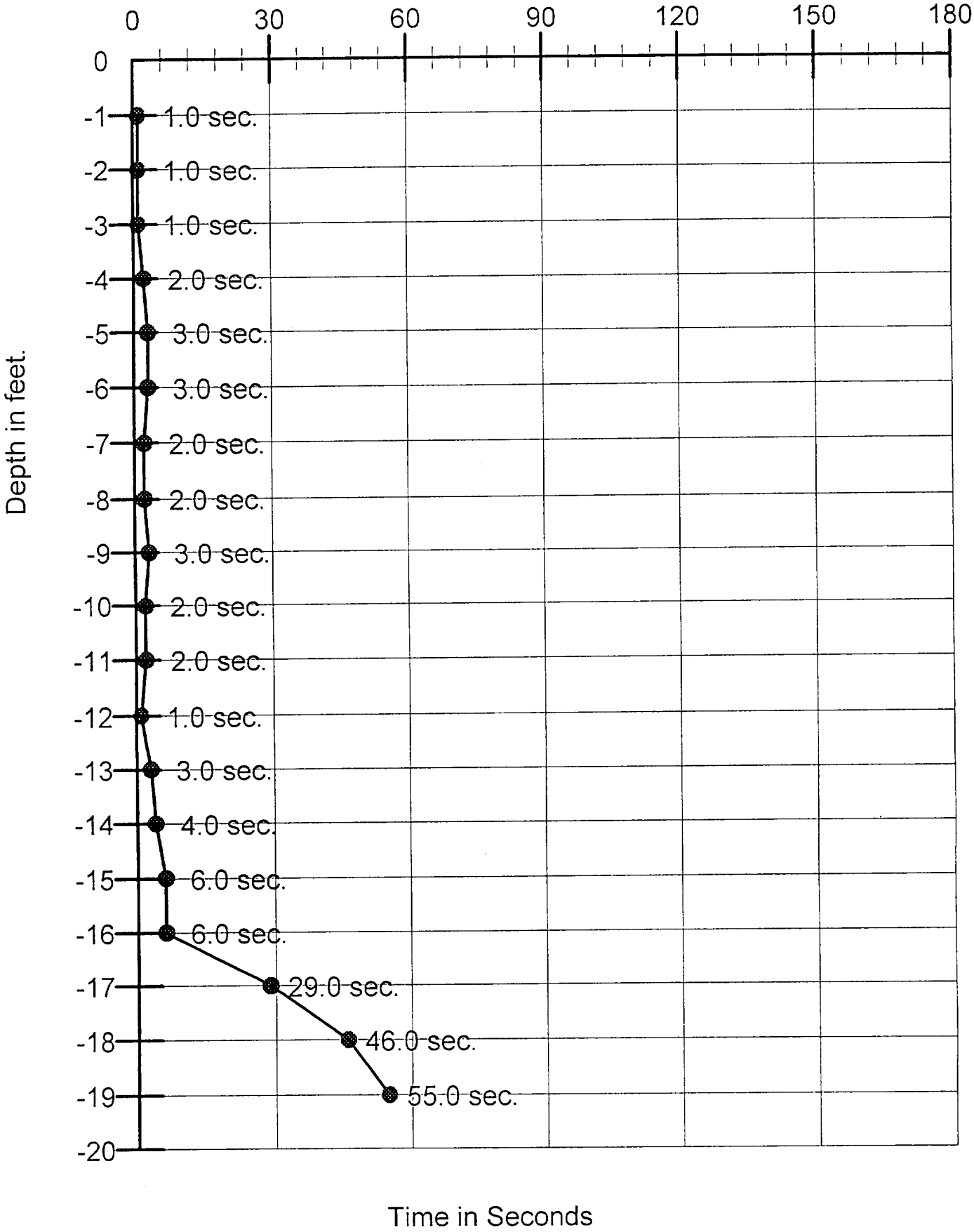


PENETRATION GRAPH

Core No: NJV 206 Run#: 1 Location: East: 366984.4 ft. North: 30162.4 ft.

Date: 5/19/96 Start Time: 1:59 PM Stop Time: 2:05 PM Jet to:

W.D. Raw: 28.0 ft. W.D.Corrected: 26.5 ft. Total Penetration: 19.5 ft. Total Recovery: 19.9 ft.

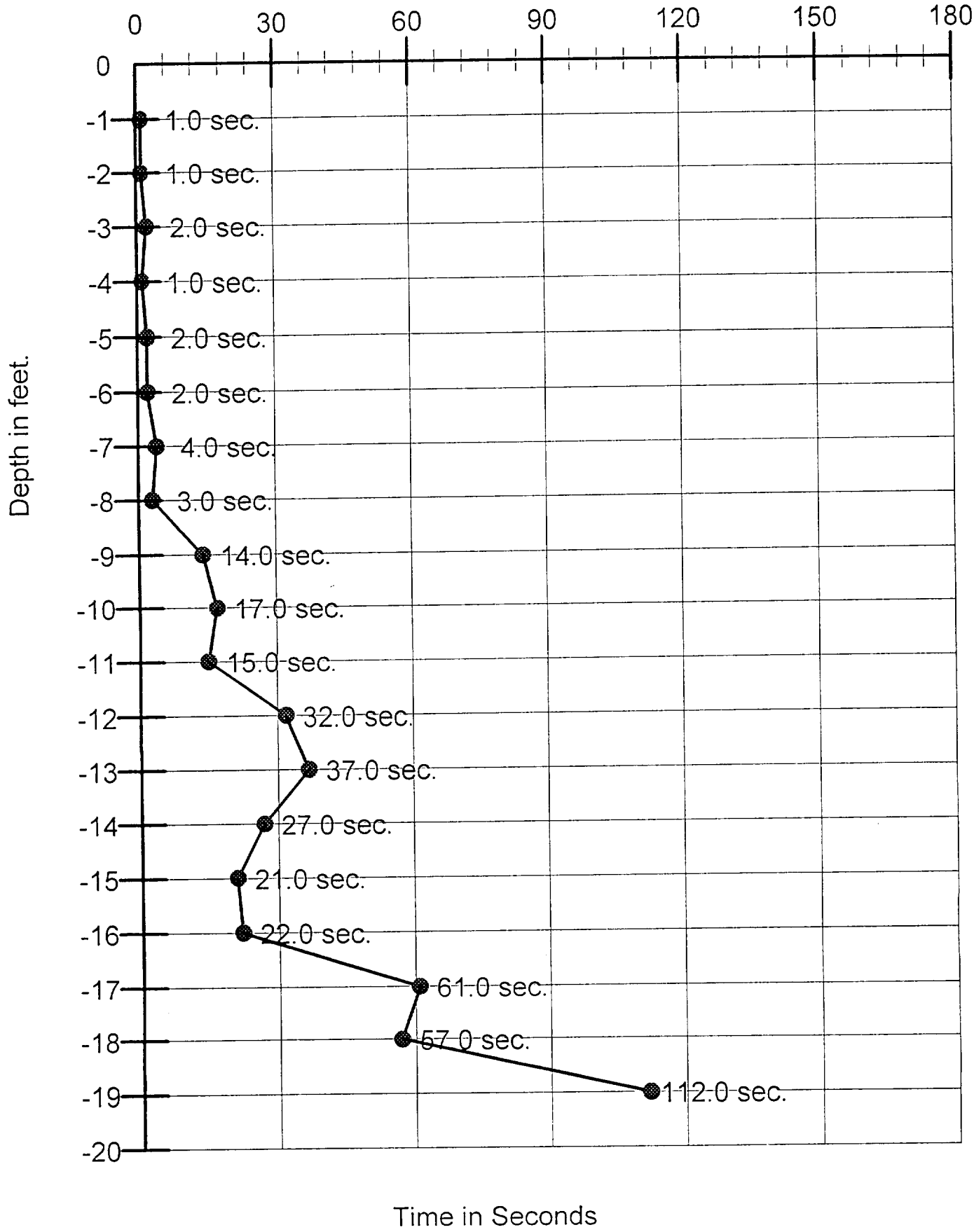


PENETRATION GRAPH

Core No: NJV 207 Run#: 1 Location: East: 368952.7 ft. North: 28957.7 ft.

Date: 5/20/96 Start Time: 1:44 PM Stop Time: 1:52 PM Jet to:

W.D. Raw: 30.5 ft. W.D.Corrected: 29.2 ft. Total Penetration: 19.0 ft. Total Recovery: 18.0 ft.

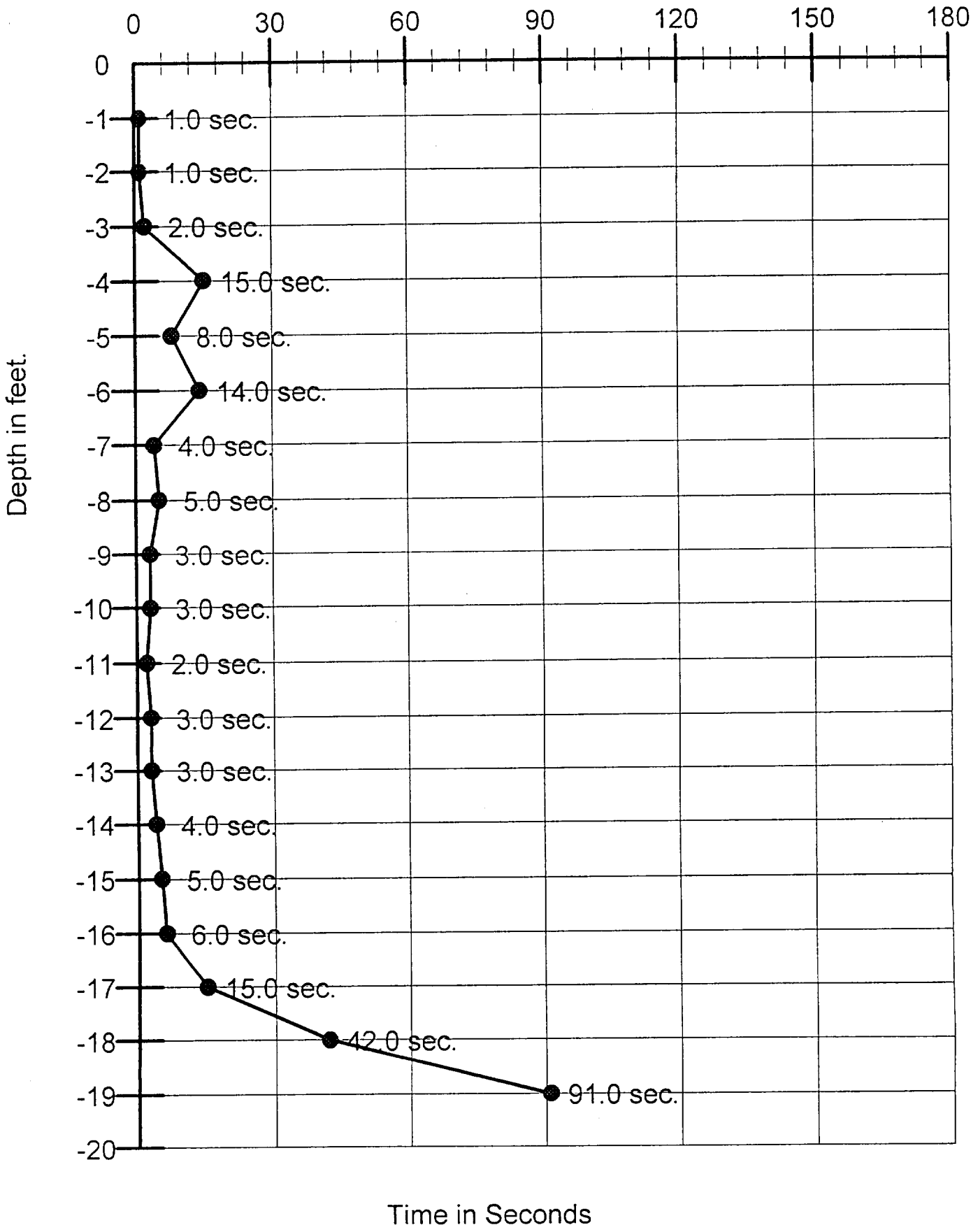


PENETRATION GRAPH

Core No: NJV 208 Run#: 1 Location: East: 366967.2 ft. North: 31424.7 ft.

Date: 5/19/96 Start Time: 2:51 PM Stop Time: 2:56 PM Jet to:

W.D. Raw: 28.2 ft. W.D.Corrected: 26.7 ft. Total Penetration: 19.0 ft. Total Recovery: 17.3 ft.

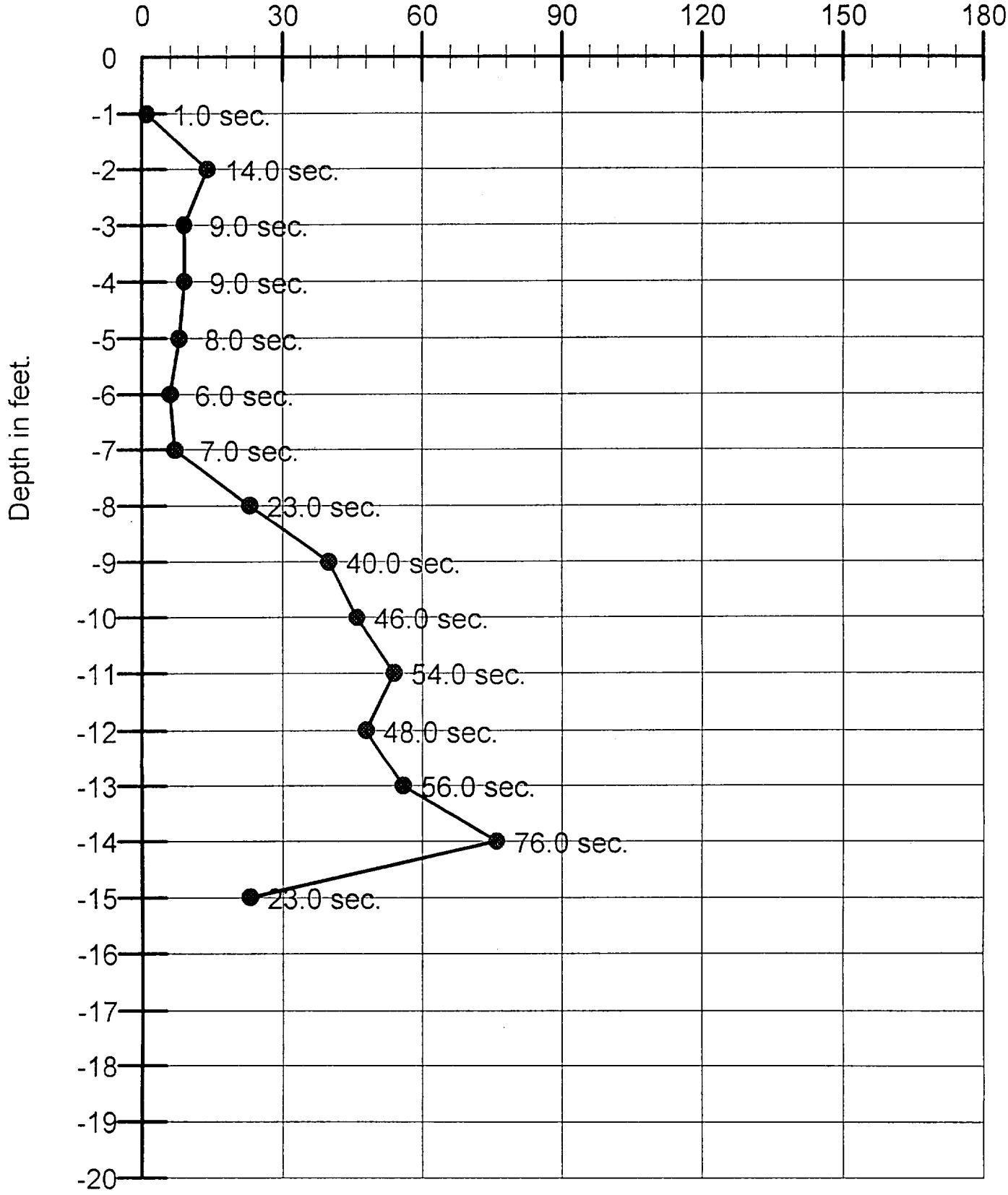


PENETRATION GRAPH

Core No: NJV 209 Run#: 1 Location: East: 367811.4 ft. North: 31217.1 ft.

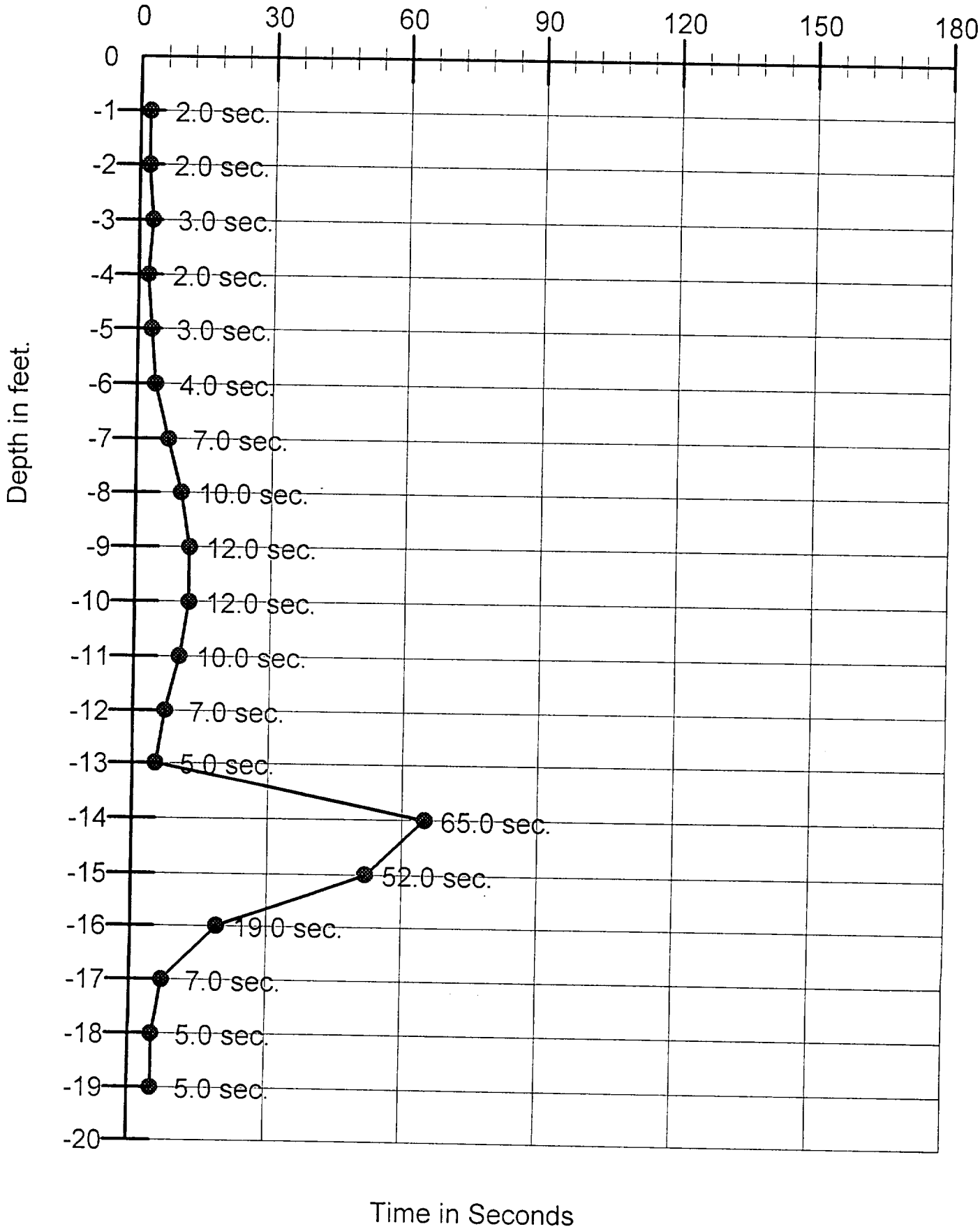
Date: 5/19/96 Start Time: 3:53 PM Stop Time: 4:04 PM Jet to:

W.D. Raw: 27.4 ft. W.D.Corrected: 26.0 ft. Total Penetration: 15.0 ft. Total Recovery: 20.3 ft.



PENETRATION GRAPH

Core No: NJV 210 Run#: 1 Location: East: 367596.1 ft. North: 29358.4 ft.
Date: 5/19/96 Start Time: 4:48 PM Stop Time: 4:54 PM Jet to:
W.D. Raw: 27.4 ft. W.D.Corrected: 26.3 ft. Total Penetration: 19.9 ft. Total Recovery: 15.9 ft.

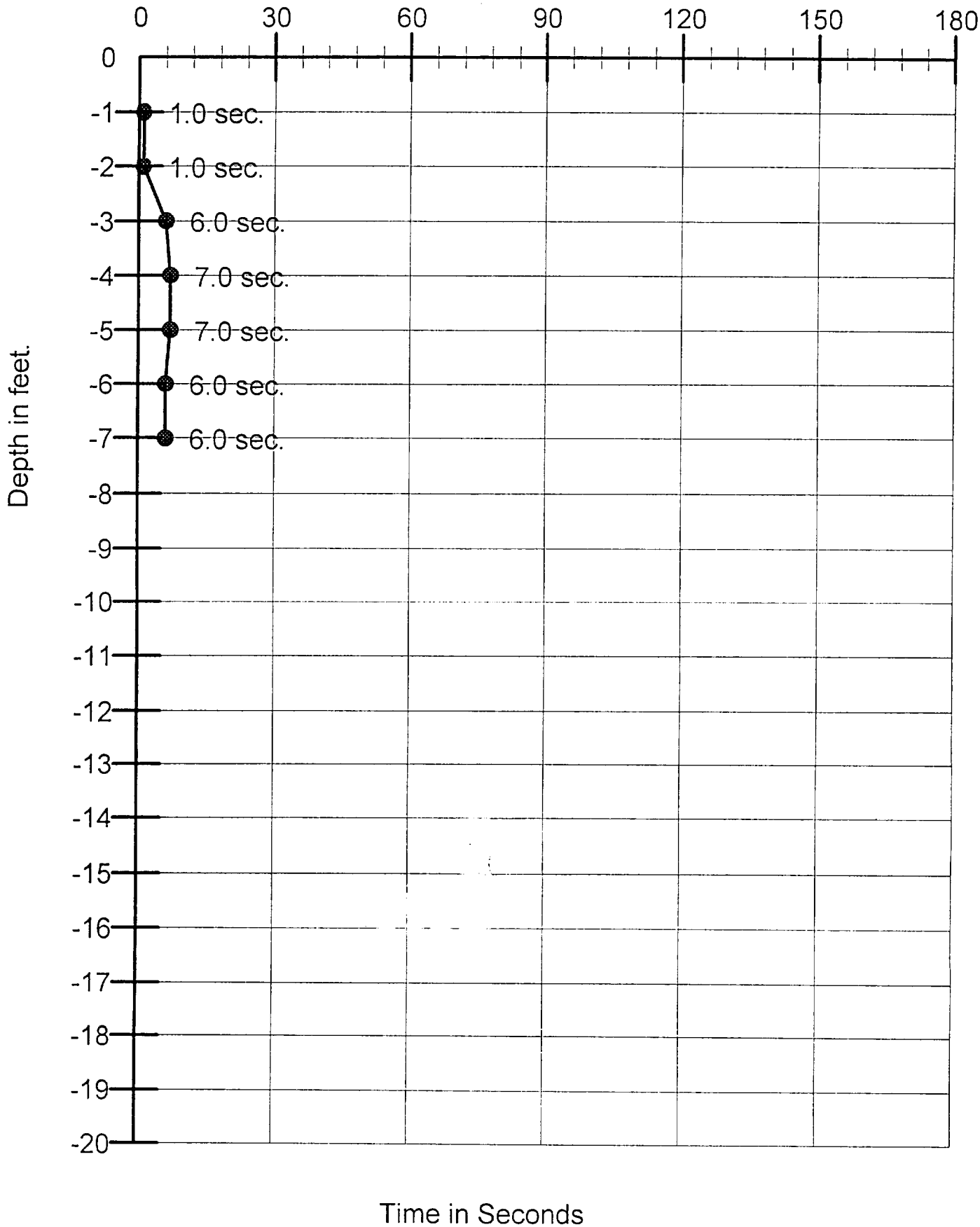


PENETRATION GRAPH

Core No: NJV 211 *Run#:* 1 *Location: East:* 370931.1 ft. *North:* 30800.5 ft.

Date: 5/20/96 *Start Time:* 8:59 AM *Stop Time:* 09:03 AM *Jet to:*

W.D. Raw: 37.2 ft. *W.D.Corrected:* 37.0 ft. *Total Penetration:* *Total Recovery:* 13.4 ft.

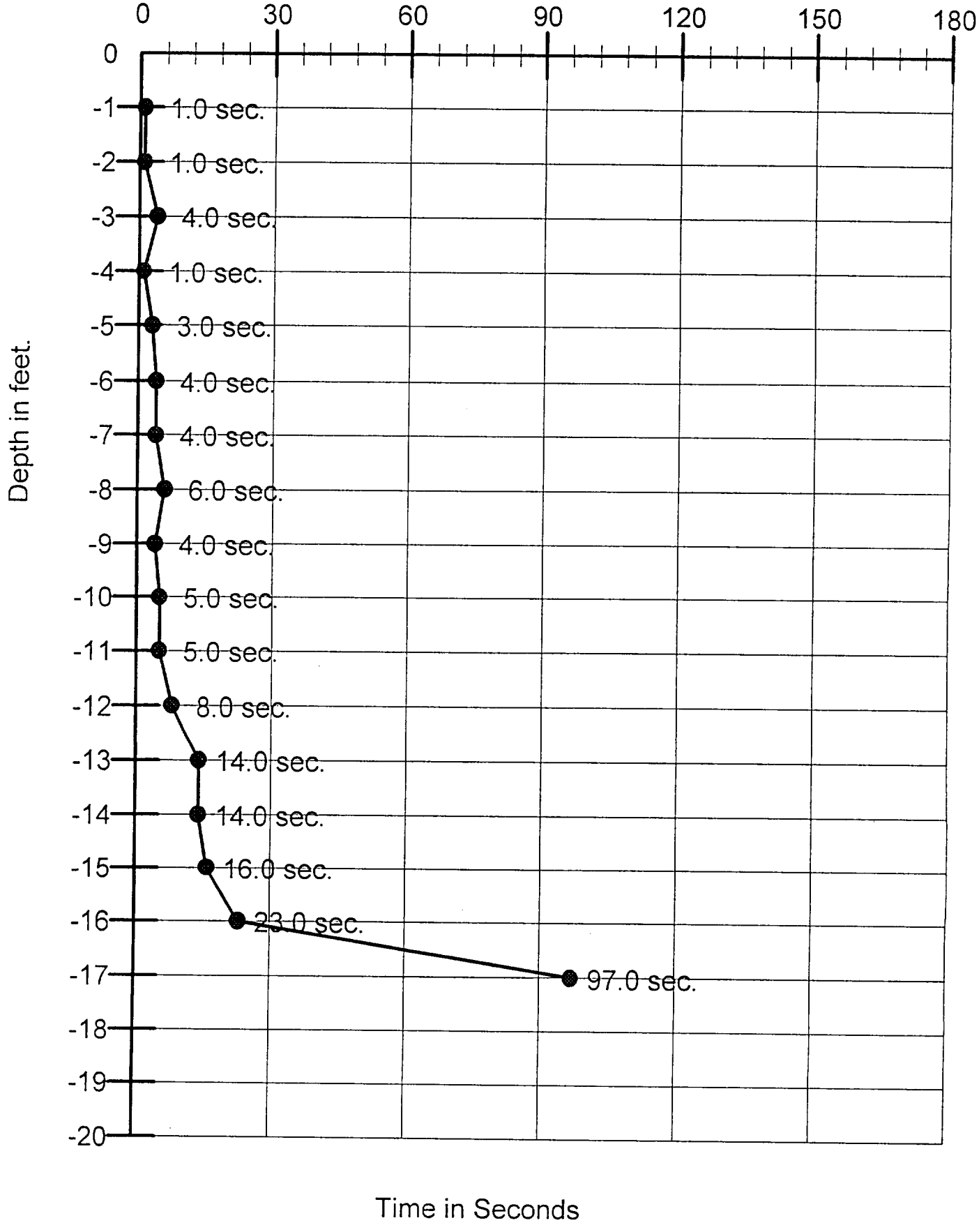


PENETRATION GRAPH

Core No: NJV 212 Run#: 1 Location: East: 372210.7 ft. North: 32417.6 ft.

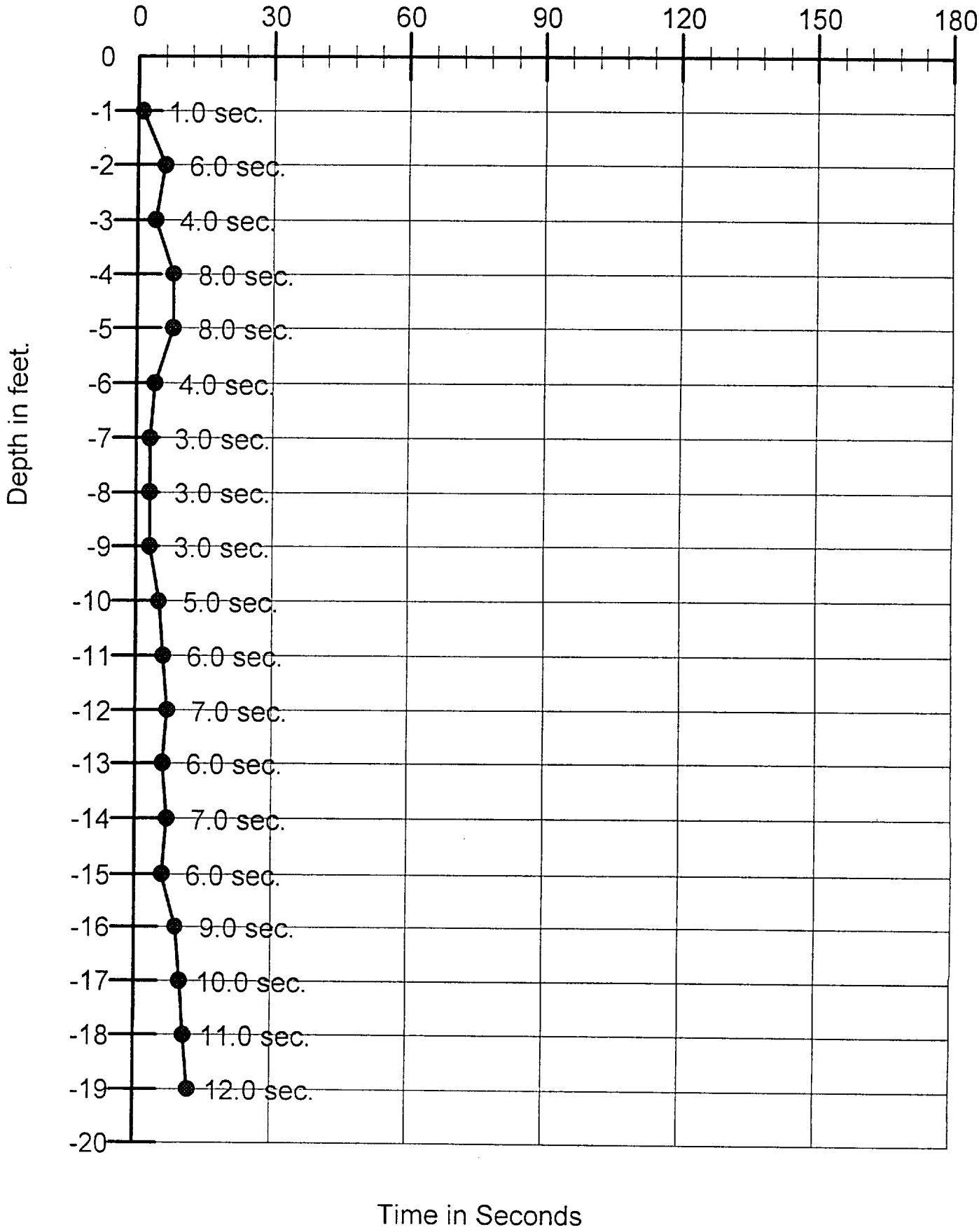
Date: 5/20/96 Start Time: 7:53 AM Stop Time: 07:57 AM Jet to:

W.D. Raw: 16.2 ft. W.D.Corrected: 15.8 ft. Total Penetration: 17.1 ft. Total Recovery: 17.4 ft.



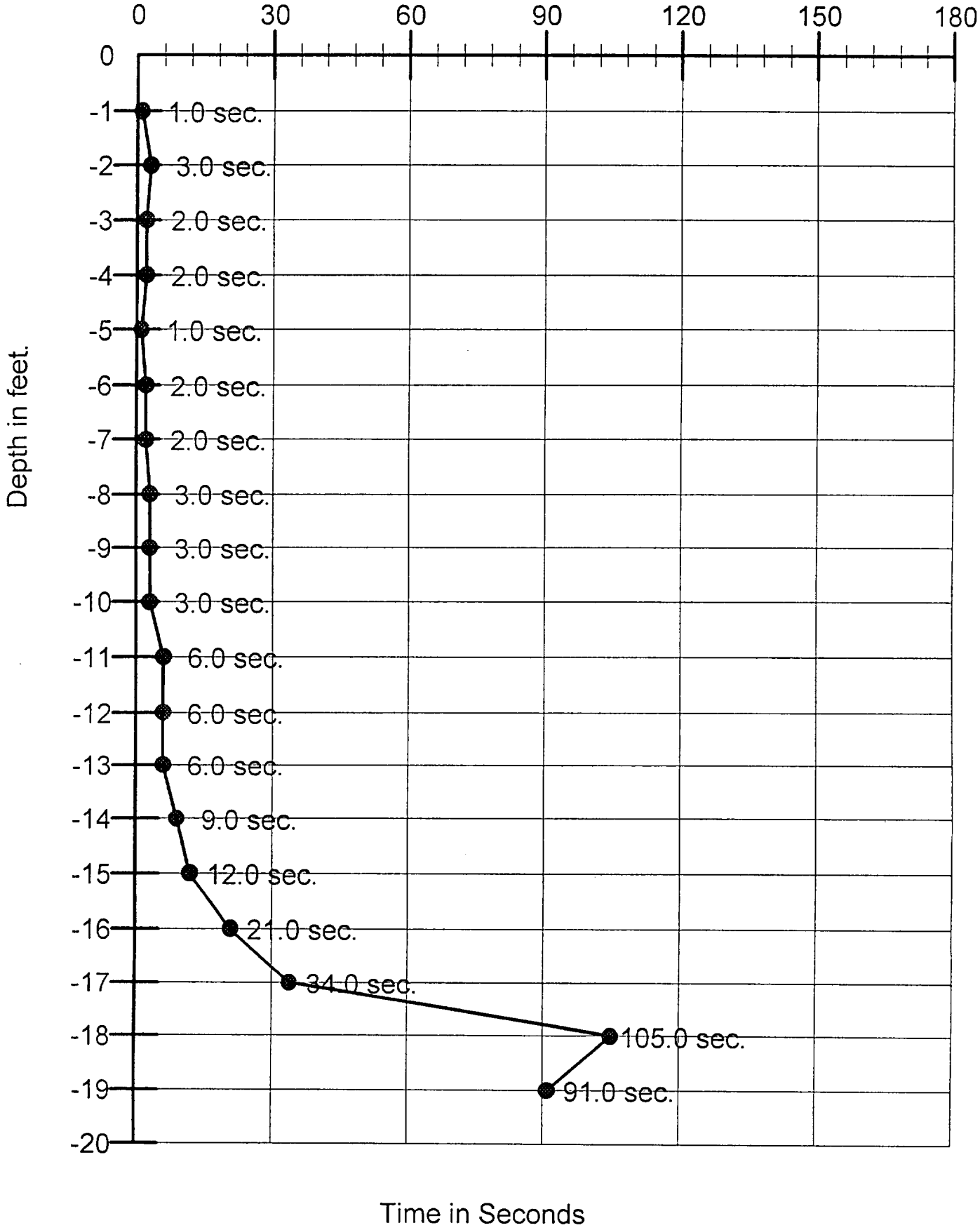
PENETRATION GRAPH

Core No: NJV 213 Run#: 1 Location: East: 3731440.0 ft. North: 31452.3 ft.
Date: 5/20/96 Start Time: 2:32 PM Stop Time: 2:35 PM Jet to:
W.D. Raw: 30.2 ft. W.D.Corrected: 28.7 ft. Total Penetration: 19.4 ft. Total Recovery: 20.3 ft.



PENETRATION GRAPH

Core No: NJV 214 Run#: 1 Location: East: 374520.1 ft. North: 31782.5 ft.
Date: 5/20/96 Start Time: 3:51 PM Stop Time: 3:59 PM Jet to:
W.D. Raw: 28.4 ft. W.D.Corrected: 26.9 ft. Total Penetration: 19.3 ft. Total Recovery: 20.0 ft.

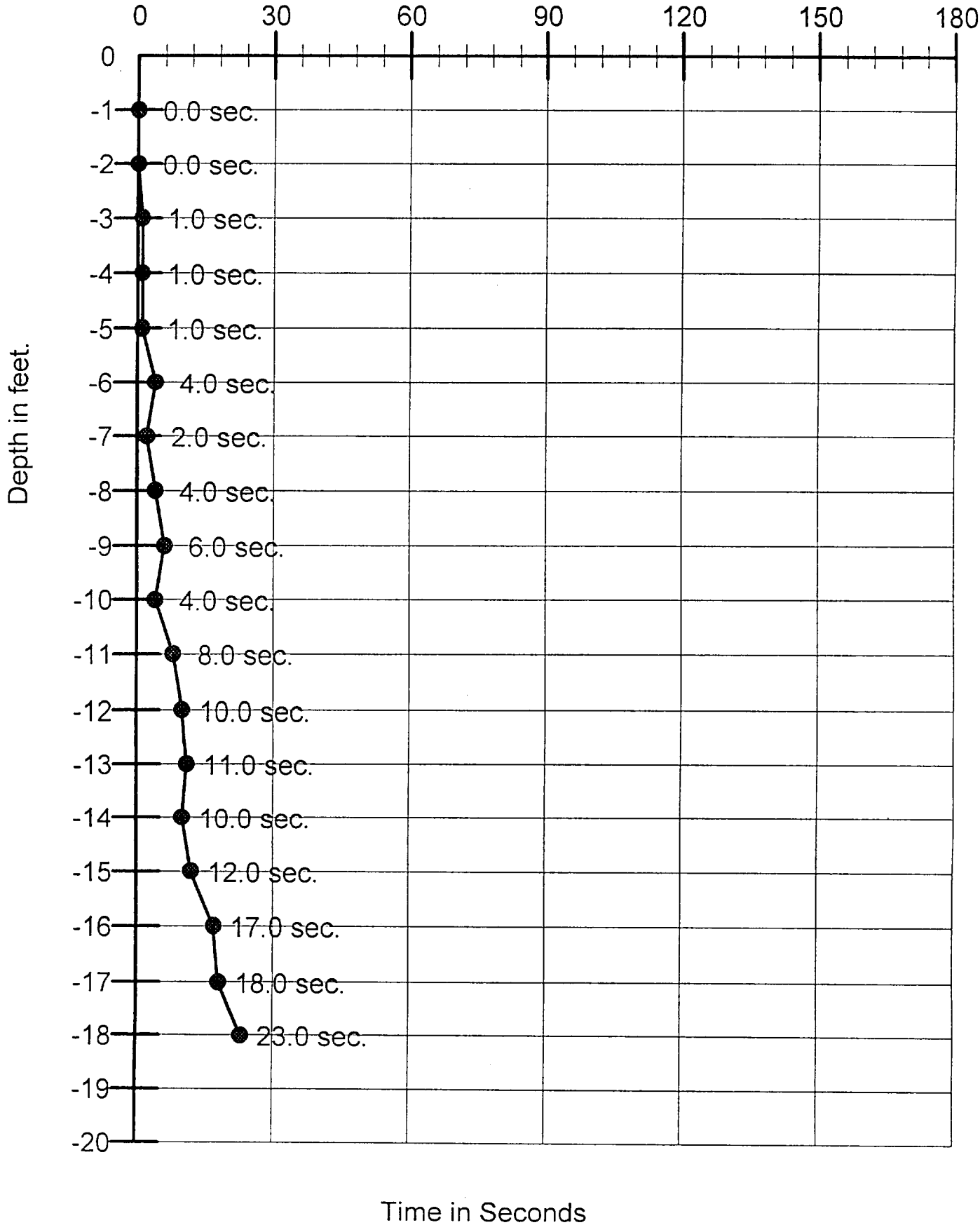


PENETRATION GRAPH

Core No: NJV 215 Run#: 1 Location: East: 378546.7 ft. North: 32226.6 ft.

Date: 5/21/96 Start Time: 4:20 PM Stop Time: 4:23 PM Jet to:

W.D. Raw: 30.8 ft. W.D.Corrected: 29.2 ft. Total Penetration: 18.5 ft. Total Recovery: 20.1 ft.

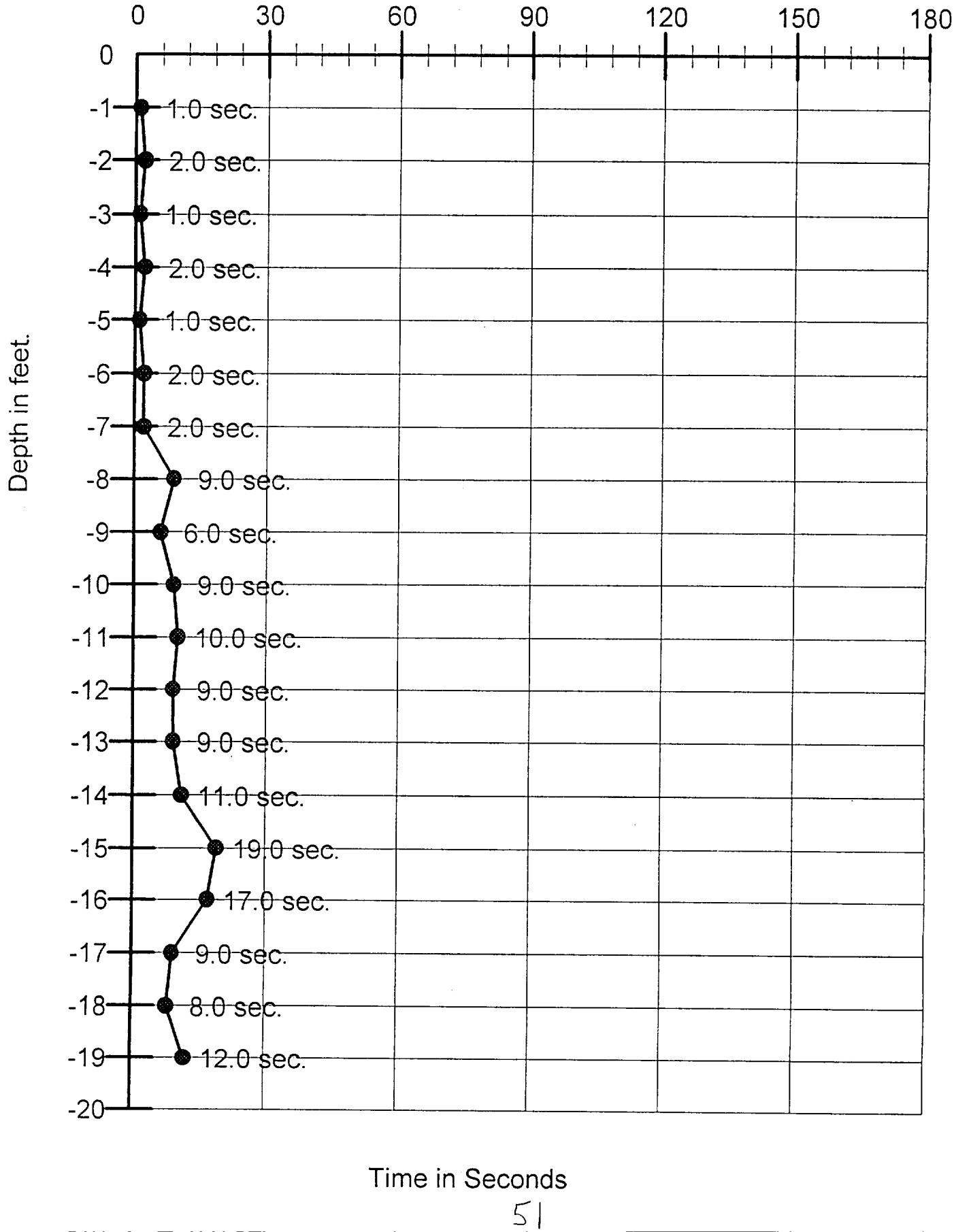


PENETRATION GRAPH

Core No: NJV 216 Run#: 1 Location: East: 380265.5 ft. North: 33587.2 ft.

Date: 5/21/96 Start Time: 5:15 PM Stop Time: 5:18 PM Jet to:

W.D. Raw: 26.0 ft. W.D.Corrected: 24.5 ft. Total Penetration: 19.3 ft. Total Recovery: 19.2 ft.

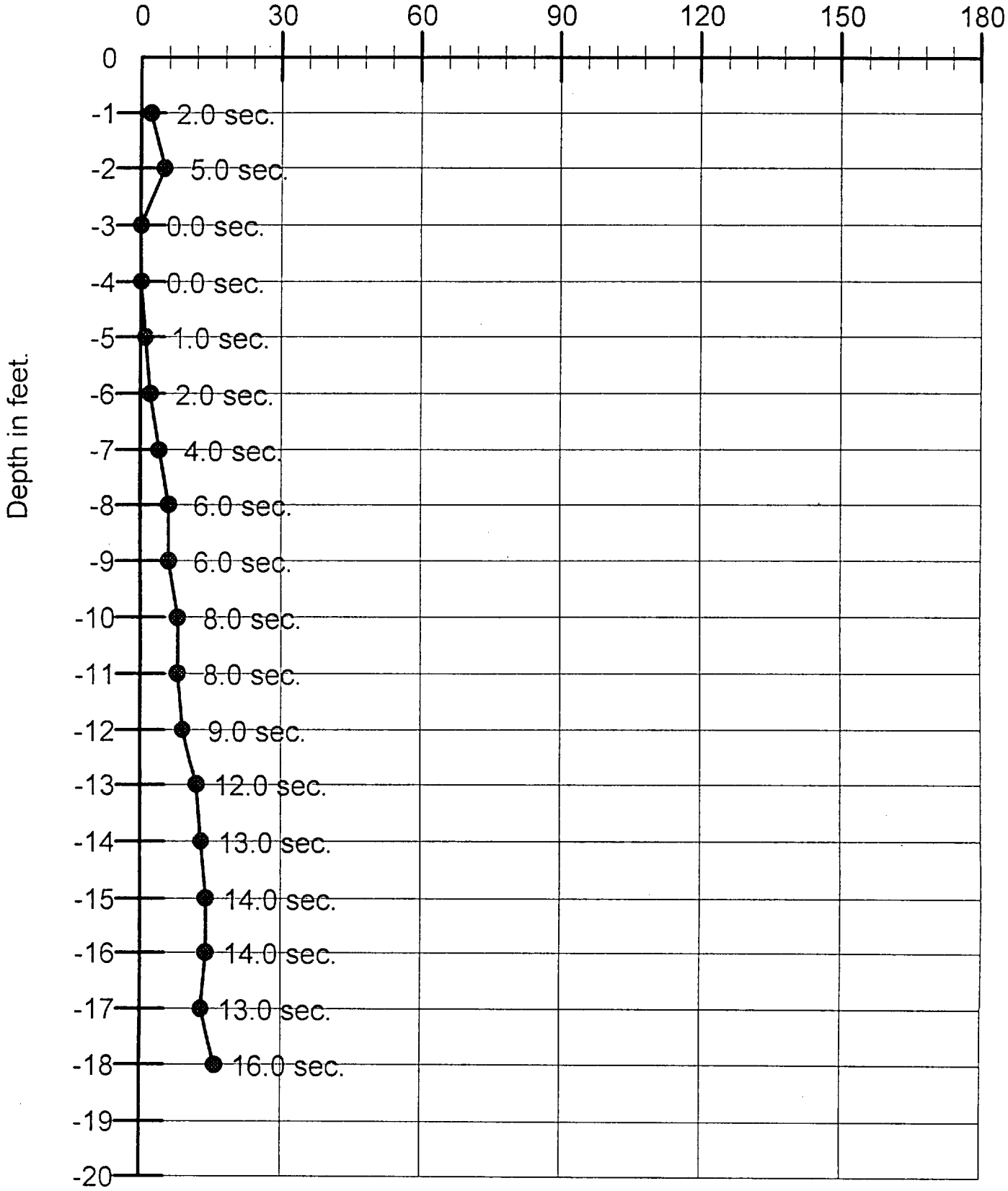


PENETRATION GRAPH

Core No: NJV 217 Run#: 1 Location: East: 381652.4 ft. North: 32849.4 ft.

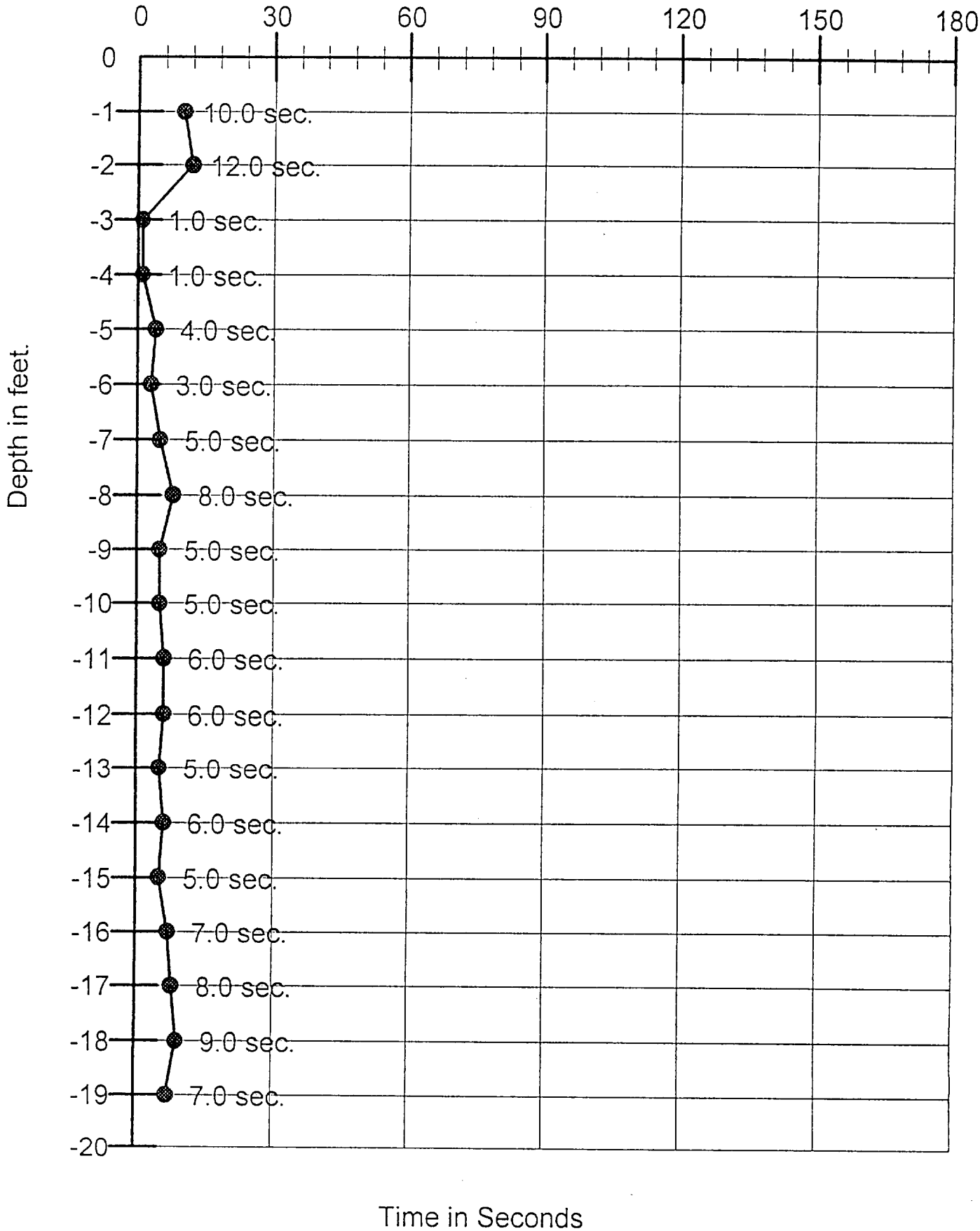
Date: 5/22/96 Start Time: 9:42 AM Stop Time: 9:45 AM Jet to:

W.D. Raw: 32.4 ft. W.D.Corrected: 32.0 ft. Total Penetration: 18.7 ft. Total Recovery: 20.0 ft.



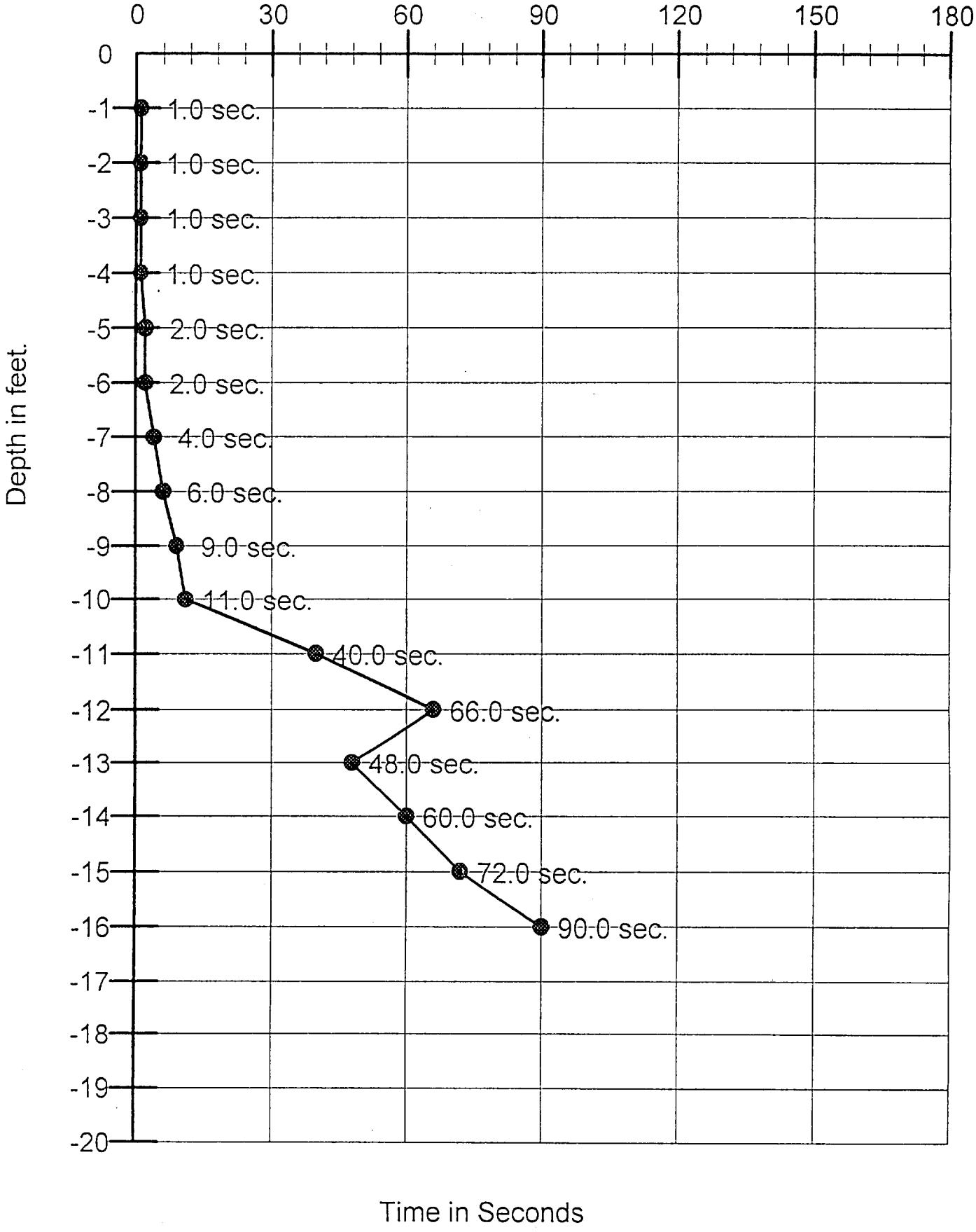
PENETRATION GRAPH

Core No: NJV 218 Run#: 1 Location: East: 374930.2 ft. North: 28578.1 ft.
Date: 5/20/96 Start Time: 4:47 PM Stop Time: 4:50 PM Jet to:
W.D. Raw: 32.0 ft. W.D.Corrected: 30.7 ft. Total Penetration: 19.6 ft. Total Recovery: 20.3 ft.



PENETRATION GRAPH

Core No: NJV219 Run#: 1 Location: East: 376050.7 ft. North: 29299.5 ft.
Date: 5/20/96 Start Time: 5:23 PM Stop Time: 5:34 PM Jet to:
W.D. Raw: 32.8 ft. W.D.Corrected: 31.7 ft. Total Penetration: 16.4 ft. Total Recovery: 16.1 ft.

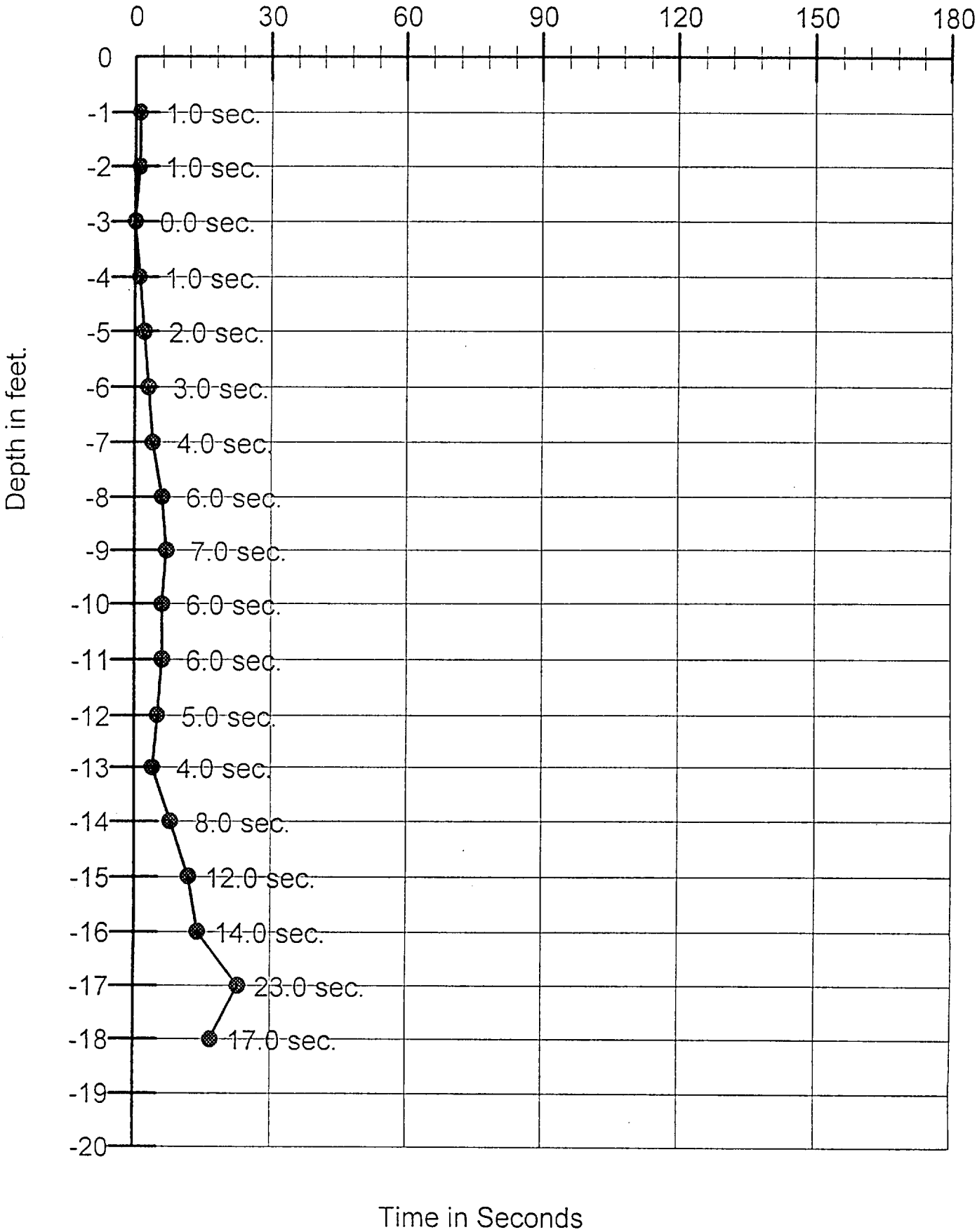


PENETRATION GRAPH

Core No: NJV 220 Run#: 1 Location: East: 377217.7 ft. North: 28534.8 ft.

Date: 5/21/96 Start Time: 11:00 A Stop Time: 11:03 A Jet to:

W.D. Raw: 37.0 ft. W.D.Corrected: 36.7 ft. Total Penetration: 18.3 ft. Total Recovery: 19.5 ft.

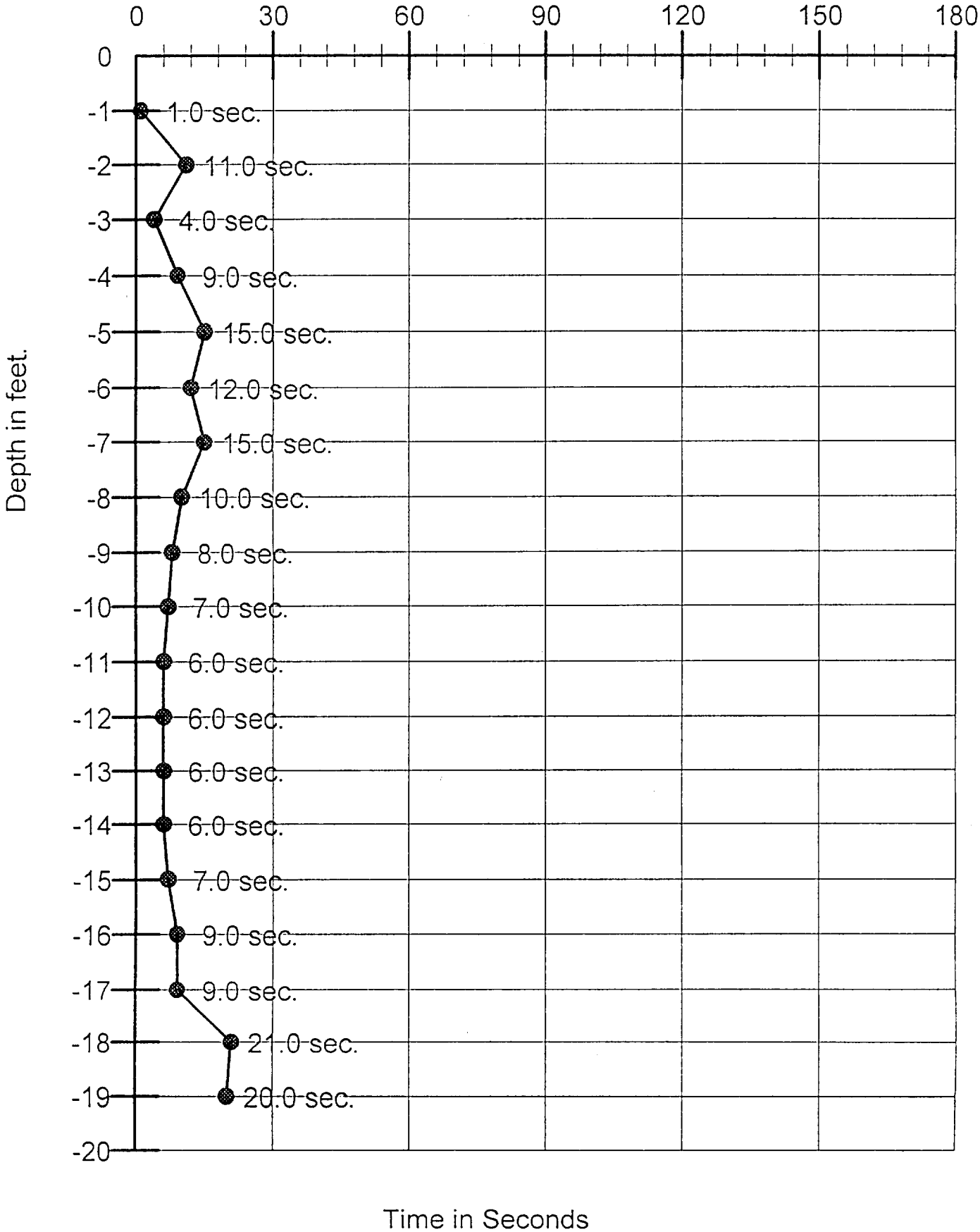


PENETRATION GRAPH

Core No: NJV 221 Run#: 1 Location: Lat.: 379187.2 Long.: 29189.6

Date: 5/21/96 Start Time: 9:38 AM Stop Time: 9:43 AM Jet to:

W.D. Raw: 36.5 ft. W.D.Corrected: 36.2 ft. Total Penetration: 19.1 ft. Total Recovery: 19.9 ft.

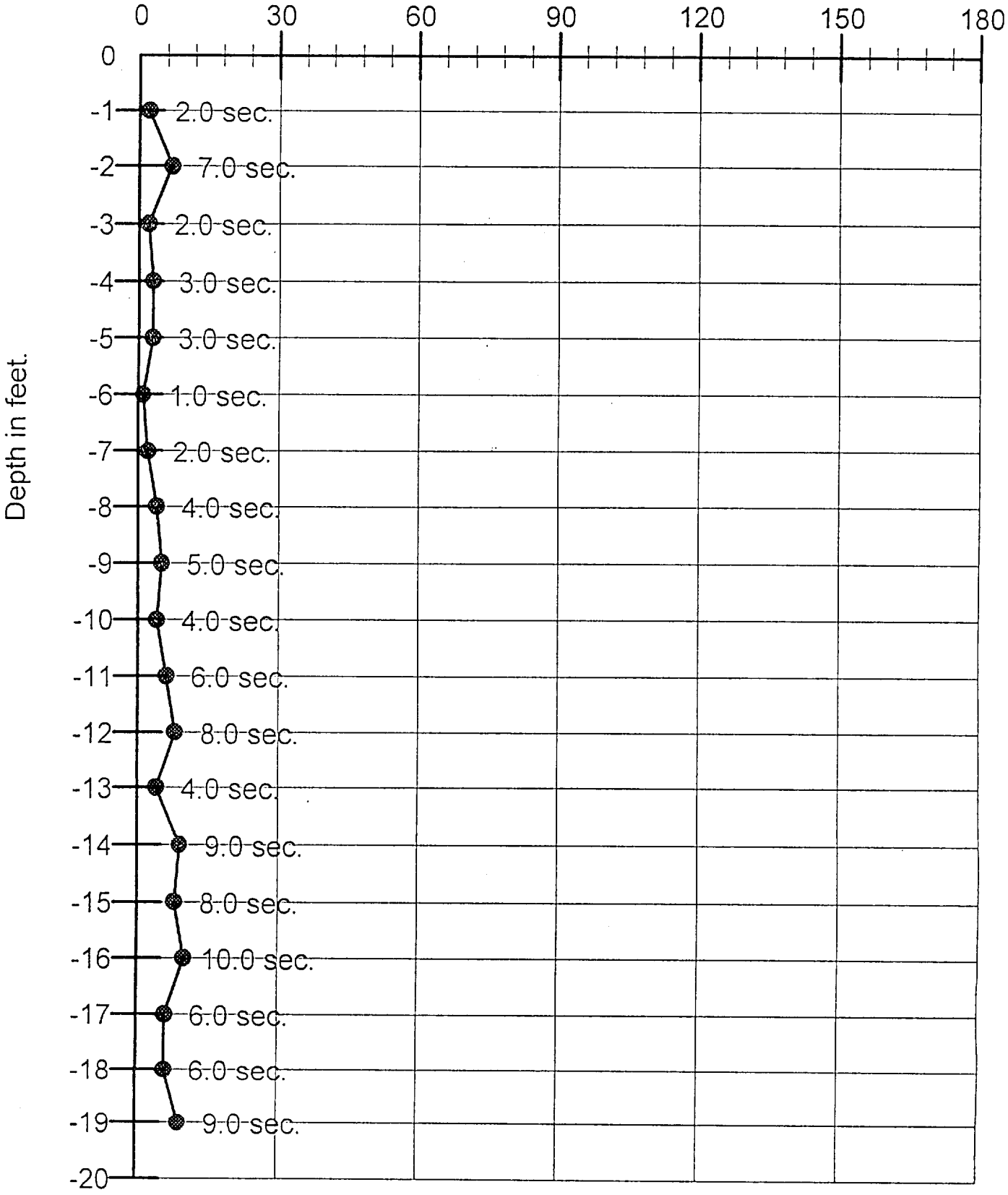


PENETRATION GRAPH

Core No: NJV 222 Run#: 1 Location: East: 373279.5 ft. North: 24628.9 ft.

Date: 5/21/96 Start Time: 3:27 PM Stop Time: 3:29 PM Jet to:

W.D. Raw: 31.2 ft. W.D.Corrected: 29.7 ft. Total Penetration: 19.5 ft. Total Recovery: 16.9 ft.

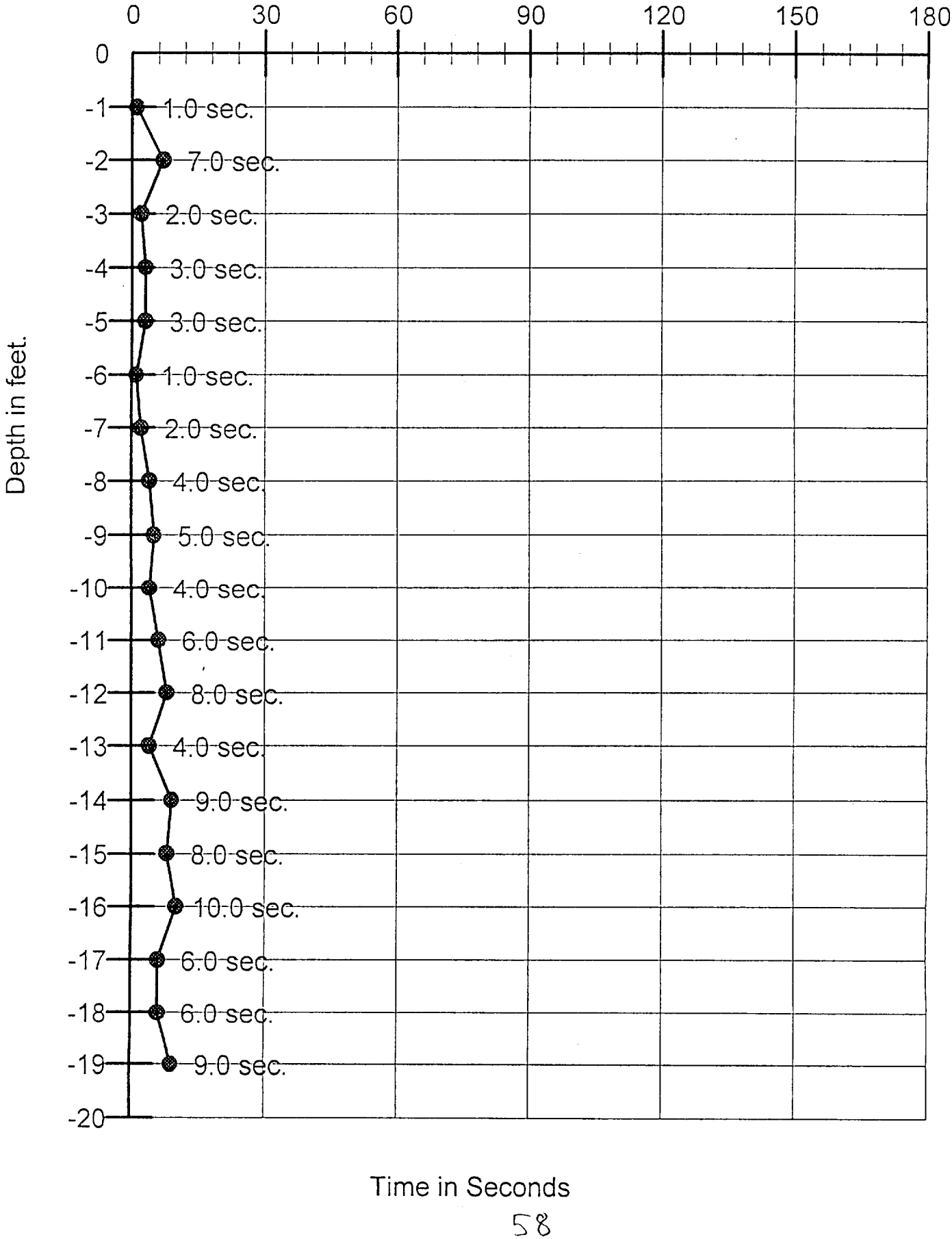


PENETRATION GRAPH

Core No: NJV223 Run#: 1 Location: East: 375609.7 ft. North: 23060.6 ft.

Date: 5/21/96 Start Time: 2:35 PM Stop Time: 2:37 PM Jet to:

W.D. Raw: 29.2 ft. W.D.Corrected: 27.9 ft. Total Penetration: 19.0 ft. Total Recovery: 19.0 ft.

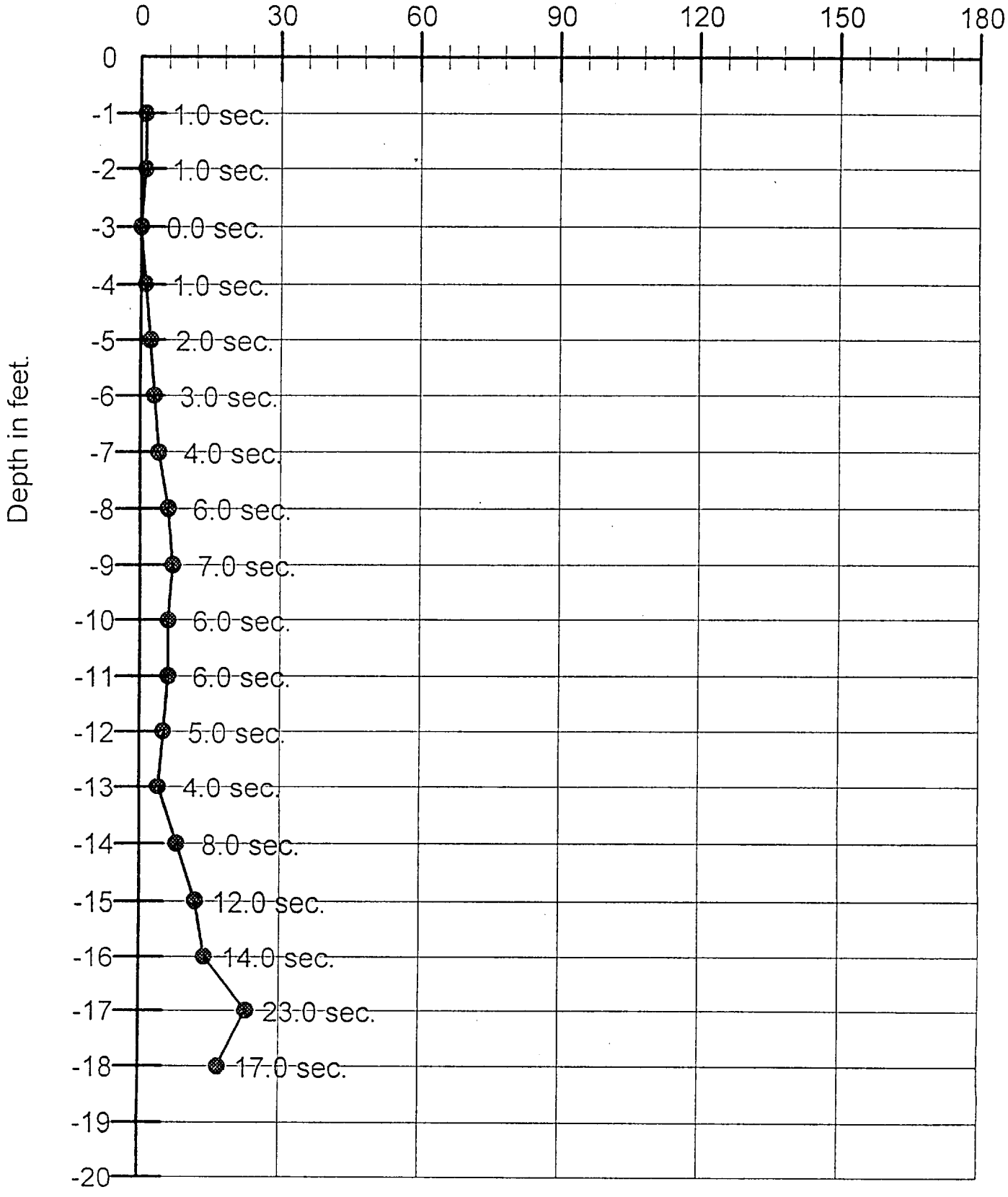


PENETRATION GRAPH

Core No: NJV 224 Run#: 1 Location: East: 377035.4 ft. North: 23395.7 ft.

Date: 5/21/96 Start Time: 12:48 PM Stop Time: 12:49 PM Jet to:

W.D. Raw: 31.8 ft. W.D.Corrected: 31.0 ft. Total Penetration: 18.4 ft. Total Recovery: 17.0 ft.

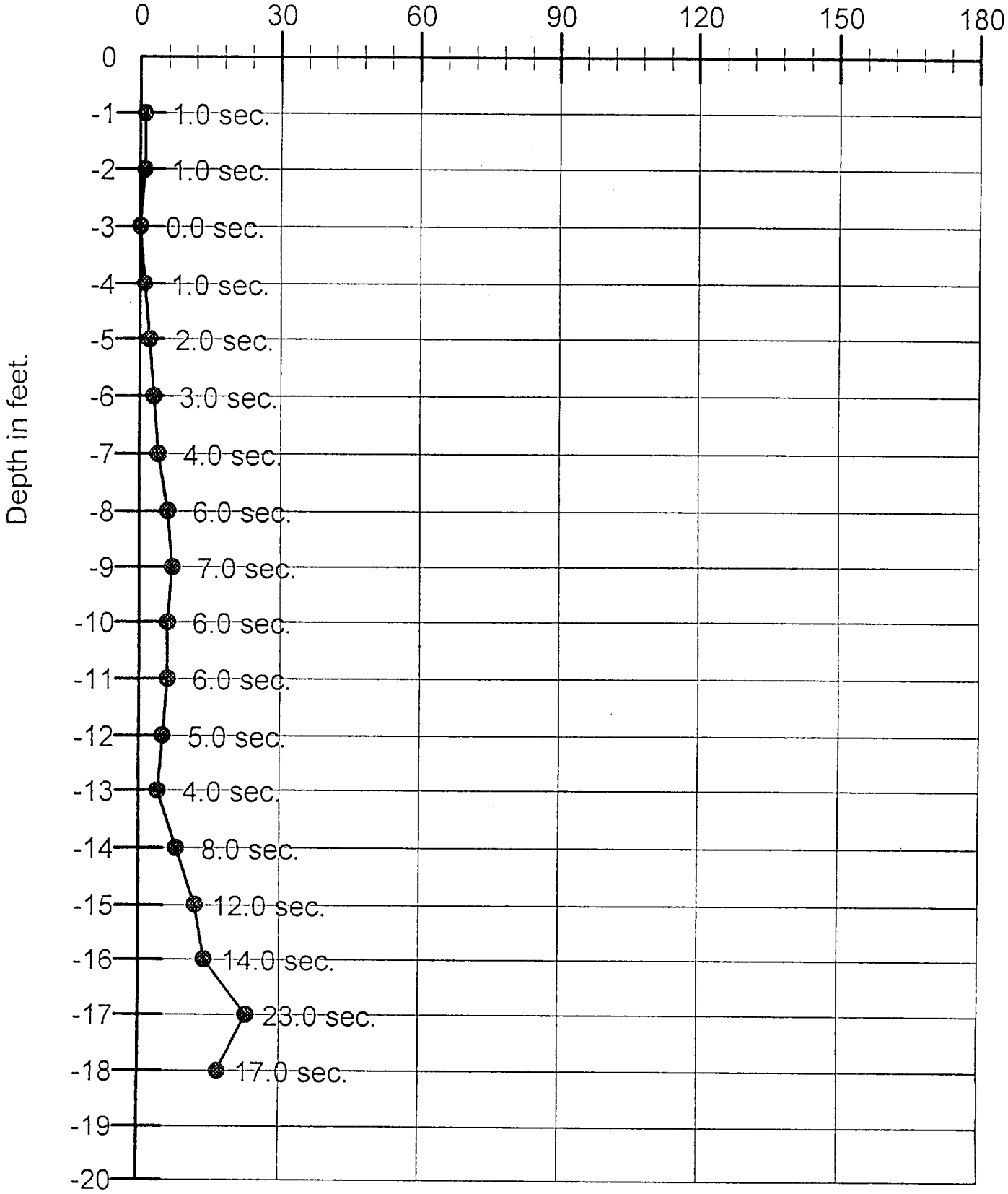


PENETRATION GRAPH

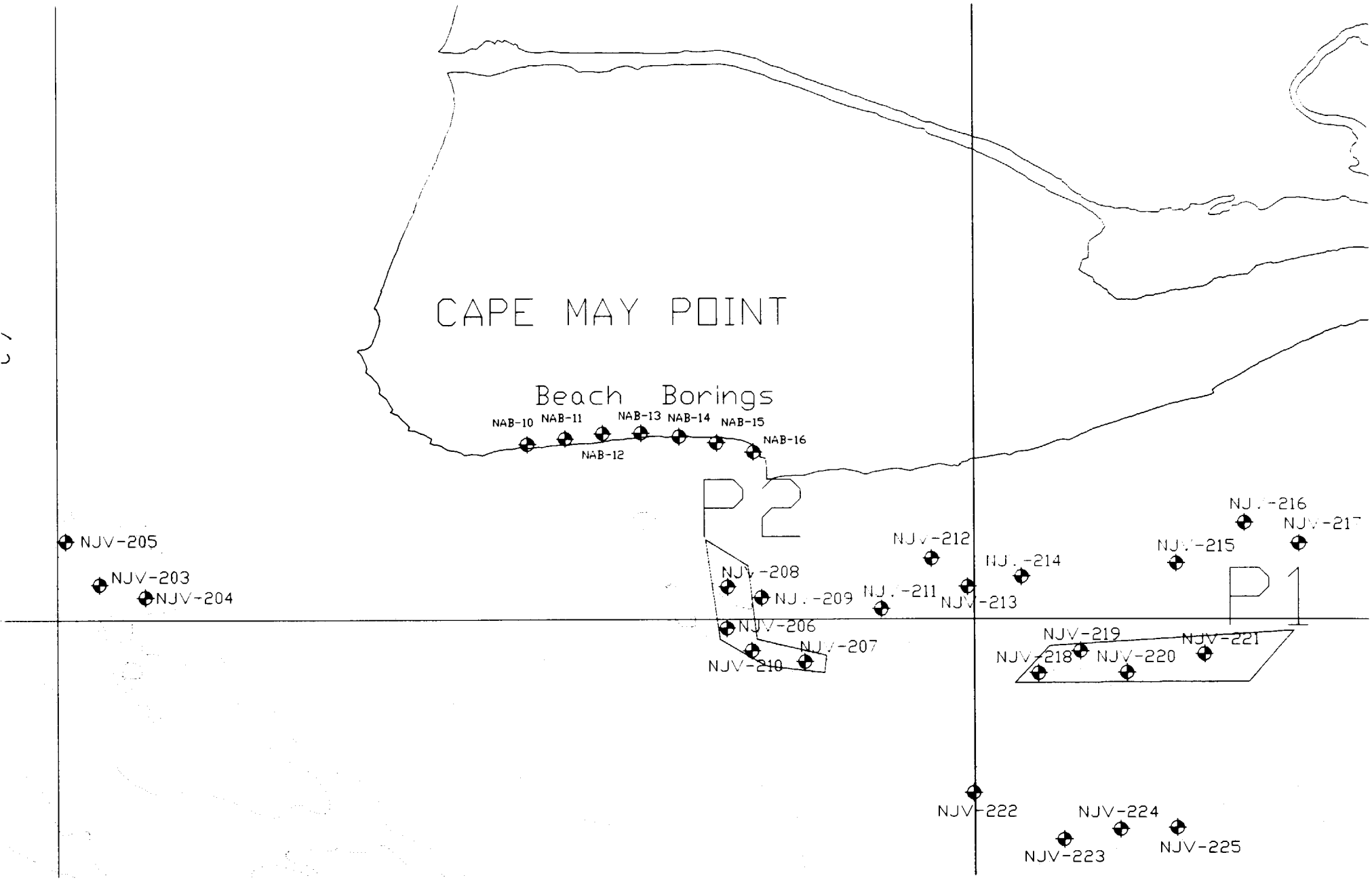
Core No: NJV 225 Run#: 1 Location: East: 378495.7 ft. North: 23461.1 ft.

Date: 5/21/96 Start Time: 1200 pm Stop Time: 12:03 p Jet to:

W.D. Raw: 32.0 ft. W.D.Corrected: 31.5 ft. Total Penetration: 18.0 ft. Total Recovery: 17.8 ft.



Section 2
Native and Borrow Material Analysis


CAPE MAY POINT
Beach Borings
NAB-10
NAB-11
NAB-12
NAB-13
NAB-14
NAB-15
NAB-16
P2
P1
NJV-205
NJV-203
NJV-204
NJV-208
NJV-209
NJV-206
NJV-207
NJV-210
NJV-212
NJV-211
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NJV-217
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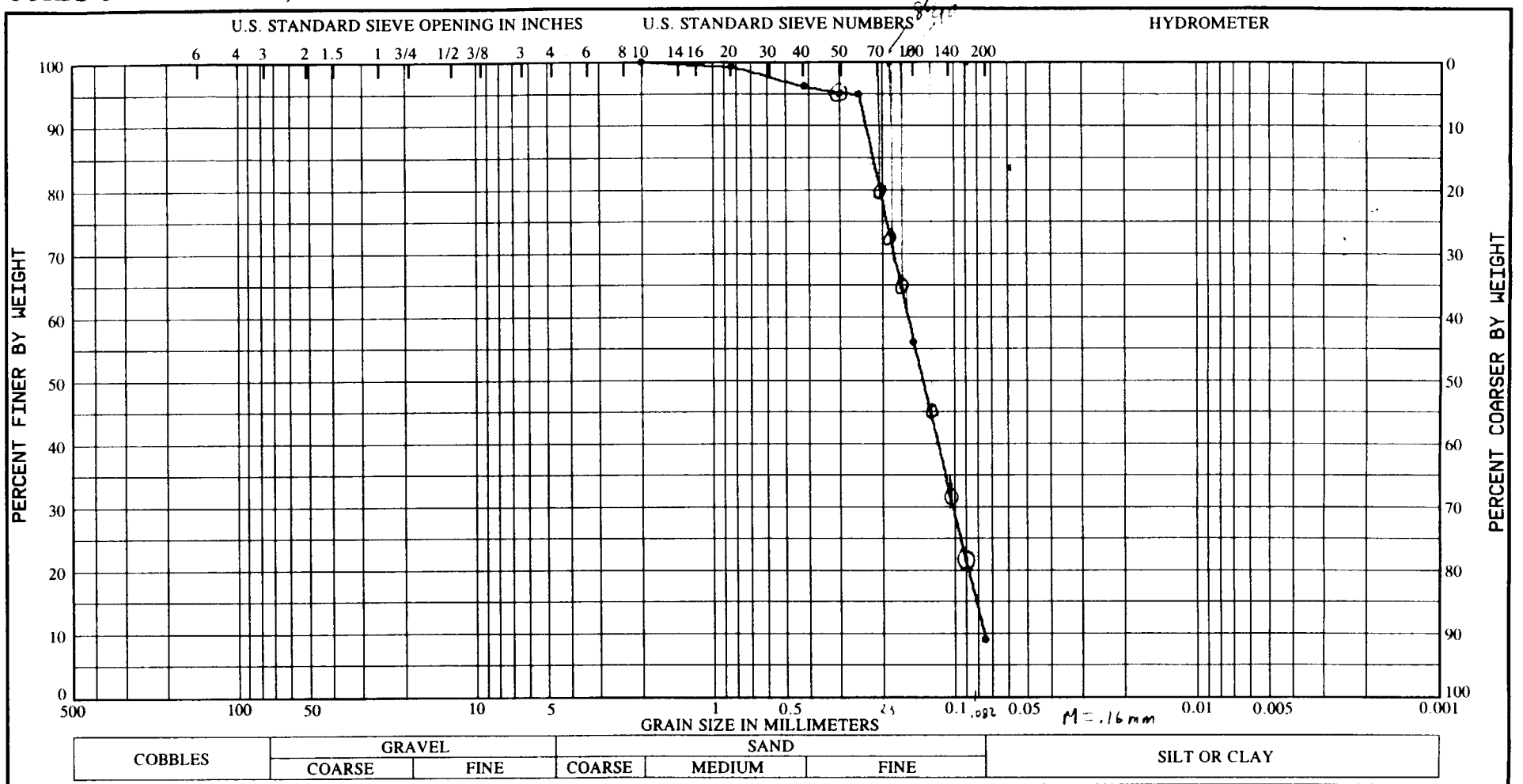
NJV-221
NJV-222
NJV-223
NJV-224
NJV-225

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30060

WORK ORDER: 8015
REQUISITION: CENAP-EN-96-813



COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

Sample No.	Depth (Ft)	(VISUAL) Classification	Nat w%	LL	PL	PI
R2-1	2.4-2.6	GRAY, POORLY GRADED SILTY SAND (SP-SM),				
		WITH A TRACE OF MICA.				

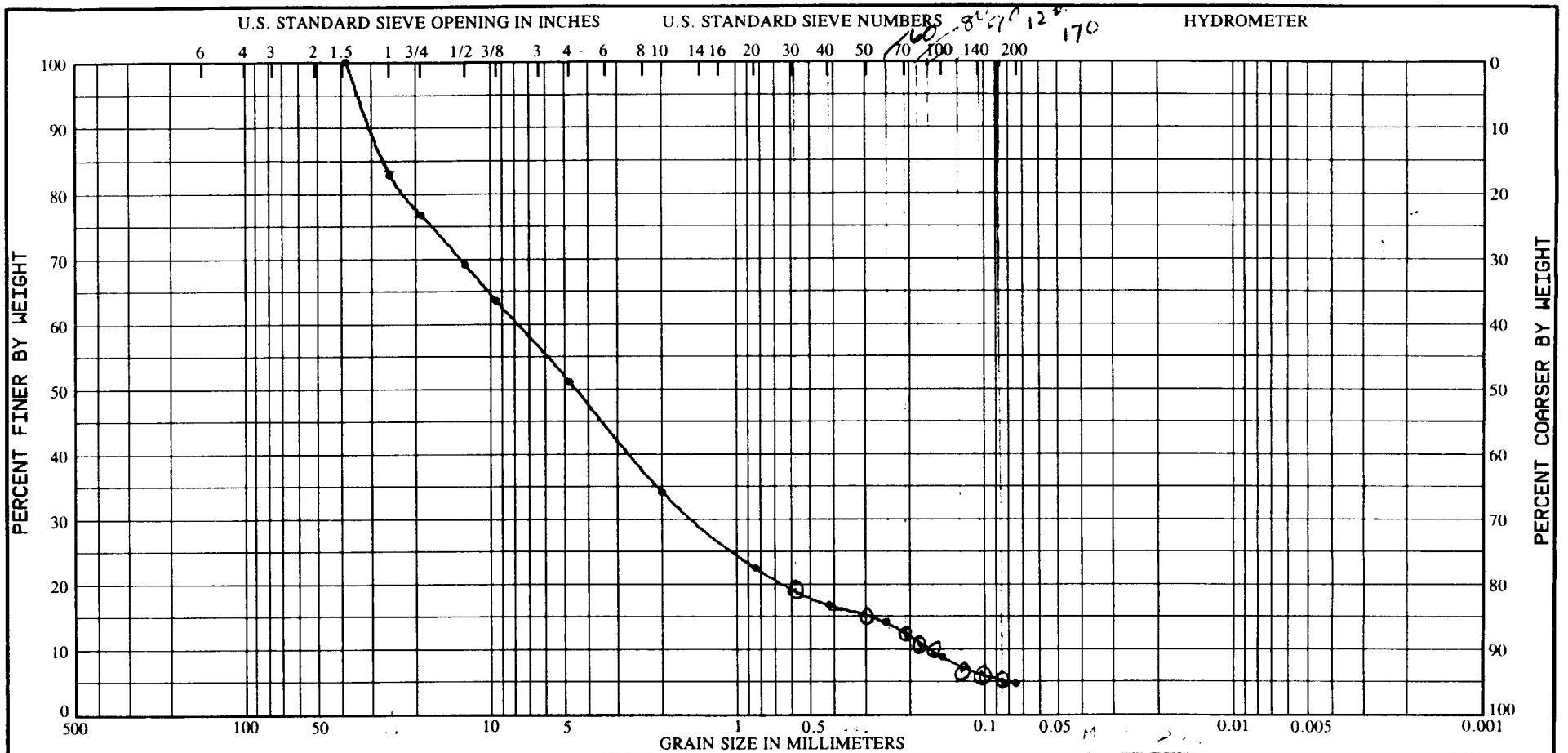
Project CAPE MAY
VIBRA-CORE SAMPLES
Lab No. 184/1247
Boring No. NJV-203
Date 07/30/96

GRADATION CURVES

OK - 100 Fine

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30060

WORK ORDER: 8015
REQUISITION: CENAP-EN-96-813



COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

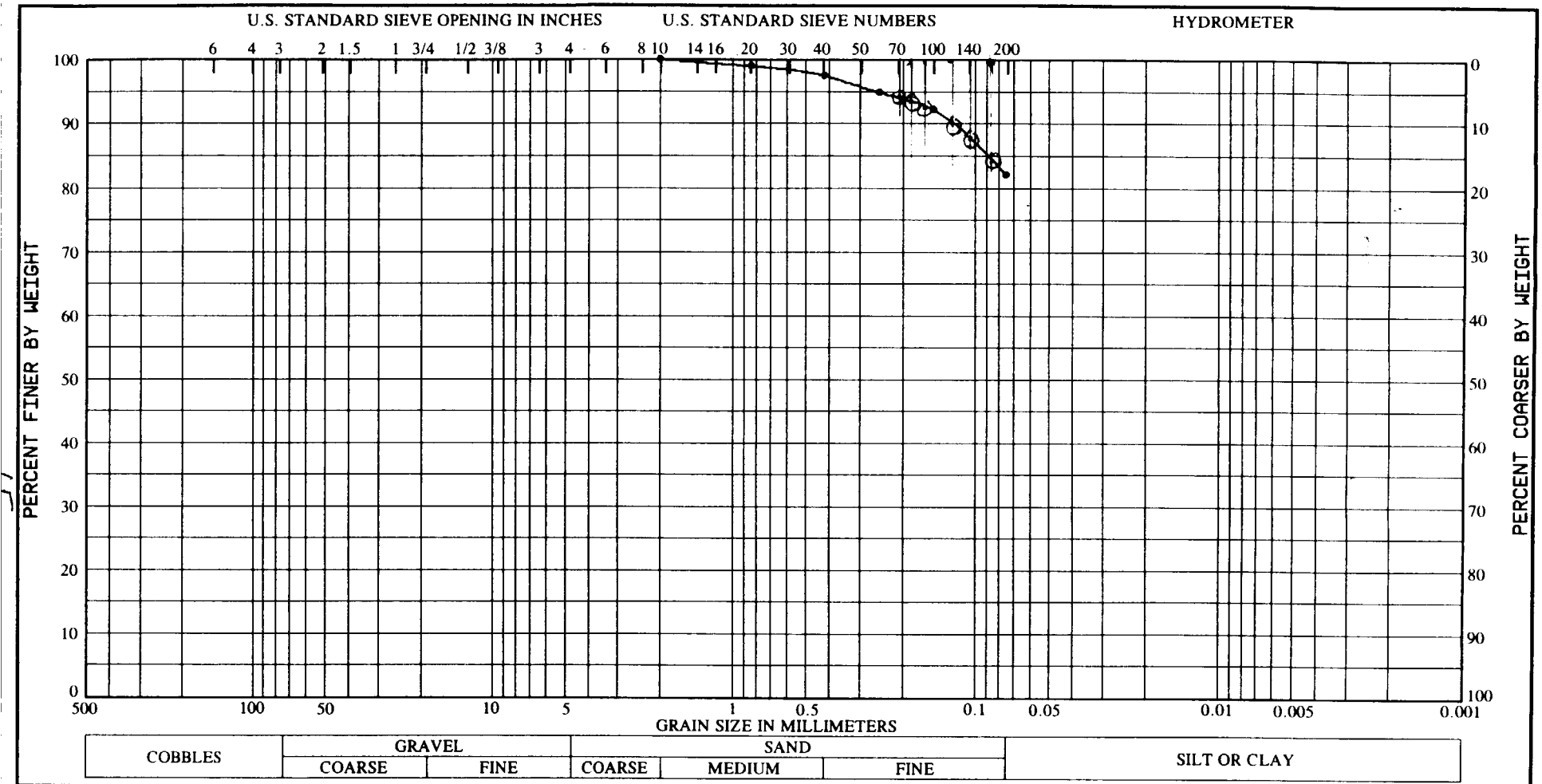
Sample No.	Depth (Ft)	(VISUAL) Classification	Nat w%	LL	PL	PI
R3-2	6.5-6.9	TAN & GRAY, SANDY POORLY GRADED GRAVEL (GP), WITH A TRACE OF MICA.				

Project CAPE MAY
VIBRA-CORE SAMPLES
Lab No. 184/1247
Boring No. NJV-203
Date 07/16/96

GRADATION CURVES

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30060

WORK ORDER: 8015
REQUISITION: CENAP-EN-96-813



COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

Sample No.	Depth (Ft)	(VISUAL) Classification	Nat w%	LL	PL	PI
R3-2	10.2-10.4	GRAY, SILTY FAT CLAY (CH), WITH A LITTLE SAND SIZES AND A TRACE OF MICA AND ORGANIC MATTER.				

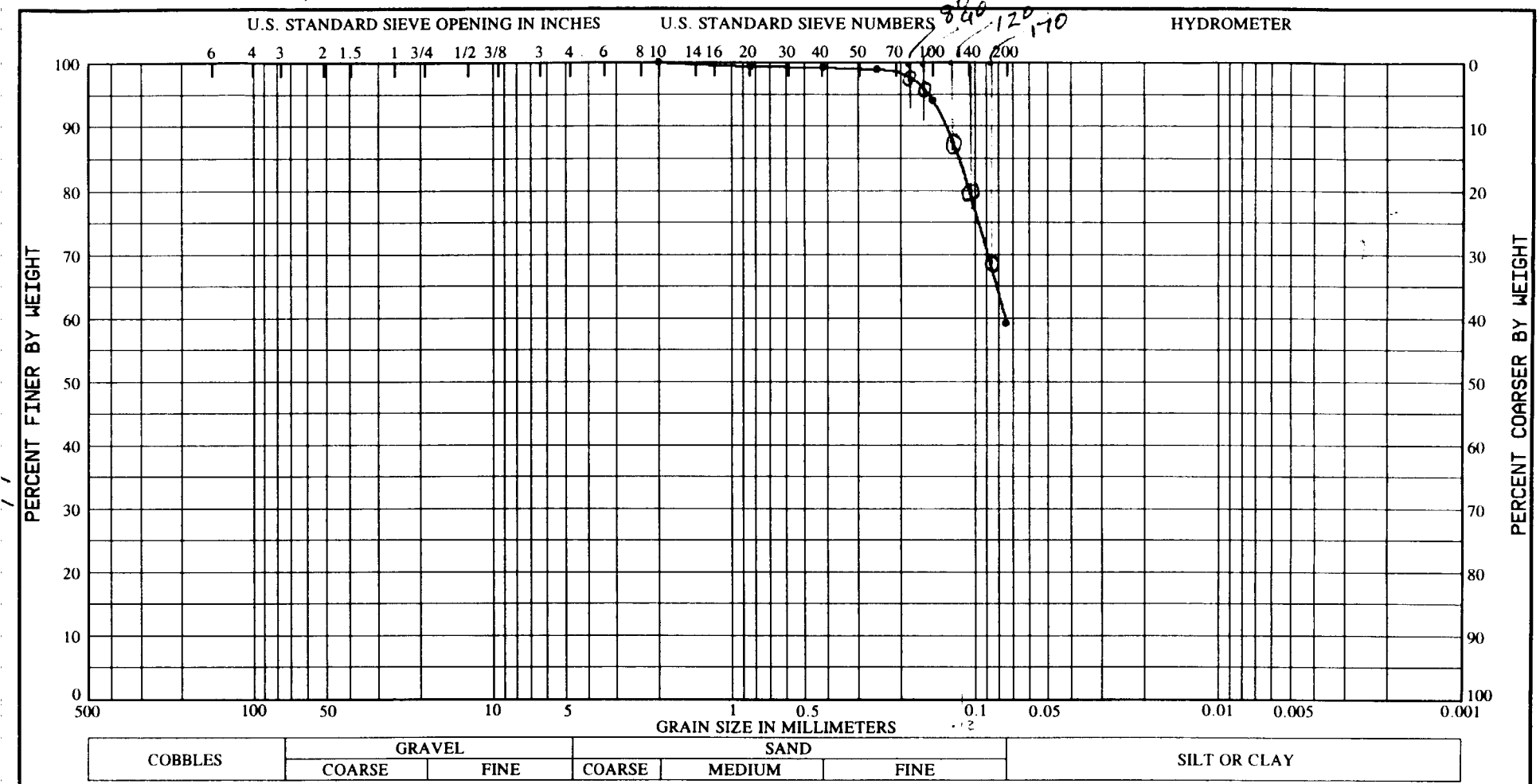
Project CAPE MAY
VIBRA-CORE SAMPLES
Lab No. 184/1247
Boring No. NJV-203
Date 07/16/96

GRADATION CURVES

To fin.

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30060

WORK ORDER: 8015
REQUISITION: CENAP-EN-96-813



COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

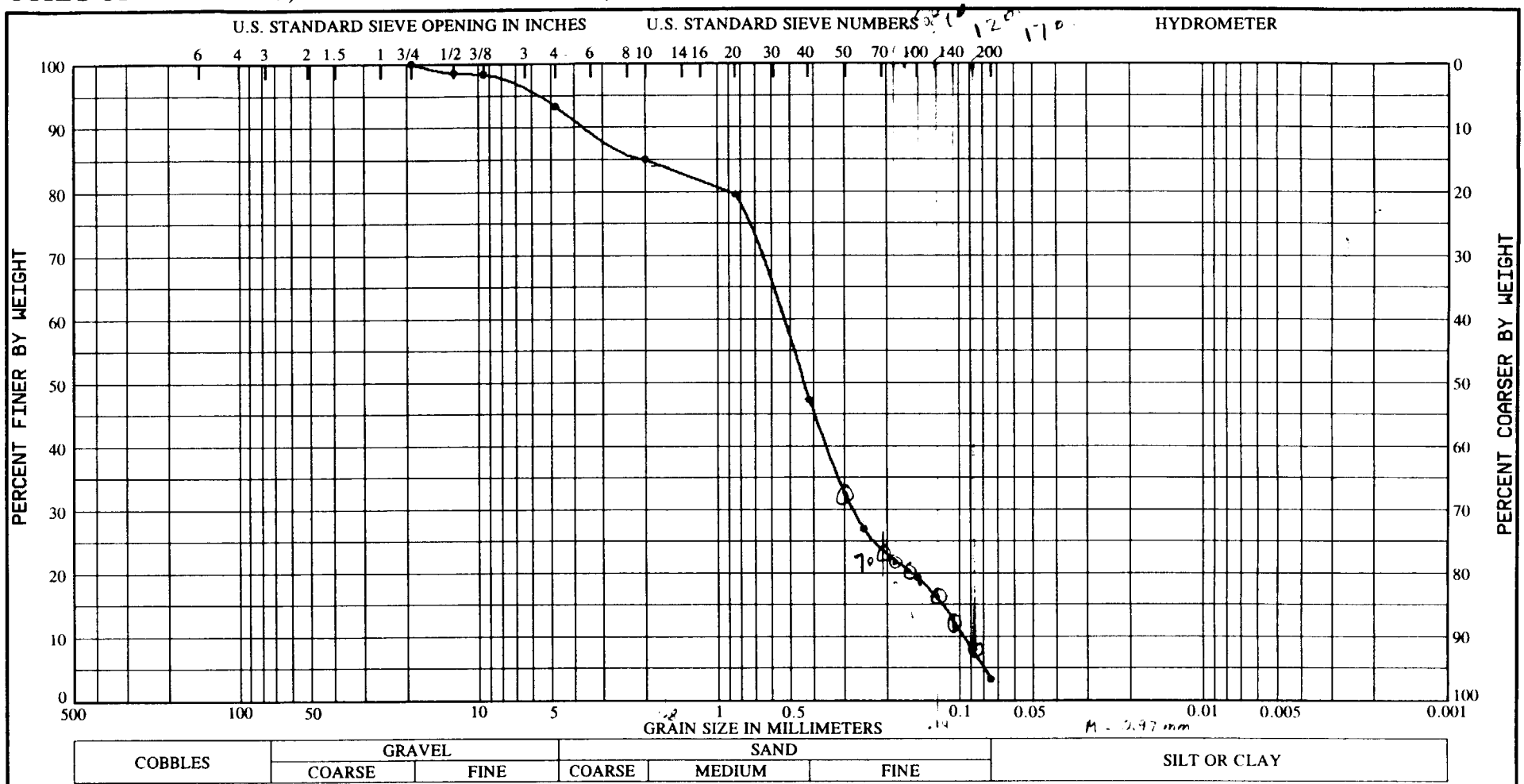
Sample No.	Depth (Ft)	(VISUAL) Classification	Nat w%	LL	PL	PI
R3-3	14.8-15.0	TAN, SANDY SILTY FAT CLAY (CH). WITH A TRACE OF MICA AND ORGANIC MATTER.				

Project CAPE MAY
VIBRA-CORE SAMPLES
Lab No. 184/1247
Boring No. NJV-203
Date 07/16/96

GRADATION CURVES

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30060

WORK ORDER: 8015
REQUISITION: CENAP-EN-96-813



COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

Sample No.	Depth (Ft)	(VISUAL) Classification	Nat w%	LL	PL	PI
1	2.9-3.1	TAN, POORLY GRADED SAND (SP), WITH A TRACE OF GRAVEL SIZES AND MICA.				

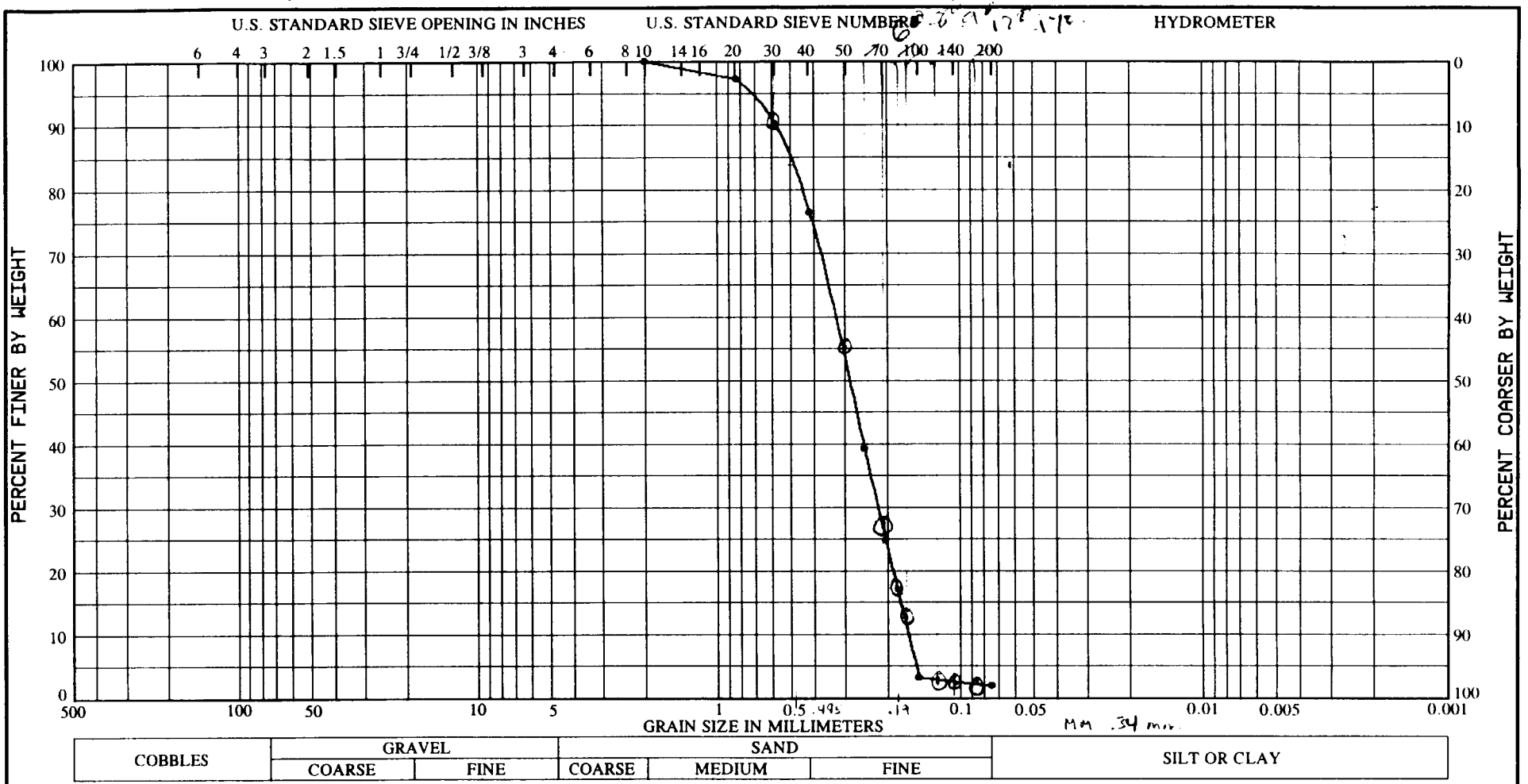
Project CAPE MAY
VIBRA-CORE SAMPLES
Lab No. 184/1248
Boring No. NJV-204
Date 07/16/96

GRADATION CURVES

OK

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30060

WORK ORDER: 8015
REQUISITION: CENAP-EN-96-813



COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

Sample No.	Depth (Ft)	(VISUAL) Classification	Nat w%	LL	PL	PI
2	7.5-7.7	TAN, POORLY GRADED SAND (SP), WITH A TRACE OF MICA.				

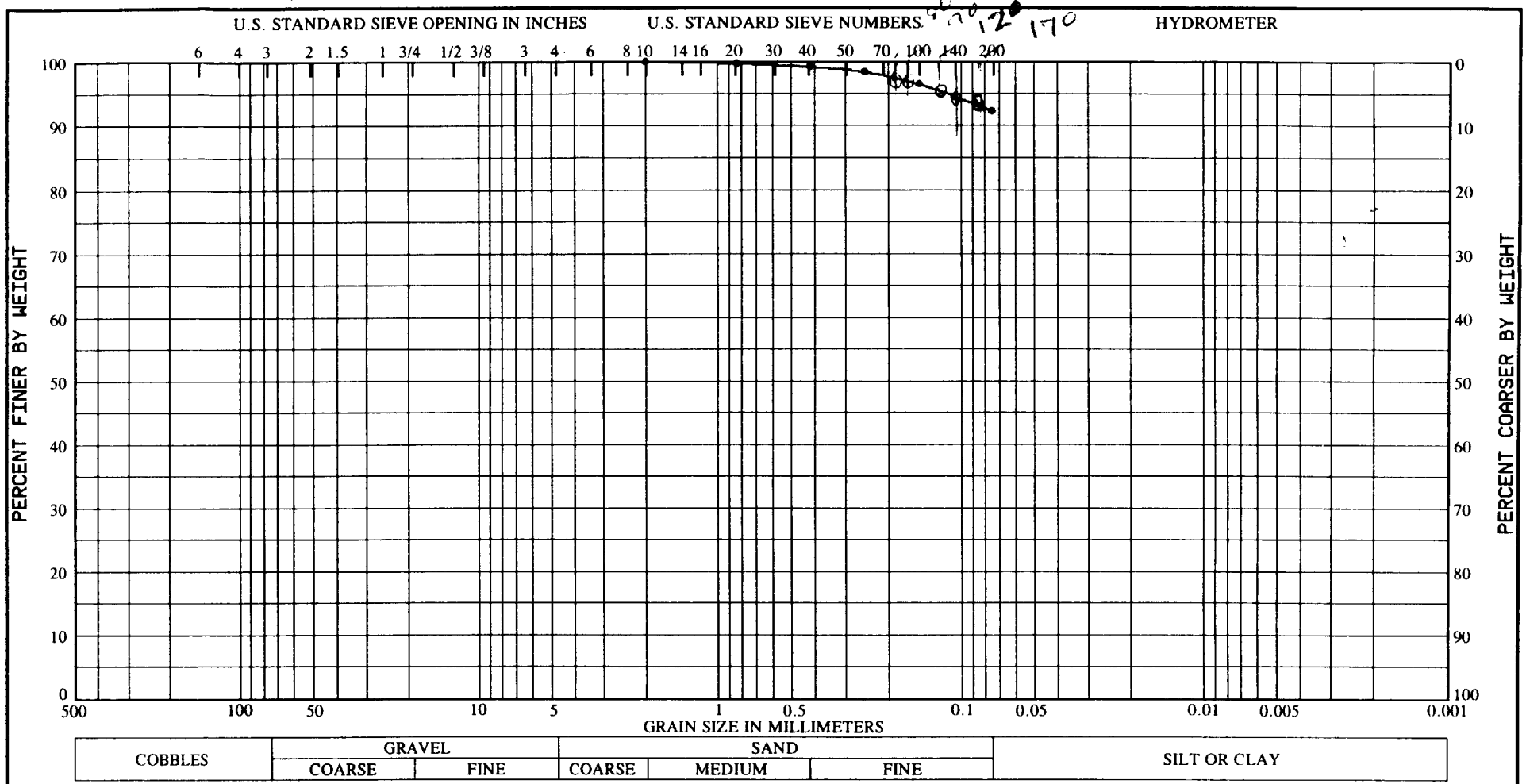
Project CAPE MAY
VIBRA-CORE SAMPLES
Lab No. 184/1248
Boring No. NJV-204
Date 07/16/96

GRADATION CURVES

ok

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30060

WORK ORDER: 8015
REQUISITION: CENAP-EN-96-813



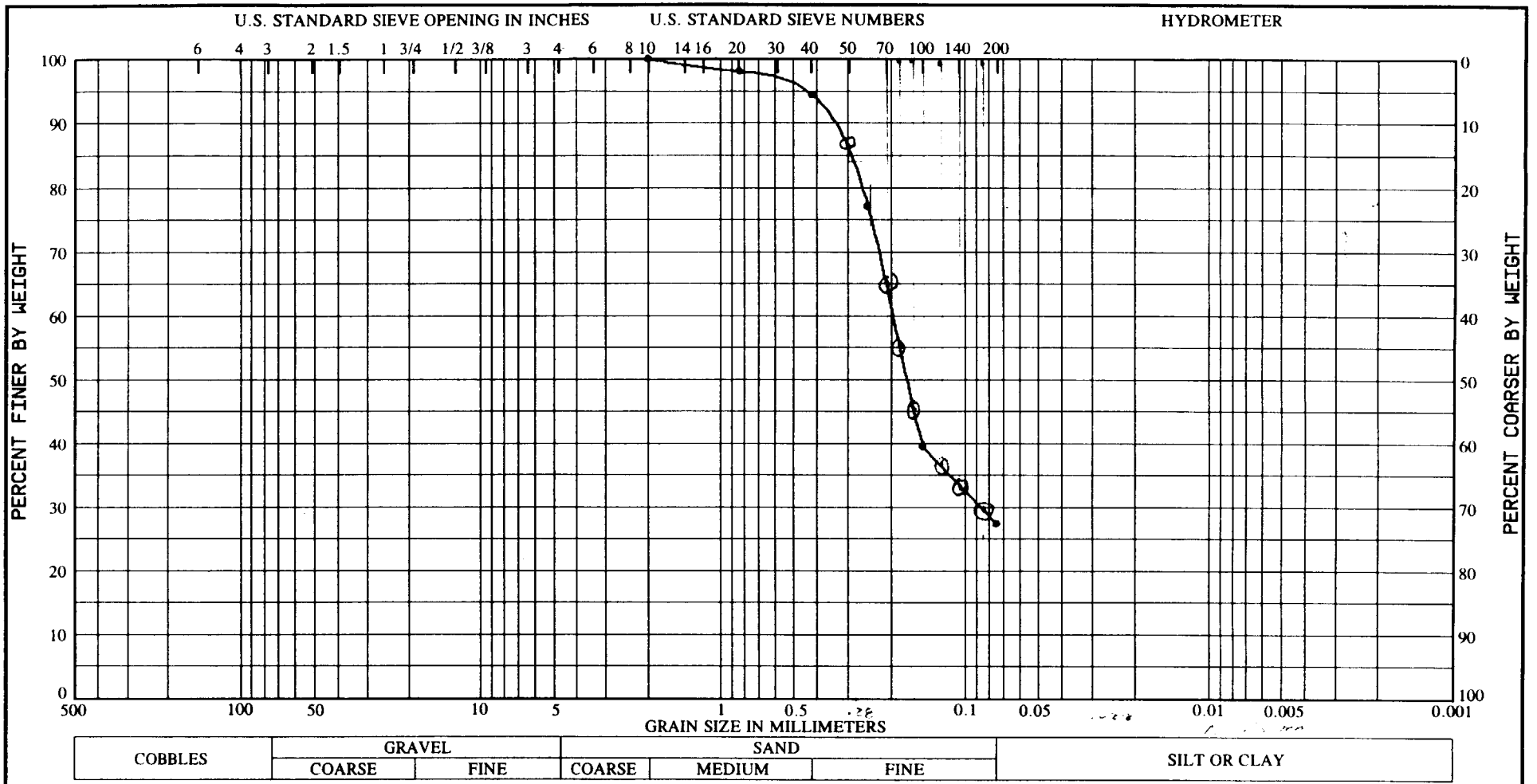
Sample No.	Depth (Ft)	(VISUAL) Classification	Nat w%	LL	PL	PI
3	12.4-12.7	GRAY, SILTY FAT CLAY (CH), WITH A TRACE OF SAND SIZES AND MICA.				

Project CAPE MAY
VIBRA-CORE SAMPLES
Lab No. 184/1248
Boring No. NJV-204
Date 07/16/96

GRADATION CURVES

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30060

WORK ORDER: 8015
REQUISITION: CENAP-EN-96-813



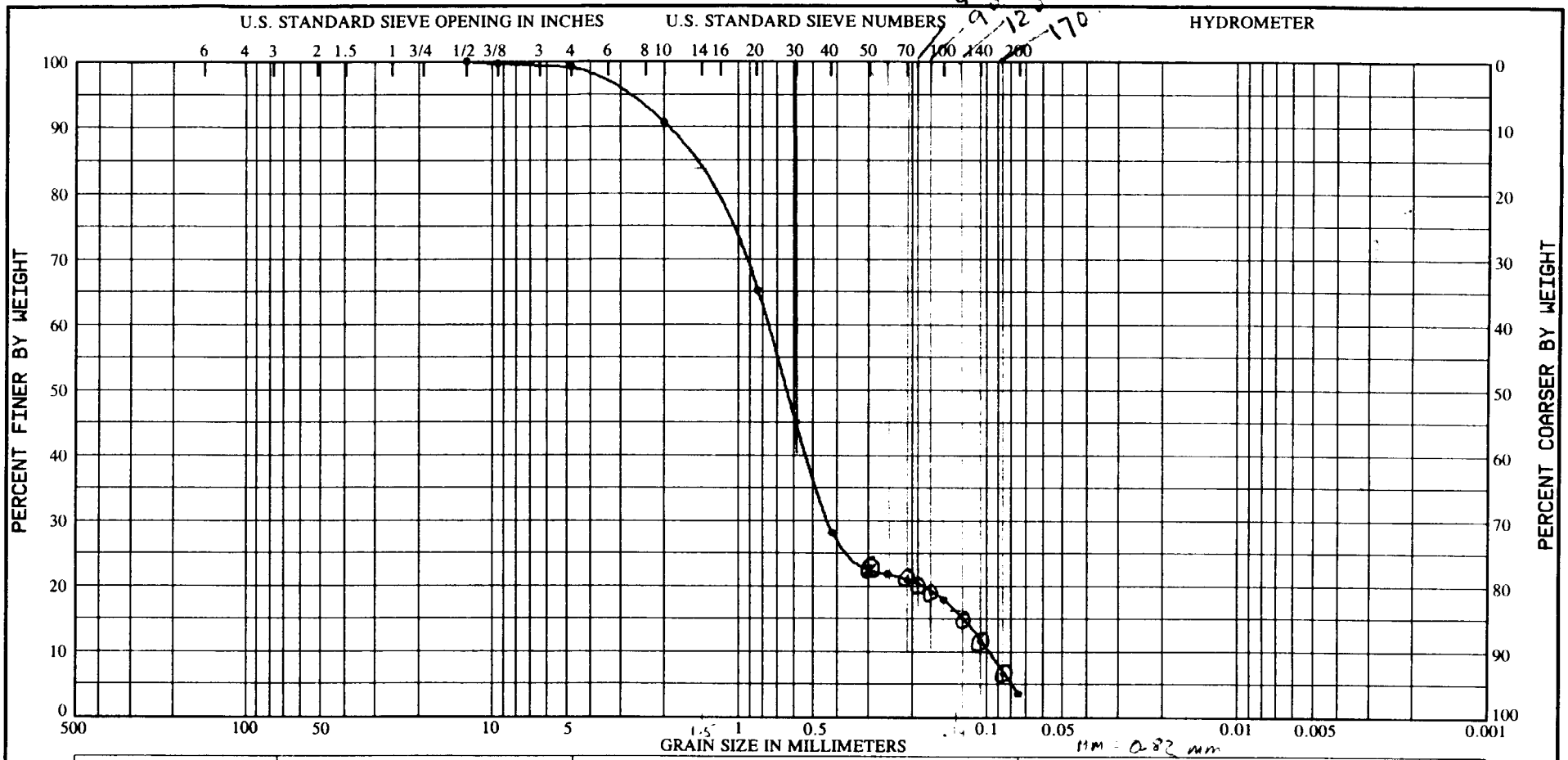
Sample No.	Depth (Ft)	(VISUAL) Classification	Nat w%	LL	PL	PI
4	16.9-17.2	GRAY, SILTY SAND (SM), WITH PLASTIC FINES AND A TRACE OF MICA.				

Project CAPE MAY
VIBRA-CORE SAMPLES
Lab No. 184/1248
Boring No. NJV-204
Date 07/16/96

GRADATION CURVES

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30060

WORK ORDER: 8015
REQUISITION: CENAP-EN-96-813



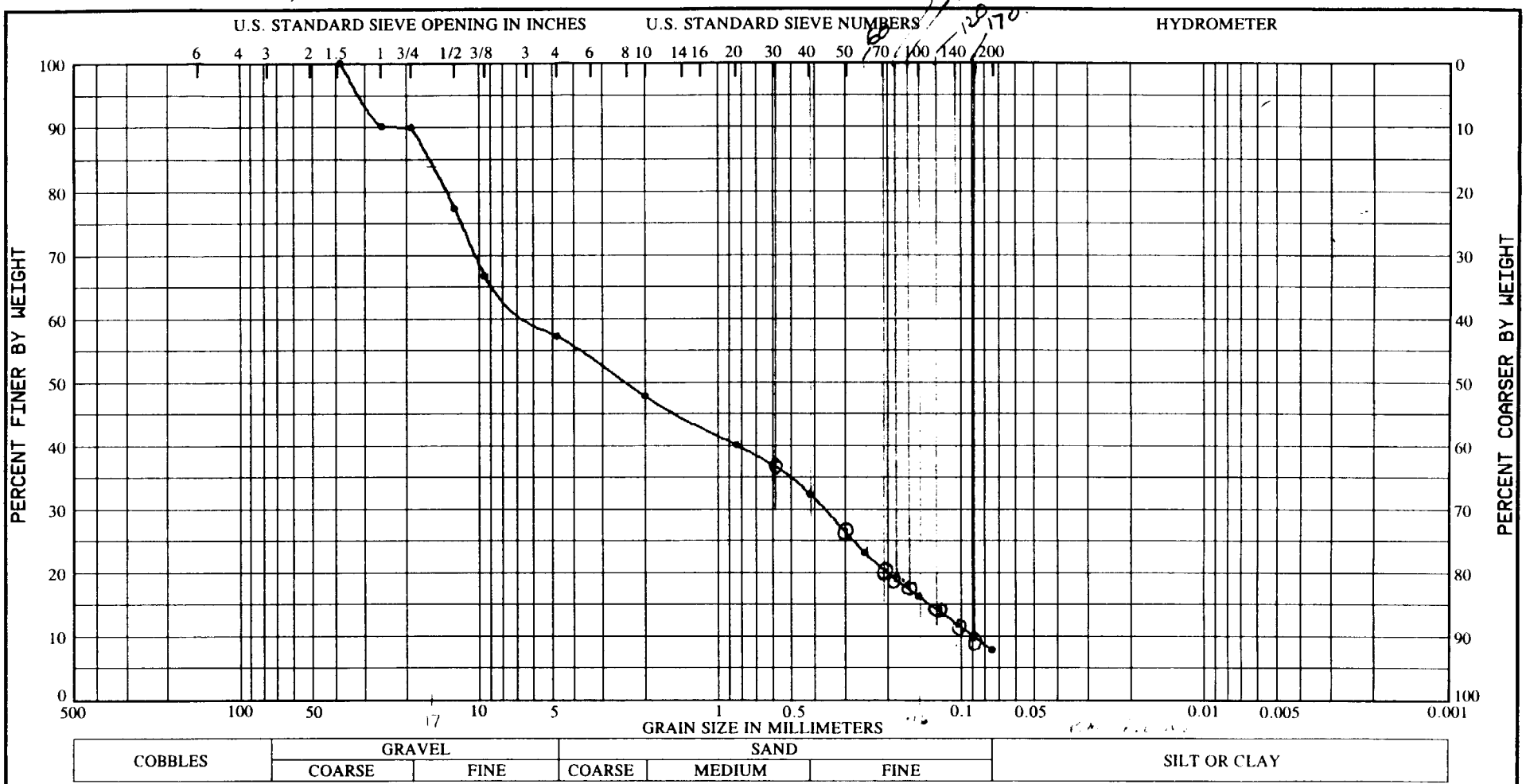
Sample No.	Depth (Ft)	(VISUAL) Classification	Nat w%	LL	PL	PI
1	2.9-3.1	GRAY, POORLY GRADED SAND (SP), WITH A TRACE OF MICA.				

Project CAPE MAY
VIBRA-CORE SAMPLES
Lab No. 184/1249
Boring No. NJV-205
Date 07/16/96

GRADATION CURVES

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30060

WORK ORDER: 8015
REQUISITION: CENAP-EN-96-813



COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

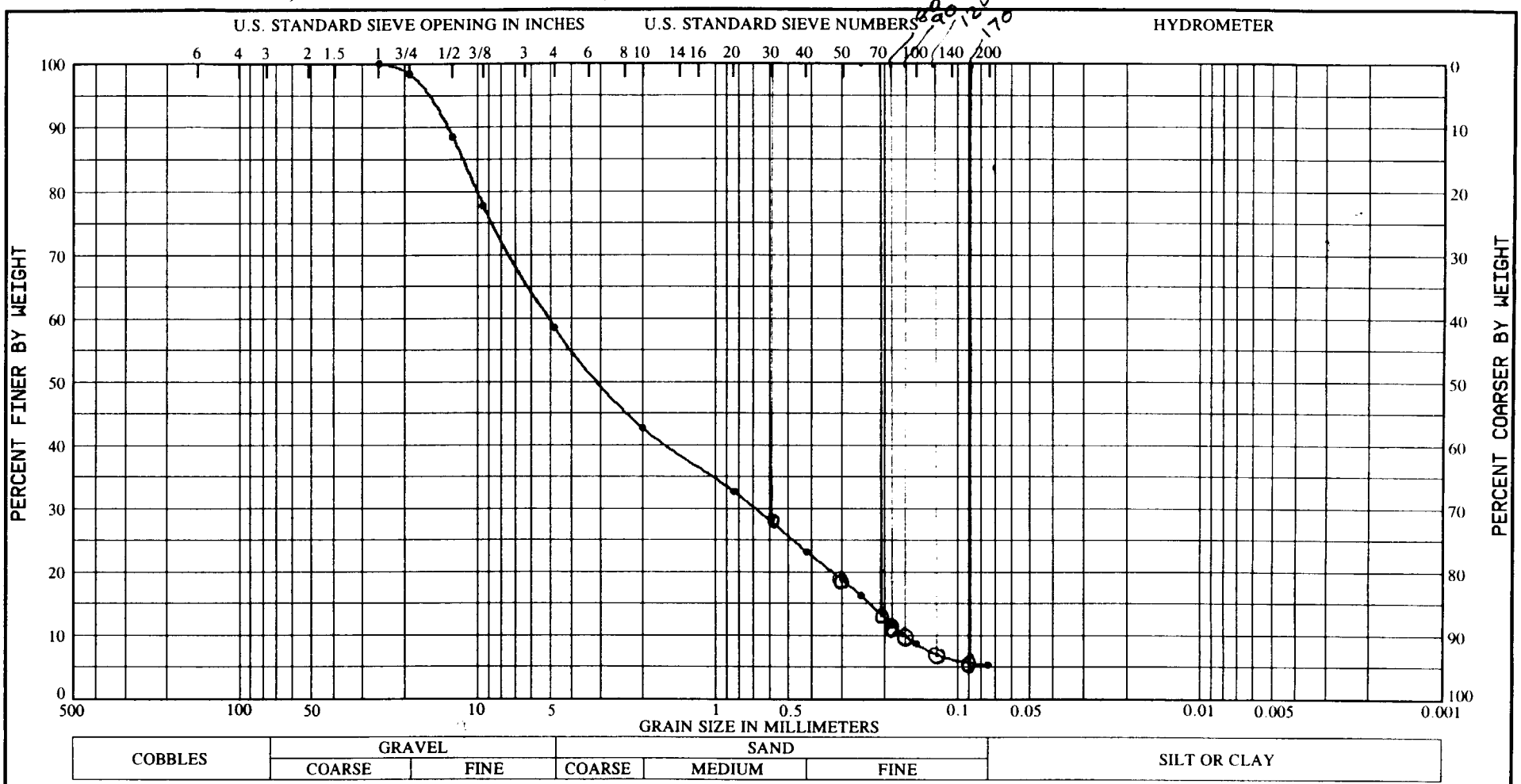
Sample No.	Depth (Ft)	(VISUAL) Classification	Nat w%	LL	PL	PI
2	5.1-5.4	GRAY, GRAVELLY POORLY GRADED SILTY SAND (SP-SM), WITH A TRACE OF MICA.				

Project CAPE MAY
VIBRA-CORE SAMPLES
Lab No. 184/1249
Boring No. NJV-205
Date 07/16/96

GRADATION CURVES

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30060

WORK ORDER: 8015
REQUISITION: CENAP-EN-96-813



COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

Sample No.	Depth (Ft)	(VISUAL) Classification	Nat w%	LL	PL	PI
3	11.2-11.5	GRAY, GRAVELLY POORLY GRADED SILTY SAND				
		(SP-SM), WITH A TRACE OF MICA.				

Project CAPE MAY
VIBRA-CORE SAMPLES
Lab No. 184/1249
Boring No. NJV-205
Date 07/16/96

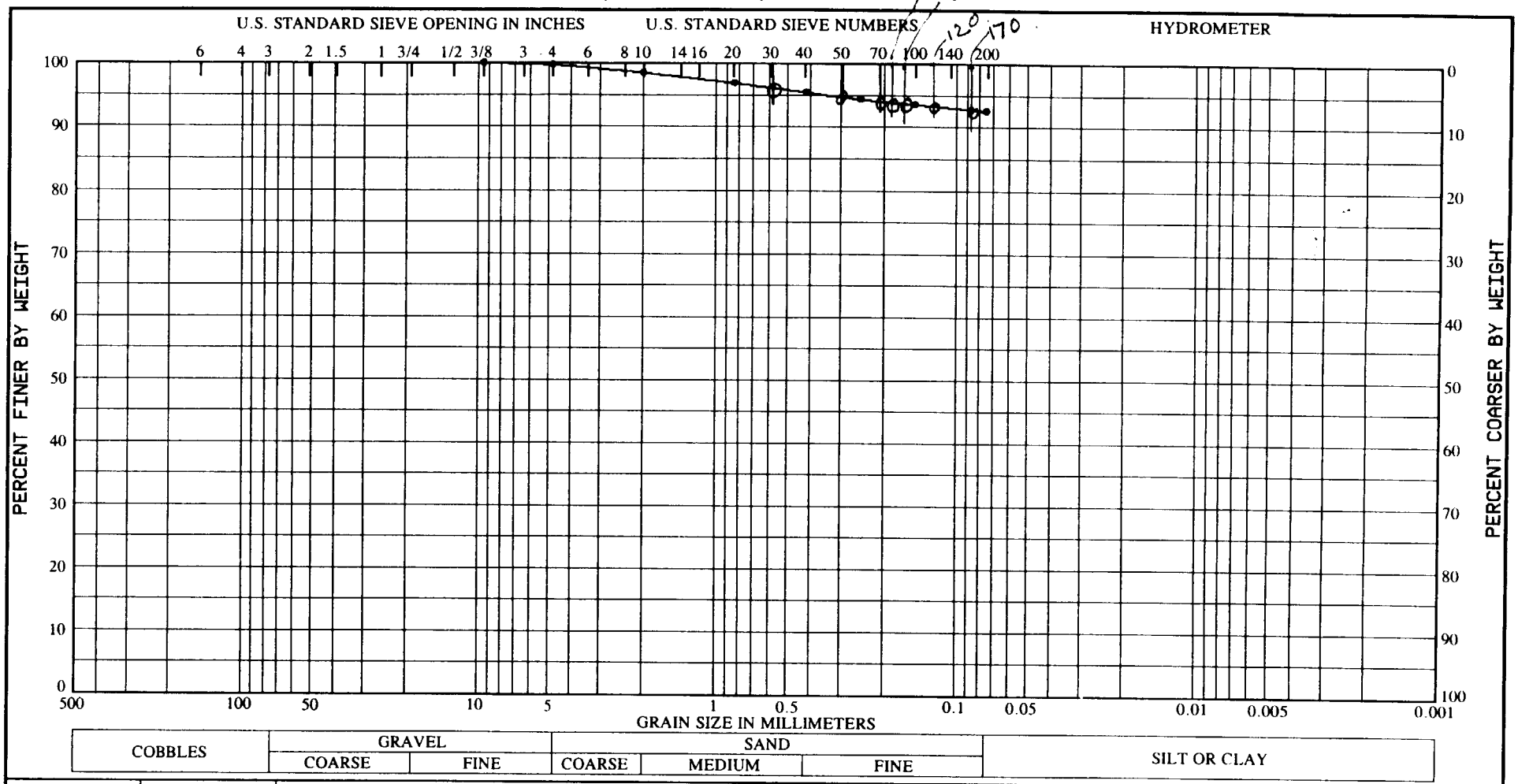
GRADATION CURVES

Too Coarse

72

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30060

WORK ORDER: 8015
REQUISITION: CENAP-EN-96-813



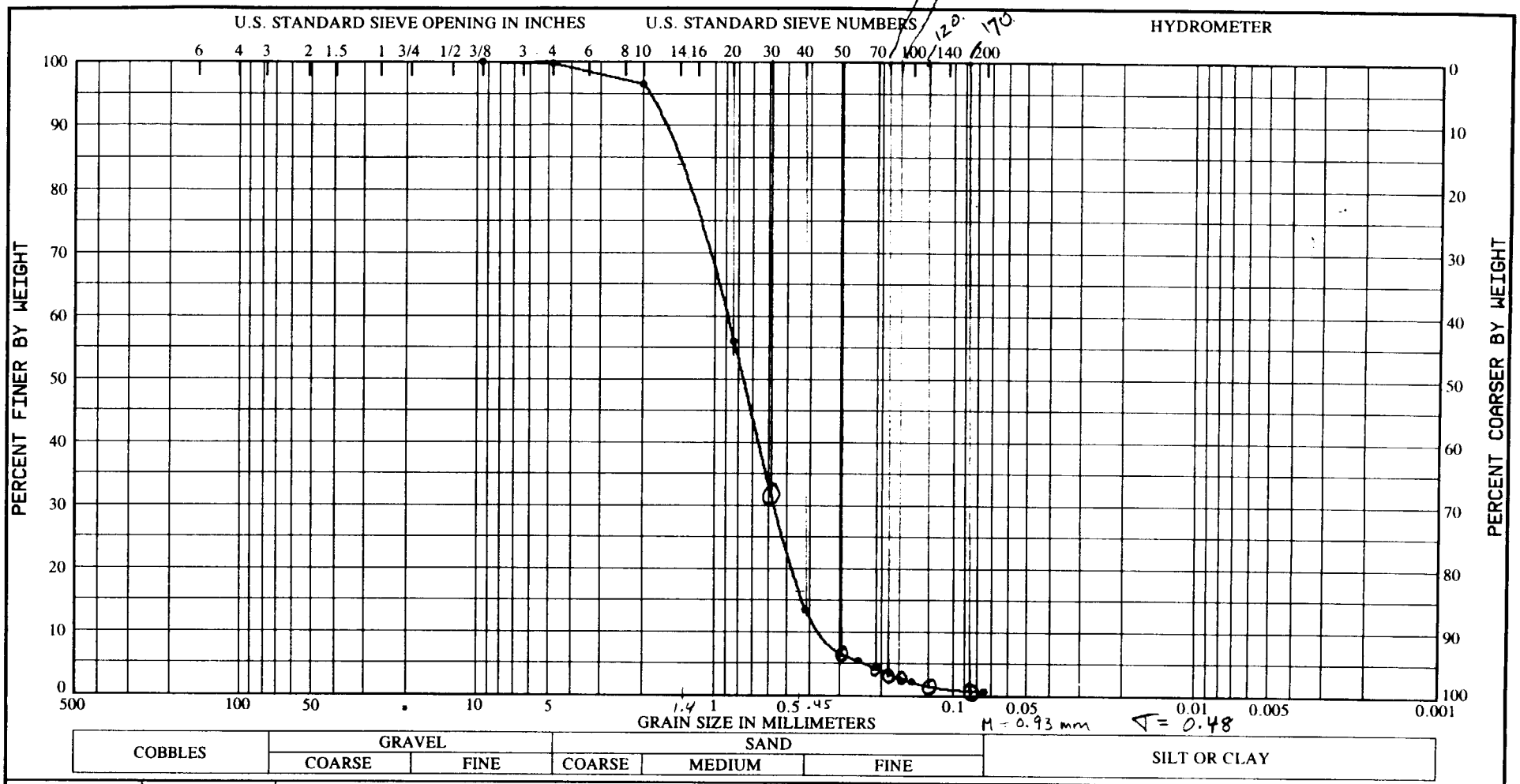
Sample No.	Depth (Ft)	(VISUAL) Classification	Nat w%	LL	PL	PI
4	15.5-15.8	GRAY, SILTY FAT CLAY (CH), WITH A TRACE OF SAND SIZES AND MICA.				

Project CAPE MAY
VIBRA-CORE SAMPLES
Lab No. 184/1249
Boring No. NJV-205
Date 07/16/96

GRADATION CURVES

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30060

WORK ORDER: 8015
REQUISITION: CENAP-EN-96-813



Sample No.	Depth (Ft)	(VISUAL) Classification	Nat w%	LL	PL	PI
1	2.9-3.1	TAN, POORLY GRADED SAND (SP), WITH A TRACE OF MICA.				

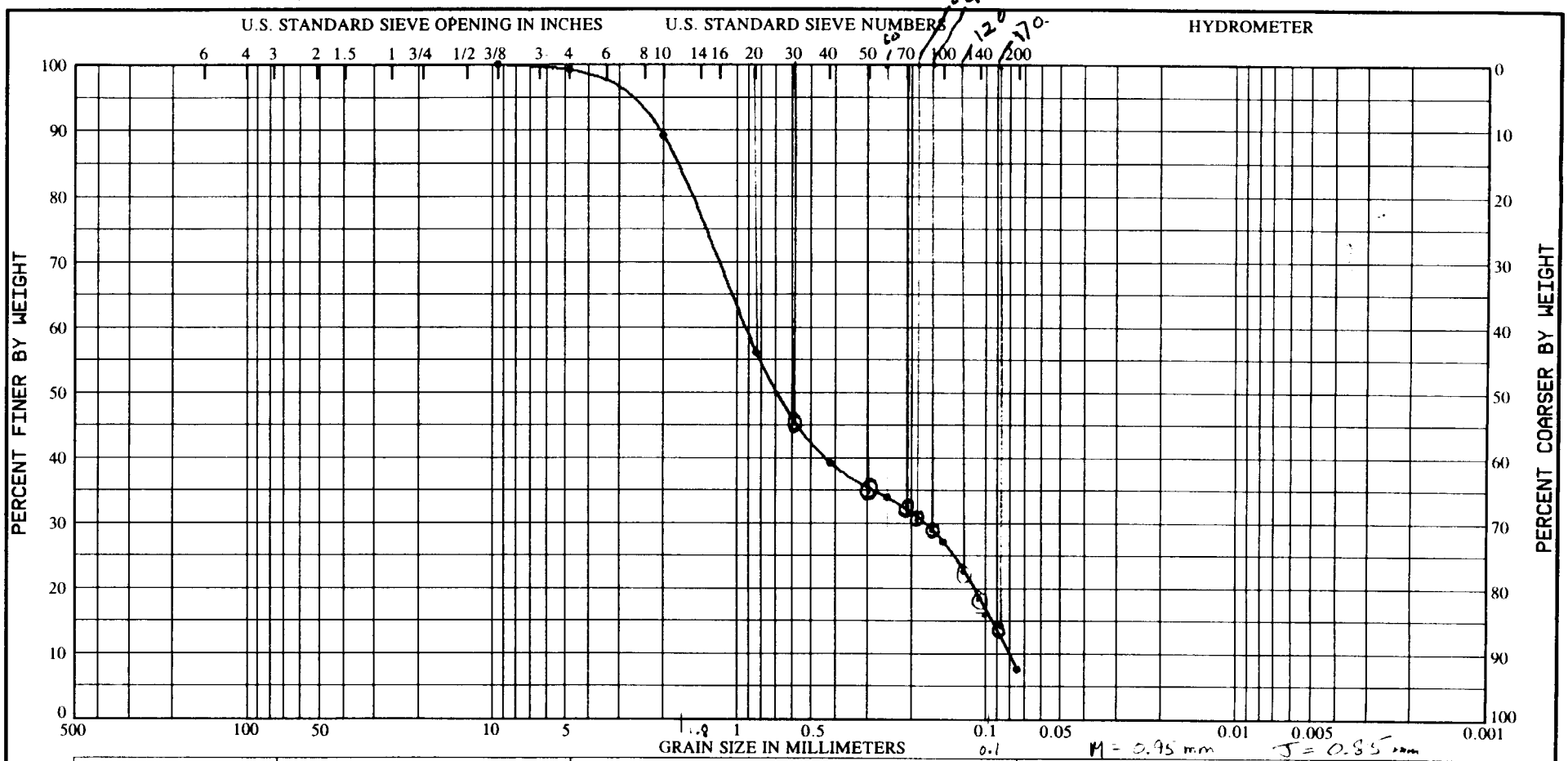
Project CAPE MAY
VIBRA-CORE SAMPLES
Lab No. 184/1250
Boring No. NVJ-206
Date 07/16/96

GRADATION CURVES

Uk Coarse

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30060

WORK ORDER: 8015
REQUISITION: CENAP-EN-96-813



COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

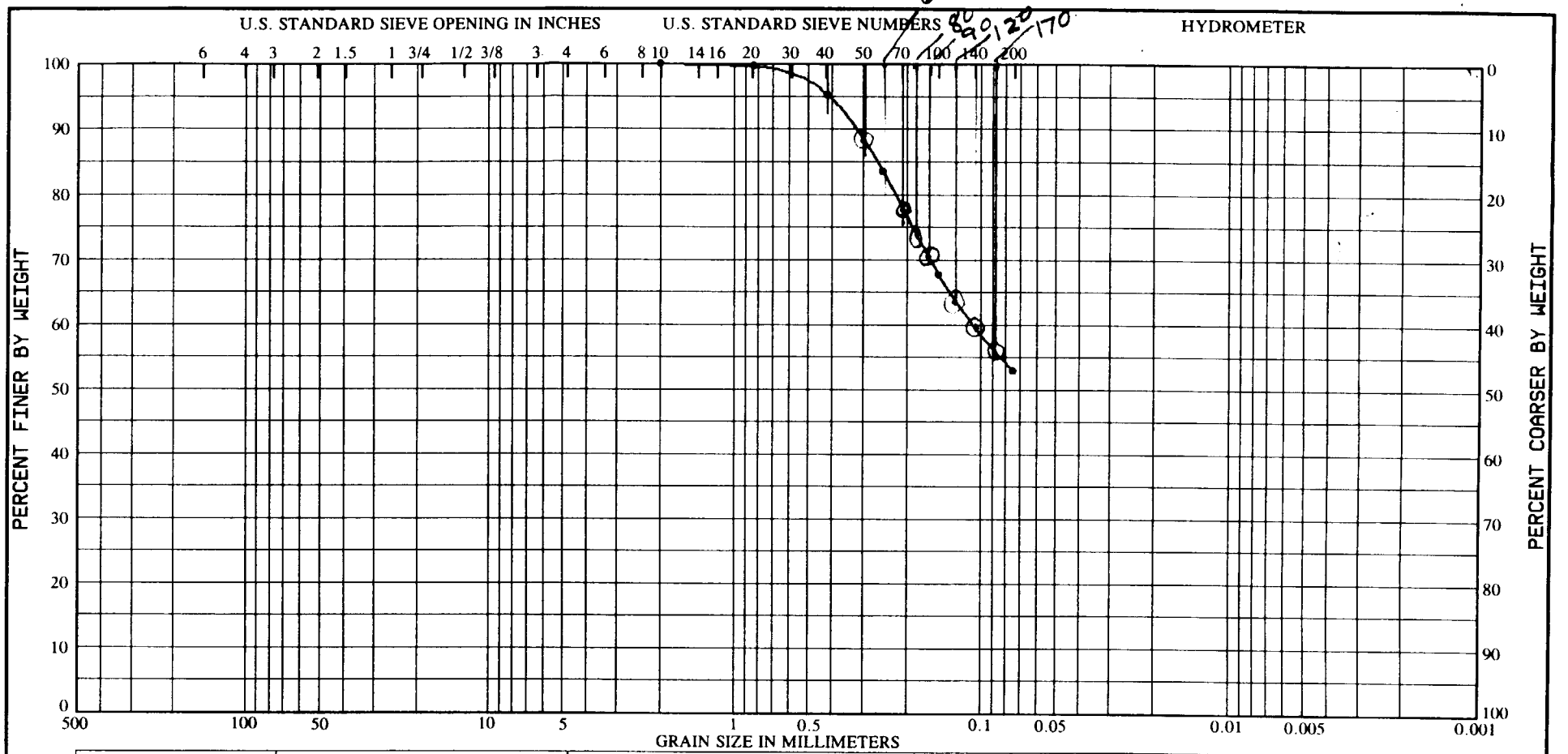
Sample No.	Depth (Ft)	(VISUAL) Classification	Nat w%	LL	PL	PI
2	6.7-6.9	GRAY, POORLY GRADED SILTY SAND (SP-SM), WITH A TRACE OF MICA.				

Project CAPE MAY
VIBRA-CORE SAMPLES
Lab No. 184/1250
Boring No. NVJ-206
Date 07/16/96

GRADATION CURVES

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30060

WORK ORDER: 8015
REQUISITION: CENAP-EN-96-813



COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

Sample No.	Depth (Ft)	(VISUAL) Classification	Nat w%	LL	PL	PI
3	9.6-9.8	GRAY, SANDY INORGANIC SILT LOW LL (ML),				
		WITH A TRACE OF MICA.				

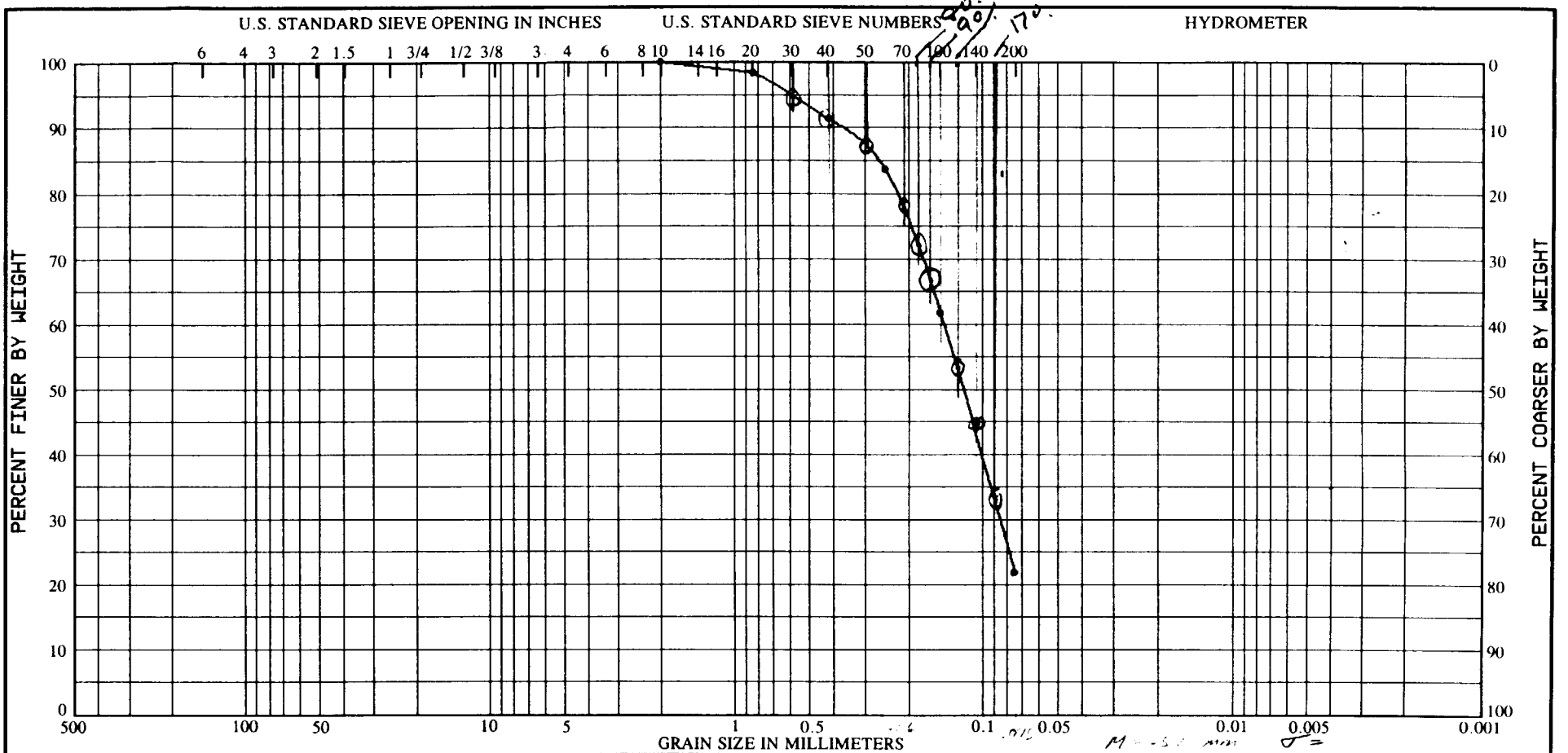
Project CAPE MAY
VIBRA-CORE SAMPLES
Lab No. 184/1250
Boring No. NVJ-206
Date 07/16/96

GRADATION CURVES

Too fine

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30060

WORK ORDER: 8015
REQUISITION: CENAP-EN-96-813



COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

Sample No.	Depth (Ft)	(VISUAL) Classification	Nat w%	LL	PL	PI
4	13.9-14.2	TAN, SILTY SAND (SM), WITH A TRACE OF MICA.				

Project CAPE MAY
VIBRA-CORE SAMPLES
Lab No. 184/1250
Boring No. NVJ-206
Date 07/16/96

GRADATION CURVES

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30060

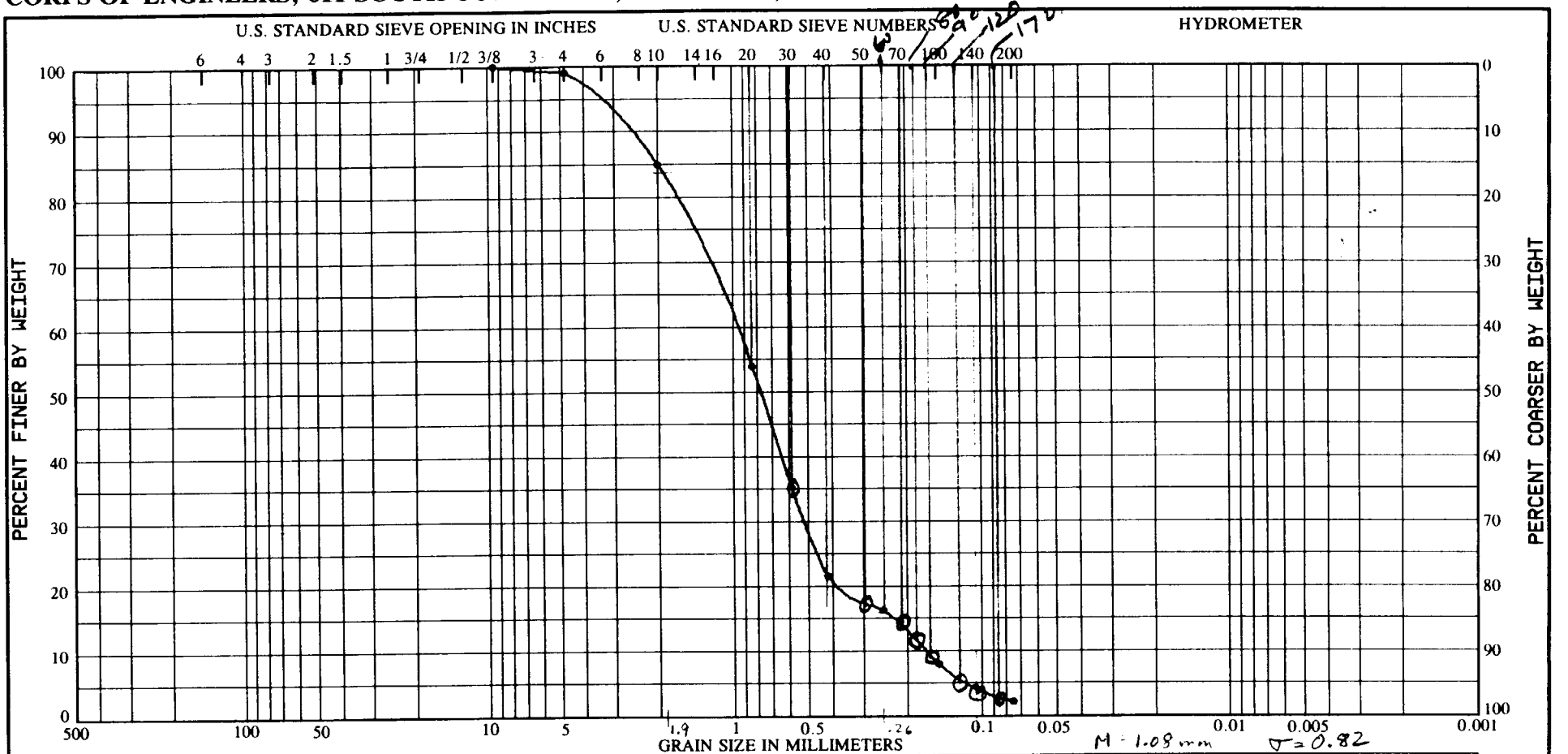
Project: *CAPE MAY*		Boring No. *NJV-207*
Location: *VIBRA-CORE SAMPLES*		Lab No. *184/1251*
Boring Depth (ft): *18.00*	Depth:	Work order: *8015*
Datum/Notes:		Requisition: *CENAP-EN-96-813*

Elev. (feet)	Depth (feet)	Leg-end	Material Description	Comments
				DEPTHS FROM TOP OF SAMPLE
	1			
	2	M=1.08 mm		
	3		TAN, POORLY GRADED SAND (SP), WITH A TRACE OF MICA AND OCCASIONAL LAYERS OF GRAY, FAT CLAY (CH)	
	4			SA, 3.7 - 4.0
	5		----------	
	6	M=1.06 mm	GRAY, FAT CLAY (CH), A TRACE OF MICA AND POCKETS OF POORLY GRADED SAND (SP).	SA, 6.4 - 6.7
	7			
	8		----------	
	9	M=.59 mm	GRAY, CLAYEY SAND (SC), WITH A TRACE OF MICA.	SA, 8.8 - 9.1
	10		----------	
	11			
	12			
	13	M= .67 mm		SA, 12.5 - 12.7
	14		TANNISH GRAY, POORLY GRADED SAND (SP), WITH A TRACE OF MICA.	
	15			
	16			
	17			
	18		----------	
	19			

Date: *07/17/96* **LABORATORY LOG AND SAMPLE DATUM** Sheet No. *1* of *1*

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30060

WORK ORDER: 8015
REQUISITION: CENAP-EN-96-813



COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

Sample No.	Depth (Ft)	(VISUAL) Classification	Nat w%	LL	PL	PI
1	3.7-4.0	TAN, POORLY GRADED SAND (SP), WITH A TRACE OF MICA.				

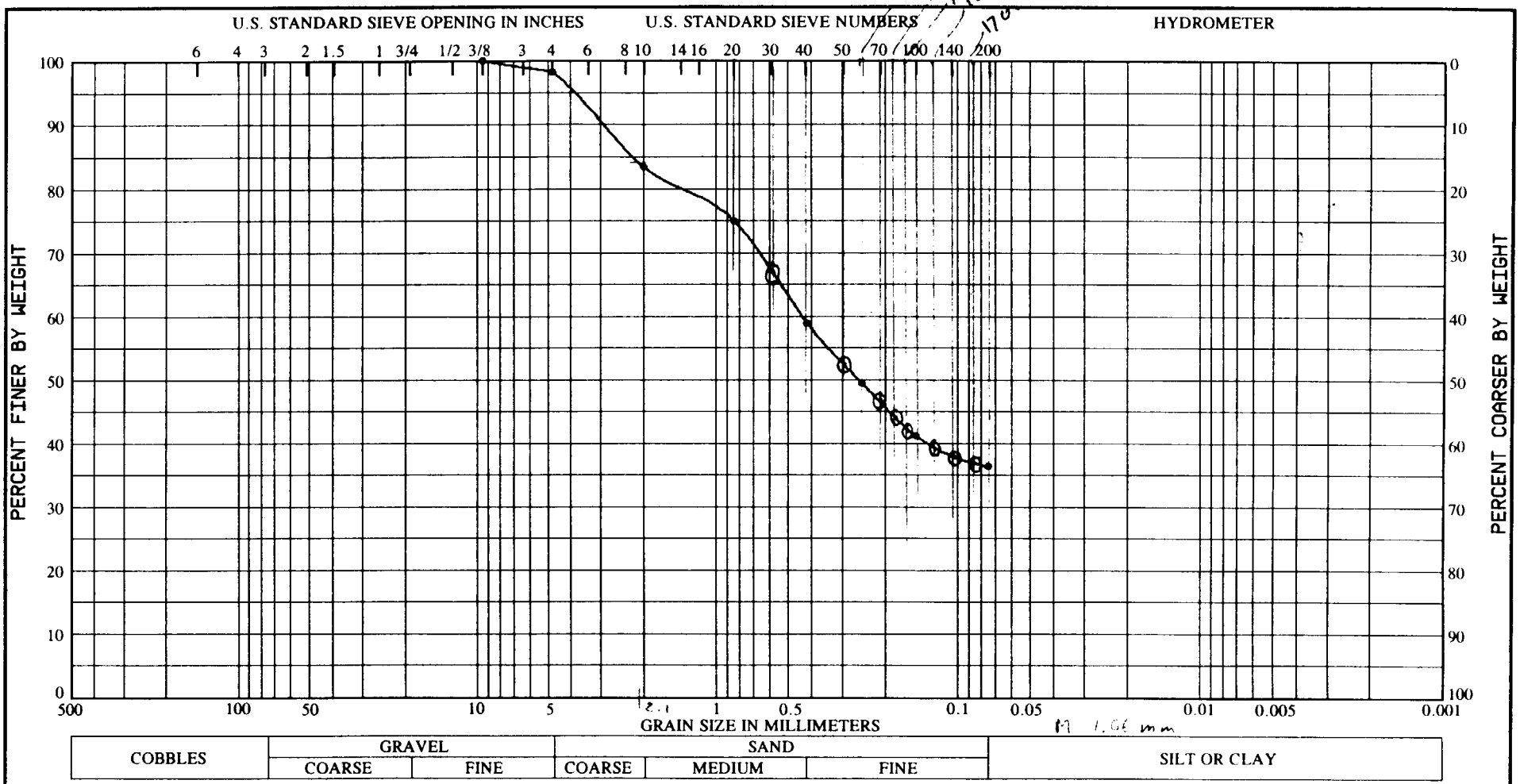
Project CAPE MAY
VIBRA-CORE SAMPLES
Lab No. 184/1251
Boring No. NJV-207
Date 07/17/96

GRADATION CURVES

OK

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30060

WORK ORDER: 8015
REQUISITION: CENAP-EN-96-813



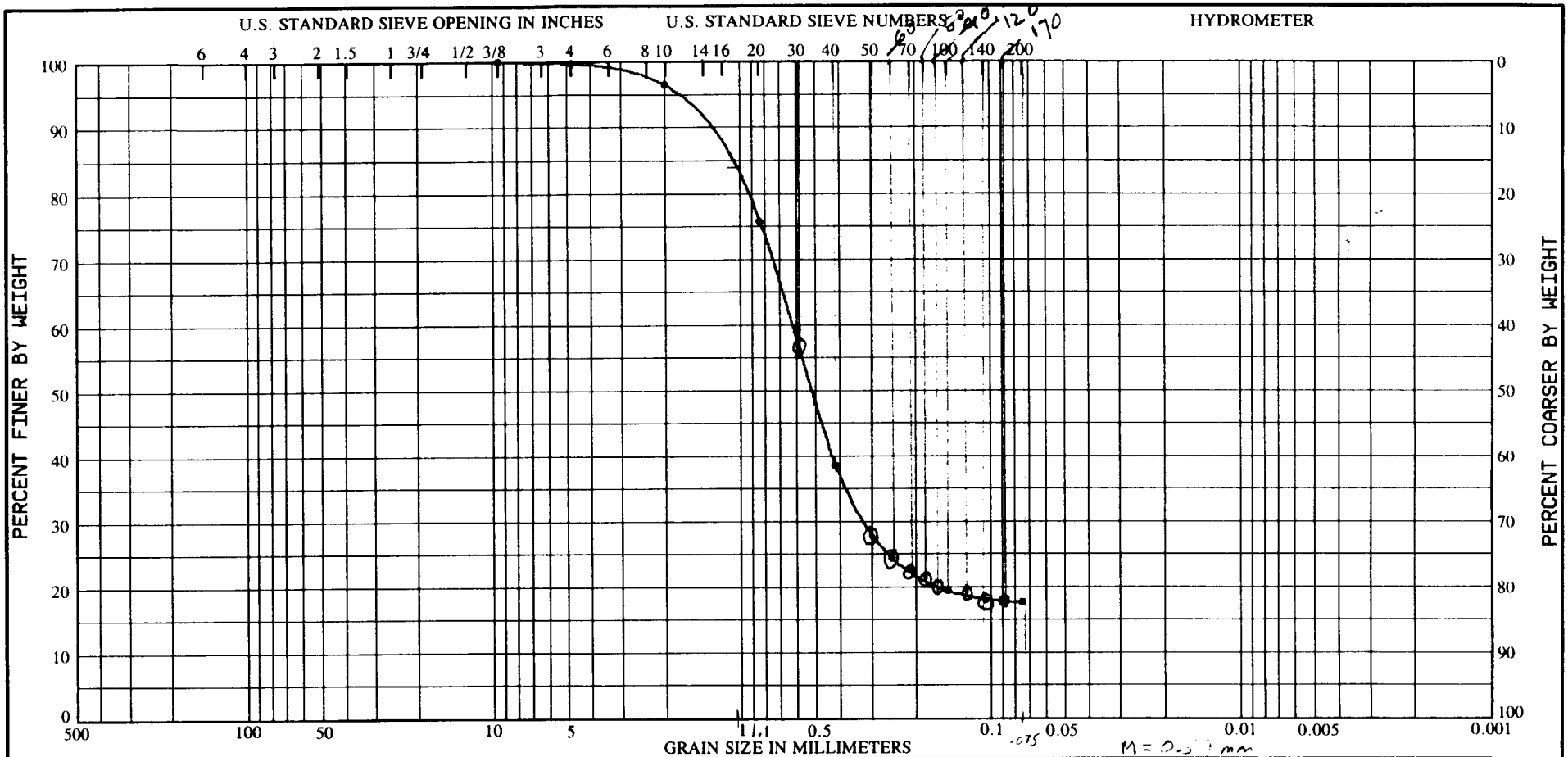
Sample No.	Depth (Ft)	(VISUAL) Classification	Nat w%	LL	PL	PI
2	6.4-6.7	GRAY, SILTY SAND (SM), SLIGHTLY PLASTIC				
		WITH A TRACE OF MICA.				

Project CAPE MAY
VIBRA-CORE SAMPLES
Lab No. 184/1251
Boring No. NJV-207
Date 07/17/96

GRADATION CURVES

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30060

WORK ORDER: 8015
REQUISITION: CENAP-EN-96-813



COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

Sample No.	Depth (Ft)	(VISUAL) Classification	Nat w%	LL	PL	PI
3	8.8-9.1	GRAY, CLAYEY SAND (SC), WITH A TRACE OF MICA.				

Project CAPE MAY
VIBRA-CORE SAMPLES
Lab No. 184/1251
Boring No. NJV-207
Date 07/17/96

GRADATION CURVES

OK

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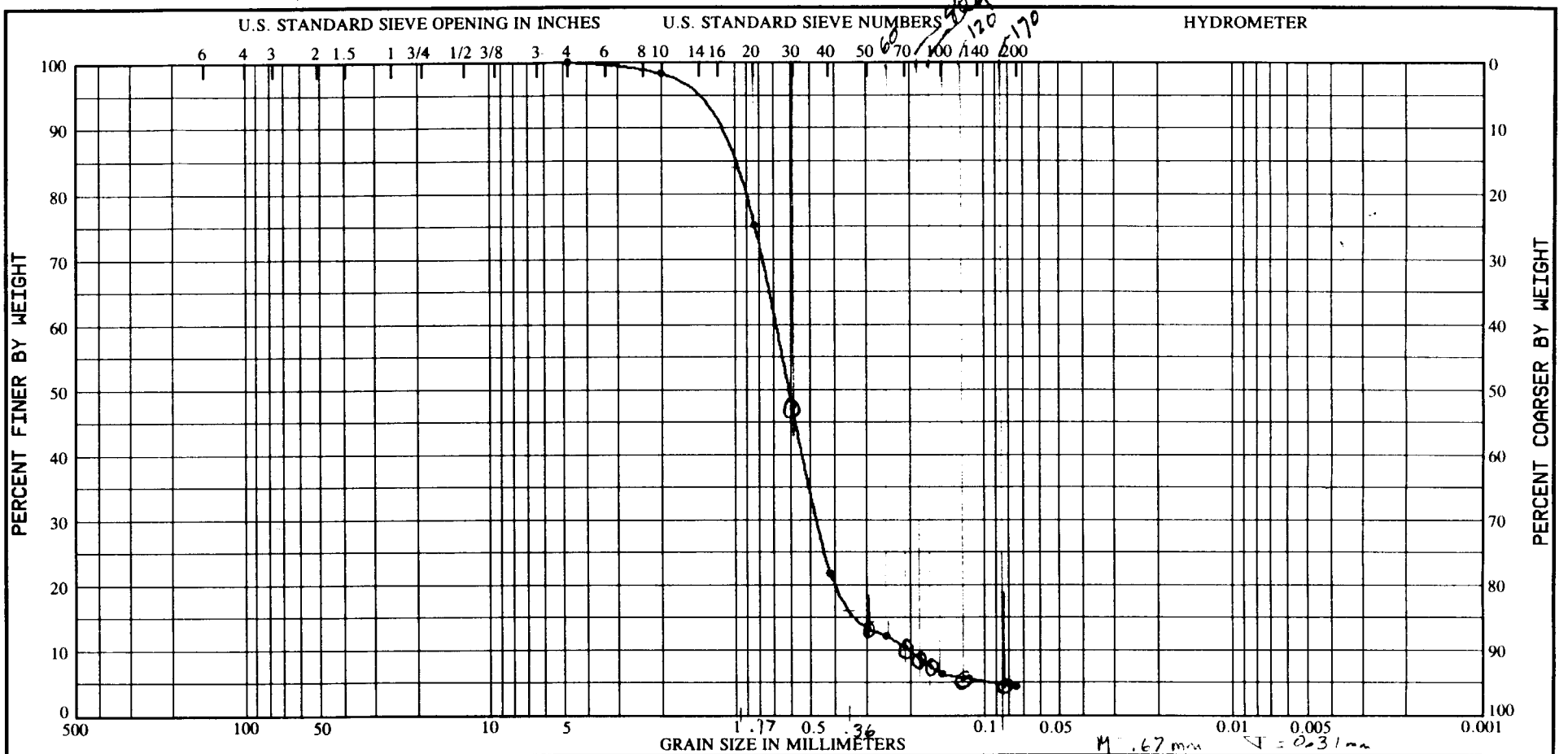
DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30060

WORK ORDER: 8015
REQUISITION: CENAP-EN-96-813



COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

Sample No.	Depth (Ft)	(VISUAL) Classification	Nat w%	LL	PL	PI
4	12.5-12.7	TANNISH GRAY, POORLY GRADED SAND (SP), WITHA TRACE OF MICA.				

Project CAPE MAY
VIBRA-CORE SAMPLES
Lab No. 184/1251
Boring No. NJV-207
Date 07/17/96

GRADATION CURVES

OK

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DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30060

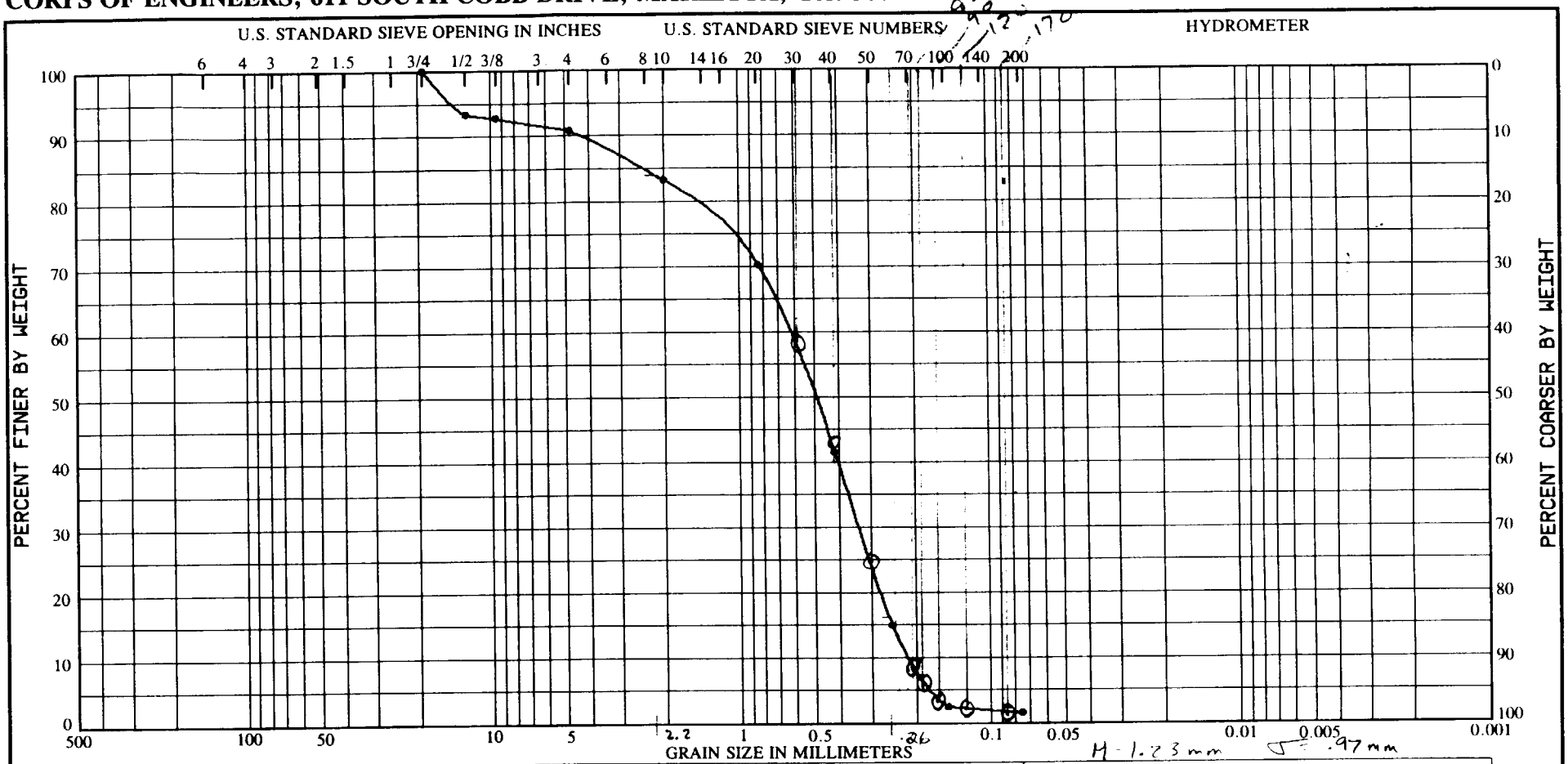
Project: *CAPE MAY*		Boring No. *NJV-208*
Location: *VIBRA-CORE SAMPLES*		Lab No. *184/1252*
Boring Depth (ft): *17.50*	Depth:	Work order: *8015*
Datum/Notes:		Requisition: *CENAP-EN-96-813*

Elev. (feet)	Depth (feet)	Leg-end	Material Description	Comments
				DEPTHS FROM TOP OF HOLE
	1		TAN, POORLY GRADED SAND (SP), WITH A TRACE OF GRAVEL SIZES AND MICA.	
	2			
	3		GRAY, FAT CLAY (CH), WITH LITTLE POCKETS OF SAND AND A TRACE OF MICA.	SA, 2.7 - 3.0
	4		GRAY, CLAYEY SAND (SC), WITH A TRACE OF MICA.	
	5		GRAY, SANDY INORGANIC SILT LOW LL (ML), WITH A TRACE OF MICA.	
	6			SA, 6.0 - 6.2
	7		GRAY, SILTY SAND (SM), SLIGHTLY PLASTIC, WITH A TRACE OF MICA.	
	8		GRAY, SANDY INORGANIC SILT LOW LL (ML), WITH A TRACE OF MICA.	
	9			SA, 9.5 - 9.7
	10			
	11			
	12			
	13		GRAY, INORGANIC SILT LOW LL (ML), WITH A TRACE OF MICA.	
	14			SA, 13.7 - 14.0
	15			
	16			
	17			
	18			
	19			

Date: *07/17/96* **LABORATORY LOG AND SAMPLE DATUM** Sheet No. *1* of *1*

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30060

WORK ORDER: 8015
REQUISITION: CENAP-EN-96-813



COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

Sample No.	Depth (Ft)	(VISUAL) Classification	Nat w%	LL	PL	PI
1	2.7-3.0	GRAY, POORLY GRADED SAND (SP), WITH A TRACE OF GRAVEL SIZES AND MICA.				

Project CAPE MAY
VIBRA-CORE SAMPLES
Lab No. 184/1252
Boring No. NJV-208
Date 07/17/96

GRADATION CURVES

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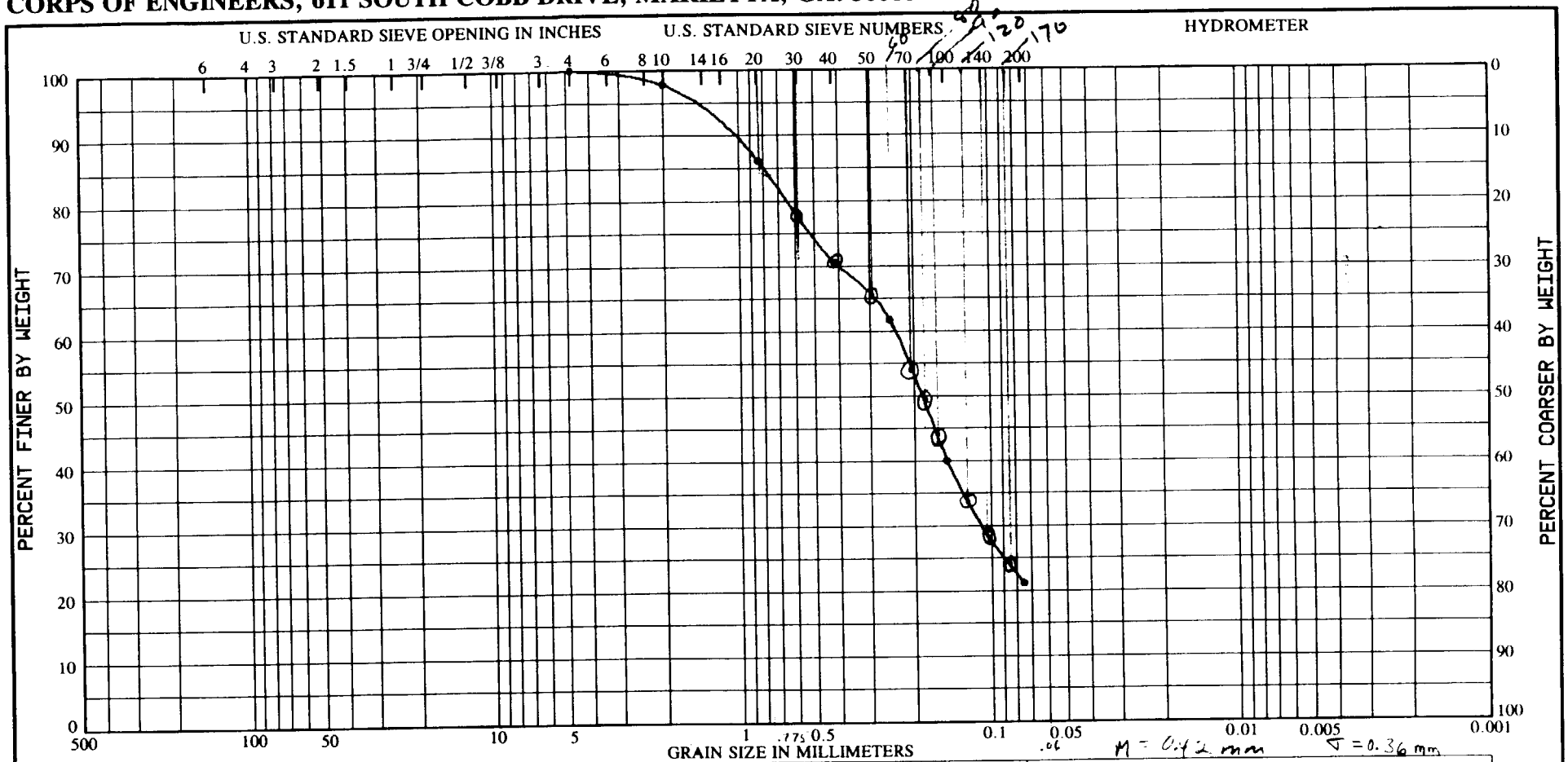
DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30060

WORK ORDER: 8015
REQUISITION: CENAP-EN-96-813



COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

Sample No.	Depth (Ft)	(VISUAL) Classification	Nat w %	LL	PL	PI
2	6.0-6.2	GRAY, SILTY SAND (SM), PLASTIC FINES AND A TRACE OF MICA.				

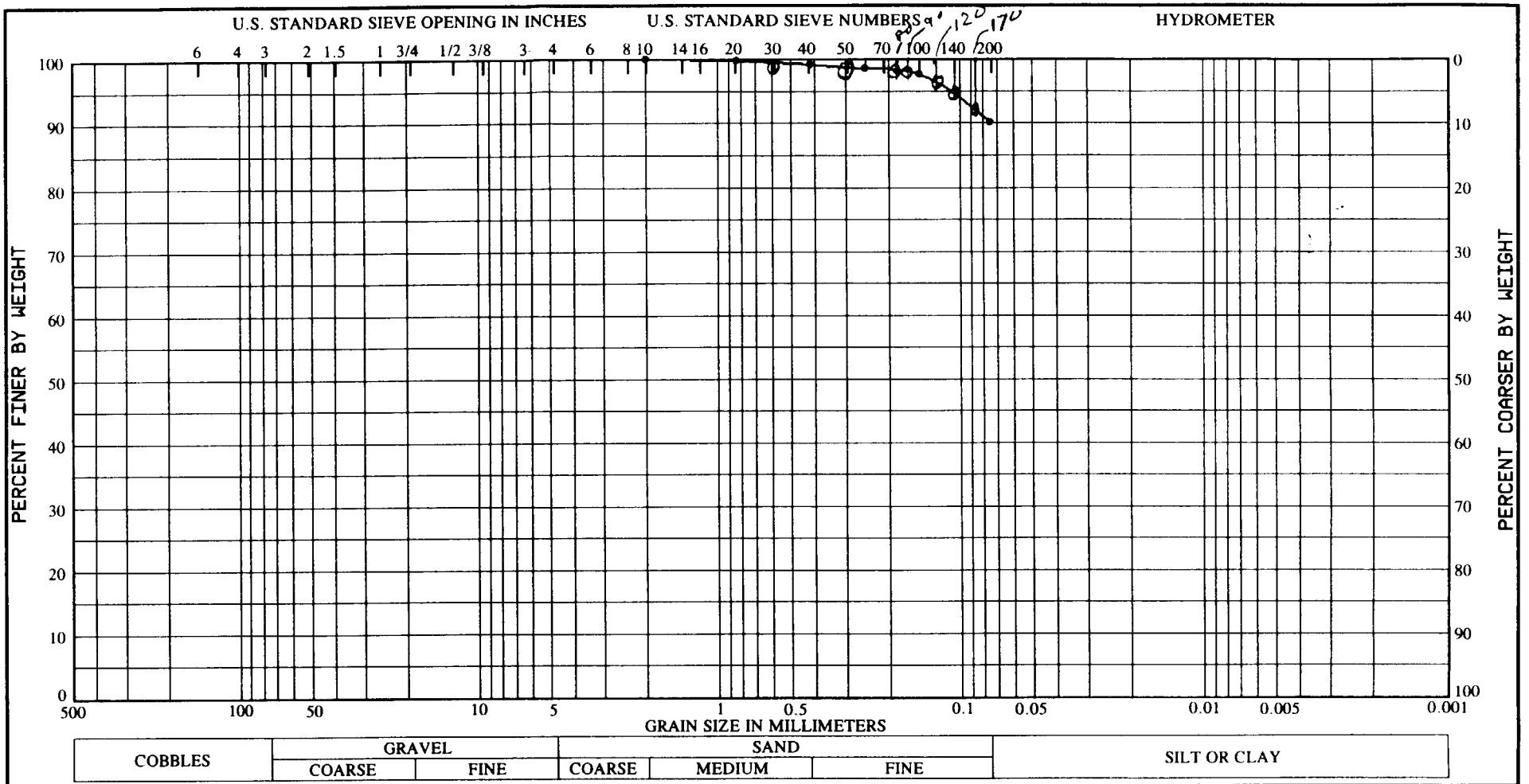
Project CAPE MAY
VIBRA-CORE SAMPLES
Lab No. 184/1252
Boring No. NJV-208
Date 07/17/96

GRADATION CURVES

98

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30060

WORK ORDER: 8015
REQUISITION: CENAP-EN-96-813



Sample No.	Depth (Ft)	(VISUAL) Classification	Nat w%	LL	PL	PI
3	9.5-9.7	GRAY, INORGANIC SILT LOW LL (ML), WITH				
		A TRACE OF SAND, MICA AND ORGANIC				
		MATTER.				

Project CAPE MAY
VIBRA-CORE SAMPLES
Lab No. 184/1252
Boring No. NJV-208
Date 07/17/96

GRADATION CURVES

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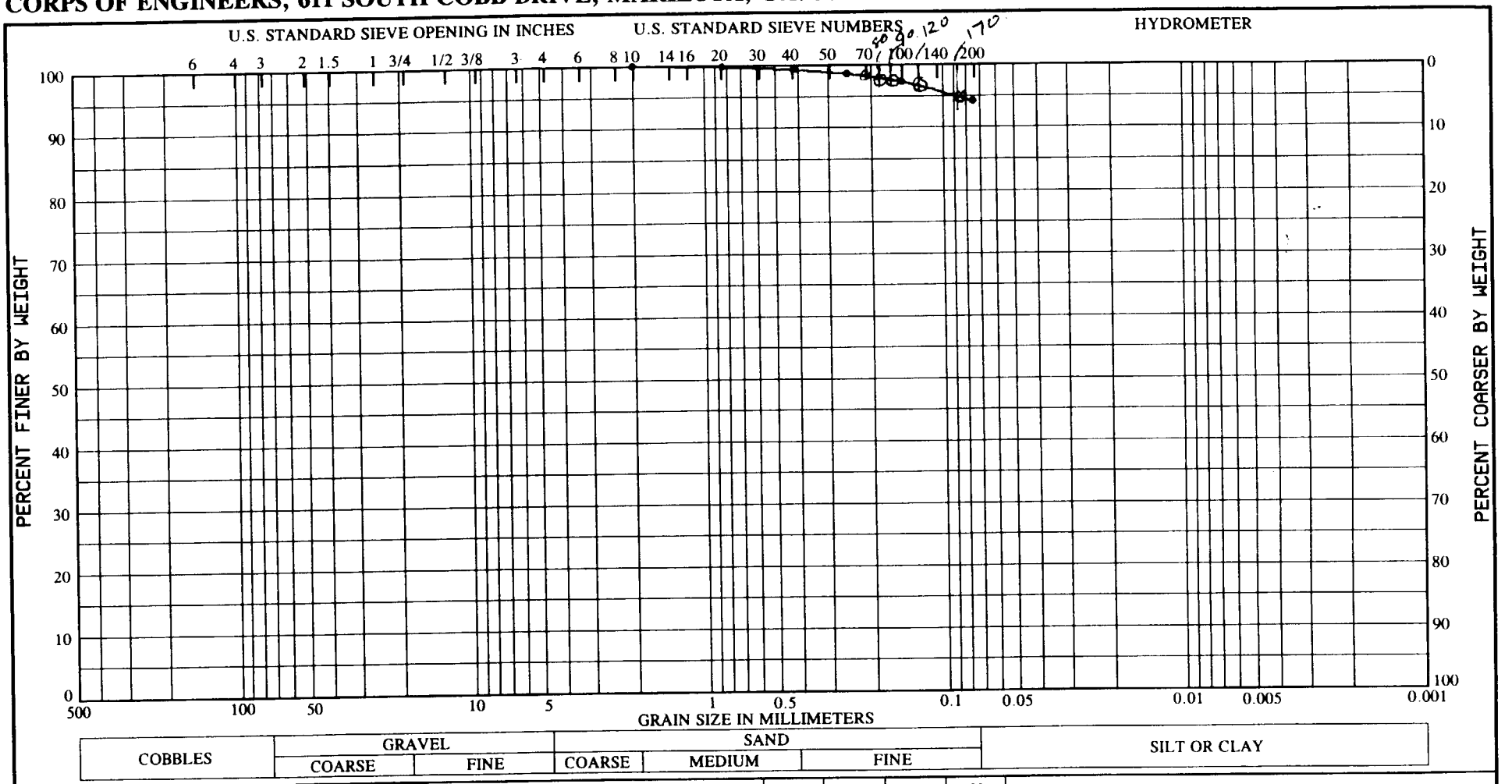
DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30060

WORK ORDER: 8015
REQUISITION: CENAP-EN-96-813



Sample No.	Depth (Ft)	(VISUAL) Classification	Nat w%	LL	PL	PI
4	13.7-14.0	GRAY, INORGANIC SILT LOW LL (ML), WITH A TRACE OF SAND SIZES AND MICA.				

Project CAPE MAY
VIBRA-CORE SAMPLES
Lab No. 184/1252
Boring No. NJV-208
Date 07/17/96

GRADATION CURVES

Too fine

88

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30060

Project: *CAPE MAY*		Boring No. *NJV-209*	
Location: *VIBRA-CORE SAMPLES*		Lab No. *184/1253*	
Boring Depth (ft): *20.30*	Depth:	Work order: *8015*	
Datum/Notes:		Requisition: *CENAP-EN-96-813*	

Elev. (feet)	Depth (feet)	Leg-end	Material Description	Comments
				DEPTHS FROM TOP OF HOLE.
	1			
	2		GRAY, SILTY FAT CLAY (CH), WITH AN OCCASIONAL TRACE OF SAND AND MICA.	SA, 2.3 - 2.5
	3			
	4		----------	
	5		GRAY, SILTY SAND (SM). SLIGHTLY PLASTIC	
	6		----------	
	7		GRAY, CLAYEY SAND (SC).	SA, 6.7 - 6.9

	8			
	9		GRAY, SANDY INORGANIC SILT LOW LL (ML), WITH A TRACE OF SAND AND MICA.	SA, 9.2 - 9.4
	10		----------	
	11			
	12			
	13			SA, 13.0 - 13.3
	14			
	15		GRAY, SILTY FAT CLAY (CH), WITH A TRACE OF SAND AND MICA.	
	16			
	17			SA, 17.0 - 17.3
	18			
	19			

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30060

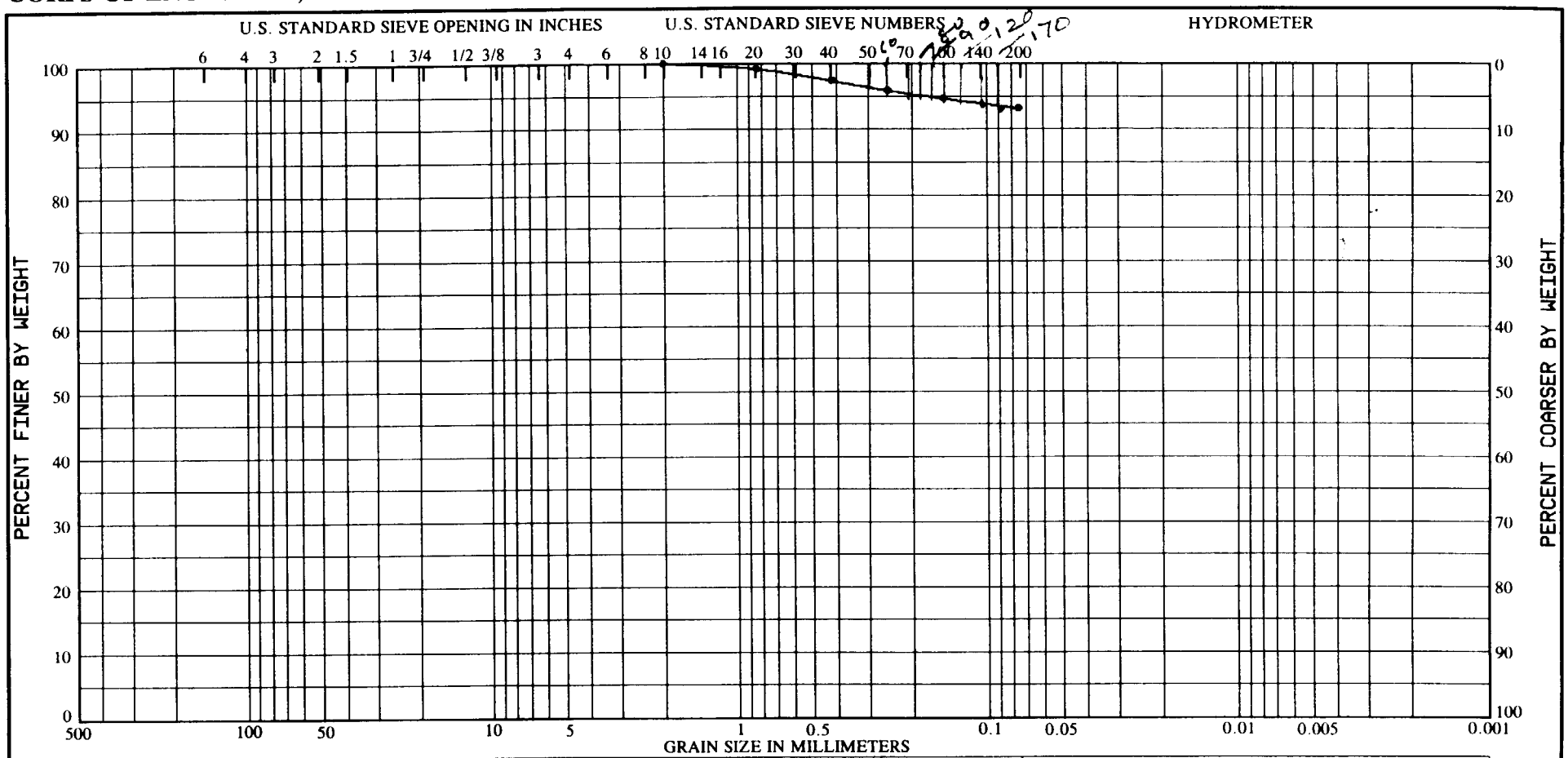
Project: *CAPE MAY*		Boring No. *NJV-209*
Location: *VIBRA-CORE SAMPLES*		Lab No. *184/1253*
Boring Depth (ft): *20.30*	Depth:	Work order: *8015*
Datum/Notes:		Requisition: *CENAP-EN-96-813*

Elev. (feet)	Depth (feet)	Leg-end	Material Description	Comments
			----------	
	21		HH	
	22			
	23			
	24			
	25			
	26			
	27			
	28			
	29			
	30			
	31			
	32			
	33			
	34			
	35			
	36			
	37			
	38			
	39			

Date: *07/17/96* **LABORATORY LOG AND SAMPLE DATUM** Sheet No. *2* of *2*

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30060

WORK ORDER: 8015
REQUISITION: CENAP-EN-96-813



COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

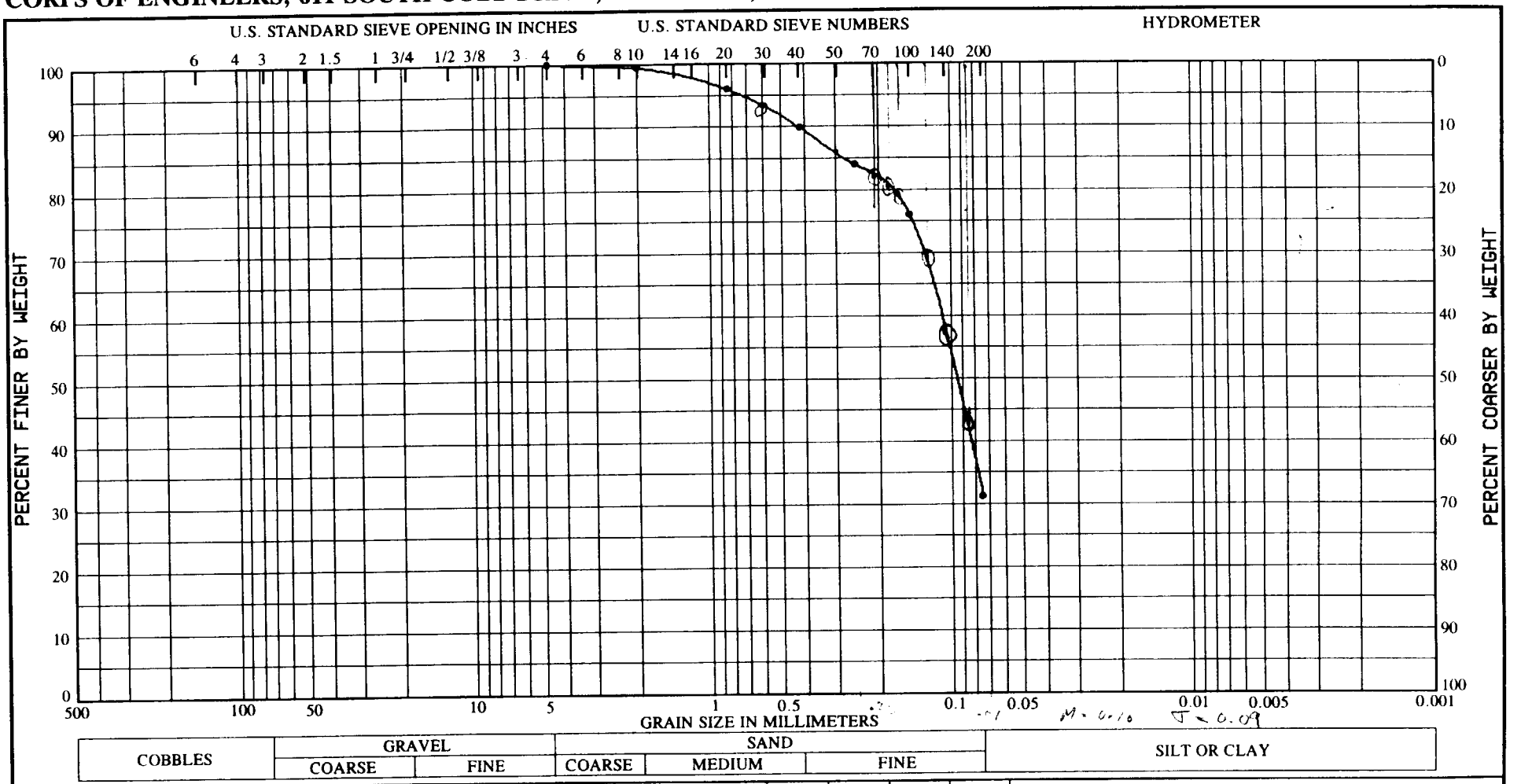
Sample No.	Depth (Ft)	(VISUAL) Classification	Nat w%	LL	PL	PI
1	2.3-3.5	GRAY, SILTY FAT CLAY (CH), WITH A TRACE OF SAND SIZES AND MICA.				

Project CAPE MAY
VIBRA-CORE SAMPLES
Lab No. 184/1253
Boring No. NJV-209
Date 07/17/96

GRADATION CURVES

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30060

WORK ORDER: 8015
REQUISITION: CENAP-EN-96-813



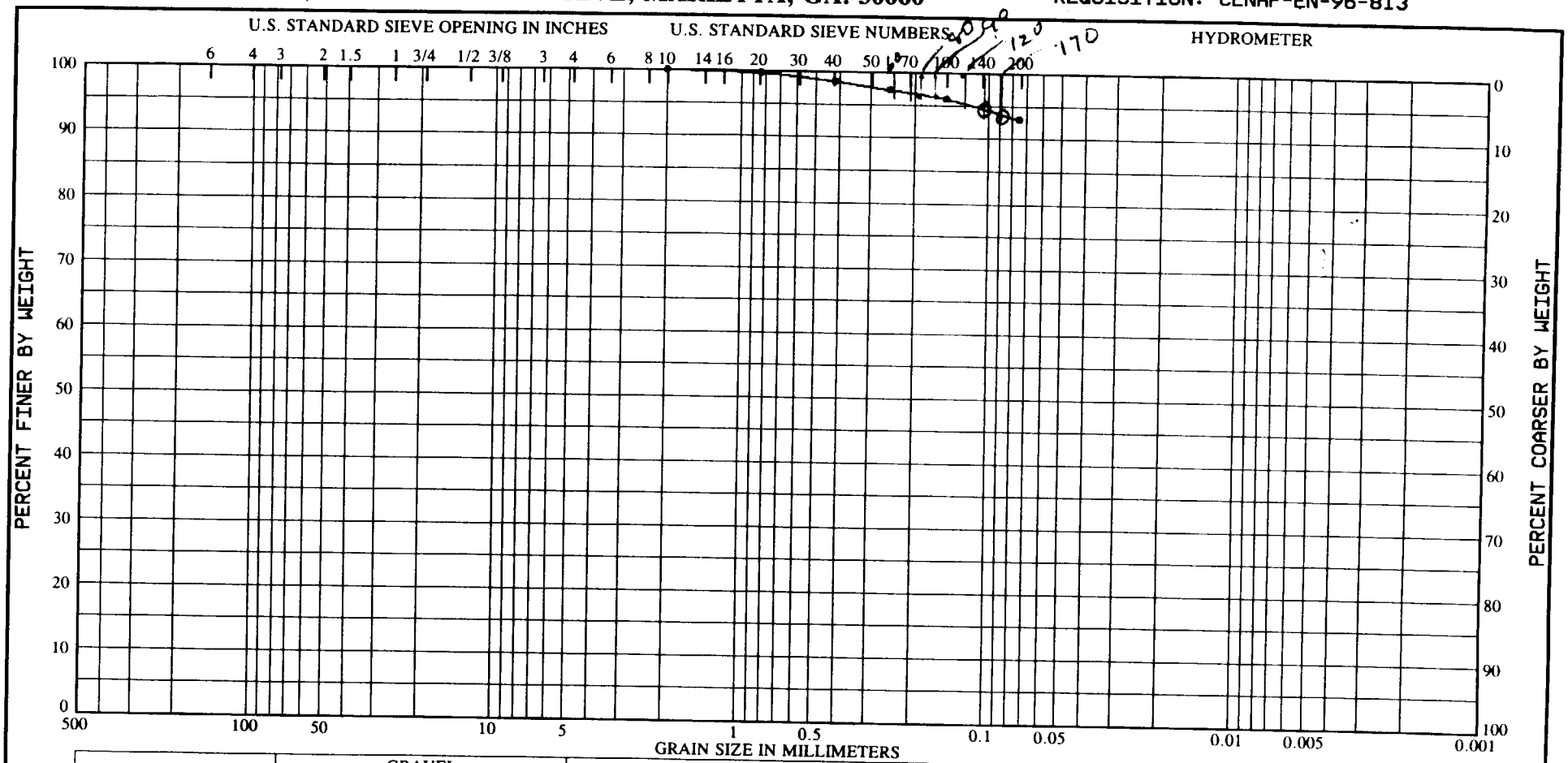
Sample No.	Depth (Ft)	(VISUAL) Classification	Nat w%	LL	PL	PI
2	6.7-6.9	GRAY, CLAYEY SAND (SC).				

Project CAPE MAY
VIBRA-CORE SAMPLES
Lab No. 184/1253
Boring No. NJV-209
Date 07/17/96

GRADATION CURVES

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30060

WORK ORDER: 8015
REQUISITION: CENAP-EN-96-813



COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

Sample No.	Depth (Ft)	(VISUAL) Classification	Nat w%	LL	PL	PI
3	9.2-9.4	GRAY, INORGANIC SILT LOW LL (ML), WITH A TRACE OF SAND, MICA AND ORGANIC MATTER.				

Project CAPE MAY
VIBRA-CORE SAMPLES
Lab No. 184/1253
Boring No. NJV-209
Date 07/17/96

GRADATION CURVES

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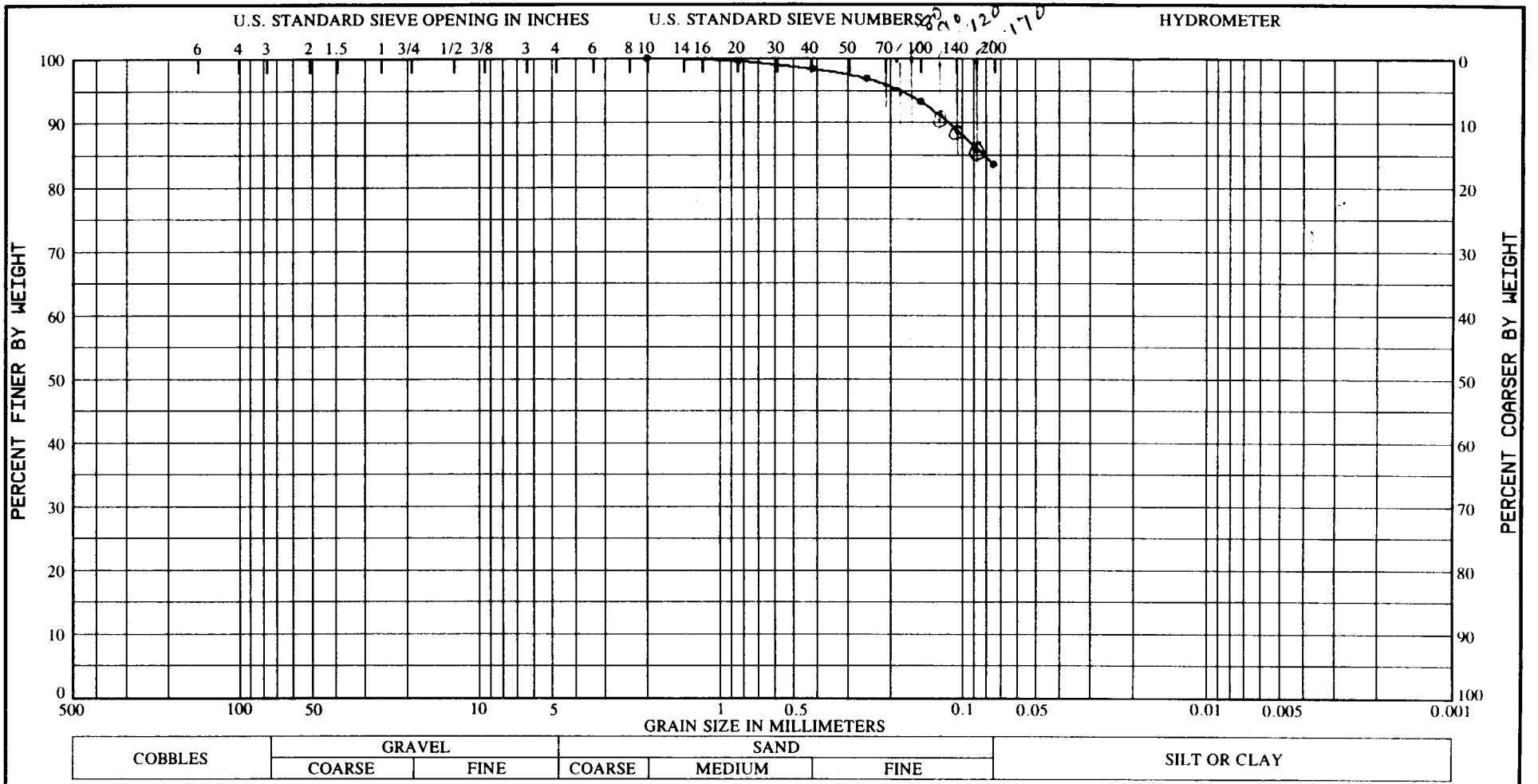
DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30060

WORK ORDER: 8015
REQUISITION: CENAP-EN-96-813



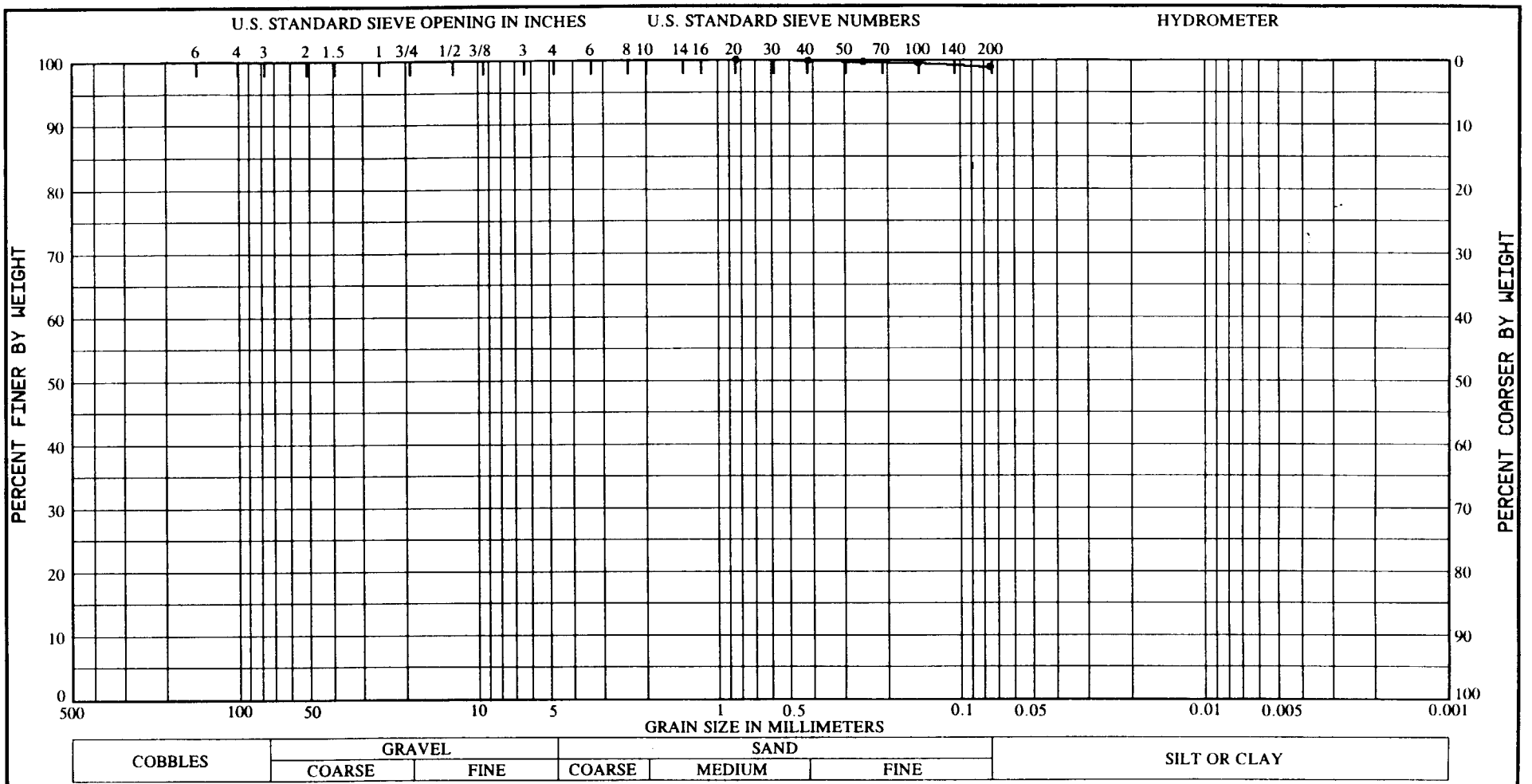
Sample No.	Depth (Ft)	(VISUAL) Classification	Nat w%	LL	PL	PI
4	13.0-13.3	GRAY, SILTY FAT CLAY (CH), WITH A LITTLE SAND SIZES AND A TRACE OF MICA.				

Project CAPE MAY
VIBRA-CORE SAMPLES
Lab No. 184/1253
Boring No. NJV-209
Date 07/17/96

GRADATION CURVES

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30060

WORK ORDER: 8015
REQUISITION: CENAP-EN-96-813



Sample No.	Depth (Ft)	(VISUAL) Classification	Nat w%	LL	PL	PI
5	17.0-17.3	GRAY, SILTY FAT CLAY (CH), WITH A TRACE OF SAND SIZES AND MICA.				

Project CAPE MAY
VIBRA-CORE SAMPLES
Lab No. 184/1253
Boring No. NJV-209
Date 07/17/96

GRADATION CURVES

Too fine

95

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30060

Project: *CAPE MAY*	Boring No. *NJV-210*
Location: *VIBRA-CORE SAMPLES*	Lab No. *184/1254*
Boring Depth (ft): *15.90* Depth:	Work order: *8015*
Datum/Notes:	Requisition: *CENAP-EN-96-813*

Elev. (feet)	Depth (feet)	Leg-end	Material Description	Comments
	1			DEPTHS FROM TOP OF HOLE.
	2	.33		SA, 2.0 - 2.2
	3			
	4			
	5		TAN & TANNISH GRAY, POORLY GRADED SAND (SP), WITH A TRACE OF MICA.	
	6			
	7	.50		SA, 7.2 - 7.5
	8			
	9			
	10		----------	
	11			
	12	.30		SA, 12.0 - 12.2
	13		GRAY, CLAYEY SAND (SC), WITH A TRACE OF MICA AND A POCKET OF FAT CLAY (CH) AT 11.0 TO 11.4'	
	14			
	15			
	16		----------	
	17			
	18			
	19			

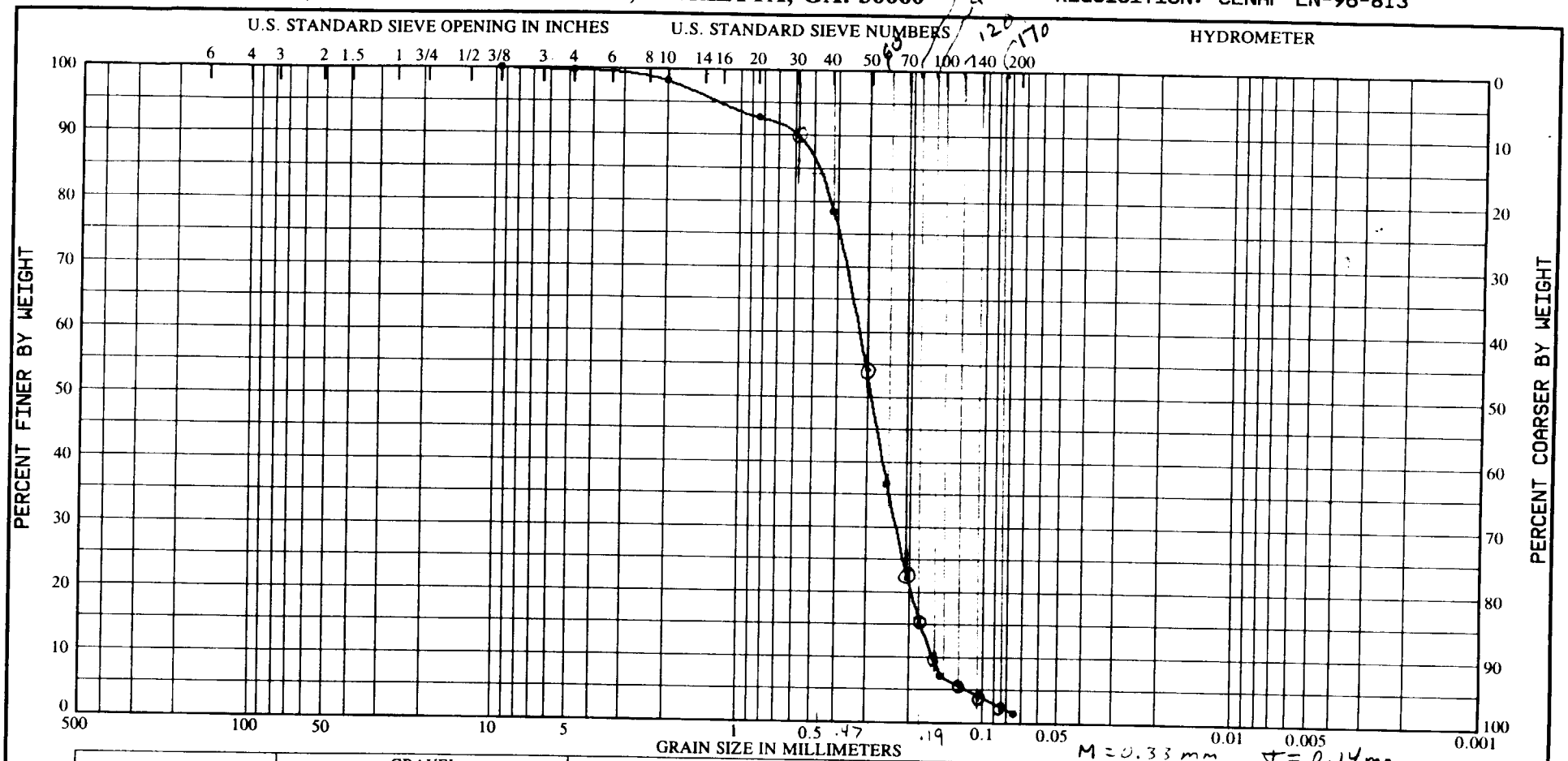
Date: *07/17/96*

LABORATORY LOG AND SAMPLE DATUM

Sheet No. *1* of *1*

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30060

WORK ORDER: 8015
REQUISITION: CENAP-EN-96-813



COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

Sample No.	Depth (Ft)	(VISUAL) Classification	Nat w%	LL	PL	PI
1	2.0-2.2	TAN & GRAY, POORLY GRADED SAND (SP), WITH A TRACE OF MICA.				

Project CAPE MAY
VIBRA-CORE SAMPLES
Lab No. 184/1254
Boring No. NJV-210
Date 07/29/96

GRADATION CURVES

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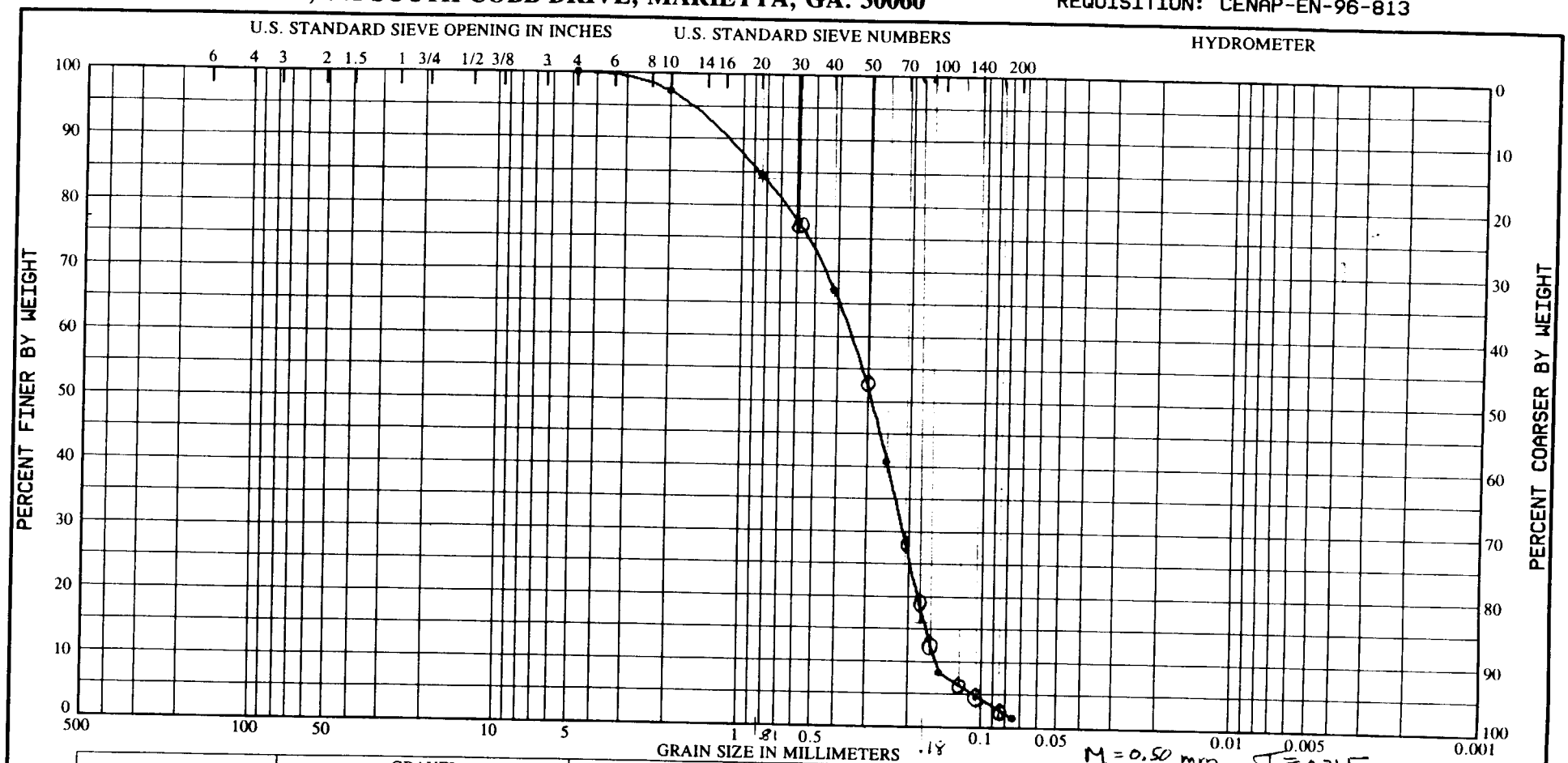
DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30060

WORK ORDER: 8015
REQUISITION: CENAP-EN-96-813



COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

Sample No.	Depth (Ft)	(VISUAL) Classification	Nat w%	LL	PL	PI
2	7.2-7.5	TAN & GRAY, POORLY GRADED SAND (SP), WITH A TRACE OF MICA.				

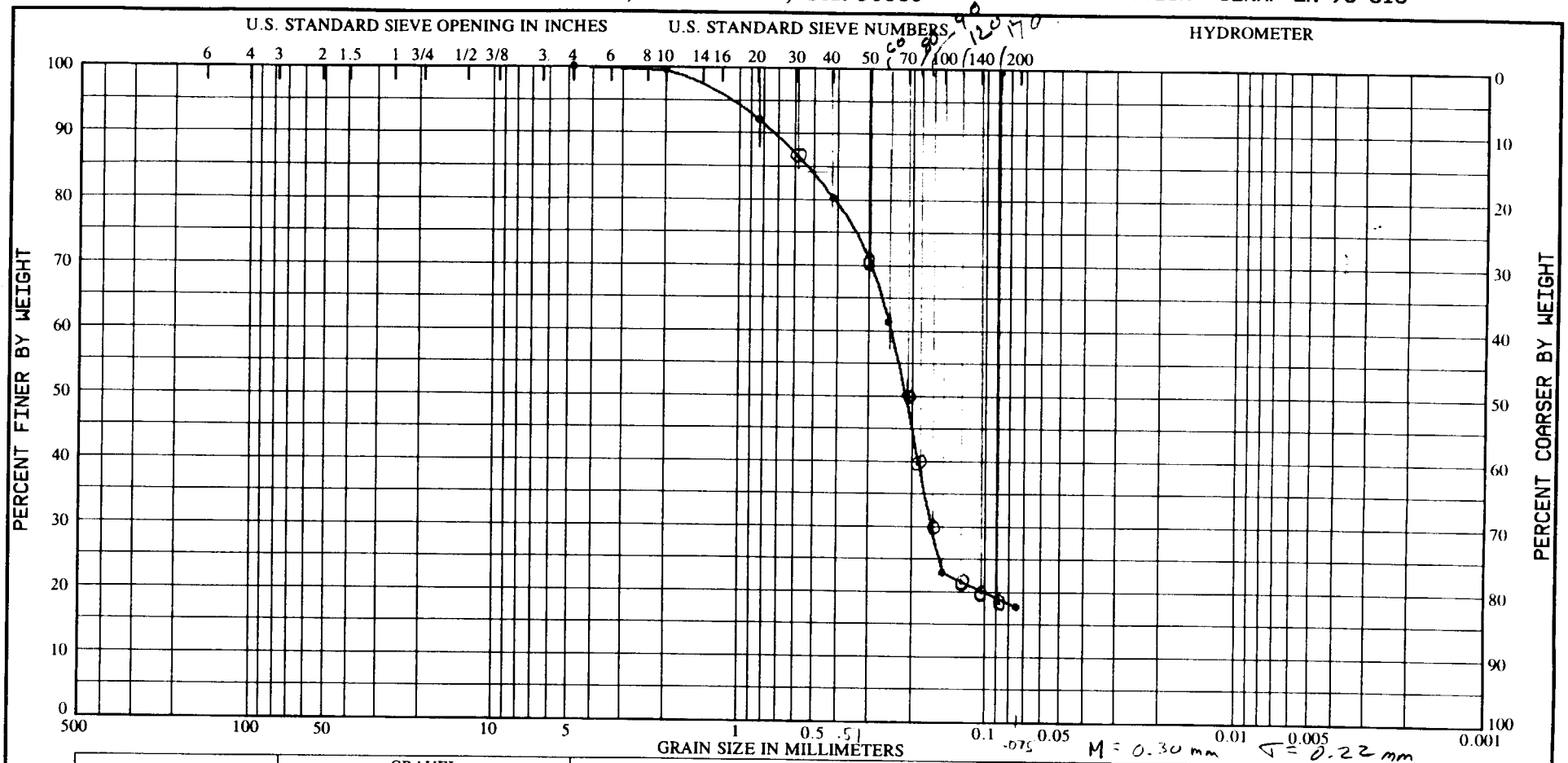
Project CAPE MAY
VIBRA-CORE SAMPLES
Lab No. 184/1254
Boring No. NJV-210
Date 07/29/96

GRADATION CURVES

98

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30060

WORK ORDER: 8015
REQUISITION: CENAP-EN-96-813



COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

Sample No.	Depth (Ft)	(VISUAL) Classification	Nat w%	LL	PL	PI
3	12.0-12.2	GRAY, CLAYEY SAND (SC), WITH A TRACE OF MICA.				

Project CAPE MAY
VIBRA-CORE SAMPLES
Lab No. 184/1254
Boring No. NJV-210
Date 07/29/96

GRADATION CURVES

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DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30060

Project: *CAPE MAY*		Boring No. *NJV-211*
Location: *VIBRA-CORE SAMPLES*		Lab No. *184/1255*
Boring Depth (ft): *20.10*	Depth:	Work order: *8015*
Datum/Notes:		Requisition: *CENAP-EN-96-813*

Elev. (feet)	Depth (feet)	Leg-end	Material Description	Comments
				DEPTHS FROM TOP OF HOLE.
	1			
	2			
	3			SA, 2.8 - 3.0
	4		TAN, POORLY GRADED SILTY SAND (SP-SM), WITH A TRACE OF GRAVEL SIZES AND MICA.	
	5			
	6			
	7			SA, 6.5 - 6.8
	8			
	9		TAN & GRAY, FAT CLAY (CH).	
	10			
	11			
	12			
	13			SA, 12.5 - 12.7
	14			
	15		TAN, POORLY GRADED SAND (SP), WITH OCCASIONAL GRAVEL SIZES AND A TRACE OF MICA.	
	16			
	17			SA, 17.0 - 17.3
	18			
	19			

Date: *07/17/96* **LABORATORY LOG AND SAMPLE DATUM** Sheet No. *1* of *2*

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30060

Project: *CAPE MAY*		Boring No. *NJV-211*
Location: *VIBRA-CORE SAMPLES*		Lab No. *184/1255*
Boring Depth (ft): *20.10*	Depth:	Work order: *8015*
Datum/Notes:		Requisition: *CENAP-EN-96-813*

Elev. (feet)	Depth (feet)	Leg-end	Material Description	Comments
	21			
	22			
	23			
	24			
	25			
	26			
	27			
	28			
	29			
	30			
	31			
	32			
	33			
	34			
	35			
	36			
	37			
	38			
	39			

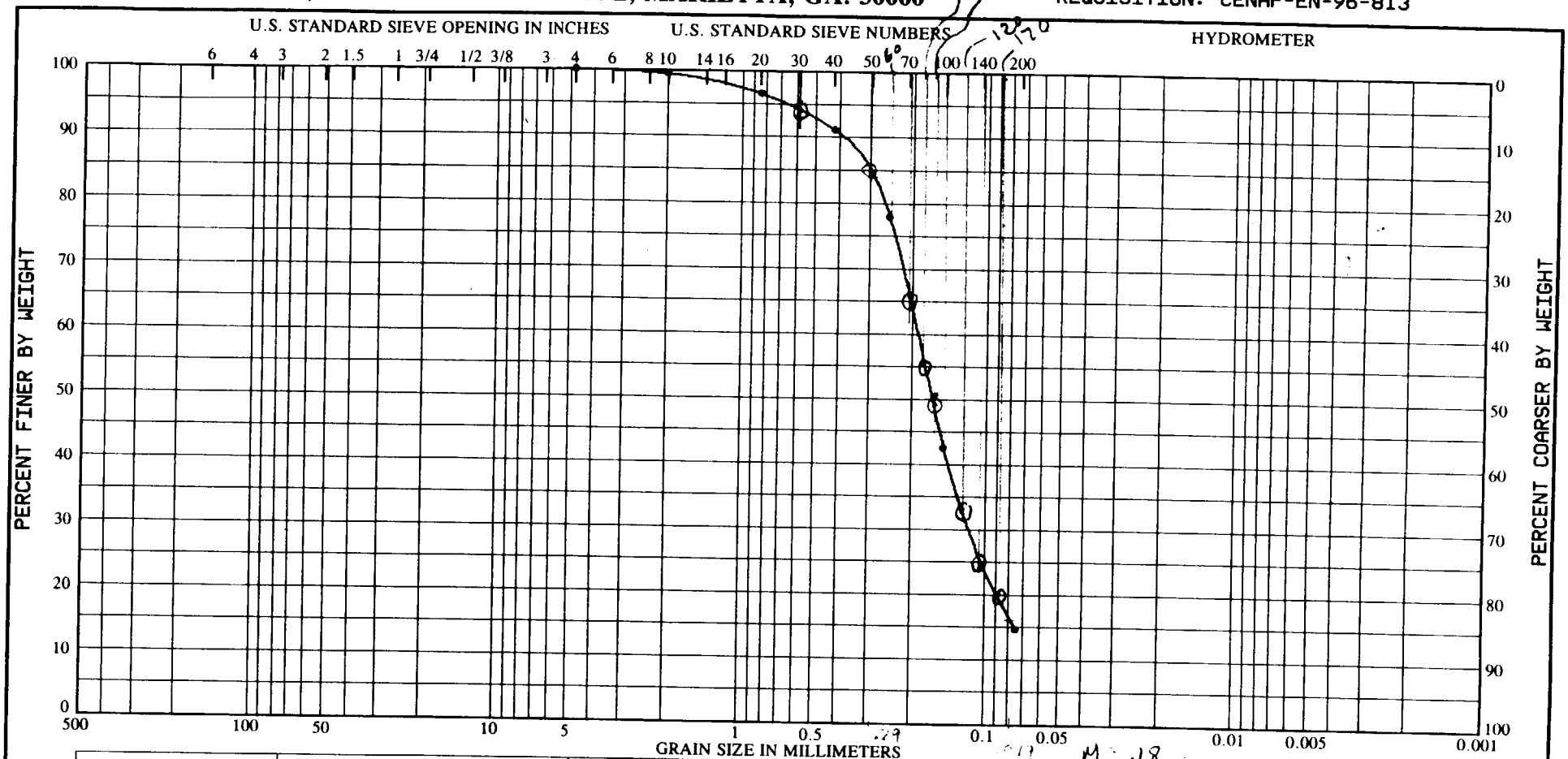
Date: *07/17/96*

LABORATORY LOG AND SAMPLE DATUM

Sheet No. *2* of *2*

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30060

WORK ORDER: 8015
REQUISITION: CENAP-EN-96-813



COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

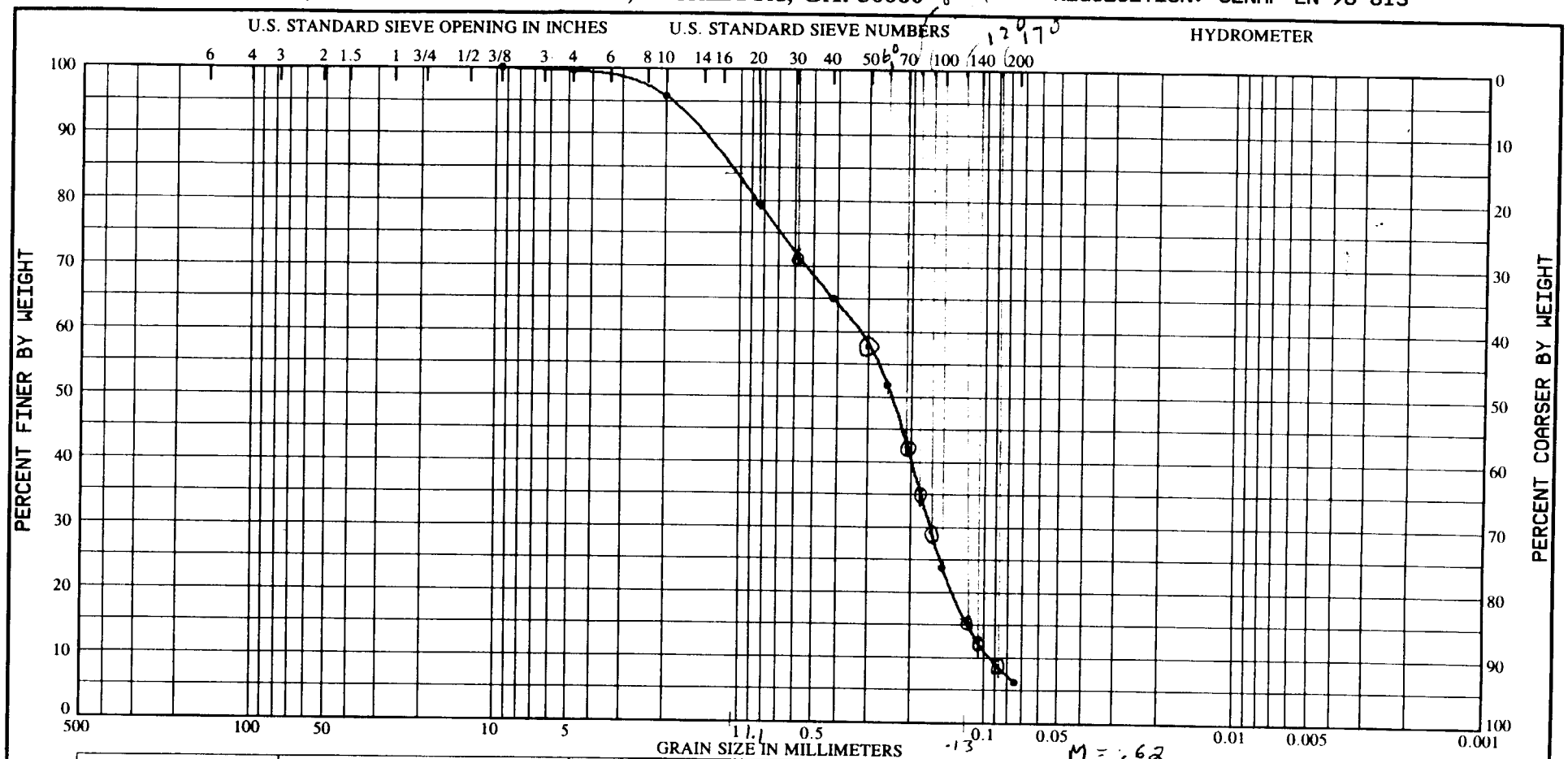
Sample No.	Depth (Ft)	(VISUAL) Classification	Nat w%	LL	PL	PI
1	2.8-3.0	TAN, SILTY SAND (SM), WITH A TRACE OF MICA.				

Project CAPE MAY
VIBRA-CORE SAMPLES
Lab No. 184/1255
Boring No. NJV-211
Date 07/17/96

GRADATION CURVES

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30060

WORK ORDER: 8015
REQUISITION: CENAP-EN-96-813



COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

Sample No.	Depth (Ft)	(VISUAL) Classification	Nat w%	LL	PL	PI
2	6.5-6.8	TAN, POORLY GRADED SILTY SAND (SP-SM).				

Project CAPE MAY
VIBRA-CORE SAMPLES
Lab No. 184/1255
Boring No. NJV-211
Date 07/17/96

GRADATION CURVES

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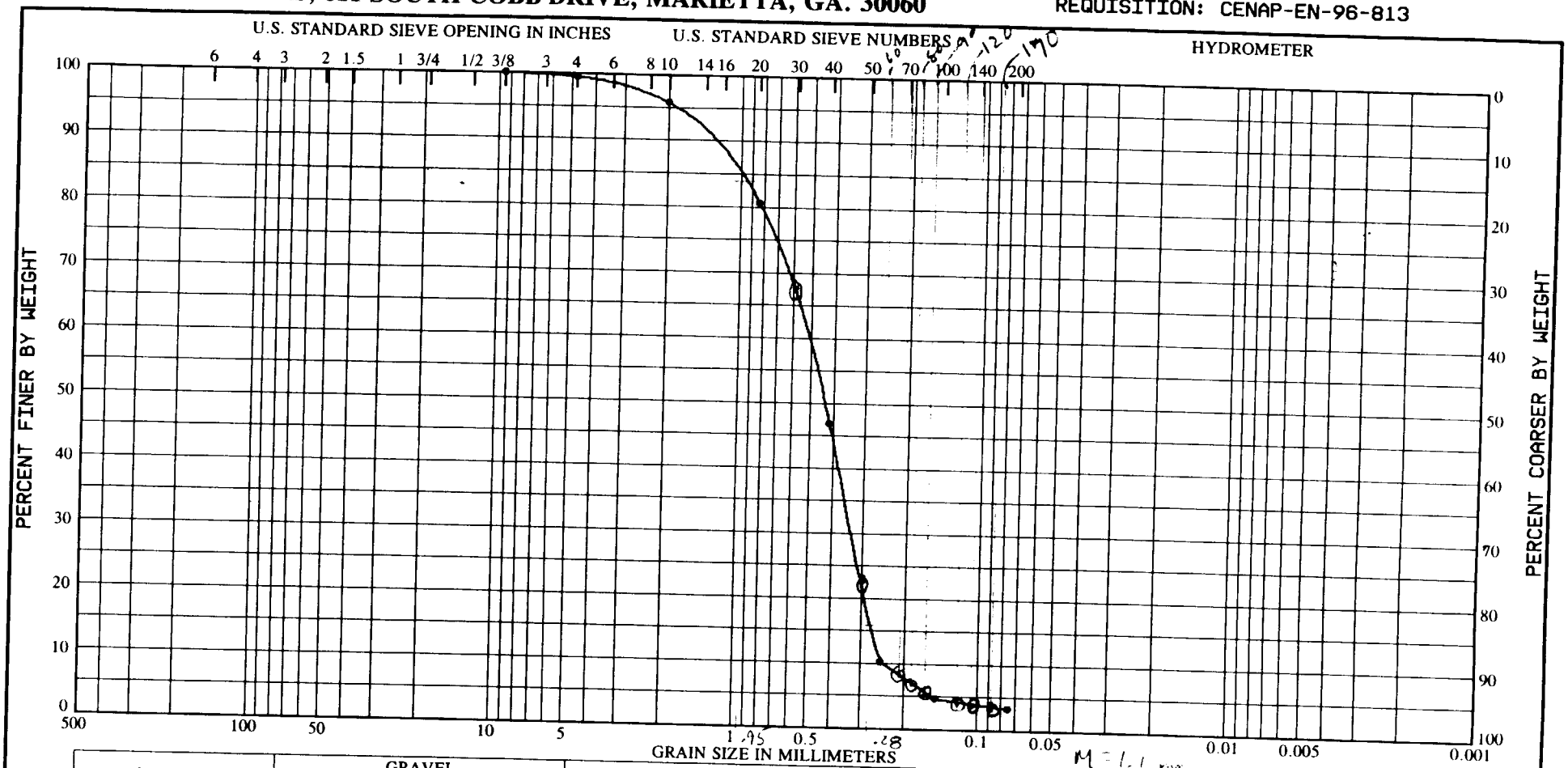
OK

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30060

WORK ORDER: 8015
REQUISITION: CENAP-EN-96-813



Sample No.	Depth (Ft)	(VISUAL) Classification	Nat w%	LL	PL	PI
3	12.5-12.7	TAN, POORLY GRADED SAND (SP), WITH A TRACE OF MICA.				

Project CAPE MAY
VIBRA-CORE SAMPLES
Lab No. 184/1255
Boring No. NJV-211
Date 07/17/96

GRADATION CURVES

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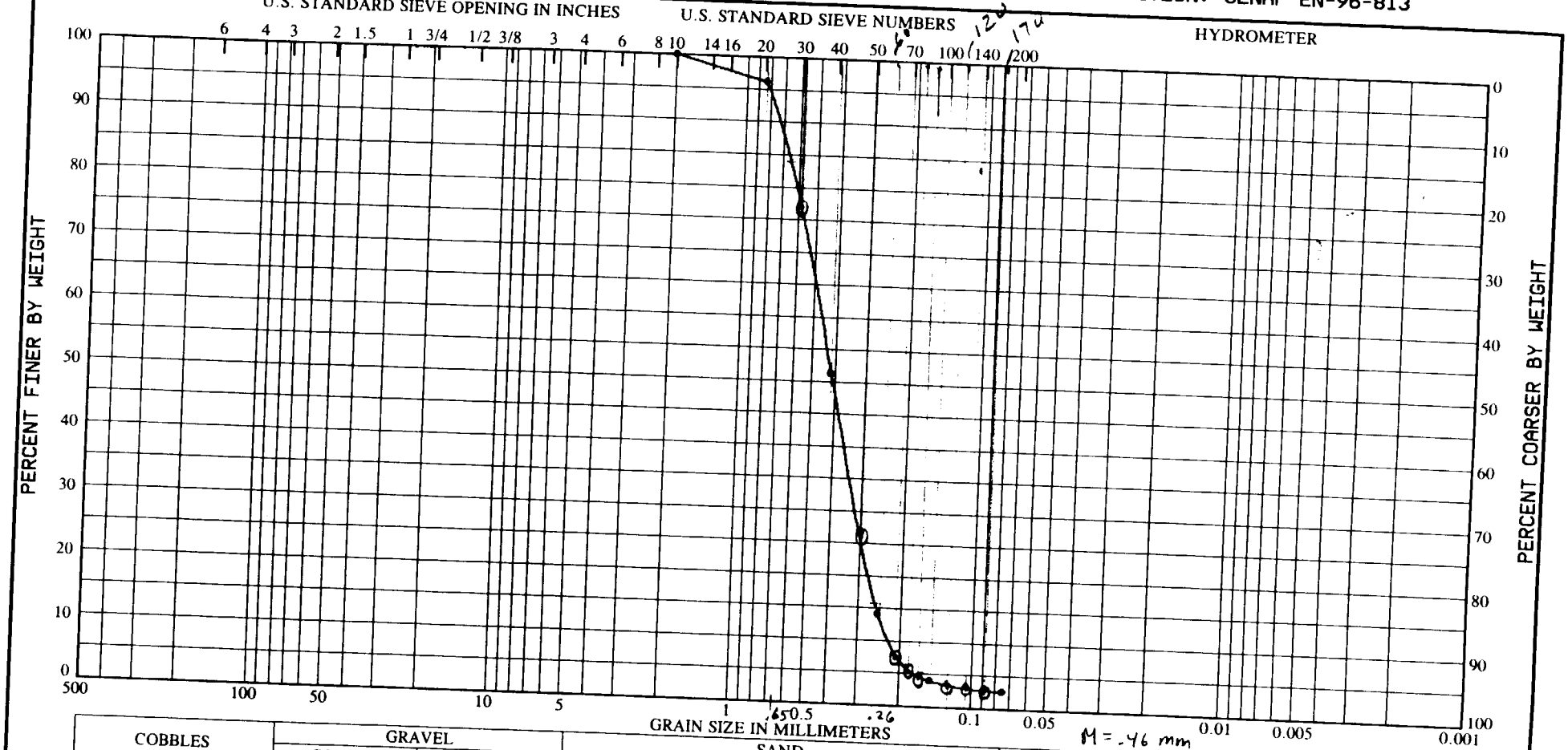
DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30060

WORK ORDER: 8015
REQUISITION: CENAP-EN-96-813



COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

Sample No.	Depth (Ft)	(VISUAL) Classification	Nat w%	LL	PL	PI
4	17.0-17.3	TAN, POORLY GRADED SAND (SP), WITH A TRACE OF MICA.				

Project CAPE MAY
VIBRA-CORE SAMPLES
Lab No. 184/1255
Boring No. NJV-211
Date 07/17/96

GRADATION CURVES

105

OK

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30060

Project: *CAPE MAY*		Boring No. *NJV-212*
Location: *VIBRA-CORE SAMPLES*		Lab No. *184/1256*
Boring Depth (ft): *17.40*	Depth:	Work order: *8015*
Datum/Notes:		Requisition: *CENAP-EN-96-813*

Elev. (feet)	Depth (feet)	Leg-end	Material Description	Comments
				DEPTHS FROM TOP OF HOLE.
	1			
	2			SA, 2.1 - 2.4
	3			
	4			
	5		TAN & GRAY, POORLY GRADED SAND (SP), WITH A TRACE OF MICA.	
	6			SA, 5.5 - 5.8
	7			
	8			
	9			
	10			
	11		----------	
	12		GRAY, SILTY SAND (SM), SLIGHTLY PLASTIC	SA, 11.5 - 11.8
	13		----------	
	14			
	15			
	16		GRAY, MIXTURE OF LEAN CLAY (CL), SILTY FAT CLAY (CH) AND POORLY GRADED SAND (SP).	SA, 16.0 - 16.3
	17		----------	
	18			
	19			

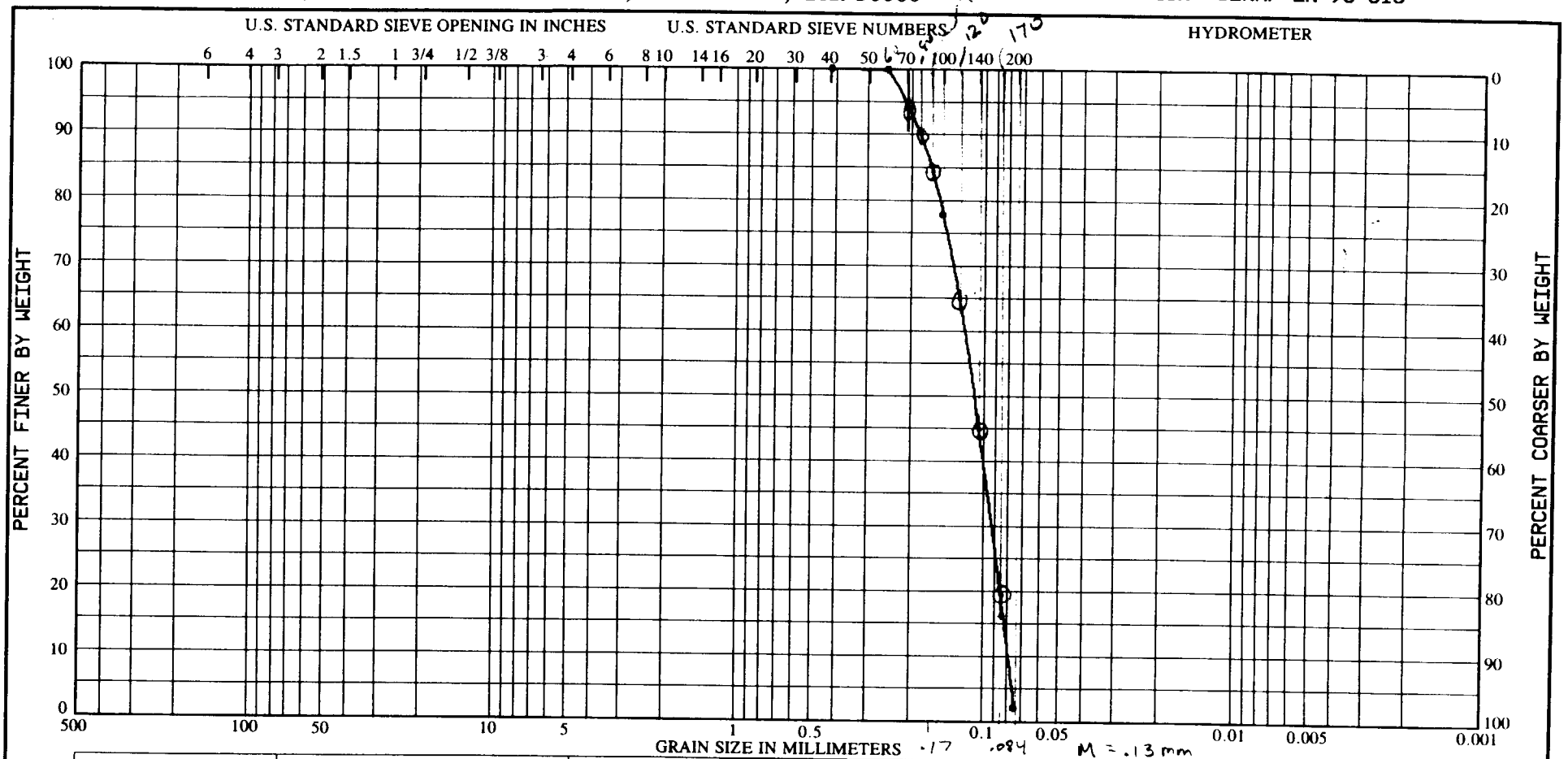
Date: *07/17/96*

LABORATORY LOG AND SAMPLE DATUM

Sheet No. *1* of *1*

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30060

WORK ORDER: 8015
REQUISITION: CENAP-EN-96-813



COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

Sample No.	Depth (Ft)	(VISUAL) Classification	Nat w%	LL	PL	PI
1	2.1-2.4	TAN & GRAY, POORLY GRADED SAND (SP), WITH A TRACE OF MICA.				

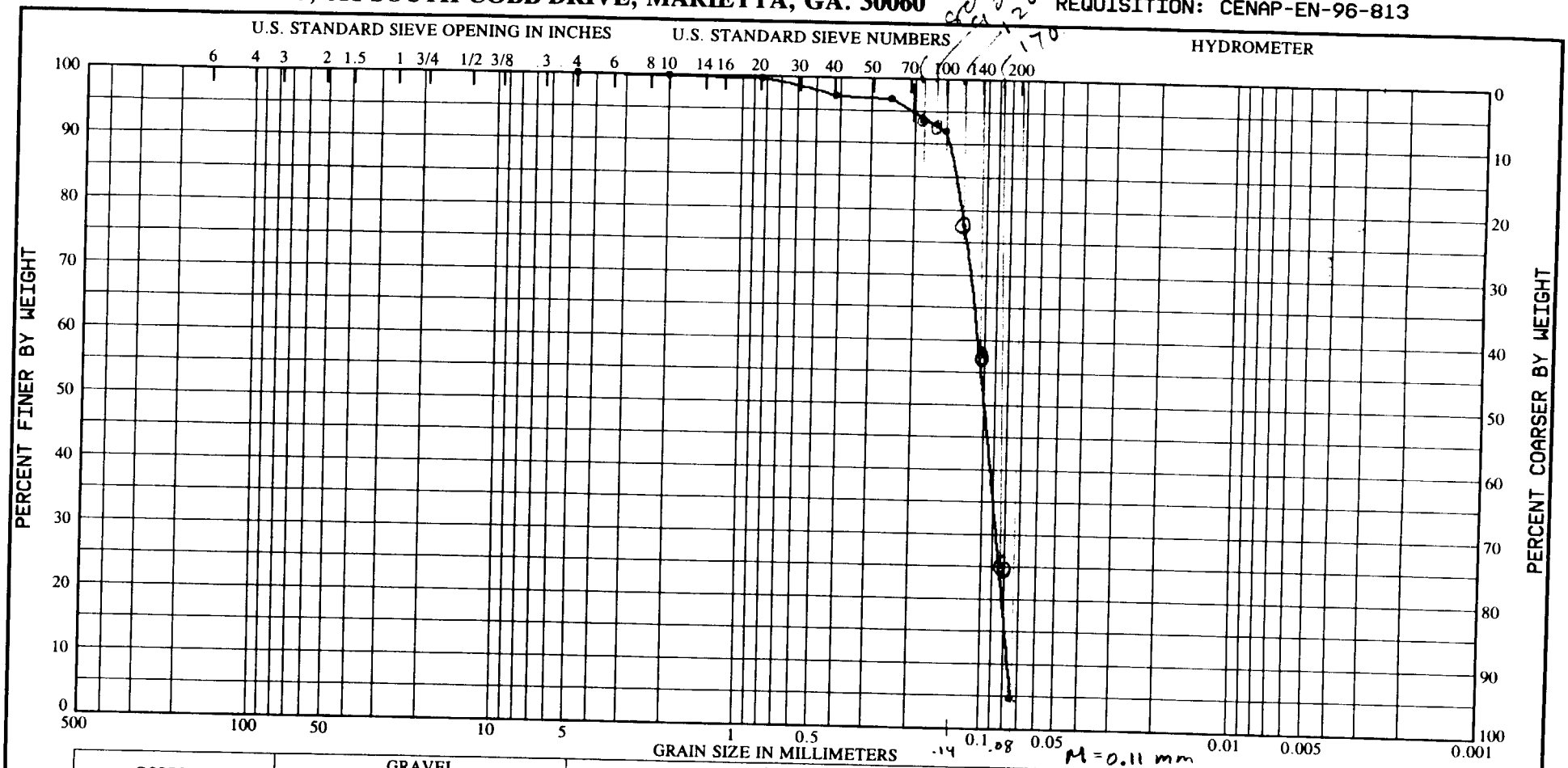
Project CAPE MAY
VIBRA-CORE SAMPLES
Lab No. 184/1256
Boring No. NJV-212
Date 07/17/96

GRADATION CURVES

OK

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30060

WORK ORDER: 8015
REQUISITION: CENAP-EN-96-813



COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

Sample No.	Depth (Ft)	(VISUAL) Classification	Nat w%	LL	PL	PI
2	5.5-5.8	TAN & GRAY, POORLY GRADED SAND (SP), WITH A TRACE OF MICA.				

Project CAPE MAY
VIBRA-CORE SAMPLES
Lab No. 184/1256
Boring No. NJV-212
Date 07/17/96

GRADATION CURVES

OK for fine!

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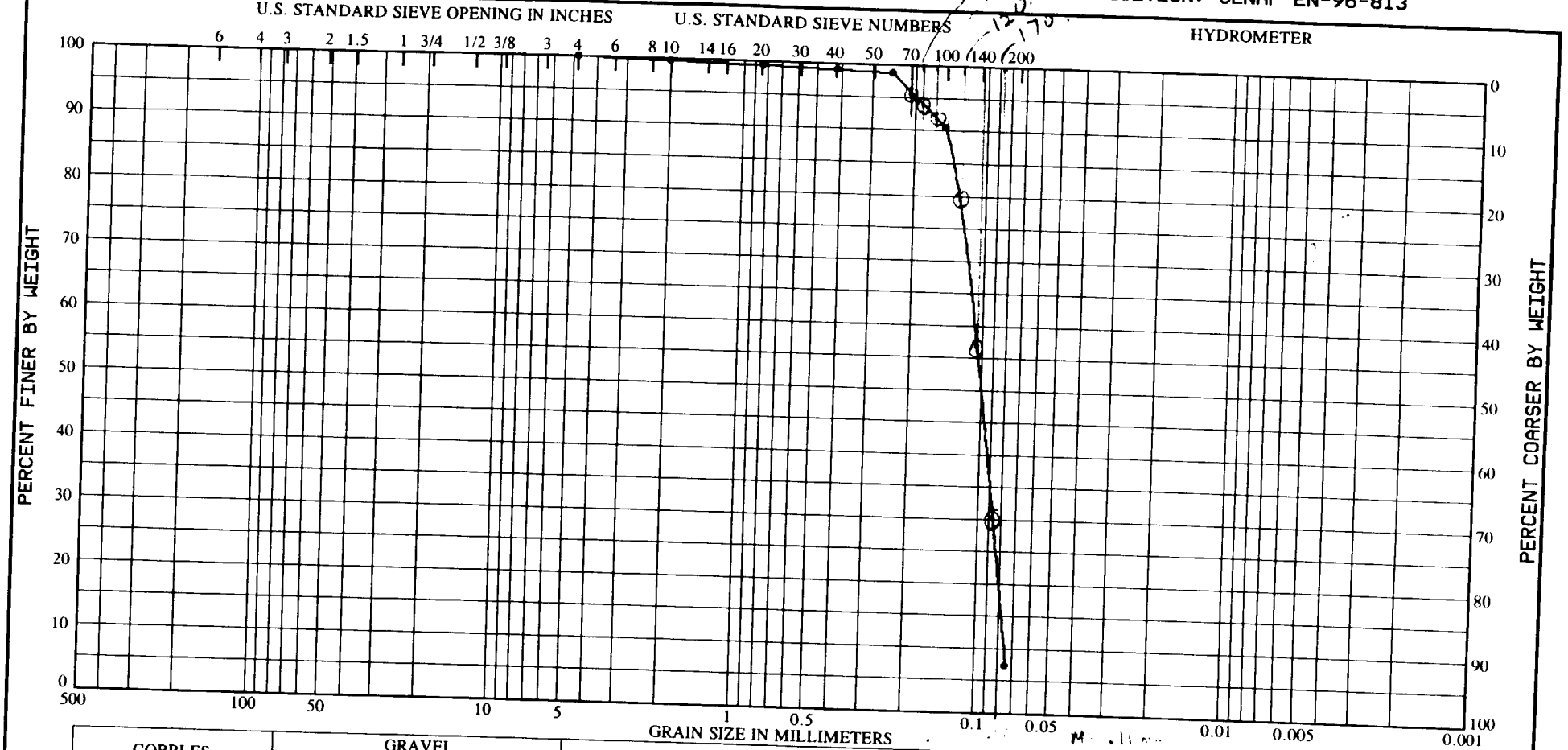
DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30060

WORK ORDER: 8015
REQUISITION: CENAP-EN-96-813



COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

Sample No.	Depth (Ft)	(VISUAL) Classification	Nat w %	LL	PL	PI
3	11.5-11.8	GRAY, POORLY GRADED SILTY SAND (SP-SM), WITH A TRACE OF MICA.				

Project CAPE MAY
VIBRA-CORE SAMPLES
Lab No. 184/1256
Boring No. NJV-212
Date 07/17/96

GRADATION CURVES

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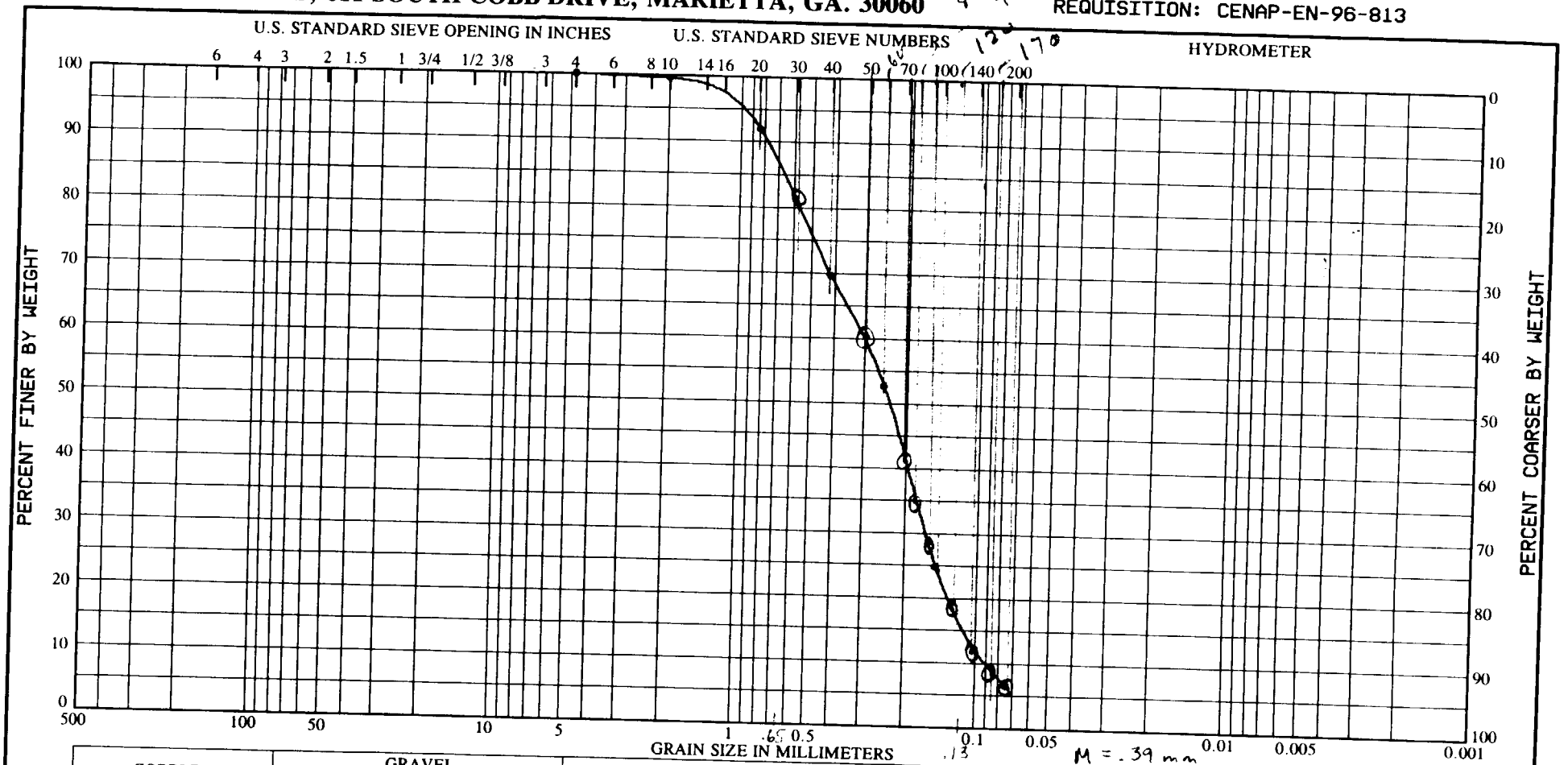
DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30060

WORK ORDER: 8015
REQUISITION: CENAP-EN-96-813



COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

Sample No.	Depth (Ft)	(VISUAL) Classification	Nat w%	LL	PL	PI
4	16.0-16.3	TAN, POORLY GRADED SILTY SAND (SP-SM), WITH A TRACE OF MICA.				

Project CAPE MAY
VIBRA-CORE SAMPLES
Lab No. 184/1256
Boring No. NJV-212
Date 07/17/96

GRADATION CURVES

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OK

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30060

Project: *CAPE MAY*		Boring No. *NJV-213*
Location: *VIBRA-CORE SAMPLES*		Lab No. *184/1257*
Boring Depth (ft): *20.00*	Depth:	Work order: *8015*
Datum/Notes:		Requisition: *CENAP-EN-96-813*

Elev. (feet)	Depth (feet)	Leg-end	Material Description	Comments
				DEPTHS FROM TOP OF HOLE.
	1			
	2		GRAY, POORLY GRADED SILTY SAND (SP-SM), PLASTIC FINES AND A TRACE OF MICA.	SA, 2.0 - 2.2
	3			
	4			
	5			
	6		GRAY, SILTY SAND (SM), PLASTIC FINES AND POCKETS OF LEAN CLAY (CL) AND A TRACE OF MICA.	SA, 6.0 - 6.3
	7			
	8			
	9		GRAY, CLAYEY SAND (SC), WITH POCKETS OF FAT CLAY (CH) AND A TRACE OF MICA.	
	10			
	11		GRAY, CLAYEY SAND (SC), WITH A LITTLE GRAVEL SIZES AND A TRACE OF MICA.	
	12		GRAY, SILTY SAND (SM), PLASTIC FINES AND A TRACE OF MICA.	SA, 12.0 - 12.2
	13			
	14		GRAY, SILTY SAND (SM), PLASTIC FINES AND POCKETS OF FAT CLAY (CH) AND A TRACE OF MICA.	
	15			
	16		GRAY ORGANIC MATTER.	
	17		GRAY, SILTY FAT CLAY (CH).	SA, 17.1 - 17.3
	18			
	19		GRAY, FAT CLAY (CH).	

Date: *07/18/96* **LABORATORY LOG AND SAMPLE DATUM** Sheet No. *1* of *2*

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30060

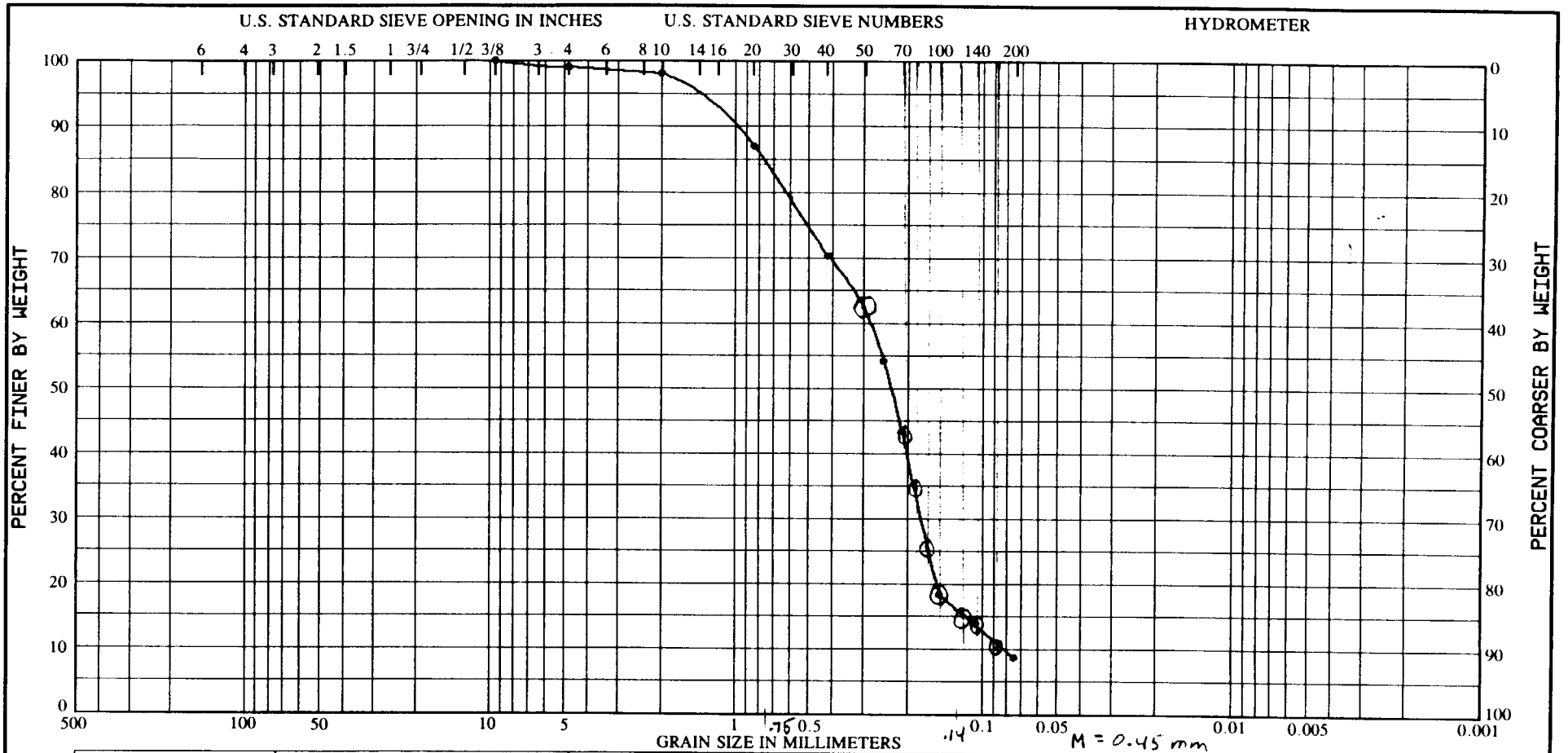
Project: *CAPE MAY*		Boring No. *NJV-213*
Location: *VIBRA-CORE SAMPLES*		Lab No. *184/1257*
Boring Depth (ft): *20.00*	Depth:	Work order: *8015*
Datum/Notes:		Requisition: *CENAP-EN-96-813*

Elev. (feet)	Depth (feet)	Leg-end	Material Description	Comments
	21			
	22			
	23			
	24			
	25			
	26			
	27			
	28			
	29			
	30			
	31			
	32			
	33			
	34			
	35			
	36			
	37			
	38			
	39			

Date: *07/18/96* **LABORATORY LOG AND SAMPLE DATUM** Sheet No. *2* of *2*

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30060

WORK ORDER: 8015
REQUISITION: CENAP-EN-96-813



COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

Sample No.	Depth (Ft)	(VISUAL) Classification	Nat w%	LL	PL	PI
1	2.0-2.2	GRAY, POORLY GRADED SILTY SAND (SP-SM), PLASTIC FINES AND A TRACE OF MICA.				

Project CAPE MAY
VIBRA-CORE SAMPLES
Lab No. 184/1257
Boring No. NJV-213
Date 07/18/96

GRADATION CURVES

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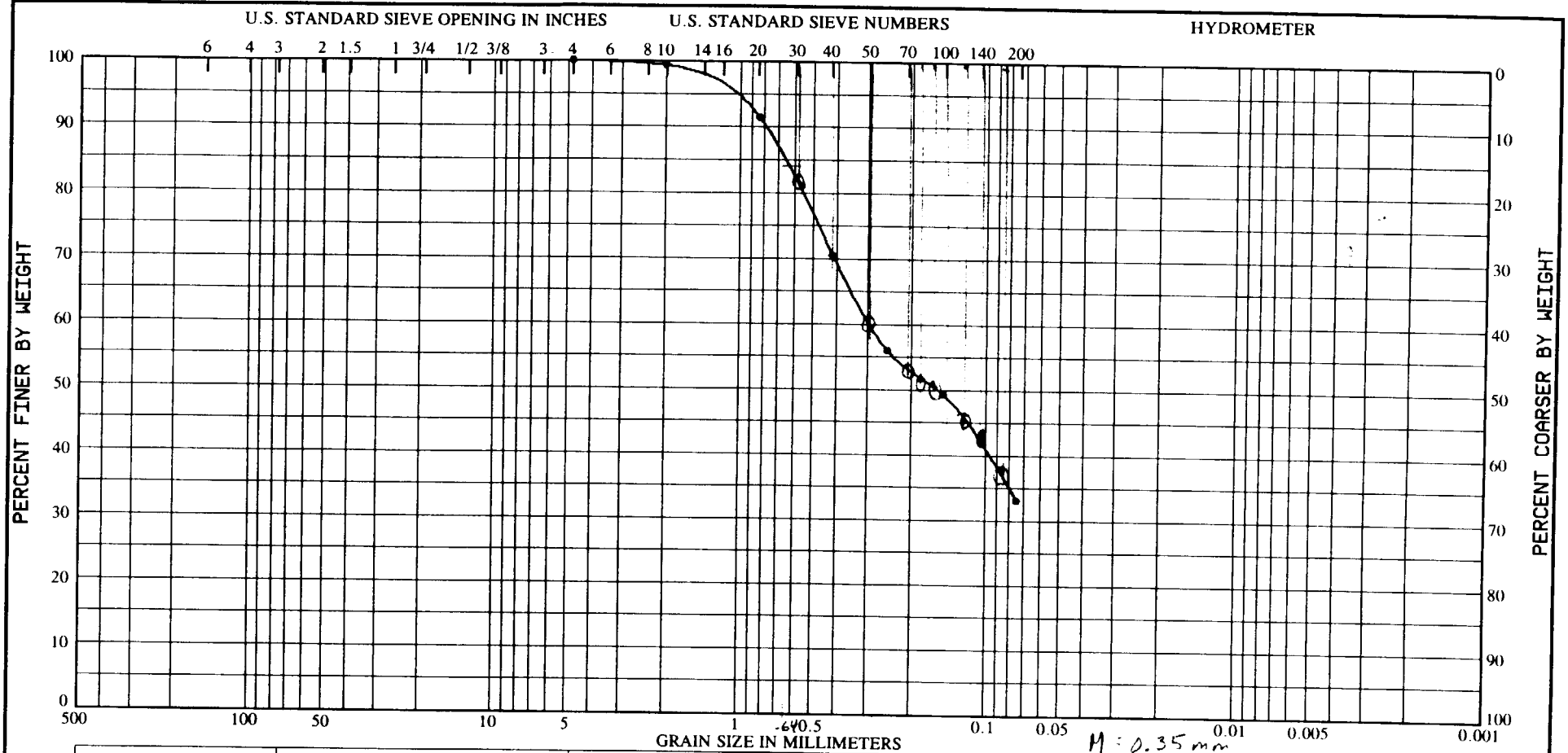
016

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30060

WORK ORDER: 8015
REQUISITION: CENAP-EN-96-813



COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

Sample No.	Depth (Ft)	(VISUAL) Classification	Nat w%	LL	PL	PI
2	6.0-6.3	GRAY, SILTY SAND (SM), PLASTIC FINES AND A TRACE OF MICA.				

Project CAPE MAY
VIBRA-CORE SAMPLES
Lab No. 184/1257
Boring No. NJV-213
Date 07/18/96

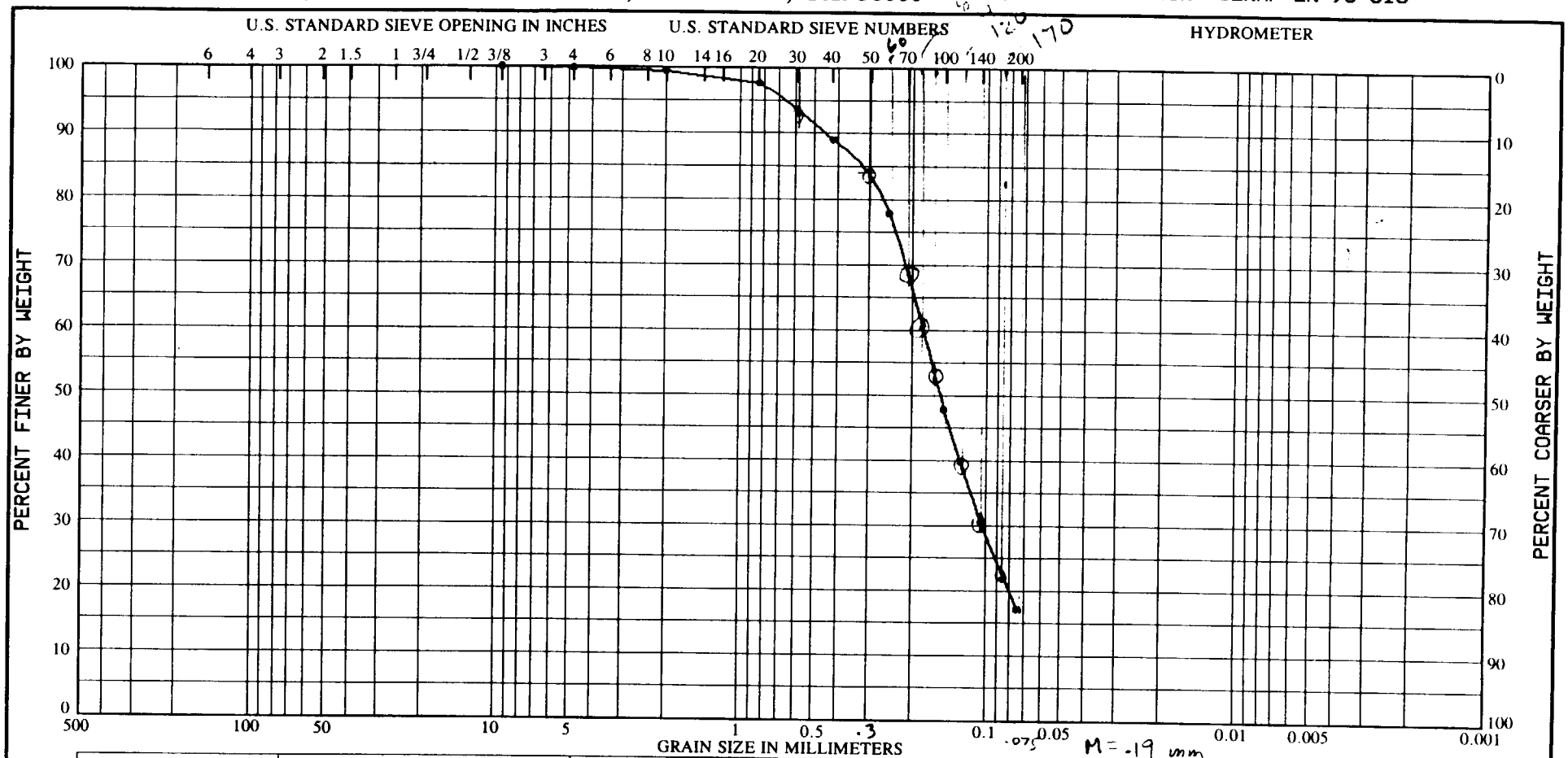
GRADATION CURVES

114

016

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30060

WORK ORDER: 8015
REQUISITION: CENAP-EN-96-813



COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

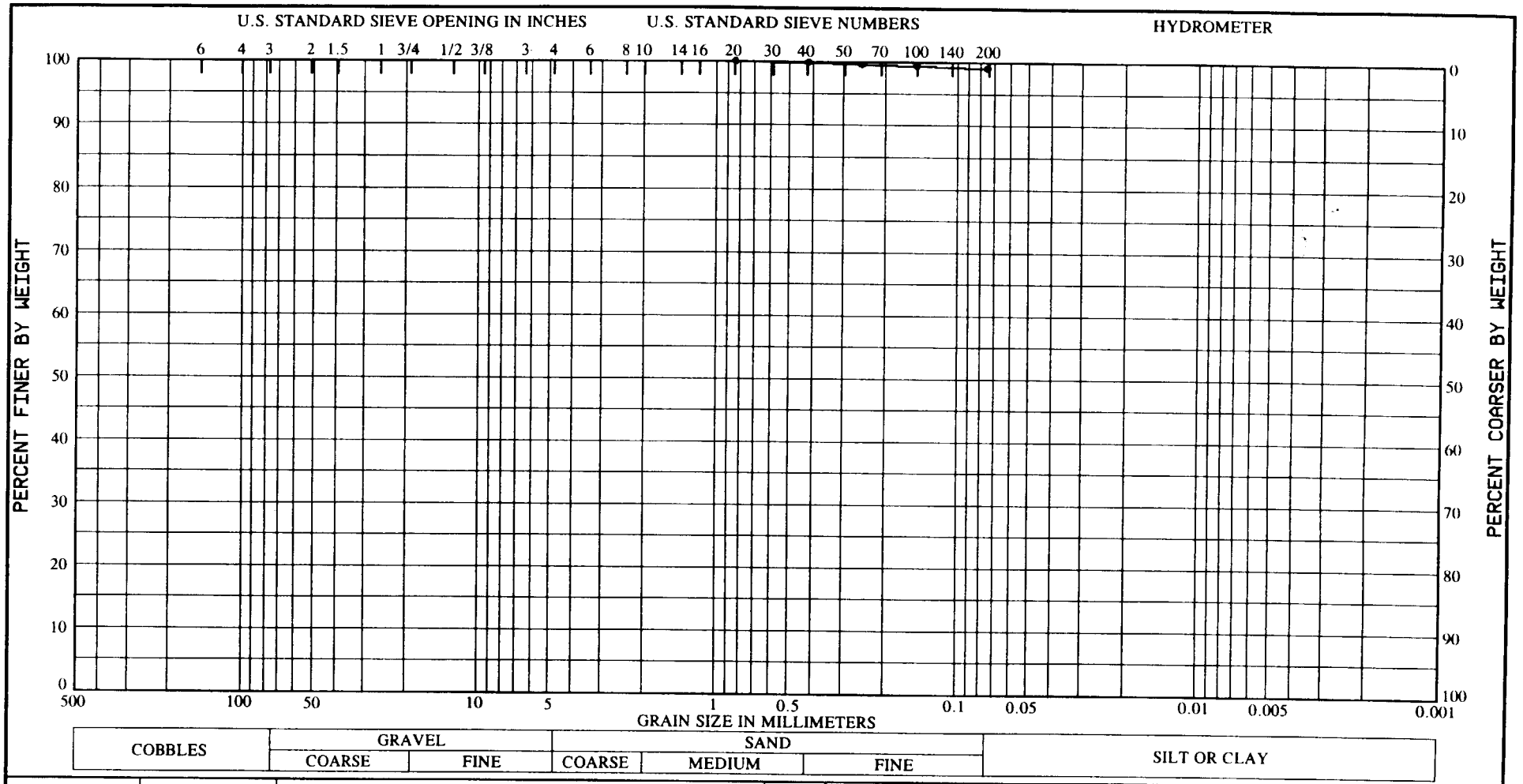
Sample No.	Depth (Ft)	(VISUAL) Classification	Nat w%	LL	PL	PI
3	12.0-12.2	GRAY, SILTY SAND (SM), PLASTIC FINES AND A TRACE OF MICA.				

Project CAPE MAY
VIBRA-CORE SAMPLES
Lab No. 184/1257
Boring No. NJV-213
Date 07/18/96

GRADATION CURVES

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30060

WORK ORDER: 8015
REQUISITION: CENAP-EN-96-813



Sample No.	Depth (Ft)	(VISUAL) Classification	Nat w%	LL	PL	PI
4	17.1-17.3	GRAY, SILTY FAT CLAY (CH).				

Project CAPE MAY
VIBRA-CORE SAMPLES
Lab No. 184/1257
Boring No. NJV-213
Date 07/18/96

GRADATION CURVES

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DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30060

Project: *CAPE MAY*		Boring No. *NJV-214*
Location: *VIBRA-CORE SAMPLES*		Lab No. *184/1258*
Boring Depth (ft): *20.00*	Depth:	Work order: *8015*
Datum/Notes:		Requisition: *CENAP-EN-96-813*

Elev. (feet)	Depth (feet)	Leg-end	Material Description	Comments
				DEPTHS FROM TOP OF HOLE.
	1			
			GRAY, SILTY SANDY FAT CLAY (CH), WITH A TRACE OF MICA.	
	2			SA, 2.0 - 2.3
	3		----------	
	4			
			GRAY, SILTY SAND (SM), PLASTIC FINES	
	5			
	6		----------	
	7			
	8		GRAY, CLAYEY SAND (SC), WITH POCKETS OF SILTY SAND (SM) PLASTIC FINES.	SA, 7.4 - 7.7
	9			
	10		----------	
	11		TAN, POORLY GRADED SAND (SP), WITH A LITTLE GRAVEL SIZES. ----------	
	12			
	13		TAN, POORLY GRADED SAND (SP), WITH A LITTLE GRAVEL SIZES AND A TRACE OF SHELL FRAGMENTS.	SA, 12.99 - 14.0
	14		----------	
	15			
	16			
	17		TAN, POORLY GRADED SAND (SP).	SA, 17.2 - 17.5
	18			
	19			

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30060

Project: *CAPE MAY*		Boring No. *NJV-214*
Location: *VIBRA-CORE SAMPLES*		Lab No. *184/1258*
Boring Depth (ft): *20.00*	Depth:	Work order: *8015*
Datum/Notes:		Requisition: *CENAP-EN-96-813*

Elev. (feet)	Depth (feet)	Leg-end	Material Description	Comments
	21			
	22			
	23			
	24			
	25			
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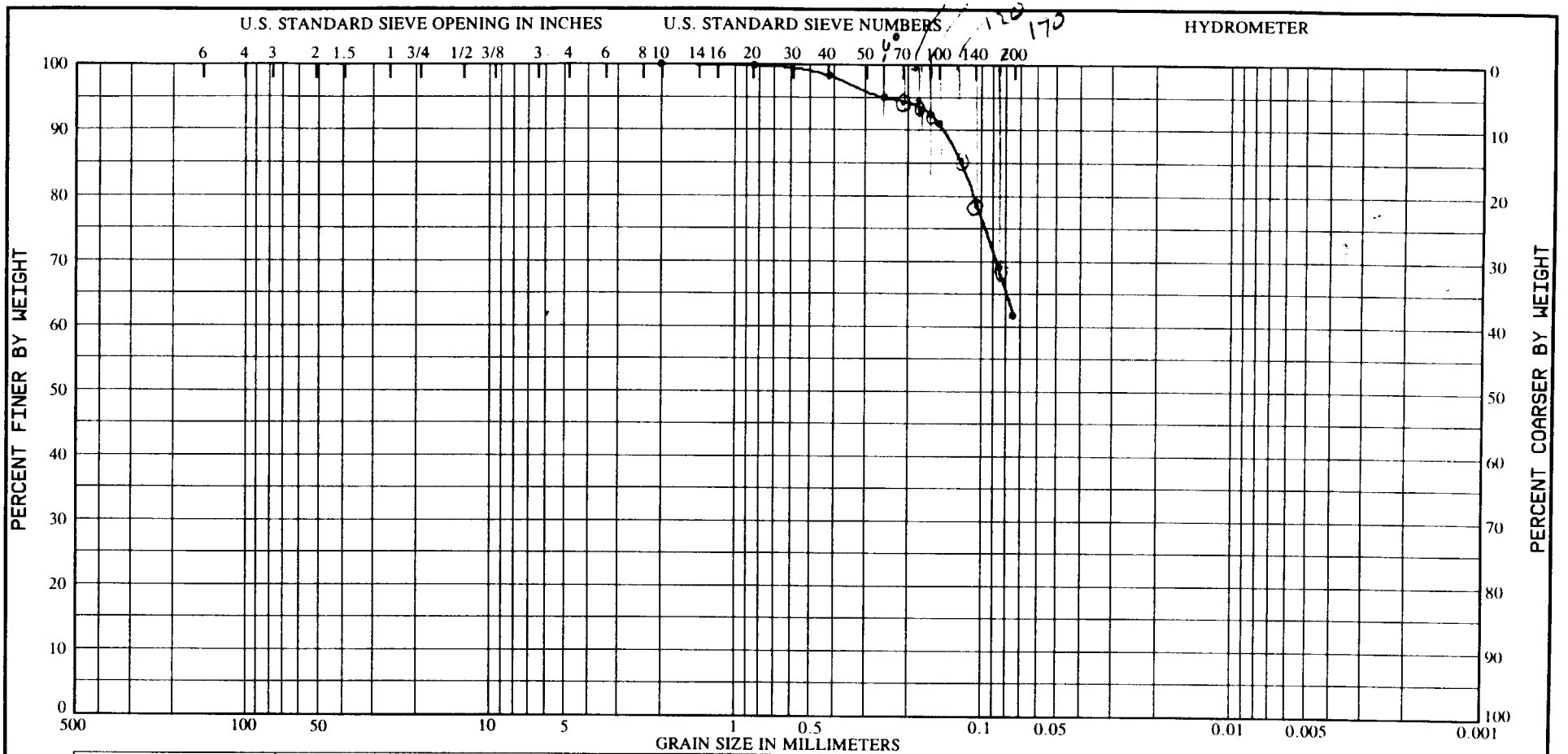
	39			

Date: *07/30/96* **LABORATORY LOG AND SAMPLE DATUM** Sheet No. *2* of *2*

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30060

WORK ORDER: 8015
REQUISITION: CENAP-EN-96-813



COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

Sample No.	Depth (Ft)	(VISUAL) Classification	Nat w%	LL	PL	PI
1	2.0-2.3	GRAY, SANDY SILTY FAT CLAY (CH), WITH A TRACE OF MICA.				

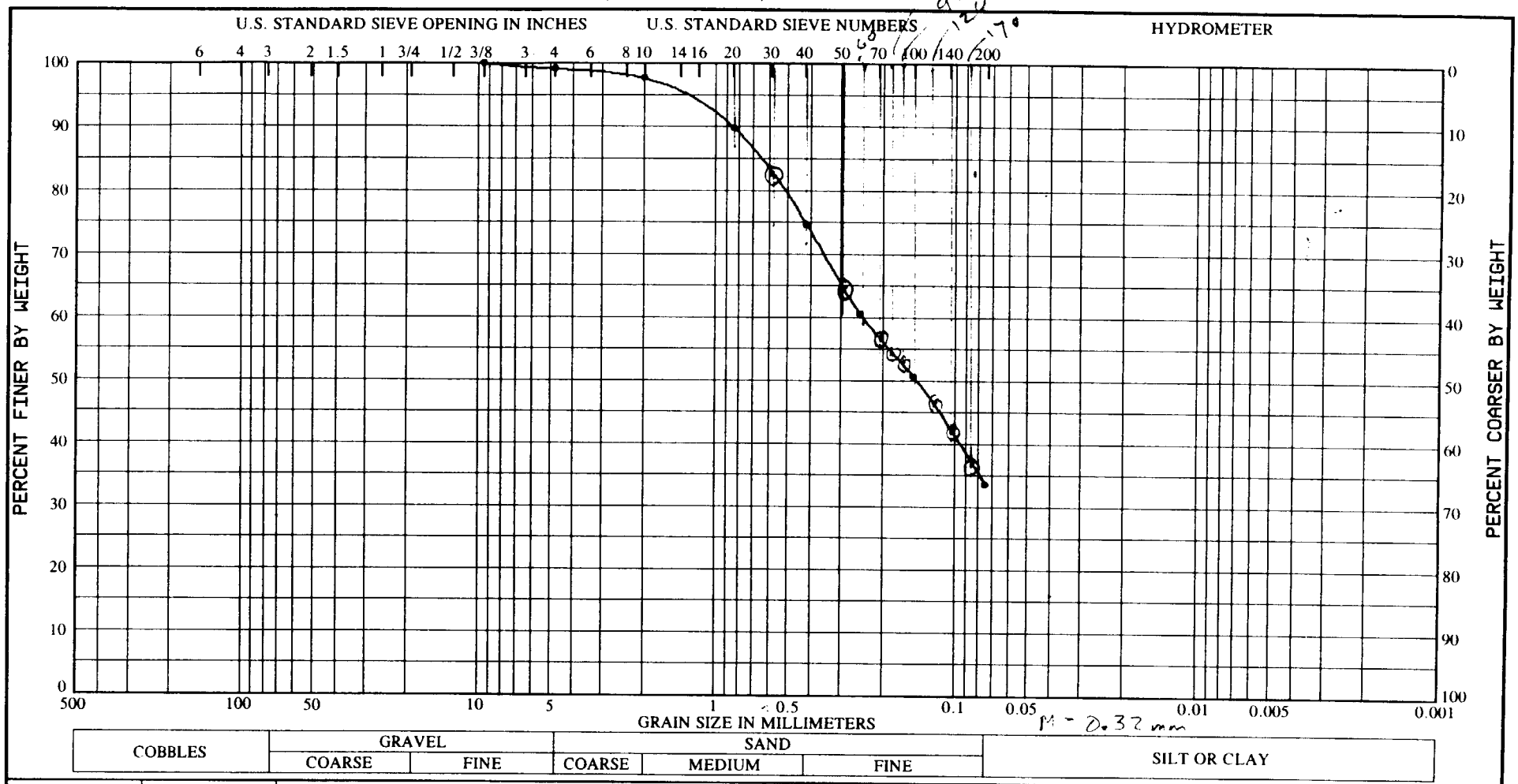
Project CAPE MAY
VIBRA-CORE SAMPLES
Lab No. 184/1258
Boring No. NJV-214
Date 07/19/96

GRADATION CURVES

Too fine

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30060

WORK ORDER: 8015
REQUISITION: CENAP-EN-96-813



COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

Sample No.	Depth (Ft)	(VISUAL) Classification	Nat w%	LL	PL	PI
2	7.4-7.7	GRAY, CLAYEY SAND (SC).				

Project CAPE MAY
VIBRA-CORE SAMPLES
Lab No. 184/1258
Boring No. NJV-214
Date 07/19/96

GRADATION CURVES

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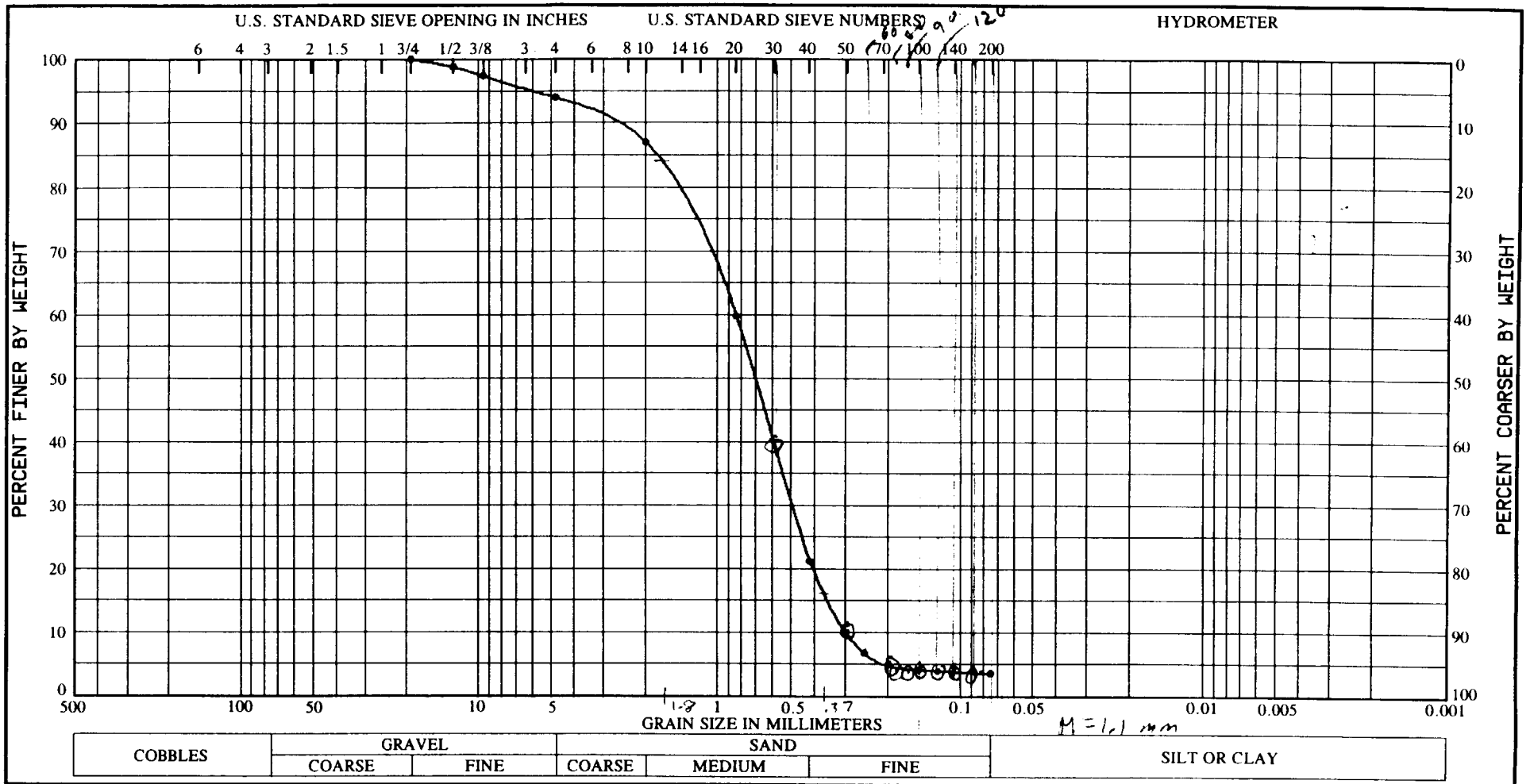
DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30060

WORK ORDER: 8015
REQUISITION: CENAP-EN-96-813



Sample No.	Depth (Ft)	(VISUAL) Classification	Nat w%	LL	PL	PI
3	12.9-14.0	TAN, POORLY GRADED SAND (SP), WITH A TRACE OF GRAVEL SIZES AND SHELL FRAGMENTS.				

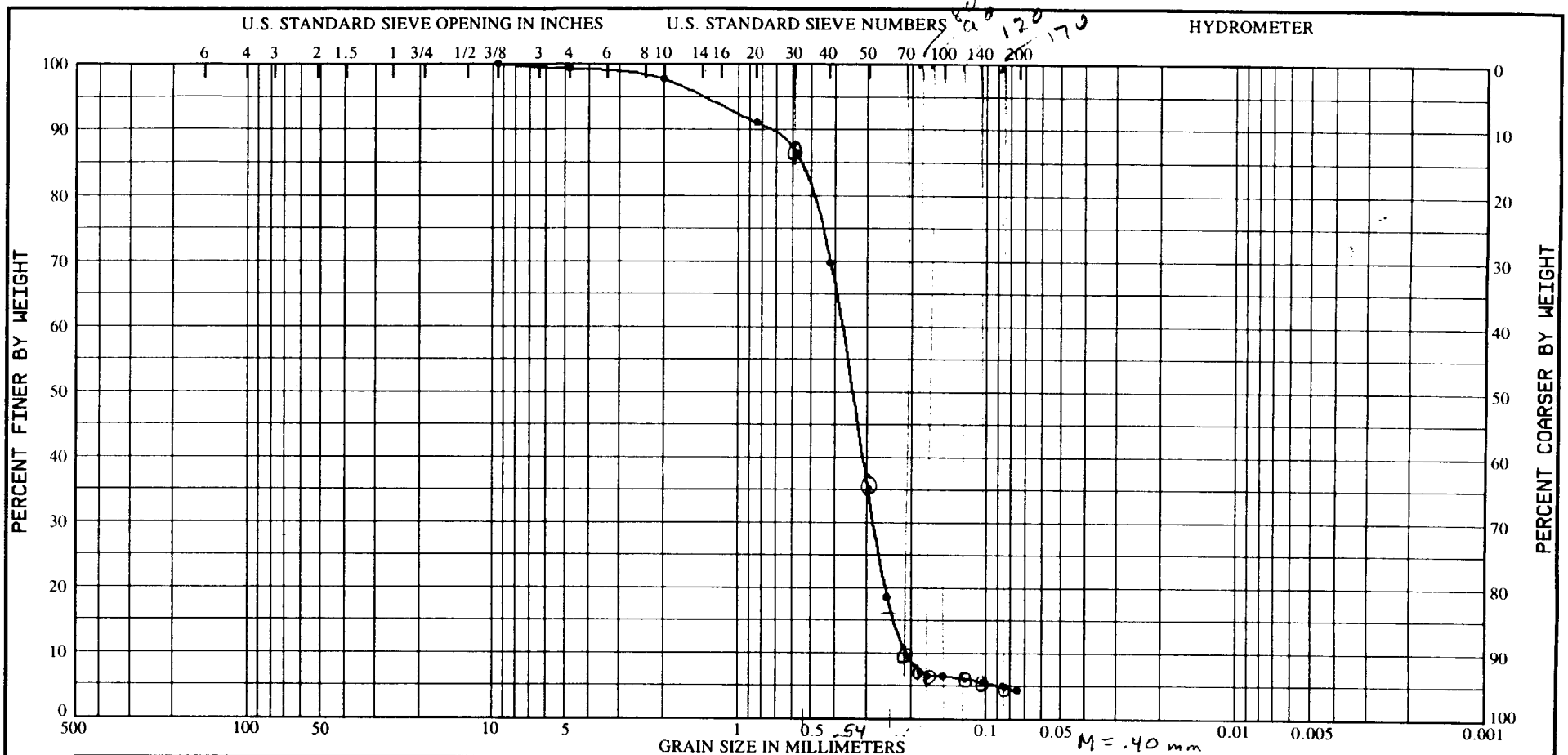
Project CAPE MAY
VIBRA-CORE SAMPLES
Lab No. 184/1258
Boring No. NJV-214
Date 07/30/96

GRADATION CURVES

OK - too Coarse

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30060

WORK ORDER: 8015
REQUISITION: CENAP-EN-96-813



COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

Sample No.	Depth (Ft)	(VISUAL) Classification	Nat w%	LL	PL	PI
4	17.2-17.5	TAN, POORLY GRADED SAND (SP).				

Project CAPE MAY
VIBRA-CORE SAMPLES
Lab No. 184/1258
Boring No. NJV-214
Date 07/19/96

GRADATION CURVES

OK

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30060

Project: *CAPE MAY*		Boring No. *NJV-215*
Location: *VIBRA-CORE SAMPLES*		Lab No. *184/1259*
Boring Depth (ft): *20.10*	Depth:	Work order: *8015*
Datum/Notes:		Requisition: *CENAP-EN-96-813*

Elev. (feet)	Depth (feet)	Leg-end	Material Description	Comments
				DEPTHS FROM TOP OF HOLE.
	1			
	2	OK	TAN & GRAY, POORLY GRADED SAND (SP), WITH A TRACE OF GRAVEL SIZES.	SA, 2.0 - 2.3
	3		----------	
	4	OK ?	TAN & GRAY, POORLY GRADED SILTY SAND (SP-SM), PLASTIC FINES.	
	5		----------	
	6	M=1.31 OK ?	GRAY, CLAYEY SAND (SC), WITH POCKETS OF FAT CLAY (CH).	SA, 6.0 - 6.2
	7			
	8		----------	
	9	OK	GRAY, POORLY GRADED SILTY SAND (SP-SM) PLASTIC FINES AND SOME GRAVEL SIZES.	SA, 9.4 - 9.9
	10		----------	
	11			
	12		TANNISH GRAY, POORLY GRADED SAND (SP), WITH POCKETS OF CLAYEY SAND (SC) AND A TRACE OF GRAVEL SIZES.	
	13		----------	
	14			
	15			
	16			
	17		TANNISH GRAY, POORLY GRADED SAND (SP), WITH POCKETS OF CLAYEY SAND (SC) AND A TRACE OF GRAVEL SIZES.	SA, 16.3 - 16.6
	18			
	19			

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30060

Project: *CAPE MAY*		Boring No. *NJV-215*
Location: *VIBRA-CORE SAMPLES*		Lab No. *184/1259*
Boring Depth (ft): *20.10*	Depth:	Work order: *8015*
Datum/Notes:		Requisition: *CENAP-EN-96-813*

Elev. (feet)	Depth (feet)	Leg-end	Material Description	Comments
	21			
	22			
	23			
	24			
	25			
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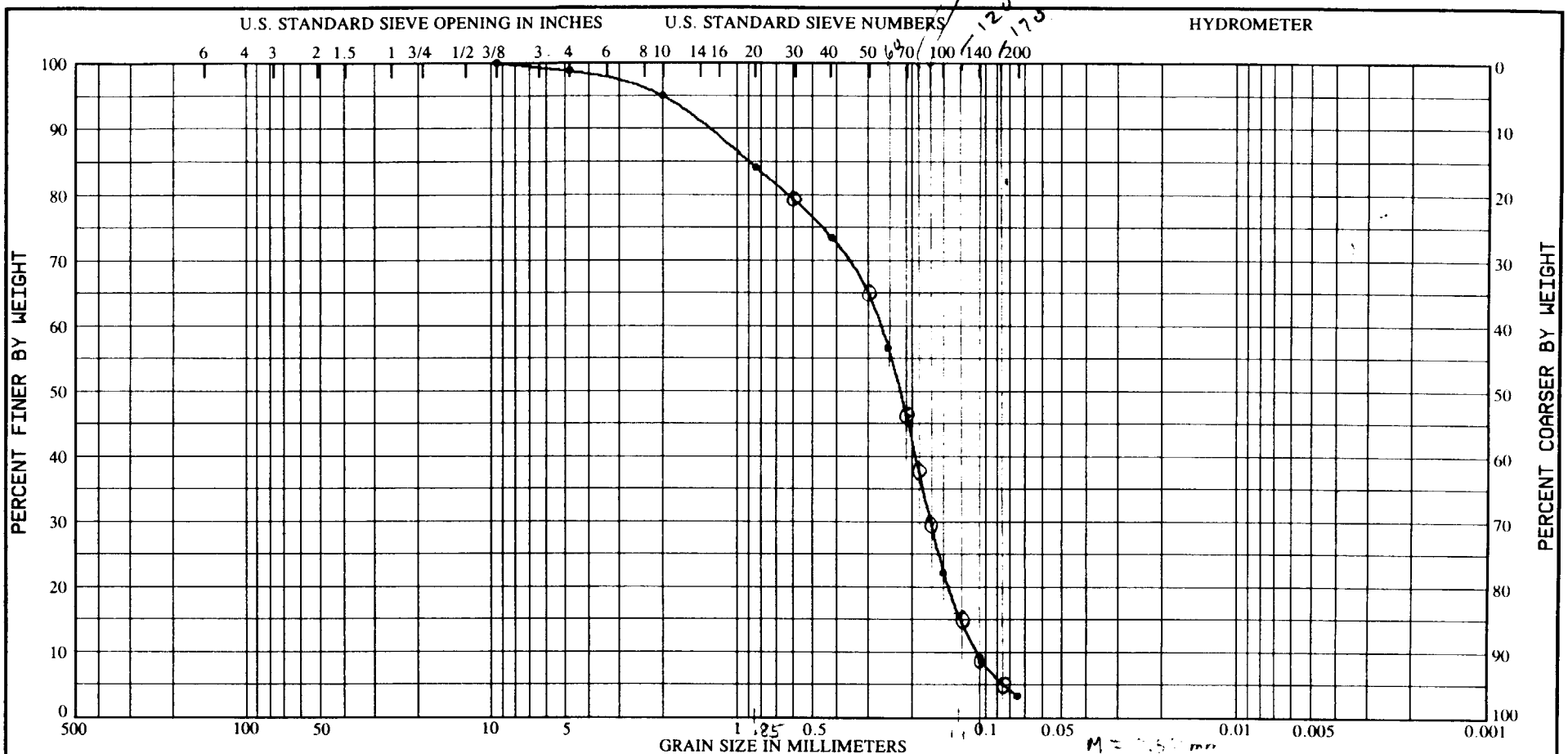
Date: *07/22/96* **LABORATORY LOG AND SAMPLE DATUM** Sheet No. *2* of *2*

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30060

WORK ORDER: 8015
REQUISITION: CENAP-EN-96-813



COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

Sample No.	Depth (Ft)	(VISUAL) Classification	Nat w%	LL	PL	PI
1	2.0-2.3	TAN, POORLY GRADED SAND (SP), WITH A TRACE OF GRAVEL SIZES				

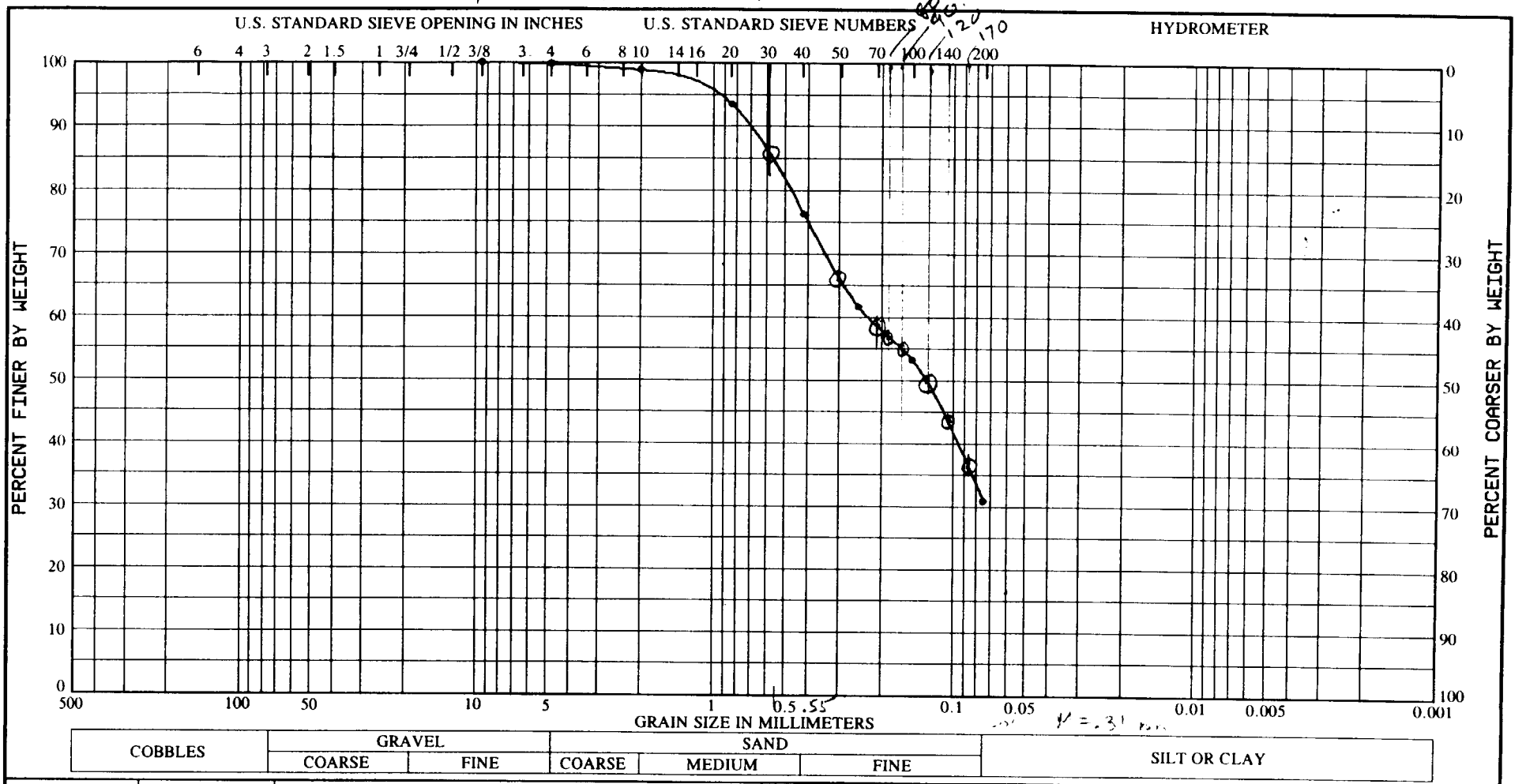
Project CAPE MAY
VIBRA-CORE SAMPLES
Lab No. 184/1259
Boring No. NJV-215
Date 07/19/96

GRADATION CURVES

OK

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30060

WORK ORDER: 8015
REQUISITION: CENAP-EN-96-813



COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

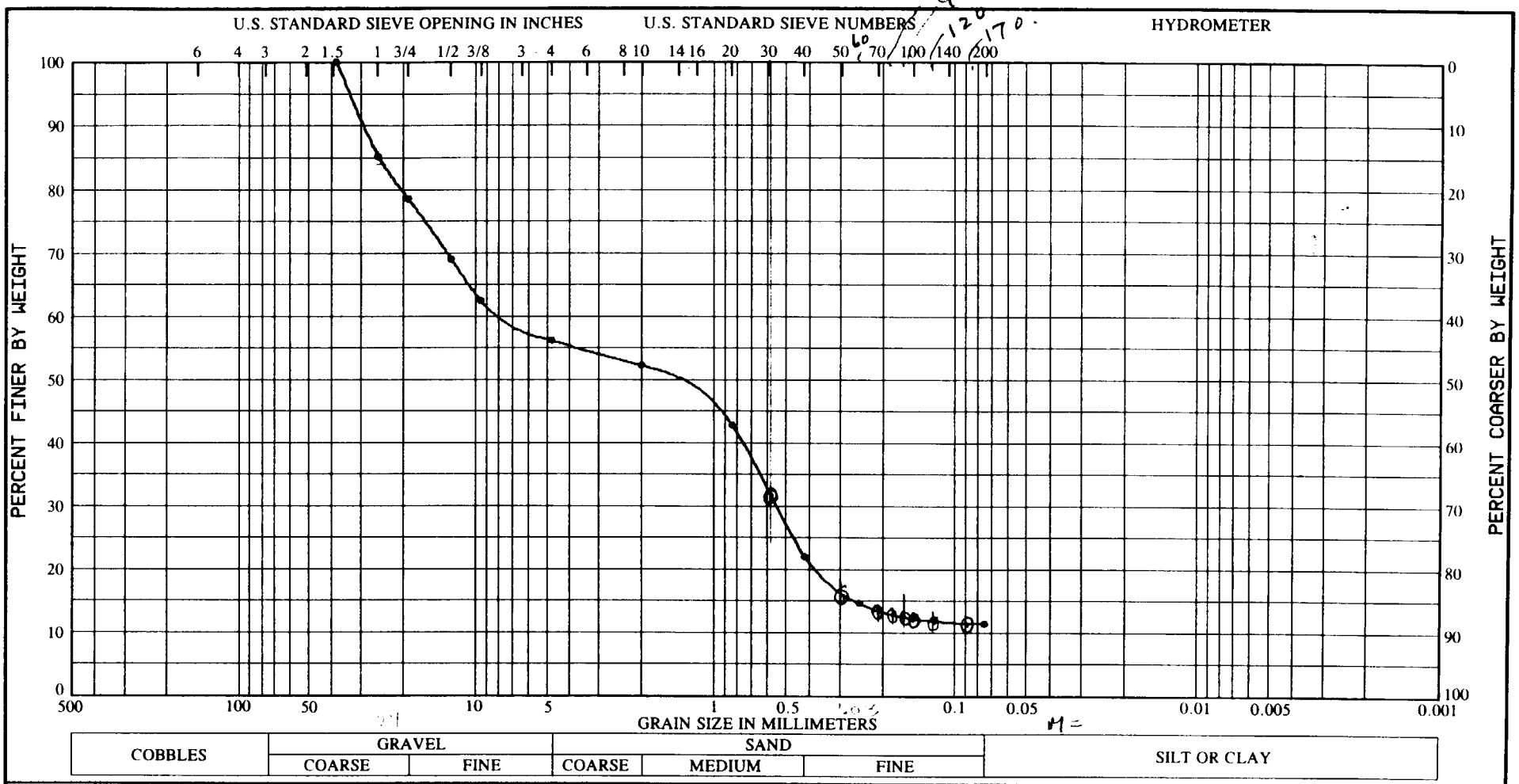
Sample No.	Depth (Ft)	(VISUAL) Classification	Nat w%	LL	PL	PI
2	6.0-6.2	GRAY, CLAYEY SAND (SC).				

Project CAPE MAY
VIBRA-CORE SAMPLES
Lab No. 184/1259
Boring No. NJV-215
Date 07/19/96

GRADATION CURVES

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30060

WORK ORDER: 8015
REQUISITION: CENAP-EN-96-813



COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

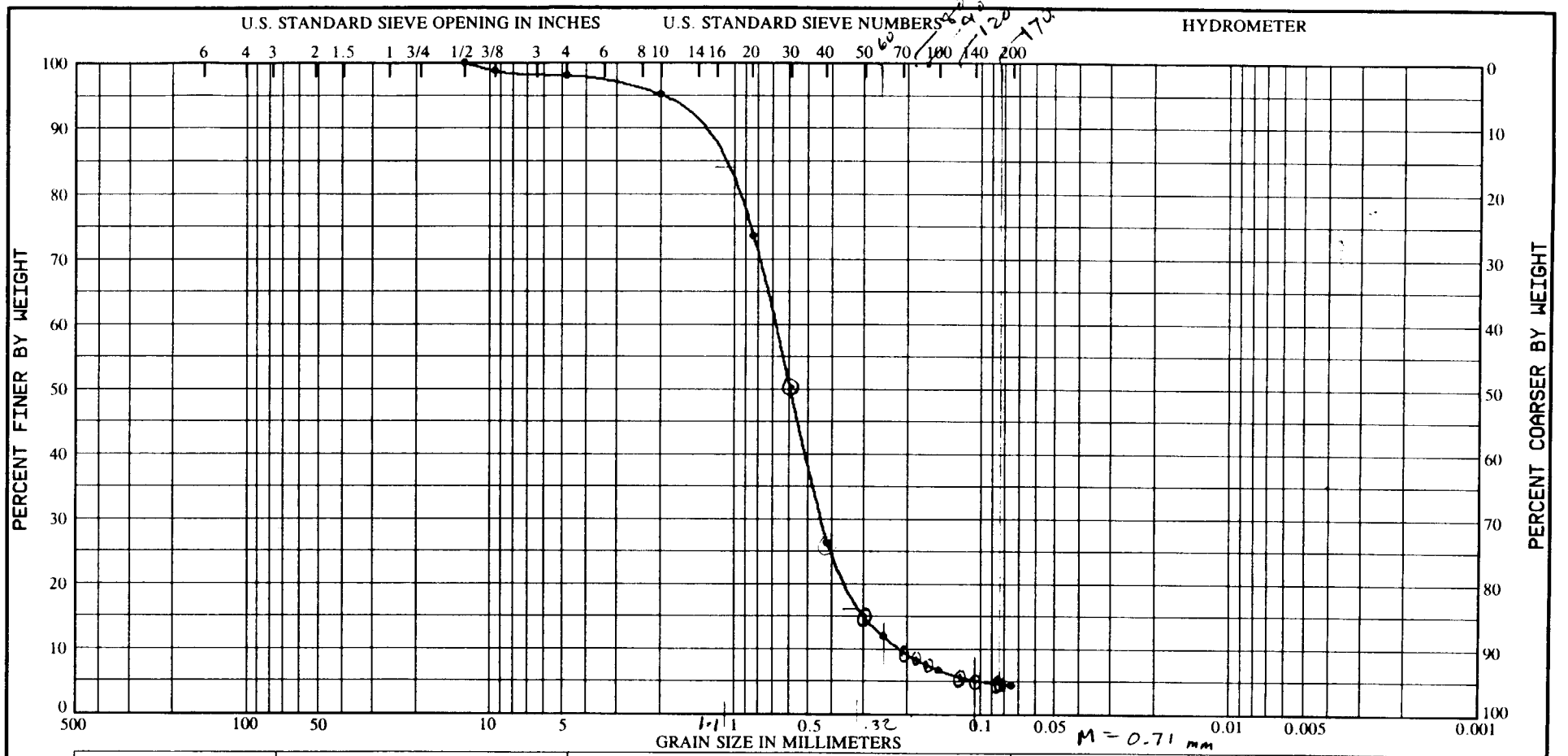
Sample No.	Depth (Ft)	(VISUAL) Classification	Nat w%	LL	PL	PI
3	9.4-9.9	GRAY, GRAVELLY POORLY GRADED SILTY SAND (SP-SM).				

Project CAPE MAY
VIBRA-CORE SAMPLES
Lab No. 184/1259
Boring No. NJV-215
Date 07/19/96

GRADATION CURVES

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30060

WORK ORDER: 8015
REQUISITION: CENAP-EN-96-813



Sample No.	Depth (Ft)	(VISUAL) Classification	Nat w%	LL	PL	PI
4	16.3-16.6	TANNISH GRAY, POORLY GRADED SAND (SP), WITH A TRACE OF GRAVEL SIZES.				

Project CAPE MAY
VIBRA-CORE SAMPLES
Lab No. 184/1259
Boring No. NJV-215
Date 07/19/96

GRADATION CURVES

OK

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DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30060

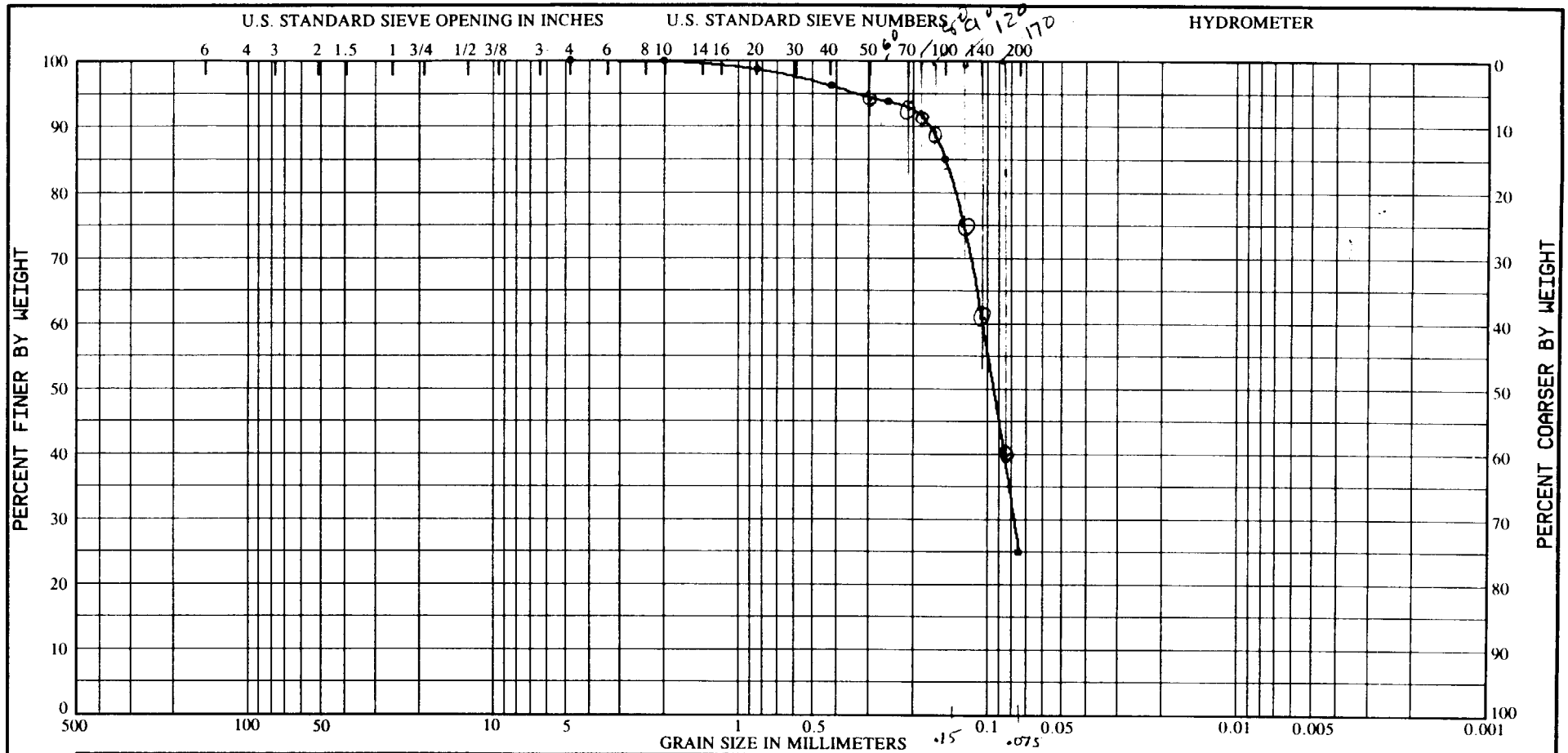
Project: *CAPE MAY*		Boring No. *NJV-216*
Location: *VIBRA-CORE SAMPLES*		Lab No. *184/1260*
Boring Depth (ft): *19.20*	Depth:	Work order: *8015*
Datum/Notes:		Requisition: *CENAP-EN-96-813*

Elev. (feet)	Depth (feet)	Leg-end	Material Description	Comments
				DEPTHS FROM TOP OF HOLE.
	1			
	2	NG	GRAY, SILTY SAND (SM).	SA, 2.0 - 2.3
	3			
	4	OK	GRAY, POORLY GRADED SAND (SP).	SA, 4.3 - 4.6
	5		GRAY, SILTY SAND (SM). SLIGHTLY PLASTIC	
	6			
	7			
	8			SA, 8.0 - 8.3
	9			
	10		GRAY, POORLY GRADED SAND (SP), WITH OCCASIONAL POCKETS OF POORLY GRADED SILTY SAND (SP-SM).	
	11			
	12			
	13			SA, 12.9 - 13.1
	14			
	15			
	16		GRAY, POORLY GRADED SILTY SAND (SP-SM), WITH A TRACE OF GRAVEL SIZES.	
	17			
	18	NG	GRAY, POORLY GRADED SAND (SP), WITH A TRACE OF GRAVEL SIZES AND POCKETS OF CLAYEY SAND (SC).	
	19			SA, 18.8 - 19.3

Date: *07/22/96* **LABORATORY LOG AND SAMPLE DATUM** Sheet No. *1* of *1*

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30060

WORK ORDER: 8015
REQUISITION: CENAP-EN-96-813



Sample No.	Depth (Ft)	(VISUAL) Classification	Nat w%	LL	PL	PI
1	2.0-2.3	GRAY, SILTY SAND (SM).				

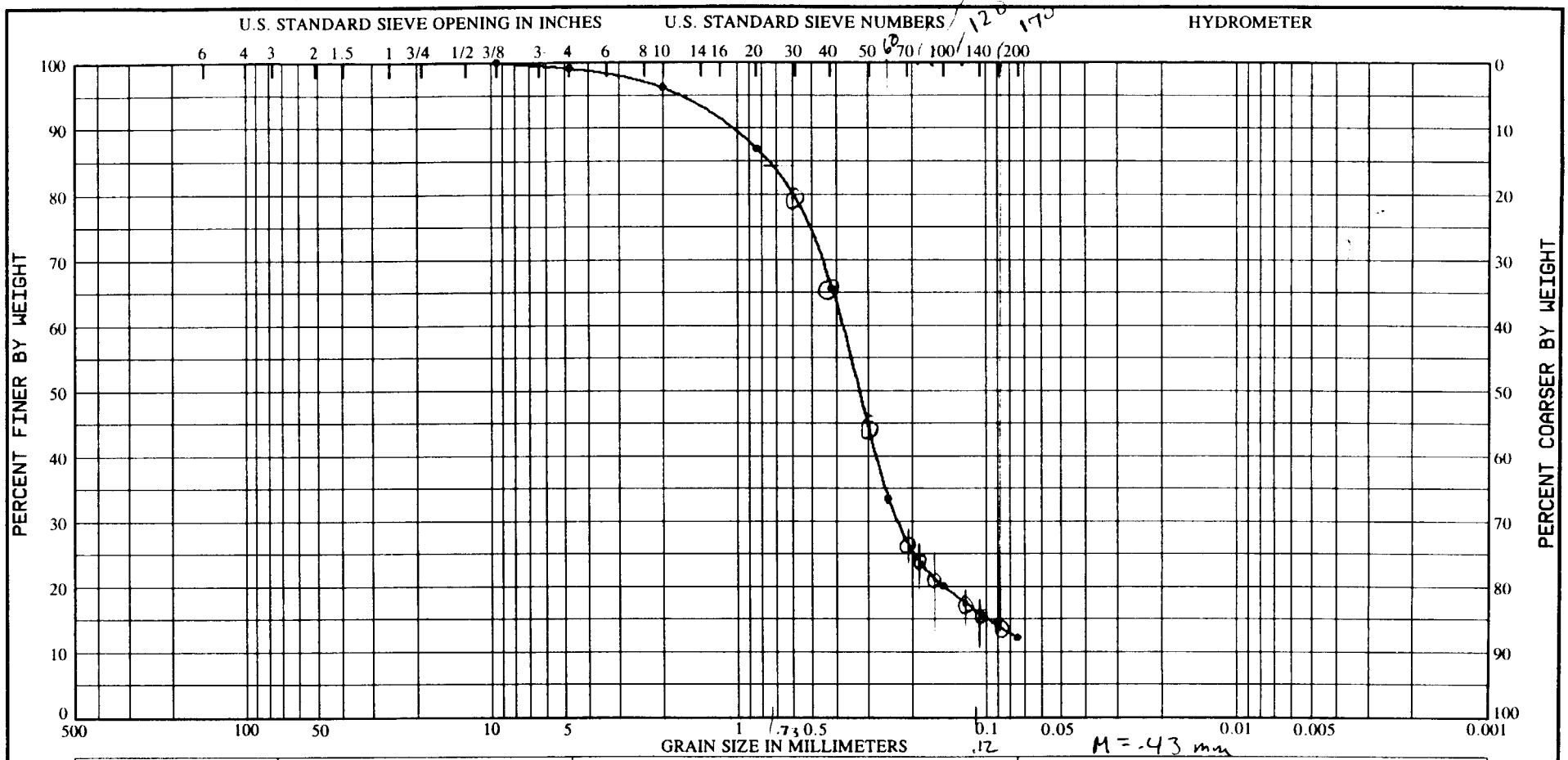
Project CAPE MAY
VIBRA-CORE SAMPLES
Lab No. 184/1260
Boring No. NJV-216
Date 07/19/96

GRADATION CURVES

Too fine

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30060

WORK ORDER: 8015
REQUISITION: CENAP-EN-96-813



COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

Sample No.	Depth (Ft)	(VISUAL) Classification	Nat w%	LL	PL	PI
2	4.3-4.6	GRAY, SILTY SAND (SM).				

Project CAPE MAY
VIBRA-CORE SAMPLES
Lab No. 184/1260
Boring No. NJV-216
Date 07/19/96

GRADATION CURVES

OK

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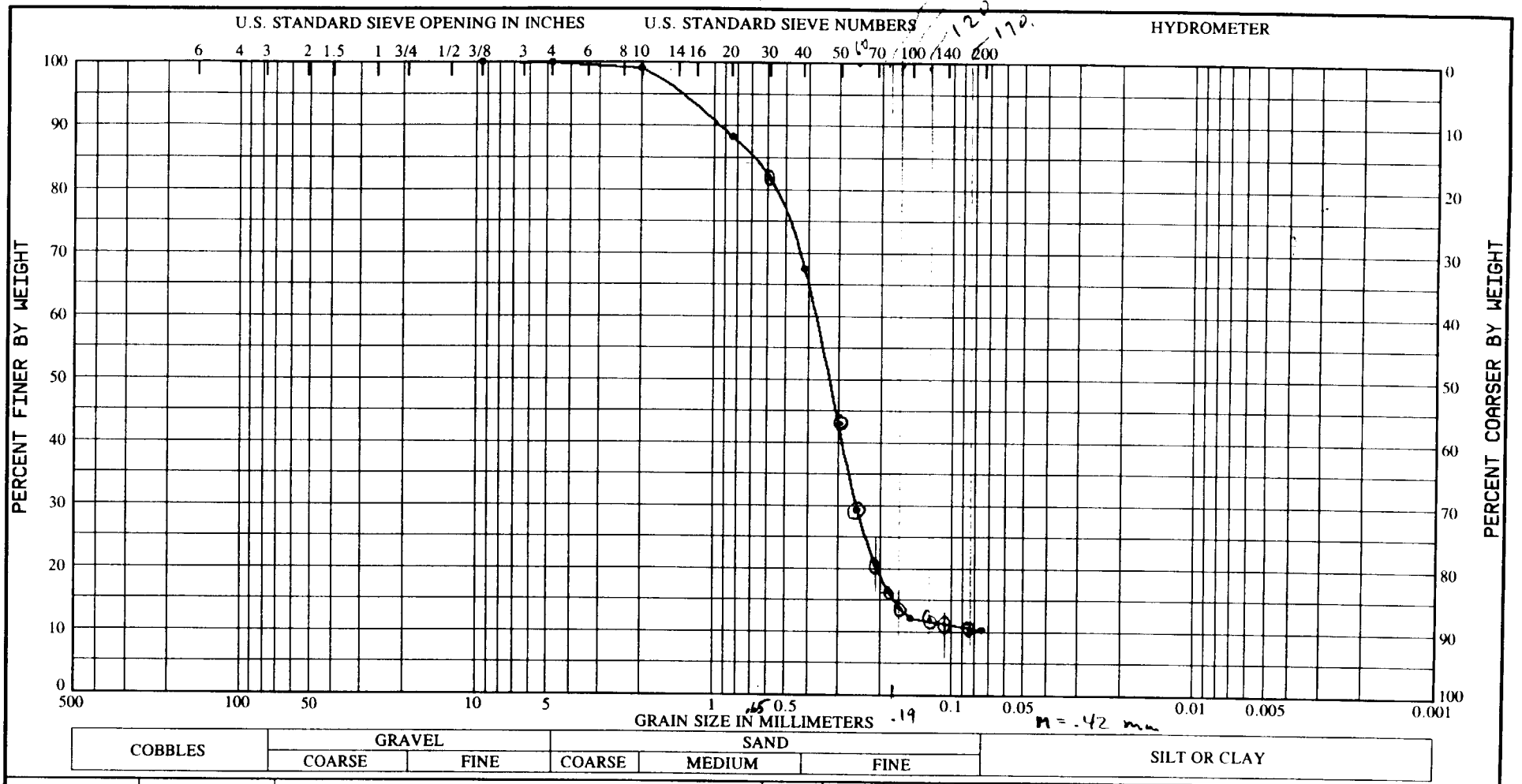
DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30060

WORK ORDER: 8015
REQUISITION: CENAP-EN-96-813



Sample No.	Depth (Ft)	(VISUAL) Classification	Nat w%	LL	PL	PI
3	8.0-8.3	GRAY, POORLY GRADED SILTY SAND (SP-SM).				

Project CAPE MAY
VIBRA-CORE SAMPLES
Lab No. 184/1260
Boring No. NJV-216
Date 07/19/96

GRADATION CURVES

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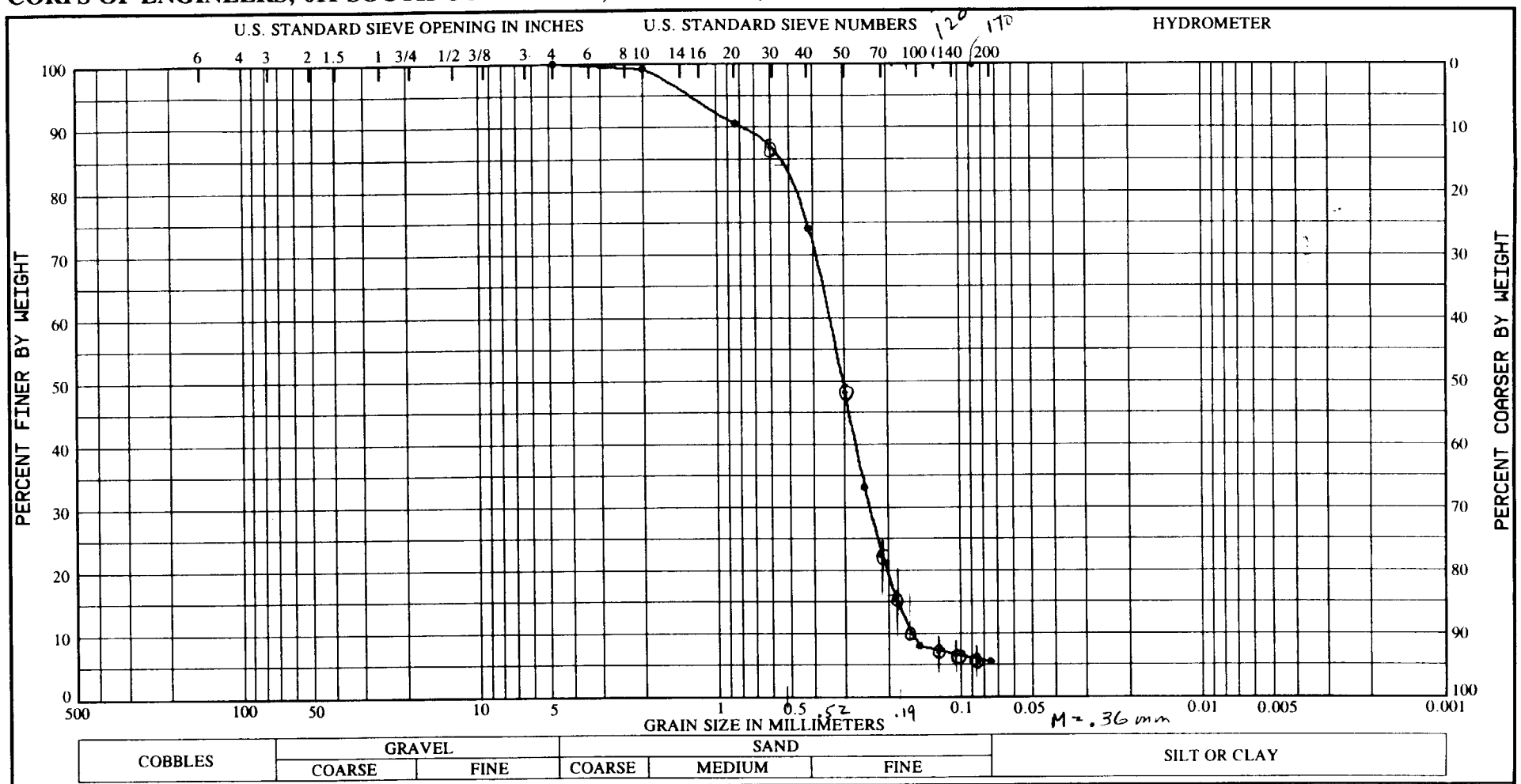
OK

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30060

WORK ORDER: 8015
REQUISITION: CENAP-EN-96-813



133

Sample No.	Depth (Ft)	(VISUAL) Classification	Nat w%	LL	PL	PI
4	12.9-13.1	TANNISH GRAY, POORLY GRADED SILTY SAND (SP-SM).				

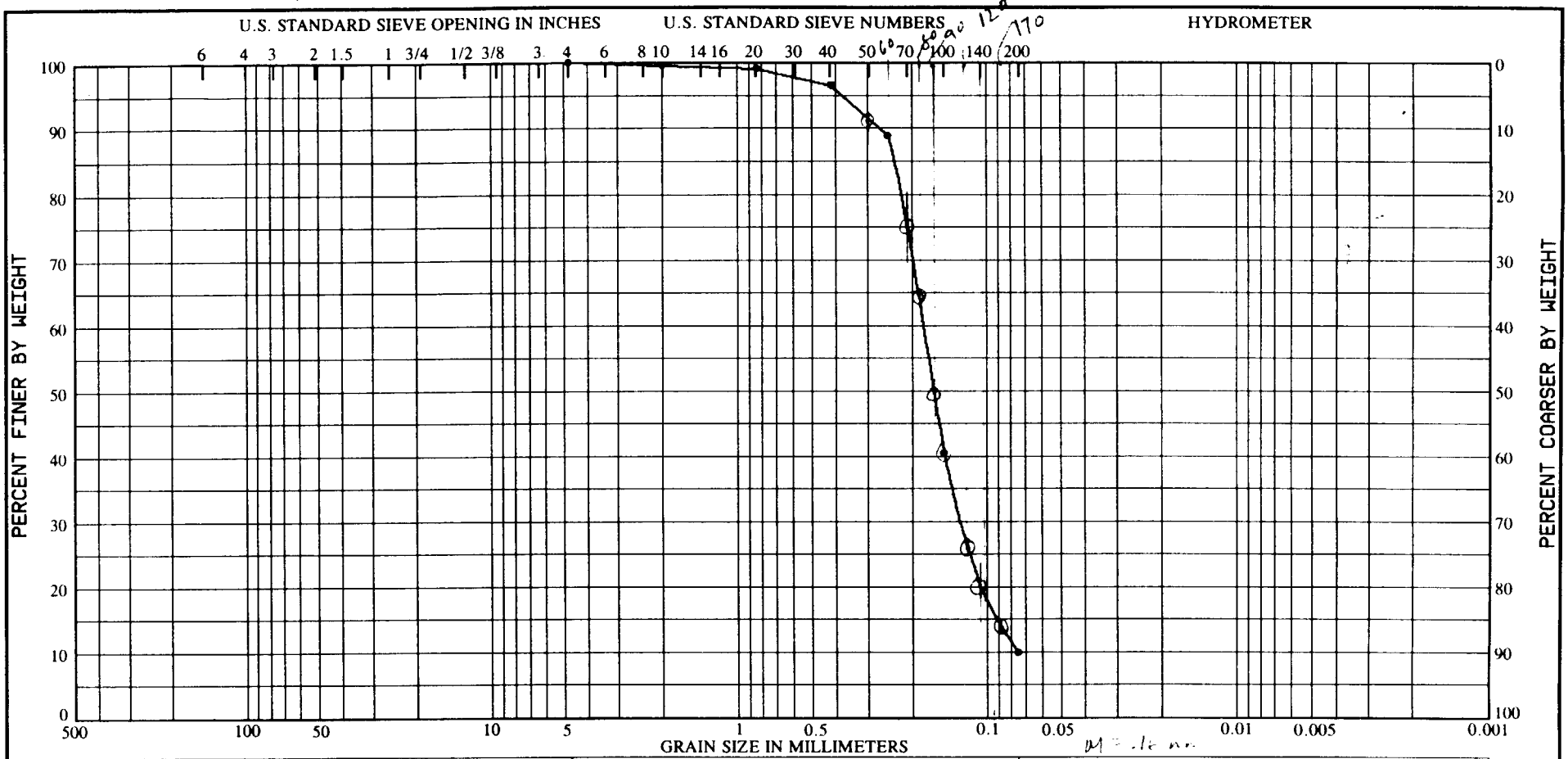
Project CAPE MAY
VIBRA-CORE SAMPLES
Lab No. 184/1260
Boring No. NJV-216
Date 07/19/96

GRADATION CURVES

OK

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30060

WORK ORDER: 8015
REQUISITION: CENAP-EN-96-813



COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

Sample No.	Depth (Ft)	(VISUAL) Classification	Nat w%	LL	PL	PI
5	18.8-19.3	GRAY, POORLY GRADED SILTY SAND (SP-SM).				

Project CAPE MAY
VIBRA-CORE SAMPLES
Lab No. 184/1260
Boring No. NJV-216
Date 07/22/96

GRADATION CURVES

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DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30060

Project: *CAPE MAY*		Boring No. *NJV-217*
Location: *VIBRA-CORE SAMPLES*		Lab No. *184/1261*
Boring Depth (ft): *20.00*	Depth:	Work order: *8015*
Datum/Notes:		Requisition: *CENAP-EN-96-813*

Elev. (feet)	Depth (feet)	Leg-end	Material Description	Comments
				DEPTHS FROM TOP OF HOLE.
	1		GRAY, POORLY GRADED SAND (SP), WITH A TRACE OF GRAVEL SIZES AND SHELL FRAGMENTS.	SA, 0.8 - 1.0
	2		GRAY, POORLY GRADED SILTY SAND (SP-SM), WITH POCKETS OF FAT CLAY (CH), AND GRAVEL SIZES AND SHELL FRAGMENTS.	SA, 2.1 - 2.4
	3			
	4			
	5	NG		
	6			
	7			SA, 7.0 - 7.2
	8			
	9			
	10		GRAY, SILTY FAT CLAY (CH), WITH A TRACE OF SAND SIZES AND MICA.	
	11			
	12			
	13			
	14			
	15			
	16			SA, 16.2 - 16.5
	17			
	18			
	19		GRAY, SILTY FAT CLAY (CH), WITH FINE SAND LENSES.	

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30060

Project: *CAPE MAY*		Boring No. *NJV-217*
Location: *VIBRA-CORE SAMPLES*		Lab No. *184/1261*
Boring Depth (ft): *20.00*	Depth:	Work order: *8015*
Datum/Notes:		Requisition: *CENAP-EN-96-813*

Elev. (feet)	Depth (feet)	Leg-end	Material Description	Comments
	21			
	22			
	23			
	24			
	25			
	26			
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	29			
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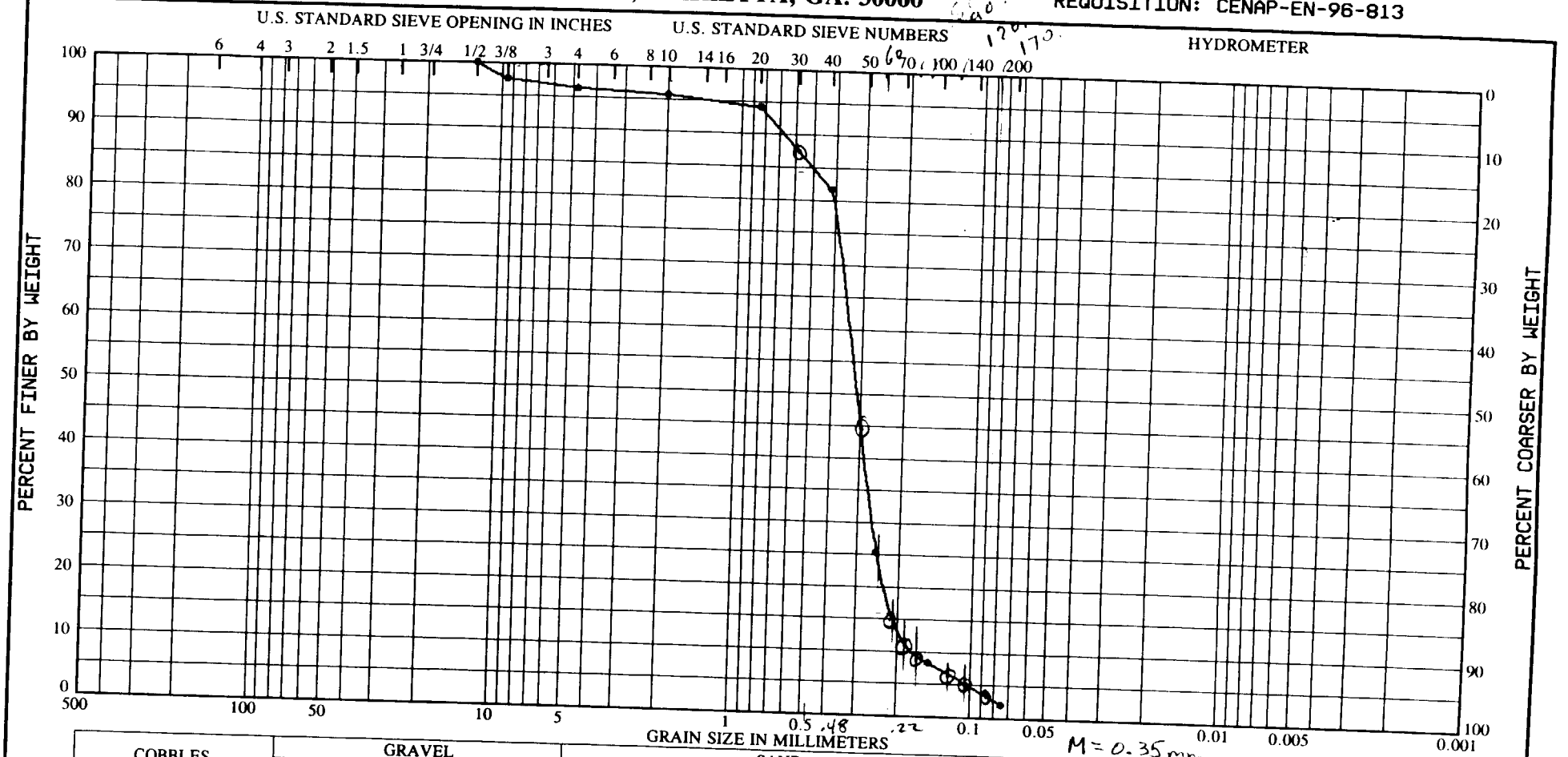
	38			
	39			

Date: *07/22/96* **LABORATORY LOG AND SAMPLE DATUM** Sheet No. *2* of *2*

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30060

WORK ORDER: 8015
REQUISITION: CENAP-EN-96-813



COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

Sample No.	Depth (Ft)	(VISUAL) Classification	Nat w%	LL	PL	PI
1	0.8-1.0	GRAY, POORLY GRADED SAND (SP), WITH A TRACE OF GRAVEL SIZES AND SHELL FRAGMENTS.				

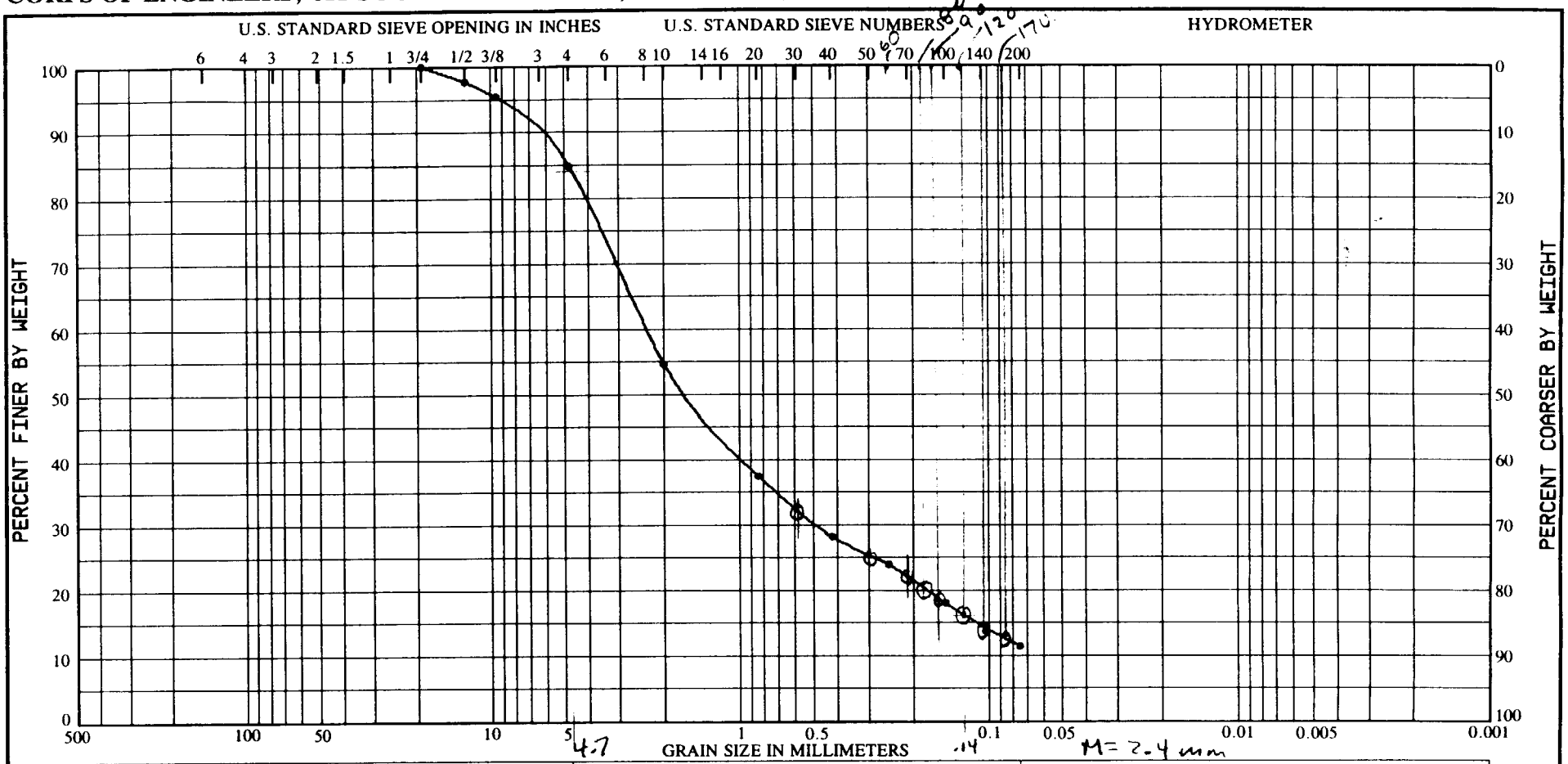
Project CAPE MAY
VIBRA-CORE SAMPLES
Lab No. 184/1261
Boring No. NJV-217
Date 07/22/96

GRADATION CURVES

137

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30060

WORK ORDER: 8015
REQUISITION: CENAP-EN-96-813



COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

Sample No.	Depth (Ft)	(VISUAL) Classification	Nat w%	LL	PL	PI
2	2.1-2.4	GRAY, POORLY GRADED SILTY SAND (SP-SM), WITH PLASTIC FINES AND A LITTLE GRAVEL SIZES.				

Project CAPE MAY
VIBRA-CORE SAMPLES
Lab No. 184/1261
Boring No. NJV-217
Date 07/30/96

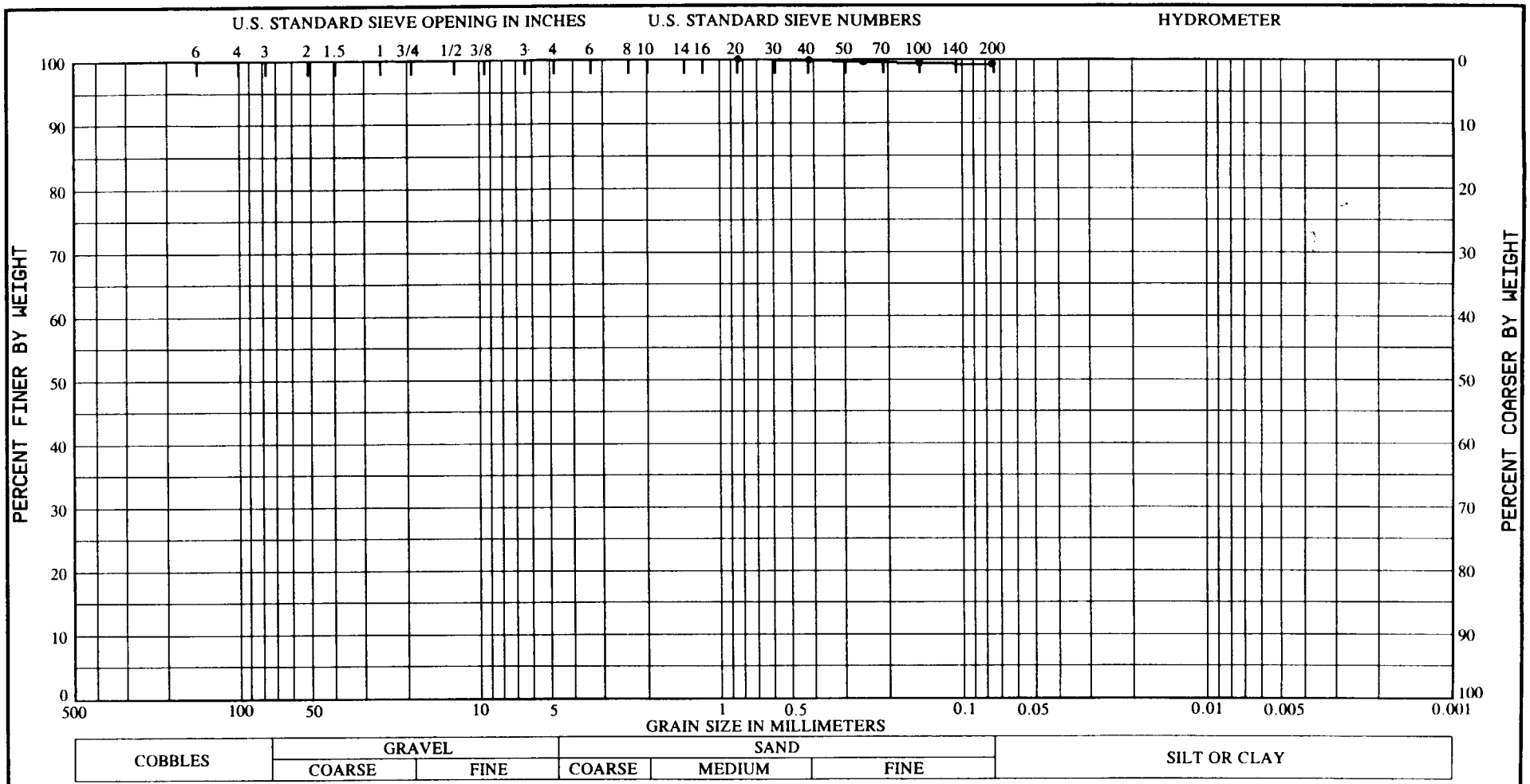
GRADATION CURVES

138

Too Coarse

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30060

WORK ORDER: 8015
REQUISITION: CENAP-EN-96-813



Sample No.	Depth (Ft)	(VISUAL) Classification	Nat w%	LL	PL	PI
3	7.0-7.2	GRAY, SILTY FAT CLAY (CH).				

Project CAPE MAY
VIBRA-CORE SAMPLES
Lab No. 184/1261
Boring No. NJV-217
Date 07/22/96

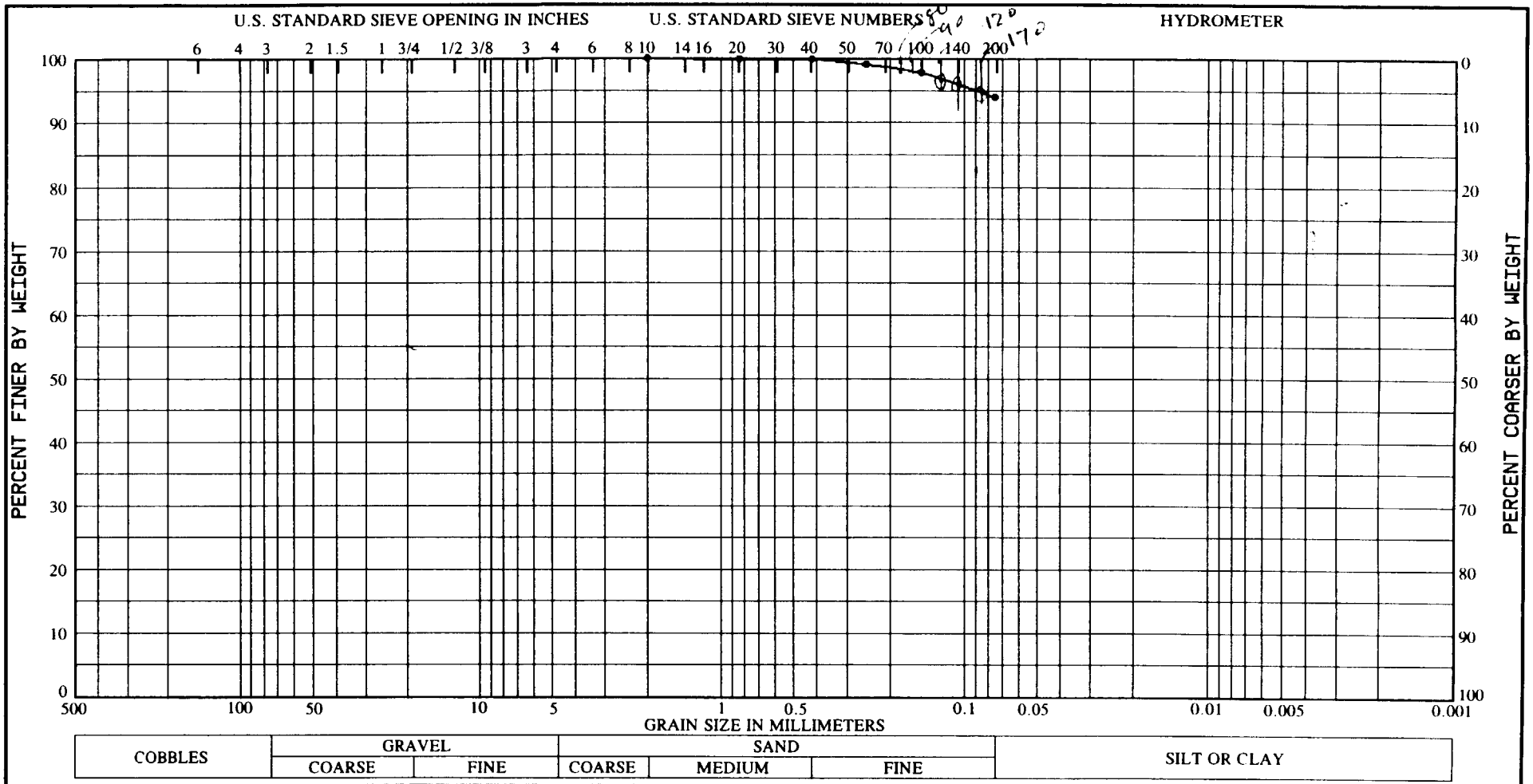
GRADATION CURVES

139

Tox Fine

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30060

WORK ORDER: 8015
REQUISITION: CENAP-EN-96-813



COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

Sample No.	Depth (Ft)	(VISUAL) Classification	Nat w%	LL	PL	PI
4	16.2-16.5	GRAY, SILTY FAT CLAY (CH), WITH A TRACE OF SAND SIZES AND MICA.				

Project CAPE MAY
VIBRA-CORE SAMPLES
Lab No. 184/1261
Boring No. NJV-217
Date 07/22/96

GRADATION CURVES

too fine

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30060

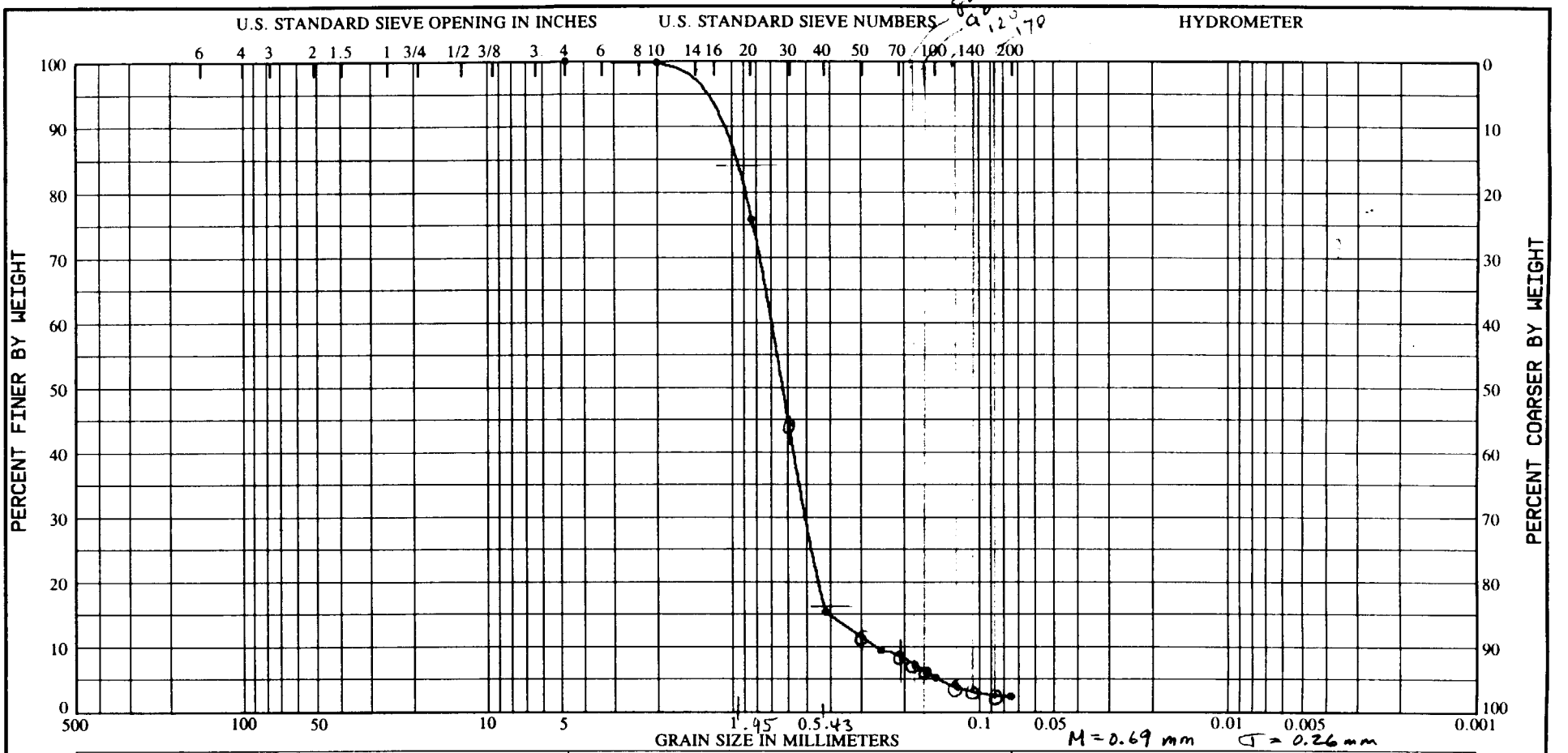
Project: *CAPE MAY*		Boring No. *NJV-218*
Location: *VIBRA-CORE SAMPLES*		Lab No. *184/1262*
Boring Depth (ft): *15.00*	Depth:	Work order: *8015*
Datum/Notes:		Requisition: *CENAP-EN-96-813*

Elev. (feet)	Depth (feet)	Leg-end	Material Description	Comments
		OK ?	TAN, POORLY GRADED SAND (SP), WITH A TRACE OF SHELL FRAGMENTS.	DEPTHS FROM TOP OF HOLE.
	1		GRAY, INORGANIC SILT LOW LL (ML), WITH ORGANIC MATTER.	
	2	M=.69 mm	TAN, POORLY GRADED SAND (SP), WITH A TRACE OF GRAVEL SIZES AND SHELL FRAGMENTS.	SA, 2.2 - 2.5
	3	?	GRAY, CLAYEY SAND (SC).	
	4	OK ?	TAN, POORLY GRADED SAND (SP). PLASTIC FINES.	
	5		GRAY, POORLY GRADED SAND (SP), WITH POCKETS OF CLAYEY SAND (SC).	
	6	OK	TAN, POORLY GRADED SAND (SP).	SA, 6.2 - 6.8 Too Coarse
	7		TAN, GRAVELLY POORLY GRADED SAND (SP).	
	8			
	9	M=.62 mm		SA, 9.5 - 9.8
	10	OK		
	11		TAN, POORLY GRADED SILTY SAND (SP-SM), WITH OCCASIONAL GRAVEL SIZES.	
	12			
	13	M=.42 mm		SA, 12.9 - 13.1
	14			
	15			
	16			
	17			
	18			
	19			

Date: *07/22/96* **LABORATORY LOG AND SAMPLE DATUM** Sheet No. *1* of *1*

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30060

WORK ORDER: 8015
REQUISITION: CENAP-EN-96-813



COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

Sample No.	Depth (Ft)	(VISUAL) Classification	Nat w%	LL	PL	PI
1	2.2-2.5	TAN, POORLY GRADED SAND (SP).				

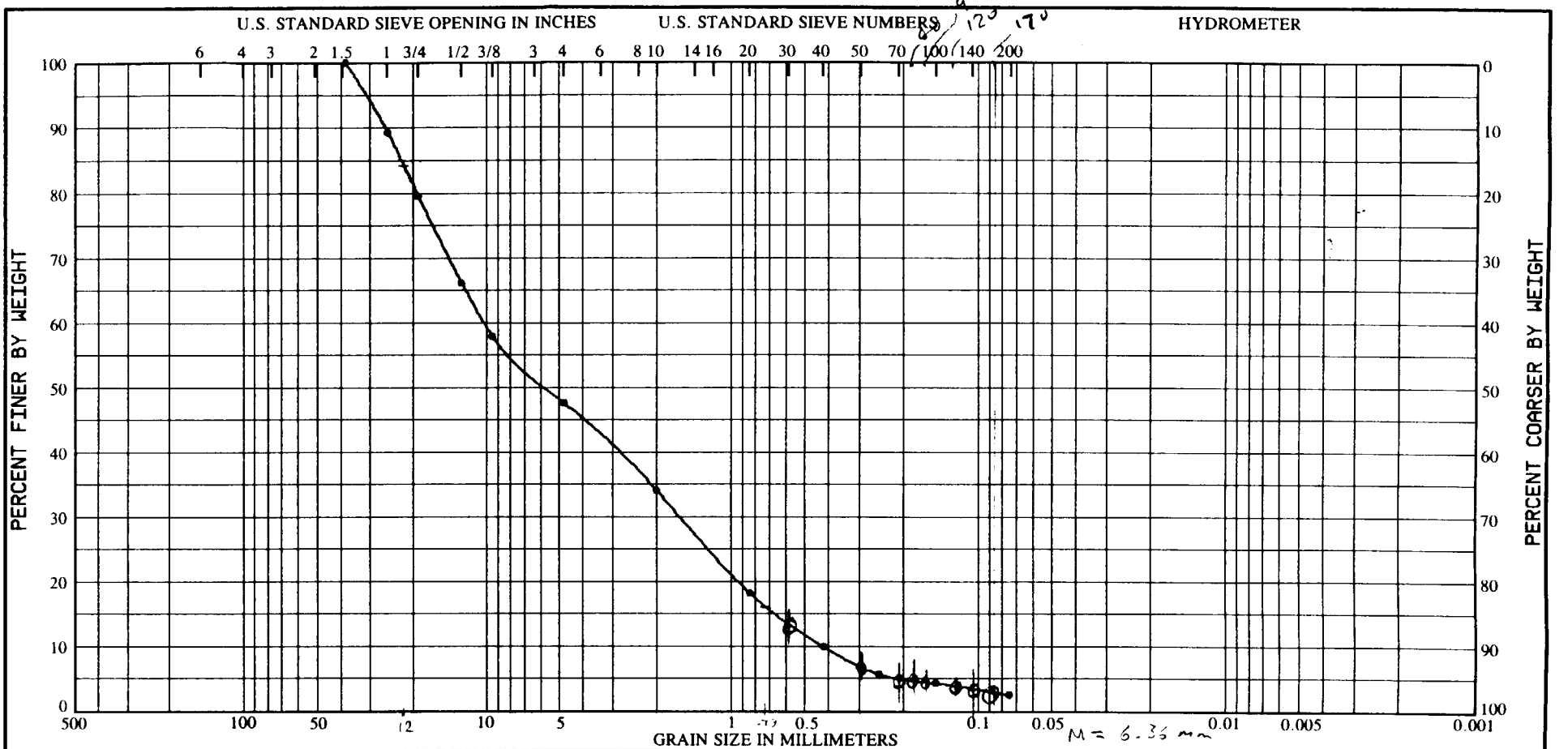
Project CAPE MAY
VIBRA-CORE SAMPLES
Lab No. 184/1262
Boring No. NJV-218
Date 07/30/96

GRADATION CURVES

OK

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30060

WORK ORDER: 8015
REQUISITION: CENAP-EN-96-813



COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

Sample No.	Depth (Ft)	(VISUAL) Classification	Nat w%	LL	PL	PI
2	6.2-6.8	TAN, SANDY POORLY GRADED GRAVEL (GP), WITH A TRACE OF MICA.				

Project CAPE MAY
VIBRA-CORE SAMPLES
Lab No. 184/1262
Boring No. NJV-218
Date 07/22/96

GRADATION CURVES

OK for wetlands fill (non recreational)

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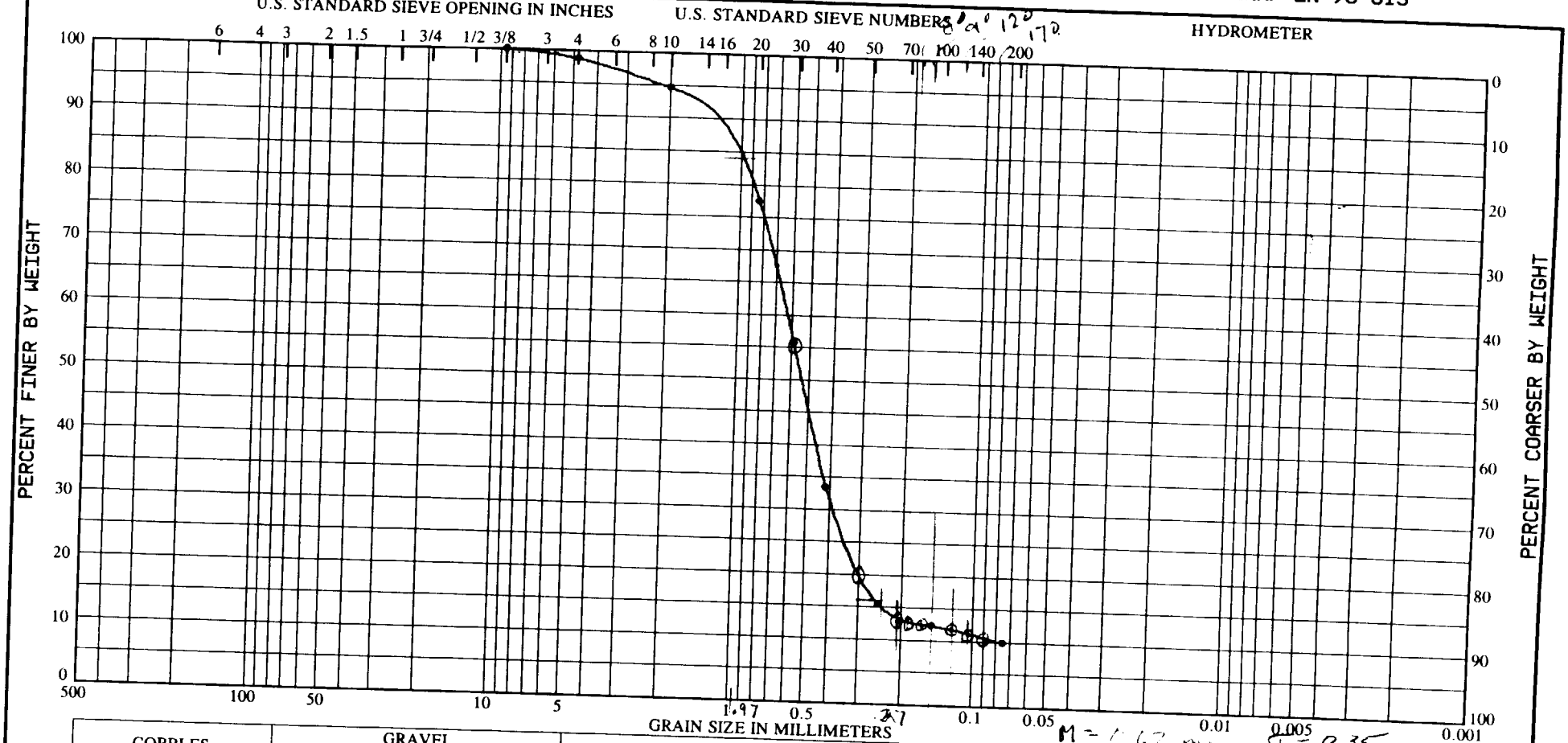
DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30060

WORK ORDER: 8015
REQUISITION: CENAP-EN-96-813



COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

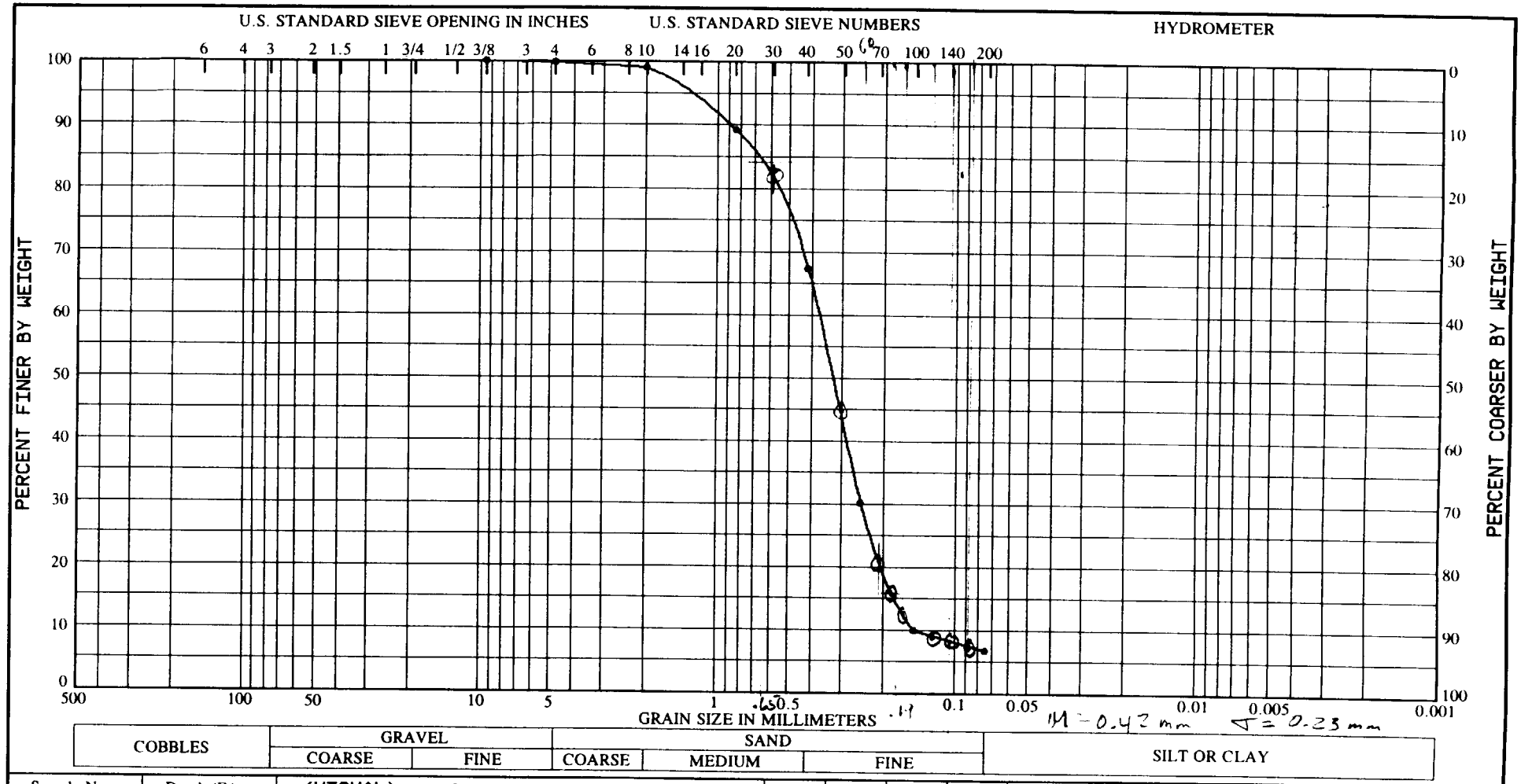
Sample No.	Depth (Ft)	(VISUAL) Classification	Nat w%	LL	PL	PI
3	9.5-9.8	TAN, POORLY GRADED SILTY SAND (SP-SM), WITH A TRACE OF GRAVEL SIZES.				

Project CAPE MAY
VIBRA-CORE SAMPLES
Lab No. 184/1262
Boring No. NJV-218
Date 07/22/96

GRADATION CURVES

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30060

WORK ORDER: 8015
REQUISITION: CENAP-EN-96-813



COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

Sample No.	Depth (Ft)	(VISUAL) Classification	Nat w%	LL	PL	PI
4	12.9-13.1	TAN, POORLY GRADED SILTY SAND (SP-SM).				

Project CAPE MAY
VIBRA-CORE SAMPLES
Lab No. 184/1262
Boring No. NJV-218
Date 07/22/96

GRADATION CURVES

OK

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30060

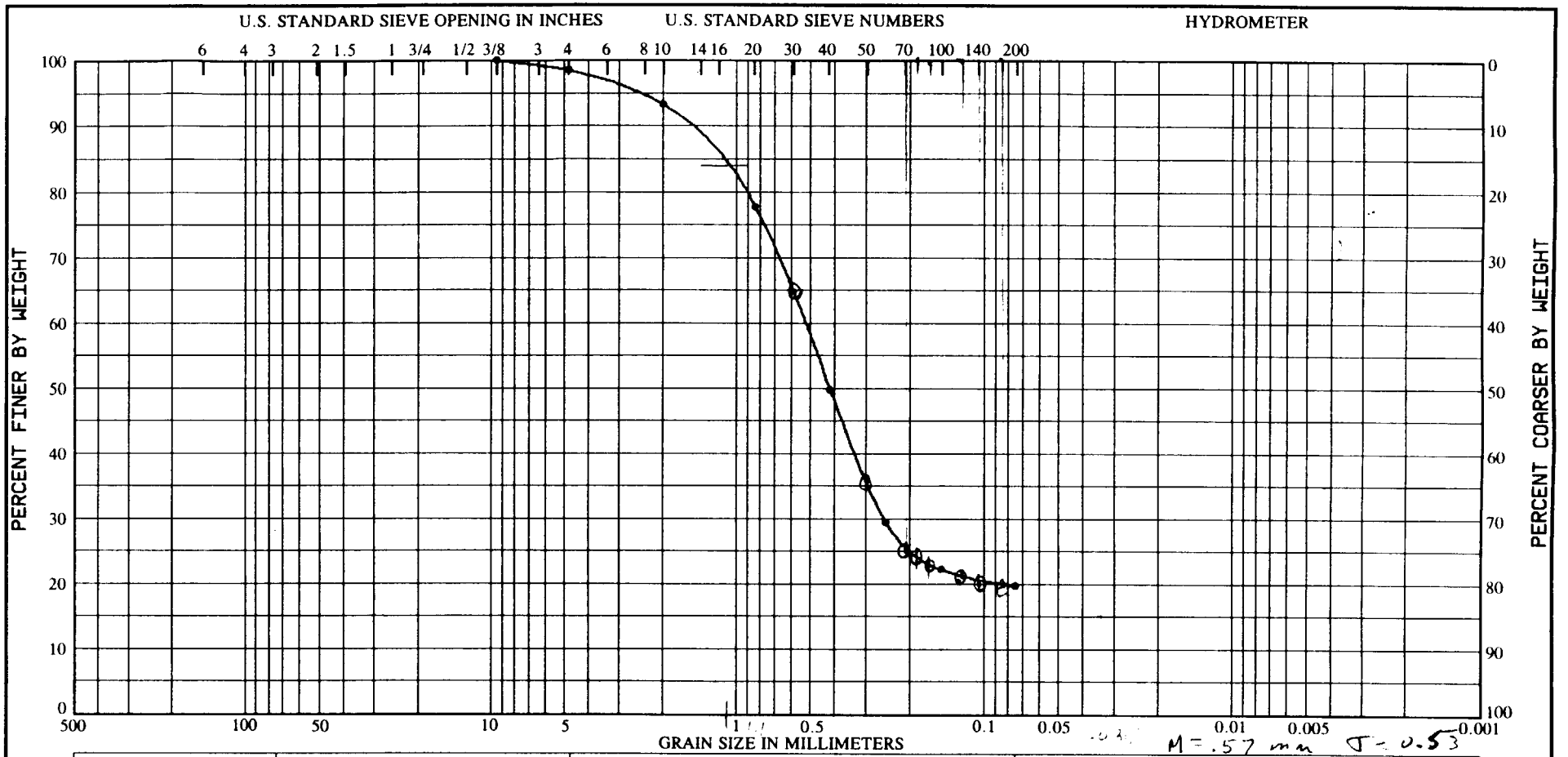
Project: *CAPE MAY*		Boring No. *NJV-219*
Location: *VIBRA-CORE SAMPLES*		Lab No. *184/1263*
Boring Depth (ft): *16.10*	Depth:	Work order: *8015*
Datum/Notes:		Requisition: *CENAP-EN-96-813*

Elev. (feet)	Depth (feet)	Leg-end	Material Description	Comments
	1		GRAY, POORLY GRADED SAND (SP), WITH A TRACE GRAVEL SIZES AND SHELL FRAGMENTS.	DEPTHS FROM TOP OF HOLE.
	2			SA, 1.9 - 2.2
	3		GRAY, CLAYEY SAND (SC), WITH A TRACE OF GRAVEL SIZES.	
	4	OK		
	5			
	6			SA, 6.0 - 6.3
	7			
	8			
	9			
	10		GRAY & TANNISH GRAY, POORLY GRADED SAND (SP), WITH POCKETS OF CLAYEY SAND (SC) AND A TRACE OF GRAVEL SIZES AND MICA.	
	11			SA, 10.5 - 10.7
	12			
	13			
	14			SA, 14.0 - 14.3
	15			
	16			
	17			
	18			
	19			

Date: *07/30/96* **LABORATORY LOG AND SAMPLE DATUM** Sheet No. *1* of *1*

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30060

WORK ORDER: 8015
REQUISITION: CENAP-EN-96-813



COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

Sample No.	Depth (Ft)	(VISUAL) Classification	Nat w%	LL	PL	PI
1	1.9-2.2	GRAY, CLAYEY SAND (SC), WITH A TRACE OF GRAVEL SIZES.				

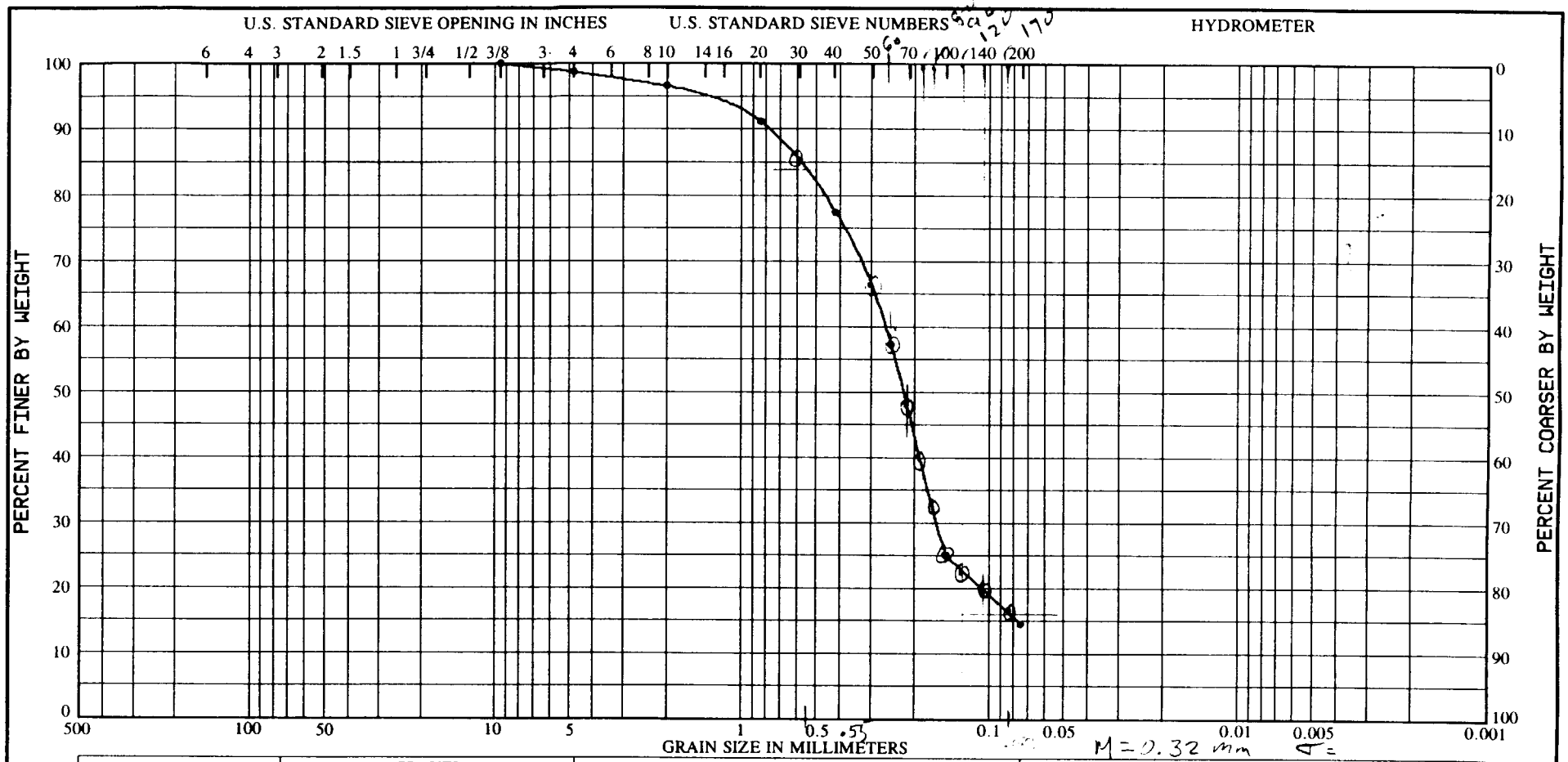
Project CAPE MAY
VIBRA-CORE SAMPLES
Lab No. 184/1263
Boring No. NJV-219
Date 07/22/96

GRADATION CURVES

OK

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30060

WORK ORDER: 8015
REQUISITION: CENAP-EN-96-813



COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

Sample No.	Depth (Ft)	(VISUAL) Classification	Nat w%	LL	PL	PI
2	6.0-6.3	GRAY & TANNISH GRAY, CLAYEY SAND (SC), WITH A TRACE OF GRAVEL SIZES.				

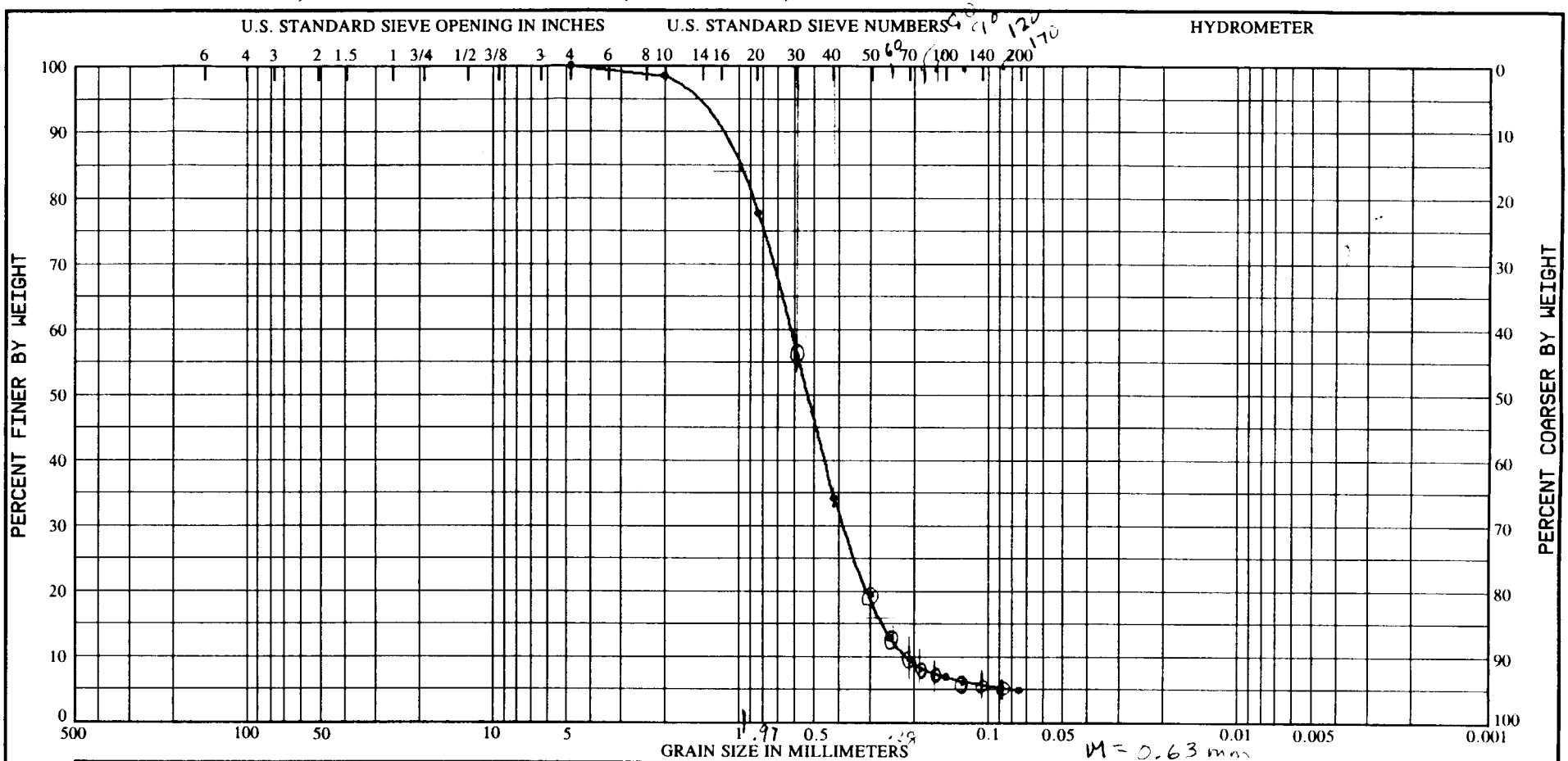
Project CAPE MAY
VIBRA-CORE SAMPLES
Lab No. 184/1263
Boring No. NJV-219
Date 07/22/96

GRADATION CURVES

OK

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30060

WORK ORDER: 8015
REQUISITION: CENAP-EN-96-813



COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

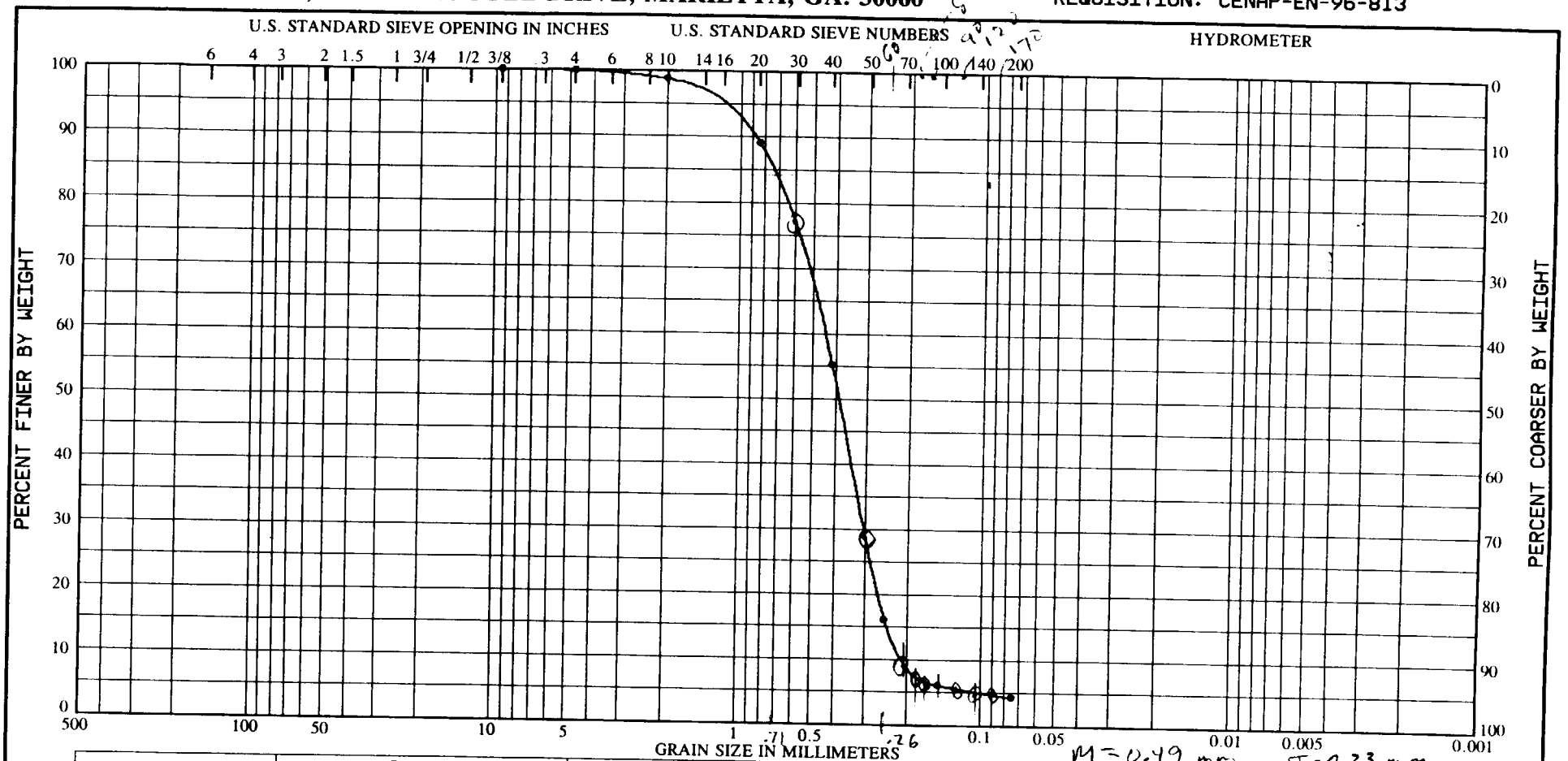
Sample No.	Depth (Ft)	(VISUAL) Classification	Nat w%	LL	PL	PI
3	10.5-10.7	GRAY & TANNISH GRAY, POORLY GRADED SILTY SAND (SP-SM), WITH A TRACE OF MICA.				

Project CAPE MAY
VIBRA-CORE SAMPLES
Lab No. 184/1263
Boring No. NJV-219
Date 07/22/96

GRADATION CURVES

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30060

WORK ORDER: 8015
REQUISITION: CENAP-EN-96-813



COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

Sample No.	Depth (Ft)	(VISUAL) Classification	Nat w%	LL	PL	PI
4	14.0-14.3	GRAY & TANNISH GRAY, POORLY GRADED SAND (SP).				

Project CAPE MAY
VIBRA-CORE SAMPLES
Lab No. 184/1263
Boring No. NJV-219
Date 07/22/96

GRADATION CURVES

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30060

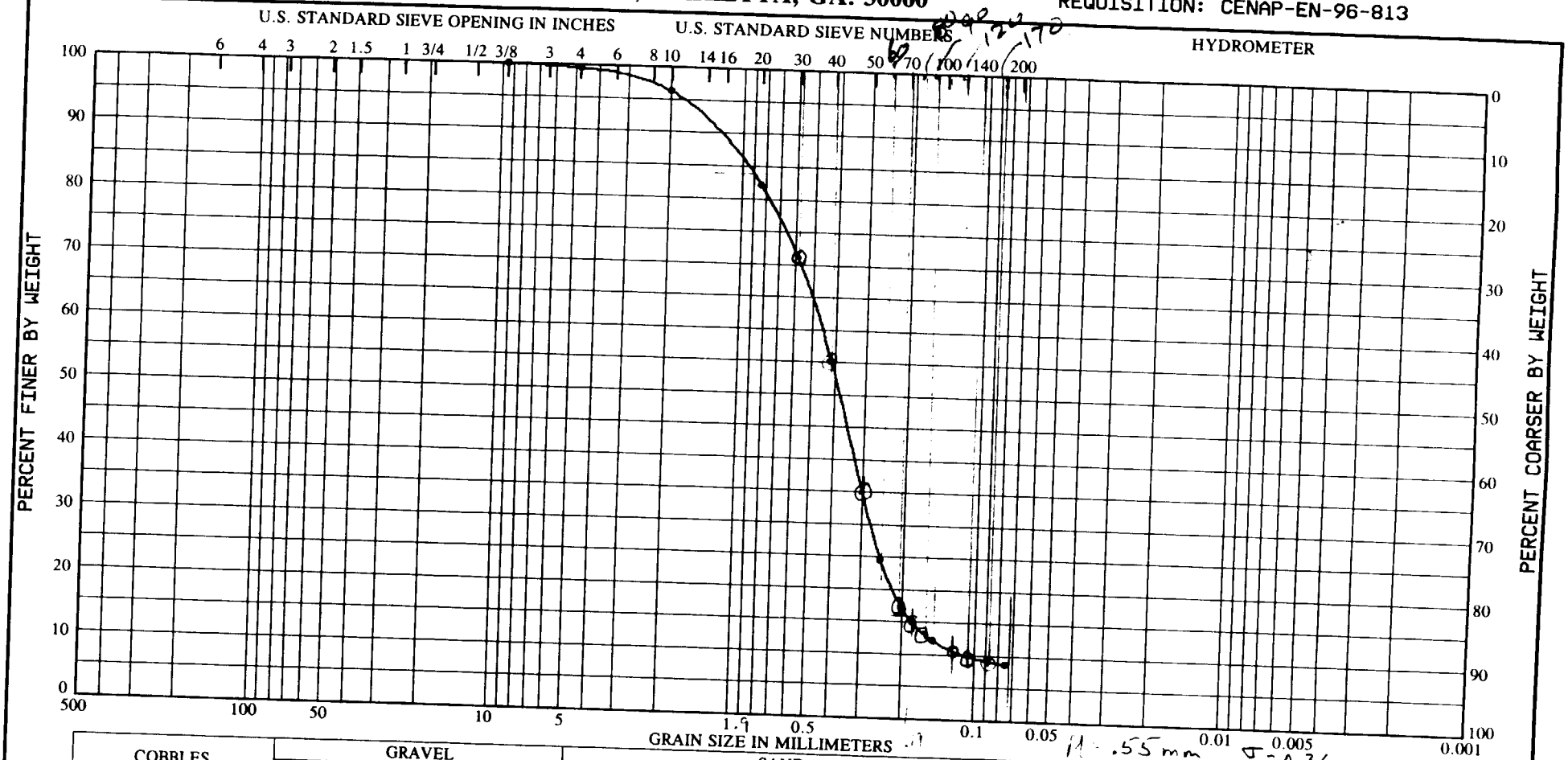
Project: *CAPE MAY*		Boring No. *NJV-220*
Location: *VIBRA-CORE SAMPLES*		Lab No. *184/1264*
Boring Depth (ft): *19.50*	Depth:	Work order: *8015*
Datum/Notes:		Requisition: *CENAP-EN-96-813*

Elev. (feet)	Depth (feet)	Legend	Material Description	Comments
				DEPTHS FROM TOP OF HOLE.
	1		TAN & GRAY, MIXTURE OF POORLY GRADED SAND (SP) & CLAYEY SAND (SC), WITH A TRACE OF GRAVEL SIZES.	
	2		----------	
	3	OK	TAN & GRAY, POORLY GRADED SAND (SP), WITH POCKETS OF CLAYEY SAND (SC).	SA, 3.0 - 3.3
	4	M=.55 mm	----------	
	5			
	6	OK	TAN, POORLY GRADED SILTY SAND (SP-SM). ----------	
	7	Coarse		SA, 7.0 - 7.5
	8	1.38 mm	TAN, POORLY GRADED SILTY SAND (SP-SM), WITH A LITTLE GRAVEL SIZES.	
	9	OK		
	10		----------	
	11			
	12	OK		
	13			SA, 13.0 - 13.3
	14			
	15		TAN & GRAY, POORLY GRADED SILTY SAND (SP-SM), WITH A TRACE OF GRAVEL SIZES.	
	16			
	17			SA, 17.0 - 17.3
	18			
	19		----------	

Date: *07/22/96* **LABORATORY LOG AND SAMPLE DATUM** Sheet No. *1* of *1*

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30060

WORK ORDER: 8015
REQUISITION: CENAP-EN-96-813



COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

Sample No.	Depth (Ft)	(VISUAL) Classification	Nat w%	LL	PL	PI
1	3.0-3.3	TAN & GRAY, POORLY GRADED SILTY SAND (SP-SM), WITH A TRACE OF MICA.				

Project CAPE MAY
VIBRA-CORE SAMPLES
Lab No. 184/1264
Boring No. NJV-220
Date 07/22/96

GRADATION CURVES

OK

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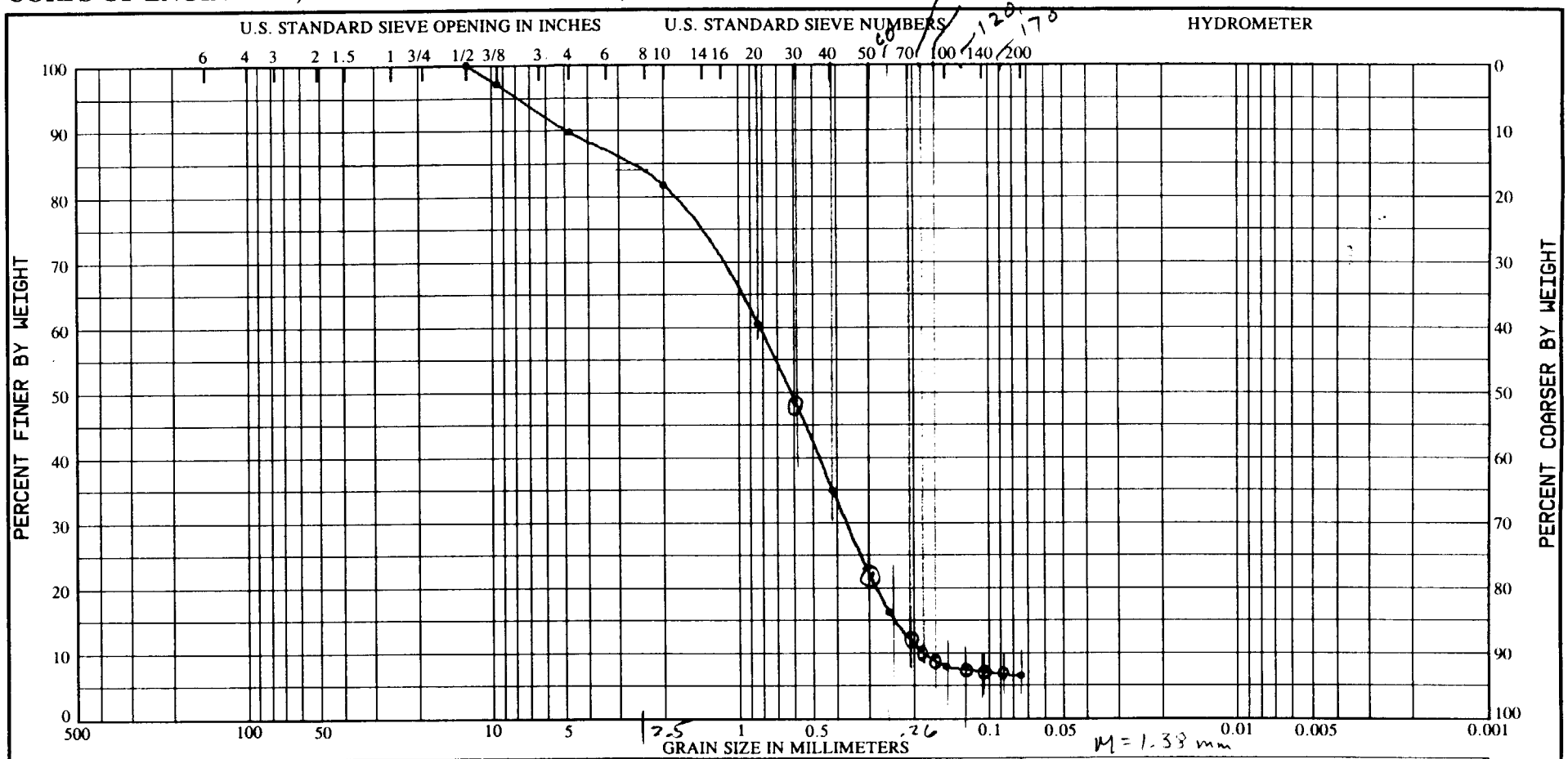
DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30060

WORK ORDER: 8015
REQUISITION: CENAP-EN-96-813



COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

Sample No.	Depth (Ft)	(VISUAL) Classification	Nat w%	LL	PL	PI
2	7.0-7.5	TAN, POORLY GRADED SILTY SAND (SP-SM), WITH A LITTLE GRAVEL SIZES AND A TRACE OF MICA.				

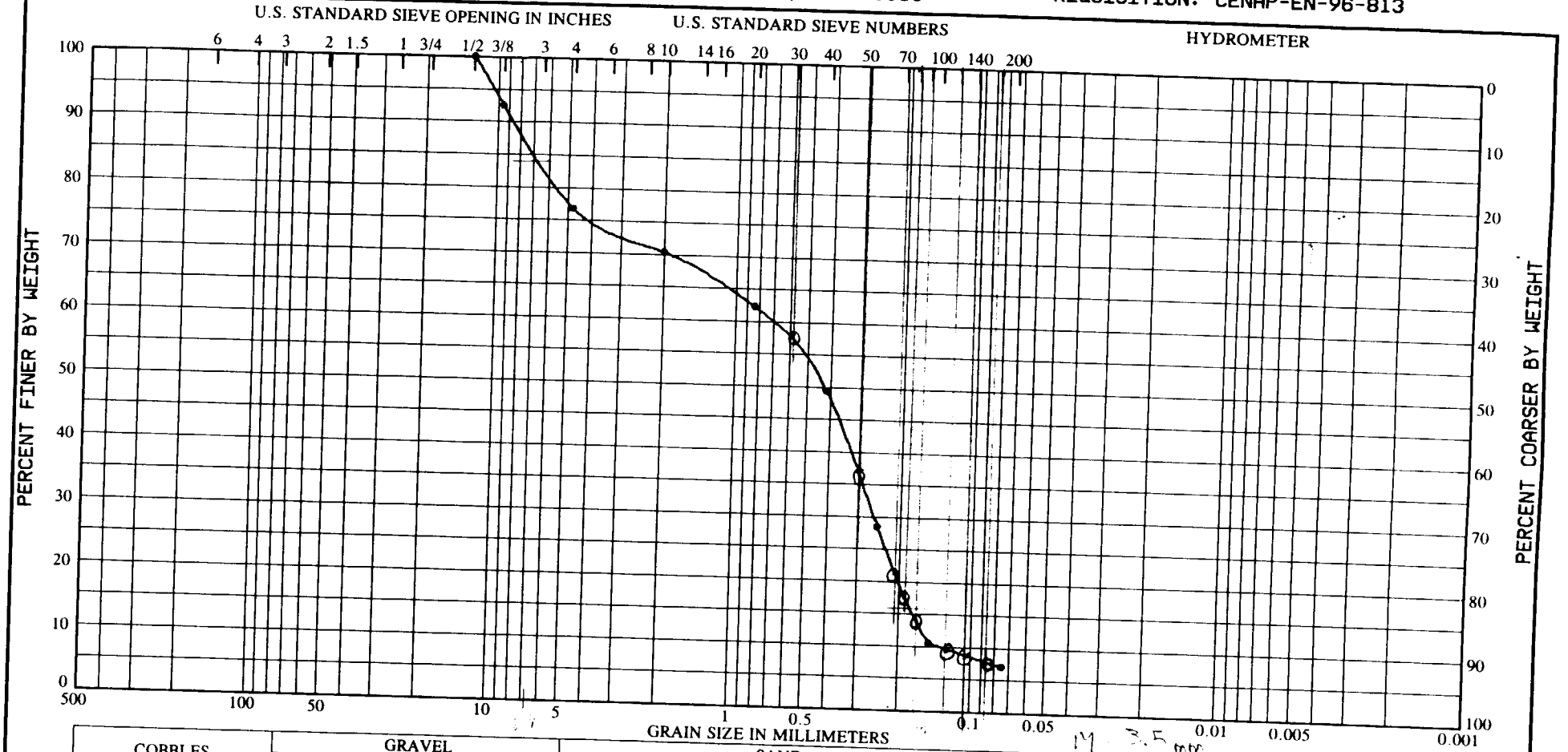
Project CAPE MAY
VIBRA-CORE SAMPLES
Lab No. 184/1264
Boring No. NJV-220
Date 07/22/96

GRADATION CURVES

153

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30060

WORK ORDER: 8015
REQUISITION: CENAP-EN-96-813



COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

Sample No.	Depth (Ft)	(VISUAL) Classification	Nat w%	LL	PL	PI
3	13.0-13.3	TAN & GRAY, POORLY GRADED SILTY SAND (SP-SM), WITH SOME GRAVEL SIZES AND A TRACE OF MICA.				

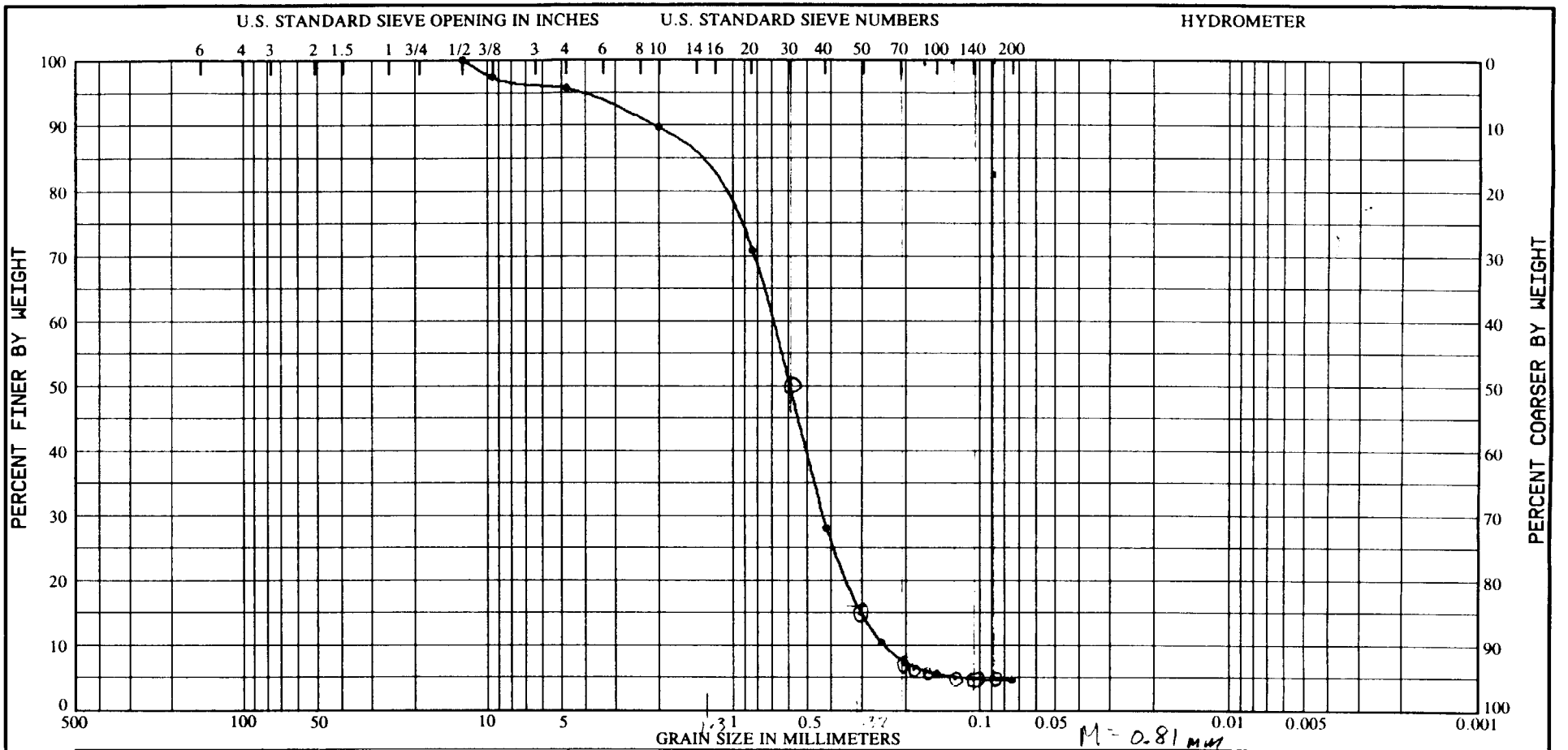
Project CAPE MAY
VIBRA-CORE SAMPLES
Lab No. 184/1264
Boring No. NJV-220
Date 07/22/96

GRADATION CURVES

154

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30060

WORK ORDER: 8015
REQUISITION: CENAP-EN-96-813



COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

Sample No.	Depth (Ft)	(VISUAL) Classification	Nat w%	LL	PL	PI
4	17.0-17.3	TAN & GRAY, POORLY GRADED SAND (SP),				
		WITH A TRACE OF GRAVEL SIZES.				

Project CAPE MAY
VIBRA-CORE SAMPLES
Lab No. 184/1264
Boring No. NJV-220
Date 07/22/96

GRADATION CURVES

OK

155

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30060

Project: *CAPE MAY*		Boring No. *NJV-221*
Location: *VIBRA-CORE SAMPLES*		Lab No. *184/1265*
Boring Depth (ft): *19.90*	Depth:	Work order: *8015*
Datum/Notes:		Requisition: *CENAP-EN-96-813*

Elev. (feet)	Depth (feet)	Leg-end	Material Description	Comments
				DEPTHS FROM TOP OF HOLE.
	1			
	2	OK ?		
	3	M=.79 mm		SA, 3.3 - 3.6
	4			
	5			
	6			
	7			
	8	M=1.5 mm		SA, 8.0 - 8.5
	9			
	10		TANNISH GRAY, POORLY GRADED SAND (SP), WITH A TRACE TO SOME GRAVEL SIZES.	
	11			
	12			
	13	M=1.02 mm		SA, 13.4 - 13.7
	14			
	15			
	16			
	17	M≅5.5 mm		SA, 17.4 - 17.9
	18			
	19			

Date: *08/01/96* **LABORATORY LOG AND SAMPLE DATUM** Sheet No. *1* of *2*

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DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30060

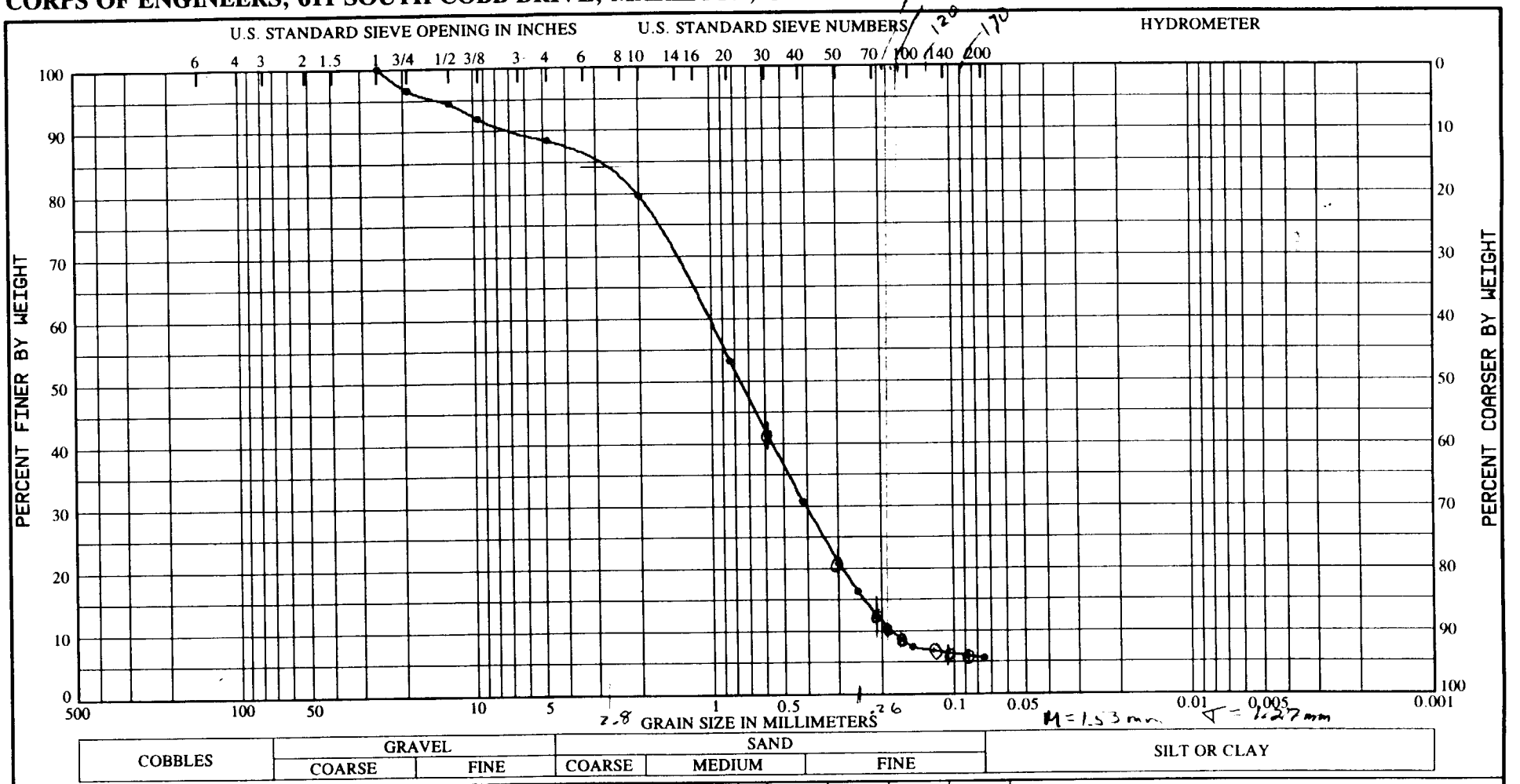
Project: *CAPE MAY*		Boring No. *NJV-221*
Location: *VIBRA-CORE SAMPLES*		Lab No. *184/1265*
Boring Depth (ft): *19.90*	Depth:	Work order: *8015*
Datum/Notes:		Requisition: *CENAP-EN-96-813*

Elev. (feet)	Depth (feet)	Leg-end	Material Description	Comments
	21			
	22			
	23			
	24			
	25			
	26			
	27			
	28			
	29			
	30			
	31			
	32			
	33			
	34			
	35			
	36			
	37			
	38			
	39			

Date: *08/01/96* **LABORATORY LOG AND SAMPLE DATUM** Sheet No. *2* of *2*

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30060

WORK ORDER: 8015
REQUISITION: CENAP-EN-96-813



COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

Sample No.	Elev (Ft)	(VISUAL) Classification	Nat w%	LL	PL	PI
2	8.0-8.5	TANNISH GRAY, POORLY GRADED SILTY SAND (SP-SM), WITH A LITTLE GRAVEL SIZES AND A TRACE OF MICA.				

Project CAPE MAY
VIBRA-CORE SAMPLES
Lab No. 184/1265
Boring No. NJV-221
Date 07/23/96

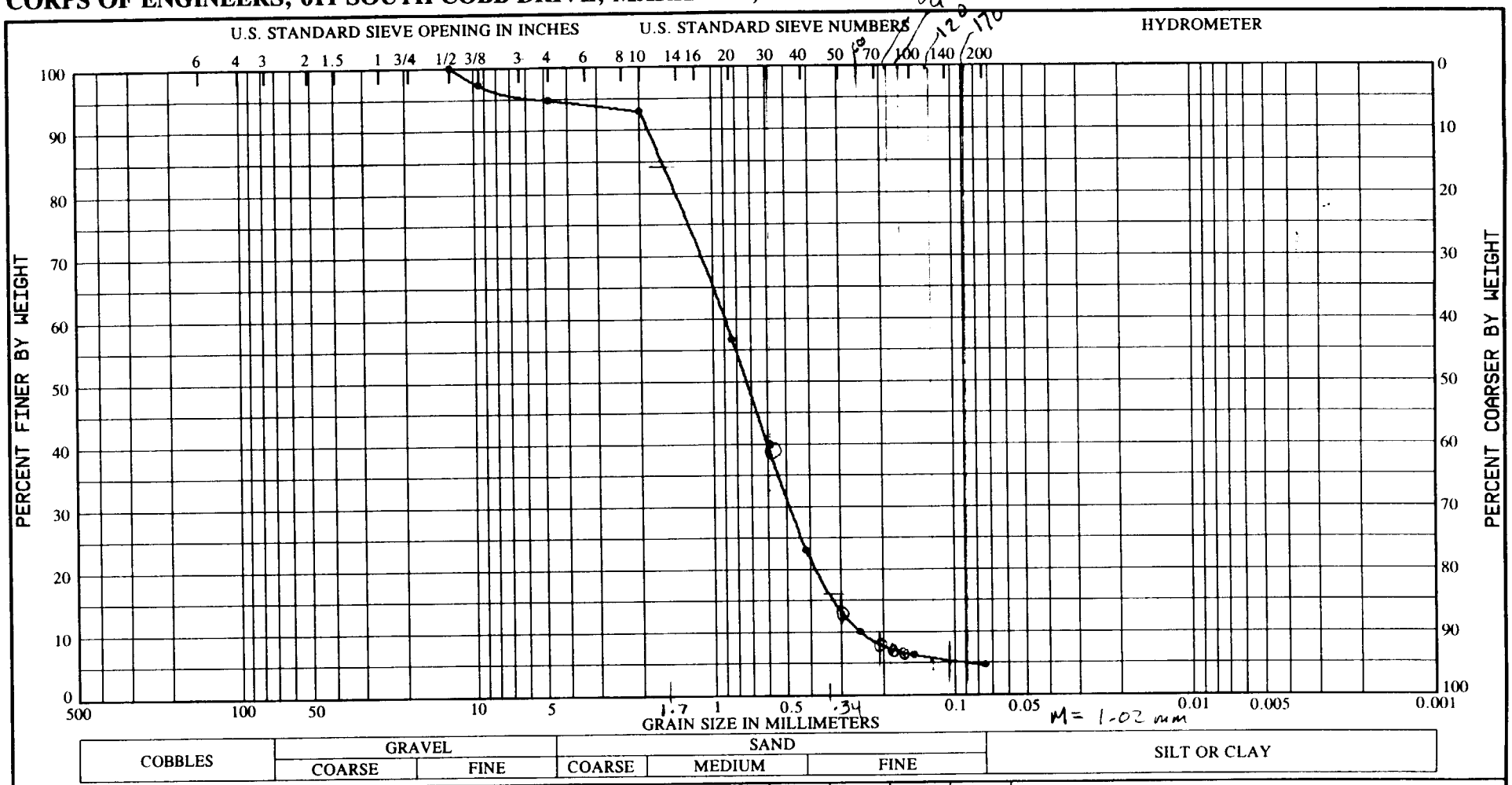
GRADATION CURVES

Too Coarse

158

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30060

WORK ORDER: 8015
REQUISITION: CENAP-EN-96-813



COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

Sample No.	Elev (Ft)	(VISUAL) Classification	Nat w%	LL	PL	PI
3	13.4-13.7	TANNISH GRAY, POORLY GRADED SAND (SP), WITH A TRACE OF GRAVEL SIZES AND MICA.				

Project CAPE MAY
VIBRA-CORE SAMPLES
Lab No. 184/1265
Boring No. NJV-221
Date 07/23/96

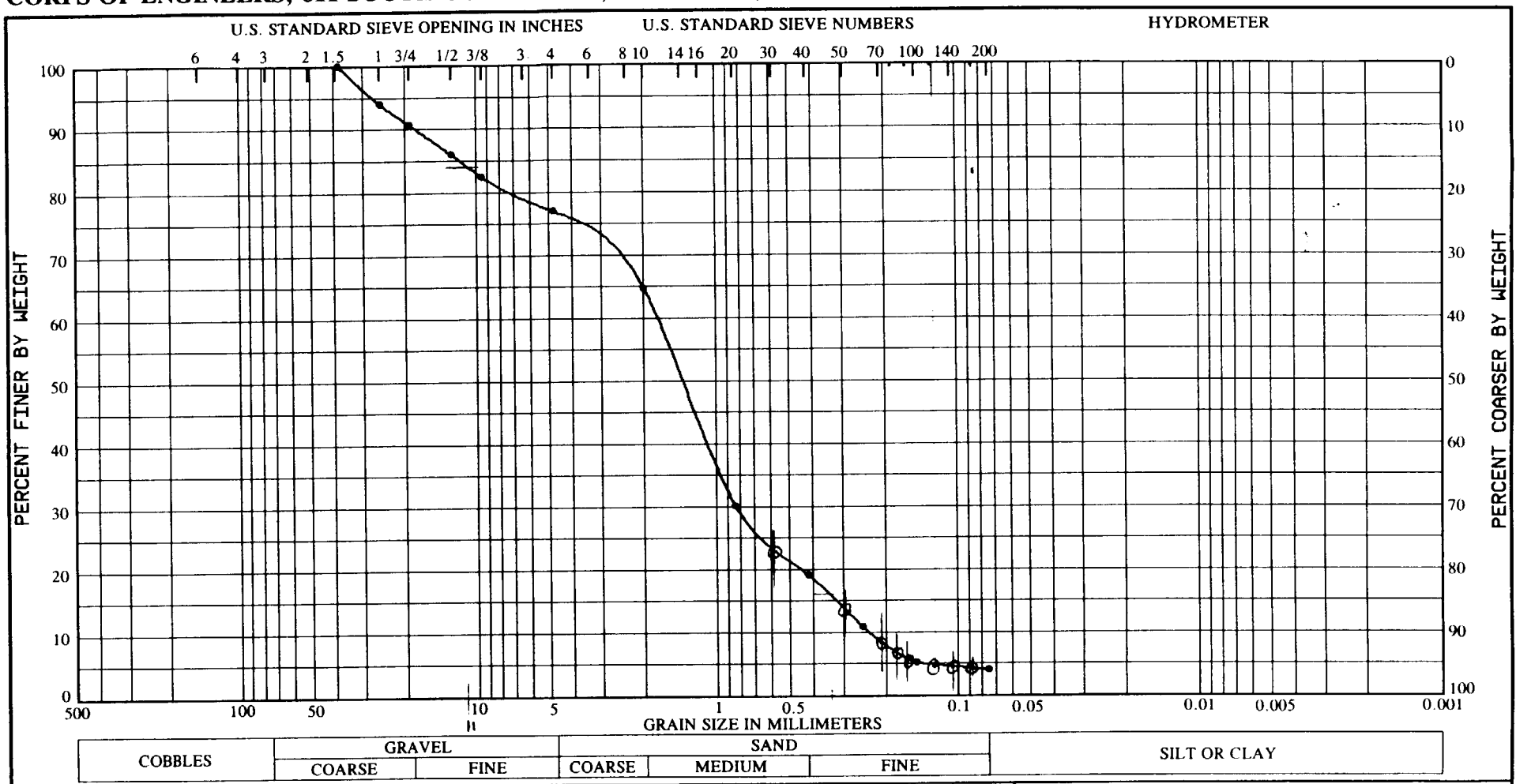
GRADATION CURVES

159

Too Coarse

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30060

WORK ORDER: 8015
REQUISITION: CENAP-EN-96-813



Sample No.	Elev (Ft)	(VISUAL) Classification	Nat w%	LL	PL	PI
4	17.4-17.9	TANNISH GRAY, POORLY GRADED SAND (SP), WITH SOME GRAVEL SIZES AND A TRACE OF MICA.				

Project CAPE MAY
VIBRA-CORE SAMPLES
Lab No. 184/1265
Boring No. NJV-221
Date 07/23/96

GRADATION CURVES

Two Coarse

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30060

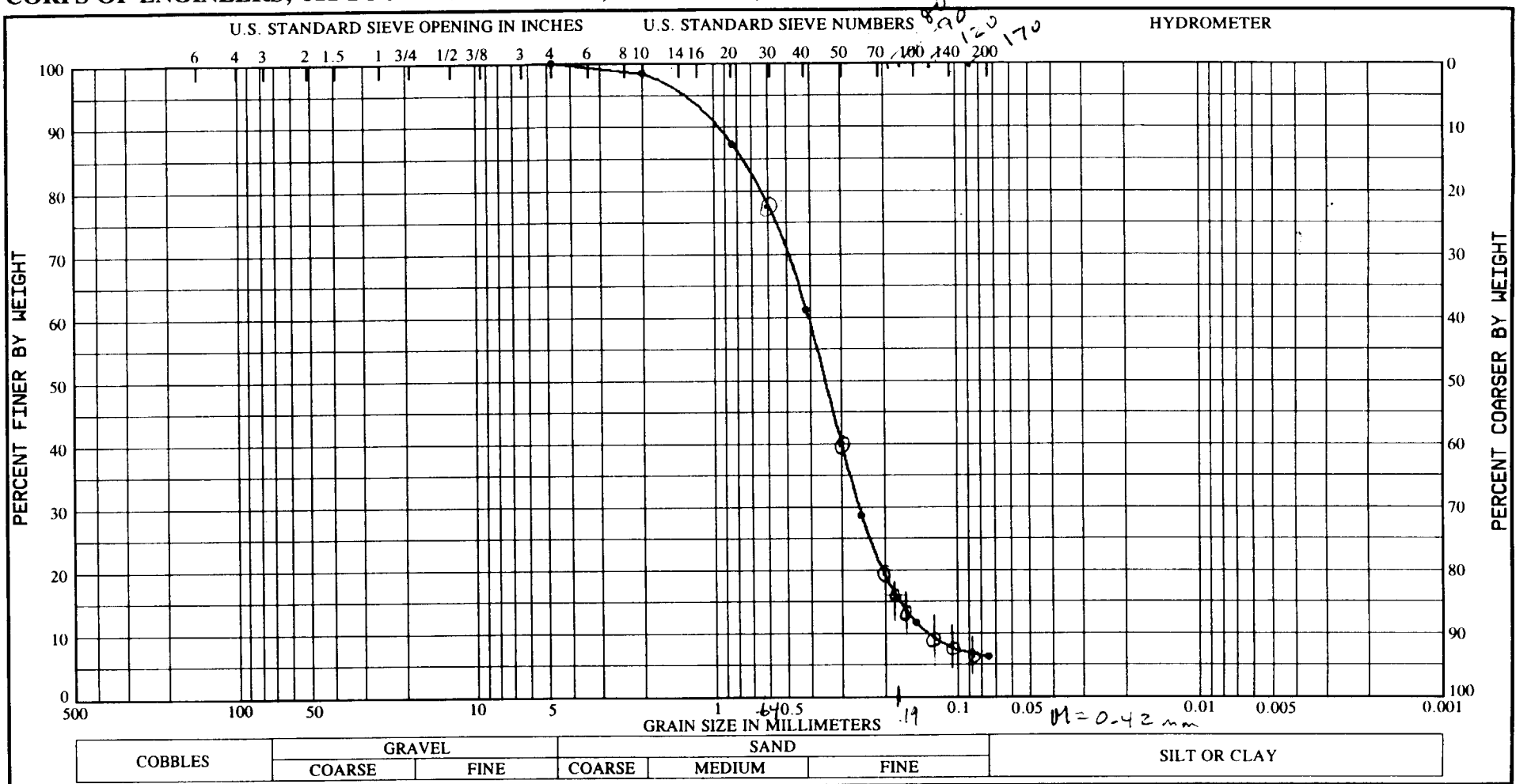
Project: *CAPE MAY*		Boring No. *NJV-222*
Location: *VIBRA-CORE SAMPLES*		Lab No. *184/1266*
Boring Depth (ft): *16.90*	Depth:	Work order: *8015*
Datum/Notes:		Requisition: *CENAP-EN-96-813*

Elev. (feet)	Depth (feet)	Leg-end	Material Description	Comments
			TANNISH GRAY, POORLY GRADED SAND (SP), WITH A TRACE OF SHELL FRAGMENTS.	DEPTHS FROM TOP OF HOLE.
	1			
			GRAY, SILTY FAT CLAY (CH), WITH A LITTLE SAND SIZES.	
	2			
	3			SA, 3.0 - 3.3
	4		GRAY, POORLY GRADED SAND (SP), WITH A TRACE OF SHELL FRAGMENTS AND MICA.	
	5			
	6			
			GRAY, CLAYEY SAND (SC), WITH A TRACE OF GRAVEL SIZES AND MICA.	
	7			SA, 7.4 - 7.7
	8			
	9		GRAY, POORLY GRADED SILTY SAND (SP-SM), WITH A TRACE OF MICA.	
	10			
	11			SA, 11.0 - 11.3
	12			
	13			
	14			SA, 14.2 - 14.5
	15		GRAY, SILTY SAND (SM), WITH A TRACE OF MICA.	
	16			
	17			
	18			
	19			

Date: *07/24/96* **LABORATORY LOG AND SAMPLE DATUM** Sheet No. *1* of *1*

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30060

WORK ORDER: 8015
REQUISITION: CENAP-EN-96-813



COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

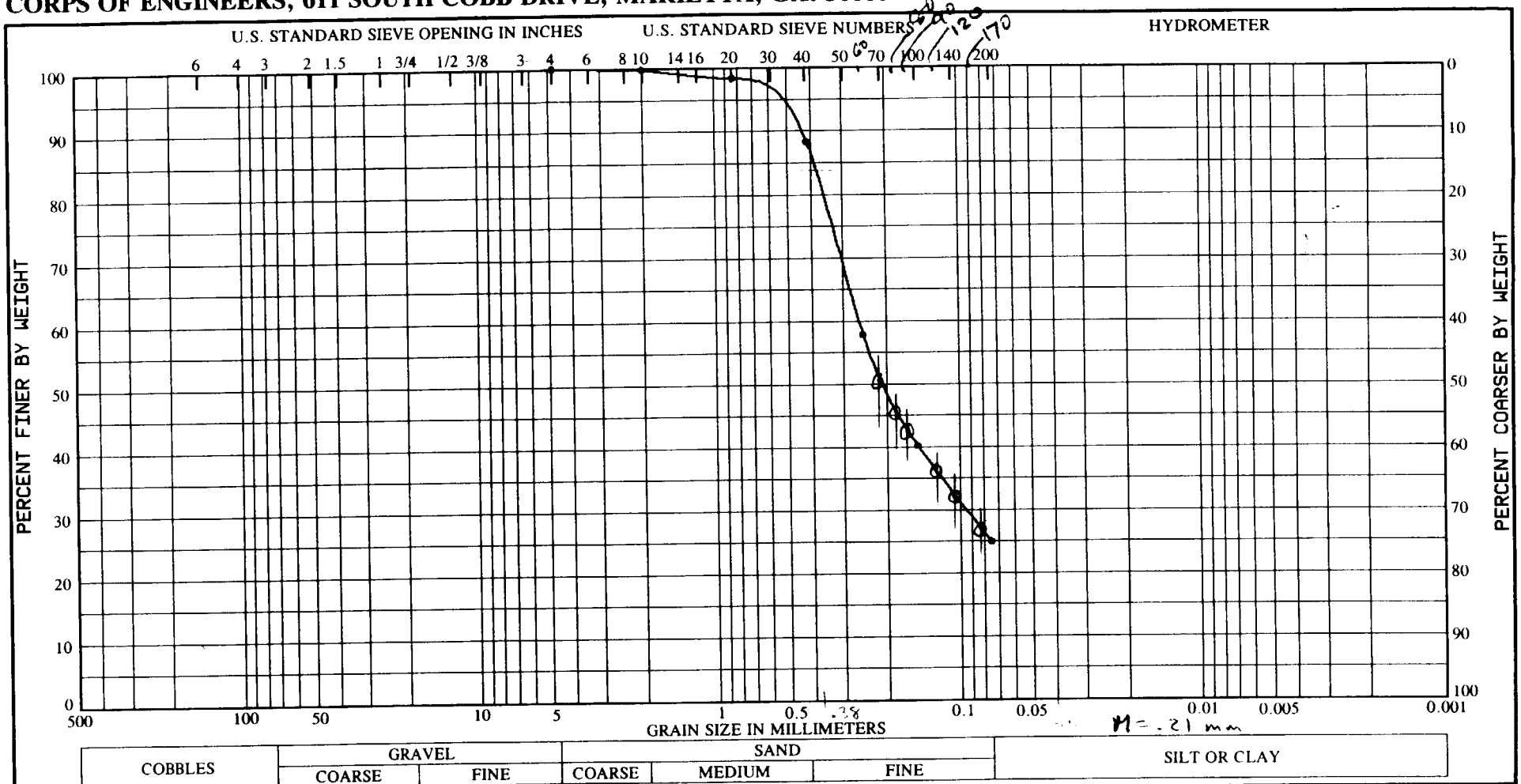
Sample No.	Elev (Ft)	(VISUAL) Classification	Nat w%	LL	PL	PI
1	3.0-3.3	GRAY, POORLY GRADED SILTY SAND (SP-SM), WITH A TRACE OF MICA.				

Project CAPE MAY
VIBRA-CORE SAMPLES
Lab No. 184/1266
Boring No. NJV-222
Date 07/24/96

GRADATION CURVES

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30060

WORK ORDER: 8015
REQUISITION: CENAP-EN-96-813



COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

Sample No.	Elev (Ft)	(VISUAL) Classification	Nat w%	LL	PL	PI
2	7.4-7.7	GRAY, CLAYEY SAND (SC), WITH A TRACE OF MICA.				

Project CAPE MAY
VIBRA-CORE SAMPLES
Lab No. 184/1266
Boring No. NJV-222
Date 07/24/96

GRADATION CURVES

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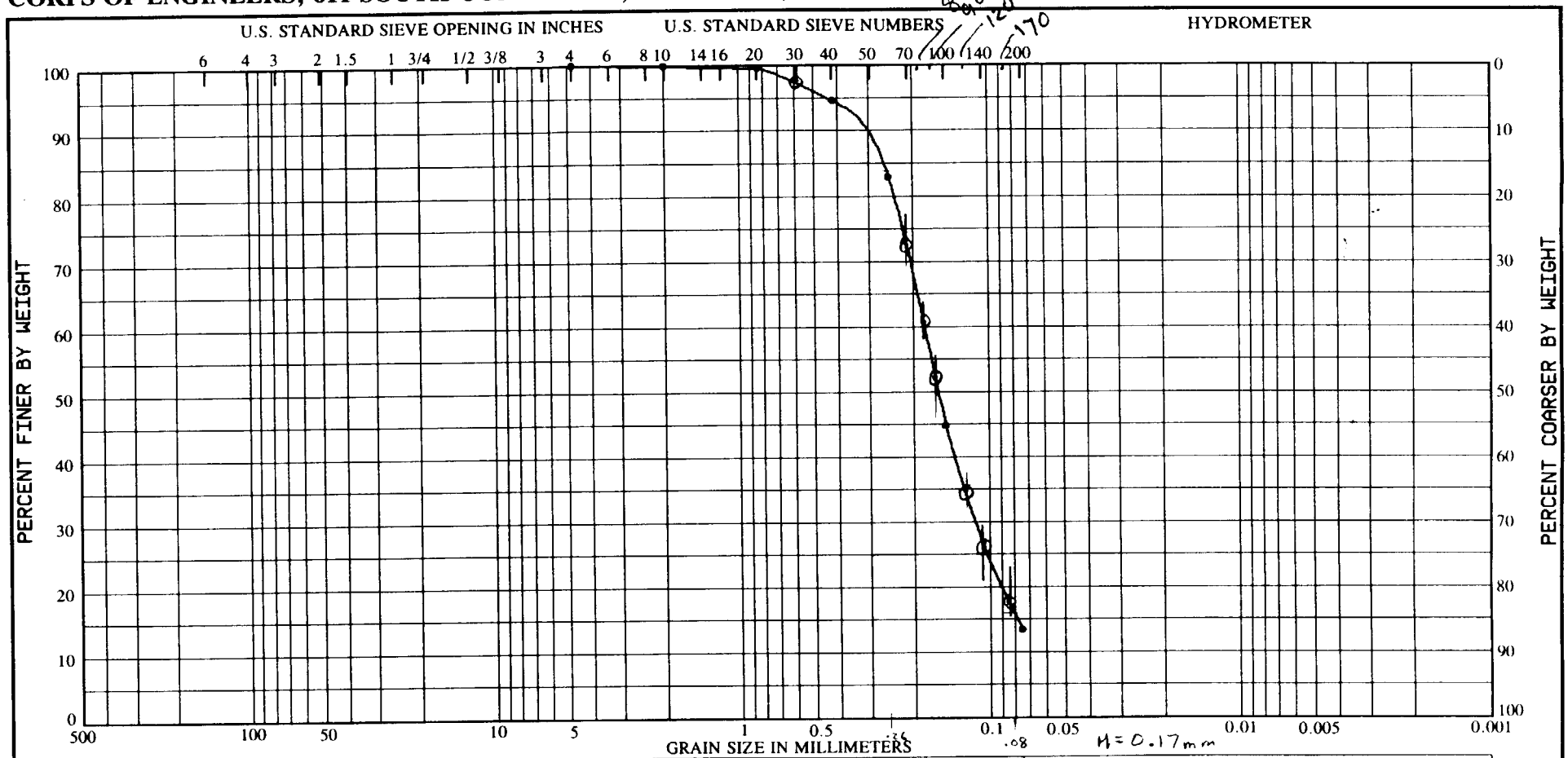
DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30060

WORK ORDER: 8015
REQUISITION: CENAP-EN-96-813



COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

Sample No.	Elev (Ft)	(VISUAL) Classification	Nat w%	LL	PL	PI
3	11.0-11.3	GRAY, SILTY SAND (SM), WITH A TRACE OF MICA.				

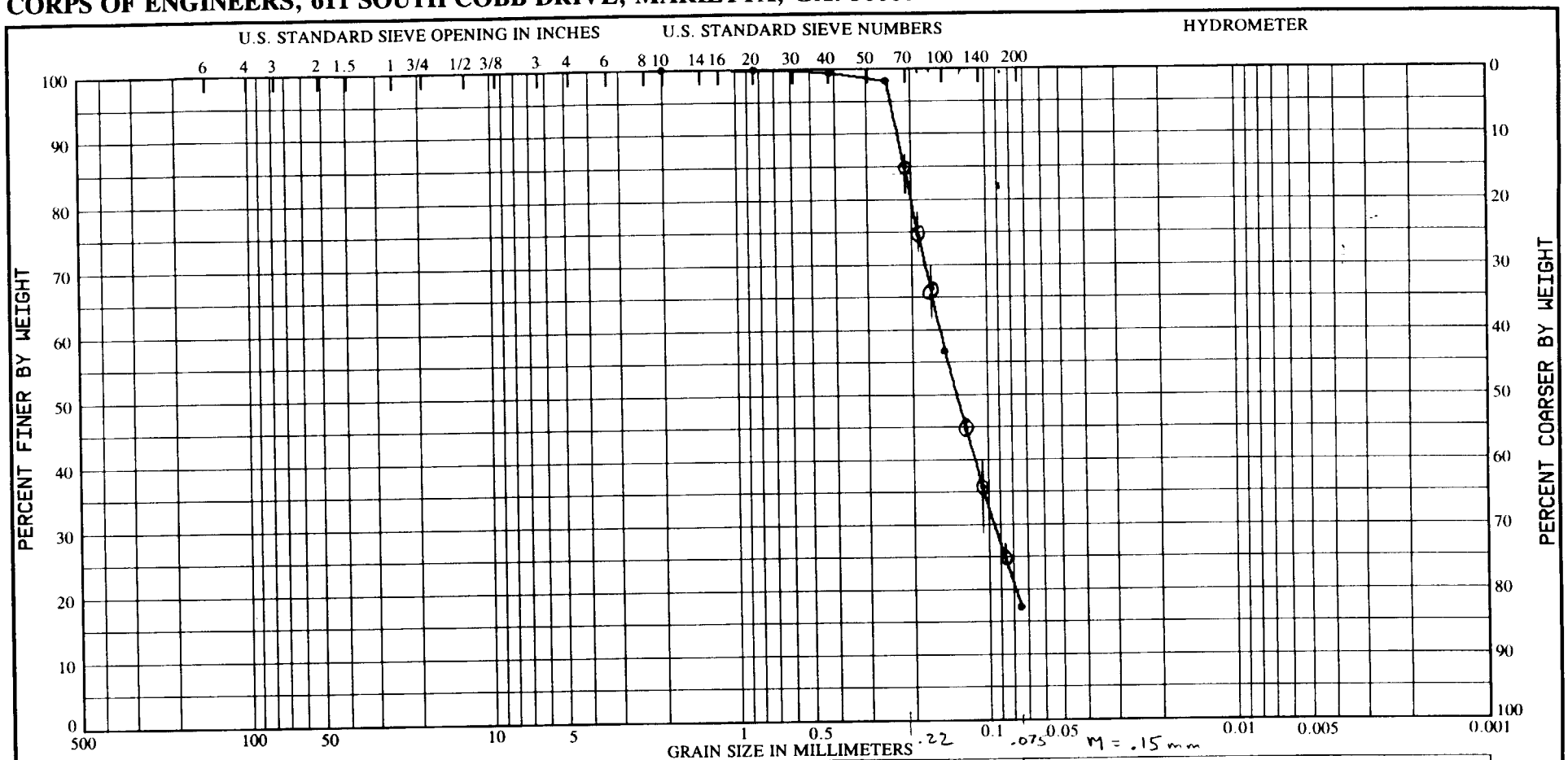
Project CAPE MAY
VIBRA-CORE SAMPLES
Lab No. 184/1266
Boring No. NJV-222
Date 07/24/96

GRADATION CURVES

OK - too fine

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30060

WORK ORDER: 8015
REQUISITION: CENAP-EN-96-813



COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

Sample No.	Elev (Ft)	(VISUAL) Classification	Nat w%	LL	PL	PI
4	14.2-14.5	GRAY, SILTY SAND (SM), WITH A TRACE OF MICA.				

Project CAPE MAY
VIBRA-CORE SAMPLES
Lab No. 184/1266
Boring No. NJV-222
Date 07/24/96

GRADATION CURVES

1/8 - 100 fine

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30060

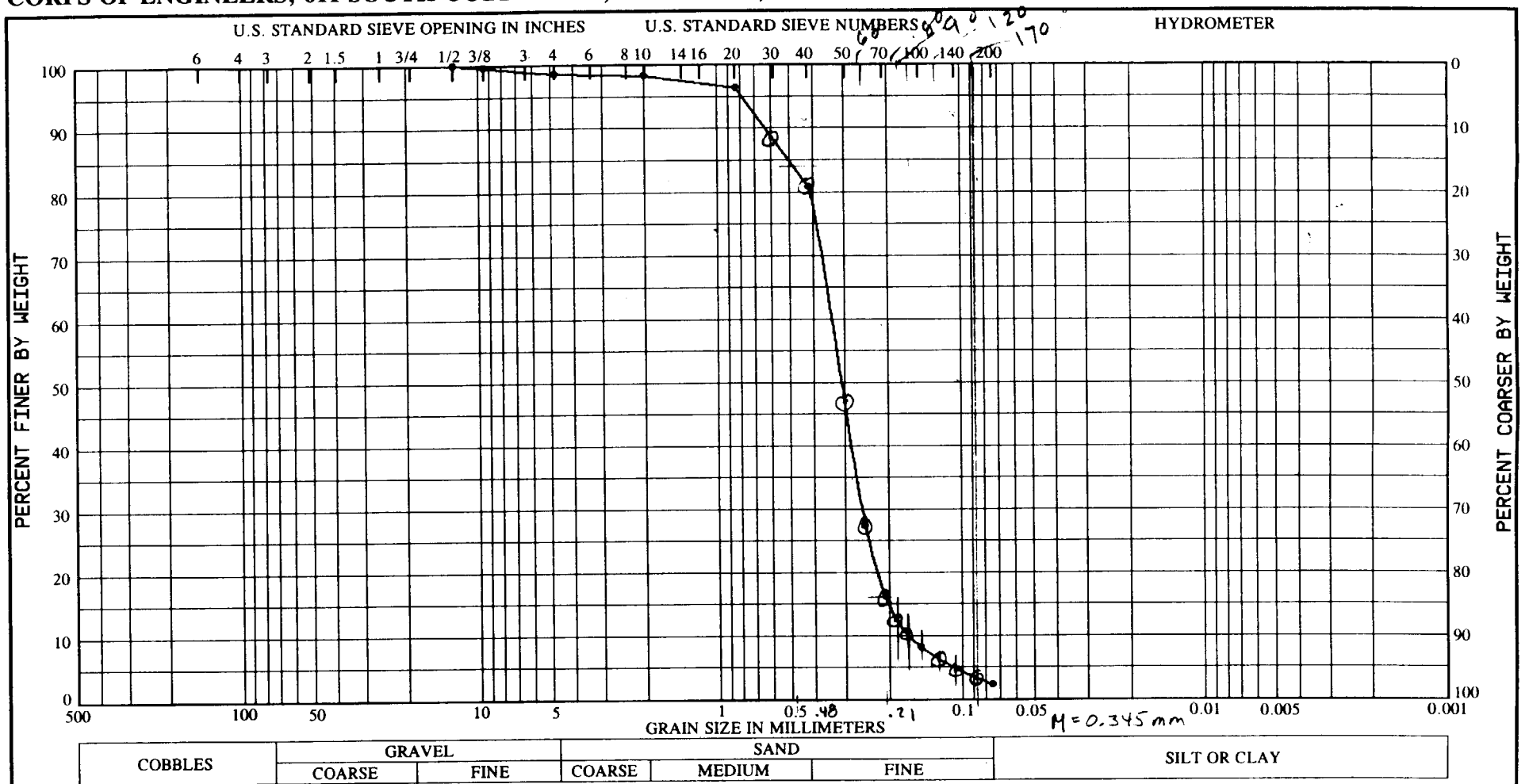
Project: *CAPE MAY*		Boring No. *NJV-223*	
Location: *VIBRA-CORE SAMPLES*		Lab No. *184/1267*	
Boring Depth (ft): *19.00*	Depth:	Work order: *8015*	
Datum/Notes:		Requisition: *CENAP-EN-96-813*	

Elev. (feet)	Depth (feet)	Legend	Material Description	Comments
				DEPTHS FROM TOP OF HOLE.
	1	OK M=.35 mm	TAN, POORLY GRADED SAND (SP), WITH A TRACE OF SHELL FRAGMENTS AND MICA.	SA, 1.5 - 1.8
	2		GRAY, LAYERED POORLY GRADED SAND (SP), AND LEAN CLAY (CL), WITH A TRACE OF SHELL FRAGMENTS.	
	3		TANNISH GRAY, POORLY GRADED SAND (SP), WITH A TRACE OF SHELL FRAGMENTS AND MICA.	
	4	NG	GRAY, SILTY FAT CLAY (CH).	
	5		GRAY, POORLY GRADED SAND (SP) TO A POORLY GRADED SILTY SAND (SP-SM), WITH A TRACE OF GRAVEL SIZES.	
	6			
	7	too fine M=.18 mm	GRAYISH TAN, POORLY GRADED SAND (SP), WITH A TRACE OF MICA.	SA, 7.7 - 7.9
	8			
	9			
	10		TANNISH GRAY, LAYERS OF POORLY GRADED SAND (SP), AND SANDY LEAN CLAY (CL).	
	11			
	12			
	13	too fine		SA, 12.9 - 13.1
	14	M=.14 mm	GRAY, MIXTURE OF POORLY GRADED SAND (SP), AND FAT CLAY (CH).	
	15			
	16			SA, 16.5 - 17.1
	17		GRAYISH TAN, POORLY GRADED SAND (SP), WITH A LITTLE GRAVEL SIZES.	
	18			
	19			

Date: *07/24/96* **LABORATORY LOG AND SAMPLE DATUM** Sheet No. *1* of *1*

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30060

WORK ORDER: 8015
REQUISITION: CENAP-EN-96-813



COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

Sample No.	Elev (Ft)	(VISUAL) Classification	Nat w%	LL	PL	PI
1	1.5-1.8	TAN, POORLY GRADED SAND (SP), WITH A TRACE OF GRAVEL SIZES AND MICA.				

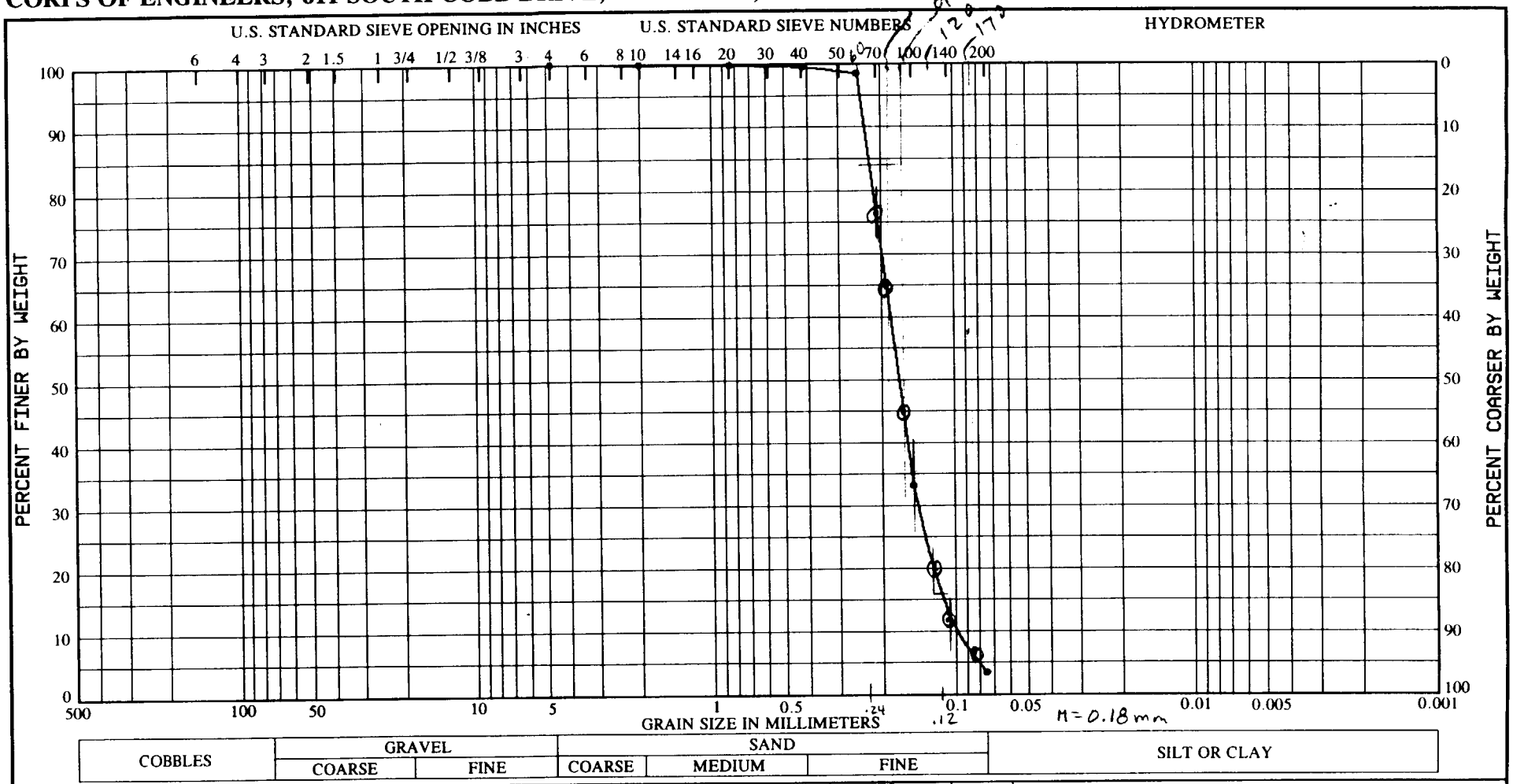
Project CAPE MAY
VIBRA-CORE SAMPLES
Lab No. 184/1267
Boring No. NJV-223
Date 07/24/96

GRADATION CURVES

OK

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30060

WORK ORDER: 8015
REQUISITION: CENAP-EN-96-813



COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

Sample No.	Elev (Ft)	(VISUAL) Classification	Nat w%	LL	PL	PI
2	7.7-7.9	GRAYISH TAN, POORLY GRADED SAND (SP), WITH A TRACE OF MICA.				

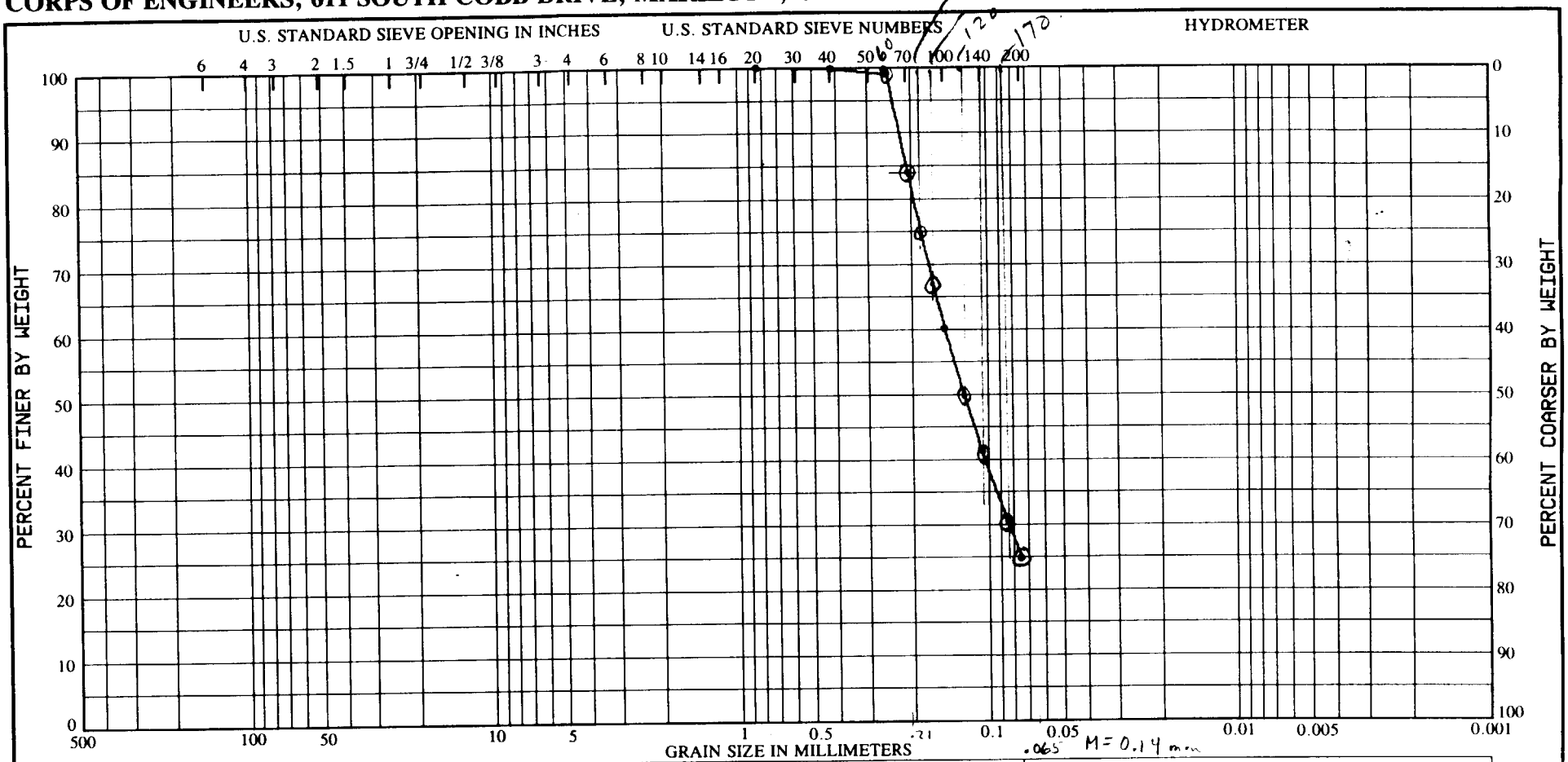
Project CAPE MAY
VIBRA-CORE SAMPLES
Lab No. 184/1267
Boring No. NJV-223
Date 07/24/96

GRADATION CURVES

OK - too fine

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30060

WORK ORDER: 8015
REQUISITION: CENAP-EN-96-813



COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

Sample No.	Elev (Ft)	(VISUAL) Classification	Nat w%	LL	PL	PI
3	12.9-13.1	GRAY, CLAYEY SAND (SC), WITH A TRACE OF MICA.				

Project CAPE MAY
VIBRA-CORE SAMPLES
Lab No. 184/1267
Boring No. NJV-223
Date 07/24/96

GRADATION CURVES

too fine

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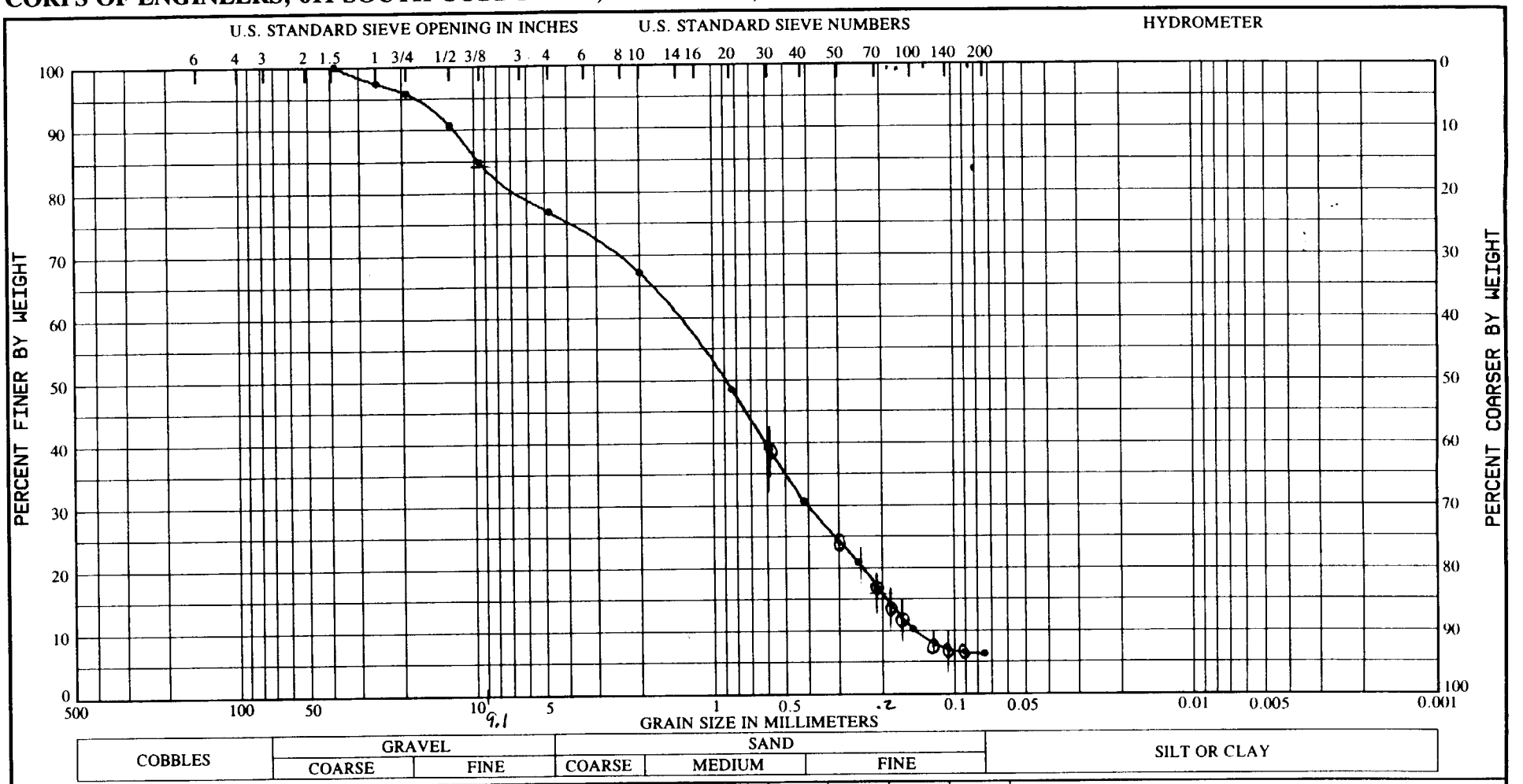
DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30060

WORK ORDER: 8015
REQUISITION: CENAP-EN-96-813



Sample No.	Elev (Ft)	(VISUAL) Classification	Nat w%	LL	PL	PI
4	16.5-17.1	GRAYISH TAN, POORLY GRADED SILTY SAND (SP-SM), WITH SOME GRAVEL SIZES AND A TRACE OF MICA.				

Project CAPE MAY
VIBRA-CORE SAMPLES
Lab No. 184/1267
Boring No. NJV-223
Date 07/24/96

GRADATION CURVES

100 coarse

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30060

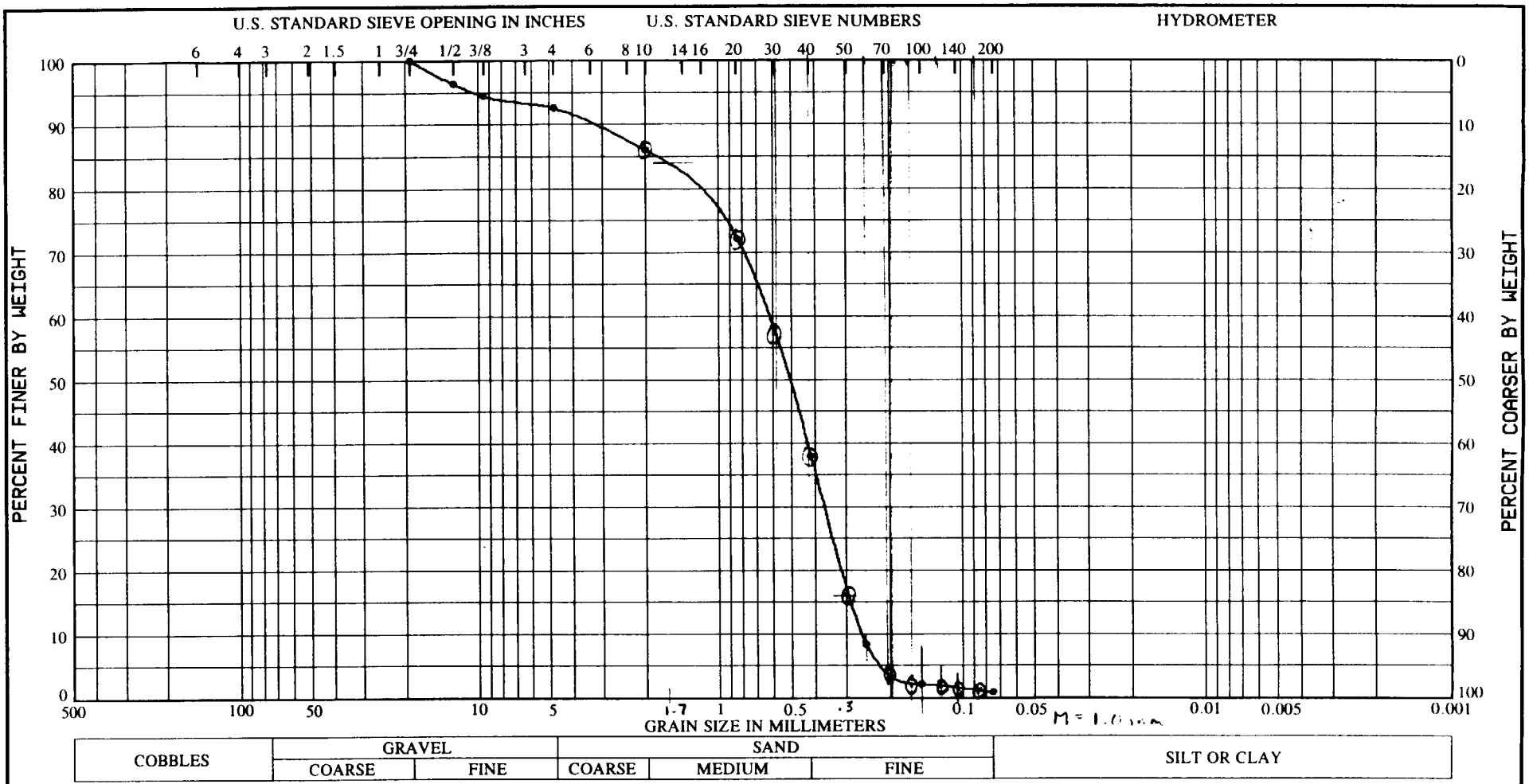
Project: *CAPE MAY*		Boring No. *NJV-224*
Location: *VIBRA-CORE SAMPLES*		Lab No. *184/1268*
Boring Depth (ft): *17.00*	Depth:	Work order: *8015*
Datum/Notes:		Requisition: *CENAP-EN-96-813*

Elev. (feet)	Depth (feet)	Leg-end	Material Description	Comments
				DEPTHS FROM TOP OF HOLE.
	1			
	2	M=.20 mm	TAN, POORLY GRADED SAND (SP), WITH A TRACE OF SHELL FRAGMENTS AND MICA AND A PLUG OF FAT CLAY (CH), AT 1.5 TO 1.7'.	SA, 2.0 - 2.3
	3		TAN, POORLY GRADED SAND (SP), WITH A TRACE OF SHELL FRAGMENTS.	
	4			
		Vf. trace	GRAY, SILTY SAND (SM), PLASTIC FINES	SA, 4.3 - 4.6
	5		TAN, POORLY GRADED SILTY SAND (SP-SM), WITH A TRACE OF GRAVEL SIZES AND MICA.	
	6			
	7	f.00 fine	GRAY, POORLY GRADED SILTY SAND (SP-SM).	
	8	M=.2 mm		SA, 8.0 - 8.2
	9			
	10			
	11			
	12			SA, 12.3 - 13.0
	13			
	14		TANNISH GRAY, POORLY GRADED SAND (SP), WITH SOME GRAVEL SIZES AND POCKETS OF CLAYEY SAND (SC), AND A TRACE OF MICA.	
	15			
	16			
	17			
	18			
	19			

Date: *07/24/96* **LABORATORY LOG AND SAMPLE DATUM** Sheet No. *1* of *1*

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30060

WORK ORDER: 8015
REQUISITION: CENAP-EN-96-813



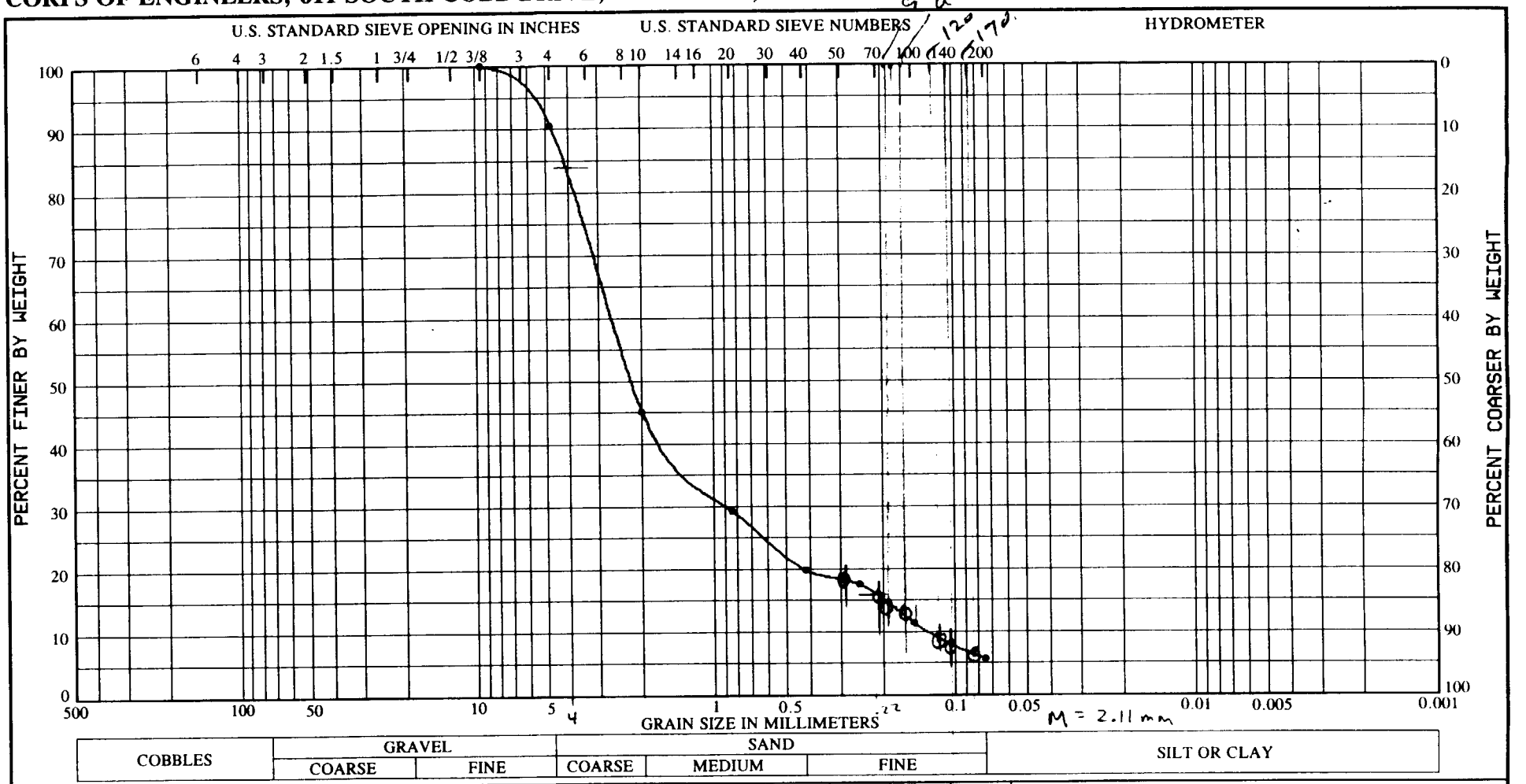
Sample No.	Elev (Ft)	(VISUAL) Classification	Nat w%	LL	PL	PI
1	2.0-2.3	TAN, POORLY GRADED SAND (SP), WITH A				
		TRACE OF GRAVEL SIZES AND MICA.				

Project CAPE MAY
VIBRA-CORE SAMPLES
Lab No. 184/1268
Boring No. NJV-224
Date 07/24/96

GRADATION CURVES

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30060

WORK ORDER: 8015
REQUISITION: CENAP-EN-96-813



COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

Sample No.	Elev (Ft)	(VISUAL) Classification	Nat w%	LL	PL	PI
2	4.3-4.6	TAN, POORLY GRADED SILTY SAND (SP-SM), WITH A TRACE OF GRAVEL SIZES AND MICA.				

Project CAPE MAY
VIBRA-CORE SAMPLES
Lab No. 184/1268
Boring No. NJV-224
Date 07/24/96

GRADATION CURVES

1.0 Coarse

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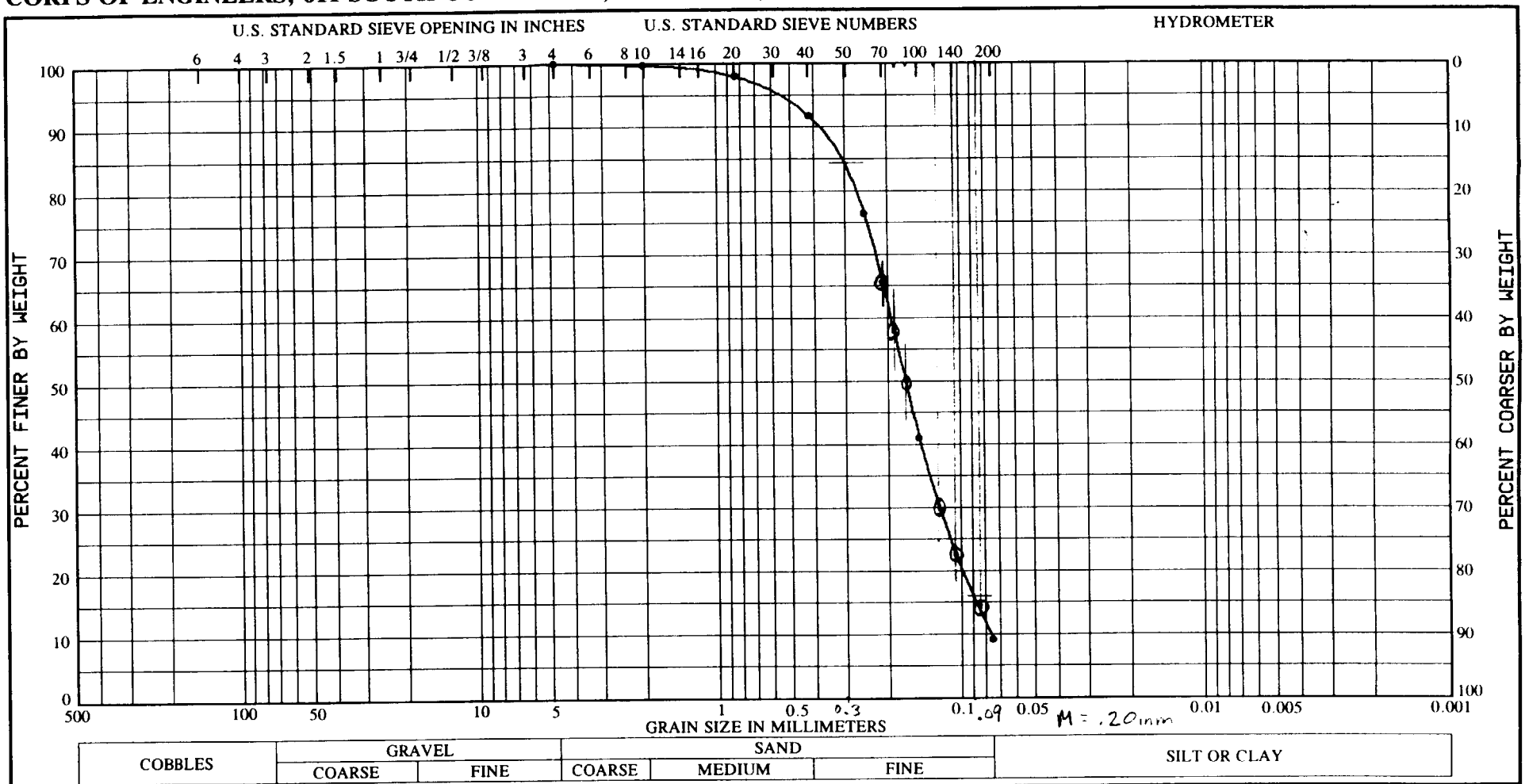
DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30060

WORK ORDER: 8015
REQUISITION: CENAP-EN-96-813



COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

Sample No.	Elev (Ft)	(VISUAL) Classification	Nat w%	LL	PL	PI
3	8.0-8.2	GRAY, POORLY GRADED SILTY SAND (SP-SM), WITH A TRACE OF MICA.				

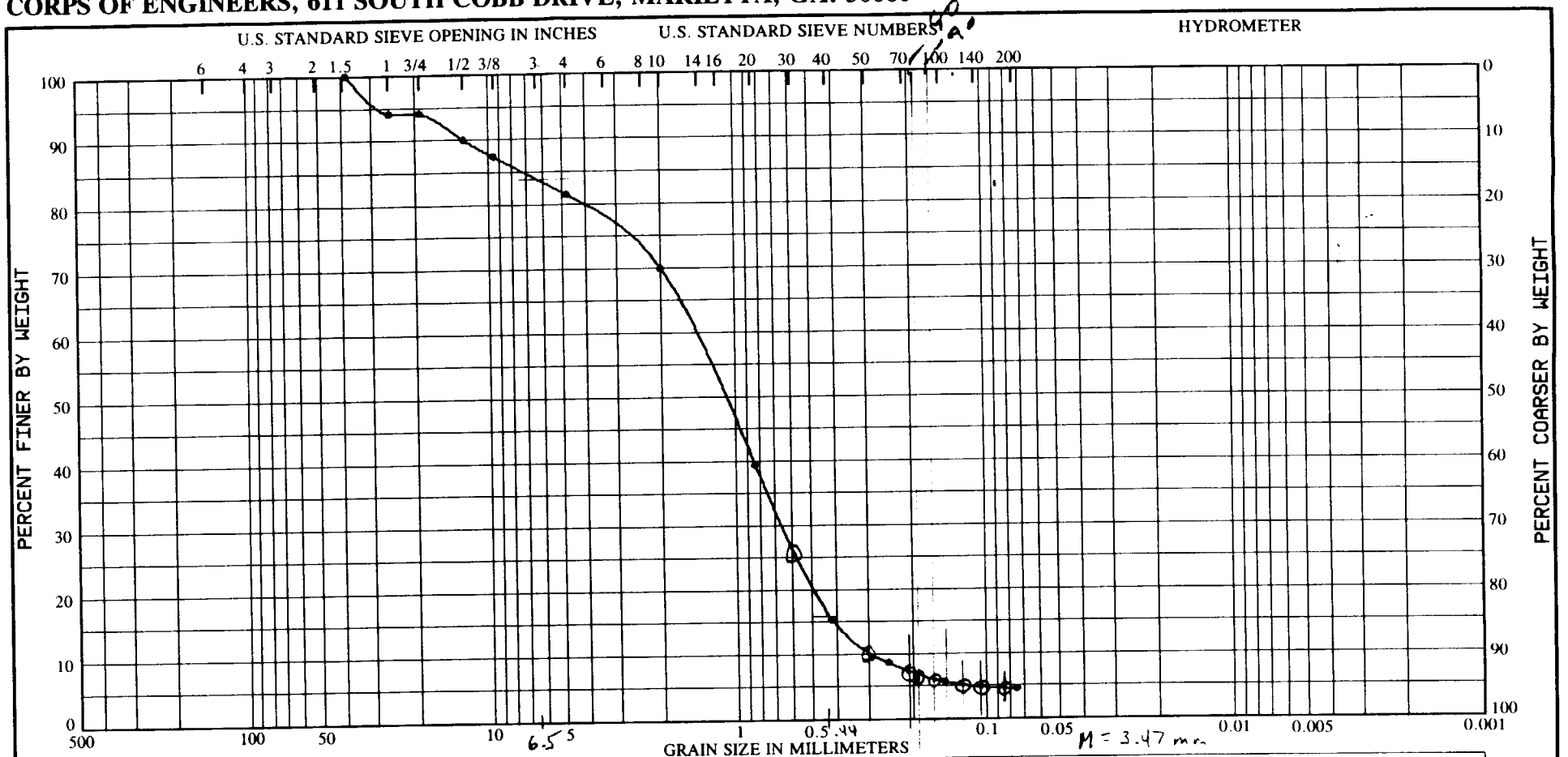
Project CAPE MAY
VIBRA-CORE SAMPLES
Lab No. 184/1268
Boring No. NJV-224
Date 07/24/96

GRADATION CURVES

OK

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30060

WORK ORDER: 8015
REQUISITION: CENAP-EN-96-813



COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

Sample No.	Elev (Ft)	(VISUAL) Classification	Nat w%	LL	PL	PI
4	12.3-13.0	TANNISH GRAY, POORLY GRADED SAND (SP), WITH A LITTLE GRAVEL SIZES AND A TRACE OF MICA.				

Project CAPE MAY
VIBRA-CORE SAMPLES
Lab No. 184/1268
Boring No. NJV-224
Date 07/24/96

GRADATION CURVES

too coarse

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30060

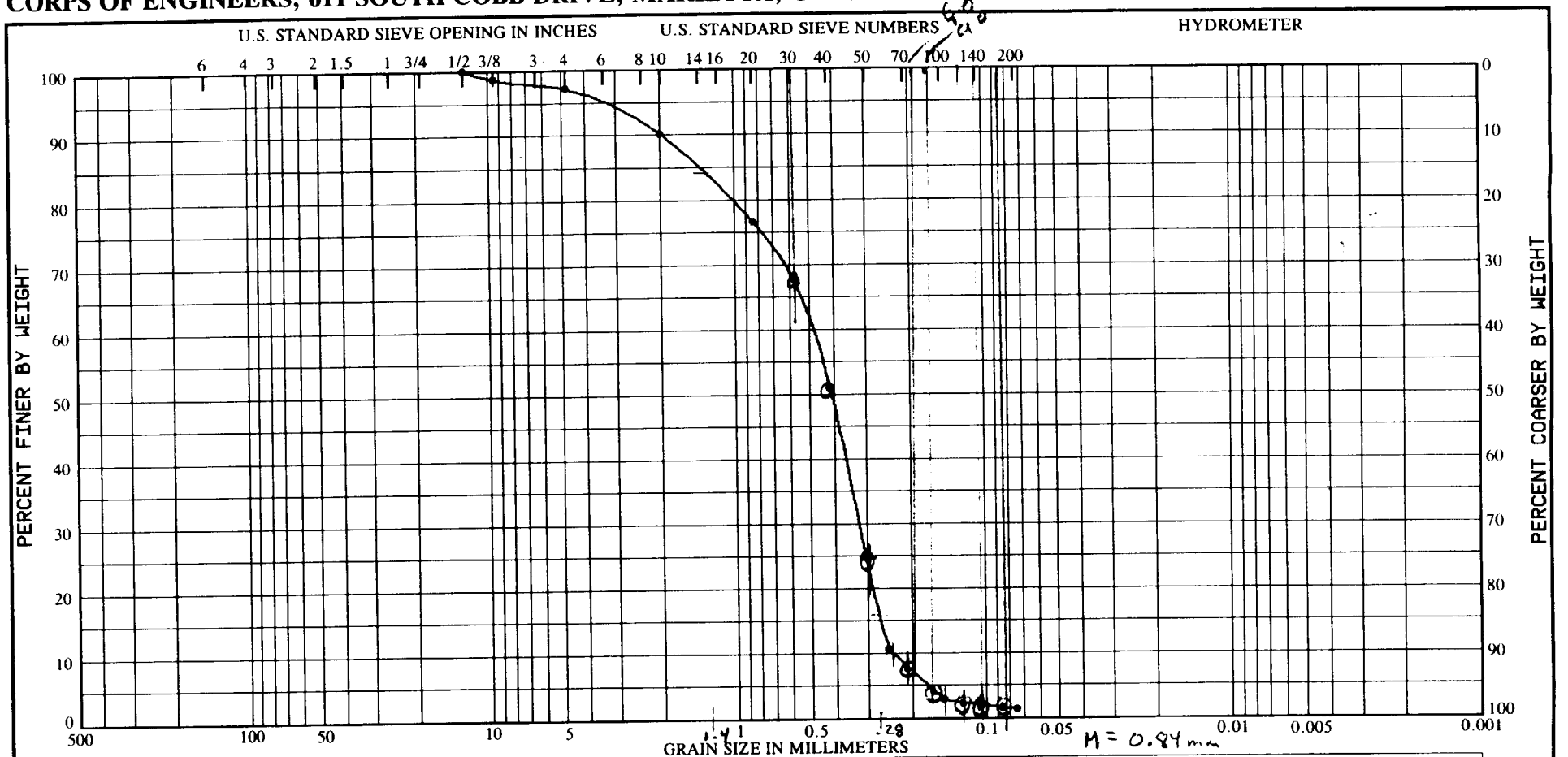
Project: *CAPE MAY*		Boring No. *NJV-225*
Location: *VIBRA-CORE SAMPLES*		Lab No. *184/1269*
Boring Depth (ft): *17.80*	Depth:	Work order: *8015*
Datum/Notes:		Requisition: *CENAP-EN-96-813*

Elev. (feet)	Depth (feet)	Leg-end	Material Description	Comments
				DEPTHS FROM TOP OF HOLE.
	1		TANNISH GRAY, POORLY GRADED SAND (SP), WITH A TRACE OF SHELL FRAGMENTS AND MICA.	
	2			SA, 1.8 - 2
	3		----------	
	4		GRAY, MIXTURE OF POORLY GRADED SILTY SAND (SP-SM), AND THIN LAYERS OF LEAN CLAY (CL). ----------	
	5	SIL		
	6			
	7			
	8			SA, 7.6 - 7.9
	9			
	10		GRAYISH TAN, POORLY GRADED SAND (SP), WITH OCCASIONAL POCKETS OF SILTY SAND (SM), WITH PLASTIC FINES AND A TRACE OF GRAVEL SIZES AT 9.3 TO 10.0'.	
	11			
	12			SA, 12.0 - 12.3
	13			
	14			
	15			
	16			SA, 15.5 - 16.7
	17			
	18		----------	
	19			

Date: *07/24/96* **LABORATORY LOG AND SAMPLE DATUM** Sheet No. *1* of *1*

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30060

WORK ORDER: 8015
REQUISITION: CENAP-EN-96-813



COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

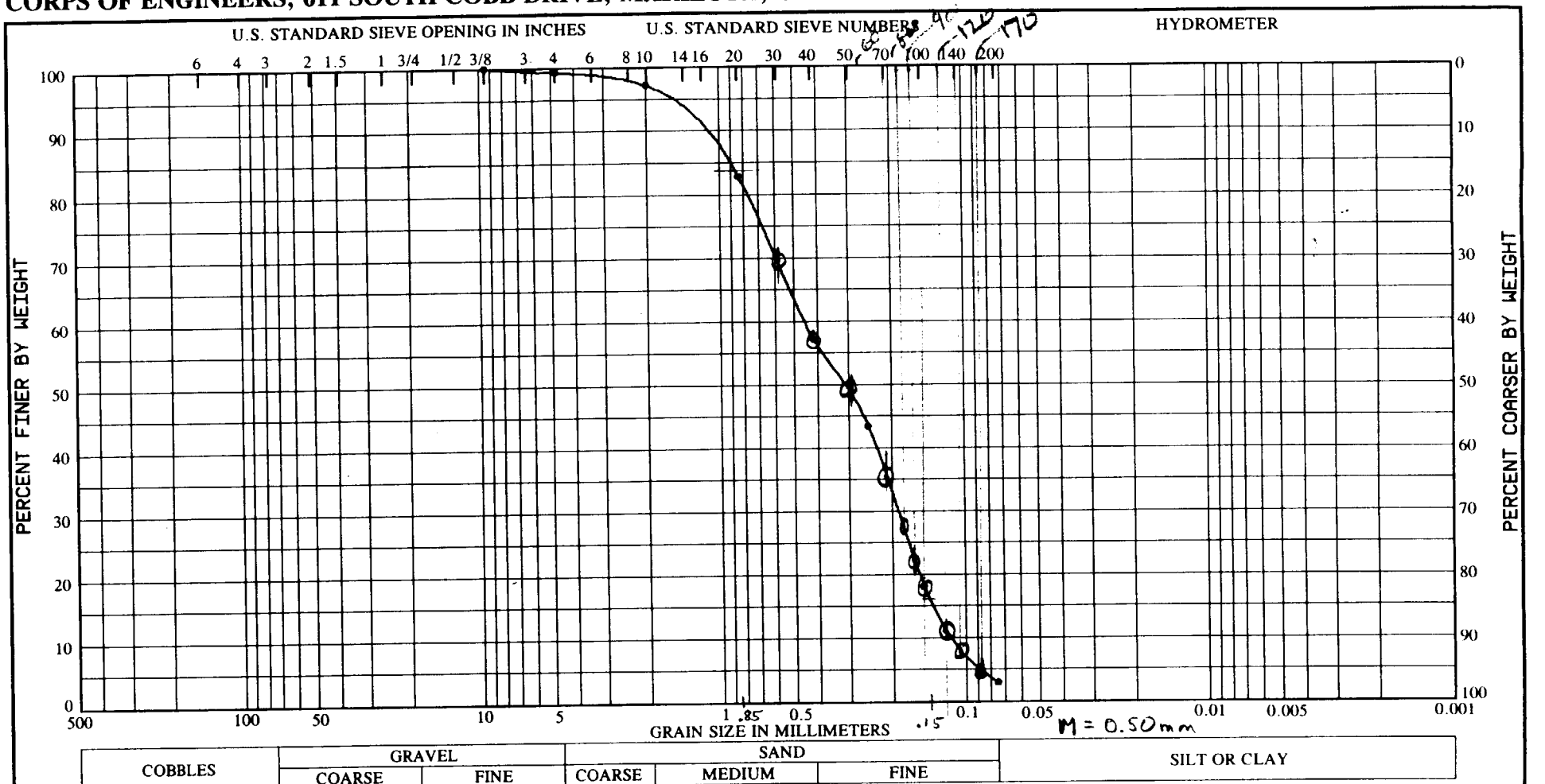
Sample No.	Elev (Ft)	(VISUAL) Classification	Nat w%	LL	PL	PI
1	1.8-2.0	TANNISH GRAY, POORLY GRADED SAND (SP), WITH A TRACE OF GRAVEL SIZES AND MICA.				

Project CAPE MAY
VIBRA-CORE SAMPLES
Lab No. 184/1269
Boring No. NJV-225
Date 07/24/96

GRADATION CURVES

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30060

WORK ORDER: 8015
REQUISITION: CENAP-EN-96-813



COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

Sample No.	Elev (Ft)	(VISUAL) Classification	Nat w%	LL	PL	PI
2	7.6-7.9	TANNISH GRAY, POORLY GRADED SAND (SP), WITH A TRACE OF MICA.				

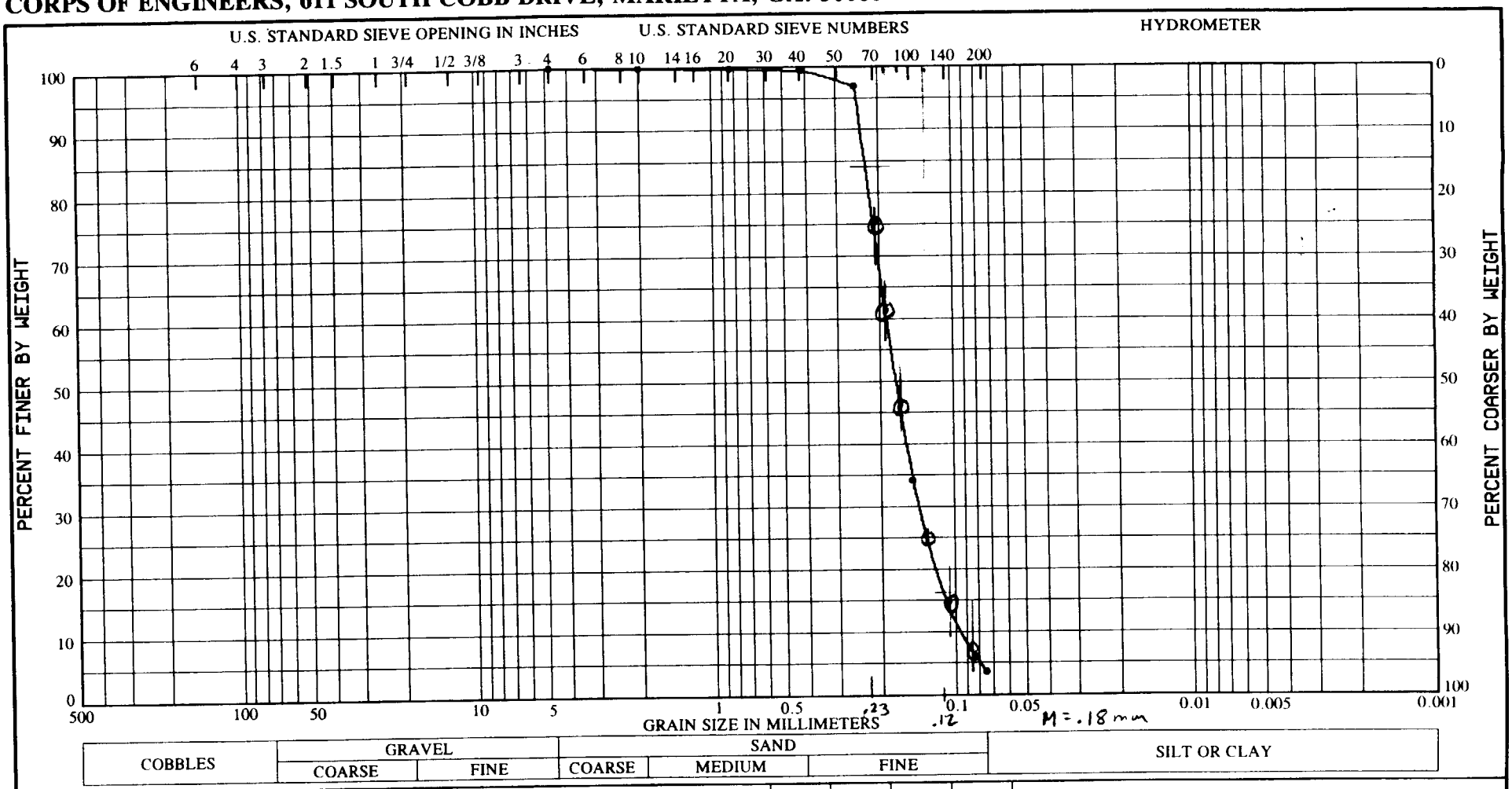
Project CAPE MAY
VIBRA-CORE SAMPLES
Lab No. 184/1269
Boring No. NJV-225
Date 07/24/96

GRADATION CURVES

OK

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30060

WORK ORDER: 8015
REQUISITION: CENAP-EN-96-813



COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

Sample No.	Elev (Ft)	(VISUAL) Classification	Nat w%	LL	PL	PI
3	12.0-12.3	TANNISH GRAY, POORLY GRADED SAND (SP), WITH A TRACE OF MICA.				

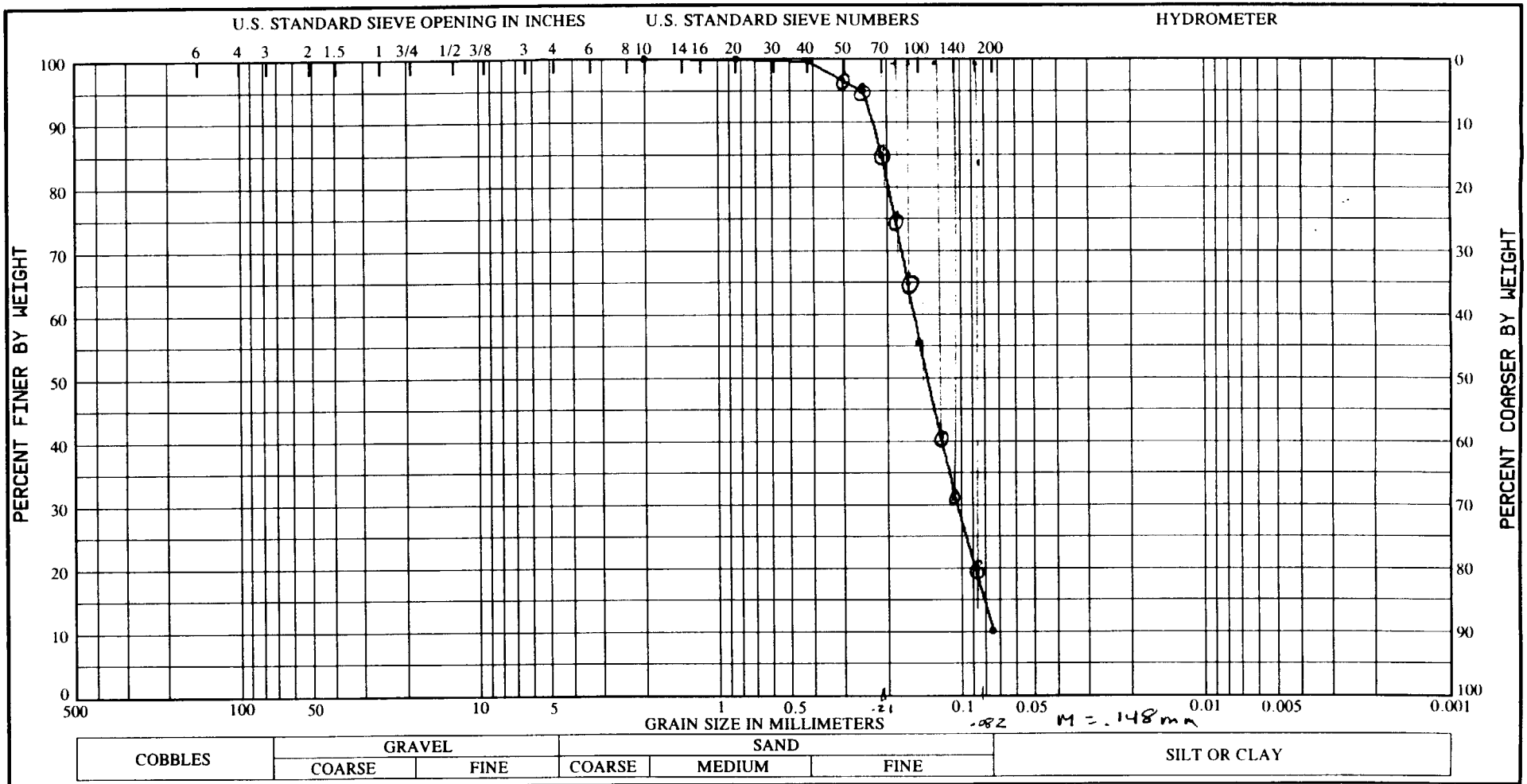
Project CAPE MAY
VIBRA-CORE SAMPLES
Lab No. 184/1269
Boring No. NJV-225
Date 07/24/96

GRADATION CURVES

OK

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30060

WORK ORDER: 8015
REQUISITION: CENAP-EN-96-813



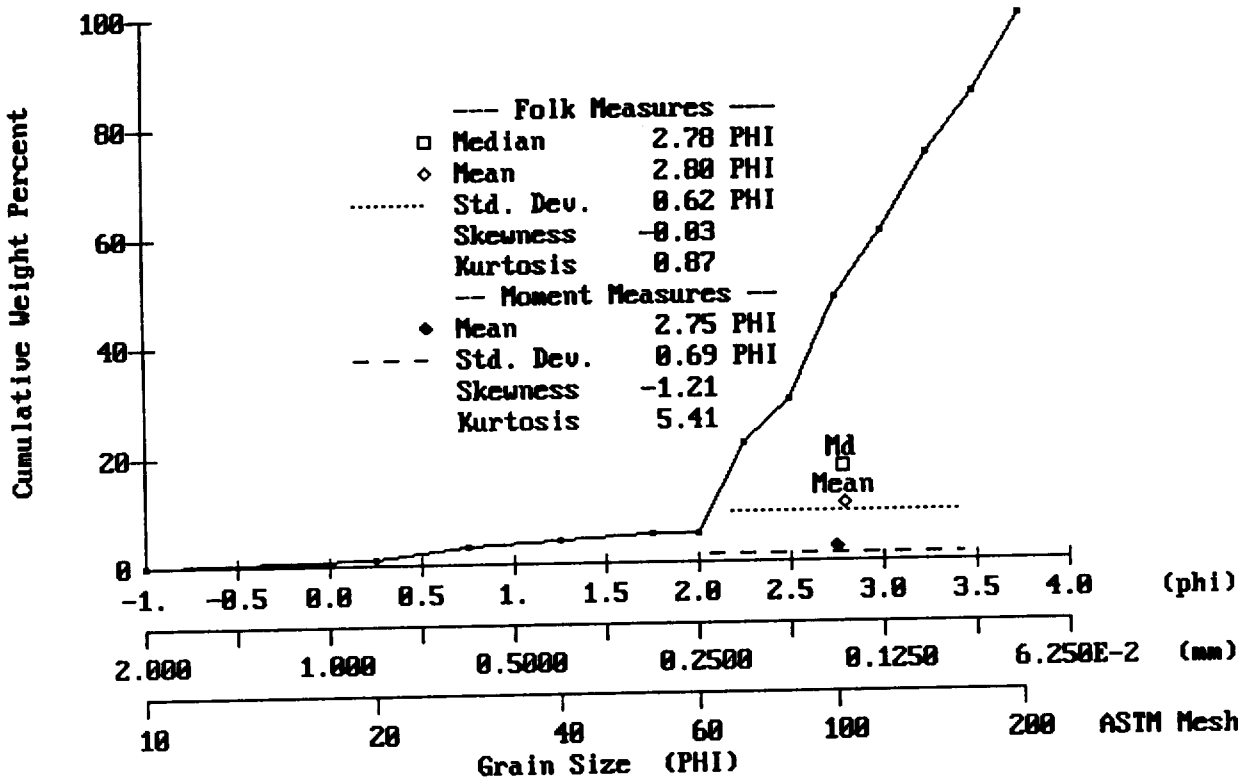
Sample No.	Elev (Ft)	(VISUAL) Classification	Nat w%	LL	PL	PI
4	15.5-16.7	TANNISH GRAY, POORLY GRADED SILTY SAND (SP-SM), WITH A TRACE OF MICA.				

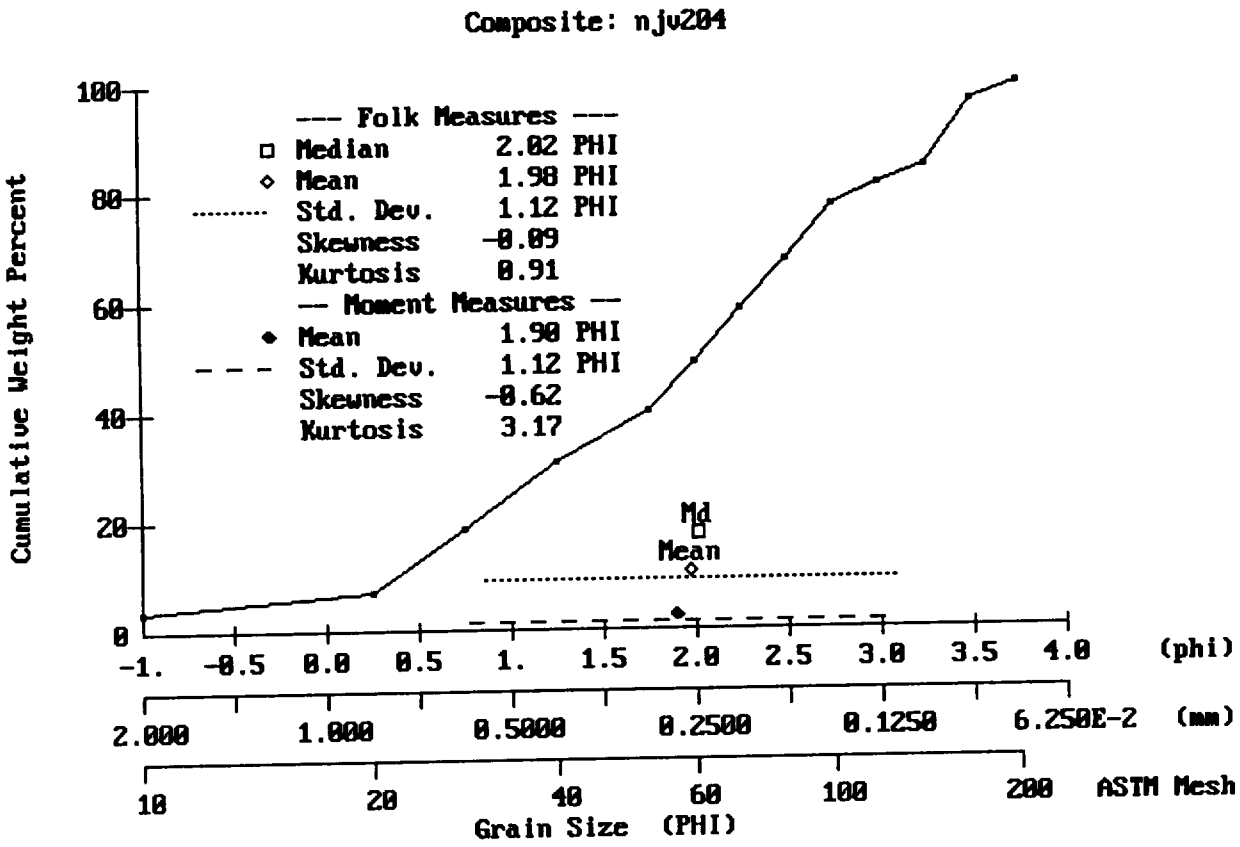
Project CAPE MAY
VIBRA-CORE SAMPLES
Lab No. 184/1269
Boring No. NJV-225
Date 07/24/96

GRADATION CURVES

OK - too fine

Composite: nju203

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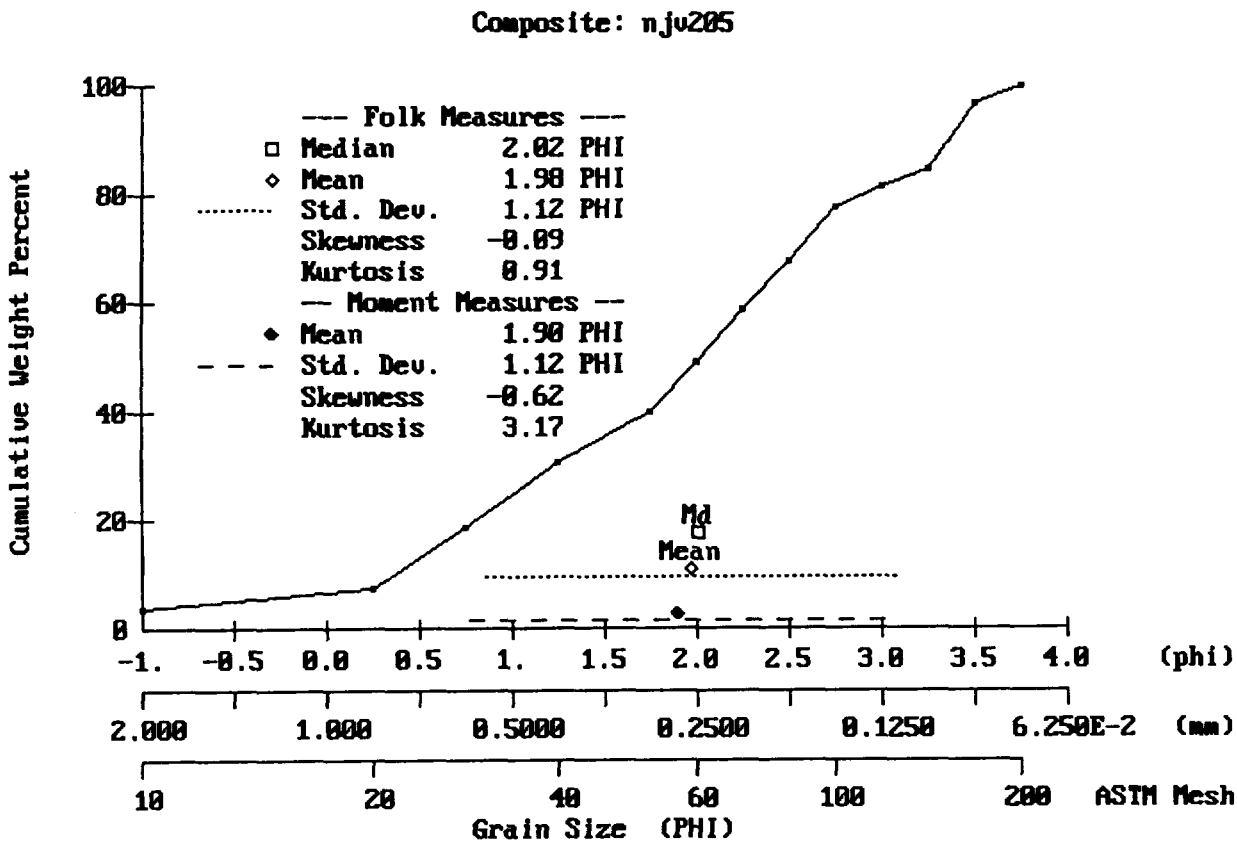
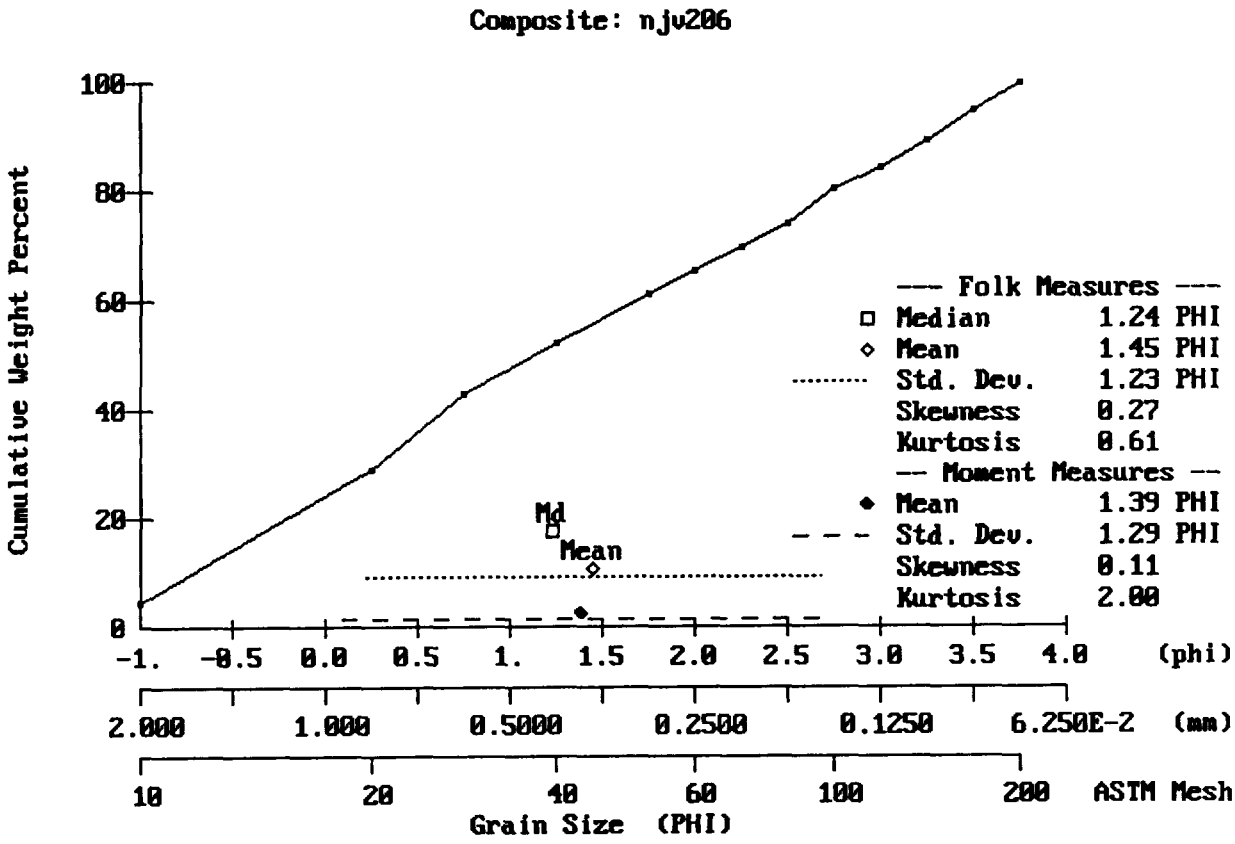
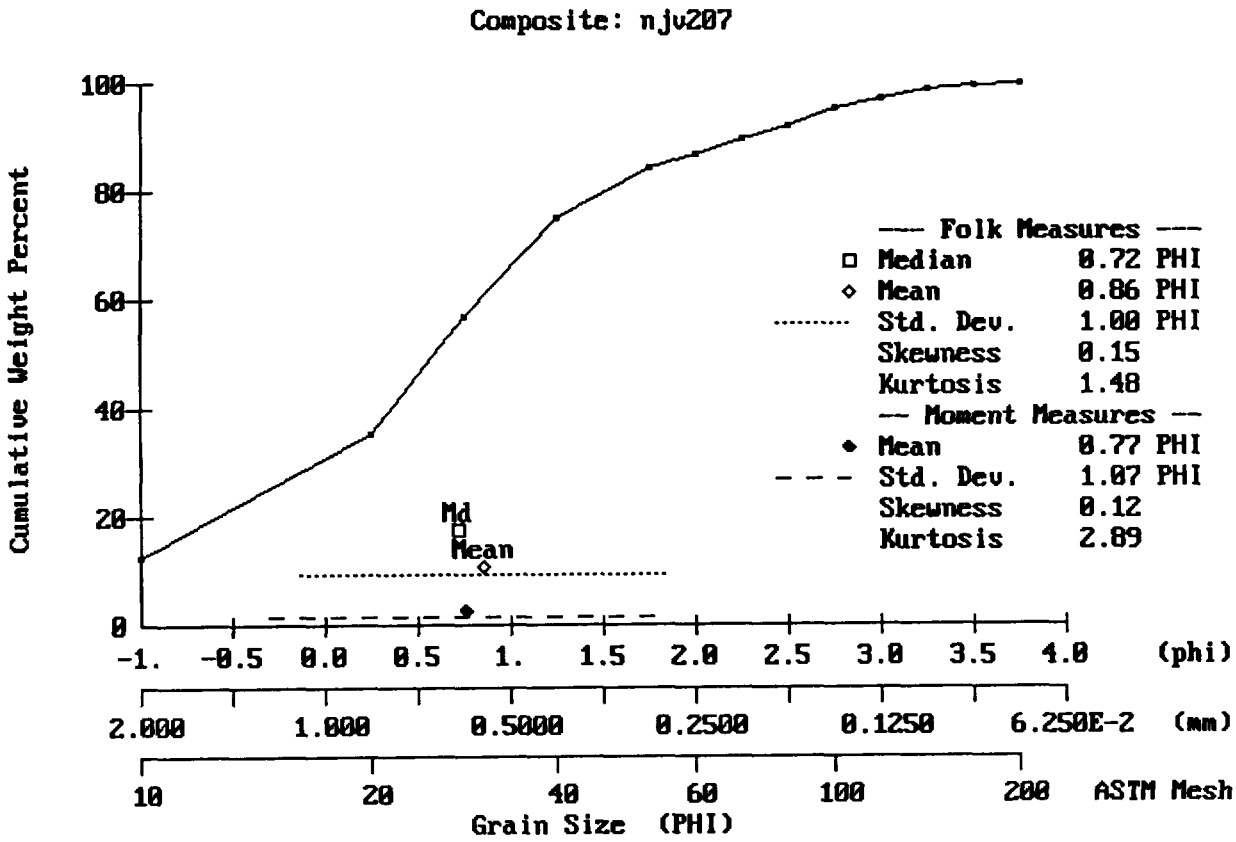
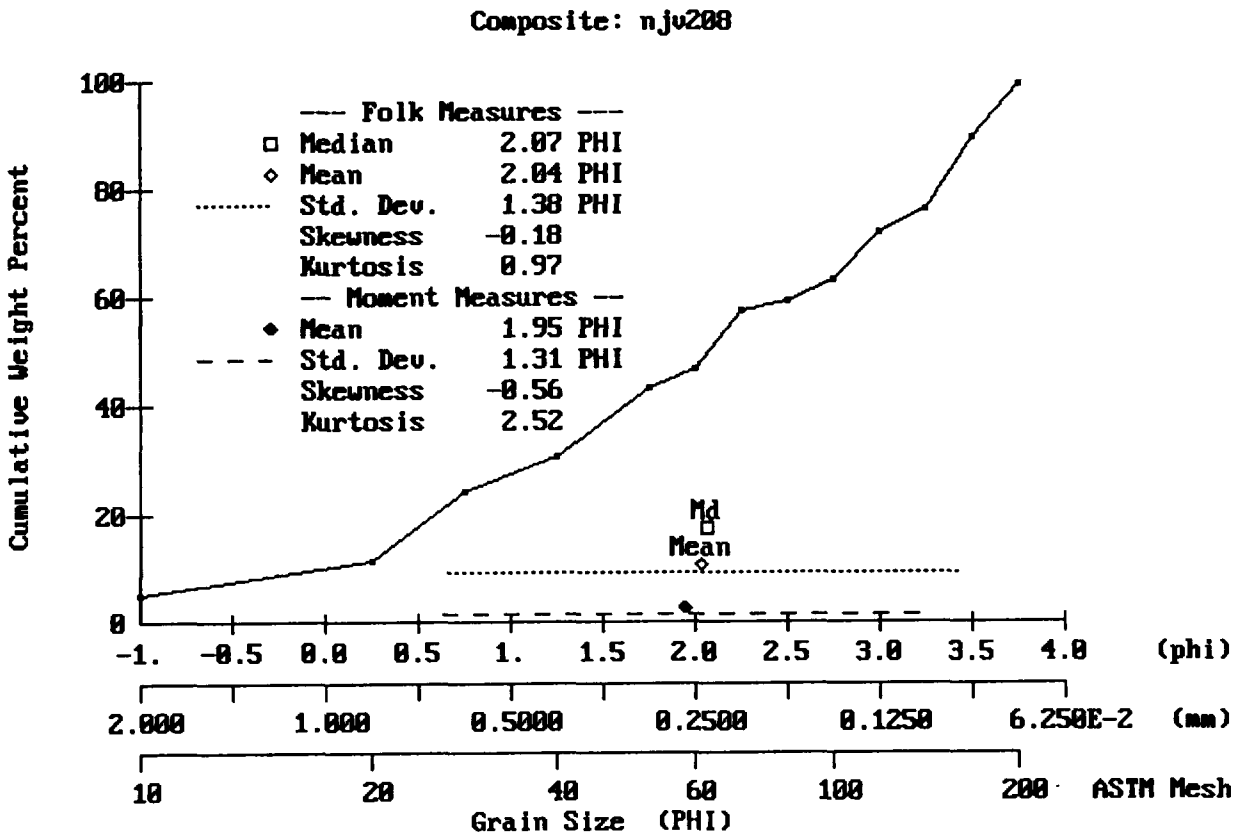
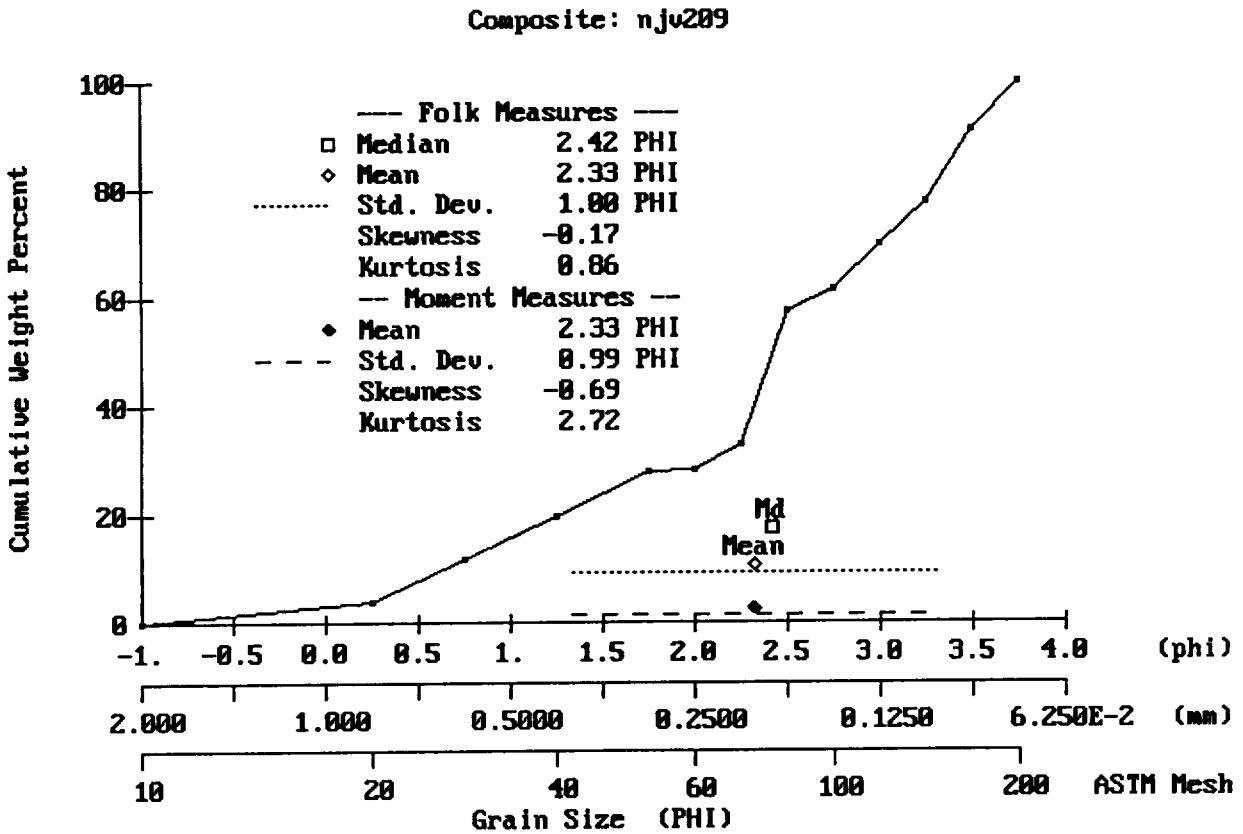
Mean 1.98 PHI
Std. Dev. 1.12 PHI
Skewness -0.09
Kurtosis 0.91
-- Moment Measures --
Mean 1.90 PHI
Std. Dev. 1.12 PHI
Skewness -0.62
Kurtosis 3.17
Md
Mean
Cumulative Weight Percent
100
80
60
40
20
0
-1. -0.5 0.0 0.5 1. 1.5 2.0 2.5 3.0 3.5 4.0 (phi)
2.000 1.000 0.5000 0.2500 0.1250 6.250E-2 (mm)
10 20 40 60 100 200 ASTM Mesh
Grain Size (PHI)

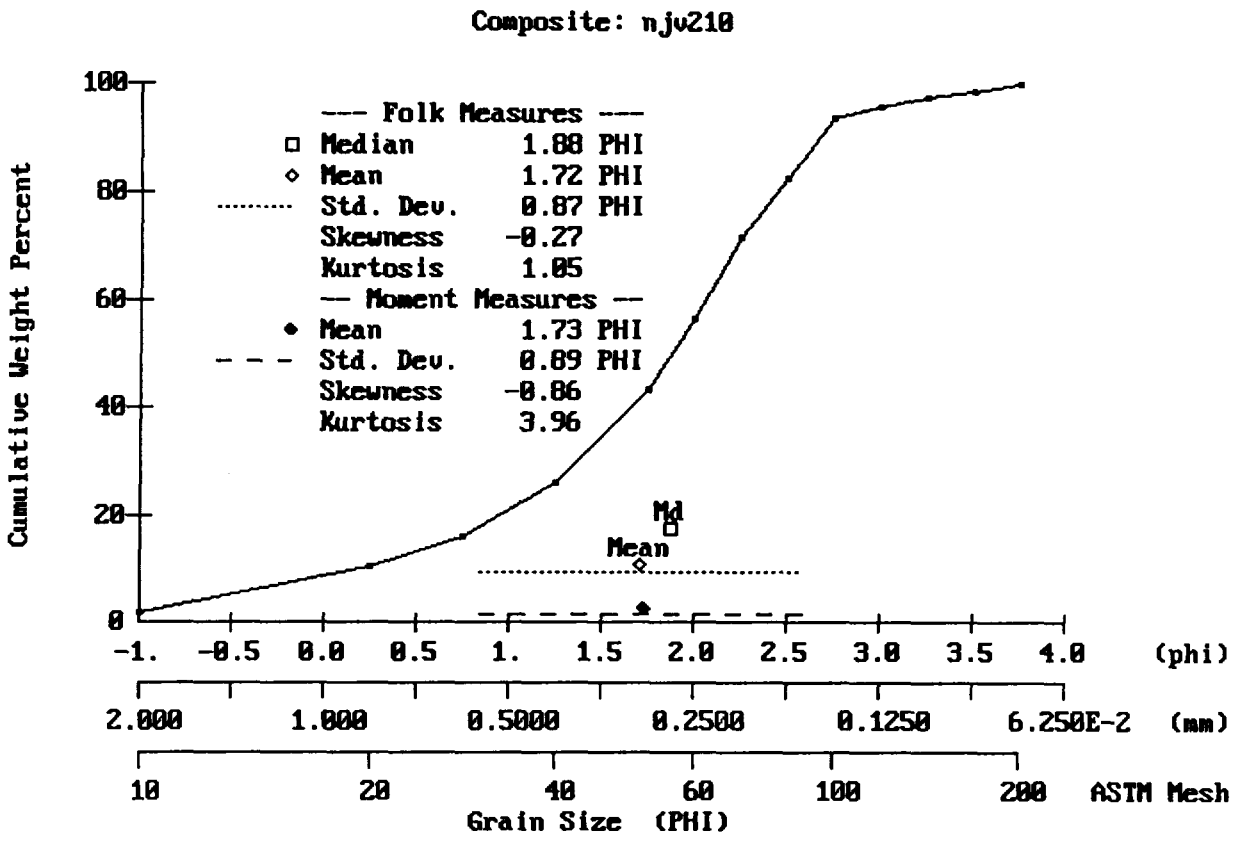

Composite: nju205
--- Folk Measures ---
Median 2.02 PHI
Mean 1.98 PHI
Std. Dev. 1.12 PHI
Skewness -0.09
Kurtosis 0.91
-- Moment Measures --
Mean 1.90 PHI
Std. Dev. 1.12 PHI
Skewness -0.62
Kurtosis 3.17
Md
Mean
Cumulative Weight Percent
100
80
60
40
20
0
-1. -0.5 0.0 0.5 1. 1.5 2.0 2.5 3.0 3.5 4.0 (phi)
2.000 1.000 0.5000 0.2500 0.1250 6.250E-2 (mm)
10 20 40 60 100 200 ASTM Mesh
Grain Size (PHI)

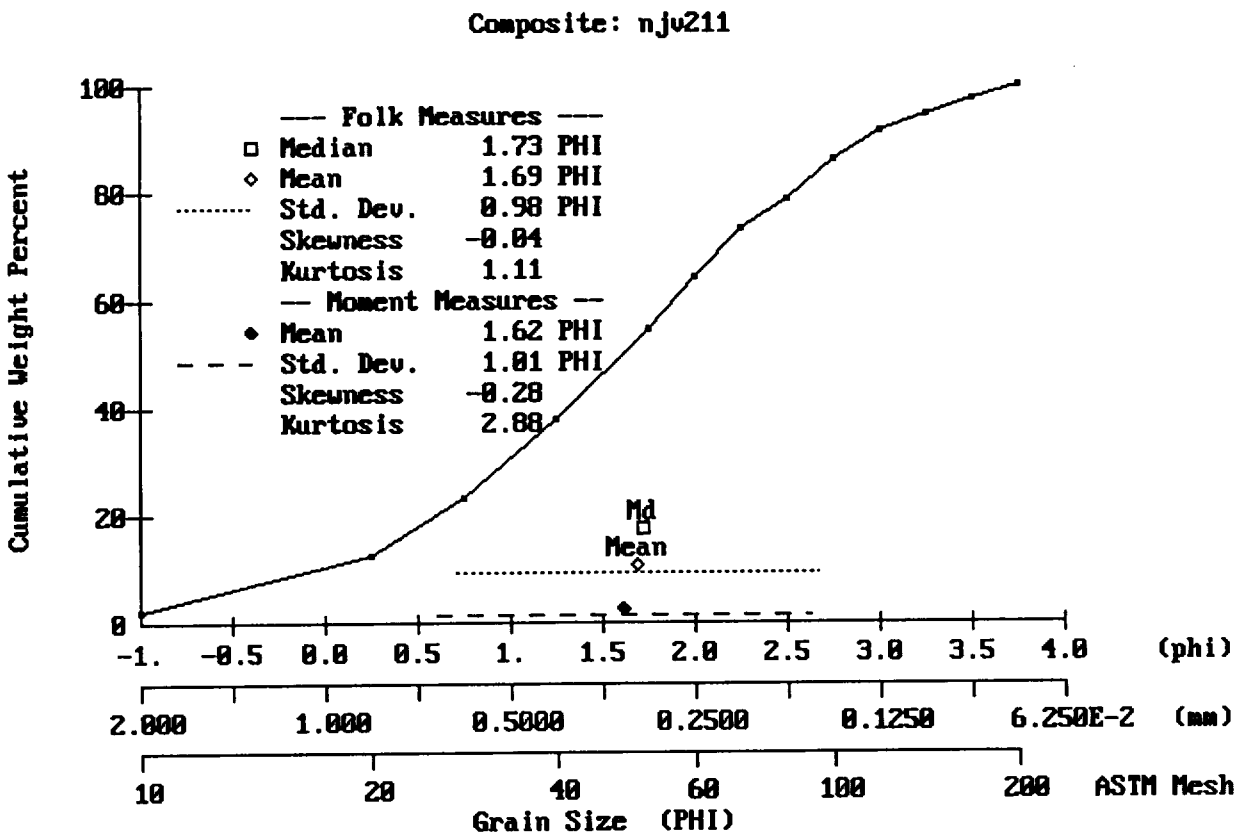

Composite: njv206
Cumulative Weight Percent
100
80
60
40
20
0
Md
Mean
--- Folk Measures ---
Median 1.24 PHI
Mean 1.45 PHI
Std. Dev. 1.23 PHI
Skewness 0.27
Kurtosis 0.61
-- Moment Measures --
Mean 1.39 PHI
Std. Dev. 1.29 PHI
Skewness 0.11
Kurtosis 2.00
-1. -0.5 0.0 0.5 1. 1.5 2.0 2.5 3.0 3.5 4.0 (phi)
2.000 1.000 0.5000 0.2500 0.1250 6.250E-2 (mm)
10 20 40 60 100 200 ASTM Mesh
Grain Size (PHI)

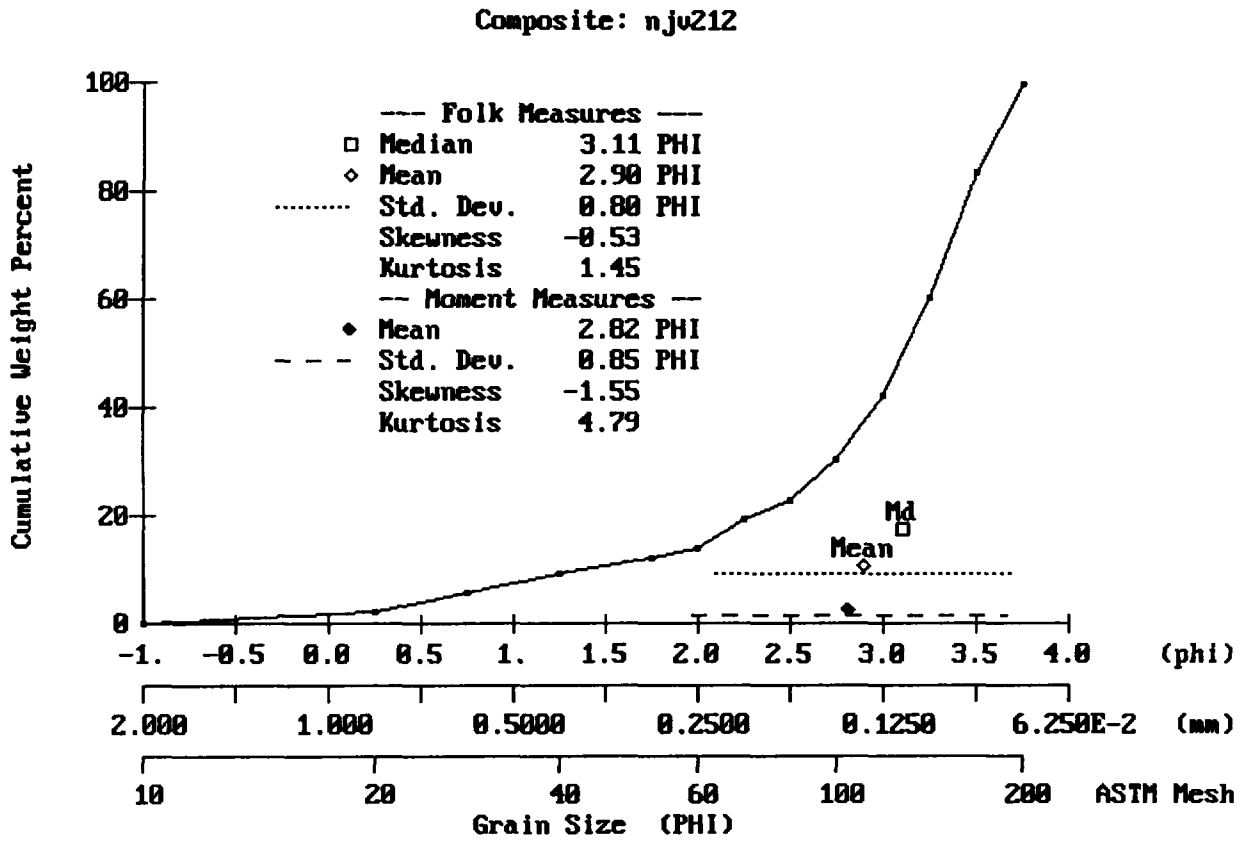

Composite: njv207
Cumulative Weight Percent
100
80
60
40
20
0
Md
Mean
— Folk Measures —
Median 0.72 PHI
Mean 0.86 PHI
Std. Dev. 1.00 PHI
Skewness 0.15
Kurtosis 1.48
— Moment Measures —
Mean 0.77 PHI
Std. Dev. 1.07 PHI
Skewness 0.12
Kurtosis 2.89
-1. -0.5 0.0 0.5 1. 1.5 2.0 2.5 3.0 3.5 4.0 (phi)
2.000 1.000 0.5000 0.2500 0.1250 6.250E-2 (mm)
10 20 40 60 100 200 ASTM Mesh
Grain Size (PHI)

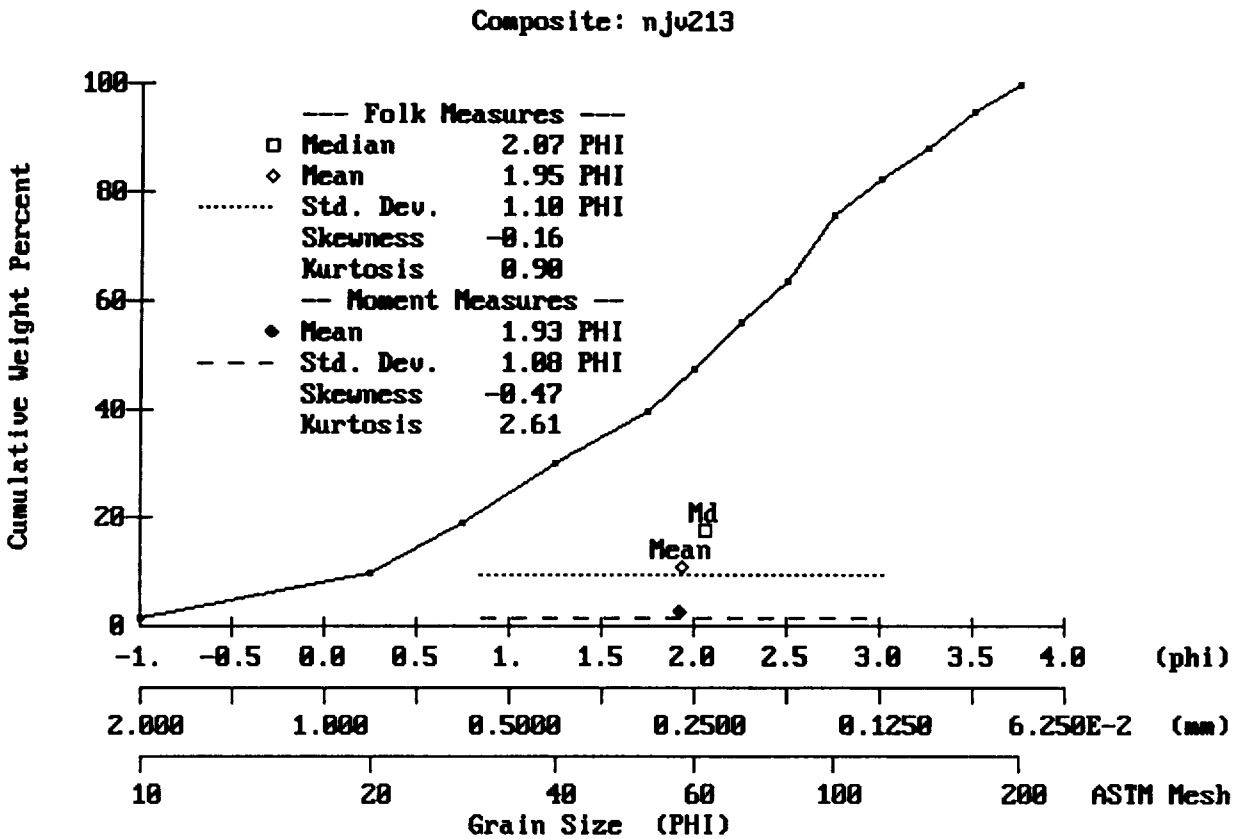

Composite: nju208
--- Folk Measures ---
Median 2.07 PHI
Mean 2.04 PHI
Std. Dev. 1.38 PHI
Skewness -0.18
Kurtosis 0.97
-- Moment Measures --
Mean 1.95 PHI
Std. Dev. 1.31 PHI
Skewness -0.56
Kurtosis 2.52
Md
Mean
Cumulative Weight Percent
100
80
60
40
20
0
-1. -0.5 0.0 0.5 1. 1.5 2.0 2.5 3.0 3.5 4.0 (phi)
2.000 1.000 0.5000 0.2500 0.1250 6.250E-2 (mm)
10 20 40 60 100 200 ASTM Mesh
Grain Size (PHI)

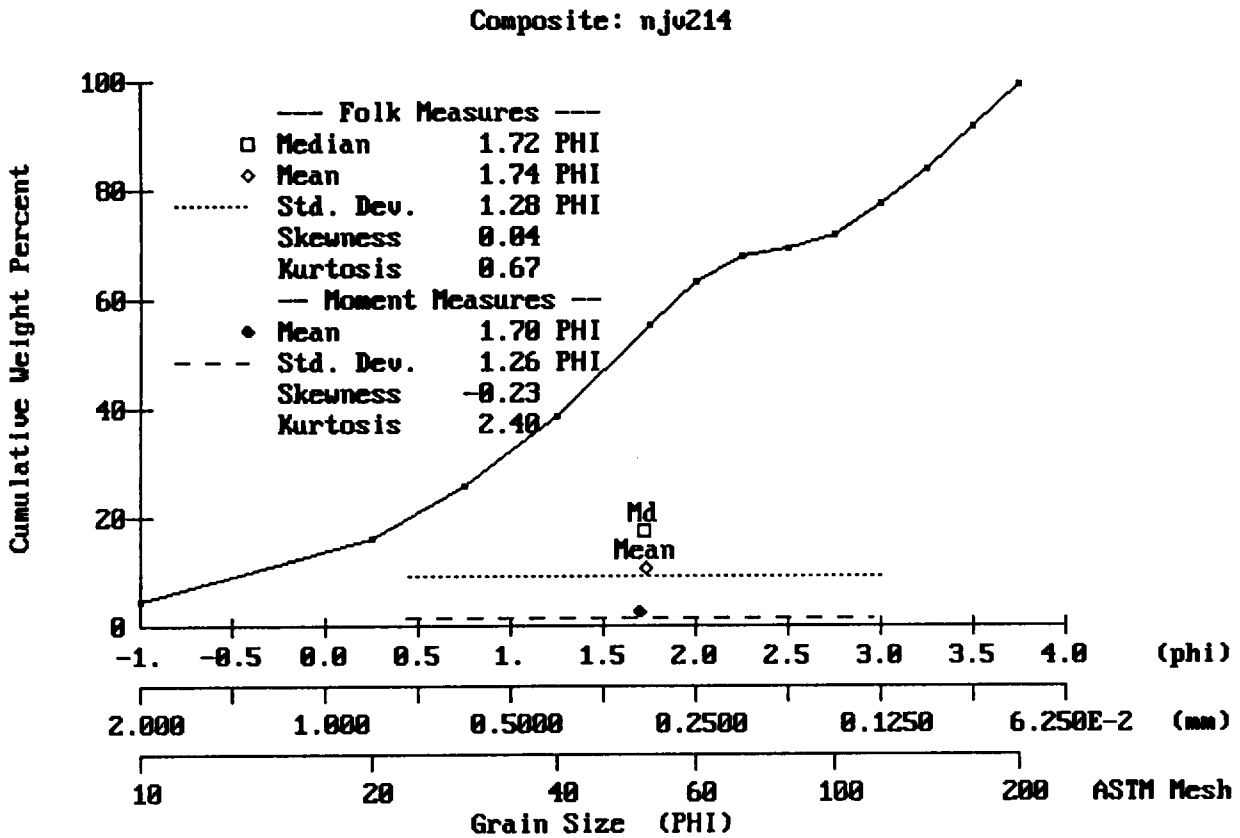

Composite: njv209
--- Folk Measures ---
Median 2.42 PHI
Mean 2.33 PHI
Std. Dev. 1.00 PHI
Skewness -0.17
Kurtosis 0.86
-- Moment Measures --
Mean 2.33 PHI
Std. Dev. 0.99 PHI
Skewness -0.69
Kurtosis 2.72
Md
Mean
Cumulative Weight Percent
100
80
60
40
20
0
-1. -0.5 0.0 0.5 1. 1.5 2.0 2.5 3.0 3.5 4.0 (phi)
2.000 1.000 0.5000 0.2500 0.1250 6.250E-2 (mm)
10 20 40 60 100 200 ASTM Mesh
Grain Size (PHI)

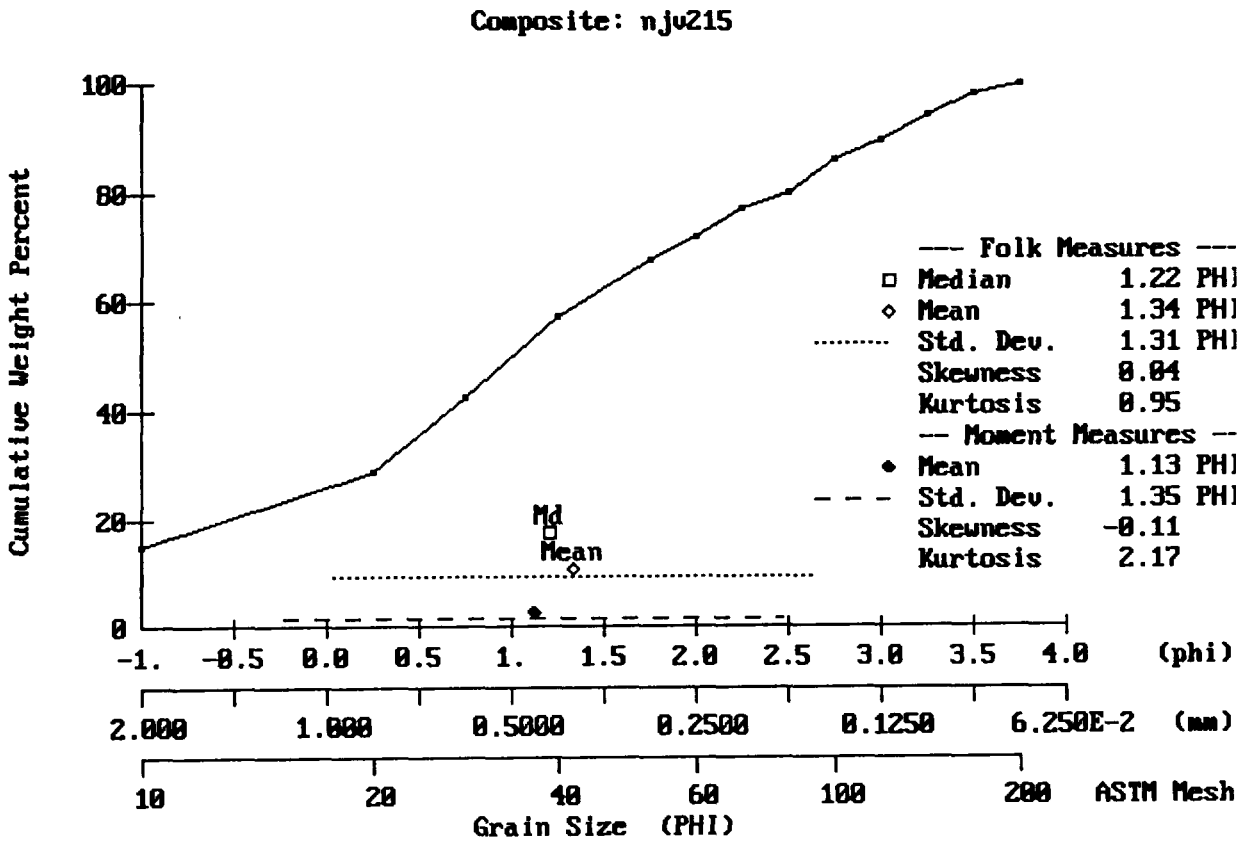

Composite: njv210
--- Folk Measures ---
Median 1.88 PHI
Mean 1.72 PHI
Std. Dev. 0.87 PHI
Skewness -0.27
Kurtosis 1.05
-- Moment Measures --
Mean 1.73 PHI
Std. Dev. 0.89 PHI
Skewness -0.86
Kurtosis 3.96
Md
Mean
Cumulative Weight Percent
100
80
60
40
20
0
-1. -0.5 0.0 0.5 1. 1.5 2.0 2.5 3.0 3.5 4.0 (phi)
2.000 1.000 0.5000 0.2500 0.1250 6.250E-2 (mm)
10 20 40 60 100 200 ASTM Mesh
Grain Size (PHI)

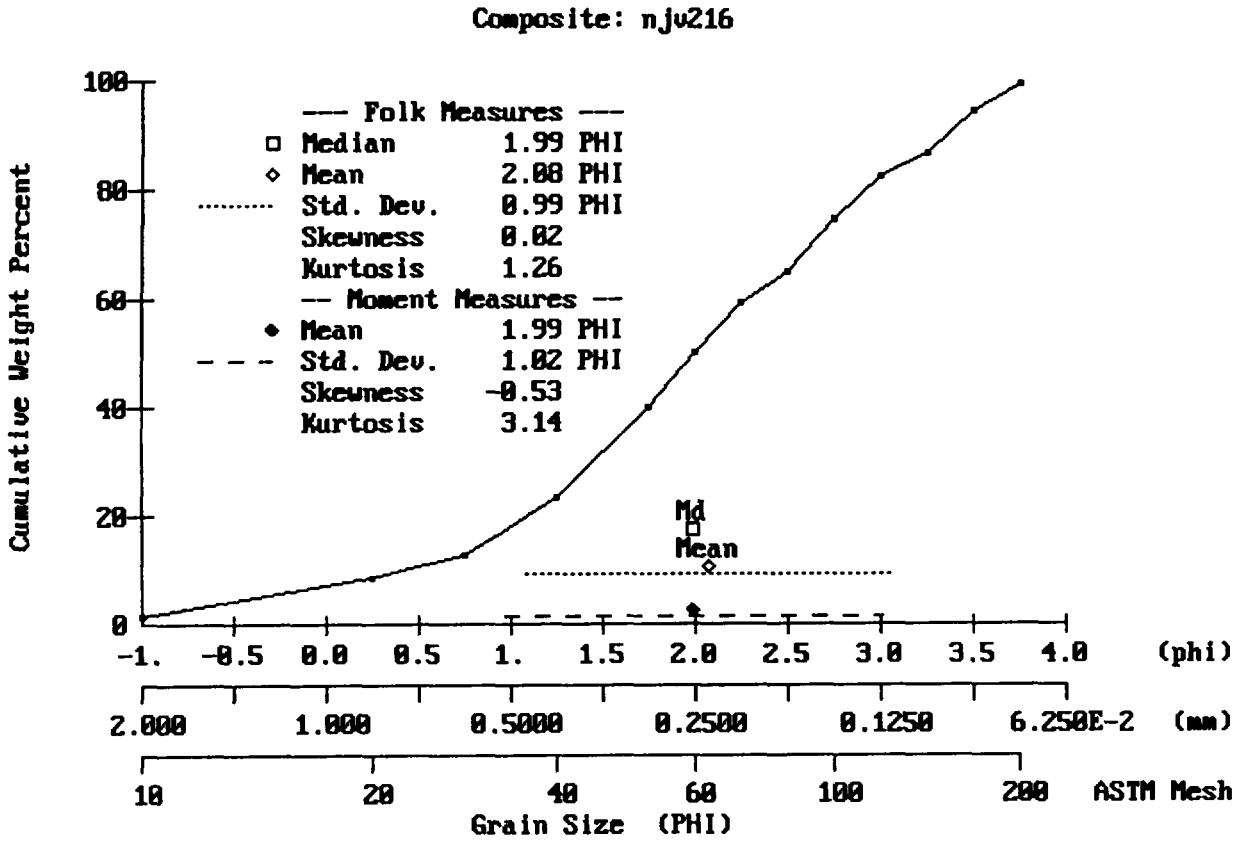

Composite: nju211
Cumulative Weight Percent
100
80
60
40
20
0
— Folk Measures —
Median 1.73 PHI
Mean 1.69 PHI
Std. Dev. 0.98 PHI
Skewness -0.04
Kurtosis 1.11
— Moment Measures —
Mean 1.62 PHI
Std. Dev. 1.01 PHI
Skewness -0.28
Kurtosis 2.88
Md
Mean
-1. -0.5 0.0 0.5 1. 1.5 2.0 2.5 3.0 3.5 4.0 (phi)
2.000 1.000 0.5000 0.2500 0.1250 6.250E-2 (mm)
10 20 40 60 100 200 ASTM Mesh
Grain Size (PHI)

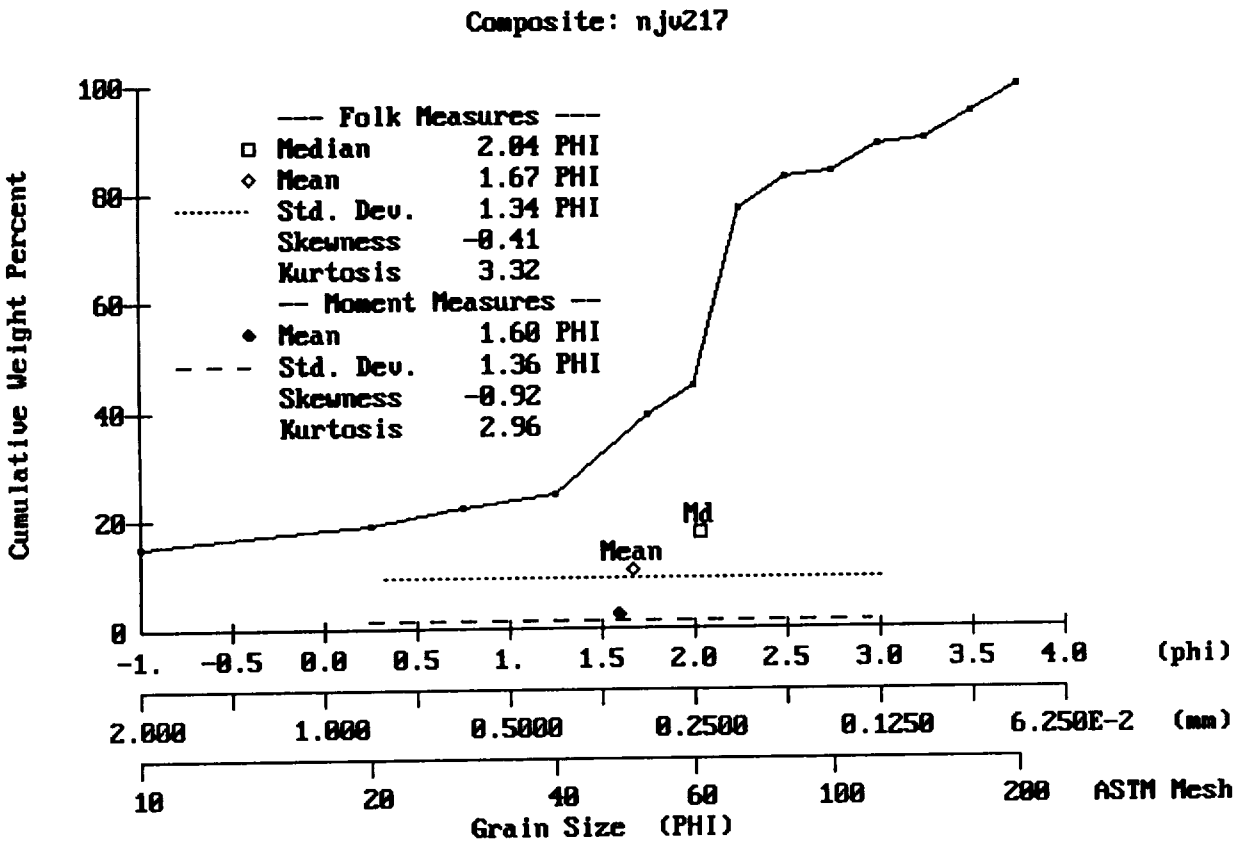

Composite: nju212
--- Folk Measures ---
Median 3.11 PHI
Mean 2.90 PHI
Std. Dev. 0.80 PHI
Skewness -0.53
Kurtosis 1.45
-- Moment Measures --
Mean 2.82 PHI
Std. Dev. 0.85 PHI
Skewness -1.55
Kurtosis 4.79
Cumulative Weight Percent
100
80
60
40
20
0
Md
Mean
-1. -0.5 0.0 0.5 1. 1.5 2.0 2.5 3.0 3.5 4.0 (phi)
2.000 1.000 0.5000 0.2500 0.1250 6.250E-2 (mm)
10 20 40 60 100 200 ASTM Mesh
Grain Size (PHI)

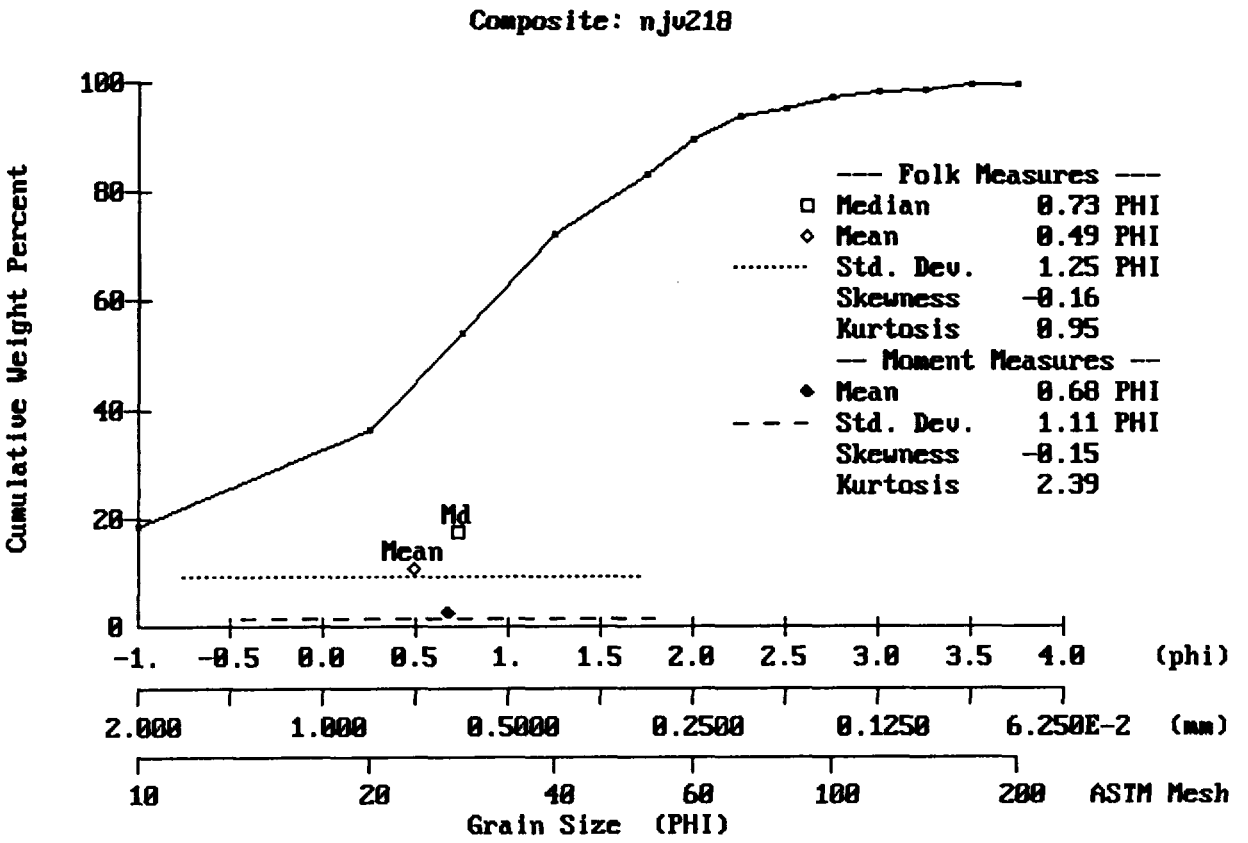

Composite: nju213
--- Folk Measures ---
Median 2.07 PHI
Mean 1.95 PHI
Std. Dev. 1.10 PHI
Skewness -0.16
Kurtosis 0.90
-- Moment Measures --
Mean 1.93 PHI
Std. Dev. 1.08 PHI
Skewness -0.47
Kurtosis 2.61
Md
Mean
Cumulative Weight Percent
100
80
60
40
20
0
-1. -0.5 0.0 0.5 1. 1.5 2.0 2.5 3.0 3.5 4.0 (phi)
2.000 1.000 0.5000 0.2500 0.1250 6.250E-2 (mm)
10 20 40 60 100 200 ASTM Mesh
Grain Size (PHI)

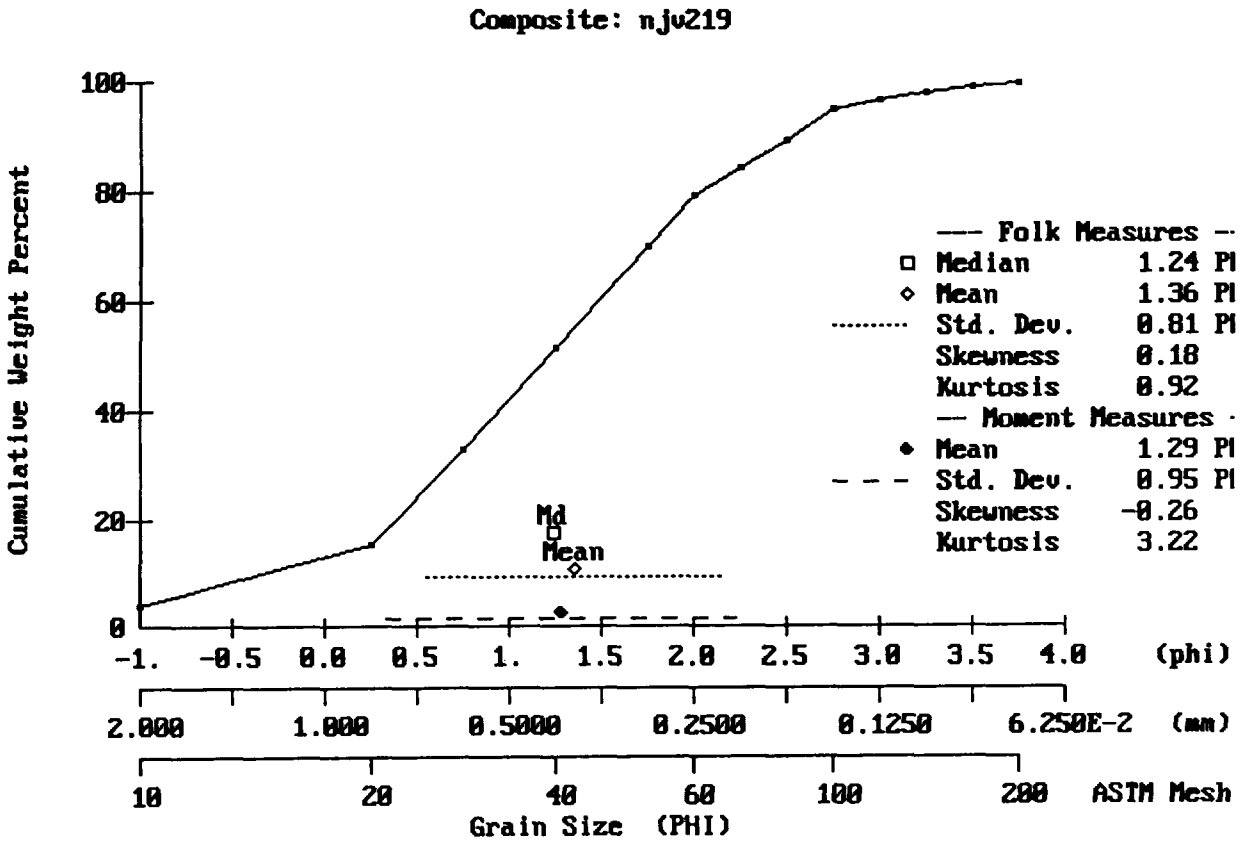

Composite: njv214
Cumulative Weight Percent
100
80
60
40
20
0
--- Folk Measures ---
Median 1.72 PHI
Mean 1.74 PHI
Std. Dev. 1.28 PHI
Skewness 0.04
Kurtosis 0.67
-- Moment Measures --
Mean 1.70 PHI
Std. Dev. 1.26 PHI
Skewness -0.23
Kurtosis 2.40
Md
Mean
-1. -0.5 0.0 0.5 1. 1.5 2.0 2.5 3.0 3.5 4.0 (phi)
2.000 1.000 0.5000 0.2500 0.1250 6.250E-2 (mm)
10 20 40 60 100 200 ASTM Mesh
Grain Size (PHI)

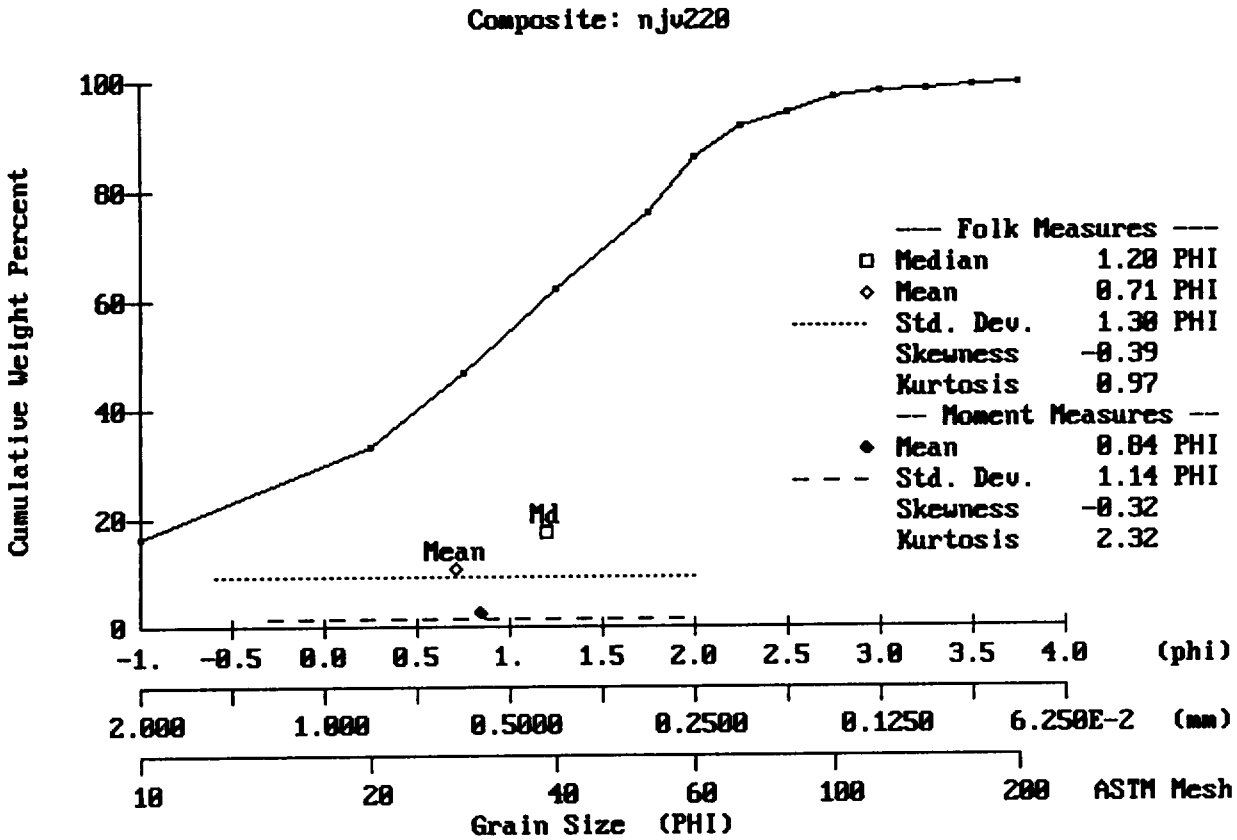

Composite: nju215
Cumulative Weight Percent
100
80
60
40
20
0
--- Folk Measures ---
Median 1.22 PHI
Mean 1.34 PHI
Std. Dev. 1.31 PHI
Skewness 0.04
Kurtosis 0.95
-- Moment Measures --
Mean 1.13 PHI
Std. Dev. 1.35 PHI
Skewness -0.11
Kurtosis 2.17
Md
Mean
-1. -0.5 0.0 0.5 1. 1.5 2.0 2.5 3.0 3.5 4.0 (phi)
2.000 1.000 0.5000 0.2500 0.1250 6.250E-2 (mm)
10 20 40 60 100 200 ASTM Mesh
Grain Size (PHI)

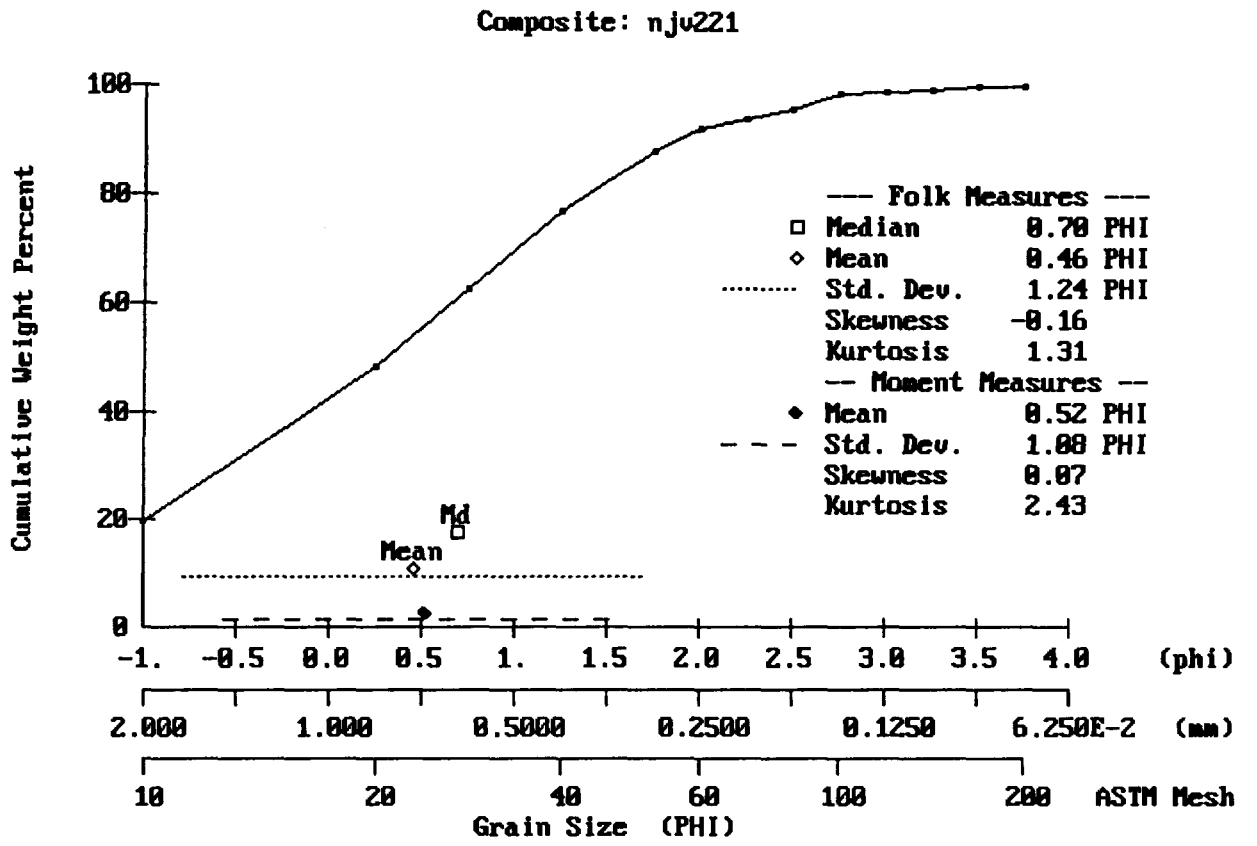

Composite: nju216
--- Folk Measures ---
Median 1.99 PHI
Mean 2.08 PHI
Std. Dev. 0.99 PHI
Skewness 0.02
Kurtosis 1.26
-- Moment Measures --
Mean 1.99 PHI
Std. Dev. 1.02 PHI
Skewness -0.53
Kurtosis 3.14
Md
Mean
Cumulative Weight Percent
100
80
60
40
20
0
-1. -0.5 0.0 0.5 1. 1.5 2.0 2.5 3.0 3.5 4.0 (phi)
2.000 1.000 0.5000 0.2500 0.1250 6.250E-2 (mm)
10 20 40 60 100 200 ASTM Mesh
Grain Size (PHI)

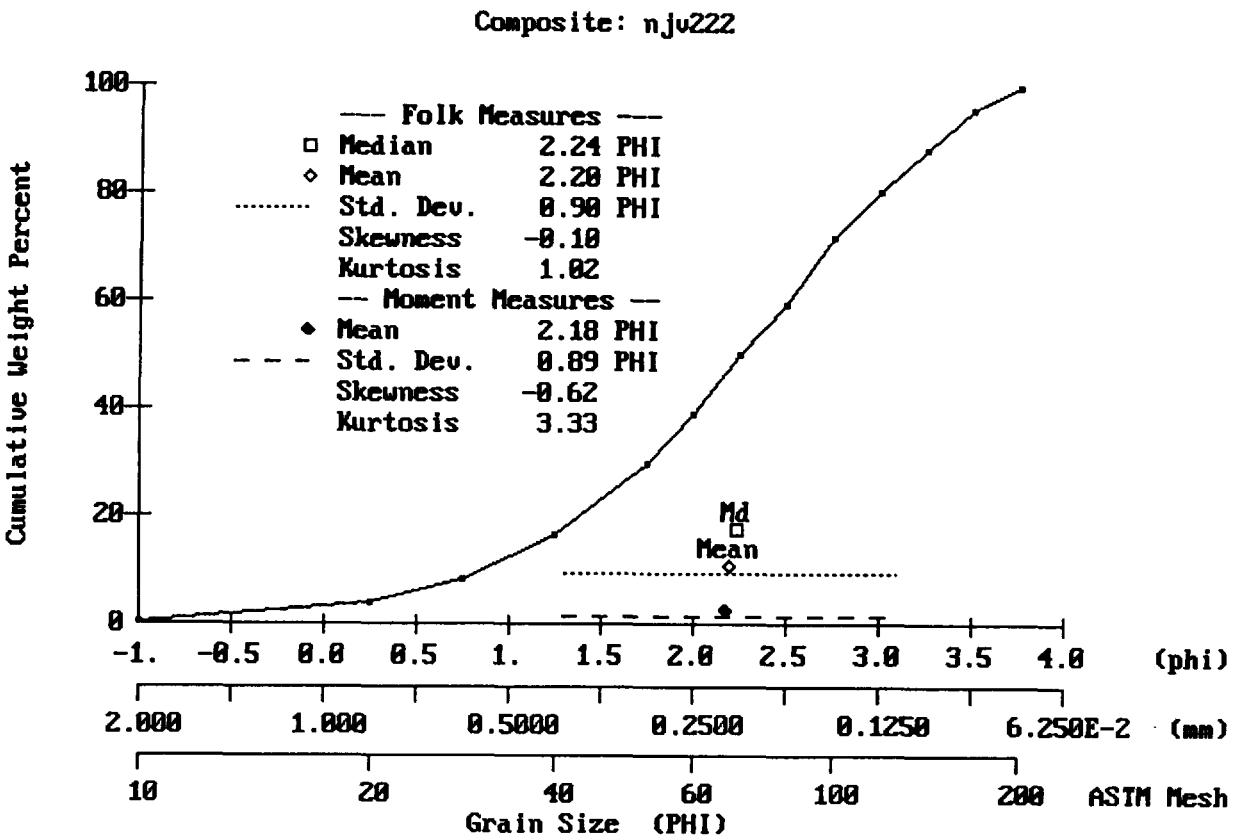

Composite: nju217
--- Folk Measures ---
Median 2.04 PHI
Mean 1.67 PHI
Std. Dev. 1.34 PHI
Skewness -0.41
Kurtosis 3.32
-- Moment Measures --
Mean 1.60 PHI
Std. Dev. 1.36 PHI
Skewness -0.92
Kurtosis 2.96
Md
Mean
Cumulative Weight Percent
100
80
60
40
20
0
-1. -0.5 0.0 0.5 1. 1.5 2.0 2.5 3.0 3.5 4.0 (phi)
2.000 1.000 0.5000 0.2500 0.1250 6.250E-2 (mm)
10 20 40 60 100 200 ASTM Mesh
Grain Size (PHI)

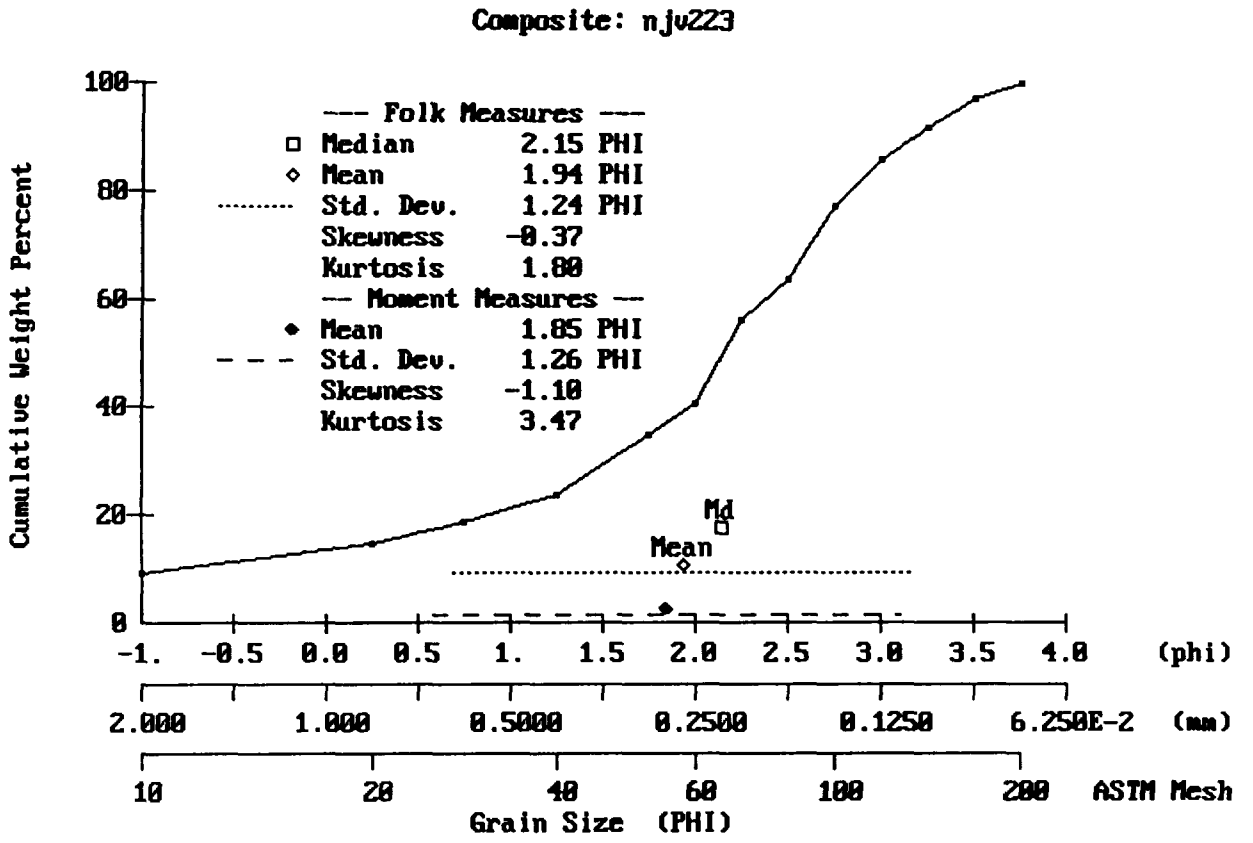

Composite: njv218
Cumulative Weight Percent
100
80
60
40
20
0
--- Folk Measures ---
Median 0.73 PHI
Mean 0.49 PHI
Std. Dev. 1.25 PHI
Skewness -0.16
Kurtosis 0.95
-- Moment Measures --
Mean 0.68 PHI
Std. Dev. 1.11 PHI
Skewness -0.15
Kurtosis 2.39
Md
Mean
-1. -0.5 0.0 0.5 1. 1.5 2.0 2.5 3.0 3.5 4.0 (phi)
2.000 1.000 0.5000 0.2500 0.1250 6.250E-2 (mm)
10 20 40 60 100 200 ASTM Mesh
Grain Size (PHI)

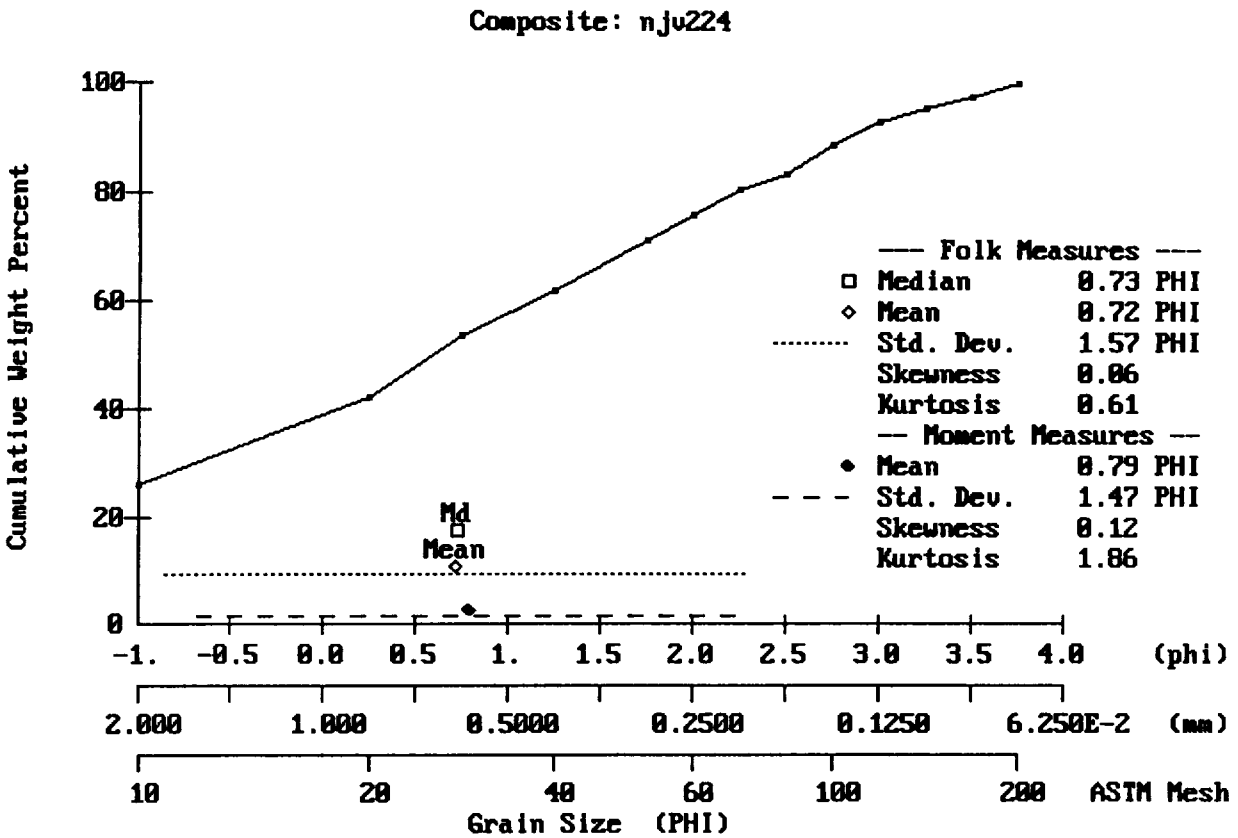

Composite: nju219
Cumulative Weight Percent
100
80
60
40
20
0
Md
Mean
-- Folk Measures --
Median 1.24 Pl
Mean 1.36 Pl
Std. Dev. 0.81 Pl
Skewness 0.18
Kurtosis 0.92
-- Moment Measures --
Mean 1.29 Pl
Std. Dev. 0.95 Pl
Skewness -0.26
Kurtosis 3.22
-1. -0.5 0.0 0.5 1. 1.5 2.0 2.5 3.0 3.5 4.0 (phi)
2.000 1.000 0.5000 0.2500 0.1250 6.250E-2 (mm)
10 20 40 60 100 200 ASTM Mesh
Grain Size (PHI)

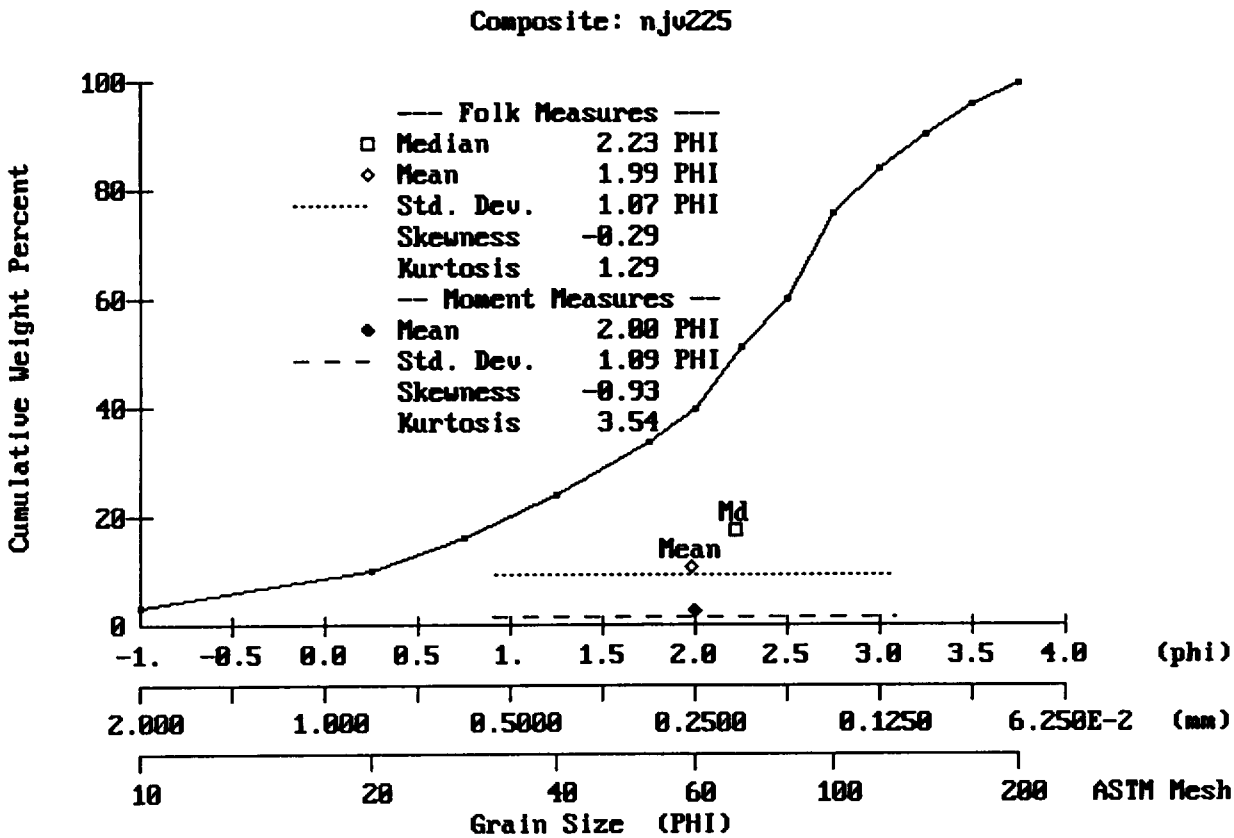

Composite: nju220
Cumulative Weight Percent
100
80
60
40
20
0
Md
Mean
-- Folk Measures --
Median 1.20 PHI
Mean 0.71 PHI
Std. Dev. 1.30 PHI
Skewness -0.39
Kurtosis 0.97
-- Moment Measures --
Mean 0.84 PHI
Std. Dev. 1.14 PHI
Skewness -0.32
Kurtosis 2.32
-1. -0.5 0.0 0.5 1. 1.5 2.0 2.5 3.0 3.5 4.0 (phi)
2.000 1.000 0.5000 0.2500 0.1250 6.250E-2 (mm)
10 20 40 60 100 200 ASTM Mesh
Grain Size (PHI)


Composite: nju221
Cumulative Weight Percent
100
80
60
40
20
0
--- Folk Measures ---
Median 0.70 PHI
Mean 0.46 PHI
Std. Dev. 1.24 PHI
Skewness -0.16
Kurtosis 1.31
-- Moment Measures --
Mean 0.52 PHI
Std. Dev. 1.08 PHI
Skewness 0.07
Kurtosis 2.43
Md
Mean
-1. -0.5 0.0 0.5 1. 1.5 2.0 2.5 3.0 3.5 4.0 (phi)
2.000 1.000 0.5000 0.2500 0.1250 6.250E-2 (mm)
10 20 40 60 100 200 ASTM Mesh
Grain Size (PHI)


Composite: nju222
Cumulative Weight Percent
100
80
60
40
20
0
— Folk Measures —
Median 2.24 PHI
Mean 2.20 PHI
Std. Dev. 0.90 PHI
Skewness -0.10
Kurtosis 1.02
-- Moment Measures --
Mean 2.18 PHI
Std. Dev. 0.89 PHI
Skewness -0.62
Kurtosis 3.33
Md
Mean
-1. -0.5 0.0 0.5 1. 1.5 2.0 2.5 3.0 3.5 4.0 (phi)
2.000 1.000 0.5000 0.2500 0.1250 6.250E-2 (mm)
10 20 40 60 100 200 ASTM Mesh
Grain Size (PHI)


Composite: njv223
--- Folk Measures ---
Median 2.15 PHI
Mean 1.94 PHI
Std. Dev. 1.24 PHI
Skewness -0.37
Kurtosis 1.80
-- Moment Measures --
Mean 1.85 PHI
Std. Dev. 1.26 PHI
Skewness -1.10
Kurtosis 3.47
Cumulative Weight Percent
100
80
60
40
20
0
Md
Mean
-1. -0.5 0.0 0.5 1. 1.5 2.0 2.5 3.0 3.5 4.0 (phi)
2.000 1.000 0.5000 0.2500 0.1250 6.250E-2 (mm)
10 20 40 60 100 200 ASTM Mesh
Grain Size (PHI)


Composite: nju224
Cumulative Weight Percent
100
80
60
40
20
0
Md
Mean
-- Folk Measures --
Median 0.73 PHI
Mean 0.72 PHI
Std. Dev. 1.57 PHI
Skewness 0.06
Kurtosis 0.61
-- Moment Measures --
Mean 0.79 PHI
Std. Dev. 1.47 PHI
Skewness 0.12
Kurtosis 1.86
-1. -0.5 0.0 0.5 1. 1.5 2.0 2.5 3.0 3.5 4.0 (phi)
2.000 1.000 0.5000 0.2500 0.1250 6.250E-2 (mm)
10 20 40 60 100 200 ASTM Mesh
Grain Size (PHI)


Composite: njv225
--- Folk Measures ---
Median 2.23 PHI
Mean 1.99 PHI
Std. Dev. 1.07 PHI
Skewness -0.29
Kurtosis 1.29
-- Moment Measures --
Mean 2.00 PHI
Std. Dev. 1.09 PHI
Skewness -0.93
Kurtosis 3.54
Md
Mean
Cumulative Weight Percent
100
80
60
40
20
0
-1. -0.5 0.0 0.5 1. 1.5 2.0 2.5 3.0 3.5 4.0 (phi)
2.000 1.000 0.5000 0.2500 0.1250 6.250E-2 (mm)
10 20 40 60 100 200 ASTM Mesh
Grain Size (PHI)

Section 3
Borrow Area Suitability Analysis

BEACH FILL OVERFILL RATIO AND VOLUME

Initial Volume	VOLI:	1140000.000	YD3
Native Mean	Nmean:	1.160	PHI
Native Standard Deviation	Nstd:	1.070	PHI
Borrow Mean	Bmean:	0.415	PHI (0.75 mm)
Borrow Standard Deviation	Bstd:	0.836	PHI
Overfill Ratio	Ra:	1.000	
Renourishment Ratio	Rj:	0.606	
Design Volume	VOLD:	1140000.000	YD3

P2 vs. Point

BEACH FILL OVERFILL RATIO AND VOLUME

Initial Volume	VOLI:	1140000.000	YD3
Native Mean	Nmean:	2.130	PHI
Native Standard Deviation	Nstd:	0.680	PHI
Borrow Mean	Bmean:	0.415	PHI
Borrow Standard Deviation	Bstd:	0.836	PHI
Overfill Ratio	Ra:	1.000	
Renourishment Ratio	Rj:	0.062	
Design Volume	VOLD:	1140000.000	YD3

P2 vs. Meadows

BEACH FILL OVERFILL RATIO AND VOLUME

Initial Volume	VOLI:	1140000.000	YD3
Native Mean	Nmean:	1.160	PHI
Native Standard Deviation	Nstd:	1.070	PHI
Borrow Mean	Bmean:	-0.464	PHI (1.38 mm)
Borrow Standard Deviation	Bstd:	0.137	PHI
Overfill Ratio	Ra:	1.000	
Renourishment Ratio	Rj:	0.358	
Design Volume	VOLD:	1140000.000	YD3

P1 vs. Point

BEACH FILL OVERFILL RATIO AND VOLUME

Initial Volume	VOLI:	1140000.000	YD3
Native Mean	Nmean:	2.130	PHI
Native Standard Deviation	Nstd:	0.680	PHI
Borrow Mean	Bmean:	-0.464	PHI
Borrow Standard Deviation	Bstd:	0.137	PHI
Overfill Ratio	Ra:	1.000	
Renourishment Ratio	Rj:	0.036	
Design Volume	VOLD:	1140000.000	YD3

P1 vs. Meadows

Section 4
Beach Boring Logs

ENGINEERS FIELD BORING LOG

DRILLING LOG (Cont) Elevation top of hole 0.00 **Hole No.** NAB–10

Project CAPE MAY POINT ST. PARK Installation Sheet 2 of 3

Elevation	Depth	Legend	Classification of materials	Blow counts	Sample # % Recovery	Remarks
		sp, a–3	**POORLY SORTED SAND,** grey, wet to saturated, very loose to dense	5 5 7 9	S–11 75%	
				8 9 12 15	S–12 60%	
–25.0	25		25.0'	7 9 12 12	S–13 80%	
		sw/ a–1–b	**SAND,** light grey, wet, medium dense, well sorted	7 9 11 13	S–14 60%	
–29.0			29.0'	10 10 12 14	S–15 75%	
	30	sp, a–3	**POORLY SORTED SAND,** grey, wet to saturated, very loose to dense	7 9 12 14	S–16 70%	
				11 11 15 18	S–17 65%	
–35.0	35		35.0'	5 4 5 7	S–18 60%	
		ml, a–4	**SANDY SILT,** brown to grey, wet	6 5 5 6	S–19 60%	
–38.4			38.4'	14 21 26 24	S–20 85%	
	40	sp, a–3	**POORLY SORTED SAND,** light brown, wet, medium dense to dense			

ROUGH DRAFT – PRELIMINARY DATA ONLY

(Army Corps of Engineers format)

ENGINEERS FIELD BORING LOG

DRILLING LOG (Cont) Elevation top of hole 0.00 **Hole No.** NAB–10

Project CAPE MAY POINT ST. PARK Installation Sheet 3 of 3

Elevation	Depth	Legend	Classification of materials	Blow counts	Sample # % Recovery	Remarks
		sp, a–3	**POORLY SORTED SAND,** light brown, wet, medium dense to	12 14 15 16	S–21 100%	
				7 9 11 14	S–22 70%	*Trace of fine gravel.*
–45.0	45		45.0'	12 15 16 18	S–23 75%	
		sw, a–1–b	**SAND WITH FINE GRAVEL,** orange brown, wet, medium dense to dense, well sorted	6 10 11 4	S–24 45%	
–47.7			47.7'			
		ml, a–4	**SILT AND CLAY TRACE SAND,** grey to orange, moist, stiff	SHELBY TUBE	#1 75%	*Pushed at 120# pressure.*
–50.0	50		50.0'			
			End of Boring			
	55					
	60					

ROUGH DRAFT – PRELIMINARY DATA ONLY

(Army Corps of Engineers format)

GEO – Technical Services

ENGINEERS FIELD BORING LOG

Project Name: CAPE MAY POINT STATE PARK	Size and type of Bit: 4 3/4" DRAG BIT
Location: ON BEACH BY OLD BUNKER	Datum for elevation shown:
Drilling Company: UNI–TECH	Mfg. designation of drill: CME 750
Boring Number: NAB–11	Total no. of overburden samples taken: Disturbed 23; Undisturbed 2
Name of Driller: J. JESTER	
Direction of Hole ■ Vertical ☐ Inclined ____ Deg. from Vert.	Total no. of core boxes: N/A
Thickness of Overburden: N/A	Elevation ground water: 0.0
Depth drilled into Rock: N/A	Date hole: Started 3/14/96; Completed 3/14/96
Total depth of hole: 50.00'	Elevation top of hole: 0.00
Signature of inspector: H. SCHWANGER	Total core recovery for boring N/A %

Elevation	Depth	Legend	Classification of materials	Blow counts	Sample # % Recovery	Remarks
		sp, a–3	**POORLY SORTED SAND,** light brown, wet, loose	2 2 1 2	S–1 60%	
–3.0			3.0'	1 1 1 1	S–2 80%	
	5	sm, a–2–7	**SILTY SAND,** dark brown, wet, loose, organic smell, trace organics, trace fine gravel	1 1 2 2	S–3 60%	
				4 5 5 5	S–4 60%	
	10			5 7 7 8	S–5 80%	
–11.5			11.5'	3 5 8 10	S–6 50%	
		sp, a–3	**POORLY SORTED SAND,** light brown, wet to saturated, medium dense	7 7 9 12	S–7 65%	
	15			5 8 9 14	S–8 55%	
				4 7 12 14	S–9 80%	*Saturated*
	20			5 6 10 11	S–10 55%	

ROUGH DRAFT – PRELIMINARY DATA ONLY

(Army Corps of Engineers format)

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ENGINEERS FIELD BORING LOG

DRILLING LOG (Cont) Elevation top of hole 0.00 **Hole No.** NAB–11

Project CAPE MAY POINT ST. PARK Installation Sheet 2 of 3

ROUGH DRAFT – PRELIMINARY DATA ONLY

Elevation	Depth	Legend	Classification of materials	Blow counts	Sample # % Recovery	Remarks
		sp, a–3	**POORLY SORTED SAND,** light brown, wet to saturated, medium dense	4 8 12 12	S–11 80%	
				1 1 2 7	S–12 60%	
	25			1 2 8 7	S–13 55%	
				11 15 16 20	S–14 55%	*More coarser material.*
	30			7 9 17 20	S–15 75%	
				17 18 20 22	S–16 65%	
				7 14 15 16	S–17 80%	
	35			4 3 4 8	S–18 75%	
–35.5			35.5'			
		ml, a–4	**SILT AND CLAY WITH TRACE SAND AND ORGANICS,** dark grey, moist, very stiff	SHELBY TUBE	#1 100%	*Pushed at 100# pressure.*
	40			8 7 8 9	S–19 70%	

(Army Corps of Engineers format)

ENGINEERS FIELD BORING LOG

DRILLING LOG (Cont) Elevation top of hole 0.00 **Hole No.** NAB–11

Project CAPE MAY POINT ST. PARK Installation Sheet 3 of 3

Elevation	Depth	Legend	Classification of materials	Blow counts	Sample # % Recovery	Remarks
		ml, a–4	**SILT AND CLAY WITH TRACE SAND AND ORGANICS,** dark grey, moist, very stiff	8 10 12 10	S–20 35%	
–42.5			42.5'			
		sp, a–3	**POORLY SORTED SAND,** orange brown, wet, medium dense to dense	6 8 16 20	S–21 60%	
	45			16 30 30 34	S–22 75%	
–46.0			46.0'			
		ml, a–4	**SILT AND CLAY WITH TRACE SAND,** dark grey, moist, stiff	6 8 5 6	S–23 100%	
–50.0	50		50.0'	SHELBY TUBE	#2 80%	*Pushed at 125# pressure. Orange brown*
			End of Boring			
	55					
	60					

ROUGH DRAFT – PRELIMINARY DATA ONLY

(Army Corps of Engineers format)

GEO – Technical Services

ENGINEERS FIELD BORING LOG

Project Name: CAPE MAY POINT STATE PARK	Size and type of Bit: 4 3/4" DRAG BIT
Location: ON BEACH 30' FROM DUNE	Datum for elevation shown:
Drilling Company: UNI–TECH	Mfg. designation of drill: CME 750
Boring Number: NAB–10	Total no. of overburden samples taken: Disturbed 24; Undisturbed 1
Name of Driller: J. JESTER	
Direction of Hole ■ Vertical ☐ Inclined_____ Deg. from Vert.	Total no. of core boxes: N/A
Thickness of Overburden: N/A	Elevation ground water: 0.0
Depth drilled into Rock: N/A	Date hole: Started 3/15/96; Completed 3/15/96
Total depth of hole: 50.00'	Elevation top of hole: 0.00
Signature of inspector: H. SCHWANGER	Total core recovery for boring N/A %

Elevation	Depth	Legend	Classification of materials	Blow counts	Sample # % Recovery	Remarks
		sp, a–3	**POORLY SORTED SAND,** light brown to light grey, moist to saturated, very loose to medium dense	2 2 2 2	S–1 50%	*Moist*
				2 2 3 3	S–2 65%	
	5			3 4 4 5	S–3 65%	*Wet*
				5 6 6 5	S–4 55%	*Saturated*
				2 2 2 2	S–5 65%	*Organic smell*
–10.0	10		10.0'			
		oh, a–5	**ORGANIC SILT,** dark brown, wet, very soft	1/1.5 1	S–6 90%	*Sand in tip of spoon.*
–11.8			11.8'			
		sp, a–3	**POORLY SORTED SAND,** grey, wet to saturated, very loose to dense	2 1 1 2	S–7 60%	*Wet with organics.*
	15			1 2 3 5	S–8 60%	
				3 3 4 5	S–9 65%	
	20			4 4 5 6	S–10 50%	

ROUGH DRAFT – PRELIMINARY DATA ONLY

(Army Corps of Engineers format)

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GEO – Technical Services

ENGINEERS FIELD BORING LOG

Project Name: CAPE MAY POINT STATE PARK	Size and type of Bit: 4 3/4" DRAG BIT
Location: ON BEACH	Datum for elevation shown:
Drilling Company: UNI–TECH	Mfg. designation of drill: CME 750
Boring Number: NAB–12	Total no. of overburden samples taken: Disturbed 25; Undisturbed 0
Name of Driller: J. JESTER	
Direction of Hole ■ Vertical ☐ Inclined_____ Deg. from Vert.	Total no. of core boxes: N/A
Thickness of Overburden: N/A	Elevation ground water: 0.0
Depth drilled into Rock: N/A	Date hole: Started 3/13/96; Completed 3/14/96
Total depth of hole: 50.00'	Elevation top of hole: 0.00
Signature of inspector: H. SCHWANGER	Total core recovery for boring N/A %

Elevation	Depth	Legend	Classification of materials	Blow counts	Sample # % Recovery	Remarks
		sw, a–1–b	**SAND,** light brown to light grey, moist to saturated, loose	1 2 3 3	S–1 60%	
				3 3 2 2	S–2 65%	
–4.5			4.5'			
	5	sm, a–2–4	**SAND WITH SILT AND ORGANICS,** dark brown, wet	2 2 3 2	S–3 80%	*Organic smell*
				woh/2.0	S–4 85%	*Grey brown*
	10			2 3 4 6	S–5 95%	
–11.0			11.0'			
		sp, a–3	**POORLY SORTED SAND,** light brown to light grey, wet, loose to dense, fine to medium grains	2 2 3 2	S–6 45%	
				2 3 5 5	S–7 90%	
	15			4 4 6 6	S–8 60%	
				6 8 9 12	S–9 90%	
	20			7 8 9 9	S–10 90%	

ROUGH DRAFT – PRELIMINARY DATA ONLY

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ENGINEERS FIELD BORING LOG

DRILLING LOG (Cont) Elevation top of hole 0.00 **Hole No.** NAB–12

Project CAPE MAY POINT ST. PARK Installation Sheet 2 of 3

Elevation	Depth	Legend	Classification of materials	Blow counts	Sample # % Recovery	Remarks
		sp, a–3	**POORLY SORTED SAND,** light brown to light grey, wet, loose to dense, fine to medium grains	12 12 13 19	S–11 45%	
				5 5 7 8	S–12 65%	
	25			8 14 19 21	S–13 75%	
				6 7 8 8	S–14 85%	*Orange brown*
	30			4 7 9 13	S–15 80%	*Interbedded colors* *Light brown*
				12 14 14 17	S–16 55%	*Grey* *Dark brown* *Orange brown*
–34.0			34.0'	9 12 15 21	S–17 70%	
	35	sw, a–1–b	**SAND,** light brown, wet, medium dense to dense	12 15 17 23	S–18 60%	
–38.3			38.3'	7 9 11 11	S–19 70%	
	40	ml, a–4	**SILT AND CLAY WITH TRACE ORGANICS AND THIN SAND LENS,** dark grey, medium	3 3 3 4	S–20 95%	

ROUGH DRAFT – PRELIMINARY DATA ONLY

(Army Corps of Engineers format)

ENGINEERS FIELD BORING LOG

DRILLING LOG (Cont) Elevation top of hole 0.00 **Hole No.** NAB–12

Project CAPE MAY POINT ST. PARK Installation Sheet 3 of 3

Elevation	Depth	Legend	Classification of materials	Blow counts	Sample # % Recovery	Remarks
–41.3		ml, a–4	**SILT AND CLAY WITH TRACE ORGANICS AND THIN SAND LENS,** dark grey, medium	5 7 10 10	S–21 75%	
			41.3'			
		sp, a–3	**POORLY SORTED SAND WITH TRACE SILT,** grey to brown, wet, medium dense to dense	4 5 5 7	S–22 100%	
	45			14 15 20 25	S–23 30%	*Saturated*
				11 7 11 11	S–24 25%	
–50.0	50		50.0'	6 6 6 7	S–25 40%	
			End of Boring			
	55					
	60					

ROUGH DRAFT – PRELIMINARY DATA ONLY

(Army Corps of Engineers format)

GEO – Technical Services

ENGINEERS FIELD BORING LOG

Project Name: CAPE MAY POINT STATE PARK	Size and type of Bit: 4 3/4" DRAG BIT
Location: ON BEACH AT HIGH TIDE MARK	Datum for elevation shown:
Drilling Company: UNI–TECH	Mfg. designation of drill: CME 750
Boring Number: NAB–13	Total no. of overburden samples taken: Disturbed 26; Undisturbed 1
Name of Driller: J. JESTER	
Direction of Hole ■ Vertical ☐ Inclined _____ Deg. from Vert.	Total no. of core boxes: N/A
Thickness of Overburden: N/A	Elevation ground water: 0.0
Depth drilled into Rock: N/A	Date hole: Started 3/13/96; Completed 3/13/96
Total depth of hole: 50.00'	Elevation top of hole: 0.00
Signature of inspector: H. SCHWANGER	Total core recovery for boring N/A %

Elevation	Depth	Legend	Classification of materials	Blow counts	Sample # % Recovery	Remarks
		sp, a–3	**POORLY SORTED FINE TO MEDIUM SAND,** light brown to light grey, moist to saturated, very loose to loose	1 2 2 3	S–1 100%	
				2 3 2 2	S–2 30%	
–4.5			4.5'			
	5	sm, a–2–7	**SILTY SAND WITH ORGANICS,** brown, saturated, very loose organics are roots	1 2 2 2	S–3 85%	
–6.5			6.5'			
		sw, a–1–b	**SAND,** light brown, wet, very loose to dense, well sorted	2 1 0 2	S–4 50%	
				8 14 15 17	S–5 95%	*Light grey*
	10			8 11 11 13	S–6 50%	
				7 9 15 17	S–7 60%	*Orange brown*
–14.0			14.0'			
	15	sp, a–3	**POORLY SORTED SAND,** light brown to orange brown, wet to saturated, medium dense to dense	7 8 9 15	S–8 60%	
				7 11 12 17	S–9 50%	
	20			9 12 12 15	S–10 55%	

ROUGH DRAFT – PRELIMINARY DATA ONLY

(Army Corps of Engineers format)

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ENGINEERS FIELD BORING LOG

DRILLING LOG (Cont) Elevation top of hole 0.00 **Hole No.** NAB–13

Project CAPE MAY POINT ST. PARK Installation Sheet 2 of 3

ROUGH DRAFT – PRELIMINARY DATA ONLY

Elevation	Depth	Legend	Classification of materials	Blow counts	Sample # % Recovery	Remarks
		sp, a–3	**POORLY SORTED SAND,** light brown to orange brown, wet to saturated, medium dense to dense	11 11 15 17	S–11 55%	
				6 8 12 15	S–12 65%	
	25			8 13 15 22	S–13 70%	
				7 8 8 9	S–14 60%	
	30			5 6 6 9	S–15 75%	*Varved @ 29.2' Sand with silt and clay layers.*
				11 15 19 21	S–16 70%	*Getting a little coarser.*
				7 10 14 15	S–17 60%	
	35			6 6 4 2	S–18 50%	
				4 5 8 12	S–19 90%	*Brown Trace gravel*
			39.5'	15 9 8 4	S–20 70%	*2 jar samples taken*
–39.5	40	ml, a–4	**SANDY SILT WITH TRACE CLAY,** grey, wet, stiff			

(Army Corps of Engineers format)

ENGINEERS FIELD BORING LOG

DRILLING LOG (Cont) Elevation top of hole 0.00

Project CAPE MAY POINT ST. PARK Installation **Hole No.** NAB–13

Sheet 3 of 3

Elevation	Depth	Legend	Classification of materials	Blow counts	Sample # % Recovery	Remarks
–40.5		ml, a–4	**SANDY SILT WITH TRACE CLAY,** grey, wet, stiff 40.5'	SHELBY TUBE	#1 0%	*Pushed at 100# pressure.*
–42.5		sm, a–2–7	**SILTY SAND,** grey, wet, medium dense 42.5'			
–43.0		sp, a–3	**POORLY SORTED SAND,** grey, wet, medium dense 43.0'	12 15 39 12	S–21 80%	*Interbedded sand and silt 42.5'–43.0'*
–43.5		sp, a–1–a				
–45.0	45	oh, a–7–5	**GRAVEL,** grey, wet, very dense 43.5'	3 5 4 4	S–22 80%	*2 jars taken*
			SILTY CLAY, grey, wet, stiff with organics 45.0'			
		oh, a–5	**SANDY CLAYEY SILT WITH ORGANICS,** brown, wet, stiff	3 4 5 6	S–23 55%	
–50.0	50		50.0'	4 4 5 4	S–24 30%	*Brown and grey*
			End of Boring			
	55					
	60					

ROUGH DRAFT – PRELIMINARY DATA ONLY

(Army Corps of Engineers format)

GEO – Technical Services

ENGINEERS FIELD BORING LOG

Project Name: CAPE MAY POINT STATE PARK	Size and type of Bit: 4 3/4" DRAG BIT
Location: 3500' WEST OF ATLANTIC	Datum for elevation shown:
Drilling Company: UNI–TECH	Mfg. designation of drill: CME 750
Boring Number: NAB–14	Total no. of overburden samples taken: Disturbed 24; Undisturbed 1
Name of Driller: J. JESTER	
Direction of Hole ■ Vertical ☐ Inclined_____ Deg. from Vert.	Total no. of core boxes: N/A
Thickness of Overburden: N/A	Elevation ground water: 0.0
Depth drilled into Rock: N/A	Date hole: Started 3/12/96; Completed 3/12/96
Total depth of hole: 50.00'	Elevation top of hole: 0.00
Signature of inspector: H. SCHWANGER	Total core recovery for boring N/A %

Elevation	Depth	Legend	Classification of materials	Blow counts	Sample # % Recovery	Remarks
		sp, a–3	**POORLY SORTED FINE SAND,** light brown to grey, moist to saturated, medium dense to dense	2 3 4 7	S–1 45%	*Moist*
				6 7 9 8	S–2 75%	*Saturated*
	5			5 7 8 8	S–3 85%	
				6 8 10 12	S–4 55%	*Trace fine gravel.*
	10			6 8 8 10	S–5 90%	
				12 10 8 9	S–6 65%	
				3 5 12 15	S–7 75%	
	15			5 6 7 7	S–8 60%	*A little more fine gravel and coarse sand.*
				1 5 8 11	S–9 75%	
	20			4 4 5 5	S–10 50%	

(Army Corps of Engineers format) ROUGH DRAFT – PRELIMINARY DATA ONLY

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ENGINEERS FIELD BORING LOG

DRILLING LOG (Cont) | Elevation top of hole 0.00 | **Hole No.** NAB–14

Project CAPE MAY POINT ST. PARK | Installation | Sheet 2 of 3

Elevation	Depth	Legend	Classification of materials	Blow counts	Sample # % Recovery	Remarks
		sp, a–3	**POORLY SORTED FINE SAND,** light brown to grey, moist to saturated, medium dense to dense	5 5 5 8	S–11 85%	
				4 5 6 8	S–12 80%	
–24.0			24.0'			
	25	sp, a–1–b	**FINE GRAVEL AND COARSE SAND WITH FINE SAND,** very light grey, saturated, medium dense	7 7 5 7	S–13 90%	*Mostly fine gravel and coarse sand.*
–26.0			26.0'			
–27.0		ml, a–4	**SANDY SILT,** dark grey, wet, 27.0' medium dense	3 4		*Silty @ 26.0'–27.0'*
		sw, a–1–b	**WELL SORTED SAND,** light grey, medium dense to dense, saturated	7 8	S–14 100%	*Back to light grey sand.*
				6 8 10 13	S–15 75%	
	30			8 8 8 12	S–16 70%	*Less coarse sand*
				5 8 10 14	S–17 80%	
	35			6 8 9 10	S–18 75%	*Organic smell with shell fragments. Trace silt and clay.*
–37.0			37.0'	7 8		
		oh, a–5	**SILT AND CLAY WITH WOOD FRAGMENTS,** dark grey, moist, stiff, interbedded with fine sand and shell fragments, dark grey, wet, medium dense to 38'	8 12	S–19 100%	*Layered 2" silt & clay 1" sand*
	40			7 5 5 6	S–20 65%	*2" silt & clay 1" sand*

(Army Corps of Engineers format)

ROUGH DRAFT – PRELIMINARY DATA ONLY

ENGINEERS FIELD BORING LOG

DRILLING LOG (Cont) Elevation top of hole 0.00 **Hole No.** NAB–14

Project CAPE MAY POINT ST. PARK Installation Sheet 3 of 3

Elevation	Depth	Legend	Classification of materials	Blow counts	Sample # % Recovery	Remarks
		oh, a–5	**SILT AND CLAY WITH WOOD FRAGMENTS,** dark grey, moist, stiff, interbedded with fine sand and shell fragments, dark grey, wet, medium dense to 38'	SHELBY TUBE	#1 100%	*Pushed at 200# pressure.*
				4 4 5 7	S–21 100%	
–44.5	45		44.5'	5 9 9 10	S–22 55%	
		sm, a–2–7	**SILT AND SAND WITH TRACE CLAY,** grey, wet, medium dense	7 8 9 9	S–23 95%	*Less silt and clay.*
–50.0	50		–50.0'	10 11 13 15	S–24 85%	
			End of Boring			
	55					
	60					

ROUGH DRAFT – PRELIMINARY DATA ONLY

(Army Corps of Engineers format)

GEO – Technical Services

ENGINEERS FIELD BORING LOG

Project Name: CAPE MAY POINT STATE PARK	Size and type of Bit: 4 3/4" DRAG BIT
Location: 2500' WEST OF ATLANTIC OCEAN	Datum for elevation shown:
Drilling Company: UNI–TECH	Mfg. designation of drill: CME 750
Boring Number: NAB–15	Total no. of overburden samples taken: Disturbed 25; Undisturbed 0
Name of Driller: J. JESTER	
Direction of Hole ■ Vertical ☐ Inclined_____ Deg. from Vert.	Total no. of core boxes: N/A
Thickness of Overburden: N/A	Elevation ground water: 0.0
Depth drilled into Rock: N/A	Date hole: Started 3/11/96; Completed 3/12/96
Total depth of hole: 50.00'	Elevation top of hole: 0.00
Signature of inspector: H. SCHWANGER	Total core recovery for boring N/A %

Elevation	Depth	Legend	Classification of materials	Blow counts	Sample # % Recovery	Remarks
		sp, a–3	**POORLY SORTED FINE SAND,** light brown to light grey, moist to saturated	3 3 4 4	S–1 50%	*Moist*
				5 6 7 6	S–2 60%	*Saturated*
	5			5 6 6 8	S–3 65%	
				6 8 9 9	S–4 55%	
				7 9 10 10	S–5 60%	
	10			12 15 18 19	S–6 70%	
				5 6 6 7	S–7 60%	*Slight organic oder.*
	15			7 8 12 14	S–8 70%	
				12 12 15 17	S–9 60%	*Very light grey.*
	20			10 11 13 15	S–10 65%	

ROUGH DRAFT – PRELIMINARY DATA ONLY

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ENGINEERS FIELD BORING LOG

DRILLING LOG (Cont) Elevation top of hole 0.00 **Hole No.** NAB–15

Project CAPE MAY POINT ST. PARK Installation Sheet 2 of 3

Elevation	Depth	Legend	Classification of materials	Blow counts	Sample # % Recovery	Remarks
		sp, a–3	**POORLY SORTED FINE SAND,** light brown to light grey, moist to saturated	11 10 13 12	S–11 50%	
				8 11 12 14	S–12 75%	
	25			7 9 9 10	S–13 65%	*Silty 24.5'–25.0' Fine gravel lens 0.1' @ 25.1'*
				9 13 16 21	S–14 90%	*Well sorted sand.*
	30			8 8 6 9	S–15 55%	
				4 5 8 9	S–16 65%	*Some silt Yellow brown*
				12 17 26 24	S–17 70%	*Poorly sorted*
	35			8 14 17 19	S–18 65%	
				15 16 20 18	S–19 55%	
	40			7 9 12 14	S–20 65%	

ROUGH DRAFT – PRELIMINARY DATA ONLY

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ENGINEERS FIELD BORING LOG

DRILLING LOG (Cont) Elevation top of hole 0.00 **Hole No.** NAB–15

Project CAPE MAY POINT ST. PARK Installation Sheet 3 of 3

Elevation	Depth	Legend	Classification of materials	Blow counts	Sample # % Recovery	Remarks
		sp, a–3	**POORLY SORTED FINE SAND,** light brown to light grey, moist to saturated	7 12 18 22	S–21 90%	*Trace silt 40.5'–41.0'*
				12 14 15 18	S–22 85%	
	45			9 9 18 26	S–23 80%	*Darker grey Varved 3/4" sand & 1/16" Silt and clay*
			48.0' **CLAY AND SILT,** dark brown, moist, stiff, trace wood fragments 49.5'	7 8 9 9	S–24 65%	*Trace silt 47.0'–48.0'*
–48.0		ml/cl, a–5/a–6	**FINE SAND WITH TRACE SILT,** moist, medium dense 50.0'	6 7 7 7	S–25 85%	
–49.5		sm, a–2–7				
–50.0	50		End of Boring			
	55					
	60					

ROUGH DRAFT – PRELIMINARY DATA ONLY

(Army Corps of Engineers format)

GEO – Technical Services

ENGINEERS FIELD BORING LOG

Project Name: CAPE MAY POINT START PARK	Size and type of Bit: 4 3/4" DRAG BIT
Location: 1500' EAST OF ATLANTIC OCEAN	Datum for elevation shown:
Drilling Company: UNI–TECH	Mfg. designation of drill: CME 750
Boring Number: NAB–16	Total no. of overburden samples taken: Disturbed 24, Undisturbed 1
Name of Driller: J. JESTER	
Direction of Hole ■ Vertical ☐ Inclined _____ Deg. from Vert.	Total no. of core boxes: N/A
Thickness of Overburden: N/A	Elevation ground water: 0.0
Depth drilled into Rock: N/A	Date hole: Started 3/07/96, Completed 3/11/96
Total depth of hole: 50.00'	Elevation top of hole: 0.00
Signature of inspector: H. SCHWANGER	Total core recovery for boring N/A %

Elevation	Depth	Legend	Classification of materials	Blow counts	Sample # % Recovery	Remarks
		sp, a–3	**POORLY SORTED FINE SAND,** light brown, moist to wet, trace shell fragments	2 3 3 3	S–1 35%	
				2 3 3 3	S–2 45%	
	5			2 2 3 3	S–3 50%	
				3 2 3 3	S–4 35%	*Medium grey to black @ 8.0'*
	10			2 3 3 4	S–5 50%	*Organic smell & trace silt. 8.5'–9.5'*
				7 7 8 11	S–6 70%	*Medium grey*
				6 9 9 11	S–7 55%	
	15			8 10 10 12	S–8 85%	*1/4" black organic layer @ 15.6'*
				6 7 7 7	S–9 15%	*medium grey 1/4" silty layer @ 19.0' color back to light brown*
	20			8 8 9 12	S–10 65%	

ROUGH DRAFT – PRELIMINARY DATA ONLY

(Army Corps of Engineers format)

DRAWN BY: DPW DWG FILE: NAB–16 Sheet 1 of 3

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ENGINEERS FIELD BORING LOG

DRILLING LOG (Cont) Elevation top of hole 0.00 **Hole No.** NAB–16

Project CAPE MAY POINT ST. PARK Installation Sheet 2 of 3

ROUGH DRAFT – PRELIMINARY DATA ONLY

Elevation	Depth	Legend	Classification of materials	Blow counts	Sample # % Recovery	Remarks
		sp, a–3	**POORLY SORTED FINE SAND,** light brown, moist to wet, trace shell fragments	5 8 9 10	S–11 50%	*Saturated*
				5 11 10 11	S–12 55%	
	25			5 8 8 12	S–13 55%	
				3 6 5 5	S–14 50%	
	30			10 20 22 24	S–15 55%	*Coarser grains Well sorted Very light grey to white.*
				15 18 22 25	S–16 55%	
–33.0			33.0'	3 4 4 5	S–17 60%	
	35	ml, a–5	**CLAYEY SILT WITH TRACE SAND,** grey, moist to wet, slight organic smell, trace shell fragments	PISTON TUBE	#1 60%	*Would not push w/ 200# pressure Cleaned out to 36.0'*
				6 6 8 7	S–18 60%	*Sand lenses of grey green.*
	40			5 6 7 6	S–19 30%	

(Army Corps of Engineers format)

ENGINEERS FIELD BORING LOG

DRILLING LOG (Cont) Elevation top of hole 0.00 **Hole No.** NAB–16

Project CAPE MAY POINT ST. PARK Installation Sheet 3 of 3

Elevation	Depth	Legend	Classification of materials	Blow counts	Sample # % Recovery	Remarks
		ml, a–5	**CLAYEY SILT WITH TRACE SAND,** grey, moist to wet, slight organic smell, trace shell fragments	3 4 5 7	S–20 60%	*Less clay more sand*
				6 5 7 7	S–21 100%	*More clay less sand*
	45			4 6 7 8	S–22 50%	
				4 5 5 7	S–23 50%	
–50.0	50		50.0'	3 3 7 7	S–24 40%	
			End of Boring			
	55					
	60					

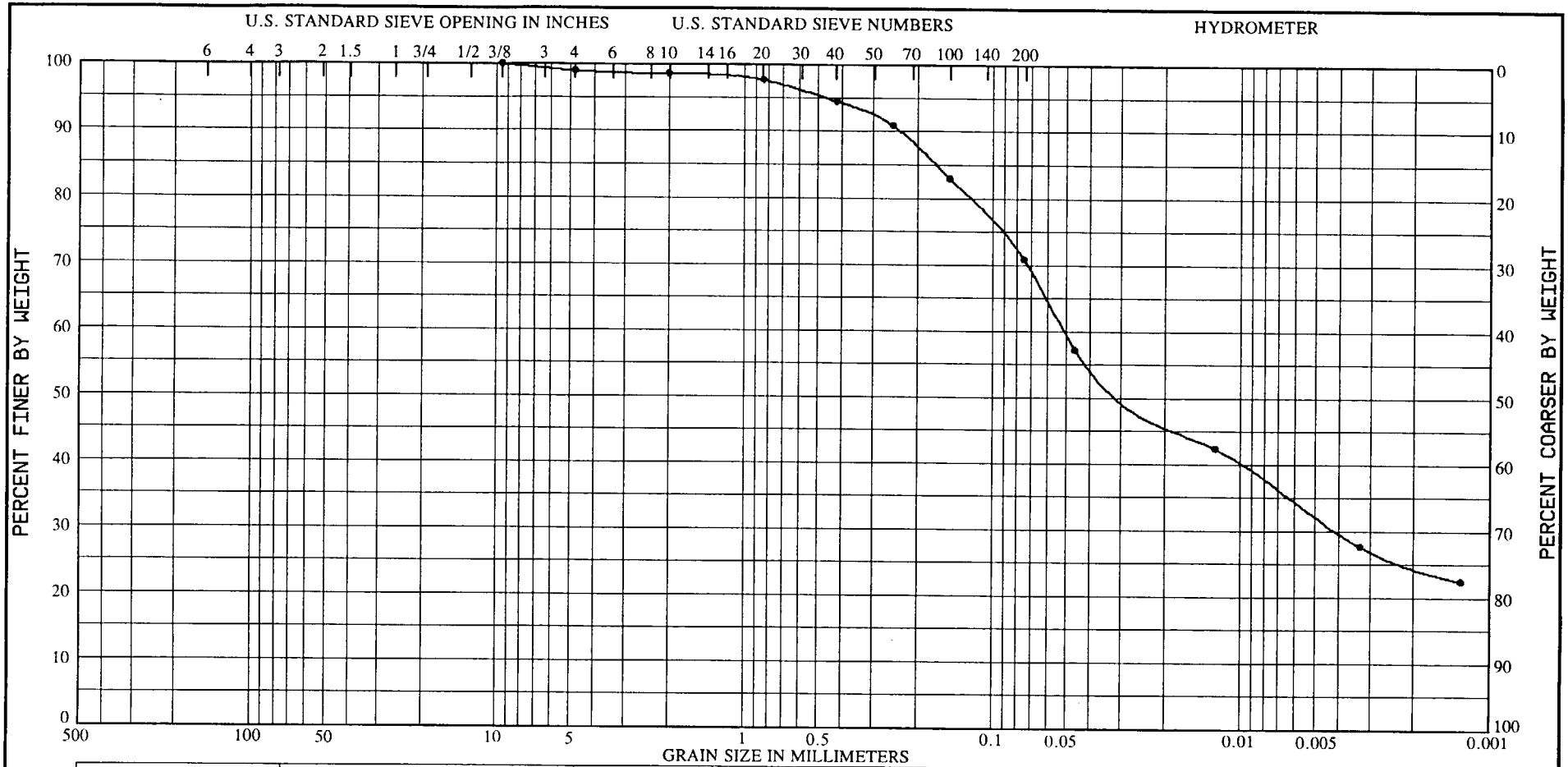
ROUGH DRAFT – PRELIMINARY DATA ONLY

(Army Corps of Engineers format)

Section 5
Soil Test Results

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30060

WORK ORDER: 7983
REQUISITION: CENAP-EN-96-811



COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

Sample No.	Depth (Ft)	Classification	Nat w%	LL	PL	PI
1	48.0-50.0	GRAY, FAT CLAY (CH), WITH SOME SAND SIZES AND A TRACE OF GRAVEL SIZES AND MICA.	35.3	75	23	52

Project LOWER CAPE MAY MEADOWS / POINT

Lab No. 184/1243

Boring No. NAB-10

Date 05/29/96

GRADATION CURVES

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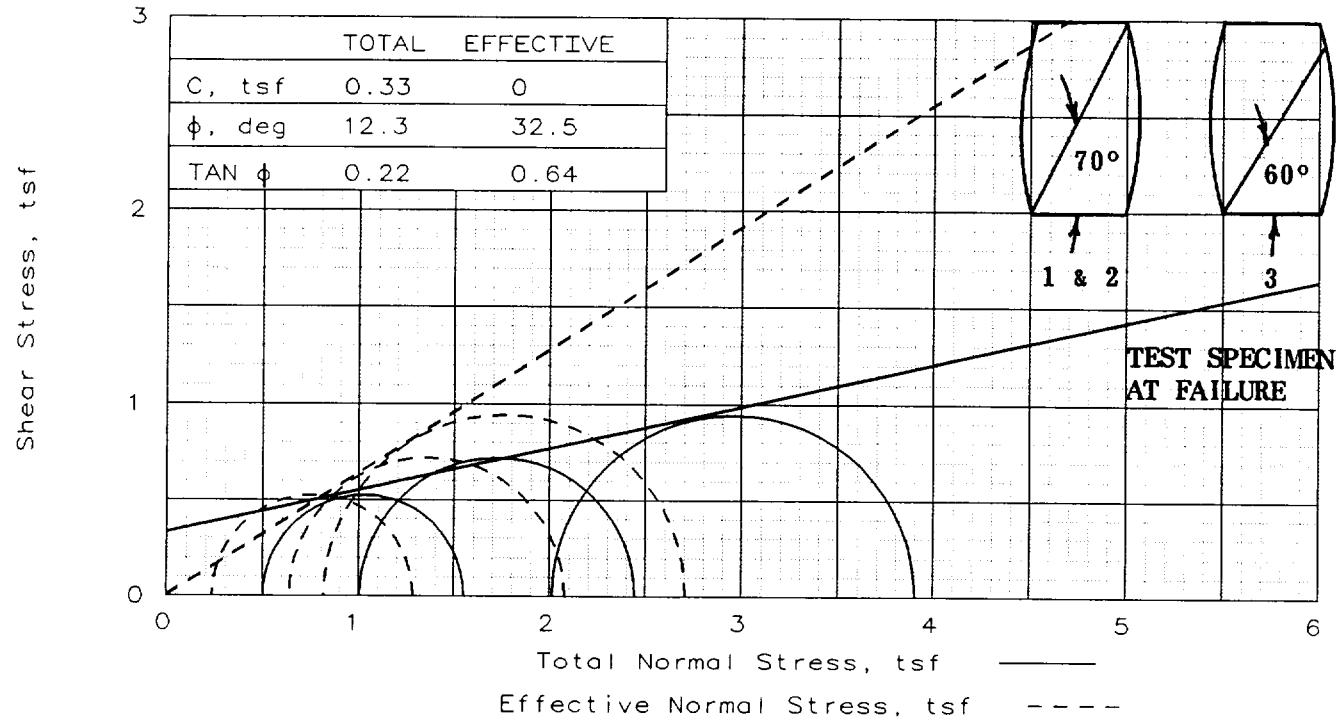
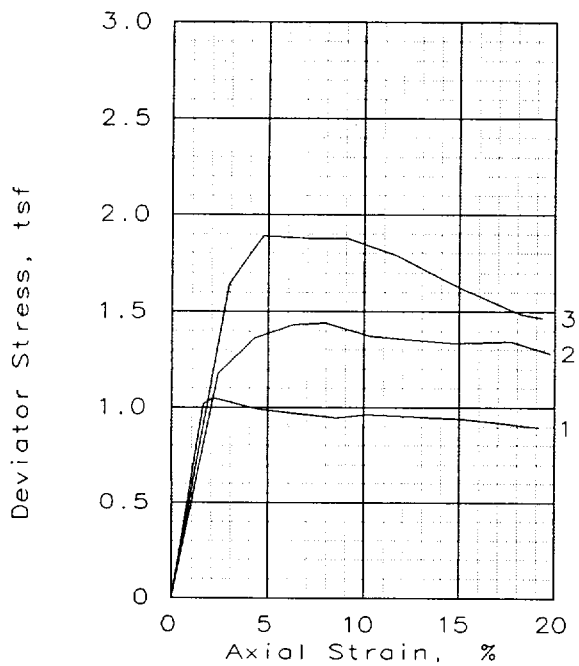




SAMPLE NO.:		1	2	3
INITIAL	WATER CONTENT, %	39.9	36.9	29.0
	DRY DENSITY, pcf	81.0	84.5	94.6
	SATURATION, %	99.7	100.0	100.0
	VOID RATIO	1.080	0.996	0.782
	DIAMETER, in	1.38	1.38	1.38
	HEIGHT, in	3.08	3.08	3.08
AT TEST	WATER CONTENT, %	36.3	33.4	25.7
	DRY DENSITY, pcf	85.1	88.6	99.5
	SATURATION, %	100.0	100.0	100.0
	VOID RATIO	0.981	0.902	0.694
	DIAMETER, in	1.36	1.36	1.35
	HEIGHT, in	3.03	3.03	3.03
BACK PRESSURE, tsf		5.04	5.04	5.04
INIT. EFF. STR., tsf		0.50	1.01	2.02
FAILURE STRESS, tsf		1.05	1.44	1.89
PORE PRESSURE, tsf		0.27	0.37	1.20
TIME TO FAILURE, min.		15	60	25
RATE, %/min.		0.14	0.13	0.19
ULTIMATE STRESS, tsf		0.94	1.33	1.61

DESCRIPTION GRAY, FAT CLAY (CH), WITH SOME SAND SIZES AND A TRACE OF GRAVEL SIZES AND MICA.

LL= 75	PL= 23	PI= 52	Gs= 2.7	CONTROLLED STRAIN TEST

TYPE OF SPECIMEN UNDISTURBED

TYPE OF TEST R w/pore pressures

REMARKS

PROJECT LOWER CAPE MAY MEADOWS / POINT

AREA

LAB. NO. 184/1243

BORING. NO. NAB-10

SAMPLE. NO. 1

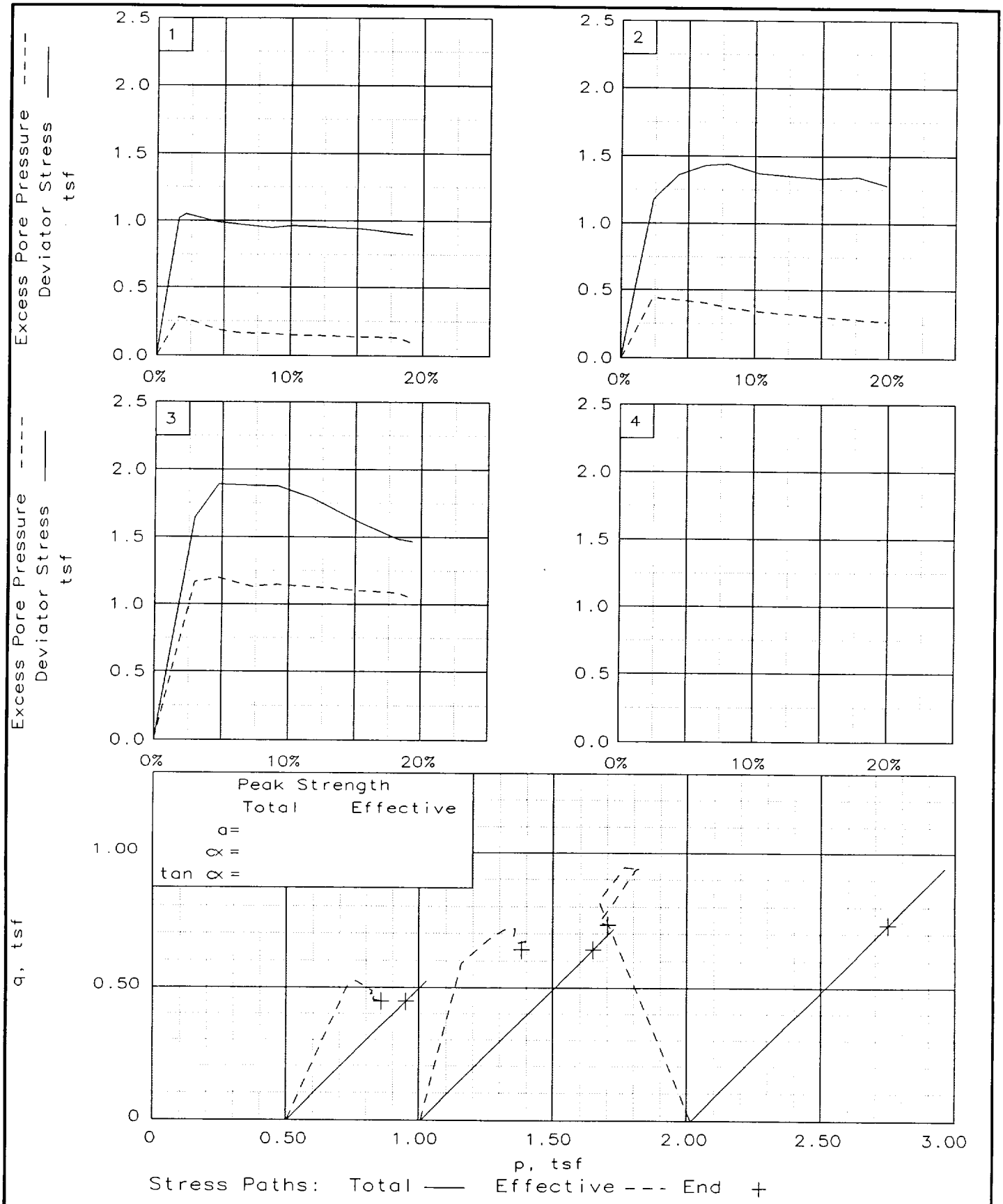
DEPTH/~~ELEV~~ 48.0 - 50.0'

LABORATORY CESAD-EN-FL **DATE** 3 JUNE, 1996

Pg 1 of 2 **TRIAXIAL SHEAR TEST REPORT**

SOUTH ATLANTIC DIVISION LABORATORY, CORPS OF ENGINEERS - MARIETTA, GEORGIA
Requisition No. CENAP-EN-96-811 Work Order No. 7983

SOUTH ATLANTIC DIVISION LABORATORY, CORPS OF ENGINEERS - MARIETTA, GEORGIA
Requisition No. CENAP-EN-96-811
Work Order No. 7983



PROJECT LOWER CAPE MAY MEADOWS / POINT

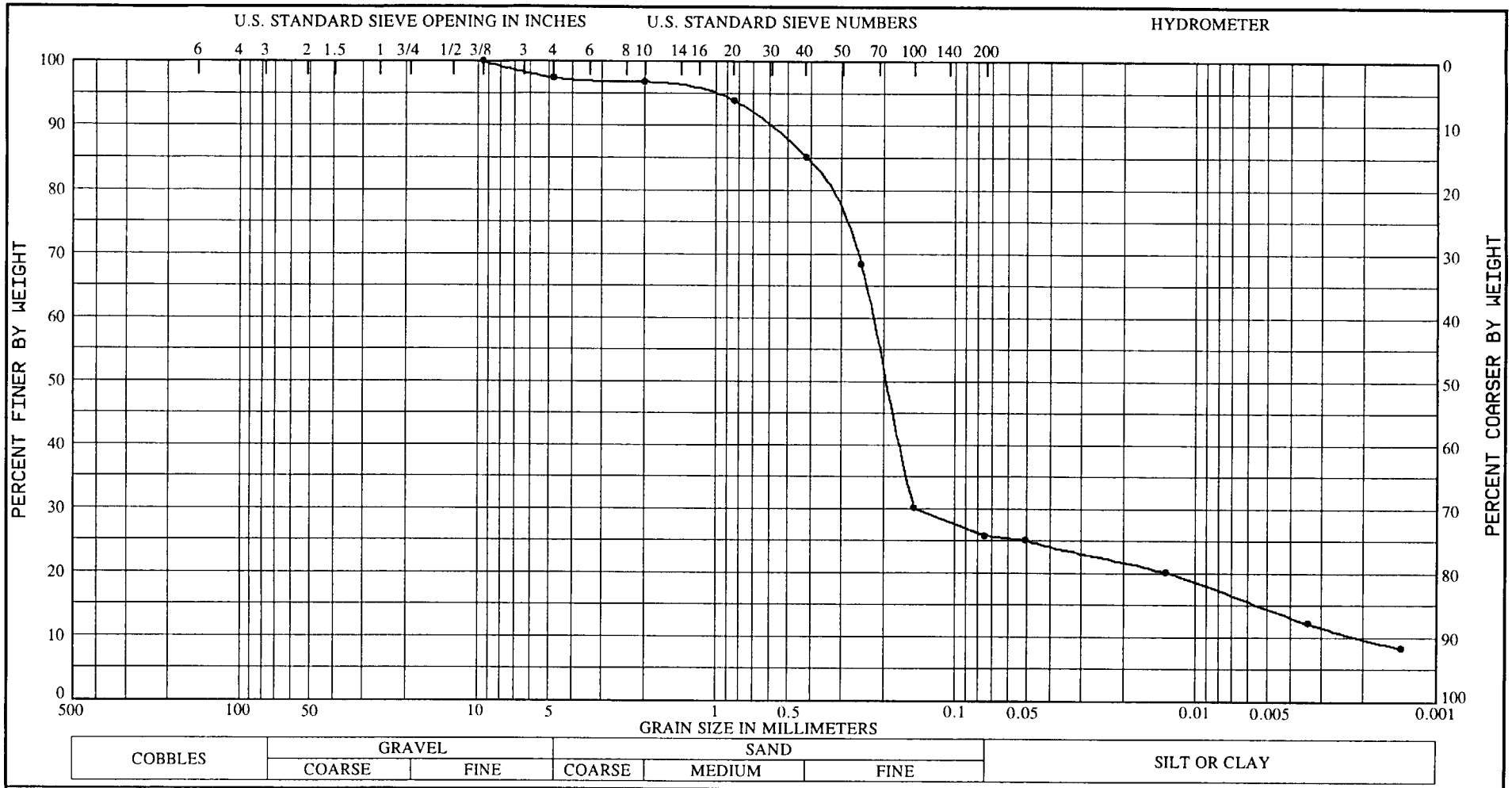
BORING NAB-10 **SAMPLE** 1 **DEPTH/~~ELEV~~** 48.0 - 50.0'

TYPE OF TEST R w/pore pressures **LAB NO.** 184/1243

LABORATORY CESAD-EN-FL **Page No.:** 2/2 **DATE** 3 JUNE, 1996

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30060

WORK ORDER: 7983
REQUISITION: CENAP-EN-96-811



Sample No.	Depth (Ft)	Classification	Nat w%	LL	PL	PI
1	36.0-38.0	GRAY, CLAYEY SAND (SC), WITH A TRACE OF GRAVEL SIZES AND MICA.	23.2	31	13	18

Project LOWER CAPE MAY MEADOWS / POINT

Lab No. 184/1244

Boring No. NAB-11

Date 05/29/96

GRADATION CURVES

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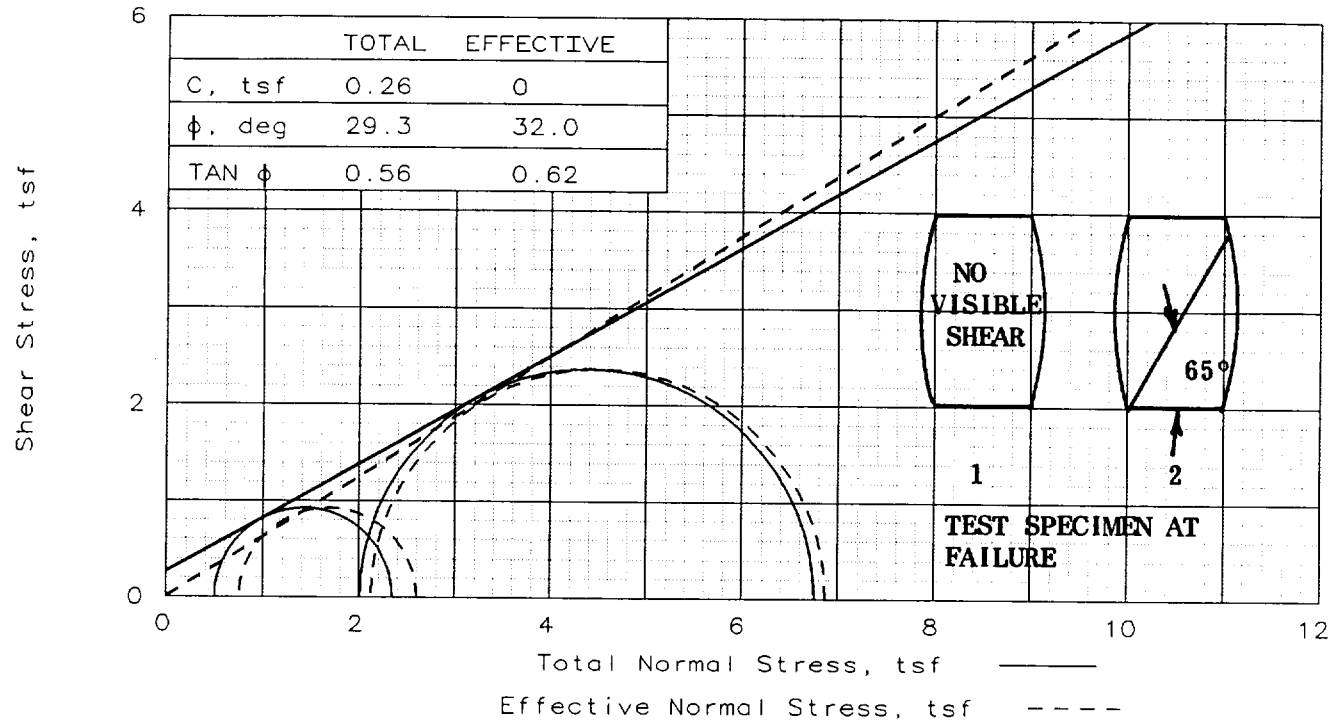
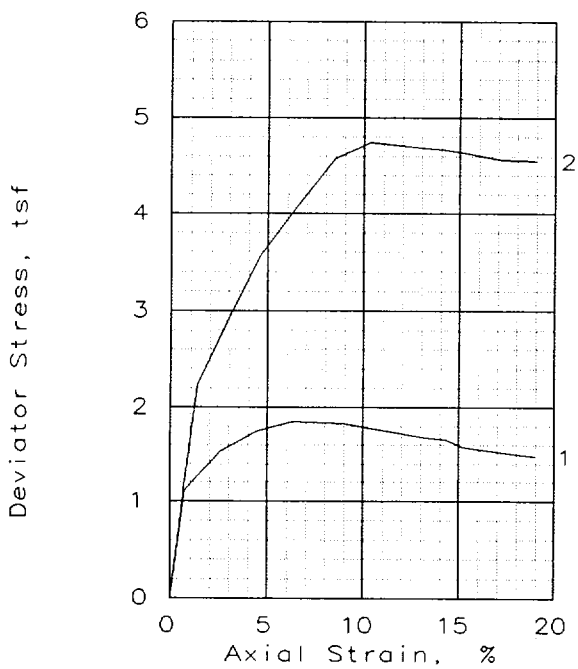




SAMPLE NO.:		1	2
INITIAL	WATER CONTENT, %	20.1	26.3
	DRY DENSITY, pcf	105.3	97.3
	SATURATION, %	91.2	97.9
	VOID RATIO	0.589	0.720
	DIAMETER, in	1.38	1.38
	HEIGHT, in	3.08	3.08
AT TEST	WATER CONTENT, %	21.7	25.2
	DRY DENSITY, pcf	105.8	99.8
	SATURATION, %	100.0	100.0
	VOID RATIO	0.582	0.676
	DIAMETER, in	1.38	1.37
	HEIGHT, in	3.07	3.05
BACK PRESSURE, tsf		5.04	5.04
INIT. EFF. STR., tsf		0.50	2.02
FAILURE STRESS, tsf		1.85	4.74
PORE PRESSURE, tsf		-0.25	-0.12
TIME TO FAILURE, min.		60	95
RATE, %/min.		0.11	0.10
ULTIMATE STRESS, tsf		1.58	4.64

DESCRIPTION GRAY, CLAYEY SAND (SC), WITH A TRACE OF GRAVEL SIZES AND MICA.

LL= 31	PL= 13	PI= 18	Gs= 2.68	CONTROLLED STRAIN TEST
TYPE OF SPECIMEN UNDISTURBED				TYPE OF TEST R w/pore pressures

REMARKS 1. Insufficient material for an additional specimen.

PROJECT LOWER CAPE MAY MEADOWS / POINT

AREA

LAB. NO. 184/1244

BORING. NO. NAB-11

SAMPLE. NO. 1

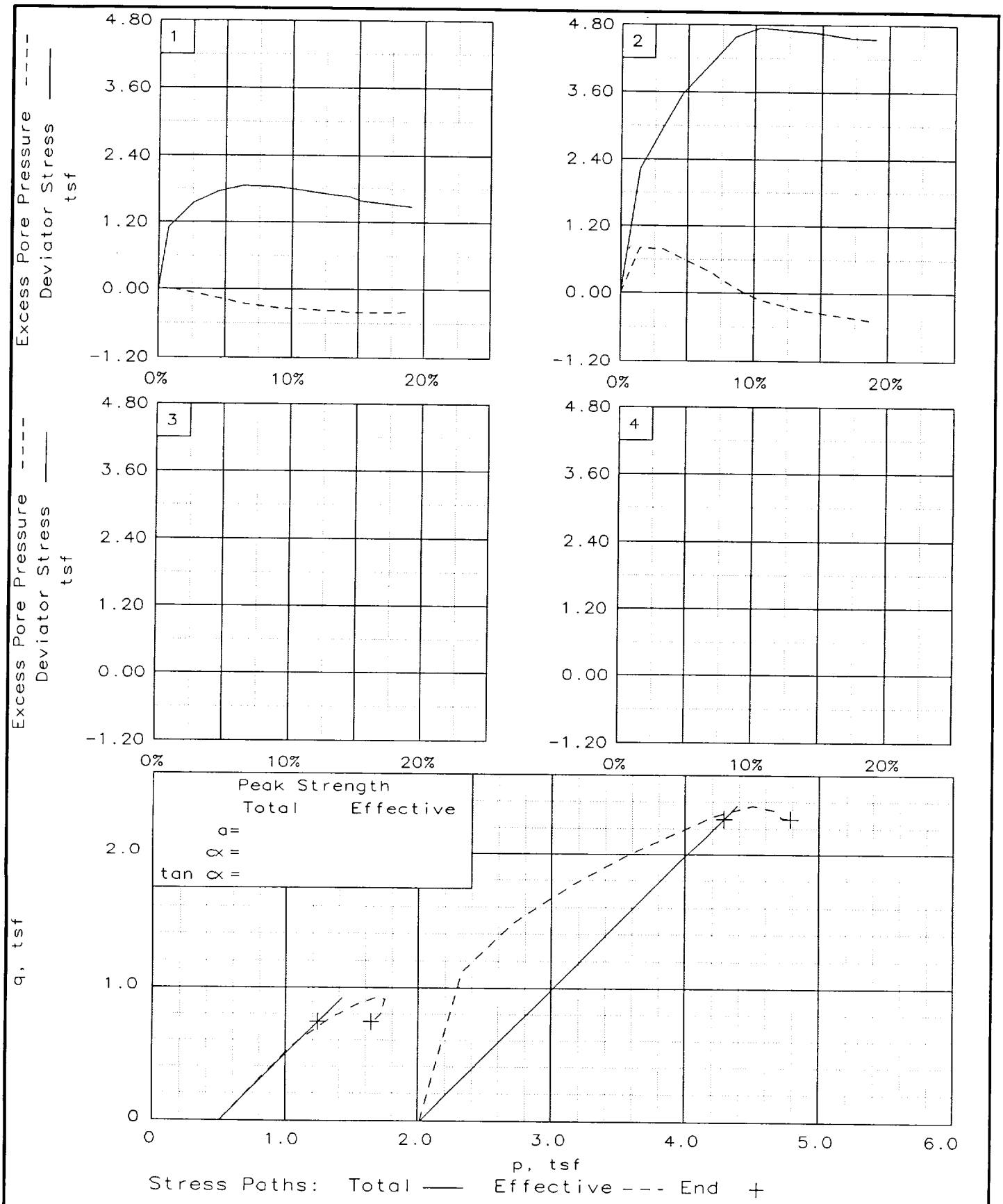
DEPTH/~~ELEV~~ 36.0 - 38.0'

LABORATORY CESAD-EN-FL **DATE** 3 JUNE, 1996

Pg 1 of 2 **TRIAXIAL SHEAR TEST REPORT**

SOUTH ATLANTIC DIVISION LABORATORY, CORPS OF ENGINEERS - MARIETTA, GEORGIA
Requisition No. CENAP-EN-96-811 Work Order No. 7983

SOUTH ATLANTIC DIVISION LABORATORY, CORPS OF ENGINEERS - MARIETTA, GEORGIA
Requisition No. CENAP-EN-96-811 Work Order No. 7983



PROJECT LOWER CAPE MAY MEADOWS / POINT

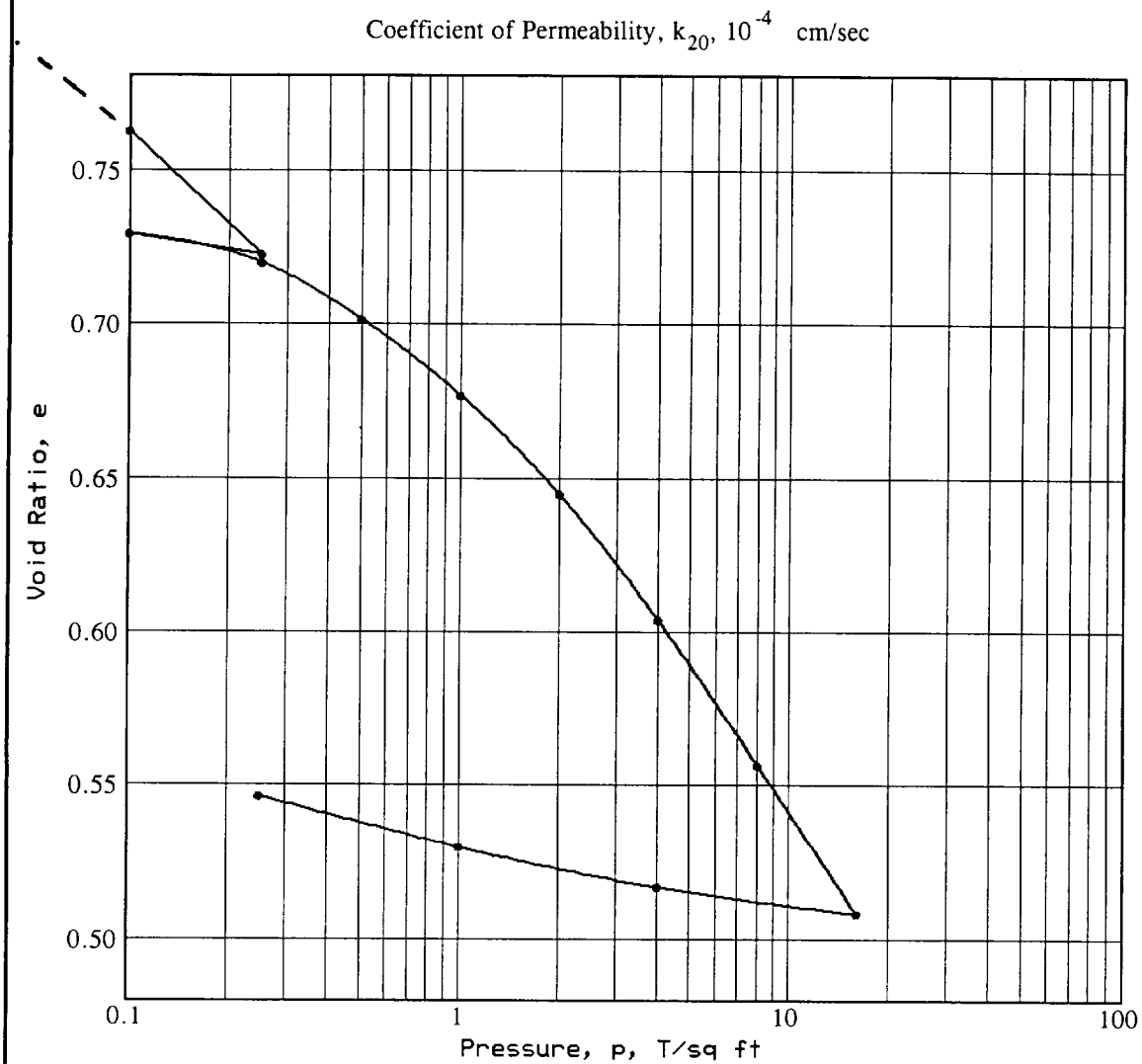
BORING NAB-11 **SAMPLE** 1 **DEPTH/~~ELEV~~** 36.0 - 38.0'

TYPE OF TEST R w/pore pressures **LAB NO.** 184/1244

LABORATORY CESAD-EN-FL **Page No.:** 2/2 **DATE** 3 JUNE, 1996

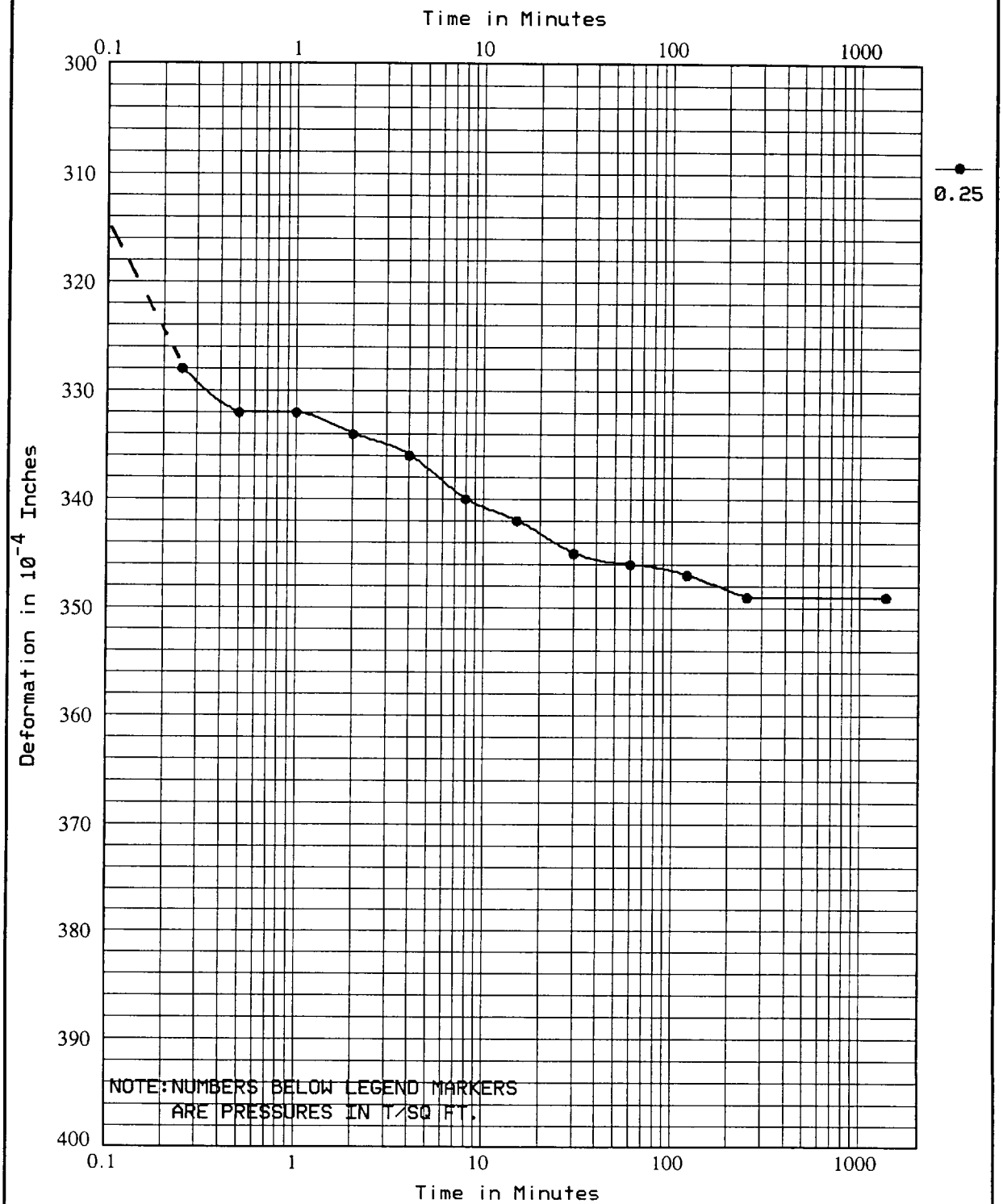
WORK ORDER: 7983
REQUSITION: CENAP-EN-96-811

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA 30066



Type of Specimen UNDISTURBED				Before Test			After Test
Diam. 2.470 in.	Height 1.000 in.			Water Content	w_o	29.2 %	w_f 20.4 %
Overburden Pressure, p_o			T/sq ft	Void Ratio	e_o	0.782	e_f 0.546
Preconsol. Pressure, p_c			T/sq ft	Saturation	S_o	100.0 %	S_f 100.0 %
Compression Index, C_c				Dry Density	γ_d	93.9 lb/ft^3	
Classification GRAY, CLAYEY SAND (SC), WITH A TRACE OF GRAVEL SIZES AND MICA.							
LL	31	G_s	2.68	Project LOWER CAPE MAY MEADOWS / POINT			
PL	13	D_{10}	0.0021 MM				
Remarks 1. SPECIMEN FLOODED				Lab No. 184/1244			
THROUGHOUT TEST. 2. TIME CURVES				Boring No. NAB-11		Sample No. 1	
FURNISHED FOR LOADS OF .25, .50				Depth (ft) 36.0-38.0		Date 06/12/96	
1.0, 2.0, 4.0, 8.0, & 16.0 T/SF				**CONSOLIDATION TEST REPORT**			

WORK ORDER: 7983
REQUSITION: CENAP-EN-96-811

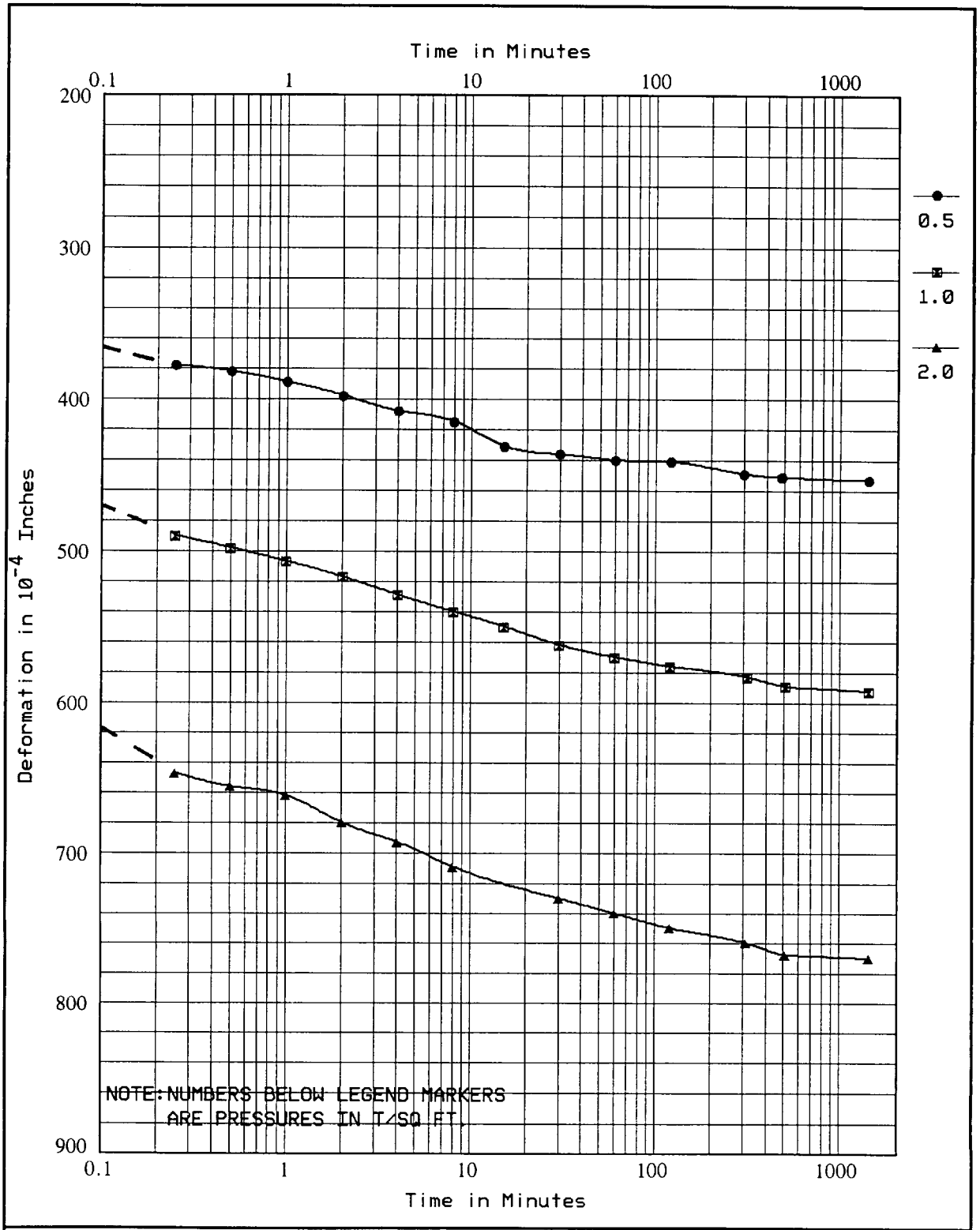


Project LOWER CAPE MAY MEADOWS / POINT			
Area			Lab No. 184/1245
Boring No. NAB-11	Sample No. 1	Depth (ft) 36.0-38.0	Date 06/17/96

CONSOLIDATION TEST - TIME CURVES

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA 30066

WORK ORDER: 7312
REQUSITION: CENAP-EN-96-811

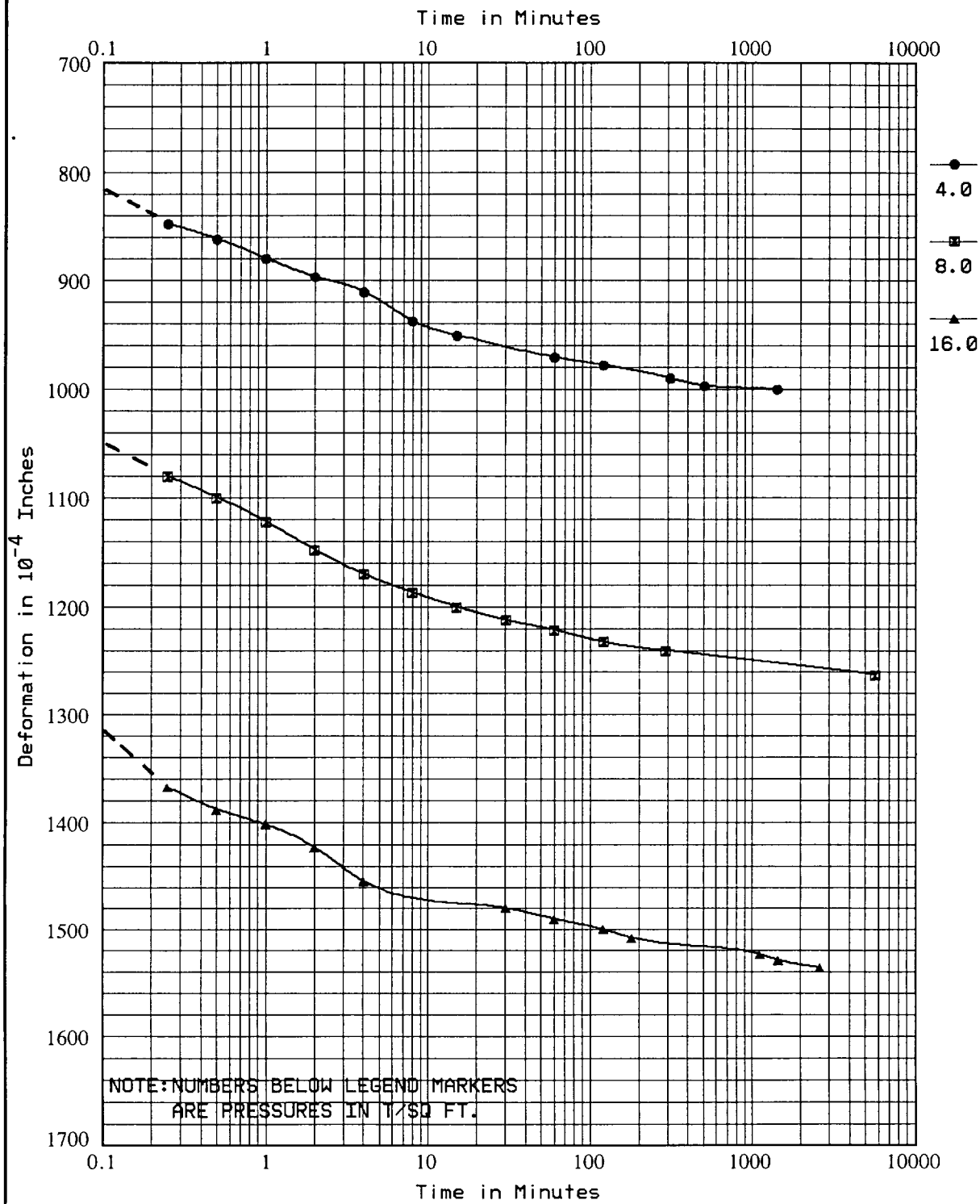


Project LOWER CAPE MAY MEADOWS / POINT			
Area			Lab No. 184/1244
Boring No. NAB-11	Sample No. 1	Depth (ft) 36.0-38.0	Date 06/04/96

CONSOLIDATION TEST - TIME CURVES

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA 30066

WORK ORDER: 7312
REQUSITION: CENAP-EN-96-811



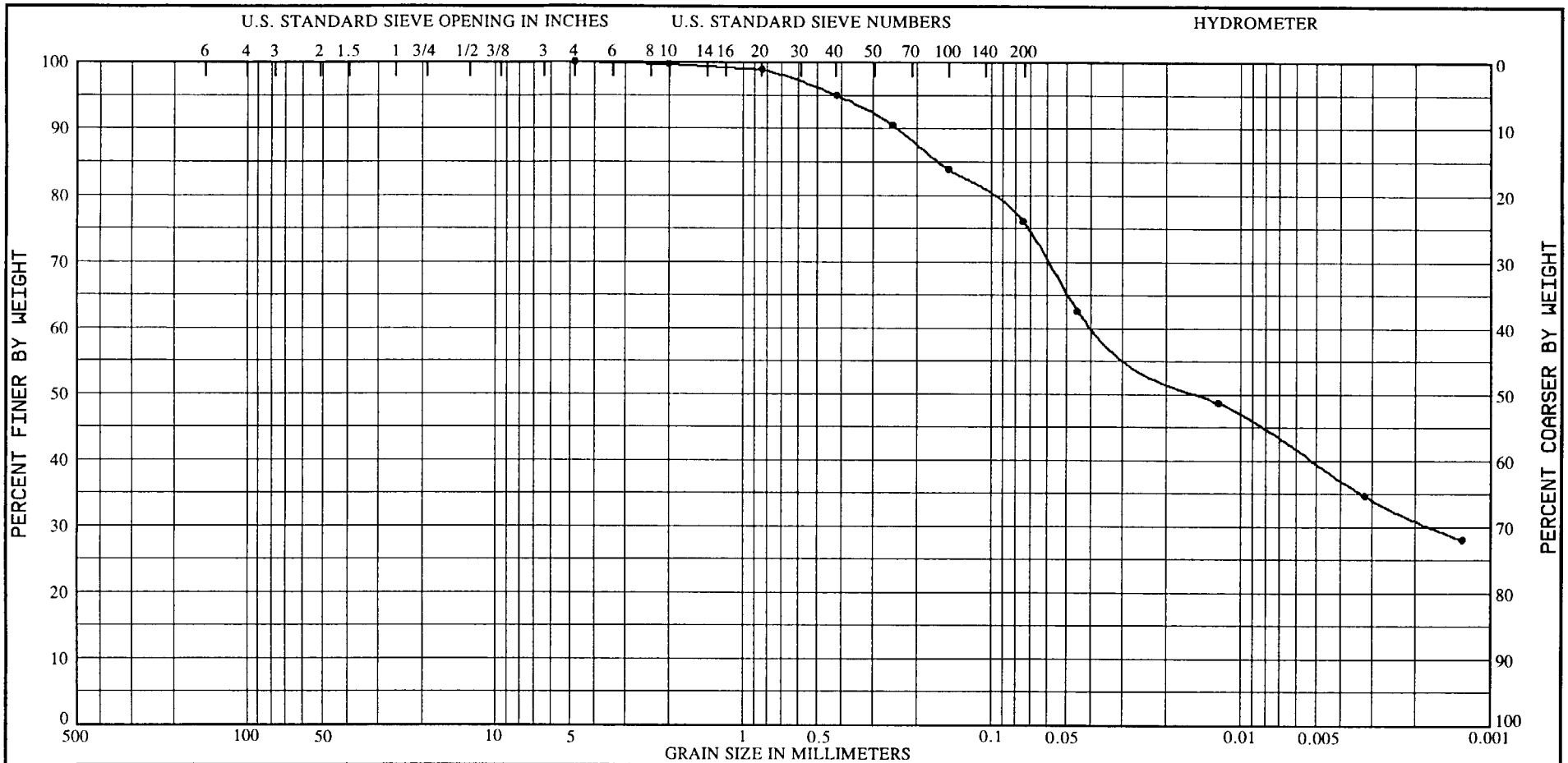
Project LOWER CAPE MAY MEADOWS / POINT			
Area			Lab No. 184/1244
Boring No. NAB-11	Sample No. 1	Depth (ft) 36.0-38.0	Date 06/04/96

CONSOLIDATION TEST - TIME CURVES

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA 30066

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30060

WORK ORDER: 7983
REQUISITION: CENAP-EN-96-811



COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

Sample No.	Depth (Ft)	Classification	Nat w%	LL	PL	PI
2	48.0-50.0	GRAY, FAT CLAY (CH), WITH SOME SAND SIZES.	36.6	60	19	41

Project LOWER CAPE MAY MEADOWS / POINT

Lab No. 184/1245

Boring No. NAB-11

Date 06/26/96

GRADATION CURVES

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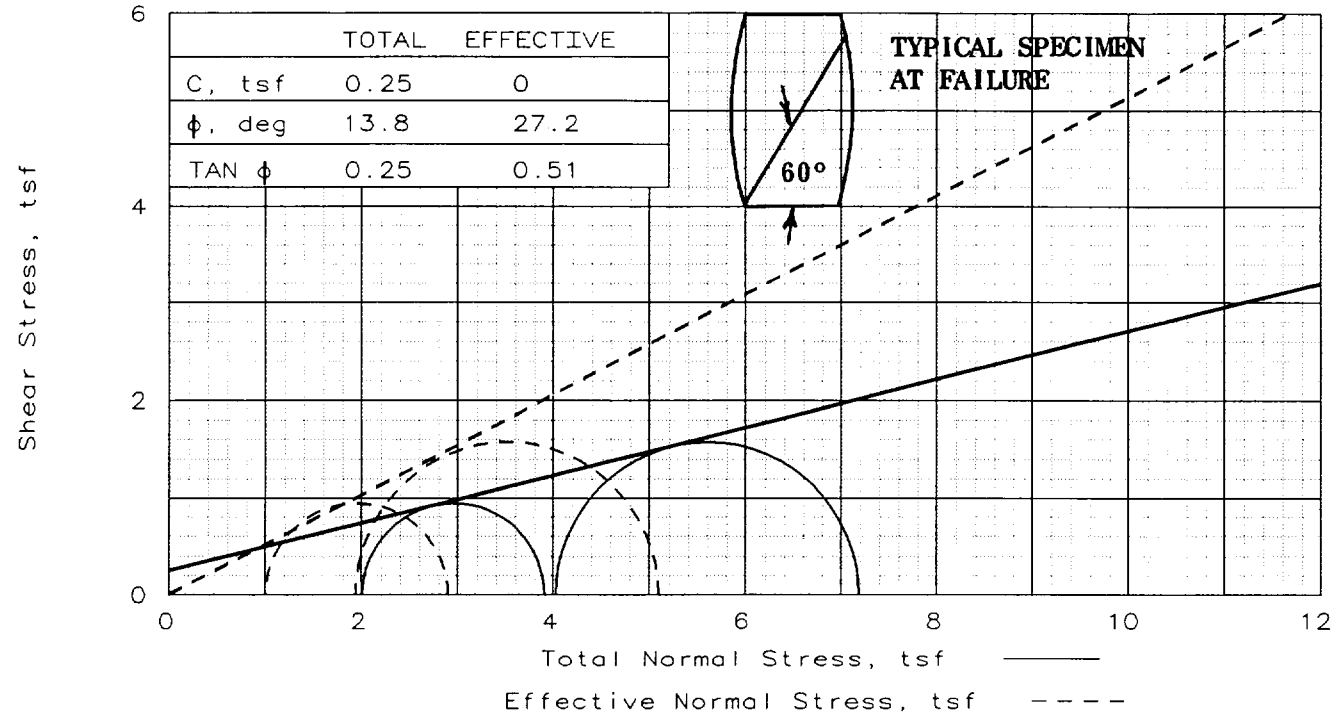
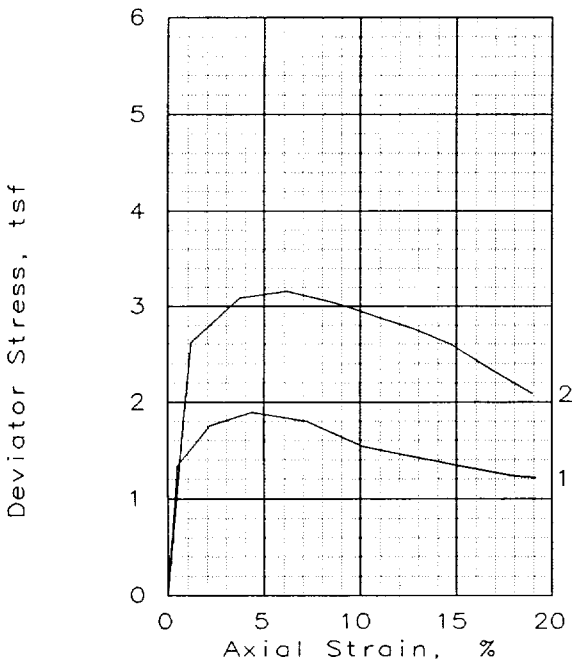




SAMPLE NO.:		1	2
INITIAL	WATER CONTENT, %	37.2	39.4
	DRY DENSITY, pcf	82.1	80.2
	SATURATION, %	96.7	98.0
	VOID RATIO	1.022	1.069
	DIAMETER, in	1.38	1.38
	HEIGHT, in	3.08	3.08
AT TEST	WATER CONTENT, %	32.6	28.2
	DRY DENSITY, pcf	88.9	94.9
	SATURATION, %	100.0	100.0
	VOID RATIO	0.867	0.750
	DIAMETER, in	1.34	1.30
	HEIGHT, in	3.00	2.91
BACK PRESSURE, tsf		5.04	5.04
INIT. EFF. STR., tsf		2.02	4.03
FAILURE STRESS, tsf		1.89	3.16
PORE PRESSURE, tsf		1.01	2.09
TIME TO FAILURE, min.		40	55
RATE, %/min.		0.11	0.11
ULTIMATE STRESS, tsf		1.33	2.60

DESCRIPTION GRAY, FAT CLAY (CH), WITH SOME SAND SIZES.

LL= 60	PL= 19	PI= 41	Gs= 2.66	CONTROLLED STRAIN TEST

TYPE OF SPECIMEN UNDISTURBED

TYPE OF TEST R w/pore pressures

REMARKS 1. Insufficient material for additional specimen.

PROJECT LOWER CAPE MAY MEADOWS / POINT

AREA

LAB. NO. 184/1245

BORING. NO. NAB-11

SAMPLE. NO. 2

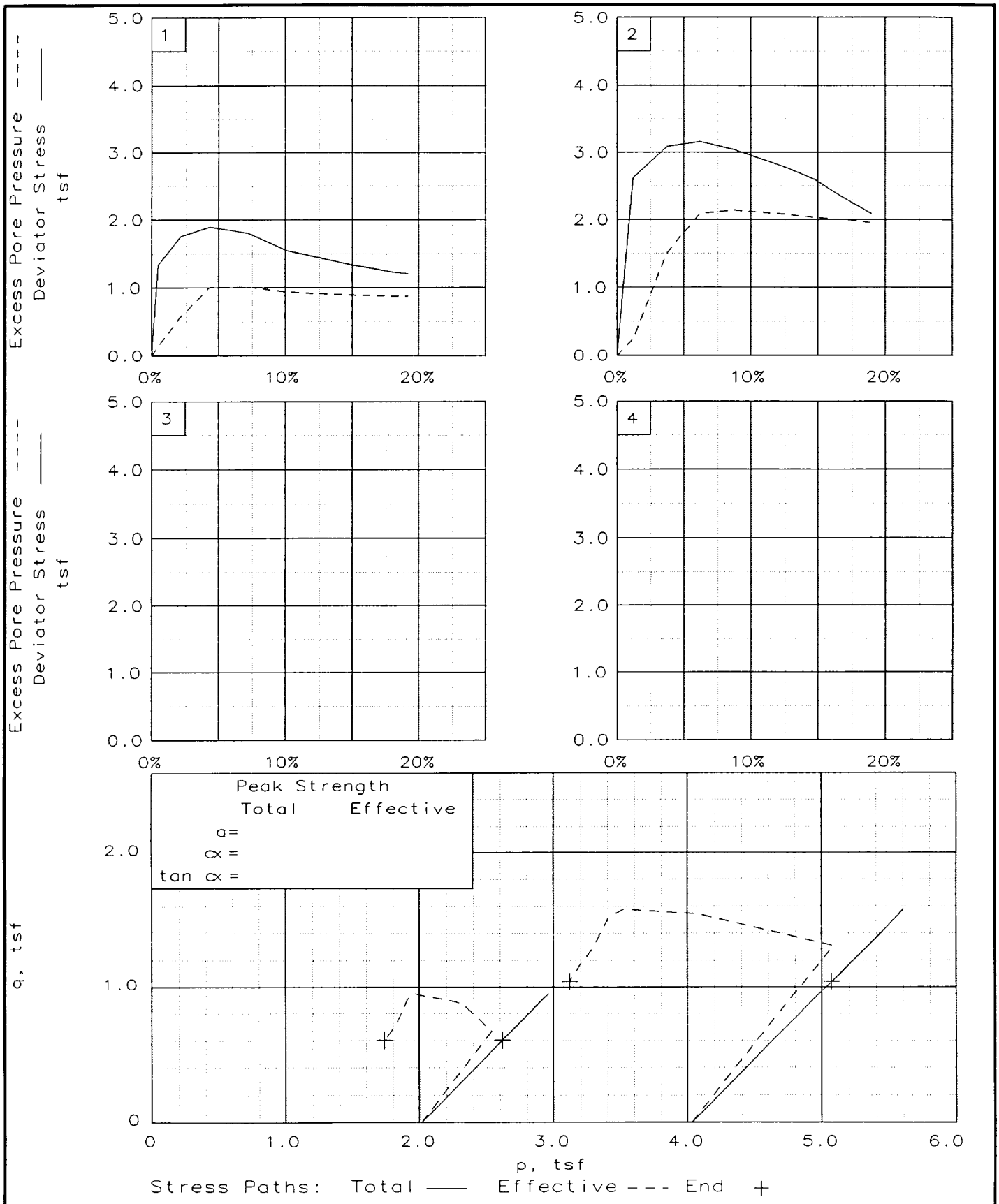
DEPTH/~~ELEV~~ 48.0 - 50.0'

LABORATORY CESAD-EN-FL **DATE** 18 JUNE, 1996

Pg 1 of 2 **TRIAXIAL SHEAR TEST REPORT**

SOUTH ATLANTIC DIVISION LABORATORY, CORPS OF ENGINEERS - MARIETTA, GEORGIA
Requisition No. CENAP-EN-96-811 Work Order No. 7983

SOUTH ATLANTIC DIVISION LABORATORY, CORPS OF ENGINEERS - MARIETTA, GEORGIA
Requisition No. CENAP-EN-96-811 Work Order No. 7983



PROJECT LOWER CAPE MAY MEADOWS / POINT

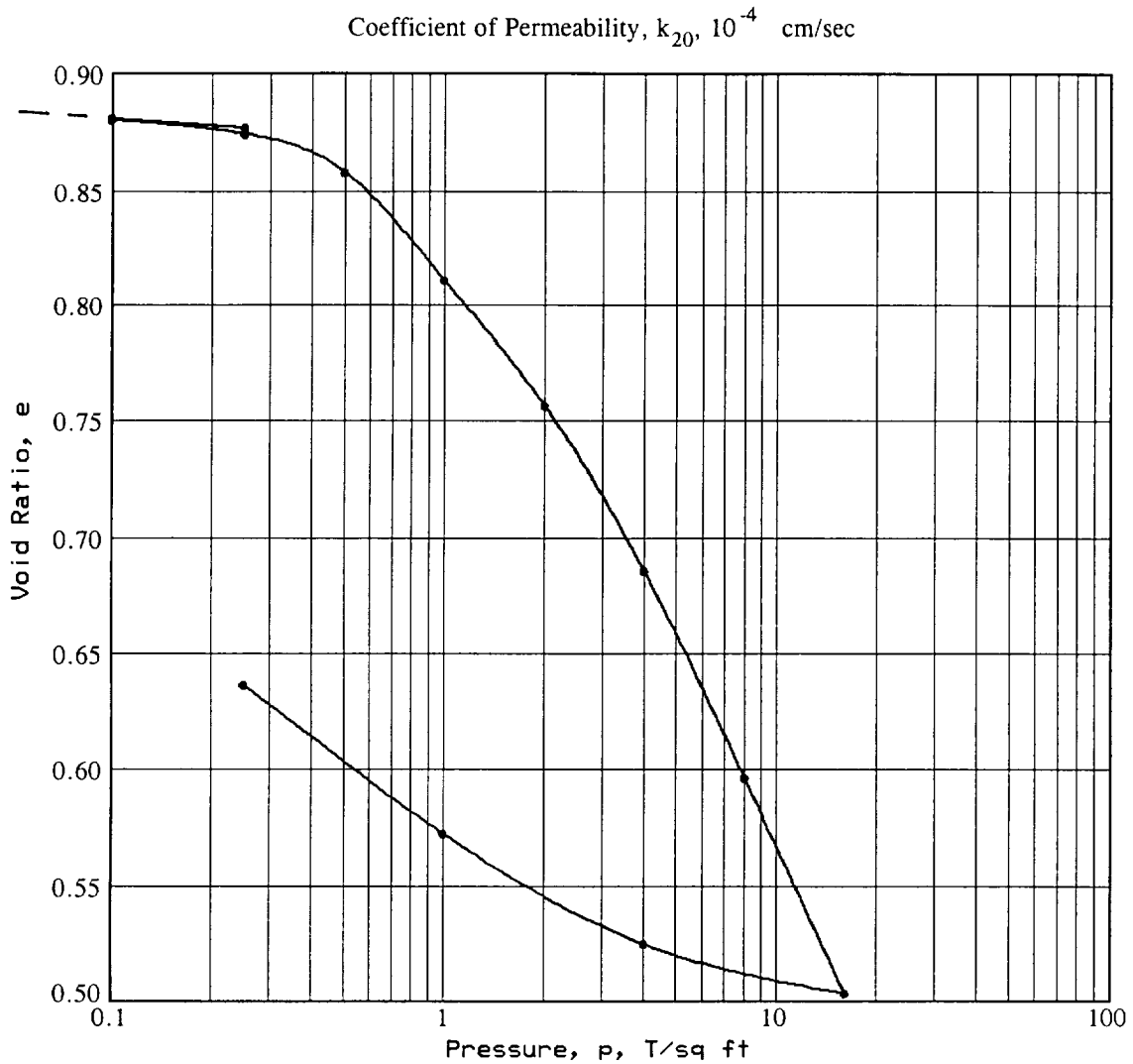
BORING NAB-11 **SAMPLE** 2 **DEPTH/~~ELEV~~** 48.0 - 50.0'

TYPE OF TEST R w/pore pressures **LAB NO.** 184/1245

LABORATORY CESAD-EN-FL **Page No.:** 2/2 **DATE** 18 JUNE, 1996

WORK ORDER: 7983
REQUSITION: CENAP-EN-96-811

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA 30066

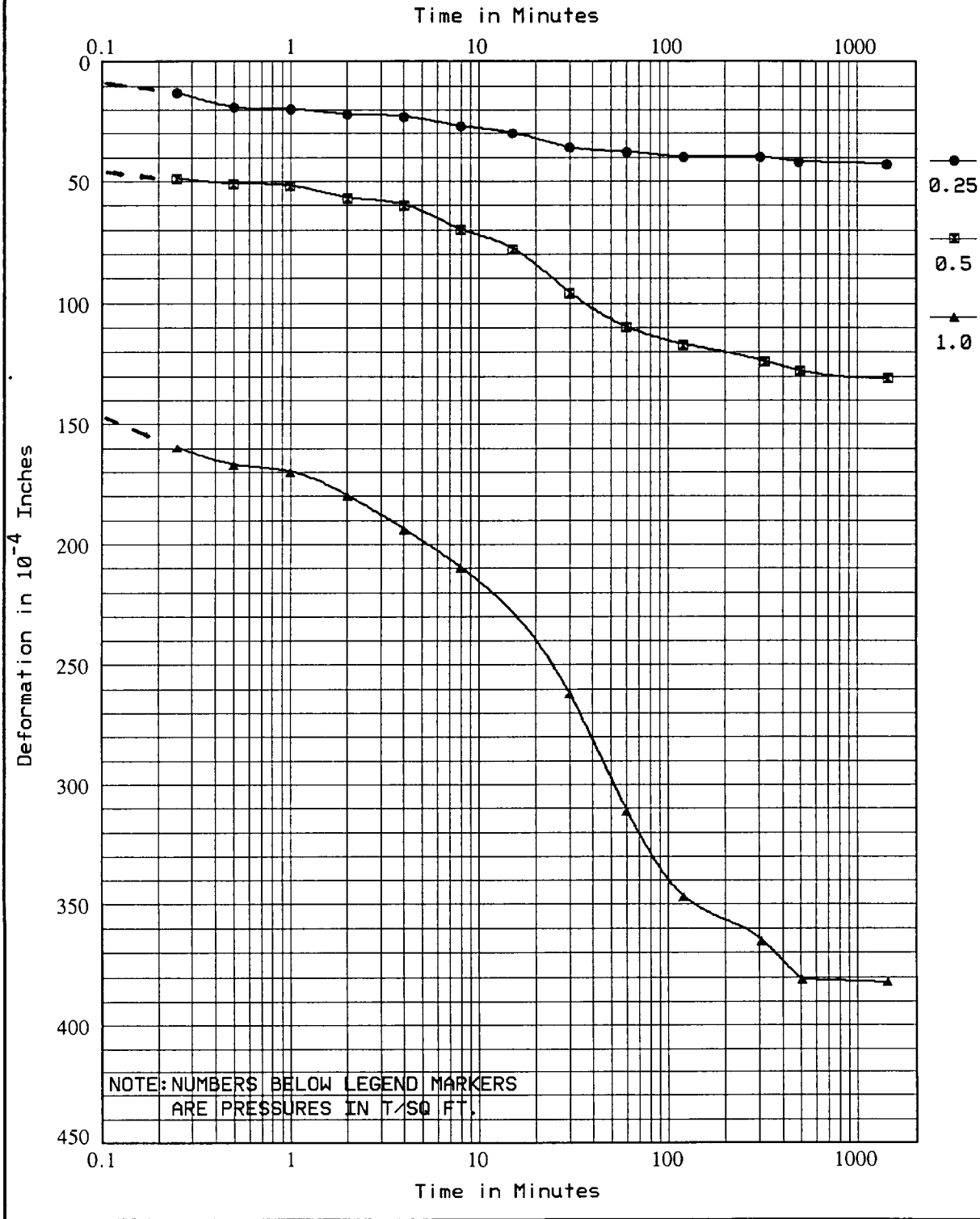


Type of Specimen UNDISTURBED			Before Test			After Test	
Diam. 2.470 in.	Height 1.000 in.	Water Content	w_o	33.2 %	w_f	23.9 %	
Overburden Pressure, p_o	T/sq ft	Void Ratio	e_o	0.882	e_f	0.636	
Preconsol. Pressure, p_c	T/sq ft	Saturation	S_o	100.0 %	S_f	100.0 %	
Compression Index, C_c		Dry Density	γ_d	88.2 lb/ft^3			

Classification GRAY, FAT CLAY (CH), WITH SOME SAND SIZES.

LL	60	G_s	2.66	Project LOWER CAPE MAY MEADOWS / POINT
PL	19	D_{10}	< 0.002 MM	
Remarks SPECIMEN FLOODED				Lab No. 184/1245
THROUGHOUT TEST. 2. TIME CURVES				Boring No. NAB-11 / Sample No. 2
FURNISHED FOR LOADS OF .25, .50				Depth (ft) 48.0-50.0 / Date 06/26/96
1.0, 2.0, 4.0, 8.0 & 16.0 T/SF.				**CONSOLIDATION TEST REPORT**

WORK ORDER: 7983
REQUSITION: CENAP-EN-96-811



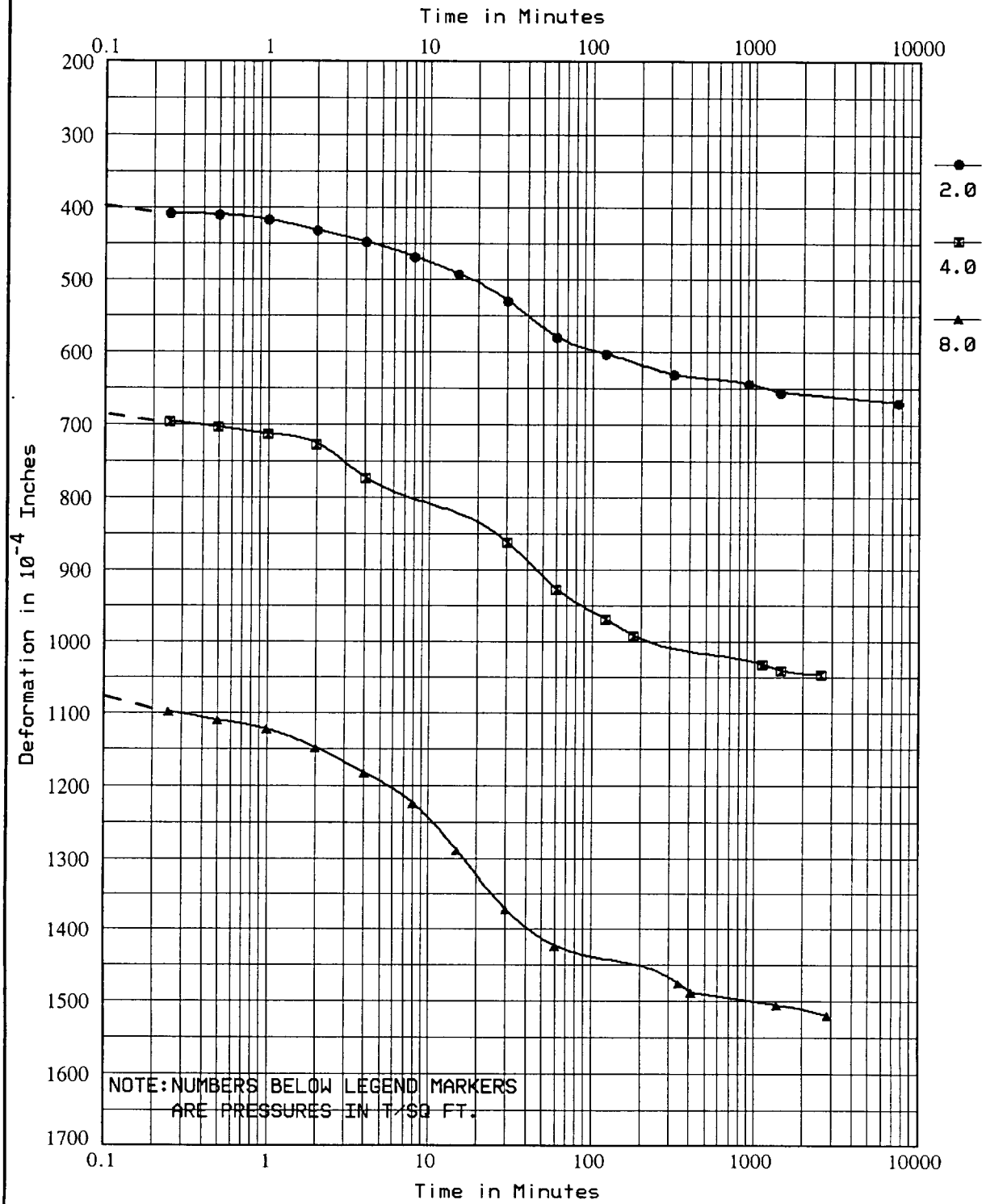
Project LOWER CAPE MAY MEADOWS / POINT			
Area			Lab No. 184/1245
Boring No. NAB-11	Sample No. 2	Depth (ft) 48.0-50.0	Date 06/04/96

CONSOLIDATION TEST - TIME CURVES

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA 30066

WORK ORDER: 7983
REQUSITION: CENAP-EN-96-811

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA 30066

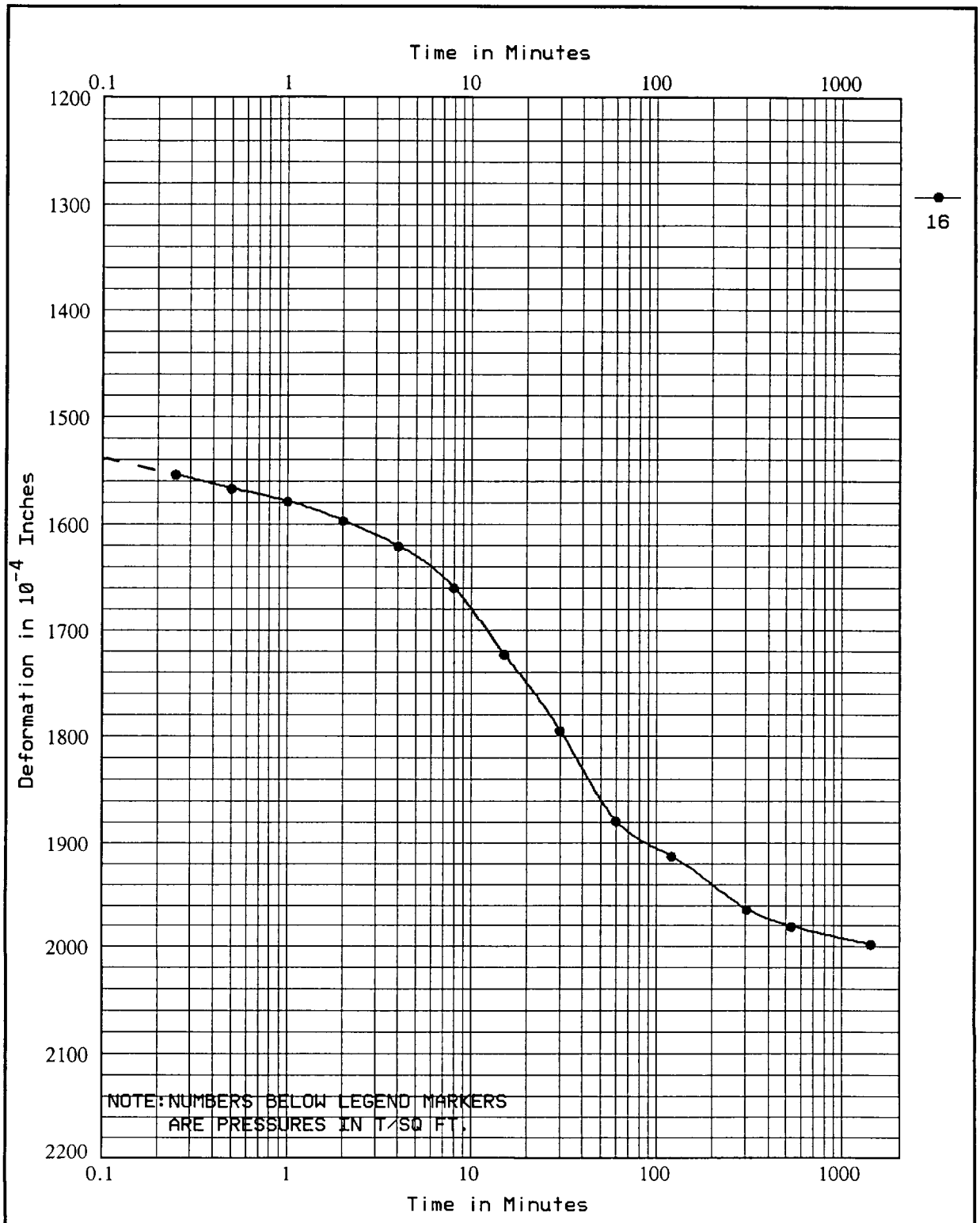


Project LOWER CAPE MAY MEADOWS / POINT			
Area			Lab No. 184/1245
Boring No. NAB-11	Sample No. 2	Depth (ft) 48.0-50.0	Date 06/18/96

CONSOLIDATION TEST - TIME CURVES

WORK ORDER: 7983
REQUSITION: CENAP-EN-96-811

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA 30066

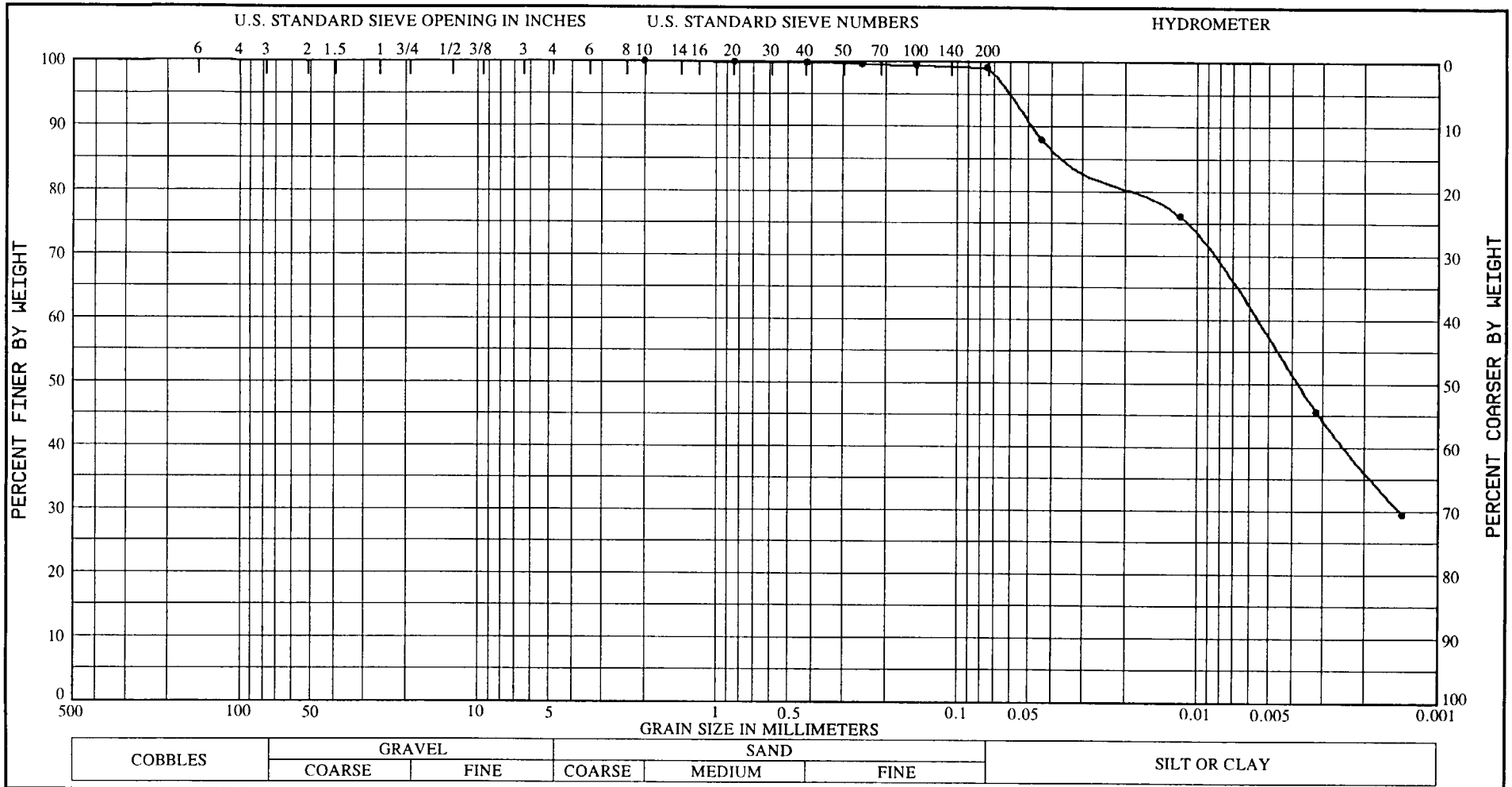


Project LOWER CAPE MAY MEADOWS / POINT			
Area			Lab No. 184/1245
Boring No. NAB-11	Sample No. 2	Depth (ft) 48.0-50.0	Date 06/18/96

CONSOLIDATION TEST - TIME CURVES

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30060

WORK ORDER: 7983
REQUISITION: CENAP-EN-96-811



COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

Sample No.	Depth (Ft)	Classification	Nat w%	LL	PL	PI
1	40.0-42.0	GRAY, CLAYEY INORGANIC SILT HIGH LL (MH), WITH A TRACE OF SAND SIZES.	58.7	85	39	46

Project LOWER CAPE MAY MEADOWS / POINT

Lab No. 184/1246

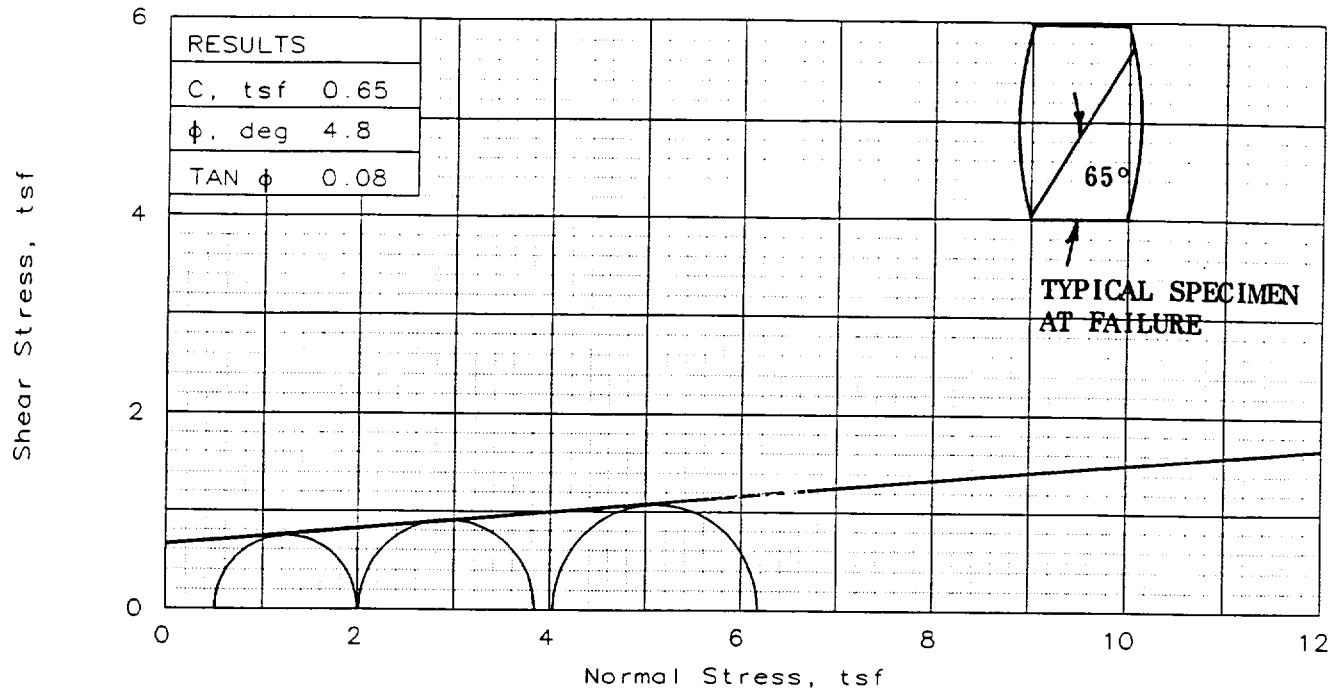
Boring No. NAB-14

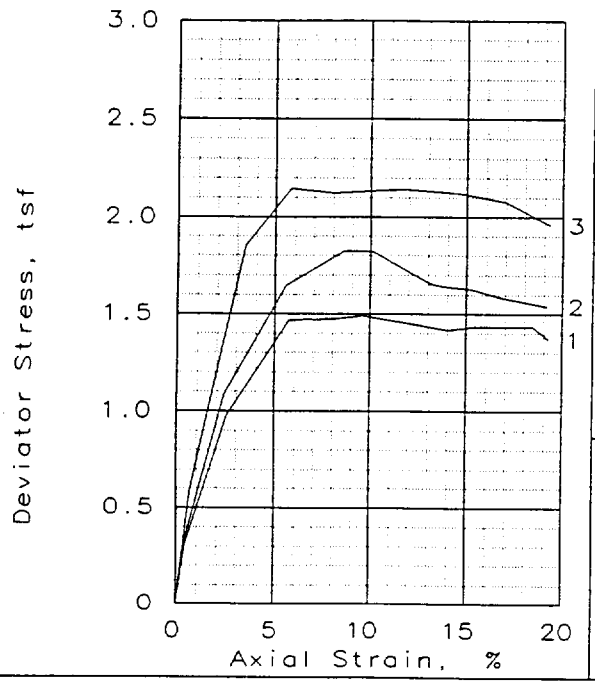
Date 06/26/96

GRADATION CURVES

249

SOUTH ATLANTIC DIVISION LABORATORY, CORPS OF ENGINEERS - MARIETTA, GEORGIA
Requisition No. CENAP-EN-96-811 Work Order No. 7983





SAMPLE NO.:		1	2	3
INITIAL	WATER CONTENT, %	64.3	54.5	57.2
	DRY DENSITY, pcf	61.2	64.8	64.4
	SATURATION, %	100.0	93.0	96.7
	VOID RATIO	1.703	1.551	1.568
	DIAMETER, in	1.38	1.38	1.38
	HEIGHT, in	3.08	3.08	3.08
AT TEST	WATER CONTENT, %	**64.3**	**54.5**	**57.2**
	DRY DENSITY, pcf	61.2	64.8	64.4
	SATURATION, %	**100.0**	**93.0**	**96.7**
	VOID RATIO	1.703	1.551	1.568
	DIAMETER, in	1.38	1.38	1.38
	HEIGHT, in	3.08	3.08	3.08
BACK PRESSURE, tsf		0.00	0.00	0.00
INIT. EFF. STR., tsf		0.50	2.02	4.03
FAILURE STRESS, tsf		1.49	1.82	2.15
PORE PRESSURE, tsf				
TIME TO FAILURE, min.		13	14	**8**
RATE, %/min.		0.74	0.61	**0.73**
ULTIMATE STRESS, tsf		1.42	1.63	2.12

DESCRIPTION GRAY, CLAYEY INORGANIC SILT HIGH LL (MH), WITH A TRACE OF SAND

LL= 85	PL= 39	PI= 46	Gs= 2.65	CONTROLLED STRAIN TEST
TYPE OF SPECIMEN UNDISTURBED				TYPE OF TEST Q

REMARKS

PROJECT LOWER CAPE MAY MEADOWS / POINT

AREA

LAB. NO. 184/1246

BORING. NO. NAB-14

SAMPLE. NO. 1

DEPTH/~~ELEV~~ 40.0 - 42.0'

LABORATORY CESAD-EN-FL **DATE** 18 JUNE, 1996

TRIAXIAL SHEAR TEST REPORT

SECTION 5

ENVIRONMENTAL INVESTIGATION

Environmental data for this study can be found in Appendix B and in the main report itself.

SECTION 6

PROJECT DESIGN

SECTION J
PROJECT DESIGN

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2.8 Shore Protection Structural Inventory

Lower Cape May Meadows

(Note: Elevations are referenced to NGVD 29, as were original mapping and surveys. To convert vertical datum to NAVD 88, subtract 1.27 from elevations.) Refer to Figure 2.8-3 for plan of existing conditions.

Dunes. Reinforced dunes extend from the groin at Lighthouse Avenue to the eastern study limit of the Meadows at the terminal groin in Cape May City (see photo 2-1 & 2-2). Dune design includes a compacted core consisting of NJDOT I-5 select fill with a top elevation varying between +6.35 and +8.35 NGVD and side slopes of 2 horizontal to 1 vertical (see figure 2.8-1). Top width of the dunes vary between 15 to 30 feet, and side slopes are 1V:3H. Average top elevation of the dunes is +16.5 NGVD. Existing dune grass is well established in those areas of dune not recently damaged by erosion. Sand fencing on the seaward side of the dunes is in a straight line configuration. Most recent repairs to the dunes were made in 1996. The profile in the figure on page J-3 was developed from 1996 surveys.

Armor Mattress. A portion of the seaward face of the reinforced dunes in Cape May Meadows is stabilized by an armor mattress (see photo 2-3). The mattress is constructed from a geogrid basket filled with 3 to 4 inch stone and extends for a distance of 450 feet east of the Lighthouse Ave. groin. The mattress is supported by a base of broken concrete rubble which is beneath a layer of graded core stone. The toe of the mattress is covered by 2 to 4 ton stone. The mattress was constructed in 1995 by the NJDEP. Condition of the mattress is good.

Outfall. One 24" diameter ductile iron stormwater outfall pipe is located approximately 1500 feet east of the Lighthouse Ave. groin, extending through the existing dune (see photos 2-4 and 2-5). Outfall pipe length is 300 feet, and the invert elevation at the seaward end is +1.90 NGVD and flow is regulated with a backflow preventer. A concrete inlet drop structure exists at the landward end, inlet elevation at +3.50 NGVD. The pipe is supported on piles and timber cribbing, and was constructed in 1993.

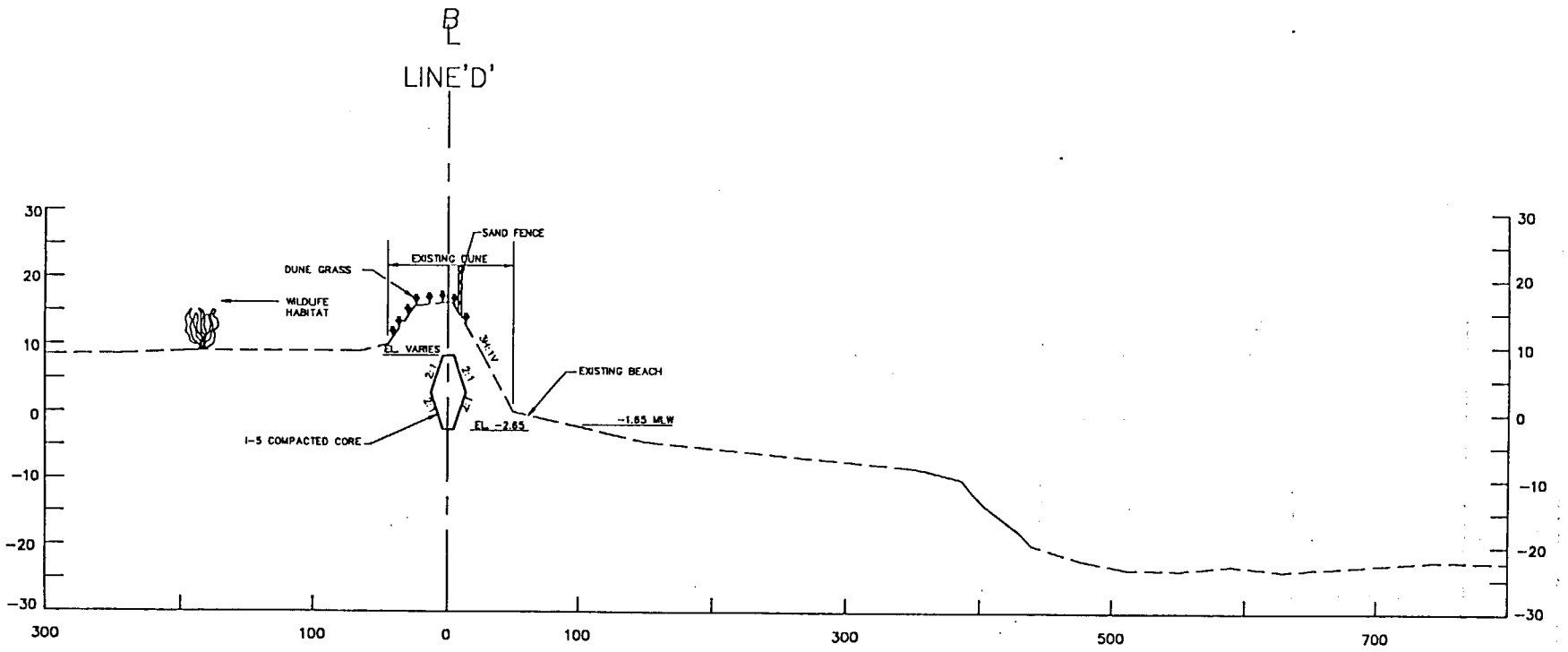
Cape May Point

Groins. There are nine groins in Cape May Point (see photos 2-6 through 2-9, figure 2.8-2). Eight of the nine groins were originally constructed of timber, except for the groin at Lehigh Avenue, which is composed entirely of stone. Top elevation of the original timber groins is approximately +9.35 NGVD. All eight groins originally constructed of timber were extended with stone. The final stone extensions were constructed from 1966-68 and all have a 14 foot wide crest. Top of crest elevations vary between +7.35 NGVD at the landward end to +3.35 NGVD at the seaward end, maintaining a low profile step design that follows the existing ground (see figure on page J-4). Lengths of the groins vary from 340' to 520'. All are in good condition except for the Lighthouse Ave. and Lehigh Ave. groins. The structural integrity of these two groins is in question due to the presence of a scour hole located at the seaward ends of these structures. The possible effect of the scour hole on these groins is discussed elsewhere in this report.

Revetment. A revetment constructed of approximately 3 to 5 ton quarrystone and recycled concrete is located between the Lighthouse Ave. and Lehigh Ave. groins and extends approximately halfway to the next groin at Whilldin Ave.(see photo 2-10.) Condition is fair; however, the majority of the recycled concrete pieces are not large enough to remain stable when subjected to wave attack.

Ruins. The remains of three concrete foundation pads exist on the beach in Cape May Meadows located approximately 450 feet east of the Lighthouse Ave. groin . Each pad is about 10 feet square at the bottom. There are also the remains of steel rails from an old railroad track located on the beach approximately 1300 feet east of the Lighthouse Ave. groin .

Also on the Cape May Meadows beach are the ruins of a concrete structure which was historically used as a military bunker (see photo 2-11). The footprint of this structure is approximately 200 feet by 100 feet and is supported on timber piles. The structure is located approximately 1400 feet east of the Lighthouse Ave. groin.

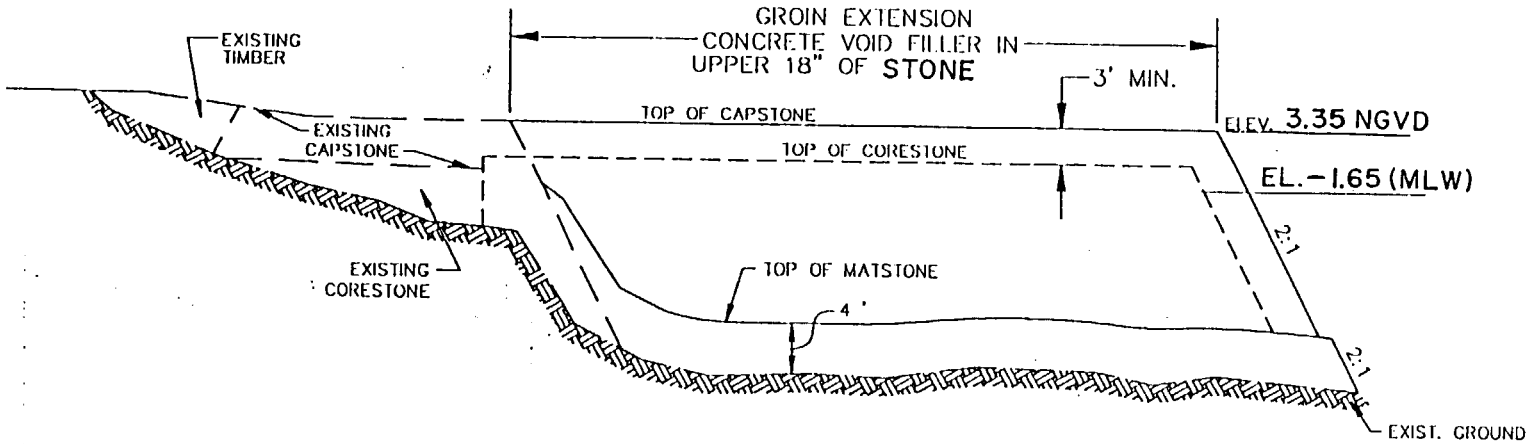


TYPICAL SURVEY PROFILE
AND EXISTING REINFORCED DUNE

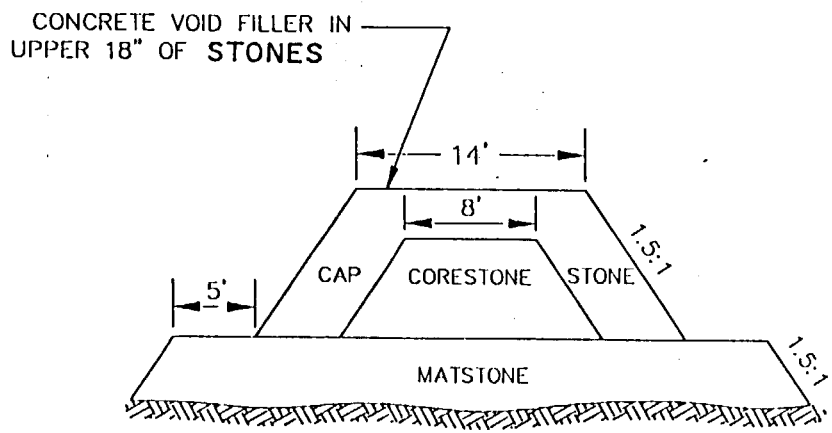
CAPE MAY MEADOWS

NOT TO SCALE

FIGURE 2.8.1



TYPICAL PROFILE OF GROIN
N.T.S.

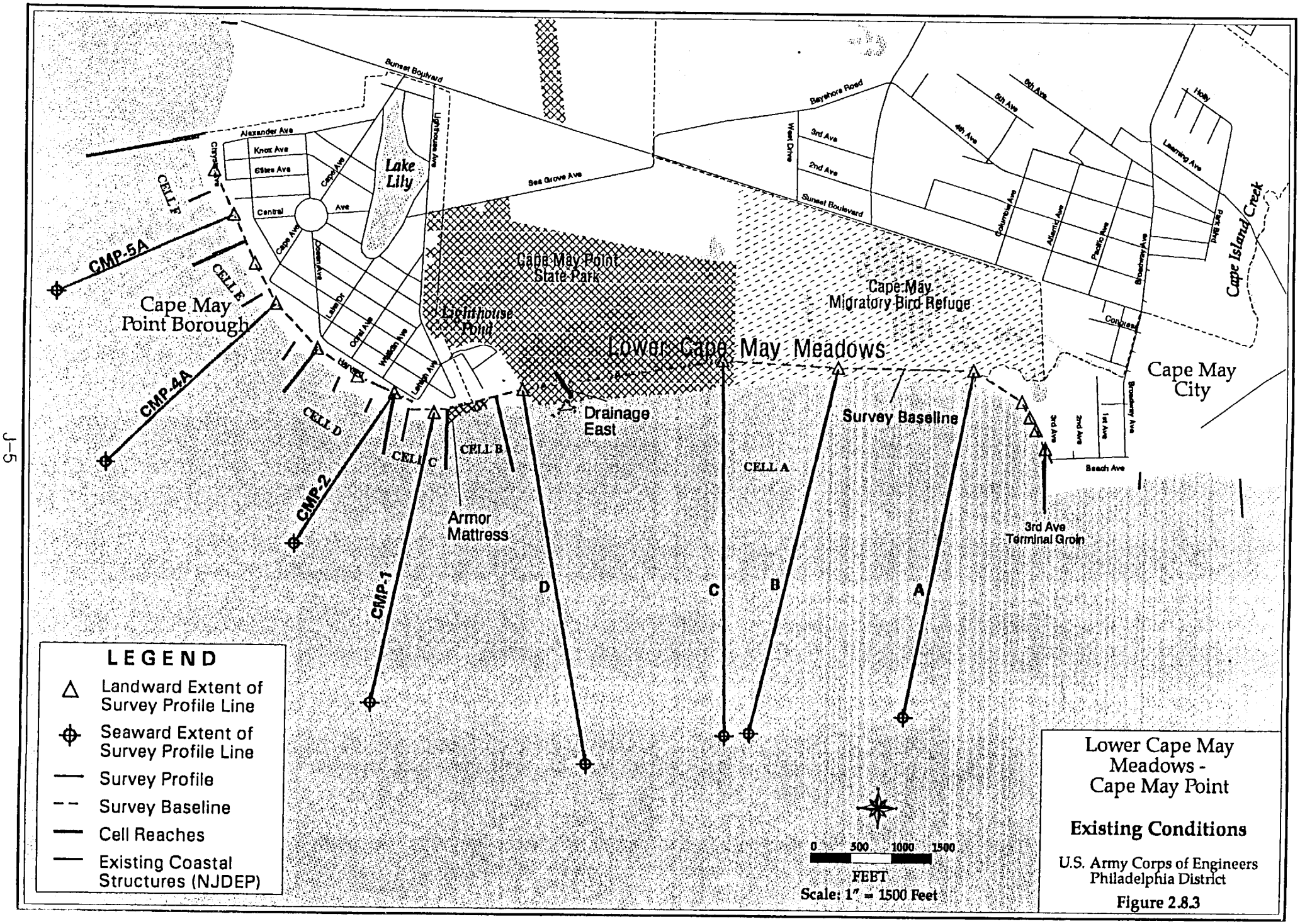


TYPICAL SECTION
GROIN EXTENSION CONSTRUCTION
N.T.S.

TYPICAL PROFILE EXISTING GROINS

CAPE MAY POINT

FIGURE 2.8.2



Lower Cape May Meadows - Cape May Point

Existing Conditions

U.S. Army Corps of Engineers
Philadelphia District

Figure 2.8.3

Photo 2-1 Seaward side of existing dune fronting Cape May Point State Park, facing west. Note exposed NJ I-5 compacted core exposed by erosion (1997).

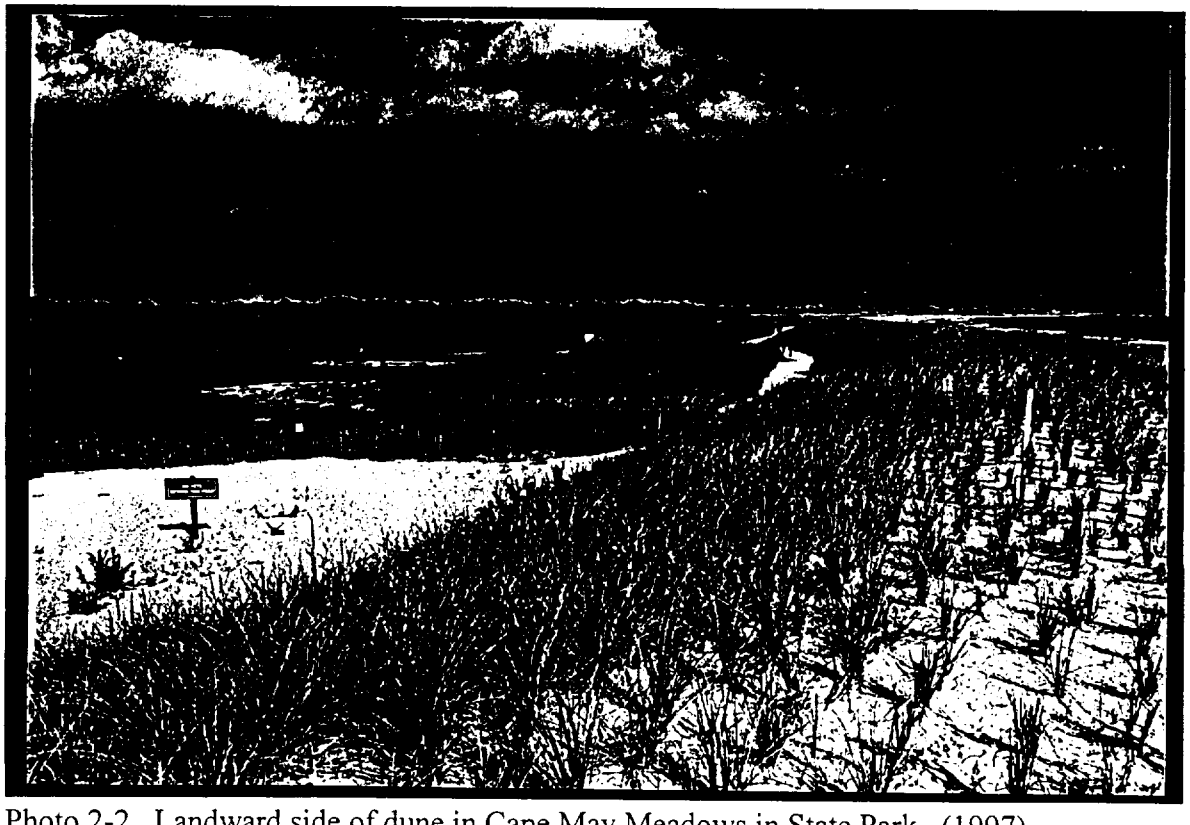


Photo 2-2 Landward side of dune in Cape May Meadows in State Park. (1997)

Photo 2-3 Armor mattress on seaward side of dune in Cape May Meadows, looking west, existing concrete ruins in background (1997).

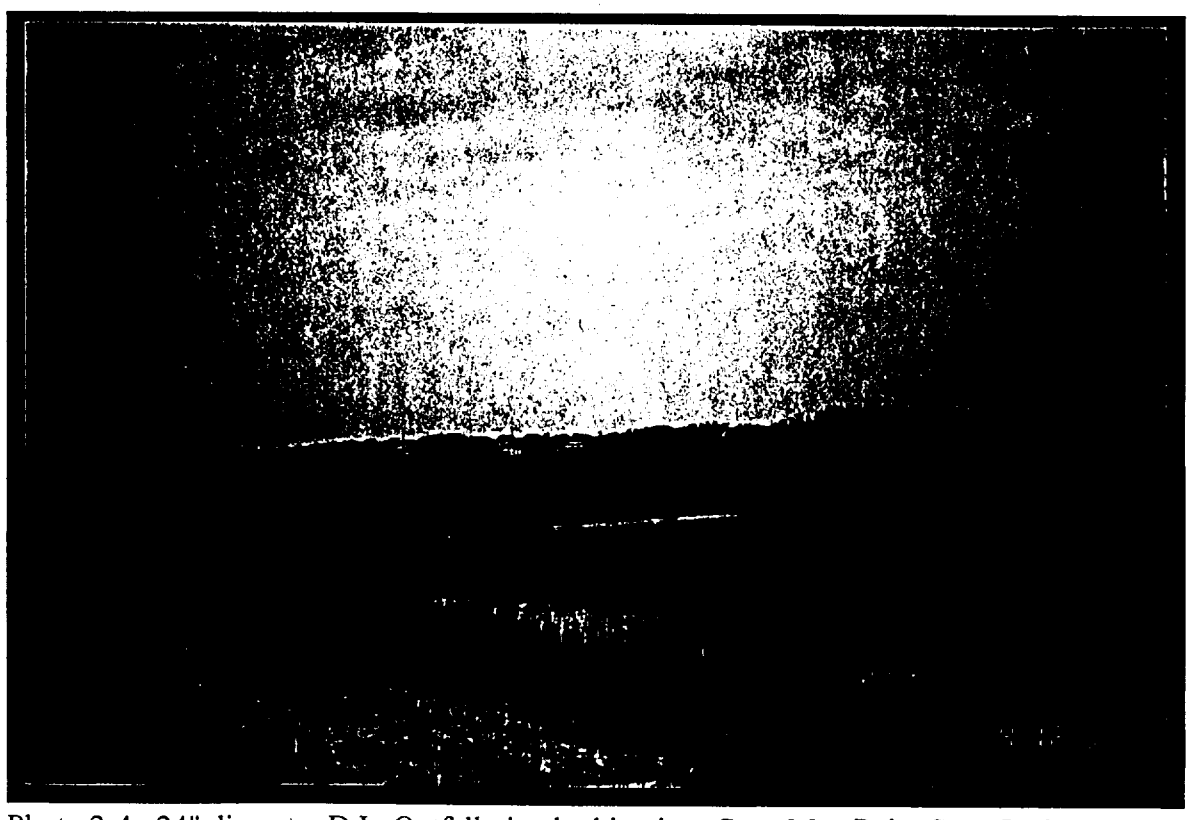


Photo 2-4 24" diameter D.I. Outfall pipe looking into Cape May Point State Park (1993).

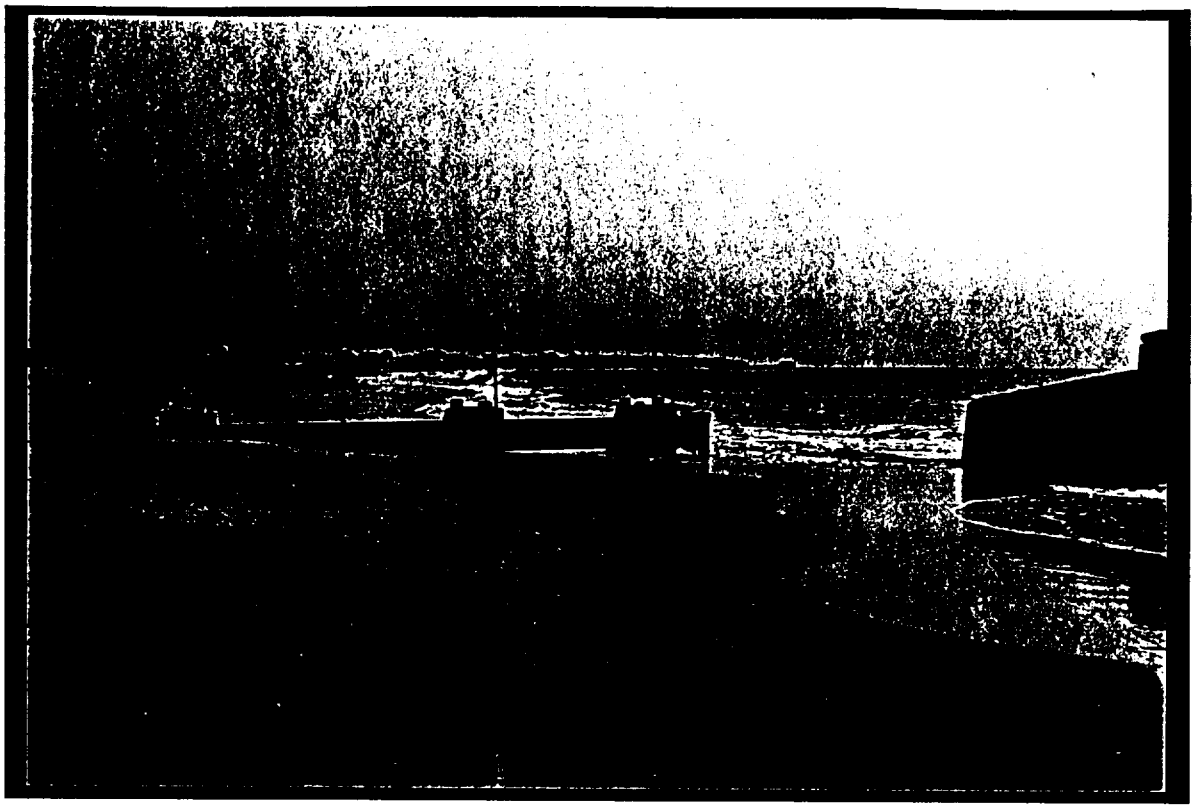


Photo 2-5 24" diameter D.I. outfall pipe looking east (1997).

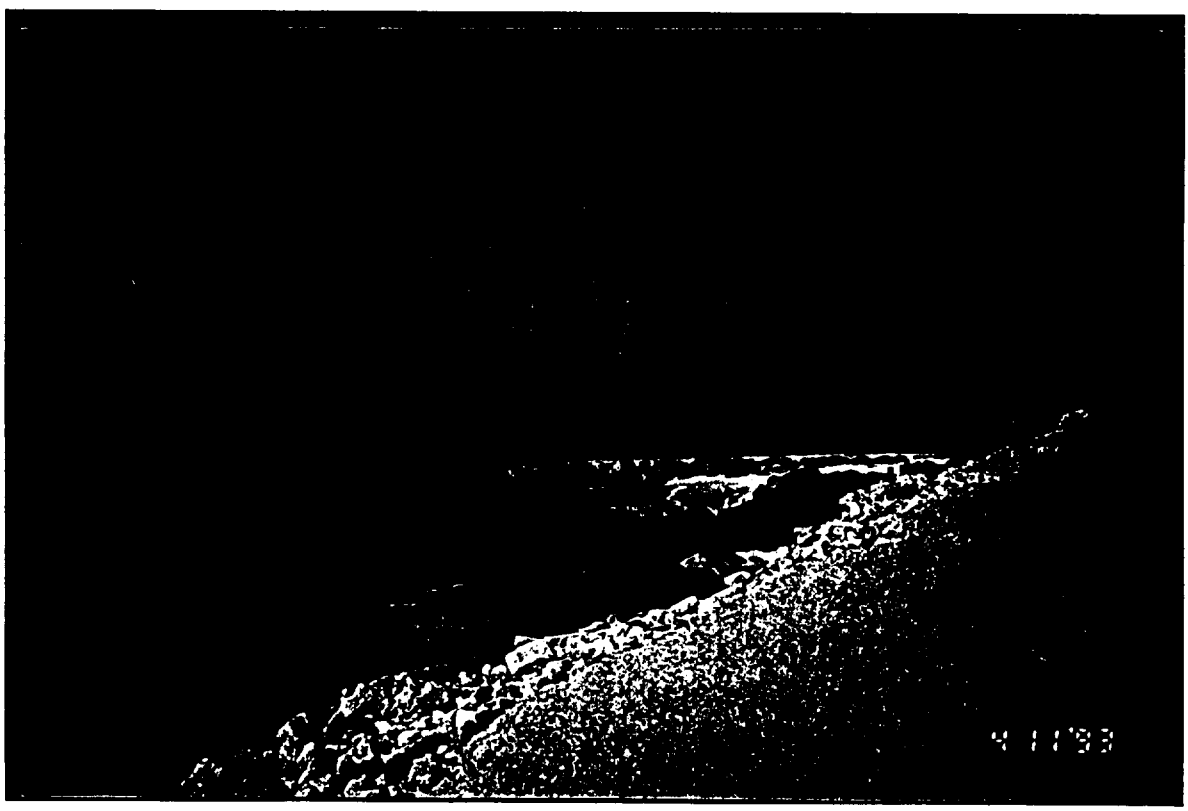


Photo 2-6 Groins at Lehigh and Whilldin Aves., Cape May Point (1993).

Photo 2-7 Groin at Coral Ave., Cape May Point (1993).

Photo 2-8 Groins at Lake Ave., Cape May Point (1993).

Photo 2-9 Groin at Central Ave., Cape May Point (1993).

Photo 2-10 Stone and concrete rubble revetment in Cape May Point.

Photo 2-11 Cape May Meadows looking east. Remains of concrete bunker in surf zone (1997).

ROAD REPLACEMENT

1. ID-2 Surface Course

2. Bituminous Concrete Base Course (8" thick)

3. Subbase (10" of AASHTO 57)

Cell	Erosion Point (ft)	Total Area to be Replaced.
1A	N/A	N/A
1B	160	2925 ft²
	180	3975 ft²
2A	120	55 ft²
	145	4166 ft²
	165	4166 ft²
2B	50	1105 ft²
	55	1900 ft²
	60	6065 ft²
	65	7125 ft²
	70	8030 ft²
	75	8940 ft²
3A	N/A	
3B	120	4,775 ft²
4	55	85 ft²
	70	1960 ft²
	90	3650 ft²
	95	3650 ft²

3975
3141
7116
7120

CELL	EROSION POINT (FT)	DESCRIPTION & QUANTITY
4	55	1 timber E/T/C pole 50 LF E/T/C WIRES
	70	2 timber E/T/C poles 100 LF E/T/C WIRES
	90	1 SAN. SEWER MH 20 LF 8" PVC SAN. SEWER PIPE 1 FIRE HYD; 40 LF 8" PVC WATER 2 timber E/T/C poles 100 LF E/T/C WIRES
	95	2 SAN. SEWER MH 30 LF 8" PVC SAN. SEWER pipe 1 FIRE HYDRANT 45 LF 8" PVC WATER 3 timber E/T/C poles 100 LF E/T/C WIRES 30 FT 2" PVC WATER LATERAL
5A	115	N/A
	125	N/A
	140	N/A
	150	1 SAN. SEWER MH 30 LF 8" PVC SAN. PIPE
5C	65	N/A
	70	N/A
	80	2 E/T/C poles 50 LF E/T/C WIRES 1 SAN. SEWER MH 160' 8" PVC SAN. SEWER PIPE 1 FIRE HYDRANT 40 LF 8" PVC WATER PIPE

National® Brand
13-782 500 SHEETS, FILLER 5 SQUARE
42-381 50 SHEETS EYE-EASE® 5 SQUARE
42-382 100 SHEETS EYE-EASE® 5 SQUARE
42-389 200 SHEETS EYE-EASE® 5 SQUARE
42-392 100 RECYCLED WHITE 5 SQUARE
42-399 200 RECYCLED WHITE 5 SQUARE
Made in U.S.A.

Cape May Point Feasibility
Infrastructure Replacement Quantities

Notes:

1. Assume residential streets for wire hook-up.
2. Assume 1 water valve for every 8" p WATER P

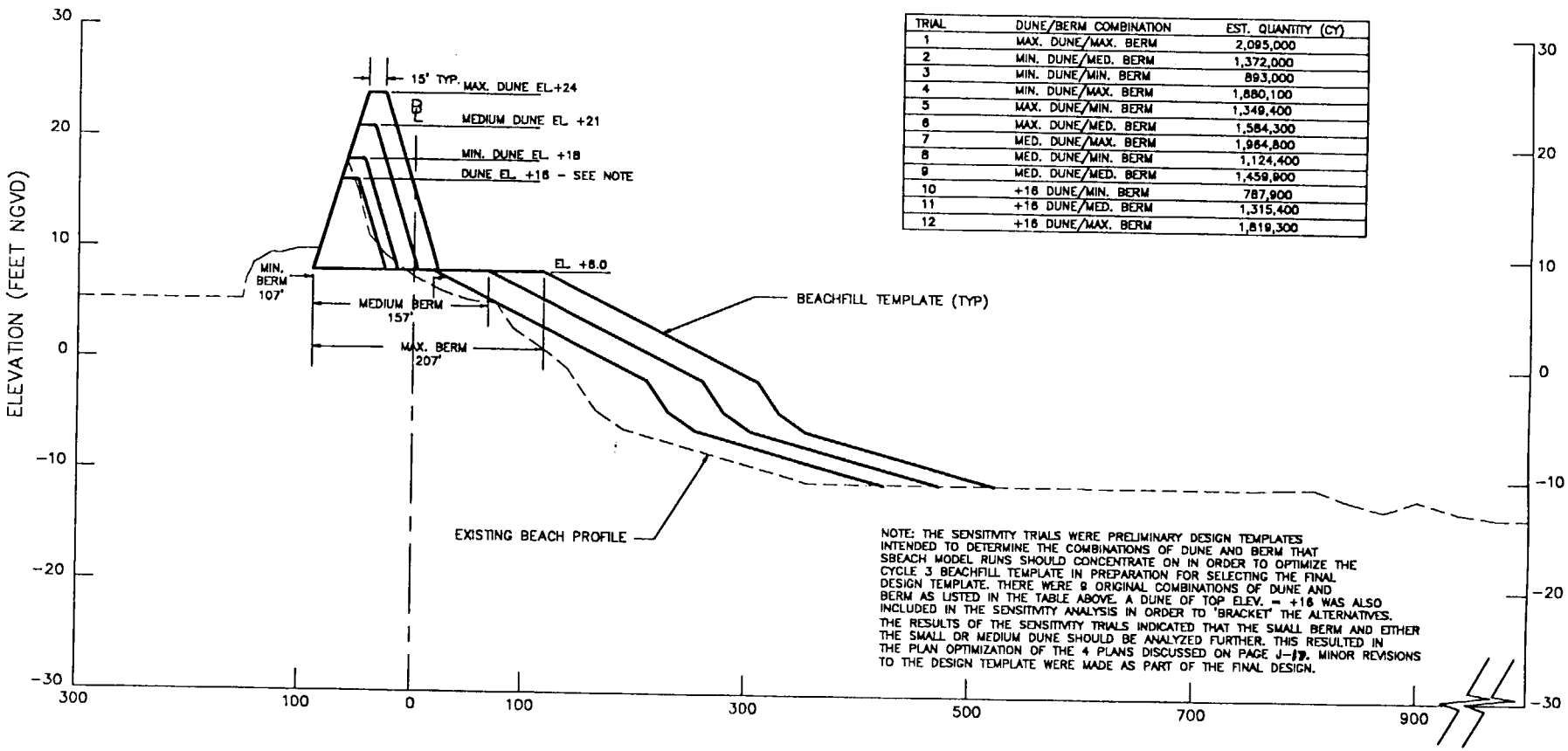
Utilities: (By Cell)

CELL	EROSION POINT (FT)	TYPE & QUANTITY REPLACED	
		24"Ø D.I. PIPE + TIMBER PILE BENTS	SEE ATT. SHEET
1A	15	ALL EROS. PTS. ADD TIDEFLEX BACKFLOW PREVENTER	115 ft, 7 pile bents
	45		146 ft, 9 pile bents
	80		182 ft, 11 pile bents
	160		265 ft, 15 pile bents
	180		320 ft, 18 pile bents + concrete box inlet
1B	160	1 SAN. SEWER MH 30 LF 8" PVC SAN. PIPE	2 timber elec/tel/cable pol 160 LF elec/tel/cable wires
	180	1 SAN. SEWER MH 50 LF 8" PVC SAN. PIPE 2 timber E/T/C POLES 180 LF E/T/C WIRES	
2A	120	N/A	
	145	1 TIMBER E/T/C POLE 1 TRANSFORMER	170 LF E/T/C WIRE 50 FT 8" PVC WATER PIPE
	165	1 TIMBER E/T/C POLE 1 TRANSFORMER 170 LF E/T/C WIRE 100' 8" PVC WATER PIPE	50 LF 2" PVC WATER LATERAL 1 FIRE HYDRANT
2B	50	1 SAN. SEWER MH 200 LF 8" PVC SAN. PIPE 80 LF 2" PVC WATER LATERAL	200 LF 8" PVC WATER PIPE
	55	1 SAN SEWER MH 235 LF 8" PVC SAN PIPE	120 LF 2" PVC WATER LATERAL 235 LF 8" PVC WATER PIPE
	60	1 SAN SEWER MH 270 LF 8" PVC SAN. PIPE	120 LF 2" PVC WATER LATERAL 270 LF 8" PVC WATER PIPE
	65	1 SAN SEWER MH 280 LF 8" PVC SAN PIPE	120 LF 2" PVC WATER LATERAL 280 LF 8" WATER LINE
	70	1 SAN SEWER MH 280 LF 8" PVC SAN. PIPE	120 LF 2" PVC WATER LATERAL 280 LF 8" PVC WATER PIPE
	75	1 SAN SEWER MH 280 LF 8" PVC SAN. PIPE 280 LF 8" PVC WATER PIPE	120 LF 2" PVC WATER LATERAL 1 timber elec/Tel/cable pol 300 LF E/T/C WIRE
3B	120	2 timber E/T/C poles 230' E/T/C WIRE 1 TRANSFORMER 230' 8" PVC SAN. PIPE 230' 8" PVC WATER PIPE 1 FIRE HYDRANT	

Quantities
ROAD/PARKING LOT REPLACEMENT

4/4

LOWER CAPE MAY MEADOWS - CAPE MAY POINT FEAS.					
	INFRASTRUCTURE COSTS				
CELL	EROSION POINT	INFRA.	COST	ROAD AREA (FT²)	COST/SF
CMP-1A	15				
	45				
	80		N/A		
	160				
	180				
CMP-1B	15	—	—	—	—
	45	—	—	—	—
	80	—	—	—	—
	160	ROAD/PARK.		3925	
	180	ROAD/PARK		7120	
CMP-2A	45	—	—	—	—
	60	—	—	—	—
	120	ROAD		55	
	145	"		4166	
	165	"		4166	
CMP-2B	5	—	—	—	—
	15	—	—	—	—
	50	ROAD		1105	
	55	"		1900	
	60			6065	
	65			7125	
	70			8030	
	75			8940	
CMP-3A & CMP-3B	10	—	—	—	—
— | —	20	—	—	—	—
— | —	55	—	—	—	—
— | —	70	—	—	—	—
— | —	105	—	—	—	—
— | —	110	—	—	—	—
— | —	115	—	—	—	—
— |	3B → 120	ROAD		4775	
CMP-4	5	—	—	—	—
	55			85	
	70			1960	
	90			3650	
	95			3650	
CMP-5A	20	—	—	—	—
	25	—	—	—	—
	35	—	—	—	—
	115	ROAD		2165	
	125			2490	
	140			3000	
	150			3350	
CMP-5B & CMP-5C	10	—	—	—	—
— | —	15	—	—	—	—
— | —	45	—	—	—	—
— | —	55	—	—	—	—
— |	5C → 65	ROAD		50	
— |	70			175	
— |	80			2110	



TRIAL	DUNE/BERM COMBINATION	EST. QUANTITY (CY)
1	MAX. DUNE/MAX. BERM	2,095,000
2	MIN. DUNE/MED. BERM	1,372,000
3	MIN. DUNE/MIN. BERM	893,000
4	MIN. DUNE/MAX. BERM	1,880,100
5	MAX. DUNE/MIN. BERM	1,349,400
6	MAX. DUNE/MED. BERM	1,584,300
7	MED. DUNE/MAX. BERM	1,964,800
8	MED. DUNE/MIN. BERM	1,124,400
9	MED. DUNE/MED. BERM	1,459,900
10	+16 DUNE/MIN. BERM	787,900
11	+16 DUNE/MED. BERM	1,315,400
12	+16 DUNE/MAX. BERM	1,819,300

NOTE: THE SENSITIVITY TRIALS WERE PRELIMINARY DESIGN TEMPLATES INTENDED TO DETERMINE THE COMBINATIONS OF DUNE AND BERM THAT SBEACH MODEL RUNS SHOULD CONCENTRATE ON IN ORDER TO OPTIMIZE THE CYCLE 3 BEACHFILL TEMPLATE IN PREPARATION FOR SELECTING THE FINAL DESIGN TEMPLATE. THERE WERE 9 ORIGINAL COMBINATIONS OF DUNE AND BERM AS LISTED IN THE TABLE ABOVE. A DUNE OF TOP ELEV. = +16 WAS ALSO INCLUDED IN THE SENSITIVITY ANALYSIS IN ORDER TO 'BRACKET' THE ALTERNATIVES. THE RESULTS OF THE SENSITIVITY TRIALS INDICATED THAT THE SMALL BERM AND EITHER THE SMALL OR MEDIUM DUNE SHOULD BE ANALYZED FURTHER. THIS RESULTED IN THE PLAN OPTIMIZATION OF THE 4 PLANS DISCUSSED ON PAGE J-17. MINOR REVISIONS TO THE DESIGN TEMPLATE WERE MADE AS PART OF THE FINAL DESIGN.

18' DUNE WITH 20' BERM

HORIZONTAL SCALE: 1"=150'
VERTICAL SCALE: 1"=15'

LOWER CAPE MAY MEADOWS - CAPE MAY POINT FEASIBILITY STUDY

CYCLE 3-SENSITIVITY ALTERNATIVES DESIGN CROSS SECTIONS SURVEY PROFILE LINE C

Beachfill Quantities for Plan Optimization (Cycle 3) by cell:

Note:
1. All quantities are in cubic yards.

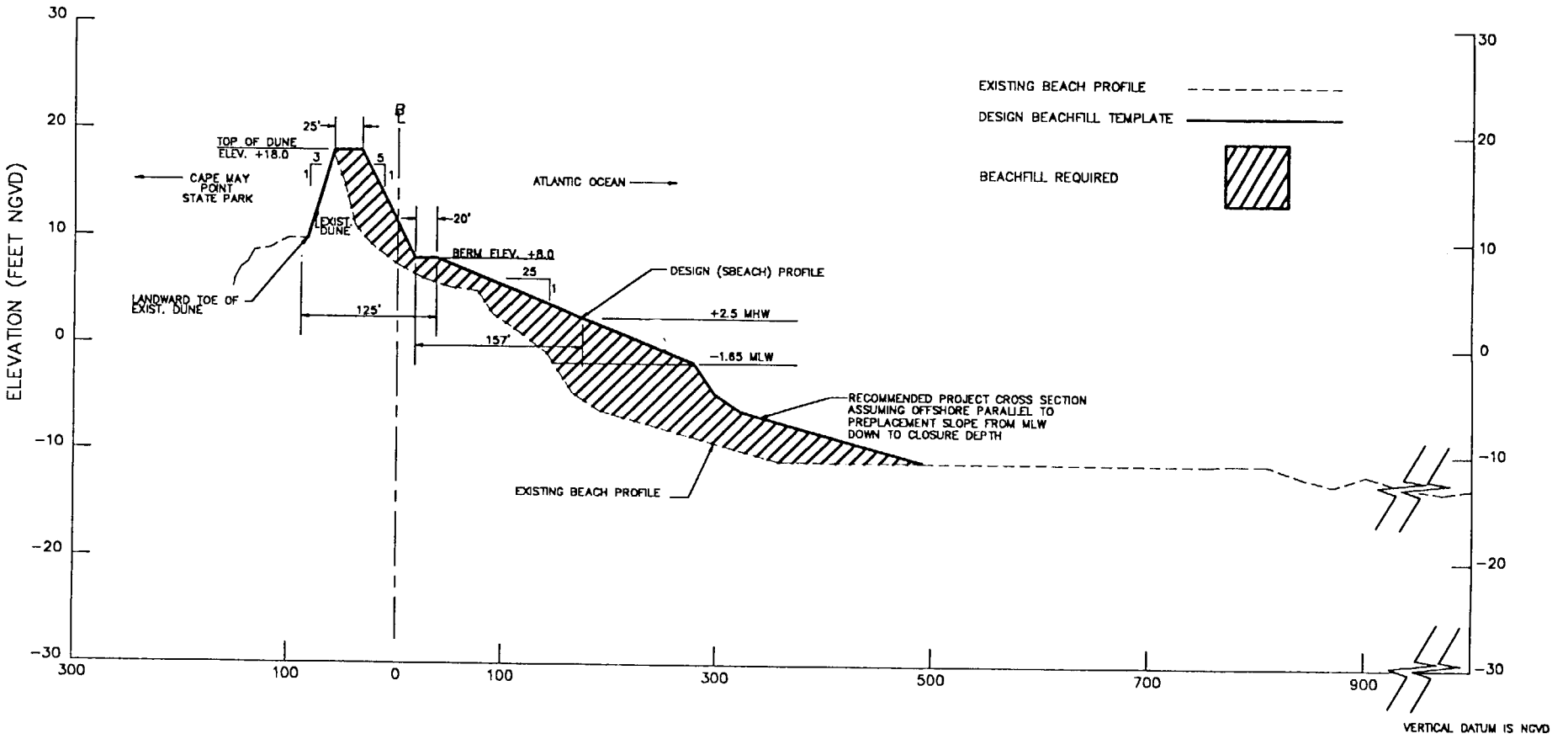
2. Cells listed have been previously referenced in without project as follows:

Cell A&B= Cell 1 & 1A
Cell C= Cell 2A
Cell D= Cell 2B&3
Cell E = Cell 4&5A

3. Nomenclature for 'Plan' represents the top elevation of the dune and the horizontal portion of the berm directly adjacent to the seaward toe of dune; (i.e. the plan labeled 18-20 represents a dune with top elevation of +18 NGVD and a horizontal berm width = 20'). See the figure on page J-18 in this appendix. Also see figures on pages J-19 to J-26 for profiles used to calculate these quantities.

Cell	Plan	21-50	21-20	18-50	18-20*
A&B	dune	182,000	182,000	85,000	85,000
	berm	936,800	803,300	824,000	695,000
C	dune	13,000	13,000	6,800	7,000
	berm	268,000	253,500	256,000	200,000**
D	dune	23,000	23,000	9,500	6,000
	berm	328,000	270,000	280,000	87,000
E	dune	23,000	23,000	12,500	3,000
	berm	462,500	384,500	400,000	124,000

*Cycle 3 initial Selected Plan placement quantities (not including renourishment)
**Quantity includes fill required to stabilize scour hole as shown on the cross section in figure on page J-23

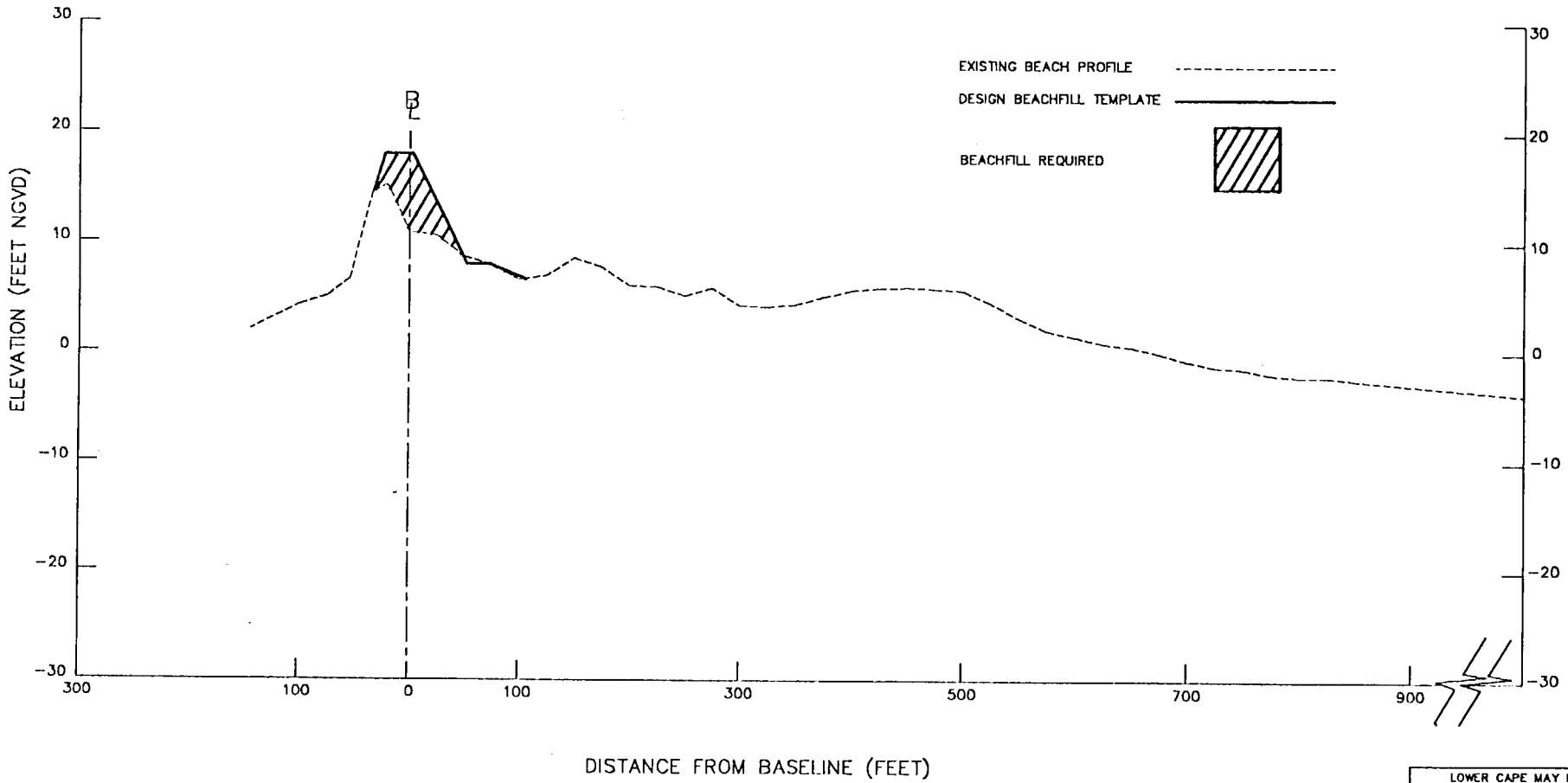


18' DUNE WITH 20' BERM

LOWER CAPE MAY MEADOWS –
CAPE MAY POINT
FEASIBILITY STUDY
CAPE MAY MEADOWS

CYCLE 3 – SELECTED FILL DESIGN TEMPLATE
PROTECTIVE DUNE AND BERM
TYPICAL PROFILE (SURVEY LINE "C")

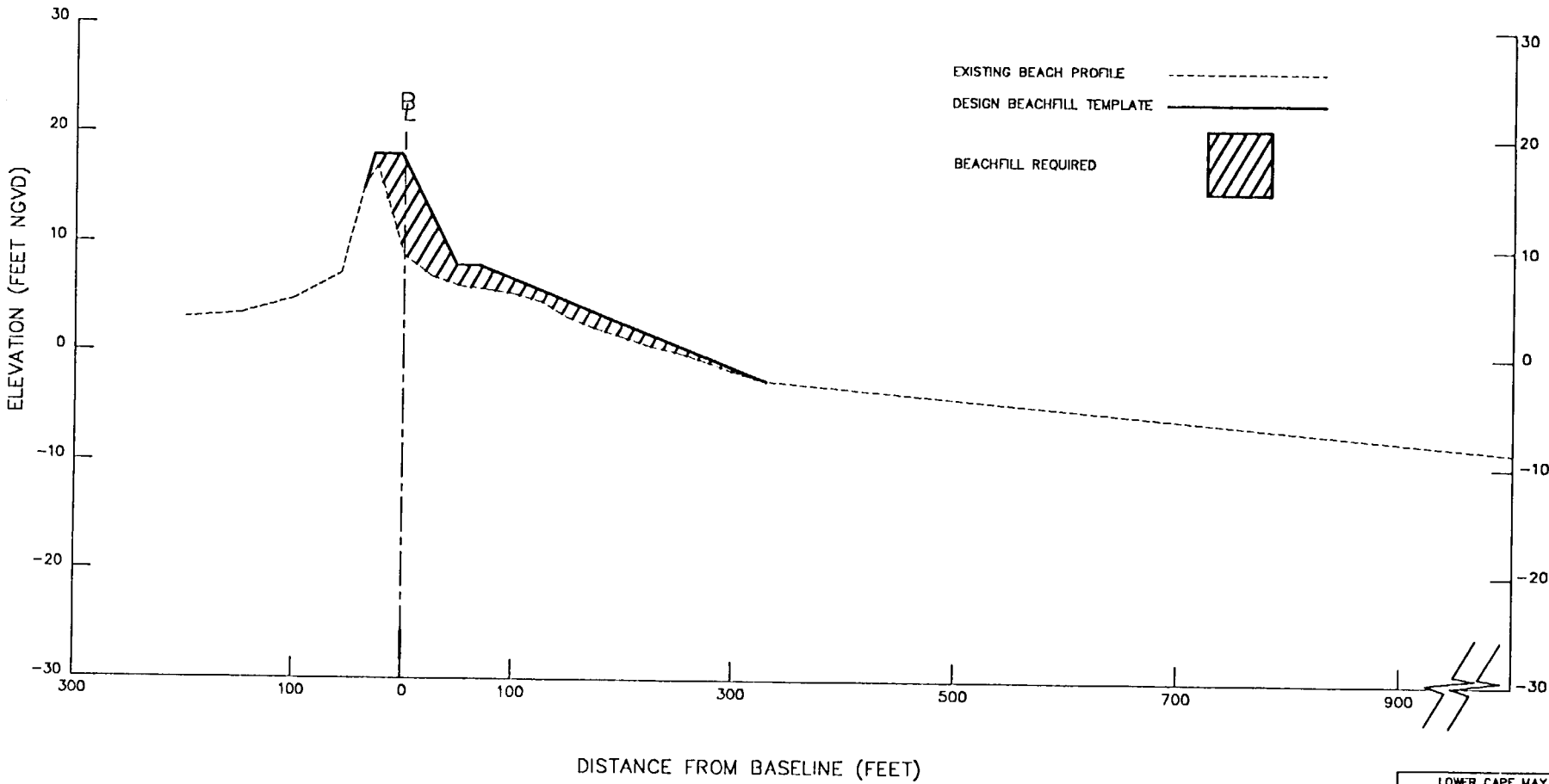
SCALE: 1"=150'



18' DUNE WITH 20' BERM

HORIZONTAL SCALE: 1"=150'
VERTICAL SCALE: 1"=15'

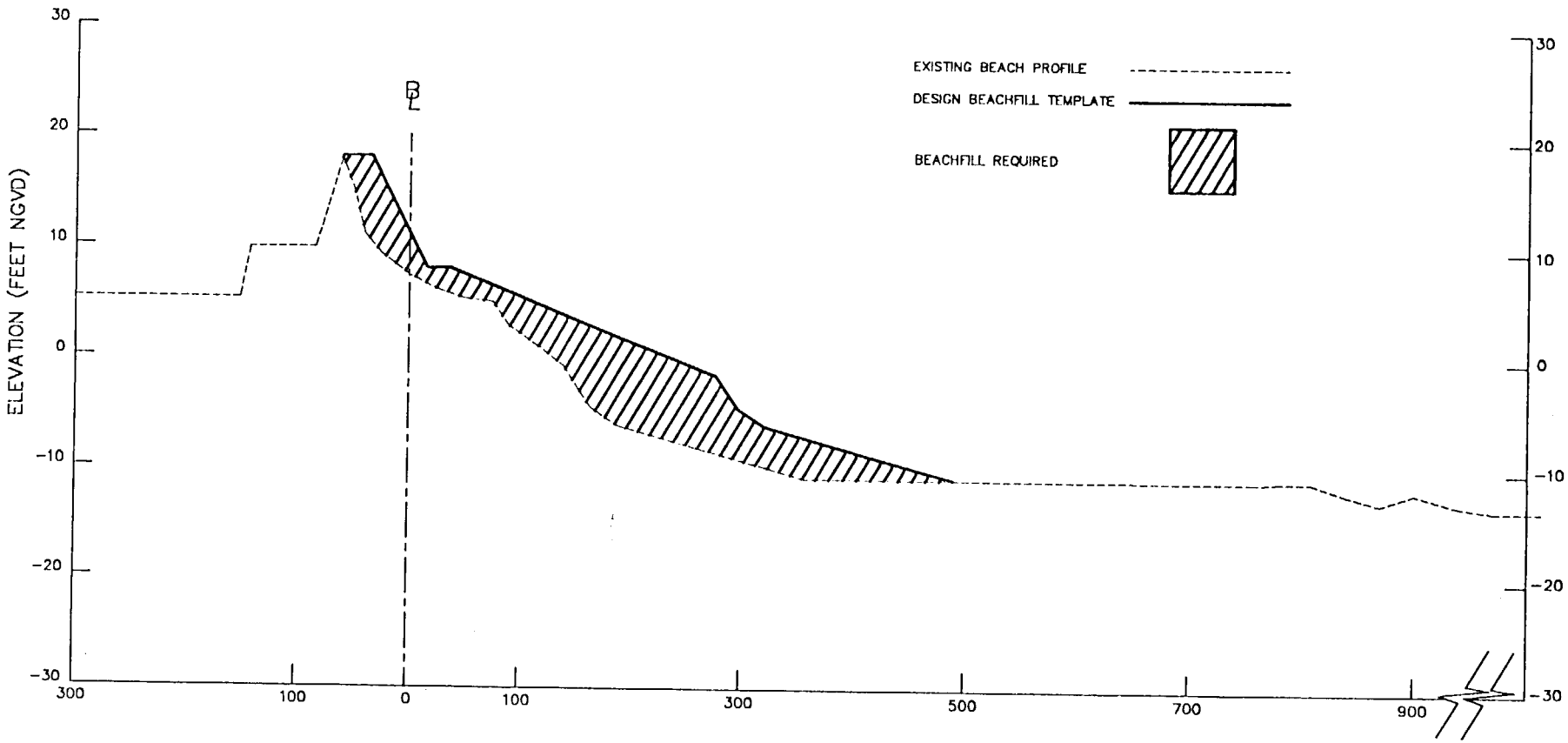
LOWER CAPE MAY MEADOWS –
CAPE MAY POINT
FEASIBILITY STUDY
CAPE MAY MEADOWS
CYCLE 3 INITIAL SELECTED PLAN
DESIGN CROSS SECTIONS
SURVEY PROFILE LINE A



18' DUNE WITH 20' BERM

HORIZONTAL SCALE: 1"=150'
VERTICAL SCALE: 1"=15'

LOWER CAPE MAY MEADOWS –
CAPE MAY POINT
FEASIBILITY STUDY
CAPE MAY MEADOWS
CYCLE 3 INITIAL SELECTED PLAN
DESIGN CROSS SECTIONS
SURVEY PROFILE LINE B



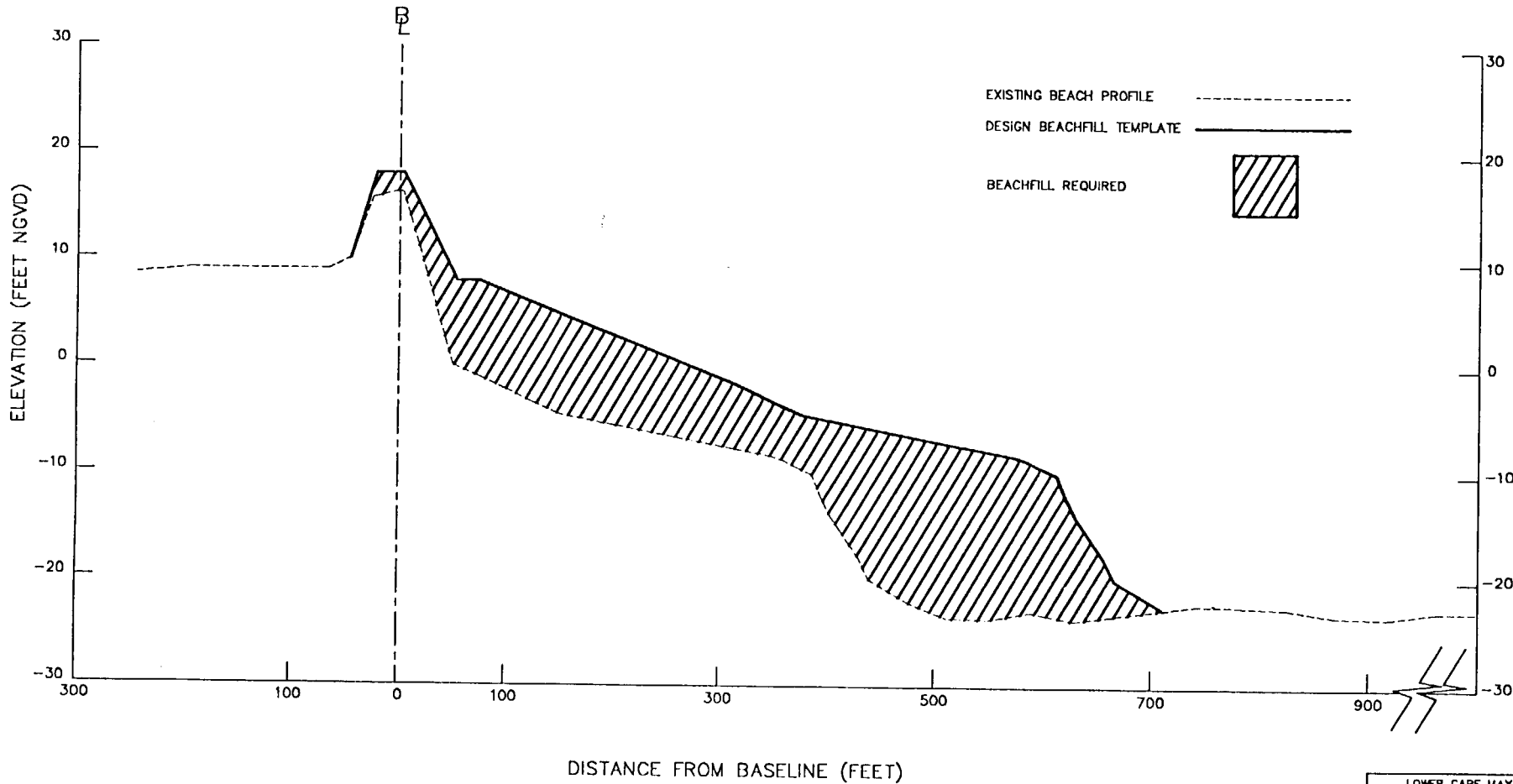
18' DUNE WITH 20' BERM

HORIZONTAL SCALE: 1"=150'
VERTICAL SCALE: 1"=15'

LOWER CAPE MAY MEADOWS
CAPE MAY POINT
FEASIBILITY STUDY
CAPE MAY MEADOWS

CYCLE 3 INITIAL SELECTED PLAN

DESIGN CROSS SECTIONS
SURVEY PROFILE LINE C



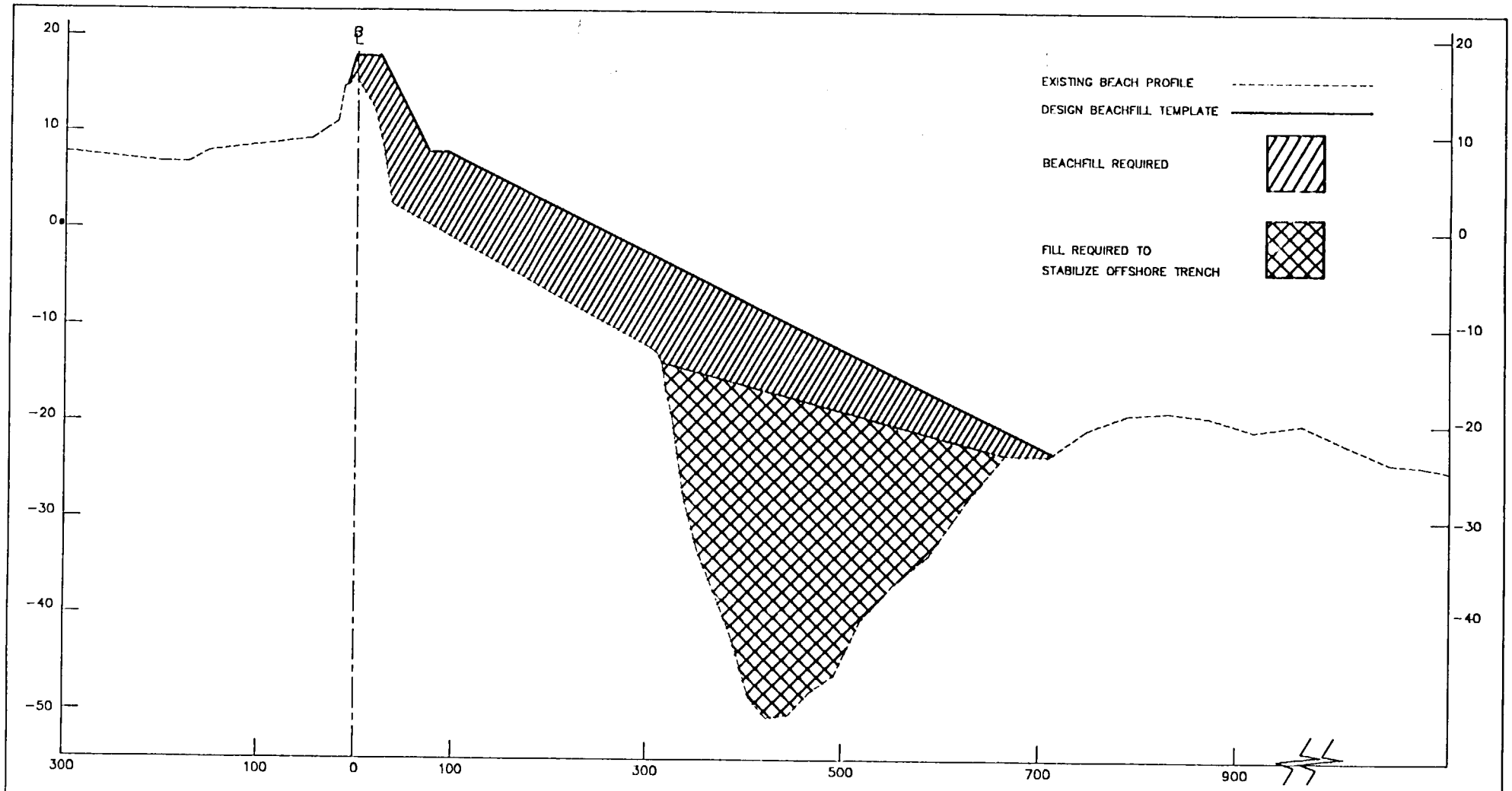
18' DUNE WITH 20' BERM

HORIZONTAL SCALE: 1"=150'
VERTICAL SCALE: 1"=15'

LOWER CAPE MAY MEADOWS –
CAPE MAY POINT
FEASIBILITY STUDY
CAPE MAY MEADOWS

CYCLE 3 INITIAL SELECTED PLAN

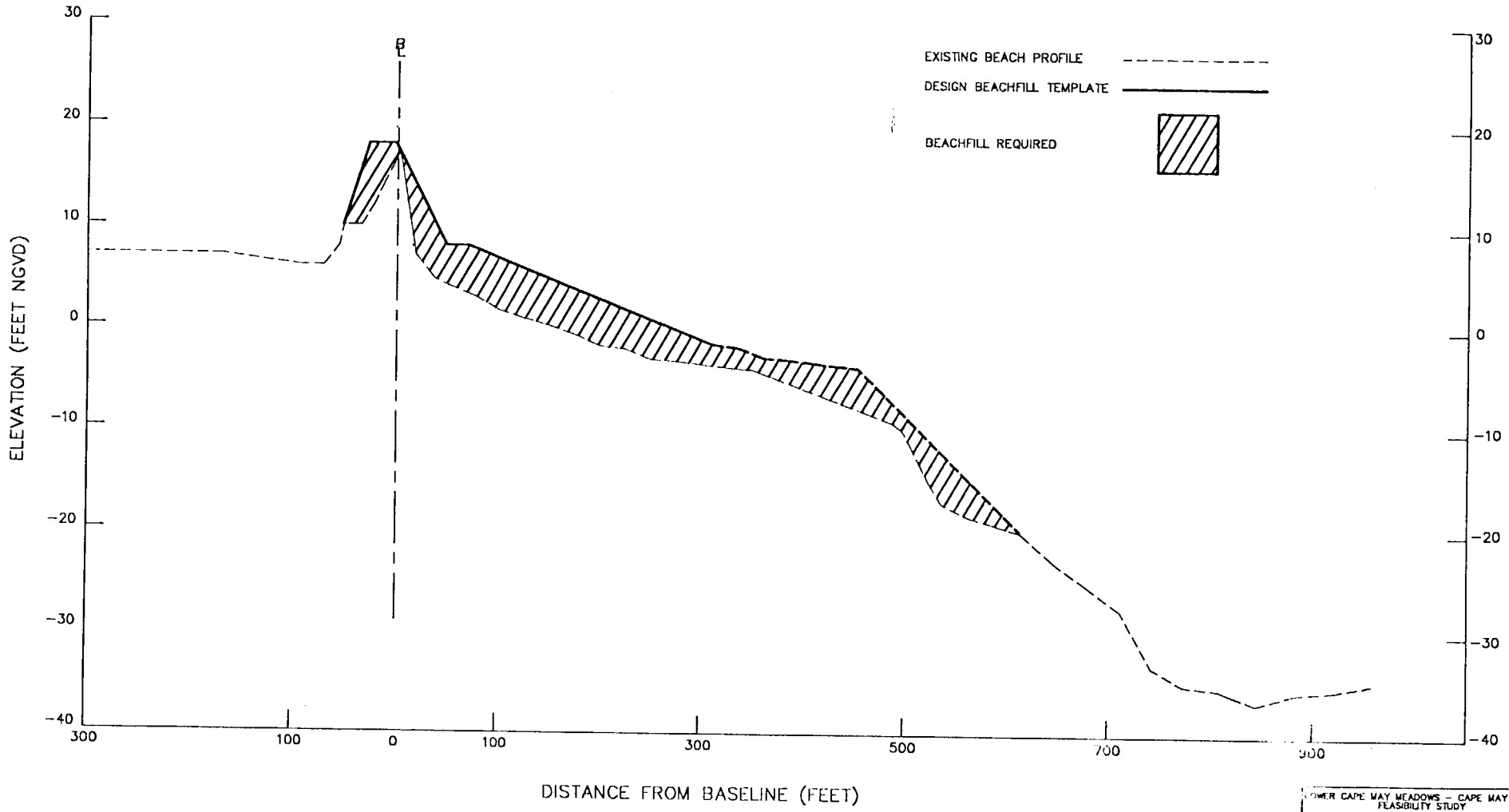
DESIGN CROSS SECTIONS
SURVEY PROFILE LINE D



HORIZONTAL SCALE: 1"=150'
VERTICAL SCALE: 1"=15'

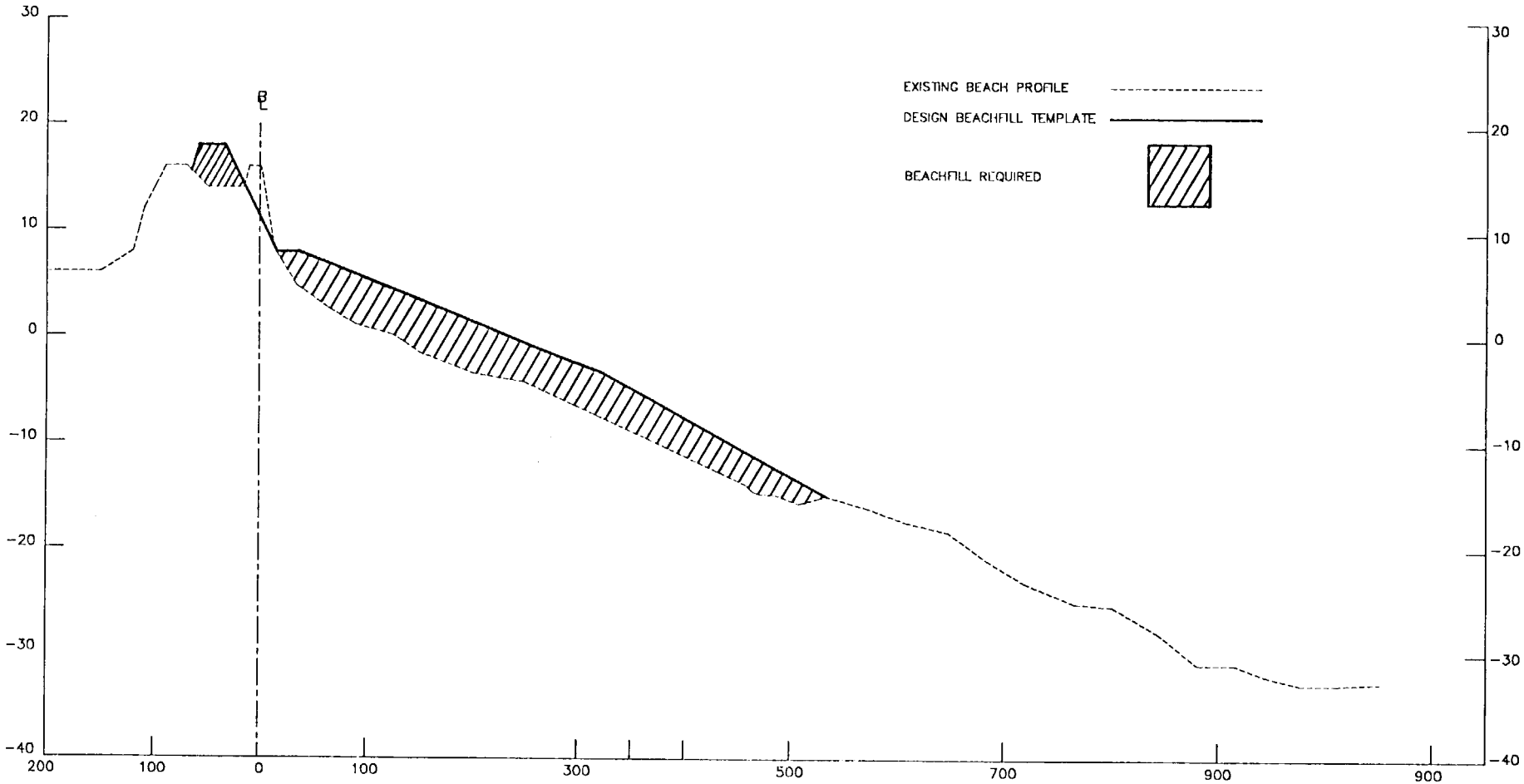
LOWER CAPE MAY MEADOWS –
CAPE MAY POINT
FEASIBILITY STUDY

CAPE MAY POINT
CYCLE 3 INITIAL SELECTED PLAN
DESIGN CROSS SECTIONS
SURVEY PROFILE LINE CMP-1



LOWER CAPE MAY MEADOWS – CAPE MAY POINT
FEASIBILITY STUDY

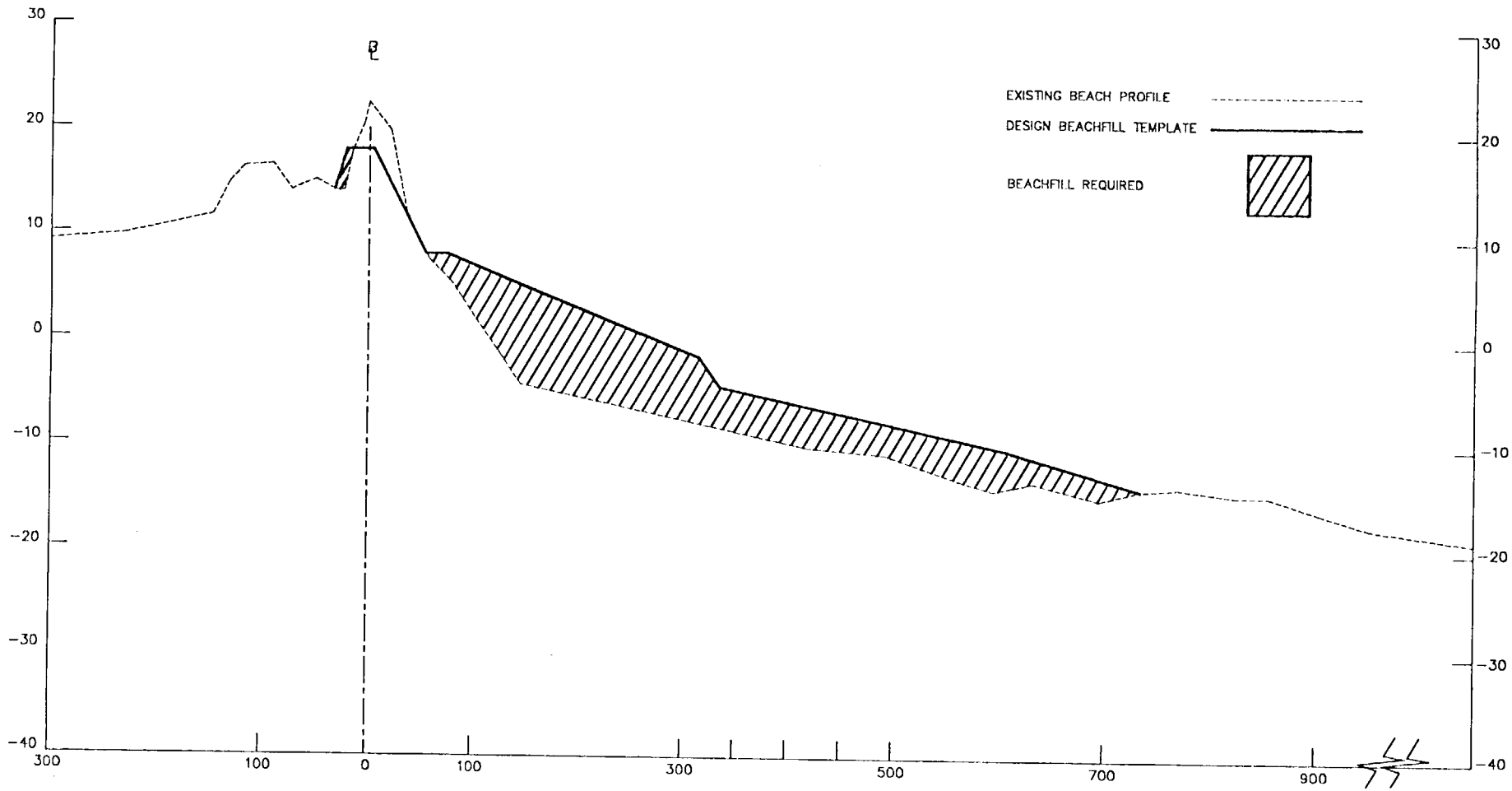
CAPE MAY POINT
SELECTED PLAN
DESIGN CROSS SECTIONS
SURVEY PROFILE LINE CMP-2



HORIZONTAL SCALE: 1"=150'
VERTICAL SCALE: 1"=15'

LOWER CAPE MAY MEADOWS –
CAPE MAY POINT
FEASIBILITY STUDY

CAPE MAY POINT
SELECTED PLAN
DESIGN CROSS SECTIONS
SURVEY PROFILE LINE CMP-3



HORIZONTAL SCALE: 1"=150'
VERTICAL SCALE: 1"=15'

LOWER CAPE MAY MEADOWS –
CAPE MAY POINT
FEASIBILITY STUDY

CAPE MAY POINT
SELECTED PLAN
DESIGN CROSS SECTIONS
SURVEY PROFILE LINE CMP–4 & 5

Cycle 3- Quantities for creating /restoring habitat area by extending shoreline forward:
(see figure on page J-31 for typical profile for small plan)

The quantity of sand in the overwash indicated by Environmental Branch areas is approximately 52,000 cy. This was calculated assuming an average depth of 3 feet of sand taken from the back toe of the existing dune into the interior. (3 feet was the avg. depth from hand augered borings taken in this location).

If this sand were removed , it would create approx. 11 acres of habitat area. Of this, approx. 5 acres would consist of vegetated, dry (above MHW) habitat in a buffer zone directly behind the landward side of the new dune.

Moving the shoreline out in the Meadows was broken into 3 alternatives, small, medium, large. The 18-20 beachfill plan (selected plan)was used to estimate this quantity.

The quantity of sand (or sandy material, it would include the compacted core of the existing dune) that could be recycled assuming an excavation limited from the back toe of the exist. dune down to elevation +2.0 NGVD (in order to create more habitat directly behind the pushed out dune) is the following:

small = 383,900 cy

medium = 442,600 cy

large = 449,600 cy

Assuming this quantity of excess sand is used, the total quantity required for extending the shoreline seaward is the following:

small = 188,300 cy (dune)+ 1,390,000 cy (berm)-383,900 cy (recycled fill) = 1,194,400cy

medium = 188,300 cy (dune)+ 1,784,000 cy (berm) - 442,600 cy (recycled fill)=1,529,700cy

large = 188,300 cy (dune)+ 2,753,000 cy (berm) - 449,600 cy (recycled fill) =2,491,700cy

Description of the Selected Plan

(Note: Elevations are referenced to NGVD 29, as were original mapping and surveys. To convert vertical datum to NAVD 88, subtract 1.27 from elevations.)

The selected plan includes a protective dune and berm restoration in Cape May Meadows and Cape May Point. The selected plan also includes habitat restoration within the existing Cape May Point State Park and Nature Conservancy, both of which are located in Cape May Meadows.

BEACHFILL DESIGN TEMPLATE

The beachfill design template for the selected plan in Cape May Meadows is shown in the figure on page J-33. The dune crest has a top elevation of +18.0 NGVD, a top width of 25 feet, and slopes of 1V:3H and 1V:5H on the landward and seaward side slopes, respectively. The total width of this dune from toe to toe is equal to 105 feet. The dune will be planted with 18 acres of dune grass and will be stabilized with 15,000 linear feet of sand fence.

The berm will extend from the seaward toe of the dune for a distance of 20 feet (at elevation +8.0 NGVD) before sloping down at 1V:25H to elevation -1.65 (MLW). The remainder of the fill assumes the offshore fill required is parallel to the existing pre-placement slope out to the closure depth for each survey profile. The total width of the berm from the seaward toe of dune to MHW is equal to 157 feet.

The plan layout of the dune/berm restoration extends from the 3rd Ave. terminal groin in Cape May City to the groin in Cape May Point located between Cape and Central Avenues, at which point the fill will transition to tie in to the existing beach and dune . The total length of fill is 10,050 feet or 1.9 miles. The initial sand placement quantity for the design fill is 1,722,000 cubic yards which does not include the initial advanced nourishment of 650,400 cubic yards. Periodic nourishment of 650,400 cubic yards would be placed every 4 years. Fill material would be obtained from borrow area P1 and P2 (figure 2.6.1). Fill quantities were calculated using the average end area method.

The proposed selected plan layout for the dune/berm restoration in Cape May Meadows also includes a plan for shifting the location of the dune and berm in a seaward direction to restore habitat area that has been eroded. This plan includes the berm and dune as described above but shown in the location on the figure on page J-32. The restoration of habitat area will be constructed by excavating the existing dune material down to elevation +2.0 NGVD and placing the spoil material seaward to reduce the amount of fill required by this option. This material to be excavated will also include some areas of sand overwash behind the existing dunes. The exception to this will be an area in the State Park frontage where the proposed dune will be placed on the existing dune in order to provide sand cover over the existing Tensar stone mattress. The dune and berm would

then be constructed by normal beachfilling operations in the proposed location (see "Construction Beachfill Template"). A 25 feet wide sand buffer will be constructed directly behind the landward toe of the proposed dune with a top berm elevation of +6.0 NGVD. This buffer will be planted with scrub/brush vegetation. The area behind the buffer zone will then be filled to a depth of 10 inches (0.83') with organic material obtained from other excavations required within the Meadows as part of the selected plan. This organic material will then be planted with wetland vegetation.

The existing 24" DI outfall pipe (Drainage East) located near the bunker ruins will be extended 112 feet in a seaward direction to maintain positive drainage from the Meadows. The landward invert of this pipe will be equipped with a self regulating tide gate (see product information insert on page J-54 to J-56).

The design beachfill template in Cape May Point will not be shifted seaward beyond the existing dune line to create/restore habitat as is proposed in Cape May Meadows. Because the offshore profiles in Cape May Point are so steep, extent of the beachfill in a seaward direction is restricted by the length of the existing groins in Cape May Point. The dune/berm restoration in Cell 'C' in Cape May Point (figure on page J-23) would be constructed in two phases. The first phase would consist of filling the scour hole up to approximately elevation -28 ft. NGVD. This would be accomplished by means of a hydraulic dredge with a submerged dredge pipeline which would be placed at the bottom of the scour hole and retracted gradually as the hole fills. The second phase would consist of normal beachfilling operations for placement of the required onshore fill as described in "Construction Beachfill Template", which is also how the remainder of the beachfill in Cape May Point will be placed. See the figure on page J-35 for a cross section of the selected plan in Cape May Point.

BEACHFILL CONSTRUCTION TEMPLATE

The constructed beachfill template is seldom the same shape as the design template because of the working limitations of equipment used to place and shape the fill. In addition, the sorting of the fill by waves and currents will naturally shape the constructed fill profile to an environmentally equilibrated form after placement.

Currently, the Philadelphia District uses a method of construction called the "overbuilding method". In this construction process the required or design fill volume will be placed on the beach at the proposed berm elevation , but with a berm width greater than the design width and a fill slope steeper than the existing equilibrium slope on the seaward side. The constructed berm is "overbuilt" in the sense that it is larger than the intended design berm width. Coastal processes re-adjust the profile to a natural equilibrium state. In this case much of the overbuilt berm sand would move offshore. The resulting profile is the intended design profile. An illustration of this is shown in the figure on page J-33a.

As an example, the proposed design/construction template for Cape May Point is shown in the figure on page J-35. The part of the design template labeled "offshore..." is the quantity that is placed up on the beach as a part of the "overbuilt berm". The 2nd part of

the overbuilt quantity is called advanced nourishment. Since the beach restoration will be done in a four year cycle, a maintenance quantity of four years worth of natural losses must be placed on the beach at the beginning of the cycle so that the intended design profile is maintained until the next restoration three years hence. This extra quantity that ensures the design profile will be left at the end of the four year cycle is called "advanced nourishment". The beach fill shown will eventually adjust to a natural slope, the proposed design template shown in the figure on page J-24. This adjustment will result in a narrower berm, leaving the impression that much of the fill has been lost, though it has only moved offshore to re-establish the design equilibrium profile. The design profile shown in the figure on page J-24 is the proposed condition of the beach at the end of the four year restoration cycle.

The selected plan also includes several localized drainage improvements within Cape May Meadows as part of the habitat restoration. These improvements include:

1. Excavation of existing drainage ditches.

2. Excavation of new drainage ditches to include reconnections between existing ditches.

3. Excavation within existing ponds to construct fish reservoirs.

4. Construction of a shallow earthen water retaining structure within the Nature Conservancy .

5. Construction of two weir flow control structures.

Note: Spraying/burning of existing phragmites is not included in this discussion.

Existing drainage ditches to be excavated are configured with a bottom width of 20' and 1V:5H side slopes. Depth of excavation ranges from a maximum of 4 feet (in the State Park) to a minimum of 0.5 ft. (in the Nature Conservancy), and vary with existing ground elevations.

The two new drainage ditches between hydrologic segments to be excavated have the same channel configuration, but are regulated with weir flow control structures. The weirs consist of removable 10 feet wide timber flash boards which are supported by small concrete gravity walls that will be designed to resist saturated earth pressures. The bottom width of the channels narrows from 20 feet to 10 feet at each weir structure. Graded riprap will be placed at the bottom of the channel at the entrance and exit of the weirs to provide scour protection. The side slopes of the channel in the transition between 20 and 10 feet bottom widths will be stabilized with geoweb, the compartments of which will be filled with low slump concrete. The geoweb will only be placed on those areas of the side slopes that result in slopes greater than 1V:3H as the channel narrows but bottom elevations remains essentially the same. The soil in the area of the failure wedge behind

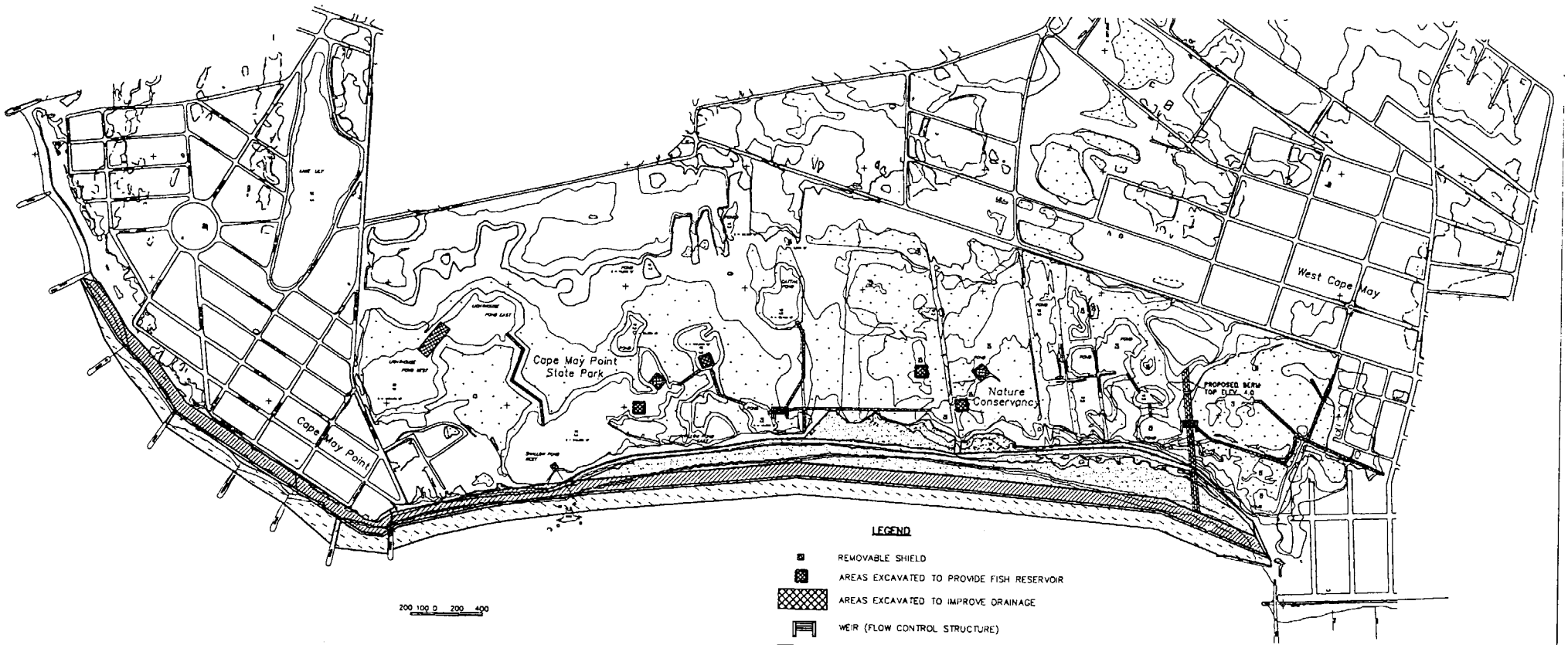
each concrete support will be excavated and replaced with granular backfill, and the soil in the area directly below each concrete support will be replaced with appropriate backfill to provide sufficient bearing to a depth equal to the base width B of the support footing.

The fish reservoirs to be excavated are located within existing ponds in the Meadows. Depth of the ponds is equal to 2 feet below existing ground at the bottom of the ponds. Each pond will be approximately 70 feet square with side slopes of 1V:5H.

The excavations for the improvements within Cape May Meadows will be accomplished by means of amphibious rotary ditchers which are capable of remaining afloat in submerged areas. In areas where access is not limited by the water table a small backhoe and bulldozer will be used, supported on timber mats if necessary. Temporary roadway will be used to provide truck access as required to relocate material.

The water retaining structure (berm) located in the Nature Conservancy will extend from the landward side of the proposed dune to high ground to the north for a distance of approximately 1000 feet. The berm will be constructed of materials excavated in other locations in the Meadows. This material will be dried out prior to construction of the berm to improve compaction. The berm will have a top elevation of +4.0 NGVD and will tie in to the existing 4' contour on the north end. Side slopes are set at 1V:6H and will be planted with appropriate vegetation. The crest width of the berm will be 15' and the total width of this berm will be 45 feet from toe to toe. The crest of the berm will also be planted with vegetation. The dimensions of this berm are such that it will blend into the surrounding landscape. The base of the berm will be supported by geogrid to strengthen the underlying soil. For design purposes a constant minimum cross section of 3 feet from top of berm to final grade at the bottom of the structure was assumed.

No disposal of any excavated materials in the Meadows will be required as all spoils will be recycled for use in the habitat restoration.. Refer to the figure on pages J-32 for typical cross sections of the drainage improvements located in Cape May Meadows.



DATE OF PHOTOGRAPHY: 3-7-93
N.J. STATE PLANE NAD 83
VERTICAL DATUM NGVD 29

LEGEND

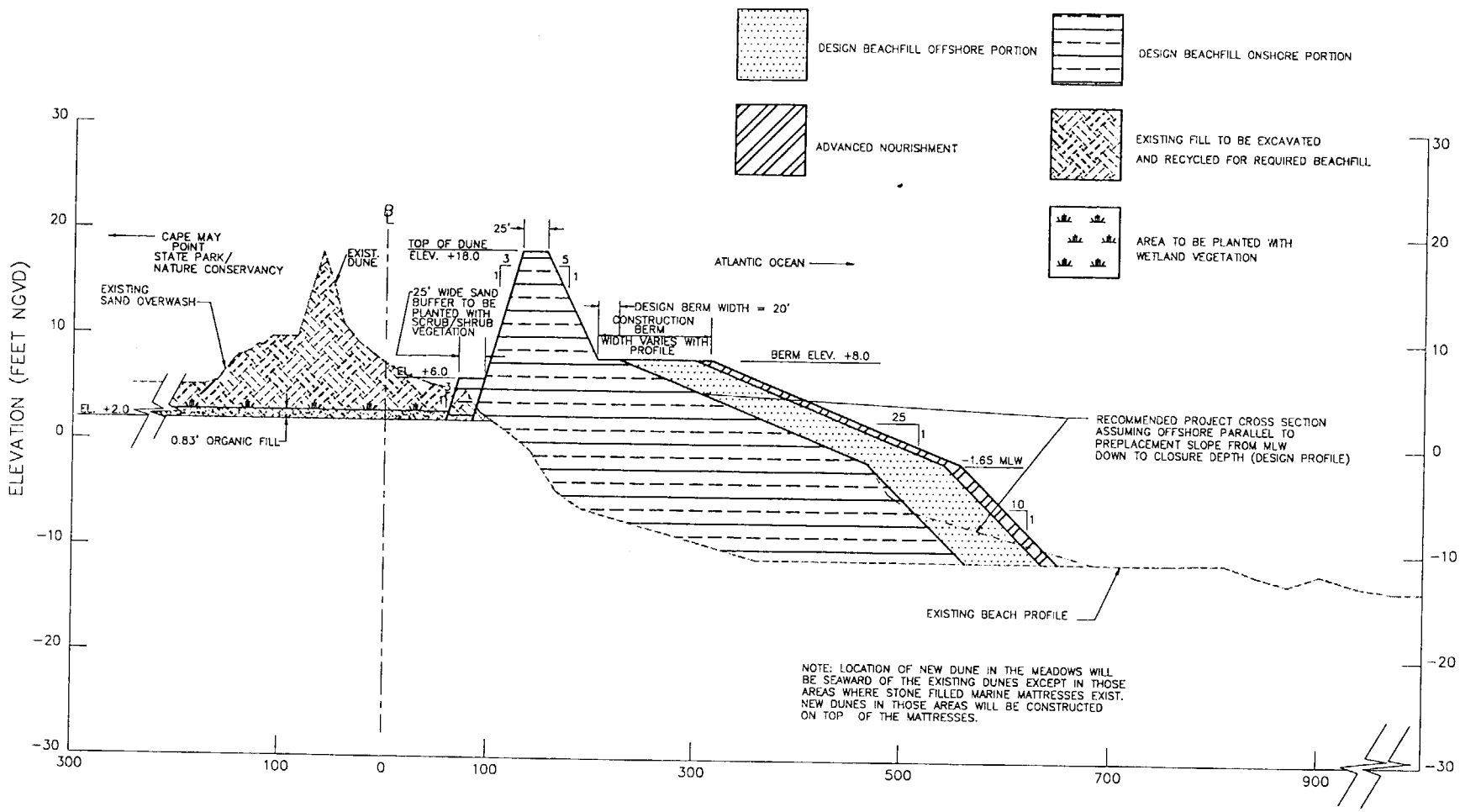
- REMOVABLE SHIELD
- AREAS EXCAVATED TO PROVIDE FISH RESERVOIR
- AREAS EXCAVATED TO IMPROVE DRAINAGE
- WEIR (FLOW CONTROL STRUCTURE)
- HABITAT AREA TO BE RECLAIMED/RESTORED
- LIMITS OF PROPOSED DUNE
- LIMITS OF PROPOSED BERM INCLUDING SLOPED PORTION DOWN TO MHW

U.S. ARMY ENGINEER DISTRICT, PHILADELPHIA
CORPS OF ENGINEERS
PHILADELPHIA, PENNSYLVANIA

LOWER CAPE MAY MEADOWS
CAPE MAY POINT
FEASIBILITY STUDY

CAPE MAY MEADOWS
SELECTED PLAN
INTERIOR RESTORATION AND
PROTECTIVE DUNE AND BERM

FIGURE 7.3-1



18' DUNE WITH 20' BERM

LOWER CAPE MAY MEADOWS -- CAPE MAY POINT
FEASIBILITY STUDY
CAPE MAY MEADOWS
SELECTED PLAN
EXTEND SHORELINE SEAWARD
PROTECTIVE DUNE AND BERM
TYPICAL PROFILE (SURVEY LINE "C")
DESIGN AND CONSTRUCTION TEMPLATE

SCALE: 1"=100'

FIGURE 7.2-2

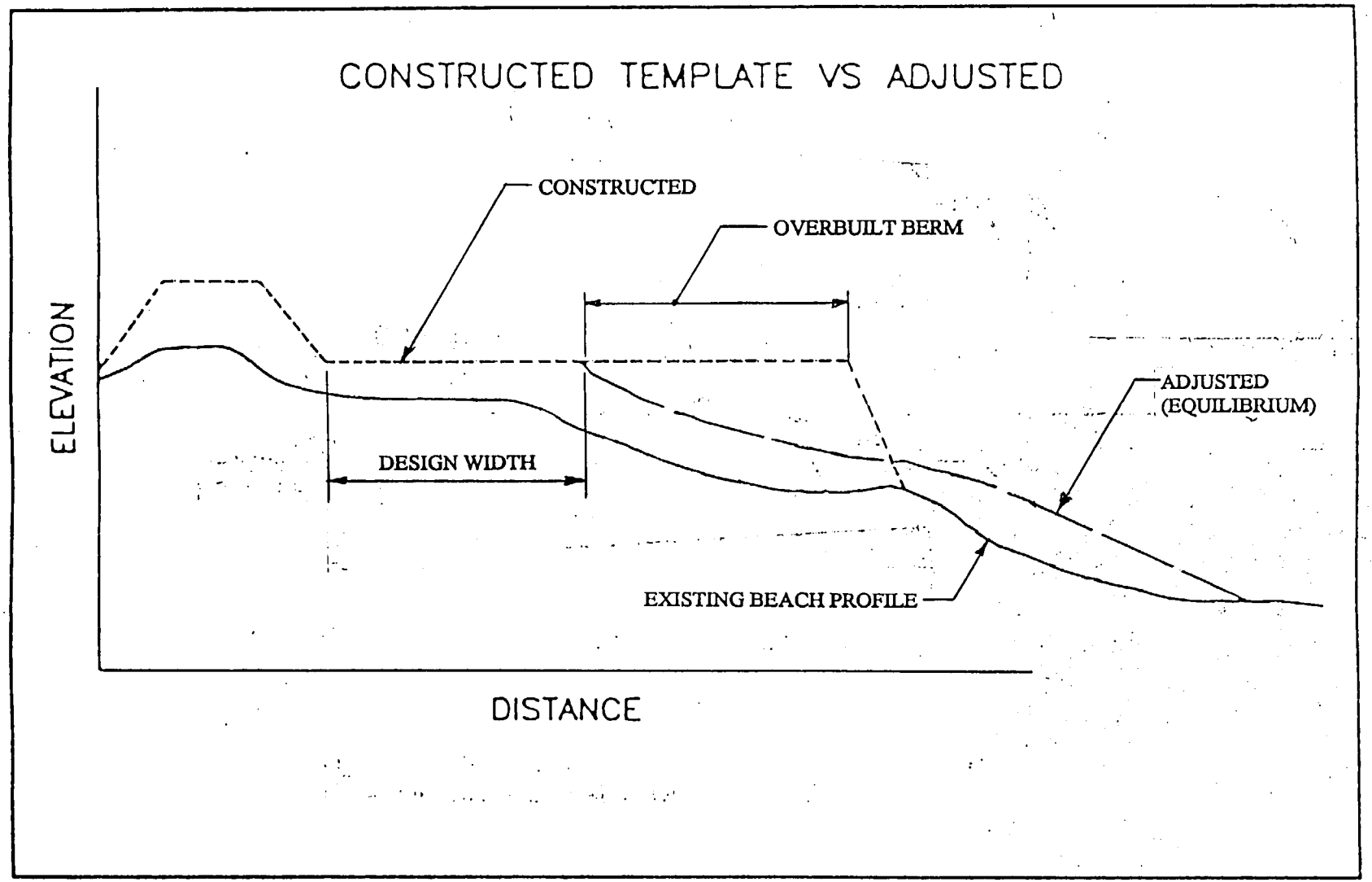
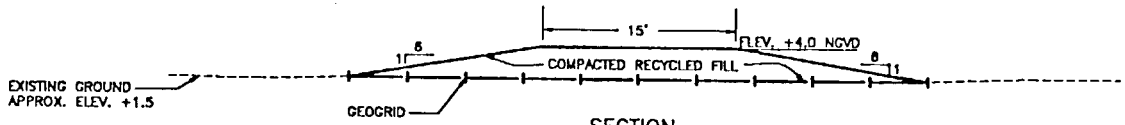
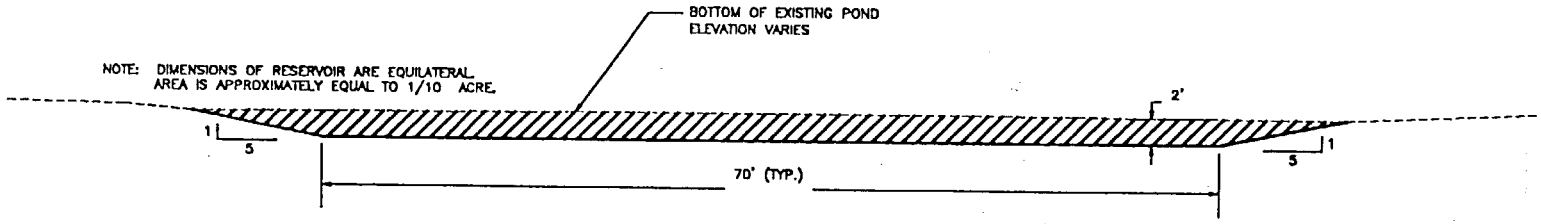


Figure 1. The overbuilding method of fill placement used to achieve required fill volume onshore, creating a wider berm and steeper slope



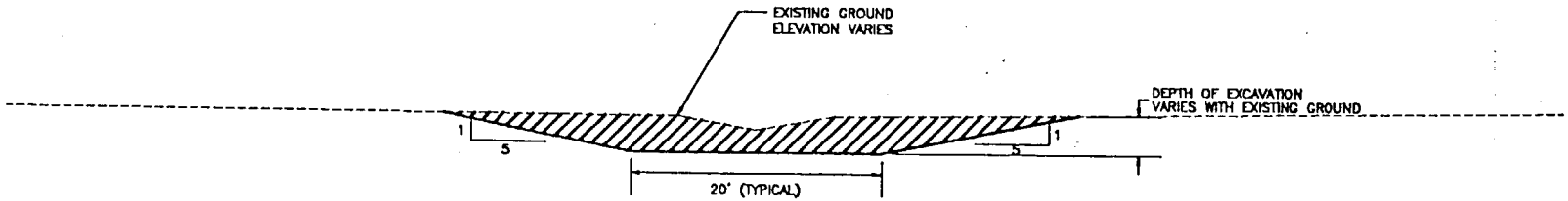
SECTION

EARTHEN BERM CONSTRUCTION
(NATURE CONSERVANCY)



SECTION

FISH RESERVOIR



SECTION

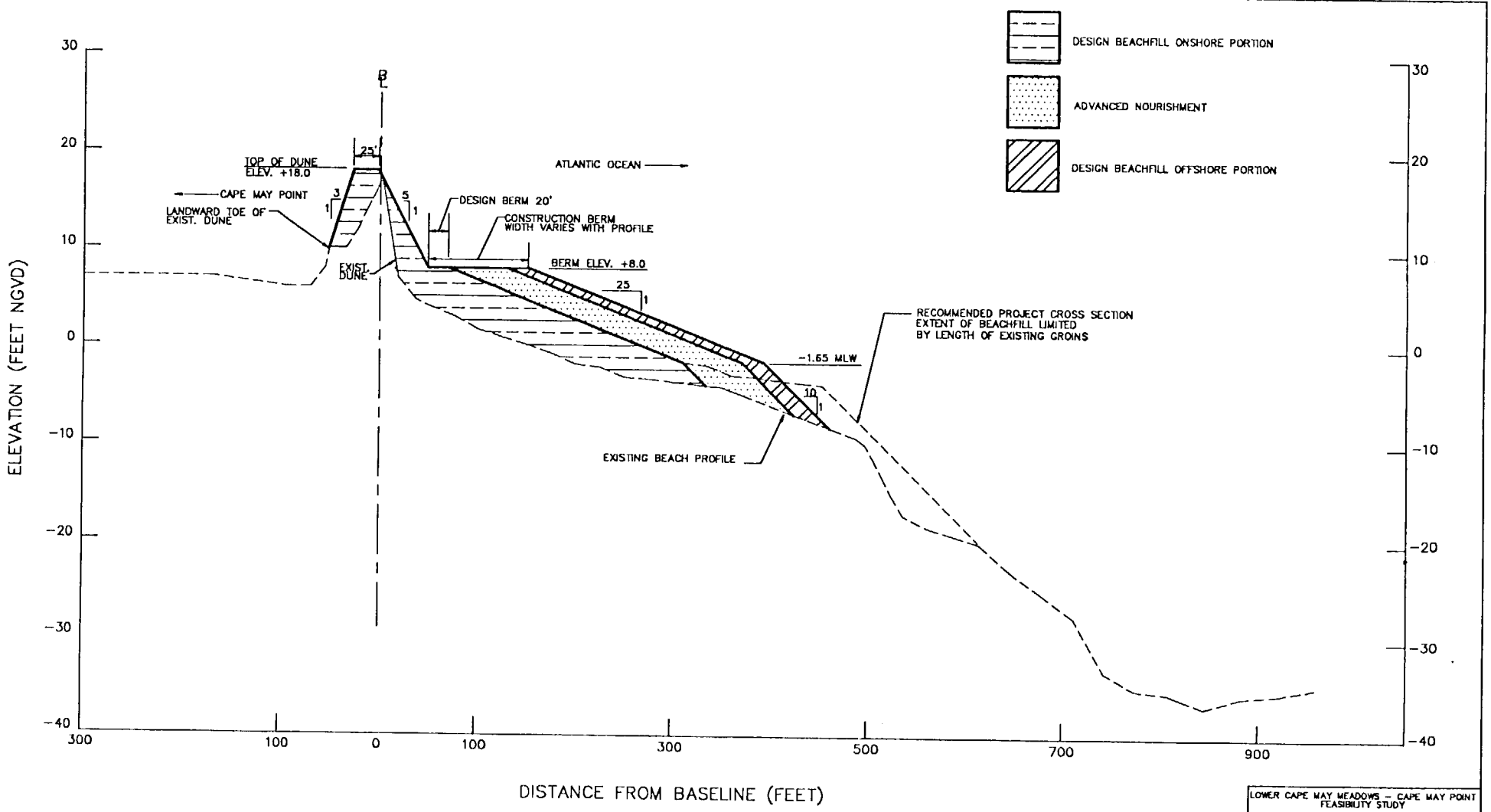
TYPICAL CHANNEL EXCAVATION

HORIZONTAL SCALE: 1"=160'
VERTICAL SCALE: 1"=15'

LOWER CAPE MAY MEADOWS –
CAPE MAY POINT
FEASIBILITY STUDY

CAPE MAY MEADOWS
INTERIOR DRAINAGE IMPROVEMENTS
SELECTED PLAN TYPICAL SECTIONS

FIGURE 7.2-3



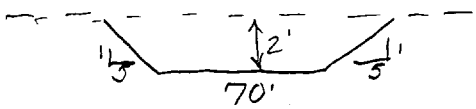
18' DUNE WITH 20' BERM

LOWER CAPE MAY MEADOWS – CAPE MAY POINT
FEASIBILITY STUDY
CAPE MAY POINT
SELECTED PLAN
PROTECTIVE DUNE AND BERM
TYPICAL PROFILE
DESIGN AND CONSTRUCTION TEMPLATE
SCALE: 1"=100'
FIGURE 5.6.1.1-8

GMG
9-16-97

Cape May Meadows - Interior Improvements Quantities.

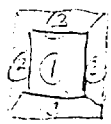
1.) Excavation for Mudholes:



1/10 acre = 4356 ft² = A

make bottom excavation 70' x 70'

A = 4900 ft²



$A_1 = (70' \times 2')$

$A_2 = +2(\frac{1}{2} \times 2' \times 10') = 140 ft^2 + 10 ft^2 = 160 ft^2$

$= 70' \times 160 ft^2 = 11200 ft^3$

$A_3\ 2(\frac{1}{2} \times 2 \times 10) \times 70' = 1400 ft^3$

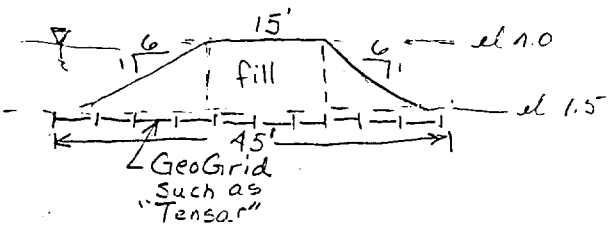
$\Sigma = 12,600$ cf

$\times 6$ Mudholes

75600 cf

quantity excav. for 6 mudholes = 2800 cy

2.) Berm construction in N.C.



GeoGrid: 45' x 765' = 34,425 ft²
assume 3 rolls @ 15' width

compacted volume for berm:

$15' \times 2.5' + (\frac{1}{2} \times 2.5' \times 15')2 = 75 ft^2$

$V = 75 ft^2 \times 765 ft = 57375 ft^3$

- assume material for berm to be recycled from excavation in the Meadows required for other drainage improvements.
- also assume recycled material to be a silt with a unit weight of
  115 lb/ft³ (compacted)
  80 lb/ft³ (loose)
- recycled material would have to be spread out and dried before placement and compaction on berm. The difference between unit weights would result in an additional volume of material excavated that would have to be handled:

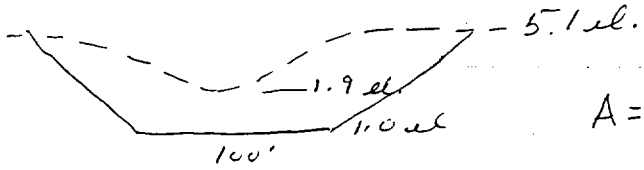
$\frac{115 lb/ft^3}{80 lb/ft^3} = 1.44$

$1.44 \times 57375 ft^3 = 82620 ft^3$

= 3060 c.y. of excavated loose material.

Excavation for Adverse Slopes (exist. channels)

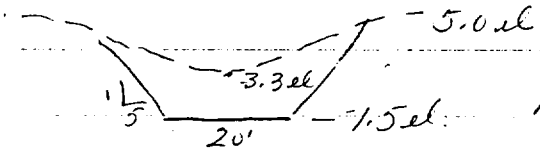
1.) A1



$A = 265\ ft^2 \times 300\ ft = 79500\ ft^3$

$V_{A1} = 2945$ cy.

2.) A2



$A = 106\ ft^2 \times 1000\ ft = 100{,}000\ ft^3$

$V_{A2} = 3700$ cy

3.) A2A

$A = 30\ ft^2$

$30\ ft^2 \times 600\ ft = 18000\ ft^3$

$V_{A2A} = 670$ cy

4.) A2B

$A = 30\ ft^2$

$30\ ft^2 \times 800\ ft = 24000\ ft^3$

$V_{A2B} = 890$ cy.

5.) A3 $V = 15\ ft^2 \times 700\ ft = 10{,}500\ cf =$ 390 c.y.

width of ditch = 15', side slopes 1:5, and 1:3.

6.) A3A

$V = 25\ ft^2 \times 1100\ ft = 27{,}500\ cf =$ 1020 c.y.

7.) Ditch behind Fowl Tract

$V = 20\ ft^2 \times 700\ ft = 14000\ cf$

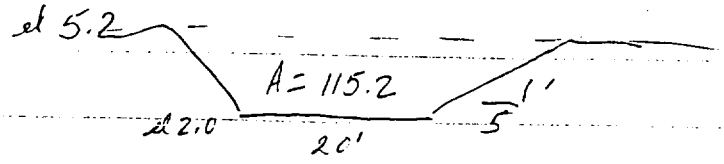
$V = 520$ c.y.

$\Sigma V_A = 2945 + 3700 + 670 + 890 + 390 + 1020 + 520$

$\boxed{\Sigma V_A = 10{,}135 \text{ c.y.}}$

Excavation for Reconnects and Ditches:

R1, R2

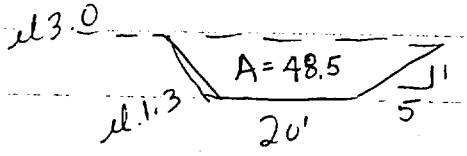


$R_1 = 200'$
$R_2 = 500'$

$V = 115.2\,ft^2 \times 700' = 80640\ cf$

$V = 3000\ cy$

R3, R4

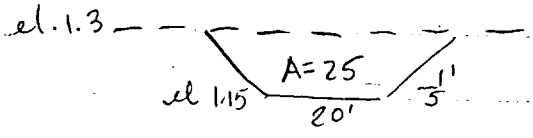


$R3 = 200'$
$R4 = 120'$

$V = 48.5\,ft^2 \times 320\,ft = 15520\,ft^3$

$V = 575\ cy$

R5, D1, D2



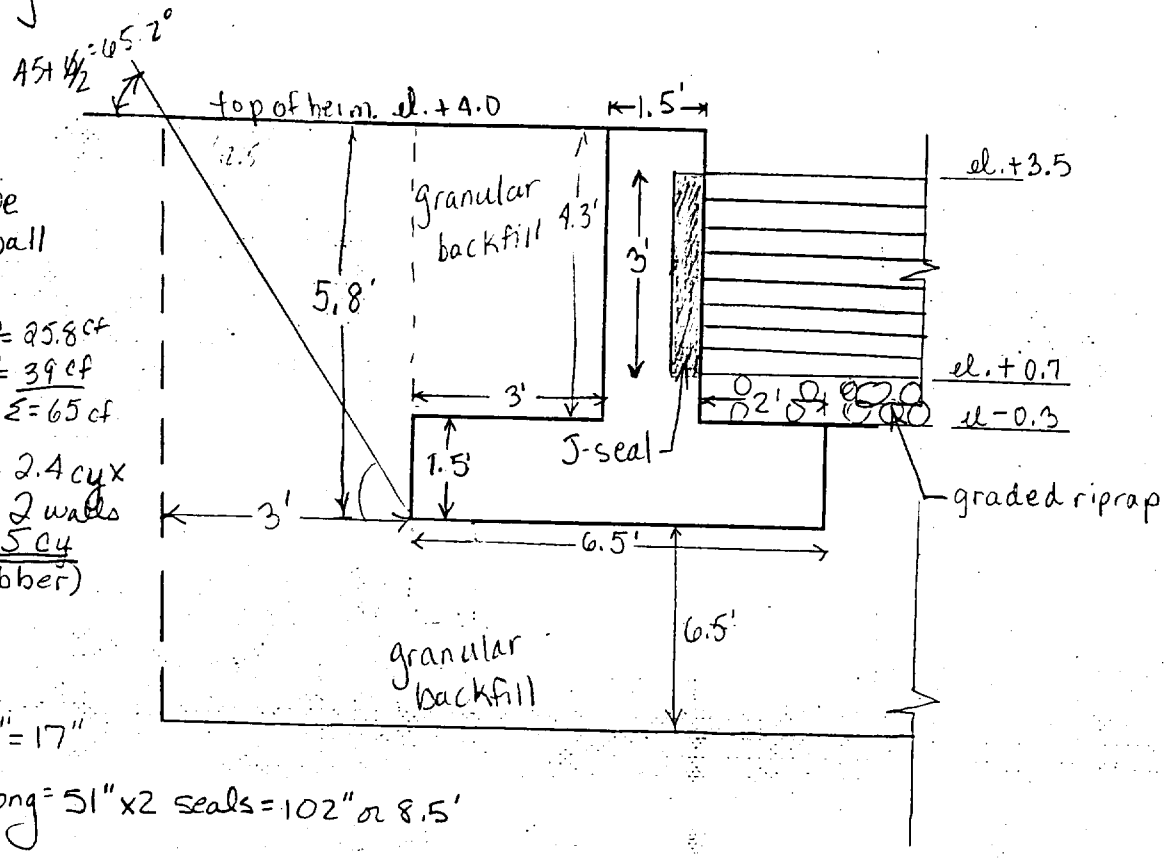
$R5 = 500'$
$D_1 = 1100'$
$D_2 = 200'$

$V = 25\,ft^2 \times 1800\,ft = 45000\,ft^3$

$V = 1667\ cy$

$$\boxed{\Sigma V_{excavated} = 3000 + 575 + 1667 = 5245\ cy}$$

Quantity - Weir Flow Control Structure



① gravity-type retaining wall

Concrete:

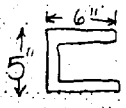
$1.5 \times 4.3' \times 4' = 25.8\ cf$

$+ 1.5 \times 6.5' \times 4' = 39\ cf$

$\Sigma = 65\ cf$

$65\ cf \times \frac{1\ yd^3}{27\ cf} = 2.4\ cy \times 2\ walls = 5\ cy$

J-seal (rubber)



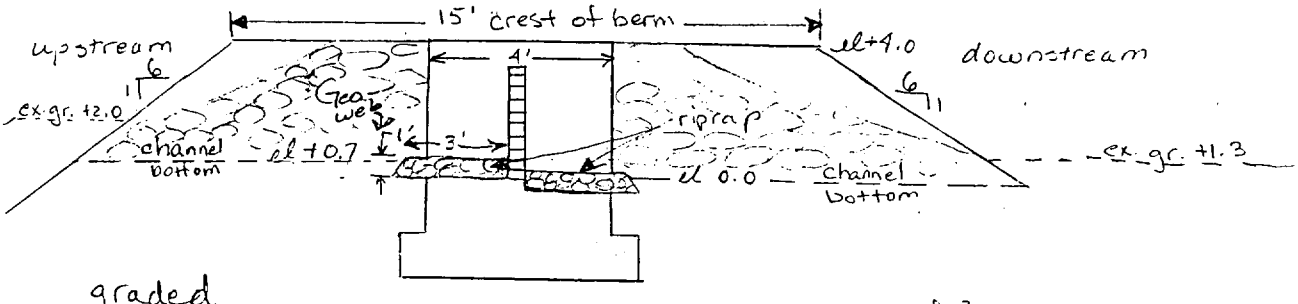
$6" \times 5" \times 6" = 17"$

$17" \times 3'\ long = 51" \times 2\ seals = 102"$ or $8.5'$

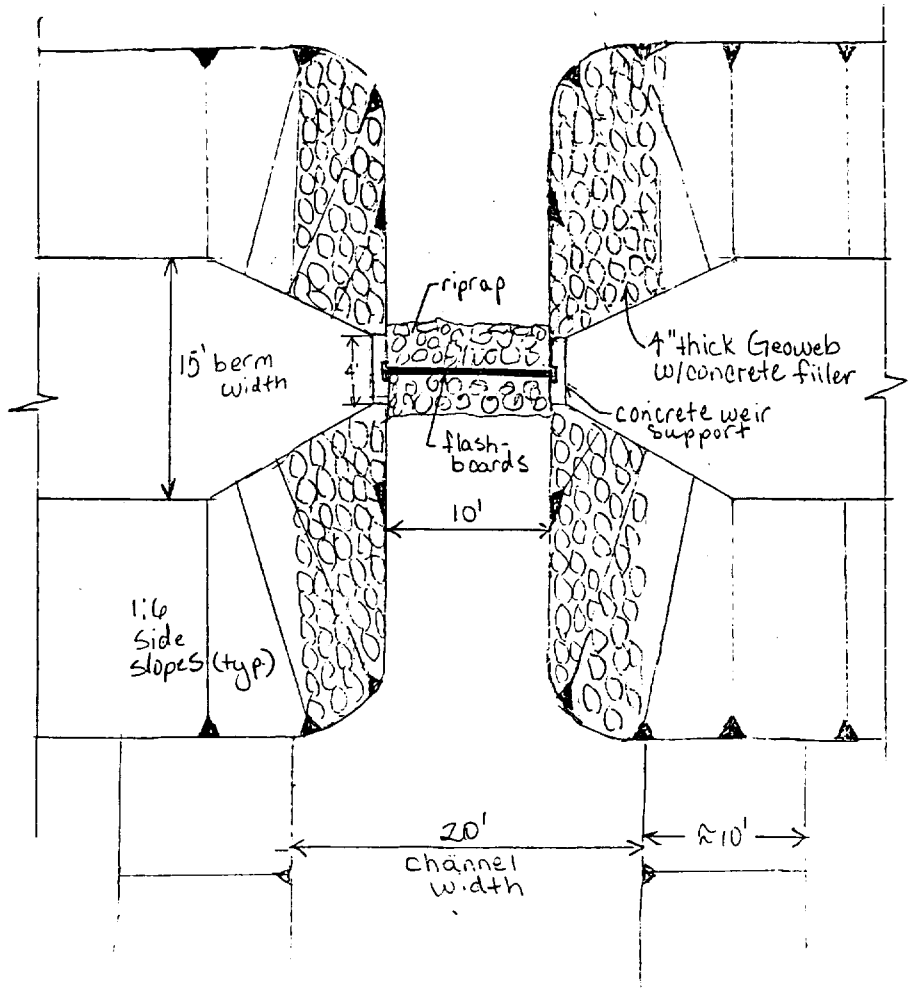
② flashboards:

- 9 @ 4"x4"x 11ft (3.5"x3.5" dressed) pressure treated timbers Southern pine - construction grade
- 8 @ 4" x 1/4" th. x 11 ft long rubber seal nailed to the bottom of each 4x4

③ Slope stabilization



- graded riprap: $1\ ft \times 3\ ft \times 10\ ft = 30\ ft^3 \times 2 = 60\ ft^3 \times \frac{ft^3}{27\ gd^3} = 2.2\ cy \times 1.7\ tons = 3.7\ tons$
  $= 7.5\ tons$
- geoweb: 4" depth, filled w/ concrete
  $4 @ 5' \times 8' = 40\ ft^2 \times 4 = 160\ ft^2$



④ granular backfill ($\phi = 35°$, $\gamma_T = 125$)

$25' \times 6.5' \times 10' = 1625$
$+ 25' \times 1.5' \times 10' + 375$
$+ (6' \times 4.3' \times 10') \times 2 \quad 516$
$\Sigma = 2516\,cf$

$151\,ft^2 \times (10' + 10' + 25' + 25')$
$= 10\,570\,cf$ (side slopes @ 1V:2H

$\frac{2516}{27} = 93$ cy of granular backfill

excavate total of 485 cy

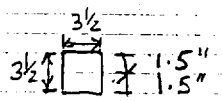
backfill spoil material from initial excavation = 390 cy

Weir Flow Control Structure

Design of timber flashboards

- Assume 5' head (from max. water elev.)
- design bottom flash board for 5' head
- assume 4"x4" sawn lumber (3½"x3½" dressed) Southern pine Construction grade

$S = 7.146\ in^3$



Check: Bending stress F_b

Compression ⊥ to grain

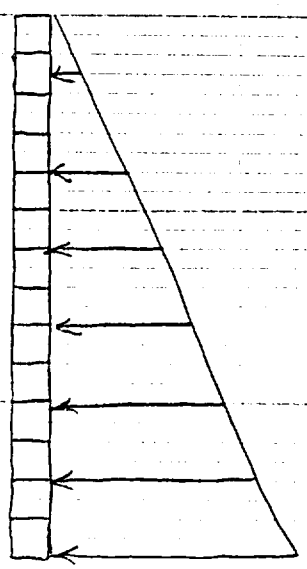
Horizontal Shear

$F_b = 825$ psi

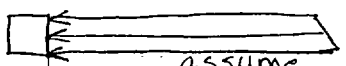
$F_v = 95$ psi

$F_{c\perp} = 375$ psi

From Timber Construction Manual 1985 Ed.



$$\sigma_u = \gamma_w H = 62.4\ \frac{lb}{ft^3} \times 5\ ft = 312\ lb/ft^2$$



last board - assume rect. press. distribution

$$P_A = 312\ \frac{lb}{ft^2} \times 5\ ft = 1560\ \frac{lb}{ft}$$

<u>Extreme Fiber Bending Stress F_b</u> (assume bottom board sees max. press.)

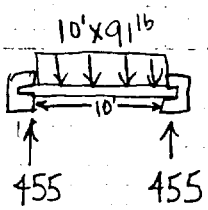
$$M = 1560\ \frac{lb}{ft} \times \frac{12\ in}{1\ ft} \times 3.5\ in = 455\ lb\text{-}in$$

$$F_b = \frac{M}{S} = \frac{455\ lb\text{-}in}{7.146\ in^3} = 63.7\ \frac{lb}{in^2} < 825\ lb/in^2 \text{ ok}$$

Horizontal Shear at Supports

$$F_v = \frac{3V}{2(bd)}$$

$$\gamma_w H = 312\ \frac{lb}{ft^2} \times \frac{1ft^2}{144\ in^2} = 2.17\ \frac{lb}{in^2}$$

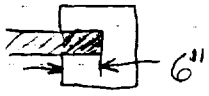


$$2.17\ \frac{lb}{in^2} \times 3.5\ in = 7.6\ \frac{lb}{in}$$

$$7.6\ \frac{lb}{in} \times 12\ \frac{in}{ft} \times 10ft = \frac{912}{2}\ lb = 455\ lb$$

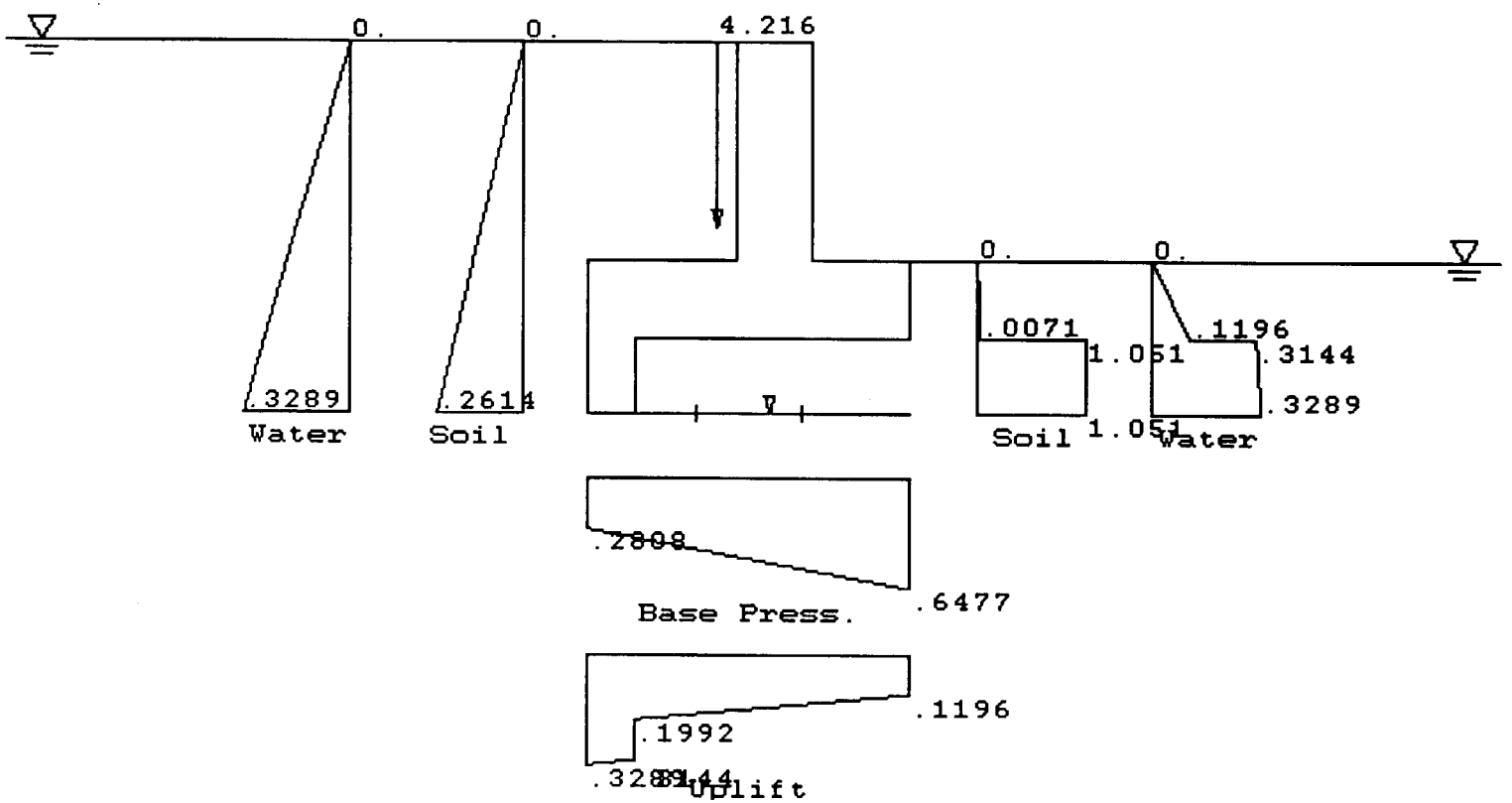
$$F_v = \frac{3(455\ lb)}{2(3.5\ in)(3.5\ in)} = 55.7\ \frac{lb}{in^2} < 95\ \frac{lb}{in^2}\ \text{OK}$$

Compression ⊥ to grain (worse than parallel to grain)



$$F_{c\perp}\ \frac{P}{A} = \frac{455\ lb}{(3.5\ in)(6")} = 21.7\ \frac{lb}{in^2} < 375\ \frac{lb}{in^2}\ \text{OK}$$

OK - USE 4" x 4" SOUTHERN PINE FLASHBOARDS
CONSTRUCTION GRADE
PRESSURE TREATED



CTWALL:

1. Initial run satisfied OT but failed in sliding.
2. Second run w/ Key added for additional P_p satisfied sliding and OT but failed in bearing. In-situ soil was assumed to be an organic silt with $\phi = 5°$, $\gamma = 85$ pcf (conservative as no boring/testing info. in the vicinity of the proposed weir exists at the time of the draft report. This info. will be obtained and accounted for in the final report.
3. Substituting a soil with a $\phi = 35°$ satisfied F.S. for bearing, so assume soil within failure wedge @ back of wall and to a depth D = B beneath base will be excavated and replaced with granular backfill $\phi = 35°$ $\gamma = 125$. Key will then not be req'd.

********** Echoprint of Input Data **********

Date: 97/10/29 Time: 12.07.12

Structural geometry data:

Elevation of top of stem (ELTS)	=	5.80 ft
Height of stem (HTS)	=	4.30 ft
Thickness top of stem (TTS)	=	1.50 ft
Thickness bottom of stem (TBS)	=	1.50 ft
Dist. of batter at bot. of stem (TBSR)	=	.00 ft
Depth of heel (THEEL)	=	3.00 ft
Distance of batter for heel (BTRH)	=	.00 ft
Depth of toe (TTOE)	=	1.50 ft
Width of toe (TWIDTH)	=	2.00 ft
Distance of batter for toe (BTRT)	=	.00 ft
Width of base (BWIDTH)	=	6.50 ft
Depth of key (HK)	=	1.50 ft
Width of bottom of key (TK)	=	1.00 ft
Dist. of batter at bot. of key (BTRK)	=	.00 ft

Structure coordinates:

x (ft)	y (ft)
.00	-1.50
.00	1.50
3.00	1.50
3.00	5.80
4.50	5.80
4.50	1.50
6.50	1.50
6.50	.00
1.00	.00
1.00	-1.50

NOTE: X=0 is located at the left-hand side of the structure. The Y values correspond to the actual elevation used.

Structural property data:
Unit weight of concrete = .150 kcf

Driving side soil property data:

Phi (deg)	c (ksf)	Moist Unit wt. (kcf)	Saturated unit wt. (kcf)	Delta (deg)	Elev. soil (ft)
30.00	.000	.115	.121	.00	5.80

Driving side soil geometry:

Soil point	Batter (in:1ft)	Distance (ft)
1	.00	500.00
2	.00	.00
3	.00	500.00

Driving side soil profile:

Soil point	x (ft)	y (ft)
1	-1497.00	5.80
2	3.00	5.80

Resisting side soil property data:

Phi (deg)	c (ksf)	Moist Unit wt. (kcf)	Saturated unit wt. (kcf)	Elev. soil (ft)	Batter (in:1ft)
5.00	.200	.075	.085	1.50	.00

Resisting side soil profile:

Soil point	x (ft)	y (ft)
1	6.50	1.50
2	506.50	1.50

Foundation property data:
phi for soil-structure interface = 4.50 (deg)
c for soil-structure interface = .000 (ksf)
phi for soil-soil interface = 5.00 (deg)
c for soil-soil interface = .200 (ksf)

Water data:
Driving side elevation = 5.80 ft
Resisting side elevation = 1.50 ft
Unit weight of water = .0624 kcf
Seepage pressures computed by Line of Creep method.

Minimum required factors of safety:
Sliding FS = 1.50
Overturning = 100.00% base in compression

Crack options:
- o Crack depth is to be calculated
- o Computed cracks *will* be filled with water

Strength mobilization factor = .6667

```
***********************
**  Sliding Results  **
***********************
```

Solution converged. Summation of forces = 0.

Wedge Number	Horizontal Loads (kips)	Vertical Loads (kips)
1	.000	.000
2	.000	.000
3	.000	.000

Water pressures on wedges:

Wedge number	Top press. (ksf)	Bottom press. (ksf)	x-coord. (ft)	press. (ksf)
1	.0000	.3289		
2			.0000	.3289
2			6.5000	.1196
3	.0000	.1196		

Points of sliding plane:
Point 1 (left), x = .00 ft, y = -1.50 ft
Point 2 (right), x = 6.50 ft, y = .00 ft

Depth of cracking = .00 ft

Wedge number	Failure angle (deg)	Total length (ft)	Weight of wedge (kips)	Submerged length (ft)	Uplift force (kips)
1	-53.183	9.119	2.413	9.119	1.500
2	12.995	6.671	4.624	6.671	1.496
3	43.752	2.169	.100	2.169	.130

Wedge number	Net force (kips)
1	-2.335
2	1.920
3	.415
SUM =	.000

```
+-----------------------------+
| Factor of safety =    1.968 |
+-----------------------------+
```

At-rest pressures on the resisting side *are used*
in the overturning analysis.

Forces on the resisting side *are used* in the sliding analysis.

Do iterate in overturning analysis.

********** Output Results **********

Date: 97/10/29 Time: 12.07.12

```
**************************
**  Overturning Results  **
**************************
```

Solution converged in 1 iterations.

SMF used to calculate K's = .6667
Alpha for the SMF = -55.5473
Calculated earth pressure coefficients:
Driving side at rest K = .4714
Driving side at rest Kc = .6866
Resisting side at rest K = .9128
Resisting side at rest Kc = .9554
At-rest K's for resisting side calculated.

Depth of cracking = .00 ft

** Driving side pressures **

Water pressures:

Elevation (ft)	Pressure (ksf)
5.80	.0000
-1.50	.3289

Earth pressures:

Elevation (ft)	Pressure (ksf)
5.80	.0000
-1.50	.2614

** Resisting side pressures **

Water pressures:

Elevation (ft)	Pressure (ksf)
1.50	.0000
.00	.1196
.00	.3144
-1.50	.3289

Earth pressures:

Elevation (ft)	Pressure (ksf)
1.50	.0000

```
***** Summary of Results *****

***************     *** Satisfied ***
* Overturning *     Required base in comp. = 100.00 %
***************     Actual base in comp.   = 100.00 %
                    Overturning ratio      =   2.41

Xr (measured from toe) =   2.82 ft
Resultant ratio        =  .4341
Stem ratio             =  .3077
Base pressure at heel =     .2808 ksf
Base pressure at toe  =     .6477 ksf

***********     *** Satisfied ***
* Sliding *     Min. Required =   1.50
***********     Actual FS     =   1.97
```

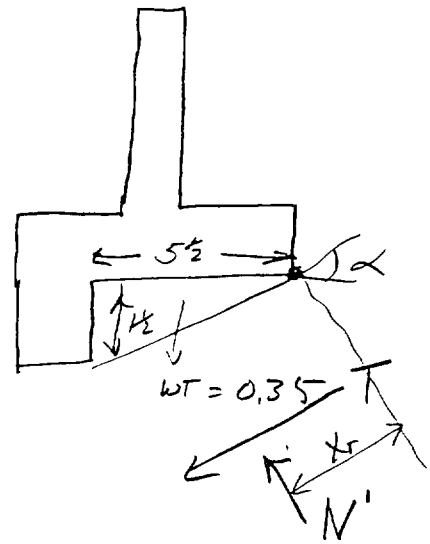
Balancing earth pressures:

Elevation (ft)	Pressure (ksf)
.00	1.0512
-1.50	1.0512

** Uplift pressures **

Water pressures:

x-coord. (ft)	Pressure (ksf)
.00	.3289
1.00	.3144
1.00	.1992
6.50	.1196



** Forces and moments **

Part	Force (kips) Vert.	Force (kips) Horiz.	Mom. Arm (ft)	Momen (ft-k
Structure:				
Structure weight.....	2.655		-3.30	-8.7
Structure, driving side:				
Moist soil.....	.000		.00	.0
Saturated soil.....	1.561		-5.00	-7.8
Water above structure.....	.000		.00	.0
Water above soil.....	.000		.00	.0
External vertical loads....	.000		.00	.0
Ext. horz. pressure loads..		.000	.00	.0
Ext. horz. line loads.....		.000	.00	.0
Structure, resisting side:				
Moist soil.....	.000		.00	.0
Saturated soil.....	.000		.00	.0
Water above structure.....	.000		.00	.0
Water above soil.....	.000		.00	.0
Driving side:				
Effective earth loads.....		.954	.93	.8
Shear (due to delta).....	.000		.00	.0
Horiz. surcharge effects...		.000	.00	.0
Water loads.....		1.201	.93	1.1
Resisting side:				
Effective earth loads.....		-.005	.50	.0
~~Balancing earth load.....~~		~~-1.577~~	~~-.75~~	~~1.1~~
Water loads.....		-.572	-.56	.3
Foundation:				
~~Vertical force on base.....~~ soil wedge 0.35	~~-3.018~~		~~-3.67~~	~~-1.28~~
Uplift.....	-1.198		-3.79	4.5
** Statics Check ** SUMS =	.000	.000		.0
	$\Sigma_V =$ 3.36	$\Sigma_H =$ 1.58		$\Sigma M =$ -11.08

$N' = \Sigma V \cos\alpha + \Sigma H \sin\alpha = 3.63$

$T = -\Sigma V \sin\alpha + \Sigma H \cos\alpha = 0.78$

$X_r = \Sigma M / N' = 3.05$

Angle of base	=	12.99 degrees
Normal force on base	=	3.295 kips
Shear force on base	=	.858 kips
Max. available shear force	=	1.657 kips

Base pressure at heel	=	.2808 ksf
Base pressure at toe	=	.6477 ksf

Xr (measured from toe)	=	2.82 ft
Resultant ratio	=	.4341
Stem ratio	=	.3077
Base in compression	=	100.00 %
Overturning ratio	=	2.41

Volume of concrete = .66 cubic yds/ft of wall

NOTE: The engineer shall verify that the computed bearing pressures below the wall do not exceed the allowable foundation bearing pressure, or, perform a bearing capacity analysis using the program CBEAR. Also, the engineer shall verify that the base pressures do not result in excessive differential settlement of the wall foundation.

INPUT CELL 8/26/97 OUTPUT RESULTS

CASE:
weir wall LC4

WALL DATA	
stem top elevation (ft)	7.300
stem height (ft)	4.300
stem top thickness (ft)	1.500
stem bottom thickness (ft)	1.500
front batter at base of stem (ft)	0.000
depth of heal (ft)	3.000
depth of toe (ft)	1.500
toe width (ft)	2.000
base with B (ft)	6.500
depth of key (ft)	1.500
key top width (ft)	1.000
key bottom width (ft)	1.000

SOIL/WATER DATA	deg	rad
angle of internal friction phi	5.000	0.087
cohesion c	0.200	
theta for back of str. wedge to vertical	0.000	0.000
angle of int. friction soil/structure	4.500	0.079
angle of int. friction base/foundation	4.500	0.079
backfill inclination from horizontal beta	0.000	0.000
water depth driving (ft)	7.300	
water depth resisting (ft)	3.500	
moist soil unit wt (kcf)	0.075	
saturated soil unit wt (kcf)	0.085	
water unit wt (kcf)	0.063	
concrete unit wt (kcf)	0.150	
resisting soil elevation (ft)	3.000	
driving soil elevation (ft)	7.300	
bouyant unt wt soil (kcf)	0.023	
height of soil above heel (ft)	4.300	
saturated soil depth above heel (ft)	4.300	
water height above soil resisting (ft)	0.000	
saturated soil depth above toe (ft)	0.000	
width of heel (ft)	3.000	
batter on back side of stem (ft)	0.000	

BEARING	
Wedge Base Width, B	6.671
Xr (measured from toe)	3.050
Shear force on the base, T	0.780
Normal force on the base, N	3.630
Angle of base, alpha	12.995
Bearing capacity factor, Nq	1.568
Bearing capacity factor, Nv	0.070

Equations

EQUATION 1:	e	0.285
EQUATION 2:	BBAR	6.100
EQUATION 3:	PSIqd,gd	1.054
EQUATION 4:	delta	12.127
EQUATION 5:	PSIqi	0.749

Earthquake data	kh	0.140
	kv	0.000
Strength mobilization factor		0.910

INERTIAL FORCE CALCULATION

	Weight (k)	ARM (FT) ABOUT BOT	OV. MOM (FT-K) KEY	arm for ste
1. Moist soil driving (rectangular)	0.000	7.300	0.000	4.300
2. Moist soil driving (triangular)	0.000	7.300	0.000	4.300
3. Saturated soil, driving (rectangular)	1.097	5.150	5.647	2.150
4. Saturated soil, driving (triangular)	0.000	5.867	0.000	2.867
5. Saturated soil, resisting (above toe)	0.000	3.000	0.000	
6. Saturated soil, resisting (key wedge)	0.351	1.000	0.351	
7. Concrete stem (rectangular)	0.968	5.150	4.983	2.150
8. Concrete stem (triangular)	0.000	4.433	0.000	1.433
9. Concrete base	1.463	2.250	3.291	
10. Concrete key (rectangular)	0.225	0.750	0.169	
11. Concrete key (triangular)	0.000	1.000	0.000	
Sums	4.102		14.440	

GLOBAL FORCES		
INERTIA FORCE, kips	0.574	
INERTIA FORCE CENTROID (ft)	3.520	wrt bottom base
STEM MOMENT (k-ft)	0.621	
STEM INERTIA FORCE, kips	0.289	
STEM INERTIA FORCE CENTROID (ft)	2.150	wrt bottom of stem

Q	0.549208	
Bearing Capacity		0.549
Factor of safety		0.151
Reqd. Factor of Safety:		3

EQUATION 6:	PSIgi	2.032
EQUATION 7:	qo	0.068
EQUATION 8:	PSIqt,gt	0.961
EQUATION 9:		0.080
		0.090

GENERAL WEDGE EARTHQUAKE ANALYSIS

INPUT DATA	
ANGLE OF INTERNAL FRICTION, DEG.	5.000
STRENGTH MOBILIZATION FACTOR, SMF	0.910
MOIST UNIT WEIGHT OF SOIL, KCF	0.075
SATURATED UNIT WEIGHT OF SOIL, KCF	0.085
BOUYANT WEIGHT OF SOIL, KCF	0.023
INCLINATION OF SOIL SURFACE, DEG	0
UNIT WEIGHT OF WATER,KCF	0.063
EIGHT OF BACKFILL BEHIND THE WALL,F	7.300
HEIGHT OF SATURATED BACKFILL, FT	7.300
HORIZONTAL SEISMIC COEFFICIENT, Kh	0.140
HEIGHT OF FILL IN THE CHANNEL, FT	3.000
HEIGHT OF WATER, RESISTING	3.500
EIGHT OF WATER (ASSUME FULL SAT.), F	3

OUTPUT RESULTS			FORCE (KIPS)	MOM ARM (FT)
STATIC DRIVING FORCE ABOVE WATER TABLE, PA1			#NUM!	
STATIC DRIVING FORCE BELOW WATER TABLE, PA2			#NUM!	
HYDROSTATIC FORCE ON BACKFILL SIDE, Pws			1.665	2.43
DELTA PAE1	3.99675	#NUM!	#NUM!	4.87
DELTA PAE2			#NUM!	4.87
STATIC RESISTING FORCE ABOVE WATER TABLE, Pp1			#NUM!	
STATIC RESISTING FORCE BELOW WATER TABLE, Pp2			#NUM!	
(ASSUMES FULL HEIGHT OF FILL IS SATURATED)				
HYDROSTATIC FORCE ON CHANNEL SIDE, Pws			0.281	2.00
DELTA PPE1	0.675	#NUM!	#NUM!	2.00
DELTA PPE2			#NUM!	
HYDRODYNAMIC WATER FORCE RESISTING			0.001	3.20

[illegible]	8/26/97	OUTPUT RESULTS	
CASE:			
weir wall	LC4		

WALL DATA			Earthquake data	kh	0.140
stem top elevation (ft)	7.300			kv	0.000
stem height (ft)	4.300				
stem top thickness (ft)	1.500		Strength mobilization factor		0.910
stem bottom thickness (ft)	1.500				
front batter at base of stem (ft)	0.000				
depth of heal (ft)	3.000				
depth of toe (ft)	1.500		INERTIAL FORCE CALCULATION		
toe width (ft)	2.000				
base with B (ft)	6.500				
depth of key (ft)	1.500				
key top width (ft)	1.000				
key bottom width (ft)	1.000				

	Weight (k)	ARM (FT) ABOUT BOT KEY	OV. MOM (FT-K)	arm for ste
1. Moist soil driving (rectangular)	0.000	7.300	0.000	4.300
2. Moist soil driving (triangular)	0.000	7.300	0.000	4.300
3. Saturated soil, driving (rectangular)	1.097	5.150	5.647	2.150
4. Saturated soil, driving (triangular)	0.000	5.867	0.000	2.867
5. Saturated soil, resisting (above toe)	0.000	3.000	0.000	
6. Saturated soil, resisting (key wedge)	0.351	1.000	0.351	
7. Concrete stem (rectangular)	0.968	5.150	4.983	2.150
8. Concrete stem (triangular)	0.000	4.433	0.000	1.433
9. Concrete base	1.463	2.250	3.291	
10. Concrete key (rectangular)	0.225	0.750	0.169	
11. Concrete key (triangular)	0.000	1.000	0.000	
Sums	4.102		14.440	

SOIL/WATER DATA	deg	rad
angle of internal friction phi	35.000	0.611
cohesion c	0.000	
theta for back of str. wedge to vertical	0.000	0.000
angle of int. friction soil/structure	31.500	0.550
angle of int. friction base/foundation	31.500	0.550
backfill inclination from horizontal beta	0.000	0.000
water depth driving (ft)	7.300	
water depth resisting (ft)	3.500	
moist soil unit wt (kcf)	0.075	
saturated soil unit wt (kcf)	0.085	
water unit wt (kcf)	0.063	
concrete unit wt (kcf)	0.150	
resisting soil elevation (ft)	3.000	
driving soil elevation (ft)	7.300	
bouyant unt wt soil (kcf)	0.023	
height of soil above heel (ft)	4.300	
saturated soil depth above heel (ft)	4.300	
water height above soil resisting (ft)	0.000	
saturated soil depth above toe (ft)	0.000	
width of heel (ft)	3.000	
batter on back side of stem (ft)	0.000	

GLOBAL FORCES		
INERTIA FORCE, kips	0.574	
INERTIA FORCE CENTROID (ft)	3.520	wrt bottom base
STEM MOMENT (k-ft)	0.621	
STEM INERTIA FORCE, kips	0.289	
STEM INERTIA FORCE CENTROID (ft)	2.150	wrt bottom of stem

BEARING	
Wedge Base Width, B	6.671
Xr (measured from toe)	3.050
Shear force on the base, T	0.780
Normal force on the base, N	3.630
Angle of base, alpha	12.995
Bearing capacity factor, Nq	33.296
Bearing capacity factor, Nv	37.152
Equations	

Q		13.09302
Bearing Capacity		13.093
Factor of safety		3.607
Reqd. Factor of Safety:		3

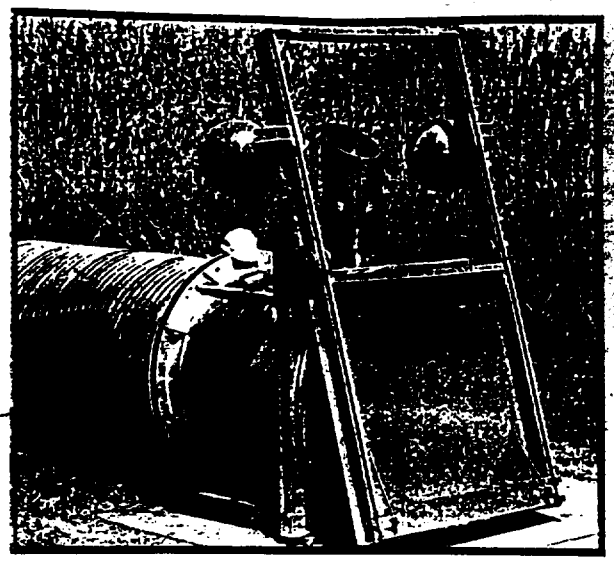
EQUATION 1:	e	0.285	EQUATION 6:	PSIgi	0.427
EQUATION 2:	BBAR	6.100	EQUATION 7:	qo	0.068
EQUATION 3:	PSIqd,gd	1.094	EQUATION 8:	PSIqt,gt	0.708
EQUATION 4:	delta	12.127	EQUATION 9:		1.303
EQUATION 5:	PSIqi	0.749			2.146

GENERAL WEDGE EARTHQUAKE ANALYSIS

INPUT DATA	
ANGLE OF INTERNAL FRICTION, DEG.	35.000
STRENGTH MOBILIZATION FACTOR, SMF	0.910
MOIST UNIT WEIGHT OF SOIL, KCF	0.075
SATURATED UNIT WEIGHT OF SOIL, KCF	0.085
BOUYANT WEIGHT OF SOIL, KCF	0.023
INCLINATION OF SOIL SURFACE, DEG	0
UNIT WEIGHT OF WATER,KCF	0.063
EIGHT OF BACKFILL BEHIND THE WALL,F	7.300
HEIGHT OF SATURATED BACKFILL, FT	7.300
HORIZONTAL SEISMIC COEFFICIENT, Kh	0.140
HEIGHT OF FILL IN THE CHANNEL, FT	3.000
HEIGHT OF WATER, RESISTING	3.500
EIGHT OF WATER (ASSUME FULL SAT.), F	3

OUTPUT RESULTS			FORCE (KIPS)	MOM ARM (FT)
STATIC DRIVING FORCE ABOVE WATER TABLE, PA1			0.000	
STATIC DRIVING FORCE BELOW WATER TABLE, PA2			0.173	
HYDROSTATIC FORCE ON BACKFILL SIDE, Pws			1.665	2.43
DELTA PAE1	3.99675	2.836209	0.197	4.87
DELTA PAE2			0.026	4.87
STATIC RESISTING FORCE ABOVE WATER TABLE, Pp1			0.000	
STATIC RESISTING FORCE BELOW WATER TABLE, Pp2			0.029	
(ASSUMES FULL HEIGHT OF FILL IS SATURATED)				
HYDROSTATIC FORCE ON CHANNEL SIDE, Pws			0.281	2.00
DELTA PPE1	0.675	1.010334	0.094	2.00
DELTA PPE2			0.012	
HYDRODYNAMIC WATER FORCE RESISTING			0.001	3.20

FOR TIDAL WETLANDS PRESERVATION & RESTORATION



Waterman/NEKTON

SRT

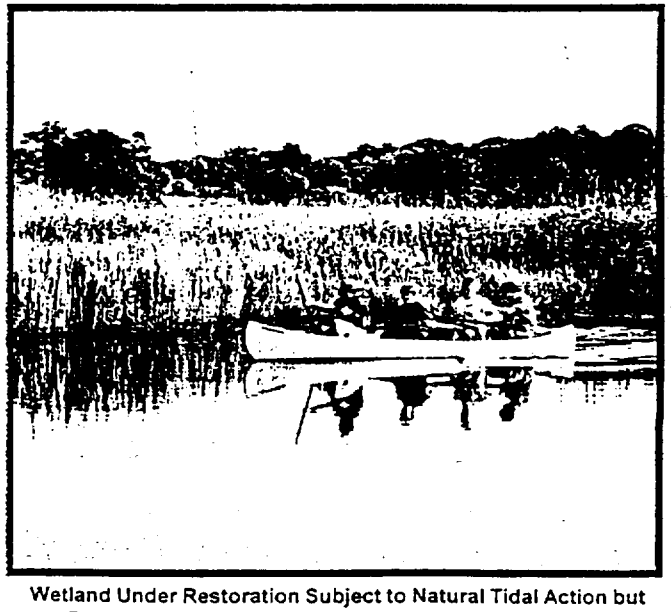
fiber 60" ø pipe
Cape Island Creek

SELF-REGULATING TIDEGATE

CAN PRODUCE THESE BENEFITS:

- ❒ RESTORES TIDAL FLUSHING OF MARSHES WITHOUT FLOODING OF UPLAND PROPERTY BEHIND DIKES AND LEVEES
- ❒ RESTORATION OF ESTUARINE PLANTS, FISH, SHELLFISH, WATERFOWL AND WILDLIFE
- ❒ REDUCES MOSQUITO BREEDING THROUGH NATURAL CONTROL
- ❒ HELPS ELIMINATE MARSH FIRES (PEAT AND PHRAGMITES OR TALL REED GRASS)
- ❒ RESCOURING OF MARSH CHANNELS WHICH IMPROVES UPLAND DRAINAGE
- ❒ REDUCES SHEET FLOODING OF THE MARSH
- ❒ DEEPENING OF DOWNSTREAM CHANNELS RESULTING IN IMPROVED NAVIGATION
- ❒ PROVEN BY 20 YEARS OF EXPERIENCE

Drainage Area Cut Off from Natural Tidal Action by Dikes with Standard Tidegate for Storm Tide Protection



Wetland Under Restoration Subject to Natural Tidal Action but Protected from Storm Tides by Waterman/Nekton SRT Installed in the Original Dike.

HOW THE WATERMAN/NEKTON **SRT** WORKS TO PROTECT OR RE-ESTABLISH WETLANDS HABITAT

The use of conventional flap gates on dikes in a coastal wetland ecosystem by its nature excludes the pulse of the tide, salt water, and tidal scouring action. This invariably results in the loss of estuarine plants, fish, shellfish, waterfowl and wildlife, followed by an increase in the growth of tall reed grass and resultant marsh fires. Loss of tidal action also results in sediment in-filling of channels followed by sheet flooding of the marsh and low-lying streets and property, obstructed drainage channels and a loss of mosquito-eating fish. This loss is followed by a significant increase in objectionable mosquito breeding.

In contrast to the conventional flap gate the Self-Regulating Tidegate (**SRT**) is a very simple patented mechanical device which is a float-actuated water control valve. It automatically opens and closes using no external source of power, while permitting reciprocal flow of water through its culvert.

The **SRT** always allows upland stormwater runoff and creek water to discharge when the tide is low. The conventional one-way gate closes when the tide rises, thereby preventing saltwater from returning to the diked watercourse or wetland. In contrast, the **SRT** can be adjusted to allow tide water to flow into the culvert thereby feeding the channel or marsh behind the dike. Because the **SRT** is located on the outfall or tidal side of the dike's culvert, its float system responds to any tidal threat by closing the gate to in-coming water when the tide reaches the design high water level. Sensing the storm tide water elevation, the **SRT** closes "early" thereby preserving a relatively large volume of potential water storage capacity behind the dike should it be needed for detention of upland runoff associated with the coastal storm. In this way the **SRT** simultaneously maintains flood protection to the upland area while allowing tidal flushing of the low-lying wetlands.

Restored tidal flushing of the wetlands will help restore the estuarine ecosystem; eliminate marsh fires (both dry peat fires, phragmites or tall reed grass fires), greatly reduce mosquito breeding, reduces sheet-flooding of the marsh; and restore upland drainage through re-scoured marsh channels. Because of the increased tidal prism to the restored wetland, deepening of the downstream channel and improved navigation will result as well.

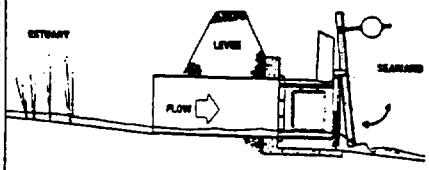
OPERATION OF THE SRT

The **SRT** is usually attached to an end wall or cross-culvert on the tidal side of a causeway or dike. The buoyant **SRT** gate is hinged on the top of the culvert so that it floats on the surface of the water until it is closed by counterfloats extending above and behind the hinge point. The position of the counterfloats on the arms is adjusted to meet the required gate closure water levels on a site-specific basis. Once the predetermined high water level is achieved, the **SRT** automatically closes and stays closed during the flood event, thereby protecting the flood prone area. Once the tide recedes on the outside of the dike the hydraulic head reverses in the culvert and the **SRT** automatically reopens thereby allowing any water to flow out of the flood protection drainage system. The **SRT** stays open, floating on the rising and falling tide as the water flows in and out, until such time as the elevation of the tide water reaches the gate closure level set by the user. Depending on the float settings, the **SRT** could close with every daily tide or it could just rise and fall with the tide for months or even years closing only during hurricane flood events. It all depends on the goals of the water management agency which adjusts the float settings.

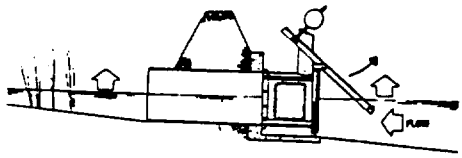
Once installed the SRT immediately begins to prevent or reverse the ecological damage brought about by use of conventional tidegates.

With the **SRT**, restored tidal action scours drainage channels free of obstructions thereby reducing backwater flooding and phragmite plants, soaks the marsh and eliminates fires. Salt water provides marsh access to mosquito-eating fish and it reintroduces all the plant seeds and the phyto- and zoo-plankton and related organisms in the food web associated with a viable estuarine ecosystem.

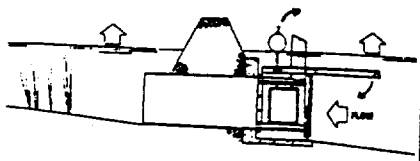
SRT IN NORMAL TIDE SEQUENCE



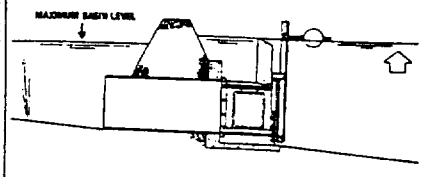
1. SRT ACTING AS NORMAL FLAP GATE ALLOWING ESTUARY DRAINAGE



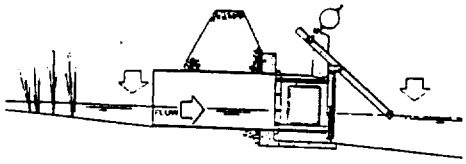
2. RISING TIDE FLOATS GATE UP ALLOWING INCOMING TIDE TO FLOOD ESTUARY BASIN



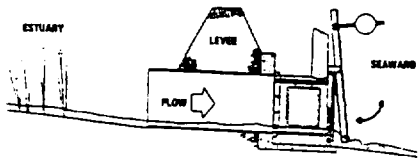
3. TIDE BEGINS TO CLOSE GATE LIMITING ESTUARY FLOOD LEVEL



4. NORMAL HIGH TIDE GATE FULLY CLOSED

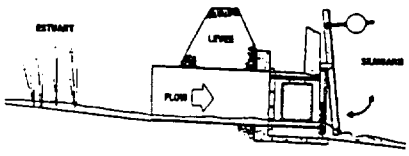


5. COVER FLOATING ON FALLING TIDE LOWERS ESTUARY FLOOD LEVEL

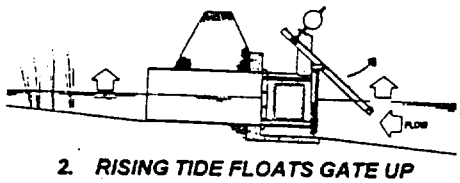


6. GATE ACTING AS NORMAL FLAP ESTUARY DRAINAGE RESUMES

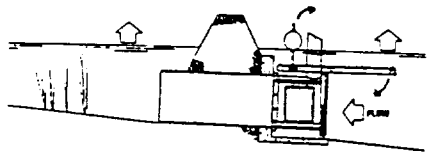
*SRT IN STORM SEQUENCE **



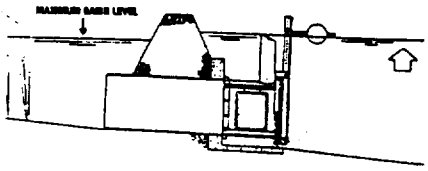
1. GATE ACTING AS NORMAL FLAP ALLOWING ESTUARY DRAINAGE



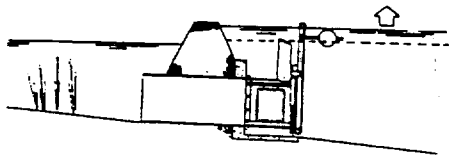
2. RISING TIDE FLOATS GATE UP FLOODING ESTUARY BASIN



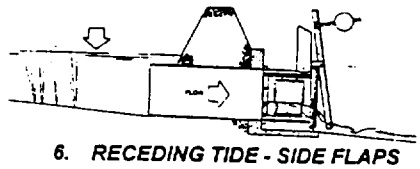
3. TIDE STARTS TO CLOSE GATE LIMITING ESTUARY FLOOD LEVEL



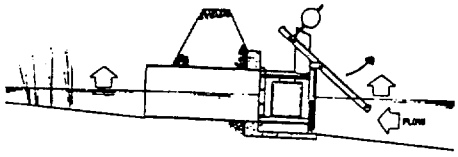
4. AT NORMAL TIDE LEVEL GATE IS CLOSED



5. WHEN TIDE EXCEEDS NORMAL HIGH TIDE LEVEL, GATE LOCKS IN CLOSED POSITION TO PREVENT GATE ACTION DUE TO SURGES



6. RECEDING TIDE - SIDE FLAPS OPEN TO ALLOW DRAINAGE OF ESTUARY - MAIN GATE COVER RESTRICTED TO PARTIALLY OPEN UNTIL NEXT TIDE



7. NEXT INCOMING TIDE - GATE UNLOCKS & RESUMES NORMAL TIDE SEQUENCE

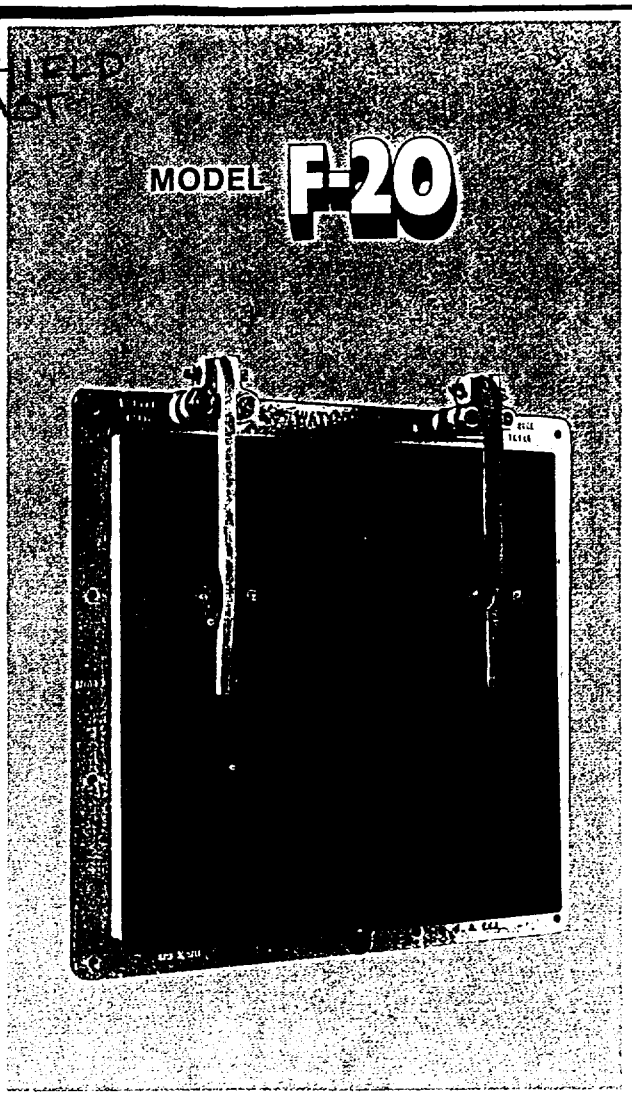
** Note that a maximum level is not exceeded on the estuary side of SRT during any phase or condition.*

REMOVABLE SHIELD
-DRAINAGE EASY

CAST IRON • AUTOMATIC

Drainage Gate

MODEL F-20



The Waterman Model F-20 Cast Iron Automatic Drainage Gate has a cast iron frame and cover (flap) with machined finished seating surfaces. A minimum 2½° seating angle and double pivoted links assure positive seating.

Hinge brackets, which can easily be field adjusted, allow the gate to be set for a very sensitive opening under low unseating pressure. Out-flow at practically full conduit capacity can be obtained.

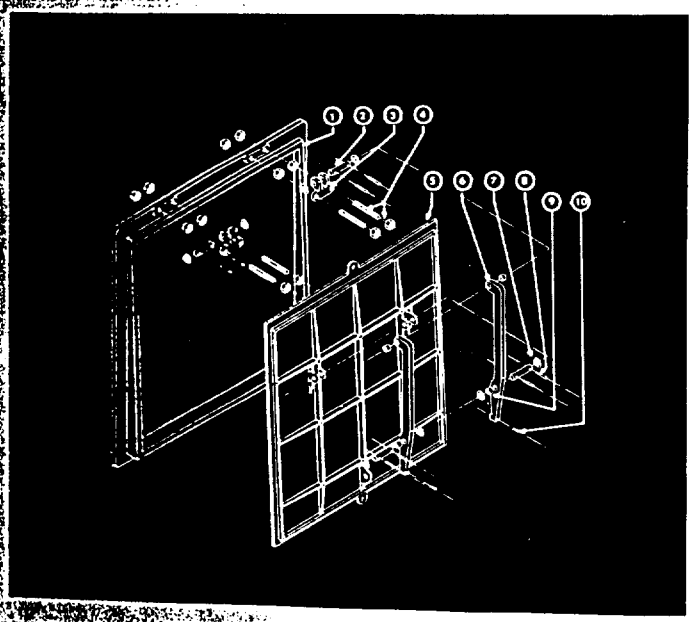
Standard features include bronze hinge bushing, stainless steel hinge pins, studs and nuts with brass retainer washers and stainless steel spring pins. Links on all gates are flame cut from steel plate, then galvanized.

A lifting eye is cast as a part of the cover for hand operation.

Optional features available include bronze or stainless steel seats, monel or brass hinge pins, studs and nuts; graphite impregnated bronze bushings and lubrication fittings—or any combination thereof.

Standard shopcoat paint is an asphaltic base dipping enamel. All special coatings are available and include Vinyl, Epoxy and Coal Tar Paints or total galvanizing per ASTM A 123.

Anchor bolts are not included and should be ordered separately. Anchor bolts of galvanized steel, stainless steel, brass or monel are available as well as galvanized steel machine bolts and tap-in expansion anchors.



FLAT BACK F-20f
SPIGOT BACK F-20sb

1. Frame (Flat or Spigot Back)
2. Hinge Pins
3. Adjustable Hinge Bracket
4. Studs and Stud Nuts
5. Cover Flap
6. Link
7. Washer
8. Retaining Spring Pin
9. Bushing
10. Set Screw

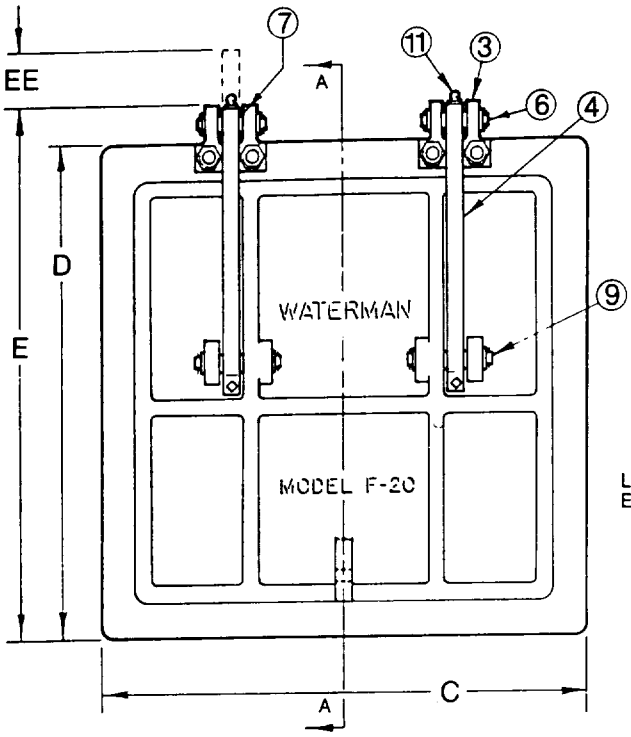
- 20 Foot Seating Head
- Square and Rectangular Opening
- Flat back or Spigot Back
- Adjustable Linkage
- Cast Iron or Bronze Seats
- Galvanized Steel Links
- Bronze Hinge Bushings
- Stainless Steel Studs, Nuts and Pins
- Minimum 2½° Seat

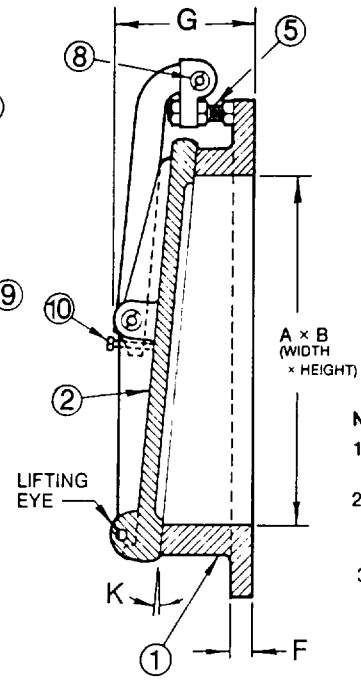
Optional:

- Monel Studs, Nuts and Pins
- Coal Tar, Epoxy, Vinyl and other Special Coatings including Total Galvanizing

BULLETIN 11.0 (1182) — PRINTED IN USA

Waterman INDUSTRIES, INC.
EXETER, CA • LUBBOCK, TX • GARDEN CITY, KS • BOISE, ID • MEMPHIS, TN
RED TOP WATER CONTROL GATES, VALVES and EQUIPMENT





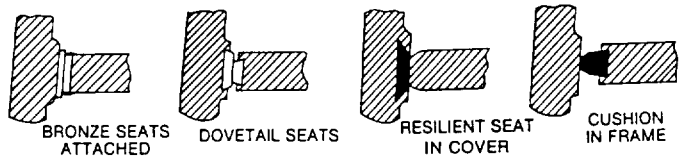
SECTION A-A

1. FRAME
2. COVER
3. PIVOT LUG
4. HINGE LINK
5. HINGE STUDS & NUTS
6. HINGE PIN
7. HINGE BUSHING
8. WASHERS
9. SPRING PIN
10. SET SCREW
11. LUBE FITTING (OPTIONAL)

NOTES:

1. FOR USE WITH SEATING HEADS UP TO 20 FEET.
2. CAST IRON, STANDARD; FABRICATED STEEL, OPTIONAL.
3. FOR SIZES OTHER THAN SHOWN, FABRICATED STEEL.

ALTERNATE SEAT DETAILS



GATE DIMENSIONS IN INCHES

A × B	C	D	E	EE	F	G	K°
12 × 12	19	19	20	3	⅝	3½	5
18 × 18	25	25	26½	3	¾	5½	5
18 × 24	26½	32½	34½	3	⅞	8	2½
18 × 36	27	45	47	3	1	9	2½
20 × 20	27	27	22	3	¾	5½	2½
24 × 18	32½	26½	28½	3	⅞	8	2½
24 × 24	30	30	32	3	⅞	8	2½
30 × 18	38½	26½	28½	3	1	8	2½
30 × 30	38½	38½	40½	3½	⅞	8	2½
36 × 24	45	33	35	3	1	8½	2½
36 × 30	45	38½	35	3	1	8½	2½
36 × 36	45	45	47	3½	1	9	2½
36 × 48	45	57	61	3½	1	9	2½
42 × 30	51	38½	40½	3	1	8	2½
42 × 42	51	51	53	4⅛	1	8	2½
48 × 24	58	34	36	3	1	10	2½
48 × 30	58	40	45	3½	1¼	10	2½

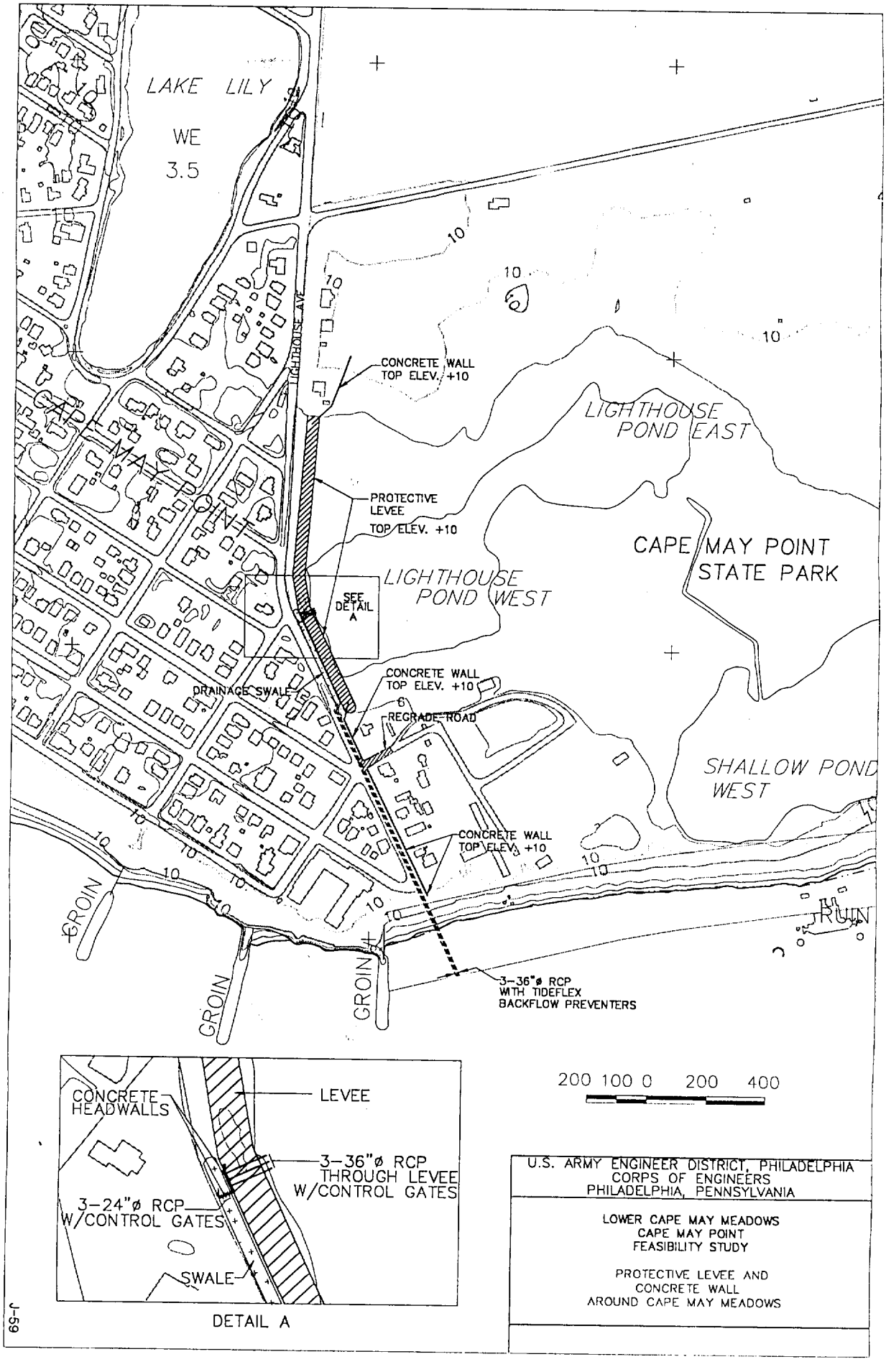
A × B	C	D	E	EE	F	G	K°
48 × 36	58	45	47	3½	1	10	2½
48 × 48	58	58	62	4⅞	1	10	2½
48 × 60	57½	70	64	6	1	11¾	2½
54 × 36	64	46	47½	3½	1¼	9	2½
54 × 54	64	64	68	6	1⅛	10	2½
60 × 30	69	39	44	3½	1¼	10	2½
60 × 36	69	45	47	3½	1¼	9	2½
60 × 48	69	57	61	4	1¼	8⅛	2½
60 × 60	70	70	74	6⅛	1¼	10	2½
72 × 48	82	58	62	6	1¼	10	2½
72 × 54	82	64	68	10	1¼	10	2½
72 × 60	82	70	74	10	1¼	10	2½
72 × 72	82	82	86	10	1½	10	2½
84 × 60	96	72	74	10	1½	12½	2½
84 × 84	96	96	99	10	1½	12½	2½
96 × 60	108	72	75	10	1½	12½	2½
96 × 96	112	112	115	10	1¾	20	2½

MODEL		
F-20-f DRAINAGE GATE		
SCALE	CATALOG DWG. NO.	REVISION NO.
NONE	0006	2

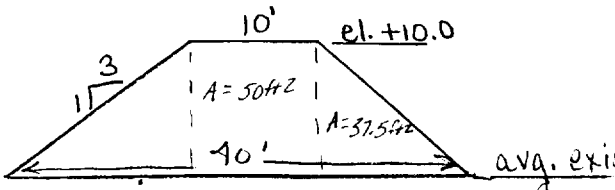
Waterman INDUSTRIES, INC.

EXETER, CA • LUBBOCK, TX • GARDEN CITY, KS • BOISE, ID
MEMPHIS, TN • GRAND ISLAND, NB • INDIANAPOLIS, IN
RED TOP WATER CONTROL GATES, VALVES and EQUIPMENT

NOTE: FOR PRELIMINARY DESIGN PURPOSES ONLY
DO NOT USE FOR INSTALLATION
UNLESS PART OF CERTIFIED & APPROVED SUBMITTAL


LAKE LILY
WE
3.5
CAPE MAY POINT
LIGHTHOUSE AVE
CONCRETE WALL
TOP ELEV. +10
PROTECTIVE
LEVEE
TOP ELEV. +10
SEE
DETAIL
A
LIGHTHOUSE
POND EAST
LIGHTHOUSE
POND WEST
CAPE MAY POINT
STATE PARK
DRAINAGE SWALE
CONCRETE WALL
TOP ELEV. +10
REGRADE ROAD
SHALLOW POND
WEST
CONCRETE WALL
TOP ELEV. +10
GROIN
GROIN
GROIN
RUIN
3-36"ø RCP
WITH TIDEFLEX
BACKFLOW PREVENTERS
200 100 0 200 400
CONCRETE
HEADWALLS
LEVEE
3-36"ø RCP
THROUGH LEVEE
W/CONTROL GATES
3-24"ø RCP
W/CONTROL GATES
SWALE
DETAIL A
U.S. ARMY ENGINEER DISTRICT, PHILADELPHIA
CORPS OF ENGINEERS
PHILADELPHIA, PENNSYLVANIA
LOWER CAPE MAY MEADOWS
CAPE MAY POINT
FEASIBILITY STUDY
PROTECTIVE LEVEE AND
CONCRETE WALL
AROUND CAPE MAY MEADOWS

(A) Levee along Lighthouse Ave.



① prepare exist. ground - regrade (fill in low spots, cut high
A = 42,000 s.f. - assume exist. ground is OL (USCS)
no disposal req'd.

② Tensar geoweb or equivalent

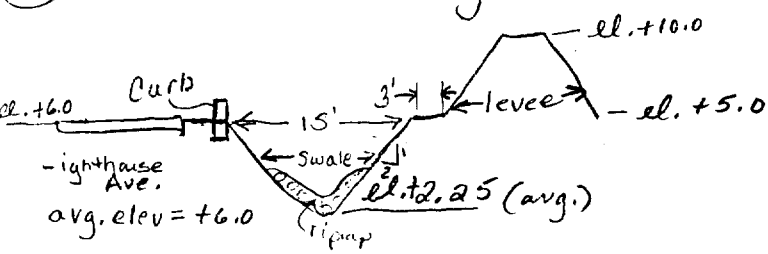
A = 42,000 s.f assume 3@15' wide rolls

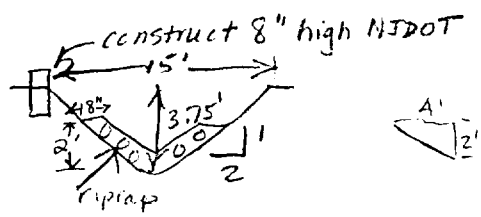
③ construct levee 125ft²x1,050 ft

V = 131,250 ft³ ≈ 4860 c.y.
acceptable fill types (U.S.C.S) are
SM, SC, ML, CL
max. 2' lifts, 95% compaction

④ Hydro seed
A = 43700 ft² ≈ 1 acre

(B) Construct Drainage Swale (along levee)





- assume mat'l. to be OL (USCS) organic silt

⑤ construct
345 l.f. NJDOT 8"
White concrete vertical curb

① excavate: 28ft²x 360ft = 10,080 ft³
V = 375 cy

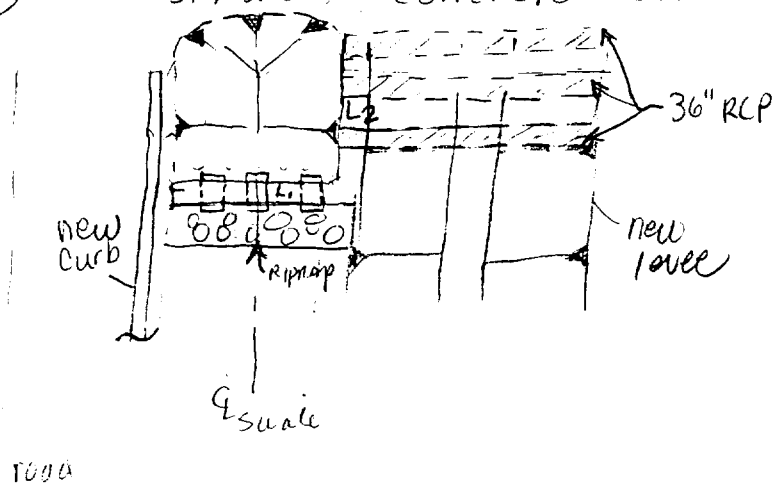
② dispose of excavated mat'l off-site

③ line bottom of swale w/ graded riprap
V = 4830 ft³ = 179cy x 1.7tons = 304 tons

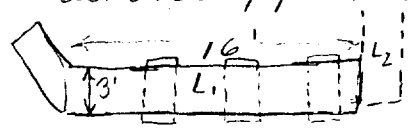
④ hydroseed: 2390 ft² = 0.06 acre

use 2.5" wall thickness for all RCP
for excavation, assume avg. exist ground elevation = +5.0

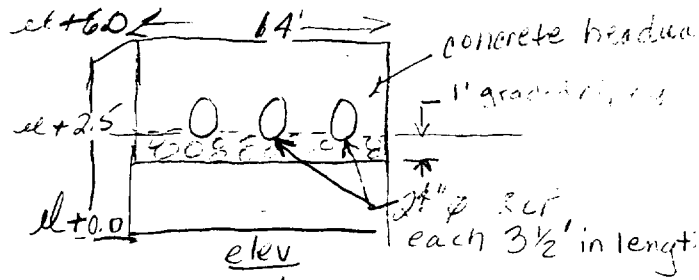
(C) Construct Concrete Culvert L-wall



L_1 : NJ DOT concrete headwall w/ 3 short sections of pipe through



plan



elev

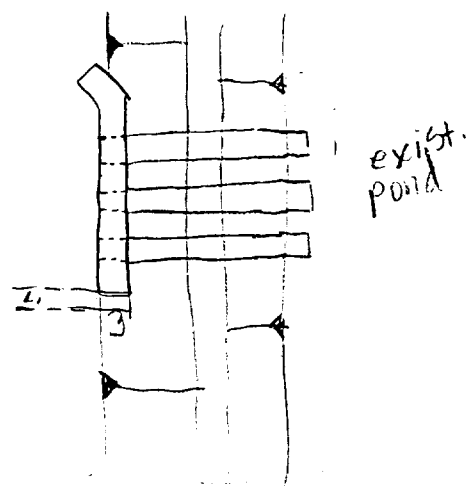
(3) pipe through L_1
3 - 24" ø RCP
each pipe 5' length

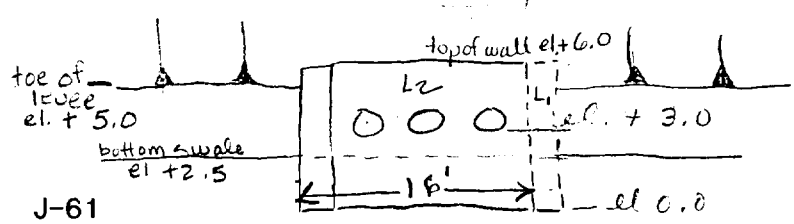
(4) assume excavation costs are included in exc. for swale (B)

① Concrete: headwall $3' \times 14' \times 6' = 252 ft^3 = 10 cy$
Type I wings $1.73' \times 2' = 3.5' \times 14' \times 1' = 2 cy$
$\Sigma V = 12 cy$

② graded riprap: $1' \times 14' \times 4' = 56 ft^3 = 2 cy = 3.5 to$

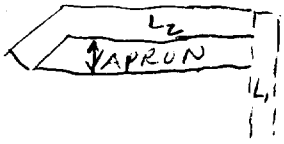
L_2 :





(C) (cont.)

L_2: ① <u>concrete</u>: headwall $3' \times 16' \times 6' = 288\ ft^3 = 11\ cy$



apron

$1.73 \times 3' = 5.2' \times 16' \times 1' = 83\ ft^3 = 3\ cy$

$\Sigma V = 14\ cy$

<u>no riprap</u>

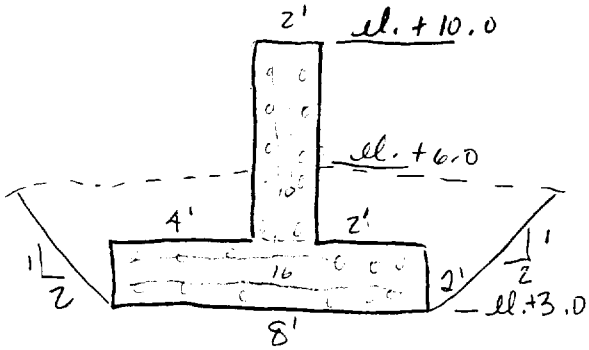
② <u>pipes through L_2</u>

3 - 36" ⌀ RCP

each pipe 48' length

outlet is into Lighthouse Pond.

(D) Construct concrete retaining wall along Lighthouse Ave.



① concrete: Type I concrete

$26\ ft^2 \times 1000 ft = 26{,}000\ ft^3$

a) V = 963 cy

b) add in $ for #5 reinforcement, 100 lb/ft

② excavate: V = 1555 cy

$3' \times 8 = 24\ ft^2$

$2 \times \frac{1}{2} \times 3 \times 6 = 18\ ft^2$

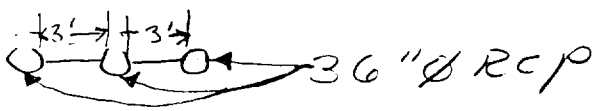
$42\ ft^2 \times 1000\ ft = 42000\ cft$

③ backfill: 42000 - 16000 - 2000

V = 24,000

dispose of 18,000 cy off-site

(E) Construct Storm Drain pipes from Swale to ocean: (along Lighthouse Ave.)



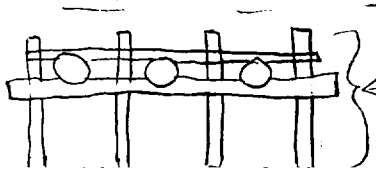
① 3 - 36"Ø RCP's installed at an avg. depth of excavation of 7' underneath existing pavement of Lighthouse Ave., through the exist./new dune and Tensar mattress out to a point beyond MHW of the new beachfill

length of pipe underneath pavement = 915 ft

length of pipe through dune cut to MHW = 104 ft

→ assume length of pipe through dune will have crib supports also

Timber crib supports:



← 1 timber pipe support system

total # of pipe support systems = 13

(E) (cont.)

each pipe support system consists of:

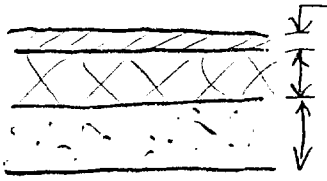
① 4-12"Ø King piles, 20' length, jetted
② 2-6x14 timbers (bottom) x 21 ft length
③ 2-4x8 timbers (top) x 21 ft length
④ 1"Ø hot-dip galvanized bolts, 2' long
# of bolts = 18

- include an extra cost for removing and replacing a 25' section of the exist. Tensar stone filled mattresses. This would require a small crane and dozer, mattresses should be moved in such a way as to prevent them breaking.

- assume the entire width of Lighthouse Ave. would be re-paved following backfilling onto pipes.

A = 18,325 ft²

use this x-section for new paving:

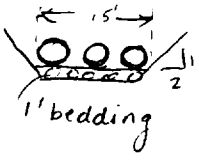


1" asphalt concrete surface (ID-2)
3" asphalt concrete base
4" AASHTO #57 aggregate base

- include a cost for 1 NJDOT Type B inlet + grate and frame, no curb piece to be installed at the end of Lighthouse Ave. near the dune, tieing in to one of the new 36"Ø RCP.

(E) (cont.)

- amount of excavation req'd to install 3 - 36"ø RCP along Lighthouse Ave.



$$\overset{d}{8'} \times \overset{w}{15'} \times \overset{l}{950'} = 114{,}000 \text{ ft}^3$$

$$2\left(\tfrac{1}{2} \times 8' \times 16' \times 950'\right) = \underline{121{,}600 \text{ ft}^3}$$

$$235{,}600 \text{ ft}^3 = 8725 \text{ c.y.}$$

- place a 1' thick layer of bedding beneath pipes (use NJ DOT I-2, compacted)

$$1' \times 15' \times 950' = 14{,}250 \text{ ft}^3 = 527 \text{ cy}$$

(F) Re-grade entrance to State Park and 5 driveways to el. +10.0

assume exist ground will require 2' of additional fill beneath new pavement. Use NJDOT I-2.

$V = (1800\ ft^2 + 330\ ft^2) \times 2' = 4256\ ft^3$

$V = 158$ c.y.

Area for new pavement following re-grading $= 2130\ ft^2$

use X-Section provided in (E) for new pavement.

(G) Control Gates.

see product insert

(1) 3 gates for 36"Ø RCP through levee to lighthouse pond

(2) 3 gates for 24"Ø RCP through wall in swale

(3) 3 gates for 36"Ø RCP draining from swale to ocean

(4) 3 'tideflex' backflow preventers on the seaward outlet of 3-36"Ø RCP pipes at MHW

"Control Gates"
Section G

RED TOP

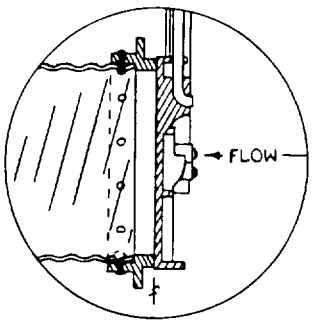
Canal Gate

FLAT COVER (SLIDE) WITH SQUARE BOTTOM

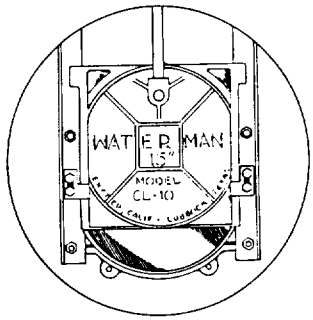
Waterman CL-10 Canal Gates are identical to our model C-10 Gates with the exception of the cast iron cover (slide) which is of a flat plate type construction with ribs reinforcing its face, to withstand the maximum heads as noted for our C-10 gates. This gate cover also features a square bottom design, which allows a more open "clog-free" flow at points of initial opening. The seat being only slightly raised above the cover plate surface helps prevent trash from collecting behind the cover which can cause difficulty in operation.

All parts are interchangeable with our standard C-10 gate.
See price list for sizes available and prices.

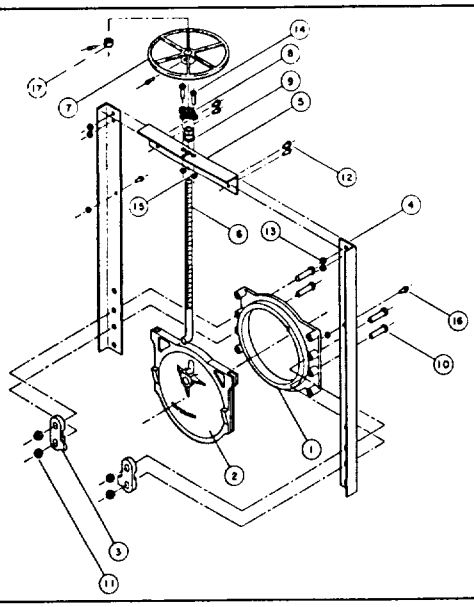
DETAIL OF COVER (SLIDE)
SHOWING VERTICAL AND HORIZONTAL RIBS



Note Flat Plate Cover with Machined or ground surface



View of Slide Cover Partially Open

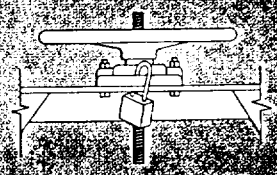


1. FRAME
2. COVER (C-10 style shown)
3. WEDGE (R & L)
4. GUIDE RAIL (R & L)
5. HEADRAIL
6. STEM
7. HANDWHEEL
8. THRUST COLLAR
9. LIFT NUT
10. WEDGE BOLT
11. WEDGE NUT
12. FRAME BOLT
13. FRAME NUT
14. COLLAR BOLT
15. COLLAR NUT
16. STOP BOLT & NUT
17. LIMIT NUT— W/Set Screw Optional

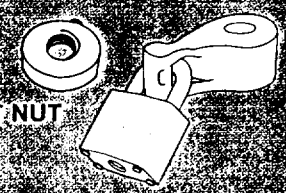
(Illustration shows C-10 style cover)

MODEL
CL-10

Features Available on Waterman Gates (C-10, CL-10, CM-10)

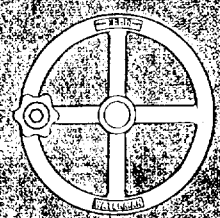


LOCKING DEVICE
A locking device is standard on all gates 36" in diameter and smaller.



LIMIT NUT

TAMPER PROOF LIMIT NUT
Limit Nuts (stop nuts) are a highly recommended optional extra. Also now available is a special tamper proof Limit Nut which may be padlocked in place.



Spinner Handwheel available for non-rising slide gates

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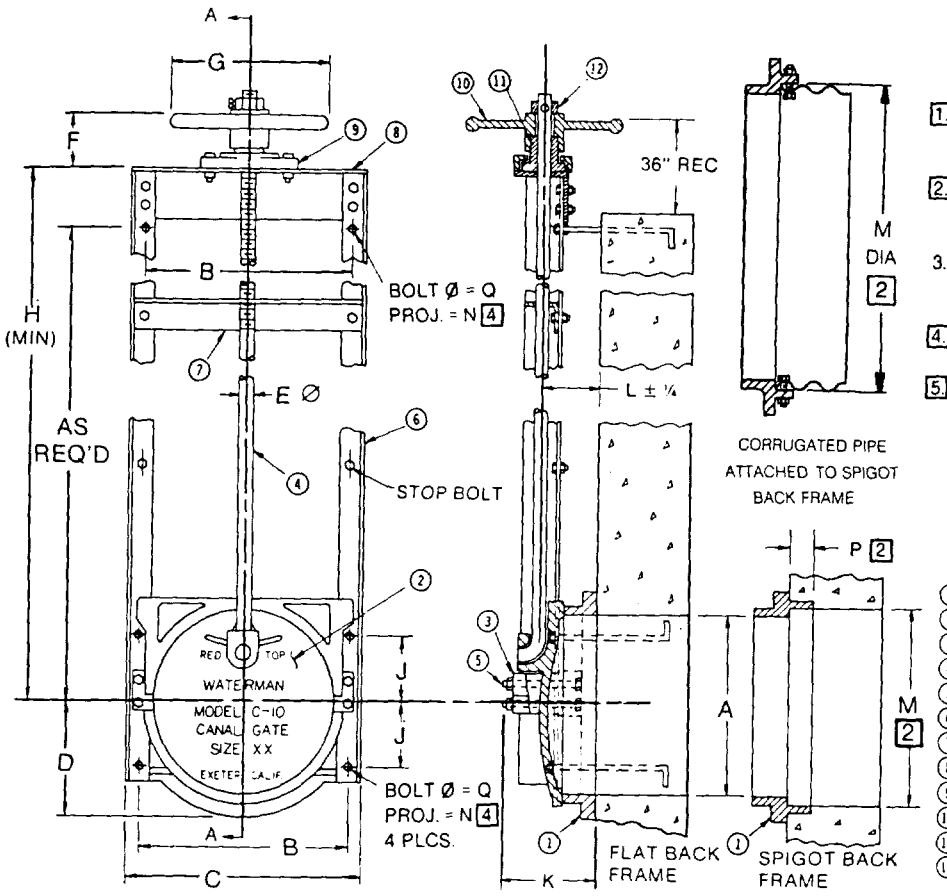

NOTES

1. Type 2 lubricated ball bearing lift used on 48" and larger gates.
2. Applies to spigot back gate only. Optional spigot, shown in separate detail.
3. All dimensions are also applicable for model CK-10, CL-10, & CM-10 gates.
4. Add grout pad thickness to anchor bolt projection.
5. Type 3E-2:1 lift used, mounted to dual headrail.

1. FRAME
2. COVER
3. WEDGE - RIGHT & LEFT
4. STEM
5. WEDGE BOLTS
6. GUIDE RAIL
7. STEM SUPPORT
8. HEAD RAIL
9. LIFT COLLAR
10. HANDWHEEL
11. LIFT NUT
12. LIMIT NUT

SECTION A-A

GATE DIMENSIONS IN INCHES

GATE SIZE A	B	C	D	E	F	G	H	J	K	L	M 2	N	P 2	Q
6	8	9⅞	4	⅞	2⅞	10	24	3	3½	2⅝	7	3½	2¼	½
8	10	12	4⅞	⅞	2⅞	10	24	3	3¾	2½	9	3½	2¼	½
10	12	13⅞	6	⅞	2⅞	10	24	3½	3¾	2½	11	3½	2¼	½
12	14	15⅞	7	⅞	2⅞	10	24	4	3½	3	13	4	2¼	½
14	16	17⅞	8	⅞	2⅞	10	27½	4¾	3¾	3¼	15	4	2¼	½
15	17	18⅞	8⅞	⅞	2⅞	10	30	5	4½	3½	16	4	2⅛	½
16	18¾	20⅝	9⅞	⅞	2⅞	10	32	5½	4½	3½	17	4½	2¼	⅝
18	21	22⅞	10½	1	3⅛	12	34	6	4½	4½	19	4½	2¼	⅝
20	23¼	25⅛	11¾	1	3⅛	12	38	7	4¾	4	21	4½	2¼	⅝
21	24	25⅞	12 5/16	1	3⅛	12	40	7	4¾	4	22	4½	2¼	⅝
24	27¼	29⅛	13⅞	1	3⅛	12	44	8	5¾	4⅛	25	4½	2¼	⅝
30	33¾	36⅛	17⅜	1⅛	4	15	54	10	6	4½	31	6	2¼	¾
36	39¾	42⅛	20½	1⅛	4	15	62	12	6¼	5⅜	37	6	2⅛	¾
42	45¾	48⅜	23⅝	1½	5	18	84	14	7	6	43	6	2½	¾
48	51¾	54⅜	26¾	1½	6	24 1	90	16	7⅜	6⅛	49⅛	6	2½	¾
54	58½	61½	30	2	6	30 1	100	18	7⅞	6½	55⅛	7	3	1
60	65	68	34	2	6	30 1	102	20	8⅛	7⅛	61⅛	7	3¼	1
72	77½	80¼	41	2	13	5	121	25½	10⅝	8¾	73¼	8	3⅜	1

MODEL		
C10f & C-10sb CANAL GATE		
SCALE	CATALOG DWG. NO.	REVISION NO.
NONE	0008	3

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GRAND ISLAND, NB • INDIANAPOLIS, IN • SOLIHULL, WEST MIDLANDS, UK
RED TOP WATER CONTROL GATES, VALVES and EQUIPMENT

NOTE: FOR PRELIMINARY DESIGN PURPOSES ONLY
DO NOT USE FOR INSTALLATION
UNLESS PART OF CERTIFIED & APPROVED SUBMITTAL

SECTION 7

CONSTRUCTION PROCEDURE AND WATER CONTROL PLAN

The method of construction used by the contractor for the beachfill portion of the project is not specified beforehand in the contract specifications. However, for the beach restoration, based on previous construction in the District, it is anticipated that the contractor will use a hydraulic dredge with a cutterhead to excavate material from the offshore borrow site. The material will then be pumped from the borrow area to the beach through a submerged pipeline. Once on the beach the pipeline will run north-south close to the proposed dune line.

The material will than be worked on the beach by bulldozers and front-end loaders. Pipe will be moved by front-end loaders with grapple arms. Miscellaneous equipment to be stored on the beach will include a light tower, fuel tank with containment, welding machine and a temporary shanty for personnel.

The method of construction for the interior habitat area drainage improvements in the Meadows would be accomplished by means of amphibious rotary ditchers which are capable of remaining afloat in the submerged areas of the marsh. Work in areas in the Meadows that are difficult to access would be accomplished by small backhoes that would be supported by portable timber mats. A small bulldozer would be required to rehandle material excavated to construct the low earthen berm in the Nature Conservancy. The use of 1-2 trucks and approximately 1500 feet of temporary mat roadway will also be required for placement of spoil material in various areas in the Meadows.

A water quality plan is required for this project.

SECTION 8

INITIAL RESERVOIR FILLING AND SURVEILLANCE PLAN - N/A

SECTION 9

STORM EMERGENCY PLANS

An emergency plan, New Jersey Hurricane Evacuation Study, 1992, was previously completed by the District in coordination with NJ State Police Office of Emergency Management, FEMA and NOAA-NWS.

SECTION 10

CONSTRUCTION MATERIALS

The beachfill material is from an offshore borrow area and is fully compatible, (overfill factor = 1.0), with the existing beach sand. The material to be excavated in the interior habitat area of the Meadows consists of silts underlain by sand. There is no suspected contamination in the selected borrow areas; therefore, the dredged material to be placed onto the beach is considered clean.

Constructability of these materials of the interior habitat area will be described in detail upon further subsurface investigation results, which are scheduled to start in late October to early November.

SECTION 11

RESERVOIR CLEARING - N/A

SECTION 12

OPERATION AND MAINTENANCE

Operation, Maintenance, Repair, Replacement, and Rehabilitation (OMRR&R) of the completed project is a non-Federal sponsor responsibility. The non-Federal sponsor will be furnished with an O&M Manual to assist them in carrying out their obligations under ER 1110-2-2902.

SECTION 13

ACCESS ROADS

The work in conjunction with the beachfill portion of this project will be done offshore or using oceanfront access to the beach. The required grading equipment will be transported via local roads in accordance with State and local regulations including a traffic control plan. Exact access to the beach will be determined and coordinated during the plans and specifications phase and will included the necessary easements.

The work in conjunction with the interior drainage improvements to Cape May Meadows will be done using access points within the State Park, along the beach oceanfront and in the City of Cape May along Broadway Ave. The required construction equipment will be transported via local roads in accordance with State and local regulations including a traffic control plan. Exact access points to the interior habitat area of the Meadows will be determined and coordinated during the plans and specifications phase with the appropriate official and will include required easements.

SECTION 14

CORROSION MITIGATION - N/A

SECTION 15

PROJECT SECURITY

Contractor personnel will be required to insure security and public safety. Typically, the District addresses project security and public access in more detail during the plans and specs phase. A contractor safety plan specific to the project site will be required.

SECTION 16

COST ESTIMATE

TOTAL PROJECT COST SUMMARY - INITIAL CONSTRUCTION

TOTAL - ALL CONTRACTS

THIS ESTIMATE IS BASED ON THE SCOPE CONTAINED IN THE FEASIBILITY STUDY

PROJECT: NEW JERSEY COASTLINE, CAPE MAY MEADOWS TO CAPE MAY POINT
LOCATION: NJ

DISTRICT: PHILADELPHIA
P.O.C.: JOSE R. ALVAREZ, P.E., CHIEF, COST ENGINEERING BRANCH

CURRENT MCACES ESTIMATE PREPARED: Oct-97
EFFECTIVE PRICING LEVEL: Oct-97

AUTHORIZ./BUDGET YEAR: FY-99/00
EFFECTIVE PRICING LEVEL: Oct-97

CCOUNT NUMBER	FEATURE DESCRIPTION	COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	OMB	COST ($K)	CNTG ($K)	TOTAL ($K)	FEATURE MID - PT	OMB	COST ($K)	CNTG ($K)	FULL ($K)
										FULLY FUNDED ESTIMATE				
01.	LANDS AND DAMAGES	$125.722	$18.858	15.00%	$144.580	1.026	$128.991	$19.348	$148.339	JAN-99	1.026	$132.345	$19.851	$152.196
06.	FISH AND WILDLIFE FACILITIES	$1,523.682	$422.031	27.70%	$1,945.713	1.026	$1,563.298	$433.004	$1,996.302	NOV -00	1.054	$1,647.716	$456.386	$2,104.000
17	BEACH REPLENISHMENT	$9,829.356	$1,456.860	14.82%	$11,286.216	1.026	$10,084.920	$1,494.738	$11,579.658	NOV -00	1.054	$10,629.505	$1,575.454	$12,205.000
	TOTAL CONSTRUCTION COST	$11,353.038	$1,878.891	16.55%	$13,231.929		$11,648.217	$1,927.742	$13,575.960			$12,277.221	$2,031.840	$14,309.061
30.	PLANNING, ENGINEERING AND DESIGN													
	Plans & Specifications	$453.000	$67.950	15.00%	$520.950	1.047	$474.291	$71.144	$545.435	APR-98	1.045	$495.634	$74.345	$569.979
	Environmental Coordination	$235.000	$35.250	15.00%	$270.250	1.047	$246.045	$36.907	$282.952	JUL-98	1.046	$257.363	$38.604	$295.968
	Value Engineering	$45.000	$6.750	15.00%	$51.750	1.047	$47.115	$7.067	$54.182	APR-98	1.045	$49.235	$7.385	$56.620
	PCA Execution	$25.000	$3.750	15.00%	$28.750	1.047	$26.175	$3.926	$30.101	JAN-99	1.047	$27.405	$4.111	$31.516
	Advertise & Award	$10.000	$1.500	15.00%	$11.500	1.047	$10.470	$1.571	$12.041	APR-99	1.047	$10.962	$1.644	$12.606
	E&D During Construction	$790.000	$118.500	15.00%	$908.500	1.047	$827.130	$124.070	$951.200	NOV-00	1.089	$900.745	$135.112	$1,035.856
	Project Management	$80.000	$12.000	15.00%	$92.000	1.047	$83.760	$12.564	$96.324	JAN-99	1.047	$87.697	$13.155	$100.851
	PLANNING, ENGINEERING AND DESIGN TOTA	$1,638.000	$245.700	15.00%	$1,883.700		$1,714.986	$257.248	$1,972.234			$1,829.041	$274.356	$2,103.397
31.	CONSTRUCTION MANAGEMENT (S & I)	$250.000	$37.500	15.00%	$287.500	1.047	$261.750	$39.263	$301.013	NOV-99	1.048	$274.314	$41.147	$315.461
	TOTAL PROJECT COST	$13,366.760	$2,180.949	16.32%	$15,547.709		$13,753.944	$2,243.601	$15,997.546			$14,512.921	$2,367.195	$16,880.115

EC 11-2-159

TOTAL COSTS (Rounded) $16,880,000

Cumulative Compounded Percent Rates of Change

	Class 1	Class 2		Class 1	Class 2
Oct 95 - FY 96	1.000	1.000	Oct 98 - FY 99	1.091	1.063
Oct 96 - FY 97	1.080	1.027	Oct 99 - FY 00	1.132	1.096
Oct 97 - FY 98	1.050	1.031			

THIS TPCS REFLECTS A PROJECT COST CHANGE $ _____

THE TOTAL MAXIMUM PROJECT COST IS $ _____

DISTRICT APPROVED:

_____ CHIEF, COST ENGINEERING

_____ CHIEF, REAL ESTATE

_____ CHIEF, PLANNING

_____ CHIEF, ENGINEERING & CONSTRUCTION

_____ CHIEF, OPERATIONS

_____ CHIEF, PROGRAMS MANAGEMENT

_____ PROJECT MANAGER

_____ DDE (PM)

DIVISION APPROVED:

_____ CHIEF, COST ENGINEERING

_____ DIRECTOR, REAL ESTATE

_____ CHIEF, PROGRAMS MANAGEMENT

_____ DIRECTOR OF PPMD

APPROVED DATE: _____

New Jersey Coast - Lower Cape May Meadows / Cape May Point Project

APPENDIX A, SECTION 16 - COST ESTIMATES

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5	Alternatives Considered	1
7	Estimated First Cost	1
8	Contingency, Engineering & Design and Construction Management	2
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Appendix A, Section 16 - Cost Estimates

1. General. This section presents detailed cost estimates for initial construction, nourishment, maintenance, monitoring and major rehabilitation resulting in total and annualized project costs for alternative storm damage reduction plans for the subject project. The alternative plans developed for Lower Cape May Meadows and Cape May Point are listed in Table 2. The dune for all alternatives has 1 on 5 side slopes and a top berm crest of 20' wide. Included in the initial construction of all the above plans is design and advanced nourishment beach fill. Also included are provisions for periodic nourishment at 4 year intervals, monitoring and major rehabilitation to restore the design beach profile damaged by significant storm events beyond that designed for in the nourishment cycle volumes. The plan layout of the NED plan with typical improved beach sections is displayed in the section of the Feasibility Study, Main Report describing the NED Plan.

2. Basis of Cost. Cost estimates presented herein are based on October 1997 price levels. Initial beach fill costs are based on beach surveys taken in 1992 and 1993. The unit prices were developed on the basis that construction procedures will be as outlined herein. All first and annual costs presented in this appendix are NED costs.

3. Initial and periodic nourishment fill costs are based on the use of a 27" hydraulic cutterhead dredge for placement of the beach fill. The location of the borrow area is displayed in the section of the Feasibility Study, Main Report describing the NED Plan.

4. Real estate costs as displayed in Table 1 are included as NED costs and reflect acquisition of easements on private beach between Lower Cape May Meadows and Cape may Point. For more information, refer to the Real Estate Appendix.

5. Alternatives Considered. Alternative plans were developed in two phases for the plan selection process. In the first phase, the alternative plans were compared during the Cycle 1 and Cycle 2 screening process. For more information on these plans refer to the section of the Feasibility Study, Main Report describing the NED Plan. Based on an analysis of these annual costs with their associated benefits, the beach restoration only plan was selected for the second phase for final plan optimization and selection.

6. The costs for the alternative plans as described in paragraph 1 for this second phase of plan selection are displayed in Table 2.

7. Estimated First Cost. The estimated project first cost is for the selected plan - Dune/berm construction with a berm width of 20 feet at elevation +8.0 ft NGVD (+6.7 ft NAVD88) and a dune elevation of +18.0 ft NGVD (+16.7ft NAVD88). This includes the placement of 2,371,800 C.Y. of hydraulically placed design and advance nourishment beach fill, and the placement of 87,120 S.Y. (18.0 acres) of dune grass and 15,000 L.F. of sand fence. This plan also includes the seaward restoration of 35 acres of previously eroded emergent wetland. This will move the

MHW line seaward a maximum distance of 280 feet. This restoration includes the elimination of 95 acres of Phragmites australis through herbicidal spraying and burning, the planting of 105 acres of emergent wetland vegetation, excavation to restore flow within existing drainage ditches, the creation of drainage ditches linking the hydrological segments of the project area, the installation of two (2) weir flow control structures, the creation of a total of six (6) fish deep water reservoirs within existing ponds and the construction of a shallow earthen water retaining structure to allow for the creation of approximately 25 acres of tidal marsh. Other costs that are included include NED real estate acquisition costs and pertinent contingency, engineering and design and construction management costs. Details of the first cost estimate are shown on Table 1.

8. Contingency, Engineering and Design and Construction Management.

Engineering and design costs include preparation of the plans and specifications, coastal and environmental pre-construction data collecting and the development of the PCA. Engineering and design costs are $1,390,000. Construction management costs are a flat $250,000 and are based on the direct labor cost. Pertaining to contingencies: 23% was applied to phragmites removal & burning to account for any additional burning that might be needed because of vegetation growth, 20% was applied to plantings to account for changes in the site conditions that would require additional plantings, 50% was applied to the organic substrate to account for variances in the availability of organic substrate and changes in the site conditions that would effect production, 20% was applied to miscellaneous site work to account for variances in the site design due to pre-construction erosion at the habitat locations, 12% was applied to mobilization, demobilization and preparatory work to account for variances in the travel distance for a dredge plant, 15% was applied to beach placement work to account for larger required beach fill quantities at the time of construction due to future pre-construction erosion, 15% was applied to dune grass and sand fencing to account for variances in the beach profile at the dune location due to future pre-construction shifting and/or eroding beach conditions, and 20% was applied to the outfalls to account for variances in material availability and the beach profile again due to pre-construction shifting and/or eroding beach conditions.

ANNUAL CHARGES

9. General. The estimates of annual charges for all alternatives are based on an economic project life of 50 years and an interest rate of 7.375%. The annual charges include annualized first cost and interest during construction, the annualized periodic nourishment costs, and post construction monitoring costs. It is noted that interest during construction was developed for the first cost of the project constructed over a six month period. For the selected plan, the total annualized cost is $2,330,000.

10. Periodic Nourishment. The periodic nourishment volume to be placed at 4 year cycles subsequent to commencement of construction and throughout the 50 year economic life is 650,400 C.Y. which includes overfill and tolerance. The placement of this material will follow the constructability outlines in paragraph 3. For more details on the development of the periodic nourishment quantity refer to the section of the Feasibility Study, Main Report describing the NED Plan. The borrow area for periodic nourishment is also shown in the section of the

Feasibility Study, Main Report describing the NED Plan. Periodic nourishment costs are developed in Table 3.

11. Major Rehabilitation Costs. Major rehabilitation costs are not included as an additional cost for significant storm events beyond that designed for in the renourishment cycle to restore the design profile. For this study, the major rehabilitation quantity is included in the periodic nourishment quantity listed above. The major rehabilitation losses are computed as the losses that would occur from the 50% risk event over the project life. For more detail on the development of the major rehabilitation quantity refer to the section of the Feasibility Study, Main Report describing the NED Plan

12. Monitoring Costs. Post construction monitoring costs include coastal and environmental monitoring over the 50 year project life. Annualized monitoring costs are $79,000.

CONSTRUCTION AND FUNDING SCHEDULE

13. General. The construction and pre-construction sequence and time schedule of the selected plan are given in the Project Management Plan (PMP). The schedule is based on the timeliness of the report's approval and allocation of funds by Congress, the foregoing construction procedures, and the ability of local interests to implement the necessary items of local cooperation. These items of local cooperation are principally the furnishing of offshore borrow easements by the State of New Jersey as well as required real estate easements, and the relocation of items for beach access.

Table 1 - Total First Cost - Selected Plan- October 1997 Price Level

Account Code	Description of Item	Qty	Unit	Unit Price	Estimated Amount	Contingency	Total Amount
01	Lands and Damages						
01.B	Post Authorization Planning						
01.B.2	Required Easements	----------	Job	LS	$0	$0	$0
01.B.8	Surveys Appraisal & Admin	----------	Job	LS	$125,722	$18,858	$144,580
	Total Lands and Damages				$125,722	$18,858	$144,580
06	Fish and Wildlife Facilities						
06.03	Wildlife Facilities and Sanctuaries						
06.03.73	Habitat and Feeding Facilities						
06.03.73.02	Site Work						
06.03.73.02 03	Brush						
	Phragmites Removal & Burning	----------	Job	LS	$167,900	$38,580	$206,480
	Plantings	----------	Job	LS	$696,092	$139,218	$835,310
	Organic Substrate	----------	Job	LS	$380,000	$190,000	$570,000
	Total Brush				$1,243,992	$367,798	$1,611,790
06.03.73.02 05	Misc. Interior Site Work						
	Excavation for Mudholes	----------	Job	LS	$39,984	$7,997	$47,981
	Excavation for Reconnects & Ditches	----------	Job	LS	$7,028	$1,406	$8,434
	Excavation for Adverse Slopes	----------	Job	LS	$13,986	$2,797	$16,783
	Berms	----------	Job	LS	$100,484	$20,097	$120,581
	Weir Control Structure	----------	Job	LS	$34,131	$5,120	$39,251
	Tidegate	----------	Job	LS	$79,748	$15,950	$95,698
	Drainage Gate	----------	Job	LS	$4,329	$866	$5,195
	Total Misc. Interior Site Work				$279,690	$54,233	$333,923
	Total Fish and Wildlife Facilities				$1,523,682	$422,031	$1,945,713
17	Beach Replenishment						
17.00.01	Mobilization, Demobilization and						
	Preparatory Work (Cape May Meadows)	----------	Job	LS	$415,438	$49,853	$465,291
	Preparatory Work (Cape May Point)	----------	Job	LS	$226,920	$27,230	$254,150
17.00.16	Hydraulic Dredging						
17.00.16.02	Site Work						
17.00.16.02.01	Sand Fill Placement (Cape May Meadows)	1,724,400	CY	$3.57	$6,156,108	$923,416	$7,079,524
	Sand Fill Placement (Cape May Point)	647,400	CY	$3.75	$2,427,750	$364,163	$2,791,913
17.00.99	Associated General Items						
17.00.99.02.01	Dune Grass	18	ACR	$28,138.56	$506,494	$75,974	$582,468
17.00.99.02.02	Sand Fence	15,000	LF	$4.14	$62,100	$9,315	$71,415
17.00.99.02.03	Outfalls	----------	Job	LS	$34,546	$6,909	$41,455
	Total Beach Replenishment				$9,829,356	$1,456,860	$11,286,216
30.	Planning, Engineering and Design (P.E. & D	----------	Job	LS	$1,638,000	$245,700	$1,883,700
31.	Construction Management (S & A)	----------	Job	LS	$250,000	$37,500	$287,500
	Total Project First Cost				$13,366,760	$2,180,949	$15,547,709
	(Rounded)				$13,367,000	$2,181,000	$15,548,000

TABLE 2 - ALTERNATIVE PLAN'S COMPONENTS, TOTAL FIRST COST

Cape May Area with a nourishment of:			530,000 for Cape May Meadow	152,100 for Cape May Point		(incls. 0% overfill factor)		
Option	Quantity	Quantity + Annual	Unit Price	Dredging Cost	Mob / Demob	Total Cost w/Cont.*	S&A	E&D	Total Cost **
PLAN 1 - INITIAL + NOURISHMENT									
Cape May Meadows	*annual:*	*530,000*							
Cell 1	1,118,800	1,118,800					S&A @ 8.93%		
		[illegible]	$3.20	$5,276,160	$380,576	$6,493,829	$579,899	$250,000	$7,323,728
Cape May Meadows & Point	*annual:*	*543,700*							
Cell 1, 2a	1,399,455	1,399,455					S&A @ 8.6%		
		[illegible]	$3.25	$6,315,254	$380,793	$7,689,030	$661,257	$250,000	$8,600,287
	annual:	*580,900*							
Cell 1, 2a, 2b	1,538,805	1,538,805					S&A @ 8.6%		
		[illegible]	$3.30	$6,995,027	$380,970	$8,470,967	$728,503	$250,000	$9,449,470
Cape May Meadows & Point	*annual:*	*615,400*							
Cell 1, 2a, 2b, 3	1,749,550	1,749,550					S&A @ 8.6%		
		[illegible]	$3.41	$8,064,480	$381,370	$9,701,286	$834,311	$250,000	$10,785,596
Cape May Meadows & Point	*annual:*	*634,200*							
Cell 1, 2a, 2b, 3, 4	1,900,450	1,900,450					S&A @ 8.23%		
		[illegible]	$3.53	$8,947,315	$381,777	$10,717,002	$882,009	$250,000	$11,849,011
Cape May Meadows & Point	*annual:*	*650,400*							
Cell 1, 2a, 2b, 3, 4, 5a	1,986,200	1,986,200					S&A @ 8.23%		
		[illegible]	$3.61	$9,518,126	$382,063	$11,373,755	$936,060	$250,000	$12,559,816
Cape May Meadows & Point	*annual:*	*682,100*							
Cell 1, 2a, 2b, 3, 4, 5a,b,c	2,408,340	2,408,340					S&A @ 8.23%		
		[illegible]	$3.79	$11,712,768	$382,638	$13,898,237	$1,143,825	$250,000	$15,292,062
PLAN 2 - INITIAL + NOURISHMENT									
Cape May Meadows	*annual:*	*530,000*							
all Plan - Exist. Sand, Cell 1	1,395,250	1,395,250					S&A @ 8.6%		
		[illegible]	$3.20	$6,160,800	$380,576	$7,511,165	$645,960	$250,000	$8,407,125
Cape May Meadows	*annual:*	*530,000*							
m Plan - Exist. Sand, Cell 1	1,738,050	1,738,050					S&A @ 8.6%		
		[illegible]	$3.20	$7,257,760	$380,576	$8,772,669	$754,450	$250,000	$9,777,119
Cape May Meadows	*annual:*	*530,000*							
ge Plan - Exist. Sand, Cell 1	2,675,450	2,675,450					S&A @ 8.23%		
		[illegible]	$3.20	$10,257,440	$380,576	$12,222,301	$1,005,895	$250,000	$13,478,197
Cape May Meadows	*annual:*	*530,000*							
Cell 1	985,300	985,300					S&A @ 8.93%		
		[illegible]	$3.20	$4,848,960	$380,576	$6,002,549	$536,028	$250,000	$6,788,577
Cape May Meadows & Point	*annual:*	*543,700*							
Cell 1, 2a	1,251,765	1,251,765					S&A @ 8.6%		
		[illegible]	$3.26	$5,853,216	$380,793	$7,157,686	$615,561	$250,000	$8,023,247
Cape May Meadows & Point	*annual:*	*580,900*							
Cell 1, 2a, 2b	1,368,380	1,368,380					S&A @ 8.6%		
		[illegible]	$3.30	$6,432,624	$380,970	$7,824,204	$672,882	$250,000	$8,747,086
Cape May Meadows & Point	*annual:*	*615,400*							
Cell 1, 2a, 2b, 3	1,543,765	1,543,765					S&A @ 8.6%		
		[illegible]	$3.41	$7,362,753	$381,370	$8,894,300	$764,910	$250,000	$9,909,210
Cape May Meadows & Point	*annual:*	*634,200*							
Cell 1, 2a, 2b, 3, 4	1,670,365	1,670,365					S&A @ 8.6%		
		[illegible]	$3.53	$8,135,114	$381,777	$9,782,972	$841,336	$250,000	$10,874,307
Cape May Meadows & Point	*annual:*	*650,400*							
Cell 1, 2a, 2b, 3, 4, 5a	1,742,315	1,742,315					S&A @ 8.23%		
		[illegible]	$3.61	$8,637,701	$382,063	$10,361,267	$852,732	$250,000	$11,463,999
Cape May Meadows & Point	*annual:*	*682,100*							
Cell 1, 2a, 2b, 3, 4, 5a,b,c	2,130,495	2,130,495					S&A @ 8.23%		
		[illegible]	$3.79	$10,659,735	$382,638	$12,687,250	$1,044,161	$250,000	$13,981,411
PLAN 3 - INITIAL + NOURISHMENT									
Cape May Meadows	*annual:*	*530,000*							
Cell 1	909,100	909,100					S&A @ 8.93%		
		[illegible]	$3.20	$4,605,120	$380,576	$5,722,133	$510,986	$250,000	$6,483,120
Cape May Meadows & Point	*annual:*	*543,700*							
Cell 1, 2a	1,171,975	1,171,975					S&A @ 8.93%		
		[illegible]	$3.26	$5,593,101	$380,793	$6,858,554	$612,469	$250,000	$7,721,023
Cape May Meadows & Point	*annual:*	*580,900*							
Cell 1, 2a, 2b	1,288,005	1,288,005					S&A @ 8.6%		
		[illegible]	$3.30	$6,167,387	$380,970	$7,519,181	$646,650	$250,000	$8,415,830
Cape May Meadows & Point	*annual:*	*615,400*							
Cell 1, 2a, 2b, 3	1,460,945	1,460,945					S&A @ 8.6%		
		[illegible]	$3.41	$7,080,336	$381,370	$8,569,521	$736,979	$250,000	$9,556,500
Cape May Meadows & Point	*annual:*	*634,200*							
Cell 1, 2a, 2b, 3, 4	1,588,845	1,588,845					S&A @ 8.6%		
		[illegible]	$3.52	$7,825,118	$381,777	$9,426,476	$810,677	$250,000	$10,487,153
Cape May Meadows & Point	*annual:*	*650,400*							
Cell 1, 2a, 2b, 3, 4, 5a	1,661,540	1,661,540					S&A @ 8.23%		
		[illegible]	$3.61	$8,346,103	$382,063	$10,025,929	$825,134	$250,000	$11,101,063
Cape May Meadows & Point	*annual:*	*682,100*							
Cell 1, 2a, 2b, 3, 4, 5a,b,c	2,042,540	2,042,540					S&A @ 8.23%		
		[illegible]	$3.79	$10,326,386	$382,638	$12,303,898	$1,012,611	$250,000	$13,566,509
Selected Plan									
Cape May Meadows	*annual:*	*530,000*							
18' dune + 20' berm	1,194,400	1,724,400							
Cape May Point	*annual:*	*120,400*							
18' dune + 20' berm	527,000	647,400					S&A		
		[illegible]	$3.62	$8,583,858	$642,358	$10,590,878	$250,000	$1,390,000	$12,230,878

Notes - Maintenance quantity includes a +40% overfill factor.
- All cost are based on using the off-shore borrow area.
* - Contingency is 15% for the dredging portion and 12% for the Mob / Demob.
** - Costs include contingency, S&A and E&D.

Table 3 Periodic Nourishment Costs

Year # 4, 12, 20, 36, 44

	Cost	Contingency	Total
Sand 650,400 cy @ $4.85/cy	$3,154,440	$473,166	$3,627,606
Mob and Demob	$419,984	$50,398	$470,382
Subtotal	**$3,574,424**	**$523,564**	**$4,097,988**
E&D (includes monitoring)	$383,400	$57,510	$440,910
Construction Management	$175,000	$26,250	$201,250
TOTAL	$4,132,824	$607,324	$4,740,148

Year # 8, 16, 24, 32, 40, 48

	Cost	Contingency	Total
Sand 650,400 cy @ $4.85/cy	$3,154,440	$473,166	$3,627,606
Mob and Demob	$419,984	$50,398	$470,382
Subtotal	**$3,574,424**	**$523,564**	**$4,097,988**
E&D (includes monitoring)	$429,600	$64,440	$494,040
Construction Management	$175,000	$26,250	$201,250
TOTAL	$4,179,024	$614,254	$4,793,278

Year # 28

	Cost	Contingency	Total
Sand 650,400 cy @ $4.85/cy	$3,154,440	$473,166	$3,627,606
Mob and Demob	$419,984	$50,398	$470,382
Subtotal	**$3,574,424**	**$523,564**	**$4,097,988**
E&D (includes monitoring)	$458,400	$68,760	$527,160
Construction Management	$175,000	$26,250	$201,250
TOTAL	$4,207,824	$618,574	$4,826,398

Year # 1

	Cost	Contingency	Total
E&D (includes monitoring)	$26,200	$3,930	$30,130
TOTAL	$26,200	$3,930	$30,130

Year # 2, 3, 5, 6, 7, 9, 10, 11, 13, 14, 15, 17, 18, 19, 21, 22, 23, 25, 26, 27, 29,30, 31, 33, 34, 35, 37, 38, 39, 41, 42, 43, 45, 46, 47, 49, 50

	Cost	Contingency	Total
E&D (includes monitoring)	$16,600	$2,490	$19,090
TOTAL	$16,600	$2,490	$19,090

A DESCRIPTION AND QUANTITY SUMMARY

1 PROJECT	Lower Cape May Meadows & Cape May Point	DATE OF ESTIMATE	October 1997
2 LOCATION	New Jersey	INVIT. OR CONTR. NO.	Feasibility
3 ESTIMATED BY	S. Johnson	CHECKED BY	
4 TYPE OF DREDGE	User 27" Cutter-Suction Dredge	TYPE OF ESTIMATE	Planning Estimate

5 DESCRIPTION OF WORK

6 EXCAVATION			REMARKS
A. REQUIRED		1,724,400 CY	6,934,752 s.f. of Dredging Area
B. PAY OVERDEPTH	+	0 CY	
C. MAX. PAY YARDAGE	=	1,724,400 CY	(YARDAGE USED ON BID FORM)
D. O.D. NOT DREDGED	-	0 CY	
E. NET PAY YARDAGE	=	1,724,400 CY	(YARDAGE USED TO FIGURE UNIT PRICE PER C.Y.)
F. NON-PAY YARDAGE	+	523,700 CY	2.0 ft overdig
G. GROSS YARDAGE	=	2,248,100 CY	(YARDAGE USED TO FIGURE PRODUCTION TIME & COST)

B DREDGING COST BID ITEM # ~~~~~~~~~~~~

				REMARKS
1 GROSS YARDAGE			2,248,100 CY	FROM SHEET A, ITEM 6 G.
2 PRODUCTION RATE		/	559,360 CY/MO	FROM SHEET C, ITEM 8.
3 DREDGING TIME		=	4.02 MONTHS	
4 TOTAL MONTHLY COST		x	$1,227,936	FROM SHEET D, ITEM 5.
SUBTOTAL.....		=	$4,936,303	
5 FIXED COSTS		+	$0	FROM SHEET E, ITEM 15.
SUBTOTAL.....		=	$4,936,303	
6 OVERHEAD	12.0%	+	$592,356	
SUBTOTAL.....		=	$5,528,659	
7 PROFIT	10.0%	+	$552,866	
SUBTOTAL.....		=	$6,081,525	
8 BOND	1.3%	+	$79,060	
9 GROSS PRODUCTION COSTS		=	$6,160,585	
10 NET PAY YARDAGE		/	1,724,400 CY	FROM SHEET A, ITEM 6 E.
11 UNIT COST		=	$3.57 /CY	
12 MAX PAY YARDAGE		x	1,724,400 CY	FROM SHEET A, ITEM 6 C.
13 DREDGING COST		=	$6,156,108	

C MONTHLY PRODUCTION SUMMARY BID ITEM # _____

			REMARKS
1 SIZE OF DREDGE....PIPELINE.....>		User 27"	
2 POWER OUTPUT.....MAIN PUMP.....>		5,000 HP	
3 NUMBER OF BOOSTERS IN LINE.....>		1	
4 POWER OUTPUT.....EACH BOOSTER.....>		4,000 HP	
5 PUMPING DISTANCES			
A. MAXIMUM PIPELINE NEEDED.....>		20,920 LF	
B. AVERAGE PIPELINE.....>		14,500 LF	
C. EQUIVALENT ADDITIONAL PIPELINE	+	1,450 LF	
D. PRODUCTION BASED ON	=	15,950 LF	
6 GROSS PRODUCTION		1216 CY/HR	SEE SHEET C \ 1, ITEM 4 F.
7 OPERATING TIME	x	460 HRS/MO	SEE SHEET C \ 1, ITEM 5 E.
			(460 Operating Hrs per Mo / 730 Hrs per Mo of Dredging = 63.0% Effective Time)
8 PRODUCTION RATE	=	559,360 CY/MO	1,724,400 Net Pay CY / 4.02 MO = 428,955 Pay CY/MO

GROSS PRODUCTION

C \ 1 BID ITEM # ~~~~~~~~~~~~

OPERATING TIME

			REMARKS
1 SIZE OF DREDGE....PIPELINE.....>		User 27"	
2 POWER OUTPUT.....MAIN PUMP.....>		5,000 HP	
3 NUMBER OF BOOSTERS IN LINE		1	Each Booster is 4000 Horsepower.
4 PRODUCTION.....(BASED ON).....>		15,950 LF	FROM SHEET C \ 2, ITEM 13.
A. ADJUSTED CHART PRODUCTION		1,350 CY/HR	FROM SHEET C \ 2, ITEM 14.
B. MATERIAL FACTOR	x	0.90	FROM SHEET C \ 3, ITEM 1 B.
C. BANK FACTOR	x	1.10	FROM SHEET C \ 3, ITEM 2 D.
D. OTHER FACTOR	x	1.00	Wave Action
E. CLEANUP FACTOR	x	0.91	10% ADDITIONAL DREDGING TIME
F. GROSS PRODUCTION	=	1,216 CY/HR	

			REMARKS
5 OPERATING TIME:			
A. BOOSTER FACTOR		0.90	10% LOSS IN PUMPING TIME PER BOOSTER
B. TIME EFFICIENCY	x	70.0%	% OF EFFECTIVE WORKING TIME WITHOUT BOOSTERS
C. NET EFFICIENCY	=	63.0%	% OF EFFECTIVE WORKING TIME INCLUDING BOOSTER LOSSES
D. MAX DREDGE TIME	x	730 HRS/MO	
E. OPERATING TIME	=	460 HRS/MO	

C \ 2 ADJUSTED CHART PRODUCTION BID ITEM #

		REMARKS
1 SIZE OF DREDGE....PIPELINE.....>	User 27"	
2 CHART HORSEPOWER.....>	5,000 HP	
3 STANDARD PRODUCTION CHART:		
STANDARD DREDGE PRODUCTION BASED ON CHART HORSEPOWER		
UP TO 6,875 L.F. OF PIPE	1500 CY/HR	
AT 13,750 L.F. OF PIPE	980 CY/HR	
AT 19,375 L.F. OF PIPE	420 CY/HR	
4 POWER OUTPUT....USED FOR DREDGE....>	5,000 HP	Chart Adjustment Factor = (Available Dredge Horsepower +
5 NUMBER OF BOOSTERS USED.....>	1	Number of Boosters x Booster H.P.) / Chart H.P.
6 POWER OUTPUT.....EACH BOOSTER.....>	4,000 HP	
7 TOTAL POWER APPLIED TO PIPELINE....>	9,000 HP	= (5000 H.P. + 1 Booster(s) x 4000 HP/Booster)
8 CHART ADJUSTMENT FACTOR (C.A.F)....>	1.80	= (9000 HP / 5000 HP)
9 ADJUSTED PRODUCTION CHART:		
ADJUSTED DREDGE PRODUCTION CHART BASED ON C.A.F.		
UP TO 12,375 L.F. OF PIPE	1500 CY/HR	
AT 24,750 L.F. OF PIPE	980 CY/HR	
AT 34,875 L.F. OF PIPE	420 CY/HR	
10 MAXIMUM LINE LENGTH.....>	20,920 LF	
11 AVERAGE LINE LENGTH.....>	14,500 LF	Actual Pipeline
12 EQUIVALENT ADDITIONAL PIPELINE +	1,450 LF	Vertical Lift of Discharge Pipe.
13 PIPE USED FOR PRODUCTION =	15,950 LF	Actual Pipeline + Equivalent Feet of Pipe
14 ADJUSTED CHART PRODUCTION	1,350 CY/HR	Interpolated from Chart

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MATERIAL FACTOR CALCULATION

C \ 3 BID ITEM #

BANK FACTOR CALCULATION ~~~~~~~~~~~~

****

1 MATERIAL FACTOR COMPUTATION:

A. MATERIAL FACTOR CHART:

DESCRIPTION	INPLACE DENSITY		FACTOR	%	QUANTITIES
MUD & SILT	1200	GR/L	3	0%	0 c.y.
MUD & SILT	1300	GR/L	2.5	0%	0 c.y.
MUD & SILT	1400	GR/L	2	0%	0 c.y.
LOOSE SAND	1700	GR/L	1.1	0%	0 c.y.
LOOSE SAND	1900	GR/L	1	0%	0 c.y.
COMP. SAND	2000	GR/L	0.9	100%	2,248,100 c.y.
STIFF CLAY	2000	GR/L	0.6	0%	0 c.y.
COMP. SHELL	2300	GR/L	0.5	0%	0 c.y.
SOFT ROCK	2400	GR/L	0.4	0%	0 c.y.
BLAST. ROCK	2000	GR/L	0.25	0%	0 c.y.

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B. MATERIAL FACTOR.....> 0.90 100% 2,248,100 c.y. (Computed from Chart)

****

REMARKS

2 BANK FACTOR COMPUTATION:

A. SIZE OF DREDGE....PIPELINE.....> User 27"

B. AVERAGE BANK HEIGHT.....> 8.73881 FT

C. BANK FACTOR CHART:

BANK HEIGHT	1	2	3	4	5	6	7	8	9
FACTOR	NA	0.43	0.55	0.65	0.78	0.9	1	1.1	1.1

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D. BANK FACTOR.....> 1.10 Interpolated from chart

>

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D MONTHLY COST SUMMARY BID ITEM #

DREDGE SIZE User 27"

			REMARKS		
1 LABOR COSTS		$348,435 /MO	FROM SHEET D \ 1		
2 EQUIPMENT COSTS			FROM SHEET D \ 2		
A. DREDGE	+	$488,859 /MO	1 EA	@	$488,859 /MO
B. WORK TUG(S)	+	$41,794 /MO	2 EA	@	$20,897 /MO
C. CREW/SURVEY TUG	+	$5,304 /MO	1 EA	@	$5,304 /MO
D. DERRICK(S)	+	$17,746 /MO	2 EA	@	$8,873 /MO
E. FUEL/WATER BARGE	+	$1,666 /MO	1 EA	@	$1,666 /MO
F. WORK BARGE	+	$4,880 /MO	2 EA	@	$2,440 /MO
H. BOOSTER(S)	+	$118,029 /MO	1 EA	@	$118,029 /MO
G. ***Unused***	+	$0 /MO	0 EA	@	$0 /MO
3 PIPELINE COSTS BASED ON PUMPING SAND			20,920 LF (ON JOB) - RATES TAKEN FROM SHEET D \ 3		
A. (1) FLOATING PIPE (AVERAGE)	+	$23,420 /MO	2,000 LF	@	$11.71 /MO
(2) FLOATING PIPE (REMAINING)	+	$0 /MO	0 LF	@	$0.011 /HR X 730 HRS/MO
B. (1) SUBMERGED PIPE (AVERAGE)	+	$21,002 /MO	3,911 LF	@	$5.37 /MO
(2) SUBMERGED PIPE (REMAINING)	+	$5,866 /MO	2,009 LF	@	$0.004 /HR X 730 HRS/MO
C. (1) SHORE PIPE (AVERAGE)	+	$16,663 /MO	8,589 LF	@	$1.94 /MO
(2) SHORE PIPE (REMAINING)	+	$3,220 /MO	4,411 LF	@	$0.001 /HR X 730 HRS/MO
4 OTHER MONTHLY COSTS	+	$131,052 /MO	FROM SHEET D \ 4		
5 TOTAL MONTHLY COST	=	$1,227,936			

D \ 1 LABOR COSTS

BID ITEM #

DREDGE SIZE: User 27"

Overtime(Pay 64 Hrs/Wk)		14.29%
Holidays/Yr	9	2.47%
Vacation		8.00%
COMPOSITE.....		24.76%

Management....		
1	CAPTAIN	$6,000
1	CHIEF ENG	5,000
1	CIVIL ENG	4,500
1	OFFICE HELP	2,000
MONTHLY MANAGEMENT COST.....		$17,500

Social Security Tax	7.65%
Workman's Compensation	11.60%
State Unemployment Comp.	6.50%
Federal Unemployment Comp.	0.80%
COMPOSITE.....	26.55%

Each Crew Position is Manned: 8 Hrs per Day
x 7 Days per Week
= 56 Hrs per Week
x 4.345 Wks per Month
= 243 Hrs per Month

Last Update...Apr 97

EA	CREW POSITION	BASIC HOURLY WAGE		O.T. VACATION & HOLIDAY 24.76%		SUB-TOTAL		TAXES INSUR 26.55%		SUB-TOTAL		FRINGE BENEFITS $4.49		HRLY COST		HOURS PER MONTH		MONTHLY COST
3	LEVERMAN	$23.15	+	$5.73	=	$28.88	+	$7.67	=	$36.55	+	$4.81	=	$41.36	x	730	=	$30,193
3	WATCH ENG	21.31	+	5.28	=	26.59	+	7.06	=	33.65	+	4.81	=	38.46	x	730	=	28,076
2	DRDG MATE	19.55	+	4.84	=	24.39	+	6.48	=	30.87	+	4.51	=	35.38	x	487	=	17,230
2	TUG MASTER	20.71	+	5.13	=	25.84	+	6.86	=	32.70	+	4.51	=	37.21	x	487	=	18,121
3	LAUNCHMAN	16.05	+	3.97	=	20.02	+	5.32	=	25.34	+	4.21	=	29.55	x	730	=	21,572
0	MAINT ENG	20.94	+	5.18	=	26.12	+	6.93	=	33.05	+	4.51	=	37.56	x	0	=	0
3	EQUIP OPER	20.43	+	5.06	=	25.49	+	6.77	=	32.26	+	4.51	=	36.77	x	730	=	26,842
1	WELDER	21.66	+	5.36	=	27.02	+	7.17	=	34.19	+	4.51	=	38.70	x	243	=	9,404
1	OILER	16.67	+	4.13	=	20.80	+	5.52	=	26.32	+	4.21	=	30.53	x	243	=	7,419
9	DECKHAND	16.05	+	3.97	=	20.02	+	5.32	=	25.34	+	4.21	=	29.55	x	2190	=	64,715
1	ELECTRICIAN	20.77	+	5.14	=	25.91	+	6.88	=	32.79	+	4.81	=	37.60	x	243	=	9,137
1	G DUMP FRMN	21.00	+	5.20	=	26.20	+	6.96	=	33.16	+	4.81	=	37.97	x	243	=	9,227
2	DUMP FOREMN	19.51	+	4.83	=	24.34	+	6.46	=	30.80	+	4.81	=	35.61	x	487	=	17,342
6	SHOREMAN	16.05	+	3.97	=	20.02	+	5.32	=	25.34	+	4.51	=	29.85	x	1460	=	43,581
3	BOOSTER ENG	21.31	+	5.28	=	26.59	+	7.06	=	33.65	+	4.81	=	38.46	x	730	=	28,076

40 Total Crew

MONTHLY CREW LABOR COST = $330,935

(Average Gross Wage = $34.00 per manhour)

TOTAL MONTHLY LABOR COST = $348,435

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D \ 2 EQUIPMENT COSTS BID ITEM # ____________

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DREDGE SIZE User 27"

	--DREDGE--	----TUGS & TENDERS-----		--------------BARGES--------------			--BOOSTER--	---OTHER---
1a. Plant Description......	HYDRAULIC	WORK TUG	CREW/SURVEY	DERRICK	FUEL/WATER	WORK	FLOATING	***Unused***
1c. Prime Eng HP...........	5,000	250	100	200	0	0	4,000	0
1d. (1) Dredge El Gen HP...	830	--	--	--	--	--	--	--
1d. Total 2nd Eng HP.......	3,310	50	40	40	10	0	200	0
1e. Plant Value...........	$10,000,000	$327,000	$48,000	$300,000	$122,000	$100,000	$1,896,000	$0
1f. Acquis Year...........	1978	1991	1991	1985	1985	1985	1980	0
1g. Pres Year.............	1995	- - - - ->-	- - - - - ->-	- - - - - ->-	- - - - - ->-	- - - - - ->-	- - - - - ->-	- - - - - ->
1h. Cost of Money Rate.....	8.125%-	- - - - ->-	- - - - - ->-	- - - - - ->-	- - - - - ->-	- - - - - ->-	- - - - - ->-	- - - - - ->
1i. Disc Money Rate:	6.500%-	- - - - ->-	- - - - - ->-	- - - - - ->-	- - - - - ->-	- - - - - ->-	- - - - - ->-	- - - - - ->
1j. Hrs Worked/Mo..........	460	- - - - ->-	- - - - - ->-	- - - - - ->-	- - - - - ->-	- - - - - ->-	- - - - - ->-	- - - - - ->
2a. LAF....................	0.970	- - - - ->-	- - - - - ->-	- - - - - ->-	- - - - - ->-	- - - - - ->-	- - - - - ->-	- - - - - ->
2b. Fuel Cost per Gal......	$0.85	- - - - ->-	- - - - - ->-	- - - - - ->-	- - - - - ->-	- - - - - ->-	- - - - - ->-	- - - - - ->
3a. Ec Index <for Acq Yr>..	2352	4438	4438	3749	3749	3749	2922	0
3b. Ec Index <for 1995>....	5023	- - - - ->-	- - - - - ->-	- - - - - ->-	- - - - - ->-	- - - - - ->-	- - - - - ->-	- - - - - ->
4a. Mos Available/Year.....	9	- - - - ->-	- - - - - ->-	- - - - - ->-	- - - - - ->-	- - - - - ->-	- - - - - ->-	- - - - - ->
5a. Useful Life (in Yrs)...	14	8	8	9.36	20	9.36	30	0
5b. Physical Life (in Hrs).	60,000	16,000	16,000	40,000	90,000	40,000	135,000	0
5c. SLV Factor............	0.10	0.10	0.10	0.10	0.05	0.05	0.10	0.00
5d. Pr Eng Fuel Factor.....	0.045	0.045	0.045	0.011	0.011	0.011	0.045	0
5e. 2nd Eng Fuel Factor....	0.039	0.039	0.039	0.011	0.011	0.011	0.039	0
5f. WLS Factor............	0.22	0.38	0.38	0.20	0.20	0.20	0.24	0.00
5g. RPR Factor............	1.30	0.80	0.80	0.70	0.60	0.60	1.20	0.00
6a. Depreciation:	6.43%	11.25%	11.25%	9.62%	4.75%	10.15%	3.00%	0.00%
6b. FCCM:	3.78%	3.94%	3.94%	3.89%	3.57%	3.74%	3.67%	0.00%
6c. Total Ownership/Year:	10.21%	15.19%	15.19%	13.51%	8.32%	13.89%	6.67%	0.00%
7a. Yearly Ownership:	$1,021,000	$49,671	$7,291	$40,530	$10,150	$13,890	$126,463	$0
7b. Monthly Ownership:	$113,444	$5,519	$810	$4,503	$1,128	$1,543	$14,051	$0
8a. (1) Hrly Pr Eng Fuel:	$191.25	$9.56	$3.83	$1.87	$0.00	$0.00	$153.00	$0.00
8a. (2) Hrly 2nd Eng Fuel:	$109.73	$1.66	$1.33	$0.37	$0.09	$0.00	$6.63	$0.00
8b. (1) Hrly Pr Eng WLS:	$42.08	$3.63	$1.46	$0.37	$0.00	$0.00	$36.72	$0.00
8b. (2) Hrly 2nd Eng WLS:	$24.14	$0.63	$0.51	$0.07	$0.02	$0.00	$1.59	$0.00
8c. (1) EAF:	2.136	1.132	1.132	1.340	1.340	1.340	1.719	0.000
8c. (2) Hrly Repair:	$448.92	$17.95	$2.64	$6.82	$1.06	$1.95	$28.10	$0.00
8d. Total Hrly Operating:	$816.12	$33.43	$9.77	$9.50	$1.17	$1.95	$226.04	$0.00
8e. Monthly Operating:	$375,415	$15,378	$4,494	$4,370	$538	$897	$103,978	$0
11. MONTHLY RATE:	$488,859	$20,897	$5,304	$8,873	$1,666	$2,440	$118,029	$0
12a. HRLY STANDBY ALLOW:	$155.40	$7.56	$1.11	$6.17	$1.55	$2.11	$19.25	$0.00
12b. Gener Fuel Allowance:	$27.52	--	--	--	--	--	--	--
12c. DREDGE HOURLY STANDBY:	$182.92	--	--	--	--	--	--	--

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D \ 3 PIPELINE COSTS BID ITEM # ~~~~~~~~~~~~

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PIPELINE SIZE: User 27" MATERIAL PUMPED: SAND

	|--------FLOATING PIPELINE---------|		|--SUBMERGED PIPELINE--|	|-SHOREPIPE-|
1a. Plant Description.....	Pipeline	Joints	Pontoons	Pipeline	Joints	Pipeline
Quantity.....>	100	1	2	400	1	40
Fixed Units Per Item..>	LF	Set	Each	LF	Set	LF
Unit Price.....>	$50.00	$12,000.00	$7,000.00	$50.00	$12,000.00	$25.00
1e. Plant Value:	$5,000.00	$12,000.00	$14,000.00	$20,000.00	$12,000.00	$1,000.00
1f. Acquis Year.....	1992	1992	1992	1992	1992	1992
1g. Pres Year.....	1995	- - - - ->-	- - - - ->-	- - - - ->-	- - - - ->-	- - - - ->-
1h. Cost of Money Rate.....	8.125%-	- - - - ->-	- - - - ->-	- - - - ->-	- - - - ->-	- - - - ->-
1i. Disc Money Rate:	6.500%-	- - - - ->-	- - - - ->-	- - - - ->-	- - - - ->-	- - - - ->-
1j. Hrs Worked/Mo.....	460	- - - - ->-	- - - - ->-	- - - - ->-	- - - - ->-	- - - - ->-
2a. LAF.....	0.970	- - - - ->-	- - - - ->-	- - - - ->-	- - - - ->-	- - - - ->-
3a. Ec Index <for Acq Yr>..	4611	4611	4611	4611	4611	4611
3b. Ec Index <for 1995>....	5023	- - - - ->-	- - - - ->-	- - - - ->-	- - - - ->-	- - - - ->-
4a. Mos Available/Year.....	9	- - - - ->-	- - - - ->-	- - - - ->-	- - - - ->-	- - - - ->-
5a. Useful Life (in Yrs)...	1.5	3.0	12.0	1.5	3.0	1.5
5b. Physical Life (in Hrs).	6,000	12,000	60,000	6,000	12,000	6,000
5c. SLV Factor.....	0.10	0.10	0.10	0.10	0.10	0.10
5g. RPR Factor.....	0.05	0.30	0.05	0.05	0.30	0.05
6a. Depreciation:	60.00%	30.00%	7.50%	60.00%	30.00%	60.00%
6b. FCCM:	5.53%	4.55%	3.82%	5.53%	4.55%	5.53%
6c. Total Ownership/Year:	65.53%	34.55%	11.32%	65.53%	34.55%	65.53%
7a. Yearly Ownership:	$3,276.50	$4,146.00	$1,584.80	$13,106.00	$4,146.00	$655.30
7b. Monthly Ownership:	$364.06	$460.67	$176.09	$1,456.22	$460.67	$72.81
8c. (1) EAF:	1.089	1.089	1.089	1.089	1.089	1.089
8c. (2) Hrly Repair:	$0.04	$0.32	$0.01	$0.18	$0.32	$0.01
8e. Monthly Operating:	$18.40	$147.20	$4.60	$82.80	$147.20	$4.60
11. Monthly Rate (EA Item):	$382.46	$607.87	$180.69	$1,539.02	$607.87	$77.41
Monthly Rate Per Section (Sum Of Items):			$1,171.02		$2,146.89	$77.41
/ Section Length (In Linear Feet):			100		400	40
			==========		==========	==========
MONTHLY RATES PER LF OF PIPELINE:			$11.71		$5.37	$1.94
5a. Useful Life (in Yrs)...	3.0	3.0	12.0	3.0	3.0	1.5
6a. Depreciation:	30.00%	30.00%	7.50%	30.00%	30.00%	30.00%
6b. FCCM:	4.55%	4.55%	3.82%	4.55%	4.55%	4.55%
6c. Total Ownership/Year:	34.55%	34.55%	11.32%	34.55%	34.55%	34.55%
7a. Yearly Ownership:	$1,727.50	$4,146.00	$1,584.80	$6,910.00	$4,146.00	$345.50
7b. Monthly Ownership:	$191.94	$460.67	$176.09	$767.78	$460.67	$38.39
12a. HRLY STANDBY ALLOW:	$0.263	$0.631	$0.241	$1.052	$0.631	$0.053
Hrly Standby Rate Per Section (Sum Of Items):			$1.135		$1.683	$0.053
/ Section Length (In Linear Feet):			100		400	40
			==========		==========	==========
HOURLY STANDBY RATES PER LF OF PIPELINE:			$0.011		$0.004	$0.001

D \ 4 OTHER MONTHLY COSTS BID ITEM #

DREDGE SIZE User 27"

			REMARKS
1	Constr./Maint.-Beach Rehandling w/Du	$131,052 /MO	
2		+ /MO	
3	>	+ $0 /MO	
4	>	+ $0 /MO	
5	>	+ $0 /MO	
6	>	+ $0 /MO	
7	>	+ $0 /MO	
8	>	+ $0 /MO	
9	>	+ $0 /MO	
10	>	+ $0 /MO	
11	>	+ $0 /MO	
12	>	+ $0 /MO	
13	>	+ $0 /MO	
14	>	+ $0 /MO	
15	TOTAL OTHER MONTHLY COSTS	= $131,052 /MO	

	E	FIXED COSTS	BID ITEM # ~~~~~~~~~~~~
DREDGE SIZE	User 27"		
			REMARKS
1	0	$0	
2 >	+	$0	
3 >	+	$0	
4 >	+	$0	
5 >	+	$0	
6 >	+	$0	
7 >	+	$0	
8 >	+	$0	
9 >	+	$0	
10 >	+	$0	
11 >	+	$0	
12 >	+	$0	
13 >	+	$0	
14 >	+	$0	
15 FIXED COSTS	=	$0	

M MOB & DEMOB BID ITEM

DREDGE SIZE User 27"

	MOBILIZATION # DAYS		$/DAY		TOTAL	DEMOBILIZATION # DAYS		$/DAY		TOTAL
1. PREPARE DREDGE FOR TRANSFER	4	x	$12,091	=	$48,365	3	x	$12,638	=	$37,913
2. PREPARE PIPELINE FOR TRANSFER	4	x	$7,441	=	$29,764	3	x	$7,698	=	$23,095
3. TRANSFER ALL PLANT 20 MILES @ 50 miles/day =	0.4	x	$32,966	=	$13,187	20 MILES 0.4	x	$32,966	=	$13,187
4. PERMANENT PERSONNEL & MISC.	L.S.			=	$1,191	L.S.			=	$0
5. PREPARE DREDGE AFTER TRANSFER	4	x	$12,638	=	$50,551	3	x	$12,091	=	$36,274
6. PREPARE PIPELINE AFTER TRANSFER	4	x	$7,698	=	$30,793	3	x	$7,441	=	$22,323
7. OTHER	Pipe Ramp			=	$11,044	0			=	$0
	SUBTOTAL MOBILIZATION				$184,895	SUBTOTAL DEMOBILIZATION				$132,791

REMARKS

8. SUBTOTAL MOBILIZATION & DEMOBILIZATION		=	$317,686
9. OVERHEAD	12.0%	+	$38,122
SUBTOTAL.....		=	$355,808
10. PROFIT	10.0%	+	$35,581
SUBTOTAL.....		=	$391,389
11. BOND	1.3%	+	$5,088
12. TOTAL MOBILIZATION & DEMOBILIZATION		=	$396,477

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M \ 1 MOB & DEMOB BID ITEM

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DREDGE SIZE User 27"

1. PREPARE DREDGE FOR TRANSFER				MOBILIZATION	DEMOBILIZATION
Labor:	17 men	@	8 hrs/day @ $34.00 per hour =	$4,624	$4,624
Equipment:		Dredge	$182.92 /hr (Standby)		
		Booster(s)	$19.25 /hr (Standby)		
			$202.17 /hr x 24 hrs per day =	$4,852	$4,852
Support equipment with operators				$2,415	$2,415
Supplies & small tools				$200	$200
Additional Fuel (plant idle)				$0	$0
Subsistence:		17 men @	$32.15 per day =	----	$547
			COST PER DAY	$12,091	$12,638

2. PREPARE PIPELINE FOR TRANSFER				MOBILIZATION	DEMOBILIZATION
Labor:	8 men	@	8 hrs/day @ $34.00 per hour =	$2,176	$2,176
Equipment:		Work Tug	$90.86 /hr		
		Crew Tug	$11.53 /hr		
		Derrick(s)	$38.58 /hr		
		Fuel Barge	$3.62 /hr		
		Work Barge	$10.61 /hr		
			$155.20 /hr x 8 hrs per day =	$1,242	$1,242
		Pipeline	$58.68 /hr (Standby) x 24 hrs per day =	$1,408	$1,408
Support equipment with operators				$2,415	$2,415
Supplies & small tools				$200	$200
Subsistence		8 men @	$32.15 per day =	----	$257
			COST PER DAY	$7,441	$7,698

****

M \ 2 MOB & DEMOB BID ITEM

****

DREDGE SIZE User 27"

3. TRANSFER PLANT			MOBILIZATION	DEMOBILIZATION
Labor:	12 men/shift (2-12 hr shifts) @	$34.00 per manhour =	$9,792	$9,792
Equipment:	Work Tug(s)	$90.86 /hr		
	Dredge	$182.92 /hr (Standby)		
	Booster(s)	$19.25 /hr (Standby)		
	Crew Tug	$1.11 /hr (Standby)		
	Derrick(s)	$12.34 /hr (Standby)		
	Fuel Barge	$1.55 /hr (Standby)		
	Work Barge	$4.22 /hr (Standby)		
	Unused	$0.00 /hr (Standby)		
	Pipeline	$58.68 /hr (Standby)		
		$370.93 /hr x 24 hrs per day =	$8,902	$8,902
Subsistence	24 men @	$32.15 per day =	$772	$772
Towing vessel(s):	4000 H.P. Rental Tug @			
	$9,000 per day (towing)			
	$4,500 per day (return to port)			
	$13,500 per day x 1 towing vessel(s) =		$13,500	$13,500
		COST PER DAY	$32,966	$32,966

4. PERMANENT PERSONNEL & MISC.			MOBILIZATION	DEMOBILIZATION
3 men @	8 hrs/day @	$34.00 per hour @ 1 DAY	$816	$816
Travel Expenses	$125 per man		$375	$375
Local hire			$0	----
		TOTAL	$1,191	$1,191

****

M \ 3 MOB & DEMOB BID ITEM

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DREDGE SIZE User 27"

5. PREPARE DREDGE AFTER TRANSFER

				MOBILIZATION	DEMOBILIZATION
Labor:	17 men @	8 hrs/day @	$34.00 per hour =	$4,624	$4,624
Equipment:	Dredge	$182.92 /hr (Standby)			
	Booster(s)	$19.25 /hr (Standby)			
		$202.17 /hr x 24 hrs per day =		$4,852	$4,852
Support equipment with operators				$2,415	$2,415
Supplies & small tools				$200	$200
Additional Fuel (plant idle)				$0	$0
Subsistence	17 men @	$32.15 per day =		$547	----
			COST PER DAY	$12,638	$12,091

6. PREPARE PIPELINE AFTER TRANSFER

Labor:	8 men @	8 hrs/day @	$34.00 per hour =	$2,176	$2,176
Equipment:	Work Tug	$90.86 /hr			
	Crew Tug	$11.53 /hr			
	Derrick(s)	$38.58 /hr			
	Fuel Barge	$3.62 /hr			
	Work Barge	$10.61 /hr			
		$155.20 /hr x 8 hrs per day =		$1,242	$1,242
	Pipeline	$58.68 /hr (Standby) x 24 hrs per day =		$1,408	$1,408
Support equipment with operators				$2,415	$2,415
Supplies & small tools				$200	$200
Subsistence	8 men @	$32.15 per day =		$257	----
			COST PER DAY	$7,698	$7,441

M \ 4 MOB & DEMOB BID ITEM

DREDGE SIZE User 27"

			REMARKS
1 EQUIPMENT COSTS - WORKING RATES			RATES TAKEN FROM SHEET D
A. WORK TUG(S)		$90.86 /HR	$41,794 /MO DIVIDED BY 460 HRS/MO
B. CREW/SURVEY TUG		$11.53 /HR	$5,304 /MO DIVIDED BY 460 HRS/MO
C. DERRICK(S)		$38.58 /HR	$17,746 /MO DIVIDED BY 460 HRS/MO
D. FUEL/WATER BARGE		$3.62 /HR	$1,666 /MO DIVIDED BY 460 HRS/MO
E. WORK BARGE		$10.61 /HR	$4,880 /MO DIVIDED BY 460 HRS/MO
2 LABOR COSTS		$34.00 /MHR	FROM SHEET D \ 1
3 EQUIPMENT COSTS - STANDBY RATES			RATES TAKEN FROM SHEET D \ 2
A. DREDGE		$182.92 /HR	1 EA @ $182.92 /HR
B. BOOSTER(S)		$19.25 /HR	1 EA @ $ 19.25 /HR
C. CREW/SURVEY TUG		$1.11 /HR	1 EA @ $ 1.11 /HR
D. DERRICK(S)		$12.34 /HR	2 EA @ $ 6.17 /HR
E. FUEL/WATER BARGE		$1.55 /HR	1 EA @ $ 1.55 /HR
F. WORK BARGE		$4.22 /HR	2 EA @ $ 2.11 /HR
G. ***Unused***		$0.00 /HR	0 EA @ $ 0.00 /HR
3 PIPELINE COSTS - STANDBY RATES			RATES TAKEN FROM SHEET D \ 3
A. FLOATING PIPELINE		$22.00 /HR	2,000 LF @ $0.011 /HR
B. SUBMERGED PIPELINE	+	$23.68 /HR	5,920 LF @ $0.004 /HR
C. SHORELINE	+	$13.00 /HR	13,000 LF @ $0.001 /HR
D. TOTAL PIPELINE COSTS	=	$58.68 /HR	20,920 LF (ON JOB)

MOBIL & DEMOB COST: $396,477

Lower Cape May Meadows & Cape May Poi

CHECKLIST FOR INPUT DATA.

BID QUANTITY 1,724,400 C.Y.
UNIT COST... $3.57 PER C.Y.
EXCAV. COST. $6,156,108
TIME..... 4.02 MONTHS

PG 1 OF 9: PROJECT TITLES

FILENAME - MDWS_123D @ P1 = 199A
PROJECT - Lower Cape May Meadows & Cape May
LOCATION - New Jersey
INVIT # - Feasibility
DATE OF EST. - October 1997
EST. BY - S. Johnson
MOB. BID ITEM # -
EXCAV. BID ITEM # -

PG 1a OF 9: LOCAL AREA FACTORS

PRESENT YEAR - 1995
ECONOMIC INDEX - 5023
LAF - 0.970
INTEREST RATE - 8.125% /yr
TIME PERIOD - January to June, 1995
PIPELINE AVAILABILITY - 9 mos/yr
BUCKET AVAILABILITY - 10 mos/yr
HOPPER AVAILABILITY - 10 mos/yr
FUEL PRICE - $0.85 /gal

PG 2 OF 9: TYPE OF EST & INDIRECT COSTS

TYPE OF EST. - Planning Estimate
CONTRACTOR'S O.H. - 12.0%
CONTRACTOR'S PROFIT - 10.0%
CONTRACTOR'S BOND - 1.3%

PG 3 OF 9: EXCAVATION QTY'S

DREDGING AREA - 6,934,752 sf
REQ'D EXCAVATION - 1,724,400 cyds
PAY OVERDEPTH - 0 cyds
CONTRACT AMOUNT - 1,724,400 cyds
NOT DREDGED - 0 cyds
NET PAY - 1,724,400 cyds
NONPAY YARDAGE - 523,700 cyds
GROSS YARDAGE - 2,248,100 cyds
NONPAY HEIGHT - 2.0 ft overdig
TOTAL BANK HEIGHT - 8.7 ft

PG 4 OF 9: MATERIAL FACTOR

RESULTANT FACTOR - 0.90

PG 5 OF 9: PIPELINE CONSIDERATIONS

FLOATING - 2,000 ft
SUBMERGED - 5,920 ft
SHORE - 13,000 ft
TOTAL - 20,920 ft
AVE. PIPELINE - 14,500 ft
COST CATEGORY - 2 SAND
EQUIVALENT - 1,450 ft
DESCRIPTION - Vertical Lift of Discharge Pipe.
BASIS OF PRODUCTION - 15,950 Feet (Ave + Equiv)

PG 6 OF 9: PRODUCTION ANALYSIS

BOOSTER(S) - 1
% EWT (NO BOOSTERS) - 70.0% (511 HRS/MO)
BOOSTER FACTOR - 0.90
% EWT (WITH BOOSTERS) - 63.0% (460 HRS/MO)
MAX. POSSIBLE - 33,425 ft
TOTAL HP AVAIL - 9,000 hp

PG 6a OF 9: HP & BOOSTER FACTOR ADJUSTMENTS

AVAIL PUMP HP - 5,000
BOOSTER HP - 4,000 hp(ea)
LOSS PER BOOSTER - 10%

PG 7 OF 9: OTHER PRODUCTION FACTORS

DREDGE SELECTED - Use HYDRAULIC DREDGE
COMPUTED BANK FACTOR - 1.1
BANK FACTOR USED - 1.1 >
OTHER FACTOR - Wave Action
CLEANUP - 10% More Time

PG 8 OF 9: HISTORICAL PRODUCTION OVERRIDES

PRODUCTION OVERRIDE - NO
PRODUCTION - 1,216 cy per hour
OPERATING TIME - 460 hours per month
BASED ON - 1 booster(s)
PRODUCTION (GROSS) - 559,360 cy per month
PRODUCTION (CONTRACT) - 428,955 pay cy per month

PG 9 OF 9: OTHER ADJUSTMENTS

SPECIAL COST/MO (1ST) - $131,052 Constr./Maint.-Beach
SP COST/MO (2ND-14TH) - $0 From Sheet D\4
SPECIAL COST LS (1ST) - $0 0
SP COST LS (2ND-14TH) - $0 From Sheet E

A DESCRIPTION AND QUANTITY SUMMARY

1 PROJECT	Lower Cape May Meadows & Cape May Point	DATE OF ESTIMATE	October 1997
2 LOCATION	New Jersey	INVIT. OR CONTR. NO.	Feasibility
3 ESTIMATED BY	S. Johnson	CHECKED BY	
4 TYPE OF DREDGE	User 27" Cutter-Suction Dredge	TYPE OF ESTIMATE	Planning Estimate

5 DESCRIPTION OF WORK

6 EXCAVATION

			REMARKS
A. REQUIRED		647,400 CY	3,449,952 s.f. of Dredging Area
B. PAY OVERDEPTH	+	0 CY	
C. MAX. PAY YARDAGE	=	647,400 CY	(YARDAGE USED ON BID FORM)
D. O.D. NOT DREDGED	-	0 CY	
E. NET PAY YARDAGE	=	647,400 CY	(YARDAGE USED TO FIGURE UNIT PRICE PER C.Y.)
F. NON-PAY YARDAGE	+	198,300 CY	1.6 ft overdig
G. GROSS YARDAGE	=	845,700 CY	(YARDAGE USED TO FIGURE PRODUCTION TIME & COST)

B DREDGING COST BID ITEM # ~~~~~~~~~~~~

				REMARKS
1 GROSS YARDAGE			845,700 CY	FROM SHEET A, ITEM 6 G.
2 PRODUCTION RATE		/	485,450 CY/MO	FROM SHEET C, ITEM 8.
3 DREDGING TIME		=	1.74 MONTHS	
4 TOTAL MONTHLY COST		x	$1,119,023	FROM SHEET D, ITEM 5.
SUBTOTAL.....		=	$1,947,100	
5 FIXED COSTS		+	$0	FROM SHEET E, ITEM 15.
SUBTOTAL.....		=	$1,947,100	
6 OVERHEAD	12.0%	+	$233,652	
SUBTOTAL.....		=	$2,180,752	
7 PROFIT	10.0%	+	$218,075	
SUBTOTAL.....		=	$2,398,827	
8 BOND	1.3%	+	$31,185	
9 GROSS PRODUCTION COSTS		=	$2,430,012	
10 NET PAY YARDAGE		/	647,400 CY	FROM SHEET A, ITEM 6 E.
11 UNIT COST		=	$3.75 /CY	
12 MAX PAY YARDAGE		x	647,400 CY	FROM SHEET A, ITEM 6 C.
13 DREDGING COST		=	$2,427,750	

C MONTHLY PRODUCTION SUMMARY BID ITEM # ~~~~~~~~~~~~

			REMARKS
1 SIZE OF DREDGE....PIPELINE.....>		User 27"	
2 POWER OUTPUT.....MAIN PUMP.....>		5,000 HP	
3 NUMBER OF BOOSTERS IN LINE.....>		0	
4 POWER OUTPUT.....EACH BOOSTER.....>		4,000 HP	
5 PUMPING DISTANCES			
A. MAXIMUM PIPELINE NEEDED.....>		11,600 LF	
B. AVERAGE PIPELINE.....>		9,900 LF	
C. EQUIVALENT ADDITIONAL PIPELINE	+	990 LF	
D. PRODUCTION BASED ON	=	10,890 LF	
6 GROSS PRODUCTION		950 CY/HR	SEE SHEET C \ 1, ITEM 4 F.
7 OPERATING TIME	x	511 HRS/MO	SEE SHEET C \ 1, ITEM 5 E.
			(511 Operating Hrs per Mo / 730 Hrs per Mo of Dredging = 70.0% Effective Time)
8 PRODUCTION RATE	=	485,450 CY/MO	647,400 Net Pay CY / 1.74 MO = 372,069 Pay CY/MO

GROSS PRODUCTION

C \ 1 BID ITEM # ~~~~~~~~~~~~

OPERATING TIME

			REMARKS
1 SIZE OF DREDGE....PIPELINE.....>		User 27"	
2 POWER OUTPUT.....MAIN PUMP.....>		5,000 HP	
3 NUMBER OF BOOSTERS IN LINE		0	Each Booster is 4000 Horsepower.
4 PRODUCTION.....(BASED ON).....>		10,890 LF	FROM SHEET C \ 2, ITEM 13.
A. ADJUSTED CHART PRODUCTION		1,196 CY/HR	FROM SHEET C \ 2, ITEM 14.
B. MATERIAL FACTOR	x	0.90	FROM SHEET C \ 3, ITEM 1 B.
C. BANK FACTOR	x	0.97	FROM SHEET C \ 3, ITEM 2 D.
D. OTHER FACTOR	x	1.00	Wave Action
E. CLEANUP FACTOR	x	0.91	10% ADDITIONAL DREDGING TIME
F. GROSS PRODUCTION	=	950 CY/HR	

			REMARKS
5 OPERATING TIME:			
A. BOOSTER FACTOR		1.00	10% LOSS IN PUMPING TIME PER BOOSTER
B. TIME EFFICIENCY	x	70.0%	% OF EFFECTIVE WORKING TIME WITHOUT BOOSTERS
C. NET EFFICIENCY	=	70.0%	% OF EFFECTIVE WORKING TIME INCLUDING BOOSTER LOSSES
D. MAX DREDGE TIME	x	730 HRS/MO	
E. OPERATING TIME	=	511 HRS/MO	

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C \ 2 ADJUSTED CHART PRODUCTION BID ITEM # ~~~~~~~~~~~~

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		REMARKS
1 SIZE OF DREDGE....PIPELINE.....>	User 27"	
2 CHART HORSEPOWER.....>	5,000 HP	
3 STANDARD PRODUCTION CHART:		
STANDARD DREDGE PRODUCTION BASED ON CHART HORSEPOWER		
UP TO 6,875 L.F. OF PIPE	1500 CY/HR	
AT 13,750 L.F. OF PIPE	980 CY/HR	
AT 19,375 L.F. OF PIPE	420 CY/HR	
4 POWER OUTPUT....USED FOR DREDGE....>	5,000 HP	Chart Adjustment Factor = (Available Dredge Horsepower +
5 NUMBER OF BOOSTERS USED.....>	0	Number of Boosters x Booster H.P.) / Chart H.P.
6 POWER OUTPUT.....EACH BOOSTER.....>	4,000 HP	
7 TOTAL POWER APPLIED TO PIPELINE....>	5,000 HP	= (5000 H.P. + 0 Booster(s) x 4000 HP/Booster)
8 CHART ADJUSTMENT FACTOR (C.A.F)....>	1.00	= (5000 HP / 5000 HP)
9 ADJUSTED PRODUCTION CHART:		
ADJUSTED DREDGE PRODUCTION CHART BASED ON C.A.F.		
UP TO 6,875 L.F. OF PIPE	1500 CY/HR	
AT 13,750 L.F. OF PIPE	980 CY/HR	
AT 19,375 L.F. OF PIPE	420 CY/HR	
10 MAXIMUM LINE LENGTH.....>	11,600 LF	
11 AVERAGE LINE LENGTH.....>	9,900 LF	Actual Pipeline
12 EQUIVALENT ADDITIONAL PIPELINE +	990 LF	Vertical Lift of Discharge Pipe.
13 PIPE USED FOR PRODUCTION =	10,890 LF	Actual Pipeline + Equivalent Feet of Pipe
14 ADJUSTED CHART PRODUCTION	1,196 CY/HR	Interpolated from Chart

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MATERIAL FACTOR CALCULATION

C \ 3 BID ITEM # ~~~~~~~~~~~~

BANK FACTOR CALCULATION

****

1 MATERIAL FACTOR COMPUTATION:

A. MATERIAL FACTOR CHART:

DESCRIPTION	INPLACE DENSITY		FACTOR	%	QUANTITIES
MUD & SILT	1200	GR/L	3	0%	0 c.y.
MUD & SILT	1300	GR/L	2.5	0%	0 c.y.
MUD & SILT	1400	GR/L	2	0%	0 c.y.
LOOSE SAND	1700	GR/L	1.1	0%	0 c.y.
LOOSE SAND	1900	GR/L	1	0%	0 c.y.
COMP. SAND	2000	GR/L	0.9	100%	845,700 c.y.
STIFF CLAY	2000	GR/L	0.6	0%	0 c.y.
COMP. SHELL	2300	GR/L	0.5	0%	0 c.y.
SOFT ROCK	2400	GR/L	0.4	0%	0 c.y.
BLAST. ROCK	2000	GR/L	0.25	0%	0 c.y.

****

B. MATERIAL FACTOR.....> 0.90 100% 845,700 c.y. (Computed from Chart)

****

REMARKS

2 BANK FACTOR COMPUTATION:

A. SIZE OF DREDGE....PIPELINE.....> User 27"

B. AVERAGE BANK HEIGHT.....> 6.65193 FT

C. BANK FACTOR CHART:

BANK HEIGHT	1	2	3	4	5	6	7	8	9
FACTOR	NA	0.43	0.55	0.65	0.78	0.9	1	1.1	1.1

****

D. BANK FACTOR.....> 0.97 Interpolated from chart

>

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D MONTHLY COST SUMMARY BID ITEM # ~~~~~~~~~~~~

DREDGE SIZE User 27"

						REMARKS
1 LABOR COSTS		$320,359 /MO	FROM SHEET D \ 1			
2 EQUIPMENT COSTS			FROM SHEET D \ 2			
A. DREDGE	+	$530,481 /MO	1 EA	@	$530,481 /MO	
B. WORK TUG(S)	+	$45,204 /MO	2 EA	@	$22,602 /MO	
C. CREW/SURVEY TUG	+	$5,802 /MO	1 EA	@	$5,802 /MO	
D. DERRICK(S)	+	$18,716 /MO	2 EA	@	$9,358 /MO	
E. FUEL/WATER BARGE	+	$1,726 /MO	1 EA	@	$1,726 /MO	
F. WORK BARGE	+	$5,078 /MO	2 EA	@	$2,539 /MO	
H. BOOSTER(S)	+	$0 /MO	0 EA	@	$129,557 /MO	
G. ***Unused***	+	$0 /MO	0 EA	@	$0 /MO	
3 PIPELINE COSTS BASED ON PUMPING SAND			11,600 LF (ON JOB) - RATES TAKEN FROM SHEET D \ 3			
A. (1) FLOATING PIPE (AVERAGE)	+	$23,800 /MO	2,000 LF	@	$11.90 /MO	
(2) FLOATING PIPE (REMAINING)	+	$0 /MO	0 LF	@	$0.011 /HR X 730 HRS/MO	
B. (1) SUBMERGED PIPE (AVERAGE)	+	$27,704 /MO	5,102 LF	@	$5.43 /MO	
(2) SUBMERGED PIPE (REMAINING)	+	$3,206 /MO	1,098 LF	@	$0.004 /HR X 730 HRS/MO	
C. (1) SHORE PIPE (AVERAGE)	+	$5,456 /MO	2,798 LF	@	$1.95 /MO	
(2) SHORE PIPE (REMAINING)	+	$439 /MO	602 LF	@	$0.001 /HR X 730 HRS/MO	
4 OTHER MONTHLY COSTS	+	$131,052 /MO	FROM SHEET D \ 4			
5 TOTAL MONTHLY COST	=	$1,119,023				

D \ 1 LABOR COSTS

BID ITEM #

DREDGE SIZE: User 27"

Overtime(Pay 64 Hrs/Wk)		14.29%
Holidays/Yr	9	2.47%
Vacation		8.00%
COMPOSITE.....		24.76%

Management....		
1	CAPTAIN	$6,000
1	CHIEF ENG	5,000
1	CIVIL ENG	4,500
1	OFFICE HELP	2,000
MONTHLY MANAGEMENT COST.....		$17,500

Social Security Tax	7.65%
Workman's Compensation	11.60%
State Unemployment Comp.	6.50%
Federal Unemployment Comp.	0.80%
COMPOSITE.....	26.55%

Each Crew Position is Manned: 8 Hrs per Day
x 7 Days per Week
= 56 Hrs per Week
x 4.345 Wks per Month
= 243 Hrs per Month

Last Update...Apr 97

EA	CREW POSITION	BASIC HOURLY WAGE		O.T. VACATION & HOLIDAY 24.76%		SUB-TOTAL		TAXES INSUR 26.55%		SUB-TOTAL		FRINGE BENEFITS $4.49		HRLY COST		HOURS PER MONTH		MONTHLY COST
3	LEVERMAN	$23.15	+	$5.73	=	$28.88	+	$7.67	=	$36.55	+	$4.81	=	$41.36	x	730	=	$30,193
3	WATCH ENG	21.31	+	5.28	=	26.59	+	7.06	=	33.65	+	4.81	=	38.46	x	730	=	28,076
2	DRDG MATE	19.55	+	4.84	=	24.39	+	6.48	=	30.87	+	4.51	=	35.38	x	487	=	17,230
2	TUG MASTER	20.71	+	5.13	=	25.84	+	6.86	=	32.70	+	4.51	=	37.21	x	487	=	18,121
3	LAUNCHMAN	16.05	+	3.97	=	20.02	+	5.32	=	25.34	+	4.21	=	29.55	x	730	=	21,572
0	MAINT ENG	20.94	+	5.18	=	26.12	+	6.93	=	33.05	+	4.51	=	37.56	x	0	=	0
3	EQUIP OPER	20.43	+	5.06	=	25.49	+	6.77	=	32.26	+	4.51	=	36.77	x	730	=	26,842
1	WELDER	21.66	+	5.36	=	27.02	+	7.17	=	34.19	+	4.51	=	38.70	x	243	=	9,404
1	OILER	16.67	+	4.13	=	20.80	+	5.52	=	26.32	+	4.21	=	30.53	x	243	=	7,419
9	DECKHAND	16.05	+	3.97	=	20.02	+	5.32	=	25.34	+	4.21	=	29.55	x	2190	=	64,715
1	ELECTRICIAN	20.77	+	5.14	=	25.91	+	6.88	=	32.79	+	4.81	=	37.60	x	243	=	9,137
1	G DUMP FRMN	21.00	+	5.20	=	26.20	+	6.96	=	33.16	+	4.81	=	37.97	x	243	=	9,227
2	DUMP FOREMN	19.51	+	4.83	=	24.34	+	6.46	=	30.80	+	4.81	=	35.61	x	487	=	17,342
6	SHOREMAN	16.05	+	3.97	=	20.02	+	5.32	=	25.34	+	4.51	=	29.85	x	1460	=	43,581
0	BOOSTER ENG	21.31	+	5.28	=	26.59	+	7.06	=	33.65	+	4.81	=	38.46	x	0	=	0

37 Total Crew

MONTHLY CREW LABOR COST = $302,859

(Average Gross Wage = $33.64 per manhour)

TOTAL MONTHLY LABOR COST = $320,359

D \ 2 EQUIPMENT COSTS BID ITEM # _____

DREDGE SIZE User 27"

	|--DREDGE--|	----TUGS & TENDERS-----			----------BARGES----------		|--BOOSTER--|	---OTHER---
1a. Plant Description.....	HYDRAULIC	WORK TUG	CREW/SURVEY	DERRICK	FUEL/WATER	WORK	FLOATING	***Unused***
1c. Prime Eng HP.....	5,000	250	100	200	0	0	4,000	0
1d. (1) Dredge El Gen HP...	830	--	--	--	--	--	--	--
1d. Total 2nd Eng HP.....	3,310	50	40	40	10	0	200	0
1e. Plant Value.....	$10,000,000	$327,000	$48,000	$300,000	$122,000	$100,000	$1,896,000	$0
1f. Acquis Year.....	1978	1991	1991	1985	1985	1985	1980	0
1g. Pres Year.....	1995	- - - - ->-	- - - - ->-	- - - - ->-	- - - - ->-	- - - - ->-	- - - - ->-	- - - - ->-
1h. Cost of Money Rate.....	8.125%	- - - - ->-	- - - - ->-	- - - - ->-	- - - - ->-	- - - - ->-	- - - - ->-	- - - - ->-
1i. Disc Money Rate:	6.500%	- - - - ->-	- - - - ->-	- - - - ->-	- - - - ->-	- - - - ->-	- - - - ->-	- - - - ->-
1j. Hrs Worked/Mo.....	511	- - - - ->-	- - - - ->-	- - - - ->-	- - - - ->-	- - - - ->-	- - - - ->-	- - - - ->-
2a. LAF.....	0.970	- - - - ->-	- - - - ->-	- - - - ->-	- - - - ->-	- - - - ->-	- - - - ->-	- - - - ->-
2b. Fuel Cost per Gal.....	$0.85	- - - - ->-	- - - - ->-	- - - - ->-	- - - - ->-	- - - - ->-	- - - - ->-	- - - - ->-
3a. Ec Index <for Acq Yr>..	2352	4438	4438	3749	3749	3749	2922	0
3b. Ec Index <for 1995>....	5023	- - - - ->-	- - - - ->-	- - - - ->-	- - - - ->-	- - - - ->-	- - - - ->-	- - - - ->-
4a. Mos Available/Year.....	9	- - - - ->-	- - - - ->-	- - - - ->-	- - - - ->-	- - - - ->-	- - - - ->-	- - - - ->-
5a. Useful Life (in Yrs)...	14	8	8	9.36	20	9.36	30	0
5b. Physical Life (in Hrs).	60,000	16,000	16,000	40,000	90,000	40,000	135,000	0
5c. SLV Factor.....	0.10	0.10	0.10	0.10	0.05	0.05	0.10	0.00
5d. Pr Eng Fuel Factor.....	0.045	0.045	0.045	0.011	0.011	0.011	0.045	0
5e. 2nd Eng Fuel Factor....	0.039	0.039	0.039	0.011	0.011	0.011	0.039	0
5f. WLS Factor.....	0.22	0.38	0.38	0.20	0.20	0.20	0.24	0.00
5g. RPR Factor.....	1.30	0.80	0.80	0.70	0.60	0.60	1.20	0.00
6a. Depreciation:	6.43%	11.25%	11.25%	9.62%	4.75%	10.15%	3.00%	0.00%
6b. FCCM:	3.78%	3.94%	3.94%	3.89%	3.57%	3.74%	3.67%	0.00%
6c. Total Ownership/Year:	10.21%	15.19%	15.19%	13.51%	8.32%	13.89%	6.67%	0.00%
7a. Yearly Ownership:	$1,021,000	$49,671	$7,291	$40,530	$10,150	$13,890	$126,463	$0
7b. Monthly Ownership:	$113,444	$5,519	$810	$4,503	$1,128	$1,543	$14,051	$0
8a. (1) Hrly Pr Eng Fuel:	$191.25	$9.56	$3.83	$1.87	$0.00	$0.00	$153.00	$0.00
8a. (2) Hrly 2nd Eng Fuel:	$109.73	$1.66	$1.33	$0.37	$0.09	$0.00	$6.63	$0.00
8b. (1) Hrly Pr Eng WLS:	$42.08	$3.63	$1.46	$0.37	$0.00	$0.00	$36.72	$0.00
8b. (2) Hrly 2nd Eng WLS:	$24.14	$0.63	$0.51	$0.07	$0.02	$0.00	$1.59	$0.00
8c. (1) EAF:	2.136	1.132	1.132	1.340	1.340	1.340	1.719	0.000
8c. (2) Hrly Repair:	$448.92	$17.95	$2.64	$6.82	$1.06	$1.95	$28.10	$0.00
8d. Total Hrly Operating:	$816.12	$33.43	$9.77	$9.50	$1.17	$1.95	$226.04	$0.00
8e. Monthly Operating:	$417,037	$17,083	$4,992	$4,855	$598	$996	$115,506	$0
11. MONTHLY RATE:	$530,481	$22,602	$5,802	$9,358	$1,726	$2,539	$129,557	$0
12a. HRLY STANDBY ALLOW:	$155.40	$7.56	$1.11	$6.17	$1.55	$2.11	$19.25	$0.00
12b. Gener Fuel Allowance:	$27.52	--	--	--	--	--	--	--
12c. DREDGE HOURLY STANDBY:	$182.92	--	--	--	--	--	--	--

****

D \ 3 PIPELINE COSTS BID ITEM # ~~~~~~~~~~~~

****

PIPELINE SIZE: User 27" MATERIAL PUMPED: SAND

	|--------FLOATING PIPELINE---------|			|--SUBMERGED PIPELINE--|		|-SHOREPIPE-|
1a. Plant Description.....	Pipeline	Joints	Pontoons	Pipeline	Joints	Pipeline
Quantity.....>	100	1	2	400	1	40
Fixed Units Per Item..>	LF	Set	Each	LF	Set	LF
Unit Price.....>	$50.00	$12,000.00	$7,000.00	$50.00	$12,000.00	$25.00
1e. Plant Value:	$5,000.00	$12,000.00	$14,000.00	$20,000.00	$12,000.00	$1,000.00
1f. Acquis Year.....	1992	1992	1992	1992	1992	1992
1g. Pres Year.....	1995	- - - - ->-	- - - - ->-	- - - - ->-	- - - - ->-	- - - - ->-
1h. Cost of Money Rate.....	8.125%	- - - - ->-	- - - - ->-	- - - - ->-	- - - - ->-	- - - - ->-
1i. Disc Money Rate:	6.500%	- - - - ->-	- - - - ->-	- - - - ->-	- - - - ->-	- - - - ->-
1j. Hrs Worked/Mo.....	511	- - - - ->-	- - - - ->-	- - - - ->-	- - - - ->-	- - - - ->-
2a. LAF.....	0.970	- - - - ->-	- - - - ->-	- - - - ->-	- - - - ->-	- - - - ->-
3a. Ec Index <for Acq Yr>..	4611	4611	4611	4611	4611	4611
3b. Ec Index <for 1995>....	5023	- - - - ->-	- - - - ->-	- - - - ->-	- - - - ->-	- - - - ->-
4a. Mos Available/Year.....	9	- - - - ->-	- - - - ->-	- - - - ->-	- - - - ->-	- - - - ->-
5a. Useful Life (in Yrs)...	1.5	3.0	12.0	1.5	3.0	1.5
5b. Physical Life (in Hrs).	6,000	12,000	60,000	6,000	12,000	6,000
5c. SLV Factor.....	0.10	0.10	0.10	0.10	0.10	0.10
5g. RPR Factor.....	0.05	0.30	0.05	0.05	0.30	0.05
6a. Depreciation:	60.00%	30.00%	7.50%	60.00%	30.00%	60.00%
6b. FCCM:	5.53%	4.55%	3.82%	5.53%	4.55%	5.53%
6c. Total Ownership/Year:	65.53%	34.55%	11.32%	65.53%	34.55%	65.53%
7a. Yearly Ownership:	$3,276.50	$4,146.00	$1,584.80	$13,106.00	$4,146.00	$655.30
7b. Monthly Ownership:	$364.06	$460.67	$176.09	$1,456.22	$460.67	$72.81
8c. (1) EAF:	1.089	1.089	1.089	1.089	1.089	1.089
8c. (2) Hrly Repair:	$0.04	$0.32	$0.01	$0.18	$0.32	$0.01
8e. Monthly Operating:	$20.44	$163.52	$5.11	$91.98	$163.52	$5.11
11. Monthly Rate (EA Item):	$384.50	$624.19	$181.20	$1,548.20	$624.19	$77.92
Monthly Rate Per Section (Sum Of Items):			$1,189.89		$2,172.39	$77.92
/ Section Length (In Linear Feet):			100		400	40
			==========		==========	==========
MONTHLY RATES PER LF OF PIPELINE:			$11.90		$5.43	$1.95
5a. Useful Life (in Yrs)...	3.0	3.0	12.0	3.0	3.0	1.5
6a. Depreciation:	30.00%	30.00%	7.50%	30.00%	30.00%	30.00%
6b. FCCM:	4.55%	4.55%	3.82%	4.55%	4.55%	4.55%
6c. Total Ownership/Year:	34.55%	34.55%	11.32%	34.55%	34.55%	34.55%
7a. Yearly Ownership:	$1,727.50	$4,146.00	$1,584.80	$6,910.00	$4,146.00	$345.50
7b. Monthly Ownership:	$191.94	$460.67	$176.09	$767.78	$460.67	$38.39
12a. HRLY STANDBY ALLOW:	$0.263	$0.631	$0.241	$1.052	$0.631	$0.053
Hrly Standby Rate Per Section (Sum Of Items):			$1.135		$1.683	$0.053
/ Section Length (In Linear Feet):			100		400	40
			==========		==========	==========
HOURLY STANDBY RATES PER LF OF PIPELINE:			$0.011		$0.004	$0.001

D \ 4 OTHER MONTHLY COSTS BID ITEM # ~~~~~~~~~~~~

DREDGE SIZE User 27"

			REMARKS
1	Constr./Maint.-Beach Rehandling w/Du	$131,052 /MO	
2	+	/MO	
3	> +	$0 /MO	
4	> +	$0 /MO	
5	> +	$0 /MO	
6	> +	$0 /MO	
7	> +	$0 /MO	
8	> +	$0 /MO	
9	> +	$0 /MO	
10	> +	$0 /MO	
11	> +	$0 /MO	
12	> +	$0 /MO	
13	> +	$0 /MO	
14	> +	$0 /MO	
15	TOTAL OTHER MONTHLY COSTS =	$131,052 /MO	

	E	FIXED COSTS	BID ITEM # ~~~~~~~~~~~~
DREDGE SIZE	User 27"		
			REMARKS
1	0	$0	
2 >	+	$0	
3 >	+	$0	
4 >	+	$0	
5 >	+	$0	
6 >	+	$0	
7 >	+	$0	
8 >	+	$0	
9 >	+	$0	
10 >	+	$0	
11 >	+	$0	
12 >	+	$0	
13 >	+	$0	
14 >	+	$0	
15 FIXED COSTS	=	$0	

M MOB & DEMOB BID ITEM

DREDGE SIZE User 27"

	MOBILIZATION # DAYS		$/DAY		TOTAL	DEMOBILIZATION # DAYS		$/DAY		TOTAL
1. PREPARE DREDGE FOR TRANSFER	2	x	$11,580	=	$23,160	2	x	$12,127	=	$24,253
2. PREPARE PIPELINE FOR TRANSFER	2	x	$7,171	=	$14,342	2	x	$7,428	=	$14,856
3. TRANSFER ALL PLANT 2 MILES @ 50 miles/day =	0	x	$32,139	=	$0	2 MILES 0	x	$32,139	=	$0
4. PERMANENT PERSONNEL & MISC.	L.S.			=	$1,182	L.S.			=	$1,182
5. PREPARE DREDGE AFTER TRANSFER	2	x	$12,127	=	$24,253	2	x	$11,580	=	$23,160
6. PREPARE PIPELINE AFTER TRANSFER	2	x	$7,428	=	$14,856	2	x	$7,171	=	$14,342
7. OTHER	Pipe Ramp			=	$11,044	0			=	$0
	SUBTOTAL MOBILIZATION				$88,838	SUBTOTAL DEMOBILIZATION				$77,794

REMARKS

8. SUBTOTAL MOBILIZATION & DEMOBILIZATION = $166,631

9. OVERHEAD 12.0% + $19,996

SUBTOTAL.....= $186,627

10. PROFIT 10.0% + $18,663

SUBTOTAL.....= $205,290

11. BOND 1.3% + $2,669

12. TOTAL MOBILIZATION & DEMOBILIZATION = $207,959

****

M \ 1 MOB & DEMOB BID ITEM

****

DREDGE SIZE User 27"

1. PREPARE DREDGE FOR TRANSFER				MOBILIZATION	DEMOBILIZATION
Labor:	17 men @	8 hrs/day @	$33.64 per hour =	$4,575	$4,575
Equipment:	Dredge	$182.92 /hr (Standby)			
	Booster(s)	$0.00 /hr (Standby)			
		$182.92 /hr x 24 hrs per day =		$4,390	$4,390
Support equipment with operators				$2,415	$2,415
Supplies & small tools				$200	$200
Additional Fuel (plant idle)				$0	$0
Subsistence:	17 men @	$32.15 per day =		----	$547
			COST PER DAY	$11,580	$12,127

2. PREPARE PIPELINE FOR TRANSFER				MOBILIZATION	DEMOBILIZATION
Labor:	8 men @	8 hrs/day @	$33.64 per hour =	$2,153	$2,153
Equipment:	Work Tug	$88.46 /hr			
	Crew Tug	$11.35 /hr			
	Derrick(s)	$36.63 /hr			
	Fuel Barge	$3.38 /hr			
	Work Barge	$9.94 /hr			
		$149.76 /hr x 8 hrs per day =		$1,198	$1,198
	Pipeline	$50.20 /hr (Standby) x 24 hrs per day =		$1,205	$1,205
Support equipment with operators				$2,415	$2,415
Supplies & small tools				$200	$200
Subsistence	8 men @	$32.15 per day =		----	$257
			COST PER DAY	$7,171	$7,428

****

M \ 2 MOB & DEMOB BID ITEM

****

DREDGE SIZE User 27"

3. TRANSFER PLANT			MOBILIZATION	DEMOBILIZATION
Labor:	12 men/shift (2-12 hr shifts) @	$33.64 per manhour =	$9,688	$9,688
Equipment:	Work Tug(s)	$88.46 /hr		
	Dredge	$182.92 /hr (Standby)		
	Booster(s)	$0.00 /hr (Standby)		
	Crew Tug	$1.11 /hr (Standby)		
	Derrick(s)	$12.34 /hr (Standby)		
	Fuel Barge	$1.55 /hr (Standby)		
	Work Barge	$4.22 /hr (Standby)		
	Unused	$0.00 /hr (Standby)		
	Pipeline	$50.20 /hr (Standby)		
		$340.80 /hr x 24 hrs per day =	$8,179	$8,179
Subsistence	24 men @	$32.15 per day =	$772	$772
Towing vessel(s):	4000 H.P. Rental Tug @			
	$9,000 per day (towing)			
	$4,500 per day (return to port)			
	$13,500 per day x 1 towing vessel(s) =		$13,500	$13,500
		COST PER DAY	$32,139	$32,139

4. PERMANENT PERSONNEL & MISC.			MOBILIZATION	DEMOBILIZATION
3 men @	8 hrs/day @	$33.64 per hour @ 1 DAY	$807	$807
Travel Expenses	$125 per man		$375	$375
Local hire			$0	----
		TOTAL	$1,182	$1,182

****

M \ 3 MOB & DEMOB BID ITEM

****

DREDGE SIZE User 27"

5. PREPARE DREDGE AFTER TRANSFER				MOBILIZATION	DEMOBILIZATION
Labor:	17 men @	8 hrs/day @	$33.64 per hour =	$4,575	$4,575
Equipment:	Dredge	$182.92 /hr (Standby)			
	Booster(s)	$0.00 /hr (Standby)			
		$182.92 /hr x 24 hrs per day =		$4,390	$4,390
Support equipment with operators				$2,415	$2,415
Supplies & small tools				$200	$200
Additional Fuel (plant idle)				$0	$0
Subsistence	17 men @	$32.15 per day =		$547	----
			COST PER DAY	$12,127	$11,580

6. PREPARE PIPELINE AFTER TRANSFER					
Labor:	8 men @	8 hrs/day @	$33.64 per hour =	$2,153	$2,153
Equipment:	Work Tug	$88.46 /hr			
	Crew Tug	$11.35 /hr			
	Derrick(s)	$36.63 /hr			
	Fuel Barge	$3.38 /hr			
	Work Barge	$9.94 /hr			
		$149.76 /hr x 8 hrs per day =		$1,198	$1,198
	Pipeline	$50.20 /hr (Standby) x 24 hrs per day =		$1,205	$1,205
Support equipment with operators				$2,415	$2,415
Supplies & small tools				$200	$200
Subsistence	8 men @	$32.15 per day =		$257	----
			COST PER DAY	$7,428	$7,171

M \ 4 MOB & DEMOB BID ITEM

DREDGE SIZE User 27"

			REMARKS
1 EQUIPMENT COSTS - WORKING RATES			RATES TAKEN FROM SHEET D
A. WORK TUG(S)		$88.46 /HR	$45,204 /MO DIVIDED BY 511 HRS/MO
B. CREW/SURVEY TUG		$11.35 /HR	$5,802 /MO DIVIDED BY 511 HRS/MO
C. DERRICK(S)		$36.63 /HR	$18,716 /MO DIVIDED BY 511 HRS/MO
D. FUEL/WATER BARGE		$3.38 /HR	$1,726 /MO DIVIDED BY 511 HRS/MO
E. WORK BARGE		$9.94 /HR	$5,078 /MO DIVIDED BY 511 HRS/MO
2 LABOR COSTS		$33.64 /MHR	FROM SHEET D \ 1
3 EQUIPMENT COSTS - STANDBY RATES			RATES TAKEN FROM SHEET D \ 2
A. DREDGE		$182.92 /HR	1 EA @ $182.92 /HR
B. BOOSTER(S)		$0.00 /HR	0 EA @ $ 19.25 /HR
C. CREW/SURVEY TUG		$1.11 /HR	1 EA @ $ 1.11 /HR
D. DERRICK(S)		$12.34 /HR	2 EA @ $ 6.17 /HR
E. FUEL/WATER BARGE		$1.55 /HR	1 EA @ $ 1.55 /HR
F. WORK BARGE		$4.22 /HR	2 EA @ $ 2.11 /HR
G. ***Unused***		$0.00 /HR	0 EA @ $ 0.00 /HR
3 PIPELINE COSTS - STANDBY RATES			RATES TAKEN FROM SHEET D \ 3
A. FLOATING PIPELINE		$22.00 /HR	2,000 LF @ $0.011 /HR
B. SUBMERGED PIPELINE	+	$24.80 /HR	6,200 LF @ $0.004 /HR
C. SHORELINE	+	$3.40 /HR	3,400 LF @ $0.001 /HR
D. TOTAL PIPELINE COSTS	=	$50.20 /HR	11,600 LF (ON JOB)

MOBIL & DEMOB COST: $207,959

Lower Cape May Meadows & Cape May Poi

CHECKLIST FOR INPUT DATA.

BID QUANTITY 647,400 C.Y.
UNIT COST... $3.75 PER C.Y.
EXCAV. COST. $2,427,750
TIME..... 1.74 MONTHS

PG 1 OF 9: PROJECT TITLES

FILENAME -	MDWS_123C @ P2 = 99A
PROJECT -	Lower Cape May Meadows & Cape May
LOCATION -	New Jersey
INVIT # -	Feasibility
DATE OF EST. -	October 1997
EST. BY -	S. Johnson
MOB. BID ITEM # -	
EXCAV. BID ITEM # -	

PG 1a OF 9: LOCAL AREA FACTORS

PRESENT YEAR -	1995
ECONOMIC INDEX -	5023
LAF -	0.970
INTEREST RATE -	8.125% /yr
TIME PERIOD -	January to June, 1995
PIPELINE AVAILABILITY -	9 mos/yr
BUCKET AVAILABILITY -	10 mos/yr
HOPPER AVAILABILITY -	10 mos/yr
FUEL PRICE -	$0.85 /gal

PG 2 OF 9: TYPE OF EST & INDIRECT COSTS

TYPE OF EST. -	Planning Estimate
CONTRACTOR'S O.H. -	12.0%
CONTRACTOR'S PROFIT -	10.0%
CONTRACTOR'S BOND -	1.3%

PG 3 OF 9: EXCAVATION QTY'S

DREDGING AREA -	3,449,952 sf
REQ'D EXCAVATION -	647,400 cyds
PAY OVERDEPTH -	0 cyds
CONTRACT AMOUNT -	647,400 cyds
NOT DREDGED -	0 cyds
NET PAY -	647,400 cyds
NONPAY YARDAGE -	198,300 cyds
GROSS YARDAGE -	845,700 cyds
NONPAY HEIGHT -	1.6 ft overdig
TOTAL BANK HEIGHT -	6.7 ft

PG 4 OF 9: MATERIAL FACTOR

RESULTANT FACTOR -	0.90

PG 5 OF 9: PIPELINE CONSIDERATIONS

FLOATING -	2,000 ft
SUBMERGED -	6,200 ft
SHORE -	3,400 ft
TOTAL -	11,600 ft
AVE. PIPELINE -	9,900 ft
COST CATEGORY -	2 SAND
EQUIVALENT -	990 ft
DESCRIPTION -	Vertical Lift of Discharge Pipe.
BASIS OF PRODUCTION -	10,890 Feet (Ave + Equiv)

PG 6 OF 9: PRODUCTION ANALYSIS

BOOSTER(S) -	0
% EWT (NO BOOSTERS) -	70.0% (511 HRS/MO)
BOOSTER FACTOR -	1.00
% EWT (WITH BOOSTERS) -	70.0% (511 HRS/MO)
MAX. POSSIBLE -	18,385 ft
TOTAL HP AVAIL -	5,000 hp

PG 6a OF 9: HP & BOOSTER FACTOR ADJUSTMENTS

AVAIL PUMP HP -	5,000
BOOSTER HP -	4,000 hp(ea)
LOSS PER BOOSTER -	10%

PG 7 OF 9: OTHER PRODUCTION FACTORS

DREDGE SELECTED -	Use HYDRAULIC DREDGE
COMPUTED BANK FACTOR -	0.97
BANK FACTOR USED -	0.97 >
OTHER FACTOR -	Wave Action
CLEANUP -	10% More Time

PG 8 OF 9: HISTORICAL PRODUCTION OVERRIDES

PRODUCTION OVERRIDE -	NO
PRODUCTION -	950 cy per hour
OPERATING TIME -	511 hours per month
BASED ON -	0 booster(s)
PRODUCTION (GROSS) -	485,450 cy per month
PRODUCTION (CONTRACT) -	372,069 pay cy per month

PG 9 OF 9: OTHER ADJUSTMENTS

SPECIAL COST/MO (1ST) -	$131,052	Constr./Maint.-Beach
SP COST/MO (2ND-14TH) -	$0	From Sheet D\4
SPECIAL COST LS (1ST) -	$0	0
SP COST LS (2ND-14TH) -	$0	From Sheet E

Lower Cape May Meadows Study:FS1
Selected Plan

Designed By: Giggi G. CENAP-En-CS
Estimated By: Sterling Johnson, CENAP-EN-EC

Prepared By:

Preparation Date: 10/20/97
Effective Date of Pricing: 10/20/97

Sales Tax: 0.00%

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PROJECT OWNER SUMMARY - Assembly.....1

DETAILED ESTIMATE DETAIL PAGE

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L. Overwash Sand.....2
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BACKUP REPORTS BACKUP PAGE

CREW BACKUP.....1
LABOR BACKUP.....6
EQUIPMENT BACKUP.....7

* * * END TABLE OF CONTENTS * * *

	QUANTITY	UOM	CONTRACT	CONTINGN	P,E & D	SIOH	TOTAL COST	UNIT COST
6 Beachfill w/Dune								
6/ A Beachfill w/Dune	1.00	MO	131,052	0	0	0	131,052	131051.71
TOTAL Beachfill w/Dune	1.00	MO	131,052	0	0	0	131,052	131051.71
6/ L Overwash Sand								
6/ L.A Overwash Sand								
6/ L.A.A Excavation	52000.00	CY	150,800	30,160	3,619	16,612	201,191	3.87
TOTAL Overwash Sand	52000.00	CY	150,800	30,160	3,619	16,612	201,191	3.87
TOTAL Overwash Sand	52000.00	CY	150,800	30,160	3,619	16,612	201,191	3.87
TOTAL Beachfill w/Dune	1.00	MO	281,852	30,160	3,619	16,612	332,243	332243.04
SP Selected Plan								
SP/01 Lands and Damages	1.00	JOB	125,722	18,858	6,966	2,738	154,284	154283.69
TOTAL Lands and Damages	1.00	JOB	125,722	18,858	6,966	2,738	154,284	154283.69
SP/06 Fish and Wildlife Facilities								
SP/06.3 Brush								
SP/06.3.1 Phragmites Removal & Burning								
SP/06.3.1.1 Phragmites Removal	95.00	ACR	58,950	11,790	3,266	1,284	75,290	792.52
SP/06.3.1.2 Phragmites Removal	95.00	ACR	58,950	11,790	3,266	1,284	75,290	792.52
SP/06.3.1.5 Phragmites Burning w/Safety&Brks	95.00	ACR	50,000	15,000	2,770	1,089	68,860	724.84
TOTAL Phragmites Removal & Burning	1.00	JOB	167,900	38,580	9,303	3,656	219,439	219439.29
SP/06.3.2 Plantings								
SP/06.3.2.A Plantings after Phrag Burning								
SP/06.3.2.A.1 Plantings after Phrag Burning	95.00	ACR	516,328	103,266	28,608	11,243	659,444	6941.52
TOTAL Plantings after Phrag Burning	1.00	JOB	516,328	103,266	28,608	11,243	659,444	659444.28
SP/06.3.2.C Plantings after Moving the Shore								

	QUANTITY	UOM	CONTRACT	CONTINGN	P,E & D	SIOH	TOTAL COST	UNIT COST
SP/06.3.2.C.1 Plantings after Moving the Shore	35.00	ACR	179,764	35,953	9,960	3,914	229,591	6559.74
TOTAL Plantings after Moving the Shore	1.00	JOB	179,764	35,953	9,960	3,914	229,591	229591.03
TOTAL Plantings	1.00	JOB	696,092	139,218	38,567	15,158	889,035	889035.31
SP/06.3.3 Marsh Edge Restoration Plan								
SP/06.3.3.A Small - Organic Substrate								
SP/06.3.3.A.E Organic Substrate	38000.00	CY	380,000	190,000	21,054	8,275	599,329	15.77
TOTAL Small - Organic Substrate	1.00	JOB	380,000	190,000	21,054	8,275	599,329	599328.90
TOTAL Marsh Edge Restoration Plan	1.00	JOB	380,000	190,000	21,054	8,275	599,329	599328.90
TOTAL Brush	1.00	JOB	1,243,992	367,798	68,924	27,089	1,707,803	1707803
SP/06.5 Interior Work								
SP/06.5.1 Excav. for Mudholes								
SP/06.5.1.1 Excavate & Disperse	2800.00	CY	39,984	7,997	2,215	871	51,067	18.24
TOTAL Excav. for Mudholes	2800.00	CY	39,984	7,997	2,215	871	51,067	18.24
SP/06.5.2 Excav. for Reconnects & Ditches								
SP/06.5.2.1 Excavate & Disperse	5245.00	CY	7,028	1,406	389	153	8,976	1.71
TOTAL Excav. for Reconnects & Ditches	5245.00	CY	7,028	1,406	389	153	8,976	1.71
SP/06.5.3 Excav. for Adverse Slopes (chnl)								
SP/06.5.3.1 Excavate & Disperse	10135.00	CY	13,986	2,797	775	305	17,863	1.76
TOTAL Excav. for Adverse Slopes (chnl)	10135.00	CY	13,986	2,797	775	305	17,863	1.76
SP/06.5.4 Berm Construction in N.C.								
SP/06.5.4.1 Geogrid	34425.00	SF	18,904	3,781	1,047	412	24,144	0.70
TOTAL Geogrid	34425.00	SF	18,904	3,781	1,047	412	24,144	0.70
SP/06.5.4.2 Misc Spreadng of Material to Dry								

		QUANTITY	UOM	CONTRACT	CONTINGN	P,E & D	SIOH	TOTAL COST	UNIT COST
SP/06.5.4.2.1	Grading of Material 6d	3060.00	CY	7,309	1,462	405	159	9,335	3.05
	TOTAL Misc Spreadng of Material to Dry	3060.00	CY	7,309	1,462	405	159	9,335	3.05
SP/06.5.4.3	Place & Compact from Stockpl 14d	3060.00	CY	32,284	6,457	1,789	703	41,233	13.47
SP/06.5.4.4	Misc Clearing & Grubbing w/Displ	1.00	ACR	4,159	832	230	91	5,311	5311.22
SP/06.5.4.5	Timber Mats 14d	1.00	JOB	35,382	7,076	1,960	770	45,189	45189.05
SP/06.5.4.6	Misc. Dewatering	14.00	DAY	2,446	489	136	53	3,124	223.11
	TOTAL Berm Construction in N.C.	3060.00	CY	100,484	20,097	5,567	2,188	128,336	41.94
SP/06.5.5	Weir Flow Control Structure								
SP/06.5.5.1	Gravity-Type Conc. Retaining Wll	10.00	CY	7,442	1,116	412	162	9,133	913.31
SP/06.5.5.2	Flashboard	88.00	SF	2,332	350	129	51	2,862	32.52
SP/06.5.5.3	Slope Stabilization	2.00	JOB	24,357	3,653	1,349	530	29,890	14944.99
	TOTAL Weir Flow Control Structure	2.00	EA	34,131	5,120	1,891	743	41,885	20942.33
SP/06.5.6	Self-Regulating TideGate	1.00	EA	79,748	15,950	4,418	1,737	101,852	101852.09
SP/06.5.7	Drainage Gate	1.00	EA	4,329	866	240	94	5,528	5528.41
	TOTAL Interior Work	1.00	JOB	279,689	54,231	15,496	6,090	355,507	355507.24
	TOTAL Fish and Wildlife Facilities	1.00	JOB	1,523,681	422,030	84,421	33,179	2,063,311	2063311
SP/17	Beach Replenishment								
SP/17.1	Beachfill w/Dune	2371800	CY	8,585,916	1,287,887	475,709	186,963	10,536,476	4.44
SP/17.2	Mob/Demob (Land-Based)	1.00	EA	37,921	4,551	2,101	826	45,398	45398.39
SP/17.3	Mob/Demob (Dredge)	1.00	JOB	604,436	72,532	33,489	13,162	723,619	723619.48
SP/17.4	Beachfill w/Dune:Sand Fence	15000.00	LF	62,046	9,307	3,438	1,351	76,141	5.08
SP/17.5	Outfall Extension								
SP/17.5.1	Outfall Extension for Small Plan								
SP/17.5.1.1	24" Ductile Iron Pipe	112.00	LF	14,020	2,804	777	305	17,907	159.88
	TOTAL 24" Ductile Iron Pipe	112.00	LF	14,020	2,804	777	305	17,907	159.88
SP/17.5.1.2	Support System for 24-inch								
SP/17.5.1.2.1	Earthwork	8.08	EA	1,018	204	56	22	1,301	161.04
SP/17.5.1.2.2	Pile Driving	7.00	EA	16,253	3,251	901	354	20,758	2965.43
SP/17.5.1.2.3	Cribbing	7.00	EA	3,254	651	180	71	4,156	593.77

	QUANTITY	UOM	CONTRACT	CONTINGN	P,E & D	SIOH	TOTAL COST	UNIT COST
TOTAL Support System for 24-inch	7.00	EA	20,526	4,105	1,137	447	26,215	3745.00
TOTAL Outfall Extension for Small Plan	1.00	JOB	34,546	6,909	1,914	752	44,122	44121.73
TOTAL Outfall Extension	1.00	JOB	34,546	6,909	1,914	752	44,122	44121.73
SP/17.6 Plantings								
SP/17.6.E Plantings for the Dune								
SP/17.6.E.1 Plantings for the Dune	18.00	ACR	506,494	75,974	28,063	11,029	621,560	34531.12
TOTAL Plantings for the Dune	18.00	ACR	506,494	75,974	28,063	11,029	621,560	34531.12
TOTAL Plantings	1.00	JOB	506,494	75,974	28,063	11,029	621,560	621560.22
TOTAL Beach Replenishment	1.00	JOB	9,831,359	1,457,160	544,714	214,083	12,047,317	12047317
TOTAL Selected Plan	1.00	MO	11,480,762	1,898,048	636,100	250,000	14,264,911	14264911
TOTAL Lower Cape May Meadows Study:FS1	1.00	EA	11,762,614	1,928,208	639,719	266,612	14,597,154	14597154

6/ A. Beachfill w/Dune			QUANTY UOM CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	MISC.	TOTAL COST
6. Beachfill w/Dune										
6/ A. Beachfill w/Dune										
L USR	<02226 1005 >	Berm Fill, (4) D-9H Dozer w/U-Blade 410 HP, Move 150' and Stockpile (includes an allowance for misc. supplies/material)			32.00	1623.06	2837.94	30.00	0.00	4491.00
			21.00 DAY CODTN_3	0.13	672	34,084	59,597	630	0	94,311
USR	<02101 1001 >	Move Shore Pipe - (includes an allowance for misc. supplies/material)			16.00	775.76	223.36	30.00	0.00	1029.13
			21.00 DAY COEMC1	0.13	336	16,291	4,691	630	0	21,612
USR	<01380 40021>	Surveying Crew (3) men			24.00	720.43	0.00	0.00	0.00	720.43
			21.00 DAY USRYA	0.13	504	15,129	0	0	0	15,129
	TOTAL	Beachfill w/Dune			1,512	65,504	64,287	1,260	0	131,052

6/ L. Overwash Sand	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	MISC.	TOTAL COST
6/ L. Overwash Sand										
6/ L.A. Overwash Sand										
TOTAL Excavation					0	91,000	59,800	0	0	150,800
TOTAL Overwash Sand					0	91,000	59,800	0	0	150,800
TOTAL Overwash Sand					0	91,000	59,800	0	0	150,800
TOTAL Beachfill w/Dune					1,512	156,504	124,087	1,260	0	281,852

SP/01. Lands and Damages	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	MISC.	TOTAL COST
SP. Selected Plan										
TOTAL Lands and Damages					0	0	0	0	125,722	125,722

SP/06. Fish and Wildlife Facilities	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	MISC.	TOTAL COST
SP/06. Fish and Wildlife Facilities										
SP/06.3. Brush										
SP/06.3.1.1. Phragmites Removal										
USR < > Helicopter					0.00	0.00	50.00	0.00	0.00	50.00
	95.00	ACR	ZC-HELICOP	1.00	0	0	4,750	0	0	4,750
USR <02102 1501 > Spraying w/Rodeo					0.00	0.00	0.00	120.00	0.00	120.00
	285.00	GAL	N/A	0.00	0	0	0	34,200	0	34,200
USR <02830 1001 > Misc. Protection of Endangered					0.00	0.00	0.00	0.00	20000.00	20000.00
	1.00	JOB	N/A	0.00	0	0	0	0	20,000	20,000
SP/06.3.1.2. Phragmites Removal										
USR < > Helicopter					0.00	0.00	50.00	0.00	0.00	50.00
	95.00	ACR	ZC-HELICOP	1.00	0	0	4,750	0	0	4,750
USR <02102 1501 > Spraying w/Rodeo					0.00	0.00	0.00	120.00	0.00	120.00
	285.00	GAL	N/A	0.00	0	0	0	34,200	0	34,200
USR <02830 1001 > Misc. Protection of Endangered					0.00	0.00	0.00	0.00	20000.00	20000.00
	1.00	JOB	N/A	0.00	0	0	0	0	20,000	20,000
TOTAL Phragmites Burning w/Safety&Brks					0	0	0	0	50,000	50,000
SP/06.3.2.A. Plantings after Phrag Burning										
TOTAL Plantings after Phrag Burning					0	285,000	47,500	183,828	0	516,328
SP/06.3.2.C. Plantings after Moving the Shore										
TOTAL Plantings after Moving the Shore					0	105,000	17,500	57,264	0	179,764
SP/06.3.3.A. Small - Organic Substrate										
TOTAL Organic Substrate					0	38,000	114,000	228,000	0	380,000
TOTAL Brush					0	428,000	188,500	537,492	90,000	1,243,992
SP/06.5. Interior Work										
TOTAL Excavate & Disperse					0	21,784	18,200	0	0	39,984
TOTAL Excavate & Disperse					0	3,672	3,357	0	0	7,028
TOTAL Excavate & Disperse					0	7,500	6,486	0	0	13,986

SP/06. Fish and Wildlife Facilities	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	MISC.	TOTAL COST
SP/06.5.4.1. Geogrid										
L HTW AA <02081 2415 > Uniaxial, 15' x 98' Rolls					0.00	0.03	0.00	0.39	0.00	0.42
Tensile Modulus = 50,000 #/SF (includes a 5% allowance for overlap & waste)	36146	SF	USKCF	9036.50	33	1,027	69	14,097	0	15,192
SP/06.5.4.2. Misc Spreadng of Material to Dry										
L BGS AA <02210 1008 > Gen Area Grading - 90hp Dozer					0.04	1.43	0.49	0.00	0.00	1.92
	3060.00	CY	CODTCC	63.75	108	4,370	1,504	0	0	5,874
SP/06.5.4.3. Place & Compact from Stockpl 14d										
L BGS AA <02220 5639 > Place Fill w/2cy HydExcav<=Stkpl					0.07	2.90	1.74	0.00	0.00	4.65
	3060.00	CY	XLABGC	54.64	224	8,878	5,339	0	0	14,218
L AF AA <02227 2001 > Compaction by Sheepsfoot Roller					0.05	2.31	1.52	0.00	0.00	3.83
8" Lifts	3060.00	CY	COFCP	54.64	154	7,083	4,645	0	0	11,728
SP/06.5.4.4. Misc Clearing & Grubbing w/Displ										
L AF AA <02102 1108 > Clearing - Medium Brush w/o Grub					9.00	126.89	189.87	0.00	0.00	316.76
	1.00	ACR	COMCE	0.00	9	127	190	0	0	317
L AF AA <02102 1501 > Burning - Light (Incinerator)					16.00	241.64	203.15	2300.00	0.00	2744.79
	1.00	ACR	UOEHZ	0.00	16	242	203	2,300	0	2,745
B MIL AA <02225 3106 > 12 Lcy Truck - 05 Mi Haul At					8.00	256.53	304.43	0.00	0.00	560.96
40 Mi/Hr	0.50	DAY	COEID	0.13	4	128	152	0	0	280
SP/06.5.4.5. Timber Mats 14d										
M BGS AA <01550 1011 > Timber Mats - 4.5' x 28'					0.00	0.00	0.00	0.00	0.00	0.00
	40.00	EA	N/A	0.00	0	0	0	0	0	0
L BGS AA <02220 5639 > Placement of Mats					32.00	1268.29	762.76	0.00	0.00	2031.05
	14.00	DAY	XLABGC	0.13	448	17,756	10,679	0	0	28,435
SP/06.5.4.6. Misc. Dewatering										
USR AA <02103 1001 > 5" diaphragm pump used for 8 hrs					3.00	123.09	17.30	0.00	0.00	140.39
	14.00	DAY	COFWB	0.50	42	1,723	242	0	0	1,965
SP/06.5.5.1. Gravity-Type Conc. Retaining Wll										
L MIL AA <03110 1434 > Retaining Wall Forms, 4', 4 Uses					0.22	8.99	0.15	0.82	0.00	9.96
(Below Gr) Plywd Forms,F&S w/Acc	355.56	SF	ACARL	22.25	80	3,198	53	291	0	3,541
L MIL AA <03305 1004 > Conc Curing, Sprayed Membrane					0.70	24.33	0.12	4.15	0.00	28.60
Curing Compound	3.56	CSF	ULABB	3.56	2	87	0	15	0	102

SP/06. Fish and Wildlife Facilities	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	MISC.	TOTAL COST
L MIL AA <03311 1243 > Pour Conc Wall,15"Tk,Crane & Bkt					1.80	67.96	16.33	54.00	0.00	138.29
3000 PSI Conc	10.00	CY	ALABG	5.00	18	680	163	540	0	1,383
L MIL AA <03311 4201 > Wall Finishes,Burlap Rub w/Grout					0.06	2.34	0.01	0.08	0.00	2.43
	355.56	SF	ACMAA	22.25	20	833	3	28	0	865
B MIL AA <03253 1003 > J-Seals, (2) @ 4/16"T x 17"W					0.13	5.38	0.05	3.60	0.00	9.03
	10.00	LF	ACARA	10.00	1	54	0	36	0	90
SP/06.5.5.2. Flashboard										
B MIL AA <06111 6201 > Flashboards, 4x4x11' So Yel Pine					0.07	2.93	0.07	0.90	0.00	3.90
- 9 Pressure Treated Boards	264.00	BF	ACARD	33.00	18	774	17	238	0	1,029
L MIL AA <03253 1001 > Rubber Seal, 1/4"T x 4"W x 11'L					0.09	3.67	0.03	1.10	0.00	4.80
	176.00	LF	ACARA	14.67	15	646	6	194	0	845
SP/06.5.5.3. Slope Stabilization										
L MIL AA <02261 1002 > Rip Rap, 10# to 100# Pieces					1.82	68.22	26.26	23.02	0.00	117.50
Random, Dumped from Truck	4.40	CY	COETF	2.20	8	300	116	101	0	517
B CIV AA <02535 1011 > GeoWeb System, 4" deep					0.04	1.30	0.04	0.96	0.00	2.30
Non-Woven Polypropylene	320.00	SF	ULABJ	80.00	12	416	13	307	0	737
L MIL AA <02221 8001 > Granular Beddng w/Sm FEnd Loader					0.03	1.42	0.73	17.14	0.00	19.30
Without Compaction	186.00	CY	CODLB	46.50	6	265	137	3,188	0	3,590
USR AA <02535 1011 > Misc. GeoWeb Material					0.00	0.00	0.00	100.00	0.00	100.00
Non-Woven Polypropylene	2.00	JOB	N/A	0.00	0	0	0	200	0	200
L MIL AA <03311 1243 > Pour Conc Fill for GeoWeb (C&B)					18.00	679.58	163.33	54.00	0.00	896.91
(3000 PSI Conc)	4.00	CY	ALABG	0.50	72	2,718	653	216	0	3,588
L MIL AA <03311 4101 > Concrete GeoWeb Finish, Screed					0.03	1.30	0.00	0.00	0.00	1.31
	320.00	SF	ACMAA	40.00	10	417	2	0	0	419
L BGS AA <02220 5639 > Misc. Excav. w/2cy Hyd Excav					0.07	2.62	1.57	0.00	0.00	4.19
	970.00	CY	XLABGC	60.63	64	2,537	1,526	0	0	4,062
L MIL AA <02226 1001 > Exc & Fill, D-4D Dozer w/S-Blade					0.08	3.74	1.65	0.00	0.00	5.39
75 HP, Move 150' and Stockpile	780.00	CY	CODTC	16.25	60	2,915	1,285	0	0	4,200
AF AA <02227 3001 > Compaction by Vibratory Plate					0.08	2.66	0.24	0.00	0.00	2.90
8" Lifts	780.00	CY	CLACE	16.25	60	2,077	185	0	0	2,262
B CIV PL <15101 1618 > 36"Iron Body,Brz Mtd,Gate Valve					64.75	2636.35	209.88	50000.00	0.00	52846.23
125# Flanged	1.00	EA	MPLUN	0.04	65	3,197	255	60,638	0	64,089

SP/06. Fish and Wildlife Facilities	QUANTY UOM CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	MISC.	TOTAL COST
B CIV AA <05651 1303 > 24" Dia Canal Gates			14.00	630.65	148.04	2700.00	0.00	3478.69
	1.00 EA SIWSE	0.25	14	631	148	2,700	0	3,479
TOTAL Interior Work			1,563	96,033	55,629	85,088	0	236,750
TOTAL Fish and Wildlife Facilities			1,563	524,033	244,129	622,580	90,000	1,480,742

SP/17. Beach Replenishment	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	MISC.	TOTAL COST
SP/17. Beach Replenishment										
TOTAL Beachfill w/Dune					0	0	0	0	8,585,916	8,585,916
SP/17.2. Mob/Demob (Land-Based)										
L USR <01630 0001 > Mob and Demob					128.00	4323.83	1996.35	0.00	0.00	6320.18
	2.00	DAY	UTDHA5	0.13	256	8,648	3,993	0	0	12,640
L USR <01630 0001 > Mob and Demob					128.00	4323.83	1996.35	0.00	0.00	6320.18
	2.00	DAY	UTDHA5	0.13	256	8,648	3,993	0	0	12,640
L USR <01630 0001 > Mob and Demob					128.00	4323.83	1996.35	0.00	0.00	6320.18
	2.00	DAY	UTDHA5	0.13	256	8,648	3,993	0	0	12,640
TOTAL Mob/Demob (Land-Based)					768	25,943	11,978	0	0	37,921
TOTAL Mob/Demob (Dredge)					0	0	0	0	604,436	604,436
SP/17.4. Beachfill w/Dune:Sand Fence										
B CIV AA <02712 6201 > Stl Post, 10'OC f/4' Sand Fence					0.06	2.29	0.03	1.00	0.00	3.32
	15000	LF	XLABC	53.57	935	34,424	440	15,000	0	49,863
TOTAL Beachfill w/Dune:Sand Fence					935	34,424	440	15,000	0	49,863
SP/17.5. Outfall Extension										
SP/17.5.1.1. 24" Ductile Iron Pipe										
B MIL AA <02455 1005 > Place 24" DI Pipe, No Fittings					0.36	15.42	1.88	35.03	0.00	52.33
	112.00	LF	XXPLAD	0.00	40	1,727	210	3,923	0	5,861
B MIL AA <15112 3011 > 24" Tideflex Backflow Preventer					6.00	235.76	2.72	5168.00	0.00	5406.48
	1.00	EA	MPLUJ	0.58	6	236	3	5,168	0	5,406
SP/17.5.1.2. Support System for 24-inch										
L CIV AA <02221 1707 > Trench, 3 CY Hyd Excav, Med Soil 14'-20' Deep, 194 CY/Hr					0.35	13.48	17.05	0.00	0.00	30.54
	16.96	CY	XXQHK	8.48	6	229	289	0	0	518
L LAM AA <02221 5002 > Backfill Trench 60HP Tr Dozer Without Compaction					0.15	7.23	10.49	0.00	0.00	17.72
	16.96	CY	CODTM	0.00	3	123	178	0	0	300
B LAM AA <02318 1008 > 12"Butt-9"TipWdPles-Up to20'Trtd Jetting					0.57	26.04	14.11	6.50	0.00	46.65
	280.00	LF	CPIDD	0.00	160	7,290	3,952	1,820	0	13,062

SP/17. Beach Replenishment	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	MISC.	TOTAL COST
B LAM AA <02318 2117 > 24" Diameter Pipe - Top Crib					2.48	96.70	9.11	36.00	0.00	141.81
Material Price:	7.00	EA	XCARB	0.88	17	677	64	252	0	993
2-3"x8" at 6ft=24 BF										
2-(1 Bolt+2 Washers+ 1 Nut)										
B LAM AA <02318 2217 > 24" Diameter Pipe - Bot Crib					2.48	96.70	9.11	126.00	0.00	231.81
Material Price:	7.00	EA	XCARB	0.88	17	677	64	882	0	1,623
2-6"x14" at 6ft=84 BF										
4-(Bolt+2 Washers+Nut)										
TOTAL Outfall Extension					249	10,958	4,759	12,045	0	27,763
SP/17.6. Plantings										
TOTAL Plantings for the Dune					0	63,000	13,500	330,545	0	407,045
TOTAL Plantings					0	63,000	13,500	330,545	0	407,045
TOTAL Beach Replenishment					1,952	134,325	30,677	357,590	9,190,352	9,712,944
TOTAL Selected Plan					3,514	658,358	274,806	980,170	9,406,074	11,319,408
TOTAL Lower Cape May Meadows Study:FS1					5,026	814,862	398,893	981,430	9,406,074	11,601,260

SRC	ITEM ID	DESCRIPTION	NO.	UOM	RATE	**** LABOR **** HOURS	COST	**** EQUIP **** HOURS	COST	TOTAL COST
	ACARA	1 B-carpnter + Small Tools			PROD = 100%				CREW HOURS =	13
MIL	B-CARPNTERL	Carpenters	1.00	HR	42.95	1.00	42.95			42.95
MIL	B-CARPNTERF	Carpenters	0.25	HR	43.45	0.25	10.86			10.86
MIL	XMIXX020 E	Small Tools	0.31	HR	1.57			0.31	0.49	0.49
	TOTAL					1.25	53.81	0.31	0.49	54.29
	ACARD	2 B-carpnter + Misc Power Tools			PROD = 100%				CREW HOURS =	8
MIL	B-CARPNTERF	Carpenters	0.25	HR	43.45	0.25	10.86			10.86
MIL	B-CARPNTERL	Carpenters	2.00	HR	42.95	2.00	85.89			85.89
MIL	XMIXX010 E	Misc. Power Tools	0.19	HR	6.40			0.19	1.22	1.22
MIL	XMIXX020 E	Small Tools	0.61	HR	1.57			0.61	0.96	0.96
	TOTAL					2.25	96.75	0.80	2.17	98.93
	ACARL	4 B-carpntr/labr(semi-skld) + MiscPowrTools			PROD = 100%				CREW HOURS =	16
MIL	B-CARPNTERL	Carpenters	2.00	HR	42.95	2.00	85.89			85.89
MIL	B-CARPNTERF	Carpenters	1.00	HR	43.45	1.00	43.45			43.45
MIL	B-CARPNTERA	Carpenters	1.00	HR	36.28	1.00	36.28			36.28
MIL	B-LABORER L	Laborers, (Semi-Skilled)	1.00	HR	34.51	1.00	34.51			34.51
MIL	XMIXX010 E	Misc. Power Tools	0.32	HR	6.40			0.32	2.05	2.05
MIL	XMIXX020 E	Small Tools	0.79	HR	1.57			0.79	1.24	1.24
	TOTAL					5.00	200.13	1.11	3.29	203.42
	ACMAA	1 B-cemtfinr + Small Tools			PROD = 100%				CREW HOURS =	24
MIL	B-CEMTFINRF	Cement Finishers	0.25	HR	42.11	0.25	10.53			10.53
MIL	B-CEMTFINRL	Cement Finishers	1.00	HR	41.61	1.00	41.61			41.61
MIL	XMIXX020 E	Small Tools	0.12	HR	1.57			0.12	0.19	0.19
	TOTAL					1.25	52.14	0.12	0.19	52.33
	ALABG	6 B-laborer + 1 60 Ton Crane/2 Conc Vibrators			PROD = 100%				CREW HOURS =	10
MIL	B-CEMTFINRL	Cement Finishers	1.00	HR	41.61	1.00	41.61			41.61
MIL	B-LABORER L	Laborers, (Semi-Skilled)	5.00	HR	34.51	5.00	172.57			172.57
MIL	B-LABORER F	Laborers, (Semi-Skilled)	1.00	HR	35.01	1.00	35.01			35.01
MIL	B-EQOPRCRNL	Equip. Operators, Crane/Shovel	1.00	HR	50.60	1.00	50.60			50.60
MIL	C65WC002 E	CONC VIBRATOR, 2.50D, EL,HI-FRE	2.00	HR	1.78			2.00	3.57	3.57
MIL	C80GV007 E	CRANE,HYD,TRK MTD, 60T /115'BOO	1.00	HR	75.40			1.00	75.40	75.40
MIL	XMIXX020 E	Small Tools	0.68	HR	1.57			0.68	1.07	1.07
MIL	B-EQOPROILL	Equip. Operators, Oilers	1.00	HR	40.00	1.00	40.00			40.00
MIL	G10HO004 E	GENERATOR, 5.5 KW, 120/240V,POR	1.00	HR	1.63			1.00	1.63	1.63
	TOTAL					9.00	339.79	4.68	81.66	421.45
	CLACE	1 B-laborer + 1 Hand Compaction Rammer			PROD = 100%				CREW HOURS =	48
MIL	B-LABORER L	Laborers, (Semi-Skilled)	1.00	HR	34.51	1.00	34.51			34.51
MIL	B-LABORER F	Laborers, (Semi-Skilled)	0.25	HR	35.01	0.25	8.75			8.75
MIL	C10WC003 E	COMPACTOR, RAMMER, 13"X11" SHOE	1.00	HR	2.39			1.00	2.39	2.39
MIL	XMIXX010 E	Misc. Power Tools	0.22	HR	6.40			0.22	1.41	1.41
MIL	XMIXX020 E	Small Tools	0.04	HR	1.57			0.04	0.06	0.06
	TOTAL					1.25	43.27	1.26	3.86	47.13

SRC	ITEM ID	DESCRIPTION	NO.	UOM	RATE	**** LABOR **** HOURS	COST	**** EQUIP **** HOURS	COST	TOTAL COST
	CODLB	1 B-eqoprmed + 1 1.5 Cy Front End Ldr, Cwlr			PROD = 100%				CREW HOURS =	4
MIL	B-LABORER L	Laborers, (Semi-Skilled)	0.50	HR	34.51	0.50	17.26			17.26
MIL	B-EQOPRMEDF	Equip. Operators, Medium	1.00	HR	48.99	1.00	48.99			48.99
MIL	L35CA004 E	LDR,FE, CRWLR, 1.50 CY	1.00	HR	34.14			1.00	34.14	34.14
	TOTAL					1.50	66.24	1.00	34.14	100.38
	CODTC	1 B-eqoprmed + 1 Dozer, Cat D-4H, 90 Hp			PROD = 100%				CREW HOURS =	48
MIL	B-EQOPRMEDF	Equip. Operators, Medium	0.25	HR	48.99	0.25	12.25			12.25
MIL	B-EQOPRMEDL	Equip. Operators, Medium	1.00	HR	48.49	1.00	48.49			48.49
MIL	T10CA004 E	BLADE, ANGLE, HYDR (FOR D4	1.00	HR	3.81			1.00	3.81	3.81
MIL	T15CA004 E	DOZER,CWLR, D-4H,PS (ADD BLADE	1.00	HR	22.97			1.00	22.97	22.97
	TOTAL					1.25	60.73	2.00	26.78	87.51
*	CODTCC	1 + 1/4 Op+Lab+Dozer,Cat D-4h,90 hp			PROD = 100%				CREW HOURS =	48
BGS *	B-EQ825B2 F	Eq Op-Bldg-Med (ENGI0825B	0.25	HR	46.81	0.25	11.70			11.70
BGS *	B-EQ825B2 L	Eq Op-Bldg-Med (ENGI0825B	1.00	HR	46.31	1.00	46.31			46.31
BGS	B-LABCOM#1L	Lab Common (LABO0172	1.00	HR	33.02	1.00	33.02			33.02
MIL	T15CA005 E	Dzr,Cwlr,D-4H,LoGrndPrs,(AddBld	1.00	HR	25.95			1.00	25.95	25.95
MIL	T10CA004 E	BLADE, ANGLE, HYDR, FOR D4	1.00	HR	3.81			1.00	3.81	3.81
MIL	XMIXX020 E	Small Tools	1.00	HR	1.57			1.00	1.57	1.57
	TOTAL					2.25	91.04	3.00	31.34	122.37
*	CODTN_3	3 B-eqoprmed + 3 Dozer, Cat D-9L, 460 Hp			PROD = 100%				CREW HOURS =	168
MIL *	B-EQOPRCRNL	Equip. Operators, Crane/Shovel	3.00	HR	50.60	3.00	151.79			151.79
MIL *	B-EQOPRCRNF	Equip. Operators, Crane/Shovel	1.00	HR	51.10	1.00	51.10			51.10
MIL *	T10CA022 E	BLADE, UNIVERSAL, HYDR (FOR D9	3.00	HR	11.53			3.00	34.58	34.58
MIL *	T15CA017 E	DOZER,CWLR, D-9N,PS (ADD BLADE	3.00	HR	106.72			3.00	320.16	320.16
	TOTAL					4.00	202.88	6.00	354.74	557.62
	COEID	1 B-trkdvrhv + 1 12 Cy Dump Truck			PROD = 100%				CREW HOURS =	4
MIL	B-TRKDVRHVL	Truck Drivers, Heavy	1.00	HR	32.07	1.00	32.07			32.07
MIL	T40XX010 E	REAR DUMP BODY,12 CY,(36,000 GV	1.00	HR	2.93			1.00	2.93	2.93
MIL	T50KE003 E	TRK,HWY, 46,000 GVW, 6X4, 3 AXL	1.00	HR	35.13			1.00	35.13	35.13
	TOTAL					1.00	32.07	2.00	38.05	70.12
	COEMC1	1 B-eqoprmed + Forklift			PROD = 100%				CREW HOURS =	168
MIL *	B-EQOPRMEDL	Eq Oper, Medium (ENGI0825B	2.00	HR	48.49	2.00	96.97			96.97
MIL *	F10CA023 E	FKLFT 6000#@24"LC ROUGH TERRAIN	2.00	HR	12.39			2.00	24.78	24.78
MIL *	XMIXX020 E	Small Tools	2.00	HR	1.57			2.00	3.14	3.14
	TOTAL					2.00	96.97	4.00	27.92	124.89

SRC	ITEM ID	DESCRIPTION	NO.	UOM	RATE	**** LABOR **** HOURS	COST	**** EQUIP **** HOURS	COST	TOTAL COST
	COETF	2 B-laborer + 1 8 Cy Dump Truck,Bckhoe/Loadr			PROD = 100%				CREW HOURS =	2
MIL	B-LABORER L	Laborers, (Semi-Skilled)	2.00	HR	34.51	2.00	69.03			69.03
MIL	B-EQOPRMEDF	Equip. Operators, Medium	1.00	HR	48.99	1.00	48.99			48.99
MIL	B-TRKDVRHVL	Truck Drivers, Heavy	1.00	HR	32.07	1.00	32.07			32.07
MIL	L50CA003 E	LDR,BH,WH, 1.38CY FE BKT, 30"DI	1.00	HR	19.21			1.00	19.21	19.21
MIL	XMIXX020 E	Small Tools	0.37	HR	1.57			0.37	0.58	0.58
MIL	T40XX008 E	REAR DUMP BODY, 8 CY,(30,000 GV	1.00	HR	2.85			1.00	2.85	2.85
MIL	T50KE003 E	TRK,HWY, 46,000 GVW, 6X4, 3 AXL	1.00	HR	35.13			1.00	35.13	35.13
	TOTAL					4.00	150.08	3.37	57.77	207.85
	COFCP	2 B-eqoprmed + 1 Tire Roller+Water Wagon,6000Gal			PROD = 100%				CREW HOURS =	56
MIL	B-LABORER L	Laborers, (Semi-Skilled)	0.50	HR	34.51	0.50	17.26			17.26
MIL	B-EQOPRMEDL	Equip. Operators, Medium	2.00	HR	48.49	2.00	96.97			96.97
MIL	B-EQOPRMEDF	Equip. Operators, Medium	0.25	HR	48.99	0.25	12.25			12.25
MIL	R30CA001 E	ROLLR,STATIC,S/P,13T,84"W,11TIR	1.00	HR	16.61			1.00	16.61	16.61
MIL	T60KI002 E	TRK,WTR,OF-HY, 6000GAL,W/CAT621	1.00	HR	66.34			1.00	66.34	66.34
	TOTAL					2.75	126.47	2.00	82.95	209.42
	COFWB	1 B-eqoprlt + 1 Wtr-pmp, Diaph 4 In.			PROD = 100%				CREW HOURS =	28
MIL	B-LABORER L	Laborers, (Semi-Skilled)	0.50	HR	34.51	0.50	17.26			17.26
MIL	B-EQOPRLT F	Equip. Operators, Light	1.00	HR	44.29	1.00	44.29			44.29
MIL	P60ML001 E	PUMP,CENTRF,DW,4"D, 465GPM/40'H	1.00	HR	8.65			1.00	8.65	8.65
	TOTAL					1.50	61.55	1.00	8.65	70.19
	MPLUJ	2 B-plumber + Small Tools			PROD = 100%				CREW HOURS =	2
MIL	B-LABORER L	Laborers, (Semi-Skilled)	1.00	HR	34.51	1.00	34.51			34.51
MIL	B-PLUMBER A	Plumbers	1.00	HR	37.40	1.00	37.40			37.40
MIL	B-PLUMBER L	Plumbers	1.00	HR	43.65	1.00	43.65			43.65
MIL	B-PLUMBER F	Plumbers	0.50	HR	44.15	0.50	22.08			22.08
MIL	XMIXX020 E	Small Tools	1.01	HR	1.57			1.01	1.59	1.59
	TOTAL					3.50	137.64	1.01	1.59	139.23
	MPLUN	1 B-plumber + 1 20 Ton Crane, Hydraulic R/T			PROD = 100%				CREW HOURS =	24
MIL	B-LABORER L	Laborers, (Semi-Skilled)	1.00	HR	34.51	1.00	34.51			34.51
MIL	B-EQOPRMEDL	Equip. Operators, Medium	0.20	HR	48.49	0.20	9.70			9.70
MIL	B-PLUMBER L	Plumbers	1.00	HR	43.65	1.00	43.65			43.65
MIL	B-PLUMBER F	Plumbers	0.50	HR	44.15	0.50	22.08			22.08
MIL	C75GV002 E	CRANE,HYD,S/P,RT,4WD,20T/70'BOO	0.20	HR	35.44			0.20	7.09	7.09
MIL	XMIXX020 E	Small Tools	1.06	HR	1.57			1.06	1.66	1.66
	TOTAL					2.70	109.94	1.26	8.75	118.69
	SIWSE	2 B-strsteel + 1 20 Ton Crane, Hydraulic R/T			PROD = 100%				CREW HOURS =	4
MIL	C75GV002 E	CRANE,HYD,S/P,RT,4WD,20T/70'BOO	1.00	HR	35.44			1.00	35.44	35.44
MIL	XMIXX020 E	Small Tools	1.00	HR	1.57			1.00	1.57	1.57
MIL	B-STRSTEELF	Structural Steel Workers	0.50	HR	44.07	0.50	22.04			22.04
MIL	B-STRSTEELL	Structural Steel Workers	2.00	HR	43.57	2.00	87.14			87.14

SRC	ITEM ID	DESCRIPTION	NO.	UOM	RATE	**** LABOR **** HOURS	COST	**** EQUIP **** HOURS	COST	TOTAL COST
MIL	B-EQOPRMEDL	Equip. Operators, Medium	1.00	HR	48.49	1.00	48.49			48.49
	TOTAL					3.50	157.66	2.00	37.01	194.67
	ULABB	2 B-laborer + Small Tools			PROD = 100%				CREW HOURS =	1
MIL	B-LABORER L	Laborers, (Semi-Skilled)	2.00	HR	34.51	2.00	69.03			69.03
MIL	B-LABORER F	Laborers, (Semi-Skilled)	0.50	HR	35.01	0.50	17.51			17.51
MIL	XMIXX020 E	Small Tools	0.27	HR	1.57			0.27	0.42	0.42
	TOTAL					2.50	86.53	0.27	0.42	86.96
	ULABJ	3 B-laborer + 1 3/4 Ton Pickup Truck			PROD = 100%				CREW HOURS =	4
MIL	B-LABORER L	Laborers, (Semi-Skilled)	2.00	HR	34.51	2.00	69.03			69.03
MIL	B-LABORER F	Laborers, (Semi-Skilled)	1.00	HR	35.01	1.00	35.01			35.01
MIL	XMIXX020 E	Small Tools	0.25	HR	1.57			0.25	0.39	0.39
MIL	T50FO003 E	TRK,HWY, 8,600GVW,4X2, 3/4T-PKU	0.40	HR	7.37			0.40	2.95	2.95
	TOTAL					3.00	104.04	0.65	3.34	107.38
	USKCF	6 B-Laborer + 1 3T Flat B Truck			PROD = 100%				CREW HOURS =	4
MIL	B-LABORER L	Laborers, (Semi-Skilled)	6.00	HR	34.51	6.00	207.08			207.08
MIL	B-SKILLWKRL	Skilled Workers	1.00	HR	24.30	1.00	24.30			24.30
MIL	B-SKILLWKRF	Skilled Workers	1.00	HR	24.80	1.00	24.80			24.80
MIL	XMIXX020 E	Small Tools	1.00	HR	1.57			1.00	1.57	1.57
MIL	T50FO011 E	TRK,HWY, 24,500 GVW, 4X2, 2 AXL	1.00	HR	14.83			1.00	14.83	14.83
MIL	T40XX016 E	FLATBED, 8'x 16.0' (ADD TRK	1.00	HR	0.73			1.00	0.73	0.73
	TOTAL					8.00	256.19	3.00	17.13	273.32
	USRYA	Means A-7, Chief, Instru. & Rdmn			PROD = 100%				CREW HOURS =	168
USR *	X-CHFPARTYL	Chief of Party	1.00	HR	33.57	1.00	33.57			33.57
USR *	X-INSTRUMNL	Instrument Man	1.00	HR	30.06	1.00	30.06			30.06
USR	X-RODMEN L	Rodmen/Chainman	1.00	HR	26.42	1.00	26.42			26.42
	TOTAL					3.00	90.05	0.00	0.00	90.05
*	UTDHA5	10 B-laborer + 5 Tractor & Lowbed Trailer, 40 Tn			PROD = 100%				CREW HOURS =	48
MIL *	B-LABORER L	Laborers, (Semi-Skilled)	10.00	HR	34.51	10.00	345.13			345.13
MIL	B-LABORER F	Laborers, (Semi-Skilled)	1.00	HR	35.01	1.00	35.01			35.01
MIL *	B-TRKDVRHVL	Truck Drivers, Heavy	5.00	HR	32.07	5.00	160.33			160.33
MIL *	XMIXX020 E	Small Tools	10.00	HR	1.57			10.00	15.70	15.70
MIL *	T45XX019 E	TRLR,LOWBOY, 75T, 3 AXLE(ADD TR	5.00	HR	10.30			5.00	51.52	51.52
MIL *	T50KE004 E	TRK,HWY, 50,000 GVW, 6X4, 3 AXL	5.00	HR	36.47			5.00	182.33	182.33
	TOTAL					16.00	540.48	20.00	249.54	790.02
	XCARB	1 X-carpnter + Misc. Power Tools			PROD = 100%				CREW HOURS =	16
MIL	XMIXX010 E	Misc. Power Tools	1.00	HR	6.40			1.00	6.40	6.40
MIL	XMIXX020 E	Small Tools	1.00	HR	1.57			1.00	1.57	1.57
MIL	X-CARPNTERF	Outside Carpenters	0.17	HR	41.33	0.17	7.03			7.03
MIL	X-CARPNTERL	Outside Carpenters	1.00	HR	40.83	1.00	40.83			40.83

SRC	ITEM ID	DESCRIPTION	NO.	UOM	RATE	**** LABOR **** HOURS	COST	**** EQUIP **** HOURS	COST	TOTAL COST
MIL	X-LABORER L	Outside Laborers, (Semi-Skilled	1.00	HR	36.76	1.00	36.76			36.76
	TOTAL					2.17	84.62	2.00	7.97	92.59
	XLABC	3 X-laborer + Small Tools			PROD = 100%				CREW HOURS =	280
MIL	XMIXX020 E	Small Tools	1.00	HR	1.57			1.00	1.57	1.57
MIL	X-LABORER L	Outside Laborers, (Semi-Skilled	3.00	HR	36.76	3.00	110.27			110.27
MIL	X-LABORER F	Outside Laborers, (Semi-Skilled	0.34	HR	37.26	0.34	12.67			12.67
	TOTAL					3.34	122.94	1.00	1.57	124.51
*	XLABGC	3 + 1 Lab+Op+2cy HydExcavCwlr+SmlTls			PROD = 100%				CREW HOURS =	184
BGS *	B-LABCOM#1F	Lab Common (LAB00172	1.00	HR	36.08	1.00	36.08			36.08
BGS *	B-LABCOM#1L	Lab Common (LAB00172	2.00	HR	35.58	2.00	71.16			71.16
BGS *	B-EQ825B1 L	Eq Op Bldg Crn/Shvl (ENGI0825B	1.00	HR	51.30	1.00	51.30			51.30
MIL	H25CA007 E	Hyd Excav,Cwlr,2cy Bkt	1.00	HR	95.34			1.00	95.34	95.34
	TOTAL					4.00	158.54	1.00	95.34	253.88
	XXQHK	1 X-eqoprhvy + 1 3.0 Cy Hydr. Excavator, Cwlr			PROD = 100%				CREW HOURS =	2
MIL	H25CA008 E	HYD EXCAV, CRWLR, 3.125CY BKT	1.00	HR	144.44			1.00	144.44	144.44
MIL	XMIXX020 E	Small Tools	0.11	HR	1.57			0.11	0.17	0.17
MIL	X-LABORER L	Outside Laborers, (Semi-Skilled	1.00	HR	36.76	1.00	36.76			36.76
MIL	X-EQOPRHVYL	Outside Equip. Operators, Heavy	1.00	HR	45.83	1.00	45.83			45.83
MIL	X-EQOPROILL	Outside Equip. Operators, Oiler	1.00	HR	31.76	1.00	31.76			31.76
	TOTAL					3.00	114.35	1.11	144.62	258.97

SRC	LABOR ID	DESCRIPTION	BASE	OVERTM	TXS/INS	FRNG	TRVL	RATE	UOM	UPDATE	**** TOTAL **** DEFAULT	HOURS
TWT	B-CARPNTER	Carpenters (CARP0001H)	25.94	0.0%	28.6%	9.60	0.00	42.95	HR	02/27/95	37.21	98
MIL	B-CEMTFINR	Cement Finishers (BRNJ0033A)	23.09	0.0%	28.6%	11.93	0.00	41.61	HR	09/06/95	34.63	40
MIL	B-EQOPRCRN	Eq Oper, Crane/Shovl (ENGI0825B)	28.62	0.0%	29.0%	13.69	0.00	50.60	HR	06/21/96	33.06	682
TWT	B-EQOPRLT	Eq Oper, Light (ENGI0825B)	23.49	0.0%	28.9%	13.50	0.00	43.79	HR	01/26/96	27.50	28
MIL	B-EQOPRMED	Eq Oper, Medium (ENGI0825B)	27.03	0.0%	29.0%	13.63	0.00	48.49	HR	06/21/96	30.73	537
TWT	B-EQOPROIL	Eq Oper, Oilers (ENGI0825B)	20.63	0.0%	28.9%	13.40	0.00	40.00	HR	06/21/96	27.56	10
MIL	B-LABORER	Laborer/Helper (LABO0172A)	19.70	0.0%	29.0%	9.11	0.00	34.51	HR	08/07/96	27.33	776
MIL	B-PLUMBER	Plumbers (PLUM0322A)	24.31	0.0%	28.5%	12.40	0.00	43.65	HR	09/06/95	36.23	40
MIL	B-SKILLWKR	Skilled Worker (LABO0222A)	15.47	0.0%	26.0%	4.82	0.00	24.30	HR	02/08/94	32.03	8
TWT	B-STRSTEEL	Struct Stl Workers (IRON0399A)	21.79	0.0%	28.5%	15.56	0.00	43.57	HR	07/24/95	40.72	10
MIL	B-TRKDVRHV	Truck Drivers, Heavy (TEAM0331A)	19.85	0.0%	29.0%	6.47	0.00	32.07	HR	08/07/96	27.58	246
MIL	X-CARPNTER	Outside Carpenter (CARP1489A)	25.21	0.0%	26.0%	9.08	0.00	40.83	HR	02/08/94	37.21	19
USR	X-CHFPARTY	Chief of Party	22.30	0.0%	25.5%	5.60	0.00	33.57	HR	07/28/92	0.00	168
MIL	X-EQOPRHVY	Outside Equip., Grp 1, ENGI0825B	26.57	0.0%	25.9%	12.37	0.00	45.83	HR	04/15/94	33.06	2
MIL	X-EQOPROIL	Outside Oiler	17.08	0.0%	26.0%	10.25	0.00	31.76	HR	02/08/94	27.56	2
USR	X-INSTRUMN	Instrument Man	19.90	0.0%	26.0%	4.99	0.00	30.06	HR	06/21/96	0.00	168
MIL	X-LABORER	Outside Laborer (LABO0172A)	21.20	0.0%	29.0%	9.42	0.00	36.76	HR	05/20/97	27.33	953
USR	X-RODMEN	Rodmen/Chainman	17.55	0.0%	25.5%	4.40	0.00	26.42	HR	07/28/92	0.00	168

SRC	ID.NO.	EQUIPMENT DESCRIPTION	DEPR	FCCM	FUEL	FOG	TR WR	TR REP	EQ REP	TOTAL RATE	** TOTAL ** HOURS
MIL	C10WC003	COMPACTOR, RAMMER, 11"X13" SHOE	0.63	0.13	0.46	0.12			1.06	2.39 HR	48
UPB	C65WC002	CONC VIBRATOR, 2.50D, EL,HI-FREQ	0.31	0.05	0.14	0.21			1.07	1.78 HR	20
MIL	C75GV002	CRANE,HYD,S/P,RT,4WD,20T/70'BOOM	11.08	5.23	4.45	1.43	1.14	0.18	11.92	35.44 HR	9
UPB	C80GV007	CRANE,HYD,TRK MTD, 60T /115'BOOM	25.34	13.31	9.13	2.54	1.11	0.18	23.80	75.40 HR	10
MIL	F10CA023	FORK LIFT,R/T 6,000#,20.00'L-HT	3.65	1.40	2.47	0.63	0.30	0.05	3.88	12.39 HR	336
UPB	G10HO004	GENERATOR, 5.5 KW, 120/240V,PORT	0.24	0.07	0.91	0.23			0.18	1.63 HR	10
UPB	H25CA007	HYD EXCAV, CRWLR, 2.00 CY BKT	32.63	12.03	8.33	3.39			38.96	95.34 HR	184
UPB	H25CA008	HYD EXCAV, CRWLR, 3.125CY BKT	44.07	17.47	12.00	2.82			68.09	144.44 HR	2
UPB	L35CA004	LDR,FE, CRWLR, 1.50 CY	8.84	3.26	3.15	1.28			17.61	34.14 HR	4
UPB	L50CA003	LDR,BH,WH, 1.38CY FE BKT, 30"DIP	5.63	2.35	2.80	0.96	0.48	0.08	6.92	19.21 HR	2
UPB	P60ML001	PUMP,CENTRF,DW,4"D, 465GPM/40'HD	1.05	0.35	4.35	1.49			1.42	8.65 HR	28
UPB	R30CA001	ROLLR,STATIC,S/P,13T,84"W,11TIRE	5.21	1.71	2.80	0.72	0.98	0.16	5.03	16.61 HR	56
UPB	T10CA004	BLADE, ANGLE, HYDR, D-4	1.46	0.54		0.08			1.74	3.81 HR	96
UPB	T10CA022	BLADE, UNIVERSAL, HYDR, D-9	4.43	1.63		0.19			5.27	11.53 HR	504
UPB	T15CA004	DOZER,CWLR, D-4H,PS	5.37	2.18	3.74	1.44			10.23	22.97 HR	48
MIL	T15CA005	DOZER,CWLR, D-4H,LGP	6.35	2.58	3.55	1.37			12.11	25.95 HR	48
UPB	T15CA017	DOZER,CWLR, D-9N,PS	30.72	11.33	14.57	4.37			45.73	106.72 HR	504
UPB	T40XX008	REAR DUMP BODY, 8.0CY	1.21	0.36		0.09			1.19	2.85 HR	2
UPB	T40XX010	REAR DUMP BODY, 12.0CY	1.24	0.37		0.09			1.22	2.93 HR	4
MIL	T40XX016	FLATBED, 8'x 16.0'	0.34	0.10					0.29	0.73 HR	4
UPB	T45XX019	TRLR,LOWBOY, 75T, 3 AXLE	3.51	1.81		0.50	1.32	0.21	2.95	10.30 HR	240
UPB	T50FO003	TRK,HWY, 8,600GVW,4X2, 3/4T-PKUP	1.71	0.52	2.30	0.69	0.19	0.03	1.93	7.37 HR	2
UPB	T50FO011	TRK,HWY, 24,700 GVW, 4X2, 2 AXLE	2.92	1.07	5.09	1.42	1.03	0.17	3.13	14.83 HR	4
MIL	T50KE003	TRK,HWY, 46,000 GVW, 6X4, 3 AXLE	9.60	2.93	9.76	2.92	0.44	0.07	9.41	35.13 HR	6
UPB	T50KE004	TRK,HWY, 50,000 GVW, 6X4, 3 AXLE	10.19	3.11	9.76	2.92	0.44	0.07	9.98	36.47 HR	240
UPB	T60KI002	TRK,WTR,OF-HY, 6000GAL,W/CAT621E	18.59	8.69	12.00	4.11	4.07	0.65	18.22	66.34 HR	56
UPB	XMIXX010	MISC. POWER TOOLS	2.17	0.76	0.60	0.27			2.60	6.40 HR	33
UPB	XMIXX020	SMALL TOOLS	0.50	0.22	0.16	0.07			0.63	1.57 HR	1231
USR	ZC-HELICOP	Helicopter		50.00						50.00 ACR	1231

** OWNER, OVERTIME, AND ADJUSTMENTS SETTINGS **

			AMOUNT	PERCENT	*ESCALATN DATE* BEGIN	END	*ESCALATN INDEX* BEGIN	END
6 Beachfill w/Dune								
	CONTINGENCY	P		0.00				
	PLANNING, ENGINEERING AND DESIGN	P		0.00				
	SIOH	P		0.00				
6/ L.A.A Excavation								
	CONTINGENCY	P		20.00				
	PLANNING, ENGINEERING AND DESIGN	P		2.00				
	SIOH	P		9.00				
SP Selected Plan								
	CONTINGENCY	P		0.00				
	PLANNING, ENGINEERING AND DESIGN	A	636,100					
	SIOH	A	250,000					
SP/01 Lands and Damages								
	CONTINGENCY	P		15.00				
	PLANNING, ENGINEERING AND DESIGN	O						
	SIOH	O						
SP/06.3.1.1 Phragmites Removal								
	CONTINGENCY	P		20.00				
	PLANNING, ENGINEERING AND DESIGN	O						
	SIOH	O						
SP/06.3.1.2 Phragmites Removal								
	CONTINGENCY	P		20.00				
	PLANNING, ENGINEERING AND DESIGN	O						
	SIOH	O						
SP/06.3.1.5 Phragmites Burning w/Safety&Brks								
	CONTINGENCY	P		30.00				
	PLANNING, ENGINEERING AND DESIGN	O						
	SIOH	O						
SP/06.3.2.A.1 Plantings after Phrag Burning								
	CONTINGENCY	P		20.00				
	PLANNING, ENGINEERING AND DESIGN	O						
	SIOH	O						
SP/06.3.2.C.1 Plantings after Moving the Shore								
	CONTINGENCY	P		20.00				
	PLANNING, ENGINEERING AND DESIGN	O						
	SIOH	O						
SP/06.3.3.A.E Organic Substrate								
	CONTINGENCY	P		50.00				
	PLANNING, ENGINEERING AND DESIGN	O						
	SIOH	O						

** OWNER, OVERTIME, AND ADJUSTMENTS SETTINGS **

		AMOUNT	PERCENT	*ESCALATN DATE* BEGIN	END	*ESCALATN INDEX* BEGIN	END
SP/06.5.1.1 Excavate & Disperse							
	CONTINGENCY	P	20.00				
	PLANNING, ENGINEERING AND DESIGN	O					
	SIOH	O					
SP/06.5.2.1 Excavate & Disperse							
	CONTINGENCY	P	20.00				
	PLANNING, ENGINEERING AND DESIGN	O					
	SIOH	O					
SP/06.5.3.1 Excavate & Disperse							
	CONTINGENCY	P	20.00				
	PLANNING, ENGINEERING AND DESIGN	O					
	SIOH	O					
SP/06.5.4.1 Geogrid							
	CONTINGENCY	P	20.00				
	PLANNING, ENGINEERING AND DESIGN	O					
	SIOH	O					
SP/06.5.4.2.1 Grading of Material 6d							
	CONTINGENCY	P	20.00				
	PLANNING, ENGINEERING AND DESIGN	O					
	SIOH	O					
SP/06.5.4.3 Place & Compact from Stockpl 14d							
	CONTINGENCY	P	20.00				
	PLANNING, ENGINEERING AND DESIGN	O					
	SIOH	O					
SP/06.5.4.4 Misc Clearing & Grubbing w/Displ							
	CONTINGENCY	P	20.00				
	PLANNING, ENGINEERING AND DESIGN	O					
	SIOH	O					
SP/06.5.4.5 Timber Mats 14d							
	CONTINGENCY	P	20.00				
	PLANNING, ENGINEERING AND DESIGN	O					
	SIOH	O					
SP/06.5.4.6 Misc. Dewatering							
	CONTINGENCY	P	20.00				
	PLANNING, ENGINEERING AND DESIGN	O					
	SIOH	O					
SP/06.5.5.1 Gravity-Type Conc. Retaining Wll							
	CONTINGENCY	P	15.00				
	PLANNING, ENGINEERING AND DESIGN	O					
	SIOH	O					

** OWNER, OVERTIME, AND ADJUSTMENTS SETTINGS **

		AMOUNT	PERCENT	*ESCALATN DATE* BEGIN	END	*ESCALATN INDEX* BEGIN	END
SP/06.5.5.2 Flashboard							
	CONTINGENCY	P	15.00				
	PLANNING, ENGINEERING AND DESIGN	0					
	SIOH	0					
SP/06.5.5.3 Slope Stabilization							
	CONTINGENCY	P	15.00				
	PLANNING, ENGINEERING AND DESIGN	0					
	SIOH	0					
SP/06.5.6 Self-Regulating TideGate							
	CONTINGENCY	P	20.00				
	PLANNING, ENGINEERING AND DESIGN	0					
	SIOH	0					
SP/06.5.7 Drainage Gate							
	CONTINGENCY	P	20.00				
	PLANNING, ENGINEERING AND DESIGN	0					
	SIOH	0					
SP/17.1 Beachfill w/Dune							
	CONTINGENCY	P	15.00				
	PLANNING, ENGINEERING AND DESIGN	0					
	SIOH	0					
SP/17.2 Mob/Demob (Land-Based)							
	CONTINGENCY	P	12.00				
	PLANNING, ENGINEERING AND DESIGN	0					
	SIOH	0					
SP/17.3 Mob/Demob (Dredge)							
	CONTINGENCY	P	12.00				
	PLANNING, ENGINEERING AND DESIGN	0					
	SIOH	0					
SP/17.4 Beachfill w/Dune:Sand Fence							
	CONTINGENCY	P	15.00				
	PLANNING, ENGINEERING AND DESIGN	0					
	SIOH	0					
SP/17.5.1.1 24" Ductile Iron Pipe							
	CONTINGENCY	P	20.00				
	PLANNING, ENGINEERING AND DESIGN	0					
	SIOH	0					
SP/17.5.1.2.1 Earthwork							
	CONTINGENCY	P	20.00				
	PLANNING, ENGINEERING AND DESIGN	0					
	SIOH	0					

** OWNER, OVERTIME, AND ADJUSTMENTS SETTINGS **

		AMOUNT	PERCENT	*ESCALATN DATE* BEGIN	END	*ESCALATN INDEX* BEGIN	END
SP/17.5.1.2.2 Pile Driving							
	CONTINGENCY	P	20.00				
	PLANNING, ENGINEERING AND DESIGN	O					
	SIOH	O					
SP/17.5.1.2.3 Cribbing							
	CONTINGENCY	P	20.00				
	PLANNING, ENGINEERING AND DESIGN	O					
	SIOH	O					
SP/17.6.E.1 Plantings for the Dune							
	CONTINGENCY	P	15.00				
	PLANNING, ENGINEERING AND DESIGN	O					
	SIOH	O					

** CONTRACTOR SETTINGS **

		AMOUNT	PCT	PCT S	RISK	DIFF	SIZE	PERIOD	INVEST	ASSIST	SUBCON
AA Prime Contractor											
OVERHEAD	P		12.00								
HOME OFFICE	P		0.00								
PROFIT	P		10.00								
BOND	P		1.00								
PL Plumber											
OVERHEAD	P		5.00								
HOME OFFICE	P		5.00								
PROFIT	P		10.00								
BOND	P		0.00								

****

A DESCRIPTION AND QUANTITY SUMMARY

****

1 PROJECT	Lower Cape May Meadows & Cape May Point	DATE OF ESTIMATE	October 1997
2 LOCATION	New Jersey	INVIT. OR CONTR. NO.	Feasibility - Renourishm
3 ESTIMATED BY	S. Johnson	CHECKED BY	
4 TYPE OF DREDGE	User 27" Cutter-Suction Dredge	TYPE OF ESTIMATE	Planning Estimate

5 DESCRIPTION OF WORK

6 EXCAVATION			REMARKS
A. REQUIRED		650,400 CY	4,305,489 s.f. of Dredging Area
B. PAY OVERDEPTH	+	0 CY	
C. MAX. PAY YARDAGE	=	650,400 CY	(YARDAGE USED ON BID FORM)
D. O.D. NOT DREDGED	-	0 CY	
E. NET PAY YARDAGE	=	650,400 CY	(YARDAGE USED TO FIGURE UNIT PRICE PER C.Y.)
F. NON-PAY YARDAGE	+	199,000 CY	1.2 ft overdig
G. GROSS YARDAGE	=	849,400 CY	(YARDAGE USED TO FIGURE PRODUCTION TIME & COST)

B DREDGING COST BID ITEM # _____

				REMARKS
1 GROSS YARDAGE			849,400 CY	FROM SHEET A, ITEM 6 G.
2 PRODUCTION RATE		/	362,900 CY/MO	FROM SHEET C, ITEM 8.
3 DREDGING TIME		=	2.34 MONTHS	
4 TOTAL MONTHLY COST		x	$1,079,278	FROM SHEET D, ITEM 5.
SUBTOTAL.....		=	$2,525,511	
5 FIXED COSTS		+	$0	FROM SHEET E, ITEM 15.
SUBTOTAL.....		=	$2,525,511	
6 OVERHEAD	12.0%	+	$303,061	
SUBTOTAL.....		=	$2,828,572	
7 PROFIT	10.0%	+	$282,857	
SUBTOTAL.....		=	$3,111,429	
8 BOND	1.3%	+	$40,449	
9 GROSS PRODUCTION COSTS		=	$3,151,878	
10 NET PAY YARDAGE		/	650,400 CY	FROM SHEET A, ITEM 6 E.
11 UNIT COST		=	$4.85 /CY	
12 MAX PAY YARDAGE		x	650,400 CY	FROM SHEET A, ITEM 6 C.
13 DREDGING COST		=	$3,154,440	

C MONTHLY PRODUCTION SUMMARY BID ITEM # ----------

			REMARKS
1 SIZE OF DREDGE....PIPELINE.....>		User 27"	
2 POWER OUTPUT.....MAIN PUMP.....>		5,000 HP	
3 NUMBER OF BOOSTERS IN LINE.....>		0	
4 POWER OUTPUT.....EACH BOOSTER.....>		4,000 HP	
5 PUMPING DISTANCES			
A. MAXIMUM PIPELINE NEEDED.....>		15,936 LF	
B. AVERAGE PIPELINE.....>		10,608 LF	
C. EQUIVALENT ADDITIONAL PIPELINE	+	1,061 LF	
D. PRODUCTION BASED ON	=	11,669 LF	
6 GROSS PRODUCTION		764 CY/HR	SEE SHEET C \ 1, ITEM 4 F.
7 OPERATING TIME	x	475 HRS/MO	SEE SHEET C \ 1, ITEM 5 E.
			(475 Operating Hrs per Mo / 730 Hrs per Mo of Dredging = 65.1% Effective Time)
8 PRODUCTION RATE	=	362,900 CY/MO	650,400 Net Pay CY / 2.34 MO = 277,949 Pay CY/MO

GROSS PRODUCTION

C \ 1 BID ITEM #

OPERATING TIME

			REMARKS
1 SIZE OF DREDGE....PIPELINE.....>		User 27"	
2 POWER OUTPUT.....MAIN PUMP.....>		5,000 HP	
3 NUMBER OF BOOSTERS IN LINE		0	Each Booster is 4000 Horsepower.
4 PRODUCTION.....(BASED ON).....>		11,669 LF	FROM SHEET C \ 2, ITEM 13.
A. ADJUSTED CHART PRODUCTION		1,137 CY/HR	FROM SHEET C \ 2, ITEM 14.
B. MATERIAL FACTOR_	x	0.90	FROM SHEET C \ 3, ITEM 1 B.
C. BANK FACTOR	x	0.82	FROM SHEET C \ 3, ITEM 2 D.
D. OTHER FACTOR	x	1.00	Wave Action
E. CLEANUP FACTOR	x	0.91	10% ADDITIONAL DREDGING TIME
F. GROSS PRODUCTION	=	764 CY/HR	

			REMARKS
5 OPERATING TIME:			
A. BOOSTER FACTOR		1.00	10% LOSS IN PUMPING TIME PER BOOSTER
B. TIME EFFICIENCY	x	65.0%	% OF EFFECTIVE WORKING TIME WITHOUT BOOSTERS
C. NET EFFICIENCY	=	65.0%	% OF EFFECTIVE WORKING TIME INCLUDING BOOSTER LOSSES
D. MAX DREDGE TIME	x	730 HRS/MO	
E. OPERATING TIME	=	475 HRS/MO	

C \ 2 ADJUSTED CHART PRODUCTION BID ITEM #

		REMARKS
1 SIZE OF DREDGE....PIPELINE.....>	User 27"	
2 CHART HORSEPOWER.....>	5,000 HP	
3 STANDARD PRODUCTION CHART:		
STANDARD DREDGE PRODUCTION BASED ON CHART HORSEPOWER		
UP TO 6,875 L.F. OF PIPE	1500 CY/HR	
AT 13,750 L.F. OF PIPE	980 CY/HR	
AT 19,375 L.F. OF PIPE	420 CY/HR	
4 POWER OUTPUT....USED FOR DREDGE....>	5,000 HP	Chart Adjustment Factor = (Available Dredge Horsepower +
5 NUMBER OF BOOSTERS USED.....>	0	Number of Boosters x Booster H.P.) / Chart H.P.
6 POWER OUTPUT.....EACH BOOSTER.....>	4,000 HP	
7 TOTAL POWER APPLIED TO PIPELINE....>	5,000 HP	= (5000 H.P. + 0 Booster(s) x 4000 HP/Booster)
8 CHART ADJUSTMENT FACTOR (C.A.F)....>	1.00	= (5000 HP / 5000 HP)
9 ADJUSTED PRODUCTION CHART:		
ADJUSTED DREDGE PRODUCTION CHART BASED ON C.A.F.		
UP TO 6,875 L.F. OF PIPE	1500 CY/HR	
AT 13,750 L.F. OF PIPE	980 CY/HR	
AT 19,375 L.F. OF PIPE	420 CY/HR	
10 MAXIMUM LINE LENGTH.....>	15,936 LF	
11 AVERAGE LINE LENGTH.....>	10,608 LF	Actual Pipeline
12 EQUIVALENT ADDITIONAL PIPELINE +	1,061 LF	Vertical Lift of Discharge Pipe.
13 PIPE USED FOR PRODUCTION =	11,669 LF	Actual Pipeline + Equivalent Feet of Pipe
14 ADJUSTED CHART PRODUCTION	1,137 CY/HR	Interpolated from Chart

MATERIAL FACTOR CALCULATION

C \ 3 BID ITEM #

BANK FACTOR CALCULATION ----------

1 MATERIAL FACTOR COMPUTATION:

A. MATERIAL FACTOR CHART:

DESCRIPTION	INPLACE DENSITY		FACTOR	%	QUANTITIES
MUD & SILT	1200	GR/L	3	0%	0 c.y.
MUD & SILT	1300	GR/L	2.5	0%	0 c.y.
MUD & SILT	1400	GR/L	2	0%	0 c.y.
LOOSE SAND	1700	GR/L	1.1	0%	0 c.y.
LOOSE SAND	1900	GR/L	1	0%	0 c.y.
COMP. SAND	2000	GR/L	0.9	100%	849,400 c.y.
STIFF CLAY	2000	GR/L	0.6	0%	0 c.y.
COMP. SHELL	2300	GR/L	0.5	0%	0 c.y.
SOFT ROCK	2400	GR/L	0.4	0%	0 c.y.
BLAST. ROCK	2000	GR/L	0.25	0%	0 c.y.

B. MATERIAL FACTOR.....> 0.90 100% 849,400 c.y. (Computed from Chart)

REMARKS

2 BANK FACTOR COMPUTATION:

A. SIZE OF DREDGE....PIPELINE.....> User 27"

B. AVERAGE BANK HEIGHT.....> 5.34763 FT

C. BANK FACTOR CHART:

BANK HEIGHT	1	2	3	4	5	6	7	8	9
FACTOR	NA	0.43	0.55	0.65	0.78	0.9	1	1.1	1.1

D. BANK FACTOR.....> 0.82 Interpolated from chart

>

D MONTHLY COST SUMMARY BID ITEM # ----------

DREDGE SIZE User 27"

						REMARKS
1 LABOR COSTS		$320,359 /MO	FROM SHEET D \ 1			
2 EQUIPMENT COSTS			FROM SHEET D \ 2			
A. DREDGE	+	$501,101 /MO	1 EA	@	$501,101 /MO	
B. WORK TUG(S)	+	$42,796 /MO	2 EA	@	$21,398 /MO	
C. CREW/SURVEY TUG	+	$5,451 /MO	1 EA	@	$5,451 /MO	
D. DERRICK(S)	+	$18,032 /MO	2 EA	@	$9,016 /MO	
E. FUEL/WATER BARGE	+	$1,684 /MO	1 EA	@	$1,684 /MO	
F. WORK BARGE	+	$4,938 /MO	2 EA	@	$2,469 /MO	
H. BOOSTER(S)	+	$0 /MO	0 EA	@	$121,420 /MO	
G. ***Unused***	+	$0 /MO	0 EA	@	$0 /MO	
3 PIPELINE COSTS BASED ON PUMPING SAND			15,936 LF (ON JOB) - RATES TAKEN FROM SHEET D \ 3			
A. (1) FLOATING PIPE (AVERAGE)	+	$23,540 /MO	2,000 LF	@	$11.77 /MO	
(2) FLOATING PIPE (REMAINING)	+	$0 /MO	0 LF	@	$0.011 /HR X 730 HRS/MO	
B. (1) SUBMERGED PIPE (AVERAGE)	+	$10,920 /MO	2,026 LF	@	$5.39 /MO	
(2) SUBMERGED PIPE (REMAINING)	+	$3,662 /MO	1,254 LF	@	$0.004 /HR X 730 HRS/MO	
C. (1) SHORE PIPE (AVERAGE)	+	$12,769 /MO	6,582 LF	@	$1.94 /MO	
(2) SHORE PIPE (REMAINING)	+	$2,974 /MO	4,074 LF	@	$0.001 /HR X 730 HRS/MO	
4 OTHER MONTHLY COSTS	+	$131,052 /MO	FROM SHEET D \ 4			
5 TOTAL MONTHLY COST	=	$1,079,278				

D \ 1 LABOR COSTS BID ITEM #

DREDGE SIZE: User 27"

Overtime(Pay 64 Hrs/Wk)		14.29%
Holidays/Yr	9	2.47%
Vacation		8.00%
COMPOSITE.....		24.76%

Management....		
1	CAPTAIN	$6,000
1	CHIEF ENG	5,000
1	CIVIL ENG	4,500
1	OFFICE HELP	2,000
MONTHLY MANAGEMENT COST.....		$17,500

Social Security Tax	7.65%
Workman's Compensation	11.60%
State Unemployment Comp.	6.50%
Federal Unemployment Comp.	0.80%
COMPOSITE.....	26.55%

Each Crew Position is Manned: 8 Hrs per Day
x 7 Days per Week
= 56 Hrs per Week
x 4.345 Wks per Month
= 243 Hrs per Month

Last Update...Apr 97

EA	CREW POSITION	BASIC HOURLY WAGE		O.T. VACATION & HOLIDAY 24.76%		SUB-TOTAL		TAXES INSUR 26.55%		SUB-TOTAL		FRINGE BENEFITS $4.49		HRLY COST		HOURS PER MONTH		MONTHLY COST
3	LEVERMAN	$23.15	+	$5.73	=	$28.88	+	$7.67	=	$36.55	+	$4.81	=	$41.36	x	730	=	$30,193
3	WATCH ENG	21.31	+	5.28	=	26.59	+	7.06	=	33.65	+	4.81	=	38.46	x	730	=	28,076
2	DRDG MATE	19.55	+	4.84	=	24.39	+	6.48	=	30.87	+	4.51	=	35.38	x	487	=	17,230
2	TUG MASTER	20.71	+	5.13	=	25.84	+	6.86	=	32.70	+	4.51	=	37.21	x	487	=	18,121
3	LAUNCHMAN	16.05	+	3.97	=	20.02	+	5.32	=	25.34	+	4.21	=	29.55	x	730	=	21,572
0	MAINT ENG	20.94	+	5.18	=	26.12	+	6.93	=	33.05	+	4.51	=	37.56	x	0	=	0
3	EQUIP OPER	20.43	+	5.06	=	25.49	+	6.77	=	32.26	+	4.51	=	36.77	x	730	=	26,842
1	WELDER	21.66	+	5.36	=	27.02	+	7.17	=	34.19	+	4.51	=	38.70	x	243	=	9,404
1	OILER	16.67	+	4.13	=	20.80	+	5.52	=	26.32	+	4.21	=	30.53	x	243	=	7,419
9	DECKHAND	16.05	+	3.97	=	20.02	+	5.32	=	25.34	+	4.21	=	29.55	x	2190	=	64,715
1	ELECTRICIAN	20.77	+	5.14	=	25.91	+	6.88	=	32.79	+	4.81	=	37.60	x	243	=	9,137
1	G DUMP FRMN	21.00	+	5.20	=	26.20	+	6.96	=	33.16	+	4.81	=	37.97	x	243	=	9,227
2	DUMP FOREMN	19.51	+	4.83	=	24.34	+	6.46	=	30.80	+	4.81	=	35.61	x	487	=	17,342
6	SHOREMAN	16.05	+	3.97	=	20.02	+	5.32	=	25.34	+	4.51	=	29.85	x	1460	=	43,581
0	BOOSTER ENG	21.31	+	5.28	=	26.59	+	7.06	=	33.65	+	4.81	=	38.46	x	0	=	0

37 Total Crew MONTHLY CREW LABOR COST = $302,859

(Average Gross Wage = $33.64 per manhour)

TOTAL MONTHLY LABOR COST = $320,359

D \ 2 EQUIPMENT COSTS BID ITEM # ----------

DREDGE SIZE User 27"

	|--DREDGE--|	----TUGS & TENDERS-----			----------BARGES----------			--BOOSTER--	---OTHER---
1a. Plant Description.....	HYDRAULIC	WORK TUG	CREW/SURVEY	DERRICK	FUEL/WATER	WORK	FLOATING	***Unused***
1c. Prime Eng HP.....	5,000	250	100	200	0	0	4,000	0
1d. (1) Dredge El Gen HP...	830	--	--	--	--	--	--	--
1d. Total 2nd Eng HP.....	3,310	50	40	40	10	0	200	0
1e. Plant Value.....	$10,000,000	$327,000	$48,000	$300,000	$122,000	$100,000	$1,896,000	$0
1f. Acquis Year.....	1978	1991	1991	1985	1985	1985	1980	0
1g. Pres Year.....	1995	- - - - ->-	- - - - ->-	- - - - ->-	- - - - ->-	- - - - ->-	- - - - ->-	- - - - ->-
1h. Cost of Money Rate.....	8.125%	- - - - ->-	- - - - ->-	- - - - ->-	- - - - ->-	- - - - ->-	- - - - ->-	- - - - ->-
1i. Disc Money Rate:	6.500%	- - - - ->-	- - - - ->-	- - - - ->-	- - - - ->-	- - - - ->-	- - - - ->-	- - - - ->-
1j. Hrs Worked/Mo.....	475	- - - - ->-	- - - - ->-	- - - - ->-	- - - - ->-	- - - - ->-	- - - - ->-	- - - - ->-
2a. LAF.....	0.970	- - - - ->-	- - - - ->-	- - - - ->-	- - - - ->-	- - - - ->-	- - - - ->-	- - - - ->-
2b. Fuel Cost per Gal.....	$0.85	- - - - ->-	- - - - ->-	- - - - ->-	- - - - ->-	- - - - ->-	- - - - ->-	- - - - ->-
3a. Ec Index <for Acq Yr>..	2352	4438	4438	3749	3749	3749	2922	0
3b. Ec Index <for 1995>....	5023	- - - - ->-	- - - - ->-	- - - - ->-	- - - - ->-	- - - - ->-	- - - - ->-	- - - - ->-
4a. Mos Available/Year.....	9	- - - - ->-	- - - - ->-	- - - - ->-	- - - - ->-	- - - - ->-	- - - - ->-	- - - - ->-
5a. Useful Life (in Yrs)...	14	8	8	9.36	20	9.36	30	0
5b. Physical Life (in Hrs).	60,000	16,000	16,000	40,000	90,000	40,000	135,000	0
5c. SLV Factor.....	0.10	0.10	0.10	0.10	0.05	0.05	0.10	0.00
5d. Pr Eng Fuel Factor.....	0.045	0.045	0.045	0.011	0.011	0.011	0.045	0
5e. 2nd Eng Fuel Factor....	0.039	0.039	0.039	0.011	0.011	0.011	0.039	0
5f. WLS Factor.....	0.22	0.38	0.38	0.20	0.20	0.20	0.24	0.00
5g. RPR Factor.....	1.30	0.80	0.80	0.70	0.60	0.60	1.20	0.00
6a. Depreciation:	6.43%	11.25%	11.25%	9.62%	4.75%	10.15%	3.00%	0.00%
6b. FCCM:	3.78%	3.94%	3.94%	3.89%	3.57%	3.74%	3.67%	0.00%
6c. Total Ownership/Year:	10.21%	15.19%	15.19%	13.51%	8.32%	13.89%	6.67%	0.00%
7a. Yearly Ownership:	$1,021,000	$49,671	$7,291	$40,530	$10,150	$13,890	$126,463	$0
7b. Monthly Ownership:	$113,444	$5,519	$810	$4,503	$1,128	$1,543	$14,051	$0
8a. (1) Hrly Pr Eng Fuel:	$191.25	$9.56	$3.83	$1.87	$0.00	$0.00	$153.00	$0.00
8a. (2) Hrly 2nd Eng Fuel:	$109.73	$1.66	$1.33	$0.37	$0.09	$0.00	$6.63	$0.00
8b. (1) Hrly Pr Eng WLS:	$42.08	$3.63	$1.46	$0.37	$0.00	$0.00	$36.72	$0.00
8b. (2) Hrly 2nd Eng WLS:	$24.14	$0.63	$0.51	$0.07	$0.02	$0.00	$1.59	$0.00
8c. (1) EAF:	2.136	1.132	1.132	1.340	1.340	1.340	1.719	0.000
8c. (2) Hrly Repair:	$448.92	$17.95	$2.64	$6.82	$1.06	$1.95	$28.10	$0.00
8d. Total Hrly Operating:	$816.12	$33.43	$9.77	$9.50	$1.17	$1.95	$226.04	$0.00
8e. Monthly Operating:	$387,657	$15,879	$4,641	$4,513	$556	$926	$107,369	$0
11. MONTHLY RATE:	$501,101	$21,398	$5,451	$9,016	$1,684	$2,469	$121,420	$0
12a. HRLY STANDBY ALLOW:	$155.40	$7.56	$1.11	$6.17	$1.55	$2.11	$19.25	$0.00
12b. Gener Fuel Allowance:	$27.52	--	--	--	--	--	--	--
12c. DREDGE HOURLY STANDBY:	$182.92	--	--	--	--	--	--	--

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D \ 3 PIPELINE COSTS BID ITEM # _____

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PIPELINE SIZE: User 27" MATERIAL PUMPED: SAND

	|--------FLOATING PIPELINE---------|		|--SUBMERGED PIPELINE--|	|-SHOREPIPE-|
1a. Plant Description.....	Pipeline	Joints	Pontoons	Pipeline	Joints	Pipeline
Quantity.....>	100	1	2	400	1	40
Fixed Units Per Item..>	LF	Set	Each	LF	Set	LF
Unit Price.....>	$50.00	$12,000.00	$7,000.00	$50.00	$12,000.00	$25.00
1e. Plant Value:	$5,000.00	$12,000.00	$14,000.00	$20,000.00	$12,000.00	$1,000.00
1f. Acquis Year.....	1992	1992	1992	1992	1992	1992
1g. Pres Year.....	1995	- - - - ->-	- - - - ->-	- - - - ->-	- - - - ->-	- - - - ->-
1h. Cost of Money Rate.....	8.125%	- - - - ->-	- - - - ->-	- - - - ->-	- - - - ->-	- - - - ->-
1i. Disc Money Rate:	6.500%	- - - - ->-	- - - - ->-	- - - - ->-	- - - - ->-	- - - - ->-
1j. Hrs Worked/Mo.....	475	- - - - ->-	- - - - ->-	- - - - ->-	- - - - ->-	- - - - ->-
2a. LAF.....	0.970	- - - - ->-	- - - - ->-	- - - - ->-	- - - - ->-	- - - - ->-
3a. Ec Index <for Acq Yr>..	4611	4611	4611	4611	4611	4611
3b. Ec Index <for 1995>....	5023	- - - - ->-	- - - - ->-	- - - - ->-	- - - - ->-	- - - - ->-
4a. Mos Available/Year.....	9	- - - - ->-	- - - - ->-	- - - - ->-	- - - - ->-	- - - - ->-
5a. Useful Life (in Yrs)...	1.5	3.0	12.0	1.5	3.0	1.5
5b. Physical Life (in Hrs).	6,000	12,000	60,000	6,000	12,000	6,000
5c. SLV Factor.....	0.10	0.10	0.10	0.10	0.10	0.10
5g. RPR Factor.....	0.05	0.30	0.05	0.05	0.30	0.05
6a. Depreciation:	60.00%	30.00%	7.50%	60.00%	30.00%	60.00%
6b. FCCM:	5.53%	4.55%	3.82%	5.53%	4.55%	5.53%
6c. Total Ownership/Year:	65.53%	34.55%	11.32%	65.53%	34.55%	65.53%
7a. Yearly Ownership:	$3,276.50	$4,146.00	$1,584.80	$13,106.00	$4,146.00	$655.30
7b. Monthly Ownership:	$364.06	$460.67	$176.09	$1,456.22	$460.67	$72.81
8c. (1) EAF:	1.089	1.089	1.089	1.089	1.089	1.089
8c. (2) Hrly Repair:	$0.04	$0.32	$0.01	$0.18	$0.32	$0.01
8e. Monthly Operating:	$19.00	$152.00	$4.75	$85.50	$152.00	$4.75
11. Monthly Rate (EA Item):	$383.06	$612.67	$180.84	$1,541.72	$612.67	$77.56
Monthly Rate Per Section (Sum Of Items):			$1,176.57		$2,154.39	$77.56
/ Section Length (In Linear Feet):			100		400	40
			==========		==========	==========
MONTHLY RATES PER LF OF PIPELINE:			$11.77		$5.39	$1.94
5a. Useful Life (in Yrs)...	3.0	3.0	12.0	3.0	3.0	1.5
6a. Depreciation:	30.00%	30.00%	7.50%	30.00%	30.00%	30.00%
6b. FCCM:	4.55%	4.55%	3.82%	4.55%	4.55%	4.55%
6c. Total Ownership/Year:	34.55%	34.55%	11.32%	34.55%	34.55%	34.55%
7a. Yearly Ownership:	$1,727.50	$4,146.00	$1,584.80	$6,910.00	$4,146.00	$345.50
7b. Monthly Ownership:	$191.94	$460.67	$176.09	$767.78	$460.67	$38.39
12a. HRLY STANDBY ALLOW:	$0.263	$0.631	$0.241	$1.052	$0.631	$0.053
Hrly Standby Rate Per Section (Sum Of Items):			$1.135		$1.683	$0.053
/ Section Length (In Linear Feet):			100		400	40
			==========		==========	==========
HOURLY STANDBY RATES PER LF OF PIPELINE:			$0.011		$0.004	$0.001

D \ 4 OTHER MONTHLY COSTS BID ITEM #

DREDGE SIZE User 27"

			REMARKS
1	Constr./Maint.-Beach Rehandling w/Du	$131,052 /MO	
2	+	/MO	
3	> +	$0 /MO	
4	> +	$0 /MO	
5	> +	$0 /MO	
6	> +	$0 /MO	
7	> +	$0 /MO	
8	> +	$0 /MO	
9	> +	$0 /MO	
10	> +	$0 /MO	
11	> +	$0 /MO	
12	> +	$0 /MO	
13	> +	$0 /MO	
14	> +	$0 /MO	
15	TOTAL OTHER MONTHLY COSTS =	$131,052 /MO	

	E	FIXED COSTS	BID ITEM #
DREDGE SIZE	User 27"		
			REMARKS
1	0	$0	
2 >	+	$0	
3 >	+	$0	
4 >	+	$0	
5 >	+	$0	
6 >	+	$0	
7 >	+	$0	
8 >	+	$0	
9 >	+	$0	
10 >	+	$0	
11 >	+	$0	
12 >	+	$0	
13 >	+	$0	
14 >	+	$0	
15 FIXED COSTS	=	$0	

M MOB & DEMOB BID ITEM

DREDGE SIZE User 27"

	MOBILIZATION # DAYS		$/DAY		TOTAL	DEMOBILIZATION # DAYS		$/DAY		TOTAL
1. PREPARE DREDGE FOR TRANSFER	4	x	$11,580	=	$46,320	3	x	$12,127	=	$36,380
2. PREPARE PIPELINE FOR TRANSFER	4	x	$7,094	=	$28,378	3	x	$7,352	=	$22,055
3. TRANSFER ALL PLANT 20 MILES @ 50 miles/day =	0.4	x	$32,072	=	$12,829	20 MILES 0.4	x	$32,072	=	$12,829
4. PERMANENT PERSONNEL & MISC.	L.S.			=	$1,182	L.S.			=	$1,182
5. PREPARE DREDGE AFTER TRANSFER	4	x	$12,127	=	$48,507	3	x	$11,586	=	$34,740
6. PREPARE PIPELINE AFTER TRANSFER	4	x	$7,352	=	$29,407	3	x	$7,094	=	$21,283
7. OTHER	Pipe Ramp			=	$11,044	0			=	$0
	SUBTOTAL MOBILIZATION				$177,667	SUBTOTAL DEMOBILIZATION				$128,470

REMARKS

8. SUBTOTAL MOBILIZATION & DEMOBILIZATION = $306,137

9. OVERHEAD 12.0% + $36,736

SUBTOTAL.....= $342,873

10. PROFIT 10.0% + $34,287

SUBTOTAL.....= $377,160

11. BOND 1.3% + $4,903

12. TOTAL MOBILIZATION & DEMOBILIZATION = $382,063

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an M \ 1 MOB & DEMOB BID ITEM

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DREDGE SIZE User 27"

1. PREPARE DREDGE FOR TRANSFER				MOBILIZATION	DEMOBILIZATION
Labor:	17 men	@	8 hrs/day @ $33.64 per hour =	$4,575	$4,575
Equipment:		Dredge	$182.92 /hr (Standby)		
		Booster(s)	$0.00 /hr (Standby)		

			$182.92 /hr x 24 hrs per day =	$4,390	$4,390
Support equipment with operators				$2,415	$2,415
Supplies & small tools				$200	$200
Additional Fuel (plant idle)				$0	$0
Subsistence:		17 men @	$32.15 per day =	----	$547
				---	---
			COST PER DAY	$11,580	$12,127

2. PREPARE PIPELINE FOR TRANSFER				MOBILIZATION	DEMOBILIZATION
Labor:	8 men	@	8 hrs/day @ $33.64 per hour =	$2,153	$2,153
Equipment:		Work Tug	$90.10 /hr		
		Crew Tug	$11.48 /hr		
		Derrick(s)	$37.96 /hr		
		Fuel Barge	$3.55 /hr		
		Work Barge	$10.40 /hr		

			$153.49 /hr x 8 hrs per day =	$1,228	$1,228
		Pipeline	$45.78 /hr (Standby) x 24 hrs per day =	$1,099	$1,099
Support equipment with operators				$2,415	$2,415
Supplies & small tools				$200	$200
Subsistence		8 men @	$32.15 per day =	----	$257
				---	---
			COST PER DAY	$7,094	$7,352

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M \ 2 MOB & DEMOB BID ITEM

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DREDGE SIZE User 27"

3. TRANSFER PLANT			MOBILIZATION	DEMOBILIZATION
Labor:	12 men/shift (2-12 hr shifts) @	$33.64 per manhour =	$9,688	$9,688
Equipment:	Work Tug(s)	$90.10 /hr		
	Dredge	$182.92 /hr (Standby)		
	Booster(s)	$0.00 /hr (Standby)		
	Crew Tug	$1.11 /hr (Standby)		
	Derrick(s)	$12.34 /hr (Standby)		
	Fuel Barge	$1.55 /hr (Standby)		
	Work Barge	$4.22 /hr (Standby)		
	Unused	$0.00 /hr (Standby)		
	Pipeline	$45.78 /hr (Standby)		

		$338.02 /hr x 24 hrs per day =	$8,112	$8,112
Subsistence	24 men @	$32.15 per day =	$772	$772
Towing vessel(s):	4000 H.P. Rental Tug @			
	$9,000 per day (towing)			
	$4,500 per day (return to port)			

	$13,500 per day x 1 towing vessel(s) =		$13,500	$13,500
			---	---
		COST PER DAY	$32,072	$32,072

4. PERMANENT PERSONNEL & MISC.			MOBILIZATION	DEMOBILIZATION
3 men @	8 hrs/day @	$33.64 per hour @ 1 DAY	$807	$807
Travel Expenses	$125 per man		$375	$375
Local hire			$0	----
			---	---
		TOTAL	$1,182	$1,182

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M \ 3 MOB & DEMOB BID ITEM

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DREDGE SIZE User 27"

5. PREPARE DREDGE AFTER TRANSFER

				MOBILIZATION	DEMOBILIZATION
Labor:	17 men @	8 hrs/day @	$33.64 per hour =	$4,575	$4,575
Equipment:	Dredge	$182.92 /hr (Standby)			
	Booster(s)	$0.00 /hr (Standby)			
		$182.92 /hr x 24 hrs per day =		$4,390	$4,390
Support equipment with operators				$2,415	$2,415
Supplies & small tools				$200	$200
Additional Fuel (plant idle)				$0	$0
Subsistence	17 men @	$32.15 per day =		$547	----
			COST PER DAY	$12,127	$11,580

6. PREPARE PIPELINE AFTER TRANSFER

Labor:	8 men @	8 hrs/day @	$33.64 per hour =	$2,153	$2,153
Equipment:	Work Tug	$90.10 /hr			
	Crew Tug	$11.48 /hr			
	Derrick(s)	$37.96 /hr			
	Fuel Barge	$3.55 /hr			
	Work Barge	$10.40 /hr			
		$153.49 /hr x 8 hrs per day =		$1,228	$1,228
	Pipeline	$45.78 /hr (Standby) x 24 hrs per day =		$1,099	$1,099
Support equipment with operators				$2,415	$2,415
Supplies & small tools				$200	$200
Subsistence	8 men @	$32.15 per day =		$257	----
			COST PER DAY	$7,352	$7,094

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M \ 4 MOB & DEMOB BID ITEM

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DREDGE SIZE User 27"

REMARKS

1 EQUIPMENT COSTS - WORKING RATES			RATES TAKEN FROM SHEET D
A. WORK TUG(S)		$90.10 /HR	$42,796 /MO DIVIDED BY 475 HRS/MO
B. CREW/SURVEY TUG		$11.48 /HR	$5,451 /MO DIVIDED BY 475 HRS/MO
C. DERRICK(S)		$37.96 /HR	$18,032 /MO DIVIDED BY 475 HRS/MO
D. FUEL/WATER BARGE		$3.55 /HR	$1,684 /MO DIVIDED BY 475 HRS/MO
E. WORK BARGE		$10.40 /HR	$4,938 /MO DIVIDED BY 475 HRS/MO
2 LABOR COSTS		$33.64 /MHR	FROM SHEET D \ 1
3 EQUIPMENT COSTS - STANDBY RATES			RATES TAKEN FROM SHEET D \ 2
A. DREDGE		$182.92 /HR	1 EA @ $182.92 /HR
B. BOOSTER(S)		$0.00 /HR	0 EA @ $ 19.25 /HR
C. CREW/SURVEY TUG		$1.11 /HR	1 EA @ $ 1.11 /HR
D. DERRICK(S)		$12.34 /HR	2 EA @ $ 6.17 /HR
E. FUEL/WATER BARGE		$1.55 /HR	1 EA @ $ 1.55 /HR
F. WORK BARGE		$4.22 /HR	2 EA @ $ 2.11 /HR
G. ***Unused***		$0.00 /HR	0 EA @ $ 0.00 /HR
3 PIPELINE COSTS - STANDBY RATES			RATES TAKEN FROM SHEET D \ 3
A. FLOATING PIPELINE		$22.00 /HR	2,000 LF @ $0.011 /HR
B. SUBMERGED PIPELINE	+	$13.12 /HR	3,280 LF @ $0.004 /HR
C. SHORELINE	+	$10.66 /HR	10,656 LF @ $0.001 /HR
D. TOTAL PIPELINE COSTS	=	$45.78 /HR	15,936 LF (ON JOB)

MOBIL & DEMOB COST: $382,063

Lower Cape May Meadows & Cape May Poi

CHECKLIST FOR INPUT DATA.

BID QUANTITY 650,400 C.Y.
UNIT COST... $4.85 PER C.Y.
EXCAV. COST. $3,154,440
TIME..... 2.34 MONTHS

PG 1 OF 9: PROJECT TITLES

FILENAME -	MDWS_123
PROJECT -	Lower Cape May Meadows & Cape May
LOCATION -	New Jersey
INVIT # -	Feasibility - Renourishment Plan
DATE OF EST. -	October 1997
EST. BY -	S. Johnson
MOB. BID ITEM # -	
EXCAV. BID ITEM # -	

PG 1a OF 9: LOCAL AREA FACTORS

PRESENT YEAR -	1995
ECONOMIC INDEX -	5023
LAF -	0.970
INTEREST RATE -	8.125% /yr
TIME PERIOD -	January to June, 1995
PIPELINE AVAILABILITY -	9 mos/yr
BUCKET AVAILABILITY -	10 mos/yr
HOPPER AVAILABILITY -	10 mos/yr
FUEL PRICE -	$0.85 /gal

PG 2 OF 9: TYPE OF EST & INDIRECT COSTS

TYPE OF EST. -	Planning Estimate
CONTRACTOR'S O.H. -	12.0%
CONTRACTOR'S PROFIT -	10.0%
CONTRACTOR'S BOND -	1.3%

PG 3 OF 9: EXCAVATION QTY'S

DREDGING AREA -	4,305,489 sf
REQ'D EXCAVATION -	650,400 cyds
PAY OVERDEPTH -	0 cyds
CONTRACT AMOUNT -	650,400 cyds
NOT DREDGED -	0 cyds
NET PAY -	650,400 cyds
NONPAY YARDAGE -	199,000 cyds
GROSS YARDAGE -	849,400 cyds
NONPAY HEIGHT -	1.2 ft overdig
TOTAL BANK HEIGHT -	5.3 ft

PG 4 OF 9: MATERIAL FACTOR

RESULTANT FACTOR -	0.90

PG 5 OF 9: PIPELINE CONSIDERATIONS

FLOATING -	2,000 ft
SUBMERGED -	3,280 ft
SHORE -	10,656 ft
TOTAL -	15,936 ft
AVE. PIPELINE -	10,608 ft
COST CATEGORY -	2 SAND
EQUIVALENT -	1,061 ft
DESCRIPTION -	Vertical Lift of Discharge Pipe.
BASIS OF PRODUCTION -	11,669 Feet (Ave + Equiv)

PG 6 OF 9: PRODUCTION ANALYSIS

BOOSTER(S) -	0
% EWT (NO BOOSTERS) -	65.0% (475 HRS/MO)
BOOSTER FACTOR -	1.00
% EWT (WITH BOOSTERS) -	65.0% (475 HRS/MO)
MAX. POSSIBLE -	18,314 ft
TOTAL HP AVAIL -	5,000 hp

PG 6a OF 9: HP & BOOSTER FACTOR ADJUSTMENTS

AVAIL PUMP HP -	5,000
BOOSTER HP -	4,000 hp(ea)
LOSS PER BOOSTER -	10%

PG 7 OF 9: OTHER PRODUCTION FACTORS

DREDGE SELECTED -	Use HYDRAULIC DREDGE
COMPUTED BANK FACTOR -	0.82
BANK FACTOR USED -	0.82 >
OTHER FACTOR -	Wave Action
CLEANUP -	10% More Time

PG 8 OF 9: HISTORICAL PRODUCTION OVERRIDES

PRODUCTION OVERRIDE -	NO
PRODUCTION -	764 cy per hour
OPERATING TIME -	475 hours per month
BASED ON -	0 booster(s)
PRODUCTION (GROSS) -	362,900 cy per month
PRODUCTION (CONTRACT) -	277,949 pay cy per month

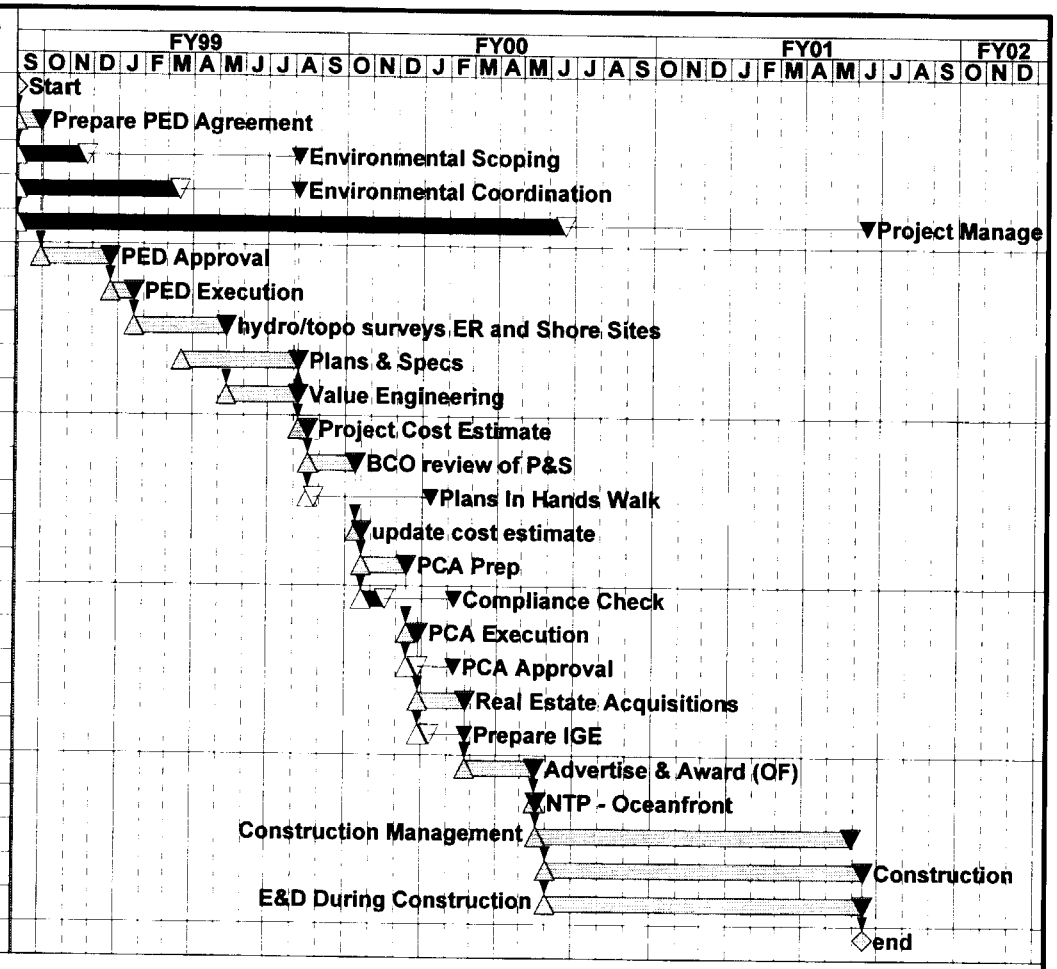
PG 9 OF 9: OTHER ADJUSTMENTS

SPECIAL COST/MO (1ST) -	$131,052	Constr./Maint.-Beach
SP COST/MO (2ND-14TH) -	$0	From Sheet D\4
SPECIAL COST LS (1ST) -	$0	0
SP COST LS (2ND-14TH) -	$0	From Sheet E

SECTION 17

SCHEDULE FOR DESIGN AND CONSTRUCTION

Activity ID	Activity Description	Orig Dur	Scheduled Start	Scheduled Finish	Resource
1000	Start	0	01SEP98		
1040	Prepare PED Agreement	21	01SEP98	29SEP98	
1060	Environmental Scoping	60	01SEP98	23NOV98	PL-E
1050	Environmental Coordination	140	01SEP98	15MAR99	PL-E
1070	Project Management	470	01SEP98	19JUN00	PL-PC+
1080	PED Approval	60	30SEP98	22DEC98	
1110	PED Execution	20	23DEC98	19JAN99	
1120	hydro/topo surveys ER and Shore	80	20JAN99	11MAY99	EN-H+
1090	Plans & Specs	100	17MAR99	03AUG99	EN-DC+
1020	Value Engineering	60	12MAY99	03AUG99	EN-DC+
1150	Project Cost Estimate	10	04AUG99	17AUG99	EN-DC+
1170	BCO review of P&S	40	18AUG99	12OCT99	PL-PC+
1250	Plans In Hands Walk	5	18AUG99	24AUG99	EN-DC+
1190	update cost estimate	5	13OCT99	19OCT99	EN-EC
1220	PCA Prep	40	20OCT99	14DEC99	EN-M+
1240	Compliance Check	20	20OCT99	16NOV99	EN-M
1230	PCA Execution	10	15DEC99	28DEC99	PL-PC+
1310	PCA Approval	10	15DEC99	28DEC99	
1180	Real Estate Acquisitions	40	29DEC99	22FEB00	CENAB-RE
1210	Prepare IGE	10	29DEC99	11JAN00	EN-M+
1200	Advertise & Award (OF)	60	23FEB00	16MAY00	EN-M
1260	NTP - Oceanfront	1	17MAY00	17MAY00	EN-M
1270	Construction Management	270	18MAY00	30MAY01	EN-M+
1280	Construction	270	01JUN00	13JUN01	CNTRCT
1290	E&D During Construction	270	01JUN00	13JUN01	
1300	end	0		13JUN01	



Project Start	01JUL98
Project Finish	13JUN01
Data Date	01SEP98
Run Date	10AUG98

Early Bar
Float Bar
Progress Bar
Critical Activity

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MPMP

Sheet 1 of 1

Lower Cape May Meadows -

Cape May Point

Design & Construction

SECTION 18

SPECIAL STUDIES

The borrow area limits have been well defined and a quantity of available material was established during the Feasibility Study.

Final environmental coordination with various resource agencies will be completed during the P&S Phase. An updated Section 7 Endangered Species Act consultation will be necessary during P&S for initial construction and for each periodic nourishment. A Water Quality Certificate will be required from the State of New Jersey for initial construction and for each periodic nourishment. Consistency with the New Jersey Coastal Zone Management Program must be assured. No compensatory mitigation is required with the project.

Appendix E

Economic Analysis

ECONOMIC APPENDIX

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LOWER CAPE MAY MEADOWS-CAPE MAY POINT FEASIBILITY STUDY

ECONOMIC APPENDIX

SOCIOECONOMIC RESOURCES

Land Use and Population. Cape May Point and the areas of West Cape May delineated in Figure C-1 are the focus of the socioeconomic and economic analysis portions of the study. They are located in Cape May County at the southern tip of New Jersey. The Atlantic Ocean borders the county to the east and the Delaware Bay borders the county to the west. According to the New Jersey Department of Commerce and Economic Development approximately 265 square miles or 58% of the total land area in Cape May County is in use. Farm or forest areas account for 48% of the land in use; industry for 13%; and residential development for 39%. The remaining areas consist of waterways, meadowlands, tide marshes, and beaches. The main transportation arteries in Cape May County are the Garden State Parkway and Route 9 which run north and south. Most of the developed areas are short distances from these roads. The main access roads to Cape May Point and West Cape May are Routes 633 (north-south) and 606 (east-west).

In 1990, Cape May County had a permanent population of 95,089, this represents a 15.6% increase from its 1980 population of 82,266. This is more than three times the State's rate of population growth of 5% during the same period. Almost all of Cape May County's population growth during the 1980s was a result of in-migration. In fact, the county has enjoyed steady growth over the past 50 years. This trend is projected to continue in the future. As shown in Table C-1, the largest increase in population occurred between 1970 and 1980 when the number of persons residing in Cape May County increased by 22,712 or 38%. The number of people 65 years old and over living in Cape May County in 1990 was 19,131, or 20% of the total population. In 1990 over 45% of Cape May Point residents were 65 years old or older. This was much higher than the 13% proportion in the State.

The boroughs of Cape May Point and West Cape May are two of the smallest municipalities in Cape May County. They encompass areas of 0.3 and 1.2 square miles, respectively. The populations of these communities declined slightly from 1980 to 1990. Cape May Point and West Cape May experienced a 3% and 6% population decline, from 255 and 1,091 persons to 248 and 1,026 persons, respectively. By 1995 the population in West Cape May had rebounded, while the number of year round residents in Cape May Point continued to decline.

Since these areas are in such close proximity to the beach and therefore considered resort communities, their population increases tremendously during the summer. The 1990 summer populations of Cape May Point and West Cape May are compared in Figure C- 2 to their permanent populations. Also, the weekend population increases between the Easter and Thanksgiving holidays. Many of the residences in these shore communities and the county are used as rental properties or second homes.

TABLE C-1
POPULATION TREND
Historical & Projected

Year	Cape May County	Cape May Point	West Cape May
1940	28,919	126	943
1950	37,131	198	897
1960	48,555	263	1,030
1970	59,554	204	1,005
1980	82,266	255	1,091
1990	95,089	248	1,026
1995	98,340	223	1,097
2000	111,197	288	1,099
2010	125,695	308	1,128
2020	139,833	329	1,157

Source: Cape May County Department of Planning

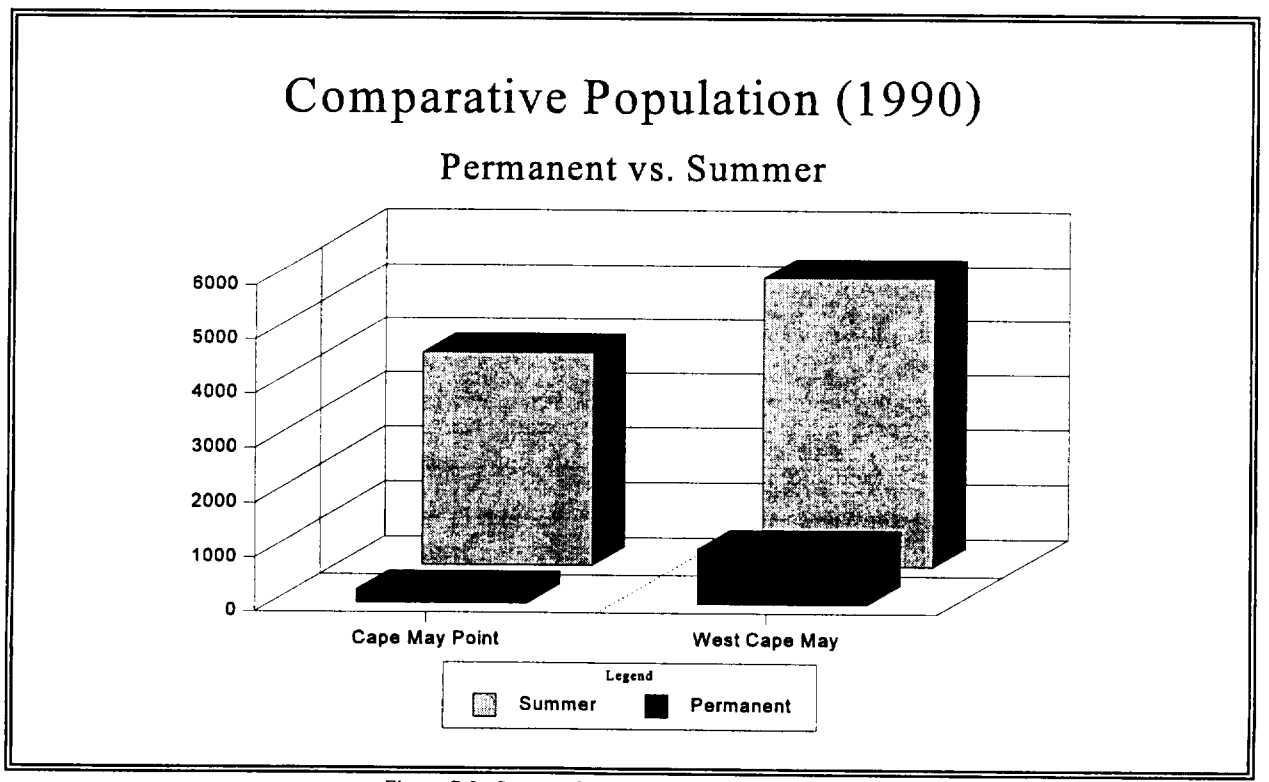


Figure C-2. Source: Cape May County Dept. of Planning

As indicated in Table C-2, housing units categorized as seasonal, or recreational in 1990 accounted for nearly half of the available units in Cape May County.

TABLE C-2
HOUSING UNITS BY USAGE CATEGORY
New Jersey & Cape May County
1990

	New Jersey		Cape May County	
Usage Category	Housing Units	Percentage	Housing Units	Percentage
TOTAL	3,075,310	100.0%	85,537	100.0%
Occupied	2,794,711	90.9%	37,856	44.3%
Owner Occupied	1,813,381	59.0%	27,242	31.8%
Renter Occupied	981,330	31.9%	10,614	12.4%
Vacant	280,599	9.1%	47,681	55.7%
For Rent	78,771	2.6%	6,401	7.5%
For Sale Only	46,271	1.5%	1,531	1.8%
Rented or sold	21,519	0.7%	1,469	1.7%
Seasonal, Recreational, or Occasional Use	100,591	3.3%	36,448	42.6%
For Migrant Workers	267	8.7e-03%	15	0.007%
Other Vacant	33,180	1.1%	1,817	2.1%

Source: Cape May County Department of Planning

In Cape May Point, almost one hundred additional housing units were constructed between 1980 and 1990. As shown in Figure C-3, there are approximately 550 residential structures in Cape May Point. Approximately sixty lots which could be developed are located between existing residences in Cape May Point. However, there are no plans in the near future for any new construction in the study area. In addition, the availability of developable land is limited.

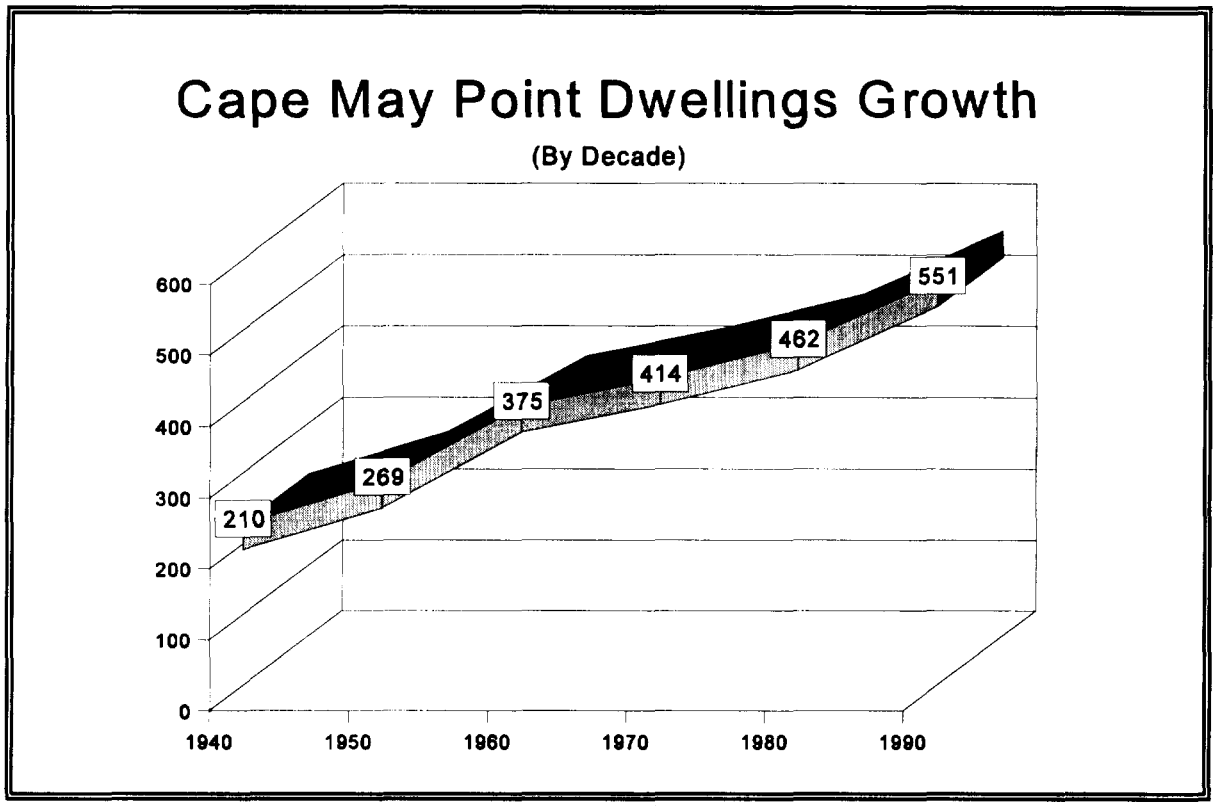


Figure C-3. Source: Bor. of Cape May Point

Employment and Income. According to 1990 census data, the majority of the civilian labor force in Cape May County worked in the managerial/professional specialty, and the technical, sales and administrative support occupations. The educational attainment of the residents of the study area is fairly high. Approximately 34% of the residents of Cape May Point who are over 18 years of age have a bachelor's, graduate, or professional degree.

The summer resort season with its increase in employment remains critical to the local economy in Cape May County. The 1993 tourist season showed a marked improvement over the rainy 1992 tourist season. The civilian labor force in the County increased from 41,500 in 1980 to 45,200 in 1993. The growth in labor force exceeded the increase in employment, causing the number and percentage of unemployed people to rise. Figure C-4 compares the unemployment rates of New Jersey, Cape May County, Cape May Point and West Cape May. The county, and the coastal communities have usually had a higher annual unemployment rate due to the seasonal resort economy. It is common for the unemployment rate to peak around 14% to 17% in the winter and drop to single digits in the summer.

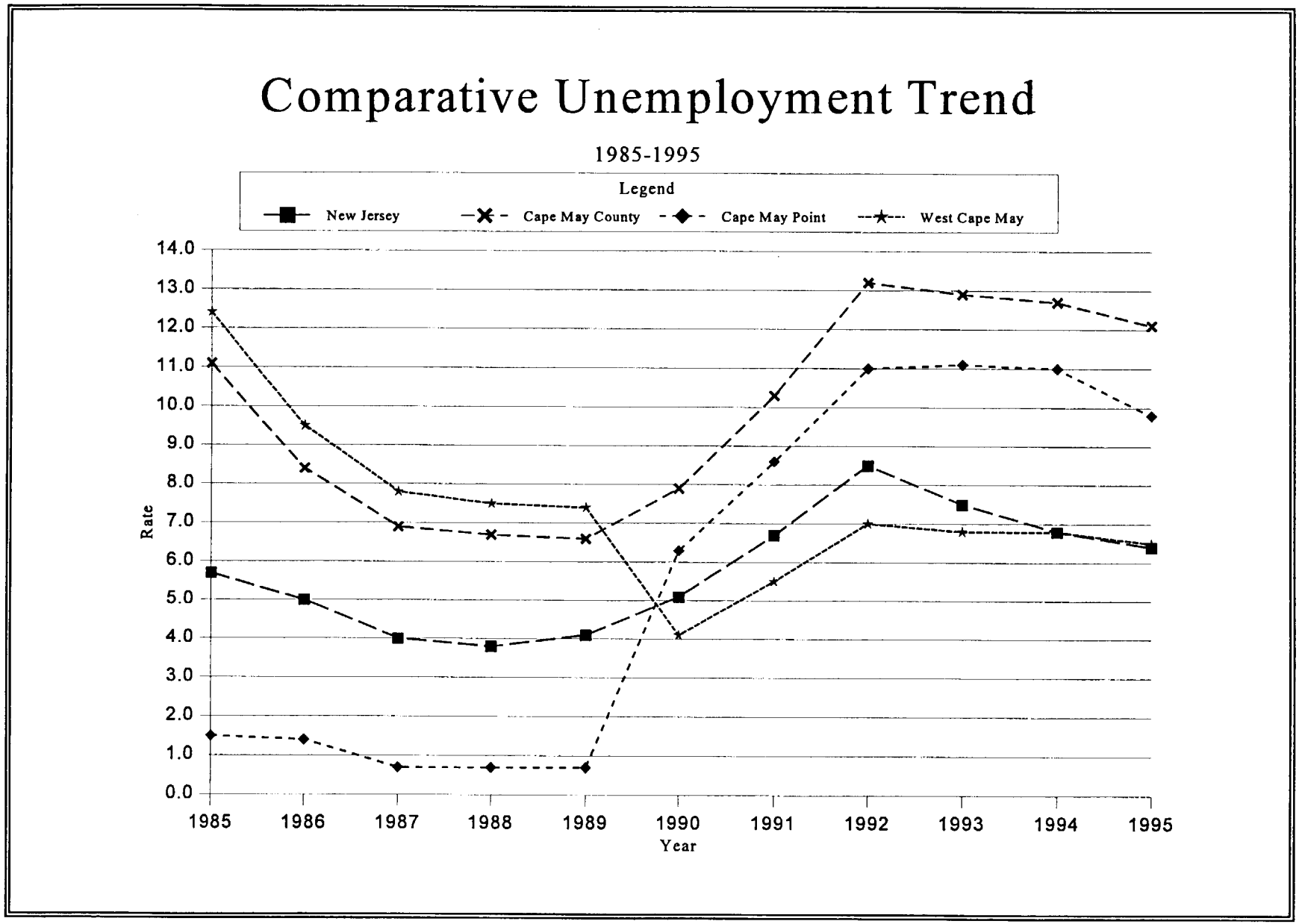


Figure C-4. Sources: U.S. Dept. of Labor & N.J. Dept. of Labor

In 1990 a higher per capita income was reported for residents of Cape May Point than for residents of West Cape May or Cape May County as a whole. As shown in Table C-3, the median value of single family homes is much higher in Cape May Point than West Cape May. In general, Cape May Point which is closest to the beach has slightly larger, more ornate homes than West Cape May. Many of the homes in West Cape May are one story ranches with the exception of more recent development and houses located on major roads such as Sunset Boulevard and Broadway Avenue.

TABLE C-3
COMPARATIVE INCOME & HOUSING VALUE
1990

	INCOME		SINGLE FAMILY UNITS	
Location	**Per Capita**	**Median Household**	**Median Value**	**Median Rent**
Cape May County	$15,538	$30,435	$112,800	$474
Cape May Point	$16,753	$23,125	$197,800	$450
West Cape May	$13,186	$24,353	$119,600	$423

Source: Cape May County Economic Development Center & Department of Planning

Regional Economy and Development. The commercial fishing and tourism industries contribute a great deal to the health of Cape May County's economy. This is particularly true along the Atlantic coast where most of the County's population resides. Agriculture is more prevalent inland from the shore.

In 1995 the commercial fishing industry provided employment for almost 2,900 fishermen. Also, food processing was Cape May County's largest manufacturing industry. According to National Marine Fisheries Service statistics, approximately 177 million pounds of seafood was harvested in 1995 and valued at approximately $96 million. The seafood industry is extremely important to the regional and national economy as evidenced from its national ranking. New Jersey is the leading national and world supplier of surf clams and ocean quahogs which are used in the production of chowders, sauces, and breaded strips. The consumption of seafood is expected to increase as people continue to be concerned about their health and diet.

The port in Cape May City is one of six major commercial fishing ports in New Jersey. In 1995 it was the leading port in the region, harvesting approximately 75 million pounds valued at $30.5 million. Cape May processors harvest a variety of seafood. There were approximately 1,800 full and part-time commercial fishing boats in New Jersey in 1994. The completion of a $60-million expansion to a seafood processing plant in Lower Township in 1993 was a significant development highlight for Cape May County. This expansion resulted in the creation of an

estimated 250 factory jobs. The demand for seafood and pending shortfall in supply has led the state to take initiative in the development of aquaculture. Plans for an $8 million aquaculture research project to produce techniques for cultivating shellfish and fin fish in "farm" facilities have been approved.

Tourism and Recreation. A wealth of natural resources and historical landmarks attract thousands of vacationers to Cape May County each year. The ambiance and sense of nostalgia motivates them to return time and time again. Cape May County has been a popular tourist haven for over 200 years. As early as 1766, advertisements were placed in newspapers to lure tourists to the local beaches. The resort business in Cape May City began to thrive with the development of motor transportation. It became known as the "country town by the seashore". The area has retained this quaint atmosphere. The neighboring community of Cape May Point is home to the Cape May Point State Park and the 134 year old Lighthouse. The park provides nature trails, access to the beach, picnic areas, a small sea animal museum, and an educational facility. The number of visitors to the State Park has increased from nearly 590,000 during fiscal year (July to June) 1993 to almost 730,000 during fiscal year 1995.

Tourists's dollars contribute directly and indirectly to the regional economy. In 1992, the New Jersey Travel Research Program reported that travel and tourism generated 346 thousand jobs in the state with a total payroll of $7.6 billion. Cape May County collected $1.1 billion in tourism revenues ranking fourth place among the 21 counties in New Jersey. In 1993 Cape May jumped to second place (behind Atlantic County) with $1.9 billion in tourism receipts. Tourism also generated over 20,000 jobs and a payroll of nearly $500 million.

Cape May Point State Park officials maintain annual attendance records. The most recent information pertaining to recreational usage is displayed by day use activity in the table below. Attendance increased nearly 10% from 663,460 in FY94 to 728,596 in FY95. Attendance in FY93 was 589,338.

Recreational Activity	FY 1994 Day Use	FY 1995 Day Use
Bike Riding	18,229	26,929
Bird Watching	54,955	143,549
Coastal Heritage Tour	4,500	38,799
Fishing	20,944	42,750
Hiking	151,520	107,375
Jogging	4,464	15,980
Nature Tour	1,584	1,450
Other Sightseeing	354,650	472,800
Picnicking	47,515	209,622
Special Events	2,416	12,196
Total	660,777	1,071,450

Recreational benefit calculations are only for increases in the recreational experience under with project conditions. No quantifiable changes in the recreational use of Lower Cape May Meadows under with project conditions were calculated. Project features will enhance the existing beach area, improve aesthetics of the natural areas, and create an environment which will possibly attract more migratory birds. Habitat units and acreage will also increase as a result of the selected plan.

Birding: According to the 1991 National Survey of Fishing, Hunting, and Wildlife-Associated Recreation, of the 54.7 million primary residential[1] participants, in the nonconsumptive recreational activity category, who reported observing wildlife around their homes, 51.3 million watched birds. Furthermore, 82% of all primary nonresidential[2] participants engaged in bird watching activities. Bird watching or birding, as it is called, has become a very popular activity and is of particular importance to Cape May County and the Lower Cape May Meadows area. According to the American Birding Association there has been an increase in the number of bird books, bird finding guides, commercial magazines and wild bird franchises. Specialized birdwatching tour agencies have also become more common.

Cape May is well known as a rest stop for migrating birds. Cape May Point has been touted by birding enthusiasts as having some of the best bird watching in the mid-Atlantic states. The southern portion of Cape May County is a highly visited site. Birding has received considerable media attention recently. The appearance of a rare bird in Lower Cape May Meadows immediately drew the attention of birders and the news media. Special events such as weekly tours, and seasonal birdwatching weekends are sponsored by the New Jersey Audubon Society's Cape May Bird Observatory. An estimated 300 to 500 visitors attend the Spring and Autumn Birdwatching Weekends.

A survey conducted by the Observatory in 1989 estimated that almost 100,000 birders are attracted to Cape May annually. The survey authors consider the Cape May peninsula one of the most valuable resting and feeding sites for migrating birds in eastern North America. In fact, Cape May is listed among the top five birding locales in North America in terms of visitation and economic impact (estimated $10 million). One of the objectives of the survey was to determine how much

---

[1] **Activity within one mile of home with a primary purpose that is wildlife-related: (1) closely observing or trying to identify birds or other wildlife, (2)photographing wildlife, (3)feeding birds or other wildlife on a regular basis, (4)maintaining natural areas of at least one-quarter acre for which benefit to wildlife is the primary purpose, or (6)visiting public parks within one mile of home for the purpose of observing, photographing, or feeding wildlife.**

[2] **Trips or outings at least one mile from home for the primary purpose of observing, photographing, or feeding wildlife. Trips to zoos, circuses, aquariums, and museums are not included.**

money birders contribute to the local economy. Birders from a wide range of places travel to Cape May. According to survey results, the majority (57.0%) of birders visited Cape May between September and February and stayed for an average of four nights. Birders contributed to the profits of motels/hotels, bed-and-breakfasts, restaurants, gas stations, specialty stores, and bookstores.

ECONOMIC ANALYSIS

General. The purpose of this economic appendix is to describe the information and methods used in the economic analysis of incidental storm damage reduction and erosion protection benefits for the developed areas surrounding Lower Cape May Meadows. The boroughs of Cape May Point and West Cape May are the focus of the economic analysis.

Conditions. A March 1996 price level, 50 year project life, and a base year of 2000 were used in the economic analysis. The values of costs and benefits were converted to an annual equivalent time basis using a 7-3/8% discount rate as applicable to public works projects.

Methodology and Assumptions. The traditional analytical approach of using damage-frequency and erosion-frequency relationships was employed to calculate probable benefits. Residential, commercial, and public-use structures in the Lower Cape May Meadows drainage basin were inventoried to determine the extent of flooding in the surrounding area. This limit was chosen based on past experience of the extent of flooding in the area. The inventory focused on structures located in the boroughs of Cape May Point and West Cape May. Figure 4.1.1 in the Without Project Hydraulic Analysis section of this report further outlines the cells in Cape May Point. Cells were assigned based on hydraulic, economic, and political factors. The following table describes the influence of the different damage mechanisms on the structures by cell designations.

Borough	Primary Cells	Types of Damage
Cape May Point	B	Wave, Erosion, Inundation
	C	Wave, Erosion, Inundation
	D	Wave & Inundation
	E	Wave, Erosion, Inundation
	F	Wave & Inundation
West Cape May	WCM	Inundation Only

A database of approximately 360 ocean block, and inland structures in Cape May Point, and 370 structures in West Cape May was compiled containing information described in the following paragraphs. The majority of the developed land in the study area is residential. Between 1993 and 1996 construction of approximately 3 new residences in Cape May Point and 6 new residences in West Cape May were completed. Furthermore, several structures were renovated or in the process of being renovated. Commercial activity in Cape May Point consists of a general store, bed and breakfast inns, and an antique shop. In West Cape May several commercial enterprises such as restaurants, a service station, a convenience store, and specialty shops are located on Sunset Boulevard and Broadway Avenue. A few commercial structures in West Cape May are vacant and available for rent.

Each structure was specifically inventoried and mapped on aerial photography at a scale of 1"=100'. Information collected includes address, construction and quality type, number of stories, first floor elevation, ground elevation, and foundation type. For multi-family residential and commercial structures the number of units and names of businesses were also gathered. Table C-4 lists these physical characteristics obtained for each structure. The assimilation of this data was enhanced by using aerial orthodigital mapping and the geographic information system, MIPS (Micro Imaging Processing System). Next, the information was coded and entered into the appraisal program and the appropriate storm damage computer models.

The structures's depreciated replacement cost values were appraised by using the Marshall and Swift Residential and Commercial Estimator Programs. The values were based on several of the characteristics listed above such as size, number of stories, construction material, quality, and condition (worn out, badly worn, average, good, very good, and excellent). The associated content value of each residential structure is estimated to be 25% of the structural replacement cost. This estimate is based on previous studies that established content value to be about 40% of structural value in primary homes and 15 to 20% of structural value in secondary/vacation homes. The study area consists mainly of vacation homes, but does contain some year round residential homes, hence the value of 25% was selected. Affluence was not claimed. The estimated total replacement cost for all structures is over 98 million dollars with contents worth almost 28 million dollars. The average replacement cost for residential structures included in the database for Cape May Point, and West Cape May is $137,000, and $117,000, respectively.

TABLE C-4
PHYSICAL CHARACTERISTICS OBTAINED FOR BUILDING INVENTORY

1.) Type
2.) Address & Block #
3.) Number of Stories
4.) Basement/Foundation
5.) Exterior Material
6.) Roof Material
7.) Quality
8.) Condition
9.) Garage/Shed
10.) Ground Elevation
11.) First Floor Elevation
12.) Structure Size
13.) Distance from Reference Line

Damages (for without and with project conditions) were calculated for eight frequency storm events (2, 5, 10, 20, 50, 100, 200, and 500-year events) for erosion, wave, and inundation damage to structures, infrastructure, and improved property. The calculations were performed using one of two damage analysis computer models, COSTDAM or the Hydrologic Engineering Center's (HEC) Structure Inventory for Damage Analysis (SID) package, depending on the structure's susceptibility to wave and/or erosion damage. Structures subject to wave attack or storm erosion were evaluated in the COSTDAM model. COSTDAM is a Fortran program originally written by the Wilmington District and updated for the Philadelphia District. COSTDAM reads an ASCII 'Control' file which contains the storm frequency parameters for each cell and an ASCII 'Structure' file which contains the database information of each structure as previously described. COSTDAM checks if a structure has been damaged by wave attack, based on the relationship between a structure's first floor elevation and the total water elevation that sustains a wave. Then COSTDAM checks for erosion damage at a structure. Finally, COSTDAM calculates inundation damages if the water elevation is higher than the first floor elevation. To avoid double counting, if damage occurs by more than one mechanism, the program takes the maximum damage of any given mechanism (wave, erosion, inundation) and drops the rest of the damage from the structure's total damages. (See Figure 5 for illustration.)

The SID computer model develops stage-damage curves. The primary function of this program is to generate elevation-damage functions by damage categories and reaches. SID also aggregates structures by flood zone based on zero-damage elevation. Samples of COSTDAM and SID structure files are shown below in Tables C-5a and C-5b, respectively.

TABLE C-5a
EXCERPT OF COSTDAM STRUCTURE FILE

1A	P4001	67.7	117.5	7.8 1.5	138.	117S20S06 1 1
1B	R4004	282.8	301.1	8.5 0.0	134.	33S03S04 1-1
2A	R5005	340.2	366.0	8.6 3.0	215.	54S03S04 1-1
2B	C4901	265.3	298.2	6.8 5.0	505.	399S16MT3 1 1
3A	R4501	569.2	585.6	5.0 6.5	176.	44S03S04 1-1
3B	R3802	542.0	559.5	5.8 4.4	71.	18S03S04 1-1
4	R1602	177.3	208.2	8.9 6.0	211.	53S03S04 1-1
5A	R0701	162.4	188.0	9.1 5.5	113.	28S03S04 1-1

Columns 1-3 contain the Cell ID (format-A3).
Columns 4-9 contain the Structure ID (format-A6).
Columns 10-19 are blank.
Columns 20-27 contain distance to front of structure (format-F8.1)
Columns 28-35 contain distance to middle of structure (format-F8.1)
Columns 36-40 contain the ground elevation (format-F5.1)
Columns 41-44 contain the distance between the first floor and the ground (format-F4.1)
Columns 45-53 contain the structure replacement cost value (format-F9.0)
Columns 54-62 contain content replacement cost value (format-F9.0)
Columns 63-65 contain the structure depth damage curve (format-A3)
Columns 66-68 contain the content depth damage curve (format-A3)
Columns 69-70 contain a code to make structure "active" (format-I2)
Columns 71-72 contain the damage category (format-I2)

TABLE C-5b
EXCERPT OF SID STRUCTURE FILE

SL	1B	R3203	8.5	-0.01	4.0
SD	1B	R3203	RESS03209.0S04	-25	
SA	1B	R3203	615 LIGHTHOUSE		
SL	1B	R3205	8.9	-1.0	8.0
SD	1B	R3205	RESS03103.0S04	-25	
SA	1B	R3205	621 LIGHTHOUSE		
SL	1B	R3201	8.8	-0.01	3.5
SD	1B	R3201	RESS03122.0S04	-25	
SA	1B	R3201	601 SEA GROVE		

Depth-damage curves for the structures were derived from previous studies of similar areas and Flood Insurance Administration (FIA) depth-damage curves adjusted for increased salt water damageability. Table C-6 displays examples of these curves. Content and depth-damage curves for certain semi-public and/or historical activities were modified using site specific interview data.

TABLE C-6
EXCERPT OF DEPTH DAMAGE CURVES

S03 (2 story, no basement, residential structure)
# of Rows (free format)
12
Depth Damage (expressed as a decimal) (free format)

0	.0
.5	.01
1	.10
2	.24
3	.30
4	.36
5	.39
6	.42
7	.47
8	.49
9	.56
10	.64

S15 (1 story, masonry, no basement, commercial structure)
# of Rows (free format)
13
Depth Damage (expressed as a decimal) (free format)

-1	.0
0	.01
.5	.05
1	.21
2	.29
3	.38
4	.46
5	.48
6	.53
7	.55
8	.59
9	.67
10	.73

STORM DAMAGE REDUCTION BENEFITS

Inundation Damage. Most of the damage to structures in Cape May Point is caused by flooding rather than wave attack or erosion. Therefore, the majority of the study effort was focused on quantifying inundation reduction benefits. When the ponds and lakes in Lower Cape May Meadows flood, the water spills over into the adjacent community. During infrequent storm

events wave attack would be a more prevalent cause of damage to structures closest to the ocean. In addition, most of the water that overtops dunes in Cape May Point drains to the Meadows. The area bounded by the extreme northwestern groins (Cell F) in Cape May Point drains to undeveloped land adjacent to the Delaware Bay. The depth-damage curves were verified using site-specific information whenever available. FIA flood claim data for Cape May Point was obtained. Damage information from structures which could be matched by address was reviewed. The curves were tested for reasonableness on a structure by structure basis and revised accordingly.

Wave Attack Damage. Oceanfront structures are subject to damage as a result of direct wave impact. However, damage is not claimed for a structure from both wave attack and erosion for the same event to avoid double counting. A structure is considered to be damaged by a wave when there is sufficient force in the total water elevation to completely damage the structure. It was assumed that a structure is destroyed if the wave strikes it at an elevation two feet above the first floor. Partial wave damages are not calculated; instead the structure is subjected to inundation damage.

Storm Recession Damage. The distance between the reference (profile) line and the oceanfront and back walls of a structure were measured in AutoCAD using the georeferenced MIPS mapping of the study area. For the structure damage/failure analysis, it was assumed that a structure is destroyed at the point that the land below the structure is eroded halfway through the structure's footprint if the structure is not on a pile foundation. If the structure is on piles, the land below the structure must have eroded through the footprint of the structure before total damage is claimed. Prior to this, for both foundation types, the percent damage claimed is equal to the linear proportion of erosion under the structure's footprint relative to the total damage point.

In addition to erosion damage to structures, damage to the land the structures are on (hence forth called improved property) was calculated. The improved property value was determined by comparing market value of the near shore land to the cost of filling in the eroded land for reutilization and using the more conservative estimate. The cost of filling/restoring the improved property is based on the different depths, widths and cubic yards of erosion produced by each storm frequency. The cost of filling/restoring eroded improved property was determined to be less expensive. The cost was prorated for the width of each cell to estimate total land erosion damages.

Erosion damages for infrastructure was also calculated. An erosion damage curve was developed for damage to infrastructure within the erosion limits. Values for roads, land, tensar mattresses, and revetments were estimated using standard engineering criteria. The judgement was made that all infrastructure damaged in Cape May Point would be replaced in-kind. The replacement cost does not necessarily relate to the number of structures in the area. Road and utilities replacement costs consisted of fixed and variable costs based on ranges of feet of replacement/repair. In general, the replacement cost of roads decreased with greater quantities eroded reflecting economies of scale. Distance from the reference line and feet of erosion per event for each road and associated utilities were used to determine damage susceptibility.

Emergency/Clean-up Costs. Clean-up costs for individual structures are based on the time for clean-up and additional meal and travel costs. Travel and meal costs are included as opposed to evacuation costs because the majority of residential and commercial structures are occupied only on a seasonal basis, and even then, not always by the structure's owner. Clean-up costs are applied to those structures affected by a particular storm event.

Emergency and clean-up costs are also calculated for the local governments. The costs are based on available post storm reports for the December 1992 storm, which had a stage frequency of approximately a 20-year event. The report includes information for Cape May Point but not West Cape May. The damage estimates represent initial appraisals of damage losses and not all costs incurred from the storm. Municipal emergency and clean-up costs include costs to remove debris, emergency protective measures, road systems, water control facilities, and emergency dunes, sand fence and vegetation. Emergency dunes accounted for almost 50% of damage losses to Cape May Point according to the report. Emergency and clean-up costs for larger events are extrapolated due to limited historical information.

WITHOUT PROJECT CONDITIONS

Improved Property & Infrastructure Damages. Annual damages for without project damages of improved property and infrastructure are in Table C-7.

TABLE C-7

Improved Property & Infrastructure Without Project Average Annual Damage (In $000s, Mar. 1996 Price Level)	
Category	Annual Damages
Improved Property	$10.9
Infrastructure	$24.8
Total	$35.7

Structure Damages. Table C-8 displays equivalent annual damages for structures in Cape May Point and West Cape May. Annual damages for Cape May Point and West Cape May are $741,000 and $212,700, respectively.

TABLE C-8

Structures Without Project Expected Annual Damage (In $000s, Mar. 1996 Price Level)				
	Annual Damages			
Reach	Inundation	Wave	Erosion	Total
Cape May Point	$435.0	$298.0	$8.0	$741.0
West Cape May	$212.7	$0.0	$0.0	$212.7
Total	$647.7	$298.0	$8.0	$953.7

Emergency/Clean-up Costs. The number of structures affected and the associated emergency costs for each storm event are in Table C-9. Average annual damages for (all affected) individuals in Cape May Point, and West Cape May are $4,700 and $1,900, respectively. Average annual damages for public entities are $25,700, and $4,100 respectively. Municipal emergency costs for Cape May Point will be significant since the Borough's close proximity to the ocean makes it more vulnerable to damaging elements. In contrast, municipal costs for West Cape May are relatively low because it is inland, and damage susceptibility is limited to inundation from the Meadows.

TABLE C-9

Structures Affected and Emergency/Clean-up Costs (in $000s, Mar. 1996 Price Level)								
CAPE MAY POINT	2yr	5yr	10yr	20yr	50yr	100yr	200yr	500yr
Structures	0	16	38	49	121	171	217	268
Indiv. Clean-up Costs $	0	4	10	12	43	85	164	243
Mun. Clean-up Costs $	0	21	50	118	263	454	719	954
WEST CAPE MAY	2yr	5yr	10yr	20yr	50yr	100yr	200yr	500yr
Structures	0	2	14	30	58	114	164	249
Indiv. Clean-up Costs $	0	0	4	8	15	43	70	132
Mun. Clean-up Costs $	0	1	8	11	35	99	169	309

TOTAL AVERAGE ANNUAL CLEANUP COSTS

CAPE MAY POINT:
(all) Individuals: $4,700
Public entities: $25,700

WEST CAPE MAY:
(all) Individuals: $1,900
Public entities: $4,100

Total Annual Damages. Total annual damages for structures, improved property, infrastructure, and emergency costs is displayed by cell in Table C-10.

TABLE C-10

Total Damages for All Categories Without Project Average Annual Damage (In $000s, Mar. 1996 Price Level)	
Reach	Annual Damages
Cape May Point	$807.1
West Cape May	$218.7
Total	$1,025.8

FUTURE WITHOUT PROJECT CONDITIONS

Future without project conditions in the absence of measures to mitigate long-term erosion in front of Cape May Meadows were evaluated. Storage capacity of the Meadows would be reduced if the shoreline were allowed to retreat at a rate of 15 feet per year, therefore allowing interior water elevations to increase over time from the ocean overtopping the dune by storm events. Estimated future water surface elevations were provided in ten year increments until the year 2050, or 50 years from the base year. Table C-11 presents the equivalent average annual number of acres not inundated by salt water. The acreage of the Meadows decreases as the shoreline erodes, subsequently acres inundated decreases. The impact of future hydraulics on equivalent average annual damages for inland structures in Cape May Point and West Cape May is displayed below in Tables C-12a and C-12b, respectively. The impact of future conditions and trial plans was evaluated for inland structures only in order to conserve time and effort.

TABLE C-11

Lower Cape May Meadows Number of Ares NOT Inundated Without Project						
Category	Time Period					
	Base Year 2000	2010	2020	2030	2040	2050
Total # of Acres	333.0	310.0	287.0	264.0	241.0	218.0
Acres Not Inundated	179.6	166.3	151.2	138.2	123.7	111.4

TABLE C-12a

CAPE MAY POINT FLOOD DAMAGES IN DECADE WITHOUT PROJECT ($000; Mar. 1996 p.l.; 7.375%)						
Property Type	Time Period					
	Base Year 2000	2010	2020	2030	2040	2050
Residential	55.4	57.0	60.5	63.1	66.5	71.4
Public	1.6	1.6	1.8	1.9	2.0	2.2
Total	57.0	58.6	62.3	65.0	68.5	73.6

TABLE C-12b

WEST CAPE MAY FLOOD DAMAGES IN DECADE WITHOUT PROJECT ($000; Mar. 1996 p.l.; 7.375%)						
Property Type	Time Period					
	Base Year 2000	2010	2020	2030	2040	2050
Residential	105.0	106.3	109.5	111.8	114.7	120.3
Commercial	88.4	90.4	95.8	99.8	105.0	115.9
Public	2.5	2.6	2.8	2.9	3.1	3.3
Total	195.9	199.3	208.1	214.5	222.8	239.5

STORM DAMAGE REDUCTION

CYCLE 2 - PRELIMINARY TRIAL ALTERNATIVES

Several trial alternatives to impede long-term shore erosion and alleviate salt water intrusion in the Meadows were evaluated. The primary focus of the study is environmental restoration. The increase in the number of acres protected (not inundated) was used as a proxy for environmental benefits. Below, Table C-13 shows the average number of acres protected from salt water for the matrix of berm and dune measures. Each alternative incidentally yields some reduction of storm damages. Average annual damages for the alternatives were calculated using the same methodologies and database as previously detailed in the without project conditions. Benefits were estimated by comparing damages under with and without project conditions. Tables C-14a and C-14b display storm damage reduction benefits by trial alternative for Cape May Point and West Cape May, respectively. Infrastructure, land, and emergency damages were not calculated for each alternative since the proportional damages were negligible.

Table C-13

Lower Cape May Meadows
Increased Number of Acres NOT Inundated by Salt Water
By Alternative

Trial Alt.	Project Size (Berm,Dune)	Acres Protected Without Project	Acres Protected With Project	Increase in Acres Protected	Percent Increased
0	Nourishment	144.5	179.2	34.7	24%
1	96' Berm, 24' Dune	144.5	328.6	184.1	127%
2	76' Berm, 18' Dune	144.5	319.2	174.7	121%
3	26' Berm, 18' Dune	144.5	307.9	163.4	113%
4	126'Berm, 18'Dune	144.5	319.6	175.1	121%
5	No Berm, 24' Dune	144.5	325.1	180.6	125%
6	46' Berm, 24' Dune	144.5	327.4	182.9	127%
7	114'Berm, 21'Dune	144.5	327.3	182.8	127%
8	14' Berm, 21' Dune	144.5	319.3	174.8	121%
9	64' Berm, 21' Dune	144.5	325.1	180.6	125%
10	44' Berm, 16' Dune	144.5	288.1	143.6	99%
11	94' Berm, 16' Dune	144.5	308.2	163.7	113%
12	144' Berm, 16' Dune	144.5	319.2	174.7	121%

TABLE C-14a

Cape May Point
Flood Damage Reduction By Alternative
(May 1996 Price Level)

Trial Alt.	Project Size (Berm,Dune)	Without Project Storm Damages	With Project Storm Damages	Storm Damage Reduction Benefits	Percent Reduced
0	Nourishment	$64,030	$56,980	$7,050	11%
1	96' Berm, 24' Dune	$64,030	$7,170	$56,860	89%
2	76' Berm, 18' Dune	$64,030	$25,660	$38,370	60%
3	26' Berm, 18' Dune	$64,030	$34,470	$29,560	46%
4	126' Berm, 18' Dune	$64,030	$23,580	$40,450	63%
5	No Berm, 24' Dune	$64,030	$19,130	$44,900	70%
6	46' Berm, 24' Dune	$64,030	$11,210	$52,820	82%
7	114' Berm, 21' Dune	$64,030	$14,370	$49,660	78%
8	14' Berm, 21' Dune	$64,030	$25,020	$39,010	61%
9	64'Berm, 21'Dune	$64,030	$19,130	$44,900	70%
10	44' Berm, 16' Dune	$64,030	$42,130	$21,900	34%
11	94' Berm, 16' Dune	$64,030	$32,730	$31,300	49%
12	144' Berm, 16' Dune	$64,030	$25,660	$38,370	60%

TABLE C-14b

West Cape May
Flood Damage Reduction By Alternative
(May 1996 Price Level)

Trial Alt.	Project Size (Berm,Dune)	Without Project Storm Damages	With Project Storm Damages	Storm Damage Reduction Benefits	Percent Reduced
0	Nourishment	$212,650	$195,890	$16,760	8%
1	96' Berm, 24' Dune	$212,650	$22,740	$189,910	89%
2	76' Berm, 18' Dune	$212,650	$92,920	$119,730	56%
3	26' Berm, 18' Dune	$212,650	$126,870	$85,780	40%
4	126' Berm, 18' Dune	$212,650	$84,480	$128,170	60%
5	No Berm, 24' Dune	$212,650	$67,260	$145,390	68%
6	46' Berm, 24' Dune	$212,650	$37,550	$175,100	82%
7	114' Berm, 21' Dune	$212,650	$48,060	$164,590	77%
8	14' Berm, 21' Dune	$212,650	$90,330	$122,320	58%
9	64' Berm, 21' Dune	$212,650	$67,260	$145,390	68%
10	44' Berm, 16' Dune	$212,650	$152,840	$59,810	28%
11	94' Berm, 16' Dune	$212,650	$119,710	$92,940	44%
12	144' Berm, 16' Dune	$212,650	$92,920	$119,730	56%

CYCLE 3 - DESIGN ALTERNATIVES

The twelve trial alternatives were refined to meet design criteria during Cycle 3 analysis. Table C-15 shows the average number of acres protected from salt water for several combinations of berm and dune designs. The storm parameters and performance of the refined designs were applied to both oceanfront and inland structures in Cape May Point. Total average annual damages and benefits were computed. Tables C-16a and C-16b display storm damage reduction benefits by alternative for Cape May Point and West Cape May, respectively.

TABLE C-15

Lower Cape May Meadows
Increased Number of Acres NOT Inundated by Salt Water
By Design Alternative

Design	Project Size (Dune, Berm)	Location (Meadows/Point)	Without Project Acres Protected	With Project Acres Protected	Increase in Acres Protected
0	Nourishment	Meadows Only	144.5	179.2	34.7
1	21' Dune, 50' Berm	Meadows & Point	144.5	327.4	182.9
2	21' Dune, 50' Berm	Meadows Only	144.5	270.9	126.4
3	21' Dune, 20' Berm	Meadows & Point	144.5	325.4	180.9
4	21' Dune, 20' Berm	Meadows Only	144.5	270.9	126.4
5	21' Dune, 50'/20' Berm	Meadows/Point	144.5	327.4	182.9
6	21' Dune, 20'/50' Berm	Meadows/Point	144.5	325.4	180.9
7	18' Dune, 50' Berm	Meadows & Point	144.5	325.1	180.6
8	18' Dune, 50' Berm	Meadows Only	144.5	270.9	126.4
9	18'/21' Dune, 50' Berm	Meadows/Point	144.5	325.2	180.7
10	18'/21' Dune, 50'/20' Berm	Meadows/Point	144.5	325.2	180.7
11	21'/18' Dune, 50' Berm	Meadows/Point	144.5	326.6	182.1
12	21'/18' Dune, 20'/ 50' Berm	Meadows/Point	144.5	325.3	180.8
13	21'/18' Dune, 50'/ 20' Berm	Meadows/Point	144.5	323.8	179.3
14	21'/18' Dune, 20'Berm	Meadows/Point	144.5	323.6	179.1
15	18' Dune, 50'/20' Berm	Meadows/Point	144.5	323.5	179.0
16	18' Dune, 20' Berm	Meadows & Point	144.5	319.6	175.1
17	18' Dune, 20' Berm	Meadows Only	144.5	270.9	126.4
18	18'/21' Dune, 20'/50' Berm	Meadows/Point	144.5	319.7	175.2
19	18'/21' Dune, 20' Berm	Meadows/Point	144.5	319.7	175.2
20	18' Dune, 20'/50' Berm	Meadows/Point	144.5	319.7	175.2

TABLE C-16a

Cape May Point Storm Damage Reduction By Alternative (May 1996 Price Level)					
Design	Project Size (Dune, Berm)	Location (Meadows/Point)	Without Project Storm Damages	With Project Storm Damages	Storm Damage Reduction Benefits
0	Nourishment	Meadows Only	$741,030	$733,980	$7,050
1	21' Dune, 50' Berm	Meadows & Point	$741,030	$105,290	$635,740
2	21' Dune, 50' Berm	Meadows Only	$741,030	$723,700	$17,330
3	21' Dune, 20' Berm	Meadows & Point	$741,030	$121,230	$619,800
4	21' Dune, 20' Berm	Meadows Only	$741,030	$723,700	$17,330
5	21' Dune, 50'/20' Berm	Meadows/Point	$741,030	$120,410	$620,620
6	21' Dune, 20'/50' Berm	Meadows/Point	$741,030	$106,050	$634,980
7	18' Dune, 50' Berm	Meadows & Point	$741,030	$168,480	$572,550
8	18' Dune, 50' Berm	Meadows Only	$741,030	$723,700	$17,330
9	18'/21' Dune, 50' Berm	Meadows/Point	$741,030	$112,100	$628,930
10	18'/21' Dune, 50'/20' Berm	Meadows/Point	$741,030	$127,100	$613,930
11	21'/18' Dune, 50' Berm	Meadows/Point	$741,030	$165,830	$575,200
12	21'/18' Dune, 20'/ 50' Berm	Meadows/Point	$741,030	$167,220	$573,810
13	21'/18' Dune, 50'/ 20' Berm	Meadows/Point	$741,030	$173,700	$567,330
14	21'/18' Dune, 20'Berm	Meadows/Point	$741,030	$175,650	$565,380
15	18' Dune, 50'/20' Berm	Meadows/Point	$741,030	$177,560	$563,470
16	18' Dune, 20' Berm	Meadows & Point	$741,030	$181,580	$559,450
17	18' Dune, 20' Berm	Meadows Only	$741,030	$723,700	$17,330
18	18'/21' Dune, 20'/50' Berm	Meadows/Point	$741,030	$117,980	$623,050
19	18'/21' Dune, 20' Berm	Meadows/Point	$741,030	$132,980	$608,050
20	18' Dune, 20'/50' Berm	Meadows/Point	$741,030	$173,980	$567,050

TABLE C-16b

West Cape May
Storm Damage Reduction By Alternative
(May 1996 Price Level)

Design	Project Size (Dune, Berm)	Location (Meadows/Point)	Without Project Storm Damages	With Project Storm Damages	Storm Damage Reduction Benefits
0	Nourishment	Meadows	$212,650	$195,890	$16,760
1	21' Dune, 50' Berm	Meadows & Point	$212,650	$34,230	$178,420
2	21' Dune, 50' Berm	Meadows Only	$212,650	$170,250	$42,400
3	21' Dune, 20' Berm	Meadows & Point	$212,650	$37,820	$174,830
4	21' Dune, 20' Berm	Meadows Only	$212,650	$170,250	$42,400
5	21' Dune, 50'/20' Berm	Meadows/Point	$212,650	$34,680	$177,970
6	21' Dune, 20'/50' Berm	Meadows/Point	$212,650	$37,120	$175,530
7	18' Dune, 50' Berm	Meadows & Point	$212,650	$60,520	$152,130
8	18' Dune, 50' Berm	Meadows Only	$212,650	$170,250	$42,400
9	18'/21' Dune, 50' Berm	Meadows/Point	$212,650	$58,940	$153,710
10	18'/21' Dune, 50'/20' Berm	Meadows/Point	$212,650	$58,940	$153,710
11	21'/18' Dune, 50' Berm	Meadows/Point	$212,650	$49,870	$162,780
12	21'/18' Dune, 20'/ 50' Berm	Meadows/Point	$212,650	$55,330	$157,320
13	21'/18' Dune, 50'/ 20' Berm	Meadows/Point	$212,650	$53,150	$159,500
14	21'/18' Dune, 20'Berm	Meadows/Point	$212,650	$61,060	$151,590
15	18' Dune, 50'/20' Berm	Meadows/Point	$212,650	$68,870	$143,780
16	18' Dune, 20' Berm	Meadows & Point	$212,650	$84,480	$128,170
17	18' Dune, 20' Berm	Meadows Only	$212,650	$170,250	$42,400
18	18'/21' Dune, 20'/50' Berm	Meadows/Point	$212,650	$82,040	$130,610
19	18'/21' Dune, 20' Berm	Meadows/Point	$212,650	$82,040	$130,610
20	18' Dune, 20'/50' Berm	Meadows/Point	$212,650	$82,040	$130,610

EXTERIOR ANALYSIS

Evaluation of the exterior design alternatives is based on incremental cost analysis of the priority benefit category, acres/habitat units. Although storm damage reduction is not considered the primary benefit category in this study, the exterior design or dune and berm design incidentally yields significant traditional NED benefits. Initial construction, interest during construction, and periodic nourishment costs were annualized over a 50 year project life at 7-3/8%. Table C-17 displays designs by average annual costs, output level in acres, and incidental average annual storm damage reduction benefits. The shaded blocks denote non-cost effective design alternatives.

TABLE C-17

Cape May Point & West Cape May
Cost-Benefit Comparison
(May 1997 Price Level)

Exterior Design	Average Annual Cost	Output (Acres)	Incidental Annual Benefit	Exterior Design	Average Annual Cost	Output (Acres)	Incidental Annual Benefit
0	$1,236,600	34.7	$24,600	11	$1,986,500	182.1	$762,400
1	$2,035,300	182.9	$841,100	12	$1,944,300	180.8	$755,300
2	$1,488,400	126.4	$61,700	13	$1,881,700	179.3	$750,900
3	$1,948,800	180.9	$820,900	14	$1,839,500	179.1	$740,700
4	$1,446,500	126.4	$61,700	15	$1,815,400	179.0	$730,700
5	$1,991,000	182.9	$825,000	16	$1,775,700	175.1	$710,400
6	$1,993,000	180.9	$837,400	17	$1,383,400	126.4	$61,700
7	$1,920,200	180.6	$748,700	18	$1,929,300	175.2	$778,600
8	$1,422,700	126.4	$61,700	19	$1,885,100	175.2	$763,100
9	$1,968,900	180.7	$808,600	20	$1,880,600	175.2	$720,800
10	$1,924,700	180.7	$793,100				

DESIGNS:

0 - Nourishment (Meadows Only)
1 - 21' Dune, 50' Berm (Meadows & Point)
2 - 21' Dune, 50' BermMeadows Only
3 - 21' Dune, 20' Berm (Meadows & Point)
4 - 21' Dune, 20' Berm (Meadows Only)
5 - 21' Dune, 50'/20'Berm (Meadows/Point)
6 - 21' Dune, 20'/50' Berm (Meadows/Point)
7 - 18' Dune, 50' Berm (Meadows & Point)
8 - 18' Dune, 50' Berm (Meadows Only)
9 - 18'/21' Dune, 50' Berm (Meadows/Point)
10 - 18'/21' Dune, 50'/20' Berm (Meadows/ Point)
11 - 21'/18' Dune, 50' Berm (Meadows/ Point)
12 - 21'/18' Dune, 20'/50' Berm (Meadows/Point)
13 - 21'/18' Dune, 50'/20' Berm (Meadows/Point)
14 - 21'/18' Dune, 20' Berm (Meadows/Point)
15 - 18' Dune, 50'/20' Berm (Meadows/Point)
16 -18' Dune, 20' Berm (Meadows & Point)
17 - 18' Dune, 20' Berm (Meadows Only)
18 - 18'/21' Dune, 20'/50' Berm (Meadows/Point)
19 - 18'/21' Dune, 20' Berm (Meadows/Point)
20 - 18' Dune, 20'/50' Berm (Meadows/Point)

Design 16 (18' dune, 20' berm) is the least cost plan which provides appreciable environmental and storm damage reduction benefits. Larger scale designs would provide additional protection. The results of an analysis to determine incremental justification of a larger design based on storm damage reduction is displayed in the following table.

Design	Design Dimensions		Incremental Cost	Incremental Incidental Benefits	Incremental BCR
	Meadows	Point			
16	18' Dune, 20' Berm	18' Dune, 20' Berm	---	---	---
20	18' Dune, 20' Berm	18' Dune, 50' Berm	$104,900	$10,400	0.10
19	18' Dune, 20' Berm	21' Dune, 20' Berm	$109,400	$52,700	0.48
18	18' Dune, 20' Berm	21' Dune 50' Berm	$153,600	$68,200	0.44
15	18' Dune, 50' Berm	18' Dune, 20' Berm	$39,700	$20,300	0.51
7	18' Dune, 50' Berm	18' Dune, 50' Berm	$144,500	$38,300	0.27
10	18' Dune, 50' Berm	21' Dune, 20' Berm	$149,000	$82,700	0.56
9	18' Dune, 50' Berm	21' Dune, 50' Berm	$193,200	$98,200	0.51
14	21' Dune, 20' Berm	18' Dune, 20' Berm	$63,800	$30,300	0.47
12	21' Dune, 20' Berm	18' Dune, 50' Berm	$168,600	$44,900	0.27
3	21' Dune, 20' Berm	21' Dune, 20' Berm	$173,100	$110,500	0.64
6	21' Dune, 20' Berm	21' Dune, 50' Berm	$217,300	$127,000	0.58
13	21' Dune, 50' Berm	18' Dune, 20' Berm	$106,000	$40,500	0.38
11	21' Dune, 50' Berm	18' Dune, 50' Berm	$210,800	$52,000	0.25
5	21' Dune, 50' Berm	21' Dune, 20' Berm	$215,300	$114,600	0.53
1	21' Dune, 50' Berm	21' Dune, 50' Berm	$259,600	$130,700	0.50

GROINS AT THE MEADOWS

Once the exterior design was selected the impact of constructing groins in addition to beachfill was analyzed. Typically groins reduce the amount of sand needed for periodic nourishment. An analysis was performed to determine the impact of constructing eight groins along the shore in front of the Meadows. It was estimated that the cost to periodically nourish the Meadows area would decrease by 60%. This decrease, however, is outweighed by the increased initial cost of constructing the groins. The exterior design with groins was eliminated from further consideration because average annual costs without groins was less costly. The following table displays the cost streams for the selected design (18' Dune, 20' Berm) with and without groins at the Meadows.

Average Annual Costs Without & with Groins
For the Selected Exterior Design

		Base Year:		2000		
		Discount Rate:		7.375%		
		Price Level:		Apr-97		
Type	**Year**	**PW Factor**	**Cost Without Groins**	**Cost With Groins**	**PW Cost Without Groins**	**PW Cost With Groins**
First Cost	2000	1.000000	5,981,213	13,981,213	5,981,213	13,981,213
IDC	2000	1.000000	186,864	428,572	186,864	428,572
Per. Nour.	2004	0.752293	4,104,290	1,641,716	3,087,631	1,235,052
Per. Nour./Groin Maint.	2008	0.565945	4,104,290	2,441,716	2,322,804	1,381,878
Per. Nour.	2012	0.425757	4,104,290	1,641,716	1,747,431	698,972
Per. Nour./Groin Maint.	2016	0.320294	4,104,290	2,441,716	1,314,581	782,068
Per. Nour.	2020	0.240955	4,104,290	1,641,716	988,950	395,580
Per. Nour./Groin Rehab.	2024	0.181269	4,104,290	6,441,716	743,981	1,167,684
Per. Nour.	2028	0.136368	4,104,290	1,641,716	559,692	223,877
Per. Nour./Groin Maint.	2032	0.102588	4,104,290	2,441,716	421,053	250,492
Per. Nour.	2036	0.077177	4,104,290	1,641,716	316,755	126,702
Per. Nour./Groin Maint.	2040	0.058059	4,104,290	2,441,716	238,293	141,765
Per. Nour.	2044	0.043678	4,104,290	1,641,716	179,266	71,706
Per. Nour./Groin Maint.	2048	0.032858	4,104,290	2,441,716	134,861	80,231
Total PW Cost:					$18,223,374	$20,965,792
CRF(50,7.375%):				0.075914		
AAC (Rounded):					$1,383,400	$1,591,587

EXTENDED SHORELINE - DESIGN 16 (18' DUNE, 20' BERM)

A comparison of the incremental increase in acres and costs for extending the shoreline in front of the Meadows is shown in Table C-18. The costs include preliminary estimates of additional sand required to extend the shoreline, place organic substrate, and cultivate native plants for the three scenarios.

TABLE C-18

Cape May Point & West Cape May
Cost-Benefit Comparison
(May 1997 Price Level)

Exterior Design	Annual Cost	Output (Acres)	Incidental Annual Benefit*
16	$1,775,700	175.1	$710,400
16S1	$1,932,700	208.6	$713,600
16S2	$2,085,700	232.6	$715,400
16S3	$2,389,700	266.1	$716,900

*Does not include $210,600 for local cost forgone

INTERIOR DIKE/LEVEE WITH DESIGN 16 (18' DUNE, 20' BERM)

Design 16 reduces storm damage to structures by 75% in Cape May Point and 60% in West Cape May. The feasibility of providing additional storm damage protection to the developed communities was analyzed. A dike or levee along Lighthouse Avenue in Cape May Point and another structure along Sunset Boulevard in West Cape May would further protect those areas from inundation from the Meadows. The maximum realizable incremental average annual benefits for Cape May Point and West Cape May are approximately $181,600 and $84,500, respectively. Such a levee would have to protect against the 500-year event.

It is possible to construct a levee with a crest elevation of 8.0 feet NGVD (between a 50-year and a 100-year event) in the Meadows along Lighthouse Avenue. However, the estimated average annual storm damage reduction gained by building a levee of that height is negligible ($2,000 for Cape May Point and $7,000 for West Cape May). It is improbable that the incremental cost to construct two dike/levee structures for less than the incremental average annual benefits is achievable.

LIGHTHOUSE AVENUE DIKE VERSUS CAPE MAY POINT BEACHFILL

As stated previously, most of the water that overtops dunes in Cape May Point drains to the Meadows. Sand placement in Cape May Point provides protection to the Meadows as well as incidental damage reduction to structures. The impacts of terminating the protective dune and berm at the Cape May Point State Park and constructing a dike along Lighthouse Avenue to shield the Meadows were examined.

The average annual cost to construct a dike is approximately $151,000 compared to the $547,000 average annual cost to continue the beachfill in Cape May Point. The dike will benefit the Meadows, however, the absence of the beachfill coupled with the presence of the dike would leave the structures in Cape May Point vulnerable to induced damage due to increased ponding. The amount of induced damages associated with the higher water surface elevations was calculated. Inland structure damages increased by 53 percent or $36,000. Oceanfront structure damages increased by 27 percent or $44,000. The dike without the protective dune and berm would adversely yield net costs/induced damages of approximately $231,000 as shown below. Extending the beachfill would contribute net benefits of $38,000.

TABLE C-19

Dike vs. Beachfill Comparison
(Avg. Ann., Oct. 1997 Price Level)

	Dike		**Protective Dune/Berm**	
	Induced Damages	Costs	Benefits	Costs
Cape May Point (inland structures)	$36,000	$151,000	$585,000*	$547,000
Cape May Point (oceanfront structures)	$44,000	---	---	
Net Costs/Induced Damages	$231,000		---	
Net Benefits	---		$38,000	

*Average annual benefits from Table C-16a for the protective dune/berm alternative (Design 16 - 18' dune, 20' berm) were updated to October 1997 price level for comparison to costs.

SELECTED PLAN
LOCAL COSTS FORGONE

State and local officials have taken action in the past to prevent the erosion of their dunes and revetment. Historically, local funds have been expended to replace dunefill, plant dune grass, install sand fences, reinforce the revetment at Cape May Point, and install gabion mattresses to protect the State Park. This cost to preserve the dunes and the revetment represents a savings under the with project condition. Therefore costs associated with dune and revetment preservation under the without project condition will become benefits under the with project condition. The average annual local costs avoided is approximately $201,600 ($119,800 for the Meadows, and $81,800 for Cape May Point).

OPTIMIZATION OF PROJECT TERMINATION

Two alternatives were evaluated to determine the optimal terminal point of the project. The least cost solution that prevents salt water intrusion to the Meadows consists of the beachfill in front of the Meadows and a dike along Lighthouse Avenue. Eventhough this alternative allows for realization of the same level of environmental benefits as does continuing the beachfill to Cape May Point, it also negatively impacts Cape May Point. The incremental cost between terminating the beachfill at Cape May Point and constructing the dike was compared to the storm damage reduction benefits from ending the beachfill in Cape May Point. The results in Table C-20 show that the incremental benefits from continuing the beachfill outweigh the incremental cost.

TABLE C-20

Incremental Cost Comparison of Project Terminal Point (Avg. Ann., Oct. 1997 Price Level)

Cape May Point	Dike	Beachfill	Incremental
Storm Damage Reduction	$0	$378,100	$378,100
Local Cost Forgone	0	81,800	81,800
Benefits During Construction	0	6,600	6,600
Incremental Average Annual Benefits:	$0	$466,500	$466,500
Average Annual Construction Costs	$151,000	$474,000	$323,000
Average Annual OMRR&R Costs	0	9,600	$9,600
Incremental Average Annual Costs:	$151,000	$483,600	$332,600
		Benefit-Cost Ratio:	1.4

ANNUALIZED COSTS

Table C-21 displays the calculations for interest during construction. It is assumed the construction costs would be evenly distributed over the construction period. The duration of construction for the project is estimated at twelve months. The planning, engineering and design phase of study will begin one year prior to the start of construction. Therefore, in accordance with ER1105-2-100, paragraph 6-153, interest during construction was based on twenty-four months. It is assumed that the construction costs would be evenly distributed over this period. First costs, and continuing construction or nourishment costs are annualized and presented in Table C-22. Major rehabilitation costs are included in the cyclical nourishment cost.

TABLE C-21

LOWER CAPE MAY MEADOWS - CAPE MAY POINT INTEREST DURING CONSTRUCTION			
Discount Rate:		7.125%	
Use Date:		Feb-2000	
Start Date:		Feb-2001	
	Monthly	Interest	Total
MONTH	Costs	Factor	Cost
1	$162,999	1.147577	$187,054
2	$162,999	1.141013	$185,984
3	$162,999	1.134488	$184,921
4	$162,999	1.128000	$183,863
5	$162,999	1.121548	$182,811
6	$162,999	1.115134	$181,766
7	$162,999	1.108757	$180,726
8	$162,999	1.102416	$179,693
9	$162,999	1.096111	$178,665
10	$162,999	1.089842	$177,643
11	$162,999	1.083609	$176,627
12	$162,999	1.077412	$175,617
13	$1,132,643	1.071250	$1,213,344
14	$1,132,643	1.065123	$1,206,405
15	$1,132,643	1.059032	$1,199,505
16	$1,132,643	1.052975	$1,192,645
17	$1,132,643	1.046953	$1,185,824
18	$1,132,643	1.040965	$1,179,043
19	$1,132,643	1.035012	$1,172,299
20	$1,132,643	1.029093	$1,165,595
21	$1,132,643	1.023207	$1,158,929
22	$1,132,643	1.017355	$1,152,301
23	$1,132,643	1.011537	$1,145,711
24	$1,132,643	1.005752	$1,139,158
Total First Cost:	$15,547,709		
	Total Investment Cost:		$16,286,131
	Minus First Cost:		15,547,709
	IDC (rounded):		$738,000

TABLE C-22

LOWER CAPE MAY MEADOWS - CAPE MAY POINT BEACHFILL & NOURISHMENT PRESENT WORTH ANALYSIS				
	Base Year:		0	2000
	Discount Rate:		7.125%	
TYPE	YEAR	COST	PW FACTOR	PW COST
Initial Cost	0	15,403,129	1.000000000	15,403,129
IDC	0	738,000	1.000000000	738,000
Real Estate	0	144,580	1.000000000	144,580
Nourishment	1	145,130	0.933488915	135,477
Nourishment	2	134,090	0.871401554	116,846
Nourishment	3	341,090	0.813443691	277,458
Nourishment	4	4,855,148	0.759340668	3,686,711
Nourishment	5	168,590	0.708836097	119,503
Nourishment	6	19,090	0.661690639	12,632
Nourishment	7	19,090	0.617680876	11,792
Nourishment	8	4,793,278	0.576598251	2,763,796
Nourishment	9	19,090	0.538248075	10,275
Nourishment	10	19,090	0.502448612	9,592
Nourishment	11	19,090	0.469030209	8,954
Nourishment	12	4,740,148	0.437834501	2,075,400
Nourishment	13	19,090	0.408713653	7,802
Nourishment	14	19,090	0.381529665	7,283
Nourishment	15	19,090	0.356153713	6,799
Nourishment	16	4,793,278	0.332465543	1,593,600
Nourishment	17	19,090	0.310352899	5,925
Nourishment	18	19,090	0.289710991	5,531
Nourishment	19	19,090	0.270441998	5,163
Nourishment	20	4,740,148	0.252454608	1,196,672
Nourishment	21	19,090	0.235663578	4,499
Nourishment	22	19,090	0.219989337	4,200
Nourishment	23	19,090	0.205357608	3,920
Nourishment	24	4,793,278	0.191699050	918,867
Nourishment	25	19,090	0.178948939	3,416
Nourishment	26	19,090	0.167046850	3,189
Nourishment	27	19,090	0.155936383	2,977
Nourishment	28	4,826,398	0.145564885	702,554
Nourishment	29	19,090	0.135883207	2,594
Nourishment	30	19,090	0.126845467	2,421
Nourishment	31	19,090	0.118408837	2,260
Nourishment	32	4,793,278	0.110533337	529,817
Nourishment	33	19,090	0.103181645	1,970
Nourishment	34	19,090	0.096318922	1,839
Nourishment	35	19,090	0.089912646	1,716
Nourishment	36	4,740,148	0.083932458	397,852
Nourishment	37	19,090	0.078350019	1,496
Nourishment	38	19,090	0.073138874	1,396
Nourishment	39	19,090	0.068274329	1,303
Nourishment	40	4,793,278	0.063733329	305,492
Nourishment	41	19,090	0.059494356	1,136
Nourishment	42	19,090	0.055537322	1,060
Nourishment	43	19,090	0.051843474	990
Nourishment	44	4,740,148	0.048395309	229,401
Nourishment	45	19,090	0.045176484	862
Nourishment	46	19,090	0.042171747	805
Nourishment	47	19,090	0.039366858	752
Nourishment	48	4,793,278	0.036748526	176,146
Nourishment	49	19,090	0.034304342	655
Nourishment	50	19,090	0.032022723	611
			TOTAL	31,649,115
			Capital Recovery Factor (50 Years @ 7.125%):	0.07360709974
			AVERAGE ANNUAL COSTS (rounded):	$2,330,000

BENEFITS DURING CONSTRUCTION

The proposed project will be constructed over twelve months with an additional month before and after construction for mobilization and demobilization. Portions of the beach will be fully nourished before the project is completed in its entirety. The portions of the beach nourished early in the construction phase will provide storm damage reduction benefits. Table C-23 shows the monthly benefits during construction and the average annual benefits this adds to overall incidental benefits.

TABLE C-23

LOWER CAPE MAY MEADOWS - CAPE MAY POINT BENEFITS DURING CONSTRUCTION				
Discount Rate:			7.125%	
Use Date:			Jan-1999	
Start Date:			Jan-2000	
Month	Work	Monthly Benefit	Interest Factor	Total Cost
1	Mob	$0	1.071250	$0
2	Meadows	$0	1.065123	$0
3	Meadows	$0	1.059032	$0
4	Meadows	$3,500	1.052975	$3,685
5	Meadows	$11,300	1.046953	$11,831
6	Meadows	$11,600	1.040965	$12,075
7	Meadows & Point	$25,500	1.035012	$26,393
8	Meadows & Point	$33,600	1.029093	$34,578
9	Meadows & Point	$33,600	1.023207	$34,380
10	Meadows & Point	$58,400	1.017355	$59,414
11	Meadows & Point	$64,400	1.011537	$65,143
12	Demob	$64,400	1.005752	$64,770
Total:				$312,268
Capital Recovery Factor (50 years @ 7.125%):				0.0736070997
BENEFITS DURING CONSTRUCTION (rounded):				$23,000

BENEFIT - COST SUMMARY

Annualized costs are displayed by category in Table C-24. The selected plan is expected to provide $944,100 in incidental storm damage reduction and other NED benefits.

TABLE C-24
NED BENEFITS AND COSTS FOR THE SELECTED PLAN

DISCOUNT RATE	7.125%	
PROJECT LIFE	50 YEARS	
PRICE LEVEL	OCT 1997	
BASE YEAR	2000	
AVERAGE ANNUAL INCIDENTAL BENEFITS:		
Storm Damage Reduction	719,500	
Local Costs Forgone	201,600	
Benefits During Construction	23,000	
TOTAL NED BENEFITS		**$944,100**
TOTAL COSTS:		
Initial Construction Costs (includes E&D monitoring)	$15,403,000	
Real Estate	145,000	
Interest During Construction	738,000	
Average Annual Construction Costs*		$2,330,000
Average Annual OMRR&R Costs		56,000
TOTAL AVERAGE ANNUAL COSTS		**$2,386,000**

*Includes interest during construction, E&D monitoring, real estate and periodic nourishment

Appendix F

Real Estate Plan

Feasibility Study
Lower Cape May Meadows-Cape May Point
Real Estate Plan

1. PURPOSE: This Real Estate Plan is for the Lower Cape May Meadows-Cape May Point Feasibility Study. This is a part of the ongoing New Jersey Shore Protection Study. This study was completed under authority of resolutions adopted by the Committee on Public Works and Transportation, U.S. House of Representatives and the Committee on Environment and Public Works, U.S. Senate, dated December 1987. The Reconnaissance Report was completed in August of 1994. The non-Federal sponsor is the New Jersey Department of Environmental Protection (NJDEP).

2. PROJECT AREA DESCRIPTION: The study area is located in Cape May County, New Jersey, in Lower Township on Cape May Point and the adjacent Atlantic coastline. The Cape May Point area is mainly residential while the Meadows area is undeveloped wetlands owned mainly by the Cape May Point State Park (NJDEP) and the Nature Conservancy (a private, non-profit entity).

3. RECOMMENDED PLAN: The purpose of this project is environmental restoration and protection. The selected plan consists of a berm with a dune placed on existing beachfront along with environmental restoration of the Meadows wetland area inland. The dune/berm would extend from the 3rd Avenue terminal groin in Cape May City to the Central Avenue groin in Cape May Point. The total length is approximately 1.9 miles. Sand will be hydraulically pumped onto the existing beach and then shaped. The environmental restoration of the interior marsh area includes reclamation of approximately 35 acres of previously eroded emergent wetlands by excavation and placement of the dune seaward of its existing location. There will also be construction to regulate drainage in the marsh. Interior construction features include: excavation to restore the flow within existing drainage ditches; creation of two new drainage ditches with weirs; excavation of fish reservoirs within existing ponds; and a berm to allow for retention of approximately 20 acres of tidal marsh. The locations of these improvements are indicated in Exhibit A. Additionally, areas owned/operated by the State Park and the Nature Conservancy will be sprayed and burned to control phragmites. These areas will then be planted with emergent wetland vegetation. Construction access points to the beach will be from the State Park parking area and the areas off of Sunset Avenue indicated in Exhibit A. The borrow site for the beachfill is below the Mean High Water Line (MHWL) and is owned and controlled by the non-Federal sponsor. This would require a right of entry for use. The existing outfall pipe, located on and operated by the State Park, will be extended to the MHWL. A portion of the State Park parking area would be used as a staging/access area during construction. Additional permanent access routes from Sunset Avenue for maintenance would be located on land owned by the Nature Conservancy. The duration of Temporary Work Area Easements (TWAE) for access and staging is estimated to be two years. This will allow sufficient time for construction, contractor mobilization/demobilization, weather delays, etc. Acreage requirements are summarized in paragraph 6 and in Exhibit A.

4. Real Estate Mapping, Plate R-1, dated 1 November 1997 is attached as Exhibit A. The maps

include delineation of the land, estates, and acreages to be acquired and indicate parcels impacted by the project.

5. OWNERSHIPS: The dune and berm will be constructed on existing beachfront owned by Cape May Point Borough, NJDEP (the State Park), and the Nature Conservancy. Lands below the MHWL extending 3 miles seaward (to include the borrow area) are owned and controlled by the NJDEP. The interior marsh restoration will primarily be on lands owned by the NJDEP and the Nature Conservancy but impacts some additional ownerships. Construction areas would exclude any existing structures. A total of 52 parcels with 16 ownerships are indicated to be impacted by the proposed project. The required staging/access area is owned by the State Park while the two perpetual access routes would be on Nature Conservancy property. The TWAE for access points will allow for sufficient parking and continued access to the adjacent properties during construction. Ownership information is indicated in Exhibit B.

6. REAL ESTATE COSTS: The detailed Real Estate Cost Estimate in MCACES format is included in Exhibit C. The required TWAE (approximately 25 ac.), perpetual restrictive dune/beach nourishment easements (approximately 87.8 ac. including the area below the Mean High Water Line), drainage maintenance easement (approximately 20.9 ac.), and road easement (approximately 2.8 ac.) are considered to have nominal value because of special benefits. The proposed project will create a betterment to the properties that otherwise would not exist. The Nature Conservancy supports the proposed plan as enhancing the ecosystem of their ownership. It is anticipated that an agreement would be entered into by the NJDEP and the Nature Conservancy to insure access for the phragmites control and emergent wetland vegetation planting.

7. RECOMMENDED ESTATES: The usual estate for an environmental restoration is fee per ER 405-1-12 Chapter 12. However, this project does not restrict access to the beachfront and will not interfere with the owners use and enjoyment of their property. As the policy is to acquire the minimum estate required, Real Estate Division recommends the following non-standard (for environmental restoration) estates:

Dune/Berm:

RESTRICTIVE DUNE EASEMENT

A perpetual and assignable easement and right-of-way in, on, over and across (the land described in Schedule A) (Tract Nos. ____), to construct, operate, maintain, patrol, repair, rehabilitate, and replace a dune system and appurtenances thereto, together with the right to post signs, plant vegetation and prohibit the grantor(s), (his) (her) (its) (their) heirs, successors, assigns and all others from entering upon or crossing over said dune easement; reserving, however, to the grantor(s), (his) (her) (its) (their) heirs, successors, assigns, the right to construct dune walkover structures in accordance with any applicable Federal, State, or local laws or regulations, provided that such structures shall not violate the integrity of the dune in shape or dimension and prior approval of the plans and specifications for such structures shall have been obtained from the District Engineer, U.S. Army Engineer District, Philadelphia, and all other

rights and privileges as may be used without interfering with or abridging the rights and easement hereby acquired; subject, however, to existing easements for public roads and highways, public utilities, railroads and pipelines.

PERPETUAL BEACH NOURISHMENT EASEMENT

A perpetual and assignable easement and right-of-way in, on, over and across (the land described in Schedule A) (Tract Nos. ____), to construct, operate, maintain, patrol, repair, renourish, and replace the beach berm and appurtenances thereto, including the right to borrow and/or deposit fill, together with the right to trim, cut, fell and remove therefrom all trees, underbrush, obstructions, and any other vegetation, structures, or obstacles within the limits of the easement; reserving, however, to the grantor(s), (his) (her) (its) (their) heirs, successors and assigns, all such rights and privileges as may be used without interfering with or abridging the rights and easement hereby acquired; subject, however to existing easements for public roads and highways, public utilities, railroads and pipelines.

Interior Marsh Drainage Maintenance: The following non-standard estate is recommended for the interior marsh ditch, weir, retention berm, and excavation/placement features:

DRAINAGE MAINTENANCE EASEMENT (Non-Standard)

A perpetual and assignable easement and right-of-way in, on, over and across (the land described in Schedule A) (Tract Nos. ____) to construct, maintain, repair, operate, patrol and replace a drainage ditch, weir, and retention berm, reserving, however, to the owners, their heirs and assigns, all such rights and privileges in the land as may be used without interfering with or abridging the rights and easement hereby acquired; subject, however to existing easements for public roads and highways, public utilities, railroads and pipelines.

Additionally, the following standard estate would be required for staging and access during construction:

TEMPORARY WORK AREA EASEMENT (Estate No. 15)

A temporary easement and right-of-way in, on, over and across (the land described in Schedule A) (Tract Nos. ____), for a period not to exceed two years, beginning with date possession of the land is granted to the United States, for use by the United States, its representatives, agents, and contractors as a work area, including the right to borrow and/or deposit fill, spoil, and waste material thereon and to move, store and remove equipment and supplies, and erect and remove temporary structures on the land and to perform any other work necessary and incident to the construction of the Cape May Villas Environmental Restoration Project, together with the right to trim, cut, fell and remove therefrom all trees, underbrush, obstructions, and any other vegetation, structures, or obstacles within the limits of the right-of-way; reserving, however, to the landowners, their heirs and assigns, all such rights and privileges as may be used without interfering with or abridging the rights and easement hereby acquired; subject, however to existing easements for public roads and highways, public utilities, railroads

and pipelines.

Ponding area:

FLOWAGE EASEMENT (Permanent Flooding) (Estate No. 5)

The perpetual right, power, privilege and easement permanently to overflow, flood and submerge (the land described in Schedule A) (Tract Nos. ____) (and to maintain mosquito control) in connection with the operation and maintenance of the Cape May Point-Lower Cape May Meadows Environmental Restoration project as authorized by the Act of Congress approved _____, and the continuing right to clear and remove any brush, debris and natural obstructions which, in the opinion of the representative of the United States in charge of the project, may be detrimental to the project, together with all right, title and interest in and to the timber, structures and improvements situate on the land; provided that no structures for human habitation shall be constructed or maintained on the land, that no other structures shall be constructed or maintained on the land except as may be approved in writing by the representative of the United States in charge of the project, and that no excavation shall be conducted and no landfill placed on the land without such approval as to the location and method of excavation and/or placement of landfill; the above estate is taken subject to existing easements for public roads and highways, public utilities, railroads and pipelines; reserving, however, to the landowners, their heirs and assigns, all such rights and privileges as may be used and enjoyed without interfering with the use of the project for the purposes authorized by Congress or abridging the rights and easement hereby acquired; provided further that any use of the land shall be subject to Federal and State laws with respect to pollution.

Access during and after construction:

ROAD EASEMENT (Estate No. 11)

A perpetual and assignable easement and right-of-way in, on, over and across (the land described in Schedule A) (Tract Nos. ____) for the location, construction, operation, maintenance, alteration, and replacement of (a) road(s) and appurtenances thereto; together with the right to trim, cut, fell and remove therefrom all trees, underbrush, obstructions, and any other vegetation, structures, or obstacles within the limits of the right-of-way; reserving, however, to the landowners, their heirs and assigns, the right to cross over or under the right-of-way as access to their adjoining land at the locations indicated in Schedule B; subject, however, to existing easements for public roads and highways, public utilities, railroads and pipelines.

Phragmites Control/Emergent Wetland Vegetation agreement: The non-Federal sponsor will enter into a perpetual agreement with the Nature Conservancy to enter onto their property as necessary to spray and burn phragmites and to plant/maintain emergent wetland vegetation. The NJDEP has indicated that they have a partnership type of relationship with the Nature Conservancy and that a cooperative agreement is preferable to fee acquisition.

8. RELOCATION OF UTILITIES AND FACILITIES: One outfall pipe, located on and owned

by the State Park ("Drainage East"), will require a 112 foot extension and is likely a relocation. An Attorney's Opinion of Compensability is being prepared to determine whether this a relocation and the appropriate measure of just compensation. The relocation will be the non-Federal sponsor's responsibility.

9. EXISTING FEDERAL OWNERSHIP: There is no Federally-owned land within the project area.

10. NAVIGATION SERVITUDE: Navigation Servitude will does not apply to this environmental restoration/protection project. Navigation Servitude does not apply as this project is not for navigation, commerce, power production or flood control. The non-Federal sponsor already owns the lands below the Mean High Water Line.

11. PUBLIC LAW 91-646 RELOCATIONS: There are no Public Law 91-646 relocations required in connection with the project.

12. HAZARDOUS, TOXIC, AND RADIOACTIVE WASTE: There is no known on-site contamination and the real estate cost estimates contained in this Real Estate Plan do not reflect the presence of contamination.

13. MINERAL ACTIVITY: There is no present or anticipated mineral activity in the vicinity of the project which may affect the operation thereof.

14. ACQUISITION SCHEDULE: The non-Federal sponsor, the New Jersey Department of Environmental Protection, has indicated that the required real estate acquisitions would be accomplished with the assistance of Lower Township which has real estate acquisition authority in the project area. It is anticipated that the State of New Jersey would enter into a State Aid Agreement with the Township. Also, an agreement would be entered into by the non-Federal sponsor and the Nature Conservancy for the right to spray and burn phragmites on the Nature Conservancy property. Following is the estimated acquisition schedule:

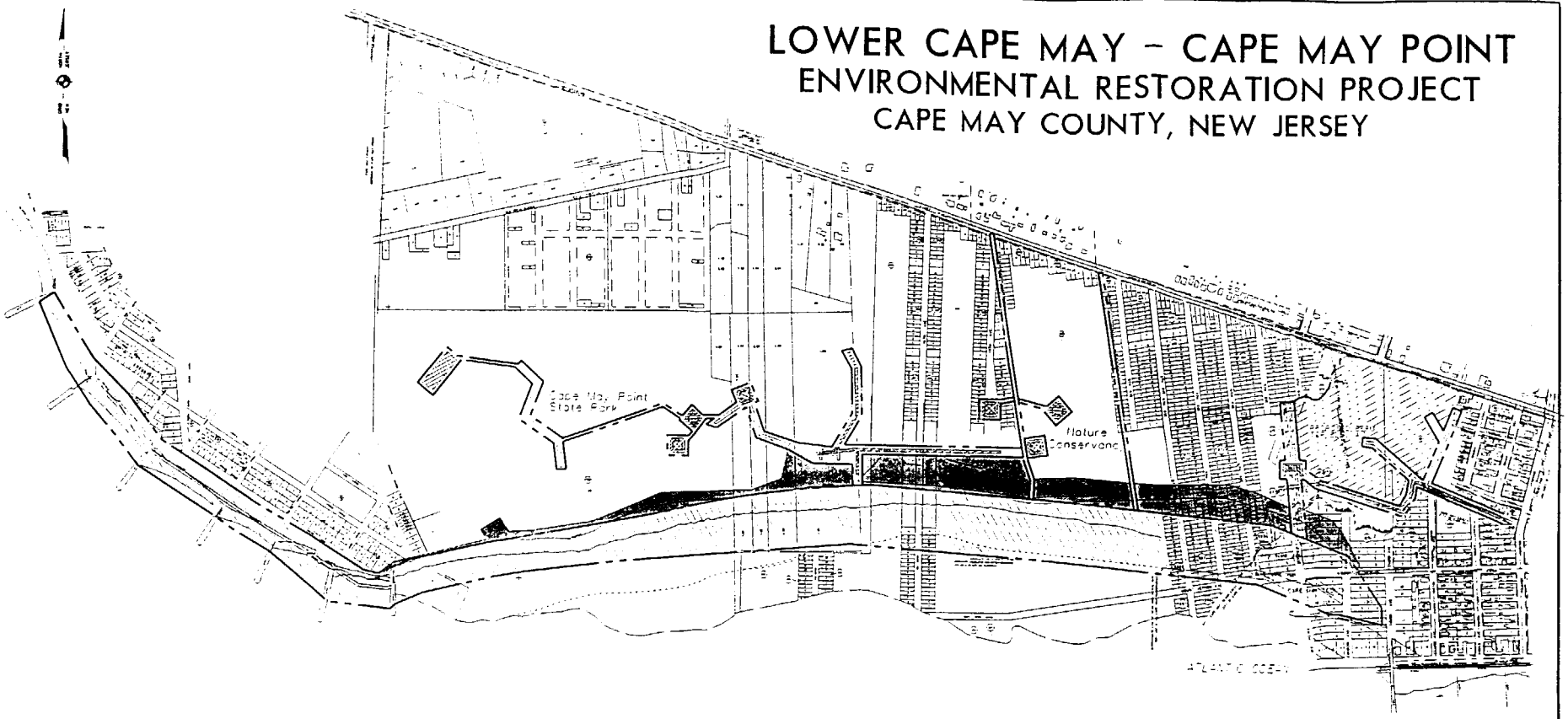
1. PCA execution	31 May 1999
2. Forward maps to sponsor	01 June 1999-08 June 1999
3. Survey	09 June 1999-15 Sep 1999
4. Title	09 June 1999-15 Sep 1999
5. Appraisals	09 June 1999-15 Sep 1999
6. Negotiations	16 Sep 1999-16 Jan 2000
7. Closings	16 Jan 2000-15 Feb 2000
8. Condemnations	16 Jan 2000-15 Apr 2000
9. Possession	16 Apr 2000-15 May 2000

The Assessment of Non-Federal Sponsor's Real Estate Acquisition Capability is included as Exhibit D.

EXHIBIT A

U. S. ARMY

LOWER CAPE MAY - CAPE MAY POINT
ENVIRONMENTAL RESTORATION PROJECT
CAPE MAY COUNTY, NEW JERSEY



NOTES:

1) THIS MAPPING WAS COMPILED FROM BASE TOPOGRAPHIC DATA PROVIDED BY PHILADELPHIA DISTRICT, U.S. ARMY CORPS OF ENGINEERS.

2) PARCEL LINES ARE DIGITALLY REPRODUCED AND ARE APPROXIMATE IN LOCATION. TRUE POSITION OF PARCEL LINES CAN ONLY BE DETERMINED THROUGH AN ACTUAL FIELD LOCATION SURVEY.

3) MAPPING IS PREDICATED ON THE NEW JERSEY STATE PLANE COORDINATE SYSTEM.

PERPETUAL RESTRICTIVE DUNE / BEACH NOURISHMENT EASEMENT
87.80 ACRES

PERPETUAL DRAINAGE EASEMENT
20.88 ACRES

PERPETUAL ROAD EASEMENT
2.83 ACRES

PERPETUAL PONDING EASEMENT
19.76 ACRES

TEMPORARY WORK AREA EASEMENT
25.07 ACRES

DATE	REVISIONS AND UPDATES	BY

PROJECT PLANNING MAP

DEPARTMENT OF THE ARMY	USING SERVICE
LOCATION OF PROJECT	TRANSPORTATION FACILITIES
STATE: NEW JERSEY	RAILROADS
COUNTY: CAPE MAY	STATE ROADS
DIVISION: NORTH ATLANTIC	FEDERAL ROADS
DISTRICT: PHILADELPHIA	AIRLINES

DEPARTMENT OF THE ARMY
U. S. ARMY ENGINEER DISTRICT, BALTIMORE
CORPS OF ENGINEERS
NORTH ATLANTIC DIVISION

DRAWN BY: CHB
TRACED BY:
CHECKED BY: CHB
SUBMITTED BY:
CHIEF, PLN
RECOMMENDED BY:

REAL ESTATE

LOWER CAPE MAY - CAPE MAY POINT
ENVIRONMENTAL RESTORATION PROJECT
CAPE MAY COUNTY, NEW JERSEY

APPROVED BY:

CHIEF, PLN BRANCH | CHIEF, REAL ESTATE DIVISION | DATE

US ARMY CORPS OF ENGINEERS, WASH DC 20314 | PLATE R-1 | SCALE IN FEET 300 150 0 300 600

INSTALLATION OR PROJECT NO. | SHEET | DRAWING NO.

EXHIBIT B

Lower Cape May Meadows-Cape May Point
Ownerships

Address	Ownership	Municipality	Block/Lot
118 First Avenue	City Of Cape May	CAPE MAY CITY	02-01015-0000-00001
108 Broadway	Carmine C. Lobascio	CAPE MAY CITY	02-01017-0000-00001
113-115 First Avenue	Thomas J. Reid	CAPE MAY CITY	02-01017-0000-00016
Sunset Blvd	State Of Nj Dept Of Env Protec	LOWER TOWNSHIP	05-00792-0000-00001-0005
656 Sunset Blvd	Leonard S. Sachar	LOWER TOWNSHIP	05-00792-0000-00002-0001
Sunset Blvd	State Of Nj Dept Of Env Protec	LOWER TOWNSHIP	05-00792-0000-00002-0002
Sunset Blvd	State Of Nj Dept Of Env Protec	LOWER TOWNSHIP	05-00792-0000-00003-0002
Sunset Blvd	State Of Nj Dept Of Env Protec	LOWER TOWNSHIP	05-00792-0000-00004-0003
	State Of Nj Dept Of Env Protec	LOWER TOWNSHIP	05-00792-0000-00020-0001
	Township Of Lower	LOWER TOWNSHIP	05-00792-0000-00020-0002
Lighthouse Rd	Township Of Lower	LOWER TOWNSHIP	05-00792-0000-00021
S Cape May	Nature Conservancy The	LOWER TOWNSHIP	05-00835-0000-00001
680 Sunset Blvd	Nature Conservancy The	LOWER TOWNSHIP	05-00840-0000-00042
16th Avenue	Nature Conservancy The	LOWER TOWNSHIP	05-00847-0000-00002
16th Avenue	Nature Conservancy The	LOWER TOWNSHIP	05-00848-0000-00001
14th Avenue	Nature Conservancy The	LOWER TOWNSHIP	05-00849-0000-00002
14th Avenue	Nature Conservancy The	LOWER TOWNSHIP	05-00850-0000-00001
S Cape May	Nature Conservancy The	LOWER TOWNSHIP	05-00851-0000-00001
16th Avenue	Nature Conservancy The	LOWER TOWNSHIP	05-00861-0000-00002
16th Avenue	Nature Conservancy The	LOWER TOWNSHIP	05-00862-0000-00001
16th Avenue	Township Of Lower	LOWER TOWNSHIP	05-00862-0000-00037
13th Avenue	Nature Conservancy The	LOWER TOWNSHIP	05-00864-0000-00001
8th Avenue	Nature Conservancy The	LOWER TOWNSHIP	05-00869-0000-00002
8th Avenue	State Of Nj Dept Of Env Protec	LOWER TOWNSHIP	05-00869-0000-00018
115 W Grant Street	John S. Van Harlingen	WEST CAPE MAY BORO	12-00028-0000-00001
109 W Grant Street	William M. Genovese	WEST CAPE MAY BORO	12-00028-0000-00002
107 W Grant Street	G. L. Knowles	WEST CAPE MAY BORO	12-00028-0000-00003
105 W Grant Street	Geo Heyn	WEST CAPE MAY BORO	12-00028-0000-00004
196 S Broadway	J. Eustace	WEST CAPE MAY BORO	12-00028-0000-00005
Sunset Blvd	Nature Conservancy The	WEST CAPE MAY BORO	12-00033-0000-00001
207 W Grant Street	Marinus Robyn	WEST CAPE MAY BORO	12-00033-0000-00002
204 W Grant Street	Louis Hollerbach	WEST CAPE MAY BORO	12-00033-0000-00003
4th Ave	Nature Conservancy The	LOWER TOWNSHIP	05-00859-0000-00001
5th Ave	Nature Conservancy The	LOWER TOWNSHIP	05-00873-0000-00001
6th Ave	Nature Conservancy The	LOWER TOWNSHIP	05-00872-0000-00001
7th Ave	Nature Conservancy The	LOWER TOWNSHIP	05-00871-0000-00001
7th Ave	Nature Conservancy The	LOWER TOWNSHIP	05-00870-0000-00001
8th Ave	Township Of Lower	LOWER TOWNSHIP	05-00870-0000-00007
8th Ave	Nature Conservancy The	LOWER TOWNSHIP	05-00886-0000-00002
7th Ave	Nature Conservancy The	LOWER TOWNSHIP	05-00887-0000-00008
8th Ave	State Of Nj Dept Of Env Protec	LOWER TOWNSHIP	05-00887-0000-00013
7th Ave	Nature Conservancy The	LOWER TOWNSHIP	05-00887-0000-00016
7th Ave	State Of Nj Dept Of Env Protec	LOWER TOWNSHIP	05-00887-0000-00020
7th Ave	Township Of Lower	LOWER TOWNSHIP	05-00888-0000-00001
7th Ave	Township Of Lower	LOWER TOWNSHIP	05-00888-0000-00019
6th Ave	Nature Conservancy The	LOWER TOWNSHIP	05-00889-0000-00013
712 Sunset Blvd.	Nature Conservancy The	LOWER TOWNSHIP	05-00858-0000-00001
4th Ave	Township Of Lower	LOWER TOWNSHIP	05-00858-0000-00022
712 Sunset Blvd.	State Of Nj Dept Of Env Protec	LOWER TOWNSHIP	05-00858-0000-00028
714 Sunset Blvd.	Township Of Lower	LOWER TOWNSHIP	05-00858-0000-00036
710 Sunset Blvd.	Nature Conservancy The	LOWER TOWNSHIP	05-00857-0000-00001
Beach	Cape May Point	CAPE MAY POINT BORO	Beach

	Parcels	Ownerships
Public:	19	4
Private:	33	12
Total	52	16

EXHIBIT C

Feasibility Study Cost Estimate-MCACES Format
Real Estate Acquisition Requirements
Lower Cape May Meadows-Cape May Point
New Jersey

	Private			Commercial			Public			Requirement		
	#	$ each	req	#	$ each	req	#	$ each	req	Base	Contingency	Total
0102-----ACQUISITIONS												
010201--- By Government												
010202--- By Non-Federal Sponsor (NFS)												
01020201 Survey and Legal Descriptions	33	500	16,500				10	500	5,000	21,500	3,225	24,725
01020102 Title Evidence	33	600	19,800				10	600	6,000	25,800	3,870	29,670
01020203 Negotiations	12	1,000	12,000				3	500	1,500	13,500	2,025	15,525
010203--- By Government on Behalf of NFS												
010204--- Review of NFS												
01020401 Survey and Legal Descriptions	33	75	2,475				10	75	750	3,225	484	3,709
01020402 Title Evidence	33	75	2,475				10	75	750	3,225	484	3,709
01020403 Negotiations	12	75	900				3	75	225	1,125	169	1,294
SUBTOTAL										68,375	10,256	78,631
0103-----CONDEMNATIONS												
010301--- By Government												
010302--- By Non-Federal Sponsor (NFS)												
010303--- By Government on Behalf of NFS												
010304--- Review of NFS												
SUBTOTAL												
0105-----APPRAISALS												
010501--- By Government												
010502--- By Non-Federal Sponsor (NFS)	33	500	16,500				10	250	2,500	19,000	2,850	21,850
010503--- By Government on Behalf of NFS												
010504--- Review of NFS	33	100	3,300				10	50	500	3,800	570	4,370
SUBTOTAL										22,800	3,420	26,220
0106-----PL 91-646 ASSISTANCE												
010601--- By Government												
010602--- By Non-Federal Sponsor (NFS)												
010603--- By Government on Behalf of NFS												
010604--- Review of NFS												
SUBTOTAL												
0107-----TEMPORARY PERMITS/LICENSES/RIGHTS-OF-WAY												
010701--- By Government												
010702--- By Non-Federal Sponsor (NFS)												
010703--- By Government on Behalf of NFS												
010704--- Review of NFS												
010705--- Other												
010706--- Damage Claims												
SUBTOTAL												
0115------ REAL ESTATE PAYMENTS												
011501---Land Payments												
01150101 By Government												
01150102 By Non-Federal Sponsor (NFS)										1	0	1
01150103 By Government on Behalf of NFS												
01150104 Review of NFS												
011502---PL 91-646 Assistance Payments												
01150201 By Government												
01150202 By Non-Federal Sponsor (NFS)												
01150203 By Government on Behalf of NFS												
01150204 Review of NFS												
011503---Damage Payments												
01150301 By Government												
01150302 By Non-Federal Sponsor (NFS)												
01150303 By Government on Behalf of NFS												
01150304 Review of NFS												
SUBTOTAL										1	0	1
REAL ESTATE TOTAL										**91,176**	**13,676**	**104,852**
Account 02 Facility/Utility Relocations (Construction cost only)										34,546	5,182	39,728
REAL ESTATE ACQUISITION TOTAL										**$125,722**	**$18,858**	**$144,580**

EXHIBIT D

ASSESSMENT OF NON-FEDERAL SPONSOR'S
REAL ESTATE ACQUISITION CAPABILITY

I. Legal Authority:

a. Does the sponsor have legal authority to acquire and hold title to real property for project purposes? Yes. The non-Federal Sponsor, the New Jersey Department of Environmental Protection (NJDEP) has acquisition authority in the project area.

b. Does the sponsor have the power of eminent domain for this project? Yes.

c. Does the sponsor have "quick-take" authority for this project? Yes.

d. Are any of the lands/interests in land required for the project located outside the sponsor's political boundary? No.

e. Are any of the lands/interests in land required for the project owned by an entity whose property the sponsor cannot condemn? No.

II. Human Resource Requirements:

a. Will the sponsor's in-house staff require training to become familiar with the real estate requirements of Federal projects including P.L. 91-646, as amended? No. The sponsor is familiar with the requirements of P.L. 91-646.

b. If the answer to II.a. is "yes", has a reasonable plan been developed to provide such training? N/A.

c. Does the sponsor's in-house staff have sufficient real estate acquisition experience to meet its responsibilities for the project? Yes.

d. Is the sponsor's projected in-house staffing level sufficient considering its other work load, if any, and the project schedule? Yes. The sponsor has indicated that assistance would be requested from the local municipalities to acquire the necessary real estate interests. If necessary, the acquisitions could be contracted to meet the project schedule.

e. Can the sponsor obtain contractor support, if required, in a timely fashion? Yes. Approximately three weeks are required to obtain contractor support.

f. Will the sponsor likely request USACE assistance in acquiring real estate? No.

III. Other Project Variables:

a. Will the sponsor's staff be located within reasonable proximity to the project site? Yes.

b. Has the sponsor approved the project/real estate schedule/milestones? Yes.

IV. Overall Assessment:

a. Has the sponsor performed satisfactorily on other USACE projects? (yes/no/not applicable) Yes.

b. With regard to this project, the sponsor is anticipated to be: Fully capable with possible contractor support.

V. Coordination:

a. Has this assessment been coordinated with the sponsor? Yes

b. Does the sponsor concur with this assessment? Yes (If "no", provide explanation).

Prepared by:

Adam L. Oestreich

ADAM L. OESTREICH
Realty Specialist

Reviewed and approved by:

Susan K. Lewis

SUSAN K. LEWIS
Chief, Civil Projects Support Branch
Real Estate Division

Appendix G

Cultural Resources

DRAFT

PHASE I
SUBMERGED AND SHORELINE CULTURAL RESOURCES INVESTIGATIONS LOWER CAPE MAY MEADOWS CAPE MAY CITY, LOWER TOWNSHIP AND THE BOROUGH OF CAPE MAY POINT CAPE MAY COUNTY, NEW JERSEY

CONTRACT DACW 61-94-D-0010
DELIVERY ORDER 37

DEPARTMENT OF THE ARMY
U.S. ARMY CORPS OF ENGINEERS
PHILADELPHIA DISTRICT

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Submitted to:

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Prepared under the supervision of:

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Richard Hunter (Hunter Research, Inc.)
Principal Investigators

September 1997

MANAGEMENT SUMMARY

This report describes the results of Phase I submerged and shoreline cultural resources investigations performed for a 1.5-mile segment of the tidal zone along New Jersey's Atlantic coast and for two offshore sand borrow areas and a nearshore sand placement area in Cape May County, New Jersey. This study was performed in connection with a program of beach nourishment and shoreline erosion control planned by the Philadelphia District of the U.S. Army Corps of Engineers. Investigative tasks included: background and documentary research; pedestrian and magnetic survey of the shoreline at low tide; remote sensing survey of the offshore borrows areas and nearshore sand placement area; analysis and evaluation of assembled research and field data; and preparation of this report.

No evidence of prehistoric terrestrial archaeological resources was noted in the shoreline survey area, the offshore sand borrow areas or the nearshore sand placement area. By "terrestrial archaeological resources" is meant resources that were originally formed on land. The potential for such remains is unclear, in part because of the difficulties of reconstructing the paleo-environment, but the prospect of significant archaeological survivals is probably quite limited owing to ongoing coastal erosion. If buried resources do indeed survive within the shoreline survey areas, the beach replenishment process should serve to enhance resource preservation and protection. To address the possibility of terrestrial archaeological resources surviving within the offshore borrow areas and being affected by dredging, a program of controlled, periodic archaeological monitoring of the renewed beach surface is recommended during and immediately following the replenishment operation. No further survey-level investigation for these types of resources is recommended.

The potential for significant early historic terrestrial (as opposed to underwater) cultural resources being found intact along this section of shoreline is somewhat more substantial. The pedestrian survey identified stone and brick rubble believed to be associated with the second Cape May lighthouse, constructed in 1847, which stood on what is now the beach front and tidal zone of Cape May Point State Park within the terrestrial survey area. The archaeological integrity of these potentially significant remains is open to question and further Phase II-level study would be required to clarify this issue. However, since the placement of additional sand on the beach will have a preservation-enhancing effect on buried remains, no further study is felt to be appropriate in this instance. The site should be clearly recorded for future reference and sand placement should be undertaken with particular care in this location.

The only other notable early historic resource known to have existed within the bounds of the survey area was an early corduroy road located on the beach to the southeast of St. Mary's By The Sea. In the early 20th century, a few surviving sections of this road were exposed by a storm. No evidence of it was found in the course of the current survey. Although sections of this feature may be preserved buried beneath the beach in the shoreline survey area or survive submerged in the Near-shore Sand Placement Area, they are more likely to have been washed away by the gradually transgressing ocean. Regardless, if segments of this resource do survive within either area, the beach replenishment process should serve to preserve and protect these features.

A variety of late 19th- and early 20th-century above-ground buildings and structures formerly stood off the beachfront of the terrestrial study area. Most, however, have long since been removed by erosion. Between 1880 and 1950, the community of South Cape May occupied the eastern section of this beach on lands which

have since been eroded into the sea. The site of this town is presently located approximately 600 feet south of the low tide mark below three and six feet of water. No evidence of South Cape May was found during the terrestrial survey or by the remote sensing survey of the Nearshore Sand Placement Area.

The largest group of historic remains identified by the terrestrial field survey are those associated with the World War II-era fortifications (Delaware Harbor Defenses Batteries #s 223 and 26 [also referred to as the Cape May Point Bunker]) at the mouth of the Delaware Bay. These remains are significant under National Register criteria A, C and D for their association with the most important global military conflict of the 20th century. They are contextually linked both with the other surviving World War II-era buildings on the grounds of the Cape May Point State Park, with the sites of other destroyed structures, now offshore, with the sites of other World War II-era resources within Cape May (most notably the lookout tower at Sunset Beach), and with the complex's sister facility, Fort Miles, at Lewes, Delaware. It is recommended that the remains of these Defense Batteries #s 223 and 26 be thoroughly documented in advance of any beach nourishment activities. This documentation work should also address through diving, probing and appropriate recording any surviving remains of Defense Battery #7, which lies just offshore in an area that is inaccessible both on foot and to underwater remote sensing.

Of the later 20th-century resources identified in the course of this survey (three jetties and a drainage pipe at Cape Island Creek), none were judged to be eligible for inclusion in the State or National Registers of Historic Places. Finally, two small, isolated magnetic targets were identified during the terrestrial remote sensing survey along the beach between Cape May City and Cape May Point. However, at each target location, a lack of signature intensity and dispersion indicates a small, isolated ferrous object. No further archaeological investigation is recommended at either target location.

Comprehensive remote sensing survey of the Nearshore Sand Placement Area and proposed Borrow Areas P-1 and P-2, using magnetic, acoustic and bathymetric instrumentation, resulted in the identification of nine targets. None of the nine targets exhibited remote sensing signatures suggestive of submerged cultural resources. No additional archaeological investigation is recommended at these nine target locations.

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CHAPTER 1

INTRODUCTION

A. Project Background and Scope-of-Work

The following technical report describes a Phase I submerged and shoreline cultural resources investigation conducted for two offshore sand borrow areas (totaling approximately 400 acres) and a 1.5-mile stretch of the Atlantic coastline and the near-shore area (approximately 200 acres in size) extending between the westernmost jetty in Cape May City and the easternmost jetty in Cape May Point in Cape May County, New Jersey (Figures 1.1 and 1.2). While the eastern end of this shoreline segment is located in Cape May City and the western end is in the Borough of Cape May Point, the length of beach in between lies within Lower Township. This work was performed in connection with U.S. Army Corps of Engineers (USACOE) plans for beach nourishment along New Jersey's Atlantic shoreline. Beach nourishment, in this instance, is being considered by the USACOE as an appropriate solution to erosion along this section of the New Jersey shoreline.

The cultural resources investigations reported here represent part of a program of ongoing environmental studies that the USACOE is carrying out in cooperation with the New Jersey Department of Environmental Protection. The work was carried out as Delivery Order No. 37 under Contract DACW61-94-D-0010 between Hunter Research, Inc. and the U.S. Army Corps of Engineers (Philadelphia District). Dolan Research, Inc. operated as a subconsultant to Hunter Research, Inc., supplying underwater archaeological survey services.

The cultural resources investigations involved two principal work elements:

1). a Phase I-level terrestrial cultural resources survey designed to locate and identify any visible remains of prehistoric and historical archaeological resources within the 1.5-mile shoreline survey area, located between the west jetty in Cape May City and the easternmost jetty in Cape May Point; and

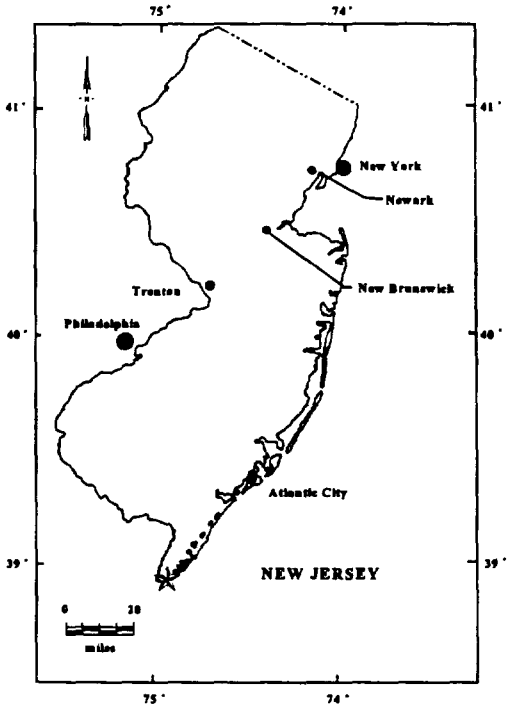

Figure 1.1. General Location of Study Area (starred).

2). a Phase I-level underwater archaeological remote sensing survey designed to locate targets associated with submerged historic and archaeological resources within the near-shore sand placement area and two proposed offshore sand borrow areas (designated as Borrow Area P-1 and Borrow Area P-2) situated near Cape May City.

Tasks performed included: background and documentary research (for both the underwater and terrestrial surveys); a pedestrian magnetometer and ground surface inspection, carried out at low tide (terrestrial survey only); acoustic, magnetic and bathymetric remote sensing with follow-up target analysis (underwater survey only); analysis of assembled research and field data; and preparation of this report.

The purpose of these investigations was twofold: to determine the presence or absence of submerged or shoreline cultural resources that are potentially eligible for inclusion in the National Register of Historic Places in areas which might be affected by proposed beach nourishment and sand borrow activities; and to assess likely project impacts and make recommendations as to the need for further cultural resources studies, if potentially significant resources are identified which may be adversely affected by the proposed project actions.

These investigations were conducted in accordance with the instructions and intents of various applicable Federal and State legislation and guidelines governing the evaluation of project impacts on archaeological resources, notably: Section 101(b)(4) of the National Environmental Policy Act of 1969; Section 1(3) and 2(b) of Executive Order 11593; Section 106 of the National Historic Preservation Act; 23 CFR 771, as amended October 30, 1980; the guidelines developed by the Advisory Council on Historic Preservation published November 26, 1980; the amended Procedures for the Protection of Historic and Cultural Properties as set forth in 36 CFR Part 800 (October 1, 1986); and New Jersey Executive Order 215.

B. Criteria of Evaluation

The information generated by these investigations was considered in terms of the criteria for evaluation outlined by the U.S. Department of the Interior, National Register Program:

The quality of significance in American history, architecture, archaeology and culture is present in districts, sites, buildings, structures and objects that possess integrity of location, design, setting, materials, workmanship, feeling and association, and:

A. that are associated with events that have made a significant contribution to the broad patterns of our history; or

B. that are associated with the lives of persons significant in our past; or

C. that embody the distinctive characteristics of a type, period or method of construction, or that represent the work of a master, or that possess high artistic values, or that represent a significant and distinguishable entity whose components may lack individual distinction; or

D. that have yielded, or may be likely to yield information important in prehistory or history.

National Register of Historic Places Bulletin 20 clarifies the National Register review process with regard to shipwrecks and other submerged cultural resources. Shipwrecks must meet at least one of the above criteria and retain integrity of location,

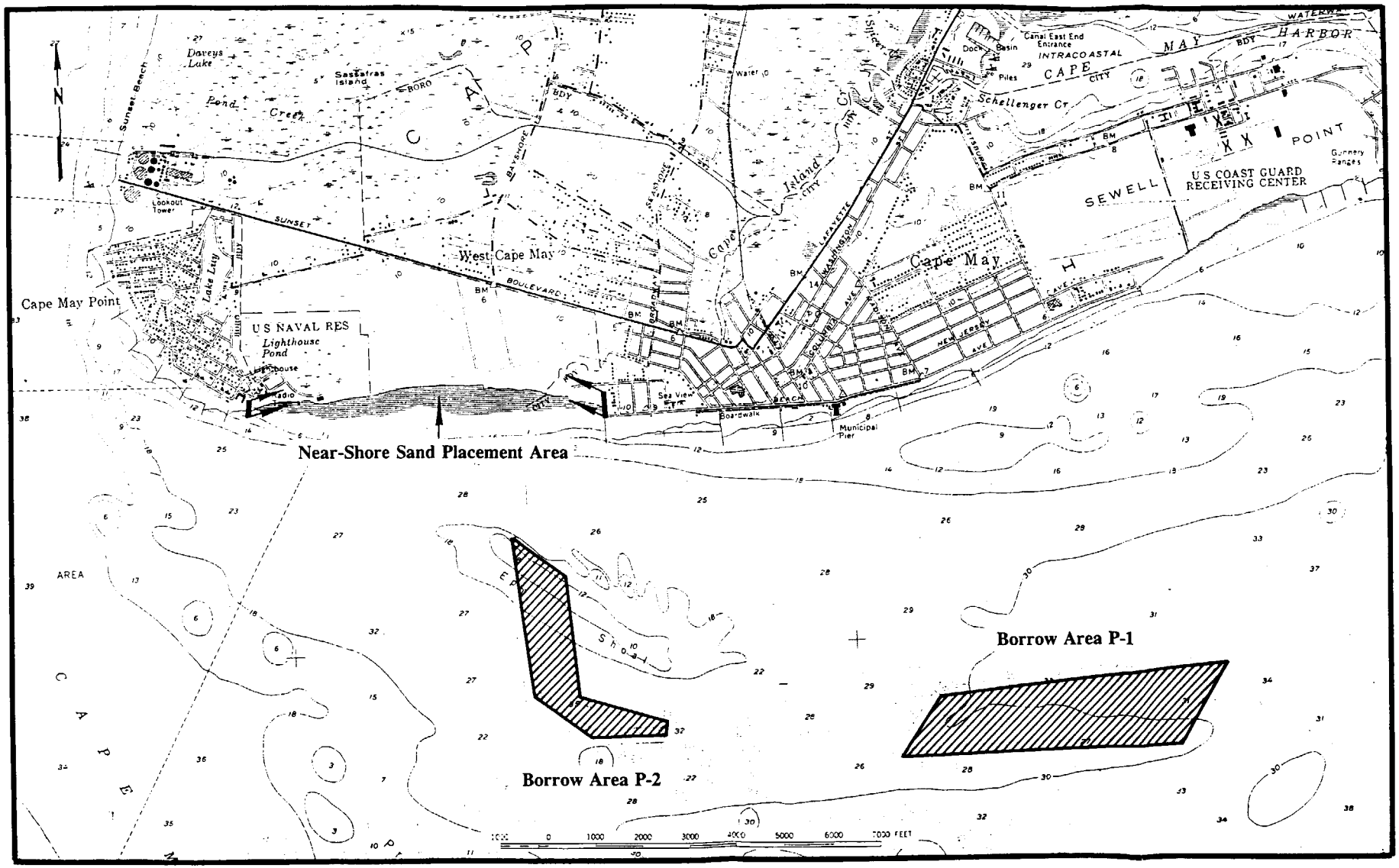

Figure 1.2. Detailed Location of Terrestrial Survey Area, Near-shore Sand Placement Area and Offshore Borrow Areas P-1 and P-2. Source: U.S.G.S. 7.5' Topographic Series, Cape May, N.J. Quadrangle (1954 [Photorevised 1972]).

design, settings, materials, workmanship, feelings and association. Determining the significance of a historic vessel depends on establishing whether the vessel is:

1. the sole, best, or a good representative of a specific vessel type; or

2. is associated with a significant designer or builder; or

3. was involved in important maritime trade, naval recreational, government, or commercial activities.

Properties which qualify for the National Register, must have significance in one or more "Areas of Significance" that are listed in National Register Bulletin 16A. Although 29 specific categories are listed, only some are relevant to the submerged cultural resources. Architecture, commerce, engineering, industry, invention, maritime history and transportation are potentially applicable data categories for the type of submerged cultural resources which may be expected in the study areas.

Ordinarily, cemeteries, birthplaces or graves of historical figures, properties owned by religious institutions or used for religious purposes, structures that have been moved from their original locations, reconstructed historic buildings, properties primarily commemorative in nature, and properties that have achieved significance within the past 50 years shall not be considered eligible for the National Register. However, such properties will qualify if they are integral parts of districts that do meet the criteria or if they fall within the following categories:

A. a religious property deriving primary significance from architectural or artistic distinction or historical importance; or

B. a building or structure removed from its original location but which is significant primarily for architectural value, or which is the surviving structure most importantly associated with a historic person or event; or

C. a birthplace or grave of a historical figure of outstanding importance if there is no other appropriate site or building directly associated with his productive life; or

D. a cemetery which derives its primary significance from graves of persons of transcendent importance, from age, from distinctive design features, or from association with historic events; or

E. a reconstructed building when accurately executed in a suitable environment and presented in a dignified manner as part of a restoration master plan, and when no other building or structure with the same association has survived; or

F. a property primarily commemorative in intent of design, age, tradition, or symbolic value has invested it with its own historic significance; or

G. a property achieving significance within the past 50 years if it is of exceptional importance.

C. Definition of Terms

The following definitions are from the Department of the Interior, National Register of Historic Places 36 CFR 63 (Federal Register, Vol. 42, No. 183, Wed. Sept. 21, 1977, pp. 47666-67):

1. A "site" is the location of a significant event, or prehistoric or historic occupation or activity or a building or structure whether standing, ruined, or vanished where the location itself maintains historical or archaeological value regardless of the value of any existing structures.

2. A "building" is a structure created to shelter and form of human activity such as a house, barn, church, hotel or similar structure. "Buildings" may refer to a historically related complex, such as a courthouse and jail or a house and barn.

3. A "structure" is a work make up of interdependent and interrelated parts in a definite pattern or organization. Constructed by man, it is often an engineering project large in scale.

4. An "object" is a material thing of functional, aesthetic, cultural, historical, or scientific value that may be, by nature or design, movable yet related to a specific setting or environment.

D. Previous Research and Principal Information Sources

Sources of information which deal with prehistoric Native American land use and occupation of the Atlantic shoreline of Cape May County in New Jersey are limited in number and tend to be either very generalized or extremely site-specific. Much previous research has been macroscopic and theoretical in approach. Using limited offshore coring data and a broad-based knowledge of coastal geomorphic processes, such research has focussed largely on the paleoenvironment and prehistoric potential of the entire Mid-Atlantic segment of the Atlantic Coastline and the nearby Delaware Bay (e.g., Belknap and Kraft 1977; Kraft 1977a; Kraft et al. 1979; Belknap and Kraft 1981; Kraft et al. 1983). Despite its broad view, this research is relevant in that it provides an overall context for the present study and as such is summarized below in Chapter 3.

In sharp contrast, there is also an uneven body of site-specific information on prehistoric activity along the New Jersey littoral, mostly generated over the past quarter century by individual development projects complying with environmental legislation. This information is largely accessible in the site maps and files of the New Jersey State Museum and in reports and cultural resource files lodged with the New Jersey State Historic Preservation Office.

Despite a statewide survey of archaeological resources conducted in the early part of this century (Skinner and Schrabisch 1913) and a number of other recent cultural resource investigations in the project vicinity (Kardas and Larrabee 1977, 1981; Gilbert/Commonwealth 1979; P/RA Research, Inc. 1980; GAI Consultants, Inc. 1992), no previously documented prehistoric sites have been noted within the tidal zone section of the southern New Jersey Atlantic shoreline studied during the course of this survey. However, the sparsity of documented prehistoric archaeological resources should not be taken as a true reflection of Native American activity along this section of the New Jersey shore. The identification and registering of archaeological sites has only taken place in any systematic and ongoing fashion over the past 20 to 30 years and the beach front within the study area has been subject, over the past 100 years, to severe erosional effects which have worked to remove and obscure both historical and prehistoric archaeological data. Subject to much less erosion, the beach to the south and west of the study area has been identified as the location of a significant archaeological site (Cook 1960, 1969a, 1969b) and has been classified by subsequent surveys (Gilbert/Commonwealth 1979) as an area of high prehistoric archaeological sensitivity.

The cultural resource surveys of recent decades have identified various types of historic resources formerly located along the shoreline within the

present survey area which have since eroded into the sea. These include the primarily residential eastern ocean-front section of Cape May Point, the first and second Cape May Lighthouses, the Cape May Point Lifesaving Station, the tracks of the Cape May Point Trolley and the village of South Cape May (Historic Sites Survey of Cape May County 1980; P/RA Research, Inc. 1980; GAI Consultants, Inc. 1992). The only resources identified by these reports as still being present on this section of beach are remains associated with a concrete bunker and several related gun emplacements constructed in 1942.

Several significant historic resources have been identified just beyond the limits of the present survey area. These include:

The Cape May Historic District National Historic Landmark (State Register 12/10/70 and National Register 12/29/70) - the historic nucleus of a world-famous ocean-front resort encompassing approximately 600 mid- to late 19th-century summer houses, Victorian hotels and commercial structures;

The Shoreham Hotel District- a potential late 19th-century residential historic district within Cape May Point Borough focused on the Shoreham Hotel, a U-shaped, Queen Anne style hotel constructed in 1889 (Clio Group, Inc. 1986); and

The Cape May Lighthouse (National Register 11/12/73) - a 175-foot tall lighthouse erected in 1859 with a keeper's house and oil house. This is the most recent of three lighthouses which have stood in this vicinity.

Several underwater archaeological investigations have been conducted along the southern New Jersey shoreline in recent years. In 1985, for example, a remote sensing survey was undertaken for the USACOE in connection with a proposed borrow area offshore from the Great Egg Harbor Inlet (Tidewater Atlantic Research 1985). Supplementary underwater archaeological research was subsequently performed in the same general area around the Great Egg Harbor Inlet and offshore from Peck Beach, Ocean City (Dolan Research, Inc. 1993). The most relevant of these underwater investigations to the current project was a magnetometer survey performed for the USACOE in June of 1982 in connection with a proposed borrow area, 6,000 feet long by 1,650 feet wide, located 1.25 miles offshore from Cape May. Nine anomalies were identified and avoidance of these features was recommended (Historic Sites Research, Inc. 1982). On the bay side of the Cape May Peninsula, a Phase I submerged and shoreline cultural resources investigation was performed by this consultant in 1995 in conjunction with two proposed sand borrow areas and a six-mile segment of tidal zone and shoreline between Norburys Landing and the mouth of the Cape May Canal. No significant resources were identified by this investigation (Dolan Research, Inc. and Hunter Research, Inc. 1996).

A wide variety of information sources have been consulted during the course of this study. Basic information sources routinely examined for all aspects of USACOE cultural resources work in New Jersey have included the site maps, files, planning documents and technical reports held by the New Jersey State Historic Preservation Office and the New Jersey State Museum, archival data and published historical materials held by the New Jersey State Archives and the New Jersey State

Library, and materials lodged at the Philadelphia District offices of the USACOE. Local and county libraries and historical societies in the project vicinity were also visited by project personnel during the course of the background research.

E. Research Methodology and Research Design

From a methodological standpoint, since this cultural resources investigation focused chiefly on the potential for submerged resources in the offshore borrow area and shoreline resources within the tidal zone, a strongly cartographic and geographic approach was adopted for the background research. Emphasis was placed initially on mapping known and suspected resources, and analyzing these locations in relation to changes in sea level, shoreline configuration and land use. Cartographic research was supplemented with oral historical research, a review of secondary sources and consideration of paleogeographic issues. Phase I-level fieldwork relied chiefly on remote sensing (for the underwater survey) and a pedestrian magnetometer and ground surface inspection (for the terrestrial survey). At this level of investigation, a non-intrusive landscape and literature-based approach to the study of cultural resources provides the most effective means of assessing archaeological potential without engaging in a complex and expensive program of subsurface investigation and diving.

The potential for prehistoric resources was assessed with reference to standard texts on New Jersey prehistory (e.g., Kraft 1986) and available preservation planning documents, including the overall framework and specific historic contexts for the New Jersey Comprehensive Historic Preservation Plan (e.g., Grumet 1990) and earlier definition of key archaeological research issues (e.g., Chesler 1982). In framing research questions concerning historic resources, the project study area was considered to possess a low potential for all types of historic resources, except shipwrecks, since most of it presently lies underwater and has been (or has become) inundated during the historic period.

The offshore borrow areas were considered to have a moderate potential for shipwrecks, a condition that could be most effectively examined through systematic documentary research and remote sensing (for detail on the remote sensing methodology, see below, Chapter 5). Documentary research aimed to provide a framework for identifying submerged historic archaeological resources which may have been deposited within the two offshore borrow areas or within the tidal zone, and to determine the extent of subsequent activities that may have removed or disturbed such resources. While the emphasis of this research focused chiefly on maritime activity in the project vicinity, a broad-based historic overview is also presented (see below, Chapter 4) in order to supply an appropriate framework for assessing the potential significance of submerged and shoreline cultural resources of the historic period. Historic maps, primary and secondary shipwreck lists, primary historical accounts, newspapers, and county and thematic histories were all used to develop a set of expected resources within the study areas. Knowledgeable local residents and other experts on New Jersey history and archaeology were also contacted. Data from the background research was also used to generate a list of shipwrecks and ship losses along this section of the Atlantic shore (see below, Appendix A).

CHAPTER 2

GEOGRAPHICAL SETTING

The study area consists of a 1.5-mile stretch of the New Jersey Atlantic shoreline and tidal zone along the Cape May peninsula (between Cape May City and Cape May Point) plus two proposed offshore sand borrow areas (Figure 1.2). The easternmost of the two sand borrow areas (Borrow Area P-1) is located to the south southeast of Cape May (between 6,500 to 8,000 feet from the shoreline). The westerly sand borrow area Borrow Area P-2) is located to the south southwest of Cape May (between 3,000 and 7,000 feet offshore).

The study area is located close to the southern tip of the State of New Jersey, roughly 70 miles southeast of Philadelphia, and lies within the outer lowland subprovince of the Atlantic Coastal Plain physiographic zone. Overall, the topography of the Coastal Plain is characterized by level to gently rolling terrain, with more than one-half of the surface area lying below 100 feet above sea level. Much of the area examined during this study lies at or below sea level and is subject to tidal fluctuation. The underlying geology consists of the Pleistocene sands and gravels of the Cape May Formation which were originally laid down in the Sangamon interglacial stage. These deposits mask earlier sediments of Cretaceous age (Wolfe 1977:138-139, 288-290).

A. Terrestrial Survey Area

The terrestrial survey area consists of a 1.5-mile-long ocean-front segment of the Cape May Peninsula (Figure 1.2). The soils of this area have been classified as belonging to the Coastal Beach-Urban Land Complex (Cu). This soil group "consists of nearly level or gently sloping areas, adjacent gently sloping or sloping sand dunes and areas developed for urban uses. The dunes are at low elevation and are subject to tidal flooding or storm flooding and constant spraying of salty water. The urban land contains much fill material. The thick deposits of sand have no profile development. The beach areas have small amounts of fine to medium gravel. The dunes are mostly of fine sand that contain little gravel, clay or silt" (Johnson 1978:14).

Within the study area, the beach is widest at the eastern end and narrows to the west. The eastern end of the study area is dominated by a range of dunes reaching as high as 11 feet in elevation. To the north of these dunes, extending along the entire length of the study area, is a tall line of manmade barrier dunes, constructed to buffer a wide, ecologically sensitive expanse of inland meadows and marsh from storm flooding and erosion.

B. Nearshore Sand Placement Area

The Nearshore Sand Placement Area, consisting of approximately 200 acres, is situated immediately adjacent to the beach between Cape May City and Cape May Point (Figure 1.2). Water depths across the area range from mean low water (MLW) to six feet (MLW). Coordinates for the corners of the Near-shore Sand Placement Area are expressed in the New Jersey State Plane Coordinate System (NAD 83) as follows:

	Northings	Eastings
(1)	35,000.00	361,000.00
(2)	35,000.00	368,500.00

C. Borrow Areas

Borrow Area P-1 contains approximately 250 acres and is situated to the south and west of the entrance of Cape May Harbor (Figure 1.2). At its nearest point, the borrow area is approximately 6,000 feet south of the Cape May shoreline at its nearest point and approximately 7,000 feet at its most distant. The borrow area is an irregular quadrilateral in shape with its longest axis oriented in an east-west direction and measuring approximately 7,000 feet. It extends roughly from a point opposite the Cape May Municipal Pier to just opposite the easternmost tip of Cape May City. Water depths across the borrow area range from 26 feet (MLW) to 33 feet (MLW). Coordinates for the corners of Borrow Area P-1 are expressed in the New Jersey State Plane Coordinate System (NAD 83) as follows:

	Northings	Eastings
(1)	29,458.09	375,270.76
(2)	29,940.64	381,504.04
(3)	28,260.40	387,354.82
(4)	28,270.27	380,358.74

Borrow Area P-2 is located between 3,200 and 6,600 feet south of the beach at Cape May. Containing about 150 acres, the borrow area is roughly L-shaped with its longest side oriented along a north-south axis. This borrow area extends from a point approximately opposite the southern terminus of 13th Avenue to a point approximately opposite the southern terminus of Broadway in Cape May City. Water depths range from between eight feet (MLW) and 35 feet (MLW). Coordinates for the corners of Borrow Area P-2 are expressed in the New Jersey State Plane Coordinate System (NAD 83) as follows:

	Northings	Eastings
(1)	33,032.16	366,410.67
(2)	32,152.91	367,487.52
(3)	29,716.30	366,764.49
(4)	29,748.20	367,703.59
(5)	29,193.26	369,521.96
(6)	28,873.07	367,927.03
(7)	28,647.25	369,462.47

CHAPTER 3

PALEOENVIRONMENT AND PREHISTORIC BACKGROUND

A. Mid-Atlantic Coastal Plain Prehistory

Atlantic coastal regions are among the most dynamic environments currently found on earth, and dynamic change was no less of a hallmark in the prehistoric past. As a consequence, paleoenvironmental reconstruction for any given coastal geographical location, such as the Middle Atlantic coastal zone, is an extraordinarily complex task fraught with uncertainty and a sparsity of scientific data.

The Pleistocene Epoch witnessed a series of cold periods and associated "ice ages," the most recent of which terminated approximately 14,000 to 12,000 years ago. One of the most dramatic effects of these "ice ages" was the lowering of ocean levels worldwide as sea water was frozen and trapped in glaciers and continental ice sheets. Milliman and Emery (1968) argue on the basis of 80 radiocarbon samples taken along the Atlantic continental shelf that sea levels 30,000 to 35,000 years ago were close to those at present. Sea levels dropped subsequently as much as 130 meters during the final Wisconsinan glacial advance around 16,000 years ago. Along the Atlantic coast, ocean beaches during this period lay at the edge of the modern continental shelf, perhaps 100 kilometers east of the modern New Jersey coastline (Figure 3.1). Belknap and Kraft (1977) question the maximum depth of sea level drop, but agree with the overall pattern.

Overall climatic patterns have changed on a regional and continental basis during the Holocene Epoch, which began at the end of the Pleistocene. Sea levels have continued to rise as a result of the release of water from melting ice sheets. As the sea level rose, it began to transgress, or cover, the land mass of the Coastal Plain (the modern Atlantic continental shelf) to the west. The Holocene marine transgression, or sea level rise, began around 14,000 years ago and proceeded rapidly until around 7,000 years ago (Milliman and Emery 1968; Kraft et al. 1983). The temporal progress of this westward movement of the coastline, which continues at present, is illustrated in Figure 3.1.

The implications of such dynamic changes for any paleoenvironmental reconstruction of the physical locations currently occupied by the coastal tidal zones of Cape May County and their near shore areas are profound. Climatic changes resulted in a succession of vegetation types moving northward, while the coastline and associated marine and eustatic environments were approaching from the east. As temperatures warmed and the climate alternated between dry and moister periods during the Holocene, open grassy environments were replaced by boreal evergreen forests and then by deciduous forests (Table 3.1). As the coastline steadily approached, the local environment shifted from inland forest to salt tidal marsh to lagoon to coastal sand barrier or nearshore underwater marine deposits. A paleoenvironmental reconstruction must therefore consider both the generally northward-moving vegetational patterns arising from the regional climatic shifts and the westward-moving coastal geomorphological changes associated with coastal environments.

The occupancy of prehistoric man within these dynamic and mobile environments is a primary focus of this study. Human occupation of the Upper Delaware River valley had begun by 11,000-10,500 year B.P. within a boreal forest composed primarily of pine and birch which shifted, as temperatures warmed, to pine and oak (Dent 1979, 1991; Stewart 1990, 1991). Similar vegetation cover extended throughout much of the region, although the presence of favorable

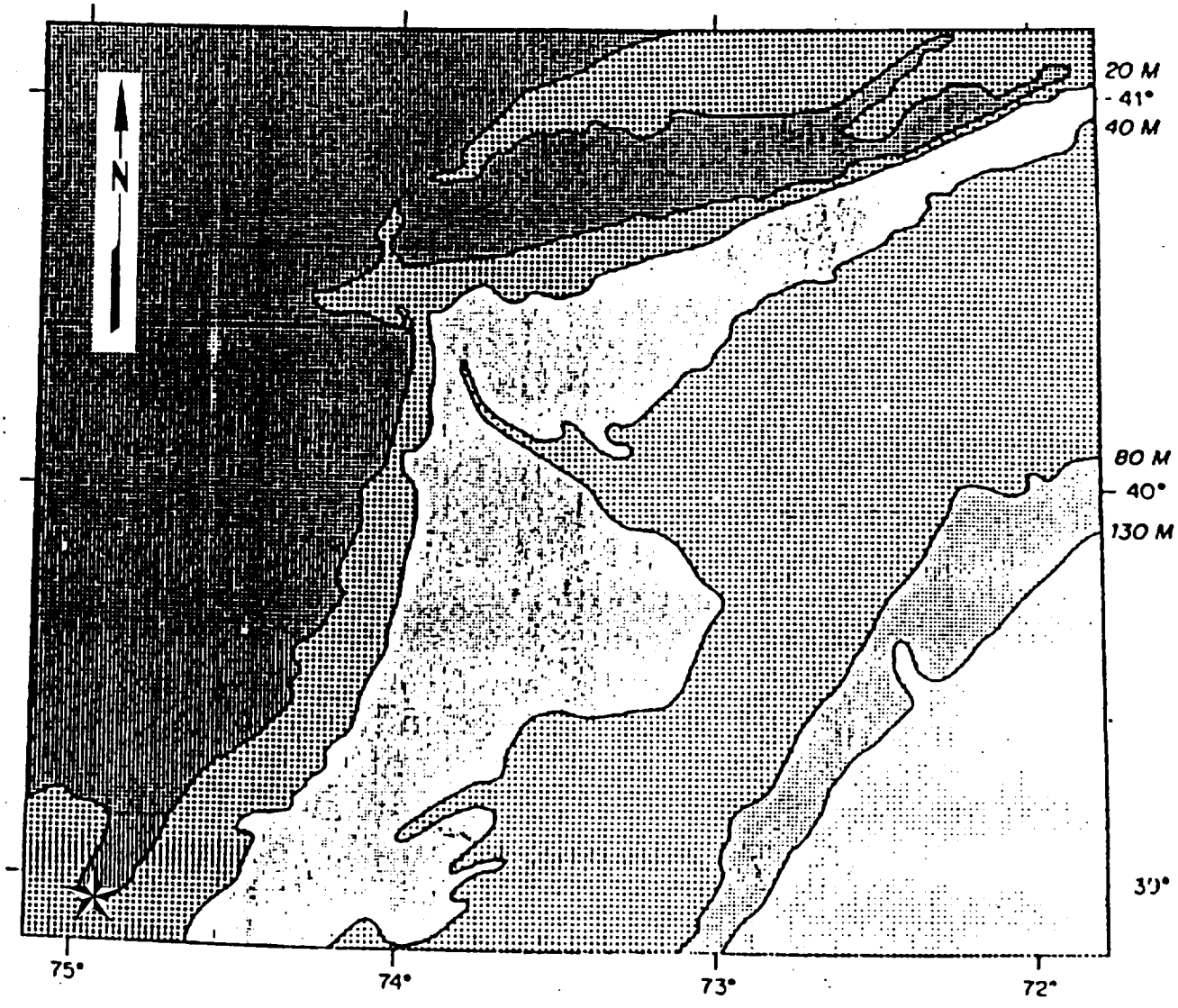

Figure 3.1. Progressive Shifts in Shoreline Positions along the New Jersey and New York Coasts (Source - Edwards and Emery 1977: Figure 3). General Location of Study Area is Starred.

TABLE 3.1

TEMPORAL CORRELATION OF PALEOENVIRONMENTAL AND CULTURAL DATA

Kyr B.P.	Climate	Vegetation	Culture
15			
	cool & wet Post-glacial	open tundra, spruce park-land	
	cool & wet (warmer) Pre-Boreal	spruce & fir forests	Paleo-Indian
			early Archaic
	10680		
10	warmer, drier Boreal	pine & birch pine & oak	
	9211		
	warm (near modern) Atlantic	oak, hemlock	Archaic
5			
	4610		
	warmest, driest Sub-Boreal	oak, hickory	Woodland I
	cooler, moister Sub-Atlantic	oak, chestnut	Woodland II
Present			

Source: Dent 1979; Custer 1989; Stewart 1990

microenvironments arising due to topography, solar exposure and surface water (ponds, lakes and rivers) exerted a considerable influence on prehistoric subsistence and adaptations.

Evidence of Paleo-Indian occupation on the Coastal Plain of New Jersey, generally in the form of isolated fluted point sites (Kraft 1977b; Cavallo 1981; Custer et al. 1983; Bello and Cresson 1995) reflect the presence of early human groups in the region. The point distribution is biased by non-systematic surface collection, but nevertheless provides some indication of the nature of Paleo-Indian adaptations. It is argued that these points and associated finds are indicative of hunting and game processing activities (Bonfiglio and Cresson 1978). Similar tool assemblages from the late Paleo-Indian site of Turkey Swamp (Cavallo 1981) near the boundary between the Inner and Outer Coastal Plains are interpreted as reflecting similar activities.

The distribution of surface finds within the Inner Coastal Plain suggests an association with poorly drained bay/basin features (Bonfiglio and Cresson 1978). Custer et al. (1983) note a difference between the continuous size distribution of fluted points from the Outer Coastal Plain as opposed to the lack of the extremes of unresharpened (longer) and heavily resharpened (short) points on the Inner Coastal Plain, and infer an adaptational difference. A settlement model proposed by Gardner (1977) for the Flint Run Paleo-Indian Complex in Virginia has been introduced to suggest that Paleo-Indian groups on the Outer Coastal Plain pursued a "cyclical" mobility pattern with groups returning to the secondary cobble sources of the Inner Coastal Plain. Those groups which occupied the Inner Plain, on the other hand, enjoyed more ready access to these cobble sources. Lithic procurement was thus "embedded" in other subsistence pursuits (Binford 1979; Goodyear 1979), and groups had less need to curate points and other retouched pieces (Custer et al. 1983).

As indicated in the earlier discussion of transgressing sea levels, the shoreline of Cape May County was not a coastal location at the time of Paleo-Indian occupancy. Edwards and Emery (1977) provide a hypothetical reconstruction of the land area of the Middle Atlantic coast around 10,000 to 12,000 years ago, which serves to illustrate potentially attractive locations for human habitation currently offshore and the eastern positions of environments currently along the Jersey coast (Figure 3.2). The current site of the South Jersey coastline was covered by inland forest, probably with surface water locations. Thus, any evidence of Paleo-Indian occupation in the vicinity of the study area would not relate directly to coastal environments but to exploitation of inland forest/riverine habitats.

Paleo-Indian hunting and gathering groups would, of course, have also occupied coastal areas, but these geographic locations currently lie on the continental shelf and are submerged. Fossil animal remains have been dredged from locations on the shelf (Merrill et al. 1965; Whitmore et al. 1967; Edwards and Emery 1977) which correlate with former estuarine locations and former shorelines, particularly the mid-shelf position of the shoreline around 10,000-9,000 years B.P. (Figure 3.3). The mammoth, oriented to more open habitats, may have occupied the region prior to the arrival of humans, but the forest mastodon was a contemporary of early Paleo-Indians. Deer and possibly caribou would also have been common inhabitants in the early Holocene forests. Fossil remains of walrus indicate the extent to which water temperatures were lower at the end of the Pleistocene and earlier in the Holocene (Edwards and Merrill 1977). The fossil shells of oysters, a shallow estuarine species, have been recovered from the shelf, and are other indicators of the successive relocation of tidal estuaries (Merrill et al. 1965). Artifacts possibly associated with Paleo-Indian/Early Archaic groups are occasionally found in underwater contexts, such as the bifacially-flaked

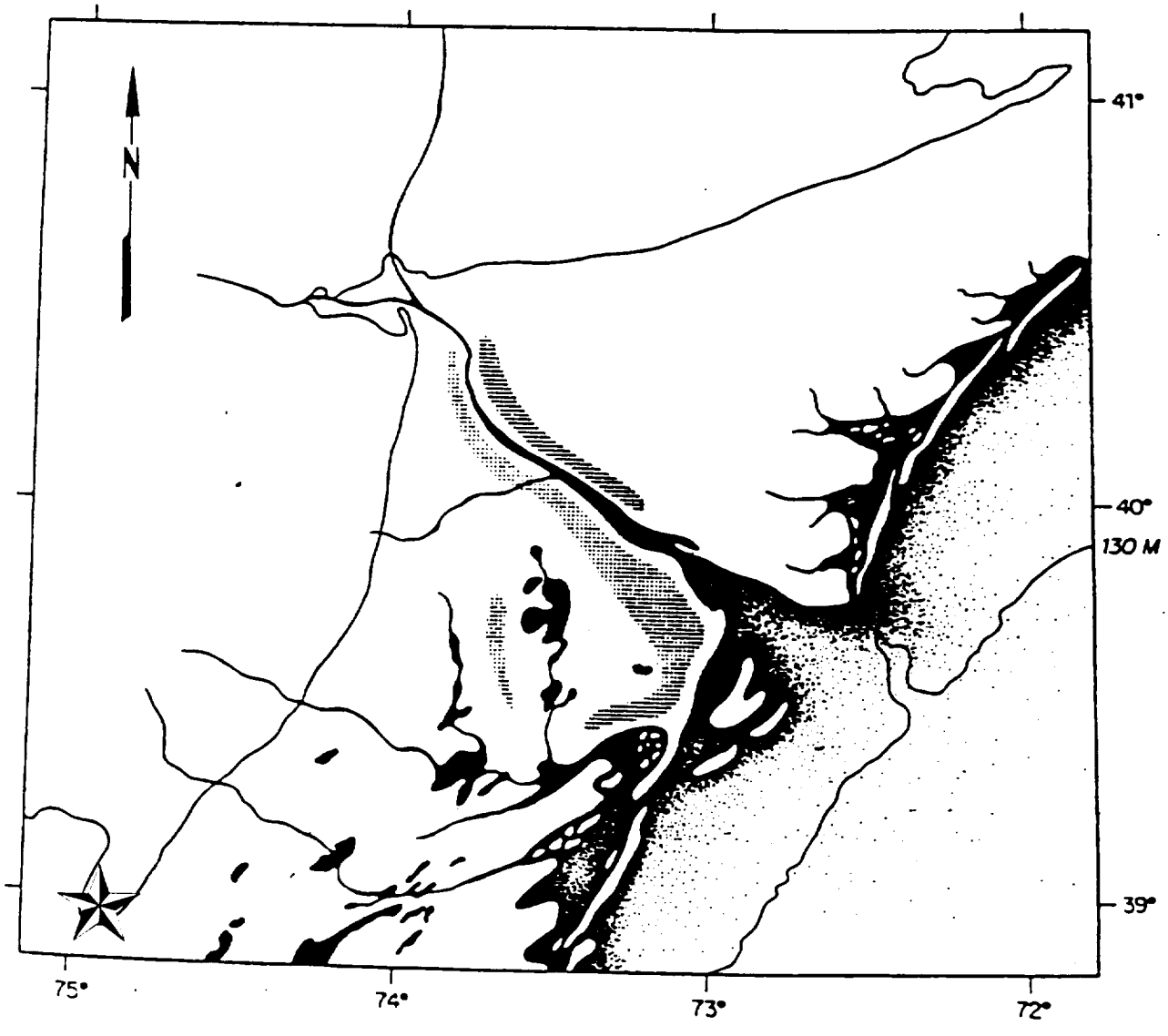

Figure 3.2. A Reconstruction of the Middle Atlantic Coastal Area 10,000 to 12,000 Years Ago (Source - Edwards and Emery 1977: Figure 6). General Location of Study Areais Starred.

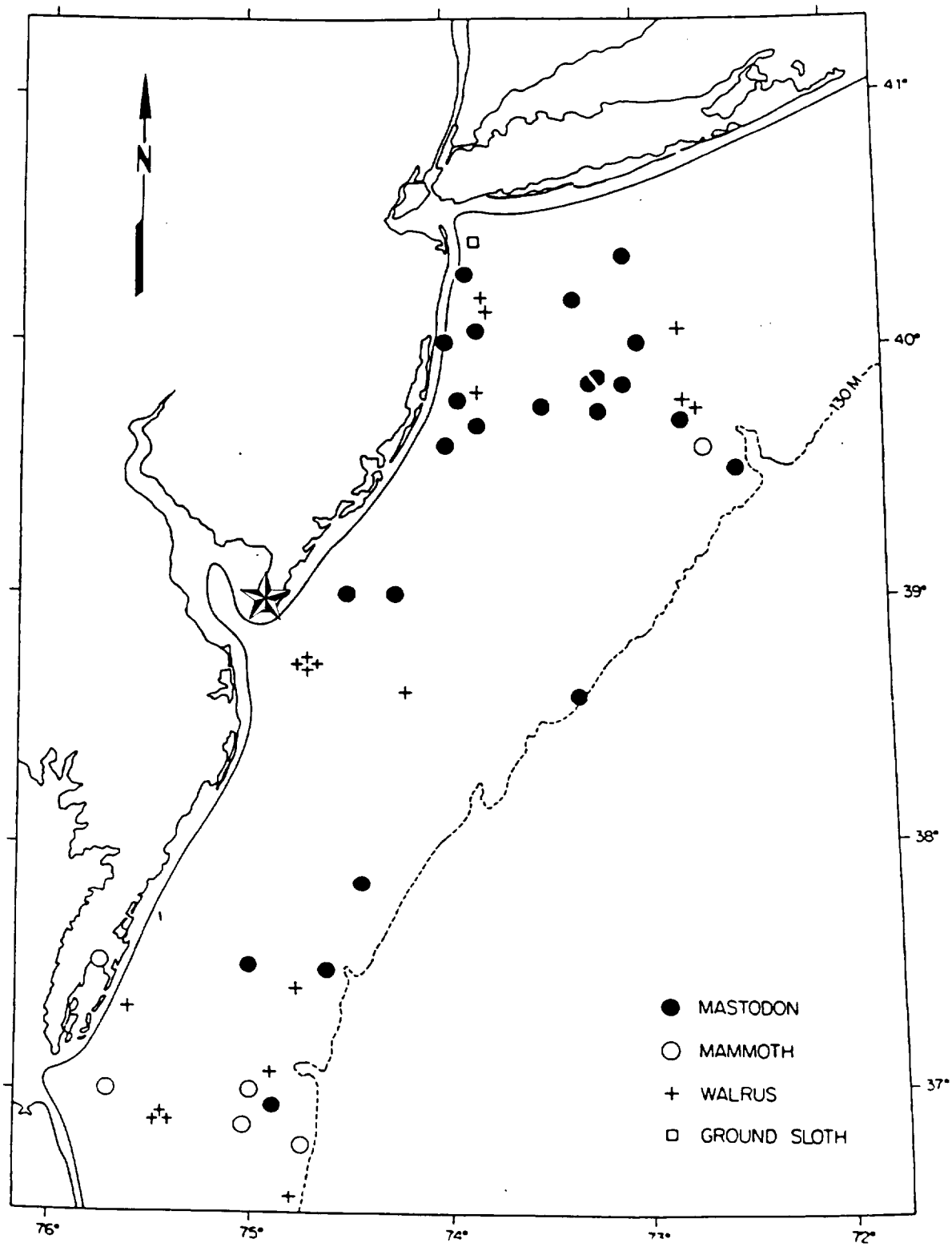

Figure 3.3. Fossil Finds on the Middle Atlantic Continental Shelf (Source - Edwards and Merrill 1977: Figure 11). General Location of Study Area is Starred.

point recovered recently from Blue Hill Bay on the coast of Maine (Crock et al. 1993).

Hypothetical reconstructions of the Middle Atlantic coast between 6,000 and 8,000 years ago (Figure 3.4) suggest estuarine areas were approaching the current coastline location, but that location remained an inland one (Edwards and Emery 1977:Figure 7; see also Kraft 1977a:Figure 24). Tidal salt marshes may have emerged in advance of the transgressing shoreline in South Jersey by 5,000 years ago, and the shoreline achieved its current location approximately 3,000 years B.P. (Kraft 1977a:Figure 27). Climatic conditions were warm and somewhat moister than in the preceding Boreal phase, with oak and hemlock as dominant vegetation species (Deevey 1952; Dent 1979), but perhaps with pine persisting in coastal areas.

This time period coincides with the emergence of another archaeologically-defined human adaptational phase, the Archaic. Material culture changes during the Archaic include the appearance of ground stone tools in addition to flaked stone artifacts. The raw materials utilized for tools also shifts from cryptocrystalline rocks to igneous rhyolite, suggestive of shifts in mobility and possibly in social organization (Custer 1986, 1989). Archaic sites have been attributed to macro-band and micro-band base camps in areas of "maximum habitat overlap" as defined by Custer (1989), such as interior freshwater swamps and bay/basin loci. Coastal tidal salt marshes and estuarine environments would have been food resource-rich habitats available for exploitation.

Climatic changes commencing about 4,600 years B.P. produced the warmest and driest conditions of the current post-glacial period, with oak and hickory becoming dominant tree species. These climatic changes appear to roughly coincide with the emergence of the archaeologically-defined Woodland I phase (Custer 1989). The Woodland I phase is typified by diagnostic lithic forms, an increase in base camps and the appearance of cache pits and ceramic storage vessels, indicative of a greater degree of sedentism. Evidence for long-distance trade/exchange is manifested in the presence of Adena material culture from the Ohio River valley at habitation and mortuary sites dating from around 2,500 to 2,000 years B.P. Increasing exploitation of estuarine resources is noted during the period of Adena influence.

The warm and dry climatic conditions began to yield to a cooler, moister modern climate with oak and chestnut vegetation about 2,000 years B.P., roughly coincident with the waning of Adena influence. By 1,000 years B.P. the trade and exchange network influence had disappeared, and the archaeologically-defined Woodland II phase emerges. Increasing evidence of sedentism is manifested in the expanded use of storage facilities and more permanent house structures. Increased gathering of shellfish and harvesting of plants reflect an intensification of food procurement evidently related to population growth. The emergence of agricultural production is also related to this sedentary settlement pattern which was maintained until European contact. Material culture is typified by distinctive ceramic forms and small triangular projectile points, the latter evidently indicative of bow-and-arrow technology (Custer 1989).

B. Study Area Prehistory

No known prehistoric sites have been identified within the bounds of the terrestrial survey area and only one site, designated the Cape May Point Site, has been documented in the project's immediate vicinity. This latter site, however, encompasses four miles of beach front on the west side of Cape May Point, where some 4,000 artifacts have been surface collected over a period of 25 years beginning in 1945. Occupation appears to date from the Early Woodland through to the Contact period with the highest concentration of artifacts dating to the Middle and Late Woodland periods. The stone artifacts recovered from the site include large numbers of chert, flint and jasper projectile

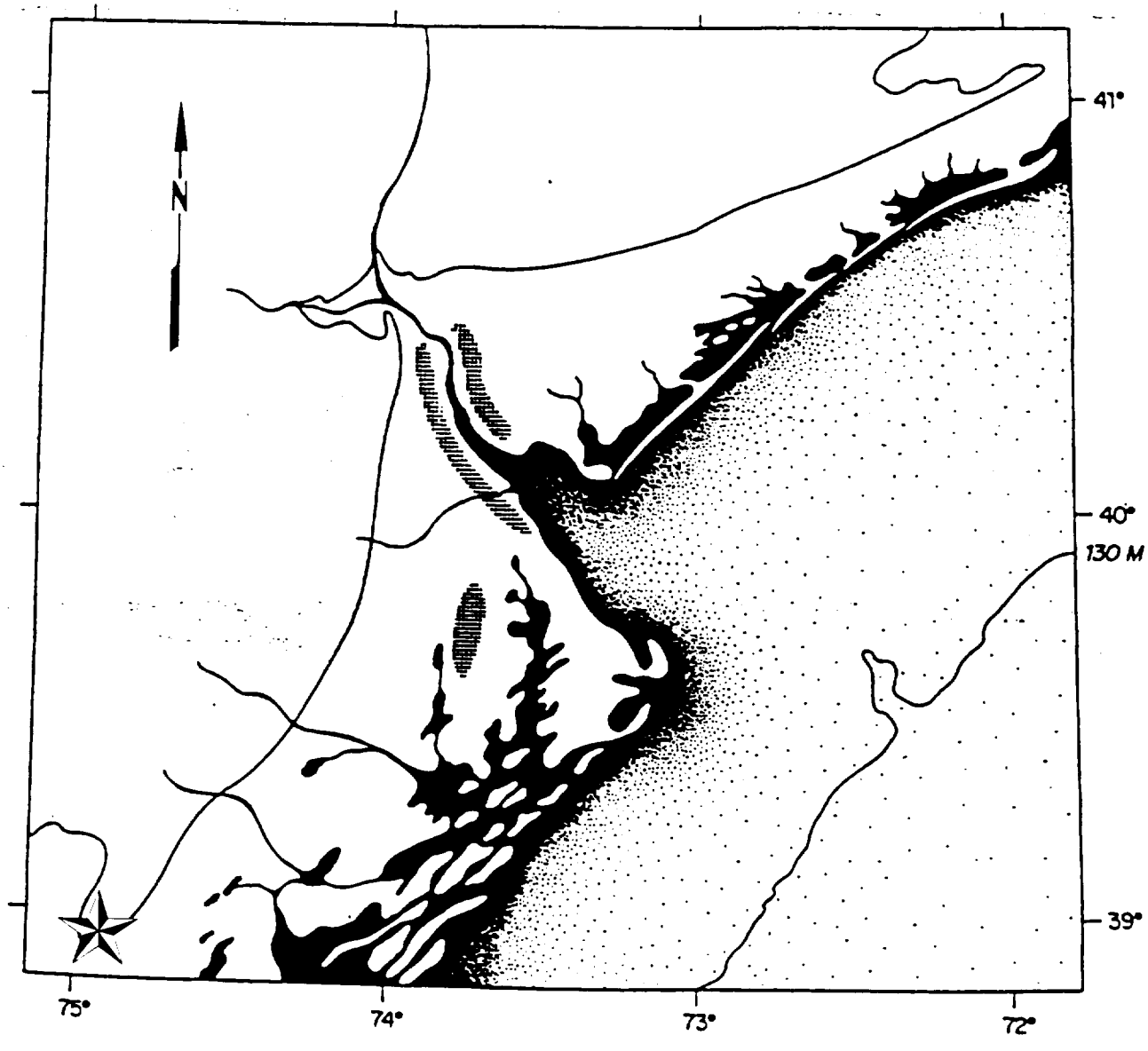

Figure 3.4. A Reconstruction of the Middle Atlantic Coastal Area 6,000 to 8,000 Years Ago (Source - Edwards and Emery 1977: Figure 7). General Location of Study Area is Starred.

points. Scrapers, drills, axes, hammerstones and gorgets have also been retrieved. Eighty-six pottery sherds were collected including examples which were identified as Riggins Fabric Impressed and Riggins Plain types. Some European goods such as gunflints, clay pipes and musket balls have also been recovered along this section of beach but due to the lack of context in which these artifacts were found it was not possible to associate them with either European or Native American utilization. Most of this segment of beach front has since been lost to erosion (Cook 1960, 1969a, 1969b).

CHAPTER 4

HISTORICAL BACKGROUND

> "When one speaks of Old Cape May it is not to be inferred that there is any definite barrier between the old and the new, but rather that, along with the accompaniments of the modern seaside resort which are common to the long line of summer towns that dot our New Jersey coast, there are, about Cape May, characteristics which are distinctive and which bear evidence of a history dating back for many generations, full of the rigorous life of fishermen, mariners and whalers. It is these old associations, these constant suggestions of residence long-established and of a long-maintained communion with the ocean, that constitute the charm of Old Cape May" (Stone 1937).

The tip of the peninsula of Cape May has a longer recorded history than any other location within the bounds of the State of New Jersey. Because of its pronounced peninsular setting, it was one of the most important landmarks for the early explorers who charted the bays and barrier islands of America's Mid-Atlantic coast. Verrazano, Hudson, Hendrickson, De Vries, Block and, of course, Mey all noted the Cape as they transited the coast in the late 16th and early 17th centuries (Coad 1972:1-2; Dorwart 1992:1-2). The information gathered by these early explorers was passed on to Europe's cartographers and as early as 1610, the Cape began appearing on maps. By 1630, Cape May was depicted on sea charts as the most notable geographic feature of the lands which would become the Colony and later the State of New Jersey (Snyder 1973).

The Cape's prominence is principally a function of its geography. But in addition to simply being the most recognizable feature along the coast of New Jersey, it was also a geographical nexus point, a link between the sea and the bay and the land. Over the 473 years which have elapsed since the first sighting of the Cape by European eyes, its history has played out as a function of these geographic realities.

Cape May's historic period truly begins on the May 5th, 1630. That spring day saw a meeting take place on the Cape's bay shore which produced the first deed for the meadow land and beach (and also comprises the current terrestrial survey area). Peter Heyssen, Captain of the Dutch ship *Walvis* (Walrus) and Gillis Hosset, ship's commissary, early Delaware colonist and former commander of the De Vries expedition, met with Sawowonwe, Wvoyt, Pemhake, Mekowetick, Techepepewoya, Mathemek, Sacoock, Anehoopeon, Janqueno and Pakaake, "lawful owners, proprietors and inhabitants of the east side of Goddyn's East bay, called Cape de Maye." Heyssen and Hosset represented Samuel Bloemmaert and Samuel Godyn, two Dutch West India Company proprietors and members of a Dutch syndicate formed to establish whale fisheries on the New Jersey coast and Delaware Bay (Stevens 1897:18-19; Dorwart 1992:3).

In return for "a certain quantity of goods," Heyssen and Hosset purchased from these ten Lenape representatives, a tract of land extending from, "the east side of Godyn's bay or Cape de Maye, reaching 4 miles from the said cape towards the bay and 4 miles along the coast southward and another 4 miles inland, being 16 square miles" (Stevens 1897:18-20). Not only was this the first deed for the study area but it is also the first European deed for Cape May lands and the first recorded land purchase from Native Americans within the state. Native unrest and limited profitability at their other whaling outposts in the present day State of Delaware kept the Dutch syndicate from ever actually establishing

a whale fishery on the Cape May tract and in 1635 ownership of the property was formerly transferred to the Dutch West India Company (Dorwart 1992:4).

With the ceding of the Delaware Valley by the Dutch to the English in the 1660s, the process of establishing land ownership largely began anew. The entire Cape May peninsula became the property of Dr. Daniel Coxe, an owner of 22 proprietary shares in the province of West Jersey. Dr. Coxe himself, although later a provincial Governor, never left England but instead hired Adlord Bowde to act as his land agent in the New World. In 1688, Bowde secured the rights to the Cape May peninsula and additional lands to the west from Sakamoy, Tamahack, Tom Nummi and others. This 95,000-acre purchase included the 16 square acres which had already been sold to the Dutch. It also included the entire southern end of the peninsula which, in the previous year, had been sold by another Native American named Panktoe to a John Dennis and a group of New England and Long Island whalers and prospective Cape May settlers. While Dennis and company had a deed signed by a Lenape chieftain, Coxe not only held a similar, albeit later, deed but also legal title derived from the Duke of York and ultimately the King of England (Dorwart 1990:14-18).

It seems that this small group of migrant whalers did find a home on the bay side of the peninsula -- not as proprietors of their own settlement, but rather as Coxe's tenants and the core of the Doctor's abortive attempt to establish a Cape May fiefdom. These men and other ambitious settlers attracted by Coxe's promotional efforts became the Cape's first verifiable residents of European descent. Thomas Budd's map of 1691 (Figure 4.1) shows the extent of Coxe's Cape May holdings. The small whaling settlement of Towne Bank and the large house Coxe had erected for his own use are both depicted on the bay side of the peninsula.

The coming of the 18th century saw the establishment of numerous "plantations" on the peninsula's upland interior and a few small settlements along the coves and streams on which ship building, fishing and whaling activities were centered. However, all evidence suggests that the windswept beach and marshland of the Lower Cape May Meadows remained entirely undeveloped until the second quarter of the 19th century. Dr. Coxe, discouraged by the limited returns from his overseas holdings, sold his Cape May interests to the West Jersey Society in 1692. The Society was composed of a group of wealthy London businessmen and investors principally interested in turning a quick profit on the division and sale of Coxe's lands (Pomfret 1956:171). Sales were successful enough that, in the same year the Society purchased the tract, it was determined that it contained enough residents to warrant being established as a county (Snyder 1969:113).

The Society's New World agent, Jeremiah Basse, sold the land at the tip of the Cape to Jonathan Pyne. Upon Pyne's death, the point passed to his son, Jonathan and Abigail Pyne. The property was sold by them to Henry Stites in 1712. Known as Stites Beach, the "Plantation" remained in the Stites family throughout the rest of the 18th century (Wheeler 1876:82). The Stites erected a house on the western end of the Cape property in the third quarter of the 18th century, but otherwise did not seek to further develop the lands, presumably utilizing the property for farming, timber and the raising of cattle. This last use of the land is recorded in the use of the name "The Cowfields" to describe the meadowland immediately to the east of Cape May Point. In 1722, Cape May County was divided into three precincts, the "Upper," "Middle" and "Lower." The study area was contained within the Lower Precinct, which was re-established in 1798 as Lower Township (Snyder 1969:114).

The first known improvement to the beach front occurred in 1822 when Congress appropriated a total of $10,750 for the construction of a lighthouse on Cape May. One acre of "unstable sand" was purchased from Mr. John Stites and his wife and a 68-foot tall brick lighthouse was erected atop a

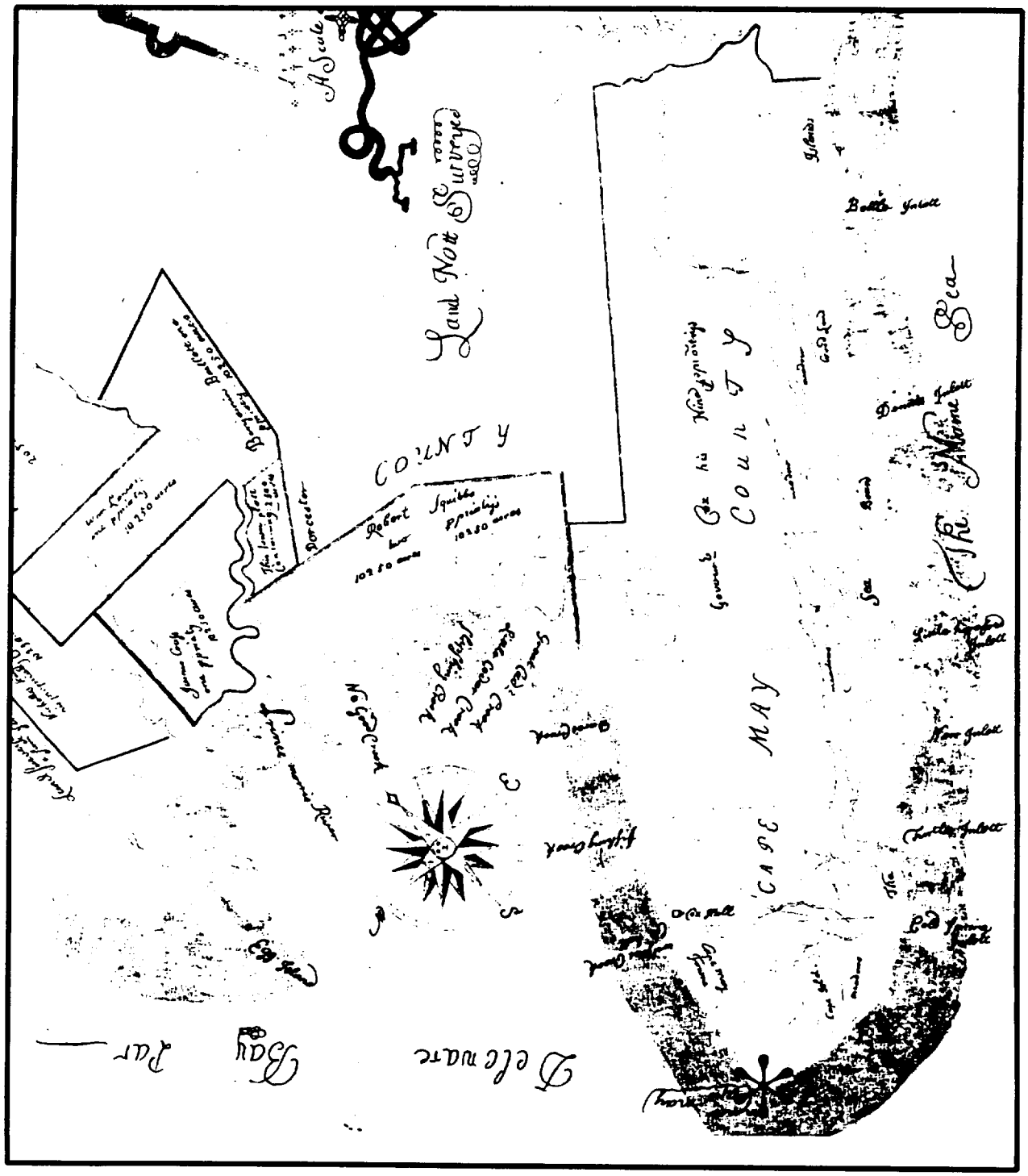

Figure 4.1. Budd, T. A. "True and Perfect Mapp of Ye Several Priatys ." 1691. Scale 1 inch: 8.5 miles (approximately). Source: Richards 1954. Study Area Indicated with an Asterisk.

stone foundation. Marking the northern edge of the entrance into Delaware Bay, the beacon towered above the surrounding landscape, punctuating the very southernmost tip of New Jersey with 15 revolving lamps. Presumably a keeper's house was also constructed to accompany the large tower. The site of this lighthouse has long been inundated by the sea and is presently located about 500 feet south of the southern terminus of the Whillden Avenue Jetty (Bailey 1990:4-5).

Two miles to the north of the lighthouse, a small settlement had developed on the piece of land known as Cape Island that is separated from the mainland by a narrow creek. Since the third quarter of the 18th century Cape Island had been familiar to Philadelphians as a pleasant place for seaside recreation. Up until approximately 1800, however, the small village had been largely populated by Delaware River pilots and fishermen. After 1801, the little town began to be actively promoted in the Philadelphia press. Boarding houses and summer cottages were erected and the town, soon to be known as Cape May City, quickly developed into one of the earliest seaside resorts in the United States.

Visitors to the new resort arrived from Philadelphia in one of two ways, either overland by stages passing through Bridgeton or Tuckahoe, or, after 1828, by steamboat (Stevens 1897:406; Dorwart 1990:69). The steamboat landed on the bay side of the peninsula near its tip and travelers went by foot, horseback or wagon to Cape Island via a winding dirt track which cut through the wetlands to the north of Lily Lake and ran to the north of the survey area through the drier upland areas. This road was the tail end of the main road which traveled down the spine of the long peninsula. A less formalized side road branched off this track at a point just west of Lilly Lake and proceeded south to the site of the lighthouse.

Although these improvements bought more people to the southern terminus of the Cape and made the region more accessible to the outside world, no development actually occurred within the bounds of the present survey area. In fact, no evidence has been found which would point to the use of the beach, marsh and meadowlands before 1847 for anything other than occasional hunting forays or turnout pasture. In that year, at the extreme western end of the survey area, a second Cape May lighthouse was constructed to replace the first which was by then threatened by erosion. Although the first lighthouse had been constructed a safe distance inland and 20 feet above sea level, the start of the year 1847 found the structure sitting in the surf. Coastal erosion has been a fact of life along this section of Cape May County's beaches since at least as early as the 18th century. The new tower was located approximately 400 yards to the northeast of the first and was situated on three acres purchased by the United States Government from Alexander Whillden, who had come into possession of Stites Beach through marriage into the Stites family. The new tower was constructed by Samuel and Nathan Middleton, local contractors, and stood 78 feet tall on a stone foundation. The massive structure was topped by a cast iron lantern holding the revolving light and 15 "catoptric" reflectors (Bailey 1990:4-8).

The following year, a lifesaving station was constructed near the foot of the tower. This would later be known as Life Saving Station #40. The Nunan map of 1850 (Figure 4.2), shows the inland position of the new tower and indicates that the "Weldon" (Whillden) Estate occupied the current survey area. Also worthy of note are the two water courses shown emptying into the ocean on the beach front between Cape Island and the lighthouse, within the bounds of the present survey area. One stream is depicted as flowing south from Lily Lake around the northern perimeter of the lighthouse and

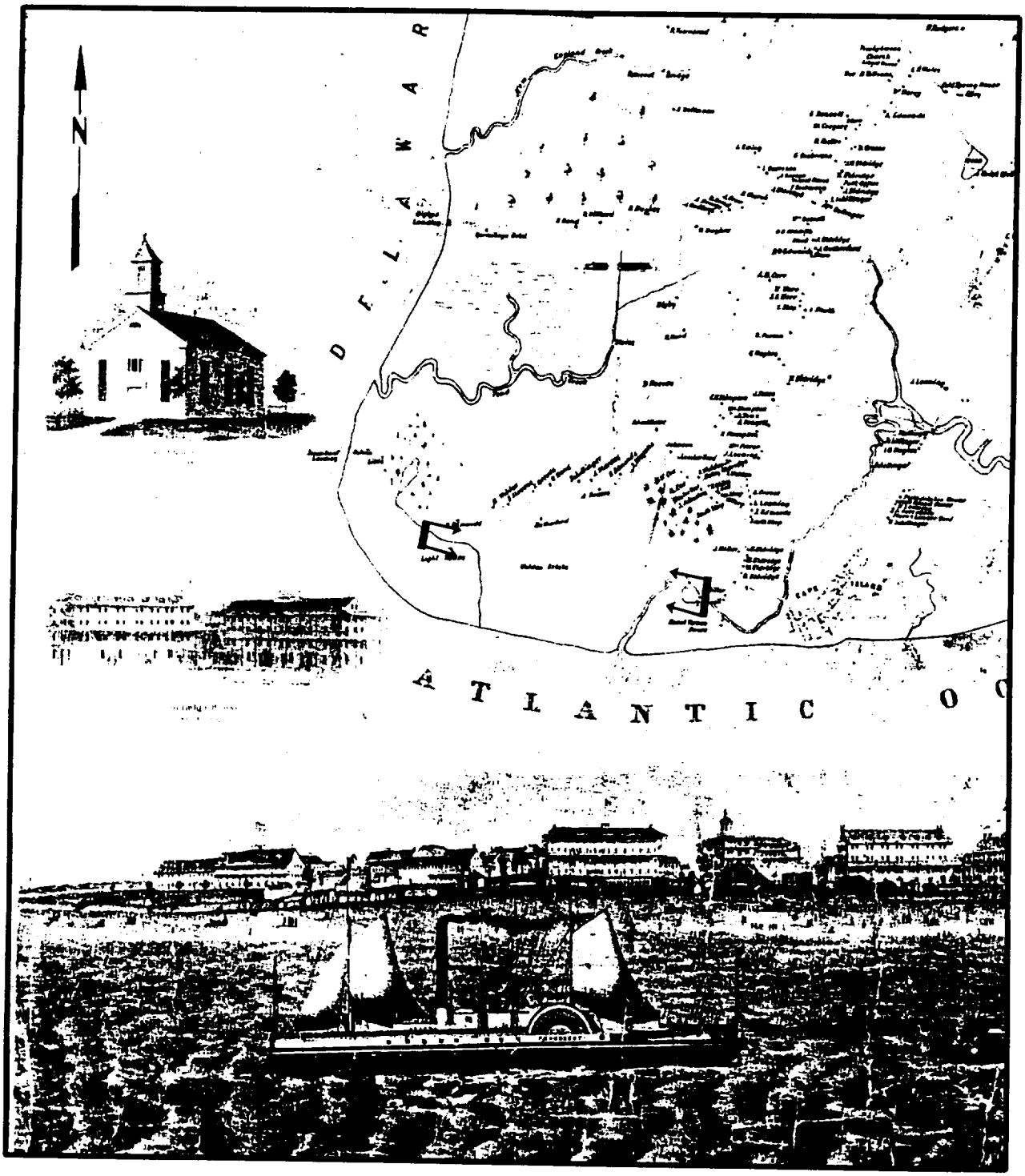

Figure 4.2. Nunan, P. Map of the Borough of Cape May Island and its Vicinity. 1850. Scale 1 inch: 1 mile (approximately). Terrestrial Survey Area Bracketed.

south to the ocean. This is an area presently occupied by wetlands and several small ponds. The other stream enters the ocean just west of Cape Island and undoubtedly represents the western mouth of Cape Island Creek. At the left of the panoramic view at the foot of the map which shows the waterfront of Cape Island, the tower of the second lighthouse is visible rising above the meadows and dunes of the survey area.

Throughout the 1850s Cape May City continued to expand westward. The newly laid streets at the western margins of the town are clearly visible on the Viele map of 1856 (Figure 4.3). This detailed map also shows the construction of the Cape Island Turnpike to the north of the survey area. This short toll road (or "horse railroad") was constructed to carry visitors quickly back and forth between the steamboat landing and the town. Within the survey area, the lighthouse tower is depicted in miniature and a stream is shown running from Lilly Lake through the survey area to the headwaters of the Cape Island Creek. No longer is Cape Island Creek depicted as having its own mouth on the beach front.

The differences between the water courses shown on the 1850 and 1856 maps clearly indicate a change in the physical features of the study area. In 1897, Steven's History of Cape May County noted the change by mentioning the presence of an in-filled inlet at the former location of the mouth of Cape Island Creek (Stevens 1897:405). In 1876, Edward Wheeler documented the details of the new configuration. Lily Lake had a connection to the sea "which ran from the shoreward end of the lake, between the strand and the lighthouse, and along the foot of the upland, to the west of Cape Island, and so into Skillinger's Creek (Cape Island Creek) and under the bridge to Cape Island Sound" (Wheeler 1876:110). One explanation for the change in topography may be linked to changes in the historic land use of the survey area.

During the early and mid-19th century, the beach area between the lighthouse and Cape May City was occupied by low-lying salt marsh which extended from a now inundated position approximately 500 yards offshore to a location approximately 500 yards inland of the present coast. At some point in the second half of the 19th century, the marsh was diked to facilitate the growing and harvesting of salt hay. The evidence of this effort can presently be seen in the remains of numerous earthen causeways and dikes which run throughout the meadows and the marsh to the north of the survey area. These changes definitely would have altered the course of the natural waterways and may be the cause in the changes of the topography depicted on the two maps. This new agricultural use of the survey area had profound changes on its physical environment. Salt hay production resulted in the gradual desalination of the lands involved, turning the salt marsh over time into a fresh water wetlands.

An additional small piece of information concerning settlement at the tip of the Cape during the 1850s can be found in the geological report for which the Viele map was drawn. In several instances, the author of the report noted the existence of a farm near the base of the lighthouse which stood on "loamy and fertile soil .... elevated only a few feet above tide level" (New Jersey State Geological Survey 1857:28).

The most notable event to occur at this location during the 1850s was the construction of the third Cape May Lighthouse. An inspection of the second lighthouse tower in 1851 had found it to have been "rough and rudely built" and already in serious disrepair. The reflector-based lantern was also found to be thoroughly insufficient (Bailey 1990:8). In 1857, at the recommendation of a congressionally-appointed lighthouse board, monies were allocated for the construction of a new lighthouse at the "Cape May entrance to the Delaware Bay" (Bailey 1990:16).

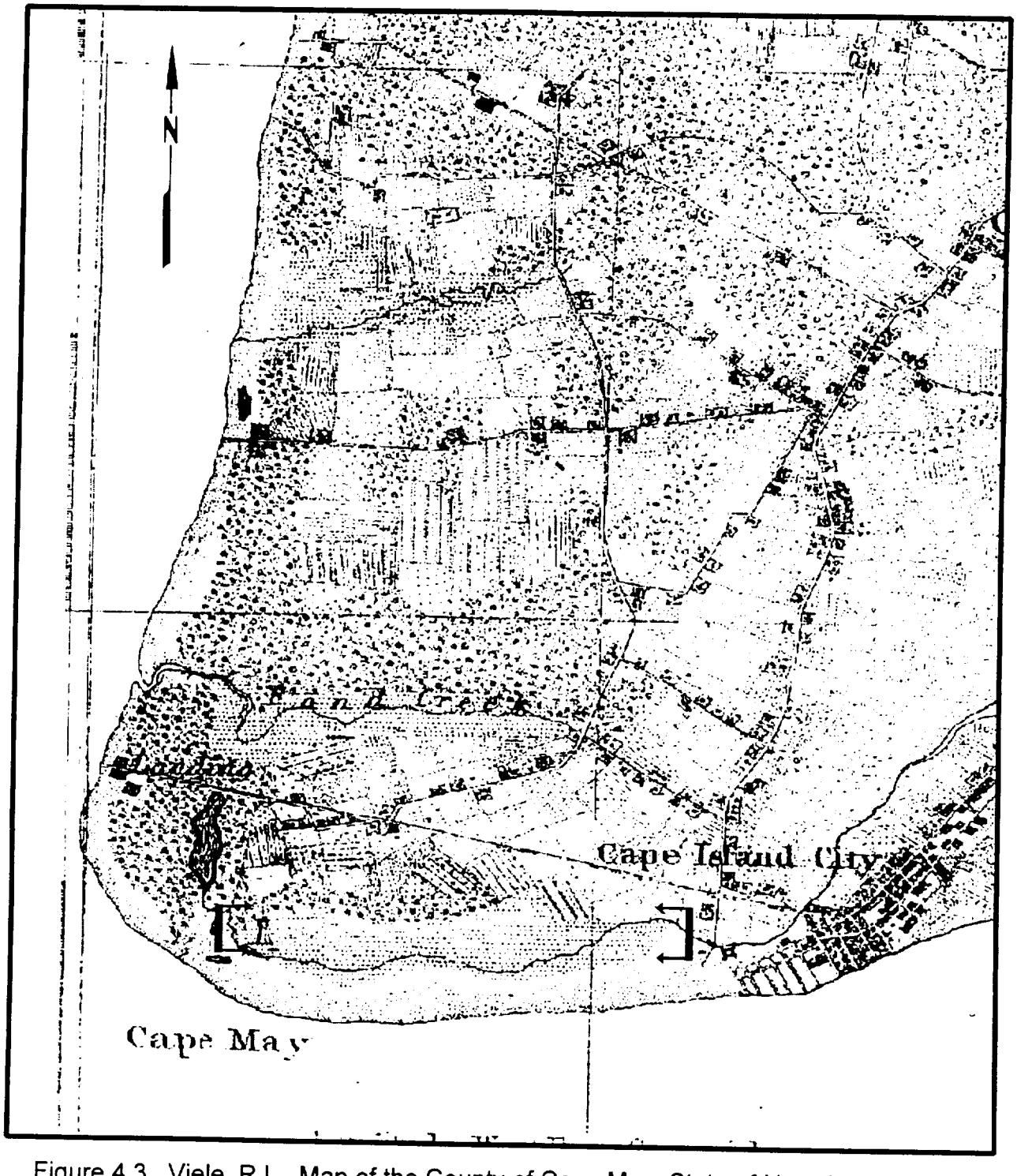

Figure 4.3. Viele, R.L. Map of the County of Cape May, State of New Jersey. 1856. Scale 1 inch: 4,200' feet (approximately). Terrestrial Survey Area Bracketed.

In 1858, the Federal government purchased two additional acres adjoining the old lighthouse property from Alexander Whillden and his wife and, in 1859, a new tower was erected 420 feet to the north of the old tower by the Army Corps of Engineers (Bailey 1990:47). Construction of the brick edifice cost $40,000. It stood 157.5 feet above the sands of the beach and was fitted with a 12-foot tall metal and glass lantern containing a seven-foot 10-inch tall fresnel lens (Bailey 1990:16). To accompany the new tower, two keeper's houses were constructed in 1860 flanking the base of the lighthouse.

Two years later, the old lighthouse tower was torn down. The base of the lighthouse (Plate 4.1) was preserved, re-roofed and transformed into a spring storage house which remained in use until the 1950s when it was finally destroyed by erosion (Bailey 1990:7).

The Beers map of 1872 (Figure 4.4) depicts a small cluster of buildings on the lighthouse property as well as noting the site of the old lighthouse. The name "D.E. Foster" is shown on the lands to the east of the government property. The other two significant changes in the landscape depicted on the map is the opening of a small cove to the south of the lighthouse and the addition of the Millville and Cape May Railroad. The tracks of this railroad can be seen entering the City of Cape May from the north. The construction of this new transportation route in 1863 opened up the area to even more vacationers and spurred additional growth.

Plate 4.1. Historic view showing the base of the second Cape May Point lighthouse after its remodeling as a storage facility. Circa 1950. Concrete base of radio tower is visible at the right of the view. Source: Bailey 1990.

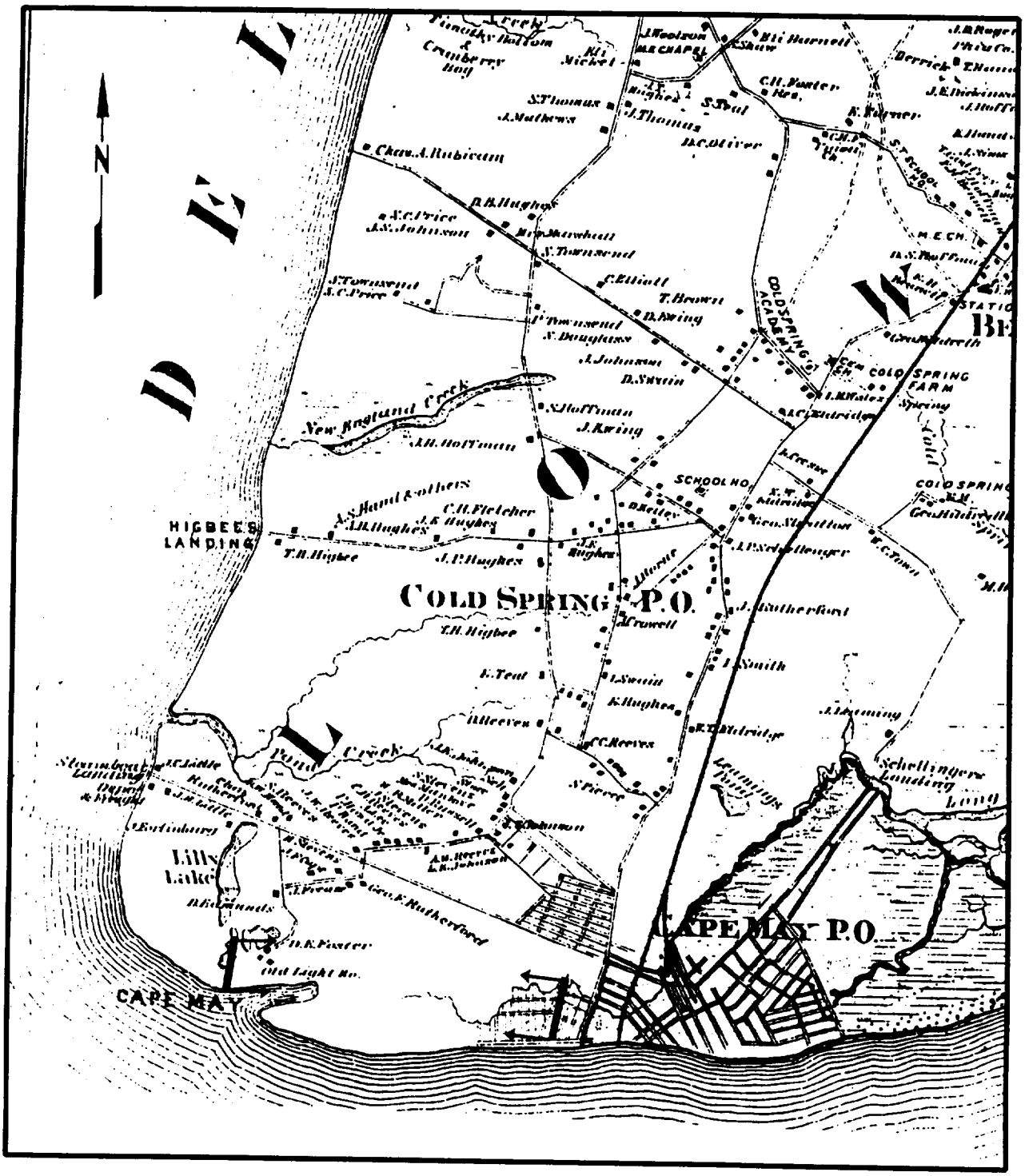

Figure 4.4. Beers F.W. Topographic Map of Cape May County, New Jersey. 1872. Scale 1 inch: 4,500 feet (approximately). Terrestrial Survey Area Bracketed.

The year 1875 saw the birth of Cape May Point as one of the peninsula's principal resorts. In that year, Alexander Whillden, who in addition to owning the land at the tip of the cape was also a prominent cotton merchant and president of the American Life Insurance Company, transferred 266 acres of property to the newly founded Sea Grove Association. Whillden was an active member of the Presbyterian church and the temperance movement and apparently had held this property for many years with the intent of eventually establishing a new resort to benefit the "scores of thousands in the great cities not far away" who "needed every summer the comfort and help of the Ocean air, and yet found themselves excluded from most popular resorts by the crowding, the confusion, the mad revelry, and recklessness which more and more characterized them" (Wheeler 1876:82).

With the financial backing of many of Philadelphia's most prominent businessmen, including John Wanamaker, Whillden and his Sea Grove Association hired James C. Sidney, a Philadelphia architect to design the new religious community's central pavilion and to lay out the town's street plan (Figure 4.5). Sidney would also serve as the new organization's secretary. The inset in Sidney's plan of 1876 shows that the land to the east of the lighthouse and the proposed town, being the current survey area, was in the ownership of Mark Devine. Whillden organized a second organization, the Union Hall Association, to begin the construction of hotels, houses and a boardwalk. The improvements made to the town site extended to the lighthouse property as well. In 1876, after being exhibited first at the Centennial Exhibition in Philadelphia, a new modern lifesaving was moved to the ocean front to the south of the lighthouse (Plate 4.2) (Bailey 1990:23).

One of the most expensive improvements made to the site was the construction of the Cape May City Passenger Railway. Narrow gauge rail line was laid linking the newly laid-out Sea Grove with the West Jersey Railroad Terminal in Cape May City and the Steamboat Landing further to the west. The tracks

Plate 4.2. Historic view showing 1876 Cape May Point lifesaving boat house (at left) and later Coast Guard Station (at right). Circa 1930. Source: Bailey 1990.

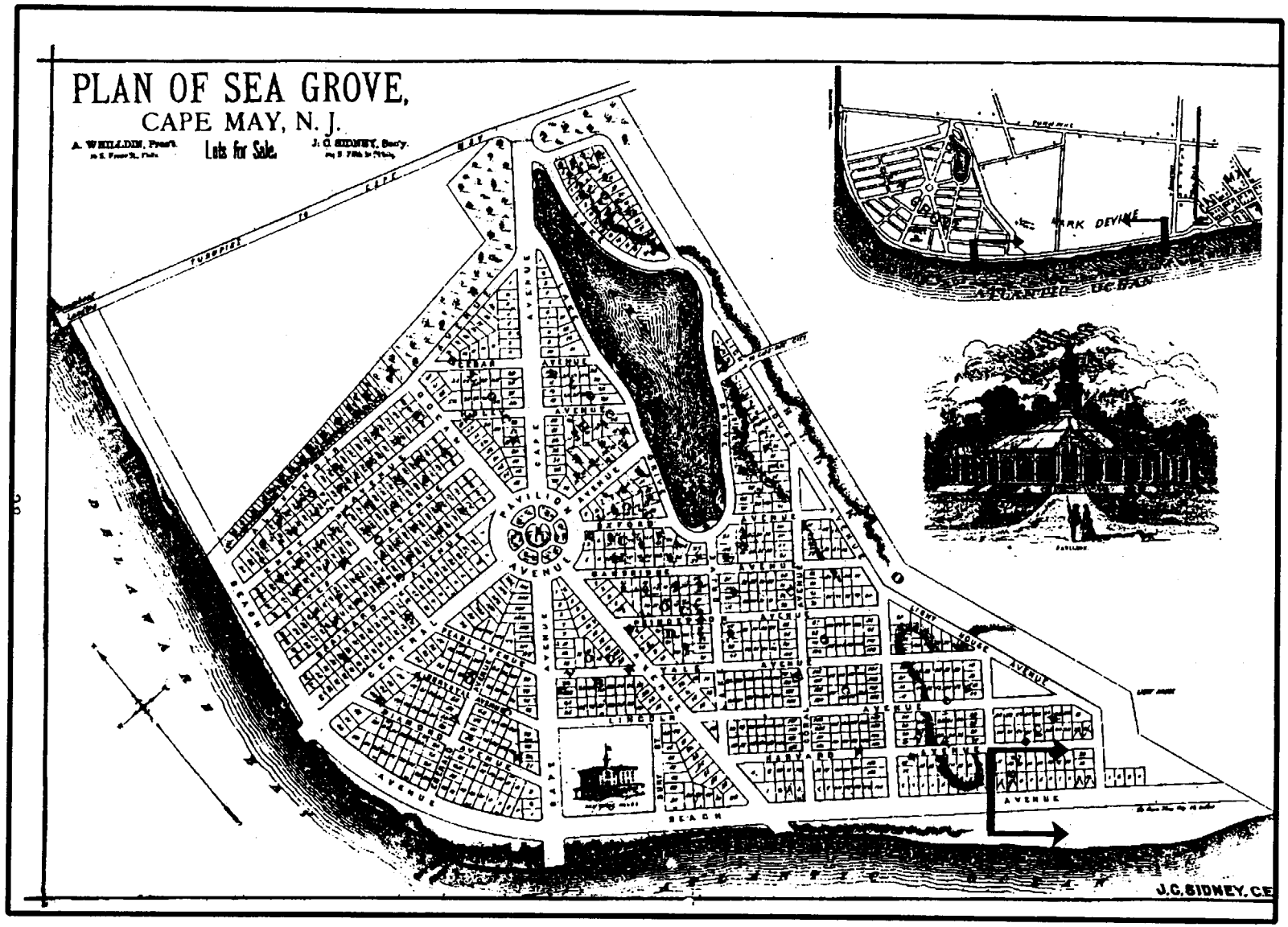

Figure 4.5. Sidney, J.C. Plan of Sea Grove, Cape May, New Jersey. 1876. Scale 1 inch: 700 feet (approximately). Terrestrial Survey Area Bracketed.

of this new railroad ran eastward from Sea Grove passing in front of the lighthouse and running along the beach front between the eastern edge of the new town and Cape May City. In 1879, Jonathan Cone, an owner of one of the steamboats which regularly plied the waters between Cape May and Philadelphia, made numerous improvements to this line. Renamed the Delaware and Cape May Railroad, a covered station was constructed at the landing, the narrow gauge track was improved and a new double ended locomotive was purchased to pull the trains. The alignment of this railroad, labeled as the Delaware Bay and Cape May Railroad, can clearly be seen on the Vermeule topographic map of the peninsula of Cape May dated 1889 (Figure 4.6). Its path lies approximately 500 feet to the south of the present shoreline (Dorwart 1992:122, 157). A carriage road also paralleled the rail tracks built to accommodate vacationers with recreational drives along the ocean front (Wheeler 1876:68).

The extent to which the construction of the town of Sea Grove changed the topography of the tip of the peninsula can be seen on a plan produced for the United States government in conjunction with the lighthouse property (Figure 4.7). Although dated 1905, the plan is actually a comparison of two earlier surveys, one done in 1847 and the other in 1858, with the plan of Sea Grove superimposed on top. The map makes clear the extent to which Whillden altered the landscape of the site, totally changing the outline of Lily Lake and removing the natural waterways and vegetation. Its southern end was filled in and firm sides were constructed with the grading of the pond's shore (Wheeler 1876:111). The plan also shows the outlines of the two properties purchased by the government for the construction of the 1847 and 1859 lighthouses. The western end of the current survey area is shown, labeled "Sunken Marsh and Flat Sand, Overflowed at Storm Times."

The birth of the new town, known after 1878 as Cape May Point, sandwiched the study area between two rapidly growing resort communities. A more attractive (less swampy) property would undoubtably have succumbed immediately to development pressures. But due to the less-than-favorable building conditions further development within the survey area was held off for a considerable period of time. The first plans for the property's development were drawn up in 1882 by Theodore M. Reger, a Philadelphia real estate investor. Reger, Thomas H. Williamson and Albert Little formed the Neptune Land Company to facilitate the development of the property formerly owned by Mark Devine. Capital stock to the value of $300,000 was issued to finance the banking and filling of the meadows and the construction of infrastructure. Three years later, Nathan Culver was hired by the company to construct the 58-foot tall "Light of India" a wooden, tin-sided elephant, sister to Margate's famous "Lucy," which was to be used in the promotion of the property. The elephant stood near the railroad lines at the terminus of what is today the derelict path of 16th Avenue (Dorwart 1992:158).

Development went slower than was expected. No building occurred on the marshier sections of the tract, these being in its western half, closest to Cape May Point. In 1887, Reger formed the Mount Vernon Land Company with the goal of focusing development on the very eastern edge of the Devine Tract. The remaining marshland was filled, building lots were graded and four roads were laid out to link the beach with present-day Sunset Avenue. A beach bulkhead and boardwalk were built and some properties soon began to be sold. During the 1880s sales were slow and after a severe national financial depression in 1893, became even worse. Just enough cottages were built to warrant the incorporation of the small development as the Borough of South Cape May in 1894 (Dorwart 1990:158).

In spite of the Borough's incorporation, the existence of the little town was still threatened. The community had been constructed on a stretch of shoreline which had lost 500 feet to erosion over the previous 40 years. By 1900, the elephant, in

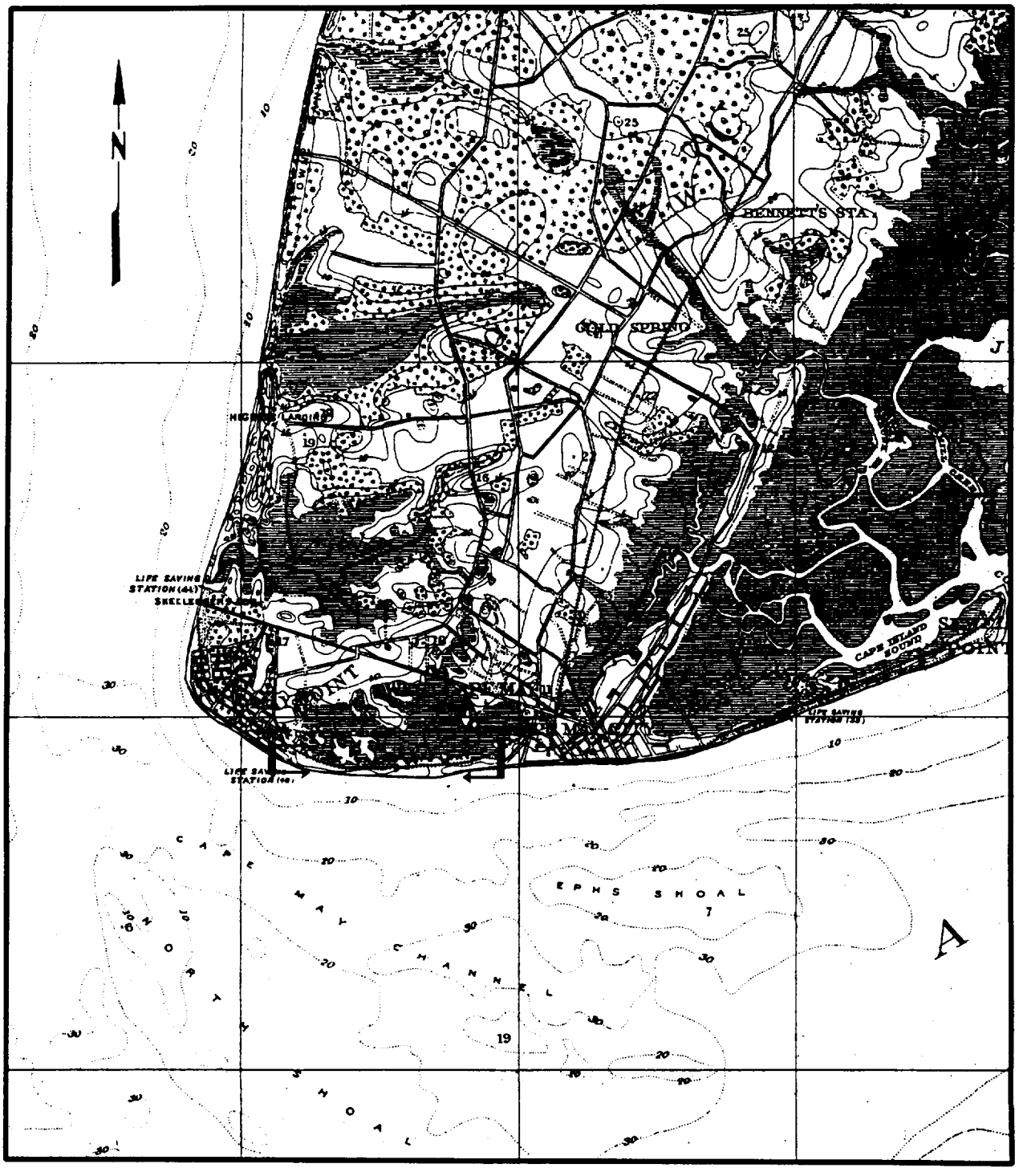

Figure 4.6. Vermeule, C.C. A Topographic Map of the Peninsula of Cape May. 1889. Scale inch: 1 mile (approximately). Terrestrial Survey Area Bracketed.

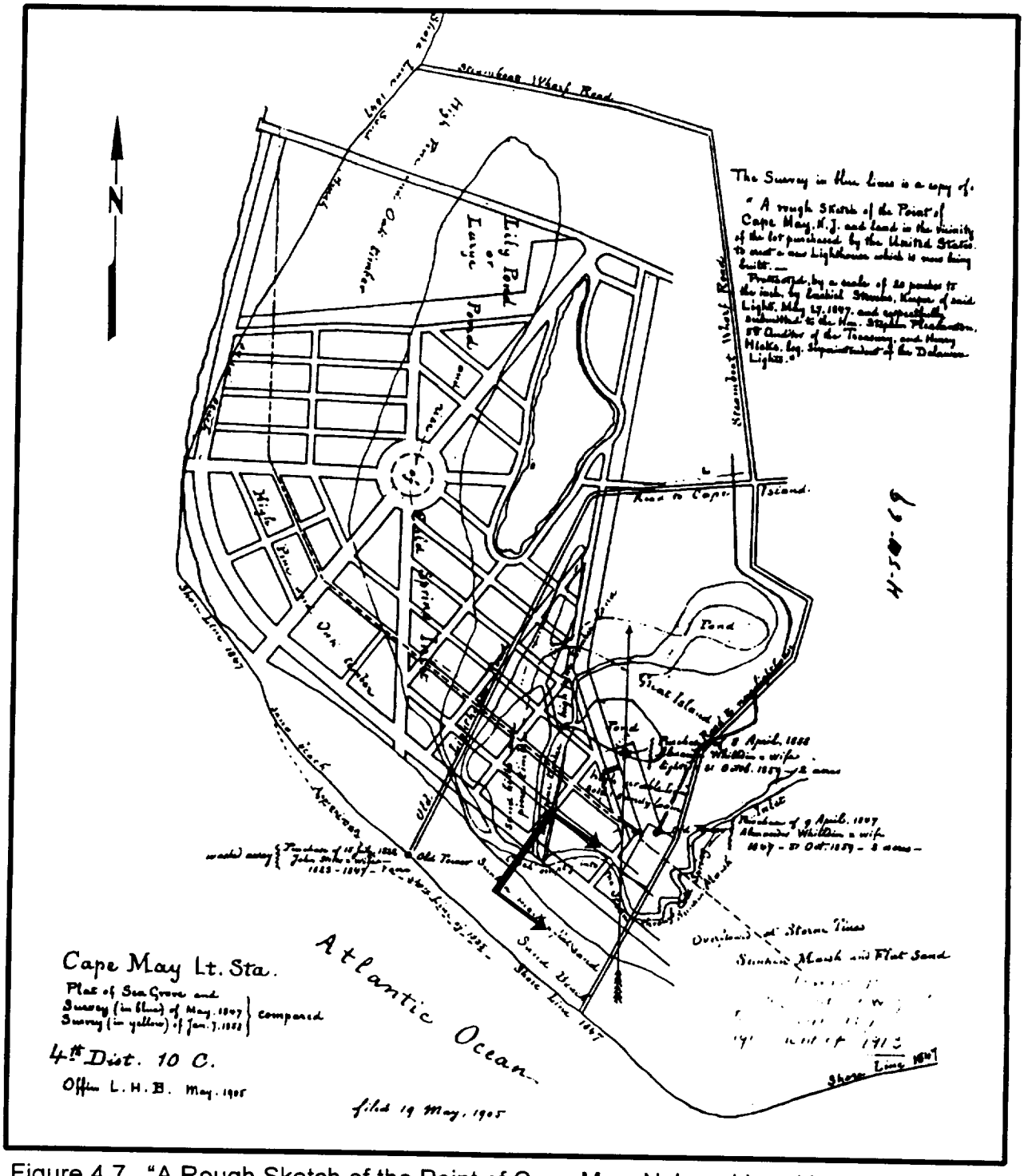

Figure 4.7. "A Rough Sketch of the Point of Cape May, N.J. and Land in the Vicinity of the Lot Purchased by the United States to Erect a New Lighthouse." 1905. Scale 1 inch: 1,000 feet (approximately). Source: Bailey 1990. Western Limit of Terrestrial Survey Area Bracketed.

disrepair, had to be dismantled and moved to Cape May Point due to the inundation of its site. In 1903, a large storm drove waves up and over the beach head damaging many of the newly constructed houses giving a preview of the community's eventual fate. A trolley line (Plate 4.3) which had been constructed in front of the town and which extended all of the way into Cape May Point, had to be moved back following the storm. The process of erosion would not be stopped and in 1908, the struggling Mount Vernon Land Company was disbanded (Dorwart 1992:158).

In spite of the Mount Vernon development's lack of previous success and the ever-present threat of consumption by the sea, the optimistic landowners of South Cape May soon formed a new real estate group, The South Cape May Improvement Company. This ambitious organization drew up impressive plans for a residential community centered on a large recreational lagoon to be built on the site of Cape Island Creek. Although preparations went as far as the assembly of a dredge, the plan was never carried out. In the early 1920s, a 60-foot pipe was installed to carry the remaining sections of the Cape Island Creek, and in 1926, the South Cape May Improvement Company was dissolved (Cape May Historical and Genealogical Society n.d.).

The effects of the development of South Cape May were principally restricted to the eastern margins of the survey area. The western end of the meadows, although largely filled in by the 1920s remained almost entirely undeveloped. The most significant changes to this area during the first quarter of the 20th century were due to the intensive drainage efforts undertaken by the Cape May County Mosquito Commission (the Commission would continue its work in the meadows as late as 1967). The only buildings to occupy these lands were those of the U.S. Coast Guard and the lighthouse complex, and the only changes to these properties were the construction of a new Coast Guard station house with observation tower (Plate 4.4), a new barn and a bulkhead to protect the site from erosion.

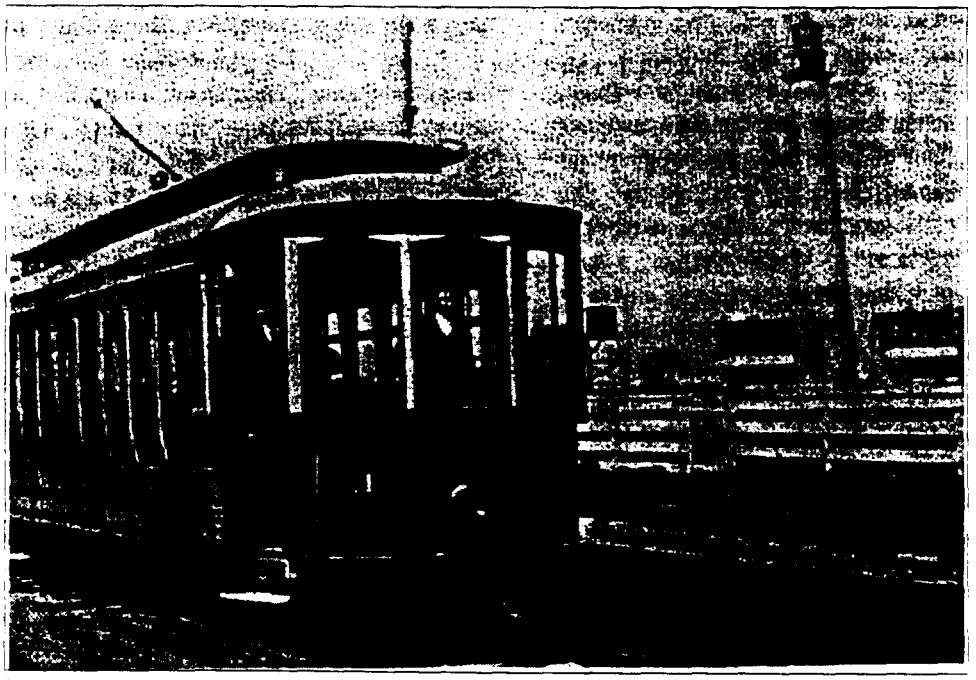

Plate 4.3. Historic view showing Cape May Point trolley and Cape May lighthouse. Circa 1920. Source: Bailey 1990.

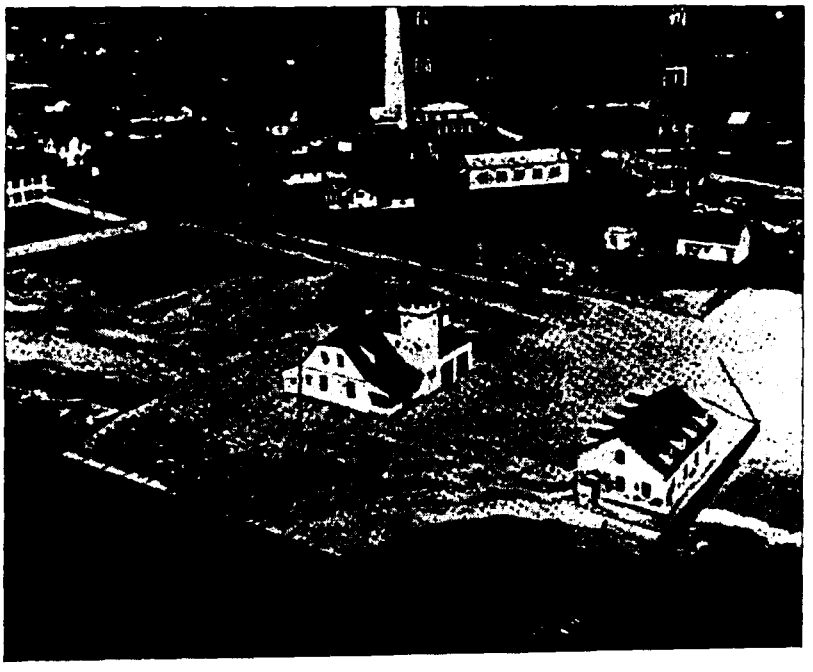

Plate 4.4. Historic view showing Cape May Point Coast Guard station. Circa 1950. Base of second lighthouse, Coast Guard barn and World War II military buildings are visible at upper right corner of the view. Source: Bailey 1990.

During this period, the meadows first began to obtain their reputation as one of the principal locations on the east coast for bird watching. On eastern North America's principal migratory route, the freshwater marshes found on this site attracted thousands of shorebirds each fall. Although much marshland was filled in the early years of the 20th century, the birds still continued to make use of the much-modified landscape. Witmer Stone, a well known ornithologist, noted that the body of water immediately to the north of the survey area and now known as Lighthouse Pond remained attractive to water fowl in spite of it being the outflow point for Cape May Point's sewer and the town dump (Stone 1937:25).

Conditions on the meadows continued to remain largely the same until the opening of World War II. Well before the start of the European conflict, the defensive importance of the Cape May peninsula and Cape May Point, in particular, had been noted. It had long been recognized that Cape May Point overlooked the entrance to the Delaware Bay and that, in any future conflict, the defense of it would be critical to the protection of the port of Philadelphia, the Philadelphia Naval Yard and the important shipyards at Hog Island, Camden and Kensington. During World War I, a six-inch gun emplacement had been constructed on the waterfront at Cape May City for exactly this purpose (Cape May Point State Park, Bunker Files, Report of Completed Works-Seacoast Fortifications, Coast Defenses of the Delaware Beach Avenue, near Cold Spring Inlet 1919).

During the 1930s, plans were drawn up for the installation of a battery of four evenly-spaced 155-millimeter guns at Cape May Point. The battery, however, was not to be built until a need arose. A 1934 plan (not illustrated) for this battery (called Battery #14) shows that two of these guns were to be placed in front of the old lighthouse base and the lifesaving station's new barn (Cape May Point State Park, Bunker Files, Sites for Battery #14 1934).

The other two guns would stand just to the west of the government property. A revised plan shows the gun battery (called Battery #11) divided into two pairs, one pair being located just behind the bulkhead at the fore of the new Coast Guard Station and the other in front of the side yard of St. Mary's Convent in Cape May Point (Cape May Point State Park, Bunker Files, Sites For Battery #11, September 1, 1938). The intent was for these batteries to provide cross fire for the larger defense system located at Fort Miles on Cape Henlopen in Delaware.

The Japanese attack on Pearl Harbor and the entry of the United States into World War II triggered the implementation of the United States' Coastal Harbor defense plans and construction of the proposed gun battery began. The placement of the guns was altered from the earlier plans. The four concrete gun emplacements were constructed in a tight row located to the east of the Coast Guard property on what was then the meadows and is now the tidal zone fronting Cape May Point State Park. Four semi-circular "Panama" gun mounts were constructed and fitted with 233-inch long guns taken from the Watertown Arsenal and the Bullar Engine Works. To provide support, four corrugated sheet steel magazines were erected in a row about 50 feet to the north of the emplacements. Construction began on December 31, 1941 and was completed with the guns mounted by June 15, 1942 (Cape May Point State Park, Bunker Files, Report of Complete Works-Seacoast Fortifications, Harbor Defenses of the Delaware, Battery 7, January 1, 1945).

In addition to the construction of the gun battery, the lighthouse and Coast Guard property were taken over for use by the army as a small military installation centered on a military radio transmitting facility. A large brick transmitter building, three large steel radio towers and several wooden barracks and support buildings were quickly constructed. The transmitting facility went into operation in January of 1942. Most of the infrastructure of the base stood to the north of the survey area. Those buildings and structures located on the land which formerly occupied the area which is now the beach and tidal zone included a large latrine building, a sentry box, a 50-caliber machine gun and mount, one of the transmitting towers and sleeping tents for the facility's Marine guard (Letter from David E. Harris to Pat Sutton, June 30, 1983, Cape May Point State Park, Bunker Files).

In September of 1942, construction began on a second gun battery at Cape May Point. Battery #223 was to be a standard medium-range battery of the Harbor Defense Program. The battery consisted of an earth-covered concrete bunker (containing shell and powder rooms, a plotting room, radio room, latrine, storeroom, an air compressor, three power generators, a "muffler gallery," a water cooler room and a cold water shower room), two six-inch Navy guns on fixed concrete mounts and fuel tanks. This massive and impressive facility was constructed just a few feet behind the gun mounts of Battery #26 (Cape May Point State Park, Bunker Files, Report of Complete Works-Seacoast Fortifications, Harbor Defenses of the Delaware, Battery 223, January 1, 1945).

Battery #223 was designed to act in tandem with similar newly-constructed batteries erected at Fort Miles to seal off the harbor. Having a maximum range of 27,100 yards, the guns could hit targets as far south as the tip of Cape Henlopen and as far north as Cape May Courthouse. Likewise the guns at Henlopen could fire as far north as Cape May City. A supporting network of spotting and triangulation towers, ensuring accuracy, existed both on the Cape May and Henlopen peninsulas. The Cape May towers included the immense concrete structures at North Wildwood, Wildwood Crest, Cape May City and Sunset Beach, Cape May Point. An additional small targeting tower was located just to the east of the battery near the Coast Guard Station. The network of towers and batteries was linked by a system of communications cables buried 30 inches below the ground surface. Sections of these copper cables were laid throughout

the area which is presently the western end of the study area beach front (Cape May Point State Park, Bunker Files).

In January of 1943, construction began on the final gun battery to be located at this facility. This would be a group of four 90-millimeter guns installed to defend the installation from aircraft or torpedo boats. The location of the new battery (Battery #7) was approximately 1,000 feet to the east of Battery #26. The battery consisted of two permanent concrete gun mounts fitted with Model M-1 fixed guns manufactured by General Motors and Wheland. Two other 90-millimeter guns were mounted on mobile carriages and when not in use were kept in a shelter on the reservation. Construction of Battery #7 was finished on June 15, 1943. Later in the war, an additional pair of 37-millimeter mobile guns was also associated with this battery (Cape May Point State Park, Bunker Files, Report of Complete Works-Seacoast Fortifications, Harbor Defenses of the Delaware, Battery #7, January 1, 1945).

The extent to which the government property had expanded during the course of World War II can be seen by the limits of the Cape May Coast Artillery Reserve shown on Figure 4.8. This military U.S.G.S. map of 1944 also shows the new path of Mount Vernon Avenue, a paved road constructed during the war to connect Cape May Point directly to Cape May City. Plates 4.5a and 4.5b, two sections of an aerial photograph taken in 1944, show both the configuration of Cape May Point's World War II Harbor Defenses (Battery #s 26 and 223 are visible at the center of Plate 4.5a with Battery #14 showing up just below) and with the overlay of the 1993 coastline, the degree to which erosion has removed the lands which formerly fronted the survey area.

Plates 4.5a and 4.5b are especially valuable in depicting the extent to which erosion has removed the site of the Borough of South Cape May. Erosion has so throughly destroyed the small town that, by 1945, the Borough had been dissolved and responsibility for government returned to Lower Township (Snyder 1969:115). After a massive storm in 1950 claimed almost the entire site of the community, the few remaining cottages were removed to lots in Cape May and West Cape May City. A storm in 1962 removed any remnants of the town site which had survived the 1950 storm.

The Cape May Point military installation remained in the possession of the Army for four years following the close of World War II. By 1949, however, the Cape May Point tract (which had grown during the war to 133 acres) was considered by the Army to be surplus and was transferred to the United States Navy. Beginning in the early 1950s and presumably in response to the start of the Cold War, the Navy began increasing the size of the infrastructure on the property. In 1953, numerous support buildings, in the form of Quonset huts, were constructed in the area now occupied by the Cape May Point State Park parking lots. Formerly a marsh area, the site was filled by the removal of the sod covering the bunker of Battery #223 and much of the surrounding earth (Cape May Point State Park, Bunker Files).

During the period of Navy occupation, the concrete bunker housed sonar equipment designed to monitor submarine activity in the Atlantic and presumably to guard against the infiltration of the Delaware Bay by submarines. A large Quonset hut was installed atop the bunker facility to provide additional room for these operations. Figure 4.9, drawn in 1953, shows the configuration of the bunker at that date. In 1959, the remains of old Coast Guard station were destroyed by fire (Bailey 1990:23). The navy continued to operate their Cape May Point facility until 1964 when the Navy made the decision to close the facility due to continual loss of land to erosion. The land was transferred to the State of New Jersey for use as a park, a use to which it is still put (Letter from W.H. Maier to E. Jerue, June 15, 1973, Cape May Point State Park, Bunker Files). Much of eastern half of the survey area is presently owned by the Nature Conservancy and is utilized as a bird sanctuary.

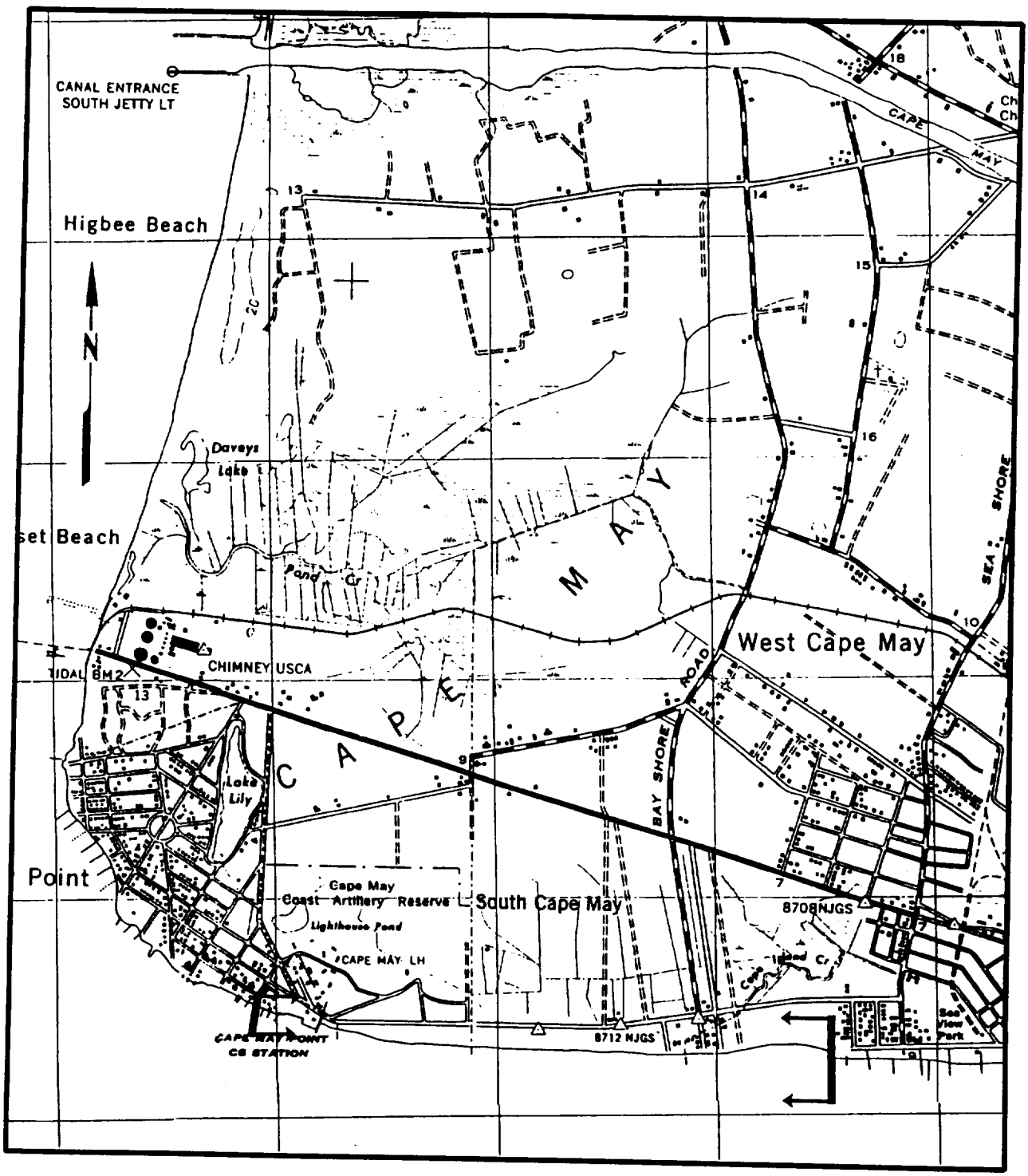

Figure 4.8. United States Army Corps of Engineers. Topographic Map, Cape May Quadrangle. 1944. Scale 1 inch: 2,900 feet (approximately). Terrestrial Survey Area Bracketed.

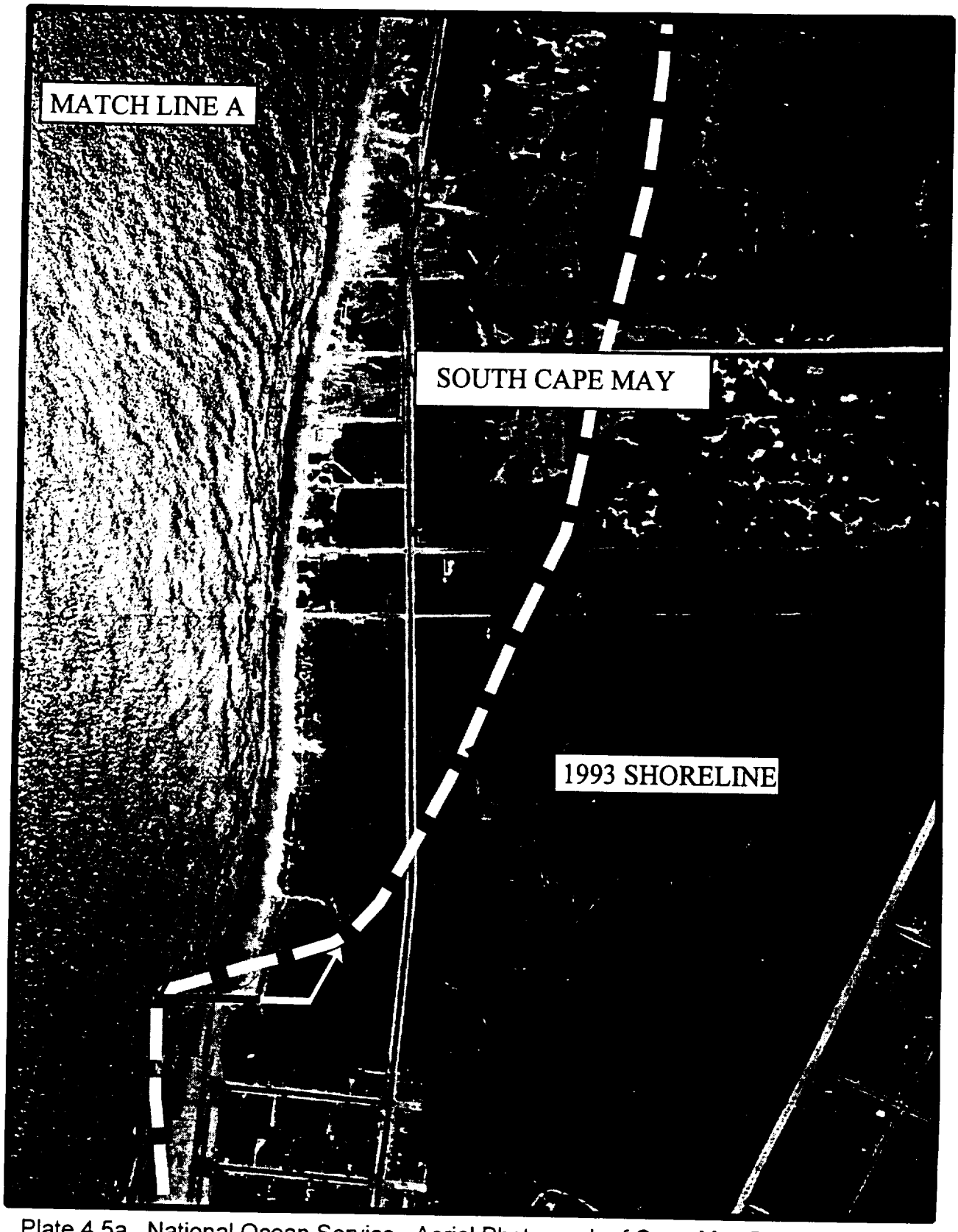

Plate 4.5a. National Ocean Service. Aerial Photograph of Cape May Point. August 5, 1944. Scale 1 inch: 550 feet. Eastern Limit of Terrestrial Survey Area Bracketed.

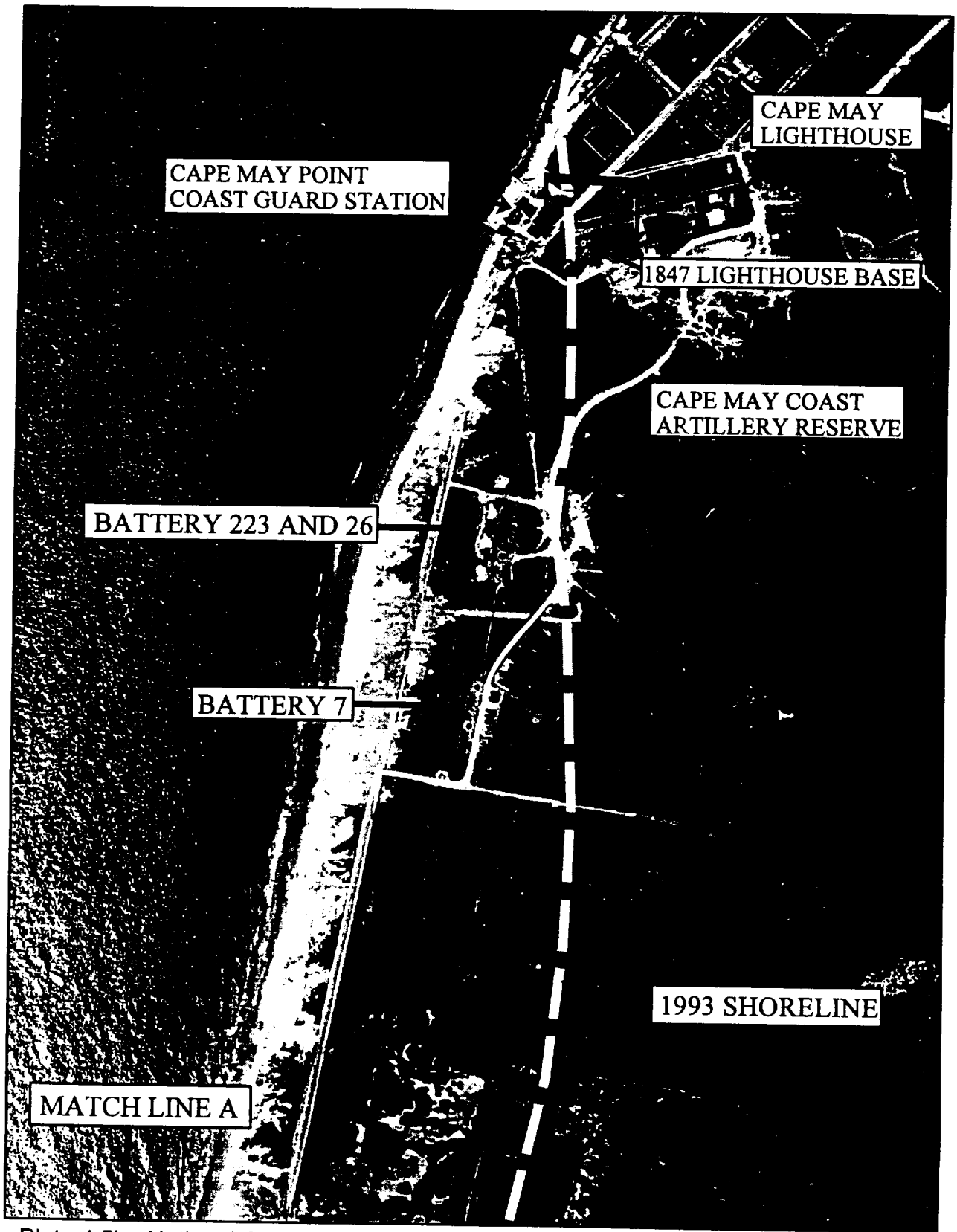

Plate 4.5b. National Ocean Service. Aerial Photograph of Cape May Point. August 5, 1944. Scale 1 inch: 550 feet. Western Limit of Terrestrial Survey Area Bracketed.

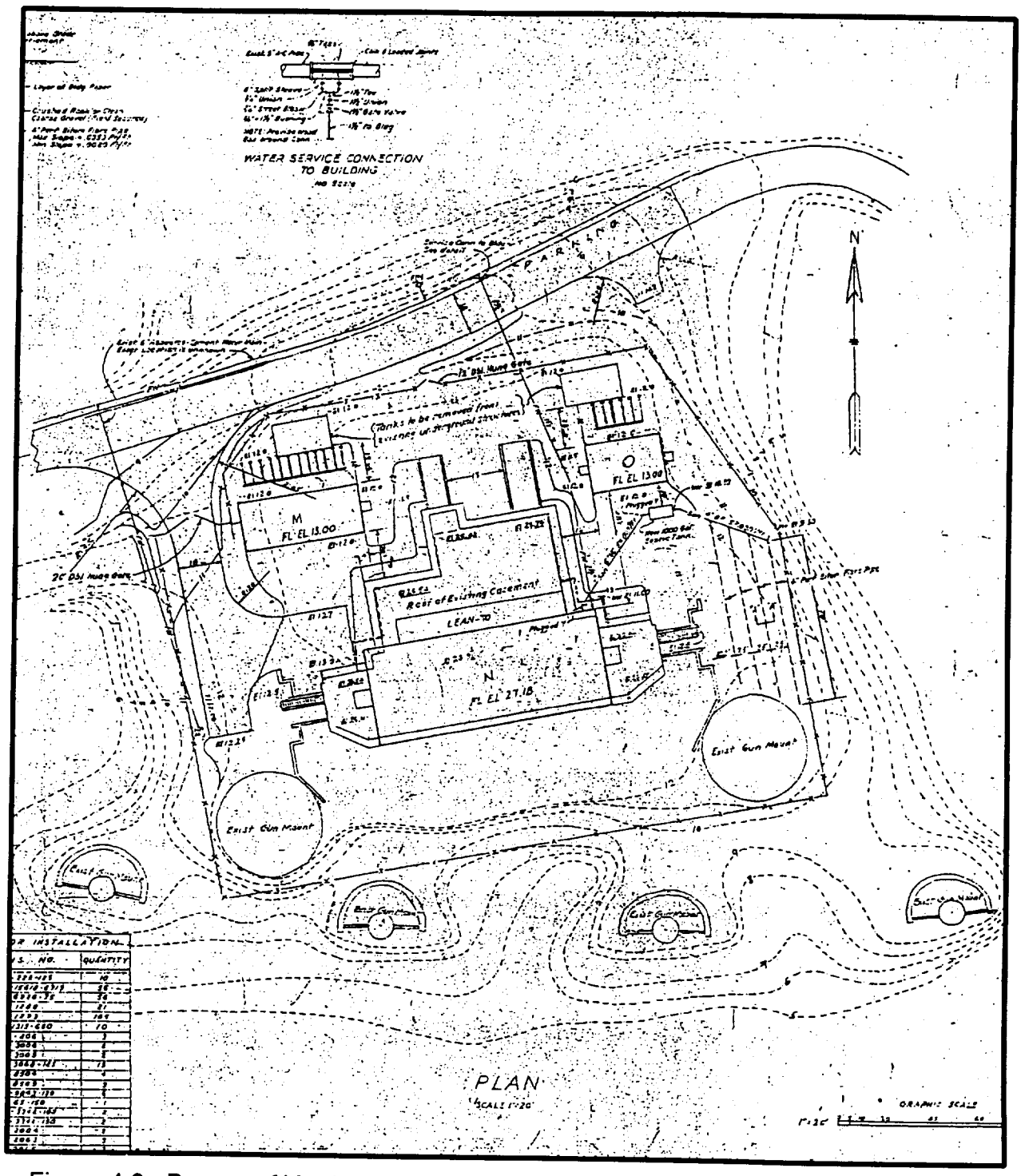

Figure 4.9. Bureau of Yards and Docks, U.S. Naval Facility Cape May Point, New Jersey. Layout of Grading and Exterior Services Plan. 1953. Scale 1inch: 70 feet (approximately). Plan Showing Former Coastal Defense Batteries 26 (gun mounts at fore) and 223 (bunker and gun mounts at rear).

CHAPTER 5

CULTURAL RESOURCES POTENTIAL

This chapter addresses in broad terms the potential for cultural resources along the tidal zone and shoreline of the study area from Cape May City to Cape May Point and within the proposed nearshore placement area and the proposed offshore sand borrow areas. First, the potential survival of prehistoric and historic terrestrial resources, i.e., resources that were formed on land and have since been inundated by water or sediment as a result of rising sea level and other offshore depositional activity, is discussed. Second, the potential for underwater resources is examined, i.e., resources such as shipwrecks, downed airplanes or jetties, whose original formation occurred in a marine environment.

A. Submerged and Shoreline Terrestrial Resources

Much research has focused upon the geomorphology of Atlantic coastal regions (Emery and Milliman 1970; Kraft 1971; Sheridan et al. 1974; Belknap and Kraft 1977; Weil 1977; Kraft et al. 1979) and of the implications of geomorphological change for archaeological site preservation (Kraft 1977a; Belknap and Kraft 1981; Kraft et al. 1983).

Since the earliest date of its occupation by mankind, the southern coast of New Jersey has been in a constant state of change. It is subject not only to dramatic wave and current resultant erosive and depository effects but also general submersive processes caused by the gradual rise of the sea and compression of underlying geologic strata. These forces continually reshape the North American Atlantic Coast line. Figures 3.1, 3.2 and 3.4 show the vast degree to which the coast line has changed over the period of human occupation. Even when considering the likelihood of the survival of on-shore and near-shore marine related historic resources one must take into account the effects of coastal change. Figure 5.1 shows the dramatic degree which the coastline within the study area has changed over only the past 150 years. An understanding of the fluctuation of the southern New Jersey coastline is essential in order to make any basic predictions about the potential for both prehistoric and historic site preservation.

Stuiver and Daddario (1963:951) published five radiocarbon dates on peat deposits above basement surfaces at increasing depths from the lagoon between the Brigantine City Barrier and the Jersey mainland. These data indicated a submergent rate of three meters per millennium from 6,000 years ago until 2,000 to 3,000 years ago, when the rate slowed to 1.2-1.4 meters per millennium. Dr. Stewart Farrell, geomorphologist at Stockton State College, has recovered radiocarbon samples from Absecon Creek near Absecon Town. These samples indicate a sea level rise of 5.5 meters since the location was a fresh water cedar swamp 4,100 years B.P., which indicate a mean rise of 1.3 meters per millennium (Farrell 1995:personal communication). However, evidence exists to indicate that sea-level rise at a given locale was not a completely linear trend, but was to some degree cyclical with fluctuating transgressive rises and regressive falls (Kraft et al. 1983:105).

As land environments are successively swallowed by coastal marshes, barrier beaches and ocean/bay waters, tectonic activity, related in the Middle Atlantic to the offshore Baltimore Canyon Trough geosyncline, and the potential "water loading" effect have resulted in a downward dip of stratigraphy

below sea bottom (Kraft and John 1978:106) (Figure 5.2). Analyses of marine cores provide evidence of a transgressive sequence stratigraphy of sedimentary facies at increasing depths as one moves offshore: shallow fine marine sands at the top; coarser barrier sands; lagoonal muds, tidal salt marsh mud and peat; and Pleistocene land surface at the bottom. Radiocarbon data reflect a parallelism of sea level dates as depth increases relative to the modern Coastal Plain (Belknap and Kraft 1977; Kraft and John 1978:106). Kraft and John cite these coastal Delaware data as classic examples of Walther's Law of Correlation of Sedimentary Facies, by which the horizontal distribution of sediments in present geographic environments is expected to be reflected in a similar vertical distribution of sediments from environments moving through geologic time (1978:106-108).

Despite the horizontal movement of coastal environments, the sedimentary sequences discussed above indicate that the environmental structure and relative positions of environmental types have remained stable, i.e. as lagoon/barrier shorelines with fringing coastal marshes which often were cut by large estuaries of (presently drowned) rivers (Kraft et al. 1983:59). Kraft et al. (1983:111) emphasize that the preservation potential for a submerged archaeological site is a function of two principal variables: the pre-Holocene topography on which the site was deposited, and the rate of sea-level rise.

Figure 5.3, taken from Kraft et al. 1983: Figure 8, illustrates the potential impact of changes in coastal geomorphology upon archaeological site preservation. The bold arrows indicate areas of ideal site discovery potential beneath marine sediments. These locations occur along the flanks of former interfluves which lie below the marine eroded zone, yet are still shallow enough to be accessible (Kraft et al. 1983:112). Other site preservation scenarios are also considered in this illustration. Site 1, a headland site near a freshwater source, is based upon the Woodland mortuary site of Island Field in Delaware; continued landward migration of the coastal barrier and sea would most likely consume this locus. Site 2, a shell midden at the edge of a marsh and lagoon may conceivably be preserved in the marsh/lagoon mud facies below a rising sea level. Site 3 would have originated adjacent to an estuary or tidal river. Due to the delay between burial and arrival of the eroding shoreline, it would become more deeply buried and stand a greater chance of survival, although its accessibility is reduced (Kraft et al. 1983:110-111).

Examples of submerged terrestrial resources which have survived inundation processes may be cited. Inundated karst formations in Sarasota County, Florida, and in the Gulf of Mexico off Fort Myers have produced evidence of prehistoric human occupation (Ruppe 1979). These examples reflect, however, the effects of geomorphological processes with the Gulf of Mexico, effects which are somewhat less dramatic than those encountered along the Atlantic coast. Clearly, the research of Kraft and others along the Delaware coast demonstrates that the study of coastal geomorphology and environments is capable of providing useful insights into the nature and condition of submerged cultural resources that may exist. It is also clear that the inundation of prehistoric and early historic archaeological sites may result in extensive resorting or removal of the archaeological record. Furthermore, while isolated artifacts preserved in the bottom sediments could survive in an excellent state of preservation, the associated context of human activity may have been destroyed. The high energy environments that are often present along ocean coastlines will lessen the likelihood that fragile evidence of prehistoric occupations would survive.

In addition to the relatively few documented occurrences of inundated terrestrial resources, considerable effort has been expended over the past quarter century in attempting to develop effective predictive models that can guide researchers intent on locating submerged prehistoric resources and assessing site preservation potential. Much of this

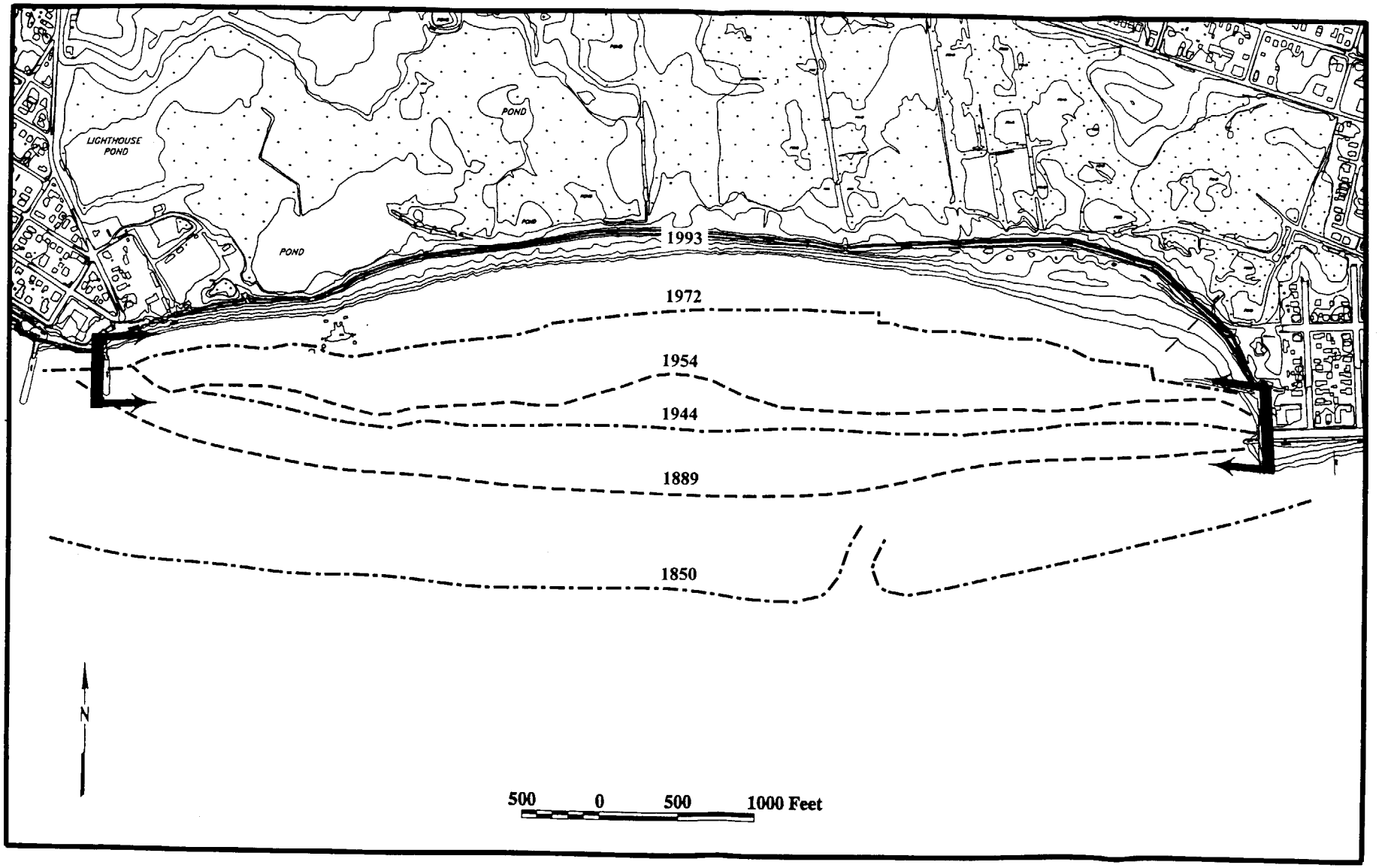

Figure 5.1. Map Showing Progressive Coastline Erosion in the Project Vicinity from 1850 to 1972, based on Historic Maps and Aerial Photography. Source: Nunan 1851; Vermeule 1889; National Ocean Service 1944; USGS 7.5' Topographic Series, Cape May, N.J. Quadrangle (1954 [Photorevised 1972]); Greenhorne & O'Mara 1993.

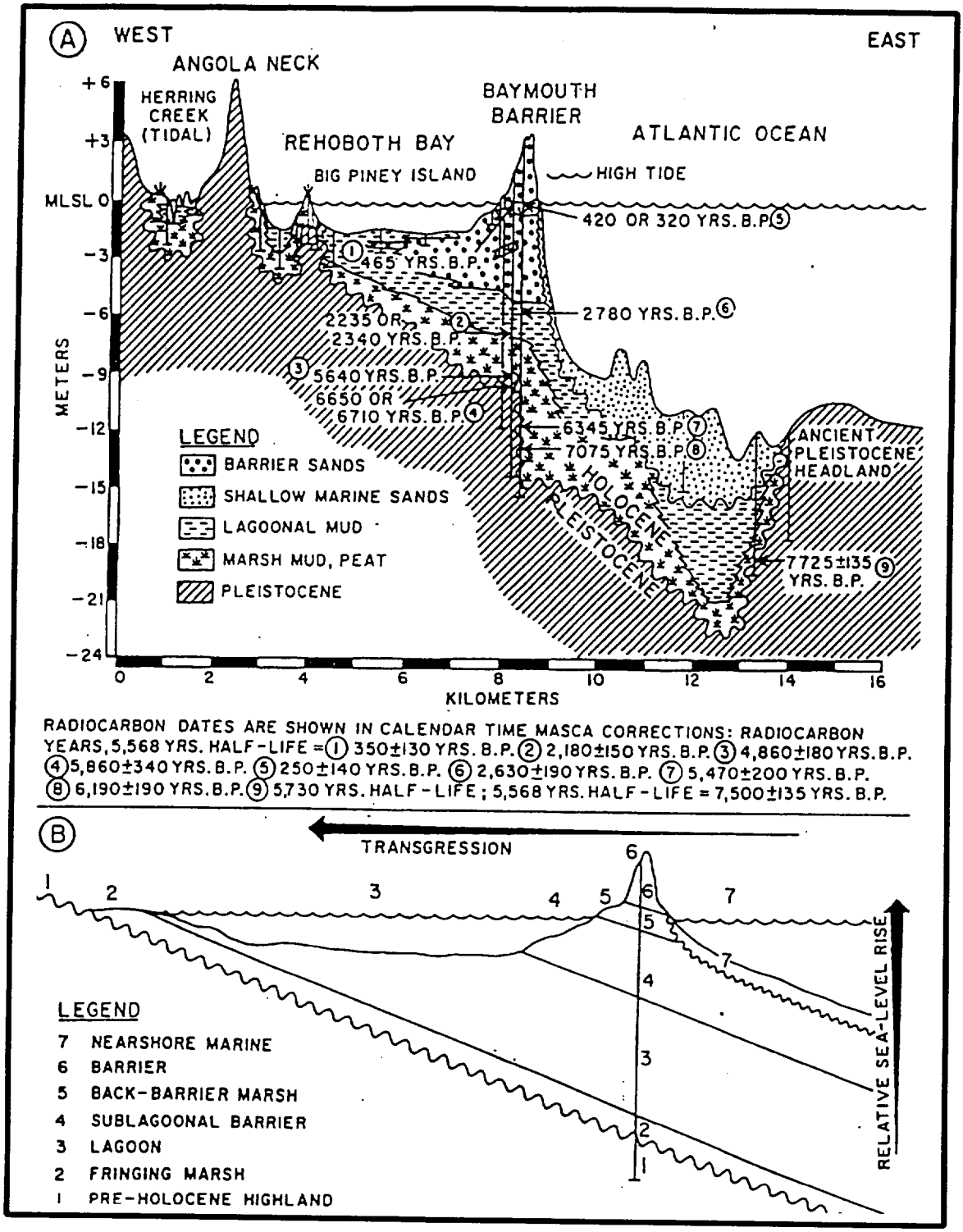

Figure 5.2. (A) A Geologic Cross Section across the Barrier Coast and Rehoboth Bay (Section line C on Figure 3.1). Note the similar sequence of geographic distribution of coastal sedimentary environments with the vertical sequence encountered In the drill boring. (B) A Schematic Illustration of the Nature of a Marine Transgression and Walther's Law of Correlation of Sedimentary Facies. Source -Kraft and John 1978: Figure 3.

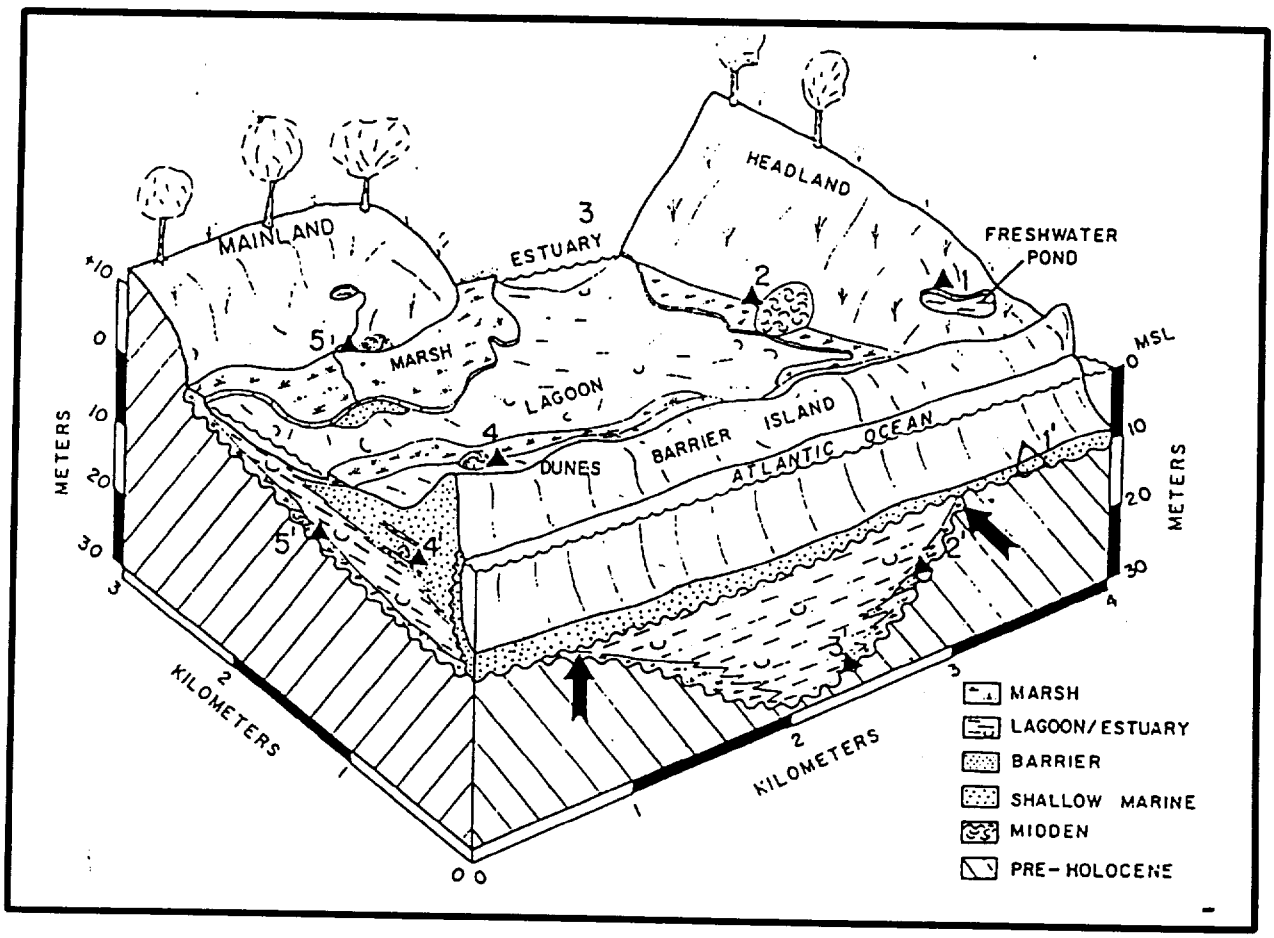

Figure 5.3. Block Diagram Illustrating Geologic Setting of Coastal Archaeological Sites in Delaware. Site Numbers 1-5 Indicate Original Environments of Deposition; Numbers 1'-5' Reflect the Geological Settings of Those Sites After Sea-level Rise, Coastal Inland Movement and/or Burial Beneath Sediments. Source - Kraft et al. 1983:Figure 8.

work has taken place in the Gulf of Mexico and along the Atlantic Continental Shelf in connection with offshore gas and oil leasing activities (e.g., Coastal Environments, Inc. 1977; Bourque 1979). For the most part, these studies conclude that paleogeographic analysis (with particular reference to sea level change and coastal geomorphic processes), coupled with remote sensing and selective core sampling, can assist in narrowing down offshore areas where site preservation potential is high. As just one example, although the location and identification of submerged Archaic sites would be difficult, their association with shell middens should increase the chances of their being detected. Indeed, investigations in the Gulf of Mexico off the west coast of Florida have confirmed both the association of prehistoric material with submerged middens and the detectability of these sites using side scan sonar remote sensing (Ruppe 1979).

The macro-scale model-building studies noted above are valuable as an overall guide to preservation potential of terrestrial resources within large expanses of ocean, but they tend to be too broad and generalized for effective application in the study of small offshore tracts such as those proposed for sand borrowing of the Jersey coast. The need for detailed, local paleogeographic data will always be paramount for site-specific offshore studies, and in most instances, such data are not readily available, and are both expensive and logistically awkward to derive and interpret.

B. Underwater Resources

As with inundated terrestrial resources, the effect of coastal geomorphic processes may either erode or bury underwater resources, and the processes may occur rapidly or slowly over time. However, because of the "accidental" and rapid manner in which many underwater resources (notably shipwrecks) are formed, and the shorter elapsed time involved before their remains are sought, they are frequently better preserved and generally more easily discovered. Underwater resources, such as shipwrecks, because they usually constitute a stronger physical (topographic, magnetic) anomaly than most inundated terrestrial resources are also far more easily identified by remote sensing techniques involving the use of magnetic, acoustic or sonar detection equipment.

In many cases, the remains of shipwrecks may be submerged, but not buried beneath sediment. Shipwreck material deposited in even the shallowest environment can settle rapidly into the bottom with its associated archaeological record intact. The wreck of the De Braak (1798), discovered near the Delaware Breakwater close to the study area, provides a classic example. A good portion of the lower hull survived intact, along with an extensive associated artifact assemblage (Shomette 1993). Even in extremely high-energy environments, evidence of the ship structure frequently survives. A recent discovery of a wooden hull sailing vessel adjacent to the Showboat Casino in Atlantic City also confirms that vessels have survived the inundation process in the project vicinity (correspondence files of the New Jersey State Historic Preservation Office). Numerous other archaeological investigations off the coasts of the states of Massachusetts, North Carolina, Florida, and Texas, and of England, Israel and Turkey, also offer examples of ship remains surviving inundation by sediment and the preservation of valuable archaeological data.

At many shipwreck sites, sand and light mud similar to the bottom sediments in portions of the study area have provided an excellent environment for preservation. Given the extent of vessel losses in the vicinity of the study area, and the level of preservation at shipwreck sites in other similar environments, it was considered very likely that well-preserved shipwreck sites would survive within the designated survey areas. However, it was felt that potential shipwreck sites would almost certainly be buried beneath an extensive amount of sand. Wrecked vessels typically act to trap sand, particularly in an environment where strong long-

shore currents transport high volumes of suspended sand up and down the coastal margins. On the other hand, buried wreck sites may sometimes become exposed again as severe coastal storms can also erode the sand which encapsulates wreck sites.

As a major conduit for exploration, colonization and expanding coastal commerce, the Delaware Bay is an obvious and natural repository for underwater resources. Strong coastal storms, often with a lethal combination of treacherous northeast winds and swift tidal currents, coupled with the presence of shallow water and historically heavy bay and coastal traffic, have conspired over the last three centuries to make the mouth of the Delaware Bay the final resting place for dozens of documented sailing vessels, steamships, barges, tugs and large modern ships. Many types of ships and vessels have been wrecked while passing up and down the bay and rounding the point at Cape May. The Cape May channel into the Delaware Bay is bordered by numerous shoals in the high energy environment which typically features strong tidal currents and turbulent seas. Several vessels attempting to reach the Harbor of Refuge at Lewes in the lee of Cape Henlopen have instead been wrecked in the mouth of the bay.

A recent Bureau of Land Management study of the Continental Shelf from the Bay of Fundy to Cape Hatteras has characterized the New Jersey Coastal Zone as an area of "moderately heavy" predicted shipwreck density (Bourque et al. 1979). An inventory of shipwrecks and all types of ship losses near Cape May and the mouth of the Delaware Bay was compiled during the background research phase of this study and confirms this predicted density (Appendix A). More than 300 shipwrecks and ship losses can be documented in the lower Delaware Bay and near the mouth of the bay since the first reported loss in 1641. Drawn from a range of primary and secondary sources, this extensive shipwreck list, while far from comprehensive, nonetheless gives an indication of the variety of shipwrecks that have occurred in the project vicinity over the last 350 years. Although there are no documented underwater resources within the limits of the two proposed sand borrow areas, Appendix A and secondary and primary historical sources show that numerous vessels have been deposited in their general vicinity throughout the historic period. The study area is therefore considered on the basis of background research to hold a high potential for yielding underwater resources of a caliber suitable for inclusion in the National Register of Historic Places.

Based on the information in Appendix A, the types of underwater resources that may be present in the Cape May vicinity include a variety of materials dating from the early 17th century through World War II. Appendix A also lists several recent shipping disasters which have occurred within the last 40 years. Potential vessel types include wrecks representative of all phases of commercial and naval activity taking place in the Delaware Bay and along the New Jersey portion of the Atlantic Coast. Wood-hulled ships, ranging from small fishing sloops, shallops, recreational sailing and motor craft and coastal schooners, to sail-rigged warships, have been lost near the mouth of Delaware Bay. Iron-hulled vessels, including paddle-wheel steamboats and World War II-era merchant ships sunk by German submarines, have also been lost in the project vicinity. Large 20th-century steamships and freighters are also among the listed losses in the region. Many of these types of vessels would potentially lend historic insights into a wide range of maritime topics, including the contexts of naval activity, shipbuilding and regional shipping, and patterns of trade and industry.

CHAPTER 6

SURVEY INVESTIGATIONS

The purpose of the fieldwork component of these cultural resources investigations was twofold: to conduct a visual and magnetometer survey of the tidal zone and shoreline of the 1.5-mile section of Cape May's Atlantic shoreline extending between the westernmost jetty in Cape May City and the easternmost jetty of Cape May Point for evidence of potentially significant cultural resources; and to carry out a comprehensive remote sensing survey within the nearshore sand placement area and two proposed offshore sand borrow areas. The major work effort was directed at the latter underwater archaeological survey, the purpose of which was to locate, identify and preliminarily assess the significance of submerged prehistoric and historic resources that might be affected by future depositional or dredging activity. The underwater survey was designed to generate sufficient magnetic, acoustic and bathymetric remote sensing data to identify anomalies caused by submerged cultural resources. Analysis of the remote sensing data aimed to isolate targets of potential historical significance that might require further investigation or avoidance. At this level of study, no diving was required to be undertaken on identified targets.

A. Terrestrial Survey

The terrestrial survey area comprised that section of beach located between the westernmost jetty at Cape May City and the eastern most jetty at Cape May Point and to the south of an arbitrary line drawn 50 feet to the north of mean high water. The terrestrial survey component of this project was carried out in two phases. In the first week of December in 1996, magnetic remote sensing data were collected along the 1.5-mile-long beach during low tide using a hand-held recording magnetometer. The second phase of work included visual inspection and photography of the tidal zone and shoreline in January of 1997. One archaeologist and one architectural historian inspected the entire shoreline on foot, walking from east to west, taking notes and photographs as they went. In addition to inspecting and recording features along the waterfront, project staff specifically asked local residents encountered en route and the staff of Cape May Point State Park whether they had any knowledge of buried or submerged cultural resources along the section of ocean front under study.

Two small, isolated magnetic targets [Cultural Resources 1 and 2] were identified during the terrestrial remote sensing survey (Figure 6.1). However, at each target location, a lack of signature intensity and dispersion indicates a small, isolated ferrous object. Both targets were located near the high tide water level of the beach: one target [1] was immediately below an access path through the dunes for off-road vehicles; and the second target [2] was located slightly to the northeast of the World War II-era battery [Cultural Resource 10].

During the second phase of the terrestrial survey no evidence of prehistoric cultural resources were located. No evidence of lithic manufacture or occupation was noted, and no traces of possible prehistoric shell middens were observed.

However, several historic and modern cultural resources were documented. The eastern edge of the study area is formed by a long stone jetty, referred to here as the Cape May City West Jetty [Cultural Resource 3], which protects the western edge of Cape May City's beach (Plate 6.1). To the west of the base of the jetty, the beach, separated from the meadows by a tall line of artificial sand dunes, sweeps inland. A broken row of wood pilings [Cultural Resource 4] was observed extending southwesterly from a position just north of the base of the stone jetty. These pilings appear to be the

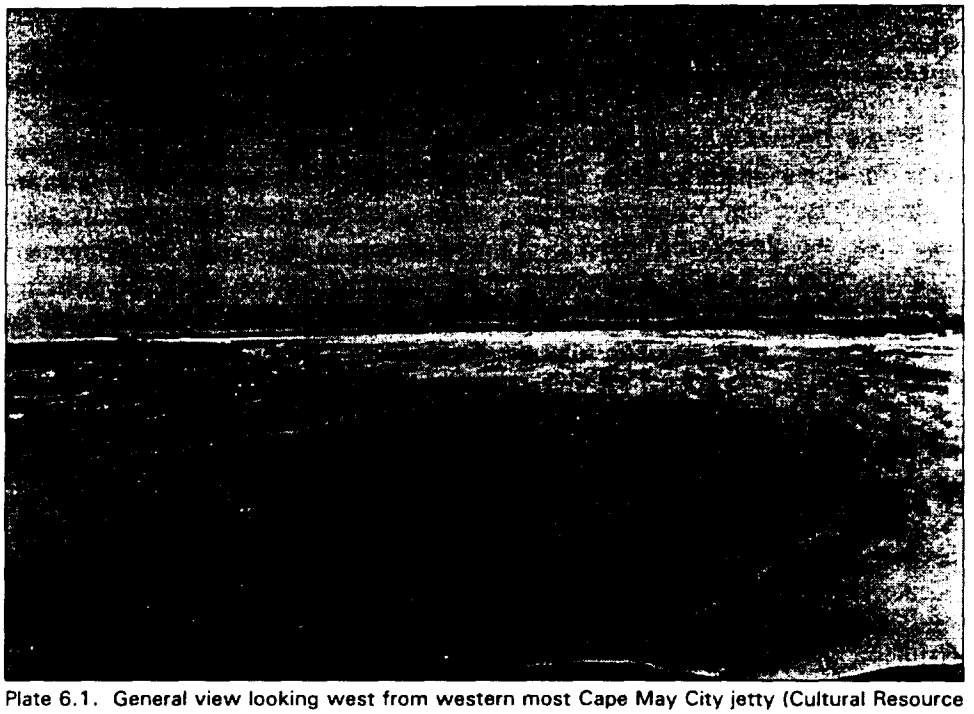

Plate 6.1. General view looking west from western most Cape May City jetty (Cultural Resource 3) showing eastern half of terrestrial survey area (Photographer: Damon Tvaryanas, January 1997) [HRI Neg. # 96069/1:3].

remains of a narrow jetty or seawall oriented nearly perpendicular to the larger stone structure. Just to the west of their position, a small drainage pipe (Cape Island Creek Drainage Pipe) [Cultural Resource 5] was noted running from a location behind the dune line and presumably extending beneath the lower sections of the beach and out into the surf. No additional cultural resources were observed on the beach between the Cape May City West Jetty and the eastern boundary of Cape May Point State Park.

Examination of the north side of the barrier dune (off the beach and just outside the designated survey area) revealed a large area of meadows intercut by numerous dikes and interspersed with many small ponds (Plate 6.2). It was apparent that many of these water control features were linked to the historic utilization of the land for salt hay farming. The rest were associated with mosquito control efforts. Several small buildings and structures were noted within the meadows. These were found to be blinds constructed in conjunction with the well-known bird watching activities which occur in the area.

The meadows were found to be intercut by dirt roads and embankments. The majority of these were constructed in conjunction with the development of the town of South Cape May [Cultural Resource 6]. The most prominent of these roads run roughly north to south and are the beds of 13th (formerly the southern terminus of Bay Shore Road) and 16th Avenues. At the terminus of 16th Avenue, a break in the barrier dune provides access to the beach. No evidence of either Mount Vernon Avenue [Cultural Resource 7] or the Delaware Bay and Cape May Railroad/Cape May Point Trolley Tracks [Cultural Resource 8] were observed.

On the beach, within the bounds of Cape May Point State Park, several potential historic resources were encountered. The most notable of these are a group of structures constructed in conjunction with the

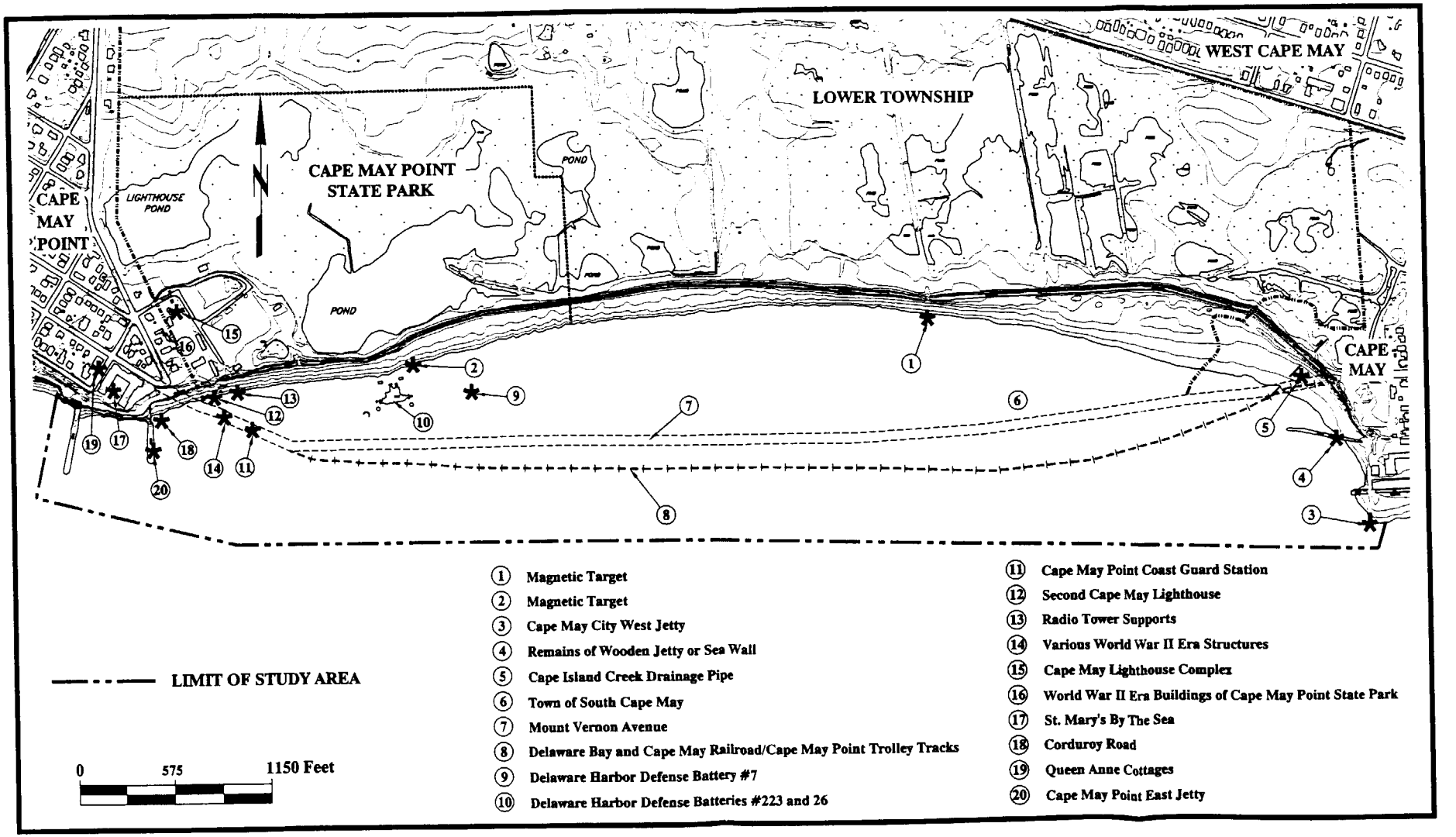

Figure 6.1. Map Showing Locations of Cultural Resources.

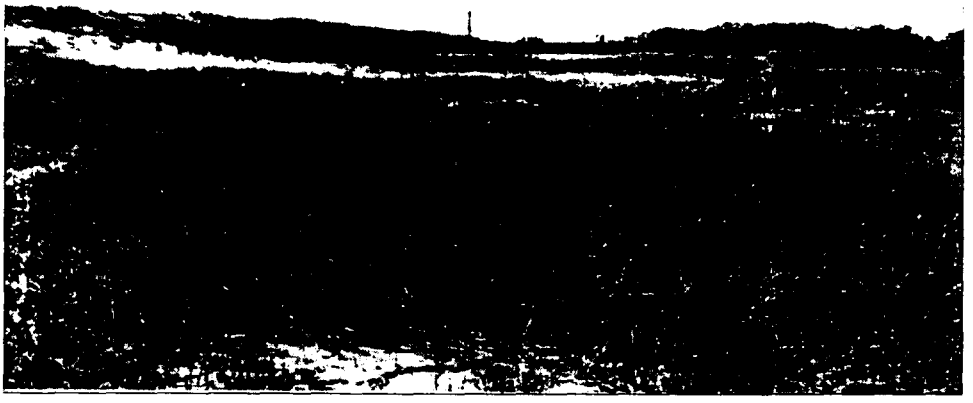

Plate 6.2. View looking west showing meadows behind barrier dunes. The Cape May Lighthouse (Cultural Resource 15) is visible in the background and center of the view (Photographer: Damon Tvaryanas, January 1997) [HRI Neg. # 96069/1:18].

World War II-era fortification of the Atlantic Coast. No evidence of Coastal Defense Battery #7 [Cultural Resource 9] was observed. However, the above ground remains of Batteries #223 and 26 [Cultural Resource 10], consisting of a large concrete bunker (Plate 6.3), concrete fuel tanks and semi-circular concrete gun emplacements, are substantial. These remains are located in the tidal zone to the east of the Cape May Point East Jetty and southeast of the Cape May Lighthouse.

Between the bunker installation and the Cape May Point East Jetty is a length of beach littered with a considerable accumulation of rubble (Plate 6.4). While some of these deposits, principally those consisting of chunks of asphalt and concrete with rebar, are likely related to previous attempts to stabilize the beach front in the vicinity of Cape May Point, in other instances, they seem to be associated with buildings which were formerly located along this section of ocean front before the land eroded into the sea.

This segment of beach front formerly contained the Cape May Point Life Saving Station [Cultural Resource 11], the second Cape May Point Lighthouse [Cultural Resource 12], a large World War II-era steel communications tower [Cultural Resource 13] and several other World War II-era military buildings and structures [Cultural Resource 14]. The most substantial of these remains are three pyramidal concrete bases which served as anchors for the long since removed communications tower (Plate 6.4). The site of the Cape May Point Lifesaving Station is presently a considerable distance beyond the low tide point but the base of the second lighthouse, constructed of stone and brick, was located just above present low tide and

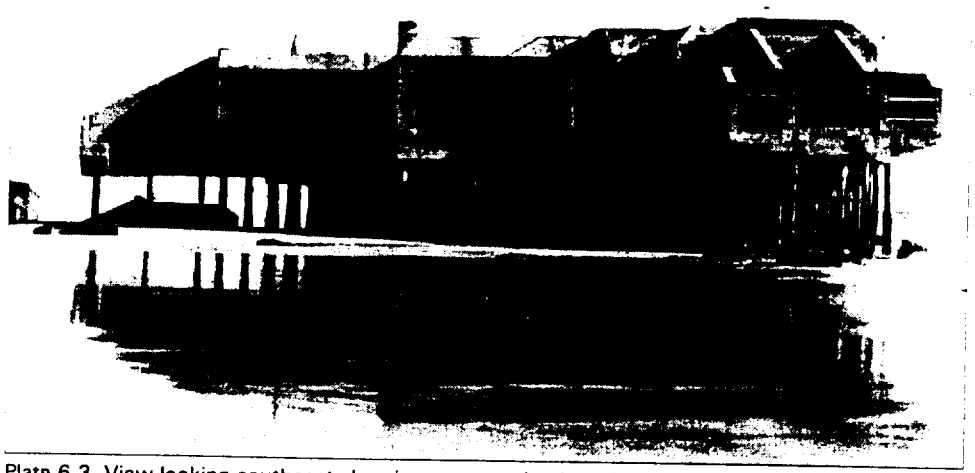

Plate 6.3. View looking southeast showing concrete bunker of Delaware Harbor Defense Battery #223 [Cultural Resource 10] at Cape May Point (Photographer: Damon Tvaryanas, January 1997) [HRI Neg. # 96069/2:20].

Plate 6.4. General view looking east from Cape May Point showing western half of terrestrial survey area. Note surf washed rubble on beach in foreground. Concrete bunker of Delaware Harbor Defense Battery #7 [Cultural Resource 10] is visible at center-right of the view and concrete radio tower supports [Cultural Resource 13] at center-left of the view (Photographer: Vincent Maresca, January 1997) [HRI Neg. # 96069/3:5].

was still visible as recently as the 1960s. A large cluster of cut stone blocks and brick rubble are possibly related to this structure and may retain some degree of archaeological integrity.

Behind the dunes to the north of these remains (and outside the survey area) are the buildings and parking lots associated with the Cape May Point State Park and the Cape May Lighthouse (Plate 6.5). The lighthouse complex [Cultural Resource 15] (listed on the State Register [6/15/73] and National Registers [11/12/73] of Historic Places) consists of the 145-foot-tall brick lighthouse, a keeper's house and an oil house. Between the lighthouse and the ocean are the administration and interpretation buildings of the State Park. These frame and brick buildings [Cultural Resource 16] were constructed as part of the former military installation during World War II. The group includes a frame officers' quarters building (park office building), an infirmary hall (nature center) and a brick transmitter building (park maintenance building). The officers' quarters building and the recreation hall are notable as examples of World War II-era temporary mobilization construction. Also associated with the park is a recently-constructed picnic pavilion, located on the top of the dune overlooking the beach.

Plate 6.5. View looking northwest showing Cape May Point State Park. The view shows from left to right, World War II era infirmary (nature center), radio transmitter building (park maintenance building), officers quarters (park offices) [Cultural Resource 16] and the Cape May Lighthouse of 1859 [Cultural Resource 15] (Photographer: Damon Tvaryanas, January 1997) [HRI Neg # 96069/2:4].

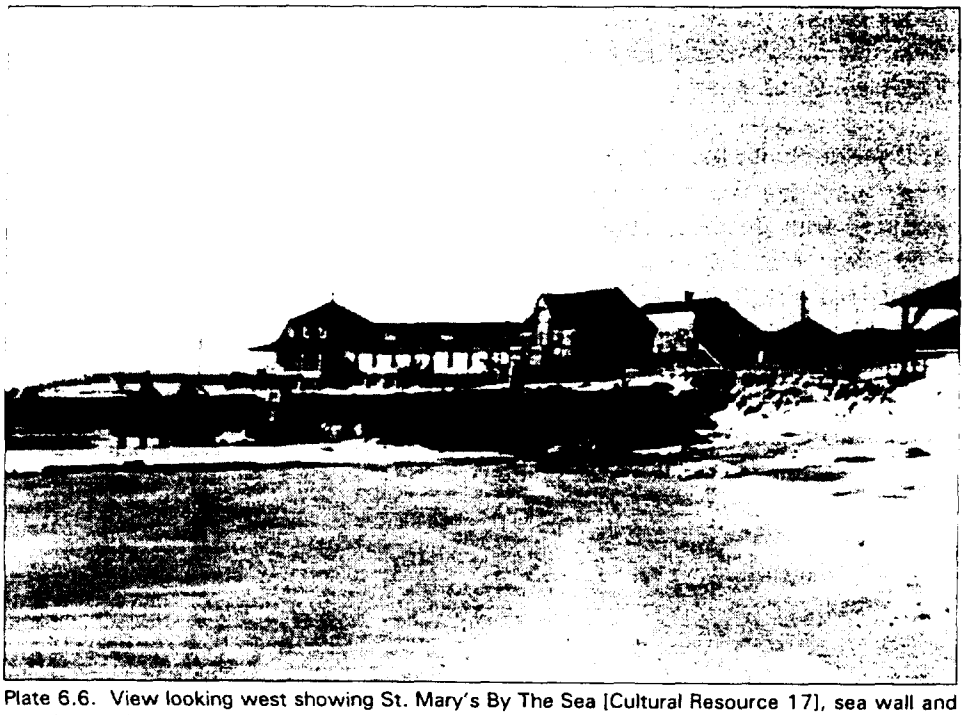

Plate 6.6. View looking west showing St. Mary's By The Sea [Cultural Resource 17], sea wall and remains on beach all located to the west of the concrete bunker of Delaware Harbor Defense Battery #223 [Historic Resource 10]. Note concrete radio tower supports [Cultural Resource 13] on beach at center-left of the view and Cape May Point State Park Picnic Pavilion at center-right of the view (Photographer: Damon Tvaryanas, January 1997) [HRI Neg # 96069/5:2].

Behind a stone-faced embankment which rises above the end of the western end of the survey area, is the St. Mary's By The Sea Convent, formerly the Shoreham Hotel [Cultural Resource 17] (Plate 6.6). The convent, located outside but immediately neighboring and overlooking the survey area, was observed to be a large, three-story, U-shaped Queen Anne style hotel building fronted by two-story porches and surmounted by a tall red mansard roof.

No evidence was observed of the corduroy road [Cultural Resource 18] that was exposed in the early 20th century and was noted to extend from the beach in front of the hotel into the surf.

A single modern frame cottage has been constructed on the bluff overlooking the sea just to the east of St. Mary's. Immediately to the west of St. Mary's on the opposite side of Leigh Avenue are two large, well-maintained frame Queen Anne cottages [Cultural Resource 19] (Plate 6.7). Both were moved to this location in the second half of the 20th century. Formerly, at least one of these cottages, the southernmost, was located on the beach front to the south of its present location. This lot has since been lost to erosion and the construction of the tall barrier dune.

The western edge of the survey area is defined by the easternmost Cape May Point jetty referred to here as the Cape May Point East Jetty [Cultural Resource 20] (Plate 6.8). This stone structure is very similar in construction to the larger jetty at the eastern end of the study area. Of some note is the earlier submerged breakwater which extends westward perpendicular from the end of this jetty. This feature lies outside the current survey area.

Plate 6.7. View looking southwest showing Queen Anne Cottages [Cultural Resource 19] on Leigh Avenue (Photographer: Damon Tvaryanas, January 1997) [HRI Neg # 96069/5:18].

Plate 6.8. View looking east showing eastern most Cape May Point jetty [Cultural Resource 20]. Although located outside of the study area, the wooden pilings visible in the front of the stone sea wall in the foreground are the remains of an early 20th century barrier (Photographer: Damon Tvaryanas, January 1997) [HRI Neg # 96069/5:20].

B. Underwater Survey Activities

1. Field Techniques and Procedures

The purpose of the fieldwork phase of the underwater archaeological survey was to carry out a comprehensive remote sensing survey within the near-shore sand placement area and the two proposed offshore sand borrow areas and. The remote sensing survey was conducted to locate, identify, and preliminarily assess the significance of submerged prehistoric and historic resources that might be affected by future dredging and disposal activities. The underwater survey was designed to generate sufficient magnetic, acoustic, and bathymetric remote sensing data to identify anomalies caused by submerged cultural resources. Analysis of the remote sensing data aimed to isolate targets of potential prehistorical and historical significance that might require further investigation or avoidance. No diving was undertaken on these targets.

All remote sensing fieldwork were carried out from a 25-foot survey vessel suitable for shoal and open water operations. A Geometrics, G-866, proton precession magnetometer, capable of +/- one gamma resolution, was employed to collect magnetic remote sensing data. A two-second sampling rate by the magnetometer's towed sensor, coupled with a 3.5 to 4-knot vessel speed, assured a magnetic sample every ten feet. A Klein two-channel acoustic recorder with a 500 kHz side-scan sensor was used to collect acoustic data. Acoustic data were recorded on wet chemical paper with an analog recorder. A Mardata precision echo depth sounder with a 208 kHz narrow beam transducer was used to collect bathymetric data. Survey vessel trackline control and position fixing were obtained by using a laptop PC-based software (Hypack) package in conjunction with a Navstar Differential Global Positioning System (DGPS) on board the survey vessel. Differential corrections were obtained from Coast Guard beacons transmitting from Wildwood, New Jersey, and Cape Henlopen, Delaware. The onboard computer and black/white monitor were interfaced with the DGPS. Positioning data from the DGPS were converted by the computer to New Jersey (NAD 83) X,Y coordinates in real time. These X,Y coordinates were used to guide the survey vessel precisely along predetermined tracklines. While surveying, vessel positions were continually updated on the computer monitor to assist the vessel operator, and the processed X,Y data were continually logged on computer disk for post processing and plotting.

Magnetic, acoustic and bathymetric data were collected simultaneously. Position coordinates and bathymetric data were logged into the onboard computer. The magnetometer sensor was towed 50 feet aft of the survey vessel, while the sonar transducer was towed off the starboard side of the survey vessel and the echosounder transducer was mounted on the vessel's transom. To allow for the detection of subtle magnetic anomalies typically associated with smaller wooden vessels, survey lane spacing for the survey was established at 75-foot offsets. Since the side-scanning sonar transducer has an effective range of more than 150 feet in each channel, 75-foot lane offsets provided comprehensive acoustic coverage for each area. A precise track plot was recorded for all survey lanes and remote sensing records were annotated at 150-foot intervals along each lane. This allowed researchers to rapidly integrate the acoustic, bathymetric and magnetic records into a survey map and to pinpoint the location of each identified target.

Magnetic data were contour plotted at ten-gamma intervals. Sonagram records were inspected for potential man-made features present on the bottom surface. After fieldwork data were collected, magnetic data were correlated with sonar and bathymetric records, and targets of potential significance were identified and designated. Targets signatures located during the survey were refined to permit highly accurate positioning and to facilitate signature analysis.

Magnetometer data were contour plotted and each anomaly was analyzed in terms of the following parameters: magnetic intensity (total distortion of the magnetic background measured in gammas); pulse duration (detectable signature duration); signature characteristics (negative monopolar, positive monopolar, dipolar, or multi-component); and spatial extent (total area of disturbance). Acoustic (side-scan sonar) targets were analyzed according to their spatial extent, configuration, location and environmental context. Magnetic records were correlated with the acoustic targets and integrated with bathymetric data to provide comprehensive remote sensing information on the identity of the material generating the remote sensing signatures. The integrated data for each target site were finally assessed with reference to typical submerged cultural resource signatures generated during three decades of magnetic and acoustic remote sensing surveys, enabling the isolation of target signatures that were suggestive of significant submerged cultural materials.

These procedures for analyzing remote sensing targets have been developed in the course of compiling a database of target signatures over the last three decades. Starting in the 1960s, archaeologists primarily relied on magnetic remote sensing data, collected with proton precession magnetometers, to locate submerged cultural resources. However, magnetic data collected alone often provide inconclusive or partial evidence on submerged cultural resource sites. Underwater archaeological research conducted over the last two decades indicates that shipwreck sites may produce a variety of magnetic signatures. Furthermore, modern debris often generates magnetic signatures that may share similar characteristics with certain types of shipwreck sites.

The ambiguous nature of magnetic signatures has led researchers to use acoustic and occasionally sub-bottom remote sensing equipment in conjunction with a magnetometer on most underwater archaeological surveys. Acoustic data, in the form of sonagram records, are produced by processing sound waves emitted into the water column on both sides of the submerged sensor and bounced back off the bottom surface and exposed objects. State-of-the-art sonar units can produce a high resolution sonagram record which is almost photographic in quality. However, a certain degree of structural integrity of a site must remain on or above the bottom to produce a reliable shipwreck signature on side-scan sonar. Where no structure survives above the bottom surface researchers must rely on magnetic data to help locate shipwreck remains. Additional data provided by acoustic instruments frequently permit target identification to be made solely from remote sensing information. A combination of magnetic and acoustic remote sensing data has proven to be the most effective method to accurately identify and assess submerged archaeological sites. Typically, the most attractive targets produce both well-defined magnetic and acoustic signatures.

2. Findings of the Remote Sensing Survey

Underwater survey work was completed in the nearshore sand placement area and the two proposed sand borrow areas by a three-person project crew from Dolan Research, Inc. between December 2- 6, 1996. All underwater field survey notes, magnetometer and sonar records, are stored at the offices of Dolan Research, 4425 Osage Avenue, Philadelphia, PA 19014.

Analysis of the remote sensing data confirmed the existence of nine remote sensing targets in the three different survey locations. However, all of the targets have signature characteristics typically generated by modern debris, or single, isolated objects on the bottom. Following is a description of the findings in each individual survey area. Targets have been listed for each area according to two general types: *High Probability Targets*, which may require further archaeological investigation; and *Other Targets*, which displayed characteristics associated with modern debris. However, no high probability targets were identified during the

survey. Target designations refer to the lane number followed by a colon and the event number at the center point of the target signature.

a). Nearshore Sand Placement Area

The Nearshore Sand Placement Area comprised a 200-acre area directly adjacent to the beach between Cape May City and Cape May Point. Although breaking waves prevented safe navigation on the lanes closest to the beach, 21 survey lanes were completed parallel to the shoreline (Figure 6.2). The derelict remains of the World War II-era battery (Delaware Harbor Defense Batteries #s 223 and 26) [Cultural Resource 10] obstructed portions of the lanes closest to the beach. Analysis of the remote sensing data confirmed the existence of one target in the Nearshore Sand Placement Area (Figure 6.3). The target appears to be related to the ruins of the World War II-era battery.

High Probability Targets

None

Other Targets

Target #: 12:666

Evidence of the magnetic signature of this target was detected in Lanes 12 and 13. The negative, monopolar signature had a maximum distortion of 109 gammas that was detected over five sample intervals. Side-scan sonar records of the target location confirm the presence of a man-made structure, possibly parts of a jetty, that appear to be associated with the military battery. A scatter of large rocks extended out in a linear orientation perpendicular to the shoreline, approximately adjacent to the battery. No further archaeological investigation is recommended at this target location.

b). Borrow Area P-1

Borrow Area P-1 comprised a 250-acre rectangular-shaped area within which 24 survey lanes were completed (Figure 6.4). Analysis of the remote sensing data confirmed the existence of three magnetic targets and two acoustic targets in Borrow Area P-1 (Figure 6.5). However, each of the five targets generated signature characteristics suggestive of modern debris or single isolated objects.

High Probability Targets

None

Other Targets

Target #: 4:275

Evidence of the magnetic signature of this target was only detected in Lane 4. The negative, monopolar signature had a maximum distortion of 30 gammas that was detected over four sample intervals. Side-scan sonar records of the target location confirm the presence of an approximately 15-foot section of dredge-like pipe which is lying isolated on the bottom. Water depth at the target location was 33 feet. No further archaeological investigation is recommended at this target location.

Target #: 5:359

Evidence of the magnetic signature of this target was only detected in Lane 5. The positive, monopolar signature had a maximum distortion of 10 gammas that was detected over five sample intervals. There was no associated acoustic image at the target location, indicating that the material responsible for generating the magnetic signature is buried beneath the bottom surface. The target is

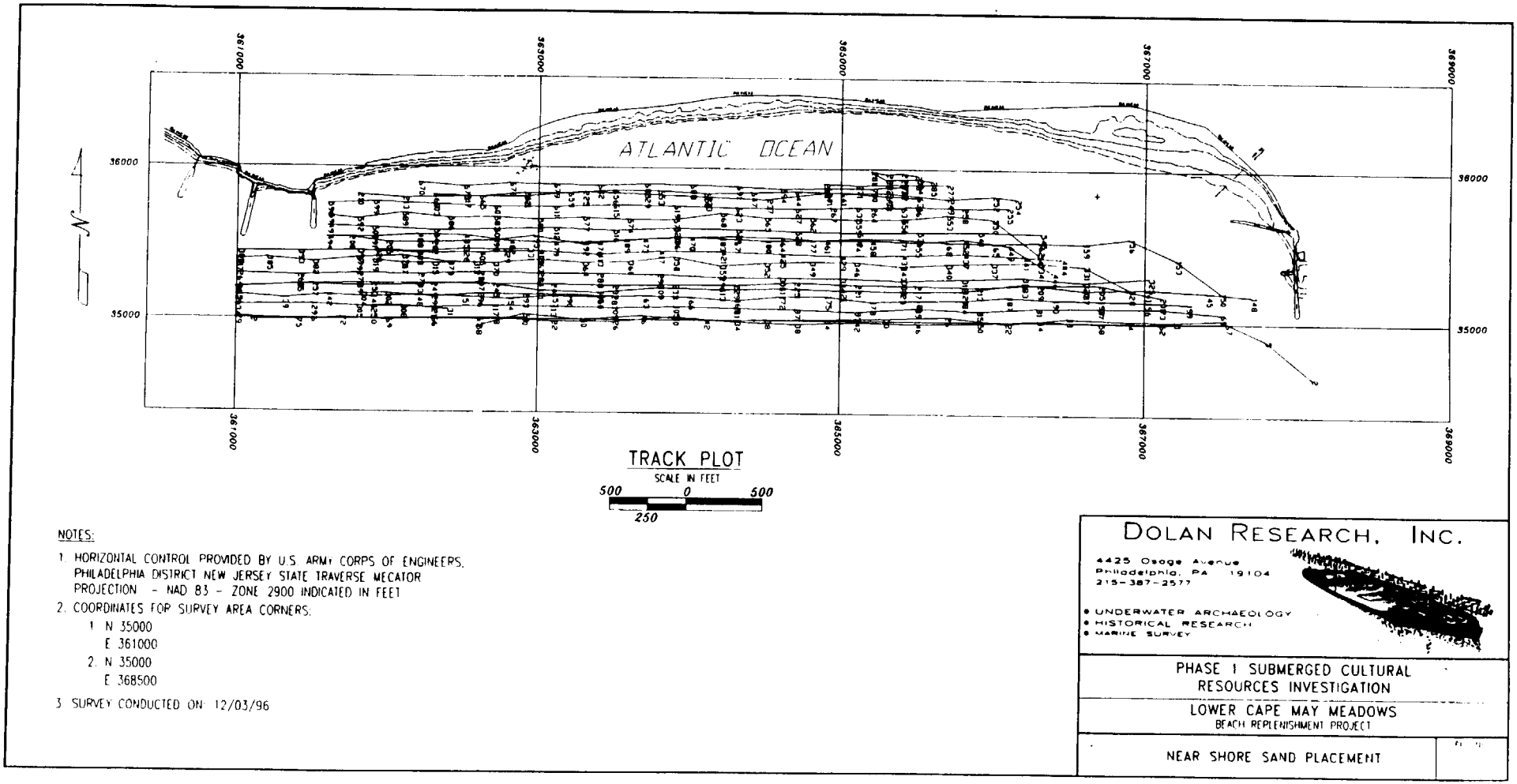

Figure 6.2. Near-shore Sand Placement Area, Tract Plot.

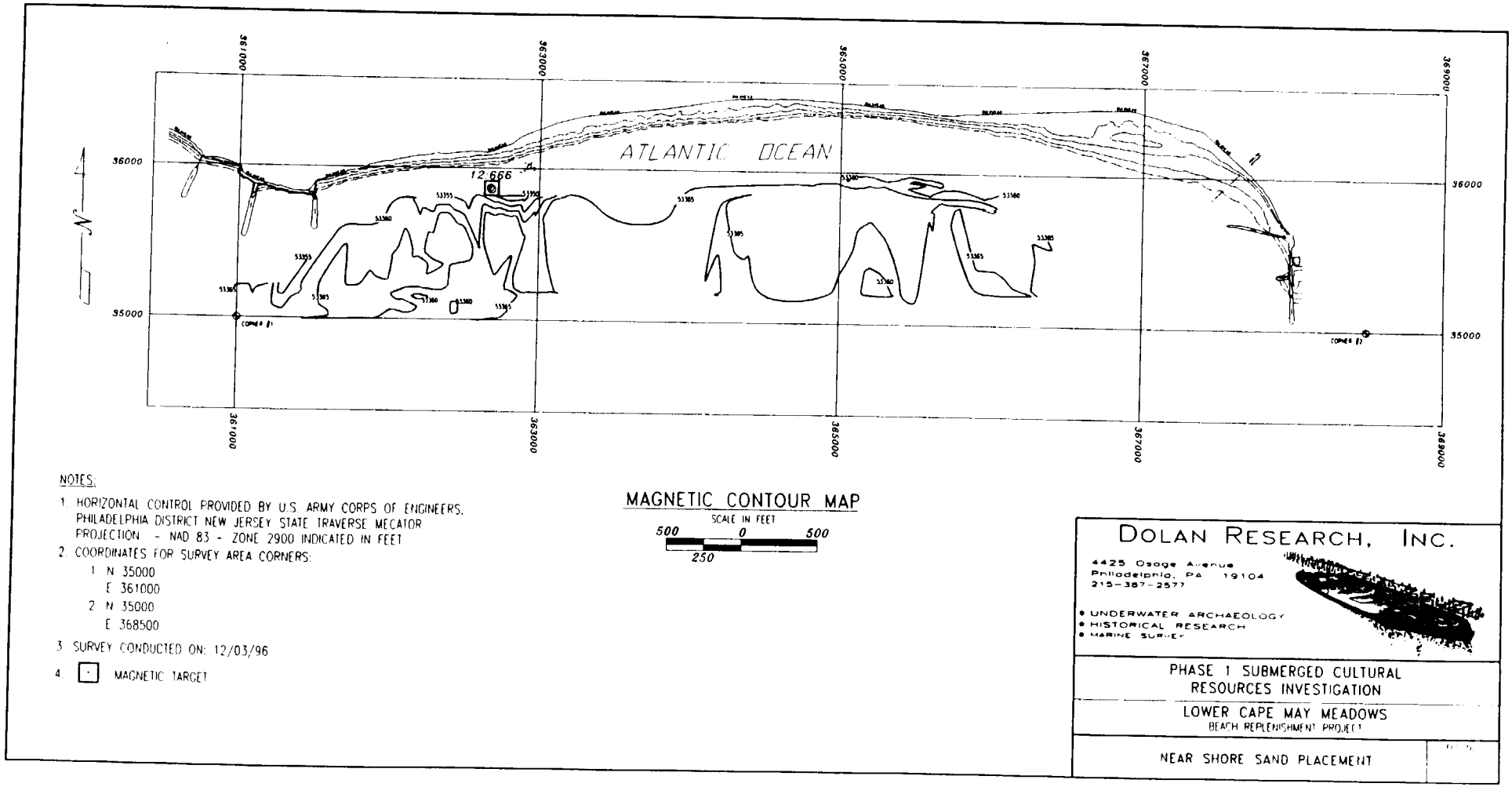

Figure 6.3. Near-shore Sand Placement Area, Magnetic Contour Map.

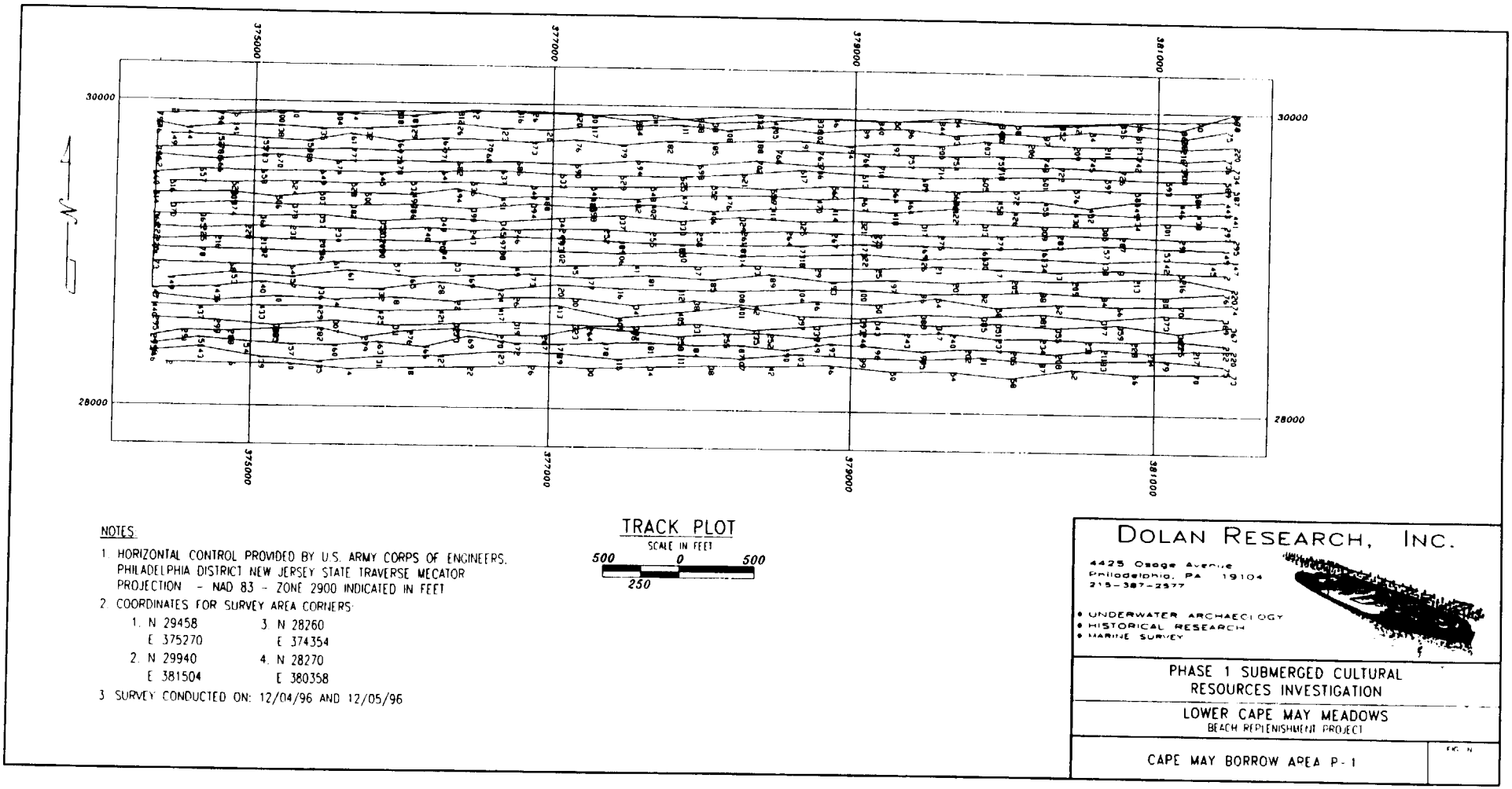

Figure 6.4. Cape May Borrow Area P-1, Tract Plot.

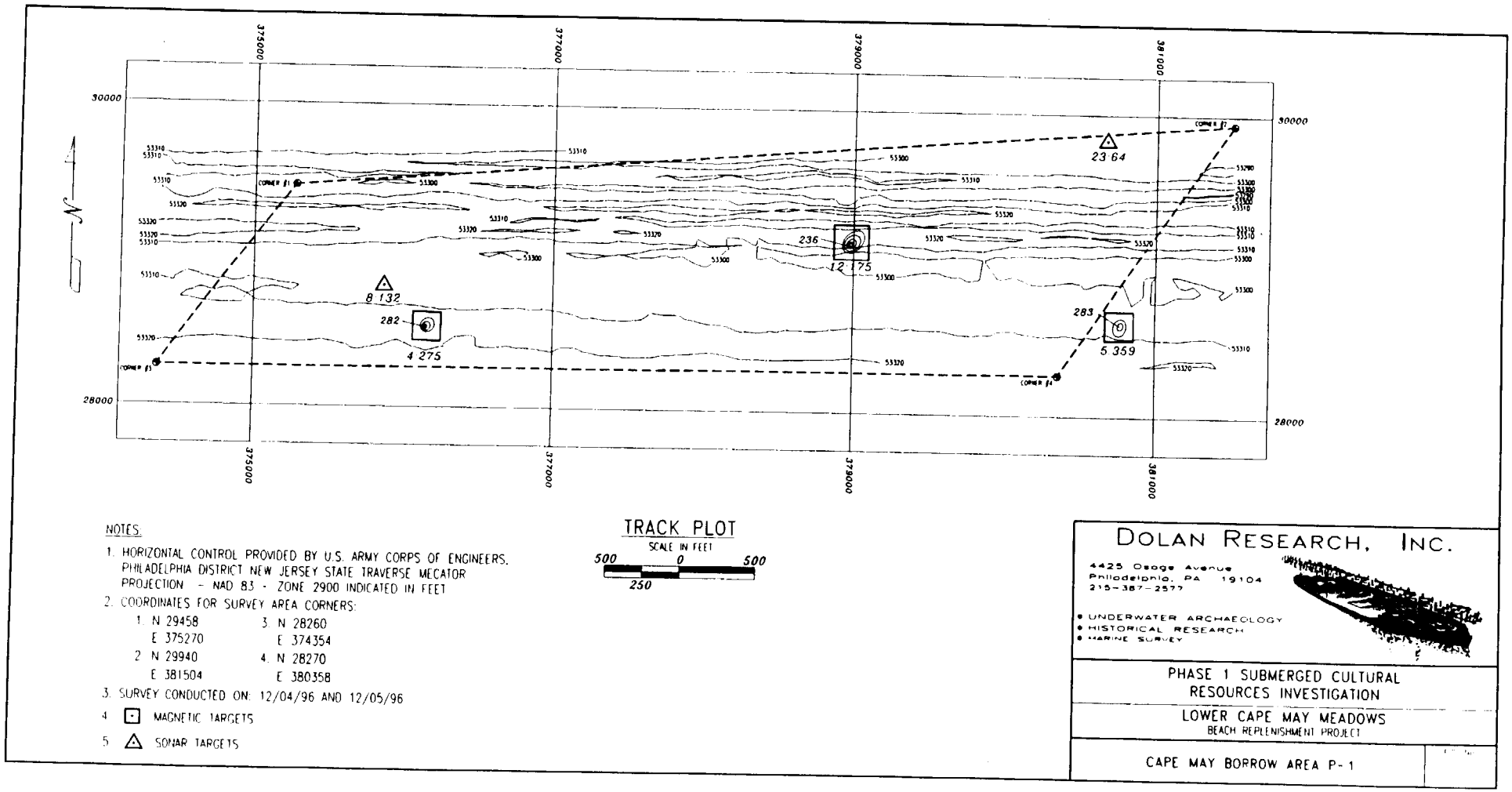

Figure 6.5. Cape May Borrow Area P-1, Magnetic Contour Map.

located just outside the eastern end of the borrow area. The lack of signature intensity and dispersion indicates an isolated object. No further archaeological investigation is recommended at this target location.

Target #: 8:132

A hard, linear object, possibly a pipe, was detected during Lanes 6, 7, and 8, near the west center of Borrow Area P-1. There was only a slight magnetic variation at the target location. The modern object appears to be isolated. No further archaeological investigation is recommended at this target location.

Target #: 12:175

Evidence of the magnetic signature of this target was only detected in Lane 12. The negative, monopolar signature had a maximum distortion of 42 gammas that was detected over four sample intervals. There was no associated acoustic image at the target location, indicating that the material responsible for generating the magnetic signature is buried beneath the bottom surface. The target is located near the east center of the borrow area. The lack of signature duration and dispersion indicates an isolated object. No further archaeological investigation is recommended at this target location.

Target #: 23:64

A hard, round object, was detected during Lanes 21, 22, and 23, near the northeast corner of Borrow Area P-1. There was only a slight magnetic variation at the target location. The object is approximately four feet in diameter and appears to be isolated. No further archaeological investigation is recommended at this target location.

c). Borrow Area P-2

Borrow Area P-2 comprised a 150-acre "L-shaped" area within which 27 survey lanes were completed (Figure 6.6). Analysis of the remote sensing data confirmed the existence of three targets in Borrow Area P-2 (Figure 6.7). Two of the targets, 7:259, and 7:257 may be associated with the same object(s). All three of the targets generated signature characteristics suggestive of modern debris.

High Probability Targets

None

Other Targets

Target #: 7:257

Evidence of the magnetic signature of this target was only detected in Lane 7. The positive, monopolar signature had a maximum distortion of 24 gammas that was detected over four sample intervals. Side-scan sonar records of the target location confirm the presence of a section of cable or small diameter pipe that is partially buried on the bottom. This target may be associated with the magnetic anomaly identified at Target 7:259. No further archaeological investigation is recommended at this target location.

Target #: 7:259

Evidence of the magnetic signature of this target was only detected in Lane 7. The positive, monopolar signature had a maximum distortion of 22 gammas that was detected over three sample

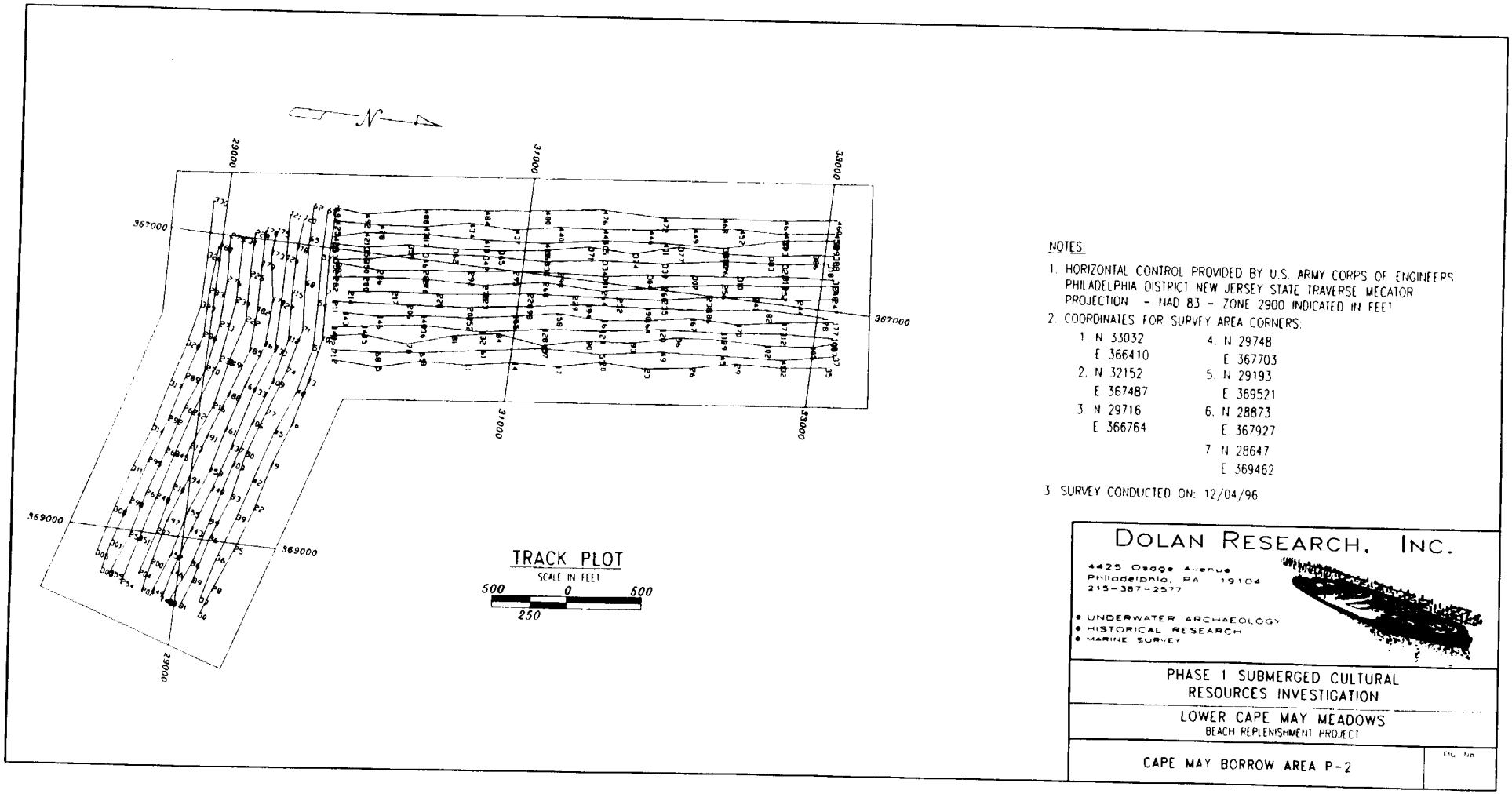

Figure 6.6. Cape May Borrow Area P-2, Tract Plot.

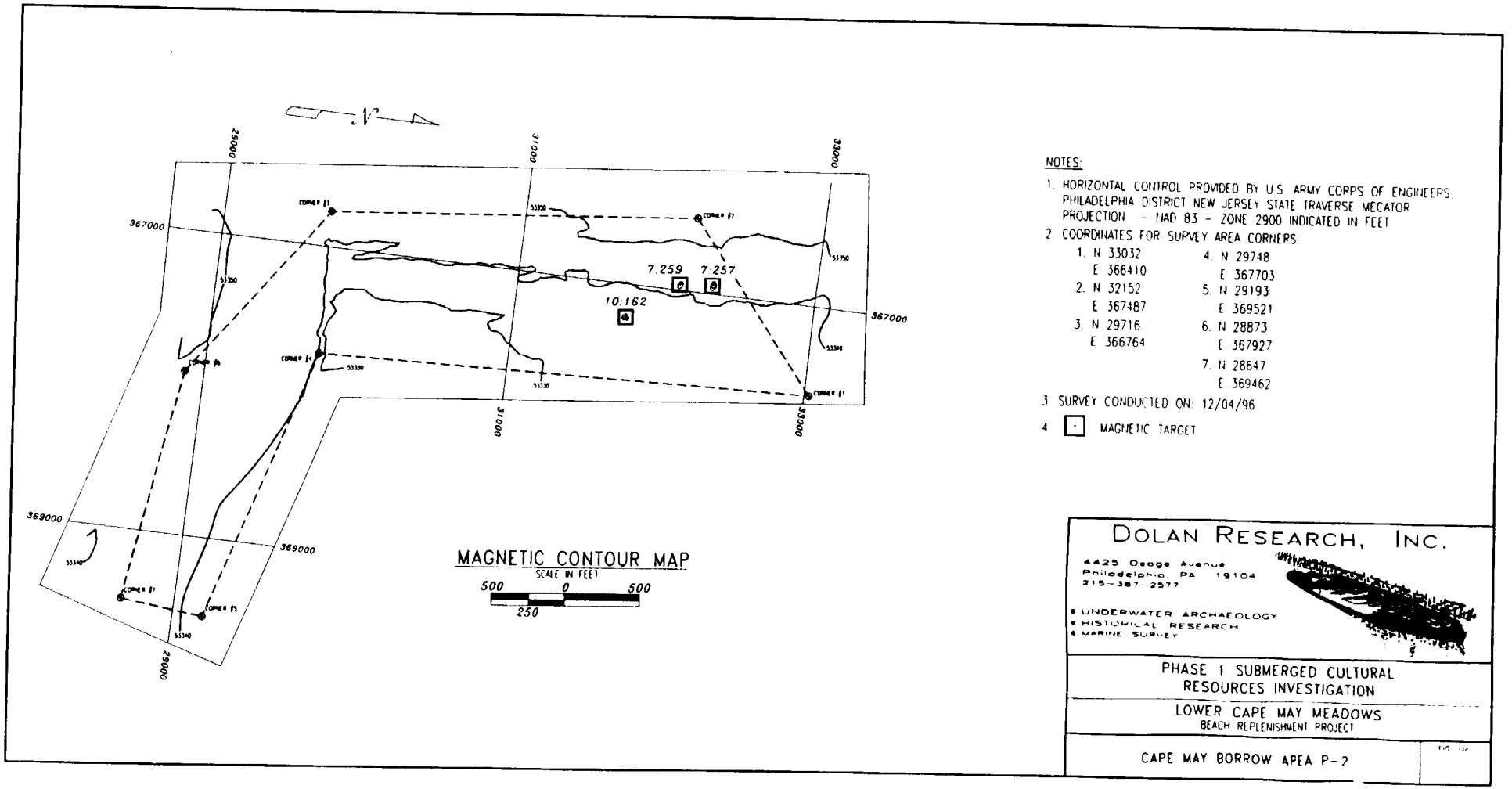

Figure 6.7. Cape May Borrow Area P-2, Magnetic Contour Map.

intervals. There was no associated acoustic image at the target location, indicating that the material responsible for generating the magnetic signature is buried beneath the bottom surface. This target may be associated with the cable/pipe identified at 7:257. No further archaeological investigation is recommended at this target location.

Target #: 10:162

Evidence of the magnetic signature of this target was only detected in Lane 10. The positive, monopolar signature had a maximum distortion of 22 gammas that was detected over four sample intervals. Side-scan sonar records of the target location confirm the presence of a manmade object, approximately ten feet long and shaped like a float for a section of dredge pipe. The object is isolated on the sandy bottom. No further archaeological investigation is recommended at this target location.

CHAPTER 7

EVALUATION, IMPACT ASSESSMENT AND RECOMMENDATIONS

As throughout the main body of this report, this chapter maintains a distinction between submerged and shoreline terrestrial resources (i.e., prehistoric and historic resources that were formed on land and have since, in some cases, been inundated by water or sediment as a result of rising sea level and other offshore erosive and depositional activity) and underwater resources (i.e., resources such as shipwrecks, downed airplanes or jetties, whose original formation occurred in a marine environment). Both types of resources are a potential issue in the proposed shoreline survey area and the near-shore sand placement area; underwater resources are the principal concern within the proposed borrow areas, although there also exists some potential for inundated prehistoric resources in these zones.

A. Submerged and Shoreline Terrestrial Resources

During the period of prehistoric and historic human activity in the Mid-Atlantic region, which extends over the past 15,000 years or so, this stretch of New Jersey's Atlantic coast shoreline between Cape May City and Cape May Point has experienced ongoing and increasing inundation as a result of rising sea level and erosion. For the most part, inundation has been accompanied by accumulation of sediments on the ocean floor, although offshore scouring and shifts in littoral drainage has produced local erosional effects. Cultural resources that were originally formed on land may now therefore lie buried beneath variable depths of beach sediment in the Atlantic Shore Zone. Alternatively, they may also have been eroded through natural forces, such as water or wind action, or through human agency such as dredging.

1. Prehistoric Resources

It is extremely difficult to reconstruct in detail the past natural environment (topography, drainage, soils, flora and fauna) and land use history of the dynamic New Jersey shore environment and thereby derive an accurate assessment of prehistoric archaeological potential. The work of Kraft and others studying the geomorphology of the Delaware coastline is a valuable aid in understanding the processes that are at work and providing a hypothetical model for predicting cultural resource occurrence (see above, Chapter 3). However, testing such a model and reconstructing the geomorphology and geoarchaeology of any given section of inundated terrain within the Atlantic Shore Zone would require extensive and systematic bathymetrically-referenced sampling of beach sediments, a task that is well beyond the scope of the current investigation. For this reason, it is not possible to offer a definitive evaluation of prehistoric archaeological potential for the Cape May City to Cape May Point tidal zone on the basis of the research conducted to date.

Although the westernmost tip of the Cape May peninsula has been identified as a significant prehistoric site (see Chapter 3), no evidence of prehistoric occupation or utilization of the current survey area, a short distance to the east, has been previously reported. Nor has any such evidence been identified by the present survey. Since the tidal zone and shoreline are to be "nourished" through the deposition of additional sand, buried prehistoric land surfaces and associated cultural resources, if these still exist, should receive additional protection as a result of the proposed project action. There would not appear, therefore, to be any need to sample sediments along the tidal

zone or shoreline in conjunction with the present project. No further prehistoric archaeological study is recommended for the shoreline and tidal zone segment of the study area.

2. Historic Resources

Within or immediately adjacent to the shoreline, various historic cultural resources have been noted on historic maps and/or identified during field inspection (Figure 6.1; Table 7.1). On this basis, the survey area was considered hold some potential for containing significant early historic terrestrial (as opposed to underwater) cultural resources. In addition to more transient activities, such as hunting and fishing, and the occasional loading and unloading of vessels traversing this section of New Jersey's Atlantic coast prior to the mid-19th century, Cape May Point also saw the construction of two lighthouses prior to 1850. The first lighthouse, a 68-foot-tall brick tower on a stone base constructed in 1822, stood approximately 150 feet south of the terminus of the Whilden Avenue jetty. This location is situated approximately 500 feet west of the Nearshore Sand Placement Area and is presently submerged beneath approximately 12 to 14 feet of water. Even if remains have survived the pounding of the surf for the 150 years which have elapsed since the lighthouse base slipped beneath the waters of the Atlantic, this resource is located outside the sand placement area and there is no need for further investigation in conjunction with the current project.

The second Cape May lighthouse [Cultural Resource 12], however, constructed in 1847, stood on what is now the beach front and tidal zone of Cape May Point State Park within the terrestrial survey area. Stone and brick rubble believed to be associated with this structure were documented during the course of this survey, although no *in-situ* foundations were observed. Many feet of soil have eroded from this location, but it can be assumed that the base and foundations of the 78-foot-tall lighthouse would have extended a considerable distance below the ground surface. Substantive remains of this structure could therefore still lie preserved beneath the sands of the beach. Technically, this Phase I-level study has identified a location where potentially eligible historical archaeological resources may survive and one would normally recommend supplementary Phase II-level investigation to fully evaluate the integrity and significance of this site. Under the circumstances, however, since the project actions will involve the placement of sand over the resource, thereby enhancing the preservation of archaeological data, this consultant feels there is no real need for further study. It is recommended that sand be placed along this section of the beach with particular care so as not to disturb possible remains buried beneath the beach. The location of the lighthouse site should also be clearly recorded, not only for the purpose of the sand placement work, but also for future reference, in the event of a resumption of shoreline erosion and renewed exposure of the lighthouse foundations.

The final early historic resource known to have existed within the bounds of the survey area was located on the beach to the southeast of St. Mary's By The Sea [Cultural Resource 17]. In the early 20th century, a few surviving sections of an early corduroy road [Cultural Resource 18] were exposed by a storm. The road, surrounded on both sides by peat beds imprinted with the hoof prints of horses and cattle, has since either eroded into the ocean or has been covered by Cape May Point's tall stone sea wall. Although other submerged sections of the feature may survive in the Nearshore Sand Placement Area (and would be protected by beach nourishment), they are more likely to have been washed away by the gradually transgressing ocean. In the opinion of the consultant, this resource -- if indeed it survives -- has probably lost all integrity and would no longer meet the criteria for inclusion in the National Register of Historic Places. No further investigation is felt to be necessary.

TABLE 7.1.
SUMMARY OF CULTURAL RESOURCES IDENTIFIED WITHIN THE ATLANTIC COAST TIDAL ZONE BETWEEN CAPE MAY CITY AND CAPE MAY POINT, CAPE MAY COUNTY, NEW JERSEY
(See Figure 6.1 for Locations of Resources)

CULTURAL RESOURCE TYPE	LOCATION	DOCUMENTARY REFERENCE	FIELD EVIDENCE	EVALUATION
1. Magnetic Target	Beach opposite the end of 16th Ave.	None	Small ferrous anomaly	Not eligible; no further study required
2. Magnetic Target	Beach to east of Battery #223	None	Small ferrous anomaly	Not eligible; no further study required
3. Cape May City West Jetty	At southern terminus of Cape May City Boardwalk	Cape May USGS 1972	Extant	Not eligible; no further study required
4. Remains of Wooden Jetty or Sea Wall	Beach near Cape May City	None	Pilings	Not eligible; no further study required
5. Cape Island Creek Drainage Pipe	Beach near Cape May City	None	Extant	Not eligible; no further study required
6. Town of South Cape May	Between 13th and 16 Avenues, Approximately 600' South of Beach	National Ocean Service 1944	No remains identified	Not eligible; no further study required
7. Mount Vernon Avenue	Between Cape May City and Cape May Point, approximately 600 feet south of beach	National Ocean Service 1944	No remains identified	Not eligible; no further study required
8. Delaware Bay and Cape May Railroad/Cape May Point Trolley Tracks	Between Cape May City and Cape May Point, approximately 600 feet south of beach	Vermeule 1889	Railroad spike	Not eligible; no further study required
9. Delaware Harbor Defense Battery #7	Cape May Point State Park, east of bunker, approximately 50 feet south of beach	Files of Cape May Point State Park	No remains identified	Full evaluation not possible; beneficial project effect; diving, probing and possible HABS/HAER recording
10. Delaware Harbor Defense Batteries #223 and 26 (Cape May Point Bunker)	In tidal zone of Cape May Point State Park	Files of Cape May Point State Park	Extant	Eligible; beneficial project effect; HABS/HAER recording; stabilization through sand placement
11. Cape May Point Coast Guard Station	100 feet off-shore from Cape May Point State Park Beach, west of bunker	Bailey 1990	No remains identified	No evaluation offered; no further study required

TABLE 7.1. (Cont.)
SUMMARY OF CULTURAL RESOURCES IDENTIFIED WITHIN THE ATLANTIC COAST TIDAL ZONE BETWEEN CAPE MAY CITY AND CAPE MAY POINT, CAPE MAY COUNTY, NEW JERSEY

CULTURAL RESOURCE TYPE	LOCATION	DOCUMENTARY REFERENCE	FIELD EVIDENCE	EVALUATION
12. Second Cape May Lighthouse	In tidal zone of Cape May Point State Park to west of bunker	Bailey 1990	Possible remains identified	Potentially eligible; beneficial project effect; no further study required
13. Radio Tower Supports	Beach to west of bunker, Cape May Point State Park	Files of Cape May Point State Park	Extant	Eligible; beneficial project effect; no further study required
14. Various World War II-era Structures	Beach to west of bunker, Cape May Point State Park	Files of Cape May Point State Park	No remains identified	No evaluation offered; no further study required
15. Cape May Lighthouse Complex	Off Lighthouse Road to the north of survey area	Bailey 1989	Extant	Listed on the National Register of Historic Places (11/12/73) and the New Jersey Register of Historic Places (6/15/73); outside survey area; beneficial project effect; no further study required
16. World War II-era Buildings of Cape May Point State Park	Cape May Point State Park to north of survey area	Files of Cape May Point State Park	Extant	Eligible; outside survey area; beneficial project effect; no further study required
17. St. Mary's By The Sea	Corner of Leigh and Lincoln Avenues, Cape May Point, north of survey area	Clio Group 1986	Extant	Eligible; outside survey area; beneficial project effect; no further study required
18. Corduroy Road	Beach to east of St. Mary's	Files of Cape May County Historical Society	No remains identified	No evaluation offered; no further study required
19. Queen Anne Cottages	West side of Leigh Avenue to north and west of survey area	Clio Group 1986	Extant	Eligible; outside survey area; beneficial project effect; no further study required
20. Cape May Point East Jetty	Beach opposite St. Mary's	Cape May USGS 1972	Extant	Not eligible; no further study required

With the exception of the resources described above, the potential, overall, for early historic resources being encountered along the beach during beach nourishment activities is considered to be slight. The tide line has shifted several hundred feet inland and wave action has removed as much as six feet of soil from atop the area which presently forms the beach front. During the historic era, most of this area was occupied by undeveloped marshland and meadow. Thus, it can be said with some certainty that is highly unlikely that any other early historic features would still survive within the terrestrial portion of the study area. In the opinion of the consultant, no further field investigation into early historic resources is warranted. In the unlikely event that additional early historic remains are unexpectedly encountered during the placement of sand on the beach, it is suggested that provision be made for such resources to be inspected, recorded and evaluated by a qualified archaeologist.

Although Cape May City and Cape May Point developed into shore resort communities during the second and third quarters of the 19th century respectively, the shoreline between the two resorts has remained largely undeveloped to this day. Most of the area which is presently beach front was meadow and tidal marsh until the 1960s. Between 1880 and 1950, the community of South Cape May [Cultural Resource 6] occupied the eastern section of this beach on lands which have since been eroded into the sea. The site of this town is presently located approximately 600 feet south of the low tide mark below three to six feet of water. No evidence of this town was found during the terrestrial survey or by the remote sensing survey of the Nearshore Sand Placement Area.

Other late 19th/early 20th-century development of the beach front included the construction of Mount Vernon Avenue [Cultural Resource 7] and a trolley/light rail line [Cultural Resource 8] which ran along the beach front connecting Cape May City with Cape May Point. Like the town of South Cape May, these resources had eroded into the sea by the 1950s. During the survey, no evidence of Mount Vernon Avenue was detected. A single railroad spike was recovered from the beach to the south and east of St. Mary's By The Sea near a point at which the trolley tracks would have turned to the north and entered the Town of Cape May Point. Because of the degree to which these resources have been subjected to the volatile and violent actions of the sea, it would be considered highly unlikely that any significant archaeological remains would survive intact beneath the ocean's surface. No further investigation of these resources is deemed necessary.

The largest group of historic remains identified by the terrestrial field survey are those associated with the World War II-era fortifications (Delaware Harbor Defenses Batteries #s 223 and 26) [Cultural Resource 10] at the mouth of the Delaware Bay. These remains are significant under National Register criteria A, C and D for their association with the most important global military conflict of the 20th century. They are contextually linked both with the other surviving World War II-era buildings [Cultural Resource 16] on the grounds of the Cape May Point State Park, the sites of other destroyed structures, now offshore [Cultural Resources 9 and 14], the sites of other destroyed World War II-era structures elsewhere within Cape May County (most notably the lookout tower at Sunset Beach), and with the complex's sister facility, Fort Miles, at Lewes, Delaware.

It is recommended that some level of recording be undertaken for those extant elements of the Delaware Harbor Defense Batteries within the survey area to provide a conditions benchmark for their future preservation and treatment. Specifically, all World War II-era defensive features located in the tidal zone in the vicinity of Coastal Defense Battery #7 [Cultural Resource 9] and the Cape May Point Bunker (including the extant remains Battery #223 [the bunker and twin six-inch gun mounts] and Battery #26 [Cultural Resource 10] should be documented through detailed recording following HABS/HAER standards. This phase of work should include the preparation of detailed

plans and drawings and photography which will serve not only to provide a historic record of these resources, but will also pinpoint their exact location and condition in the event of future digging on the site. In the case of Defense Battery #7, an emplacement consisting of four 90-millimeter guns mounted in 1943, any recording will need to be preceded by a diving and probing investigation to determine whether or not intact remains still survive. The site of this installation is presently located sufficiently far from the beach that it was not fully observable during the pedestrian survey and was too close to the beach to allow for safe navigation in conjunction with the Nearshore Sand Placement Area underwater remote sensing activities.

The process of beach nourishment, if undertaken with due care, should prove to be nothing but advantageous to the long-term preservation of the World War II-era features within the survey area. Indeed, beach replenishment presents the opportunity to help stabilize the structurally-threatened Cape May Point Bunker. Presently, the bunker rests solely and somewhat precariously upon its wood pilings. Due to the erosion of sand, these pilings are exposed to significant wear from the action of the surf. Beach nourishment in the area of the bunker should include the deposition of sufficient sand as is necessary to restabilize the base of the bunker and protect the structurally important pilings from additional wear. Extreme care should be taken to insure that the process does not in any way impact the structural integrity of the bunker. This action would also help to return the bunker to its historic context by partially restoring its historic relationship to the ground surface and the water.

Other 20th-century resources identified in the course of this survey included three jetties [Cultural Resources 3, 4 and 20] and the drainage pipe at Cape Island Creek [Cultural Resource 5]. None of these features are considered National Register-eligible resources due to their relatively late dates and limited historical significance.

Two small, isolated magnetic targets [Cultural Resources 1 and 2] were identified during the terrestrial remote sensing survey along the beach between Cape May City and Cape May Point. However, at each target location, a lack of signature intensity and dispersion indicates a small, isolated ferrous object. Both targets were located near the high tide water level of the beach: one target [Cultural Resource 1] was immediately below an access path through the dunes for off-road vehicles; and the second target [Cultural Resource 2] was located slightly east of the World War II-era battery [Cultural Resource 10]. No further archaeological investigation is recommended at either target location.

Several significant resources were identified neighboring but not within the survey area. Those not already discussed in this chapter include the substantial remains within Cape May Meadows of salt hay farming activities, St. Mary's By The Sea Convent (Shoreham Hotel) [Cultural Resource 17], the Queen Anne Cottages [Cultural Resource 19] on Leigh Avenue and the Cape May Lighthouse, oil house and tender's house [Cultural Resource 15] (see Chapter 1). None of these resources would be negatively affected by the replenishment of the Cape May shoreline. In fact, the reconstruction of the beach would improve the historic character of many of these resources and help to physically buffer them from additional erosion and flooding.

B. Underwater Resources

Background research confirms European maritime activity along the New Jersey Atlantic coast from at least as early as the first quarter of the 17th century. English, Dutch (and to a lesser extent Scandinavian) sailors were the first Europeans to explore the region during this period and were also the first to extensively traverse the waterways of the interior while establishing settlements in the present-day states of Pennsylvania, New Jersey and New York. This local maritime activity was very limited in

scope, however, and the vast majority of shipping activity within the offshore study areas was almost exclusively transient (i.e., coastal). Vessels crossing the study areas were participating in the network of coastal trade that linked the Delaware Bay ports and New York with other ports from Maine to Texas. International maritime traffic was also present in the project vicinity and involved shipping passing from the eastern seaboard to ports in the Caribbean and Central and South America. Much of this coastal traffic, when caught in heavy seas and bad weather deliberately sought shelter in the Delaware Bay.

As a result of the extensive historic maritime activity offshore of New Jersey's Atlantic coast, a wide variety of underwater resources may be anticipated in the vicinity of the study areas. The proposed dredging of the two offshore sand borrow areas and subsequent beach replenishment could threaten potentially significant underwater resources that have been deposited in the immediate project vicinity, if these were found to survive.

Comprehensive remote sensing survey of the Nearshore Sand Placement Area and proposed Borrow Areas P-1 and P-2 using magnetic, acoustic and bathymetric instrumentation resulted in the identification of nine targets. However, none of the nine targets exhibited remote sensing signatures suggestive of submerged cultural resources. Eight of the targets identified displayed signature characteristics typical of modern debris, or single, isolated objects lying on the bay floor. Target 12:666 identified within the Nearshore Sand Placement Area appears to be a jetty associated with the derelict World War II-era battery [Cultural Resource 10] that now lies in the ocean. No additional underwater archaeological investigation is recommended at these nine target locations.

C. Summary

In summary, the conclusions and recommendations from these Phase I submerged and shoreline cultural resources investigations are as follows:

1. The potential for significant submerged prehistoric terrestrial resources within the sand borrow areas is unclear, in large part because detailed reconstruction of the paleoenvironment is not possible at this level of study. There is a negligible potential for submerged historic terrestrial resources within the borrow areas because they were inundated throughout the historic period.

2. A program of controlled, periodic archaeological monitoring of the renewed beach surface is recommended during and immediately following the replenishment operation to check for archaeological materials originating in the offshore sand borrow material.

3. No evidence of prehistoric archaeological resources was noted within the terrestrial survey area during these studies. No further pre-project investigation of prehistoric resources in the tidal zone or along the shoreline is considered necessary within the shoreline survey area, since deposition of sand will enhance preservation of buried resources (if indeed these exist below ground).

4. The only early historic remains of concern identified by the terrestrial survey were the remains of the second Cape May Lighthouse erected in 1847. The

archaeological integrity of these potentially significant remains is open to question and further Phase II-level study would be required to clarify this issue. However, since the placement of additional sand on the beach will have a preservation-enhancing effect on buried remains, no further study is felt to be appropriate in this instance. The site should be clearly recorded for future reference and sand placement should be undertaken with particular care in this location.

5. Various above-ground structures and structural remains (chiefly, buildings, gun emplacements and jetties) dating from the early to the late 20th century have been identified within the shoreline survey area. Most of these cultural features are not considered historically significant, although the remains of World War II-era defensive installations are notable exceptions. The World War II-era bunker and the related gun emplacements are eligible for the National Register under Criterion A, C and D. Therefore, it is recommended that a program of thorough documentation in accordance with HABS/HAER standards be undertaken to record these features before the sand placement occurs. Beach nourishment plans should include an allowance for sufficient sand deposition in order to help stabilize the bunker and protect the supporting pilings from additional wear. Care should be taken not to damage or remove these historic features during the placement of sand.

6. Nine magnetic underwater targets have been identified in the Nearshore Sand Placement Area the two offshore sand borrow areas. However, none of the nine target exhibited remote sensing signatures suggestive of submerged cultural resources. No further investigation of submerged remote sensing targets at either of the three survey locations is considered necessary.

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APPENDIX A

LIST OF DOCUMENTED SHIPWRECKS IN THE PROJECT VICINITY

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LIST OF DOCUMENTED SHIPWRECKS IN THE PROJECT VICINITY

As part of the program of historical research, several shipwreck lists were consulted to develop a framework for assessing potential submerged cultural resource types in the vicinity of the shoreline survey areas and the potential borrow areas.

The following wrecks are listed in Historical and Biographical Atlas of the New Jersey Coast (Woolman, Price and Rose 1878); Shipwrecks of New Jersey (North 1963); Shipwrecks off the New Jersey Coast (Krotee and Krotee 1965); Shipwrecks of New Jersey (Gentile 1988); and Shipwrecks of New Jersey: 656 Wreck Sites from Sandy Hook to Cape May (Harnick 1993).

Many of the wrecks, particularly the more modern accidents that occurred in or near inlets, were subsequently salvaged or removed because they were threats to safe navigation. Others almost certainly became quickly buried in the rapidly shifting sand patterns typical of high energy coastal.

Name	Date	Comments
Seneca	1744	Ship lost at Cape May on December 16.
Prosperity	1745	Ship lost at Cape May on January 1.
Two Sisters	1748	Ship lost at Cape May on December 29.
Edinburgh	1755	Ship became a total wreck near Cape May on October 20.
Planter	1765	Ship lost at Cape May on August 15.
Content	1769	Ship lost at Cape May in September.
Kingston	1769	Ship lost at Cape May in September.
Hope	1769	Ship lost at Cape May in September.
Chance	1771	Ship lost at Cape May on February 17.
Joseph W. Pharo	1856	Schooner lost on Cape May Beach.

APPENDIX A (Cont.)

LIST OF DOCUMENTED SHIPWRECKS IN THE PROJECT VICINITY

Name	Date	Comments
Shetucket	1870	Ship from Philadelphia and bound for New York, laden with coal and guano, came ashore at Cape May on January 18.
Silver Spray	1872	Sloop from Virginia and bound for Islip, L.I., laden with oysters wrecked on the Cape May shore on December 23.
John Stradley	1876	Ship wrecked near Cape May on March 26 and was a total loss.
Corinne	1877	Ship lost near Cape May on February 28.
Cordova	1877	Schooner from Philadelphia, laden with coal, went ashore at Cape May Inlet on May 8 and was a total loss.
Hornet	1883	Ship became a total wreck near Cape May on September 5.
Rhodella Blew	1884	Ship became a total wreck near Cape May on March 26.
Hippodrome	1886	Ship became a total wreck near Cape May on November 17.
Sallie C. Norton	1888	Schooner lost trying to enter shoal surrounding Cape May Channel on October 10.
W. S. Jordan	1902	Ship lost near Cape May.
Clarella II	1930	Ship lost near Cape May on September 4.
St. Augustine	1944	Ship sank near Cape May on January 6.

APPENDIX B

RESUMES

J. Lee D. Cox Jr.

Curriculum vitae

Address
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Date of Birth
June 24, 1959

OCCUPATION: Maritime Archaeologist

EDUCATION: East Carolina University, Greenville, N.C.
Maritime History and Underwater Research
M.A. Degree; May, 1985

Duke University, Durham, N.C.
Major; Anthropology/Archaeology
B.A. Degree; May 1981

EXPERIENCE: Career Related

June-July, 1994 — Principal Investigator in the Phase I and II underwater archaeological project in the Delaware Bay and River. The multi-faceted investigation, which was associated with the Delaware Comprehensive Navigation Project, included remote sensing of four sand borrow areas, the ground truthing of eleven targets near the shipping channel, and the Phase II investigation of two wreck sites in the river. Work was completed for Hunter Research and the Army Corps of Engineers, Philadelphia District.

March, 1994 — Principal Investigator in a Phase I underwater archaeological investigation in Vines Creek, near Dagsboro, Sussex County, Delaware. Work was completed for Hunter Research.

October, 1993 — Principal Investigator in a Phase I underwater archaeological investigation completed in conjunction with the Fort Mott (N.J.) Pier Rehabilitation Project. Work was completed for Hudson Engineers.

October, 1993 — Principal Investigator in a Phase I underwater archaeological remote sensing survey across Mantua Creek. Project was undertaken in conjunction with the proposed placement of a 30-inch force sewer main under the creek and adjacent tidal marsh. Work was completed for the Gloucester County Utilities Authority.

September, 1993 — Principal Investigator in a Phase I underwater archaeological and bathymetric remote sensing survey at two proposed sand borrow areas in the Atlantic Ocean, offshore of Delaware's Atlantic Coast. Work was completed for the Army Corps of Engineers, Philadelphia District.

August, 1993 — Archaeologist in a data recovery project on the shore of the Savannah River. Three vessels, including a center-board vessel, were excavated in conjunction with navigational improvement of the Savannah River. Work was completed for Mid-Atlantic Technology and the Army Corps of Engineers, Savannah District.

June-July, 1993 — Principal Investigator in the Phase I and II underwater archaeological project in the Delaware Bay and River. The investigation, which was associated with the Delaware Comprehensive Navigation Project, focused on selected channel

deepening areas, channel side slope portions, and turns between various channel ranges. Five previously identified targets were also investigated. Work was completed for The Greeley-Polhemus Group and the Army Corps of Engineers, Philadelphia District.

April-May, 1993	Principal Investigator in a Phase I underwater archaeological survey in Great Egg Harbor Inlet, Ocean City, New Jersey. Work was completed for the Army Corps of Engineers, Philadelphia District, in conjunction with an on-going beach replenishment project.
March, 1993	Archaeologist in a Phase II underwater archaeological investigation of remote sensing targets at the mouth of the Cape Fear River, North Carolina. Work was completed for Tidewater Atlantic Research and the Army Corps of Engineers, Wilmington District.
December, 1992	Principal Investigator in a Phase I underwater archaeological survey in the Santee River, Georgetown County, South Carolina. Work was completed for Post, Buckley, Schuh, & Jernigan, and the South Carolina Department of Highways and Public Transportation.
November, 1992	Principal Investigator in a Phase I underwater archaeological survey in San Juan Harbor, San Juan, Puerto Rico. Work was completed for ArcheoMarine and the Army Corps of Engineers, Jacksonville District.
October, 1992	Archaeologist in a Phase I underwater archaeological survey in the Mississippi River, Prairie du Chein, Wisconsin. Work was completed for Tidewater Atlantic Research.
September, 1992	Archaeologist in a Phase I underwater archaeological survey in Aguadillo Harbor, Aguadillo, Puerto Rico. Work was completed for Mid- Atlantic Technology and the Army Corps of Engineers, Jacksonville District.
July, 1992	Principal Investigator in a Phase I underwater archaeological survey in the Stono River, Charleston, South Carolina. Work was completed in conjunction with the proposed completion of the Mark Clark Expressway.
July, 1992	Principal Investigator in a Phase I underwater archaeological survey in the Delaware River and Salem River, Gloucester County, New Jersey and New Castle County, Delaware. Work was completed for The Greeley-Polhemus Group and the Army Corps of Engineers, Philadelphia District.
June, 1992	Archaeologist in the Data Recovery Project at a mid-nineteenth century sloop rigged sailing vessel in the North East Cape Fear River, Wilmington, North Carolina. Work was completed for Tidewater Atlantic Research and the Army Corps of Engineers, Wilmington District.
May, 1992	Principal Investigator in a Phase I underwater archaeological survey in Rancocas Creek, Riverside, New Jersey. Work was completed for the Delran Sewerage Authority.
April, 1992	Principal Investigator in a Phase I underwater archaeological survey in the Delaware River, Gloucester County, New Jersey and Delaware County, Pennsylvania. Work was completed for Hunter Research and Sun Oil Company.
March, 1992	Principal Investigator in a Phase I underwater archaeological survey in the Delaware River, Gloucester County, New Jersey and New Castle County, Delaware. Work was completed for Keystone Cogeneration Systems.

January, 1992	Completed Statement of Historical Significance for the National Register Nomination Form of the U.S. Coast Guard Icebreaker Glacier. Work was completed for the U.S. Coast Guard.
December, 1991	Archaeologist in a Phase I remote sensing survey in Savannah River, Savannah, Georgia. Work was completed for Tidewater Atlantic Research and the Army Corps of Engineers, Savannah District.
December, 1991	Principal Investigator in Phase I underwater archaeological survey in Rancocas Creek, Riverside Park, New Jersey. Work was completed for the Delran Sewerage Authority.
November, 1991	Principal Investigator in Phase II Underwater Archaeological Investigation of three identified archaeological sites within the Burlington Coast Guard Station, Lake Champlain, Vermont. Work was completed for John Milner Associates and the United States Coast Guard.
October 1991	Archaeologist in a Phase I remote sensing survey at Brunswick, Georgia. Work was completed for Tidewater Atlantic Research and the Army Corps of Engineers, Savannah District.
September 1991	Archaeologist in Phase Ib underwater archaeological target investigation in Atlantic Ocean off Galilee, Rhode Island. Work was completed for Mr. Warren Reiss and AT&T.
September 1991	Archaeologist in Phase Ib target investigation in Atlantic Ocean adjacent to Beaufort Inlet, North Carolina. Initiated the documentation of a 19th century steamboat discovered in work area. Work was completed for Tidewater Atlantic Research and the Army Corps of Engineers, Wilmington District.
August 1991	Completed background research and compiled content outline for Liberty State Park's traveling exhibit on the New York/New Jersey Harbor Estuary. Work was completed for Van Sickle & Rolleri.
August 1991	Archaeologist in the data recovery project at the wreck site of a 19th century tug/tow boat on the bank of the Savannah River. After complete excavation, the hull and all surviving steam machinery was comprehensively documented. Upon completion of data recovery, the steam engine, drive shaft and propeller were all raised and removed from the hull for conservation and eventual display in a local museum. Work was completed for Tidewater Atlantic Research and the Army Corps of Engineers, Savannah District.
July 1991	Archaeologist in the Phase I remote sensing and diving survey in Tobago Harbor in an effort to locate 17th century French and Dutch shipwreck sites. Work was completed for the Trinidad & Tobago National Museum.
June 1991	Archaeologist in a Phase II investigation of two shipwreck sites in Lake Superior. An ROV was used to map and record the remains of the two vessels which rest in waters below 100 feet deep. A National Register Nomination was completed for one of the wreck sites. Work was completed for Tidewater Atlantic Research.
June 1991	Principal Investigator in Phase Ib Underwater Archaeological Investigation for the State Route 58, Clarksville Bypass Project, Kerr Reservoir, Clarksville, Mecklenburg County, Virginia. Project was completed by Dolan Research, Inc. for Harland Bartholomew & Associates and the Virginia Department of

Transportation.

May 1991	Archaeologist in a Phase I remote sensing survey adjacent to Beaufort Inlet, North Carolina. Work was completed for Tidewater Atlantic Research and the Army Corps of Engineers, Wilmington District.
April 1991	Principal Investigator in Phase Ib Underwater Archaeological Investigation for the Woodrow Wilson Bridge Improvement Study. Project was completed by Dolan Research, Inc. for DeLeuw, Cather & Company of Virginia and the Virginia Department of Transportation.
February-March 1991	Archaeologist in the mitigation of a nineteenth century derelict vessel in the Savannah River, Savannah, Georgia. Work was completed for GAI and the Army Corps of Engineers, Savannah District.
January 1991	Conducted historical research for Phase I archaeological investigation at Naval Weapon Station, Earle, New Jersey, and Naval Weapon Station, Charleston, South Carolina, in conjunction with Homeporting Study for AOE-6 ships. Work was completed for Tidewater Atlantic Research, Inc., and Turner, Collie and Braden, Inc.
December 1990	Archaeologist in Phase I Underwater Archaeological Survey of Foundry Cove, Cold Spring, New York. Work was completed for Tidewater Atlantic Research, in conjunction with Grossman & Associates, and the Environmental Protection Agency.
October 1990	Archaeologist in Phase I Underwater Archaeological Survey of the Cape Fear River, below Wilmington, North Carolina. Work was completed for the Army Corps of Engineers, Wilmington District, by Tidewater Atlantic Research.
August 1990	Archaeologist in Phase I Underwater Archaeological Survey of three potential borrow areas off of Sarasota and Venice, Florida. Work was completed for the Army Corps of Engineers, Jacksonville District, by Tidewater Atlantic Research.
July/September 1990	Archaeologist in the Phase I & II Underwater Archaeological Investigation of the Sheboygan, Wisconsin, waterfront. Excavation and site documentation was completed on a mid-nineteenth century schooner, identified during initial remote sensing survey. Work was completed for the city of Sheboygan by Tidewater Atlantic Research.
May 1990	Principal Investigator in the Phase I Underwater Archaeological Investigation for the MD 213 Relocated, Alternate N-1B Bridge across the Chester River, Chestertown, Maryland. Project was completed by Dolan Research for John Milner Associates and the Maryland State Highway Administration.
April 1990	Completed background historical and archaeological research in conjunction with the construction of a bridge for the U.S. Route 58, Clarksville Bypass, Mecklenberg County, Virginia. Research was completed by Dolan Research for John Milner Associates.
April 1990	Principal Investigator in the Phase I Underwater Archaeological Investigation at the Salem Maritime National Historic Site, Salem, Massachusetts. Project was completed by Dolan Research for Louis Berger Associates and the National Park Service.
March 1990	Principal Investigator in the Phase II documentation of a mid-nineteenth century centerboard sailing vessel in the Cohansey River, Bridgeton, New Jersey. Project was completed by Dolan Research for Alan Mounier, Archaeologist.

Jan. - April 1990	Directed historical research and planning for the interpretive exhibit at Fort Mott, NJ. In addition to producing historical data for the exhibition, information was compiled for a fort brochure which included a self guided tour. Project was completed by Dolan Research for Van Sickle and Rolleri.
Nov. 1989 - Jan. 1990	Archaeologist in the Phase I and II underwater archaeological investigation at nine proposed range light locations in the Chesapeake Bay. Project was competed by Dolan Research, in conjunction with Ocean Surveys, Inc.
August - Dec. 1989	Completed background research and preliminary planning on the proposed exhibition at the Philadelphia Maritime Museum on the topic of early history and formation of the United States Navy in Philadelphia. Work was completed by Dolan Research for the Philadelphia Maritime Museum.
August 1989	Principal Investigator in the Phase I underwater archaeological investigation in Rock Creek, Anne Arundel County, Maryland. Three areas within the creek water system were surveyed for submerged cultural resources. Project was completed by Dolan Research for Dames and Moore.
July 1989	Archaeologist in the Phase I underwater archaeological investigation at the Charleston Navy Base, Cooper River, Charleston, South Carolina. Project was completed by Tidewater Atlantic Research for the United States Navy.
June 1989	Archaeologist in the Phase I and II underwater archaeological investigation at South Shore, Milwaukee, Wisconsin. Project was completed by Tidewater Atlantic Research for the Milwaukee Sewerage Authority.
April 1989	Archaeologist in the Phase I investigation at Brown Shoal, Delaware Bay. Project was completed by Ocean Surveys, Inc. for the Corps of Engineers, Philadelphia District.
March 1989	Field Director in the Phase II underwater archaeological investigation for the proposed Route 58 Midtown Tunnel, Portsmouth and Norfolk, Virginia. Project was completed by John Milner Associates for the Virginia Department of Transportation.
March 1989	Archaeologist in the Phase II and III investigation of two mid-nineteenth century shipwrecks in the Atlantic Ocean, offshore Longbranch, New Jersey. Project was completed by Tidewater Atlantic Research for Alpine Engineering and the Corps of Engineers, New York District.
November 1988	Archaeologist in a Phase II underwater archaeological investigation in the Gulf of Mexico near Ship Island, Mississippi. Project was completed by GAI Consultants for the Army Corps of Engineers, Mobile District.
September 1988	Field Director for the Phase II and III underwater archaeological investigation at the mouth of Crosswicks Creek, Bordentown, NJ. Project was completed by Louis Berger and Associates for the New Jersey Department of Transportation.
September 1988	Archaeologist for East Carolina University's graduate fieldschool in Bermuda. Work completed included assisting the Bermuda Maritime Museum's excavation of the 1620 NOS Shipwreck.
July - Sept. 1988	Completed background research and planning for proposed exhibition at the Philadelphia Maritime Museum on the history of underwater exploration and research.

July 1988	Archaeologist in the Phase II and III underwater archaeological investigation at a colonial rice plantation canal at Litchfield Beach, South Carolina. The project was completed by Tidewater Atlantic Research for Steve Coggans and Associates.
June 1988	Archaeologist in the Phase I and II terrestrial investigation for cultural resources adjacent to Chocowinity Bay, Chocowinity, North Carolina. Work was completed by Tidewater Atlantic research for the Weyerhauser Corporation.
April 1988	Archaeologist in the Phase I investigation of the Savannah River, Savannah, Georgia. Work was completed by Tidewater Atlantic Research for the Corps of Engineers, Savannah District.
Apr. 1987-Mar. 1988	Guest Curator at the Philadelphia Maritime Museum for the exhibition, "Ironclad Intruder: U.S.S. MONITOR." The exhibition focused on the historical significance, mythic role and archaeological investigation of the MONITOR. In addition to planning and organizing the entire exhibition, the curator also edited the exhibition catalogue.
December 1987	Archaeologist in the Phase II investigation for the Grace Memorial Bridge replacement project in the Cooper River, Charleston, South Carolina. Work was completed by Tidewater Atlantic Research for the South Carolina Division of Highways.
Sept.- Oct. 1987	Principle Investigator in the Phase I investigation in the Delaware River. The project was completed by the Maritime Historical Institute for Corps of Engineers, Philadelphia District's Delaware Comprehensive Navigation Project. Sixteen specific areas were studied in the Delaware, Salem and Maurice Rivers.
August 1987	Archaeologist in the Phase II and III investigation in Pensacola Harbor, Florida. Work, completed by Tidewater Atlantic Research in conjunction with the Navy Experimental Dive Unit, Panama City, Florida, documented and mapped thirteen remote sensing targets identified by the Army Corps of Engineers, Mobile District.
August 1987	Principal Investigator for the Phase I and II Archaeological Investigation in Slaughter Creek, Dorchester County, Maryland. Project was completed by John Milner Associates for the Maryland Department of Transportation in conjunction with a planned bridge replacement project.
July 1987	Archaeologist working in conjunction with the Hampton Roads Naval Museum and the United States Navy's Mobile Diving and Salvage Unit, Little Creek, Virginia to document the remains of the Civil War Sloop of War CUMBERLAND. Documentation of the site was achieved with the *SHARPS* system (Sonic High Accuracy Positioning System).
June 1987	Archaeologist in the excavation of the War of 1812 Brig JEFFERSON, in Sacketts Harbor, Lake Ontario, New York. The project was funded in part by the National Geographic Society.
March 1987	Archaeologist in the Phase I survey assessing the potential for submerged cultural resources in conjunction with the proposed construction of a tunnel under the Elizabeth River, between Portsmouth and Norfolk, Virginia. Work was completed by John Milner Associates for the Virginia Department of Transportation.

August, Oct. 1986	Archaeologist in the Phase I investigation offshore of Ocean City, Maryland. The project was completed by Tidewater Atlantic Research for the Maryland Geologic Survey in conjunction with a proposed beach replenishment project.
July 1986	Principal Investigator in the Phase I, II and III investigation of Presque Isle Bay, Erie, Pennsylvania. The work, completed by the Maritime Historical Institute, was funded by a grant from the Pennsylvania Bureau for Historic Preservation, utilizing grant-in-aid funding from the Pennsylvania Division of Coastal Zone Management.
May - June 1986	Principal Investigator for the Phase III investigation of three shipwrecks in Pennsylvania waters. Two vessels in the Delaware River and one vessel in Misery Bay, Lake Erie, were documented. The work was funded by a grant from the Pennsylvania Bureau for Historic Preservation.
May - June 1986	Archaeologist in the Phase I underwater archaeological investigation in Long Island Sound, adjacent to New Rochelle, New York. Project was completed by Tidewater Atlantic Research for EBASCO.
April 1986	Principal Investigator for the Phase I investigation for submerged cultural resources in Delaware Bay. Work was completed for the Corps of Engineers, Philadelphia District.
March 1986	Principal Investigator for the Phase I and II investigation in Crosswicks Creek, Bordentown, New Jersey, in the vicinity of the right of way for a bridge span of I-295. In conjunction with a remote sensing survey in the creek, a site assessment of two eighteenth century wrecks was completed. The project was jointly funded by the Philadelphia Maritime Museum and the Pennsylvania Bureau for Historic Preservation.
December 1985	Archaeologist in the Phase I survey at Charleston, South Carolina. Work was completed by Tidewater Atlantic Research for the Corps of Engineers, Charleston District.
August 1985	Archaeologist in the Phase I and II underwater archaeological survey in the Potomac River at Alexandria, Virginia.
August 1985	Archaeologist in the Phase I and II survey in St. Michaels, Maryland, Harbor. The project was completed by Tidewater Atlantic Research for the Maryland Historic Trust.
July 1985	Principal Investigator for the Phase I and II investigation in Misery Bay, Lake Erie. The project was funded by the Pennsylvania Bureau for Historic Preservation and the Philadelphia Maritime Museum.
March 1985	Archaeologist in the Phase I survey offshore from Ocean City, New Jersey. The project was completed by Tidewater Atlantic Research for the Army Corps of Engineers, Philadelphia District.
December 1984	Archaeologist in the Phase I survey offshore from Kitts Hummock, Pickering Beach, Broadkill Beach and Bowers Beach, Delaware. Work was completed by Tidewater Atlantic Research for the Delaware Division of Soil and Water Conservation.
July 1984	Archaeologist representing the state of Pennsylvania during the Phase I and II underwater archaeological survey in Misery Bay, Lake Erie. The objective of the survey was to locate evidence of Oliver Perry's fleet from the War of 1812. The

Pennsylvania Bureau for Historic Preservation sponsored this project which was conducted jointly by the Philadelphia Maritime Museum and the United States Naval Reserve Mobile Diving and Salvage Unit II, Little Creek, Virginia.

May 1984 — Principal Investigator for the Phase I and II underwater archaeological survey in nine designated areas in the Delaware River. The work was funded by the Pennsylvania Bureau for Historic Preservation and the Philadelphia Maritime Museum and involved the participation of graduate students and personnel from East Carolina University.

June 1983 — Archaeologist in the Phase I and II underwater archaeological investigation in Wenona Harbor, Maryland. The project was completed by Tidewater Atlantic Research for the Maryland Geologic Survey.

October 1982 — Archaeologist in a Phase I and II underwater archaeological survey in the Chattahochie River at Columbus, Georgia. The investigation, completed by Tidewater Atlantic Research, was sponsored by the Confederate Naval Museum in an attempt to locate discarded ordnance from the Civil War.

GRANTS RECEIVED:

April 1986 — Wrote proposal and directed for the Maritime Historical Institute, the Presque Isle Bay Underwater Archaeological Survey. Funding for the project was made available by the Pennsylvania Bureau for Historic Preservation utilizing grant-in-aid funding from the Pennsylvania Division of Coastal Zone Management. A magnetometer and side scan sonar survey with diving investigations was completed in Presque Isle Bay, Lake Erie.

July 1985 — Wrote proposal and directed for the Philadelphia Maritime Museum a grant from the Pennsylvania Bureau for Historic Preservation which was designed to document and assess three shipwrecks in Pennsylvania waters to determine the archaeological and historical significance of each.

July 1984 — Wrote proposal and directed for the Philadelphia Maritime Museum a grant from the Pennsylvania Bureau for Historic Preservation which was designed to assess the potential presence of submerged cultural resources in the Monongahela, Ohio and Allegheny Rivers and the Lake Erie Shoreline.

July 1983 — Wrote proposal and directed for the Philadelphia Maritime Museum a grant from the Pennsylvania Bureau for Historic Preservation which was designed to assess the potential presence of submerged cultural resources in the Delaware and Susquehanna Rivers.

REPORTS:

February, 1994 — Submerged Cultural Resources Investigation Delaware Atlantic Coast From Cape Henlopen To Fenwick Island. Submitted to the Army Corps of Engineers, Philadelphia District.

January, 1994 — Submerged Cultural Resources Investigations, Delaware River Main Channel Deepening Project, Delaware, New Jersey, and Pennsylvania. Submitted to The Greeley-Polhemus Group and the Army Corps of Engineers, Philadelphia District.

November, 1993 — Phase IA & IB Underwater and Terrestrial Archaeological Survey; Gloucester County Utilities Authority, Mantua Creek Force Main, Gloucester County.

	Submitted to Gloucester County Utilities Authority.
June, 1993	Submerged Cultural Resources Investigation, Great Egg Harbor Inlet & Peck Beach, Ocean City, New Jersey. Submitted to the Army Corps of Engineers, Philadelphia District.
May, 1993	Underwater Archaeological Reconnaissance: Route US 17A/SC 41, Santee River Bridge Replacement, Berkeley and Georgetown Counties, South Carolina. Submitted to Post, Buckley, Schuh & Jernigan.
October, 1992	Aquatic Cultural Resources Investigation, Salem Cove - Delaware River, Salem County, New Jersey and New Castle County, Delaware. Submitted to the Army Corps of Engineers, Philadelphia District.
June, 1992	Phase I Underwater Archaeological Remote Sensing Survey; Riverside Sewerage Authority STP Upgrade, Burlington County, New Jersey. Submitted to Richard Alaimo Associates.
April, 1992	Submerged Cultural Resource Survey; Keystone Cogeneration Plant, Delaware River, New Castle County, Delaware & Gloucester County, New Jersey. Submitted to Keystone Cogenerations Systems and the Delaware Division of Historical and Cultural Affairs.
April, 1992	Submerged Cultural Resource Survey; Keystone Cogeneration Plant, Delaware River, Gloucester County, New Jersey. Submitted to Keystone Cogenerations Systems and the Office of the New Jersey Heritage.
March, 1992	A Phase II Archaeological Evaluation of Identified Archaeological Resources at the USCG Station Burlington, Burlington, Vermont. Submitted to United States Coast Guard.
February, 1992	Statement of Historical Significance for the USCG Icebreaker Glacier. Statement was submitted to the United States Coast Guard in conjunction with the development of a nomination form for the National Register of Historic Places.
January, 1992	Phase I Underwater Archaeological Remote Sensing Survey; Delran Sewerage Authority Pipeline Extension, Burlington County, New Jersey. Submitted to Richard Alaimo Associates.
September 1991	Phase Ib Underwater Archaeological Survey for the U.S. Route 58, Clarksville Bypass Study, Clarksville, Mecklenburg and Halifax Counties, Virginia. Submitted to Harland Bartholomew and Associates, Inc.
June 1991	Phase Ib Underwater Archaeological Survey for the Woodrow Wilson Bridge Improvement Study. Submitted to DeLeuw, Cather & Company of Virginia.
December 1990	Phase 1a Cultural Resources Investigation for the U.S. Route 58 Corridor Study (Clarksville Bypass), Mecklenburg County, Virginia. Co-authored with Cheek, Stevens, Seifert and Meyer. Submitted by John Milner Associates to the Virginia Department of Transportation.
July 1990	MD 213 Relocated, Alternate N-1B Phase I Underwater Archaeological Reconnaissance Chester River, Chester River, Chestertown, Maryland. Submitted by Dolan Research and John Milner Associates to the Maryland State Highway Administration

May 1990	Underwater Archaeological Remote Sensing Reconnaissance, Salem Maritime National Historic Site, Salem, Massachusetts. Submitted by Dolan Research to Louis Berger Associates and the National Park Service.
April 1990	Archaeological Investigation: Cohansey River Wreck Site, Bridgeton, New Jersey. Submitted by Dolan Research to Alan Mounier, Archaeologist.
March 1990	Fort Mott Historical Narrative. Submitted by Dolan Research to Van Sickle and Rolleri.
January 1990	Archaeological Discussion of Magnetic and Acoustic Remote Sensing Data for the Chesapeake Range Lights Project, Maryland and Virginia. Submitted by Dolan Research to Ocean Surveys, Inc.
September 1989	Underwater Archaeological Investigation of Rock Creek, Anne Arundel County, Maryland. Submitted by Dolan Research to Dames and Moore.
June 1989	Phase II Archaeological Investigations for the Proposed Route 58 Midtown Tunnel Portsmouth and Norfolk, Virginia. Co-authored with Stevens and Heck. Submitted by John Milner Associates to the Virginia Department of Transportation.
February 1989	A Report on the Phase I and Phase II Archaeological Investigation for Revolutionary War Vessels Within the Alignment of I-295 (The Trenton Complex) Crosswicks Creek, Bordentown, New Jersey. Co-authored with Fokken. Submitted by Louis Berger & Associates to the New Jersey Department of Transportation.
July 1988	Submerged Cultural Resources Investigations, Delaware River, Main Navigational Channel, Philadelphia, PA. to Artificial Island, New Jersey. Submitted to the Corps of Engineers, Philadelphia District.
May 1988	Submerged Cultural Resources Investigations, Maurice River, New Jersey. Submitted to the Corps of Engineers, Philadelphia District.
April 1988	Submerged Cultural Resources Investigations, Salem Cove and River, New Jersey. Submitted to the Corps of Engineers, Philadelphia District.
January 1988	A Phase I Cultural Resources Survey for the Proposed Route 58 Midtown Tunnel Portsmouth and Norfolk, Virginia. Co-authored with Cheeks, Stevens, Meyer and Glendening. Submitted by John Milner Associates to the Virginia Department of Transportation.
December 1987	Underwater Archeological Survey and Evaluation for the Route 16 Bridge Replacement over Slaughter Creek, Dorchester County, Maryland. Co-authored with Struthers and Parrington. Submitted by John Milner Associates to the Maryland State Highway Administration.
December 1986	Presque Isle Bay Underwater Archaeology Survey. Submitted to the Pennsylvania Historical and Museum Commission.
November 1986	A Historical and Archaeological Assessment of Three Submerged Cultural Resources in Pennsylvania. Submitted to the Pennsylvania Historical and Museum Commission.
July 1986	A Marine Cultural Resources Reconnaissance and On Site Evaluation of Crosswicks Creek, Bordentown, New Jersey. Co-authored with Watts.

Submitted to the Philadelphia Maritime Museum.

April 1986	A Sensitivity Level Investigation of Cultural Resources in the Vicinity of; the Main Navigational Channel, Delaware River, Wilmington to the Sea and a Proposed Deepwater Port. Submitted to the Corps of Engineers, Philadelphia District.
October 1985	A Preliminary Survey to Analyze the Potential Presence of Submerged Cultural Resources in the Ohio, Monongahela and Allegheny Rivers and the Pennsylvania Portion of Lake Erie. Submitted to the Pennsylvania Bureau for Historic Preservation.
September 1984	A Preliminary Survey to Analyze the Potential Presence of Submerged Cultural Resources in the Delaware and Susquehanna Rivers. Submitted to the Pennsylvania Bureau for Historic Preservation.
July 1983	A Reconnaissance of the Chattahochie River at Columbus, Georgia. Co-authored with Watts, Still and Hall. Submitted to the Confederate Naval Museum at Columbus, Georgia.
June 1983	The Yorktown Shipwreck Project; Fall Work Season 1982. Co-authored with Newell. Submitted to the Virginia Branch for Underwater Archaeology, Gloucester Point, Virginia.
March 1983	Submerged Survey for Sir Walter Raleigh's Lost Colony: Roanoke Island, North Carolina. Submitted to the North Carolina Underwater Archaeology Branch, Fort Fisher, North Carolina.

PUBLICATIONS:

1990	*USS Shipwreck: Underwater Archaeology and U.S. Navy Divers.* In, Underwater Archaeology Proceedings from the Society for Historical Archaeology Conference. Tuscon.
1988	Ironclad Intruder: U.S.S. MONITOR: A collection of essays on the history, symbolism and archaeological importance of the U.S.S. MONITOR. Co-edited with M. Jehle. Philadelphia Maritime Museum. Philadelphia.
1988	*Shipwrecks.* In, The Delaware Estuary: Rediscovering a Forgotten Resource. Edited by T. Bryan and J. Pennock. University of Delaware Sea Grant Program, Newark.
1987	*Preliminary Investigation of a Revolutionary War Era Vessel in Crosswicks Creek, Bordentown, New Jersey.* In, Underwater Archaeology Proceedings from the Society for Historical Archaeology Conference. Savannah.

LECTURES:

Episcopal Academy Family Forum Lecture Series, 1994
Philadelphia Maritime Museum Friends of the Library Lecture Series, 1993
The 21st Annual Conference on Underwater Archaeology, Tuscon, AZ., 1990
The 43rd National Preservation Conference, National Trust for Historic Preservation, Philadelphia, 1989
New Jersey State Museum Lecture Series, 1988
Pennsylvania Historical and Museum Commission, 4th Annual Archaeology Workshop, 1988

The 18th Annual Conference on Underwater Archaeology, Savannah, GA, 1987
Philadelphia Maritime Museum Membership Lecture Series, 1986
The 16th Annual Conference on Underwater Archaeology, Boston, MA, 1985

MEMBERSHIPS:
Society for Historical Archaeology
Society of Professional Archaeologists (certified in museology, marine survey, and underwater archaeology)
Pennsylvania Archaeological Council
Florida Archaeological Council
Philadelphia Ship Preservation Guild
University City (Philadelphia) Arts League, Board of Directors.

Richard W. Hunter
PRESIDENT

Ian C. Burrow
VICE PRESIDENT

RICHARD W. HUNTER
President/Principal Archaeologist, MA, SOPA

Education

Ph.D. Candidate, Geography, Rutgers University, New Brunswick, New Jersey, 1984-present

M.A., Archaeological Science, University of Bradford, England, 1975

B.A., Archaeology and Geography, University of Birmingham, England, 1973

Experience

1986- Principal Archaeologist, Hunter Research, Inc.
Cultural Resource Consultants, Trenton, NJ

Founder and principal stockholder of firm providing archaeological and historical research, survey, excavation, evaluation, and report preparation services in the Northeastern United States. Specific expertise in historical and industrial archaeology (mills, iron and steel manufacture, pottery manufacture), historical geography, historic landscape analysis.

Participation in:

- Project management, budgeting and scheduling
- Proposal preparation and client negotiation
- Hiring and supervision of personnel
- Supervision of research, fieldwork, analysis and report preparation

1983-1986 Vice-President/Archaeologist, Heritage Studies, Inc., Princeton, NJ

Principal in charge of archaeological projects.
Responsibilities included:

- Survey, excavation, analysis, and reports
- Client solicitation, negotiation, and liaison
- Project planning, budgeting, and scheduling
- Recruitment and supervision of personnel

1981-1983 Principal Archaeologist, Cultural Resource Group,
Louis Berger & Associates, Inc., East Orange, NJ

Directed historical and industrial archaeological work on major cultural resource surveys and mitigation projects in the Mid-Atlantic region. Primary responsibility for report preparation and editing.

1979-1981 Archaeological Consultant, Hopewell, NJ

1978-1981 Adjunct Assistant Professor, Department of Classics and Archaeology, Douglass College, Rutgers University, NJ

1978-1979 Research Editor, Arete Publishing Company, Princeton, NJ

Prepared and edited archaeological, anthropological, and geographical encyclopedia entries (Academic American Encyclopedia, 1980).

1974-1977 Archaeological Field Officer, Northampton Development Corporation, Northampton, England

Supervised archaeological salvage projects executed prior to development of the medieval town of Northampton (pop. 230,000). Experience included:

- Monitoring of construction activity
- Supervision of large scale urban excavations
- Processing of stratigraphic data and artifacts
- Preparation of publication materials

1969-1970 Research Assistant, Department of Planning and Transportation, Greater London Council

Special Skills and Interests

- historic landscape analysis
- geographic information systems
- water-powered mill sites
- iron and steel manufacture before the Industrial Revolution
- scientific methods in archaeology

Publications

Hopewell: A Historical Geography. Township of Hopewell. Richard L. Porter, co-author. 1991.

"Contracting Archaeology? Cultural Resource Management in New Jersey, U.S.A" (with Ian Burrow). The Field Archaeologist (Journal of the Institute of Field Archaeologists) 12, March 1990, 194-200.

"American Steel in the Colonial Period: Trenton's Role in a 'Neglected' Industry." In Canal History and Technology Proceedings IX, 83-118, 1990. Richard L. Porter, co-author.

"The Demise of Traditional Pottery Manufacture on Sourland Mountain, New Jersey, during the Industrial Revolution." Ch. 13 in Domestic Potters of the Northeastern United States, 1625-1850. Studies in Historical Archaeology, Academic Press, 1985.

"Scientific Aids in Pottery Fabric Analysis." In Medieval Pottery, Processing and Publication. Department of the Environment, U.K. Government, 1983.

Excavations at St. Peter's Street, Northampton, 1973-74. Northampton Development Corp., 1979. John Williams, senior author.

"Excavations at Thorplands, Northampton, 1970 and 1974." Northamptonshire Archaeology 12, 97-154, 1977.

Professional Affiliations

Society of Professional Archaeologists (accredited 1979; certification in field research, collections research, theoretical or archival research)
New Jersey State Historic Sites Review Board (Member, 1983-present)
Professional Archaeologists of New York City (PANYC)
Society for Historical Archaeology
Society for Industrial Archaeology
Society for Post-Medieval Archaeology
Council for Northeast Historical Archaeology
Archaeological Society of New Jersey

Richard W. Hunter
PRESIDENT

Ian C. Burrow
VICE PRESIDENT

DAMON TVARYANAS
Architectural Historian

Education

M.S. Historic Preservation, University of Pennsylvania, 1993
B.A. Fine Arts, New York University, 1991

Experience

1996- Architectural Historian
Hunter Research, Inc.

Participation in:
- Historical and archival research
- Historic structures survey and evaluation
- Report preparation

1992-1996 Historic Preservation Consultant
Brandywine Conservancy, Chadd's Ford, PA and Eagle's Mere, PA Historic Committee

Assisted the Conservancy and Historic Committee in numerous preservation activities. Participation in:
- Historic structures survey and evaluation
- Preparation of National Register of Historic Places Nominations
- Historic research, boundary delineation and mapping
- Preparation of state applications for determinations of eligibility
- Public outreach

1991-1992 Museum Assistant
Carpenter's Hall, Philadelphia, PA

Assisted curator develop and implement systems for the recording and conservation of museum's artifact, furnishing, art and tool collections.

1992 Intern
Architectural History Foundation

Prepared comprehensive, annotated bibliography of nonserial publications pertaining to the subject of pre-1865 American architectural history.

1991 Intern
Allaire State Park, Allaire, NJ

Performed interpretive duties at the working blacksmith and carpenter shops of a 19th-century iron furnace complex interpreted as a living history museum. Developed guided tour of the park to introduce basic architectural concepts to school and youth groups.

Richard W. Hunter
PRESIDENT

Ian C. Burrow
VICE PRESIDENT

VINCENT MARESCA III
Senior Archaeologist, BA

Education

B.A. History, Trenton State College, Trenton, New Jersey, 1992.

Experience

1996 - Present — Senior Archaeologist
Hunter Research, Inc., Trenton, New Jersey

Technical and supervisory responsibilities for selected field, laboratory, drafting operations and report preparation.
Participation in:

- survey and excavation
- supervision of personnel
- field photography
- stratigraphic and artifact analysis
- preparation of field report graphics

1994 - 1996 — Assistant Archaeologist/Draftsperson
Hunter Research, Inc., Trenton, New Jersey

1992 - 1994 — Field Assistant
Hunter Research, Inc., Trenton, New Jersey

Field assistant for various archaeological field projects in Pennsylvania, New Jersey and New York.
Participation in:

- excavation and survey
- field recording
- laboratory processing of artifacts
- drafting in field and preparation of final report graphics

1989 (6-12) — Laborer
Harris Brothers Construction Company, Belmar, New Jersey

1986 & 1988 — Worked on projects in a team involving surveying, landscaping, paving, and operating heavy machinery.

Certifications

Course for Occupational Safety and Health for Hazardous Waste Site Operations, January 1994
Introduction to Global Positioning Systems

Professional Affiliations

Middle Atlantic Archaeological Conference
Eastern States Archaeological Federation
Archaeological Society of New Jersey
Council of Northeast Historic Archaeology

APPENDIX C

PROJECT ADMINISTRATIVE SUMMARY

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PROJECT ADMINISTRATIVE SUMMARY

HUNTER RESEARCH, INC.
PROJECT SUMMARY

Project Name:	PHASE I SUBMERGED AND SHORELINE CULTURAL RESOURCES INVESTIGATIONS, LOWER CAPE MAY MEADOWS, CAPE MAY CITY, LOWER TOWNSHIP AND THE BOROUGH OF CAPE MAY POINT, CAPE MAY COUNTY, NEW JERSEY
Level of Survey:	I
HRI Project Reference:	96069
Date of Report:	1997, September
Client:	U.S. Army Corps of Engineers
Address:	The Wanamaker Building, 100 Penn Square East, Philadelphia, PA 19107-3390
Review Agency:	NJSHPO

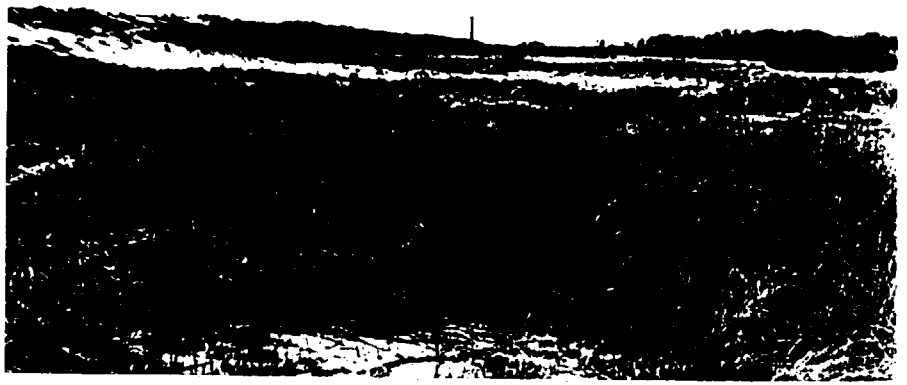
PROJECT CHRONOLOGY

Date of Contract Award:	11/06/1996
Notice to Proceed:	11/06/1996
Background Research:	December 1996-August 1997
Fieldwork:	December 1996-January 97
Analysis:	January-February 1997
Report Written:	January-September 1997

PROJECT PERSONNEL:

Principal Investigator:	Lee Cox (Dolan Research); Richard Hunter (Hunter Research)
Background Research:	Lee Cox (Dolan Research); Damon Tvaryanas and Vincent Maresca (Hunter Research)
Field Supervisor:	Lee Cox (Dolan Research); Damon Tvaryanas (Hunter Research)
Field Assistants:	Wess Hall and Ralph Wilbanks (Dolan Research); Vincent Maresca (Hunter Research)
Analysis:	Lee Cox (Dolan Research); Damon Tvaryanas (Hunter Research)
Draftsperson:	Jason Fantom (Dolan Research); Vincent Maresca and Barba Kutzner (Hunter Research)
Report Written By:	Lee Cox (Dolan Research); Richard Hunter, Damon Tvaryanas and Vincent Maresca (Hunter Research)

Artifacts and Records to be Deposited: Offices of Dolan Research and Hunter Research



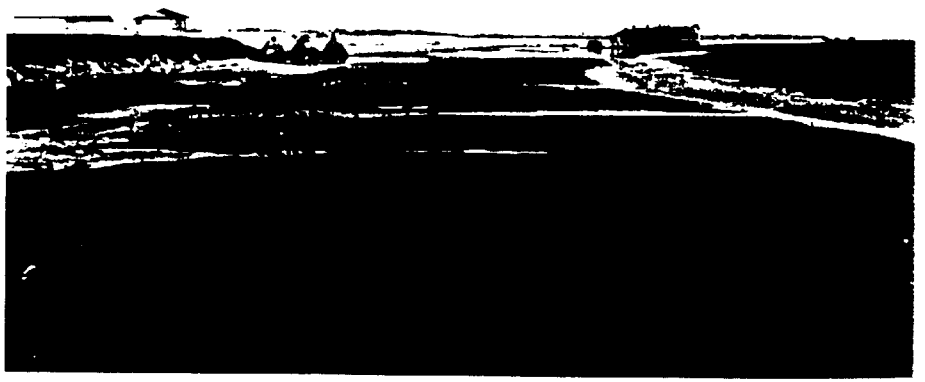


Plate 6.3. View looking southeast showing concrete bunker of Delaware Harbor Defense Battery #223 [Cultural Resource 10] at Cape May Point (Photographer: Damon Tvaryanas, January 1997) [HRI Neg. # 96069/2:20].

Plate 6.4. General view looking east from Cape May Point showing western half of terrestrial survey area. Note surf washed rubble on beach in foreground. Concrete bunker of Delaware Harbor Defense Battery #7 [Cultural Resource 10] is visible at center-right of the view and concrete radio tower supports [Cultural Resource 13] at center-left of the view (Photographer: Vincent Maresca, January 1997) [HRI Neg. # 96069/3:5].

Plate 6.1. General view looking west from western most Cape May City jetty (Cultural Resource 3) showing eastern half of terrestrial survey area (Photographer: Damon Tvaryanas, January 1997) [HRI Neg. # 96069/1:3].

Plate 6.2. View looking west showing meadows behind barrier dunes. The Cape May Lighthouse (Cultural Resource 15) is visible in the background and center of the view (Photographer: Damon Tvaryanas, January 1997) [HRI Neg. # 96069/1:18].

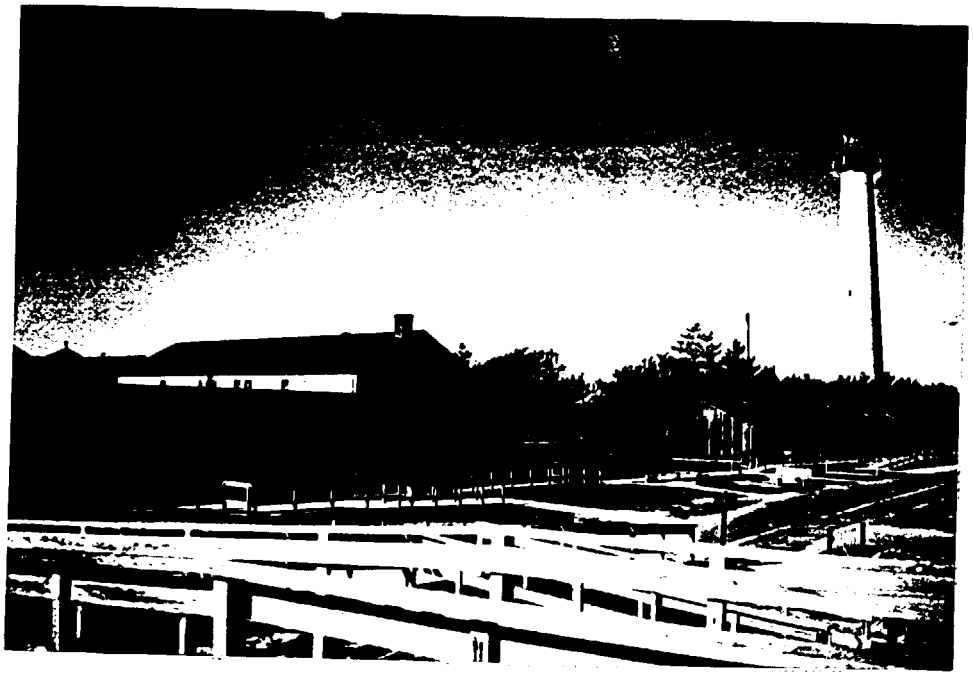


Plate 6.7. View looking southwest showing Queen Anne Cottages [Cultural Resource 19] on Leigh Avenue (Photographer: Damon Tvaryanas, January 1997) [HRI Neg # 96069/5:18].

Plate 6.8. View looking east showing eastern most Cape May Point jetty [Cultural Resource 20]. Although located outside of the study area, the wooden pilings visible in the front of the stone sea wall in the foreground are the remains of an early 20th century barrier (Photographer: Damon Tvaryanas, January 1997) [HRI Neg # 96069/5:20].

Plate 6.5. View looking northwest showing Cape May Point State Park. The view shows from left to right, World War II era infirmary (nature center), radio transmitter building (park maintenance building), officers quarters (park offices) [Cultural Resource 16] and the Cape May Lighthouse of 1859 [Cultural Resource 15] (Photographer: Damon Tvaryanas, January 1997) [HRI Neg # 96069/2:4].

Plate 6.6. View looking west showing St. Mary's By The Sea [Cultural Resource 17], sea wall and remains on beach all located to the west of the concrete bunker of Delaware Harbor Defense Battery #223 [Historic Resource 10]. Note concrete radio tower supports [Cultural Resource 13] on beach at center-left of the view and Cape May Point State Park Picnic Pavilion at center-right of the view (Photographer: Damon Tvaryanas, January 1997) [HRI Neg # 96069/5:2].