APPENDIX A

Example Coastal Flood Insurance Study
For A Site Along the Atlantic Ocean

Guidelines and Specifications for Wave Elevation Determination and V Zone Mapping Example Study

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Introduction

This example study is being prepared as an appendix to the Guidelines and Specification for Wave Elevation Determination and V Zone Mapping in order to provide a realistic application of the described methodology. It does not claim to cover all cases and scenarios which may be found in the field, nor is it meant to be directly applied to all coastal Flood Insurance Studies.

It is the determination of the Coastal High Hazard Area (CHHA) or V-Zone, which is critical to any coastal analysis, and it is important to keep the V-Zone definitions in mind throughout a coastal study, including this example. The CHHA is defined as the most landward of three points:

1) the point where a three foot wave height may occur;
2) the point where the eroded ground profile (or non-eroded profile if applicable) is 3 feet below the calculated wave runup elevation; and
3) the inland limit of the Primary Frontal Dune (PFD) as defined in the National Flood Insurance Program (NFIP) regulations.

A good coastal study is performed to locate all of these points for each transect, where applicable, so that the most landward can be chosen.

The site chosen for this example is found approximately 62 miles southeast of Boston, Massachusetts, along the Atlantic Ocean within Cape Cod Bay. For the purposes of reference, this area will be referred to throughout this example as Smithville. Smithville's corporate limits have been fictitiously created; however, much of the ground data used to perform this analysis comes from real surveyed information.

Five transects have been analyzed in this example study. Transect A typifies a large dune experiencing dune retreat, transect B typifies a small dune experiencing dune removal, transect C can be characterized as a steep bluff with a revetment, transect D typifies a seawall, and transect E is characterized as a marsh.

Several methods were used to determine deepwater wave heights and periods for this study. Based on the geometry of the local study site, the Automated Coastal Engineering System (ACES), developed by the U.S. Army Corps of Engineers (USACE), was considered to be the most appropriate for determining wave conditions.

Runup elevations were determined using the Federal Emergency Management Agency's (FEMA's) current wave runup model (RUNUP 2.0) and guidance from the Shore Protection Manual (1984). Wave height and crest elevations were determined using FEMA's Wave Height Analysis for Flood Insurance Studies (WHAFIS 3.0) model.

Compile Necessary Data and Information

The first step in preparing a detailed coastal analysis is to compile the information needed to run the appropriate models. Keep in mind that the overall goal is to delineate, as accurately as possible, the hazards associated with major coastal storms, specifically the base (100-year) flood, which is the flood having a one percent chance of being equalled or exceeded in any given year. The following is a list of materials that may be helpful when preparing a coastal study:

- Effective Flood Insurance Rate Map (FIRM), and Flood Insurance Study (FIS)
- Local topography of a suitable contour interval and scale

- USGS quadrangle maps
- NOAA nautical charts/bathymetric data
- Aerial photographs/land cover data
- Ground surveys
- WIS wave hindcast reports number 19 and 30
- Buoy and gage data (if available)
- Shore Protection Manual (1984)
- Historical flooding information (if available)
- WHAFIS 3.0, RUNUP 2.0, and ACES 1.07 models
- NFIP regulations

Most of the above materials are easily obtained. The FIRM and FIS are available through the local map repository, and the other documents can be obtained from the various agencies. The WHAFIS, and RUNUP models can be obtained from FEMA, and the ACES model is available through the Federal Software Exchange Center in Springfield, Virginia.

Locate Transects

Each transect is used to represent a length of shoreline which contains similar physical features and cultural characteristics. Since the defined 100-year stillwater elevation does not vary along the shoreline for this example, one transect could be used to represent several different sections of the study site. Figure 7-1 in Part 7 of the Exhibit shows the length of beach represented by each transect, as well as the location of each transect. The Smithville site was found to be accurately described by locating the five transects described in Table 1.

Determine Stillwater Elevation

To determine the stillwater elevation for the Smithville site, two references were consulted. The first was the USACE's

September 1988 report entitled "Tidal Flood Profiles New England Coastline". This document reports a 100-year stillwater elevation (without the wave setup component) of 10.4 feet National Geodetic Vertical Datum (NGVD). Also reported in this document are the mean high water and mean low water elevations for the Smithville site.

The second document used to determine the 100-year stillwater elevation was the current Flood Insurance Study (FIS) for the Smithville site. It too reports a stillwater elevation of 10.4 feet NGVD for this site. The covers of these references, and pages used to determine the 100-year stillwater can be found in the Exhibit, Part 1. Table 2 summarizes the findings.

The stillwater elevation used for this example is 10.4 feet NGVD, without the wave setup component. In this example, it was assumed that this elevation does not vary along the beach within the study area; however, this condition may not be valid for every study. For larger studies it is not uncommon to find stillwater elevations varying significantly along the shoreline.

Determine Wave Characteristics and Wave Setup Magnitude

Wave Characteristics

There are several methods for determining deepwater wave characteristics H_{mo} (deepwater wave height), and T_p (wave period); however, these methods are dependent on the type of event being considered. In the northeastern United States, "Northeasters" can cause significant flooding in coastal areas due to their long duration and intensity. Along most of the Atlantic coast, and in the Gulf of Mexico, hurricanes are the dominant event. The Smithville site however, happens to be exposed to both types of events, therefore, a determination had to be made as to the most appropriate for flood insurance purposes. Since the site is sheltered from southerly exposure by a massive cape, and the shoreline is more exposed to the northeast, it was determined that a "Northeaster" would be the more critical event. This is also documented in the FIS on page 5 as shown in Part 1 of the Exhibit.

Using the USACE's Automated Coastal Engineering System (ACES), 19 fetches were delineated at 6 degree intervals from approximately 343° (compass heading) to approximately 91° as shown in Figure 2-1 in Part 2 of the Exhibit. The length of each fetch was also determined and this information is summarized in Table 2-2 in that same part. Using ACES with the restricted fetch option, 6 predominant wind directions were initially analyzed (5°, 15°, 25°, 35°, 45° and 55°). A fifty mph average overwater wind speed sustained for the duration of the event was assumed, and used as the observed wind speed. The results of these six computations showed that the mean wave direction at approximately 22°. Therefore, a seventh wind direction of 22° was used to determine another set of wave conditions. A sixty mph wind was also used to determine yet another set of wave conditions, and the output from these runs has been included in Part 2 of the Exhibit. The results have also been summarized in Table 2-1 of the Exhibit. As seen from Table 2-1, the waves computed using the restricted fetch option are quite steep (H_{mo}/L_o is approximately 0.043). Since Northeasters do not typically have wave steepness values of this magnitude, a ninth ACES run was made, this time using the open water fetch option, with a fetch length of 160 statue miles, and an overwater wind speed of fifty mph. This computation resulted in a wave steepness much lower than the restricted fetch computations, and is more typical of northeast storm waves.

As a check to the ACES computations, we referenced the USACE-WES Wave Information Study (WIS) Report 30, entitled "Hindcast Wave Information for the US Atlantic Coast" and dated March 1993. The maximum waves computed over a twenty year period, at sites 93, 94, and 95, resulted in wave steepnesses of approximately 0.023, 0.022, and 0.030, respectively. Computed wave heights ranged from approximately 20 feet to 31 feet, and wave periods ranged from approximately 13 seconds to 15 seconds. These values are summarized in Table 2-1 in the Exhibit, and the WIS report pages from which these values were taken have also been included in Part 2 of the Exhibit.

Station 93 in the WIS report is the most applicable to the Smithville site, and the ACES open water wave period computation (12.7 seconds) compares with the WIS 20-year maximum wave period (13 seconds); however, the wave height computed using ACES (28.0 feet) is slightly larger than the 20-year maximum reported in the WIS report (20.3 feet). Given the relatively complex geometry in the vicinity of the Smithville site, we considered the ACES open water computations to be the most appropriate. These conditions, along with the various water surface elevations used are summarized in Table 2, and these values will be used throughout this example for further computations. Since the study area is small, and not drastically convoluted, we assumed that the wave conditions would be constant for the entire length of shoreline; however, in large studies or in areas where there are more complex shoreline geometries, this assumption may not be appropriate.

Setup Computation

Along the open coast, when waves approach the shore, they attenuate and eventually break in shallow water. This wave action can significantly increase mean water surface elevations close to shore. Therefore, a setup component was computed using the methodology outlined in the Shore Protection Manual (SPM). A nearshore slope of approximately 1/85 was used for this computation, and this was assumed to be relatively constant throughout the study area (refer to Table 4-2 through 4-5 in Part 4 of the Exhibit). Since the wave conditions where also assumed to be constant, and the nearshore slope does not vary drastically, we assumed that the magnitude of the wave setup would remain approximately constant for the Smithville site. For other studies however, these assumptions may not be appropriate. Good engineering judgement should be used in making such assumptions, and if there is any doubt as to the validity of an assumption, it should be tested for appropriateness.

For the Smithville site, a wave setup magnitude of approximately 2.0 feet was computed. The steps used to arrive at this value are presented as Worksheet 2-1 in Part 2 of the Exhibit.

Perform Erosion / Scour Assessment

For this example an erosion assessment was performed at transects A and B. For transect D, a scour assessment was made. For transects C and E, it was assumed that erosion would not be significant given the relatively mild slopes and heavy land cover.

Transect A typifies a large dune whose crest rises to 25 feet NGVD. Transect B typifies a small dune whose crest only reaches 15 feet NGVD. The FEMA erosion methodology was used to compute an eroded profile for each of these two cross sections, and the results are presented as Worksheets 3-1 and 3-2 in Part 3 of the Exhibit. The pre-storm ground elevations were determined using field data and USGS quadrangle maps.

Transect A was found to have a reservoir area greater than 540 ft^2, therefore the dune face was retreated rather than removed. Transect B was found to have a reservoir area less than 540 ft^2, therefore, the dune was removed. Figures 3-1 and 3-2 in Part 3 of the Exhibit show the pre-storm and eroded profiles for transects A and B. No historical information could be obtained documenting the effects of storm induced erosion in this area.

Transect D was used to represent the seawall along the shoreline at the northern corporate limit of Smithville. Since the toe of this structure was not protected, the effects of scour needed to be addressed. It was assumed that the amount of scour would be approximately equal to the significant wave height at the seawall.
The scour depth at the toe of the seawall for this example was found to be approximately 2.2 feet. The scour elevation at the toe of the seawall for this example was found to be approximately 3.8 feet NGVD. The procedure for this analysis is presented as Worksheet 3-3 in part 3 of the Exhibit. The approach outlined in Worksheet 3-3 is being presented as an attempt at quantifying toe scour. The results obtained appear to be reasonable in terms of qualitative guidance and general experience; however, this procedure may not be appropriate for every case. The results of this analysis are shown graphically in Figure 3-3 of Part 3 in the Exhibit.

Perform Runup / Overtopping Analysis

Runup Computations

Runup computations were made along transects A, B, and C, using the FEMA runup model. Mean wave conditions, local bathymetry, stillwater elevation (without the wave setup component), and eroded ground elevations were used as input. The mean deepwater wave characteristics (H_{bar} and T_{bar}) were computed using the following relationship:

$$H_{bar} = H_{mo} * 0.625$$
$$T_{bar} = T_p * 0.85$$

where H_{mo} is the deepwater significant wave height, and T_p is the dominant wave period, both of these values were computed previously. Nine wave conditions where input for each transect representing a variety of conditions from 1.05 H_{bar} to 0.95 H_{bar} and 1.05 T_{bar} to 0.95 T_{bar}. A stillwater elevation of 10.4 feet NGVD was used for each transect. Nearshore bathymetry was averaged using water depths obtained from the USGS quadrangle map, as shown in the Table 4-2 to 4-4 in the Exhibit, and are further summarized in Table 3. A roughness coefficient of 0.60 was assumed for the rock revetment at transect C, and a coefficient of 0.90 was assumed for the grass along that same transect.

For transect D (seawall), the methodology found in the SPM was used to compute a runup elevation. This elevation was found to be 27.9 feet NGVD; however, it was assumed that this elevation would not be appropriate for floodplain management purposes since it is more than 3 feet above the wall cap elevation. Nevertheless, this computation implies that overtopping should be considered.

Given the mild slope, and heavily vegetated ground surface along transect E, runup was assumed to be negligible. The runup results for the remaining transects are summarized in Table 4. It can be seen from Table 4 that the runup elevations for each transect are less than the stillwater elevation plus the wave setup component previously computed (12.4 feet NGVD). However, these results should not be dismissed because they will be needed to compute a possible location of the V-Zone (ie. that were the eroded ground profile is 3 feet below the mean runup elevation).

The input and output files used for the FEMA runup model, as well as transect D runup computations are presented in Part 4 of the Exhibit.

Overtopping

Overtopping was assessed at transect D, and reviewed for appropriateness at transect B. Since the eroded dune crest for transect A was much higher than the computed runup elevation, overtopping was not assessed at this location. Furthermore, since the bluff crest at transect C is much higher than the computed runup elevation for that transect, overtopping was not considered. For transect E overtopping was not applicable.

For transect D, the runup elevation was found to be quite substantial, therefore, overtopping was assessed at this location. Using the procedure outlined in the main text of the Guidelines and Specifications for Wave Elevation Determination and V-Zone Mapping, it was found that overtopping may exceed 1 cfs/ft. Therefore, the V-Zone should extend, at a minimum, 25 feet landward of the seawall cap, and an area of Zone AO (shallow water flooding) should be delineated landward of the V-Zone.

The details of the overtopping assessment for transect D are presented as Worksheet 4-2 at the end of Part 4 in the Exhibit.

As the water level rises in front of a structure or dune, it will reach a level where overtopping becomes excessive, this may cause high velocities landward of the structure crest. Therefore, in cases where structures or dunes are completely inundated during the 100-year event, it is good practice to extend the V-Zone, at a minimum, 25 feet landward of the crest to allow for energy dissipation when overtopping becomes critical. For transect B, this was found to be the case; therefore, the final location of the V-Zone should be extended at least 25 feet landward of the eroded dune crest.

Perform WHAFIS

The WHAFIS 3.0 model was used for transects A through E to determine appropriate wave crest elevations along each. Eroded ground elevations were used, and vegetation was modeled where appropriate. A printout of the input and output files for each transect is located in Part 5 of the Exhibit.

For transect A, marsh grass (Region 2 SPAT) was assumed to exist from approximately station 700 inland to approximately station 3500. A stillwater flood elevation of 12.4 feet NGVD was used from station 0 to approximately station 700, where the wave setup component was removed from the stillwater elevation. A 100-year stillwater elevation of 10.4 feet NGVD was then used from approximately station 700 inland to approximately station 3500. All buildings were assumed to be elevated above surge for this transect.

For transect B, marsh grass (Region 2 SPAT) was assumed to exist from station 400 inland, and the first and only row of buildings was assumed to be removed due to erosion.

For transect C, the rock revetment from station 120 to station 220 was not modeled; however, based on a field inspection by a certified professional engineer, the structure was assumed to be likely to withstand the 100-year event. The WHAFIS model input was terminated at approximately station 220, where the ground elevation rises and remains above 12.4 feet NGVD.

For transect D, the seawall cap was surveyed at 18.2 feet NGVD. Taking into consideration the overtopping and scour assessment, combined with the results of a field inspection by a certified professional engineer, it was assumed the structure would likely withstand the 100-year event, and was modeled in place.

For transect E, marsh grass (Region 2 SPAT) was assumed to exist from station 500 inland to station 4200, and the wave setup component was removed from the 100-year stillwater flood at approximately station 500.

Construct Wave Envelopes

The wave envelope combines the results of all modeling and analysis in a graphical manner, making it one of the most critical components of the coastal flood insurance study. Figures 6-1 through 6-5 of Part 6 of the Exhibit presents the information typically shown on a wave envelope. Stationing is shown along the X-axis (from the pre-storm zero NGVD), and elevation is shown along the Y-axis. In each figure, pre-storm and eroded ground elevations, wave crests, average zone wave heights, and the inland limit of the V-Zone are shown. The average zone wave heights shown on figures 6-1 through 6-5 where computed at a minimum 200 foot increment given the scale of the work maps (1"=1000'). It is assumed that a width less than 1/20th of an inch can not accurately be shown. Tables 6-1 through 6-5 in Part 6 of the exhibit are presented to summarize the final results for transects A through D, respectively. Table 5 is presented to summarize the various criteria used in determining the inland limit of the V-Zone for each transect based on the 3 criteria mentioned in the introduction to this example. Tables 6-6 through 6-23 of the Exhibit are presented for completeness, and are meant to supplement the wave envelope figures.

Mapping The Results

After creating the wave envelopes, the zero station was transferred to the base maps (USGS quadrangle in this example) to obtain a fixed reference point from which to delineate the flood zones. Using this point, in conjunction with summary tables 6-1 through 6-5, and the wave envelopes, the flood zone boundaries and elevations were delineated on the work maps.

Once that was done for each transect, the next step was to interpolate the location of these boundaries between transects. The wave crest envelopes and work maps are used together to find the location of zone changes in reference to physical features such as ground elevations, roads, houses, vegetation, seawalls, revetments, dunes, etc... Boundary lines are then delineated outward perpendicular to the transect, following the direction of identified physical features, and generally parallel to the shoreline. These zones are extended from the transect to a point where there is a significant change in physical features. Once this point is reached for each transect, the engineer must examine how a logical transition can be made across the areas between transects where zones have not been delineated. In some cases this area may be so dramatically different from the surrounding areas that an additional transect must be added to accurately describe it.

Figure 1 shows a general schematic of how results are interpolated between transects. The solid arrows extending outward from the transect lines terminate at the points where physical features were judged to have changed significantly. As shown in Figure 1 by the dashed lines, similar zones are then connected through areas where the physical features between the transects could be described as a combination of the two transects. Notice that transect 3 in Figure 1 contains an area of Zone AE (El. 11) and Zone X, and transect 2 does not; therefore, these two zones where tapered to an end using engineering judgement given the physical features of the area. Similarly, for transect 1, Zone VE (El. 17) differed from the Zone VE (El. 15) found along transects 2 and 3; therefore, zone VE (El. 17) was terminated at a location deemed to be the most logical based on physical features (end of a seawall, revetment, dune, etc...). Note that in some cases it can be assumed that a transect is applicable at several locations along the coast which are not necessarily physically connected; however, caution should be used when exercising this technique over long stretches of shoreline because stillwater elevations, wave characteristics, and nearshore bathymetry may vary significantly.

The above described methodology was used for delineating the flood zones at the Smithville site, and the results are presented in Part 7 of the Exhibit.

Review and Evaluate Results/Compare to Historical Flooding Information

Using the various summary tables and figures in Part 6 of the Exhibit, and the maps in Part 7, the results are reviewed for reasonableness. No historical flooding information was available for the Smithville site, so a direct comparison between the presented results and past flooding occurrences could not be made; however, a review of the major components of this study, and the assumptions made will help in determining the studies reasonableness.

The 100-year stillwater elevation of 10.4 NGVD was obtained from two different sources, and is believed to be the best available information. Given the two harbors at either end of the study area, this elevation alone (without wave setup, beach erosion, wave height analysis, or runup computations) would inundate the marsh areas at a minimum to an elevation of approximately 10 feet NGVD.

Deepwater wave conditions were determined using several methods. The ACES results seemed to generally agree with the information published for Station 93 in the WIS report 30, and the results appear to be reasonable based on past experience and the understanding of typical northeast storm waves.

The wave setup contribution to the stillwater elevation was computed using the methodology outlined in the SPM. According to this methodology, the setup component is a function of deepwater wave height, wave period, and nearshore beach slope. The nearshore slope was averaged for the site; however, the magnitude of the setup component is only slightly affected by changes in nearshore slope. Therefore, the averaging of this slope is not considered to have a major impact on the overall magnitude of the setup computation. The wave characteristics are more critical in the determination of the wave setup, and confidence in these values is crucial. As mentioned previously, we are fairly confident with these values, and the assumption that they will not vary significantly along the shoreline within the study area.

The erosion assessment for transects A and B was performed using standard FEMA methodology based on the 540 ft^2 rule. No historical information was available for a comparison of these results. Since scour is know to occur in front of seawalls exposed to wave action, the depth of scour at transect D was estimated assuming that the scour depth at the toe of the structure would be approximately equal to the significant wave height occurring directly in front of the wall. Once the scour assessment was performed, the integrity of the wall was reviewed for failure due to wave action and soil pressure. The wall was found to be stable under these conditions; however, no historical data was available for a comparison. No erosion assessment was performed for Transect E due to its relatively mild slope and heavy vegetation. The rock revetment at transect C was reported to have withstood several large historical events with little to no damage. The revetment was judged to be in good condition based on a field inspection, and it was assumed to withstand the 100-year event based on the recommendations from a professional engineer with experience in coastal structures. Furthermore, this structure was assumed to prevent excessive erosion.

Runup analysis was performed for transects A, B, and C using the FEMA runup model version 2.0. For transect D, the methodology outlined in the SPM was used. At transect E, wave runup was not applicable given the mild slope. According to the USGS quadrangle map, the nearshore bathymetry was fairly constant throughout the study area, and was therefore averaged for the entire length of the site. The computed runup elevations at transects A, B, and C, were lower than the computed setup component; therefore, they were not plotted on the wave envelopes. However, the point where the eroded ground profile was 3 feet below the computed runup elevation was still considered in locating the inland limit of the V-Zone, although this point was found to be seaward of the inland limit of the primary frontal dune. For transect D, the runup elevation was considered to be excessive since it rose more than 3 feet above the crest of the seawall. Therefore, it was recommended that the computed runup elevation not be used for floodplain management purposes. No historical data was available to compare the results of the runup analysis.

Overtopping analysis was performed only at transect D, the seawall, and was found to most likely be excessive. Therefore, the V-Zone was extended 25 feet landward of the crest of the structure to allow for adequate energy dissipation. Furthermore, a shallow water ponding area (Zone AO depth 2 feet) was delineated behind the seawall based on the overtopping assessment. For transect B, the dune remnant was completely inundated, thus overtopping was assumed to be extensive; however, the inland limit of the primary frontal dune was found to be further landward than the 25 feet required for excessive overtopping. Overtopping was not considered at transect C or A since the crest of the bluff and dune were much higher than the computed runup elevation. Overtopping was not applicable at transect E. No historical data was available to compare the results of the overtopping assessment.

After comparing the results of this study with those found on the effective FIRM, it was obvious that the inland limit of the primary frontal dune had not been considered in the previous analysis. Furthermore, the elevations along the shoreline proposed in this study were slightly larger than those shown on the effective FIRM. The WHAFIS model input used for the effective study was not available for review; however, the differences in these elevations may be due to differences in the magnitude of the wave setup component, or the wave conditions.

The floodplain boundaries matched well with those found on the effective FIRM, as did the zone elevations landward of the dunes and first row of structures. The results of this study were found to be generally consistent with the information shown on the effective FIRM, and were found to be reasonable.

Table 1 - Transect Descriptions

Transect	Description
A	Represents approximately 1.3 miles of shoreline along a LARGE DUNE.
B	Represents approximately 2.4 miles of shoreline along a SMALL DUNE.
C	Represents approximately 1.0 mile of shoreline along a REVETMENT backed by a steep BLUFF.
D	Represents approximately 0.2 miles of shoreline along a SEAWALL.
E	Represents approximately 0.3 miles of MARSH along the shoreline.

Table 2 - Summary of Water Elevations and Wave Characteristics

Parameter	Magnitude
Mean Low Water	-4.0 feet NGVD
Mean High Water	+5.0 feet NGVD
100-year Stillwater	+10.4 feet NGVD
Wave Setup Component	+2.0 feet
Deepwater Wave Height	+28.0 feet
Deepwater Wave Period	+12.7 seconds
Mean Deepwater Wave Height	17.5 feet
Mean Deepwater Wave Period	10.8 seconds
Significant Wave height near seawall	2.2 feet

Table 3 - Summary of Wave Runup Elevations

Transect	Mean Runup Elevation in feet NGVD
A	12.3
B	12.1
C	11.6
D	27.9[1]

[1]Not used for floodplain management purposes.

Table 4 - V-Zone Inland Limit Summary

Transect	WHAFIS		RUNUP		PFD		OTHER		REG	
	Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev
A	314	15	278[3]	12	700	12[5]	N/A	N/A	700	12
B	200	13	303[3]	12	400	12[1]	328[6]	12[1]	400	12
C	170	15	172[3]	12	N/A	N/A	N/A	N/A	219[9]	16[8]
D	300	15	300[4]	21[2]	N/A	N/A	325[7]	21[2]	325	15[8]
E	704	13	N/A	N/A	N/A	N/A	N/A	N/A	704	13

Station zero is located at 0 NGVD

[1]Elevation based on runup analysis

[2]Three feet above crest of structure

[3]Eroded ground profile three feet below runup elevation

[4]Station located at the base of the seawall

[5]WHAFIS elevation at eroded dune face

[6]Station set 25 feet landward of eroded dune crest due to excessive overtopping

[7]Station set 25 feet landward of structure crest due to excessive overtopping

[8]Average WHAFIS zone elevation seaward of structure

[9]Zone boundary extended to this station given map scale

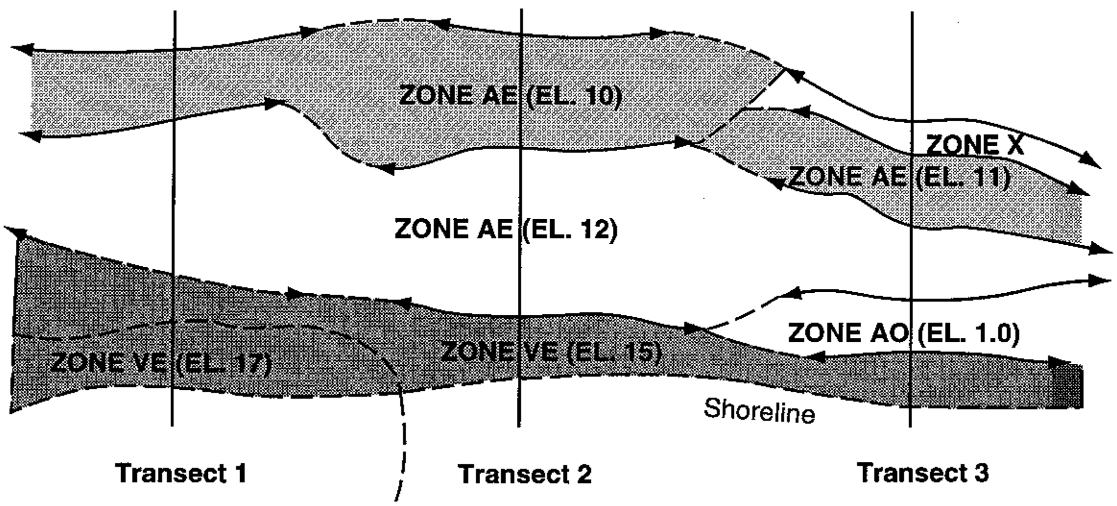

Figure 1 - Zone Mapping Schematic

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PART 1: STILLWATER ELEVATION DETERMINATION

Table 1-1: Summary of Water Surface Elevations

Water Level	Elevation (ft - NGVD)	Source
100-year SWFL (w/o setup)	10.4	Corps 1988 Report
Mean High Water	+5	Corps 1988 Report
Mean Low Water	-4	Corps 1988 Report
100-year SWFL (w/o setup)	10.4	FIS (1991)

Pages of Tidal Flood Profiles USACE Report (1988)

TIDAL FLOOD PROFILES
NEW ENGLAND COASTLINE

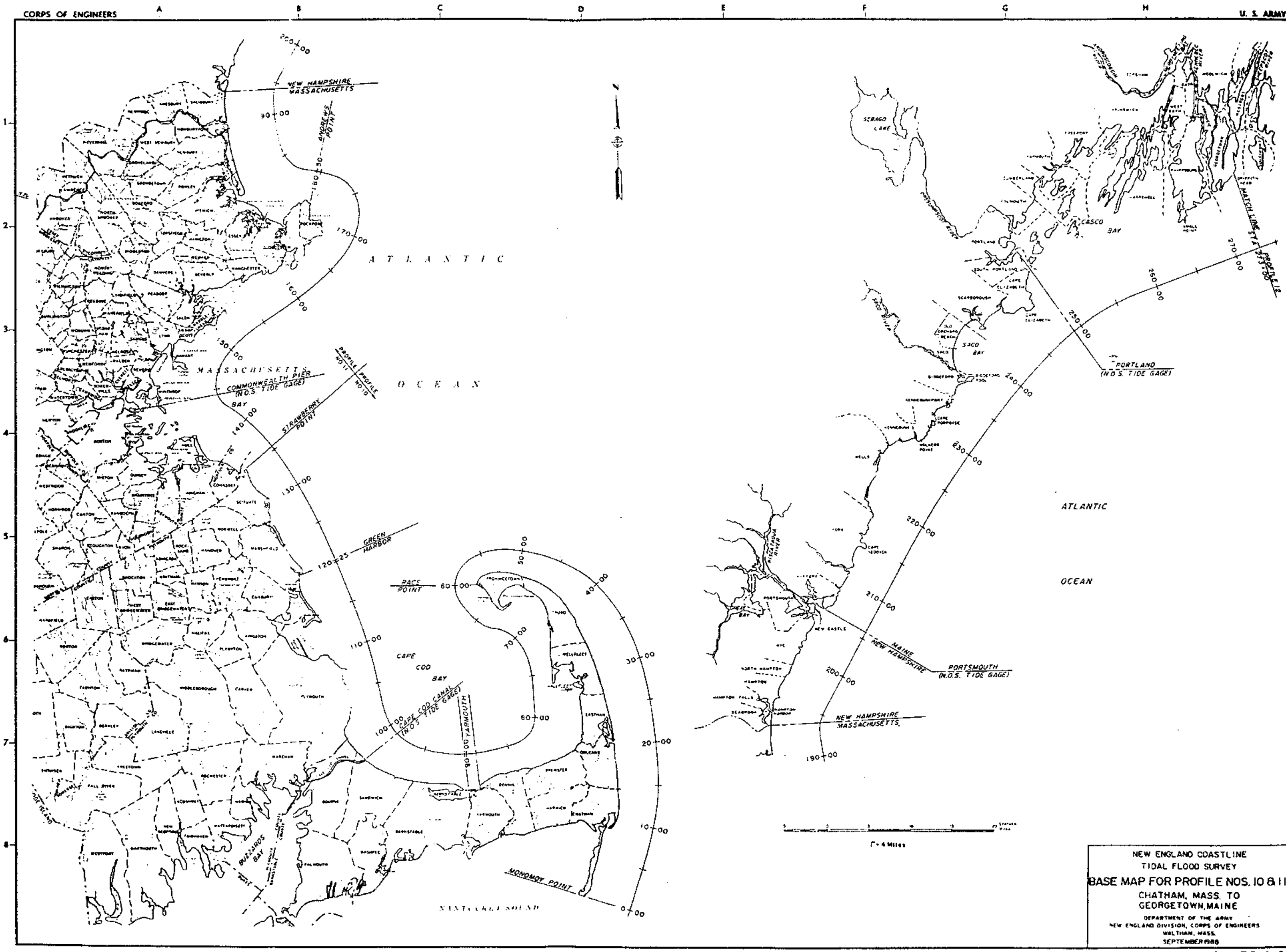
PREPARED BY THE

HYDRAULICS AND WATER QUALITY SECTION

NEW ENGLAND DIVISION

U.S. ARMY CORPS OF ENGINEERS

SEPTEMBER 1988

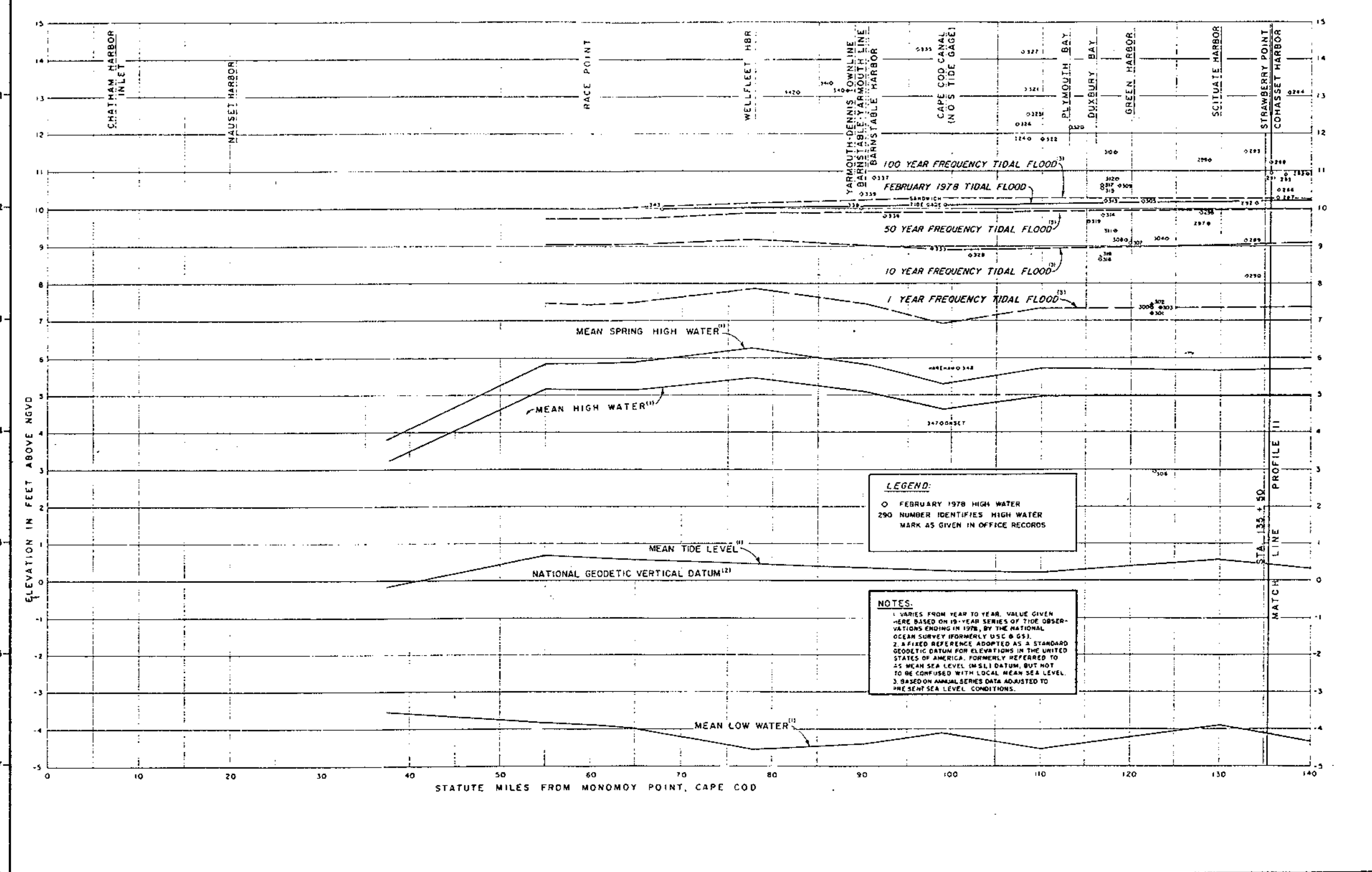


NEW ENGLAND COASTLINE
TIDAL FLOOD SURVEY
BASE MAP FOR PROFILE NOS. 10 & 11
CHATHAM, MASS. TO
GEORGETOWN, MAINE
DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
WALTHAM, MASS.
SEPTEMBER 1988

PLATE C-24

CORPS OF ENGINEERS

U. S. ARMY



NEW ENGLAND COASTLINE
TIDAL FLOOD SURVEY

TIDAL FLOOD PROFILE NO. 10

CHATHAM, MASS.
TO COHASSET, MASS.

DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
WALTHAM, MASS.
SEPTEMBER 1988

PLATE C-25

Pages of FIS Report (1991)

FLOOD INSURANCE STUDY

TOWN OF
SMITHVILLE, MASSACHUSETTS
YOUR COUNTY

Federal Emergency Management Agency

COMMUNITY NUMBER - 123456

TABLE 1 - SUMMARY OF STILLWATER ELEVATIONS

FLOODING SOURCE AND LOCATION	ELEVATION (feet) 10-YEAR	50-YEAR	100-YEAR	500-YEAR
CAPE COD BAY				
At Smithville Corporate limits	9.1	10.0	10.4	11.4

The effects of wave action were also considered in the determination of flood hazard areas. Coastal structures that are located above stillwater flood elevations can still be severely damaged by wave runup, wave-induced erosion, and wave-borne debris. For example, during the northeasters of January and February 1978, considerable damage along the Massachusetts coast was caused by wave activity, even though most of the damaged structures were above the high-water level. The extent of wave runup past stillwater levels depends greatly on the wave conditions and local topography.

Wave heights and corresponding wave crest elevation were determined using the National Academy of Sciences (NAS) methodology (Reference 8). The wave runup was determined using the methodology developed by Stone and Webster Engineering Corporation for FEMA (Reference 9).

3.2 Hydraulic Analyses

Hydraulic analyses, considering storm characteristics and the shoreline and bathymetric characteristics of the flooding source studied, were carried out to provide estimates of the elevations of floods of the selected recurrence intervals along the shoreline.

Coastal high hazard areas are areas of special flood hazards along the open coast that, at a minimum, include primary frontal dunes. During major storms, these dunes receive the full impact of the wave attack and respond in a sacrificial manner; the wave energy spent eroding the dunes will often reduce the wave damage inland. Because of their vulnerability to wave attack and their role as the frontline defense against storms, primary frontal dunes are designated as coastal high hazard areas. Other areas of coastline subject to high velocity wave action are also coastal high hazard areas. The COE has established the 3-foot breaking wave as the criterion for identifying these coastal high hazard areas (Reference 10). The 3-foot wave was determined to be the minimum size wave capable of causing significant damage to conventional wood frame or brick veneer structures.

PART 2: WAVE CHARACTERISTICS AND WAVE SETUP

Table 2-1: Summary of Wave Computations

Method	Fetch (mi)	Uobs (mph)	Hmo (ft)	Tp (sec)	Lo (ft)	Hmo/Lo (-)	Wind dir.
ACES-Restricted	160.0	50	25.2	10.7	586.7	0.0430	5
ACES-Restricted	160.0	50	26.1	10.9	605.5	0.0431	15
ACES-Restricted	160.5	50	26.3	10.9	606.6	0.0434	25
ACES-Restricted	160.5	50	25.6	10.8	592.2	0.0432	35
ACES-Restricted	159.2	50	24.3	10.5	561.8	0.0433	45
ACES-Restricted	159.2	50	22.2	10.1	522.8	0.0425	55
ACES-Restricted	160.5	50	26.3	10.9	608.9	0.0432	22
ACES-Restricted	160.5	60	33.6	12.2	762.8	0.0440	22
ACES-Open Water	160.0[1]	50	28.0	12.7	826.6	0.0339	-
WIS 30, Site 93	-	-	20.3	13	866.1	0.0234	-
WIS 30, Site 94	-	-	24.9	15	1153.1	0.0216	-
WIS 30, Site 95	-	-	30.5	14	1004.5	0.0304	-

[1]Average fetch length of restricted fetch computations, input for ACES

Column 1: Method used to determine Hmo and Tp
Column 2: Fetch length computed by ACES in statue miles
Column 3: Observed overwater wind speed in mile per hour
Column 4: Deepwater wave height in feet
Column 5: Peak wave period in seconds
Column 6: Deepwater wave length in feet ($g*Tp^2/2\pi$)
Column 7: Wave steepness
Column 8: Wind direction from North (compass heading)

Table 2-2: ACES Fetch Values

Fetch Number	Direction	Length (miles)
0	334	19
1	340	58
2	346	58
3	352	59
4	358	109
5	4	124
6	10	140
7	16	147
8	22	162
9	28	178
10	34	22
11	40	25
12	46	25
13	52	24
14	58	22
15	64	20
16	70	22
17	76	23
18	82	22

Column 1: Fetch number corresponding to Figure 2-1
Column 2: Fetch direction from north (compass heading)
Column 3: Fetch length in statue miles

Figure 2-1: ACES Fetches

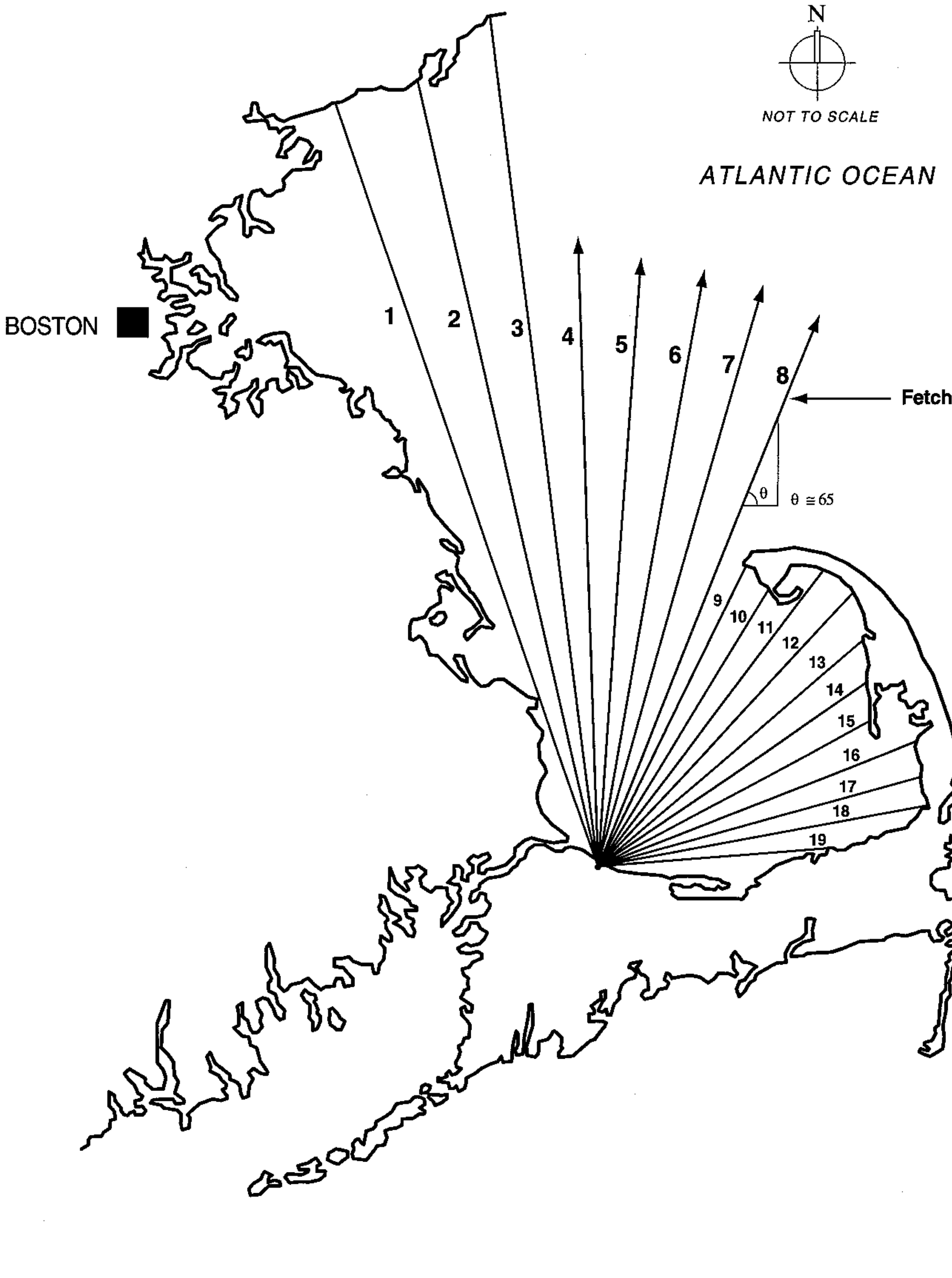

N
NOT TO SCALE
ATLANTIC OCEAN
BOSTON
1
2
3
4
5
6
7
8
Fetch
θ
θ ≅ 65
9
10
11
12
13
14
15
16
17
18
19

Figure 2-1

ACES Output

WIND ADJUSTMENT AND WAVE GROWTH

Elevation of Observed Wind	Zobs:	30.00 ft	Wind Observation Type
Observed Wind Speed	Uobs:	50.00 mph	---------------------
Air-Sea Temp. Difference	delT:	0.00 deg C	Overwater
Duration of Observed Wind	DurO:	15.00 hr	
Duration of Final Wind	DurF:	20.00 hr	
Latitude of Observation	LAT:	41.70 deg	
Length of Wind Fetch	F:	160.00 mi	Wave Growth Equations
Equiv. Neutral Wind Speed	Ue:	49.35 mph	---------------------
Adjusted Wind Speed	Ua:	73.67 mph	Restricted Fetch
Wave Height	HmO:	25.24 ft	Deep-water
Wave Period	Tp:	10.71 sec	Fetch-limited
Wave Direction	Wdir:	5.00 deg	
Mean Wave Direction	Theta:	21.00 deg	

WIND ADJUSTMENT AND WAVE GROWTH

Elevation of Observed Wind	Zobs:	30.00 ft	Wind Observation Type
Observed Wind Speed	Uobs:	50.00 mph	---------------------
Air-Sea Temp. Difference	delT:	0.00 deg C	Overwater
Duration of Observed Wind	DurO:	15.00 hr	
Duration of Final Wind	DurF:	20.00 hr	
Latitude of Observation	LAT:	41.70 deg	
Length of Wind Fetch	F:	160.00 mi	Wave Growth Equations
Equiv. Neutral Wind Speed	Ue:	49.35 mph	---------------------
Adjusted Wind Speed	Ua:	73.67 mph	Restricted Fetch
Wave Height	HmO:	26.11 ft	Deep-water
Wave Period	Tp:	10.87 sec	Fetch-limited
Wave Direction	Wdir:	15.00 deg	
Mean Wave Direction	Theta:	21.00 deg	

WIND ADJUSTMENT AND WAVE GROWTH

Elevation of Observed Wind	Zobs:	30.00 ft	Wind Observation Type
Observed Wind Speed	Uobs:	50.00 mph	---------------------
Air-Sea Temp. Difference	delT:	0.00 deg C	Overwater
Duration of Observed Wind	DurO:	15.00 hr	
Duration of Final Wind	DurF:	20.00 hr	
Latitude of Observation	LAT:	41.70 deg	
Length of Wind Fetch	F:	160.49 mi	Wave Growth Equations
Equiv. Neutral Wind Speed	Ue:	49.35 mph	---------------------
Adjusted Wind Speed	Ua:	73.67 mph	Restricted Fetch
Wave Height	HmO:	26.26 ft	Deep-water
Wave Period	Tp:	10.90 sec	Fetch-limited
Wave Direction	Wdir:	25.00 deg	
Mean Wave Direction	Theta:	22.00 deg	

WIND ADJUSTMENT AND WAVE GROWTH

Elevation of Observed Wind	Zobs:	30.00 ft	Wind Observation Type
Observed Wind Speed	Uobs:	50.00 mph	--------------------
Air-Sea Temp. Difference	delT:	0.00 deg C	Overwater
Duration of Observed Wind	DurO:	15.00 hr	
Duration of Final Wind	DurF:	20.00 hr	
Latitude of Observation	LAT:	41.70 deg	
Length of Wind Fetch	F:	160.49 mi	Wave Growth Equations
Equiv. Neutral Wind Speed	Ue:	49.35 mph	--------------------
Adjusted Wind Speed	Ua:	73.67 mph	Restricted Fetch
Wave Height	HmO:	25.62 ft	Deep-water
Wave Period	Tp:	10.78 sec	Fetch-limited
Wave Direction	Wdir:	35.00 deg	
Mean Wave Direction	Theta:	22.00 deg	

WIND ADJUSTMENT AND WAVE GROWTH

Elevation of Observed Wind	Zobs:	30.00 ft	Wind Observation Type
Observed Wind Speed	Uobs:	50.00 mph	--------------------
Air-Sea Temp. Difference	delT:	0.00 deg C	Overwater
Duration of Observed Wind	DurO:	15.00 hr	
Duration of Final Wind	DurF:	20.00 hr	
Latitude of Observation	LAT:	41.70 deg	
Length of Wind Fetch	F:	159.17 mi	Wave Growth Equations
Equiv. Neutral Wind Speed	Ue:	49.35 mph	--------------------
Adjusted Wind Speed	Ua:	73.67 mph	Restricted Fetch
Wave Height	HmO:	24.28 ft	Deep-water
Wave Period	Tp:	10.53 sec	Fetch-limited
Wave Direction	Wdir:	45.00 deg	
Mean Wave Direction	Theta:	23.00 deg	

WIND ADJUSTMENT AND WAVE GROWTH

Elevation of Observed Wind	Zobs:	30.00 ft	Wind Observation Type
Observed Wind Speed	Uobs:	50.00 mph	--------------------
Air-Sea Temp. Difference	delT:	0.00 deg C	Overwater
Duration of Observed Wind	DurO:	15.00 hr	
Duration of Final Wind	DurF:	20.00 hr	
Latitude of Observation	LAT:	41.70 deg	
Length of Wind Fetch	F:	159.17 mi	Wave Growth Equations
Equiv. Neutral Wind Speed	Ue:	49.35 mph	--------------------
Adjusted Wind Speed	Ua:	73.67 mph	Restricted Fetch
Wave Height	HmO:	22.21 ft	Deep-water
Wave Period	Tp:	10.12 sec	Fetch-limited
Wave Direction	Wdir:	55.00 deg	
Mean Wave Direction	Theta:	23.00 deg	

WIND ADJUSTMENT AND WAVE GROWTH

Elevation of Observed Wind	Zobs:	30.00 ft	Wind Observation Type
Observed Wind Speed	Uobs:	50.00 mph	---------------------
Air-Sea Temp. Difference	delT:	0.00 deg C	Overwater
Duration of Observed Wind	DurO:	15.00 hr	
Duration of Final Wind	DurF:	20.00 hr	
Latitude of Observation	LAT:	41.70 deg	
Length of Wind Fetch	F:	160.49 mi	Wave Growth Equations
Equiv. Neutral Wind Speed	Ue:	49.35 mph	---------------------
Adjusted Wind Speed	Ua:	73.67 mph	Restricted Fetch
Wave Height	HmO:	26.30 ft	Deep-water
Wave Period	Tp:	10.91 sec	Fetch-limited
Wave Direction	Wdir:	22.00 deg	
Mean Wave Direction	Theta:	22.00 deg	

WIND ADJUSTMENT AND WAVE GROWTH

Elevation of Observed Wind	Zobs:	30.00 ft	Wind Observation Type
Observed Wind Speed	Uobs:	60.00 mph	---------------------
Air-Sea Temp. Difference	delT:	0.00 deg C	Overwater
Duration of Observed Wind	DurO:	15.00 hr	
Duration of Final Wind	DurF:	20.00 hr	
Latitude of Observation	LAT:	41.70 deg	
Length of Wind Fetch	F:	160.49 mi	Wave Growth Equations
Equiv. Neutral Wind Speed	Ue:	59.26 mph	---------------------
Adjusted Wind Speed	Ua:	94.17 mph	Restricted Fetch
Wave Height	HmO:	33.62 ft	Deep-water
Wave Period	Tp:	12.15 sec	Fetch-limited
Wave Direction	Wdir:	22.00 deg	
Mean Wave Direction	Theta:	22.00 deg	

WIND ADJUSTMENT AND WAVE GROWTH

Elevation of Observed Wind	Zobs:	30.00 ft	Wind Observation Type
Observed Wind Speed	Uobs:	50.00 mph	---------------------
Air-Sea Temp. Difference	delT:	0.00 deg C	Overwater
Duration of Observed Wind	DurO:	15.00 hr	
Duration of Final Wind	DurF:	20.00 hr	
Latitude of Observation	LAT:	41.70 deg	
Length of Wind Fetch	F:	160.00 mi	Wave Growth Equations
Equiv. Neutral Wind Speed	Ue:	49.35 mph	---------------------
Adjusted Wind Speed	Ua:	73.67 mph	Open-Water Fetch
Wave Height	HmO:	28.01 ft	Deep-water
Wave Period	Tp:	12.71 sec	Fetch-limited

WIS Report 30
March 1993

US Army Corps of Engineers
Waterways Experiment Station

Wave Information Studies of US Coastlines

Hindcast Wave Information for the US Atlantic Coast

by Jon M. Hubertz, Rebecca M. Brooks, Willie A. Brandon, Barbara A. Tracy
Coastal Engineering Research Center

Approved For Public Release; Distribution Is Unlimited

Prepared for Headquarters, U.S. Army Corps of Engineers

Pages from WIS Report 30

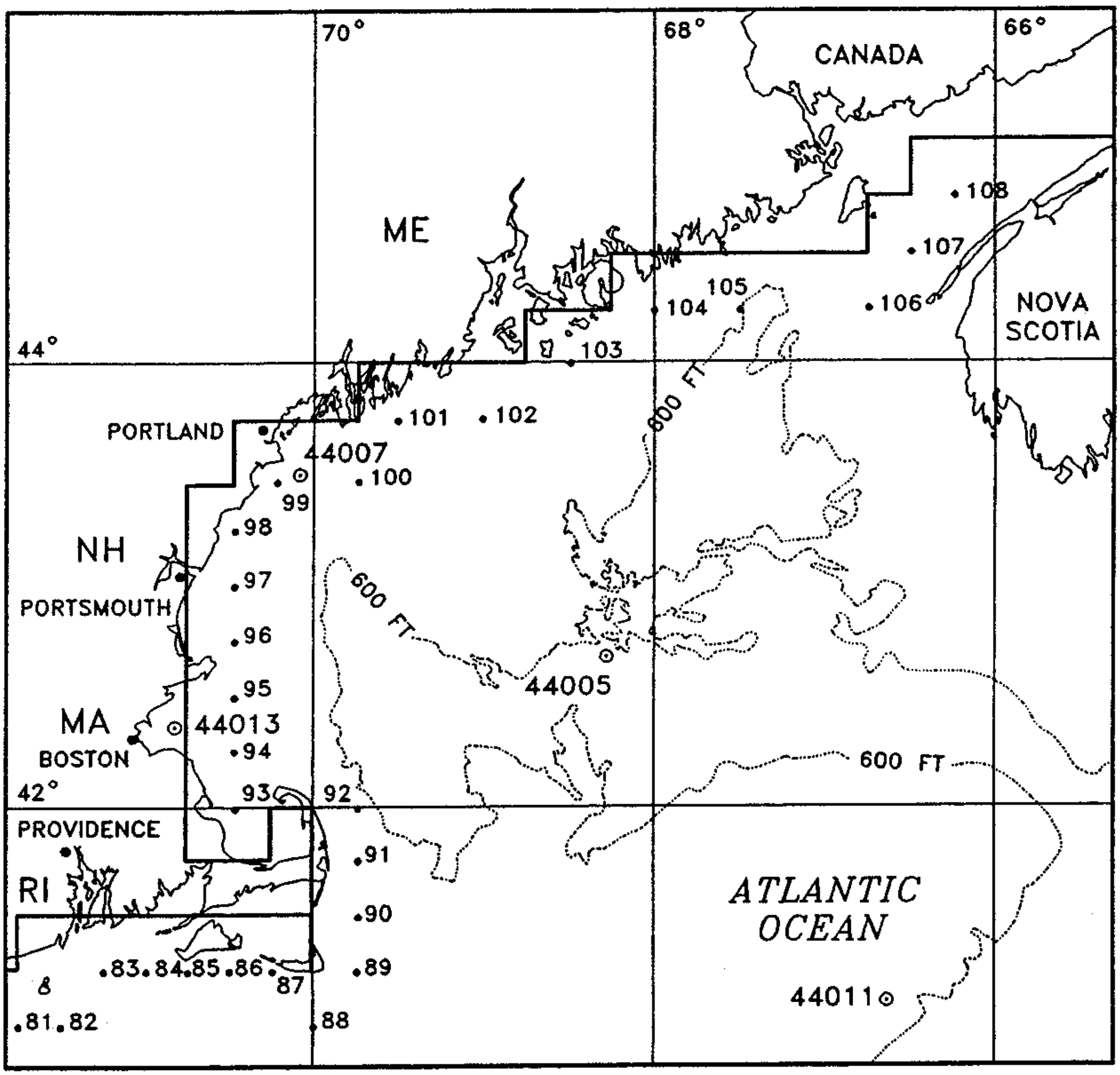


Figure 2. (Sheet 4 of 4)

WIS ATLANTIC REVISION 1956 - 1975
LAT: 42.00 N, LONG: 70.50 W, DEPTH: 18 M

STATION: 93

OCCURRENCES OF WIND DIRECTION BY MONTH FOR ALL YEARS

WD(deg) DIRECTION BAND & CENTER	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
337.50 - 22.49 (0.0)	673	564	616	572	402	276	201	383	522	520	590	657	5976
22.50 - 67.49 (45.0)	319	421	403	246	251	188	125	206	407	439	354	372	3731
67.50 - 112.49 (90.0)	251	301	372	256	268	162	85	139	383	313	298	391	3219
112.50 - 157.49 (135.0)	262	349	416	404	393	337	222	246	318	379	352	355	4033
157.50 - 202.49 (180.0)	386	302	421	542	763	781	786	618	550	554	637	432	6772
202.50 - 247.49 (225.0)	570	426	416	715	1111	1462	1674	1434	896	760	657	587	10708
247.50 - 292.49 (270.0)	1075	914	940	1104	1050	1073	1317	1227	953	1101	912	908	12574
292.50 - 337.49 (315.0)	1424	1243	1376	961	722	521	550	707	771	894	1000	1258	11427
TOTAL	4960	4520	4960	4800	4960	4800	4960	4960	4800	4960	4800	4960	58440

STATION: 93

SUMMARY OF MEAN Hmo(m) BY MONTH AND YEAR

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	MEAN
1956	1.79	0.85	1.00	0.67	0.59	0.51	0.50	0.57	0.56	0.73	0.79	0.81	0.78
1957	0.97	0.91	0.90	0.71	0.56	0.43	0.50	0.40	0.51	0.73	0.82	1.11	0.71
1958	1.11	1.11	1.23	1.01	0.56	0.51	0.49	0.49	0.68	0.80	0.91	1.06	0.83
1959	1.15	0.94	1.05	0.63	0.53	0.44	0.49	0.47	0.49	0.72	0.93	1.07	0.74
1960	1.05	1.22	1.21	0.65	0.47	0.58	0.46	0.42	0.54	0.84	0.80	0.96	0.77
1961	1.13	0.85	0.92	0.85	0.66	0.55	0.41	0.43	0.66	1.11	1.01	1.01	0.80
1962	0.95	1.04	1.46	0.72	0.49	0.47	0.46	0.59	0.69	0.78	1.20	1.12	0.83
1963	1.01	1.02	0.97	0.88	0.63	0.52	0.47	0.46	0.80	0.83	1.08	1.07	0.81
1964	1.40	1.26	1.06	0.68	0.67	0.62	0.52	0.55	0.64	0.73	0.88	1.16	0.85
1965	1.33	1.03	0.89	0.71	0.52	0.64	0.47	0.58	0.57	0.82	0.91	0.83	0.77
1966	1.59	0.98	0.79	0.52	0.58	0.54	0.50	0.47	0.67	0.75	0.85	1.23	0.79
1967	0.97	1.22	1.14	1.27	0.93	0.58	0.45	0.47	0.80	0.72	0.98	1.39	0.91
1968	1.34	1.19	1.04	0.90	0.60	0.51	0.46	0.59	0.50	0.81	1.15	1.32	0.87
1969	1.14	1.98	1.27	0.79	0.70	0.50	0.58	0.59	0.57	0.82	1.02	1.46	0.95
1970	1.12	0.94	0.94	0.77	0.64	0.57	0.51	0.56	0.60	0.80	0.88	1.41	0.81
1971	1.13	0.91	1.08	0.89	0.64	0.53	0.56	0.62	0.48	0.64	0.99	1.17	0.80
1972	0.98	1.11	0.99	0.78	0.71	0.60	0.45	0.56	0.79	0.83	1.08	1.03	0.83
1973	1.17	1.36	1.06	0.88	0.62	0.60	0.58	0.47	0.63	0.83	1.01	1.17	0.86
1974	0.90	1.33	1.04	0.92	0.64	0.55	0.50	0.53	0.60	0.86	1.31	1.14	0.85
1975	1.23	0.96	1.35	1.19	0.61	0.68	0.69	0.52	0.66	0.85	1.07	1.52	0.94
MEAN	1.17	1.11	1.07	0.82	0.62	0.55	0.50	0.52	0.62	0.80	0.98	1.15	

STATION: 93

MAX Hmo(m)*10 WITH ASSOCIATED Tp(sec) AND Dp(deg/10) BY MONTH AND YEAR

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	MAX
1956	6015 4	21 527	4510 1	27 7 6	21 635	11 414	11 422	27 8 2	19 6 1	27 8 2	21 636	27 630	6015 4
1957	28 735	22 7 1	33 836	23 7 0	15 636	14 520	11 420	10 420	14 521	24 7 2	27 8 3	43 9 4	43 9 4
1958	28 735	28 735	4310 4	4710 2	20 6 3	13 5 1	12 429	11 419	30 735	20 7 5	21 632	32 8 1	4710 2
1959	32 732	21 631	33 8 1	17 6 4	11 425	11 5 1	14 512	11 422	24 736	21 613	35 8 2	38 8 1	38 8 1
1960	24 631	34 835	5612 3	28 7 1	11 413	24 7 2	12 515	10 5 3	15 512	3510 4	21 630	5410 1	5612 3
1961	4511 4	46 9 4	28 8 0	31 8 0	15 526	12 420	10 424	10 422	21 6 0	4911 3	34 9 0	32 8 0	4911 3
1962	25 7 1	36 9 4	5411 3	19 636	14 530	11 427	12 428	30 8 1	31 8 1	28 735	5210 0	45 936	5411 3
1963	34 836	38 936	29 735	23 736	17 6 1	15 6 0	12 531	13 429	27 7 0	45 935	27 8 1	32 735	45 935
1964	5011 3	36 836	28 7 3	17 531	12 426	14 534	19 6 0	17 6 1	20 635	20 634	30 8 1	5511 0	5511 0
1965	41 9 4	28 612	27 7 1	26 735	11 425	12 5 5	11 423	12 430	15 535	20 632	21 631	33 836	41 9 4
1966	4410 2	33 8 0	23 7 0	20 7 2	13 531	11 422	11 422	11 424	16 5 6	21 630	20 636	35 8 2	4410 2
1967	25 7 1	38 8 1	35 8 1	5110 1	4510 3	24 8 4	10 422	10 420	24 8 4	25 736	34 835	4810 1	5110 1
1968	4210 3	5211 2	3910 1	18 635	16 5 1	11 414	10 420	11 536	12 5 1	20 633	43 9 1	38 9 0	5211 2
1969	31 8 0	6213 3	4510 3	24 7 1	12 419	11 423	13 5 3	13 521	18 6 1	24 7 1	37 9 3	38 9 1	6213 3
1970	35 836	29 8 0	33 8 1	20 527	18 7 1	11 423	11 425	22 735	12 430	34 8 0	28 7 0	42 936	42 936
1971	34 836	22 6 0	40 9 2	25 735	16 535	10 423	11 419	20 6 0	12 531	20 6 6	25 736	32 8 1	40 9 2
1972	27 735	24 736	20 7 0	29 8 1	34 8 1	16 512	11 419	12 5 2	34 8 1	24 7 1	30 8 1	20 6 5	34 8 1
1973	27 736	38 9 2	36 9 1	19 512	13 5 3	13 536	13 520	11 423	16 523	25 735	19 527	31 9 4	38 9 2
1974	27 7 0	35 835	22 7 0	25 7 1	23 7 0	14 6 3	12 433	13 521	15 528	32 836	5210 3	35 8 1	5210 3
1975	44 9 1	30 8 1	39 9 1	4410 3	35 8 1	23 7 5	27 8 3	17 6 3	20 635	36 8 1	4710 2	5312 4	5312 4
MAX	6015 4	6213 3	5612 3	5110 1	4510 3	24 8 4	27 8 3	30 8 1	34 8 1	4911 3	5210 3	5511 0	

MAX Hmo(m): 6.2 MAX Tp(sec): 13. MAX Dp(deg): 25. DATE(gmt): 69021015

MAX WIND SPEED(m/sec): 26. MAX WIND DIRECTION(deg): 335. DATE(gmt): 64120112

WIS ATLANTIC REVISION, 1956 - 1975
LAT: 42.25 N, LONG: 70.50 W, DEPTH: 27 M

STATION: 94

OCCURRENCES OF WIND DIRECTION BY MONTH FOR ALL YEARS

WD(deg) DIRECTION BAND & CENTER	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
337.50 - 22.49 (0.0)	667	581	635	591	395	267	212	370	519	528	574	662	6001
22.50 - 67.49 (45.0)	315	406	422	243	253	181	113	206	388	410	365	365	3667
67.50 - 112.49 (90.0)	250	299	350	256	258	181	85	130	385	313	288	398	3193
112.50 - 157.49 (135.0)	258	357	429	396	400	327	218	252	315	388	359	351	4050
157.50 - 202.49 (180.0)	400	312	419	551	762	771	786	601	554	542	651	440	6789
202.50 - 247.49 (225.0)	562	427	422	711	1097	1461	1648	1429	909	789	657	597	10709
247.50 - 292.49 (270.0)	1097	913	945	1097	1068	1085	1338	1246	957	1101	939	899	12685
292.50 - 337.49 (315.0)	1411	1225	1338	955	727	527	560	726	773	889	967	1248	11346
TOTAL	4960	4520	4960	4800	4960	4800	4960	4960	4800	4960	4800	4960	58440

STATION: 94

SUMMARY OF MEAN Hmo(m) BY MONTH AND YEAR

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	MEAN
1956	2.19	0.97	1.15	0.79	0.64	0.63	0.57	0.63	0.72	0.91	0.93	1.05	0.93
1957	1.09	0.98	1.08	0.80	0.60	0.51	0.53	0.45	0.58	0.87	0.99	1.25	0.81
1958	1.58	1.26	1.53	1.27	0.73	0.64	0.51	0.54	0.72	1.02	1.00	1.19	1.00
1959	1.27	1.00	1.16	0.77	0.58	0.53	0.54	0.57	0.57	0.92	1.07	1.23	0.85
1960	1.13	1.46	1.33	0.72	0.61	0.71	0.50	0.44	0.68	0.95	0.90	1.12	0.88
1961	1.27	0.98	1.10	0.96	0.80	0.60	0.47	0.47	0.85	1.31	1.17	1.09	0.92
1962	1.01	1.25	1.77	0.82	0.65	0.51	0.52	0.72	0.87	0.96	1.38	1.34	0.98
1963	1.16	1.15	1.08	0.94	0.74	0.58	0.52	0.51	1.00	0.96	1.45	1.16	0.93
1964	1.56	1.37	1.21	0.78	0.75	0.68	0.59	0.61	0.76	0.83	1.00	1.40	0.96
1965	1.53	1.17	0.95	0.78	0.57	0.69	0.51	0.63	0.71	0.90	1.06	0.98	0.87
1966	1.82	1.03	0.91	0.60	0.65	0.57	0.57	0.50	0.77	0.84	1.22	1.41	0.91
1967	1.20	1.33	1.25	1.48	1.13	0.66	0.49	0.51	0.93	0.82	1.13	1.62	1.04
1968	1.50	1.33	1.28	1.07	0.69	0.61	0.52	0.60	0.66	0.88	1.36	1.45	1.00
1969	1.31	2.55	1.46	0.91	0.83	0.59	0.70	0.61	0.72	0.93	1.40	1.76	1.14
1970	1.17	1.14	1.05	0.90	0.78	0.65	0.58	0.62	0.64	0.96	1.16	1.66	0.94
1971	1.20	1.10	1.22	1.04	0.80	0.57	0.60	0.66	0.65	0.79	1.16	1.32	0.92
1972	1.07	1.32	1.15	0.85	0.87	0.76	0.49	0.63	0.93	0.93	1.23	1.29	0.96
1973	1.27	1.51	1.27	1.16	0.78	0.67	0.68	0.56	0.71	0.97	1.06	1.36	1.00
1974	0.98	1.39	1.17	1.01	0.80	0.66	0.57	0.60	0.75	0.97	1.49	1.41	0.98
1975	1.52	1.06	1.53	1.32	0.70	0.78	0.79	0.61	0.82	1.00	1.20	1.93	1.11
MEAN	1.34	1.27	1.23	0.95	0.73	0.63	0.56	0.57	0.75	0.94	1.17	1.35	

STATION: 94

MAX Hmo(m)*10 WITH ASSOCIATED Tp(sec) AND Dp(deg/10) BY MONTH AND YEAR

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	MAX
1956	7615 6	26 619	5110 3	33 8 8	22 635	13 414	16 518	29 8 6	25 7 8	28 8 4	27 810	28 630	7615 6
1957	34 8 8	23 7 3	39 9 8	26 7 2	16 6 0	18 619	14 519	10 423	13 532	25 7 3	30 8 5	48 9 5	48 9 5
1958	4610 9	41 9 8	4911 8	5610 4	22 8 8	16 5 1	13 530	16 519	31 736	31 8 8	23 631	33 8 5	5610 4
1959	3913 9	23 631	41 9 9	18 517	12 519	11 420	16 512	12 8 9	26 7 3	361011	41 9 5	44 9 4	44 9 4
1960	25 631	42 9 9	7012 6	26 7 3	13 412	23 7 5	13 517	11 519	20 710	37 9 5	22 529	6211 4	7012 6
1961	5110 7	6011 6	33 8 9	31 736	21 6 6	16 519	11 432	11 421	32 8 9	5510 4	38 8 1	36 8 5	6011 6
1962	23 617	41 9 7	6713 8	25 7 9	14 530	11 426	12 428	31 7 0	33 8 7	35 7 0	5710 2	5410 2	6713 8
1963	37 8 0	39 835	31 8 8	23 633	19 7 5	15 5 3	12 518	18 516	29 8 5	46 9 1	5110 9	34 735	5110 9
1964	5410 5	41 8 3	29 8 5	18 619	13 425	16 520	16 5 1	17 517	23 636	21 635	34 8 3	6010 1	6010 1
1965	45 9 5	50 911	28 7 3	26 736	12 518	13 519	12 421	13 428	16 535	21 632	24 620	36 836	50 911
1966	5310 7	38 8 0	23 7 1	21 6 2	14 516	11 419	11 421	12 421	21 711	22 630	27 912	40 9 4	5310 7
1967	42 910	41 8 3	38 8 2	6112 7	5210 3	25 8 6	11 418	13 519	25 8 7	25 7 1	36 8 1	53 9 1	6112 7
1968	4710 5	6011 4	4810 3	22 619	25 810	17 7 9	12 519	12 421	1712 9	23 6 2	5010 4	39 836	6011 4
1969	31 736	7513 4	5210 4	23 619	18 518	12 518	19 5 1	12 520	19 6 1	25 7 1	41 9 5	561110	7513 4
1970	36 8 1	33 810	33 7 1	24 811	17 6 3	14 519	15 519	25 7 2	14 518	34 8 1	32 7 1	5110 9	5110 9
1971	36 8 1	28 7 9	4610 8	27 7 1	17 6 2	11 423	15 519	20 6 1	14 8 9	21 7 7	38 9 9	37 8 1	4610 8
1972	28 736	4110 8	23 7 0	31 735	37 9 5	31 8 8	14 518	13 423	43 9 4	28 7 8	32 8 2	34 9 9	43 9 4
1973	30 8 8	41 9 3	40 9 3	38 910	18 517	15 712	17 520	12 6 9	17 519	36 9 8	19 618	35 8 9	41 9 3
1974	28 7 1	36 8 1	30 7 9	31 8 7	24 7 2	16 6 3	12 535	15 8 9	20 617	32 8 1	5812 7	5711 9	5812 7
1975	47 9 1	32 8 3	4410 5	46 9 5	39 8 2	21 6 7	26 7 5	17 6 0	21 635	38 8 2	5310 4	6912 6	6912 6
MAX	7615 6	7513 4	7012 6	6112 7	5210 3	31 8 8	26 7 5	31 7 0	43 9 4	5510 4	5812 7	6912 6	

MAX Hmo(m): 7.6 MAX Tp(sec): 15. MAX Dp(deg): 58. DATE(gmt): 56010918

MAX WIND SPEED(m/sec): 26. MAX WIND DIRECTION(deg): 340. DATE(gmt): 64120112

WIS ATLANTIC REVISION 1956 - 1975
LAT: 42.50 N, LONG: 70.50 W, DEPTH: 55 M

STATION: 95

OCCURRENCES OF WIND DIRECTION BY MONTH FOR ALL YEARS

WD(deg) DIRECTION BAND & CENTER	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
337.50 - 22.49 (0.0)	678	574	661	622	385	263	218	377	507	530	566	675	6056
22.50 - 67.49 (45.0)	314	401	430	237	252	192	116	203	384	384	371	380	3664
67.50 - 112.49 (90.0)	232	296	348	246	253	161	83	127	359	312	278	384	3079
112.50 - 157.49 (135.0)	277	359	416	398	408	330	206	247	320	378	357	359	4055
157.50 - 202.49 (180.0)	393	312	424	573	744	752	774	594	554	557	679	442	6798
202.50 - 247.49 (225.0)	575	443	433	701	1104	1479	1632	1420	930	814	658	615	10804
247.50 - 292.49 (270.0)	1105	917	919	1081	1065	1079	1355	1256	960	1115	957	893	12702
292.50 - 337.49 (315.0)	1386	1218	1329	942	749	544	576	736	786	870	934	1212	11282
TOTAL	4960	4520	4960	4800	4960	4800	4960	4960	4800	4960	4800	4960	58440

STATION: 95

SUMMARY OF MEAN Hmo(m) BY MONTH AND YEAR

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	MEAN
1956	2.33	1.03	1.18	0.83	0.66	0.67	0.59	0.65	0.73	0.92	0.97	1.12	0.97
1957	1.11	0.98	1.08	0.85	0.61	0.57	0.54	0.46	0.60	0.88	1.07	1.33	0.84
1958	1.72	1.27	1.58	1.38	0.80	0.71	0.53	0.57	0.74	1.06	1.04	1.18	1.05
1959	1.33	1.01	1.21	0.80	0.59	0.56	0.59	0.57	0.59	1.02	1.16	1.28	0.89
1960	1.14	1.54	1.35	0.75	0.69	0.75	0.53	0.45	0.71	0.97	0.95	1.20	0.92
1961	1.32	1.02	1.13	0.98	0.85	0.61	0.49	0.49	0.89	1.37	1.21	1.12	0.96
1962	1.06	1.27	1.77	0.86	0.71	0.53	0.54	0.75	0.89	1.02	1.43	1.41	1.02
1963	1.18	1.18	1.14	0.95	0.80	0.59	0.55	0.52	1.02	0.98	1.58	1.19	0.97
1964	1.63	1.41	1.24	0.82	0.78	0.69	0.63	0.65	0.80	0.85	1.05	1.47	1.00
1965	1.58	1.24	0.95	0.82	0.58	0.69	0.54	0.67	0.75	0.96	1.12	1.04	0.91
1966	1.86	1.04	0.97	0.59	0.67	0.59	0.60	0.52	0.80	0.88	1.31	1.44	0.94
1967	1.28	1.37	1.23	1.50	1.19	0.68	0.52	0.53	0.98	0.88	1.18	1.67	1.08
1968	1.53	1.36	1.36	1.12	0.70	0.65	0.56	0.61	0.67	0.90	1.40	1.48	1.03
1969	1.35	2.70	1.50	0.97	0.89	0.64	0.75	0.63	0.77	0.95	1.54	1.89	1.20
1970	1.15	1.23	1.07	0.95	0.86	0.70	0.63	0.64	0.66	1.00	1.20	1.70	0.98
1971	1.22	1.19	1.25	1.07	0.85	0.59	0.62	0.68	0.71	0.82	1.21	1.36	0.96
1972	1.09	1.38	1.22	0.87	0.94	0.86	0.52	0.65	0.97	0.96	1.26	1.34	1.00
1973	1.33	1.54	1.33	1.25	0.85	0.74	0.73	0.57	0.75	0.98	1.09	1.47	1.05
1974	1.00	1.37	1.25	1.05	0.84	0.70	0.59	0.61	0.78	1.01	1.52	1.49	1.02
1975	1.58	1.07	1.56	1.34	0.73	0.81	0.83	0.63	0.87	1.02	1.25	2.04	1.15
MEAN	1.39	1.31	1.27	0.99	0.78	0.67	0.59	0.59	0.78	0.97	1.23	1.41	

STATION: 95

MAX Hmo(m)*10 WITH ASSOCIATED Tp(sec) AND Dp(deg/10) BY MONTH AND YEAR

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	MAX
1956	9314 7	33 719	5610 7	33 8 9	22 635	16 513	18 618	29 8 5	23 6 8	28 8 5	31 718	29 630	9314 7
1957	34 8 9	22 911	38 8 7	27 813	15 6 1	22 619	16 519	10 536	15 519	26 7 3	33 8 6	51 9 6	51 9 6
1958	5010 9	45 9 8	5711 7	54 9 3	23 810	19 5 1	13 514	18 617	29 7 0	33 8 8	26 715	31 7 1	5711 7
1959	4013 9	24 631	49 910	21 615	15 519	14 518	20 611	12 810	24 7 4	501012	46 9 5	48 9 5	501012
1960	25 631	49 9 9	7211 6	23 6 1	16 512	20 6 3	15 518	14 519	22 612	38 8 5	26 619	6610 4	7211 6
1961	5310 7	6711 7	35 8 9	32 8 7	221012	18 619	11 519	11 421	31 810	55 9 4	39 8 2	38 8 5	6711 7
1962	29 813	42 9 8	6712 8	26 7 9	15 518	11 425	14 519	29 7 2	37 8 7	351110	58 9 0	5612 9	6712 8
1963	36 8 0	38 8 1	33 8 7	23 633	25 614	15 5 3	15 518	22 616	30 8 6	46 834	6211 9	35 8 1	6211 9
1964	5710 7	40 8 3	29 8 4	22 619	15 812	18 619	14 519	22 617	22 8 9	22 635	36 912	6210 4	6210 4
1965	47 9 6	561111	28 7 4	24 635	15 519	13 519	15 519	16 520	19 618	27 812	27 719	39 835	561111
1966	6110 4	42 9 4	23 636	18 6 3	16 516	14 520	12 420	14 519	21 712	22 630	35 912	41 9 5	6110 4
1967	48 910	41 8 5	38 8 3	5613 9	5410 5	26 8 6	12 518	17 519	24 7 7	24 636	34 735	5710 6	5710 6
1968	50 9 4	6410 4	51 9 7	26 615	26 711	18 710	16 520	16 519	17 519	23 6 2	5410 6	39 8 0	6410 4
1969	321010	8813 5	5610 6	25 620	23 618	15 517	20 810	12 422	19 6 1	23 6 1	43 9 5	681110	8813 5
1970	35 8 2	36 811	32 7 2	29 812	20 619	17 619	18 619	25 7 6	17 618	32 735	31 7 3	601010	601010
1971	38 9 5	30 812	5210 9	25 7 3	17 812	12 519	18 619	19 6 3	15 531	21 7 8	3910 9	42 9 4	5210 9
1972	26 7 1	4510 9	26 614	29 7 1	36 7 1	35 8 8	18 618	16 520	4710 7	28 8 8	36 9 4	36 9 9	4710 7
1973	31 736	44 9 3	42 9 4	46 910	22 616	19 712	21 619	12 610	21 618	39 9 9	24 618	36 8 6	46 910
1974	26 619	34 734	29 8 9	32 8 7	25 614	20 712	13 535	17 520	25 618	30 734	6010 4	631110	631110
1975	49 9 4	31 7 2	50 9 5	4511 9	38 9 5	20 618	25 8 8	17 6 0	21 635	34 7 1	6010 6	8412 7	8412 7
MAX	9314 7	8813 5	7211 6	5613 9	5410 5	35 8 8	25 8 8	29 7 2	4710 7	55 9 4	6211 9	8412 7	

MAX Hmo(m): 9.3 MAX Tp(sec): 14. MAX Dp(deg): 65. DATE(gmt): 56010918

MAX WIND SPEED(m/sec): 27. MAX WIND DIRECTION(deg): 345. DATE(gmt): 64120112

Worksheet 2-1: Wave Setup Computations (SPM pg. 3-107)

Given:28.0 = Hmo (feet)
12.7 = Tp (seconds)
1/85 = Nearshore slope (see Part 4 of Exhibit)

Compute:Deepwater wave length Lo

$Lo = g*Tp^2/2\pi = (32.2*12.7)/(2*\pi) = 826.6$ (feet)

Wave Steepness Hmo/Lo

Hmo/Lo = 28.0/826.6 = 0.0339

Using Figure 3-53 on page 3-109 of SPM find

S/Hmo = 0.038 for slope 1/30 at ds/Hmo=0.5
S/Hmo = 0.035 for slope 1/100 at ds/Hmo=0.5

Interpolate S/Hmo for a slope of 1/85

S/Hmo = 0.0352 for slope 1/85 at ds/Hmo=0.5

Compute

2*(S/Hmo at ds/Hmo=0.5) = S/Hmo at shoreline = 0.0705

Compute setup magnitude S in feet

S = Hmo * S/Hmo = 28.0*0.0705 = 1.97 or

<u>Setup is approximately 2.0 feet</u>

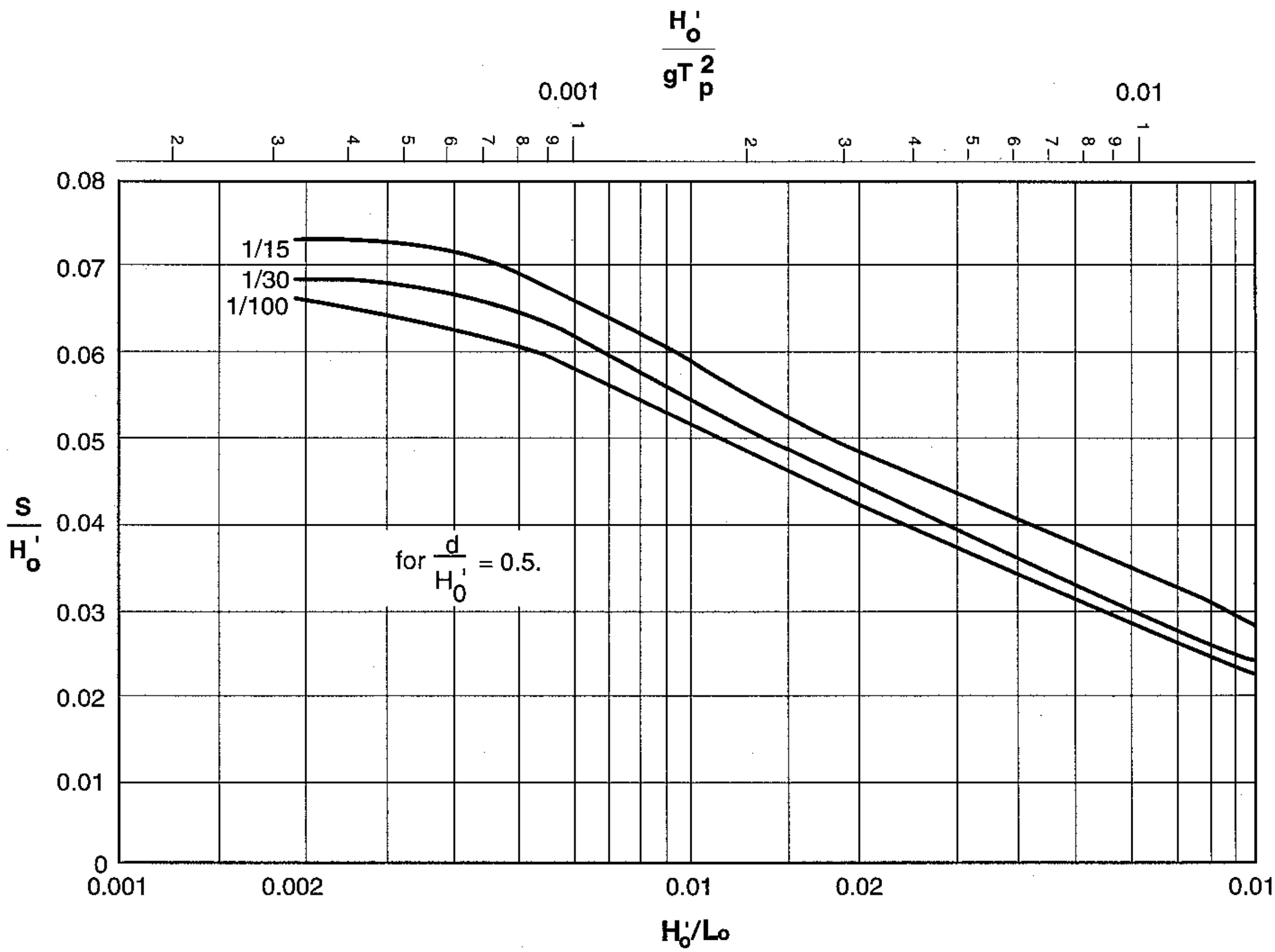


Figure 3-53: Predicted random wave (sea) setup on plane slopes for $\frac{d}{H_0}$ = 0.5.

PART 3: EROSION/SCOUR

Worksheet 3-1: Erosion analysis for Transect A

Pre-Storm Profile

	Station	Elevation
profile-points	-150.0	-4.0
	0.0	0.0
	185.0	5.0
	250.0	10.0
	300.0	20.0
	350.0	25.0
	400.0	20.0
	650.0	10.0
	700.0	8.0
	3500.0	10.4

FEMA's Treatment of sand dune erosion in 100-year event

Unit: ENGLISH
Critical area: 540.0 ft²
Seaward slope: 1 on 12.5
Approach slope: 1 on 40.0
Face slope: 1 on 1.0
SWFL: 10.4 ft (w/o setup)
Reservoir area: 1440.4 ft²

Points on profile and eroded profile for case of duneface retreat

Profile Point	Profile Station	Profile Elevation	Eroded Profile Point	Eroded Profile Station	Eroded Profile Elevation
1	-150.0	-4.0	1	-150.0	-4.0
			start SEAWARD-SLOPE	-99.0	-2.6
			start APPROACH-SLOPE	-53.2	1.0
2	.0	.0	2	(eroded)	
3	185.0	5.0	3	(eroded)	
			intersection with profile	223.2	7.9
4	250.0	10.0	4	(eroded)	
5	300.0	20.0	5	(eroded)	
			start FACE-SLOPE	321.8	10.4
			end erosion	334.8	23.5
6	350.0	25.0	6	350.0	25.0
7	400.0	20.0	7	400.0	20.0
8	650.0	10.0	8	650.0	10.0
9	700.0	8.0	9	700.0	8.0
10	3500.0	10.4	10	3500.0	10.4

Deposition area: 622.68 ft²

Figure 3-1: Transect A, Pre-Storm/Eroded Ground Elevations

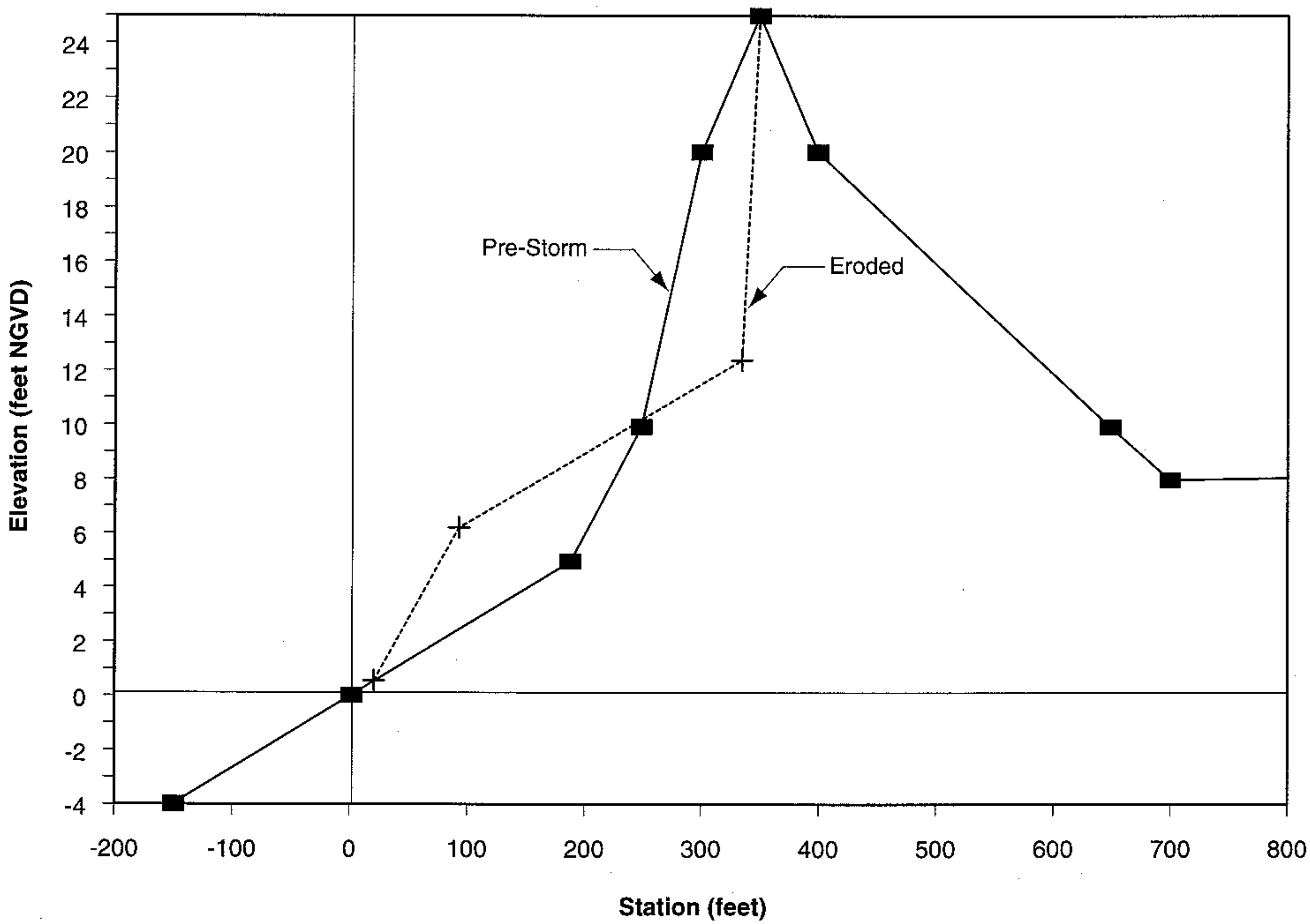


Figure 3-1. Transect A, PFD Retreat

Worksheet 3-2: Erosion analysis for Transect B

Pre-Storm Profile

	Station	Elevation
profile-points	-60.0	-4.0
	0.0	0.0
	75.0	5.0
	100.0	10.0
	200.0	15.0
	275.0	10.0
	400.0	8.0
	3500.0	10.4

FEMA's Treatment of sand dune erosion in 100-year event

Unit: ENGLISH
Critical area: 540.0 ft²
Removal slope: 1 on 50.0
SWFL: 10.4 ft (w/o setup)
Reservoir area: 211.6 ft²
Toe location: point 3

Points on profile and eroded profile for case of dune removal

Profile Point	Profile Station	Profile Elevation		Eroded Profile Point	Eroded Profile Station	Eroded Profile Elevation
1	-60.0	-4.0		1	-60.0	-4.0
2	.0	.0		2	.0	.0
3	75.0	5.0	start REMOVAL-SLOPE	3	75.0	5.0
4	100.0	10.0		4	(eroded)	
5	200.0	15.0		5	(eroded)	
6	275.0	10.0		6	(eroded)	
			end erosion		302.8	9.6
7	400.0	8.0		7	400.0	8.0
8	3500.0	10.4		8	3500.0	10.4

Dune removal area: 988.89 ft²

Figure 3-2: Transect B, Pre-Storm/Eroded Ground Elevations

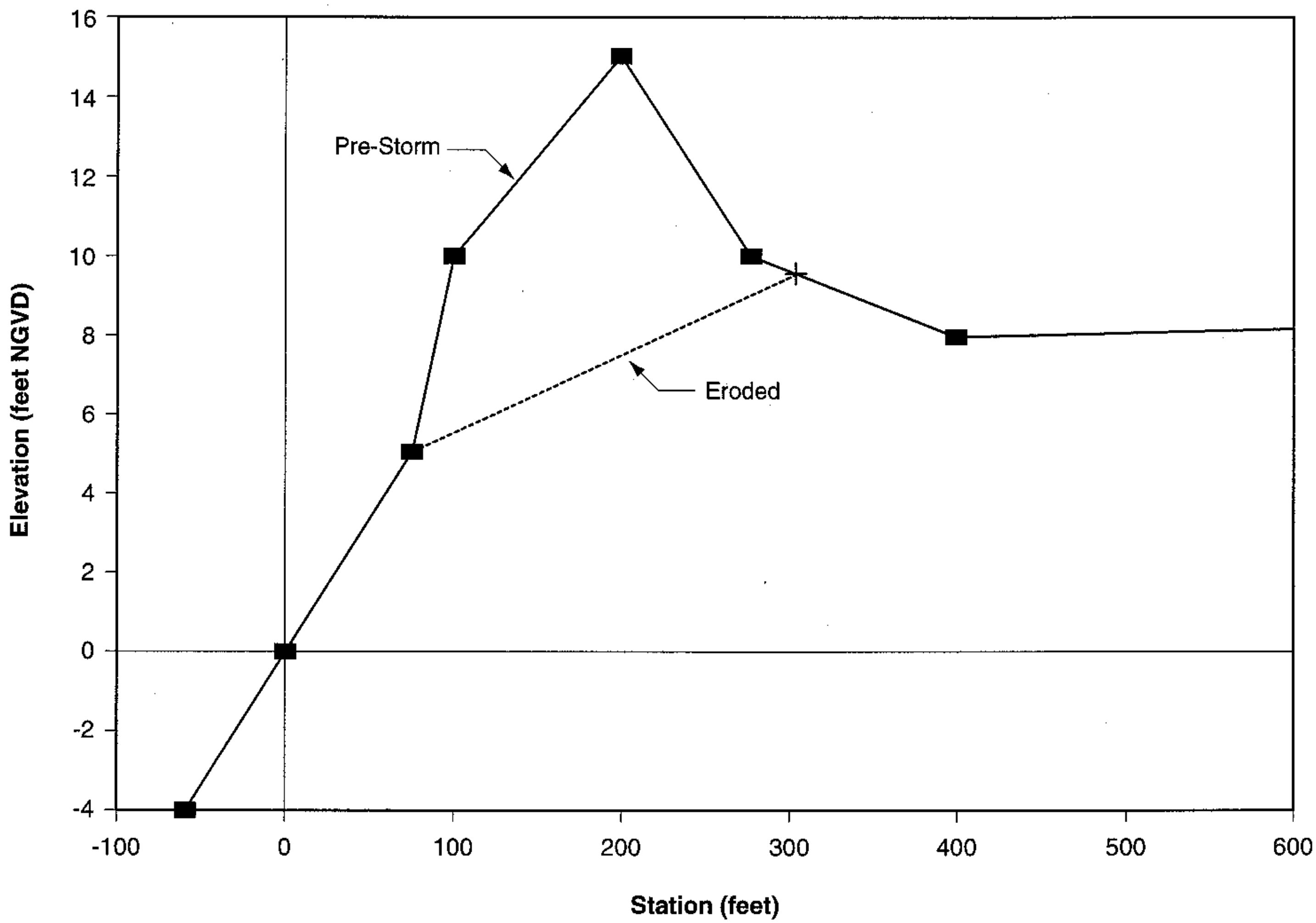


Figure 3-2. Transect B, Dune Removal

Worksheet 3-3: Scour Assessment Transect D

Given: 10.4 = 100-year Stillwater Elevation without setup (ft NGVD
6.0 = Average Ground Elevation from wall base 300 feet seaward (ft NGVD)
12.7 = Tp (seconds)

Compute: Average Water Depth and Shallow Water Wave Length

10.4 - 6.0 = 4.4 feet = average water depth = d
151.2 = Tp * $(g*d)^{1/2}$ = 12.7 * $(32.2 * 4.4)^{1/2}$

Find: Pre-Storm Ground Elevation 1 Wave Length from the Wall

From Figure 3-3 pre-storm ground elevation is approximately = 5.9 feet NGVD

Compute:

Pre-storm water depth one wavelength seaward of wall is approximately: 10.4 - 5.9 = 4.5 feet

Approximate Hs = 0.78/1.6 * 4.5 feet = 2.2 feet

Approximate scour elevation at wall base is approximately = 6.0 - 2.2 = 3.8 feet NGVD

<u>Scour elevation at wall toe is approximately 3.8 feet NGVD</u>

Figure 3-3: Transect D, Pre-Storm/Eroded Ground Elevations

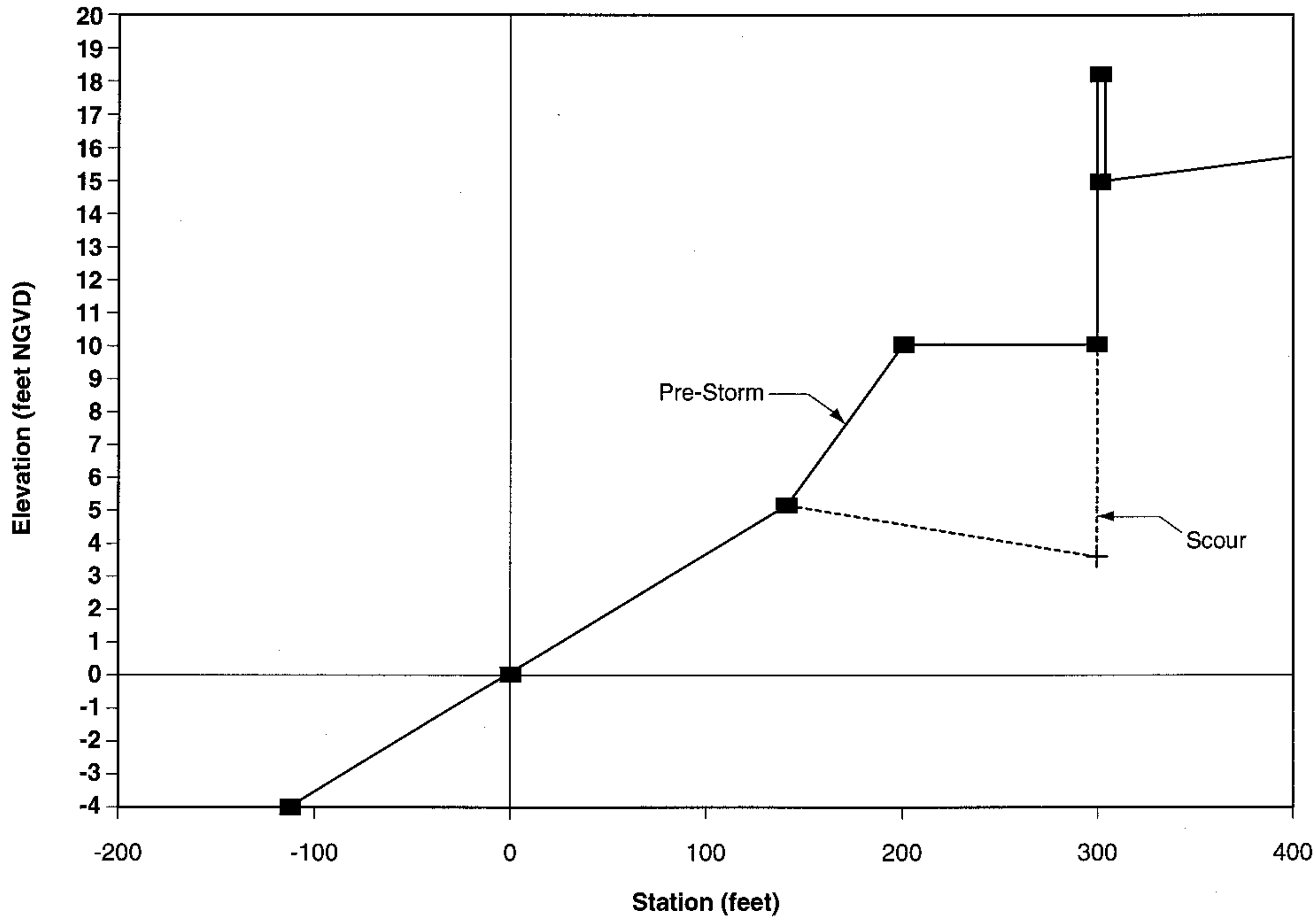


Figure 3-3. Transect D, Seawall

PART 4: WAVE RUNUP/OVERTOPPING

Table 4-1: Summary of Runup Elevations

Transect	Slope Number	Station 1 (ft)	Station 2 (ft)	Computed Runup Elevation (ft NGVD)
A	8	322	335	12.3
B	7	303	-	12.1
C	8	200	220	11.6
D	-	300	300	27.9[1]
E	N/A	N/A	N/A	N/A

[1] Runup elevation exceeds structure crest by more than 3 feet

Column 1: Transect letter
Column 2: Slope number from RUNUP model output
Column 3 and 4: Stations between which water is running up
Column 5: Computed runup elevation (10.4 feet plus average runup magnitude from RUNUP model output)

All sounding taken from USGS quadrangle

Table 4-2: Average Distance to -6 foot sounding (-10 feet NGVD)

Transect	Station (ft from 0 NGVD)
A	-570
B	-900
C	-550
D	-250
E	-650
Avg.	-585

Table 4-3: Average Distance to -18 foot sounding (-22 feet NGVD)

Transect	Station (ft from 0 NGVD)
A	-1500
B	-1500
C	-1600
D	-1400
E	-1500
Avg.	-1500

Table 4-4: Average Distance to -30 foot sounding (-34 feet NGVD)

Transect	Station (ft from 0 NGVD)
A	-2400
B	-2900
C	-2400
D	-2800
E	-2850
Avg.	-2670

Table 4-5: Summary of Average Nearshore Bathymetry

Station (ft from 0 NGVD)	Elevation (ft NGVD)
-585	-10
-1500	-22
-2670	-34

Transect A, RUNUP model input and output

FILE: G&S_TAR.IN

```
  Transect A, G&S Example, Dune Retreat
  Runup calculations on Eroded Transect
1.0
  -34.0 -2670.0 1.0
  -22.0 -1500.0 1.0
  -10.0  -585.0 1.0
   -4.0  -150.0 1.0
   -2.6   -99.0 1.0
    1.0    53.0 1.0
    7.9   223.0 1.0
   10.4   322.0 1.0
   23.5   335.0 1.0
1  25.0   350.0 1.0
 10.4   16.6  10.3
 10.4   16.6  10.8
 10.4   16.6  11.3
 10.4   17.5  10.3
 10.4   17.5  10.8
 10.4   17.5  11.3
 10.4   18.4  10.3
 10.4   18.4  10.8
 10.4   18.4  11.3
```

FILE: G&S_TAR.OUT

```
CLIENT- Transect A, G&S Example, D** WAVE RUNUP-VERSION 2.0  ** ENGINEERED BY         JOB
PROJECT-Runup calculations on Eroded Transect                                  RUN      PAGE  1

************************************************************************************************************************
```

CROSS SECTION PROFILE

	LENGTH	ELEV.	SLOPE	ROUGHNESS
1	-2670.0	-34.0		
			97.50	1.00
2	-1500.0	-22.0		
			76.25	1.00
3	-585.0	-10.0		
			72.50	1.00
4	-150.0	-4.0		
			36.43	1.00
5	-99.0	-2.6		
			42.22	1.00
6	53.0	1.0		
			24.64	1.00
7	223.0	7.9		
			39.60	1.00
8	322.0	10.4		
			.99	1.00
9	335.0	23.5		
			10.00	1.00
10	350.0	25.0		

LAST SLOPE 1.00 LAST ROUGHNESS 1.00

****

OUTPUT TABLE

INPUT PARAMETERS			RUNUP RESULTS			
WATER LEVEL ABOVE DATUM (FT.)	DEEP WATER WAVE HEIGHT (FT.)	WAVE PERIOD (SEC.)	BREAKING SLOPE NUMBER	RUNUP SLOPE NUMBER	RUNUP ABOVE WATER LEVEL (FT.)	BREAKER DEPTH (FT.)
10.40	16.60	10.30	2	8	1.66	26.46
10.40	16.60	10.80	2	8	1.83	26.83
10.40	16.60	11.30	2	8	1.99	27.20
10.40	17.50	10.30	2	8	1.75	27.69
10.40	17.50	10.80	2	8	1.92	28.07
10.40	17.50	11.30	2	8	1.92	28.45
10.40	18.40	10.30	2	8	1.84	28.91
10.40	18.40	10.80	2	8	1.84	29.30
10.40	18.40	11.30	2	8	2.02	29.69

					Average 1.89	

Transect B, RUNUP model input and output

FILE: G&S_TBR.IN

```
  Transect B, G&S Example, Dune Removal
  Runup calculations on Un-eroded Transect
50.0
  -34.0 -2670.0 1.0
  -22.0 -1500.0 1.0
  -10.0  -585.0 1.0
   -4.0   -60.0 1.0
    0.0     0.0 1.0
    5.0    75.0 1.0
1   9.6   303.0 1.0
 10.4   16.6  10.3
 10.4   16.6  10.8
 10.4   16.6  11.3
 10.4   17.5  10.3
 10.4   17.5  10.8
 10.4   17.5  11.3
 10.4   18.4  10.3
 10.4   18.4  10.8
 10.4   18.4  11.3
```

FILE: G&S_TBR.OUT

```
CLIENT- Transect B, G&S Example, D      ** WAVE RUNUP-VERSION 2.0 **        ENGINEERED BY              JOB
PROJECT-Runup calculations on Un-eroded Transect                                                  RUN         PAGE   1
*************************************************************************************************************************


                  CROSS SECTION PROFILE

                LENGTH   ELEV.    SLOPE     ROUGHNESS

    1          -2670.0   -34.0
                                  97.50        1.00
    2          -1500.0   -22.0
                                  76.25        1.00
    3           -585.0   -10.0
                                  87.50        1.00
    4            -60.0    -4.0
                                  15.00        1.00
    5               .0      .0
                                  15.00        1.00
    6             75.0     5.0
                                  49.57        1.00
    7            303.0     9.6

                   LAST SLOPE  50.00     LAST ROUGHNESS   1.00
```

****

OUTPUT TABLE

INPUT PARAMETERS			RUNUP RESULTS			
WATER LEVEL ABOVE DATUM (FT.)	DEEP WATER WAVE HEIGHT (FT.)	WAVE PERIOD (SEC.)	BREAKING SLOPE NUMBER	RUNUP SLOPE NUMBER	RUNUP ABOVE WATER LEVEL (FT.)	BREAKER DEPTH (FT.)
10.40	16.60	10.30	2	7	1.66	26.46
10.40	16.60	10.80	2	7	1.66	26.83
10.40	16.60	11.30	2	7	1.66	27.20
10.40	17.50	10.30	2	7	1.58	27.69
10.40	17.50	10.80	2	7	1.75	28.07
10.40	17.50	11.30	2	7	1.75	28.45
10.40	18.40	10.30	2	7	1.66	28.91
10.40	18.40	10.80	2	7	1.66	29.30
10.40	18.40	11.30	2	7	1.84	29.69
					Average 1.69	

Transect C, RUNUP model input and output

FILE: G&S_TCR.IN

```
  Transect C, G&S Example, Bluff
  Runup calculations on Un-eroded Transect
8.0
  -34.0 -2670.0 1.0
  -22.0 -1500.0 1.0
  -10.0  -585.0 1.0
   -4.0   -80.0 1.0
    0.0     0.0 1.0
    5.0   100.0 0.9
    6.0   120.0 0.6
   10.0   200.0 0.6
   12.5   220.0 0.6
1  20.0   280.0 0.9
 10.4   16.6  10.3
 10.4   16.6  10.8
 10.4   16.6  11.3
 10.4   17.5  10.3
 10.4   17.5  10.8
 10.4   17.5  11.3
 10.4   18.4  10.3
 10.4   18.4  10.8
 10.4   18.4  11.3
```

FILE: G&S_TCR.OUT

```
CLIENT- Transect C, G&S Example, B** WAVE RUNUP-VERSION 2.0  ** ENGINEERED BY          JOB
PROJECT-Runup calculations on Un-eroded Transect                               RUN      PAGE  1
*********************************************************************************************************************
```

CROSS SECTION PROFILE

	LENGTH	ELEV.	SLOPE	ROUGHNESS
1	-2670.0	-34.0		
			97.50	1.00
2	-1500.0	-22.0		
			76.25	1.00
3	-585.0	-10.0		
			84.17	1.00
4	-80.0	-4.0		
			20.00	1.00
5	.0	.0		
			20.00	1.00
6	100.0	5.0		
			20.00	.90
7	120.0	6.0		
			20.00	.60
8	200.0	10.0		
			8.00	.60
9	220.0	12.5		
			8.00	.60
10	280.0	20.0		

LAST SLOPE 8.00 LAST ROUGHNESS .90

****

OUTPUT TABLE

INPUT PARAMETERS			RUNUP RESULTS			
WATER LEVEL ABOVE DATUM (FT.)	DEEP WATER WAVE HEIGHT (FT.)	WAVE PERIOD (SEC.)	BREAKING SLOPE NUMBER	RUNUP SLOPE NUMBER	RUNUP ABOVE WATER LEVEL (FT.)	BREAKER DEPTH (FT.)
10.40	16.60	10.30	2	8	1.10	26.46
10.40	16.60	10.80	2	8	1.20	26.83
10.40	16.60	11.30	2	8	1.20	27.20
10.40	17.50	10.30	2	8	1.10	27.69
10.40	17.50	10.80	2	8	1.21	28.07
10.40	17.50	11.30	2	8	1.21	28.45
10.40	18.40	10.30	2	8	1.10	28.91
10.40	18.40	10.80	2	8	1.10	29.30
10.40	18.40	11.30	2	8	1.21	29.69
					Average 1.15	

Worksheet 4-1: Wave Runup Calculations for Transect D (SPM pg.7-25)

Given:

28.0 = Hmo (feet)
12.7 = Tp (seconds)
2.0 = Structure Toe Elevation (feet NGVD)
10.4 = Stillwater Elevation (w/o wave setup)

Compute:

8.4 = Water Depth at Structure Toe (10.4 - 2.0) = ds
17.5 = H bar = 0.625 * 28.0 (feet)
10.8 = T bar = 0.85 * 12.7 (seconds)
0.0047 = H bar/(g*Tp^2)
0.4792 = ds/H bar

From Figure 7-14, page 7-25 of SPM find R/H bar (assume slope of 1/10)

1.0 = R/H bar

Compute Runup Magnitude = R/H bar * H bar = 1 * 17.5 = 17.5 feet

Compute Runup Elevation = 17.5 + 10.4 = 27.9 feet NGVD

Runup Elevation = 27.9 feet NGVD[1]

[1] Computed runup elevation is greater than 3 feet above structure crest

Worksheet 4-2: Overtopping Assessment for Transect D

Given:

18.2 = Eroded crest of structure, dune, or bluff (feet NGVD)
10.4 = 100-year stillwater elevation w/o setup (feet NGVD)
8.4 = Water depth at structure toe (feet) = dt
28.0 = Incident Hos = Hmo for this case

Compute:

7.8 = Freeboard available = 18.2 - 10.4 (feet)
0.3 = dt/Hos

Find from Figure 18 in the <u>Guidelines and Specifications for Wave Elevation determination and V-Zone Mapping</u>

0.34 = F/Hos for Qbar = 1 cfs/ft
1.25 = F/Hos for Qbar = 0.01 cfs/ft

Compute:

9.5 = Freeboard required for Qbar = 1.0 cfs/ft (feet)
35.0 = Freeboard required for Qbar = 0.01 cfs/ft (feet)

Conclusions:

Overtopping exceeds 1 cfs/ft, V-Zone should extend at a minimum 25 feet landward of wall crest, and the wave crest immediately seaward of wall should be extended to this point. Zones AO (depth 2 feet) and AO (depth 1 foot) should be delineated if appropriate.

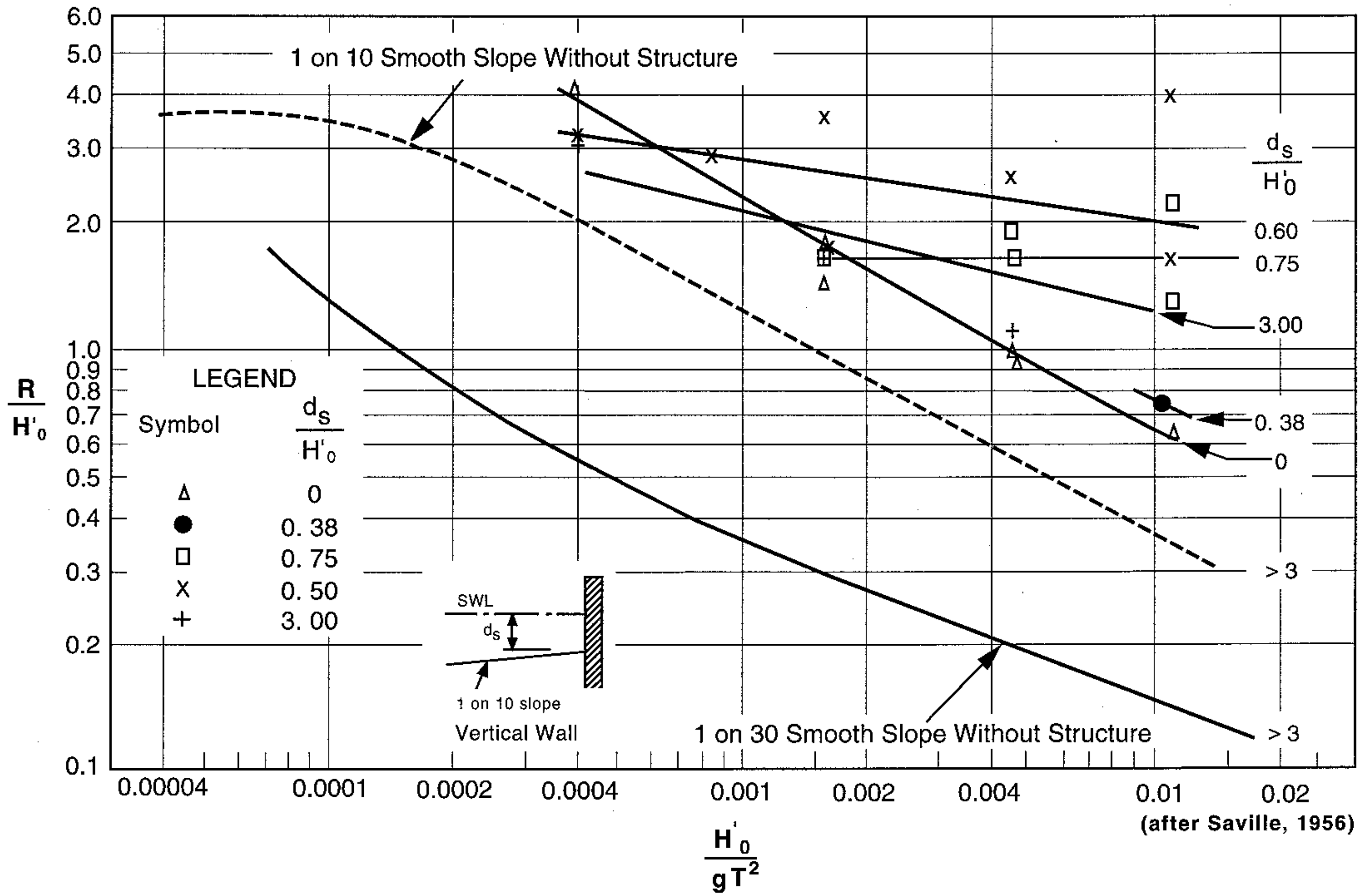


Figure 14. Wave Runup Guidance from Vertical Wall, From Reference 12.

PART 5: WAVE HEIGHT ANALYSIS (WHAFIS)

WHAFIS input and output

FILE: WHAFIS.IN

```
  G&S Example, Transect A (Dune Retreat)
IE      0    0.00   0.000    8.900  12.400  28.000  12.700
IF     13    1.00
IF    289    7.90
IF    388   10.40
IF    390   12.40
AS    706   10.40          10.4000
VH    716   10.00   2        1        0        1
MG   SPAT
VH    766    8.00   2        1        0        1
MG   SPAT
VH   3566   10.40   2        1        0        1
MG   SPAT
ET
  G&S Example, Transect B (Dune Removal)
IE      0    0.00   0.000    8.900  12.400  28.000  12.700
IF     75    5.00
IF    303    9.60
VH    400    8.00   2        1        0        1                10.400
MG   SPAT
VH   3500   10.40   2        1        0        1
MG   SPAT
ET
  G&S Example, Transect C (Bluff)
IE      0    0.00   0.000    8.900  12.400  28.000  12.700
IF    100    5.00
IF    200   10.00
IF    219   12.40
ET
  G&S Example, Transect D (Seawall)
IE      0    0.00   0.000    8.900  12.400  28.000  12.700
IF    140    5.00
IF    300    3.80
IF    301   12.40
ET
  G&S Example, Transect E (Marsh)
IE      0    0.00   0.000    8.900  12.400  28.000  12.700
IF    165    5.00
VH    500    5.40   2        1        0        1                10.400
MG   SPAT
VH   4200   10.40   2        1        0        1
MG   SPAT
ET
```

FILE: WHAFIS.OUT

1 *** THE FOLLOWING MESSAGES ARE THE RESULTS FROM THE 100-YR ELEVATION INTERPOLATION FOR THE TRANSECT:

G&S Example, Transect A (Dune Retreat)

1 *** THE FOLLOWING MESSAGES ARE THE RESULTS FROM THE 100-YR ELEVATION INTERPOLATION FOR THE TRANSECT:

G&S Example, Transect B (Dune Removal)

1 *** THE FOLLOWING MESSAGES ARE THE RESULTS FROM THE 100-YR ELEVATION INTERPOLATION FOR THE TRANSECT:

G&S Example, Transect C (Bluff)

1 *** THE FOLLOWING MESSAGES ARE THE RESULTS FROM THE 100-YR ELEVATION INTERPOLATION FOR THE TRANSECT:

G&S Example, Transect D (Seawall)

1 *** THE FOLLOWING MESSAGES ARE THE RESULTS FROM THE 100-YR ELEVATION INTERPOLATION FOR THE TRANSECT:

G&S Example, Transect E (Marsh)

1

WAVE HEIGHT COMPUTATIONS FOR FLOOD INSURANCE STUDIES (VERSION 3.0, 9_88)
G&S Example, Transect A (Dune Retreat)

PART1 INPUT

IE	.000	.000	.000	8.900	12.400	28.000	12.700	.000	.077	.000
IF	13.000	1.000	.000	12.400	.000	.000	.000	.000	.027	.000
IF	289.000	7.900	.000	12.400	.000	.000	.000	.000	.025	.000
IF	388.000	10.400	.000	12.400	.000	.000	.000	.000	.045	.000
IF	390.000	12.400	.000	12.400	.000	.000	.000	.000	1.000	.000
AS	706.000	10.400	.000	10.400	.000	.000	.000	.000	-.040	.000
VH	716.000	10.000	2.000	1.000	.000	1.000	.000	10.400	-.040	.000
MG	SPAT	.000	.000	.000	.000	.000	.000	.000	.000	.000
VH	766.000	8.000	2.000	1.000	.000	1.000	.000	10.400	.000	.000
MG	SPAT	.000	.000	.000	.000	.000	.000	.000	.000	.000
VH	3566.000	10.400	2.000	1.000	.000	1.000	.000	10.400	.001	.000
MG	SPAT	.000	.000	.000	.000	.000	.000	.000	.000	.000
ET	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000

1

	END STATION	END ELEVATION	FETCH LENGTH	SURGE ELEV 10-YEAR	SURGE ELEV 100-YEAR	INITIAL WAVE HEIGHT	INITIAL W. PERIOD		BOTTOM SLOPE	AVERAGE A-ZONES
IE	.000	.000	.000	8.900	12.400	28.000	12.700	.000	.077	.000

	END STATION	END ELEVATION	NEW SURGE 10-YEAR	NEW SURGE 100-YEAR					BOTTOM SLOPE	AVERAGE A-ZONES
IF	13.000	1.000	.000	12.400	.000	.000	.000	.000	.027	.000

	END STATION	END ELEVATION	NEW SURGE 10-YEAR	NEW SURGE 100-YEAR					BOTTOM SLOPE	AVERAGE A-ZONES
IF	289.000	7.900	.000	12.400	.000	.000	.000	.000	.025	.000

	END STATION	END ELEVATION	NEW SURGE 10-YEAR	NEW SURGE 100-YEAR					BOTTOM SLOPE	AVERAGE A-ZONES
IF	388.000	10.400	.000	12.400	.000	.000	.000	.000	.045	.000

	END STATION	END ELEVATION	NEW SURGE 10-YEAR	NEW SURGE 100-YEAR					BOTTOM SLOPE	AVERAGE A-ZONES
IF	390.000	12.400	.000	12.400	.000	.000	.000	.000	1.000	.000

	END STATION	END ELEVATION	NEW SURGE 10-YEAR	NEW SURGE 100-YEAR					BOTTOM SLOPE	AVERAGE A-ZONES
AS	706.000	10.400	.000	10.400	.000	.000	.000	.000	-.040	.000

	END STATION	END ELEVATION	REGION 1	REGION 1 WEIGHT	REGION 2	NO. OF PLANT TYPES	NEW SURGE 10-YEAR	NEW SURGE 100-YEAR	BOTTOM SLOPE	AVERAGE A-ZONES
VH	716.000	10.000	2.000	1.000	.000	1.000	.000	10.400	-.040	.000

	PLANT TYPE	DRAG COEFF.	COVERAGE RATIO	AVG. STEM HEIGHT	NUMBER DENSITY	BASE STEM DIAMETER	MID STEM DIAMETER	TOP STEM DIAMETER	LEAF-STEM AREA RATIO	
MG	SPAT	.000	.000	.000	.000	.000	.000	.000	.000	.000

PLANT CHARACTERISTICS INCLUDING VALUES SUPPLIED BY THE PROGRAM

PLANT TYPE	DRAG COEFF.	COVERAGE RATIO	AVG. STEM HEIGHT	NUMBER DENSITY	BASE STEM DIAMETER	MID STEM DIAMETER	TOP STEM DIAMETER	LEAF-STEM AREA RATIO
SPAT	.100	1.000	.850	327.000	.023	.011	.011	1.380

	END STATION	END ELEVATION	REGION 1	REGION 1 WEIGHT	REGION 2	NO. OF PLANT TYPES	NEW SURGE 10-YEAR	NEW SURGE 100-YEAR	BOTTOM SLOPE	AVERAGE A-ZONES
VH	766.000	8.000	2.000	1.000	.000	1.000	.000	10.400	.000	.000

	PLANT TYPE	DRAG COEFF.	COVERAGE RATIO	AVG. STEM HEIGHT	NUMBER DENSITY	BASE STEM DIAMETER	MID STEM DIAMETER	TOP STEM DIAMETER	LEAF-STEM AREA RATIO	
MG	SPAT	.000	.000	.000	.000	.000	.000	.000	.000	.000

PLANT CHARACTERISTICS INCLUDING VALUES SUPPLIED BY THE PROGRAM

PLANT TYPE	DRAG COEFF.	COVERAGE RATIO	AVG. STEM HEIGHT	NUMBER DENSITY	BASE STEM DIAMETER	MID STEM DIAMETER	TOP STEM DIAMETER	LEAF-STEM AREA RATIO
SPAT	.100	1.000	.850	327.000	.023	.011	.011	1.380

	END STATION	END ELEVATION	REGION 1	REGION 1 WEIGHT	REGION 2	NO. OF PLANT TYPES	NEW SURGE 10-YEAR	NEW SURGE 100-YEAR	BOTTOM SLOPE	AVERAGE A-ZONES
VH	3566.000	10.400	2.000	1.000	.000	1.000	.000	10.400	.001	.000

	PLANT TYPE	DRAG COEFF.	COVERAGE RATIO	AVG. STEM HEIGHT	NUMBER DENSITY	BASE STEM DIAMETER	MID STEM DIAMETER	TOP STEM DIAMETER	LEAF-STEM AREA RATIO	
MG	SPAT	.000	.000	.000	.000	.000	.000	.000	.000	.000

PLANT CHARACTERISTICS INCLUDING VALUES SUPPLIED BY THE PROGRAM

PLANT TYPE	DRAG COEFF.	COVERAGE RATIO	AVG. STEM HEIGHT	NUMBER DENSITY	BASE STEM DIAMETER	MID STEM DIAMETER	TOP STEM DIAMETER	LEAF-STEM AREA RATIO
SPAT	.100	1.000	.850	327.000	.023	.011	.011	1.380

---END OF TRANSECT---

NOTE:

SURGE ELEVATION INCLUDES CONTRIBUTIONS FROM ASTRONOMICAL AND STORM TIDES.

1

PART2: CONTROLLING WAVE HEIGHTS, SPECTRAL PEAK WAVE PERIOD, AND WAVE CREST ELEVATIONS

LOCATION		CONTROLLING WAVE HEIGHT	SPECTRAL PEAK WAVE PERIOD	WAVE CREST ELEVATION
IE	.00	9.45	12.70	19.01
IF	13.00	8.70	12.70	18.49
	116.50	6.76	12.70	17.13
	220.00	4.80	12.70	15.76
IF	289.00	3.48	12.70	14.84
IF	388.00	1.55	12.70	13.49
IF	390.00	.01	12.70	12.41
AS	706.00	.00	.00	10.40
VH	716.00	.07	.31	10.45
VH	766.00	.23	.57	10.56
	876.00	.47	.80	10.73
	1036.00	.71	.99	10.90
	1196.00	.86	1.13	11.00
	1436.00	.97	1.29	11.08
	1756.00	.95	1.45	11.07
	2396.00	.70	1.70	10.89
	2716.00	.53	1.80	10.77
	2876.00	.44	1.84	10.71
	3036.00	.34	1.89	10.64
	3196.00	.24	1.89	10.57
	3356.00	.14	1.89	10.50
	3516.00	.03	1.89	10.42
VH	3566.00	.01	1.89	10.41

PART3 LOCATION OF AREAS ABOVE 100-YEAR SURGE

BETWEEN 390.00 AND 706.00

PART4 LOCATION OF SURGE CHANGES

STATION	10-YEAR SURGE	100-YEAR SURGE
706.00	8.90	10.40

PART5 LOCATION OF V ZONES

STATION OF GUTTER	LOCATION OF ZONE
313.68	WINDWARD

PART6 NUMBERED A ZONES AND V ZONES

STATION OF GUTTER	ELEVATION	ZONE DESIGNATION	FHF
.00	19.01		
		V11 EL=19	55
12.80	18.50		
		V11 EL=18	55
88.49	17.50		
		V11 EL=17	55
164.14	16.50		
		V11 EL=16	55
239.36	15.50		
		V11 EL=15	55
313.68	14.50		
		V11 EL=15	55
313.68	14.50		
		A 4 EL=14	20
387.11	13.50		
		A 4 EL=13	20
389.83	12.50		
		A 4 EL=12	20
390.00	12.41		
706.00	10.40		
		A 4 EL=10	20
737.90	10.50		
		A 4 EL=11	20
3348.81	10.50		
		A 4 EL=10	20
3566.00	10.41		

ZONE TERMINATED AT END OF TRANSECT

WAVE HEIGHT COMPUTATIONS FOR FLOOD INSURANCE STUDIES (VERSION 3.0, 9_88)
G&S Example, Transect B (Dune Removal)

PART1 INPUT

IE	.000	.000	.000	8.900	12.400	28.000	12.700	.000	.067	.000
IF	75.000	5.000	.000	12.025	.000	.000	.000	.000	.032	.000
IF	303.000	9.600	.000	10.885	.000	.000	.000	.000	.009	.000
VH	400.000	8.000	2.000	1.000	.000	1.000	.000	10.400	.000	.000
MG	SPAT	.000	.000	.000	.000	.000	.000	.000	.000	.000
VH	3500.000	10.400	2.000	1.000	.000	1.000	.000	10.400	.001	.000
MG	SPAT	.000	.000	.000	.000	.000	.000	.000	.000	.000
ET	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000

1

	END STATION	END ELEVATION	FETCH LENGTH	SURGE ELEV 10-YEAR	SURGE ELEV 100-YEAR	INITIAL WAVE HEIGHT	INITIAL W. PERIOD		BOTTOM SLOPE	AVERAGE A-ZONES
IE	.000	.000	.000	8.900	12.400	28.000	12.700	.000	.067	.000

	END STATION	END ELEVATION	NEW SURGE 10-YEAR	NEW SURGE 100-YEAR					BOTTOM SLOPE	AVERAGE A-ZONES
IF	75.000	5.000	.000	12.025	.000	.000	.000	.000	.032	.000

	END STATION	END ELEVATION	NEW SURGE 10-YEAR	NEW SURGE 100-YEAR					BOTTOM SLOPE	AVERAGE A-ZONES
IF	303.000	9.600	.000	10.885	.000	.000	.000	.000	.009	.000

	END STATION	END ELEVATION	REGION 1	REGION 1 WEIGHT	REGION 2	NO. OF PLANT TYPES	NEW SURGE 10-YEAR	NEW SURGE 100-YEAR	BOTTOM SLOPE	AVERAGE A-ZONES
VH	400.000	8.000	2.000	1.000	.000	1.000	.000	10.400	.000	.000

	PLANT TYPE	DRAG COEFF.	COVERAGE RATIO	AVG. STEM HEIGHT	NUMBER DENSITY	BASE STEM DIAMETER	MID STEM DIAMETER	TOP STEM DIAMETER	LEAF-STEM AREA RATIO	
MG	SPAT	.000	.000	.000	.000	.000	.000	.000	.000	.000

PLANT CHARACTERISTICS INCLUDING VALUES SUPPLIED BY THE PROGRAM

PLANT TYPE	DRAG COEFF.	COVERAGE RATIO	AVG. STEM HEIGHT	NUMBER DENSITY	BASE STEM DIAMETER	MID STEM DIAMETER	TOP STEM DIAMETER	LEAF-STEM AREA RATIO
SPAT	.100	1.000	.850	327.000	.023	.011	.011	1.380

	END STATION	END ELEVATION	REGION 1	REGION 1 WEIGHT	REGION 2	NO. OF PLANT TYPES	NEW SURGE 10-YEAR	NEW SURGE 100-YEAR	BOTTOM SLOPE	AVERAGE A-ZONES
VH	3500.000	10.400	2.000	1.000	.000	1.000	.000	10.400	.001	.000

	PLANT TYPE	DRAG COEFF.	COVERAGE RATIO	AVG. STEM HEIGHT	NUMBER DENSITY	BASE STEM DIAMETER	MID STEM DIAMETER	TOP STEM DIAMETER	LEAF-STEM AREA RATIO	
MG	SPAT	.000	.000	.000	.000	.000	.000	.000	.000	.000

PLANT CHARACTERISTICS INCLUDING VALUES SUPPLIED BY THE PROGRAM

PLANT TYPE	DRAG COEFF.	COVERAGE RATIO	AVG. STEM HEIGHT	NUMBER DENSITY	BASE STEM DIAMETER	MID STEM DIAMETER	TOP STEM DIAMETER	LEAF-STEM AREA RATIO
SPAT	.100	1.000	.850	327.000	.023	.011	.011	1.380

---END OF TRANSECT---

NOTE:

SURGE ELEVATION INCLUDES CONTRIBUTIONS FROM ASTRONOMICAL AND STORM TIDES.

1

PART2: CONTROLLING WAVE HEIGHTS, SPECTRAL PEAK WAVE PERIOD, AND WAVE CREST ELEVATIONS

LOCATION		CONTROLLING WAVE HEIGHT	SPECTRAL PEAK WAVE PERIOD	WAVE CREST ELEVATION
IE	.00	9.45	12.70	19.01
IF	75.00	5.41	12.70	15.81
	177.60	3.44	12.70	13.92
	280.20	1.44	12.70	12.01
IF	303.00	1.00	12.70	11.58
VH	400.00	1.24	12.70	11.27
	550.00	1.39	12.70	11.38
	710.00	1.44	12.70	11.41
	870.00	1.43	12.70	11.40
	1190.00	1.35	12.70	11.34
	1830.00	1.01	12.70	11.10
	2150.00	.81	12.70	10.97
	2470.00	.62	12.70	10.83
	2790.00	.43	12.70	10.70
	3110.00	.24	12.70	10.56
	3430.00	.04	12.70	10.43
VH	3500.00	.01	12.70	10.41

PART3 LOCATION OF AREAS ABOVE 100-YEAR SURGE

NO AREAS ABOVE 100-YEAR SURGE IN THIS TRANSECT

PART4 LOCATION OF SURGE CHANGES

STATION	10-YEAR SURGE	100-YEAR SURGE
75.00	8.90	12.02
303.00	8.90	10.89
400.00	8.90	10.40

PART5 LOCATION OF V ZONES

STATION OF GUTTER	LOCATION OF ZONE
200.05	WINDWARD

PART6 NUMBERED A ZONES AND V ZONES

STATION OF GUTTER	ELEVATION	ZONE DESIGNATION	FHF
.00	19.01		
		V10 EL=19	50
12.03	18.50		
		V10 EL=18	50
35.44	17.50		
		V10 EL=17	50
58.84	16.50		
		V10 EL=16	50
75.00	15.81		
		V 9 EL=16	45
91.79	15.50		
		V 9 EL=15	45
146.00	14.50		
		V 8 EL=14	40
200.04	13.50		
		V 7 EL=13	35
200.05	13.36		
		A 4 EL=13	20
253.85	12.50		
		A 4 EL=12	20
303.00	11.58		
		A 4 EL=12	20
328.76	11.50		
		A 4 EL=11	20
400.00	11.27		
		A 4 EL=11	20
3263.31	10.50		
		A 4 EL=10	20
3500.00	10.41		

ZONE TERMINATED AT END OF TRANSECT

1

WAVE HEIGHT COMPUTATIONS FOR FLOOD INSURANCE STUDIES (VERSION 3.0, 9_88)
G&S Example, Transect C (Bluff)

PART1 INPUT

IE	.000	.000	.000	8.900	12.400	28.000	12.700	.000	.050	.000
IF	100.000	5.000	.000	12.400	.000	.000	.000	.000	.050	.000
IF	200.000	10.000	.000	12.400	.000	.000	.000	.000	.062	.000
IF	219.000	12.400	.000	12.400	.000	.000	.000	.000	.126	.000
ET	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000

1

	END STATION	END ELEVATION	FETCH LENGTH	SURGE ELEV 10-YEAR	SURGE ELEV 100-YEAR	INITIAL WAVE HEIGHT	INITIAL W. PERIOD		BOTTOM SLOPE	AVERAGE A-ZONES
IE	.000	.000	.000	8.900	12.400	28.000	12.700	.000	.050	.000

	END STATION	END ELEVATION	NEW SURGE 10-YEAR	NEW SURGE 100-YEAR					BOTTOM SLOPE	AVERAGE A-ZONES
IF	100.000	5.000	.000	12.400	.000	.000	.000	.000	.050	.000

	END STATION	END ELEVATION	NEW SURGE 10-YEAR	NEW SURGE 100-YEAR					BOTTOM SLOPE	AVERAGE A-ZONES
IF	200.000	10.000	.000	12.400	.000	.000	.000	.000	.062	.000

	END STATION	END ELEVATION	NEW SURGE 10-YEAR	NEW SURGE 100-YEAR					BOTTOM SLOPE	AVERAGE A-ZONES
IF	219.000	12.400	.000	12.400	.000	.000	.000	.000	.126	.000

---END OF TRANSECT---

NOTE:

SURGE ELEVATION INCLUDES CONTRIBUTIONS FROM ASTRONOMICAL AND STORM TIDES.

1

PART2: CONTROLLING WAVE HEIGHTS, SPECTRAL
PEAK WAVE PERIOD, AND WAVE CREST ELEVATIONS

LOCATION		CONTROLLING WAVE HEIGHT	SPECTRAL PEAK WAVE PERIOD	WAVE CREST ELEVATION
IE	.00	9.45	12.70	19.01
IF	100.00	5.69	12.70	16.38
IF	200.00	1.86	12.70	13.70
IF	219.00	.01	12.70	12.41

PART3 LOCATION OF AREAS ABOVE 100-YEAR SURGE

NO AREAS ABOVE 100-YEAR SURGE IN THIS TRANSECT

PART4 LOCATION OF SURGE CHANGES

STATION	10-YEAR SURGE	100-YEAR SURGE

NO SURGE CHANGES IN THIS TRANSECT

PART5 LOCATION OF V ZONES

STATION OF GUTTER	LOCATION OF ZONE
170.31	WINDWARD

PART6 NUMBERED A ZONES AND V ZONES

STATION OF GUTTER	ELEVATION	ZONE DESIGNATION	FHF
.00	19.01		
		V11 EL=19	55
19.54	18.50		
		V11 EL=18	55
57.56	17.50		
		V11 EL=17	55
95.59	16.50		
		V11 EL=16	55
132.99	15.50		
		V11 EL=15	55
170.31	14.50		
		V11 EL=15	55
170.31	14.50		
		A10 EL=14	50
202.99	13.50		
		A10 EL=13	50
217.62	12.50		
		A10 EL=12	50
219.00	12.41		

ZONE TERMINATED AT END OF TRANSECT

1

WAVE HEIGHT COMPUTATIONS FOR FLOOD INSURANCE STUDIES (VERSION 3.0, 9_88)
G&S Example, Transect D (Seawall)

PART1 INPUT

IE	.000	.000	.000	8.900	12.400	28.000	12.700	.000	.036	.000
IF	140.000	5.000	.000	12.400	.000	.000	.000	.000	.013	.000
IF	300.000	3.800	.000	12.400	.000	.000	.000	.000	.046	.000
IF	301.000	12.400	.000	12.400	.000	.000	.000	.000	8.600	.000
ET	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000

1

	END STATION	END ELEVATION	FETCH LENGTH	SURGE ELEV 10-YEAR	SURGE ELEV 100-YEAR	INITIAL WAVE HEIGHT	INITIAL W. PERIOD		BOTTOM SLOPE	AVERAGE A-ZONES
IE	.000	.000	.000	8.900	12.400	28.000	12.700	.000	.036	.000

	END STATION	END ELEVATION	NEW SURGE 10-YEAR	NEW SURGE 100-YEAR					BOTTOM SLOPE	AVERAGE A-ZONES
IF	140.000	5.000	.000	12.400	.000	.000	.000	.000	.013	.000

	END STATION	END ELEVATION	NEW SURGE 10-YEAR	NEW SURGE 100-YEAR					BOTTOM SLOPE	AVERAGE A-ZONES
IF	300.000	3.800	.000	12.400	.000	.000	.000	.000	.046	.000

	END STATION	END ELEVATION	NEW SURGE 10-YEAR	NEW SURGE 100-YEAR					BOTTOM SLOPE	AVERAGE A-ZONES
IF	301.000	12.400	.000	12.400	.000	.000	.000	.000	8.600	.000

--END OF TRANSECT---

NOTE:

SURGE ELEVATION INCLUDES CONTRIBUTIONS FROM ASTRONOMICAL AND STORM TIDES.

1

PART2: CONTROLLING WAVE HEIGHTS, SPECTRAL PEAK WAVE PERIOD, AND WAVE CREST ELEVATIONS

LOCATION		CONTROLLING WAVE HEIGHT	SPECTRAL PEAK WAVE PERIOD	WAVE CREST ELEVATION
IE	.00	9.45	12.70	19.01
	105.00	6.64	12.70	17.05
IF	140.00	5.69	12.70	16.38
	252.00	5.84	12.70	16.49
IF	300.00	5.92	12.70	16.54
IF	301.00	.01	12.70	12.41

PART3 LOCATION OF AREAS ABOVE 100-YEAR SURGE

NO AREAS ABOVE 100-YEAR SURGE IN THIS TRANSECT

PART4 LOCATION OF SURGE CHANGES

STATION	10-YEAR SURGE	100-YEAR SURGE

NO SURGE CHANGES IN THIS TRANSECT

PART5 LOCATION OF V ZONES

STATION OF GUTTER	LOCATION OF ZONE
300.49	WINDWARD

PART6 NUMBERED A ZONES AND V ZONES

STATION OF GUTTER	ELEVATION	ZONE DESIGNATION	FHF
.00	19.01		
		V11 EL=19	55
27.42	18.50		
		V11 EL=18	55
80.78	17.50		
		V11 EL=17	55
133.87	16.50		
		V11 EL=16	55
261.35	16.50		
		V11 EL=17	55
300.01	16.50		
		V11 EL=16	55
300.25	15.50		
		V11 EL=15	55
300.49	14.50		
		A 9 EL=14	45
300.74	13.50		
		A 9 EL=13	45
300.98	12.50		
		A 9 EL=12	45
301.00	12.41		

ZONE TERMINATED AT END OF TRANSECT

1

WAVE HEIGHT COMPUTATIONS FOR FLOOD INSURANCE STUDIES (VERSION 3.0, 9_88)
G&S Example, Transect E (Marsh)

PART1 INPUT

IE	.000	.000	.000	8.900	12.400	28.000	12.700	.000	.030	.000
IF	165.000	5.000	.000	11.740	.000	.000	.000	.000	.011	.000
VH	500.000	5.400	2.000	1.000	.000	1.000	.000	10.400	.001	.000
MG	SPAT	.000	.000	.000	.000	.000	.000	.000	.000	.000

VH	4200.000	10.400	2.000	1.000	.000	1.000	.000	10.400	.001	.000
MG	SPAT	.000	.000	.000	.000	.000	.000	.000	.000	.000
ET	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000

1

	END STATION	END ELEVATION	FETCH LENGTH	SURGE ELEV 10-YEAR	SURGE ELEV 100-YEAR	INITIAL WAVE HEIGHT	INITIAL W. PERIOD		BOTTOM SLOPE	AVERAGE A-ZONES
IE	.000	.000	.000	8.900	12.400	28.000	12.700	.000	.030	.000

	END STATION	END ELEVATION	NEW SURGE 10-YEAR	NEW SURGE 100-YEAR					BOTTOM SLOPE	AVERAGE A-ZONES
IF	165.000	5.000	.000	11.740	.000	.000	.000	.000	.011	.000

	END STATION	END ELEVATION	REGION 1	REGION 1 WEIGHT	REGION 2	NO. OF PLANT TYPES	NEW SURGE 10-YEAR	NEW SURGE 100-YEAR	BOTTOM SLOPE	AVERAGE A-ZONES
VH	500.000	5.400	2.000	1.000	.000	1.000	.000	10.400	.001	.000

	PLANT TYPE	DRAG COEFF.	COVERAGE RATIO	AVG. STEM HEIGHT	NUMBER DENSITY	BASE STEM DIAMETER	MID STEM DIAMETER	TOP STEM DIAMETER	LEAF-STEM AREA RATIO	
MG	SPAT	.000	.000	.000	.000	.000	.000	.000	.000	.000

PLANT CHARACTERISTICS INCLUDING VALUES SUPPLIED BY THE PROGRAM

PLANT TYPE	DRAG COEFF.	COVERAGE RATIO	AVG. STEM HEIGHT	NUMBER DENSITY	BASE STEM DIAMETER	MID STEM DIAMETER	TOP STEM DIAMETER	LEAF-STEM AREA RATIO
SPAT	.100	1.000	.850	327.000	.023	.011	.011	1.380

	END STATION	END ELEVATION	REGION 1	REGION 1 WEIGHT	REGION 2	NO. OF PLANT TYPES	NEW SURGE 10-YEAR	NEW SURGE 100-YEAR	BOTTOM SLOPE	AVERAGE A-ZONES
VH	4200.000	10.400	2.000	1.000	.000	1.000	.000	10.400	.001	.000

	PLANT TYPE	DRAG COEFF.	COVERAGE RATIO	AVG. STEM HEIGHT	NUMBER DENSITY	BASE STEM DIAMETER	MID STEM DIAMETER	TOP STEM DIAMETER	LEAF-STEM AREA RATIO	
MG	SPAT	.000	.000	.000	.000	.000	.000	.000	.000	.000

PLANT CHARACTERISTICS INCLUDING VALUES SUPPLIED BY THE PROGRAM

PLANT TYPE	DRAG COEFF.	COVERAGE RATIO	AVG. STEM HEIGHT	NUMBER DENSITY	BASE STEM DIAMETER	MID STEM DIAMETER	TOP STEM DIAMETER	LEAF-STEM AREA RATIO
SPAT	.100	1.000	.850	327.000	.023	.011	.011	1.380

--END OF TRANSECT--

NOTE:

SURGE ELEVATION INCLUDES CONTRIBUTIONS FROM ASTRONOMICAL AND STORM TIDES.

1

PART2: CONTROLLING WAVE HEIGHTS, SPECTRAL
PEAK WAVE PERIOD, AND WAVE CREST ELEVATIONS

LOCATION		CONTROLLING WAVE HEIGHT	SPECTRAL PEAK WAVE PERIOD	WAVE CREST ELEVATION
IE	.00	9.45	12.70	19.01
	107.25	6.69	12.70	16.65
IF	165.00	5.19	12.70	15.37
	265.00	4.58	12.70	14.55
	365.00	4.09	12.70	13.80
	465.00	3.66	12.70	13.10
VH	500.00	3.52	12.70	12.86
	630.00	3.16	12.70	12.61
	750.00	2.90	12.70	12.43
	870.00	2.69	12.70	12.28
	1030.00	2.48	12.70	12.13
	1270.00	2.25	12.70	11.97
	1430.00	2.13	12.70	11.89
	1590.00	2.04	12.70	11.83
	1910.00	1.87	12.70	11.71
	2230.00	1.72	12.70	11.60
	2870.00	1.40	12.70	11.38
	3510.00	.73	12.70	10.91
	3830.00	.39	12.70	10.67
	3990.00	.22	12.70	10.55
	4150.00	.05	12.70	10.44
VH	4200.00	.01	12.70	10.41

PART3 LOCATION OF AREAS ABOVE 100-YEAR SURGE

NO AREAS ABOVE 100-YEAR SURGE IN THIS TRANSECT

PART4 LOCATION OF SURGE CHANGES

STATION	10-YEAR SURGE	100-YEAR SURGE
165.00	8.90	11.74
500.00	8.90	10.40

PART5 LOCATION OF V ZONES

STATION OF GUTTER	LOCATION OF ZONE
703.81	WINDWARD

PART6 NUMBERED A ZONES AND V ZONES

STATION OF GUTTER	ELEVATION	ZONE DESIGNATION	FHF
.00	19.01		
		V10 EL=19	50
23.36	18.50		
		V10 EL=18	50
68.82	17.50		
		V10 EL=17	50
114.22	16.50		
		V 9 EL=16	45
159.29	15.50		
		V 9 EL=15	45
165.00	15.37		
		V 8 EL=15	40
271.55	14.50		
		V 6 EL=14	30
407.95	13.50		
		V 5 EL=13	25
500.00	12.86		
		V 5 EL=13	25
703.81	12.50		
		V 5 EL=13	25
703.81	12.50		
		A 5 EL=12	25
2525.07	11.50		
		A 5 EL=11	25
4064.40	10.50		
		A 5 EL=10	25
4200.00	10.41		

ZONE TERMINATED AT END OF TRANSECT

PART 6: WAVE ENVELOPES

Table 6-1: Summary of Flood Zones for Transect A

Station 1 (feet from 0 NGVD)	Station 2 (feet from 0 NGVD)	Elevation (feet NGVD)	Designation
0	200	17	VE
200	400	14	VE
400	700	12	VE[1]
700	3283	11	AE
3283	3500	10	AE

[1]Inland limit of primary frontal dune

Table 6-2: Summary of Flood Zones for Transect B

Station 1 (feet from 0 NGVD)	Station 2 (feet from 0 NGVD)	Elevation (feet NGVD)	Designation
0	200	16	VE
200	400	12	VE[1]
400	3263	11	AE
3263	3500	10	AE
3283	3500	10	AE

[1]Inland limit of primary frontal dune

Table 6-3: Summary of Flood Zones for Transect C

Station 1 (feet from 0 NGVD)	Station 2 (feet from 0 NGVD)	Elevation (feet NGVD)	Designation
0	219[1]	16	VE

[1]V-Zone extended to this station given map scale

Table 6-4: Summary of Flood Zones for Transect D

Station 1 (feet from 0 NGVD)	Station 2 (feet from 0 NGVD)	Elevation (feet NGVD)	Designation
0	200	17	VE
200	325	15	VE[1]
325	525	2[2]	A0

[1]Based on overtopping assesment
[2]Ponding area of depth 2 feet due to overtopping

Table 6-5: Summary of Flood Zones for Transect E

Station 1 (feet from 0 NGVD)	Station 2 (feet from 0 NGVD)	Elevation (feet NGVD)	Designation
0	200	17	VE
200	400	14	VE
400	704	13	VE[1]
704	2525	12	AE
2525	4200	11	AE

[1]WHAFIS VE zone termination

Figure 6-1: Wave Envelope, Transect A

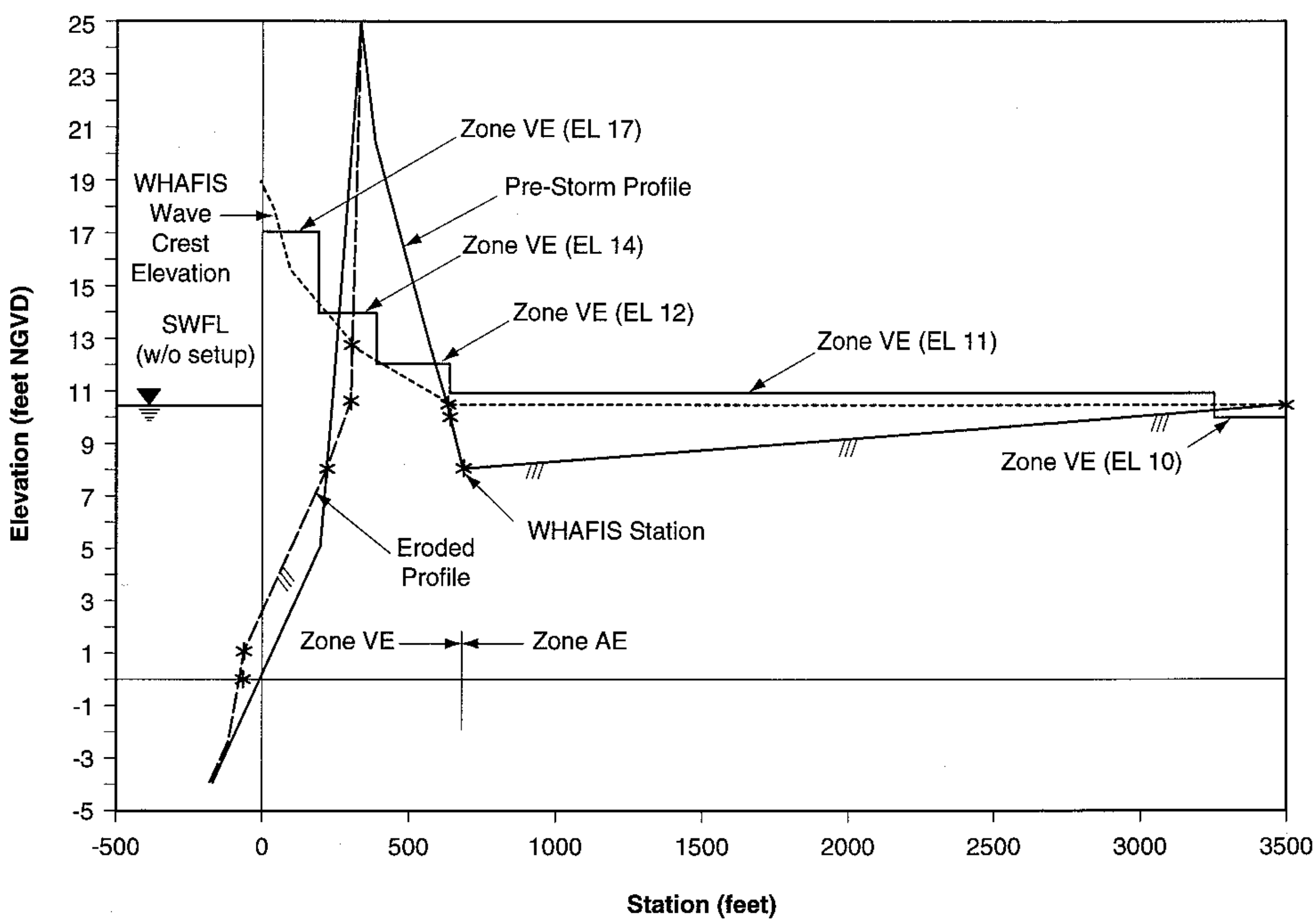


Figure 6-1. Transect A, Dune Retreat

Figure 6-2: Wave Envelope, Transect B

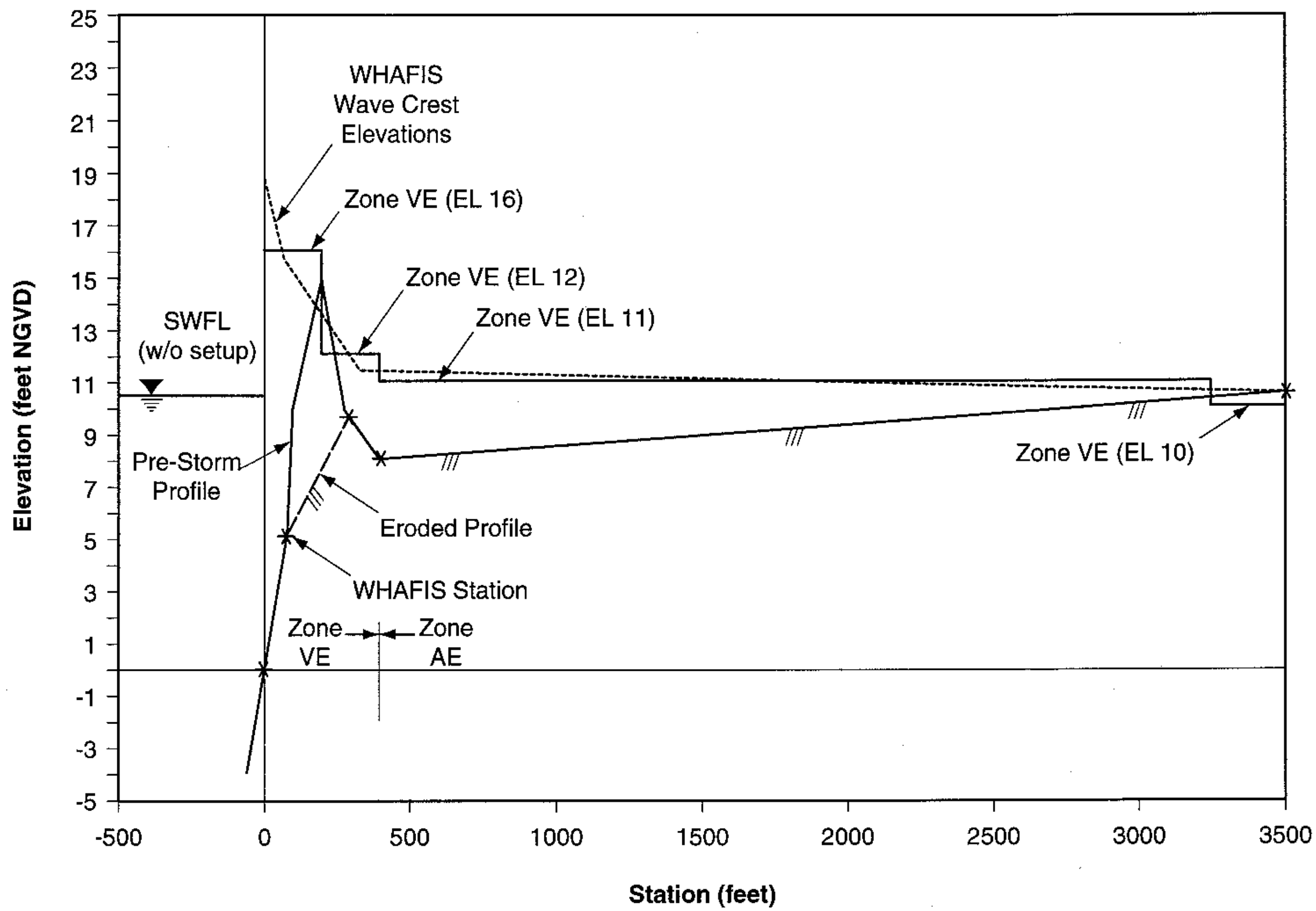


Figure 6-2. Transect B, Dune Removal

Figure 6-3: Wave Envelope, Transect C

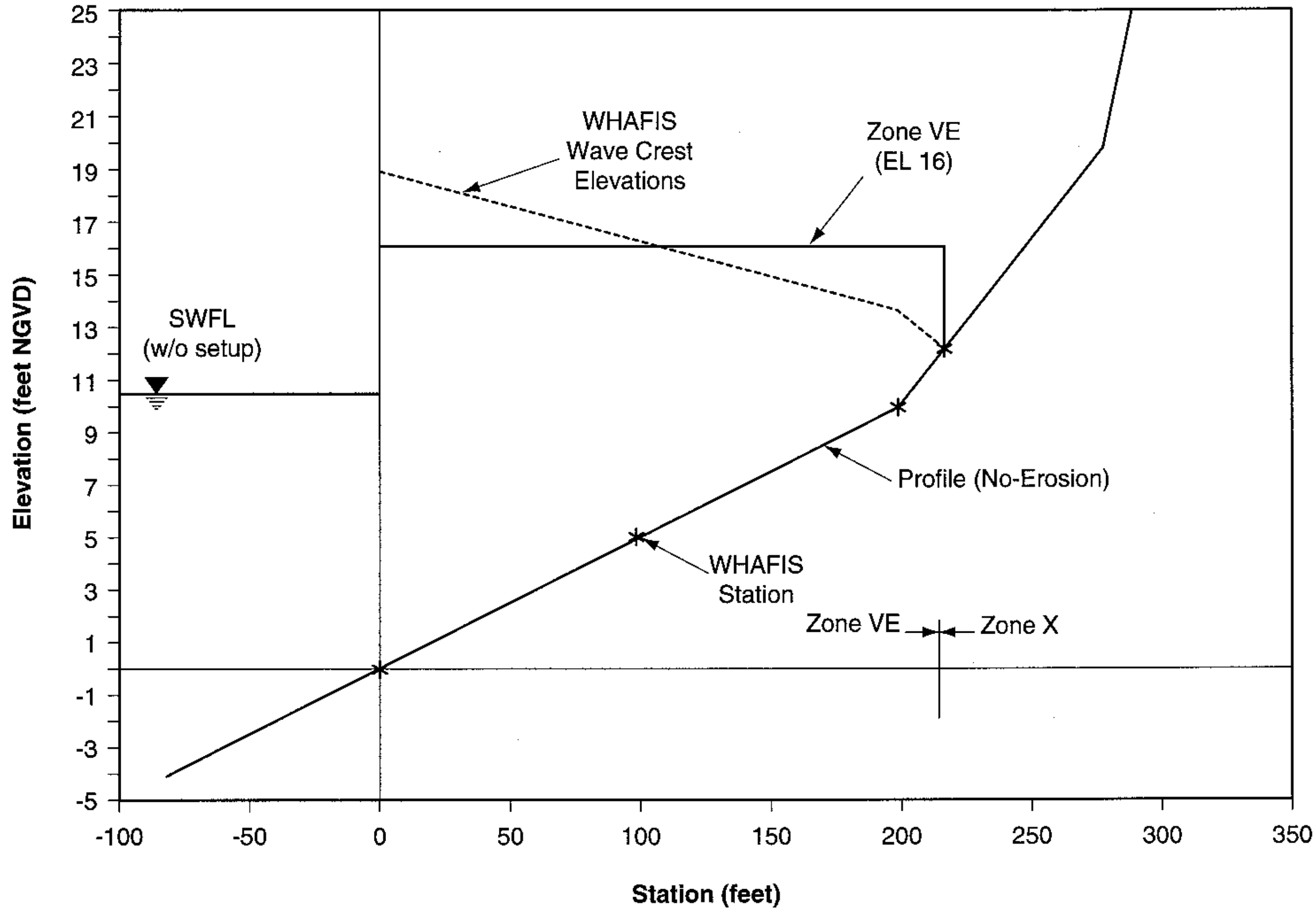


Figure 6-3. Transect C, Buff Reventment

Figure 6-4: Wave Envelope, Transect D

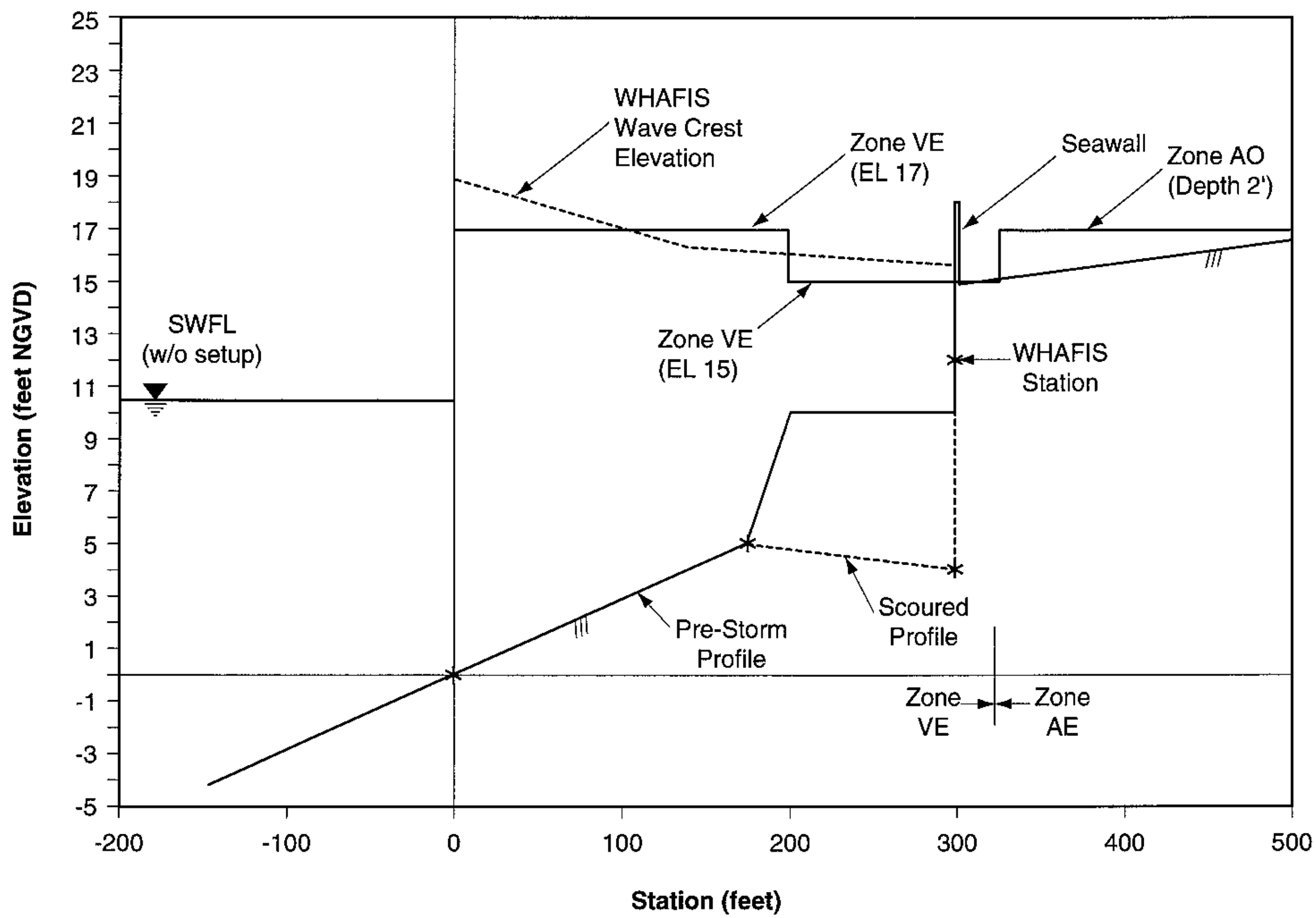


Figure 6-4. Transect D, Seawall

Figure 6-5: Wave Envelope, Transect E

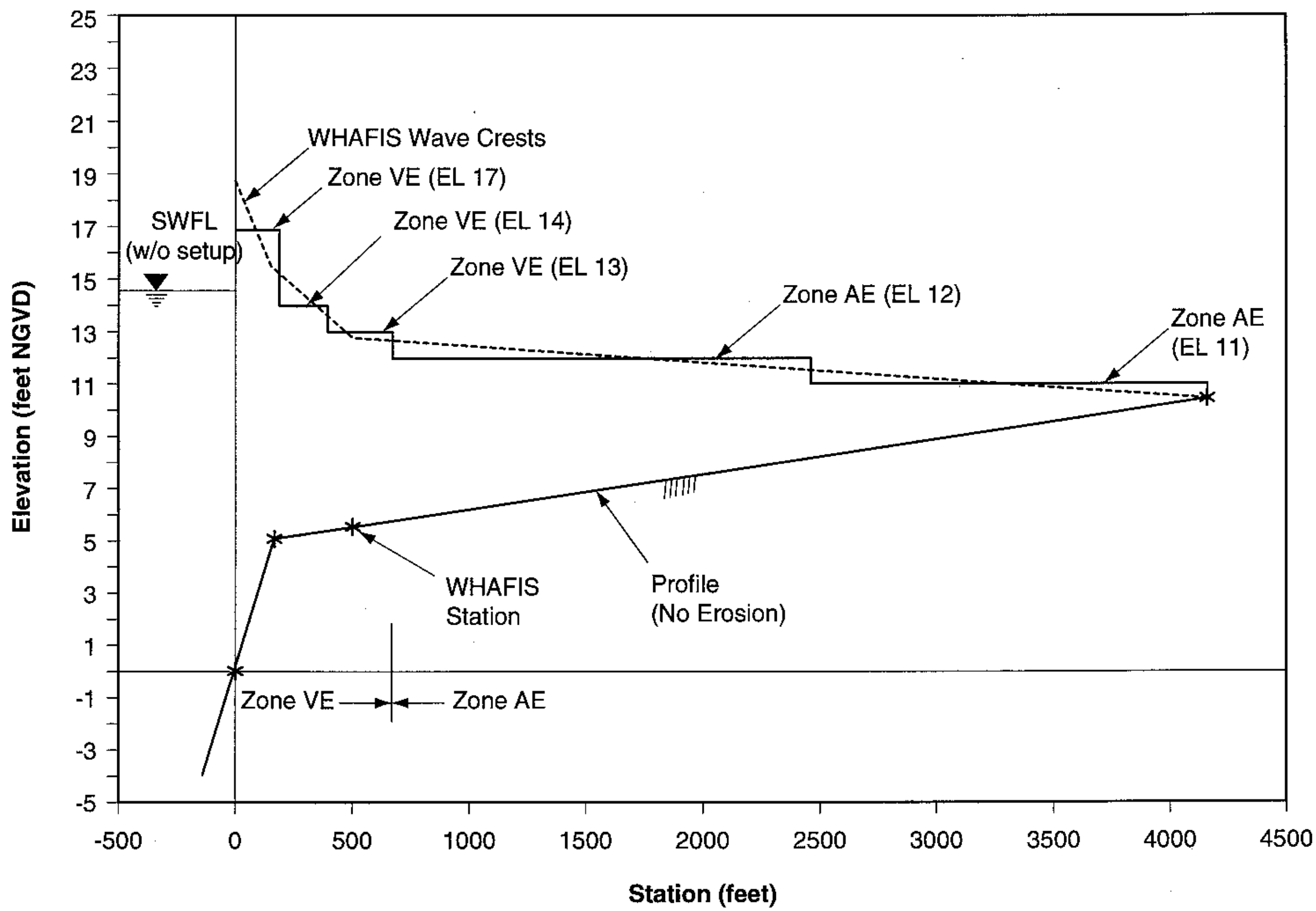


Figure 6-5. Transect E, Marsh

Table 6-6: Pre-Storm Profile, Transect A

Station (ft from 0 NGVD)	Elevation (ft NGVD)
-150	-4.0
0	0.0
185	5.0
250	10.0
300	20.0
350	25.0
400	20.0
650	10.0
700	8.0
3500	10.4

Notes: SWFL should be dropped to 10.4 feet NGVD after dune crest. Marsh grass from approximately station 200 to station 3500. Average tidal flat width is approximately 333 feet. Assuming seaward edge of tidal flat is -4 feet NGVD, and landward edge is +5 feet NGVD, 0 NGVD was interpolated and station zero was set to this point.

Table 6-7: Eroded Profile, Transect A

Station (ft from 0 NGVD)	Elevation (ft NGVD)
-150	-4.0
-99	-2.6
-53	1.0
223	7.9
322	10.4
335	23.5
350	25.0
400	20.0
650	10.0
700	8.0
3500	10.4

Table 6-8: WHAFIS Elevations, Transect A

Station[1] (ft from 0 NGVD)	Elevation (ft NGVD)
-66	0.0
-53	1.0
223	7.9
322	10.4
324	12.4
640	10.4
650	10.0
700	8.0
3500	10.4

[1]Stationing in this table is from 0 NGVD on prestrom profile; however, stationing in WHAFIS model was adjusted to correspond to 0 NGVD on the eroded profile

Table 6-9: WHAFIS Wave Envelope, Transect A

Station (ft from 0 NGVD)	Elevation (ft NGVD)
-66	19.0
-53	18.5
23	17.5
98	16.5
173	15.5
248	14.5
321	13.5
324	12.5
324	12.4
640	10.4
672	10.5
3283	10.5
3500	10.4

Table 6-10: Pre-Storm Profile, Transect B

Station (ft from 0 NGVD)	Elevation (ft NGVD)
-60	-4.0
0	0.0
75	5.0
100	10.0
200	15.0
275	10.0
400	8.0
3500	10.4

Notes: SWFL dropped to 10.4 feet NGVD after crest of dune. Marsh grass from station 400 to station 3500. Average tidal flat width is approximately 132 feet. Assuming seaward edge of tidal flat is -4 feet NGVD, and landward edge is +5 feet NGVD, 0 NGVD was interpolated and station zero was set to this point. The first and only row of houses is assumed to be removed due to erosion.

Table 6-11: Eroded Profile, Transect B

Station (ft from 0 NGVD)	Elevation (ft NGVD)
-60	-4.0
-0	0.0
75	5.0
303	9.6
400	8.0
3500	10.4

Table 6-12: WHAFIS Elevations, Transect B

Station (ft from 0 NGVD)	Elevation (ft NGVD)
0	0.0
75	5.0
303	9.6
400	8.0
3500	10.4

Table 6-13: WHAFIS Wave Envelope, Transect B

Station (ft from 0 NGVD)	Elevation (ft NGVD)
0	19.0
12	18.5
35	17.5
59	16.5
75	15.8
92	15.5
146	14.5
200	13.5
200	13.4
254	12.5
303	11.6
329	11.5
400	11.3
3263	10.5
3500	16.4

Table 6-14: Pre-Storm Profile, Transect C

Station (ft from 0 NGVD)	Elevation (ft NGVD)
-80	-4.0
0	0.0
100	5.0
200	10.0
280	20.0
300	30.0
350	50.0

Notes: Randomly placed quarry stone from approximately station 120 to station 220. Grass from station 220 inland. Average tidal flat width is approximately 180 feet. Assuming seaward edge of tidal flat is -4 feet NGVD, and landward edge is +5 feet NGVD, 0 NGVD was interpolated and station zero was set to this point. Revetment found to be stable during 100-year event.

Table 6-15: WHAFIS Elevations, Transect C

Station (ft from 0 NGVD)	Elevation (ft NGVD)
0	0.0
100	5.0
200	10.0
219	12.4

Table 6-16: WHAFIS Wave Envelope, Transect C

Station (ft from 0 NGVD)	Elevation (ft NGVD)
0	19.0
20	18.5
58	17.5
96	16.5
133	15.5
170	14.5
203	13.5
218	12.5
219	12.4

Table 6-17: Pre-Storm Profile, Transect D

Station (ft from 0 NGVD)	Elevation (ft NGVD)
-110	-4.0
0	0.0
140	5.0
200	10.0
300	10.0
300	18.2
302	18.2
302	15.0
950	20.0

Notes: Wall cap surveyed from filed at 18.2 NGVD. Average tidal flat width is approximately 250 feet. Assuming seaward edge of tidal flat is -4 feet NGVD, and landward edge is +5 feet NGVD, 0 NGVD was interpolated and station zero was set to this point. Toe scour was approximated. Wall found to be stable during 100-year event.

Table 6-18: Eroded Profile, Transect D

Station (ft from 0 NGVD)	Elevation (ft NGVD)
-110	-4.0
-0	0.0
140	5.0
300	3.8
300	18.2
302	18.2
302	15.0
950	20.0

Table 6-19: WHAFIS Elevations, Transect D

Station (ft from 0 NGVD)	Elevation (ft NGVD)
0	0.0
140	5.0
300	3.8
301	12.4

Table 6-20: WHAFIS Wave Envelope, Transect D

Station (ft from 0 NGVD)	Elevation (ft NGVD)
0	19.0
27	18.5
81	17.5
134	16.5
300	15.5
301	12.4

Table 6-21: Pre-Storm Profile, Transect E

Station (ft from 0 NGVD)	Elevation (ft NGVD)
-135	-4.0
0	0.0
165	5.0
500	5.4
4200	10.4

Notes: SWFL should be dropped to 10.4 feet NGVD at approximately station 500. Marsh grass from approximately station 165 to station 4200. Average tidal flat width is approximately 300 feet. Assuming seaward edge of tidal flat is -4 feet NGVD, and landward edge is +5 feet NGVD, 0 NGVD was interpolated and station zero was set to this point. No erosion performed.

Table 6-22: WHAFIS Elevations, Transect E

Station (ft from 0 NGVD)	Elevation (ft NGVD)
0	0.0
165	5.0
500	5.4
4200	10.4

Table 6-23: WHAFIS Wave Envelope, Transect E

Station (ft from 0 NGVD)	Elevation (ft NGVD)
0	19.0
23	18.5
69	17.5
114	16.5
159	15.5
165	14.5
272	13.5
408	12.5
500	12.4
704	10.4
2525	10.5
4064	10.5
4200	10.4

PART 7: MAPPING

Figure 7-1: Transect Locations

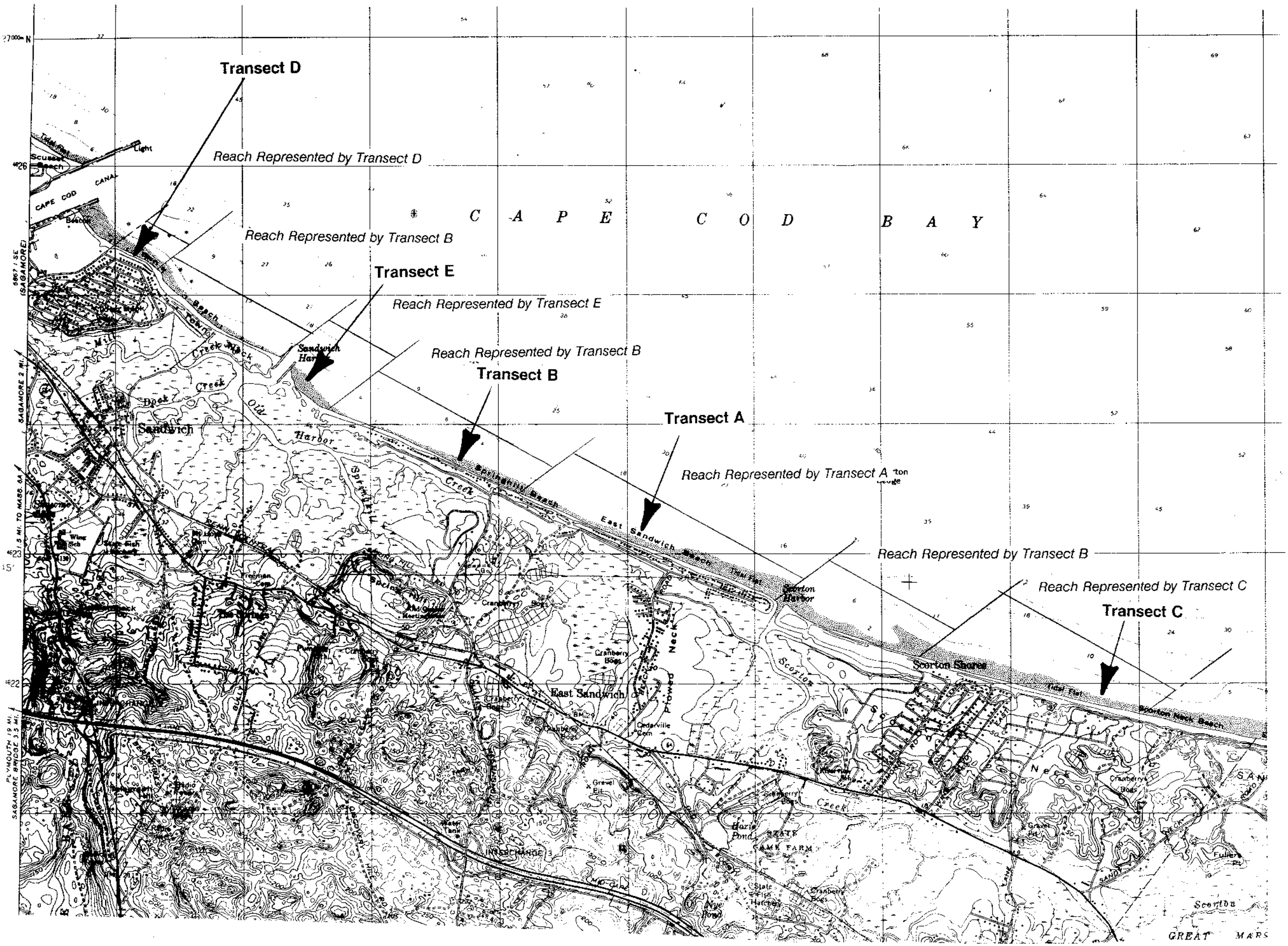
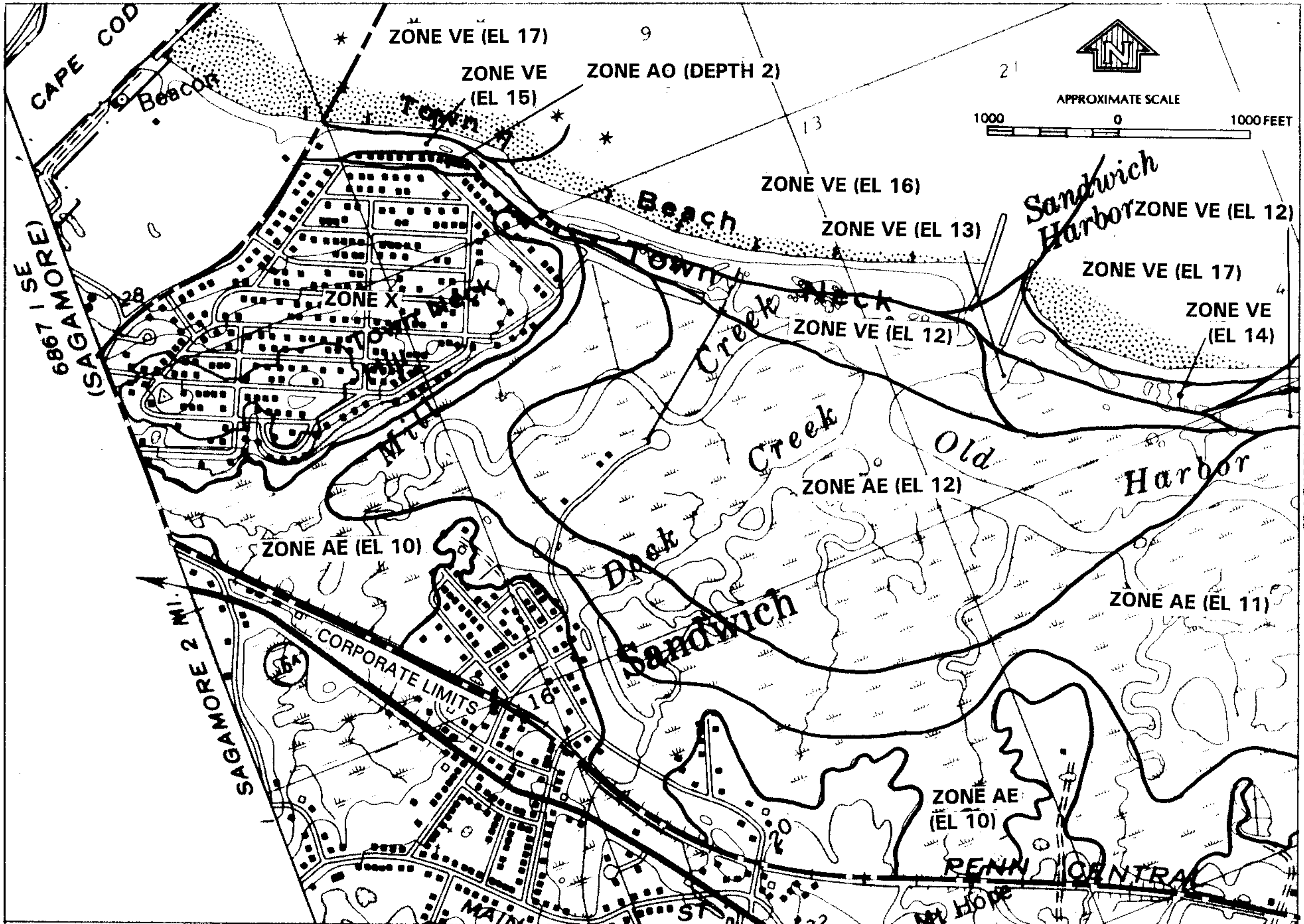
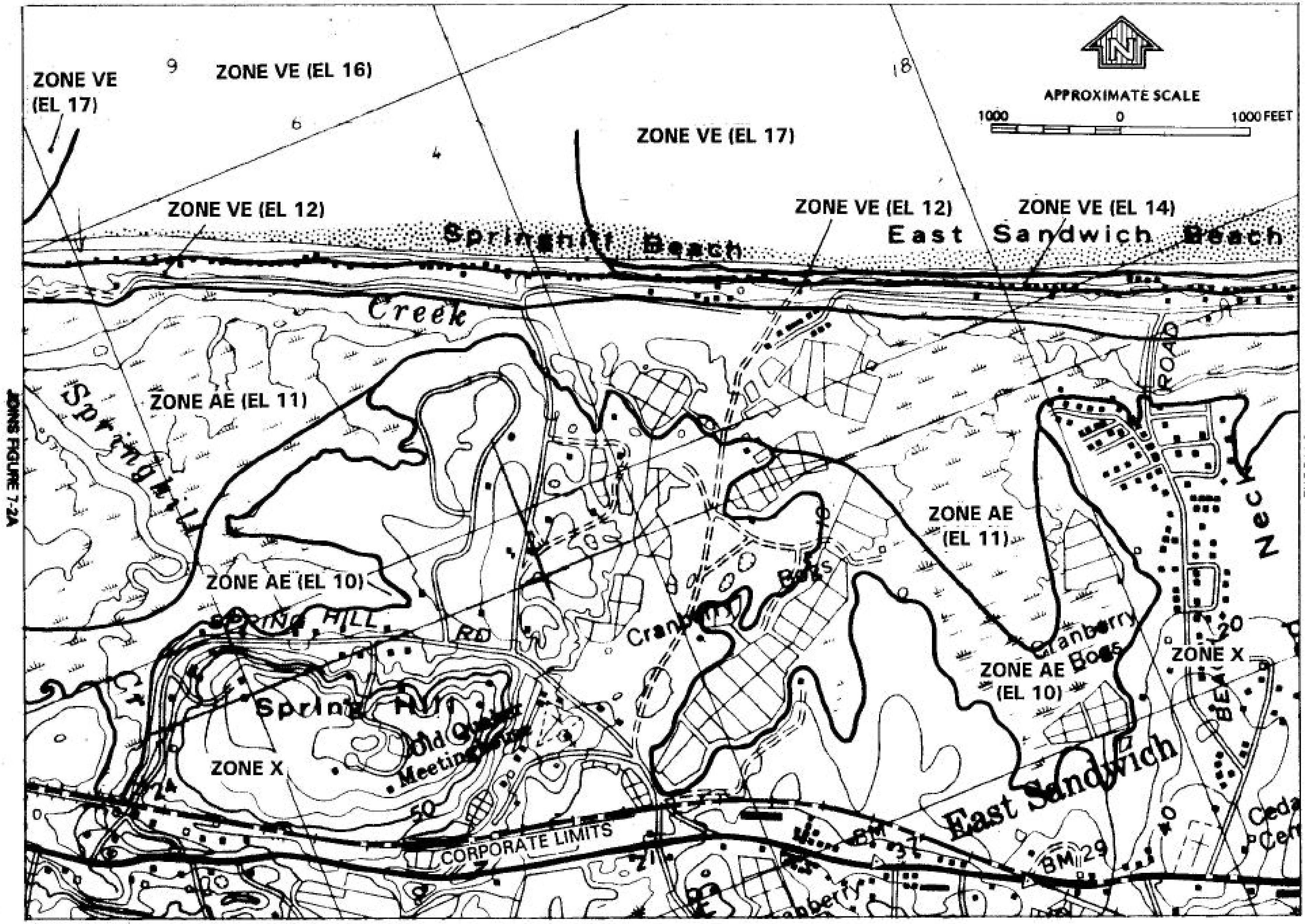

Transect D
Reach Represented by Transect D
Reach Represented by Transect B
Transect E
Reach Represented by Transect E
Reach Represented by Transect B
Transect B
Transect A
Reach Represented by Transect A
Reach Represented by Transect B
Reach Represented by Transect C
Transect C
CAPE COD BAY
CAPE COD CANAL
Sandwich
Sandwich Harbor
Old Harbor
Springhill Beach
East Sandwich Beach
East Sandwich
Scorton Harbor
Scorton Shores
Scorton Neck Beach
Tidal Flat
Plowed Neck
GREAT MARS
PLYMOUTH 19 MI.
SAGAMORE BRIDGE 3.5 MI.
SAGAMORE 2 MI.
6867 I SE (SAGAMORE)

Figure 7-2: Flooding Delineation

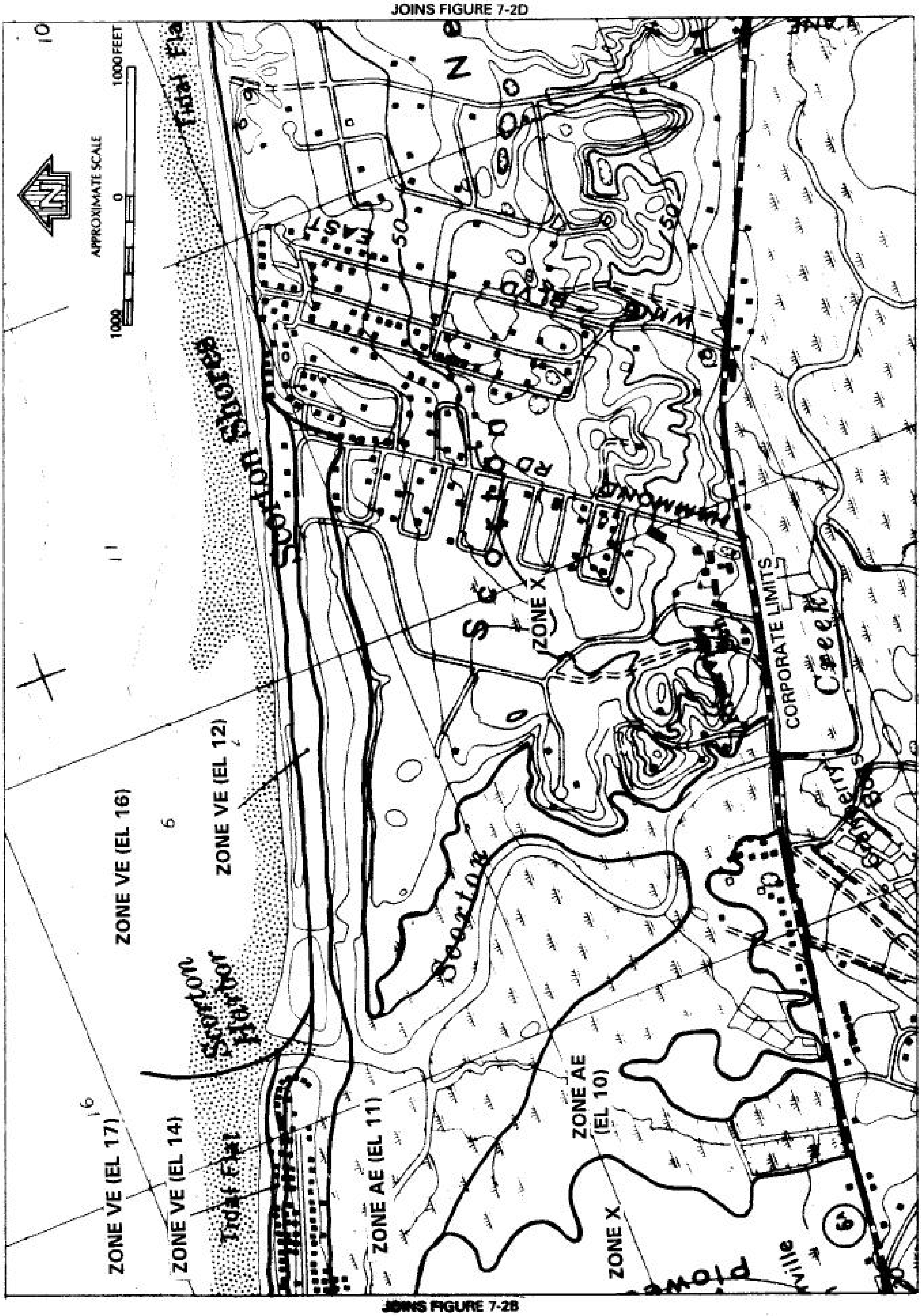


JOINS FIGURE 7-2B
APPROXIMATE SCALE
1000
0
1000 FEET
CAPE COD
Beacon
6867 I SE
(SAGAMORE)
SAGAMORE 2 MI.
ZONE VE (EL 17)
ZONE VE
(EL 15)
ZONE AO (DEPTH 2)
Town
Beach
Town
Neck
ZONE VE (EL 16)
ZONE VE (EL 13)
ZONE VE (EL 12)
Sandwich
Harbor
ZONE VE (EL 12)
ZONE VE (EL 17)
ZONE VE
(EL 14)
ZONE X
Creek
Creek
Old
Harbor
ZONE AE (EL 12)
ZONE AE (EL 10)
Dock
Sandwich
ZONE AE (EL 11)
CORPORATE LIMITS
ZONE AE
(EL 10)
PENN CENTRAL
Mt Hope
MAIN
ST

FIGURE 7-2A


JOINS FIGURE 7-2A
JOINS FIGURE 7-2C
APPROXIMATE SCALE
1000
0
1000 FEET
ZONE VE
(EL 17)
ZONE VE (EL 16)
ZONE VE (EL 17)
ZONE VE (EL 12)
ZONE VE (EL 12)
ZONE VE (EL 14)
East Sandwich Beach
Creek
ZONE AE (EL 11)
ZONE AE
(EL 11)
ZONE AE (EL 10)
ZONE AE
(EL 10)
ZONE X
ZONE X
Bogs
Cranberry
Bogs
ROAD
Neck
RD
Spring
Meeting
CORPORATE LIMITS
East Sandwich
BM 29
20
40
50
9
6
4
18
FIGURE 7-2B

JOINS FIGURE 7-2D



JOINS FIGURE 7-2B

FIGURE 7-2C

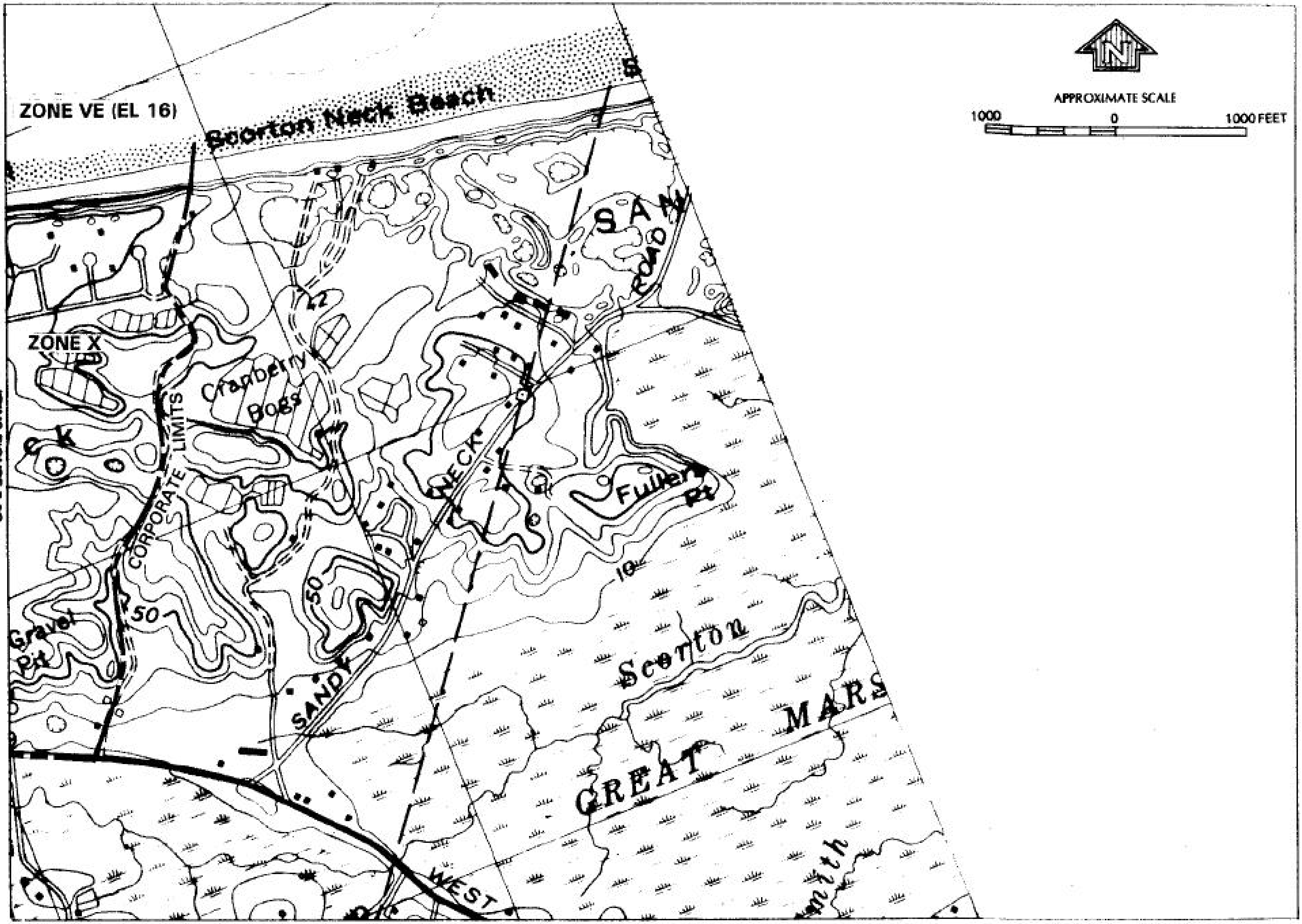


FIGURE 7-2D

JBINS FIGURE 7-2C