COLLEGE OF THE ATLANTIC

COASTAL GEOLOGY: SAND BEACH, ACADIA NATIONAL PARK

SENIOR PROJECT SUBMITTED IN
CANDIDACY FOR THE DEGREE OF
HUMAN ECOLOGY
TO

DR. CARL KETCHUM (SPONSOR) Carl Ketchum 5/13/82
DR. WILLIAM DRURY (SPONSOR) William H. Drury
MS. MARCIA DWORAK (SPONSOR) Marcia Dworak
DR. DONALD CASS (ADVISOR) Donald A. Cass
MR. STUART DICKEY (ADVISOR) Stuart Dickey
MR. DAVID MAHONEY (ADVISOR) 5/13/82

BY
KARL LANGFORD PORTER
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Although nature begins with the cause and ends with the experience, we must follow the opposite course, namely, begin with the experience and by means of it investigate the cause...

Leonardo da Vinci
Notebooks

ABSTRACT

The results of a repeated series of surveys made at Sand Beach in Acadia National Park between February 1 - April 30, 1982 are presented. Three line section surveys of the beach were determined twice weekly. The beach profile changes are correlated with wind, wave and tide data. The results indicate that waves induce the greatest amount of erosion or accretion to the beach. The beach material is of 30 - 50 % biogenous derivation. The coarseness (0.282 mm median grain size) of the sediment coupled with the high degree of sorting by wave action has resulted in a highly permeable and therefore moderately steep winter berm foreslope. Extensive areas of the beachface are susceptible to the transport of sediment due to the large tidal range. The key results indicate that the northeast winds are associated with the largest erosional periods while southerly and northwesterly winds are associated with periods of beach sand enhancement or redistribution. The primary mechanisms for erosion, sand redistribution and accretion is the wave state associated with these winds.

INTRODUCTION

Sand beaches are in a constant state of flux. The sediment is continuously shifted by the wave and wind action. The changes however, have a natural rhythm to them. The effects of the pounding surf from the winter storms erodes a great deal of material, only to be replenished by the calmer waters of summer.

This paper discusses the changes observed on Sand Beach in Acadia National Park from February 1 - May 1, 1982. Sand Beach is loctaed in the upper end of Newport Cove, a drowned, glacially-eroded U-shaped valley. The cove protects the beach and leaves it exposed to the open ocean towards the southeast only. Waves therefore can only approach from the southerly direction. Further, in an isolated, restricted bay like that enclosing Sand Beach, sediment can only move onshore or off. Sand beach is thus uniquely suited for the observance of the relationship between the wind, waves and changes in beach topography.

The purpose of this report is to determine the dominant factors in the shifting of the sediment of Sand Beach. The results indicate that offshore winds induce an onshore transport of sediment and the onshore winds associated with winter Northeaster's have the greatest erosional capacity. Further, Sand Beach exhibits peculiarities at both the east and west ends. The west end is protected from the wind by the cliffs running along the sides of the cove. The east end is also protected by cliffs. In addition it is subject to the affects of a brook which erodes and transports sediment from the upper beach seaward producing a flattened beachface. The rest of the beach remained in a state of near equilibrium through most of the observational period.

In the balance of the paper the characteristics of Sand Beach are discussed followed by an examination of the main dynamic processes that affect beaches and a survey of beach types. This background information is then used to discuss the procedure of the survey, the analysis of the results and the conclusion of the report.

CHARACTERISTICS AND LOCATION OF SAND BEACH

Sand Beach lies in Newport Cove on the island of Mount Desert, Maine (44° 20' N., 68° 09 W) (Figures 1-3). The nearby hills of Great Head were glacially scoured and contain only thin residual soil cover and minor till deposits. The geometry of the cove is such that the larger western side trends southerly a

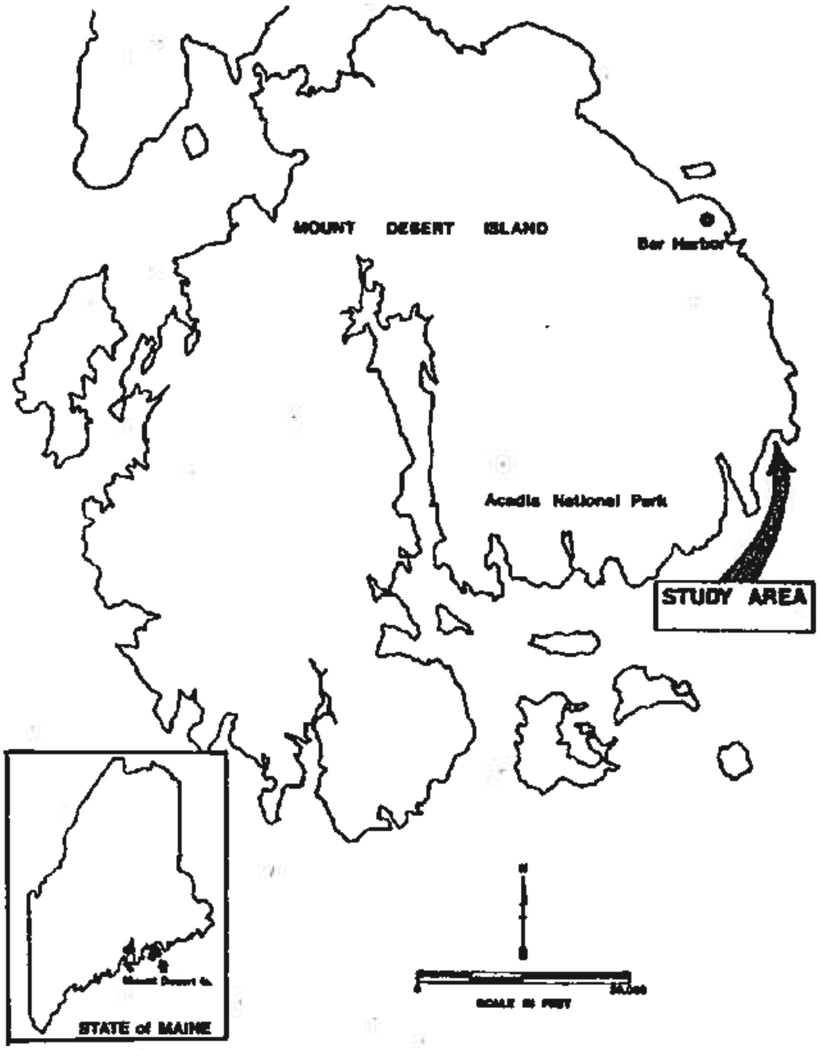


Figure 1 : Location of Study Area

distance of approximately 2500 meters, whereas, the shorter, parallel eastern side extends only about 425 meters. The width across the cove at the widest point is approximately 600 meters. The water depth varies from zero to 35 meters. The perimeter of the cove is bounded by granite cliffs (Leonard and Cameron 1979). These perimeter rocks, which are often interrupted by eroded basaltic dikes and extensive jointing, generally support near vertical cliffs which extend down below the waterline. These cliffs often times, however grade into near horizontal ledges up to 20 meters wide.

Sand Beach was part of a 100 acre donation of land made by Eleanor Morgan Satterlee in 1949 (Barden 1970). It is the only sand beach in Acadia National Park. During the busy summer months, it is estimated that over 2500 people visit the beach aech day (Barden 1970). The beach is of the sandy pocket barrier type. The narrow beach is of limited extent, and the sand is a shallow veneer overlying rock. The beach has been built across a small inlet so as to dam the brook and form a long narrow pond extending northwest-southeast. There is a moderately large frontal dune ridge and a small backdune aeolian flat supporting a variety of plants. The vegetated dune is 140 meters long. The length of the beach at the seaward edge of the winter berm is 275 meters. At the low waterline it is 290 meters.

The beachface is oriented towards the south southeast with no obstruction between the beach and the open ocean. The prevailing wind is westerly, an oblique onshore wind; however the higher velocity winds are generally the offshore northwesterly winds and the onshore southwesterly winds. During winter the northwesterly winds occur far more frequently than the southerly winds. It is the wind-driven winter storms that produce high seas occasionally causing serious damage to the coast.

Acadia National Park is exposed to northern temperate climatic conditions, (Figure 1) where ambient temperatures reach extremes of -30 degrees Fahrenheit in winter to 100 degrees Fahrenheit in summer. The mean annual precipitation in the area is 48.9 inches. The procession of contrasting air masses and the relatively frequent passage of storms brings about a roughly twice weekly alternation from fair to cloudy or stormy conditions. Northeaster's sometimes seriously affect this area. They generate very strong winds and haevy rain or snow, they can produce abnormally high wind driven tides affecting the beach.

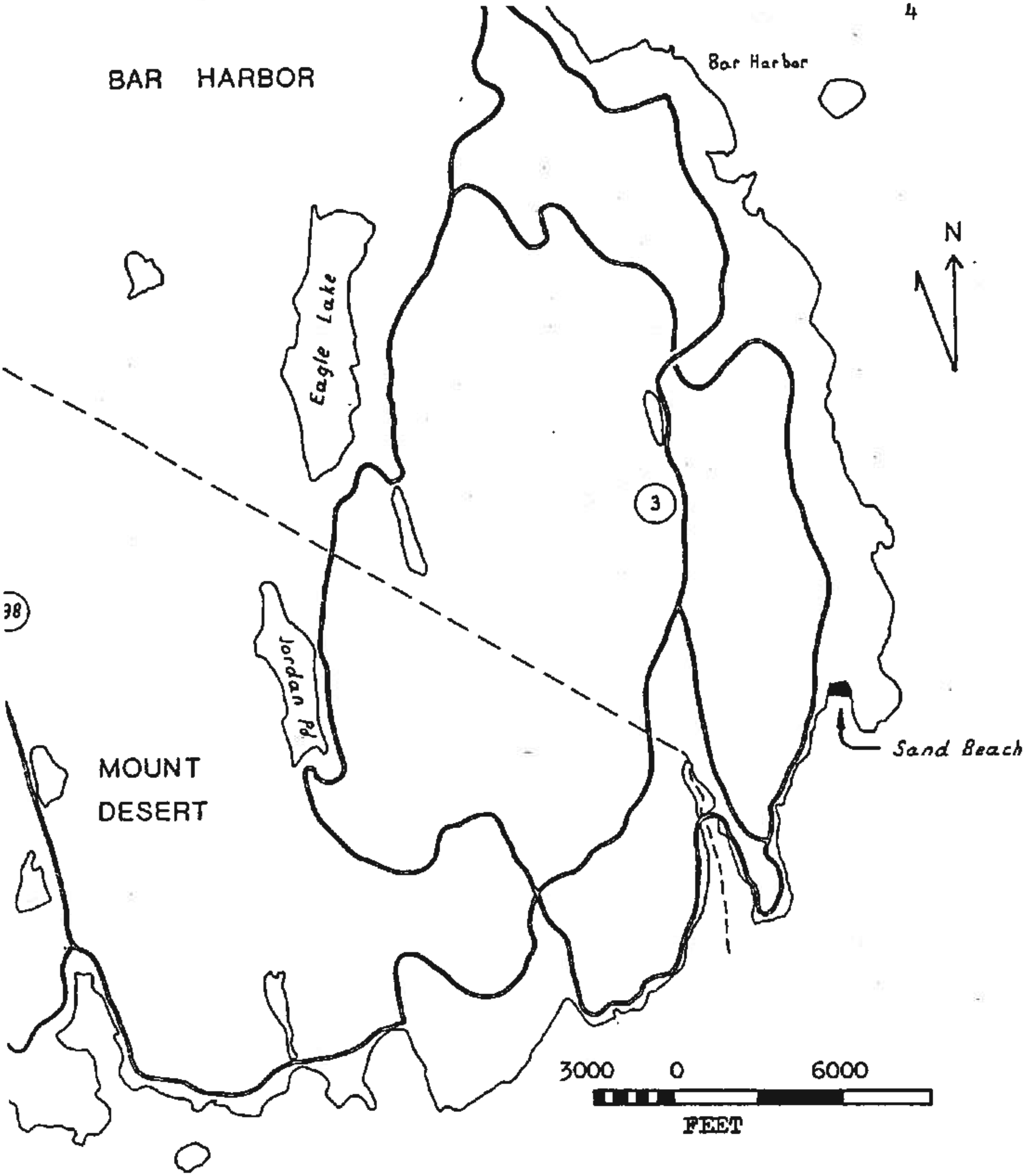


Figure 2 : Eastern half of MDI locating Sand Beach, Newport Cove, Acadia National Park

Occasionally, in summer or fall, a storm of tropical origin arrives. Usually the storm will be similar to a Northeaster. But a few such storms may retain near or full hurricane force. The occurence of these storms is infrequent, very often not affecting the area at all in most years. Two or more such storms in one year should be expected about one year in twenty.

It is during the winter months that the Atlantic waves wreak havoc on the beach. Periodically (5-10 years) severe storms intensify the devastation. The storms of January 9 and February 7, 1978, caused the removal of the berm and aeolian ramp of the previous summer, leaving a straight profile from low water to the tip of the new erosional scarp. The total erosional recession of the dune line caused by these storms was 3-5 meters along the entire beach (Nelson and Fink 1978).

On December 27, 1969, in a period of 2 hours, half of the foredune area was swept out to sea. The waves approached Newport Cove from the southeast, funneled along the western side of the cove towards the beach, and carried sand clockwise toward Great Head (Barden 1970).

Mr. Franklin J. Anthony, who lived in the caretaker's house of the Satterlee estate from 1911 to 1940, remembers storms which carried away the entire beach. There was not enough sand, he said, from one side of the beach to the other to fill a bucket. However, he remembers that less than one week later the surf had shifted the sand back to the beach. Mr. Anthony is of the opinion that over the years the beach has increased slightly in size despite the storms (Barden 1970).

Further back in the history of the beach one encounters the story of the schooner Tay.

> "During a heavy storm on the night of Friday, July 27, 1911 the schooner Tay, Saint John, New Brunswick, I.W. Scott, Captain, was driven ashore on Sand Beach. Her complement was the Captain, his son as passenger, and six crewmen. Of the eight in the ship's company seven survived, one being lost overboard before the vessel struck.
> The cargo consisted of a deck load of shingles and long lumber in the hold. The shingles were washed overboard; the long lumber was saved and sold to a local building contractor.
> The schooner was a total loss. What remained of the hulk was thrown high on the beach by the storm waves there to remain exposed until covered by sand washed over it by waves of later storms.
> For thirty years and more the hulk of the schooner Tay lay buried in the sand, a forgotten victim of a stormy sea, and the incident of her wrecking has lain nearly equally forgotten

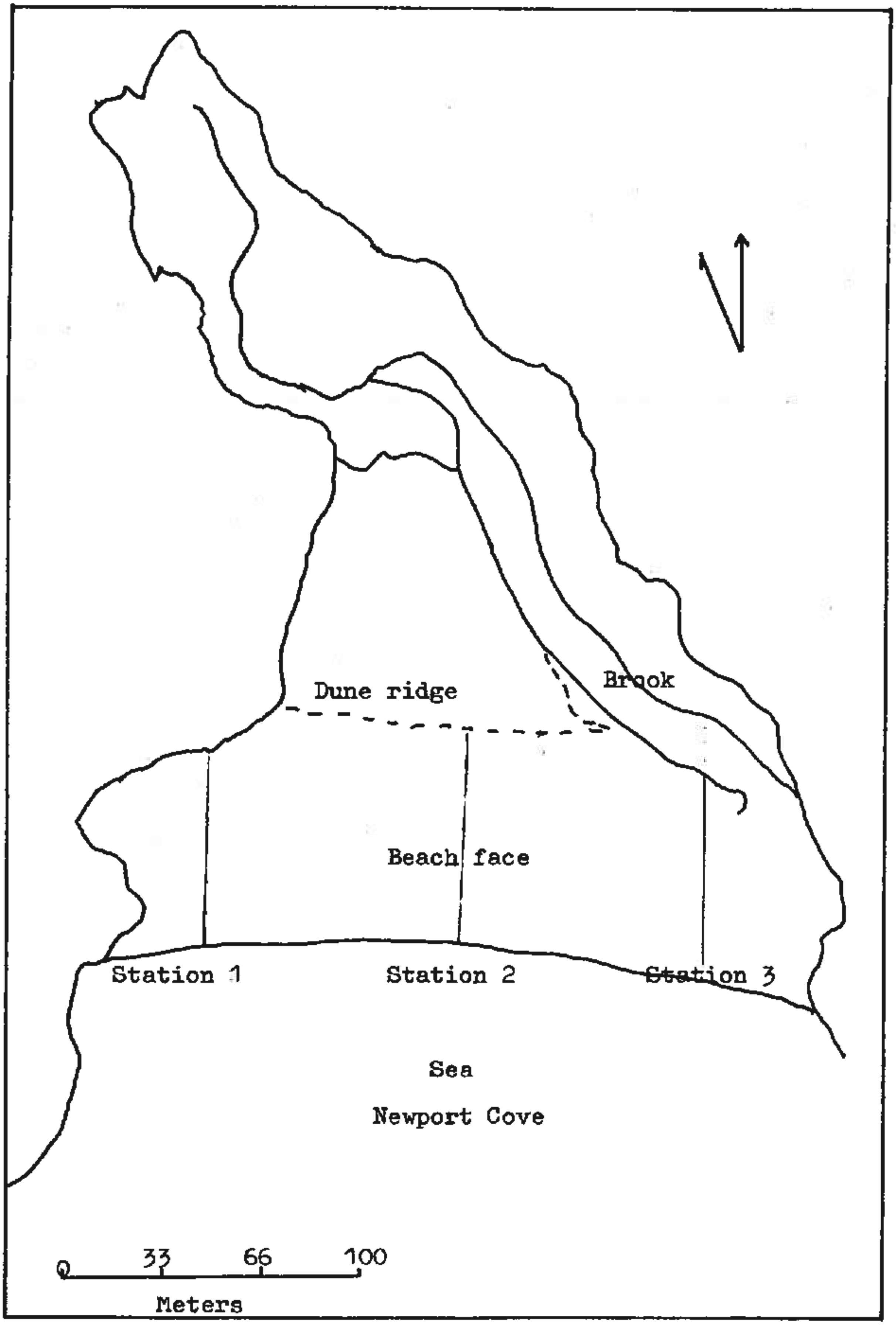


Figure 3: Sand Beach, Newport Cove, Acadia National Park

in the minds of those who then knew of it and who are here now to recall it.
A great storm struck this part of the Maine coast on November 25-26, 1950. Wind driven waves of unusual height and power produced awe inspiring surf along the Ocean drive and at Sand Beach. Their reach onto the shore was of unusual length, so much so that, after more than thirty years, they reached and uncovered the hulk of the Tay. There it lies, a relic from the past, a bit of the history of the sea and its once considerable traffic. Succeeding storms will doubtless once more cover it with sand and again it will be forgotten until another convulsion of the elements brings it to light. The process of re-burying may be long and that of exhumation still longer, but the sea is timeless and the cycle will probably be fulfilled." (Barden 1970).

DYNAMIC PROCESSES

The general morphology and the specific characteristics of this beach system is a response to a variety of processes. Essential to an understanding of this process-response model is the recognition of possible feedback mechanisms. These mechanisms explain how some response characteristics influence or alter the dynamics of the system. The main factors that affect evolution of a beach are the waves, winds, beach material and tides.

Waves

Waves initiate sand transport in most of the daily and long term beach processes. The waves act upon both the surf zone, which extends from the breakpoint to and the swash zone. The breakpoint is that part of the beach where the waves break. The swash zone is that part of the beachface covered and uncovered by the uprush and backwash of the wave. It is primarily in the area between just seaward of the breakpoint and the upward swash limit that most of the sediment transport occurs. Sediment transport is enhanced in this zone because of the suspension of sediment due to turbulence of the breaking wave and the transport capacity of the translational waves. The higher current velocities encountered in this zone pick up and carry away larger and greater numbers of particles from the sand sized particles up.

Waves are commonly characterized as either swell or storm waves. These characterizations are primarily a function of the age of the wave train. The swell are remnants of distant storms having rounded crests and a gentle slope while storm waves are locally generated and have steep faces and sharp crests. The theoretical maximum wave steepness is 1 to 7. Swell waves have low steepness values while storm waves have high steepness values because of both their greater heights and shorter periods. The wave steepness can be increased by an increase in the wave height or by a decrease in the wave length both of which occur as the waves move into shallow water. Swell waves move sand landward at all depths within the surf zone as well as beyond the breaker zone to cause a net accumulation on the berm. Storm waves however generally move sand from the seaward edge of the breaker zone towards the shore, while sand in the surf zone is transported seaward.

Whether a wave is constructive or destructive in terms of sediment transport depends on both the wave steepness and the grain size of the beach sediment. Larger grains can be accumulated by waves of greater steepness, and still be moved landward. This is because of the higher percolation capacity of larger grains which reduces the erosion capacity of the backwash. Cobbles and boulders are moved landward by the highest energy waves.

As the swash of the wave ascends the sloping beach face more and more of its energy is lost and the forward velocity decreases to zero. The energy of the swash has its source in the energy of the incoming wave,but the velocity of the backwash as the flow returns down the beach face is due to gravity. The backwash accelerates from rest until it reaches its maximum velocity near the plunge line of the breakers. Because of these variations in velocity the sediment is sorted as it is moved about on the beach foreshore, the smaller grains accumulating in the slower-moving water near the top of the swash and the coarsest material near the plunge line, where the energy is greatest. Due to water percolation into the beachface and the frictional drag on the swash, the return backwash tends to be weaker than the shoreward uprush. This moves sediments onshore until a slope is built up in which gravity supports the backwash and offshore sand transport.

The deep water wave length can be calculated from wave period by the relationship $L=5.12 \times t^2$, where L is the deep water wave length in feet and t is the wave period in seconds (King 1971). The wave steepness can be found by a simple ratio of height-to-length computation (see Appendix II). The energy in a wave is equally divided between potential energy and kinetic energy. The potential energy results from the elevation and depression of the water surface, and the kinetic energy is a summation of the kinetic energy of the motion of the particles in the wave train and advances with the group velocity. The wave energy is determined from the formula $e=4Lh^2t^2$, where e is the wave energy in foot-pounds per foot of wave crest per wave length, h is the deep water wave height and t is the wave period in seconds(King 1971).

Wind

The main winds effecting the beach fall into three categories, Northwest, south to southeast and northeast winds. Wind observations were obtained from the daily reports compiled at Great Duck Island every four hours by the U.S. Coast Guard. This open water station is located directly offshore of Mount Desert Island.

Sand transport by wind can occur by creep, saltation and air suspension. Each process dominates at a specific wind velocity. Creep, a rolling of sand grains along the ground surface is associated with low winds. Saltation, a low (1-2 inches) leap downwind of sand grains repeated over and over is caused by medium velocity winds. Suspension which is a carrying of granules through the air just above the sand surface is indicative of high velocity winds.

Northwest Winds

The northwest winds are strongest in winter and they are important in the redistribution of sand within the system during non-storm conditions. They blow offshore, thus flattening the incoming waves. This promotes an onshore transport of sand. Because of their high velocity and dryness, the winds are capable of transporting large volumes of sand from the dunes and the backshore area seaward(Nelson and Fink 1978).

South to Southwest Winds

South to southwest winds occur throughout the year. They are responsible for the formation of locally generated waves which transport sand onshore. A further redistribution of sand often occurs due to these winds as they transport sand to the east or northeast end of the beach via littoral drift or by aeolian means (Nelson and Fink 1978).

Northeast winds

The northeast winds are moist, high velocity winds generally associated with storm activity. The waves produced are locally generated, steep, of short wave length and of high energy, thus causing marked erosion on the beach. These winds initiate the erosional phases that transport sand from the beachface offshore.

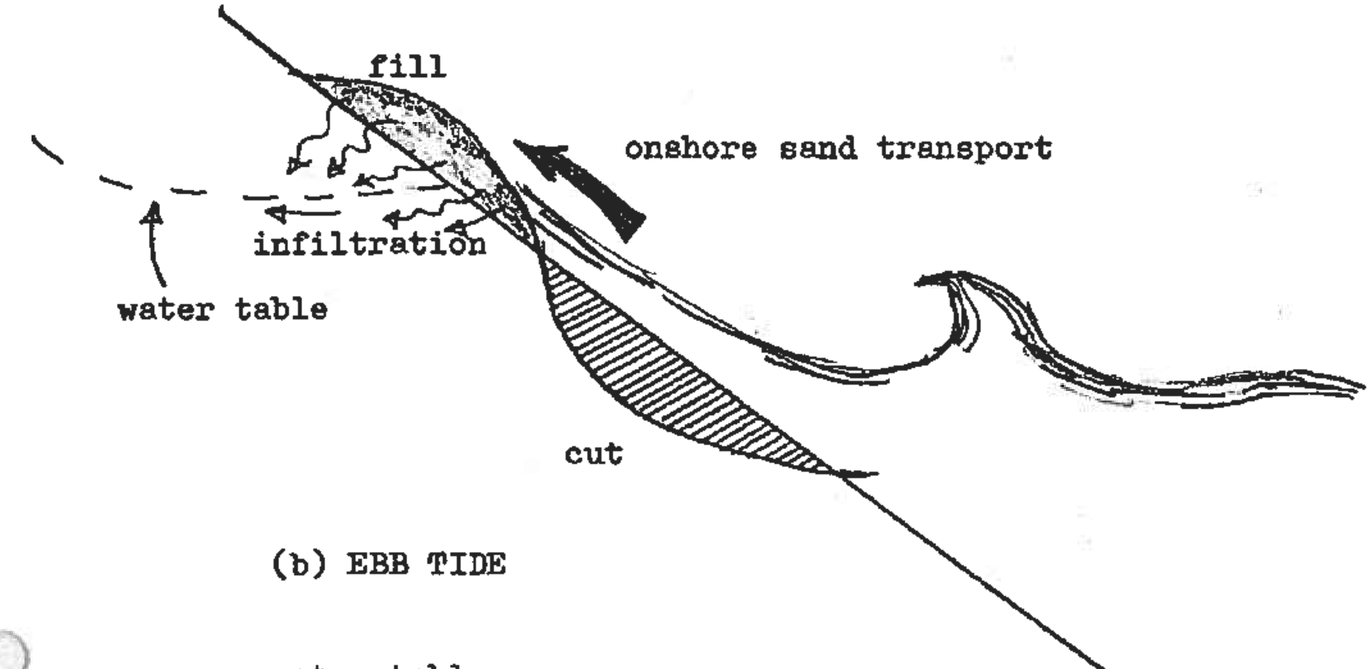
Beach Material

The sand size of the beach is medium sized ranging from .100 mm to 1.18 mm. The bulk of the material lies within .150 mm to .425 mm. It is moderately well sorted and comprised of 30-50 % biogenous material. At the east and west end of Sand Beach, large bay rocks derived from erosion of local bedrcok are exposed by the succesion of storms and locally(east end) by a brook. The coarse grain size coupled with sorting of the beach material by the wave action produces a highly permeable situation. This results in the moderately steep berm foreslope of the winter profile. The beach material of Sand Beach is unique in that it has a relatively large biogenous content. The high percentage of shell material is thought to result from ; (a) the exposure during winter of boulders and rocks at the east and west ends of Sand Beach provide habitats for calcareous organisms. This zone is temporary, so any attached organisms that establish themselves there are killed, ground and buried by the accreting sand of summer. This provides a continuous source of shell material available for deposition on the beach, (b) shell material can concentrate on the beach by the winds, which remove and blow inland the finer quartz sand to form dunes. The quartz sand is more susceptible to movement by wind because of its round shape. The shell material is predominantly of a flat, long shape, not conducive to aeolian transport, (c) the supply of terrigenous sands is either very low or of the wrong grain size for the dynamic processes specific to Sand Beach, so shell material derived from the adjacent shallow water area which is characterized by an abundance of marine organisms with carbonate shells or parts provides material for deposition on the beach. (Leonard and Cameron 1979).

Tides

The affect of wave action changes hourly due to the daily rise and fall of the tide. As the semidiurnal tide ebbs the wave swash weakens --- thus effectively depositing more sediment on the lower beach than it erodes. During the flood, the backwash is weaker than the shoreward swash due to the slope of the water table (see Figure 4)(Komar 1976). The onshore current during the flooding tide is more rapid than the longer period offshore current of the ebb tide. Aside from these hourly changes, long term differences are observed during spring and neap tides. Each month spring tides cause erosion to take place near the neap tide high water mark, and neap tides result in deposition there. The range of the mesotidal tides in this area are from 4.1 meters at

(a) FLOOD TIDE



(b) EBB TIDE

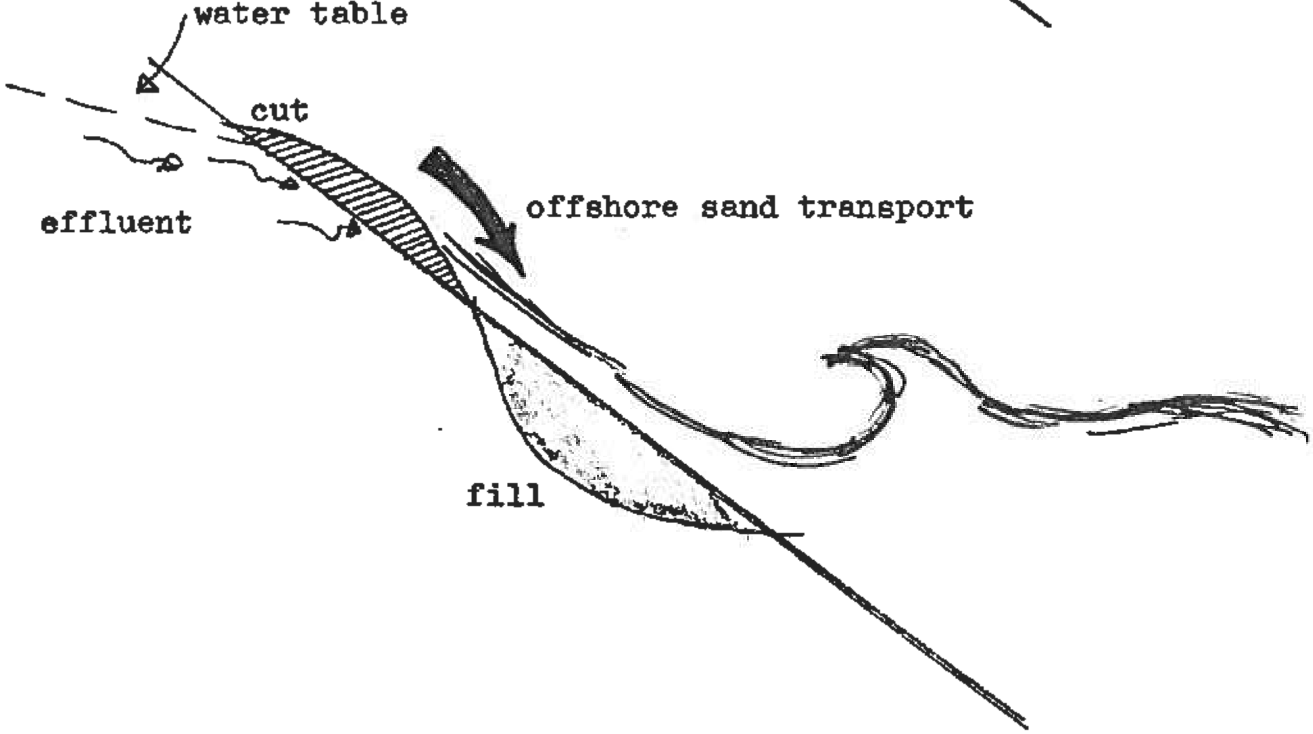


Figure 4: Effects of Flood and Ebb tides

spring tide to 2,9 meters at neap tide. The larger the tidal range, the greater the influence of the wave swash in a vertical direction. This is directly proportional to the beach width and height, as well as the dissipation of wave energy over a larger surface area. The beach surface, a number of feet above mean tide level reaches its minimum elevation a few days after spring tide and its maximum elevation following the neap tide. The relatively large tidal range, coupled with the near horizontal ledges of the cove's perimeter, contribute to the formation of a large biologically productive intertidal zone.

BEACH PROFILE TYPES

The profiles of Sand Beach show a gradual change from a winter profile to the initial summer profile. Hypothetical profile types are shown in Figure 5. The winter beachface is characterized by its upwardly concave profile. The slope is flat to slightly concave upward from the low water mark to the winter berm with few sharp slope breaks. This is especially typical of the post storm profile. The winter berm is the higher terrace observed on the those profiles recorded at Sand Beach in the month of February. It is landward of the summer berm, and built by the larger waves of winter. Storms cut away at it, but the post storm activity soon builds it up again. Often times it is marked by an accumulation of large driftwood logs at its inner margin. In the winter the sand shifts offshore to form a series of underwater bars parallel to the shoreline. The overall profile slope is smaller in the winter than in the summer. The summer profile is recognized by its wide berm, flat shallow water portion of the profile, and by a smooth deep water profile devoid of bars. The volume of sand involved remains relatively constant; the area under the winter and summer sections are about the same. The sediment shifts from the bar and back again. A beach that shows these characteristics is at equilibrium(Nelson and Fink 1978).

This equilibrium mode is governed by the asymmetry of the energy dissipation of the shoreward wave orbital motion versus the seaward motion. Because of the frictional drag on the wave swash and water percolation into the beach, more sand tends to be transported shoreward than seaward. Opposing this shoreward movement is the local beach slope such that gravity aids the return swash of the water in moving sand offshore. At equilibrium there must be a balance between the quantity of sand that is carried up and down the beach

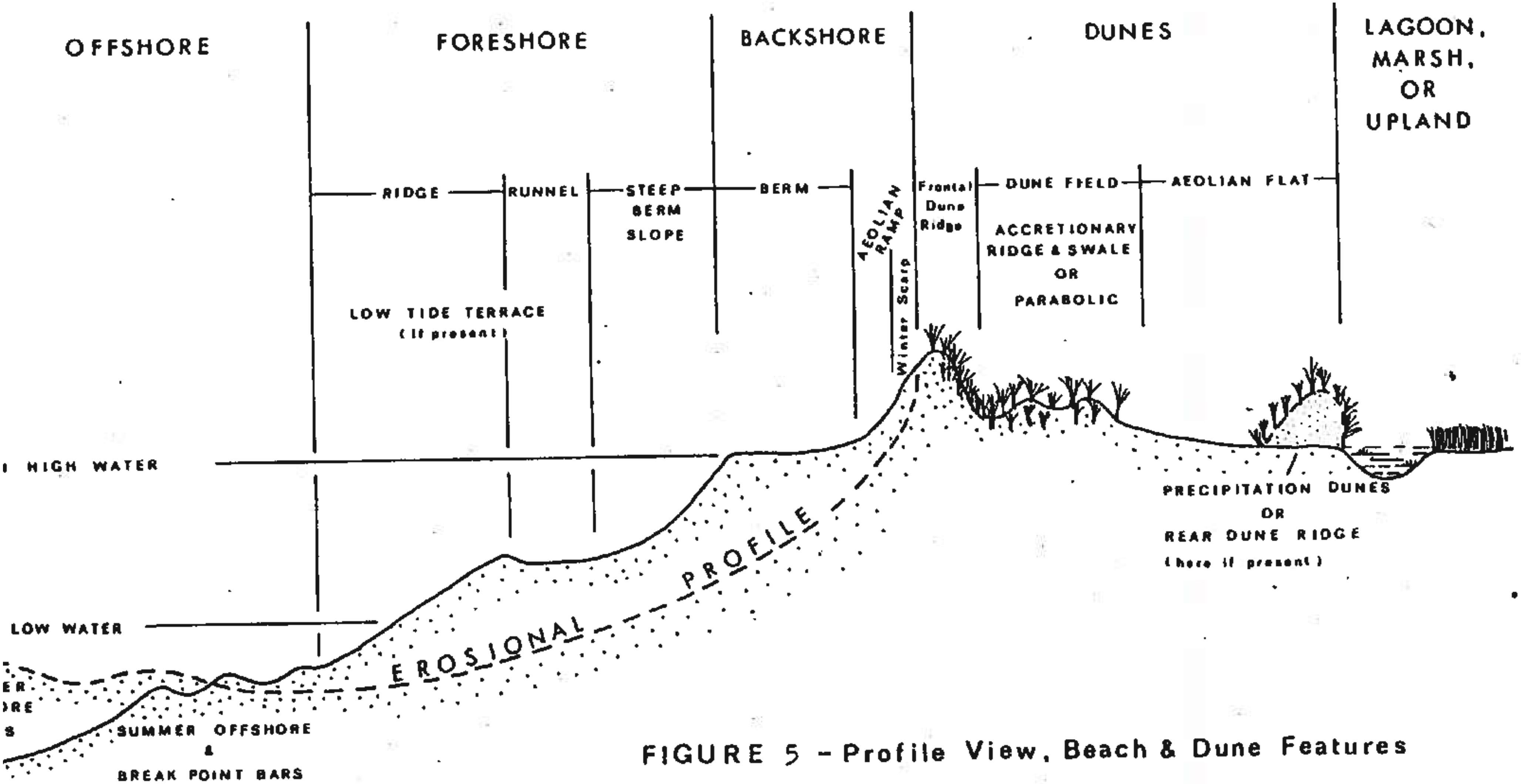


FIGURE 5 - Profile View, Beach & Dune Features

(Reprinted from Nelson and Fink, 1978)

under the wave action.

The constructional profile is marked by offshore bars, breakpoint bars, a ridge and runnel system, the steep berm slope, crest, and platform which extends to the frontal dune ridge.

The offshore bar is composed of sand removed from the intertidal beachface, berm and frontal dune during winter. It is the major source for onshore transport as the beach is built up. The offshore bars become smaller and fewer as the winter storm waves become less frequent. The breakpoint bars are small and separated by troughs. They are visible at low tide beneath the breakers of low swell. With each tide the sand may migrate up the beach to supply a significant amount over time to the steep berm slope.

A ridge and runnel system forms in the summer and migrates (the breakpoint bar is the migrating ridge) up the beach until the runnel is filled and the ridge welds onto the berm. This is one of the main mechanisms for transport of sand from the offshore bars to the berm and the steep berm slope. The system of ridges and runnels forms at the breakpoint. As the tide rises or falls, the breaker position jumps from one ridge to the next with little wave action occurring within the runnels. This system operates best in calm conditions accompanied by moderate swell. Other factors which determine the development of a ridge and runnel system are (a) a large tidal range such that an extensive low-tide terrace is developed; (b) low wave energy, which is indicative of Sand Beach as it is sheltered from the open ocean; (c) an abundance of beach material.

The face of the berm forms the steep upper beachface common on accreting profiles. The base of the steep bermface joins the low tide terrace, which may be composed of coarser grained sediment covered with a thin veneer of fine sand deposited by the retreating tide. At the edge of the berm is the crest, the berm then extends as a platform to the frontal dunes. The platform accumulates at the level of the spring tide high water mark and extends seaward from the toe of the frontal dune ridge for as much as 40 meters. This berm widens through the summer. The frontal dune ridge is the result of a constructive upgrowth process which is the natural interaction between sand blown landward from the berm and beach vegetation, primarily American Beachgrass (Ammophila breviligulata). The wind blown sand is trapped by the beachgrass which when partially covered or even buried by up to 1 meter, is stimulated to grow vigorously both, horizontally, by rhizome extension, and vertically upward through the sand. The repetition of trapping and subsequent growth combine to build a ridge limited in dimensions only by sand grain size, wind transport velocity, amount of sand and storm frequency. The functional roles of frontal dune ridges are to (a) act as a buffer against storm erosion of backdune and marsh areas and (b) as a storage compartment of sand for vital beachface replenishment during storms (from Nelson and Fink 1978)

PROCEDURE

Topographical surveys of Sand Beach were recorded twice weekly at low tide utilizing an approximate survey method (see Appendix I) for the period. The techniques employed were combined with methods established by Emery, 1961, which seemed to produce highly reliable results. Wind velocity and direction were estimated at the same time as that of the survey determination. Wind speed and direction were also obtained for the wave generating area from the U.S.C.G. lightstation on Great Duck Island. Estimated wave dimensions were obtained as well from the station.

The data analysis proceeded by estimating the volume of sand added or removed from the survey sections. This was followed by an examination of the observed changes in the beach slope to wind direction and wave state. The analysis is summarized with respect to erosional, accretionary, and equilibrium conditions. A discussion of the analysis includes the tide state and beach gradient.

ANALYSIS OF THE OBSERVATIONS

Consecutive profiles of the sections made at Sand Beach are presented in Figures 6-14. They appear on the same graph so that the amount of erosion or accretion can be readily ascertained. The wind data during the period between surveys is used to aid and relate the observed erosion and accretion to the local wind conditions.

In general the profiles show a correlation between the movement of sand at both the west, center, and east stations. At times the observations at section 3 differed from the general characteristics of the other two. Section 2, located at the center of the beach is assumed to have characteristics indicat-

FIGURES <u>6</u>, <u>7</u>, and <u>8</u> DEPICT STATION 1

Station 1 is located at the West end of Sand Beach. The profile transect extends from the water's edge to the base of the cliff upon which the granite steps leading down to the beach are located on. The transect line runs about 200 feet.

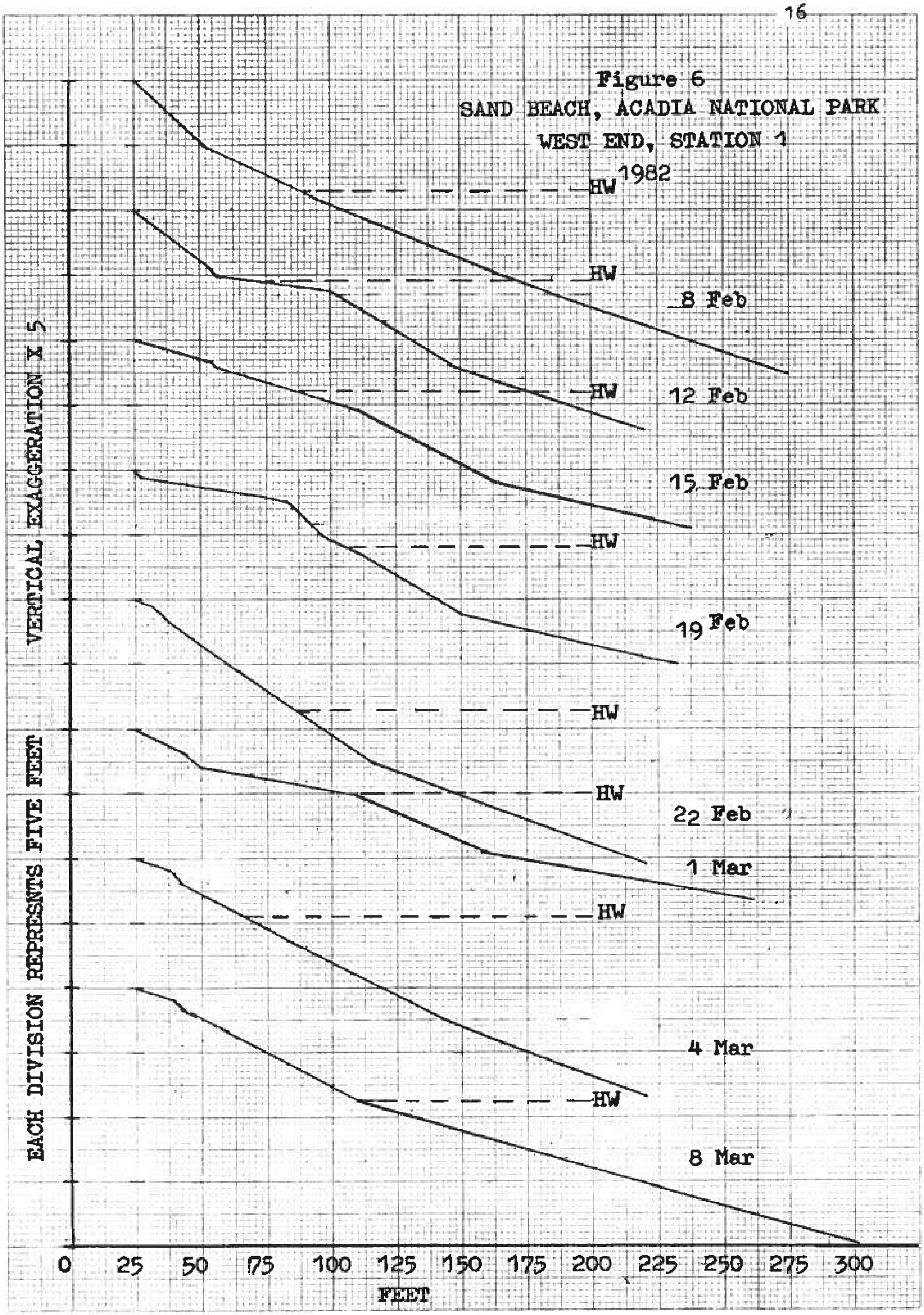


Figure 6
SAND BEACH, ACADIA NATIONAL PARK
WEST END, STATION 1
1982

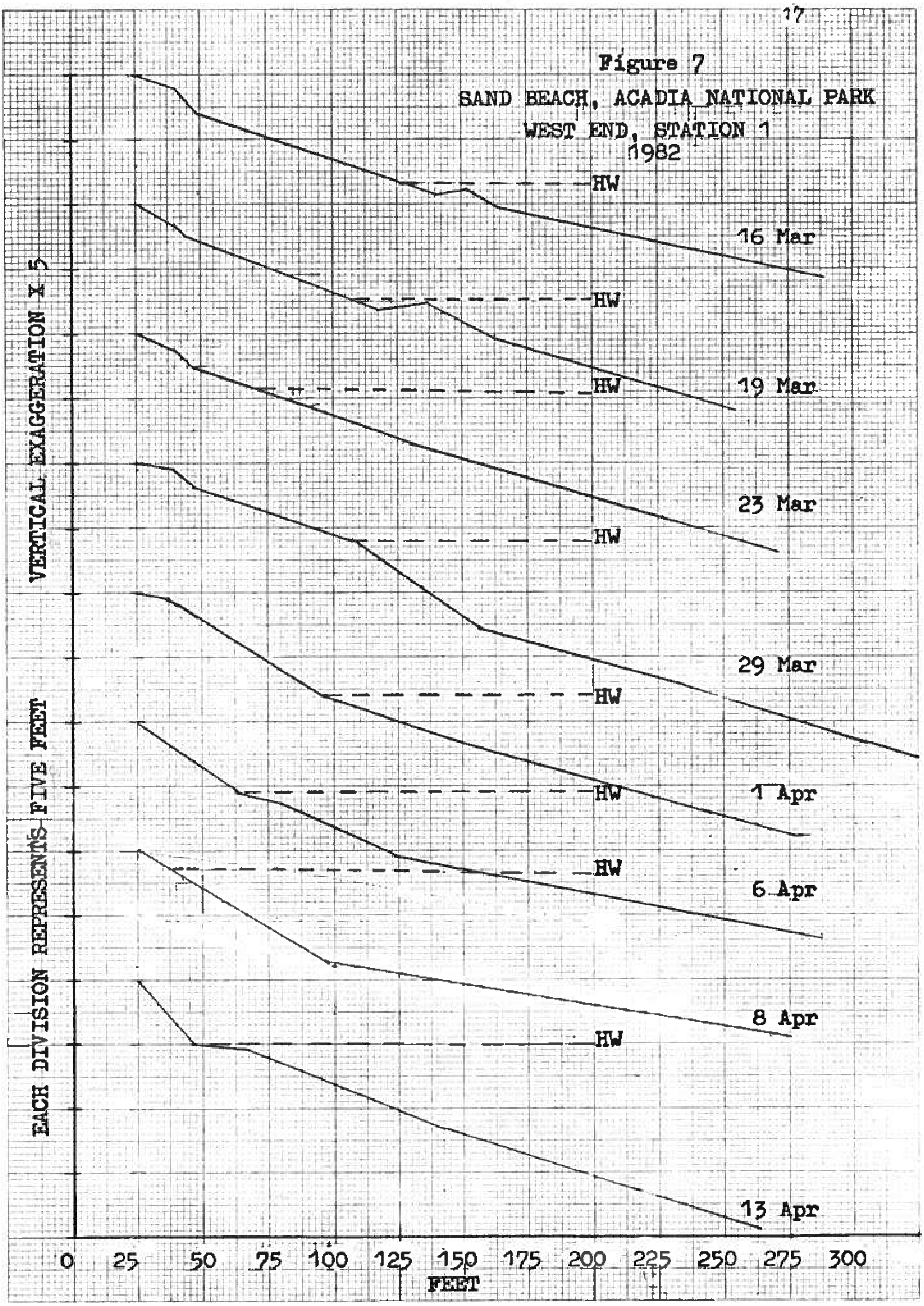


Figure 7

SAND BEACH, ACADIA NATIONAL PARK
WEST END, STATION 1
1982

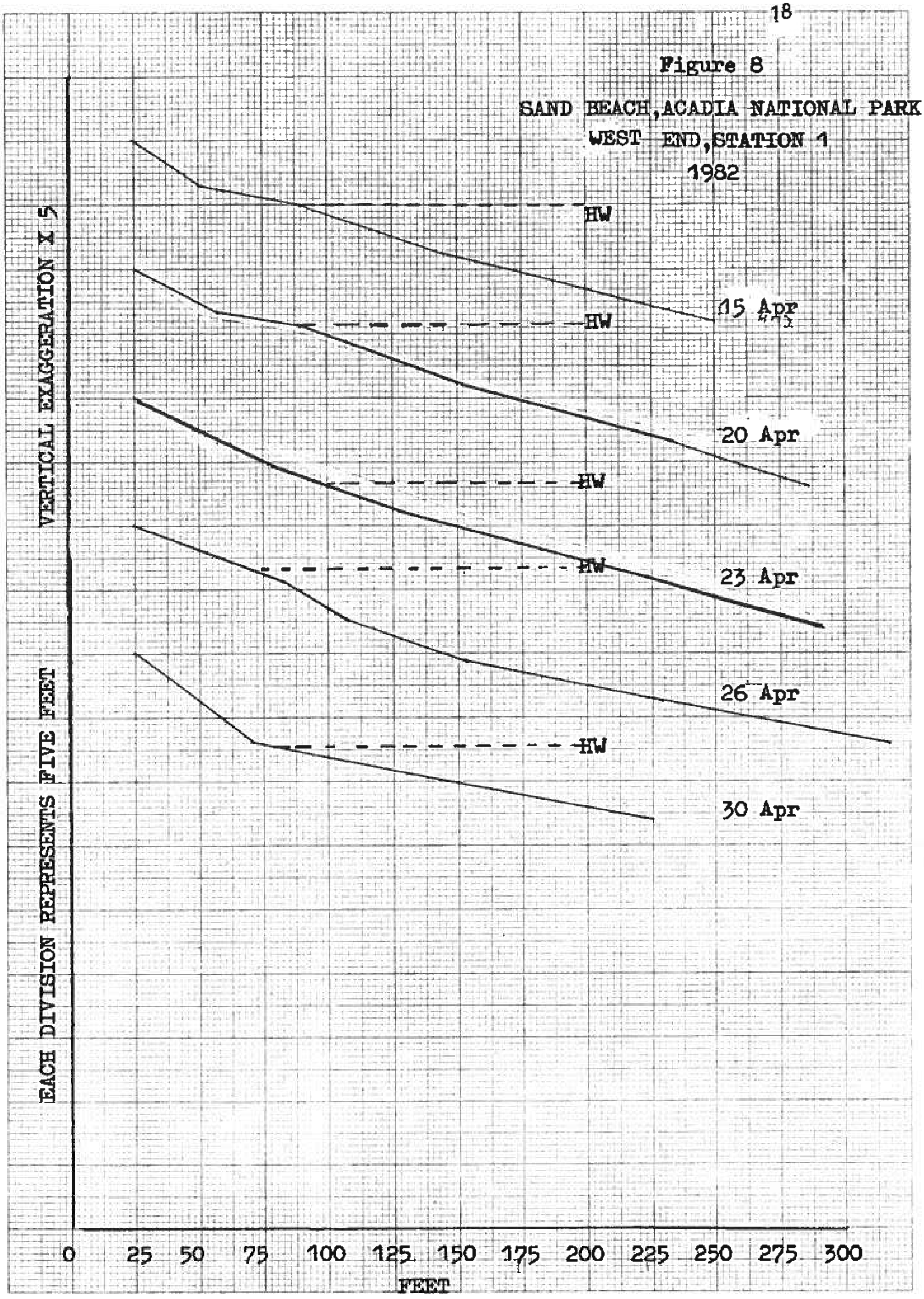


Figure 8

SAND BEACH, ACADIA NATIONAL PARK
WEST END, STATION 1
1982

FIGURES 9, 10, and 11 DEPICT STATION 2

Station 2 is located at the approximate center of Sand Beach. The profile transect extends from the water's edge to the dune fence directly in front of the dune ridge. The transect line runs about 275 feet.

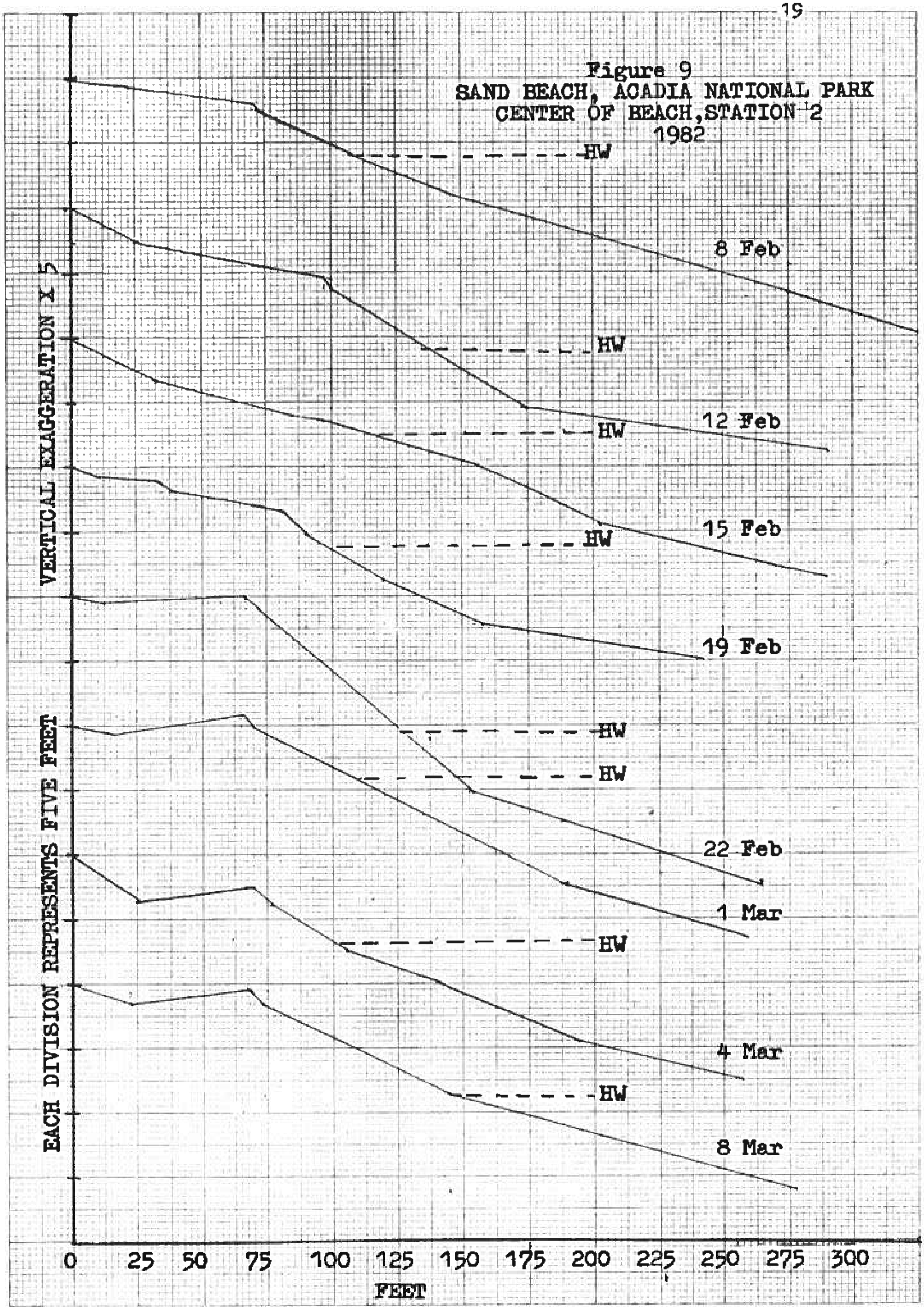


Figure 9
SAND BEACH, ACADIA NATIONAL PARK
CENTER OF BEACH, STATION 2
1982

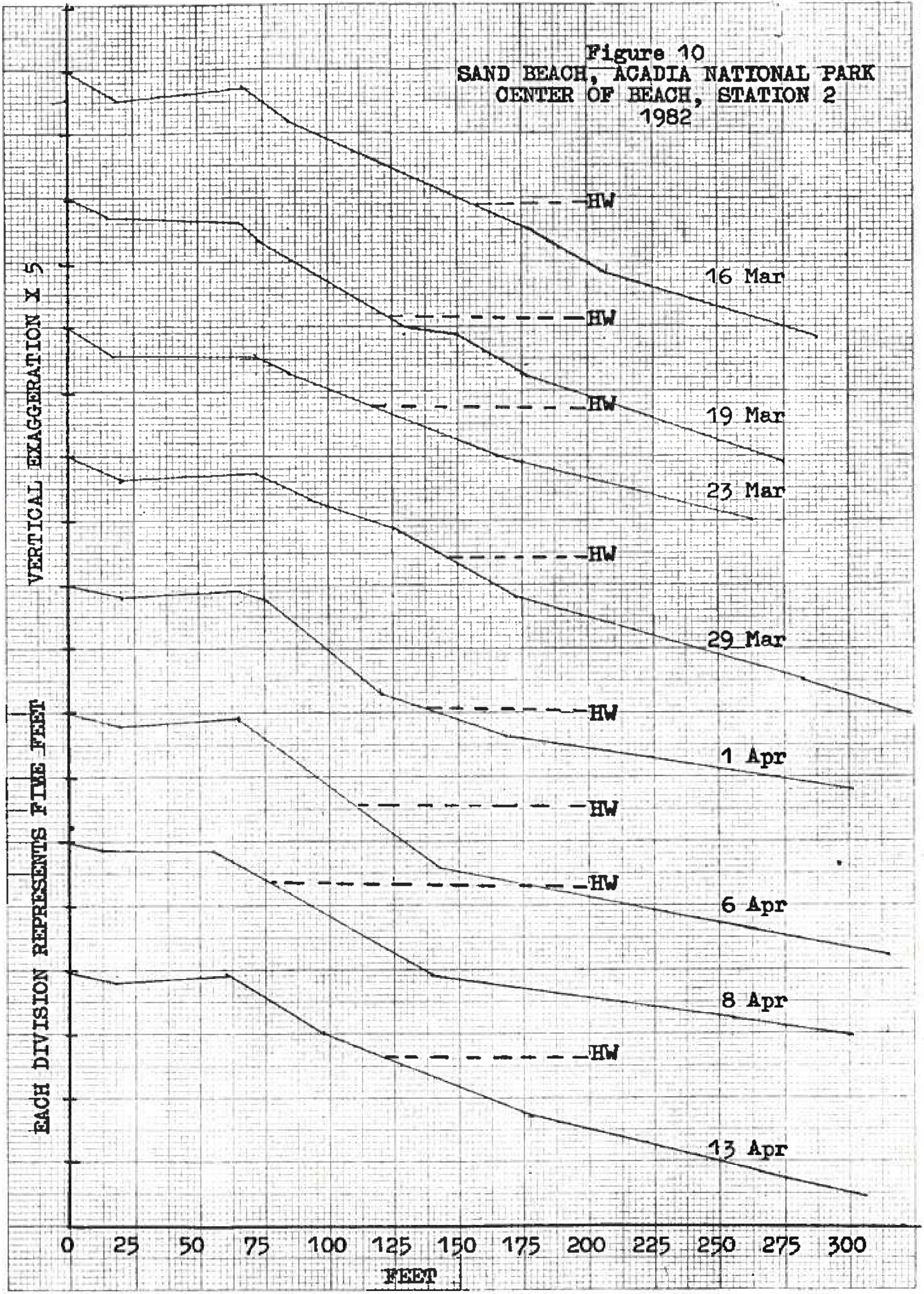


Figure 10
SAND BEACH, ACADIA NATIONAL PARK
CENTER OF BEACH, STATION 2
1982

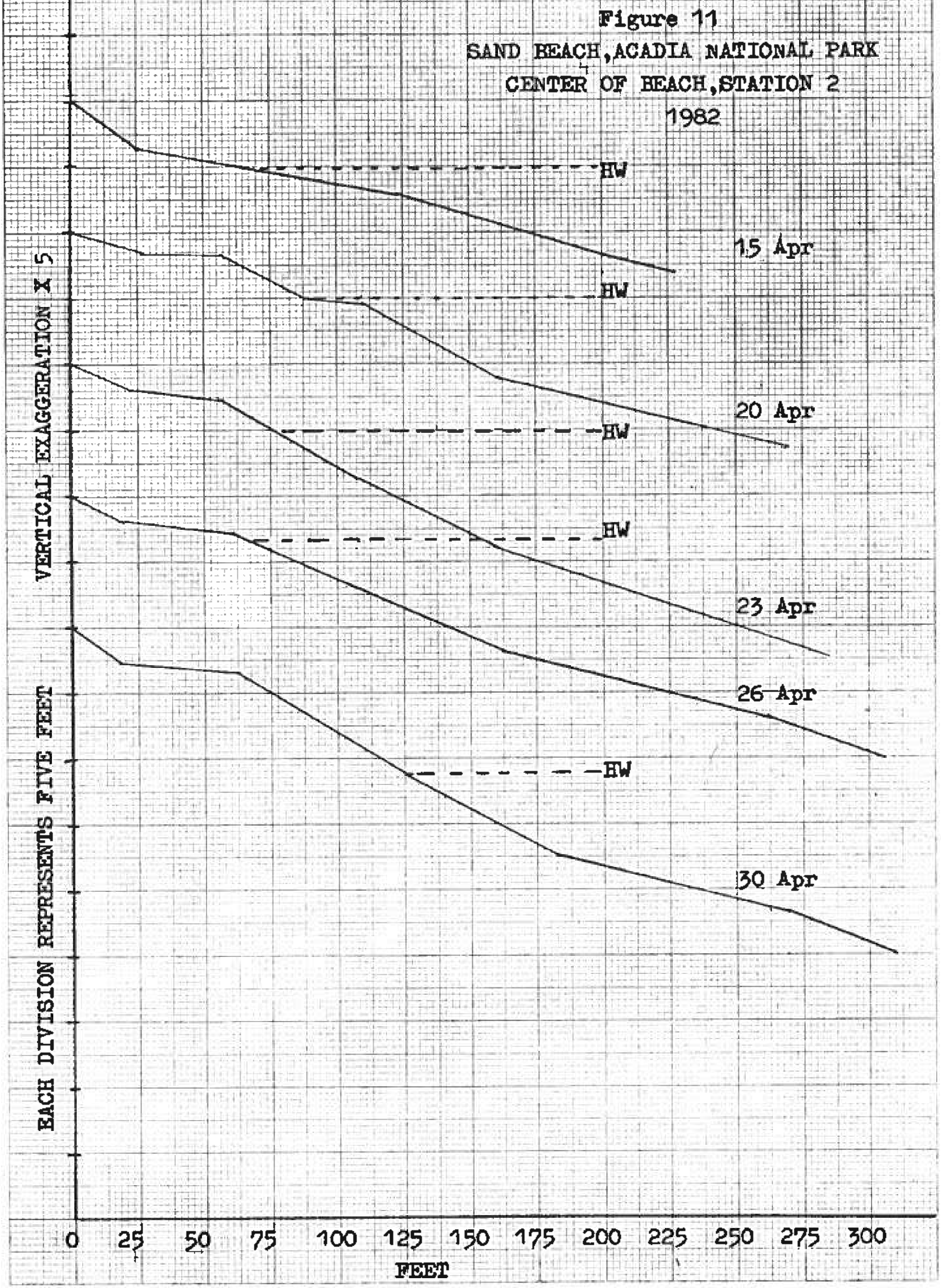


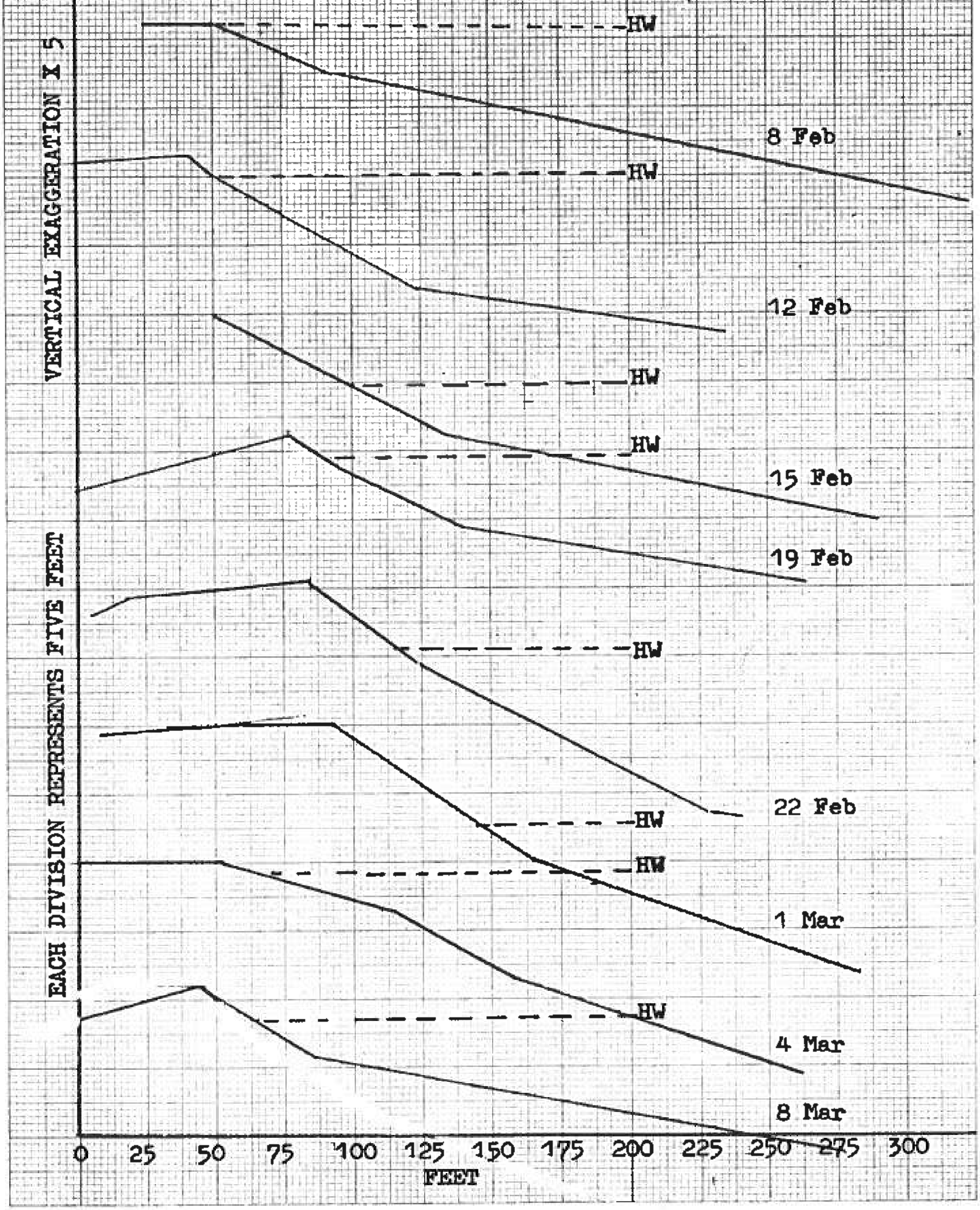
Figure 11
SAND BEACH, ACADIA NATIONAL PARK
CENTER OF BEACH, STATION 2
1982
HW
15 Apr
HW
20 Apr
HW
HW
23 Apr
26 Apr
HW
30 Apr
VERTICAL EXAGGERATION X 5
EACH DIVISION REPRESENTS FIVE FEET
0
25
50
75
100
125
150
175
200
225
250
275
300
FEET

FIGURES 12, 13, and 14 DEPICT STATION 3

Station 3 is located at the East end of Sand Beach. The profile transect extends from the water's edge to the brook. The continuous meandering of the brook causes a shift from time to time of the position of its banks. The transect line runs about 275 feet.

Figure 12

SAND BEACH, ACADIA NATIONAL PARK
EAST END STATION 3
1982



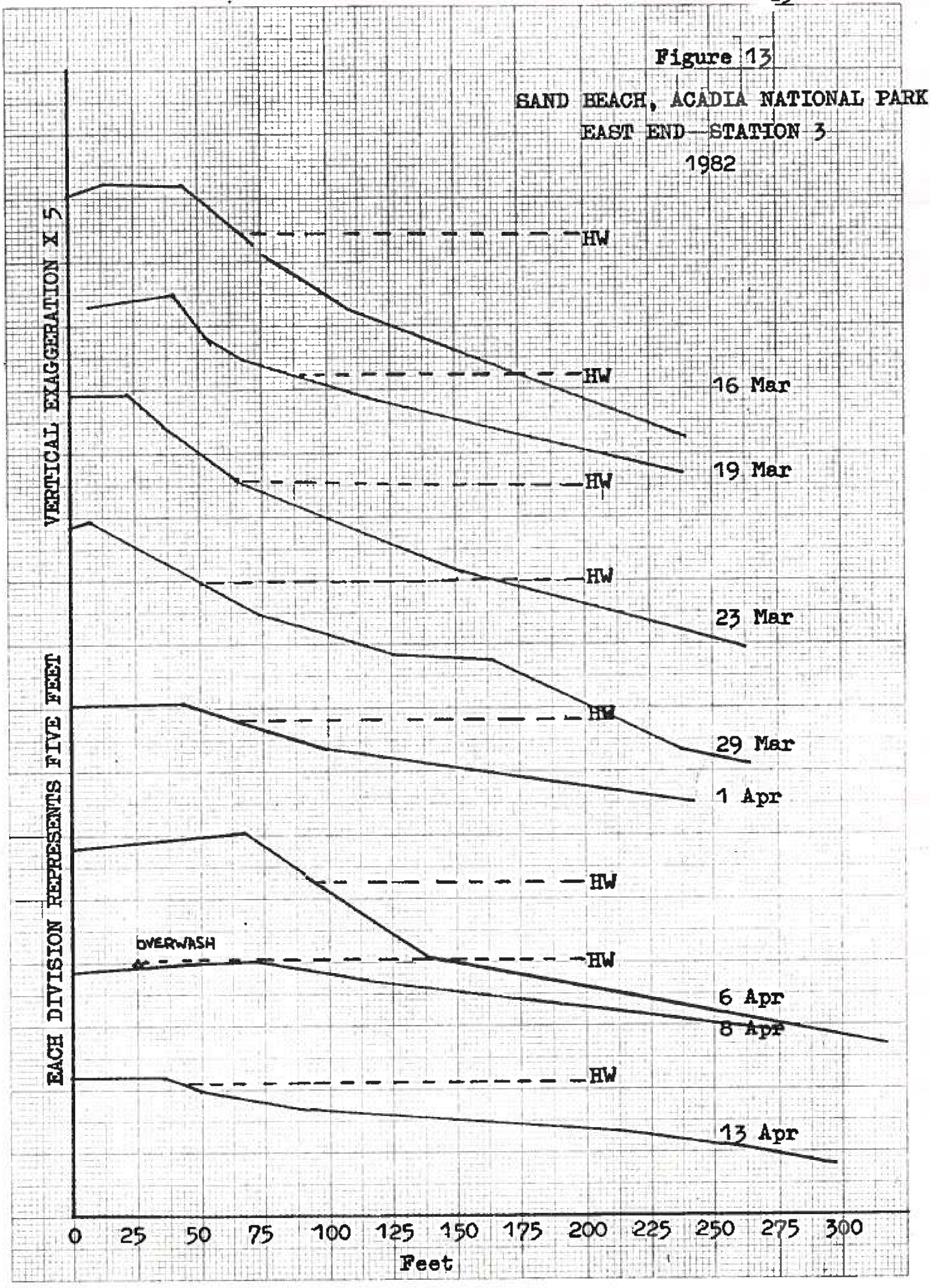
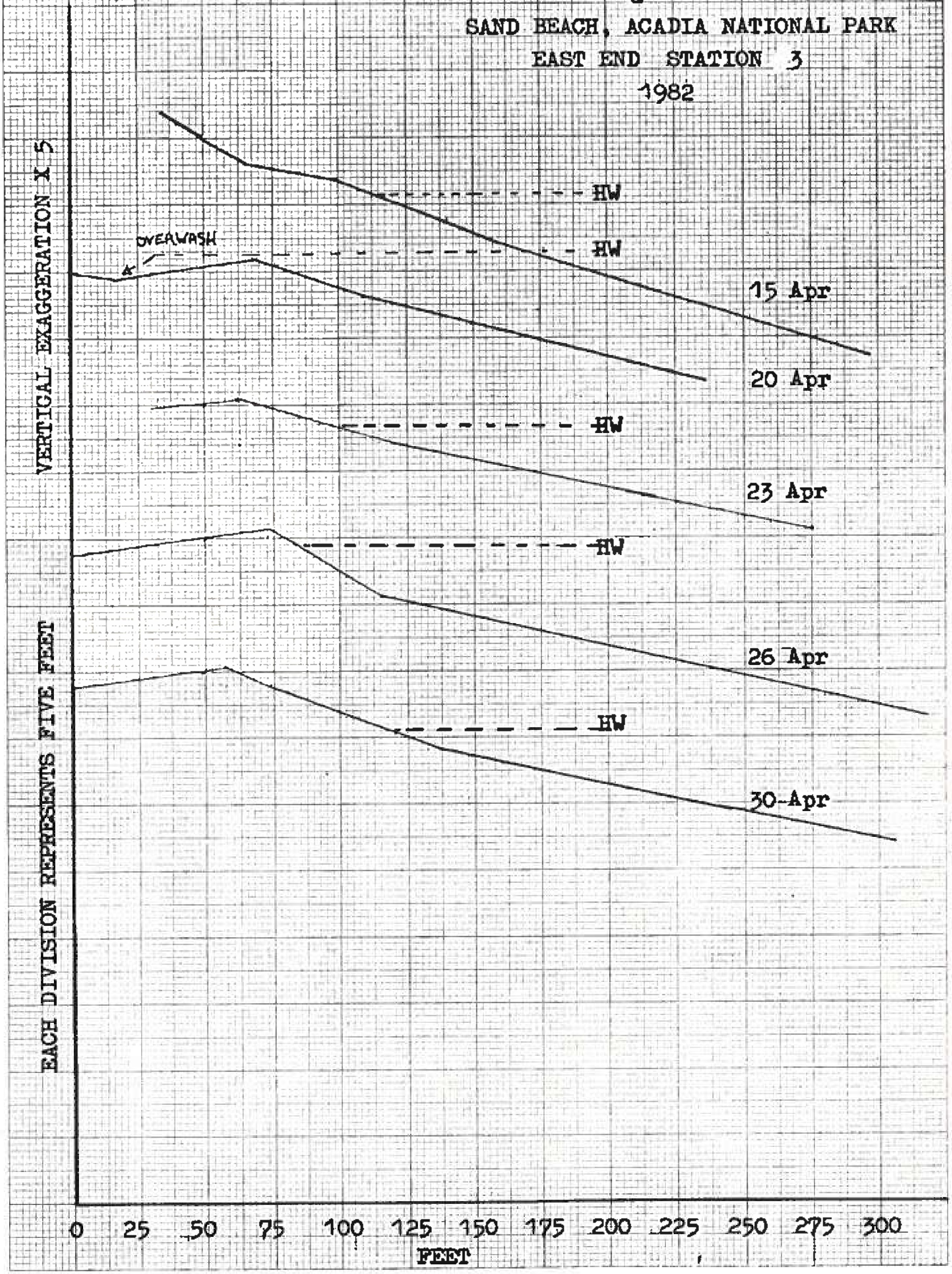


Figure 13

SAND BEACH, ACADIA NATIONAL PARK
EAST END STATION 3
1982

Figure 14

SAND BEACH, ACADIA NATIONAL PARK
EAST END STATION 3
1982



ive of most of the beachface. Sections 1 and 3, situated at the far ends were observed to exhibit peculiarities as a result of their locations.

Section 1 is situated at the western corner of the beach, and its transect line runs 200 feet. It terminates at the base of the cliffs bounding the cove. These cliffs reduce the effect of the prevailing westerlies at this section. It should be noted that during times of heavy rains, water splashes down these cliffs. A number of small semi-permanent channels on the sides of these cliffs/hills have been established as a result of this rain water action.

Section 3 is bounded by a brook. This brook is fed by the lagoon behind the dune ridge (see Figure 3). During most of the observation period the brook was free flowing. Its volume increased however in times of snow, rain and warm temperatures when melting of ice and snow increased the input to the lagoon. Immediately beyond the brook are cliffs similar in height and slope to those bounding the west end (section 1). These easterly located cliffs act as a wind buffer in a fashion similar to those of the west end, blocking winds from the east.

In the following, the conditions under which erosion dominated the beach will be considered first, followed by an examination of the factors causing deposition on the upper beach. Finally the correlation between the movement of sand as related to the wind direction, wave period, the state of the tides, and the beach gradient is discussed.

Erosional Conditions

The period between Feb. 8 and Feb. 12 was marked by variable southwesterly winds of up to 12 knots which resulted in erosion along sections 2 and 3. (up to 450 sq. feet per section line). Section 1 was not affected as the cliffs running parallel to that section transect,acted as a buffer. A week later (Feb. 22) northeasterly winds blowing steadily for 5 days (maximum 24 knots) (waves 5 ft., 3 sec.) caused further erosion, transporting at least 600 sq feet per section line of sand seaward from each of the sections. This latter period produced a classic upwardly concave winter erosional profile. A third erosional period occurred prior to March 5 in which seas attained heights of 4 ft with short periods of 3 seconds. The winds were moderate and changed from a northeasterly direction at the beginning of the time interval to a northwesterly direction resulting in a lower profile than that of the previous

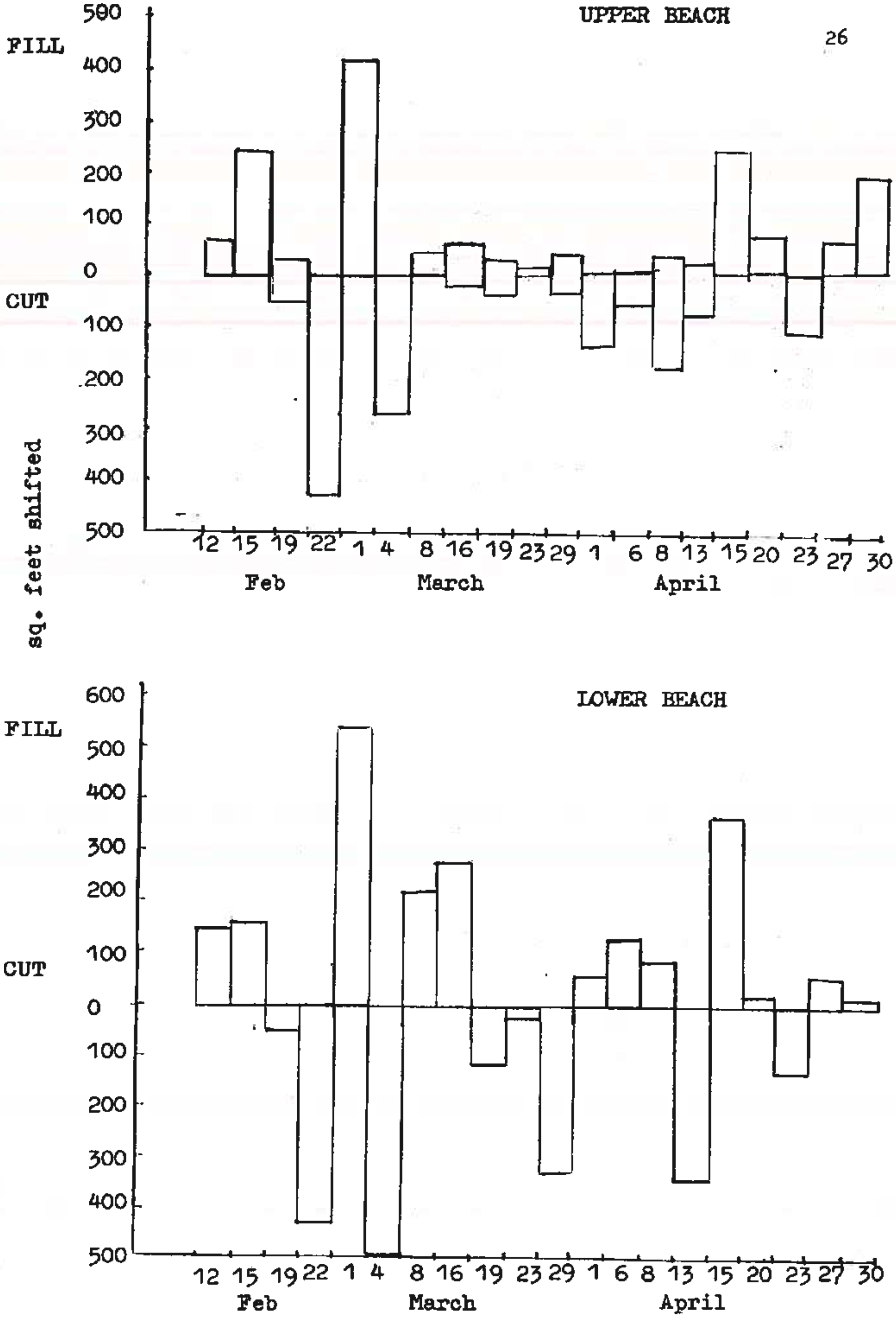


Figure 15: Cut and Fill to Upper and Lower beach, Station1

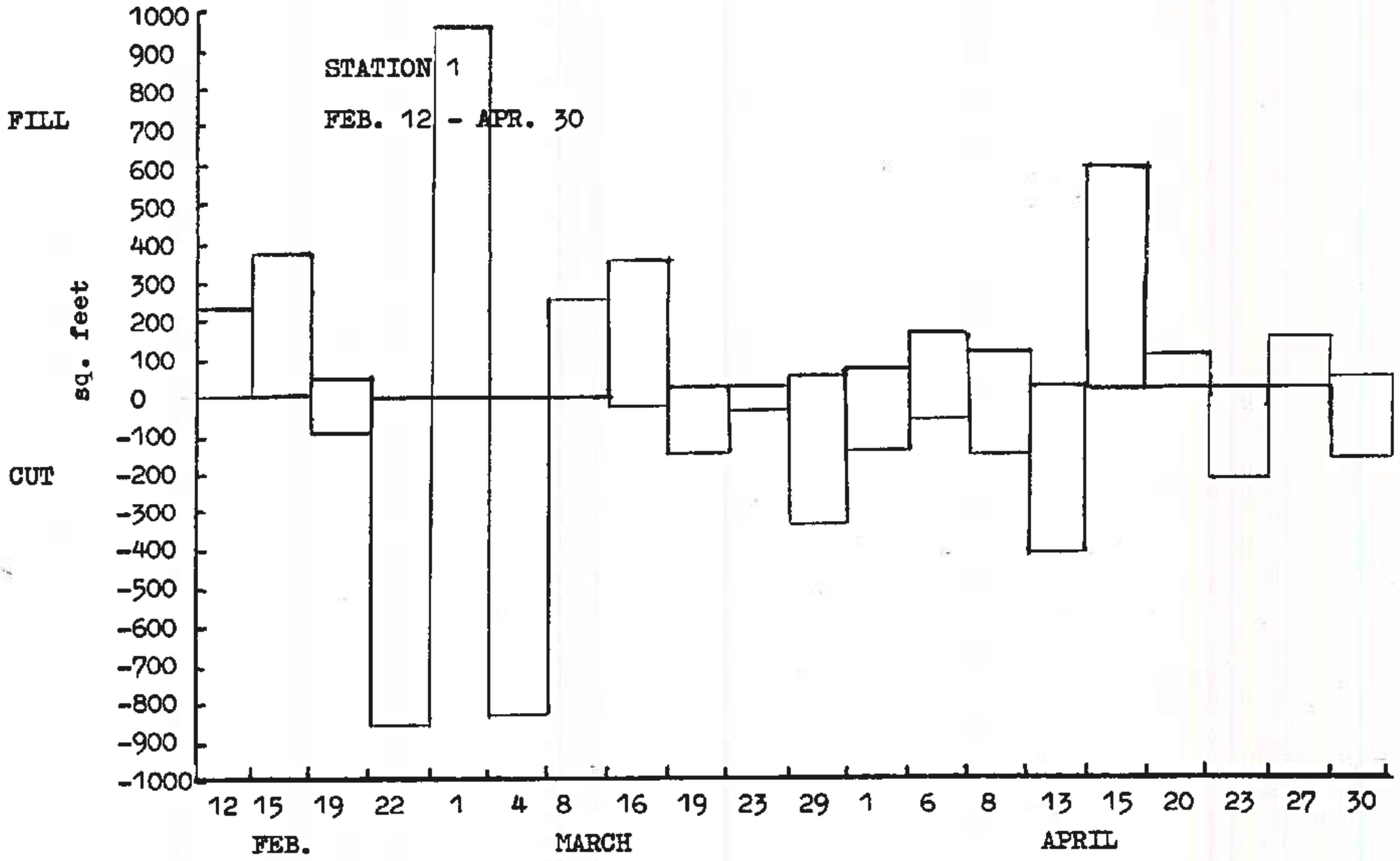


Figure 16: Cut and fill to entire beachface along transect line of Station 1

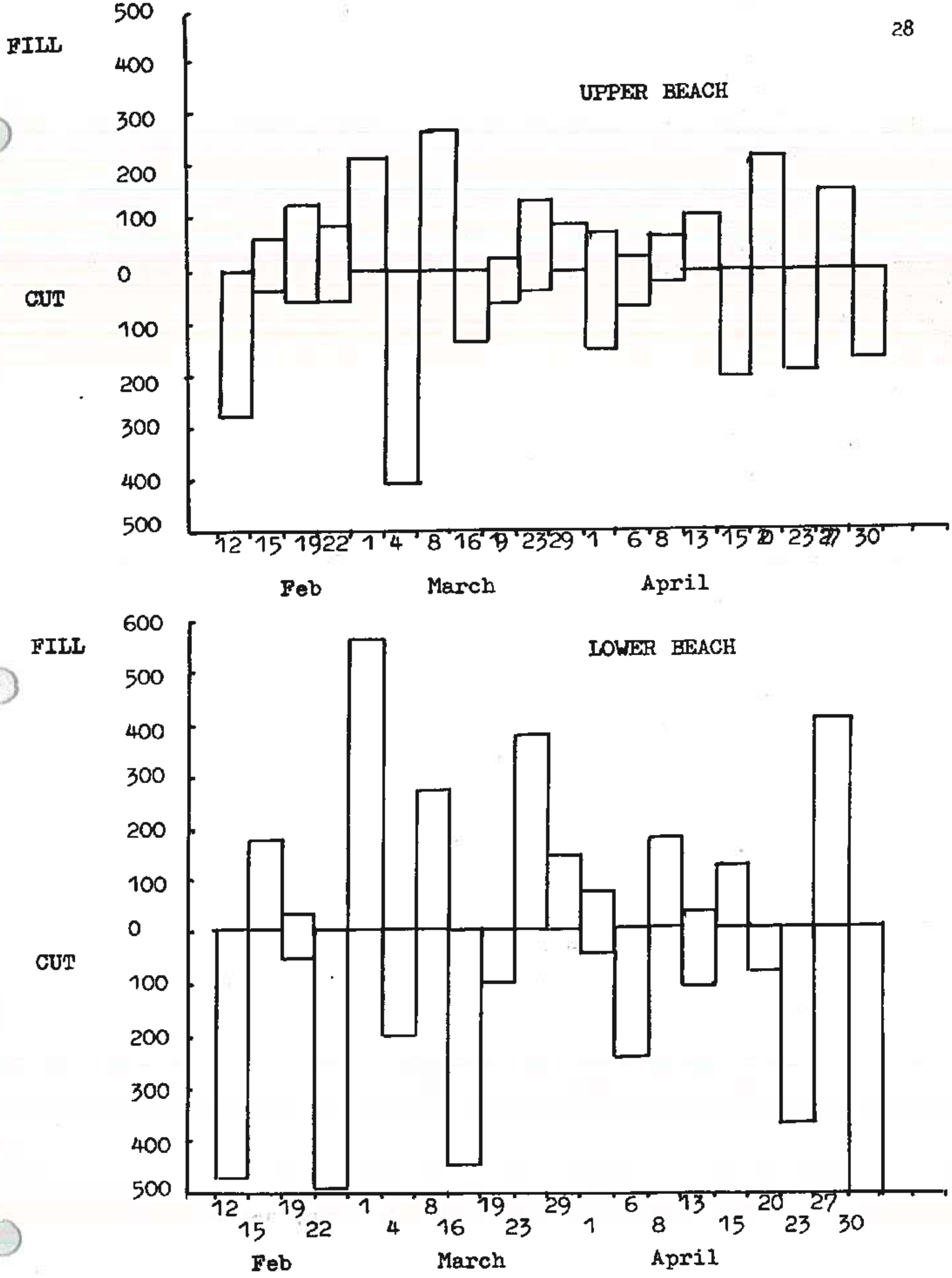


Figure 17: Cut and fill to Upper and Lower beach, Station 2

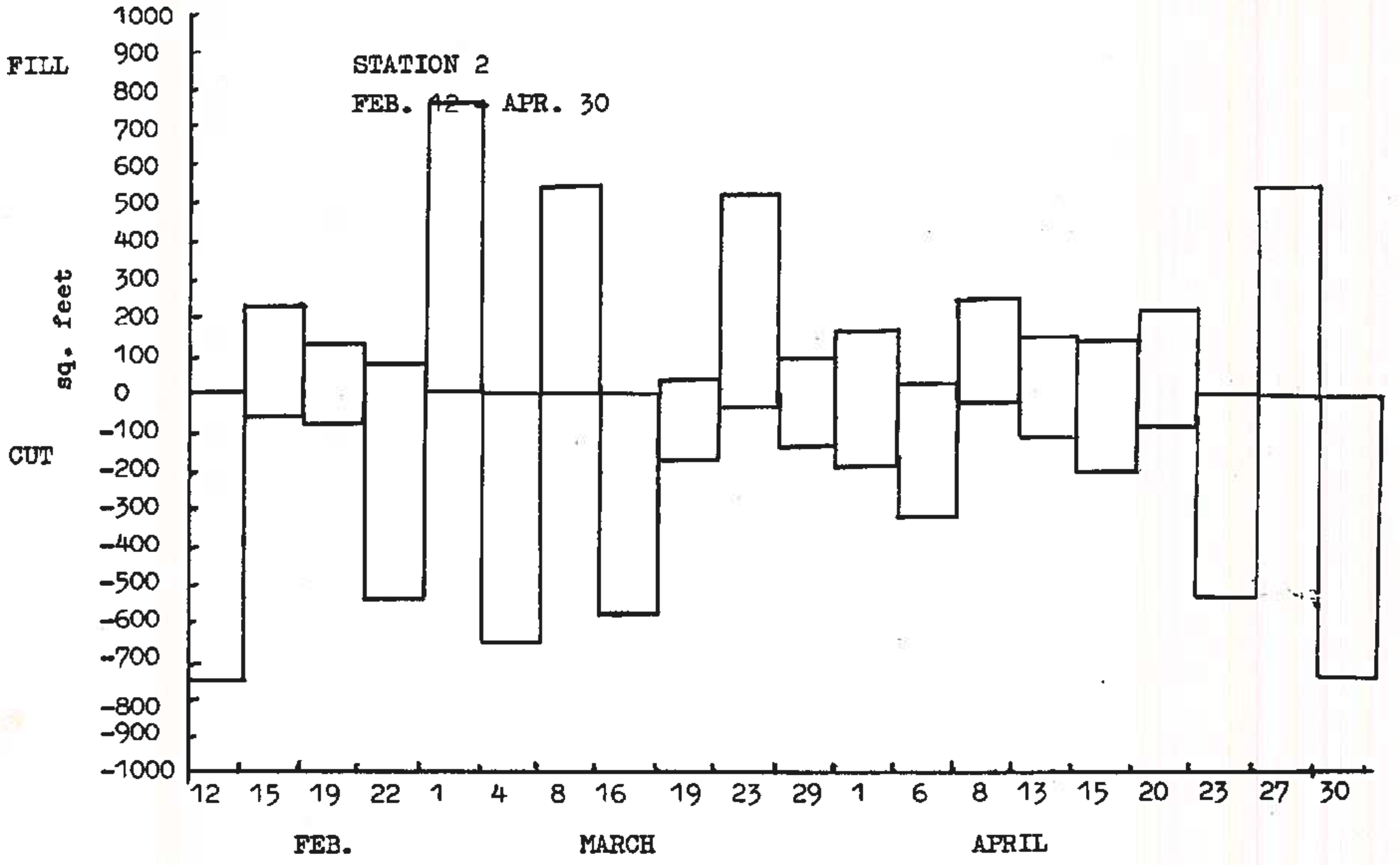
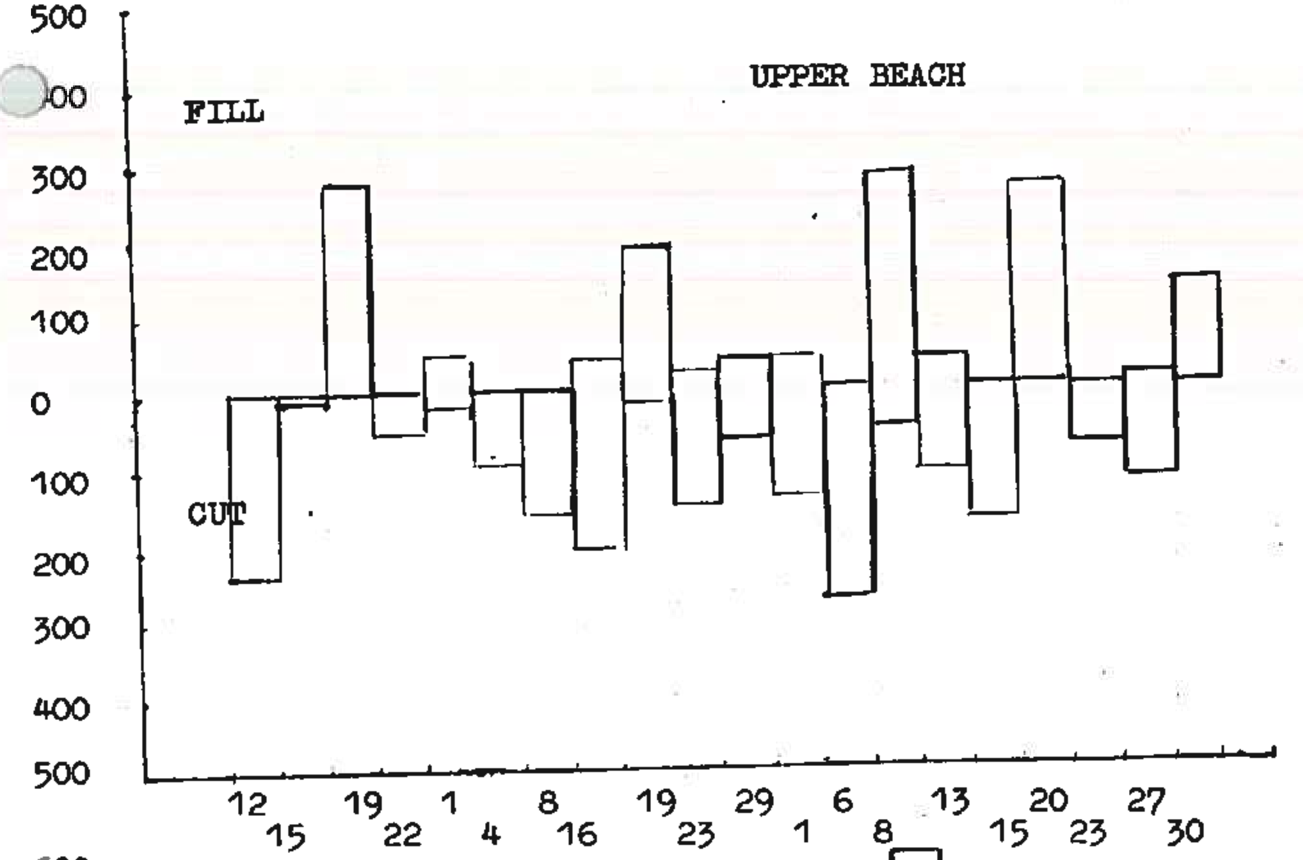


Figure 18: Cut and fill to entire beachface along transect line of Station 2



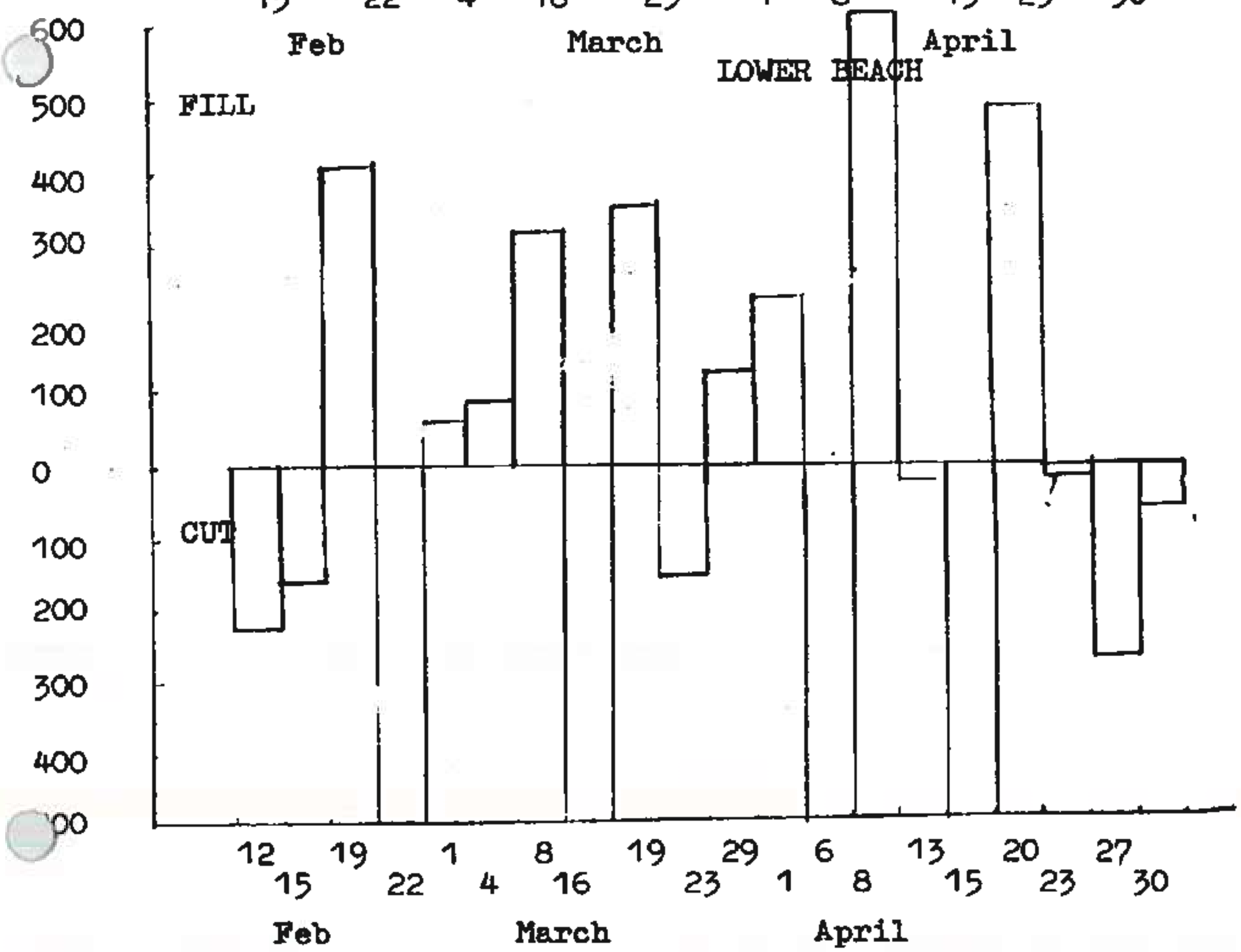


Figure 19: Cut and fill to Upper and Lower beach, Station 3

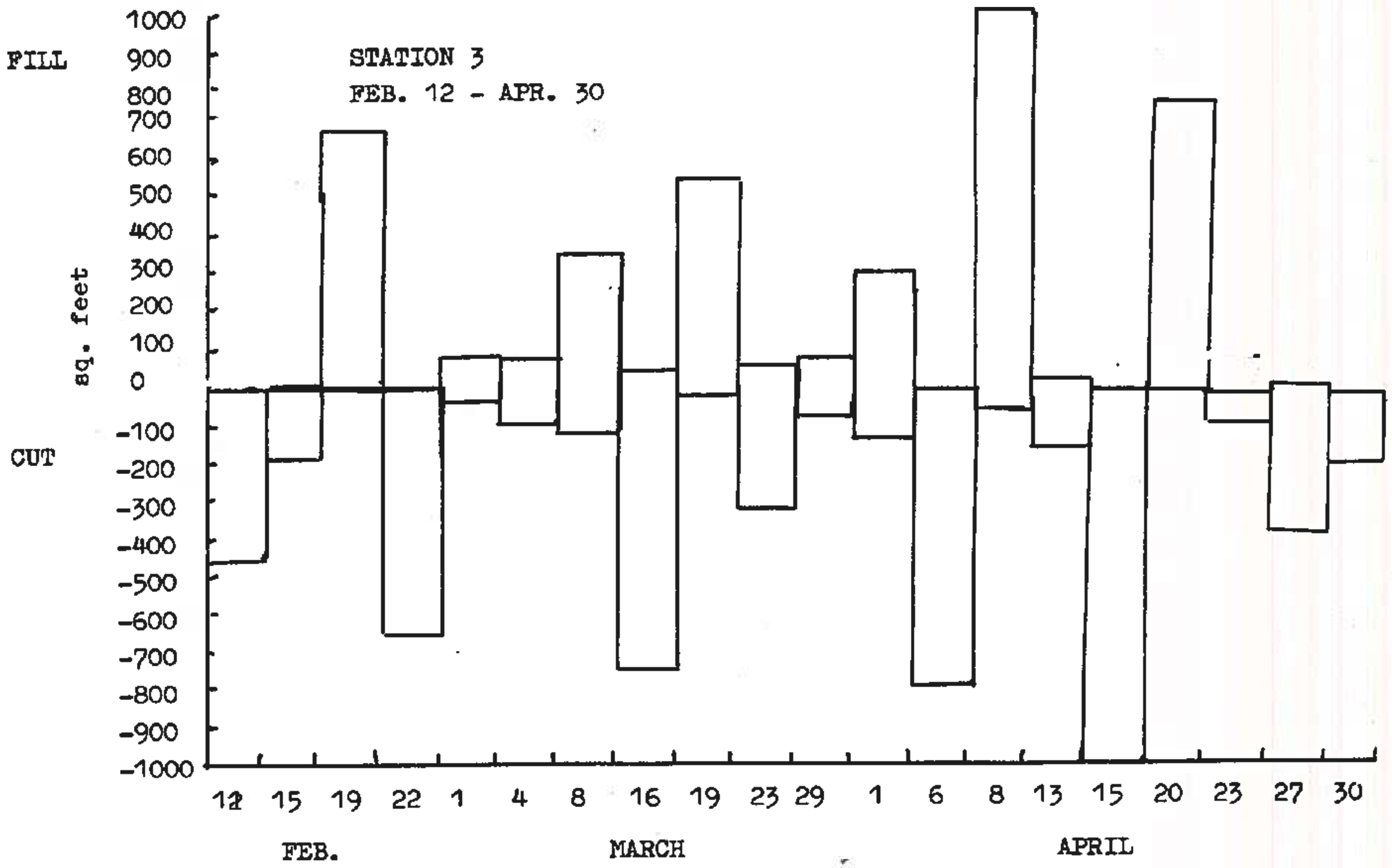


Figure 20: Cut and fill to entire beachface along transect line of Station 3

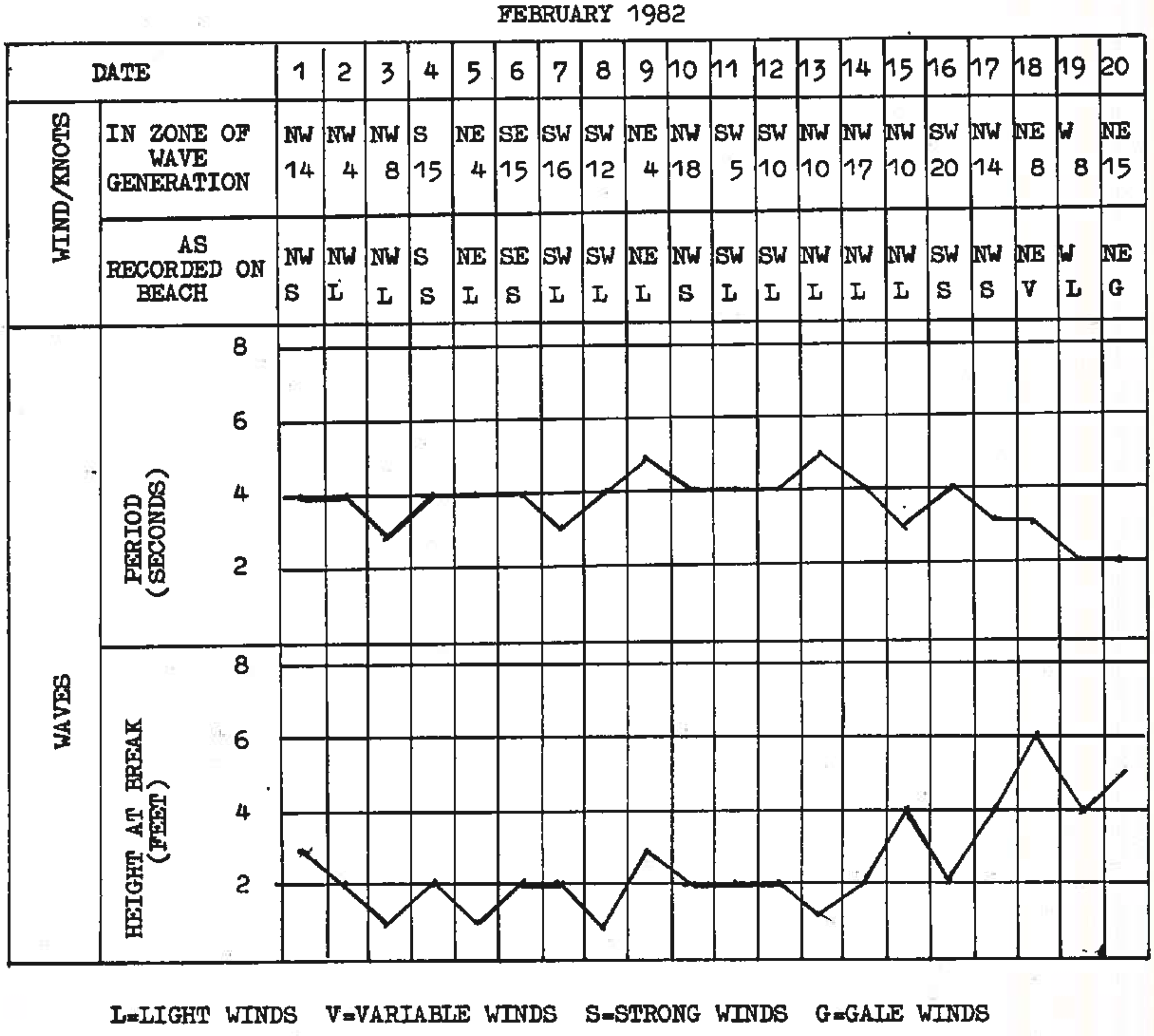
survey. Thereafter the beach remained fairly stable as it attained a state of equilibrium. Erosional and accretional phases occurred, but the volume of sand shifted remained relatively small. From April 23 -27, south south west winds produced an erosional profile once again.

Section 3 (east end) as mentioned before appears to be governed by different processes than sections 1 and 2. Section 3 was marked by a regular alternation between erosion and accretion. The brook serves to sweep everything in its path offshore during periods of rain or the melting of snow. This is particularly evident for the period preceding March 16 when warm temperatures melted considerable amounts of snow, and for the period prior to that of April 15 when steady rains swelled the volume of water flow from the brook. Section 3 is also unprotected from northeasterly winds that sweep down from the backdune area and beyond. The backdune only extends to within 40 feet of the section. The meandering of the brook has not permitted a stable dune to exist closer. The gusting offshore winds therefore blow much of the material from the top of the beach in this area seaward. If it settles on the lower portion it is swept away by the wide swath of the brook as it fans out on its course to the sea. As winter and spring turns to summer, this aeolian induced erosional process will cease as the winds from the south begin to dominate and the brook dries up.

Accretionary Conditions

As expected accretion accompanied offshore winds blowing parallel to shore, especially those from the northwest. The period Feb. 22 to March 1 and April 13 to 15 are two examples of these conditions. Another time period March 23 - 29 with offshore northwesterly winds resulted in accretion on the upper beach face as sand was shifted from the lower beach to the upper portion. This effect was produced by the weather conditions in conjunction with the occurrence of spring tides at this time. The migration of ridge and runnel systems up the beach due to the influence of wave action is the main mechanism for this effect.

Three other periods of northwesterly winds resulted in erosion on the upper beach in conjunction with accretion on the lower beach. It is hypothesized that these results are due to either (a) aeolian drift of sand from the upper beach to the lower; (b) a steepening of the incoming waves by the offshore wind which will cause destruction of the upper beach (King and


FEBRUARY 1982

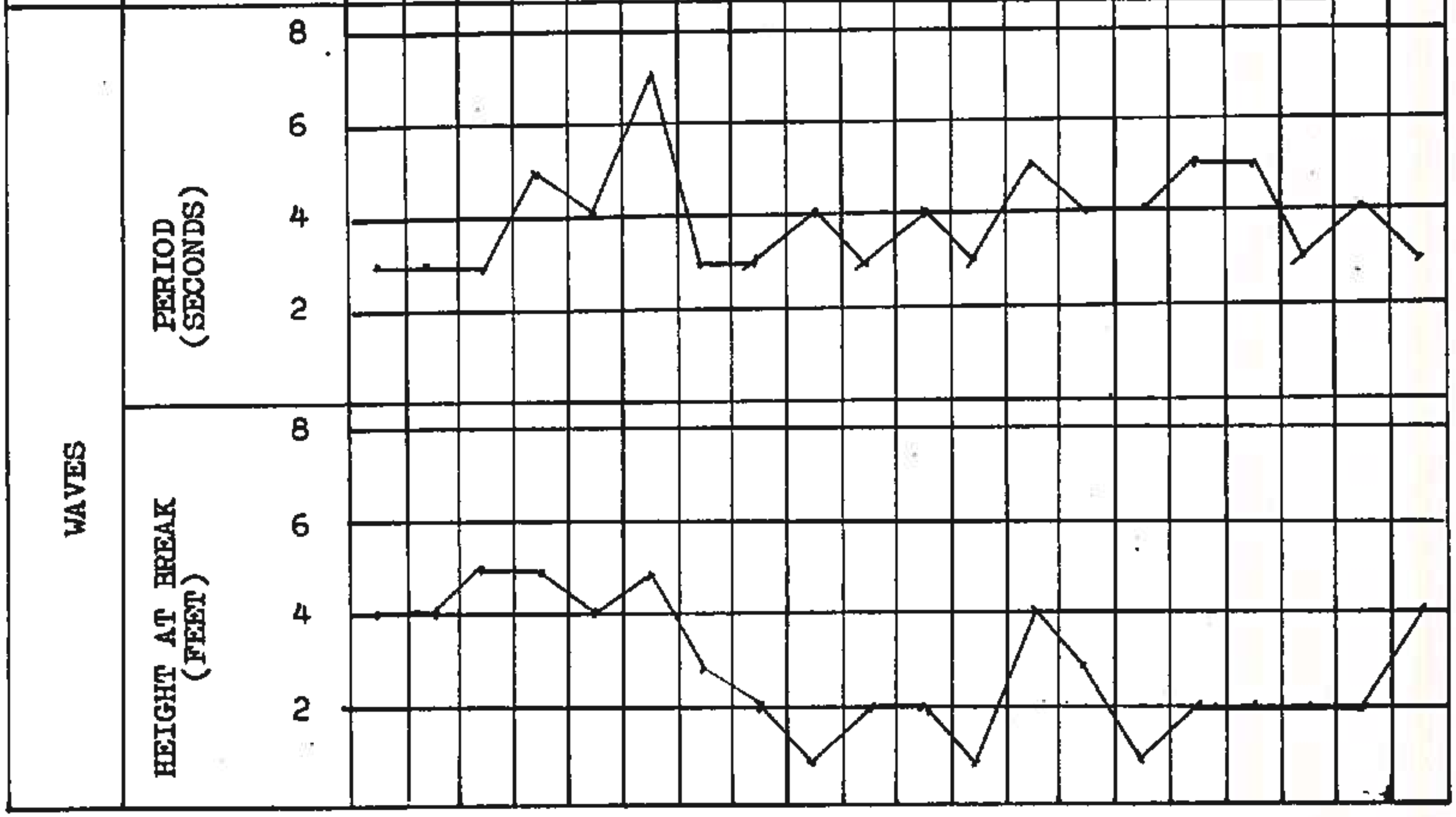
DATE		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
WIND/KNOTS	IN ZONE OF WAVE GENERATION	NW 14	NW 4	NW 8	S 15	NE 4	SE 15	SW 16	SW 12	NE 4	NW 18	SW 5	SW 10	NW 10	NW 17	NW 10	SW 20	NW 14	NE 8	W 8	NE 15
	AS RECORDED ON BEACH	NW S	NW L	NW L	S S	NE L	SE S	SW L	SW L	NE L	NW S	SW L	SW L	NW L	NW L	NW L	SW S	NW S	NE V	W L	NE G

L=LIGHT WINDS V=VARIABLE WINDS S=STRONG WINDS G=GALE WINDS

Figure 21: wind and wave data

FEBRUARY/MARCH 1982

	DATE	21	22	23	24	25	26	27	28	1	2	3	4	5	6	7	8	9	10	11	
WIND/KNOTS	IN ZONE OF WAVE GENERATION	NE 24	NE 16	NW 11	NW 15	NW 24	NW 27	NW 12	NW 15	NE	SW	W	NW	SW	NE	SE	NW	NE	--	SW	
	AS RECORDED ON BEACH	NE S	NW S	NW S	NW S	NW S	NW G	NW S	NW V	NE L	SW V	W V	NW L	SW V	NE L	SE L	NW S	NE L	-- O	SW L	

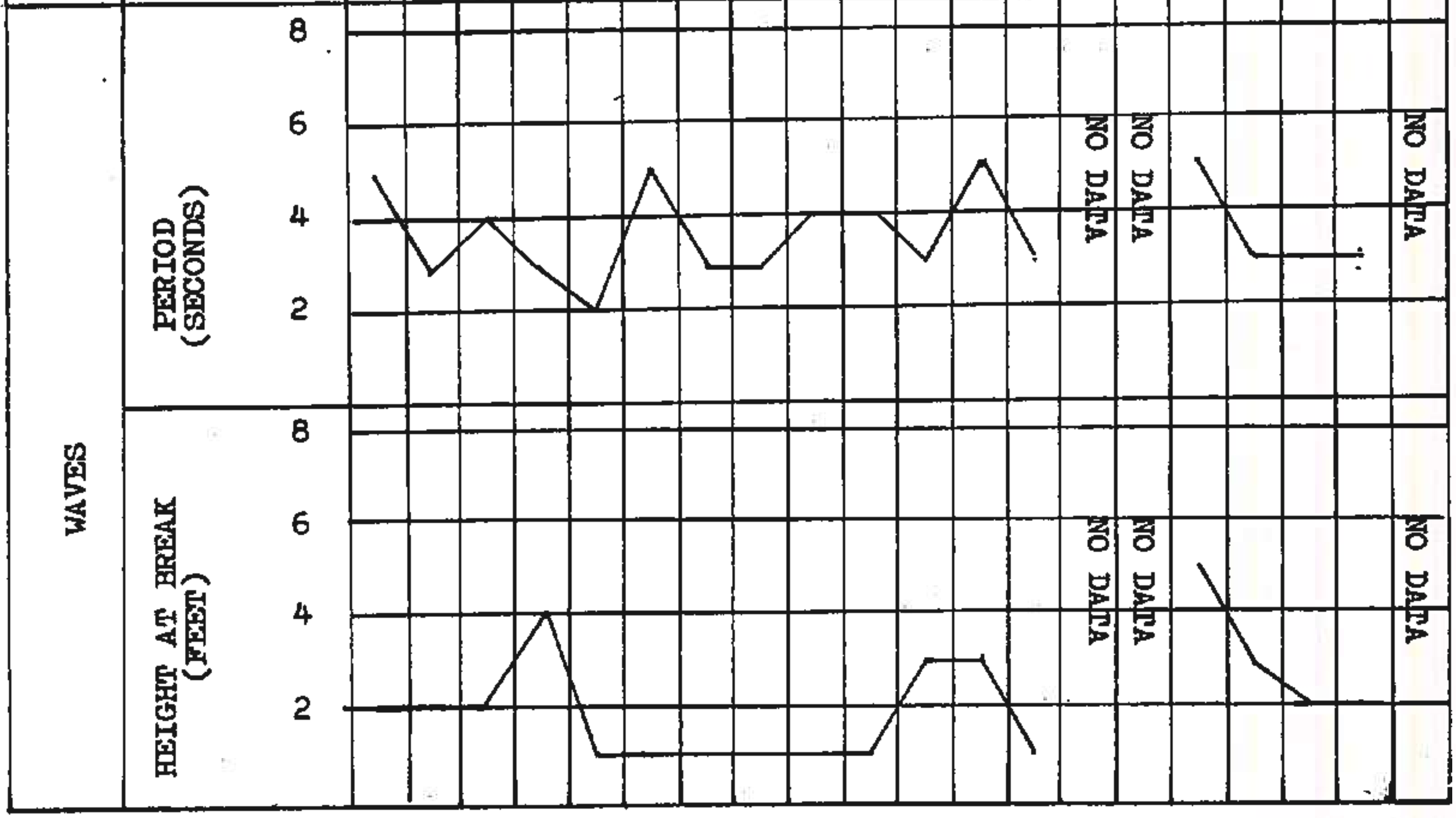


L=LIGHT WINDS V=VARIABLE WINDS S=STRONG WINDS G=GALE WINDS

Figure 22: wind and wave data

MARCH 1982

DATE		12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
WIND/KNOTS	IN ZONE OF WAVE GENERATION	NE	NE	SW	NW	NW	NW	N	E	SW	NW	NE	NW	SE	SE	SE	W	NW	NW	NW	
		15	11	15	17	18	10	8	8	8	10	17	11	8	8	11	20	23	18	15	
	AS RECORDED ON BEACH	SW	SW	NW	NW	NW	NW	NW	SE	SW	SW	NW	NW	NW	SW	SE	NW	NW	SE	W	SW
		L	L	S	S	V	L	L	L	L	L	S	L	L	L	L	S	S	S	L	S

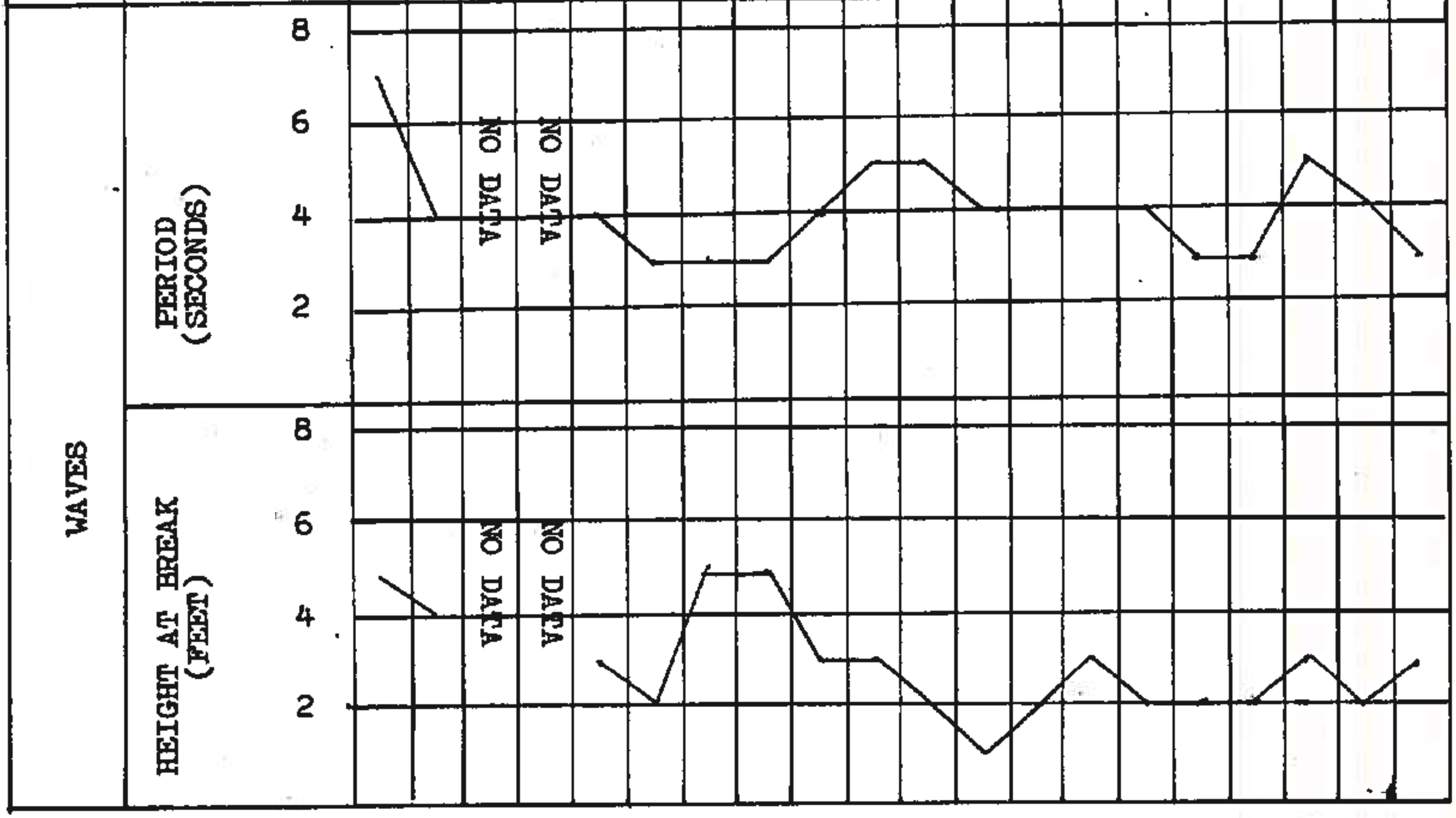


L=LIGHT WINDS V=VARIABLE WINDS S=STRONG WINDS G=GALE WINDS

Figure 23: Wind and wave data

APRIL 1982

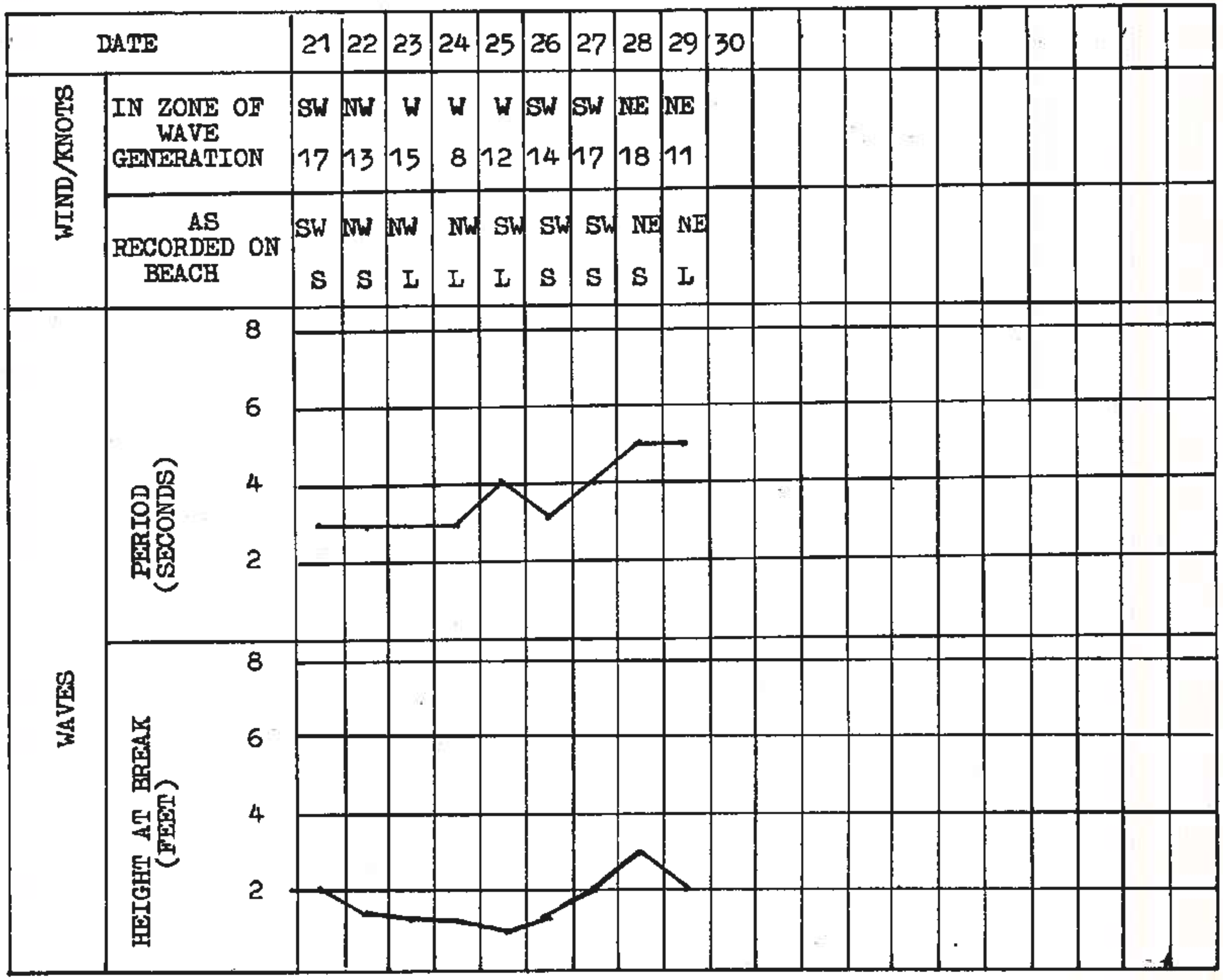
DATE		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
WIND/KNOTS	IN ZONE OF WAVE GENERATION	W 26	NW 20		SE 20	NW 20	NW 20	NE 30	NW 30	NW 20	NW 20	SW 13	NE 6	S 18	NW 15	NW 6	SW 17	SW 19	SW 25	SW 20	SW 16
	AS RECORDED ON BEACH	NW S	NW S	SE S	SE S	NW S	NW S	NE S	NW S	NW L	NW L	NW V	NW L	SW L	SW L	SW L	SW L	SE S	SW S	NW S	SW S



L=LIGHT WINDS V=VARIABLE WINDS S=STRONG WINDS G=GALE WINDS

Figure 24: Wind and Wave data

APRIL



DATE		21	22	23	24	25	26	27	28	29	30
WIND/KNOTS	IN ZONE OF WAVE GENERATION	SW 17	NW 13	W 15	W 8	W 12	SW 14	SW 17	NE 18	NE 11	
	AS RECORDED ON BEACH	SW S	NW S	NW L	NW L	SW L	SW S	SW S	NE S	NE L	

L=LIGHT WINDS V=VARIABLE WINDS S=STRONG WINDS G=GALE WINDS

Figure 25: Wind and wave data

Williams 1971); (c) the generation of a landward acting bottom current, initiated by the offshore wind blowing the surface of the water in an offshore direction and thus causing a landward moving bottom current to be established to replace the seaward moving surface water; or a combination of all three.

Correlation with Wind direction

There is a close correlation between wind direction and sand movement; accretion took place on the beach with an offshore wind in a consistent manner. The periods of Feb, 8-15, Feb. 22 - March 1, and especially April 13-15 when extremely high velocity northwest winds occurred were observed to produce accretion throughout the entire beach. At other times when the wind had a general northwesterly but variable direction accretion would occur on the upper beach while a nearly equal volume of sand would be eroded from the lower beach. The reverse occurred with an onshore wind. The southerly winds of April 8-13 resulted in erosion. As expected the Northeaster of Feb. 19-22 with its accompanying storm waves produced an erosional effect on the beach. It is interesting to note that the greater the variability of the winds between surveys, the smaller the change in beach profile (see March 19-23).

With an offshore wind the waves affecting the beach are normally long low swells which have travelled far from the generating area. Onshore winds generate local waves of low energy. Northeast winds generate storm waves of high energy. Wave steepness, ameasure of the wave height to length, indicates the effect of wind direction on the waves. The following figures express the wave steepness for onshore, offshore and high energy storm winds:

	Wind onshore (SW,SE,S)	Wind offshore NW,N)	NE Winds
max:	0.0651	0.1085	0.1085
min:	0.0122	0.0078	0.0078
mean:	0.0308	0.0383	0.0469

It appears that high velocity northwest winds generate steep waves if they blow for a period of significant duration. The wave steepness has an important effect on the movement of beach material, since steep waves have been shown to be destructive on the upper beach, moving material to deeper water, while flat waves build up the top of the beach. The maximum change normally takes place in the upper part of the beach (King and Williams 1971), because the coarser material accumulates here. The locally generated steep waves are then capable of eroding the beach. Such circumstances were recorded for the period of April 1-6. This leads to a steeper gradient and the wave energy is dissipated over a smaller area than at low water, when the gradient is usually flatter. The wind also has a direct effect on the movement of sand by causing the operation of currents, which are effective in moving sand thrown into suspension by the waves. An offshore wind blows the surface water seaward, tending to create a shoreward acting bottom current; which results in a constructive effect near the shore in shallow water. These effects can be reversed by an offshore wind (see Figures 21-25).

Tide Conditions

Spring and neap tide conditions were noted to ascertain whether or not there was a correlation between the state of the tide and the sand movement on the beach. Under calm sea conditions, the beach was eroded slightly above mean tide level at spring tide, while at neap tide deposition occurred in the same zone. The cause of this sand movement is most probably related to the level at which constructive waves are most effective. Since this is at, or a little below, high water level, the sand deposited and built up near the high water level of neap tides is generally moved up the beach by spring tides to the new high water level. Under these conditions therefore erosion takes place near the neap tide high water level at spring tides, and deposition to the same area at neap tides. The water of the semidiurnal tide deposits more sand on the lower beach as it ebbs than it erodes. The flood tide produces an accretionary effect on the upper beach because its backwash is weaker than its shoreward swash.

Beach Slope

The beach slope depends on the sand size, the wave steepness and the wave period or length. The sand of Sand Beach is of medium size which accounts for the moderately steep slopes. It does undergo a bit of a sorting process as there are two general gradient values. One for the upper beach on which the waves deposit coarser material as the tide rises and falls. The lower beach however consists of somewhat smaller sand sizes as the sorting action by waves is more thorough there only because the water is in contact with that area during its daily cycle for a longer period of time. The rate of percolation through coarse material is more rapid than through fine material. This means that the backwash is rendered less effective; the force of the swash and backwash must be equalized by an increase of gradient, which increases the efficiency of the backwash but decreases that of the swash. The steepness of the beach causes a concentration of wave energy within a fairly narrow horizontal zone; this increases the mobility of the beach which leads to rapid changes to the beach via wave action.

The sand size for Sand Beach (0.282 mm median grain size) is fairly constant and thus the variation of gradient recorded must be accounted for by a change in the wave steepness and period. For waves of a constant period it was found that the beach slope increased with decreasing steepness of the waves. The slope in the high tide swash zone adapts itself most readily to the prevailing wave dimensions. If the rate of percolation through the swash zone slope material is taken to be constant, it follows that as the wave steepness increases, the volume of the swash moving up the beach will also increase. But because the amount of swash percolating through the beach remains constant, the backwash will increase in proportion to the swash. So if a low, swell wave runs up the swash zone, and any point half the swash is lost by percolation, then the backwash will be half the swash in volume. If a subsequent wave has double the swash volume, then only one-quarter of it will be lost by percolation and the backwash will be three-quarters' of the swash. This relatively powerfull backwash needs a less steep gradient to reach equilibrium.

In regards to wave period, if the wave period increases with the amplitude remaining the same, the beach slope decreases, as the backwash will again be increased in proportion to the swash. The beach becomes saturated with water as the waves increase their frequency, leaving more water available for backwash. The greater the backwash, the greater the seaward movement of suspended sediment.

DISCUSSION

An integrated study of the meteorolgy,sedimentology, and geomorphology of the coastal waters and adjacent shoreline of Newport Cove has uncovered systematic interrelationships between (a) the driving forces of wave, wind, tide and rainfall; (b) the geometry of the beach; and (c) the physical environment that has developed there.

These studies have led to the following conclusions:

(1) Erosion to the beach results primarily from locally generated waves. Northeasters' produce the greatest seaward transport of sand, while occasionally onshore southerly winds and offshore northwesterly winds may contribute to further erosion on the beach.

(2) Northwest winds generally erode material from the upper beach by aeolian means and deposit it on the lower portion of the beach. The wave action coupled with the semidiurnal tide is then capable of shifting this sediment to an offshore position.

(3) Accretion is most pronounced during periods of moderate offshore or parallel to shore winds. Northwest winds may generate a landward acting bottom current, initiating a period of sediment deposition upon the beachface.

(4) Periods of extreme wind variability do not significantly affect the beach profile.

(5) Swell waves tend to move sand landward at all depths within the surf zone as well as beyond the breaker zone to cause a net accumulation on the berm.

(6) Storm waves move sand from the seaward edge of the breaker zone towards the shore, while sand in the surf zone is transported seaward.

(7) The east end of Sand Beach exhibits a greater variability in erosional and accretional phases than does the rest of the beach. This is attributed to the location of a brook there, and the absence of a dune system. The beach at the east end therefore is subject to erosion from both the landward and seaward edges.

Sand Beach appears to be in a state of equilibrium. The beach shows both erosional and constructive profile types during the course of the spring with the volume of the sediment shifted remaining relatively constant.

ACKNOWLEDGEMENTS

I would like to thank the many people who have aided in this study. Especially those who helped me through the trying times. The College of the Atlantic community, Sandra and Marcia, and my advisors and project sponsors all deserve a special thanks. Logistical assistance provided by The National Park Service of Acadia National Park, and the Southwest Harbor Coast Guard personnel is greatly appreciated. Special mention goes to Carl Ketchum for his support in the manuscript preparation.

APPENDIX I

SURVEY/MAPPING

SURVEY

The investigation of Sand Beach entailed a number of concepts preliminary to the actual surveying. Due to limited funds, tools, and skills I had to utilize surveying methods established by those who first developed the science. The tools for measurement included (a) my stride, for measuring ground distances, (b) a slope board for measuring the ground gradient, and (c) a lensatic compass for directional finding.

Stride

The standardization of my stride for Sand Beach involved the following procedure. I first carefully measured with a tape a half mile course involving varying slopes and terrains similar to those encountered at Sand Beach. I then proceeded to walk this course for a total of two round trips carrying what I would normally carry while conducting the survey. The average of these four trips was then computed. One of these trips differed from the average by more than one percent however, so I restrode the course another time so that the average was within one percent of every figure that composed it. This average stride was then divided into the number of inches the stride course was in length. My stride is 61.01 inches or .00091 of a mile.

Slope Board

To measure the grade of the beach at various points I used a slope board. This is essentially a simplified transit. It is constructed of a 11 inch x 15 inch drawing board. Attached to this board is a plumb line and 3 oz. bob. The idea behind this contraption is that the plumb line hangs across a scale on the board, and the figure that the string cuts on the scale is the amount of slope from where you stand if you sight along the top edge of the board parallel with the ground.

The assembly of the slope board includes boring a hole in its middle near the upper sighting edge, from this edge a perpendicular line is dropped down the middle of the board. At ten inches down on this line, an intersecting line is drawn. The intersection of these two lines is zero on the scale. From here, in both directions ticks are made 1/10 of an inch apart. Each of these ticks represents one percent of slope. The plumb line is attached to the hole at the top of the board with the bob hanging below the board so that it can freely swing (Greenhood, 1964. Mapping, pp. 230-232). (see figure 1A)

Compass

I used a lensatic compass to establish the bearings of the various locations. The local declination was determined by examination of a USGS Triangulation station located at Great Head (approximately 1/4 mile from Sand Beach).

MAPPING

The physical mapping technique involved what is known as the compass traverse method. In addition I combined this with the techniques of triangulation and hypsography. The profile transects, stations 1,2 and 3 are located at the following positions. "Station 1: This profile is at the Western end of the beach at the foot of the granite stairs that descend from the parking lot. As you look at the stairway from the berm, count the posts supporting the hand railing. The third one from the bottom, when aligned with a range pole, gives the profile line. Bearing = 188°; Station 2: This profile approximates the midpoint of the beach. It is about 60 feet east of the fenced walkway into the backdune area. There is a green metal fence stake set about 20 feet behind (landward) the snowfence. The profile line runs through the stake and the trunk of the largest pine tree in that small clump on the southern edge of the pond. Bearing = 195°".

Station 3: This profile is located at the Eastern end, 150 paces east of Station 2 at a bearing of 20 °. Once at the station, the bearings of the profile perpendicular in direction to the sea is 203 . Stations 1 and 2 have been previously occupied by Nelson and Fink, 1977. (Note- from Febuary 8 to March 4, Stations 1 and 2 were located at positions approximately 20 paces west of their subsequent positions.)

Traverse

The traverse method (figure 2) uses a series of straight lines. It is the measurement of these lines in regards to both length and compass direction that establishes the control for making the map. The procedure first involves ascertaining magnetic north. from the starting point. The starting point A was chosen to be a rock at the base of the granite steps leading down to the beach (station 1). The second procedural step is to sight line

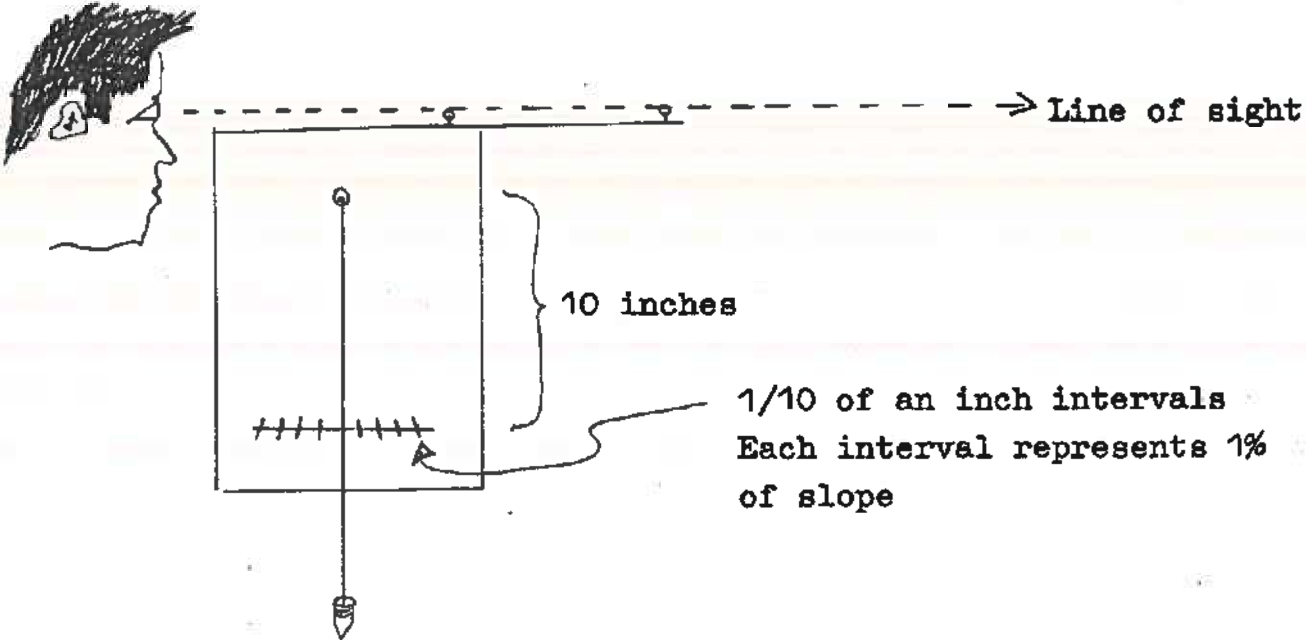


FIGURE 1A : Slope board

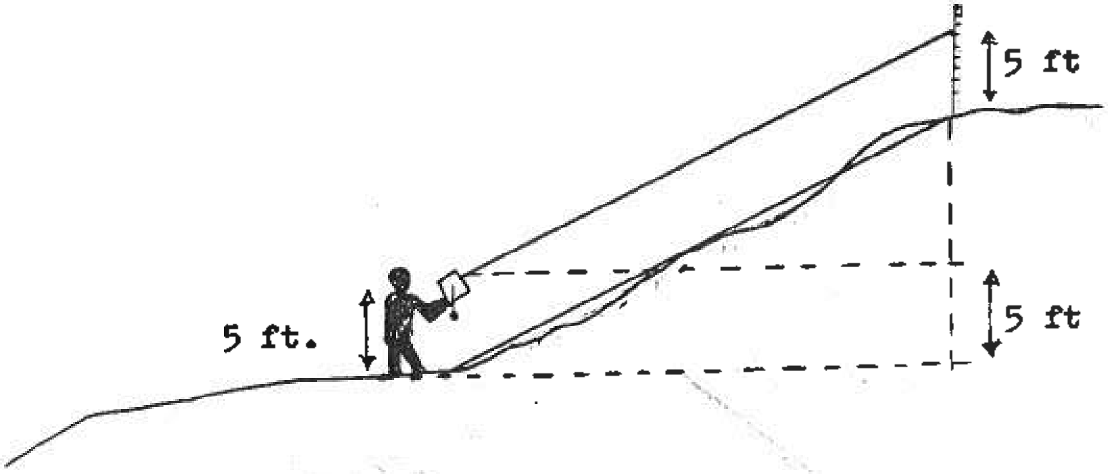


FIGURE 2A : Method of levelling

AC. The magnetic azimuth of line AC is recorded. AC is then measured in strides and recorded. At C, the azimuth of CF is taken. Then its distance was measured. The completion of the traverse proceeds in the same way around the circuit back to A. All of the measurments were.recorded in the field book.

Hypsography

Hypsography techniques are used to determine the ground gradients. This is where the slope board comes in. The upper edge of the board is used to sight along the ground slope. Making sure the plumb line is protected from the wind, a reading is taken when the swing of the bob stops. To compensate for the fact that the sighting is taken at eye level, approx-i matelt five feet above the ground surface, a stick five feet in height is sighted upon. (figure 3A). Its plain that the raised-up triangle is an identical twin of the ground conforming one which is all but hidden from direct measurement. Therefore the angle at the foot of the person sighting must be the same as the angle at his eye, allowing him to read the angle off the slope board with confidence. This information together with the knowledge that one of the other angles is 90 degrees and the distance from A to B can be measured by striding gives the other sides, lengths and angles by trigonometry. The most useful facts derived are those of the slope value, the sloping distance, and the horizontal distance between these two points and the height of this point above another.

Checks

Various checks and balances were used in the finish mapping. Briefly, the finish mapping consists of deciding a position for station A on the mapping sheet (placing it on a vertical line of the cross-ruled paper) a line is then drawn to indicate magnetic North. A protractor is used to lay off the number of degrees in the magnetic bearing of line AB from point A. Then on this angle, line AB is laid out, according to scale. At station B, another north-south line is drawn. With protractor at B a line with the bearing of BC is drawn to the appropriate scale length. This procedure is continued in a similar fashion around the circuit(figure 4A).

As in all measurement taking there must be a recognition of the possibility

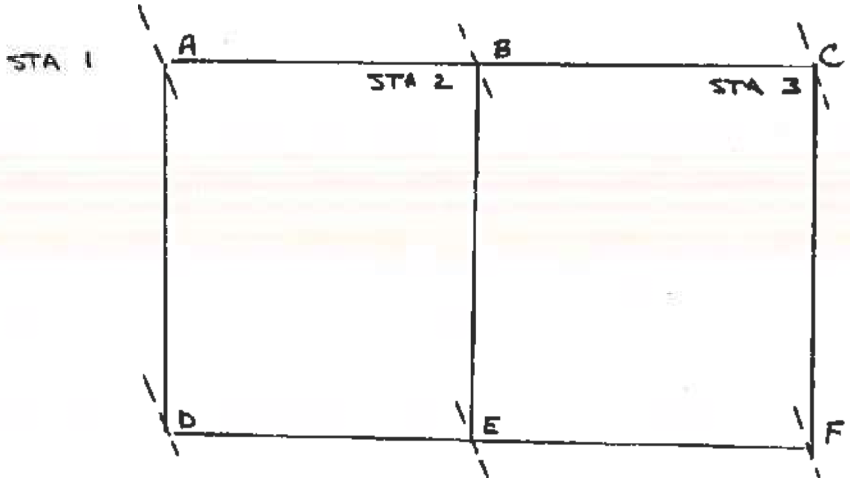


FIGURE 4A

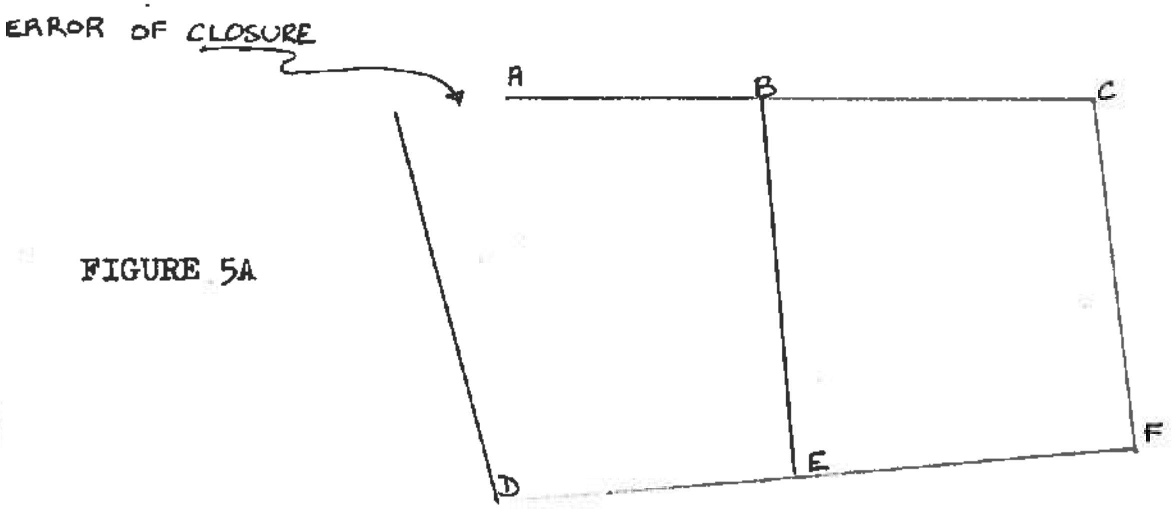


FIGURE 5A

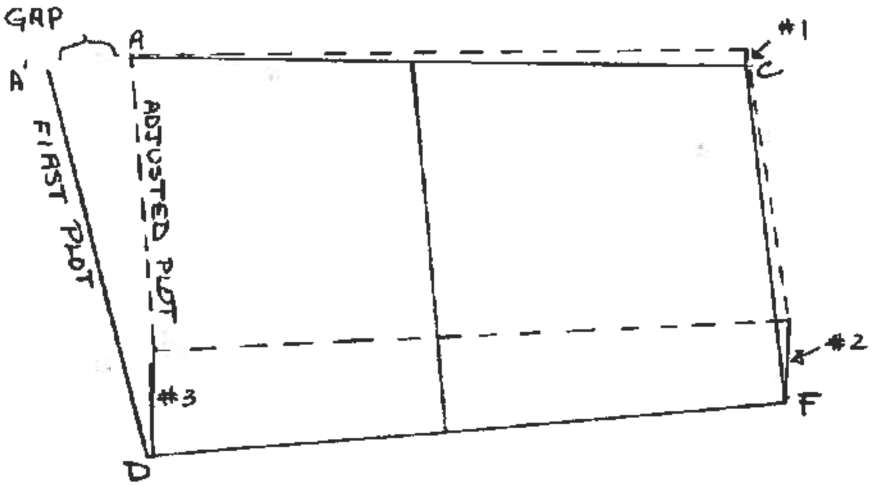


FIGURE 6A

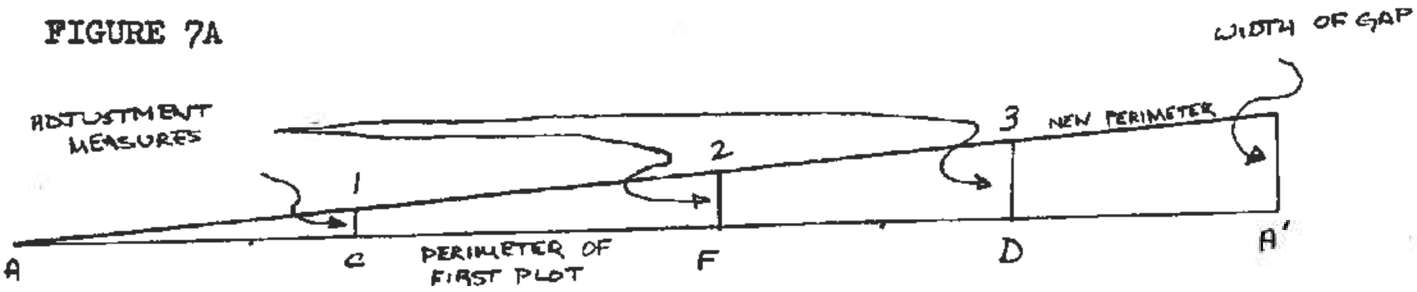


FIGURE 7A

of error. When conducting a traverse, a single mistake somewhere along the line, from the first compass sighting to the final plotting at A, will result in a failure of the last leg of the traverse closing up against A (figure 5 A). This is known as the error of closure. The discrepancy may also be a compound of mistakes. Often times these cancel each other out. The common way of solving this is to either leave the traverse figure open as a statement of honest error too implicit in the job, considering the equipment, or to close the gap by distributing the margin of error through the entire traverse. The accepted allowance of error for such a traverse figure is three percent before it is required that the work be done over (Greenhood, 1964.Mapping,pp 212).

For the sake of appearance the traverse map can be drawn by adjusting the gap. This "adjustment of error of closure" is apportioned in this way (see figure 6 A). A line is drawn across the gap, then parallel with this gap-line, lines are drawn through the other stations. On a single straight line (figure 7 A)the total perimeter distance of the faulty plot is laid out. On this the legs of the traverse are marked out: AB, BC, etc. At the end a perpendicular is erected with the same length as that of the gap. The end of this is connected with the end of line A, making a triangle. At B,C and D perpendiculars are also constructed. This triangle hypotenuse thus cuts each of these segments at just the right distance to use. Each corresponding measured station segment is then laid off in the plotted figure, with the parallels drawn through each station marked. A new perimeter can then be drawn through each marked point, closing the gap.

APPENDIX II

WAVE DATA

FEBRUARY

DATE	HEIGHT/FT	PERIOD/S	LENGTH/FT	WAVE STEEPNESS	WAVE ENERGY
FEB. 1	3	4	81.92	.0366	5904
FEB. 2	2	4	81.92	.0244	5243
FEB. 3	1	3	46.08	.0217	369
FEB. 4	2	4	81.92	.0244	2624
FEB. 5	1	4	81.92	.0122	656
FEB. 6	2	4	81.92	.0244	2624
FEB. 7	2	3	46.08	.0434	1476
FEB. 8	1	4	81.92	.0122	656
FEB. 9	3	5	128	.0234	9225
FEB. 10	2	4	81.92	.0244	2624
FEB. 11	2	4	81.92	.0244	2614
FEB. 12	2	4	81.92	.0244	2624
FEB. 13	1	5	128	.0078	1025
FEB. 14	2	4	81.92	.0244	2624
FEB. 15	4	3	46.08	.0868	7872
FEB. 16	2	4	81.92	.0244	2624
FEB. 17	4	3	46.08	.0868	7872
FEB. 18	6	3	46.08	.1308	13284
FEB. 19	4	2	20.48	.1953	2624
FEB. 20	5	2	20.48	.2441	4100
FEB. 21	4	3	46.08	.0868	7872
FEB. 22	4	3	46.08	.0868	7872

FEBRUARY/MARCH

DATE	HEIGHT/FT	PERIOD/S	LENGTH/FT	WAVE STEEPNESS	WAVE ENERGY
FEB. 23	5	3	46.08	.1085	9225
FEB. 24	5	5	128	.0390	25625
FEB. 25	4	4	81.92	.0488	10496
FEB. 26	5	7	250.88	.0199	50225
FEB. 27	3	3	46.08	.0651	3321
FEB. 28	2	3	46.08	.0434	1476
MAR. 1	1	4	81.92	.0122	656
MAR. 2	4	3	46.08	.0868	7972
MAR. 3	3	3	46.08	.0651	3321
MAR. 4	1	4	81.92	.0122	656
MAR. 5	2	3	46.08	.0434	1476
MAR. 6	2	4	81.92	.0244	2624
MAR. 7	1	3	46.08	.0217	369
MAR. 8	4	5	128	.0312	16400
MAR. 9	3	4	81.92	.0366	7972
MAR. 10	1	4	81.92	.0122	656
MAR. 11	2	5	46.08	.0434	4100
MAR. 12	2	5	128	.0156	4100
MAR. 13	2	3	46.08	.0434	1476
MAR. 14	2	4	81.92	.0247	2624
MAR. 15	4	3	46.08	.0868	5904
MAR. 16	1	2	20.48	.0488	164

MARCH/APRIL

DATE	HEIGHT/FT	PERIOD/S	LENGTH/FT	WAVE STEEPNESS	WAVE ENERGY
MAR. 17	1	5	128	.0078	1025
MAR. 18	1	3	46.08	.0217	369
MAR. 19	1	3	46.08	.0217	369
MAR. 20	1	4	81.92	.0122	656
MAR. 21	1	4	81.92	.0122	656
MAR. 22	3	3	46.08	.0656	3321
MAR. 23	3	5	128	.0234	9225
MAR. 24	1	3	46.08	.0217	369
MAR. 25	NO DATA *				
MAR. 26	NO DATA *				
MAR. 27	5	5	128	.0390	25625
MAR. 28	3	3	46.08	.0651	3321
MAR. 29	2	3	46.08	.0434	1476
MAR. 30	2	3	46.08	.0434	1476
APR. 1	5	7	250.88	.0199	50225
APR. 2	4	4	81.92	.0488	10496
APR. 3	NO DATA*				
APR. 4	NO DATA*				
APR. 5	3	4	81.92	.0366	5904
APR. 6	2	3	46.08	.0434	1476
APR. 7	5	3	46.08	.1085	9225
APR. 8	5	3	46.08	.1085	9225

APRIL

DATE	HEIGHT/FT	PERIOD/S	LENGTH/FT	WAVE STEEPNESS	WAVE ENERGY
APR. 9	3	4	81.92	.0366	7872
APR. 10	3	5	128	.0234	13284
APR. 11	2	5	128	.0156	4100
APR. 12	1	4	81.92	.0122	656
APR. 13	2	4	81.92	.0247	2624
APR. 14	3	4	81.92	.0366	7972
APR. 15	2	4	81.92	.0247	2624
APR. 16	2	3	46.08	.0434	1476
APR. 17	2	3	46.08	.0434	1476
APR. 18	3	5	128	.0334	13284
APR. 19	2	4	81.92	.0244	2624
APR. 20	3	3	46.08	.0651	3321
APR. 21	2	3	46.08	.0434	1476
APR. 22	2	3	46.08	.0434	1476
APR. 23	1	3	46.08	.0217	369
APR. 24	1	3	46.08	.0217	369
APR. 25	1	4	81.92	.0122	656
APR. 26	2	4	81.92	.0244	2624
APR. 27	2	4	81.92	.0244	2624
APR. 28	3	5	128	.0234	13284
APR. 29	2	5	128	.0156	4100
APR. 30					

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