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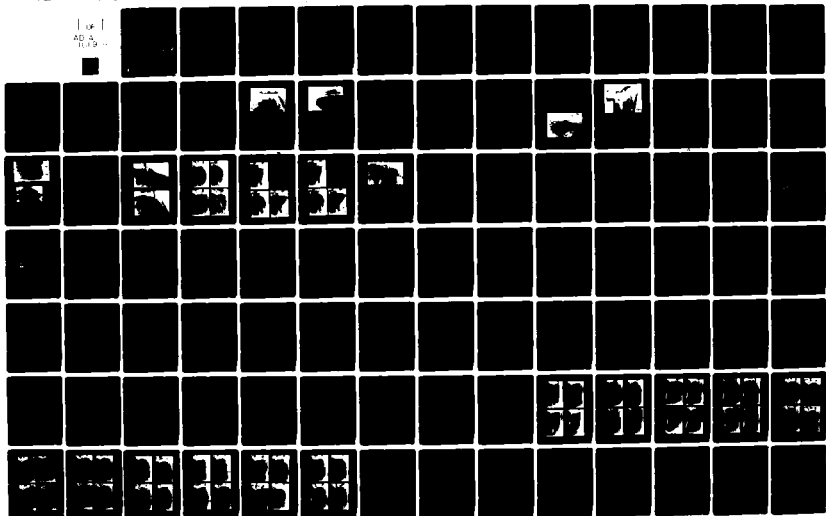
COASTAL ENGINEERING RESEARCH CENTER FORT BELVOIR VA  
MOVABLE-BED LABORATORY EXPERIMENTS COMPARING RADIATION STRESS A--ETC(U)  
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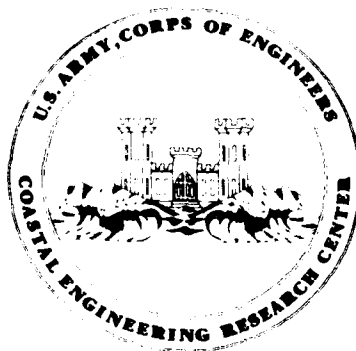


MR 81-4

**Movable-Bed Laboratory Experiments  
Comparing Radiation Stress and  
Energy Flux Factor as Predictors  
of Longshore Transport Rate**

by  
Philip Vitale

MISCELLANEOUS REPORT NO. 81-4  
APRIL 1981



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## PREFACE


This report is published to provide coastal engineers insight into the important coastal process of longshore transport along sandy beaches by presenting the results of three-dimensional movable-bed laboratory tests. It is hoped that future studies will expand on the analyses of the data in this report. The report was prepared under the nearshore sediment transport research program of the U.S. Army Coastal Engineering Research Center (CERC).

The report was written by Philip Vitale, Hydraulic Engineer, under the general supervision of Dr. R.M. Sorensen, Chief, Coastal Processes and Structures Branch, Research Division.

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Comments on this publication are invited.

Approved for publication in accordance with Public Law 166, 79<sup>th</sup> Congress, approved 31 July 1945, as supplemented by Public Law 172, 88<sup>th</sup> Congress, approved 7 November 1963.

  
TED E. BISHOP  
Colonel, Corps of Engineers  
Commander and Director

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# CONVERSION FACTORS, U.S. CUSTOMARY TO METRIC (SI) UNITS OF MEASUREMENT

U.S. customary units of measurement used in this report can be converted to metric (SI) units as follows:

Multiply	by	To obtain
inches	25.4	millimeters
	2.54	centimeters
square inches	6.452	square centimeters
cubic inches	16.39	cubic centimeters
feet	30.48	centimeters
	0.3048	meters
square feet	0.0929	square meters
cubic feet	0.0283	cubic meters
yards	0.9144	meters
square yards	0.836	square meters
cubic yards	0.7646	cubic meters
miles	1.6093	kilometers
square miles	259.0	hectares
knots	1.852	kilometers per hour
acres	0.4047	hectares
foot-pounds	1.3558	newton meters
millibars	$1.0197 \times 10^{-3}$	kilograms per square centimeter
ounces	28.35	grams
pounds	453.6	grams
	0.4536	kilograms
ton, long	1.0160	metric tons
ton, short	0.9072	metric tons
degrees (angle)	0.01745	radians
Fahrenheit degrees	5/9	Celsius degrees or Kelvins <sup>1</sup>

<sup>1</sup>To obtain Celsius (C) temperature readings from Fahrenheit (F) readings, use formula:  $C = (5/9) (F - 32)$ .

To obtain Kelvin (K) readings, use formula:  $K = (5/9) (F - 32) + 273.15$ .

# SYMBOLS AND DEFINITIONS

$a'$	ratio of sand volume to total volume of a sand deposit
$b$	subscript for breaker
$C$	wave phase velocity
$C_g$	wave group velocity
$d$	water depth
$d_{50}$	median sand size
$\overline{E}$	energy density
$F_x$	flux of wave energy per alongshore distance
$g$	acceleration of gravity
$H$	wave height
$\overline{H}$	average wave height
$H_{rms}$	root-mean-square wave height
$H_s$	significant wave height
$I_l$	longshore transport rate in immersed weight per unit time
$i$	subscript for any point seaward of breaker zone
$K_p$	empirical coefficient relating $I_l$ to $P_{lb}$
$K_s$	empirical coefficient relation $I_l$ to $S_{xy}$
$k$	wave number = $2\pi/L$
$L$	wavelength
$n$	ratio of $C_g$ to $C$
$o$	subscript for deepwater condition
$P_l$	energy flux term
$P_{lb}$	longshore energy flux factor as used in this report
$P_{ls}$	longshore energy flux factor as used in the SPM
$Q$	longshore transport rate in volume per unit time
$R$	range of coordinate system defined in Figure 7

# SYMBOLS AND DEFINITIONS--Continued

r	correlation coefficient
S	station of coordinate system defined in Figure 7
$S_{xy}$	radiation stress component (flux of y-momentum in x-direction)
T	wave period
t	time
u	onshore component of water particle velocity
v	alongshore component of water particle velocity
x	coordinate in onshore direction
y	coordinate in alongshore direction
z	coordinate in vertical direction
$\alpha$	angle between wave crest and shoreline
$\alpha_g$	angle between wave generator and shoreline
$\beta$	angle of beach slope with horizontal
$\eta$	water surface elevation
$\theta$	wave phase
$\xi$	surf similarity parameter as used in this report
$\xi_b$	surf similarity parameter as used in Kamphuis and Readshaw (1978)
$\rho$	mass density of water
$\rho_s$	mass density of sand
$\omega$	angular frequency of wave = $2\pi/T$

MOVABLE-BED LABORATORY EXPERIMENTS COMPARING  
RADIATION STRESS AND ENERGY FLUX FACTOR AS PREDICTORS  
OF LONGSHORE TRANSPORT RATE

by  
*Philip Vitale*

I. INTRODUCTION

Three-dimensional movable-bed laboratory tests were conducted to compare radiation stress and energy flux factor as predictors of the longshore sediment transport rate. The tests were performed in the U.S. Army Coastal Engineering Research Center's (CERC) Shore Processes Test Basin (SPTB). This report presents derivations of the radiation stress and the energy flux factor, documents the experimental setup and procedure, tabulates most of the data, and performs the data analyses. Many photos were taken during the tests; however, only a few were used in the report. The complete set of test photos is available from CERC's Coastal Engineering Information and Analysis Center (CEIAC).

II. EMPIRICAL RELATIONS

The longshore transport data are related empirically to the two expressions representing wave conditions. One, radiation stress, is based on momentum flux, the other on energy flux. An important concept which is also used in the data analyses is the surf similarity parameter.

1. Momentum Flux.

The dependent variable studied here is the longshore transport rate caused by waves approaching the beach; therefore, the consequential momentum term is the onshore flux of alongshore momentum. The derivation of the term follows Longuet-Higgins (1970) which applies the concept of wave momentum flux to the generation of longshore currents.

The coordinate system used is shown in Figure 1. The y-axis is along the shoreline, the x-axis is normal to the shoreline and positive shoreward, and the z-axis originates at the stillwater level and is positive upward. Using this system, the onshore flux of alongshore momentum is the flux of y-momentum in the x-direction,  $S_{xy}$ . This term is one component of what is commonly called the radiation stress tensor.

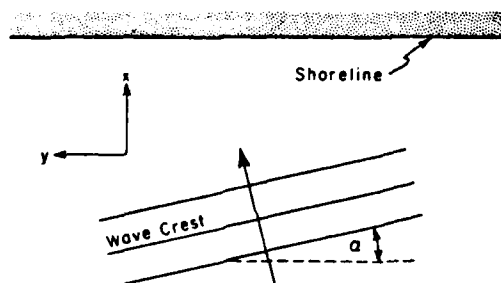


Figure 1. Coordinate system for momentum flux derivation.

According to small-amplitude wave theory, the components of the water particle velocity in the x- and y-directions for a wave traveling at an angle,  $\alpha$ , to the shoreline (Fig. 1) are, respectively,

$$u = \frac{H}{2} \frac{gT}{L} \frac{\cosh [k(z + d)]}{\cosh kd} \cos \theta \cos \alpha \quad (1)$$

$$v = \frac{H}{2} \frac{gT}{L} \frac{\cosh [k(z + d)]}{\cosh kd} \cos \theta \sin \alpha \quad (2)$$

where

- H = wave height
- g = acceleration of gravity
- T = wave period
- L = wavelength
- d = water depth
- k = wave number
- $\theta$  = wave phase.

The last two terms are defined as

$$k = \frac{2\pi}{L}$$

and

$$\theta = kx - \omega t$$

where  $t$  is time, and  $\omega$  the wave angular frequency

$$\omega = \frac{2\pi}{T}$$

The y-momentum (alongshore momentum) per unit volume is  $\rho v$  where  $\rho$  is the water mass density. The flux of this momentum in the x-direction (onshore) per unit alongshore distance and unit water depth is  $\rho v u$ . Integrating over the water column and averaging over time produce the mean alongshore momentum flux in the x-direction per unit alongshore distance

$$\overline{S_{xy}} = \overline{\int_{-d}^{\eta} \rho v u \, dz} \quad (3)$$

where the overbar denotes the mean with respect to time and  $\eta$  the water surface elevation. Substituting equations (1) and (2) into (3) and dropping terms of higher than second order produce

$$S_{xy} = (\overline{EC}_g \cos \alpha) \frac{\sin \alpha}{C} \quad (4)$$

where  $C$  is the wave phase velocity,  $C_g$  the wave group velocity, and  $\bar{E}$  the wave energy density

$$\bar{E} = \frac{\rho g H_{rms}^2}{8} \quad (5)$$

where  $H_{rms}$  is the root-mean-square (rms) wave height. The term in parentheses in equation (4) is the flux of wave energy per alongshore distance,  $F_x$ , assuming straight and parallel bathymetric contours. When zero wave energy dissipation is assumed,

$$F_x = \bar{E} C_g \cos \alpha = \text{constant} \quad (6)$$

In this report, dissipation is assumed to be zero up to the breaker zone; therefore,  $F_x$  is constant from deep water to the breaker zone. Since the ratio of  $\sin \alpha$  to  $C$  is constant due to Snell's law, equation (4), which represents the alongshore wave momentum entering the surf zone, is constant seaward of the breaker zone.

Equation (4) can be revised for application of monochromatic waves, as in this report. For such wave conditions, the average wave height,  $\bar{H}$ , measured during the tests (and discussed later in Section IV) is equal to  $H_{rms}$ . By rewriting equation (4),

$$S_{xy} = \left( \frac{\rho g \bar{H}^2}{8} C_g \cos \alpha \right) \frac{\sin \alpha}{C} \quad (7)$$

$S_{xy}$  is now defined for use with laboratory monochromatic wave data. Note that equation (4) is valid for any wave condition; equation (7) is valid only for conditions where  $\bar{H}$  equals  $H_{rms}$ .

## 2. Energy Flux.

In literature, the longshore transport rate has been empirically related most frequently to a term found by multiplying both sides of equation (4) by the wave phase velocity,  $C$ , to yield

$$P_\ell = (\bar{E} C_g \cos \alpha) \sin \alpha \quad (8)$$

Unlike  $S_{xy}$ ,  $P_\ell$  is not constant seaward of the breaker line; therefore, specifying where  $P_\ell$  is being calculated is necessary. This report, following convention, determines  $P_\ell$  at the breaker line,

$$P_{\ell b} = (\bar{E} C_g \cos \alpha)_b \sin \alpha_b \quad (9)$$

representing the value of  $P_\ell$  at the point closest to where the longshore transport is occurring. The subscript  $b$  denotes breaker values. The term

in parentheses in equation (9) has been shown to be constant (see eq. 6) seaward of the breaker line; therefore, subscript b may be replaced by i which represents any point seaward of the breaker line. Making this change, using equation (5), and letting  $H_{rms}$  equal  $\bar{H}$  for monochromatic waves, equation (9) becomes

$$P_{lb} = \left( \frac{\rho g \bar{H}^2}{8} C_g \cos \alpha \right)_i \sin \alpha_b \quad (10)$$

The Shore Protection Manual (SPM) (U.S. Army, Corps of Engineers, Coastal Engineering Research Center, 1977) provides a term similar to  $P_{lb}$  except that the wave height used is the significant height,  $H_s$ . The term, called the longshore energy flux factor, is defined as

$$P_{ls} = \left( \frac{\rho g H_s^2}{8} C_g \cos \alpha \sin \alpha \right)_b \quad (11)$$

$P_{ls}$  is derived in Galvin and Schweppe (1980). The relationship between  $H_{rms}$  and  $H_s$  has been shown in Longuet-Higgins (1952) to be

$$H_s^2 = 2 H_{rms}^2 \quad (12)$$

assuming a Rayleigh distribution of wave heights as well as a number of other conditions. Therefore,

$$P_{lb} = \frac{P_{ls}}{2} \quad (13)$$

Since  $P_{lb}$  and  $P_{ls}$  are essentially the same terms, this report uses the SPM terminology and refers to  $P_{lb}$  as the longshore energy flux factor.

### 3. Longshore Transport Rate.

The longshore transport rate,  $Q$ , given in the SPM in units of volume per unit time, is also commonly shown as  $I_l$  with units of immersed weight per unit time. The relationship between the two is

$$I_l = (\rho_s - \rho) g a' Q \quad (14)$$

where  $\rho_s$  is the mass density of sand and  $a'$  the ratio of sand volume to total volume of a sand deposit, which takes into account the sand porosity. For discussions of equation (14), see Komar and Inman (1970) and Galvin (1979). Since the laboratory tests described here measured  $I_l$  directly, this term is used in most of the data analysis.

#### 4. Empirical Relations.

The expressions derived in the preceding paragraphs are used to set up the following empirical relations

$$I_l = K_p P_{lb} \quad (15)$$

and

$$I_l = K_s S_{xy} \quad (16)$$

where  $K_p$  and  $K_s$  are coefficients to be determined from the test data in this report.

Equation (15) is based on the concept that the work done in moving the sand alongshore is proportional to the energy which approaches the beach. The units are consistent and  $K_p$  is dimensionless.

Equation (16) is based on the concept that the sand transported alongshore depends on the alongshore force exerted by the wave motion on the bed inside the surf zone. By the equation of motion, this force is related to the change of momentum inside the surf zone. The alongshore momentum,  $S_{xy}$ , enters the surf zone through the breaker line but cannot exit through the shoreline boundary. Therefore, the change in alongshore momentum is  $S_{xy}$  and equation (16) results.  $K_s$  has dimensions of length over time.

#### 5. Surf Similarity Parameter.

Kamphuis and Readshaw (1978) showed that  $K_p$  and  $K_s$  are dependent upon the surf similarity parameter,

$$\xi_b = \frac{\tan \beta}{(H_b/L_o)^{1/2}} \quad (17)$$

in which  $\tan \beta$  is the beach slope,  $H_b$  the breaker height, and  $L_o$  the deepwater ( $d/L > 1/2$ ) wavelength.  $\xi_b$  reflects variations in beach shape, breaker type, and rate of energy dissipation. Using the results of laboratory tests, the following relationships were found by Kamphuis and Readshaw

$$K_p \approx 0.7\xi_b \quad \text{for} \quad 0.4 < \xi_b < 1.4 \quad (18)$$

$$K_s \approx 0.08\xi_b \quad \text{for} \quad 0.4 < \xi_b < 1.25 \quad (19)$$

For values of  $\xi_b$  higher than the upper limits,  $K_p$  and  $K_s$  become independent of  $\xi_b$ .

The surf similarity parameter is evaluated in this report to determine its effect on the longshore transport rate.

### III. EXPERIMENTAL SETUP

This section discusses the setup in the SPTB (Figs. 2 and 3) and describes the wave generators, wave gages, and cameras and their positions. Also discussed are the sand-moving system, the method for measuring the longshore current velocity, and the size distribution of the sand used in the experiment. The design of the setup was based in large part on Fairchild (1970).



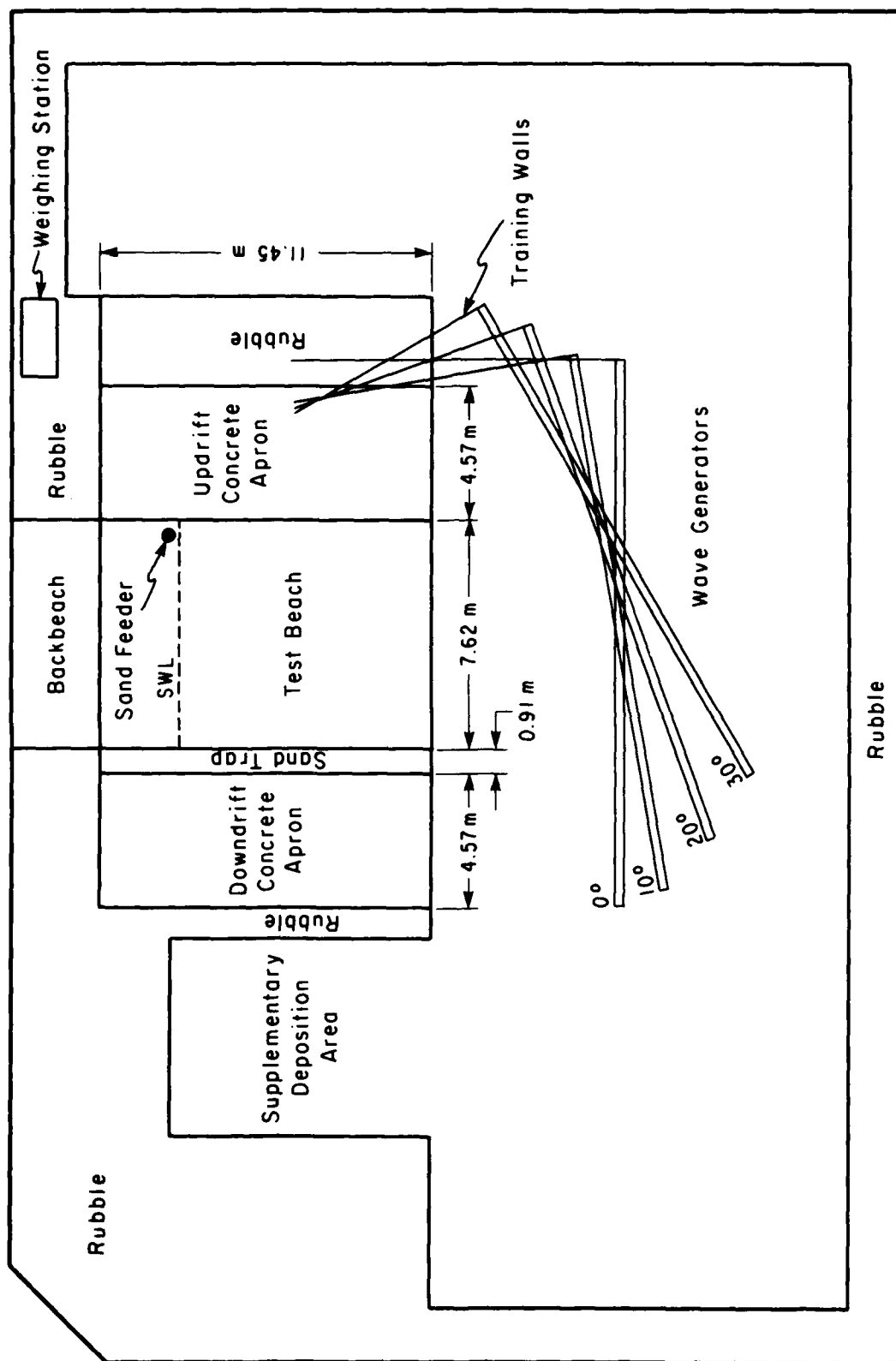


Figure 2. Diagram of test basin setup.

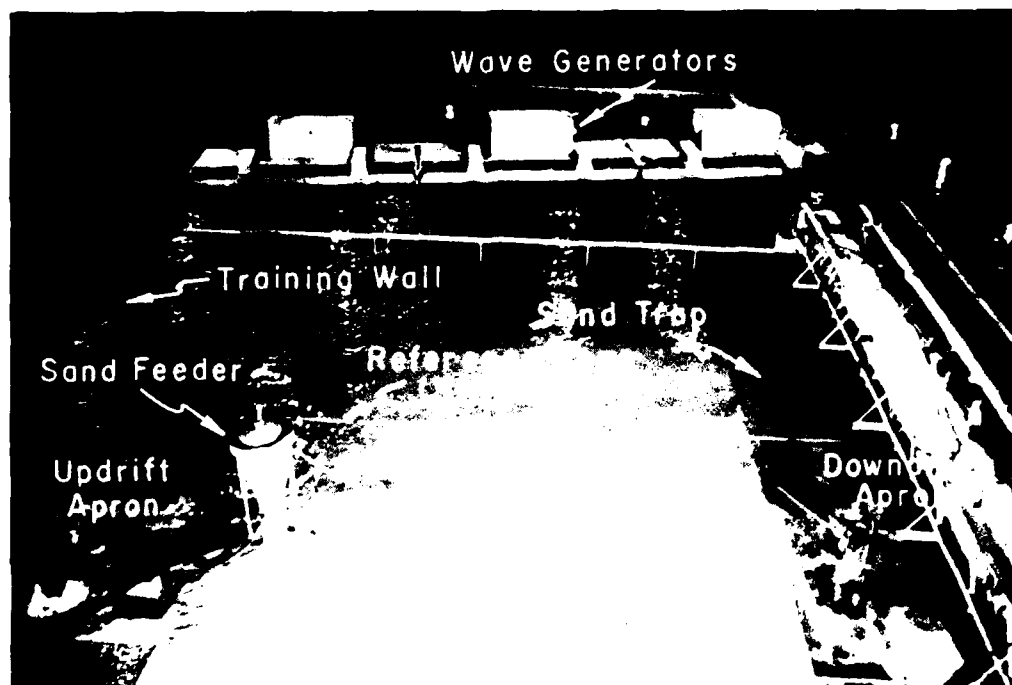


Figure 3. Photo of test basin setup.

#### 1. Basin Layout.

A diagram of the basin setup is shown in Figure 2. The basin is 45.72 meters long, 30.48 meters wide, and 1.22 meters deep. The alongshore and the shore-normal directions of the sand beach were 7.62 and 11.45 meters, respectively. The backbeach was 3.05 meters in the shore-normal direction, but it was not part of the test beach.

Immediately downdrift of the beach was the sand trap, 0.91 meter wide and 12.7 centimeters deep (Fig. 4), used to catch the longshore transport.

Concrete aprons, 4.57 meters in the alongshore direction, were located on the downdrift side of the sand trap and on the updrift side of the beach. The updrift apron provided enough distance for the longshore current to develop between the updrift training wall and the beach. This phenomenon is discussed in Galvin and Eagleson (1965). The downdrift apron served two purposes--one as a platform for depositing the longshore transport that escaped the trap, the other as a surface on which the waves traveled to diminish diffraction effects since no downdrift training walls were used.

The major limitation in the experimental planning was the size of the SPTB, which permitted three wave generators, each 6.10 meters long, to be linked together and leave enough room to be rotated through various angles to the beach. The other limitation was the decision not to use downdrift training walls due to the wave reflection problem. When downdrift training walls are used, the wave energy, which is reflected off the beach at an angle in the downdrift direction, strikes the downdrift wall and is reflected back toward the updrift direction. The energy is then reflected by the updrift wall and the process repeats. The reflected wave energy is being trapped within the

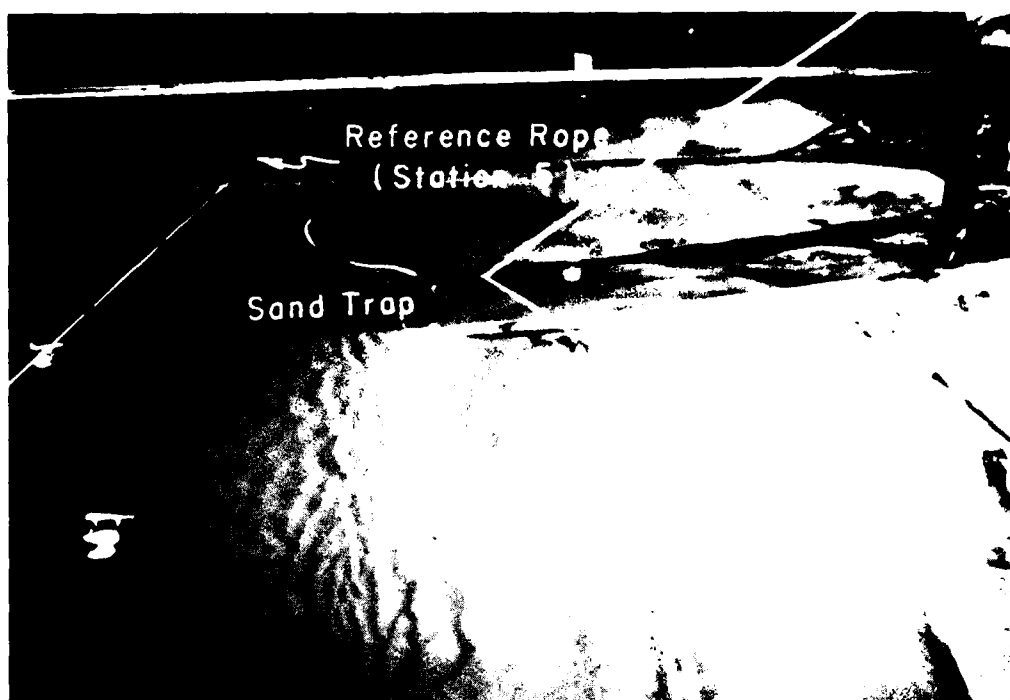


Figure 4. Photo of sand trap.

two walls; this produces some complicated wave variability problems (e.g., see Fairchild, 1970). With no downdrift training walls, the reflected wave energy moves away from the beach area into the outer parts of the test basin where most of it is eventually dissipated by the rubble slope along the edge of the basin (Fig. 2). This, however, creates a problem with wave diffraction. The energy of the wave leaving the generator spreads laterally into still water and gradually decreases the wave height toward the updrift end of the wave crest.

To minimize the decrease in wave height over the test beach, it was designed using the diffraction diagram for a wave traveling past a semi-infinite breakwater from Figure 2-33 of the SPM. The period and angle used in the diffraction analysis were 3 seconds and  $10^\circ$ , respectively, since these values produced the maximum diffraction closest to the beach. The spreading of wave energy into the shadow of a breakwater is analogous to the spreading of wave energy into the area of the test basin downdrift of the generators. The diagram (Fig. 5) indicated that the alongshore length of the beach should be 7.62 meters. Most of the diffraction-caused decrease in wave height occurs over the downdrift concrete apron.

Rubble, ranging in size from 7.62 to 15.24 centimeters, was placed at several locations in the basin to absorb wave energy and provide gradual slopes between the concrete aprons and the basin floor. The beach, sand traps, concrete aprons, and adjacent rubble were all built to the same shore-normal profile (Fig. 6). This profile was based on Chesnutt's (1978) long-term two-dimensional tests in which waves were run onto a sand beach to determine profile response. After superposing several of Chesnutt's (1978)

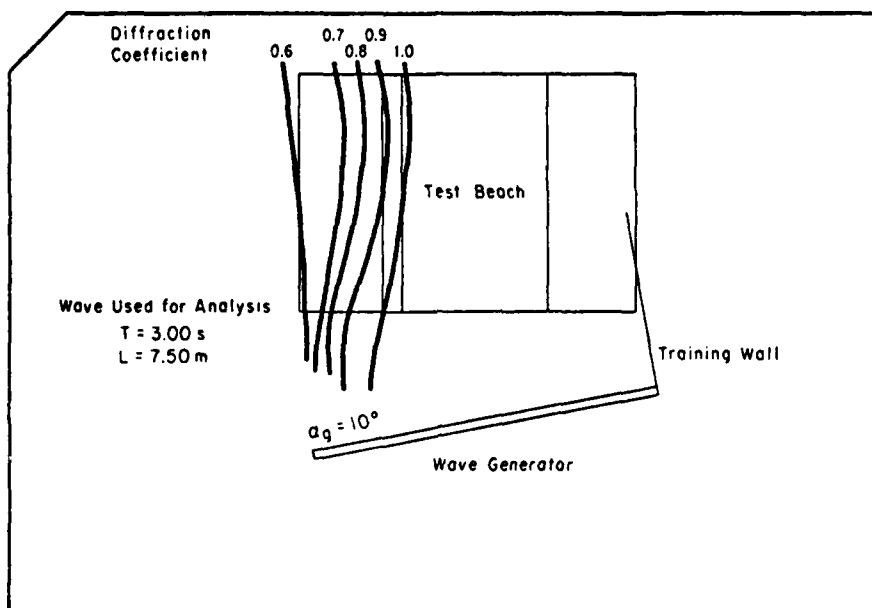


Figure 5. Diagram of diffraction analysis used to determine the alongshore length of the test beach.

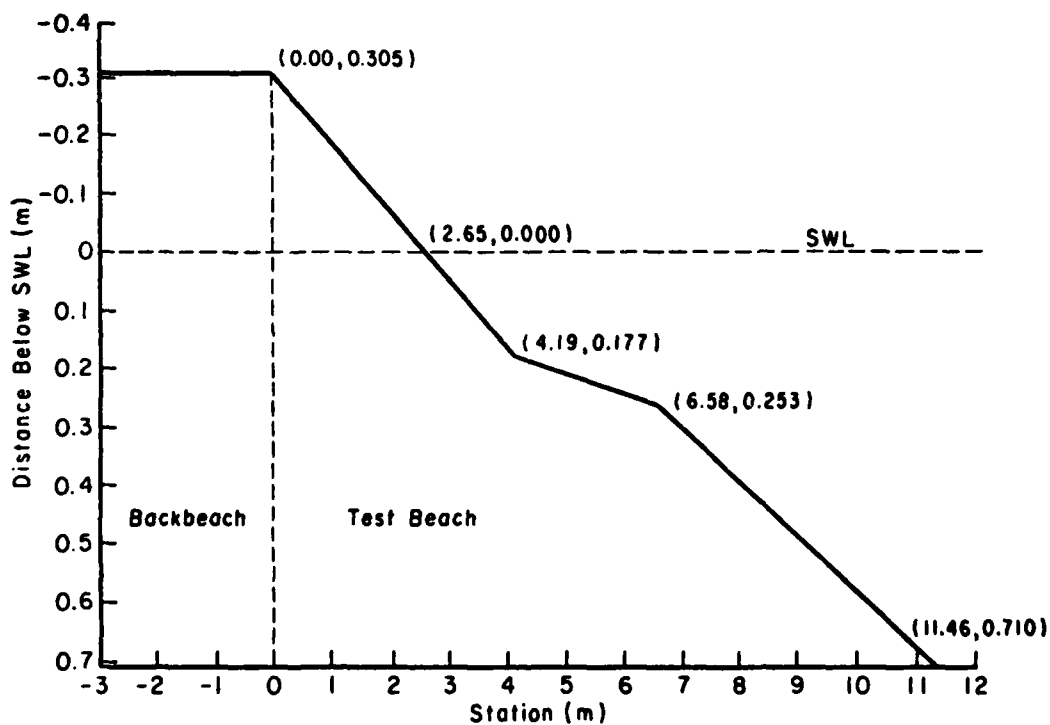


Figure 6. Shore-normal profile of the test beach, sand trap, concrete aprons, and adjacent rubble.

profiles run for 80 hours or more with wave periods similar to those used in this experiment, the shore-normal profile in Figure 6 was drawn as a compromise or average through the superposed profiles. This profile was used to lessen the onshore-offshore adjustment of the beach.

Figure 7 shows the coordinate system used for the test beach. The origin is at the updrift, shoreward corner of the beach. Ranges (in meters) are along the alongshore axis, and stations (in meters) along the shore-normal axis. Any point on the beach, or in the basin, can be described by a range-station pair.

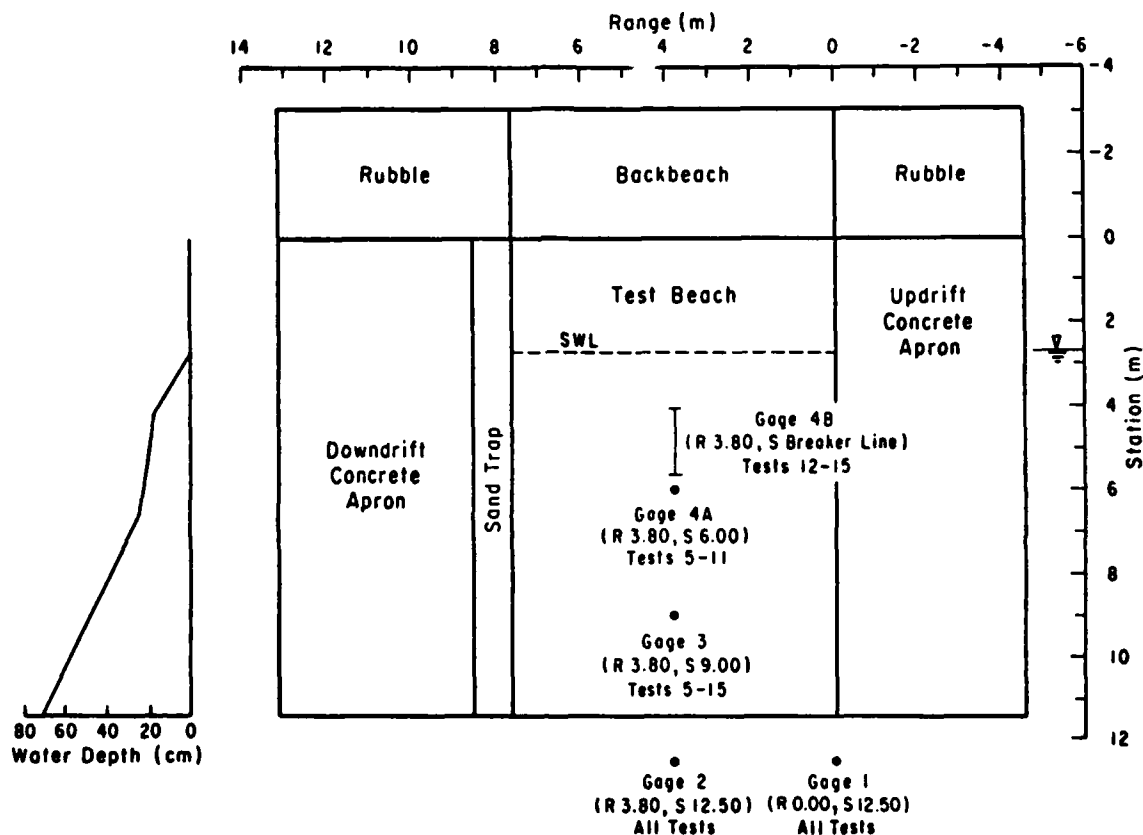


Figure 7. Coordinate system used for test beach with locations of wave gages (R = range, S = station).

## 2. Generators.

The three piston-type 6.10 meter-long generators used in this experiment produced only monochromatic waves and are discussed in Stafford and Chesnutt (1977). The generators were set at four different angles--0°, 10°, 20°, and 30°--to the beach during the experiment. For each setting, an updrift training wall was built from the generator to the 1-foot depth. This allowed circulation past the wall to feed the longshore current. Figure 2 shows the setup of the four generators and training wall.

For the 10° and 20° tests, the training wall was curved to allow for wave refraction. However, since the wall stopped at the 1-foot depth, the curves

were small and considered not worth the construction effort. Therefore, the curve for the 30° tests was deleted and a straight training wall was used.

### 3. Sand-Moving System.

As the waves approached the beach at an angle, the sand moved in the downdrift direction. Most of it deposited in the sand trap. The sand which escaped the trap deposited either on the downdrift concrete apron or beyond the apron and rubble (covered to keep sand from being lost within it) onto the basin floor. This area is shown in Figure 2 as the supplementary deposition area. Although separate measurements of the sand deposited in each area were not taken, it is estimated that 80 to 95 percent of the longshore transport fell into the trap. The greater the transport rate and the suspended sediment, the greater was the amount of sand escaping the sand trap.

The trap was cleaned continually during a test using an eductor attached to a small centrifugal pump. Water was pumped through the eductor at high speed, creating a suction to pick up the sand (Fig. 8). The sand was pumped to the weighing station (Fig. 9), deposited in one of two bins, and weighed submerged. When divided by the appropriate time period, the value became the immersed weight longshore transport rate.

After the weighing, the sand was pumped, using another eductor, into a sand feeder. The sand feeder is a vertical cylinder open at both ends in which sand is introduced through the top and removed by waves through the bottom. A diagram and a photo of the feeder are given in Figures 10 and 11. The primary advantage of the feeder is that it permits waves to control the amount of sand introduced onto the beach. Savage (1961) discusses the feeder and its development.

In summary, the complete sand-moving system (Fig. 12) included the following:

- (a) A sand trap, a downdrift concrete apron, and a downdrift deposition area which trapped the sand;
- (b) a downdrift eductor-pump combination which moved the trapped sand to the weighing station;
- (c) a weighing station which weighed the amount of sand moved;
- (d) an updrift eductor-pump combination which moved the sand from the weighing station to the sand feeder; and
- (e) a sand feeder which redeposited the sand onto the beach.

### 4. Instruments.

Wave heights were measured using parallel-wire wave gages (see Fig. 7). Gages 1 and 2, located seaward of the toe of the beach, were used for all 15 tests. Gage 3, located over the beach, was used for tests 5 to 15. Gage 4A, located close to the breaker line, was used for tests 5 to 11. Beginning with test 12 for the remainder of the tests, gage 4A was adjusted to measure the breaker height and then renamed gage 4B.

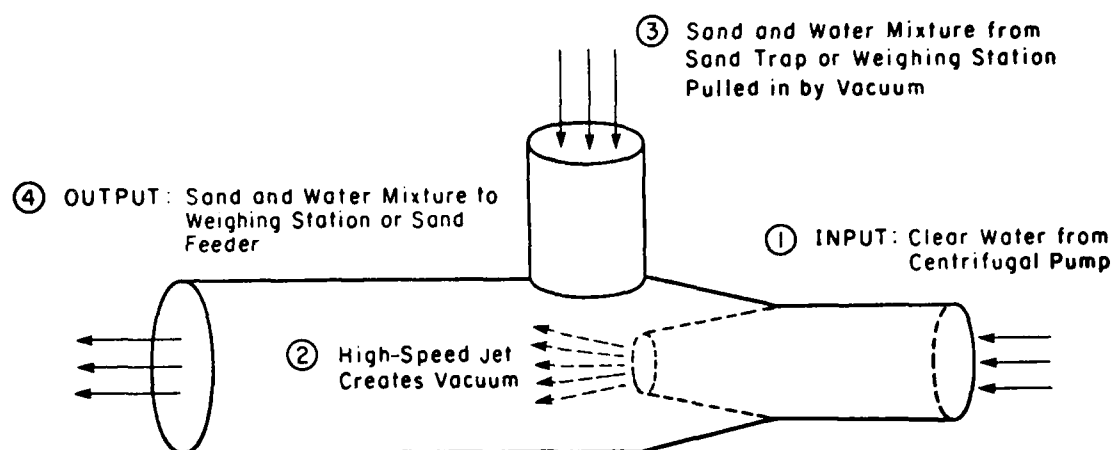


Figure 8. Diagram of eductor.

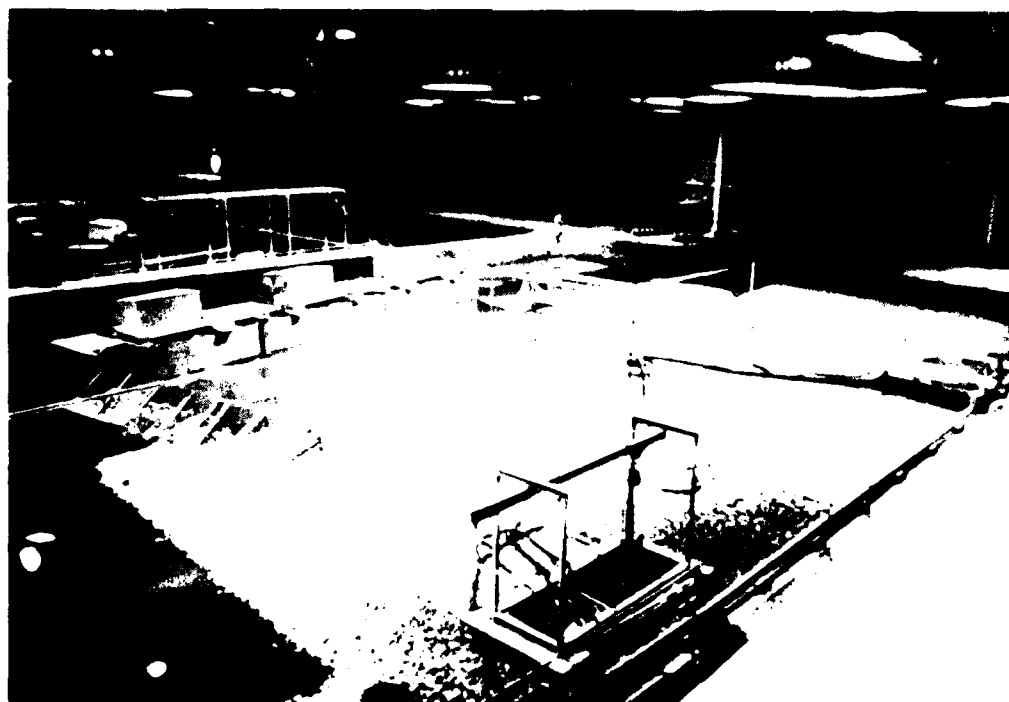


Figure 9. Photo of weighing station.



Figure 11. Photo of sand feeder.

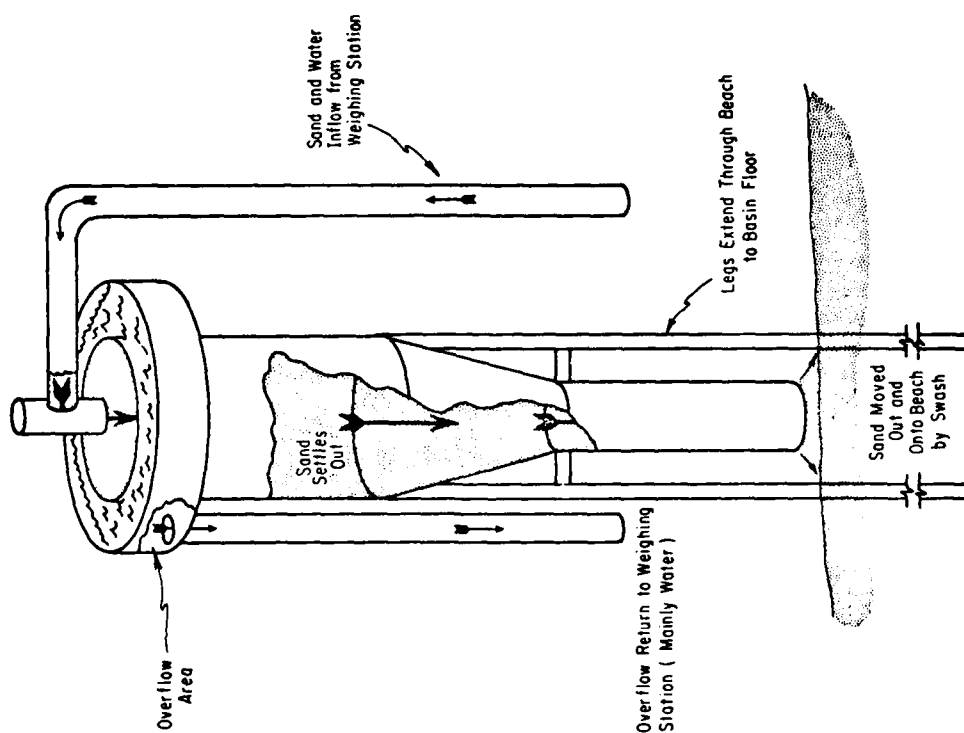


Figure 10. Diagram of sand feeder.



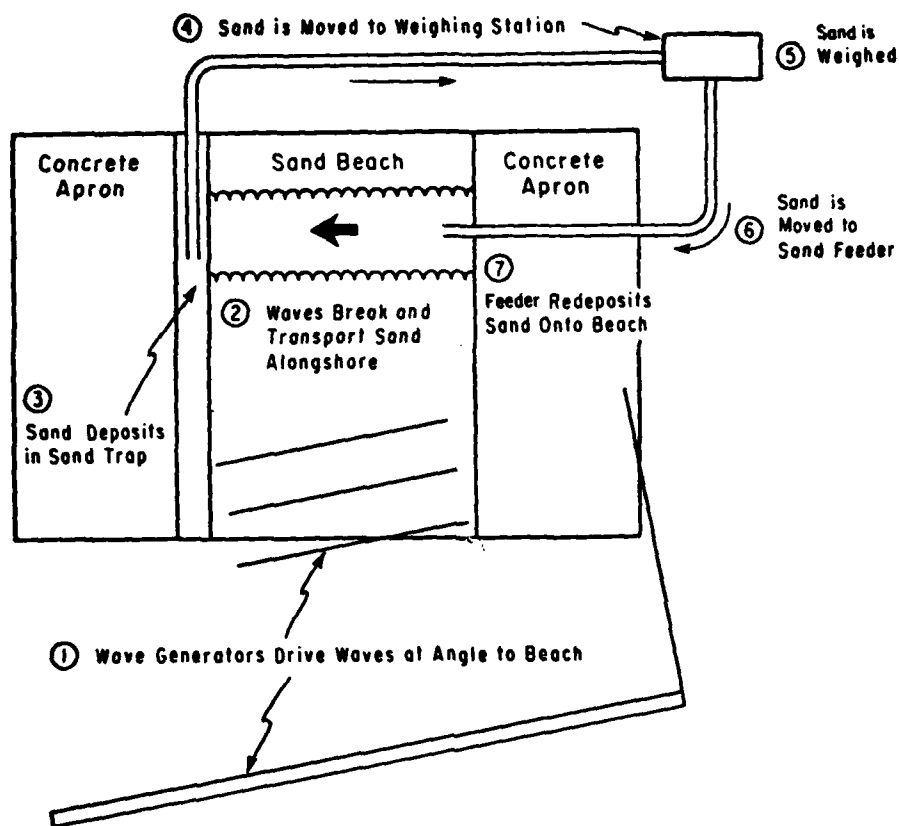


Figure 12. Diagram of complete sand-moving system.

Two cameras were mounted over the beach on the catwalk of the SPTB. One was a view camera with an adapter for taking 4- by 5-inch Polaroid black-and-white photos, and the other a standard 35-millimeter camera. The locations of the cameras are given in Table 1.

Other instruments used in the tests include standard hydraulic scales for weighing the sand, and a standard level and rod for surveying the beach after each test.

Table 1. Locations of overhead cameras mounted on the catwalk.

Location <sup>1</sup>	Camera	
	View (m)	35-mm (m)
Range	3.9	3.9
Station	4.9	4.7
Elevation above SWL	8.5	8.5

<sup>1</sup>Accurate only to  $\pm 0.1$  meter.

### 5. Dye Injection.

Longshore current velocities for tests 5 to 15 were measured by injecting dye into the surf zone through a hose which ran from the sand feeder to a small stake in the surf zone. Dye was poured by hand into the top of the hose. Table 2 gives the locations of the dye injection by test numbers. The change in location of the stake in tests 7 to 10 was a procedural error and not planned for a special purpose. The dye injection procedure is discussed in detail in the next section.

Table 2. Locations of dye injection by test number.

Test Nos.	Dye injected at range (m)	Dye timed from range (m)	Dye timed to range (m)	Timed distance traveled (m)
5 and 6	3.00	3.60	7.60	4.00
7 to 10	3.82	3.82	7.73	3.78
11 to 15	3.00	3.73	7.73	4.00

### 6. Sand Size.

Figure 13 shows the size distribution of the sand used for all 15 tests. The median diameter was 0.22 millimeter. The geometric standard deviation is defined as

$$\sigma_g = \frac{d_{16}^{1/2}}{d_{84}} \quad (20)$$

where  $d_{16}$  and  $d_{84}$  are the sand sizes at which 16 and 84 percent, respectively, of the sample is coarser. The value of  $\sigma_g$  for the sand used was 1.22. Figure 13 indicates that the sand was well sorted.

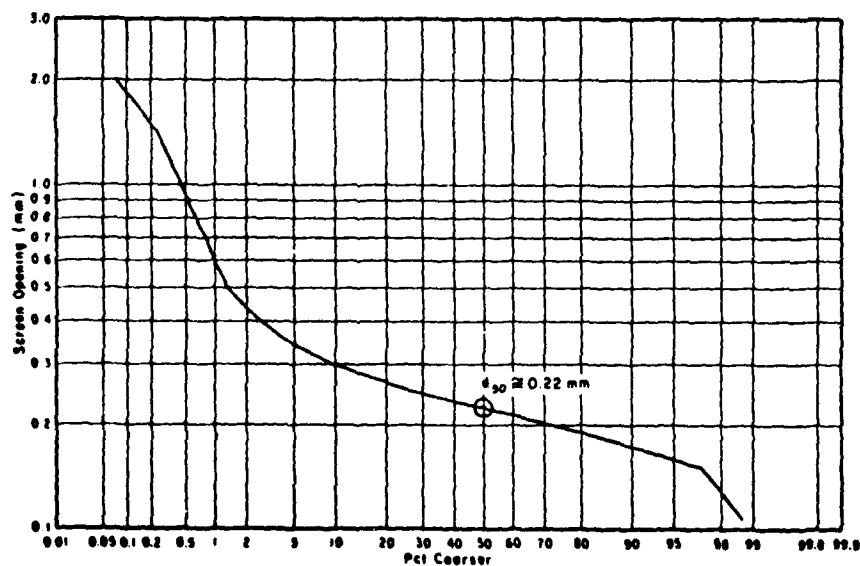


Figure 13. Size distribution of sand used for all tests.

#### IV. EXPERIMENTAL PROCEDURE

Each test was composed of three major data collection cycles: an hourly cycle, a daily cycle, and a test cycle. For example, wave heights were measured every hour (hourly cycle), water temperature was measured twice a day (daily cycle), and beach surveys were taken at the end of each test (test cycle). The typical test schedule was 4 hourly cycles daily for 6 days for a total of 24 run-hours per test. Tests 1 and 2, as discussed later, were exceptions to this schedule. Figure 14 is a schematic diagram of the interrelationship of the three cycles. Since waves were run every other day, a complete test took about 3 weeks.

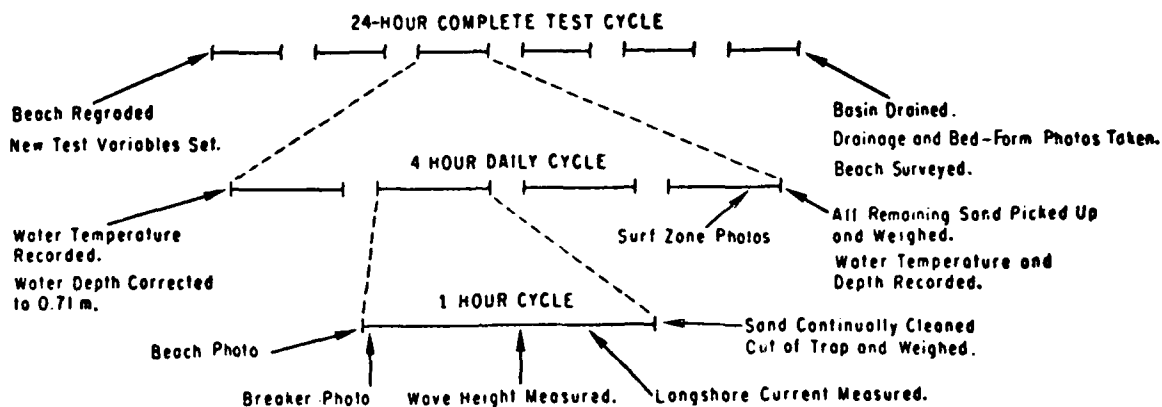


Figure 14. Schematic diagram of the interrelationship of the three experimental cycles.

##### 1. Hourly Cycle.

The various types of data collected in a typical hourly cycle are shown in Figure 14, along with an indication of time of collection. Before a new hour of run-time was started, photos of the beach were taken from overhead with both the 35-millimeter camera (Fig. 15) and the view camera. A reference rope in the alongshore direction at station 5 and painted arrows on the concrete at each station bordering the beach can be seen in Figure 15. Photos, such as shown in Figure 15, provide a record of the change in waterline and breaker bar throughout the tests. The waves were then turned on and usually, within 5 minutes of the start, an overhead photo of the breaking wave was taken with the view camera. The angle between the breaking wave and the reference rope was later measured from the photo to determine the breaking angle of the wave (see Fig. 16). Note that this procedure assumes the alongshore direction remained constant throughout the test. In actuality, however, the alongshore contours are changing, as evidenced in Figure 15.

After a run-time of 30 minutes, wave data were collected for 2 minutes. A sample strip-chart record is shown in Figure 17. The wave height was determined from this record. For a given length of wave record, a horizontal line was drawn along what appeared to be the average wave-crest elevation. A horizontal line was also drawn for the wave troughs. The distance between the two lines was measured to determine the average wave height,  $\bar{H}$ . This procedure assumes that a nearly uniform distribution of wave heights is produced by the monochromatic wave generators.



Figure 15. Example of overhead photo.



Figure 16. Example of photo of breaking wave.

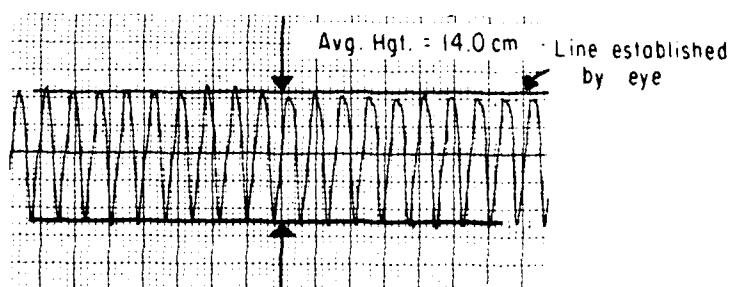


Figure 17. Example of strip-chart wave record.

Immediately after the wave data were collected, dye was injected into the surf zone, as discussed in Section III, and the leading edge of the dye was timed over a distance of approximately 4 meters (see Table 2) to determine the longshore current velocity. Also recorded were the station at which the dye left the downdrift edge of the beach and the station at which the waves were breaking. Therefore, the determination of whether the dye moved offshore, along the breaker line, or onshore could be made. Most of the dye injections traveled along the breaker line.

During the hourly cycle, sand was continually picked up from the trap area and weighed when a bin was full. A complete record of the amount of sand moved in a given time period existed only at the end of the day after the waves had been stopped and all the remaining sand had been picked up and weighed. Therefore, the longshore transport rate can be given for a daily cycle or a test cycle only.

## 2. Daily Cycle.

At the start of every test day (see Fig. 14), the water temperature was recorded, the water level was corrected to 0.710 meter, the wave gages were calibrated, and a check of all equipment was made. The hourly cycles were then started. Four hourly cycles were usually completed each day.

Shortly before the waves were turned off at the end of the day, photos of the surf zone were taken from the side (see Fig. 18 for examples). After the waves were stopped, all the sand in the sand trap, on the downdrift concrete apron, and in the downdrift deposition area was moved to the weighing station and weighed. The day's longshore transport movement was then determined after the final weighing. This quantity, divided by the total number of run-hours, provided the immersed weight longshore transport rate for the day.

## 3. Test Cycle.

At the beginning of each test, new test values for the wave period,  $T$ , the generator angle,  $\alpha_g$ , and the generator eccentricity,  $Ecc$ , were selected and set (Fig. 14).  $Ecc$  is half the distance the generator bulkhead moves. The combination of period and eccentricity produced a predicted wave height, using the calibration curve of the generators (see Fig. 2 in Fairchild, 1970). This guided the selection of  $T$  and  $Ecc$  but was not used for wave height determination.

The beach was regraded to the shore-normal profile (see Fig. 6) before each new test. This included raking the beach to remove all traces of ripples from the prior test. The basin was usually flooded to cover the entire beach and left over a weekend to allow the new beach to stabilize before the new test cycle began.

After the test was completed, the basin was drained in 10-centimeter increments, producing depth contours of 0, 10, 20, 30, 40, 50, and 60 centimeters. An overhead photo of the waterline was taken at each increment. An example series is shown in Figure 19. Surveys of the beach were then taken, using a standard level and rod, along ranges 1.5, 2, 3, 4, 5, 6, 7, and 7.6 meters. The elevation on each range was read at all major breaks in slope.

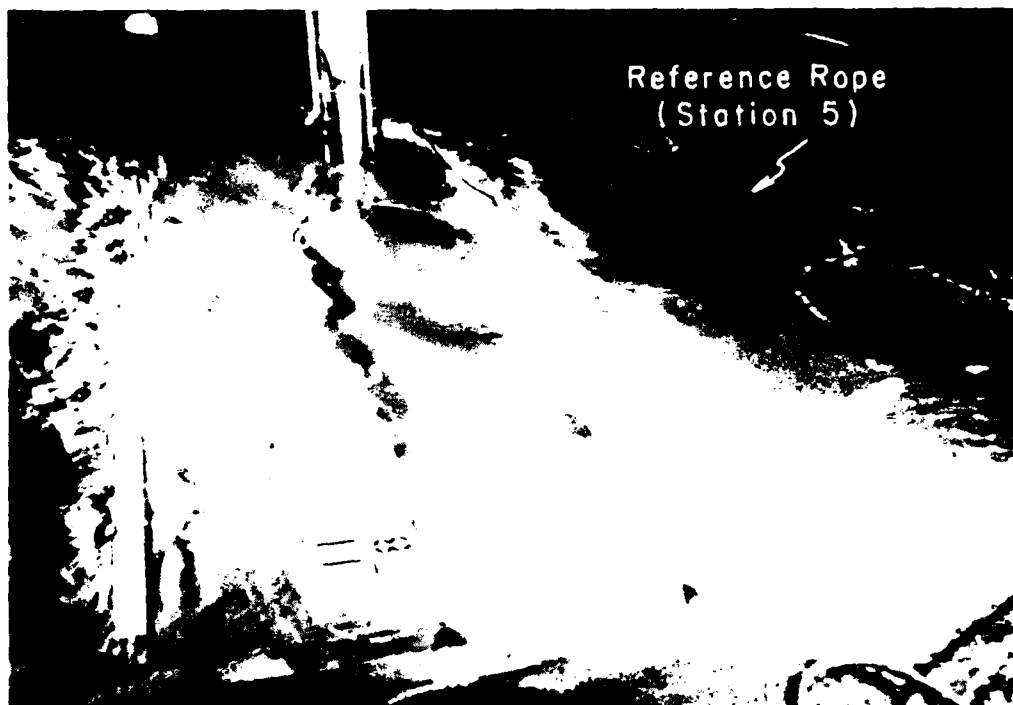


Figure 18. Example of surf zone photos.

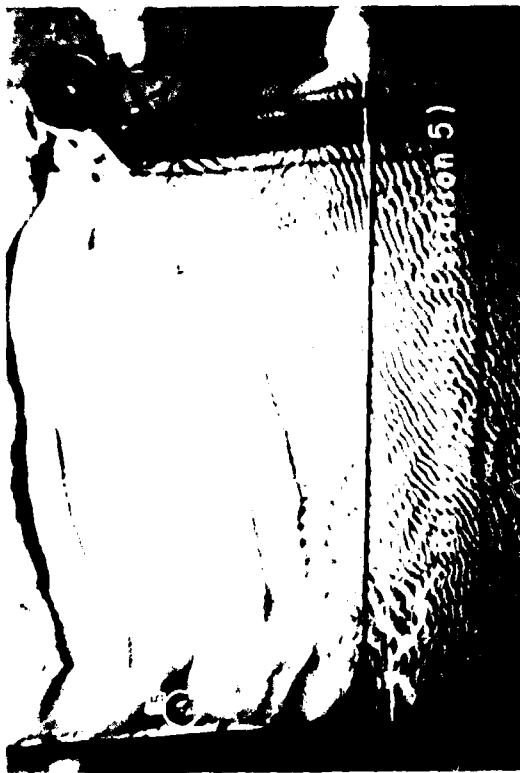
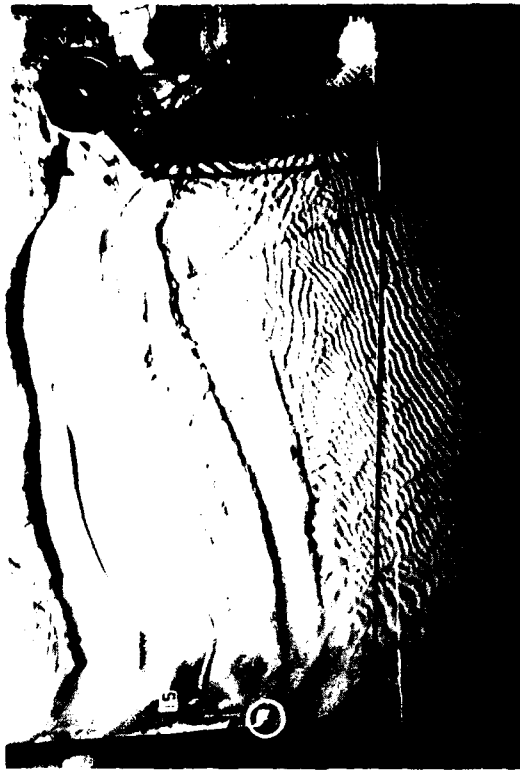


Figure 19. Example series of drainage photos.

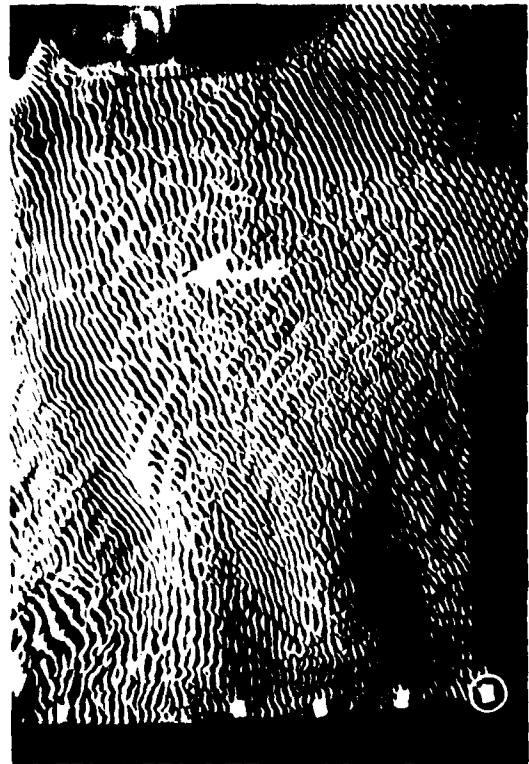


Figure 19. Example series of drainage photos.--Continued



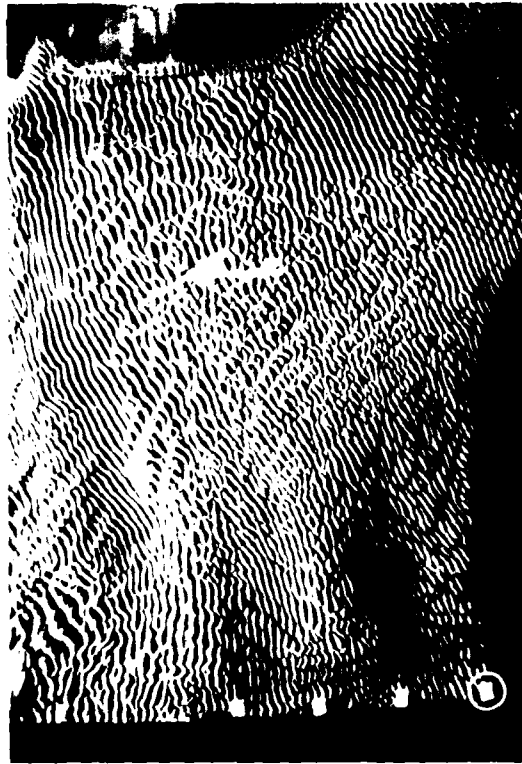


Figure 19. Example series of drainage photos.--Continued

Finally, photos of the beach were taken at close range to document important bed forms, such as ripples and bars (Fig. 20).

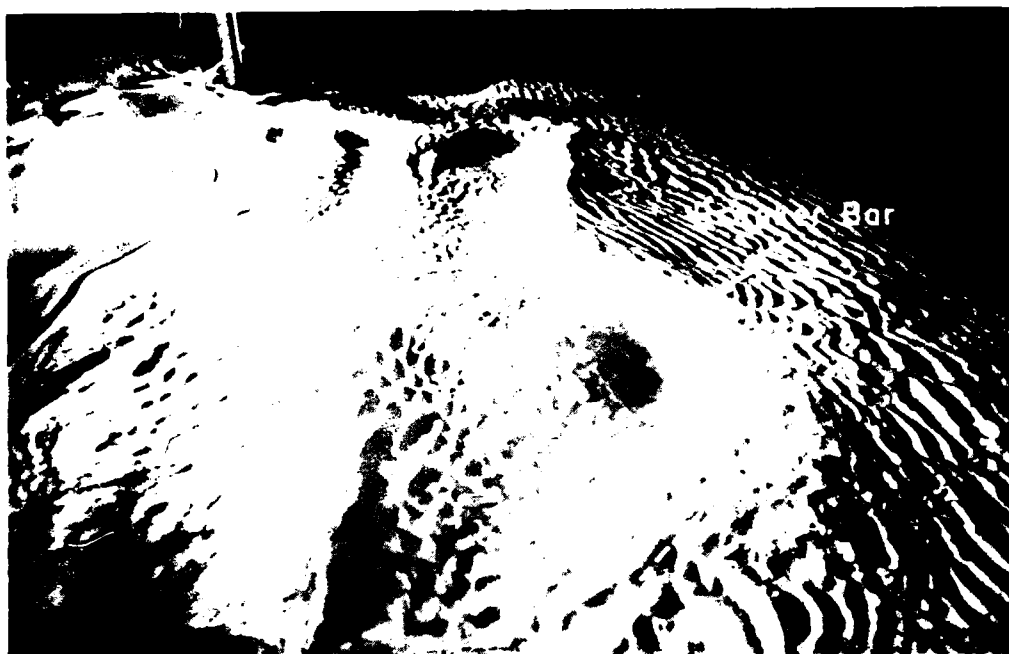


Figure 20. Example of bed-form photo.

#### 4. Range of Variables.

Table 3 gives the test variables for all 15 tests. Note that the 0.710-meter water depth and the sand were the same for all tests. The wave heights listed are the average of all the hourly measurements of gages 1 and 2 for each test.

Table 3. Test cycle variables and data.

Test No.	Total run-time (hr)	Period (s)	Generator angle (degrees)	Water temperature (°C.)	Wave height (cm)	Breaker angle (degrees)	Longshore current (cm/s)	$I_L \cdot 10^4$ (N/s)
1	25	2.35	10	22.8	8.2	8	-- <sup>1</sup>	6,117
2	50	2.35	10	22.8	8.0	7	--	6,890
3	24	1.50	10	20.7	12.8	7	--	8,396
4	24	1.90	10	15.9	11.5	7	--	6,188
5	24	3.00	10	12.6	7.2	3	3	7,544
6	24	2.35	20	12.3	7.7	9	17	9,966
7	24	1.90	20	11.7	10.2	11	30	7,281
8	24	1.90	20	13.8	10.0	11	20	3,446
9	24	1.50	20	14.7	10.3	15	27	5,227
10	24	1.90	20	18.8	16.5	15	29	10,605
11	24	2.35	00	20.7	7.4	-5	0	892
12	24	2.35	30	23.1	8.1	20	28	16,328
13	24	3.00	30	23.2	6.9	15	7	11,941
14	24	3.00	30	19.4	15.6	30	23	32,938
15	24	1.90	30	16.1	15.1	19	40	25,502

<sup>1</sup>Not available.

## V. DATA

The data collected during the experiments are provided in Appendixes A to D. Appendix A contains the hourly and daily data for each test. Appendix B lists the beach survey data, which are plotted in Appendix C, taken after each test. Appendix D provides 35-millimeter photos of the beach taken during a test with the waves stopped.

### 1. Hourly and Daily Data in Appendix A.

Table 4 is an example of how the daily and hourly data are tabulated in Appendix A. Column 1 lists the run-time over which the data were collected. Run-time is defined as the cumulative time of wave operation from the beginning of the test. A run-time of 05 10 means that up to that point, waves had been run at the beach for a cumulative total of 5 hours and 10 minutes. This would be the case even if the first wave had been run 2 days before.

Column 2 lists the length of time (in minutes) waves were stopped to take overhead photos of the beach. The letters CFD or TC indicate that the testing was completed for the day or the test was completed. Between any two entries in column 2, the waves were run continuously. For example, from the beginning of the test at run-time 00 00 to run-time 01 00 (see Table 4), the waves were continuously run. At that point the waves were stopped for 5 minutes to take overhead photos of the beach. The waves were then restarted and run continuously until run-time 02 00.

Columns 3 and 4 list the water temperature and the water depth, respectively. These measurements were taken in the morning before the testing started and in the afternoon after the testing stopped.

Column 5 lists the immersed weight of sand moved during testing from the previous entry in the column. A value is always listed with a CFD or TC entry since it was only at the end of the day that the balance of sand not weighed during the time the waves were running could be picked up and weighed. In Table 4, the value of 4,227 immersed pounds of sand is the quantity of sand transported from run-hour 04 00 to 08 00. This column is not a cumulative listing of sand transported.

Columns 6, 7, 8, and 9 list the wave heights measured by gages 1, 2, 3, and 4A or 4B, respectively. Section III discusses the locations of these gages, which are shown in Figure 7. Column 10 lists the breaker angles measured from the Polaroid 4- by 5-inch photos of the breaking waves (see Fig. 16). Column 11 lists the longshore current velocity measured by dye injections, as discussed in Section III. Column 12 lists the breaker type, using the following code: sg, surging; p, plunging; c, collapsing; and sp, spilling. A double entry indicates both types of breakers were evident with the first type predominant.

### 2. Summary Data Table.

For a comparison of test conditions, Table 3 provides the average values of water temperature, wave height, wave breaker angle, longshore current velocity, and average longshore transport rate in immersed pounds per second for each test. Also included are the wave period and generator angle.

Table 4. Example of hourly and daily data tables in Appendix A.

RUN TIME HR MN	MINUTES STOPPED	WATER TEMP CELSIUS	WATER DEPTH CM	IMMERSED HEIGHT LBS	GENERATOR ANGLE 30 DEGREES				BREAKER ANGLE DEGREES	LONGSHORE CURRENT CM/S	BREAKER TYPE
					GAGE 1	GAGE 2	GAGE 3	GAGE #A/H			
0 0		22.7	71.0						15		
0 30					6.6	7.6	7.1	7.1	15	6	SG
1 0	5										
1 30					6.7	8.0	7.3	6.4	15	8	SG
2 0	10										
2 30					6.1	7.6	7.0	6.1	10	8	SG
3 0	5										
3 30					6.2	7.8	6.7	6.0	10	8	SG
4 0	CFD	23.1	70.4	4239							
4 30		22.9	71.0								
5 0					7.2	7.0	5.9	11.9	10	8	SG
5 30	10										
6 0					6.7	6.8	6.1	11.6	10	7	SG
6 30	10										
7 0					6.8	6.9	6.0	11.9	12	8	SG
7 30	10										
8 0					7.1	6.8	6.4	11.1	13	9	SG
8 30	CFD	23.1	71.0	4227							
9 0		23.6	71.0								
9 30					6.3	7.3	7.0	11.7	15	9	SG
10 0	15										
10 30					6.2	7.0	7.0	12.2	15	8	SG
11 0	CFD	23.8	70.9	1861							
11 30		23.7	71.0								
12 0					6.6	6.6	6.2	10.6	20	6	SG
12 30	10										
13 0					7.2	6.5	6.8	9.9	14	9	SG
13 30	10										
14 0					7.1	6.4	6.9	9.4	16	10	SG
14 30	10										
15 0					7.0	6.6	6.0	9.1	16	8	SG
15 30	CFD	23.5	71.0	3566							
16 0		23.5	71.0								
16 30					7.1	6.8	6.5	9.2	10	9	SG
17 0	10										
17 30					6.8	6.8	6.4	9.6	10	7	SG
18 0	10										
18 30					6.5	6.7	5.8	8.6	15	7	SG
19 0	10										
19 30					6.2	6.7	6.8	10.9	12	7	SG
20 0	CFD	22.9	71.0	3633							
20 30		22.8	71.0								
21 0					6.6	7.0	6.1	6.4	16	5	SG
21 30	20										
22 0					6.5	7.1	6.2	6.5	10	5	SG
22 30	60										
23 0					5.9	7.6	7.3	7.5	10	8	SG
23 30	10										
24 0					5.8	6.2	7.2	8.0	12	6	SG
24 30	CFD	23.1	71.0	3789							
25 0											
25 30					5.7	7.6	6.5	6.8	13	5	SG
26 0	5										
26 30					6.2	7.9	7.7	7.3	11	8	SG
27 0											
27 30											
28 0	TC	23.1	71.0	1880							

<sup>1</sup>CFD = testing completed for day; TC = testing completed.

### 3. Survey Data.

After each test, the SPTB was drained and the beach was surveyed. The distance and elevation pairs are listed in Appendix B and plotted in Appendix C. The elevation datum is the stillwater level (SWL), which corresponded to a 0.710-meter water depth.

### 4. Overhead Photos.

Every hour during testing, the waves were stopped to take an overhead 35-millimeter photo of the beach (see Fig. 15). The photos show the waterline, the longshore bar, and the swash zone. They are useful for a qualitative description of how the beach responded to the waves. Appendix D contains a series of photos for run-times 01 00, 08 00, 16 00, and 24 00.

## VI. DATA ANALYSIS

This section includes the data analysis to determine the relations between  $I_L$  and  $S_{xy}$  and  $I_L$  and  $P_{lb}$ . The empirical coefficients found from these relations are then, in turn, related to the surf similarity parameter,  $\xi$ , which is adapted to the data collected. Also included is an explanation of the calculations of  $S_{xy}$ ,  $P_{lb}$ ,  $\xi$ , and  $I_L$ , along with plots of the various relationships. The wave height used in the calculations is that measured at the toe of the beach (average of gages 1 and 2 wave heights). The breaker wave height, which would have been a better value, was not used for the following reasons. The wave height at the toe of the beach was measured for all 15 tests; the breaker height was not. Also, only one gage was used to measure breaker height, while two were used at the beach toe. The significant difference in height between waves measured at the two beach toe gages (see App. A) indicates that some wave height variability existed along the wave crest. Therefore, the average of the measurements at the two beach toe gages is probably a more reliable estimate of the entire wave passing the toe than the one gage measurement at the breaker is of the entire breaker wave. A comparison of the data in this report with past studies is shown in a  $Q$  versus  $P_{lb}$  graph.

#### 1. Calculation of $S_{xy}$ .

Equation (7)

$$S_{xy} = \left( \frac{\rho g \bar{H}^2}{8} C_g \cos \alpha \right) \frac{\sin \alpha}{C}$$

was used to calculate  $S_{xy}$ . Rearranging the equation,

$$S_{xy} = \frac{\rho g}{16} \bar{H}^2 n \sin 2\alpha \quad (21)$$

where  $n$  is the ratio  $C_g/C$  and a function of the water depth and wave period or length.  $S_{xy}$  was calculated at the toe of the beach by using the average of the wave heights measured at that location (see Fig. 7), and by using the generator angle for  $\alpha$ . This was calculated for each set of wave data. Thus, for the standard 24-hour test, 24 values of  $S_{xy}$  were calculated (see App. E). The average of  $S_{xy}$  for each test is listed in Table 5.

Table 5. Test cycle calculations.

Test	Total run time (hr)	S <sub>xy</sub> (N/m)	P <sub>lb</sub> (J/m/s)	I <sub>l</sub> (N/s)	K <sub>s</sub> (m/s)	K <sub>p</sub>	ξ
1	25	1.179	2.201	0.6116	0.5190	0.2779	0.6604
2	30	1.137	2.043	0.6889	0.6058	0.3373	0.6686
3	24	2.280	3.232	0.8396	0.3682	0.2598	0.3374
4	24	2.158	3.615	0.6188	0.2868	0.1712	0.4508
5	24	0.987	0.789	0.7544	0.7640	0.9557	0.8997
6	24	1.977	2.144	0.9966	0.5042	0.4648	0.6815
7	24	3.161	4.158	0.7281	0.2303	0.1751	0.4787
8	24	3.018	3.918	0.3446	0.1142	0.0880	0.4835
9	24	2.808	4.286	0.5227	0.1862	0.1220	0.3761
10	24	8.250	14.761	1.0605	0.1285	0.0718	0.3764
12	24	2.942	4.839	1.6328	0.5550	0.3374	0.6644
13	24	2.241	2.948	1.1941	0.5328	0.4051	0.9190
14	24	11.578	28.802	3.2938	0.2845	0.1144	0.6112
15	24	9.253	13.536	2.5502	0.2756	0.1884	0.3934

2. Calculation of P<sub>lb</sub>.

Equation (10)

$$P_{lb} = \left( \frac{\rho g \bar{H}^2}{8} C_g \cos \alpha \right)_i \sin \alpha_b$$

was used to calculate P<sub>lb</sub>. The term in the parentheses, like S<sub>xy</sub>, was calculated at the toe of the beach. However, the sine term used the breaker angle as measured from the photos of the breaking waves. The breaker angle used in the calculation was the average of the breaker angles collected 30 minutes before and after the wave data were collected (see Fig. 14). P<sub>lb</sub> was calculated for each set of wave data, 24 values of P<sub>lb</sub> were calculated for the standard 24-hour test (see App. E). The average of P<sub>lb</sub> for each test is listed in Table 5.

## 3. Calculation of ξ.

The surf similarity parameter of Kamphuis and Readshaw (1978) was presented in equation (17) as

$$\xi_b = \frac{\tan \beta}{(H_b/L_o)^{1/2}}$$

For the data in this report, a different surf similarity parameter is needed since  $\bar{H}$  will be substituted for H<sub>b</sub>, as discussed at the beginning of this section. Therefore, the surf similarity parameter in the following analysis is

$$\xi = \frac{\tan \beta}{(\bar{H}/L_o)^{1/2}} \quad (22)$$

The same beach slope was used for all 15 tests and was determined as shown in Figure 21. A value of  $\xi$  was calculated for each test using the average  $\bar{H}$  for the entire test. These values are listed in Table 5.

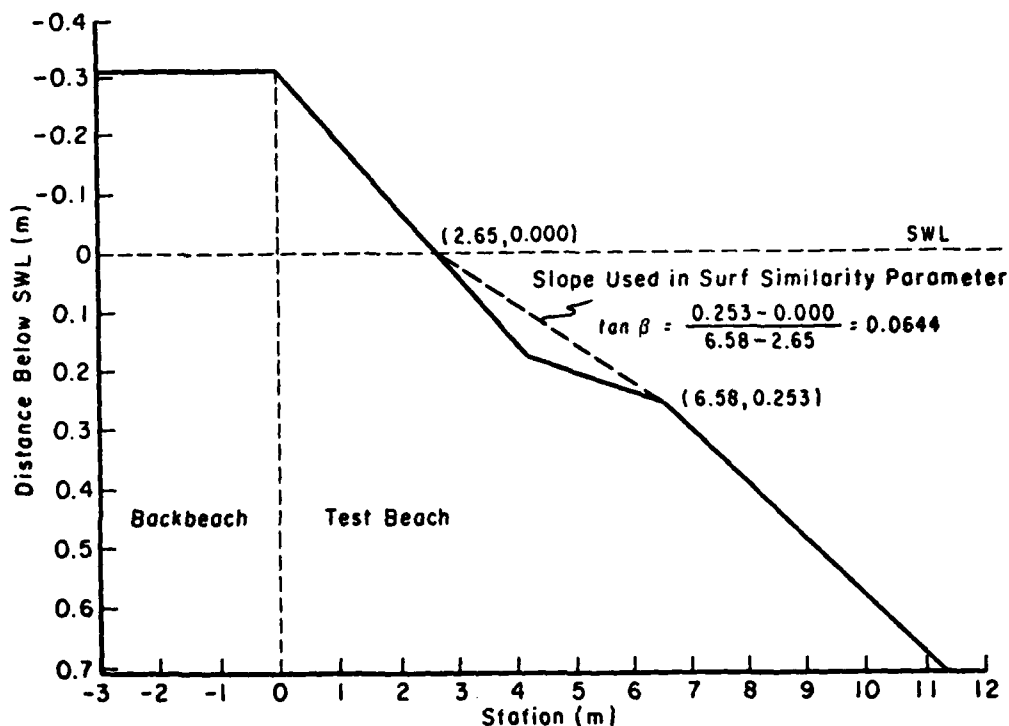


Figure 21. Determination of beach slope used to calculate the surf similarity parameter.

#### 4. Special Tests.

Three tests were performed under special circumstances. Test 2 was a repeat of test 1; test 8 was a repeat of test 7, except the sand feeder was moved shoreward; and test 11 was done with a generator angle of zero.

Tests 1 and 2 were both run with a period of 2.35 seconds, a generator angle of  $10^\circ$ , and a generator eccentricity of 5.97 centimeters. Test 1 ran for 25 hours, test 2 for 50 hours. A twofold comparison of the two tests was originally planned. The first 25 hours of test 2 data was to be compared to the test 1 data, and then, both sets of data were to be compared to the last 25 hours of test 2. Unfortunately, due to an experimental error, only the first 30 hours of the test 2 longshore transport data was collected accurately. Therefore, the only comparison made was test 1 to the first 30 hours of test 2. Reference to test 2 in the remainder of the report refers to the first 30 hours only. Appendix A contains all 50 hours of test 2 data.

Table 6 compares the results of the two tests. The differences listed give an indication of the repeatability of the data collection. The longshore transport rate changed by 12.6 percent, which is a significant variation. This is an inherent problem of longshore transport tests, indicating that some important unknown factors are at work.

Table 6. Comparison of tests 1 and 2.

Test	Total run-time (hr)	Avg H (cm)	Avg $\alpha_b$ (degrees)	$I_\ell$ (N/s)	$S_{xy}$ (N/m)	$P_{\ell b}$ (J/m/s)
1	25	8.17	8	0.612	1.18	2.20
2	30	8.03	7	0.689	1.14	2.04
Pct difference <sup>1</sup>		-1.7	-12.5	+12.6	-3.4	-7.3

$$^1 \text{Pct difference} = \frac{(\text{Test 1} - \text{Test 2}) 100}{\text{Test 1}}$$

Tests 7 and 8 were both run with a period of 1.90 seconds, a generator angle of  $20^\circ$ , and a generator eccentricity of 5.97 centimeters. The only difference was that the sand feeder, which was located at the SWL for all other tests, was moved shoreward 1.4 meters for test 8. The feeder was moved because the shoreline at the end of test 7 significantly angled shoreward toward the downdrift side of the beach. This can be seen in the test 7 photos in Appendix D. The feeder was moved shoreward to see if a straight shoreline resulted. It did, as the photos in Appendix D for test 8 show. Another major effect was the change in  $I_\ell$  from 0.728 newton per second for test 7 to 0.345 newton per second for test 8, a decrease of 53 percent. Test 8 is excluded from the remaining data analyses.

Test 11 was run with a period of 2.35 seconds, a generator angle of  $0^\circ$ , and a generator eccentricity of 5.97 centimeters. The test was meant as a control to determine the amount of sand moved by the diffusion caused by breaking waves. This value of  $I_\ell$  for test 11 was 0.089 newton per second. A comparable quantity of sand, 0.059 newton per second, also moved updrift. Test 11 is also excluded from the remaining data analyses.

##### 5. Daily Cycle Graphs.

As discussed previously, longshore transport could be measured only on a daily cycle or test cycle basis. For the typical 24-hour test, six values of longshore transport rate were calculated. Each rate covered a period of 4 run-hours. During this time period, four values of  $S_{xy}$  and  $P_{\ell b}$  were calculated, averaged, and related to the corresponding value of  $I_\ell$ . These values are listed in Appendix F and plotted in Figures 22 and 23. Table 7 lists the important statistical parameters.

Table 7. Daily cycle statistics.

Relation	Figure No.	$r^2$	Least squares lines		
			Standard slope	Y-intercept	Through origin slope
$I_\ell$ versus $S_{xy}$	22	0.74	0.21	0.38	0.28
$I_\ell$ versus $P_{\ell b}$	23	0.73	0.09	0.58	0.13

The square of the correlation coefficients,  $r^2$ , represents the fraction of the variation of  $I_\ell$  about its mean which is explained by the abscissa term.  $r^2$  for  $S_{xy}$  and  $P_{\ell b}$  are 0.74 and 0.73, respectively. These numbers show that  $I_\ell$  correlates well with both terms to approximately equal degrees. The least squares lines listed in Table 7 are in Figures 22 and 23, which also include the least squares lines calculated with the limitation that the lines pass through the origin. The slopes of these lines are 0.28 for the  $I_\ell$  versus  $S_{xy}$  graph and 0.13 for the  $I_\ell$  versus  $P_{\ell b}$  graph.



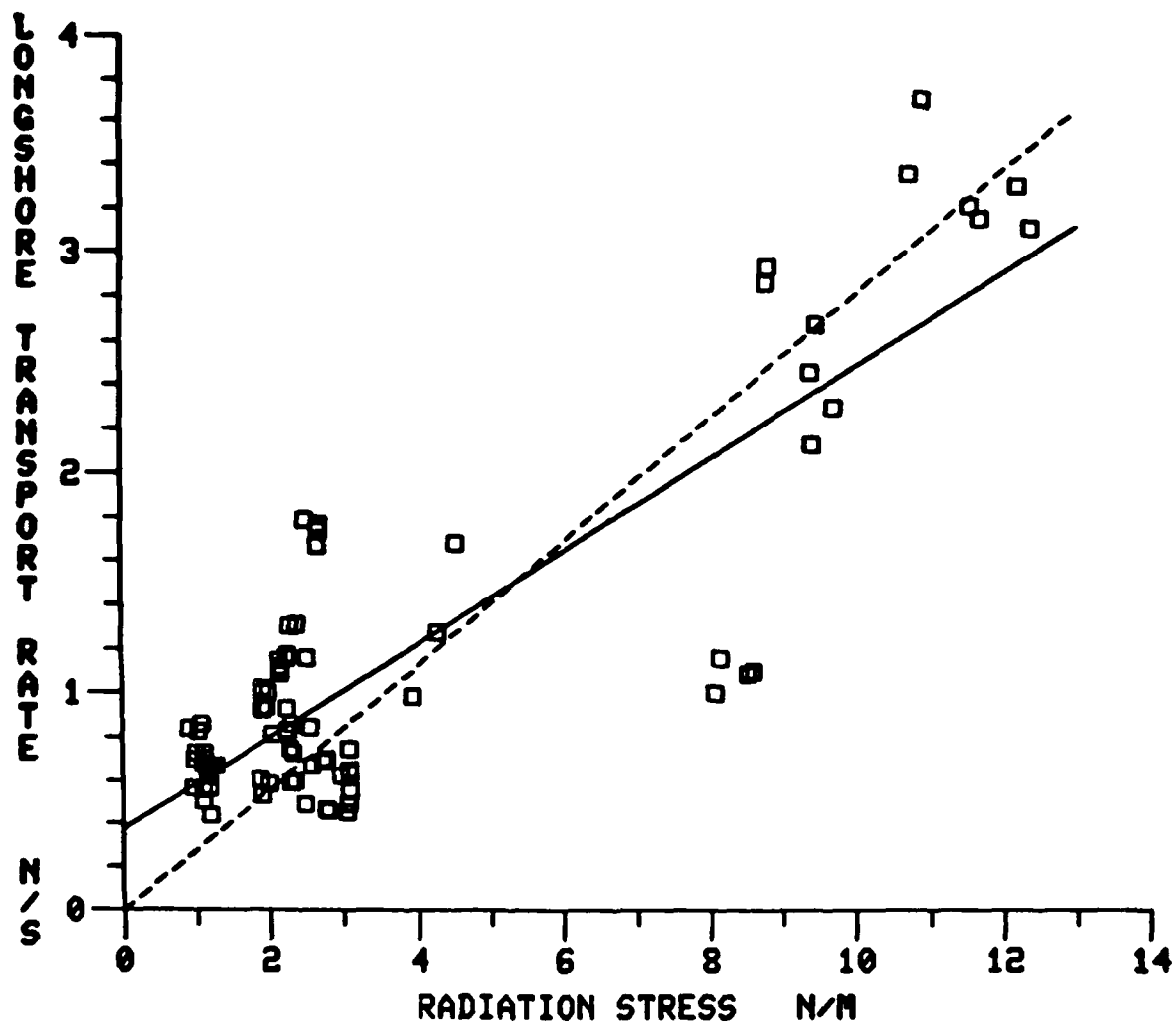


Figure 22. Relation between longshore transport rate,  $I_l$ , and radiation stress,  $S_{xy}$ , using daily cycle data (tests 8 and 11 excluded).

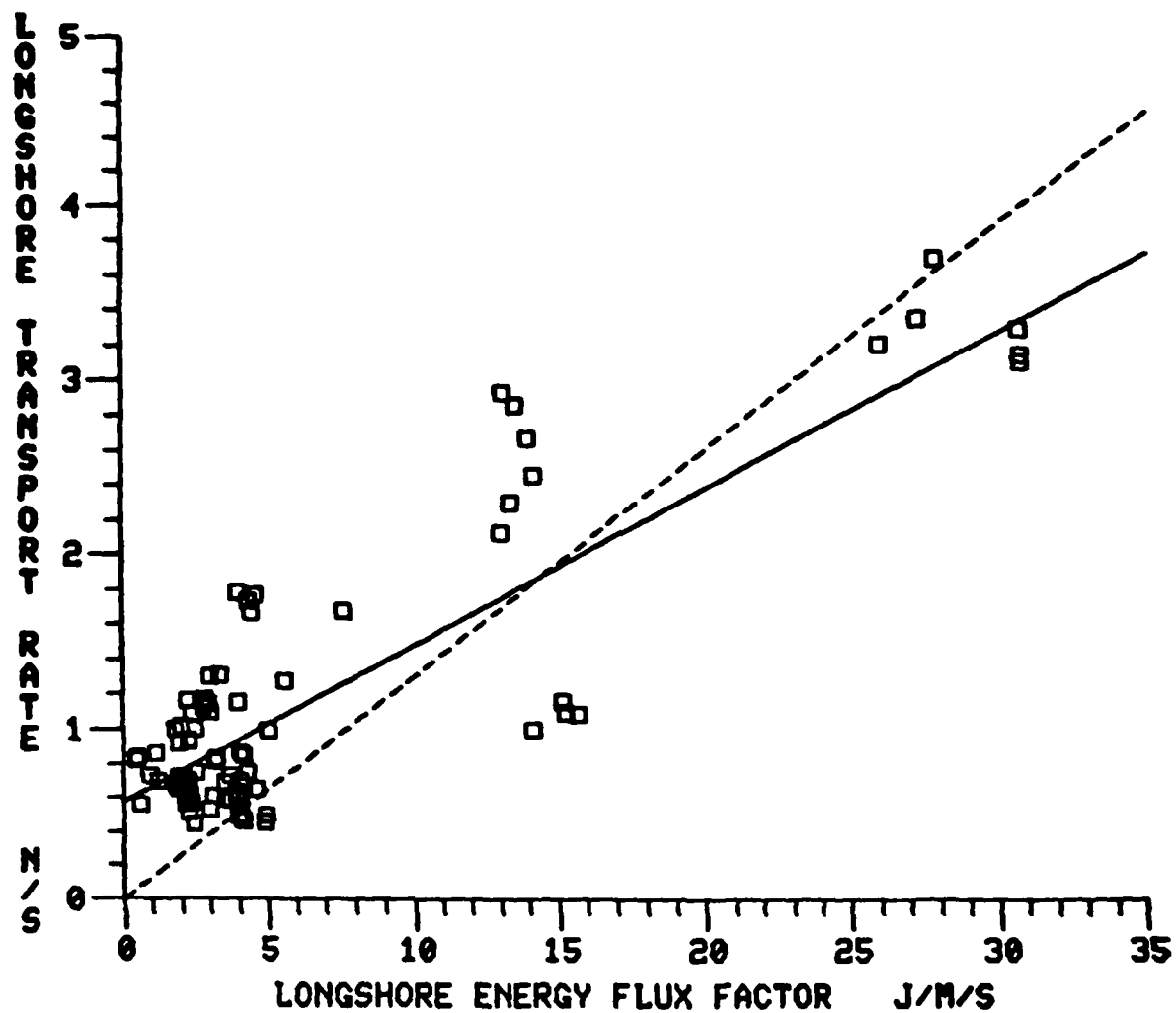


Figure 23. Relation between longshore transport rate,  $I_L$ , and longshore energy flux factor,  $P_{Lb}$ , using daily cycle data (tests 8 and 11 excluded).

## 6. Test Cycle Graphs.

The average longshore transport rate for each test was calculated and compared with the test average of  $S_{xy}$  and  $P_{lb}$ . These values are listed in Table 5 and plotted in Figures 24 and 25. Statistical values are in Table 8.  $r^2$  for  $I_l$  versus  $S_{xy}$  and  $I_l$  versus  $P_{lb}$  are 0.72 and 0.74, respectively. As with the daily cycle calculations,  $I_l$  is shown to correlate well with both terms to approximately equal degrees. Figures 24 and 25 include both the standard least squares line and the least squares line forced through the origin. The slopes of the latter lines are 0.26 for the  $I_l$  versus  $S_{xy}$  graph and 0.13 for the  $I_l$  versus  $P_{lb}$  graph.

Table 8. Text cycle statistics.

Relation	Figure No.	$r^2$	Least squares lines		
			Standard slope	Y-intercept	Through origin slope
$I_l$ versus $S_{xy}$	24	0.72	0.21	0.40	0.26
$I_l$ versus $P_{lb}$	25	0.74	0.09	0.58	0.13
$K_s$ versus $\xi$	26	0.70	0.82	-0.07	
$K_p$ versus $\xi$	27	0.56	0.89	-0.22	

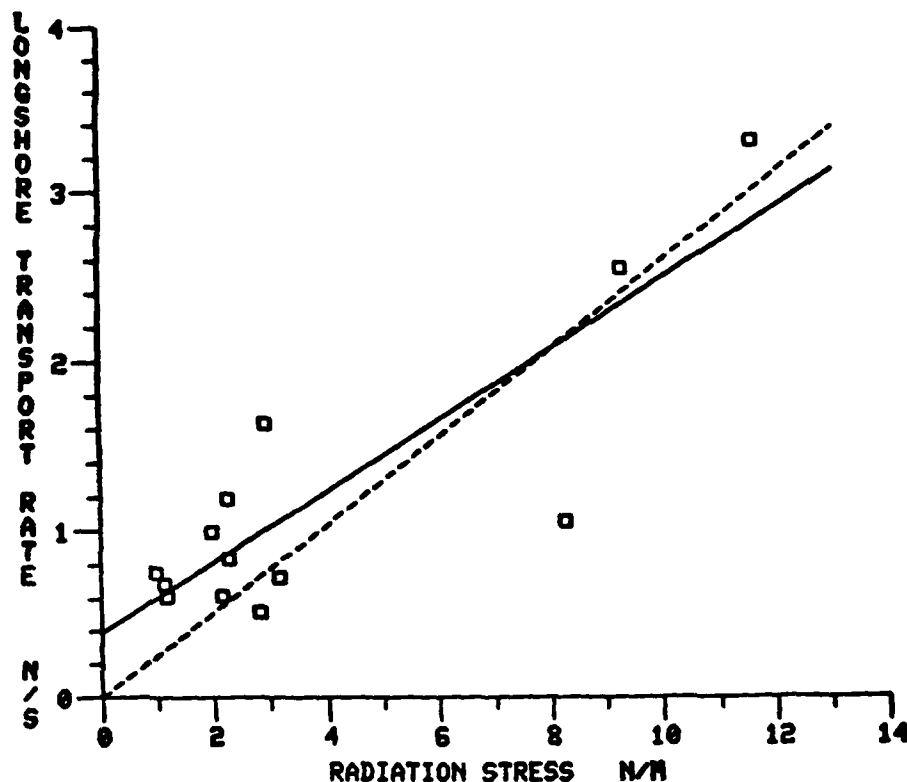


Figure 24. Relation between longshore transport rate,  $I_l$ , and radiation stress,  $S_{xy}$ , using test cycle data (tests 8 and 11 excluded).

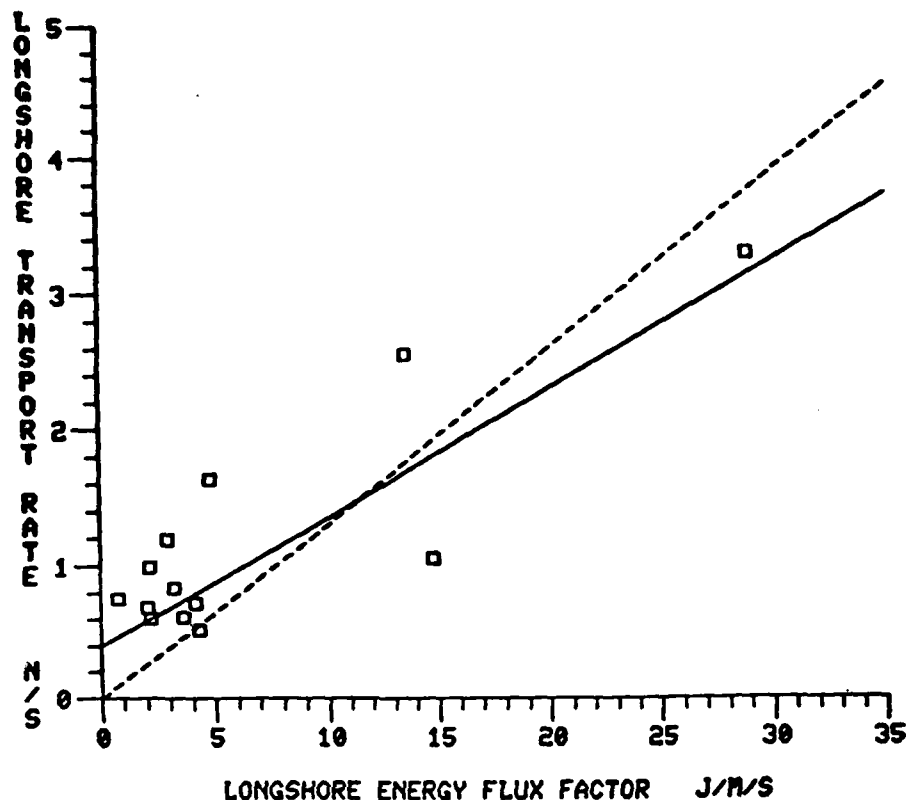


Figure 25. Relation between longshore transport rate,  $I_l$ , and longshore energy flux factor,  $P_{lb}$ , using test cycle data (tests 8 and 11 excluded).

#### 7. Surf Similarity Relation.

Figures 26 and 27 were drawn to test the dependence of  $K_s$  and  $K_p$  on  $\xi$ . Test numbers are indicated in the figures. Table 8 lists the statistics. The  $K$  terms were calculated using equations (15) and (16). These graphs show that  $K$  is far from being constant, as is commonly assumed, and that it is strongly related to  $\xi$ .

#### 8. Comparison to Past Data.

The units of  $I_l$  and  $P_{lb}$  were converted to those used in the SPM and plotted in Figure 28, which is taken from Figure 4-36 of the SPM. The SPM figure was modified by shifting the x-axis to convert from  $P_{ls}$  to  $P_{lb}$ . Equation (13) shows the relation between  $P_{lb}$  and  $P_{ls}$ . Test numbers for the data points of this report are noted in Figure 28.

Two major observations are immediately apparent. The first is that the laboratory data in this report, as in laboratory data from past reports, have considerable scatter. Since the surf similarity parameter,  $\xi$ , in this report varies by a significant amount for the different tests, as shown in Figures 26 and 27, some scatter is expected. The surf similarity parameter, of course, does not explain all of the scatter in the laboratory data. There are still some laboratory and scale effects which are not yet understood.

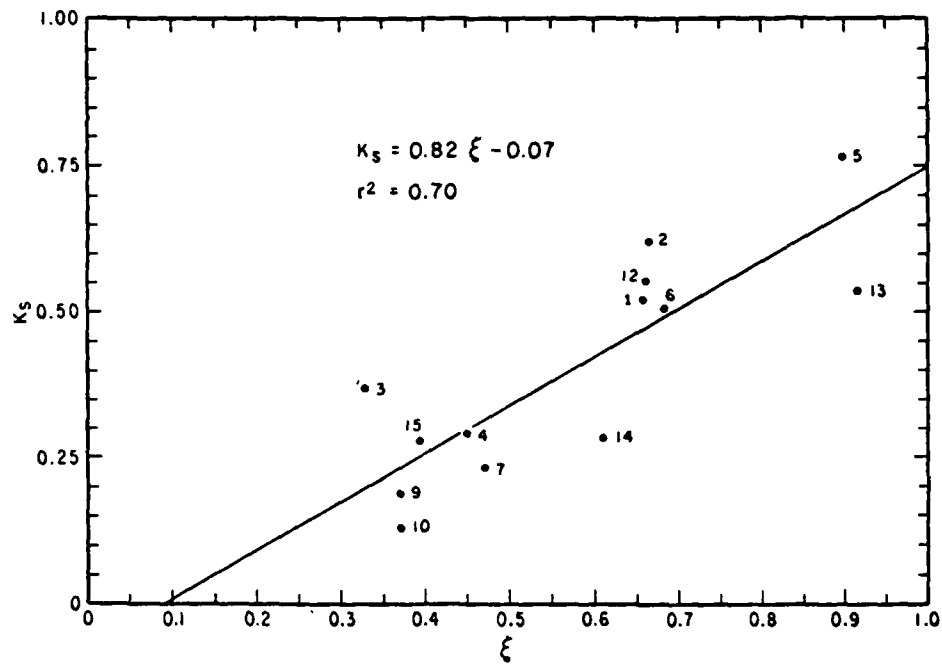


Figure 26. Relation between  $K_s$  and the surf similarity parameter,  $\xi$ , using test cycle data (tests 8 and 11 excluded).

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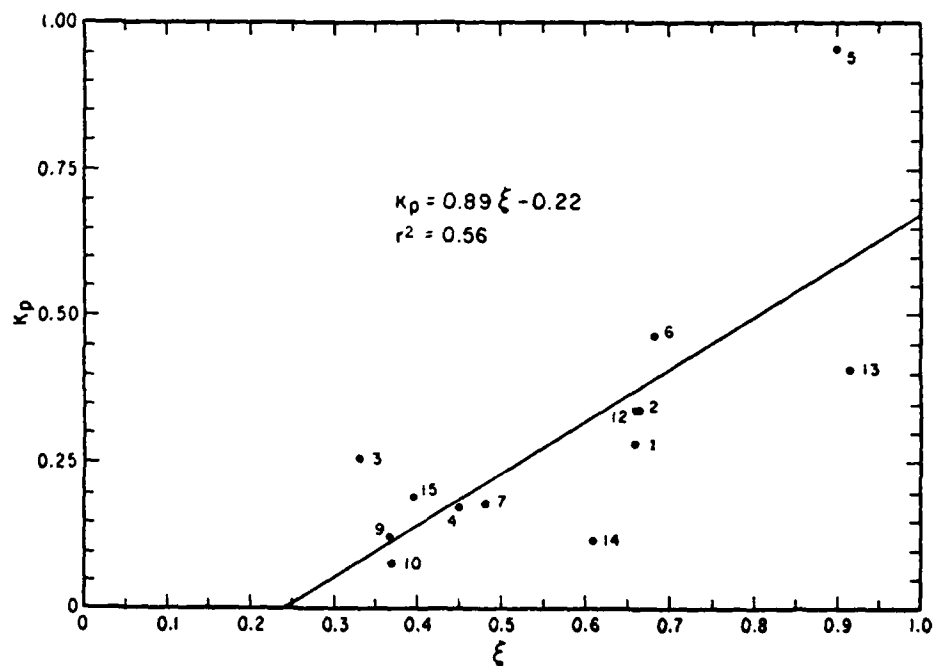


Figure 27. Relation between  $K_p$  and the surf similarity parameter,  $\xi$ , using test cycle data (tests 8 and 11 excluded).

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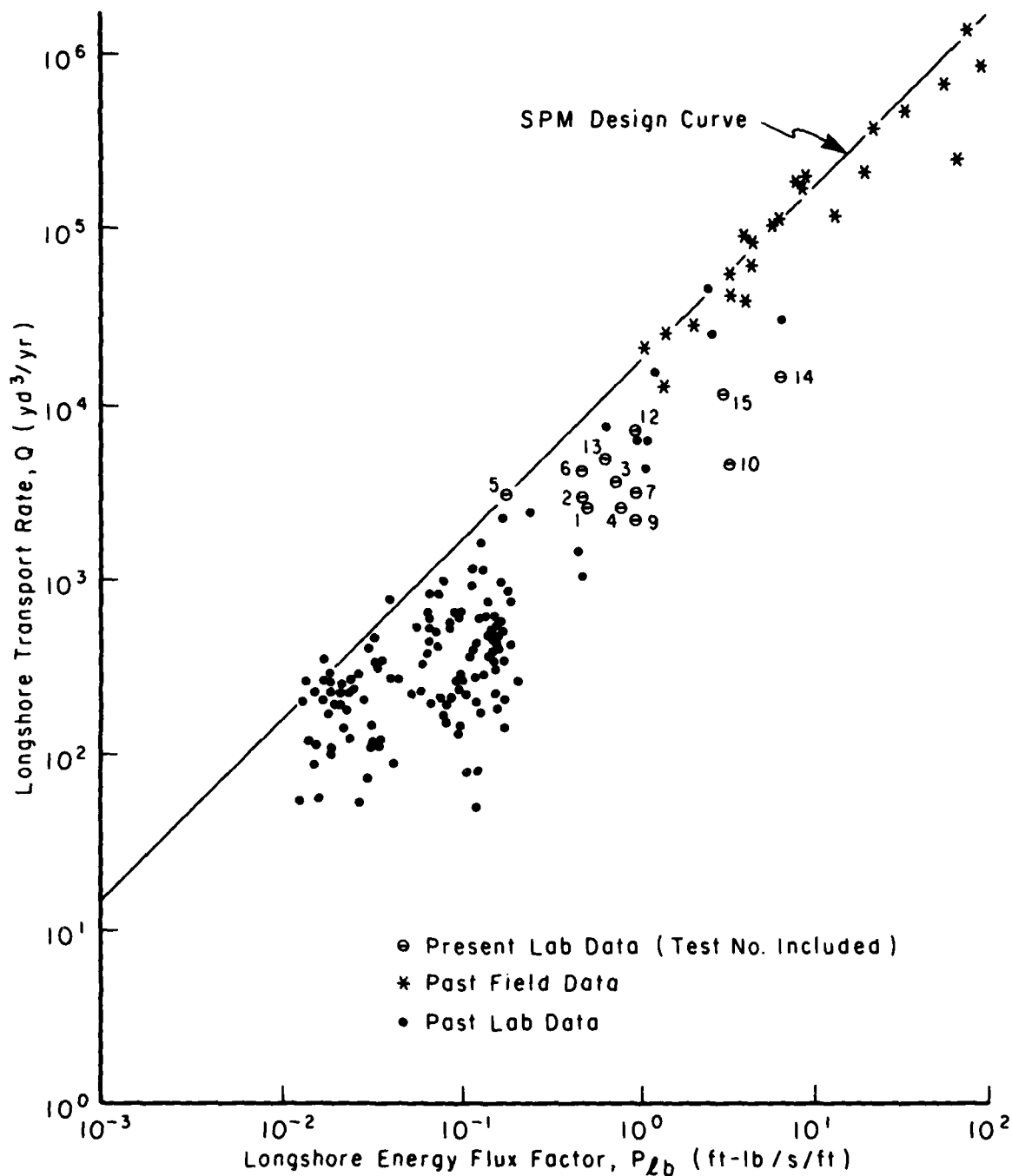


Figure 28. Comparison of data in this report to past reports, using SPM Figure 4-36 (tests 8 and 11 excluded).

The second observation is that most of the data fall beneath the SPM curve connoting low values of  $K_p$ . Since the SPM curve is based on field data, mostly from Komar and Inman (1970), a possible explanation is that the field data were collected under conditions of higher values of  $\xi$  than those for the laboratory data. Kamphuis and Readshaw (1978) suggest that Komar and Inman's data were indeed collected under conditions of high  $\xi_b$ . It seems reasonable to assume that the  $\xi$  values were also high.

## VII. SUMMARY AND CONCLUSIONS

An analysis of the radiation stress,  $S_{xy}$ , and the energy flux factor,  $P_{lb}$ , shows that both predict longshore transport rate,  $I_l$ , to comparable degrees. Approximately 70 percent of the variance of  $I_l$  about its mean is explained by each term. There appears to be no major advantage in choosing one over the other to predict the longshore transport rate. However,  $S_{xy}$  has the advantage of being constant seaward of the breaker zone while  $P_{lb}$  is not. This makes the calculation of  $S_{xy}$  more convenient than  $P_{lb}$ , which must be determined at the breaker line. On the other hand,  $P_{lb}$  has the advantage of having the same units as  $I_l$ , which means that  $K_p$  is dimensionless.

The empirical coefficients,  $K_s$  and  $K_p$ , are far from constant although  $K_p$  is commonly assumed to be so in practice. Part of the variation of the coefficients can be related to the variation of the surf similarity parameter,  $\xi$ , as shown in Figures 26 and 27. These figures show that  $K_s$  and  $K_p$  will increase with  $\xi$ . The considerable scatter evident in Figure 28 can be partly explained by the relation between the empirical coefficients and  $\xi$ . The data in this report and past laboratory and field data are compared in Figure 28. The laboratory data generally predict lower values of  $I_l$  for a given  $P_{lb}$  compared to the field data. Part of this trend can be explained by the differences in the surf similarity parameters, assuming the field data were collected under conditions of high  $\xi$ . Also, laboratory and scale effects probably contribute to the lower laboratory transport rates. The relative importance of these factors is suggested as a subject of future research.

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## APPENDIX A

### HOURLY AND DAILY DATA

The data in this appendix are available on computer cards from CEIAC.

RUN TIME		MINUTES STOPPED <sup>1</sup>	WATER TEMP CELSIUS	PERIOD 2.38 SECONDS	WATER DEPTH CM	IMMERSED HEIGHT LBS	TEST 01 GENERATOR ANGLE 10 DEGREES				BREAKER ANGLE DEGREES	LONGSHORE CURRENT CM/S	BREAKER TYPE
HR	MM						GAGE 1	GAGE 2	GAGE 3	GAGE 4A/4B			
0	0				71.0								
0	30												
0	40												
1	0	CFD	23.5		71.0	300	10.0	0.4					
1	10												
1	32												
2	0	CFD			71.0	412	9.0	0.0					
2	8												
2	32						10.0	0.2					
3	0	43											
3	10												
3	30						10.2	0.0					
4	0												
4	10												
4	30	CFD				1370	9.0	7.0					
5	0												
5	40						8.4	0.4					
6	0												
6	35												
6	40						9.2	0.0					
7	0	40											
7	0												
7	3												
7	30						10.2	0.4					
8	0												
8	7												
8	30	CFD	22.5		71.0	1810	9.8	0.0					
9	0												
9	5												
9	30						9.0	7.2					
10	5												
10	30						9.4	7.2					
11	5												
11	30						10.2	5.0					
12	0	40											
12	5												
12	30						10.0	0.2					
13	0												
13	7												
13	30	CFD	22.5		71.0	2508	10.0	0.2					
14	0												
14	0												
14	30						9.2	8.0					
15	0												
15	30						9.6	7.4					
16	0												
16	30						9.6	7.4					
17	0												
17	30						11.0	0.2					
18	0	40											
18	30						10.0	0.0					
19	5												
19	30	CFD	22.8		71.0	3200	10.0	0.0					
20	0												
20	0												
20	5												
20	30						10.0	5.0					
21	0												
21	5												
21	30						9.0	7.0					
22	0												
22	5												
22	30						10.2	0.0					
23	0	40											
23	5												
23	30						10.0	5.8					
24	0												
24	30						10.0	0.0					
24	55												
25	0	TC				2040							

RUN TIME		MINUTES STOPPED <sup>1</sup>	WATER TEMP CELSIUS	PERIOD 2.38 SECONDS	WATER DEPTH CM	IMMERSED HEIGHT LBS	TEST 02 GENERATOR ANGLE 10 DEGREES				BREAKER ANGLE DEGREES	LONGSHORE CURRENT CM/S	BREAKER TYPE
HR	MM						GAGE 1	GAGE 2	GAGE 3	GAGE 4A/4B			
0	0		22.5		71.0								
0	10												
0	30						10.4	5.0					
1	0												
1	32						10.0	5.0					
2	0												
2	5												
2	30						10.4	0.4					
3	3												
3	30						10.0	0.4					
4	0												
4	5												
4	30						10.4	0.0					

<sup>1</sup> CFD = testing completed for day; TC = testing completed.

TEST OR CONT		MINUTES STOPPED	WATER TEMP CELSIUS	WATER DEPTH CM	IMMERSED HEIGHT LBS	WAVE HEIGHT CM				BREAKER ANGLE DEGREES	LONGSHORE CURRENT CM/S	BREAKER TYPE
RUN TIME						GAGE 1	GAGE 2	GAGE 3	GAGE 4/5			
5 0												
5 7												
5 30						10.4	6.4			6		
6 0		CFD		71.0	3252							
6 30						9.2	5.6			8		
7 0						10.0	5.4			7		
7 30												
8 0												
8 5										9		
8 30						10.8	6.2					
9 0		CFD	21.5	71.0	1644							
9 30						9.2	6.2			7		
10 0												
10 30						8.4	7.8			7		
11 0						9.6	6.6			7		
11 30						9.6	6.4			6		
12 0												
12 30						9.4	6.6			9		
13 0												
13 30		CFD	21.5	71.0	2944	9.4	6.6					
14 0												
14 30						9.5	6.4			6		
15 0						10.0	6.0			6		
15 30						9.9	6.0			7		
16 0												
16 30						9.8	6.0			7		
17 0												
17 30						10.0	6.0			8		
18 0						9.5	6.4			7		
18 30												
19 0												
19 30		CFD		71.0	3290	9.5	6.4			7		
20 0												
20 30						9.2	6.4			7		
21 0						9.3	6.1			7		
21 30												
22 0						9.9	6.4			6		
22 30												
23 0						9.8	6.3			8		
23 30												
24 0						9.4	6.7			10		
24 30		CFD	22.0	71.0	2844	7.5	6.8			9		
25 0						10.2	6.6			9		
25 30												
26 0						9.8	6.1			9		
26 30						10.1	6.2			9		
27 0						9.7	6.6			9		
27 30						9.7	6.4			2		
28 0												
28 30												
29 0												
29 30		CFD	23.0	71.0	2754	9.7	6.1			7		
30 0						9.0	7.1			8		
30 30						9.5	7.2			9		
31 0						9.6	6.2			8		
31 30		75				9.2	5.6			6		
32 0												
32 30		CFD	23.7	71.0		8.7	7.3			6		
33 0						9.3	6.5			5		
33 30						9.4	6.6			7		
34 0												
34 30												
35 0												
35 30												
36 0												
36 30												
37 0												
37 30												
38 0												
38 30		85								4		

TEST 02 CONT

RUN TIME HR MN	MINUTES STOPPED	WATER TEMP CELSIUS	WATER DEPTH CM	IMMERSED HEIGHT LBS	BAGE 1	WAVE HEIGHT CM BAGE 2	BAGE 3	BAGE 4A/4B	BREAKER ANGLE DEGREES	LONGSHORE CURRENT CM/S	BREAKER TYPE
39 0					10.8	5.7					
39 48									6		
39 58					10.0	7.0					
40 0	CFD	23.5	71.0								
40 15									5		
40 30					9.2	7.1					
41 0									5		
41 5					9.1	7.3					
41 30					9.3	7.0					
42 5									7		
42 30					9.6	7.6					
43 0	60				9.9	8.6					
43 10									6		
43 30					9.8	5.4					
44 0					9.7	6.3					
44 2									7		
44 30					9.2	5.6					
45 0	CFD	24.5	71.0		9.1	5.9					
45 5					9.3	6.9					
45 30									6		
46 1									6		
46 40									7		
47 0									7		
47 8									7		
47 30									7		
48 0									6		
48 8									6		
48 30									6		
49 0	50								6		
49 5									6		
49 30									6		
50 0	TC										

PERIOD 1.50 SECONDS TEST 03 GENERATOR ANGLE 10 DEGREES

0 0		22.5	71.0								
0 17									6		
0 30					13.2	12.3					
1 0	5								6		
1 6					13.1	11.6					
1 30	5								6		
2 0					12.7	12.4					
2 3									6		
2 30	80				12.4	15.1					
3 0									6		
3 30	CFD	22.0	70.9	2792	13.1	14.6					
4 0		21.8	71.1						6		
4 5					13.2	14.7					
4 30	5								6		
5 0					12.8	13.3					
5 4									7		
5 30	CFD	21.8	70.7		13.6	12.9					
6 0		21.0	71.0						7		
6 30	CFD	21.0	71.0	2752	11.0	13.9					
7 0									6		
7 30	5				9.7	15.3					
8 0					11.8	14.4					
8 30	110								6		
9 0					11.3	14.0					
9 30	5								6		
10 0					11.3	15.0					
10 30	5				13.2	13.2					
11 0									6		
11 30	CFD	21.0	70.9	3018	11.4	10.6					
12 0		20.5	71.0						6		
12 30					12.8	14.5					
13 0	5								6		
13 30					12.0	12.2					
14 0	115				12.1	11.6					
14 30									6		
15 0	5								6		
15 30									6		
16 0	CFD	20.2	70.9	2420					6		
16 30		19.5	71.0						6		
17 0	5								6		
17 30									6		

## TEST 03 CONT

RUN TIME HR MN	MINUTES STOPPED	WATER TEMP CELSIUS	WATER DEPTH CM	IMMERSED HEIGHT LOB	HAVE HEIGHT CM				BREAKER ANGLE DEGREES	LONGSHORE CURRENT CM/S	BREAKER TYPE
					GAGE 1	GAGE 2	GAGE 3	GAGE 4A/B			
18 0	100										
18 3									7		
18 30					12.4	12.2					
19 0	5										
19 2									6		
19 30					12.8	11.8					
20 0	CPD	19.0	71.0	2626							
20 0		18.0	71.0								
20 3									10		
20 30					13.1	13.2					
21 0	5										
21 4									11		
21 30					12.1	11.3					
22 0	115										
22 8									8		
22 30					12.9	11.8					
23 0	5										
23 3					13.2	13.0			2		
23 30											
24 0	TC			2700					4		

PERIOD 1.90 SECONDS TEST 04 GENERATOR ANGLE 10 DEGREES

0 0		15.0	71.0								
0 4									8		
0 30					9.6	11.5					
1 0	5								8		
1 5					10.4	13.2					
1 30	115								6		
2 0					11.1	13.8					
2 3											
2 30	5				11.0	15.4			6		
3 0											
3 2											
3 30	CPD	15.0	71.0	2300							
4 0		18.0	71.0								
4 0									8		
4 6					11.9	16.2					
4 30	5								6		
5 0					11.0	14.2					
5 3											
5 30	115				10.8	13.8			8		
6 0											
6 4	5								7		
6 30					10.2	12.8					
7 0	CPD	15.8	70.0	2104							
7 2		14.8	71.0								
7 30									6		
8 0	5				11.8	12.5					
8 11									8		
8 30	115				11.2	13.2					
9 0					10.0	12.7			7		
9 7											
9 30	5				10.0	13.7			6		
10 0											
10 5											
10 30	CPD	15.2	71.0	1912							
11 0		18.2	71.0						7		
11 7					10.3	12.3					
11 30	5								9		
12 0					10.1	12.5					
12 8	115								8		
12 30					9.4	12.0					
13 0	5								8		
13 5					9.5	12.8					
13 30	CPD	15.8	71.0	1896							
14 0		17.0	71.0						8		
14 4					9.9	13.3					
14 30	5								8		
15 0					9.4	11.8					
15 3	110								7		
15 30					8.8	11.8					
16 0	5								7		
16 5					8.8	12.4					
16 30	CPD	18.5	71.0	1968							
17 0		18.5	71.0						6		
17 3					10.4	13.7					
17 30	5								6		
18 0					10.4	12.4					
18 3	115								8		
18 30					8.5	11.3					
19 0	5										
19 5											
19 30											
20 0											
20 3											
20 30											
21 0											
21 3											
21 30											
22 0	115										
22 4											
22 30											
23 0	5										

TEST 04 CONT		MINUTES STOPPED	WATER TEMP CELSIUS	WATER DEPTH CM	IMMERSED HEIGHT LBS	WAVE HEIGHT CM				BREAKER ANGLE DEGREES	LONGSHORE CURRENT CM/S	BREAKER TYPE
RUN TIME	HR MN					GAGE 1	GAGE 2	GAGE 3	GAGE 04/05			
23 5										6		
23 30						0.1	11.6			6		
23 50												
24 0		TC	10.5	71.0	1720							

		PERIOD 3.00 SECONDS		TEST 05		GENERATOR ANGLE 10 DEGREES						
0 0			12.0	71.0						4		
0 30						6.0	8.9	8.2	11.0			
1 0		5								2		
1 30						7.0	8.1	7.9	10.0			
2 0		40								2		
2 30						6.8	7.6	7.9	9.8			
3 0		5								2		
3 30						6.8	7.6	8.2	11.4			
4 0		CPD	11.5	70.9	1832							
4 30			13.5	71.0								
5 0		5				5.9	7.4	7.6	10.4			
5 30										1		
6 0		115				6.0	8.8	8.9	9.8			
6 30						6.7	7.8	8.1	11.0			
7 0		5								3		
7 30		CPD	11.5	70.9	2724	7.0	7.4	8.6	10.0			
8 0			13.0	71.0								
8 30		5				6.8	9.0	10.2	10.4			
9 0										2		
9 30		85				6.4	8.0	8.6	10.2			
10 0						6.6	8.2	9.1	10.6			
10 30		5								0		
11 0						6.2	8.0	8.0	10.4			
11 30		CPD	13.0	71.0	2674							
12 0						6.4	7.7	8.0	9.6			
12 30		5								1		
13 0						6.6	8.0	8.2	9.2			
13 30		40								6		
14 0						7.0	7.8	7.1	9.0			
14 30		5								5		
15 0						6.2	8.2	8.3	9.7			
15 30		CPD	13.0	70.9	2370							
16 0			14.0	71.0						2		
16 30						7.4	7.7	7.2	9.2		2	P=SG
17 0		5								3		
17 30						7.6	7.8	8.4	9.2		3	P=SG
18 0		115								7		
18 30						6.4	8.7	9.1	9.9		2	P=SG
19 0		5								4		
19 30		CPD	14.0	70.9	2788	6.5	8.5		10.0		3	
20 0			14.0	71.0						3		
20 30		5				6.4	7.4	7.7	9.0		3	SG
21 0										0		
21 30						7.2	8.8	7.3	8.8			SG
22 0		85								10		
22 30						6.9	7.0	8.1	9.3		3	SG
23 0		5								2		
23 30						6.7	8.0	7.8	9.6		3	SG
23 50												
24 0		TC	13.6	70.9	2266							

		PERIOD 2.39 SECONDS		TEST 06		GENERATOR ANGLE 20 DEGREES						
0 0			71.0							13		
0 30						10.1	5.7	7.4	10.0		17	P
1 0		5								6		
1 30						9.8	5.8	7.3	8.6		15	P

TEST 00 CONT		MINUTES STOPPED	WATER TEMP CELSIUS	WATER DEPTH CM	IMMERSED HEIGHT LBS	WAVE HEIGHT CM				BREAKER ANGLE DEGREES	LONGSHORE CURRENT CM/S	BREAKER TYPE
HR	MIN					GAGE 1	GAGE 2	GAGE 3	GAGE 4A/5B			
2	0	115								10	17	SP-P
2	30					10.2	5.5	6.4	6.2			
3	0	5								11	17	SP-P
3	30					9.8	5.5	6.6	6.6			
4	0	EPD	19.5	71.0	3242							
4	30		11.5	71.0						11	19	P
5	0	5				9.6	6.6	7.8	9.6			
5	30					9.2	6.0	7.0	8.6	10	17	P
6	0	115								9	16	P
6	30					8.5	6.0	7.1	8.6			
7	0	5								9	15	P
7	30					8.3	6.7	8.2	9.2			
8	0	EPD	11.5	70.9	3040					7	16	P
8	30		18.0	71.0						8	17	P
9	0	5				9.3	6.1	6.8	9.6			
9	30					8.8	6.0	7.0	9.0	10	15	P
10	0	80								7	15	P
10	30					8.4	6.6	7.4	9.0			
11	0	5				9.4	6.1	6.5	9.9			
11	30									9	17	P
12	0	EPD	12.5	71.0	2990					9	17	P
12	30		12.0	71.0						9	17	P
13	0	5				9.1	6.1	7.0	9.1			
13	30					8.5	6.8	7.2	9.0	9	19	P
14	0	100								9	16	P
14	30					9.1	6.0	7.2	8.8			
15	0	5								6	10	P
15	30					8.8	6.4	6.5	8.8			
16	0	EPD	12.5	70.9	3304					11	17	P
16	30		14.0	71.0						9	16	P
17	0	5				9.3	6.5	7.0	9.4			
17	30					9.6	7.1	7.0	9.2	12	17	P
18	0	120								6	16	P
18	30					9.6	6.7	6.5	8.7			
19	0	5								11	15	P
19	30					9.3	6.4	7.0	8.7			
20	0	EPD	13.5	71.0	3920					7	16	P
20	30		12.5	71.0						11	19	P
21	0	5				8.8	6.5	7.8	8.9			
21	30					8.0	6.7	6.6	10.0	7	16	P
22	0	95								11	15	P
22	30					9.2	6.1	6.5	9.7			
23	0	5								7	16	P
23	30					9.3	6.1	6.1	8.8			
24	0	TC	12.5	70.9	3254					8	16	P

PERIOD 1.40 SECONDS TEST 07 GENERATOR ANGLE 20 DEGREES

0	0		9.3	71.0						11	36	P
0	30					11.4	13.0	13.0	14.2	12		
1	0	5								9	30	P
1	30					12.1	11.2	12.0				
2	0	80			2064					10	29	P
2	30					12.4	10.6	12.3				
3	0	5								12	29	P
3	30					11.1	11.0	12.0				
4	0	EPD	9.5	71.0	1600					10	31	P
4	30		13.0	71.0						11	32	P
5	0	5				9.3	10.3	12.7				
5	30					9.1	9.6	12.7				
6	0	85			1130							

TEST 07 CONT		MINUTES STOPPED	WATER TEMP CELSIUS	WATER DEPTH CM	IMMERSED HEIGHT LBS	WAVE HEIGHT CM			BREAKER ANGLE DEGREES	LONGSHORE CURRENT CM/S	BREAKER TYPE
RUN TIME	HR MN					SAGE 1	SAGE 2	SAGE 3			
0 0											
0 40						8.8	11.7	14.3	10	33	P
7 0		5									
7 4											
7 30						8.9	11.0	11.3	10	32	P
8 0		CPD	11.5	70.0	1216						
8 0			11.5	71.0							
8 3											
8 30		5				8.5	9.9	12.1	9	29	P
9 0											
9 4						8.4	9.4	12.6	12	31	P
9 30		75									
10 0						9.7	11.2	13.6	12	30	P
10 4		5									
10 30						9.7	9.2	14.0	10	33	P
11 0											
11 4											
11 30		CPD	11.5	70.0	2234						
12 0			12.5	71.0							
12 4		5				9.8	10.4	12.8	11	30	P
12 30											
13 0						10.0	10.4	13.1	12	29	P
13 4		80									
14 0						9.4	11.2	13.4	11	32	P
14 30		5									
15 0						8.6	9.4	12.5	11	29	P
15 30		CPD	12.5	71.0	2010						
16 0			12.5	71.0							
16 30		5				9.6	11.4	12.0	12	28	P
17 0											
17 4						9.0	11.6	12.1	9	31	P
17 30		90									
18 0						9.6	10.7	12.4	11	32	P
18 30		CPD									
19 0			12.5	71.0							
19 4											
19 30						8.6	9.9	12.6	12	28	P
20 0		CPD	12.5	71.0	2000						
20 0			12.5	71.0							
20 4						9.3	10.1	12.6	12	25	P
20 30		5									
21 0						10.0	11.6	12.3	11	28	P
21 4		100									
22 0						9.7	10.8	11.6	11	28	P
22 30		5									
23 0						8.8	10.2	12.4	11	28	P
23 30											
23 4		TC	12.5	71.0	1800				13		
24 0											

PERIOD 1.90 SECONDS TEST 08 GENERATOR ANGLE 20 DEGREES

0 0			12.4	71.0					9	24	P
0 30						10.4	11.7	9.5	15.3		
1 0		5									
1 4						9.5	9.3	10.8	9	36	P
1 30		105									
2 0						10.6	9.1	12.7	12	26	P
2 30		5									
3 0						9.7	9.3	11.9	11	23	P
3 30		CPD	12.5	70.0	2304						
4 0			13.0	71.0							
4 30		5				9.1	9.6	13.8	12	23	P
5 0											
5 30		90				8.8	9.9	12.8	13	21	P+BP
6 0											
6 30		5				8.2	11.5	12.4	12	26	P
7 0											
7 30		CPD	12.5	70.0	1224	7.2	10.6	11.8	11	26	P
8 0			14.0	71.0							
8 30		5				7.6	11.2	11.8	8	19	P
9 0											
9 30		80				8.5	10.4	12.8	12	26	P
10 0						9.4	12.6	12.3	10	15	P



TEST 00 CONT												
RUN TIME		MINUTES STOPPED	WATER TEMP CELSIUS	WATER DEPTH CM	IMMERSED HEIGHT LBS	WAVE HEIGHT CM				BREAKER ANGLE DEGREES	LONGSHORE CURRENT CM/S	BREAKER TYPE
HR	MM					GAGE 1	GAGE 2	GAGE 3	GAGE 4A/50			
11	0	S										
11	30											
12	0	CPD	14.0	70.0	1002	8.9	12.5	13.0	14.0	11	18	P
12	30		14.0	71.0								
13	0	S										
13	30					8.4	12.4	12.6	14.9	10	17	P
14	0	90										
14	30					8.2	12.4	12.5	14.9	10	19	P
15	0	S				7.9	12.2	12.8	15.8	10	17	P
15	30											
16	0	CPD	14.0	70.0	730	8.1	11.6	13.2	15.8	10	15	P
16	30		15.0	71.0								
17	0	S				8.4	11.1	13.2	15.3	8	19	P
17	30											
18	0	100				8.2	11.1	14.7	15.5	10	17	P
18	30											
19	0	S				8.0	11.7	13.8	14.7	10	20	P
19	30											
20	0	CPD	15.0	70.0	600	9.3	11.0	14.0	15.0	11	17	P
20	30		15.5	71.0								
21	0	S				7.7	12.0	11.4	15.0	13	18	P
21	30											
22	0	S				7.9	12.6	12.0	15.0	10	16	P
22	30											
23	0	S				8.6	12.0	11.7	17.0	10	15	P
23	30											
24	0	TC	14.5	70.0	700	9.5	11.7	12.2	16.8	11	15	P
PERIOD 1.50 SECONDS TEST 00												
GENERATOR ANGLE 20 DEGREES												
0	0		13.0	71.0								
0	30											
1	0	S				9.8	12.0	11.0	11.4	19		
1	30											
2	0	85				11.7	9.4	10.8	10.5	16	35	SP-P
2	30											
3	0	S				12.0	9.4	11.0	12.0	13	40	SP-P
3	30											
4	0	CPD	13.5	71.0	2110	12.1	10.5	11.0	12.0	13	30	SP-P
4	30		13.5	71.0								
5	0	S				11.2	9.5	12.0	11.1	16	30	SP-P
5	30											
6	0	105				11.7	9.4	11.1	11.0	14	32	SP-P
6	30											
7	0	S				11.1	8.9	11.0	12.0	14	26	SP-P
7	30											
8	0	CPD	14.0	70.0	1920	10.6	9.6	10.4	13.4	14	27	SP-P
8	30		14.5	71.0								
9	0	S				10.8	8.6	11.2	12.5	14	24	SP-P
9	30											
10	0	95				11.0	9.1	10.8	12.0	14	27	SP-P
10	30											
11	0	S				9.8	7.6	11.0	13.1	15	22	SP
11	30											
12	0	CPD	14.5	71.0	1930	10.2	8.6	10.2	12.5	14	27	SP
12	30		14.5	71.0								
13	0	S				11.2	8.7	11.0	12.9	14	23	SP
13	30											
14	0	90				11.8	9.4	11.5	13.2	13	31	SP
14	30											
15	0	S				11.7	9.0	11.8	12.2	15	22	SP
15	30											
16	0	CPD	15.0	70.0	1940	10.8	9.9	10.7	13.7	15	27	SP
16	30		15.5	71.0								

TEST 09 CONT												
RUN TIME		MINUTES STOPPED	WATER TEMP CELSIUS	WATER DEPTH CM	IMMERSED WEIGHT LBS	WAVE HEIGHT CM				BREAKER ANGLE DEGREES	LONGSHORE CURRENT CM/S	BREAKER TYPE
HR	MM					GAGE 1	GAGE 2	GAGE 3	GAGE 4A/4B			
16	4									13		
16	30					11.2		11.9	13.4		35	BP
17	0	5										
17	4					11.3	10.0	11.9	13.1	14	20	BP
17	30											
18	0	5										
18	3									16		
18	30					11.4	10.1	11.0	11.7		19	BP
19	0	5										
19	4									17		
19	30					12.1	9.0	11.4	11.0		10	BP
20	0	CPD	19.5	71.0	1070							
20	0		19.5	71.0								
20	5									15		
20	30					11.5	9.0	11.0	12.0		20	BP
21	0	5										
21	4									15		
21	30					11.4	8.3	11.0	10.1		30	BP
22	0	CPD	19.5	71.0	804							
22	0		19.5	71.0								
22	4									15		
22	30					11.1	9.0	12.1	10.0		10	BP
23	0	5										
23	5									15		
23	30					12.2	10.2	12.2	10.5		21	BP
23	50									16		
24	0	TC	19.5	71.0	804							

TEST 10											
PERIOD 1.90 SECONDS					GENERATOR ANGLE 20 DEGREES						
		19.7	71.0								
0 0											
0 10											
0 30					14.4	10.3	17.1	12.9			
1 0	5										
1 30					15.3	10.0	10.3	13.0			
2 0	90										
2 30					14.3	17.1	17.6	15.3			
3 0	5										
3 30					15.3	10.2	10.6	15.2			
4 0	CPD	18.5	70.9								
4 30		19.3	71.0								
5 0					14.7	10.0	10.3	14.1			
5 30	5										
6 0	100				13.0	17.4	17.0	16.2			
6 30					15.3	17.7	19.2	15.9			
7 0	5										
7 30					15.0	17.9	10.9	16.2			
8 0	CPD	18.9	71.0								
8 30		19.2	71.0								
9 0					14.7	10.5	10.3	17.7			
9 30	5										
10 0					14.4	10.2	17.4	10.3			
10 30	5										
11 0					13.0	10.3	17.1	19.2			
11 30											
12 0	CPD	18.5	70.9	9950	14.7	17.9	10.0	10.2			
12 30		18.4	71.0								
13 0					15.3	17.3	17.1	10.4			
13 30	5										
14 0	70				14.4	10.0	10.4	10.4			
14 30					15.0	21.0	17.4	17.1			
15 0	5										
15 30					13.7	19.5	15.5	10.3			
16 0	CPD	18.0	70.9	3920							
16 30		18.9	71.0								
17 0					14.1	19.2	16.5	17.4			
17 30	5										
18 0	180				14.4	10.0	19.1	19.2			
18 30					14.1	19.0	19.2	10.6			
19 0	5										
19 30											
20 0	CPD	18.3	70.9	3950	13.7	20.7	16.0	19.7			
20 30		18.8	71.0								
21 0					15.5	19.5	17.1	10.5			
21 30	5										

TEST 10 CONT											
RUN TIME	MINUTES	WATER	WATER	IMMERSED	WAVE HEIGHT				BREAKER	LONGSHORE	BREAKER
HR MN	STOPPED	TEMP	DEPTH	HEIGHT	GAGE 1	GAGE 2	GAGE 3	GAGE 4A/4B	ANGLE	CURRENT	TYPE
		CELSIUS	CM	LOB					DEGREES	CM/S	
21 30					14.3	19.2	17.0	18.2		27	P
22 0	00										
22 30					13.7	18.9	18.2	17.9	17	27	P
23 0	0										
23 30					14.6	18.0	18.2	18.5	16	36	P
24 0	0	18.2	70.0	3760					18		
TEST 11											
PERIOD 2.35 SECONDS					GENERATOR ANGLE 00 DEGREES						
0 0		20.7	71.0								
0 30					10.2	9.0	7.8	14.0	-7	-0	P
1 0	5										
1 30					9.7	8.5	7.6	14.4	-8	-7	P
2 0	40										
2 30											
2 53					9.4	9.2	9.6	13.8	-9	0	P
3 0	10										
3 30					9.2	9.7	10.0	14.9	-3	0	P
4 0	CFD	20.8		682							
4 30		21.7	71.0								
5 0					9.1	9.2	9.6	13.8	-5	0	P
5 30	5										
6 0					9.8	9.0	9.1	12.5	-3	0	P
6 30	11										
7 0					10.2	9.9	8.9	14.6	-6	0	P
7 30	5										
8 0					9.9	9.0	8.7	12.9	-5	0	P
8 30	CFD	22.0	70.9	890							
9 0		21.8	71.0								
9 30					9.6	9.1	8.7	14.4	-6	0	P
10 0	5										
10 30					9.1	9.1	9.9	13.5	-3	0	P
11 0	5										
11 30					9.0	9.6	9.0	13.8	-6	0	P
12 0	10										
12 30					9.6	9.2	8.7	14.0	-4	3	P
12 53	CFD	20.8	70.9	70							
13 0		20.6	71.0								
13 30					9.6	9.4	10.8	11.3	-6	0	P
14 0	5										
14 30					9.7	9.8	8.6	13.7	-4	0	P
15 0	5										
15 30					9.2	9.0	9.2	12.9	-3	2	P
16 0	5										
16 30					9.4	9.2	8.6	13.2	-6	0	P
17 0	CFD	20.0	70.9	310							
17 30		19.9	71.0								
18 0					9.2	9.0	9.1	14.1	-6	2	P
18 30	7										
19 0					9.6	9.9	9.0	12.8	-6	2	P
19 30	5										
20 0					9.5	9.2	9.2	12.6	-5	2	P
20 30	5										
21 0					9.2	9.6	9.6	13.5	-3	1	P
21 30	CFD	19.7	71.0	215							
22 0		20.4	71.0								
22 30					9.0	9.1	8.2	12.8	-6	2	P
23 0	5										
23 30					9.6	9.4	9.0	12.5	-6	0	P
24 0	5										
24 30					9.9	9.8	8.6	12.9	-4	0	P
25 0	9										
25 30					9.1	9.4	8.8	12.8	-5	0	P
26 0	TC	20.2	70.9	286					-6		
TEST 18											
PERIOD 2.35 SECONDS					GENERATOR ANGLE 30 DEGREES						
0 0		23.4	71.0								
0 13	CFD										
0 13		29.3	71.0								
0 19											

TEST 12 CONT											
RUN TIME	MINUTES	WATER	WATER	IMMERSED	WAVE HEIGHT				BREAKER	LONGSHORE	BREAKER
HR MN	STOPPED	TEMP	DEPTH	HEIGHT	AGE 1	AGE 2	AGE 3	AGE 4A/BB	ANGLE	CURRENT	TYPE
		CELSIUS	CM	LOB					DEGREES	CM/S	
0 30					9.7	5.3	7.3	9.0		20	P
1 0	5										
1 30					9.9	9.0	8.1	9.0	21	25	P
2 0	25										
2 30					10.3	4.9	6.7	8.5	22	23	P
3 0	10										
3 30					10.0	4.7	6.1	8.0	19	24	P
4 0	CPD	22.9	71.0	3793							
4 30		22.8	71.0								
5 0	5				10.3		7.5	11.2	18	25	P
5 30											
6 0	55				10.3		6.0	8.4	21	21	P
6 30											
7 0	5				9.5		6.9	9.4	24	20	P
7 30											
8 0	CPD	22.9	70.9	5437	10.3		6.2	8.3	17	20	P
8 30		23.0	71.0								
9 0	5				9.0	5.7	6.7	10.1	21	20	P
9 30											
10 0	5				11.0	4.7	6.1	9.0	19	25	P
10 30											
11 0	55				10.5	4.9	6.5	9.0	17	20	P
11 30											
12 0	EPD	23.1	70.9	5402	10.3	5.2	6.1	9.2	23	20	P
12 30		23.1	71.0								
13 0	5				11.3	4.3	6.0	8.0	22	25	P
13 30											
14 0	5				10.1	4.9	6.1	8.0	16	23	P
14 30											
15 0	70				11.0	4.9	5.0	9.1	18	29	P
15 30											
16 0	CPD	23.4	70.9	5420	9.9	5.3	6.0	8.0	22	33	P
16 30		23.6	71.0								
17 0	10				9.3	6.4	6.9	8.4	22	29	P
17 30											
18 0	30				9.2	6.1	6.1	8.2	22	37	P
18 30											
19 0	92				9.6	5.6	6.2	8.2	18	32	P
19 30											
20 0	CPD	23.9	71.0	5724	9.9	6.0	6.3	9.0	21	40	P
20 30		22.6	71.0								
21 0	10				9.7	6.5	7.3	10.1	21	33	P
21 30											
22 0	18				9.5	5.8	7.0	11.0	20	33	P
22 30											
23 0	10				9.1	4.8	6.2	10.3	18	32	P
23 30											
24 0	70				9.5	5.0	6.2	9.0	19	29	P
24 30											
25 0	TC	22.3	71.0	5775					20		
25 30											
26 0											
PERIOD 1.00 SECONDS TEST 13 GENERATOR ANGLE 30 DEGREES											
0 30		22.7	71.0								
1 0	5				6.6	7.0	7.1	7.1	19	6	SC
1 30											
2 0	10				6.7	6.0	7.3	6.4	15	8	SC
2 30											
3 0	5				6.1	7.6	7.0	9.1	18	8	SC
3 30											
4 0	CPD	22.1	70.8	4239	6.2	7.8	6.7	9.0	16	8	SC
4 30		22.9	71.0								
5 0	10				7.2	7.0	5.9	11.0	19	8	SC
5 30											
6 0					6.7	6.8	6.1	11.0	19	7	SC

TEST 13 CONT											
RUN TIME	MINUTES	WATER	WATER	IMMERSED	WAVE HEIGHT				BREAKER	LONGSHORE	BREAKER
HR MM	STOPPED	TEMP	DEPTH	HEIGHT	GAGE 1	GAGE 2	GAGE 3	GAGE 4B/4C	ANGLE	CURRENT	TYPE
		CELSIUS	CM	LOS					DEGREE	CM/S	
0 0	10										
0 5											
0 32					6.8	6.9	6.0	11.9	12	8	SG
7 0	10										
7 6											
7 30					7.1	6.8	6.4	11.1	13	9	SG
8 0	CFD	23.1	71.0	4227							
8 0		23.6	71.0								
8 3					6.3	7.3	7.0	11.7	15	9	SG
8 30	15										
9 0					6.2	7.0	7.0	12.2	15	8	SG
9 30	CFD	23.8	70.0	1861							
10 0		23.7	71.0								
10 8					6.6	6.6	6.2	10.6	20	6	SG
10 30	10										
11 0					7.2	6.5	6.8	9.9	14	9	SG
11 2	10										
11 30					7.1	6.4	6.9	9.4	16	10	SG
12 0	10										
12 5					7.0	6.6	6.0	9.1	16	8	SG
12 30	CFD	23.5	71.0	3500							
13 0		23.5	71.0								
13 4					7.1	6.8	6.5	9.2	18	9	SG
14 0	10										
14 30					6.8	6.8	6.4	9.6	16	7	SG
15 0	10										
15 30					6.5	6.7	5.8	8.6	15	7	SG
16 0	10										
16 8					6.2	6.7	6.8	10.9	18	7	SG
16 30	CFD	22.9	71.0	3633							
17 0		22.8	71.0								
17 6					6.8	7.0	6.1	6.4	16	5	SG
17 30	20										
18 0					6.5	7.1	6.2	6.5	18	5	SG
18 30	40										
19 0					5.9	7.8	7.3	7.5	14	8	SG
19 30	10										
20 0					5.8	6.2	7.2	8.8	12	8	SG
20 30	CFD	23.1	71.0	3789							
21 0		71.0									
21 5					5.7	7.6	6.5	6.8	13	5	SG
21 30	5										
22 0					6.2	7.9	7.7	7.3	11	8	SG
22 30	TC	23.1	71.0	1000							
23 0											
23 30											
23 55											
24 0											

TEST 14											
PERIOD 3.00 SECONDS				GENERATOR ANGLE 30 DEGREES							
0 0		20.5	71.0								
0 10											
0 30											
1 0	10				15.2	17.4	14.7	17.8	27	33	P
1 2											
1 30					15.0	16.8	15.8	16.8	28	31	P
2 0	40										
2 6					15.6	14.7	15.3	15.8	28	27	P
2 30	32										
3 0					15.6	16.2	15.6	16.8	23	40	P
3 30	CFD	22.4	70.0	10350							
4 0		22.8	71.0								
4 6					14.1	16.8	11.4	19.2	28	29	P
4 30	10										
5 0					14.4	17.0	12.6	18.8	29	21	P
5 30	10										
6 0					15.0	18.2	12.0	18.6	29	21	P
6 6											
6 30	40				15.6	17.7	12.2	18.6	31	24	P
7 0	CFD	19.8	70.0	10030							
7 0		19.8	71.0								
7 30					14.0	18.3	11.4	19.2	31	19	P
8 0	10										
8 30					14.7	18.8	12.0	19.5	29	17	P
9 0	15										
9 30					14.7	18.2	11.5	19.5	30	20	P
10 0	25										
10 30											
11 0											

## TEST 14 CONT

RUN TIME HR MN	MINUTES STOPPED	WATER TEMP CELSIUS	WATER DEPTH CM	IMMERSED HEIGHT LOS	GAGE 1	GAGE 2	GAGE 3	GAGE 4/5/6	BREAKER ANGLE DEGREES	LONGSHORE CURRENT CM/S	BREAKER TYPE
11 3											
11 30											
12 0	EPD	19.4	70.0	10001	14.4	14.0	12.3	10.6	30	10	P
12 30		19.6	71.0								
13 0											
13 30	10				14.1	14.1	13.4	17.0	32	20	P
14 0											
14 30	15				14.6	15.0	13.5	16.0	30	22	P
15 0											
15 30	75				14.6	15.0	13.2	17.2	32	10	P
16 0	15										
16 30											
17 0	EPD	19.1	71.0	10020	14.7	15.2	13.5	16.8	20	10	P
17 30		19.5	71.0								
18 0					13.8	14.0	12.8	17.0	30	26	P
18 30	10										
19 0					15.0	15.0	12.6	17.0	30	23	P
19 30	15										
20 0					14.1	17.7	13.5	16.0	32	21	P
20 30	75										
21 0					14.3	14.0	12.8	17.1	33	10	P
21 30	EPD	19.2	70.0	10170							
22 0		19.2	71.0								
22 30					13.2	14.4	12.5	19.1	33	22	P
23 0	15										
23 30					15.2	17.4	12.2	18.6	32	22	P
24 0	25										
24 30	5										
25 0					14.3	14.2	12.0	18.0	20	21	P
25 30	85										
26 0					15.0	15.0	12.3	17.4	31	22	P
26 30											
27 0	TC	17.4	70.0	11094							

TEST 15  
PERIOD 1.00 SECONDS GENERATOR ANGLE 30 DEGREES

0 0				71.0							
0 30					13.0	14.0	13.2	16.0	10	40	SP-P
1 0	5										
1 30					13.0	17.6	14.6	18.3	16	36	P
2 0	5										
2 30					12.6	17.6	15.3	18.3	16	40	SP-P
3 0	195										
3 30					13.7	14.2	15.3	18.3	20	40	P
4 0	EPD		71.0	7420							
4 30			71.0								
5 0					14.0	15.0	13.2	19.5	18	40	P-SP
5 30	5										
6 0					13.4	17.0	12.6	19.2	16	35	P-SP
6 30	5										
7 0					13.4	16.0	13.5	18.0	17	30	P-SP
7 30	90										
8 0					14.6	14.0	13.4	19.4	19	30	P-SP
8 30	EPD		71.0	6804							
9 0		10.0	71.0								
9 30					13.2	17.0	14.6	18.9	19	36	P-SP
10 0	15										
10 30	5										
11 0					13.9	14.0	13.8	19.1	19	35	P-SP
11 30	5										
12 0					13.8	14.4	14.0	19.5	19	40	P-SP
12 30	90										
13 0					13.0	14.0	14.3	18.6	20	40	P-SP
13 30	EPD	10.0	71.0	7029							
14 0		19.5	71.0								
14 30					12.0	17.0		19.6	19	40	P-SP
15 0	5										
15 30					13.2	15.9		19.4	19	40	P-SP
16 0	5										
16 30					14.4	19.0		19.2	20	40	P-SP

TEST 18 CONT											
RUN TIME MO HH	MINUTES STOPPED	WATER TEMP CELSIUS	WATER DEPTH CM	IMMERSED HEIGHT LBS	WAVE HEIGHT CM				BREAKER ANGLE DEGREES	LONGSHORE CURRENT CM/S	BREAKER TYPE
					GAGE 1	GAGE 2	GAGE 3	GAGE 4A/4B			
15 0	55										
15 4											
15 30											
16 0	EPL	19.5	70.0	8622	13.2	10.3		10.9	10	40	P=SP
16 0		10.0	71.0								
16 5											
16 30	10				12.5	10.6	12.8	10.6	10	40	P=SP
17 0											
17 3											
17 30					12.6	10.8	10.7	10.7	10	41	P=SP
18 0	10										
18 3											
18 30					13.4	15.0	12.2	20.1	23	43	P=SP
19 0	115										
19 3											
19 30					13.1	17.3	12.3	20.6	10	43	P=SP
20 0	EPL	10.5	70.0	9456							
20 0		17.0	71.0								
20 3											
20 30					13.1	15.0		20.1	10	30	P
21 0	10										
21 3											
21 30					12.0	10.5		20.6	10	40	P
22 0	20										
22 3											
22 30					12.0	10.3		20.9	20	40	P
23 0	00										
23 3											
23 30					13.2	15.0		19.5	21	41	P
24 0	70	10.5	70.0	9220							

APPENDIX B

BEACH SURVEY DATA



## TEST 1

RANGE 1.5		RANGE 2.0		RANGE 3.0		RANGE 4.0		RANGE 5.0		RANGE 6.0		RANGE 7.0		RANGE 7.6	
STA	ELEV	STA	ELEV	STA	ELEV	STA	ELEV	STA	ELEV	STA	ELEV	STA	ELEV	STA	ELEV
(M)	(M)	(M)	(M)	(M)	(M)	(M)	(M)	(M)	(M)	(M)	(M)	(M)	(M)	(M)	(M)
0.00	.275	0.00	.275	0.00	.280	0.00	.275	0.00	.280	0.00	.270	0.00	.280	0.00	.275
1.37	.135	1.39	.135	1.18	.105	1.31	.135	1.40	.135	1.40	.140	1.50	.130	.03	.140
1.02	.110	1.75	.105	1.08	.120	1.80	.105	1.61	.140	1.85	.110	1.05	.130	1.30	.150
2.12	.145	2.13	.120	1.71	.090	2.03	.120	2.02	.110	2.53	.010	2.40	.005	1.58	.115
2.70	.005	2.05	.005	2.19	.115	2.70	.010	3.20	.120	3.17	.135	2.40	.100	2.40	.010
3.20	.005	3.30	.005	2.80	.005	2.94	.005	3.40	.110	3.45	.170	3.34	.105	3.00	.005
3.63	.150	3.60	.160	3.15	.050	3.12	.005	4.19	.160	3.70	.005	3.63	.100	3.20	.005
3.80	.005	3.70	.005	3.33	.115	3.30	.005	4.00	.240	4.73	.230	4.40	.180	4.30	.175
4.30	.115	4.00	.105	3.87	.090	3.70	.115	4.00	.255	4.20	.100	4.20	.235	4.05	.215
4.95	.225	4.44	.240	4.00	.105	4.77	.215	4.94	.340	7.28	.330	6.35	.325	6.25	.200
5.03	.270	4.60	.240	4.03	.250	5.08	.240	6.04	.405	6.23	.445	7.41	.385	5.60	.240
6.00	.310	6.70	.305	6.40	.305	6.22	.330	6.17	.440	6.03	.440	6.40	.440	6.63	.305
7.24	.330	7.24	.325	7.19	.325	7.07	.335	6.97	.505	6.97	.505	10.10	.410	7.33	.330
7.85	.390	7.80	.380	7.00	.305	6.83	.405	11.00	.675	11.00	.605	11.10	.670	7.90	.380
8.12	.410	8.23	.405	8.25	.425	9.05	.575	11.93	.720	11.93	.710	11.93	.710	10.10	.580
8.50	.450	8.55	.445	8.40	.455	11.00	.670							11.03	.670
8.84	.480	8.80	.470	8.84	.475	11.03	.720							11.03	.670
9.23	.505	9.33	.520	9.28	.510									10.00	.520
10.20	.595	10.37	.605	10.30	.605										
11.25	.675	11.93	.715	11.98	.700										
11.93	.720														

## TEST 2 (after 25 hours)

RANGE 1.5		RANGE 2.0		RANGE 3.0		RANGE 4.0		RANGE 5.0		RANGE 6.0		RANGE 7.0		RANGE 7.6	
STA	ELEV	STA	ELEV	STA	ELEV	STA	ELEV	STA	ELEV	STA	ELEV	STA	ELEV	STA	ELEV
(M)	(M)	(M)	(M)	(M)	(M)	(M)	(M)	(M)	(M)	(M)	(M)	(M)	(M)	(M)	(M)
0.00	.285	0.00	.300	0.00	.315	0.00	.295	0.00	.290	0.00	.285	0.00	.285	0.00	.300
1.74	.115	1.81	.105	1.90	.095	1.90	.190	1.89	.145	1.51	.155	1.34	.140	1.48	.150
2.15	.150	2.10	.120	2.07	.005	1.94	.135	1.86	.180	1.74	.120	1.40	.115	2.99	.005
3.05	.005	3.05	.000	3.17	.040	2.58	.005	2.62	.005	2.59	.000	2.58	.005	3.15	.075
3.50	.080	3.37	.080	3.24	.075	3.14	.110	3.10	.110	3.10	.115	3.08	.090	3.00	.090
3.75	.130	3.44	.100	3.44	.100	3.42	.160	3.40	.200	3.47	.200	3.44	.190	5.00	.225
3.93	.080	3.87	.080	3.66	.065	3.61	.095	3.70	.100	3.81	.095	3.40	.100	6.74	.310
4.50	.070	4.13	.115	4.33	.135	4.40	.170	4.51	.180	4.45	.180	4.47	.170	6.03	.375
5.93	.255	4.45	.135	5.59	.230	5.30	.235	5.67	.240	5.43	.270	5.60	.265	9.19	.500
7.01	.320	5.50	.245	6.98	.315	6.70	.325	6.95	.345	6.66	.340	6.93	.330	10.67	.925
8.05	.470	6.00	.295	6.32	.450	6.02	.400	6.23	.425	6.35	.455	6.20	.410	12.08	.670
10.00	.580	7.00	.380	6.33	.525	9.40	.520	9.62	.535	9.48	.520	9.45	.520		
11.44	.675	8.48	.525	10.70	.640	10.73	.635	10.82	.660	10.40	.660	10.73	.640		
12.01	.710	10.76	.635	11.86	.715	11.87	.715	11.87	.715	11.90	.710	11.81	.705		
		11.98	.735												

## TEST 2 (after 50 hours)

RANGE 1.5		RANGE 2.0		RANGE 3.0		RANGE 4.0		RANGE 5.0		RANGE 6.0		RANGE 7.0		RANGE 7.6	
STA	ELEV	STA	ELEV	STA	ELEV	STA	ELEV	STA	ELEV	STA	ELEV	STA	ELEV	STA	ELEV
(M)	(M)	(M)	(M)	(M)	(M)	(M)	(M)	(M)	(M)	(M)	(M)	(M)	(M)	(M)	(M)
0.00	.285	0.00	.290	0.00	.310	0.00	.295	0.00	.285	0.00	.285	0.00	.290	0.00	.300
.50	.180	1.07	.130	1.30	.145	.09	.195	.92	.140	.94	.205	.94	.190	1.24	.160
2.04	.150	2.12	.110	1.78	.120	1.63	.140	1.58	.145	1.41	.140	1.40	.140	1.70	.115
2.37	.185	2.91	.105	2.14	.105	1.82	.145	1.75	.160	1.65	.145	2.20	.055	1.85	.075
2.92	.005	3.22	.050	2.70	.005	2.17	.090	1.86	.120	2.53	.000	2.42	.005	2.45	.005
3.19	.050	3.52	.100	3.10	.000	2.60	.005	2.20	.085	2.90	.075	2.92	.085	2.83	.005
3.30	.085	3.74	.145	3.30	.110	2.96	.060	2.92	.085	3.12	.130	3.27	.145	3.10	.100
3.80	.180	3.92	.090	3.80	.090	3.17	.100	3.02	.090	3.00	.145	3.47	.160	3.50	.085
5.01	.070	5.15	.115	5.03	.030	5.30	.080	5.10	.085	5.72	.100	5.70	.100	4.75	.100
6.19	.130	6.00	.235	6.44	.340	6.00	.160	6.32	.130	6.45	.195	6.40	.165	9.40	.280
7.21	.285	6.00	.275	6.31	.345	6.40	.240	6.50	.210	6.44	.240	6.70	.240	7.20	.335
6.74	.330	7.20	.350	11.80	.710	6.07	.355	6.32	.160	6.60	.370	7.20	.350	8.50	.045
6.63	.470	10.10	.590			6.49	.520	6.17	.380	6.50	.405	6.53	.405	10.00	.570
10.10	.600	11.98	.705			11.70	.715	9.60	.715	10.00	.590	10.00	.590	11.90	.715
11.00	.790									11.00	.705	11.00	.705		

## TEST 3

RANGE 1.5		RANGE 2.0		RANGE 3.0		RANGE 4.0		RANGE 5.0		RANGE 6.0		RANGE 7.0		RANGE 7.6	
STA	ELEV	STA	ELEV	STA	ELEV	STA	ELEV	STA	ELEV	STA	ELEV	STA	ELEV	STA	ELEV
(M)	(M)	(M)	(M)	(M)	(M)	(M)	(M)	(M)	(M)	(M)	(M)	(M)	(M)	(M)	(M)
0.00	.275	0.00	.310	0.00	.315	0.00	.295	0.00	.295	0.00	.290	0.00	.295	0.00	.310
1.00	.085	1.00	.100	1.08	.110	1.05	.115	1.49	.130	1.40	.145	1.50	.130	1.67	.130
2.70	.010	2.30	.000	1.72	.000	2.07	.005	2.02	.000	1.51	.090	1.55	.080	1.40	.105
2.80	.005	3.70	.105	2.94	.000	3.00	.000	2.16	.000	1.06	.080	1.90	.005	1.90	.000
3.20	.000	3.03	.005	3.21	.005	3.41	.105	2.40	.000	1.71	.080	3.70	.175	2.00	.110
3.50	.124	4.30	.105	3.40	.090	3.67	.085	3.19	.075	2.09	.000	3.90	.145	3.92	.145
3.75	.120	4.73	.270	3.60	.110	4.06	.230	3.33	.115	3.40	.090	4.30	.125	4.30	.120
4.10	.150	6.00	.275	4.02	.095	5.50	.260	3.66	.085	3.60	.130	5.33	.240	5.20	.215
4.60	.180	6.00	.280	6.36	.175	6.23	.260	6.36	.170	6.93	.090	6.47	.185	6.61	.205
5.07	.220	7.02	.295	6.06	.130	6.50	.240	4.70	.200	9.11	.430	6.76	.280	7.75	.360
5.45	.270	8.45	.505	5.37	.245	6.00	.240	5.20	.235	5.93	.240	7.22	.490	9.50	.520
5.99	.280	10.77	.635	6.31	.255	7.40	.285	5.46	.215	6.55	.255	8.30	.405	11.90	.705
6.70	.280	11.99	.710	7.34	.260	9.20	.480	6.57	.270	6.90	.245	9.23	.405		
7.00	.285			8.00	.310	9.77	.545	6.97	.230	7.90	.240	11.90	.705		
8.70	.230			8.04	.370	11.90	.705	7.95	.300	8.00	.300				
9.00	.435			9.12	.470			8.00	.290	8.05	.435				
10.03	.530			10.00	.605			8.73	.305	9.75	.555				
11.07	.630			11.00	.710			9.50	.615	11.00	.705				
11.90	.680							9.00	.675						
								11.90	.705						

## TEST 4

RANGE 1.5		RANGE 2.0		RANGE 3.0		RANGE 4.0		RANGE 5.0		RANGE 6.0		RANGE 7.0		RANGE 7.6	
STA	ELEV	STA	ELEV	STA	ELEV	STA	ELEV	STA	ELEV	STA	ELEV	STA	ELEV	STA	ELEV
(M)	(M)	(M)	(M)	(M)	(M)	(M)	(M)	(M)	(M)	(M)	(M)	(M)	(M)	(M)	(M)
0.00	.280	0.00	.285	0.00	.275	0.00	.285	0.00	.295	0.00	.300	0.00	.285	0.00	.310
1.10	.155	1.02	.125	.07	.235	1.34	.135	.08	.230	1.34	.125	1.25	.135	1.20	.170
1.36	.145	1.01	.105	1.01	.125	1.04	.105	1.05	.115	1.35	.100	1.20	.075	1.24	.115
1.60	.105	1.07	.095	1.01	.070	1.71	.105	2.07	.050	1.77	.040	1.85	.015	1.67	.0400
2.11	.110	2.10	.090	1.03	.100	1.07	.090	2.03	.005	2.14	.005	2.00	.0000	2.21	.0005
2.75	.0000	2.29	.085	2.05	.005	2.05	.005	2.05	.0000	2.01	.075	2.00	.0070	3.20	.0070
3.09	.0080	2.71	.0005	3.09	.070	2.05	.005	3.59	.120	3.40	.125	3.10	.135	3.07	.140
3.35	.0035	3.04	.0075	4.10	.110	2.04	.005	4.07	.130	3.01	.105	3.00	.005	4.04	.100
4.34	.130	3.29	.0000	4.71	.115	3.10	.105	4.00	.140	3.01	.095	3.70	.145	4.73	.135
4.05	.110	4.28	.150	5.37	.220	3.00	.090	4.05	.170	4.21	.130	4.10	.165	5.03	.235
5.07	.225	4.07	.105	6.10	.200	3.04	.095	5.72	.250	4.05	.200	4.05	.170	6.10	.230
7.00	.285	5.04	.105	6.00	.205	4.15	.170	6.04	.270	5.15	.200	5.17	.225	7.00	.295
8.02	.0005	6.05	.250	7.03	.205	4.70	.140	7.05	.260	6.75	.250	6.05	.250	8.00	.500
10.26	.975	7.07	.325	8.02	.435	4.97	.160	7.00	.230	7.10	.200	6.72	.285	9.55	.505
11.73	.705	8.35	.010	9.09	.520	5.19	.170	8.03	.440	7.20	.255	7.27	.295	11.00	.700
11.90	.715	9.20	.505	10.34	.595	5.40	.225	9.30	.505	7.01	.300	7.05	.325		
		9.95	.550			6.10	.220	9.00	.500	8.57	.430	8.00	.400		
		10.75	.605			6.40	.215	10.00	.480	9.15	.450	9.00	.515		
		11.03	.705			6.05	.275	11.01	.475	9.70	.415	9.50	.500		
		11.90	.715			7.31	.285	11.00	.705	10.30	.670	9.00	.900		
						7.73	.305					10.20	.505		
						8.20	.335					10.02	.605		
						8.48	.345					11.90	.700		
						9.00	.400								
						9.92	.540								
						10.20	.590								
						11.00	.700								

## TEST 5

RANGE 1.5		RANGE 2.0		RANGE 3.0		RANGE 4.0		RANGE 5.0		RANGE 6.0		RANGE 7.0		RANGE 7.6	
STA	ELEV	STA	ELEV	STA	ELEV	STA	ELEV	STA	ELEV	STA	ELEV	STA	ELEV	STA	ELEV
(M)	(M)	(M)	(M)	(M)	(M)	(M)	(M)	(M)	(M)	(M)	(M)	(M)	(M)	(M)	(M)
0.00	.275	0.00	.275	0.00	.260	0.00	.280	0.00	.265	0.00	.280	0.00	.275	0.00	.290
.95	.185	.90	.185	.98	.175	.98	.175	.90	.170	.85	.185	.97	.185	1.00	.180
1.34	.150	1.32	.225	1.05	.155	1.02	.190	1.02	.235	1.04	.205	1.10	.195	1.00	.135
1.36	.145	2.72	.0005	2.70	.005	1.70	.105	2.74	.010	2.05	.010	2.55	.010	2.00	.040
2.07	.105	4.00	.0035	4.10	.220	2.00	.010	3.65	.025	3.20	.090	3.20	.100	2.03	.015
2.73	.0000	4.05	.0000	4.00	.170	3.45	.105	4.10	.220	4.00	.220	3.00	.170	3.15	.040
3.70	.005	5.30	.230	6.10	.205	4.10	.220	4.70	.165	4.00	.170	4.00	.165	3.00	.145
4.00	.0005	6.11	.270	6.00	.310	4.01	.175	5.00	.245	5.74	.200	6.10	.200	4.00	.100
5.07	.205	6.70	.305	7.00	.310	5.09	.300	6.07	.330	6.00	.330	6.70	.310	5.30	.215
6.15	.250	7.02	.350	7.00	.305	6.02	.300	7.00	.310	7.00	.325	7.00	.285	6.10	.225
6.05	.300	8.00	.075	8.03	.520	7.07	.310	8.00	.455	8.23	.370	8.00	.330	6.00	.270
7.00	.330	11.22	.075	11.30	.085	8.00	.465	8.00	.470	8.00	.455	9.27	.400	7.00	.505
8.70	.070	11.90	.715	11.90	.715	9.51	.555	10.57	.635	10.12	.870	10.00	.610	8.97	.620
11.70	.705					11.55	.700	11.90	.705	11.90	.600	11.97	.700	10.00	.505
11.00	.715					11.97	.715			11.97	.705			11.00	.710

## TEST 6

RANGE 1.5		RANGE 2.0		RANGE 3.0		RANGE 4.0		RANGE 5.0		RANGE 6.0		RANGE 7.0		RANGE 7.6	
STA	ELEV	STA	ELEV	STA	ELEV	STA	ELEV	STA	ELEV	STA	ELEV	STA	ELEV	STA	ELEV
(M)	(M)	(M)	(M)	(M)	(M)	(M)	(M)	(M)	(M)	(M)	(M)	(M)	(M)	(M)	(M)
0.00	.275	0.00	.295	0.00	.285	0.00	.295	0.00	.285	0.00	.290	0.00	.280	0.00	.275
1.00	.174	.70	.215	1.00	.195	1.00	.195	1.00	.195	1.10	.180	1.10	.180	1.10	.185
1.04	.154	1.10	.180	1.50	.155	2.70	.100	2.05	.105	1.80	.115	1.00	.100	2.15	.055
2.00	.095	1.50	.135	2.20	.110	2.00	.005	2.70	.005	2.40	.015	2.00	.010	2.05	.055
3.10	.034	1.00	.150	2.70	.070	3.30	.040	3.00	.070	3.20	.070	3.10	.075	3.10	.115
3.30	.004	2.00	.005	3.50	.000	4.00	.105	3.30	.075	3.40	.155	3.40	.105	3.50	.070
3.60	.004	3.60	.035	4.20	.140	4.00	.105	3.75	.145	3.60	.105	3.00	.085	4.00	.155
4.00	.115	3.50	.100	4.70	.145	5.00	.225	4.00	.195	4.35	.160	4.00	.155	5.00	.235
5.20	.235	5.75	.085	5.30	.235	6.00	.305	5.00	.215	5.10	.235	5.10	.240	6.00	.290
5.70	.240	6.00	.140	6.00	.295	7.00	.405	6.30	.281	6.10	.260	6.05	.235	7.00	.505
6.70	.300	7.05	.205	7.20	.345	8.00	.475	7.00	.375	7.10	.300	6.70	.320	8.00	.470
7.10	.335	7.70	.235	8.20	.415	9.00	.570	8.00	.475	7.00	.375	8.30	.405	9.00	.590
7.70	.305	8.50	.275	9.20	.505	10.00	.600	9.00	.575	8.00	.485	10.70	.405	10.00	.635
8.00	.370	7.00	.325	10.10	.580	11.00	.705	10.00	.675	9.00	.575	10.70	.405	11.00	.700
8.60	.475	7.00	.335	11.10	.670			11.00	.705	10.00	.670	11.00	.705		
9.20	.510	8.10	.405												
9.90	.545	8.00	.405												
10.70	.590	9.00	.535												
10.90	.600	10.30	.600												
11.00	.600	11.00	.670												
11.90	.710	11.90	.710												

## TEST 7

RANGE 1.5		RANGE 2.0		RANGE 3.0		RANGE 4.0		RANGE 5.0		RANGE 6.0		RANGE 7.0		RANGE 7.6	
STA	ELEV	STA	ELEV	STA	ELEV	STA	ELEV	STA	ELEV	STA	ELEV	STA	ELEV	STA	ELEV
(M)	(M)	(M)	(M)	(M)	(M)	(M)	(M)	(M)	(M)	(M)	(M)	(M)	(M)	(M)	(M)
0.00	.284	0.00	.285	0.00	.285	0.00	.290	0.00	.285	0.00	.290	0.00	.280	0.00	.275
1.53	.100	1.55	.110	1.03	.085	1.30	.150	1.23	.180	.95	.185	.59	.230	.00	.255
2.02	.120	2.05	.120	2.30	.045	1.30	.085	1.23	.095	.95	.100	.59	.125	.00	.130
2.34	.074	2.91	.025	2.70	.030	2.13	.035	1.02	.015	1.23	.090	1.50	.025	1.35	.015
2.62	.0000	3.10	.045	3.30	.070	2.39	.045	2.01	.005	1.72	.025	2.19	.080	1.75	.080
3.70	.0000	3.50	.055	4.11	.130	2.63	.060	3.17	.0000	2.99	.100	2.52	.080	2.65	.175
3.97	.0000	3.95	.125	4.00	.105	2.09	.005	3.20	.100	2.40	.135	3.00	.105	3.07	.005
4.10	.009	4.27	.085	5.70	.220	3.30	.075	3.02	.175	3.04	.115	3.03	.220	3.09	.125
4.04	.145	4.00	.155	6.00	.230	3.05	.155	4.01	.170	3.35	.135	4.75	.205	3.04	.190
4.91	.190	4.97	.185	7.20	.315	4.00	.160	5.10	.220	4.00	.205	5.23	.245	4.00	.200
5.15	.105	5.05	.205	7.00	.300	4.00	.150	5.00	.205	4.70	.165	5.00	.225	5.17	.250
6.05	.215	6.02	.255	8.77	.405	5.00	.205	6.01	.200	6.70	.275	6.70	.275	5.01	.225
6.03	.205	7.03	.340	9.00	.405	6.10	.195	7.00	.270	6.10	.220	7.10	.300	6.52	.225
6.02	.300	8.00	.430	10.00	.500	6.07	.245	7.70	.320	6.70	.305	8.30	.435	6.00	.290
8.00	.395	9.00	.405	11.00	.600	7.01	.305	8.00	.405	7.33	.305	7.27	.320	7.00	.320
9.00	.480	10.00	.500	12.00	.710	8.00	.360	9.35	.535	8.21	.425	10.00	.600	8.30	.400
10.00	.575	11.00	.590			8.03	.400	10.27	.610	8.00	.400	11.00	.600	9.00	.400
11.00	.680	12.00	.710			9.70	.590	11.00	.670	9.53	.595	11.00	.690	10.00	.570
12.00	.715					10.59	.670	12.00	.710	11.00	.690	12.00	.710	11.00	.690
						11.00	.695			11.00	.710			11.00	.700
						12.00	.710			12.00	.710			12.00	.710

## TEST 8

RANGE 1.5		RANGE 2.0		RANGE 3.0		RANGE 4.0		RANGE 5.0		RANGE 6.0		RANGE 7.0		RANGE 7.6	
STA	ELEV	STA	ELEV	STA	ELEV	STA	ELEV	STA	ELEV	STA	ELEV	STA	ELEV	STA	ELEV
(M)	(M)	(M)	(M)	(M)	(M)	(M)	(M)	(M)	(M)	(M)	(M)	(M)	(M)	(M)	(M)
0.00	.289	0.00	.280	0.00	.289	0.00	.295	0.00	.300	0.00	.300	0.00	.295	0.00	.285
.09	.215	.32	.265	.42	.260	.79	.215	.92	.210	.76	.235	.68	.230	.88	.220
.92	.115	.40	.115	.45	.115	.45	.070	.46	.130	.83	.115	.69	.145	.63	.155
.93	.090	.79	.030	1.38	.019	1.76	.015	1.63	.010	1.78	.015	1.76	.005	1.72	.015
1.18	.008	1.11	.025	1.96	.080	2.63	.120	2.21	.125	2.05	.065	2.14	.140	2.70	.105
1.52	.005	1.80	.005	2.51	.005	3.63	.175	3.16	.145	2.66	.115	4.32	.215	3.68	.175
1.87	.008	2.29	.110	3.31	.175	4.32	.150	3.68	.100	3.22	.145	5.04	.245	4.26	.185
2.15	.180	2.93	.155	3.76	.185	5.13	.170	4.68	.175	4.03	.235	5.76	.205	5.10	.225
2.51	.145	3.46	.170	4.36	.190	5.70	.215	5.05	.205	5.15	.245	6.43	.265	6.27	.235
2.67	.170	3.95	.165	4.81	.175	6.74	.225	6.50	.230	5.55	.212	6.80	.270	7.30	.260
2.72	.175	4.70	.195	5.58	.230	7.56	.265	7.55	.285	6.92	.241	7.91	.345	8.20	.305
3.40	.175	5.11	.190	6.65	.240	8.32	.305	8.36	.355	8.05	.355	8.81	.355	9.79	.355
4.07	.215	6.08	.205	7.38	.315	9.41	.520	9.51	.535	9.46	.551	9.50	.540	10.63	.625
4.49	.245	6.43	.245	8.10	.375	9.92	.575	10.09	.605	10.80	.615	10.20	.610	11.93	.695
7.46	.335	7.25	.305	8.76	.445	10.68	.660	.7	.660	11.93	.705	11.06	.655		
8.48	.435	7.78	.370	9.40	.510	11.40	.695	11.93	.705			11.93	.695		
9.46	.510	8.95	.415	10.16	.565										
10.19	.580	9.36	.510	10.95	.645										
10.99	.685	10.16	.570	11.93	.705										
11.93	.710	10.98	.645												
		11.93	.710												

## TEST 9

RANGE 1.5		RANGE 2.0		RANGE 3.0		RANGE 4.0		RANGE 5.0		RANGE 6.0		RANGE 7.0		RANGE 7.6	
STA	ELEV	STA	ELEV	STA	ELEV	STA	ELEV	STA	ELEV	STA	ELEV	STA	ELEV	STA	ELEV
(M)	(M)	(M)	(M)	(M)	(M)	(M)	(M)	(M)	(M)	(M)	(M)	(M)	(M)	(M)	(M)
0.00	.270	3.00	.285	0.00	.285	0.00	.300	0.00	.305	0.00	.300	0.00	.295	0.00	.290
1.13	.155	1.18	.125	1.36	.115	1.96	.090	1.40	.135	1.61	.090	1.28	.140	1.24	.140
1.36	.170	1.67	.130	1.73	.075	2.02	.065	1.60	.090	1.71	.085	1.61	.070	2.00	.020
1.68	.180	2.00	.100	2.02	.075	2.63	.010	1.65	.080	2.97	.015	2.31	.005	2.66	.125
1.82	.075	2.71	.005	2.69	.020	3.07	.060	1.85	.095	3.17	.065	2.66	.070	3.23	.085
2.63	.005	3.52	.000	3.03	.080	3.42	.050	2.49	.010	3.38	.078	3.12	.095	3.85	.170
3.09	.080	3.89	.155	3.50	.070	3.89	.085	3.35	.100	4.68	.170	4.00	.215	4.62	.170
3.38	.085	4.48	.165	3.91	.145	4.68	.150	4.20	.185	5.16	.175	4.66	.200	5.00	.195
3.65	.155	5.30	.205	4.45	.175	5.97	.225	4.83	.215	5.85	.165	5.17	.165	5.64	.195
4.23	.140	6.36	.190	5.15	.220	6.18	.220	5.30	.240	6.55	.220	6.15	.180	6.39	.220
4.77	.195	5.90	.210	6.46	.200	6.86	.210	6.17	.190	7.16	.230	6.97	.230	7.10	.280
5.27	.175	6.46	.205	6.97	.240	7.70	.245	6.98	.220	8.09	.290	7.64	.310	8.05	.370
5.86	.205	6.92	.240	7.53	.265	8.43	.265	8.10	.250	9.48	.535	8.36	.310	9.88	.485
6.23	.190	7.37	.260	8.22	.320	9.99	.530	9.39	.490	10.61	.640	9.31	.490		
6.91	.245	8.15	.300	9.07	.405	10.65	.628	10.68	.625	11.06	.705	11.72	.705	11.73	.769
7.30	.250	8.90	.420	9.92	.530	11.02	.710	11.02	.710						
7.76	.380	10.10	.535	11.02	.710										
8.45	.385	11.93	.710												
9.36	.580														
10.19	.580														
11.93	.710														

## TEST 10

RANGE 1.5		RANGE 2.0		RANGE 3.0		RANGE 4.0		RANGE 5.0		RANGE 6.0		RANGE 7.0		RANGE 7.6	
STA	ELEV	STA	ELEV	STA	ELEV	STA	ELEV	STA	ELEV	STA	ELEV	STA	ELEV	STA	ELEV
(M)	(M)	(M)	(M)	(M)	(M)	(M)	(M)	(M)	(M)	(M)	(M)	(M)	(M)	(M)	(M)
0.00	.280	0.00	.285	0.00	.285	0.00	.300	0.00	.295	0.00	.300	0.00	.295	0.00	.290
1.04	.155	.98	.175	1.25	.130	1.59	.115	1.16	.170	1.66	.115	1.58	.115	1.68	.110
1.04	.135	1.07	.135	1.37	.055	1.65	.105	1.27	.145	2.49	.005	2.08	.070	4.09	.040
2.07	.010	1.85	.015	2.15	.005	2.57	.010	1.85	.085	3.33	.070	2.45	.005	4.35	.005
2.64	.055	2.05	.015	3.00	.070	3.79	.075	2.93	.010	3.74	.090	3.54	.090	3.73	.125
3.48	.085	2.85	.095	3.92	.110	4.32	.145	3.67	.090	4.63	.165	4.45	.175	4.46	.175
3.91	.105	3.69	.105	3.92	.125	4.70	.110	4.22	.125	5.63	.160	5.23	.160	5.03	.195
4.15	.195	4.13	.155	4.40	.200	5.48	.225	4.75	.100	6.52	.255	6.07	.285	6.61	.265
4.42	.215	4.45	.210	4.86	.130	6.36	.255	5.98	.220	7.79	.350	7.68	.330	8.27	.235
5.05	.200	5.02	.150	5.65	.225	7.28	.338	8.44	.250	8.60	.445	8.73	.485	8.67	.260
5.60	.225	5.79	.250	6.52	.275	8.28	.405	7.45	.325	9.58	.550	9.50	.595	7.84	.360
6.46	.285	6.52	.320	7.68	.355	9.27	.368	8.98	.430	10.67	.650	10.61	.640	8.64	.435
6.95	.315	6.97	.305	8.58	.440	10.95	.630	9.46	.540	11.93	.675	11.93	.690	9.60	.535
7.43	.355	7.60	.365	9.82	.495	11.93	.695	10.67	.625					10.38	.595
8.39	.425	8.30	.430	10.92	.610			11.38	.690					11.92	.695
8.90	.440	9.28	.465	11.92	.695			11.95	.688						
9.97	.485	10.08	.495												
10.40	.535	10.05	.565												
11.19	.605	11.93	.680												
11.92	.685														

## TEST 11

RANGE 1.5		RANGE 2.0		RANGE 3.0		RANGE 4.0		RANGE 5.0		RANGE 6.0		RANGE 7.0		RANGE 7.6	
STA	ELEV	STA	ELEV	STA	ELEV	STA	ELEV	STA	ELEV	STA	ELEV	STA	ELEV	STA	ELEV
(M)	(M)	(M)	(M)	(M)	(M)	(M)	(M)	(M)	(M)	(M)	(M)	(M)	(M)	(M)	(M)
0.00	.280	0.00	.290	0.00	.300	0.00	.300	0.00	.310	0.00	.310	0.00	.310	0.00	.305
1.50	.110	1.34	.120	1.14	.190	.93	.190	.95	.200	.96	.200	.96	.200	.75	.205
2.50	.080	1.60	.090	1.27	.180	1.63	.110	1.61	.115	1.63	.120	.96	.110	1.64	.185
3.10	.010	1.70	.070	2.33	.010	1.82	.010	1.68	.015	1.65	.015	1.65	.055	1.15	.135
3.22	.070	2.34	.020	2.59	.080	2.40	.020	2.65	.075	2.13	.035	2.38	.005	1.90	.030
3.45	.120	3.02	.040	2.76	.090	3.65	.110	3.01	.105	3.20	.070	2.87	.110	2.17	.010
3.79	.090	4.13	.150	3.08	.090	3.98	.100	3.52	.095	3.71	.135	3.16	.165	2.79	.030
4.25	.170	4.64	.160	3.29	.130	4.19	.170	3.85	.190	4.63	.170	3.42	.075	3.14	.090
5.17	.190	5.28	.180	3.68	.070	5.14	.220	4.79	.180	4.98	.205	3.74	.120	3.65	.120
6.02	.300	6.10	.140	4.08	.140	5.95	.280	5.44	.260	5.99	.270	4.38	.170	4.62	.175
7.03	.330	6.91	.300	4.62	.200	6.82	.320	6.63	.290	6.92	.325	4.98	.200	5.05	.195
8.03	.400	7.39	.350	5.20	.210	7.79	.390	7.68	.385	7.91	.365	5.83	.230	5.82	.220
9.51	.520	8.06	.440	6.12	.270	8.98	.480	8.39	.460	8.25	.450	6.75	.290	6.60	.245
10.60	.610	9.07	.520	7.14	.330	9.96	.570	9.42	.510	9.42	.550	7.64	.360	7.56	.335
11.96	.710	10.16	.620	8.08	.400	10.87	.660	10.16	.580	10.29	.610	8.72	.400	8.58	.405
		11.93	.710	9.95	.450	11.97	.710	11.23	.680	11.20	.675	9.79	.450	9.30	.560
				9.97	.580	11.93	.710	11.96	.710	11.91	.700	10.60	.630	10.38	.595
				11.96	.720							11.27	.675	11.93	.690
												11.98	.780	11.98	.780

## TEST 12

RANGE 1.5		RANGE 2.0		RANGE 3.0		RANGE 4.0		RANGE 5.0		RANGE 6.0		RANGE 7.0		RANGE 7.6	
STA	ELEV	STA	ELEV	STA	ELEV	STA	ELEV	STA	ELEV	STA	ELEV	STA	ELEV	STA	ELEV
(M)	(M)	(M)	(M)	(M)	(M)	(M)	(M)	(M)	(M)	(M)	(M)	(M)	(M)	(M)	(M)
0.00	.280	0.00	.280	0.00	.300	0.00	.310	0.00	.310	0.00	.310	0.00	.285	0.00	.285
.70	.285	.70	.285	1.18	.120	1.15	.135	1.57	.100	1.25	.135	.97	.100	.96	.100
1.05	.124	1.31	.135	1.78	.150	1.37	.095	2.01	.095	1.40	.140	1.47	.140	1.20	.115
2.40	.041	1.67	.175	2.10	.040	2.08	.095	2.70	.210	2.40	.005	2.40	0.000	1.75	.100
3.12	.075	2.55	0.000	3.30	.000	2.25	.080	3.10	.030	2.80	.055	3.05	.000	2.35	.005
3.92	.180	3.10	.085	3.92	.070	2.66	.065	3.38	.080	3.02	.070	3.91	.195	2.78	.000
4.05	.145	3.46	.075	3.66	.130	3.42	.065	3.92	.155	3.61	.145	4.09	.145	3.17	.005
4.80	.280	3.78	.160	4.02	.140	3.68	.070	4.71	.140	4.21	.170	4.62	.210	3.38	.100
5.66	.285	4.18	.150	5.00	.220	4.06	.130	5.10	.200	5.00	.240	5.00	.230	3.77	.165
6.66	.330	4.90	.250	5.92	.225	4.70	.140	5.82	.270	5.55	.230	5.55	.270	4.25	.140
7.23	.340	5.66	.280	6.64	.330	5.61	.240	6.84	.310	6.43	.300	6.80	.230	4.87	.215
7.80	.395	6.61	.335	7.15	.345	6.19	.220	7.94	.430	7.80	.375	7.80	.375	5.48	.200
8.63	.470	7.23	.350	7.71	.400	6.90	.330	8.78	.460	7.93	.370	7.38	.350	6.12	.240
9.35	.510	7.98	.390	8.45	.430	7.42	.380	9.40	.540	8.84	.491	8.87	.355	6.90	.205
9.85	.560	8.78	.500	9.12	.510	8.24	.410	10.24	.600	9.37	.505	9.70	.485	7.57	.350
10.93	.610	9.35	.505	10.08	.580	9.10	.500	11.08	.670	10.15	.600	9.92	.620	8.23	.380
10.90	.650	10.00	.580	10.74	.640	10.27	.610	11.85	.705	10.46	.670	10.16	.670	8.82	.440
11.24	.670	10.80	.640	11.62	.710	10.84	.680			11.40	.690	10.88	.620	9.37	.490
11.71	.705	11.39	.690			11.60	.695			11.93	.705	11.20	.690	9.88	.560
11.93	.710	11.87	.710									11.83	.705	10.40	.605
														10.82	.620
														11.53	.695
														11.96	.705

## TEST 13

RANGE 1.5		RANGE 2.0		RANGE 3.0		RANGE 4.0		RANGE 5.0		RANGE 6.0		RANGE 7.0		RANGE 7.6	
STA	ELEV	STA	ELEV	STA	ELEV	STA	ELEV	STA	ELEV	STA	ELEV	STA	ELEV	STA	ELEV
(M)	(M)	(M)	(M)	(M)	(M)	(M)	(M)	(M)	(M)	(M)	(M)	(M)	(M)	(M)	(M)
0.00	.285	0.00	.285	0.00	.310	0.00	.310	0.00	.315	0.00	.315	0.00	.310	0.00	.310
.70	.175	.82	.175	1.98	.180	.95	.175	.84	.205	1.24	.210	1.50	.150	1.03	.085
1.05	.150	1.10	.145	2.04	.020	1.02	.140	1.37	.100	1.87	.130	2.28	.085	2.53	.005
1.40	.120	1.25	.145	2.53	.075	1.84	.055	1.88	.090	2.48	.100	2.92	.085	3.38	.000
1.80	.090	1.32	.145	2.92	.155	2.94	.010	2.48	.095	2.75	.090	3.53	.140	4.44	.220
2.40	.005	1.80	.055	3.62	.215	2.80	.005	3.05	.105	2.75	.085	5.31	.220	5.31	.220
2.74	.050	2.15	.005	3.61	.210	3.40	.115	3.41	.220	3.09	.130	5.84	.215	6.25	.270
3.01	.131	2.49	.050	4.03	.220	4.53	.180	4.29	.180	3.68	.255	5.99	.275	6.91	.310
3.98	.210	2.77	.130	5.62	.240	4.49	.195	4.49	.180	4.42	.180	6.88	.300	7.78	.340
4.16	.215	3.13	.200	6.43	.295	5.63	.205	5.53	.255	5.13	.210	7.63	.345	8.77	.430
4.71	.204	3.91	.215	6.96	.330	5.97	.260	6.22	.270	5.95	.270	8.87	.470	9.53	.520
5.12	.230	4.45	.215	7.48	.350	6.48	.300	6.95	.325	6.74	.355	9.84	.541	10.42	.600
6.31	.280	4.82	.200	8.19	.430	7.00	.355	7.57	.380	7.48	.365	10.35	.615	11.81	.690
6.92	.330	5.45	.240	9.22	.520	7.68	.365	8.41	.400	8.77	.470	11.38	.685	11.97	.705
7.40	.370	6.49	.290	10.19	.590	8.44	.455	9.27	.515	9.88	.555	11.94	.708		
8.28	.430	7.01	.330	11.15	.685	9.39	.520	9.88	.575	10.86	.610				
8.78	.475	7.62	.360	11.88	.710	10.34	.600	10.78	.645	11.17	.670				
9.48	.515	8.10	.430			11.88	.685	11.46	.695	11.94	.708				
10.24	.590	8.82	.480			11.05	.710	11.05	.710						
11.09	.695	9.44	.525												
11.93	.710	10.17	.580												
		11.18	.665												
		11.93	.710												

## TEST 14

RANGE 1.5		RANGE 2.0		RANGE 3.0		RANGE 4.0		RANGE 5.0		RANGE 6.0		RANGE 7.0		RANGE 7.6	
STA	ELEV	STA	ELEV	STA	ELEV	STA	ELEV	STA	ELEV	STA	ELEV	STA	ELEV	STA	ELEV
(M)	(M)	(M)	(M)	(M)	(M)	(M)	(M)	(M)	(M)	(M)	(M)	(M)	(M)	(M)	(M)
0.00	.284	0.00	.280	0.00	.300	0.00	.305	0.00	.310	0.00	.305	0.00	.305	0.00	.305
.40	.284	.29	.255	0.00	.040	0.00	.110	.23	.290	.13	.300	0.00	.235	.33	.255
.94	.225	.41	.115	.62	.035	.60	.040	.20	.130	.13	.170	.92	.194	.77	.230
.70	.090	.97	.015	1.55	.075	1.37	.080	1.15	.010	1.22	.020	1.72	.040	1.92	.120
1.26	.030	1.18	.025	1.79	.110	1.85	.115	1.78	.080	1.62	.040	2.22	.080	2.04	.010
1.15	.020	1.43	.090	2.28	.200	2.19	.180	2.21	.115	2.52	.110	2.95	.135	3.00	.090
2.23	.000	2.14	.135	3.20	.220	3.00	.200	2.36	.105	2.81	.155	3.49	.140	3.34	.165
2.91	.200	2.92	.225	3.93	.240	3.93	.310	3.23	.245	3.50	.240	4.43	.210	4.01	.130
3.58	.270	3.59	.200	4.95	.245	4.87	.310	4.02	.285	4.23	.260	5.16	.285	4.94	.210
4.31	.294	4.24	.240	5.80	.275	5.72	.325	4.72	.295	4.94	.285	6.34	.375	6.04	.310
4.94	.289	4.92	.255	6.74	.330	6.73	.319	5.71	.350	5.76	.360	6.98	.355	6.97	.305
5.63	.300	5.65	.270	7.63	.385	7.64	.405	6.67	.310	6.30	.390	8.06	.425	7.92	.420
6.38	.300	6.58	.290	8.82	.440	8.79	.515	7.35	.380	7.00	.380	8.92	.480	8.74	.485
7.07	.305	7.31	.330	9.85	.535	9.78	.515	8.19	.435	7.72	.390	9.78	.560	9.53	.540
8.94	.490	8.12	.305	10.91	.670	10.81	.680	9.32	.560	8.55	.445	11.01	.685	10.87	.590
9.90	.550	8.88	.485	11.37	.710	11.43	.710	9.95	.530	9.40	.545	11.98	.670	11.85	.621
10.68	.600	9.56	.590	11.98	.719	11.92	.710	10.71	.655	10.24	.590			11.94	.685
11.27	.685	10.51	.630					11.34	.715	11.15	.660				
11.98	.710	11.29	.685					11.93	.715	11.93	.705				

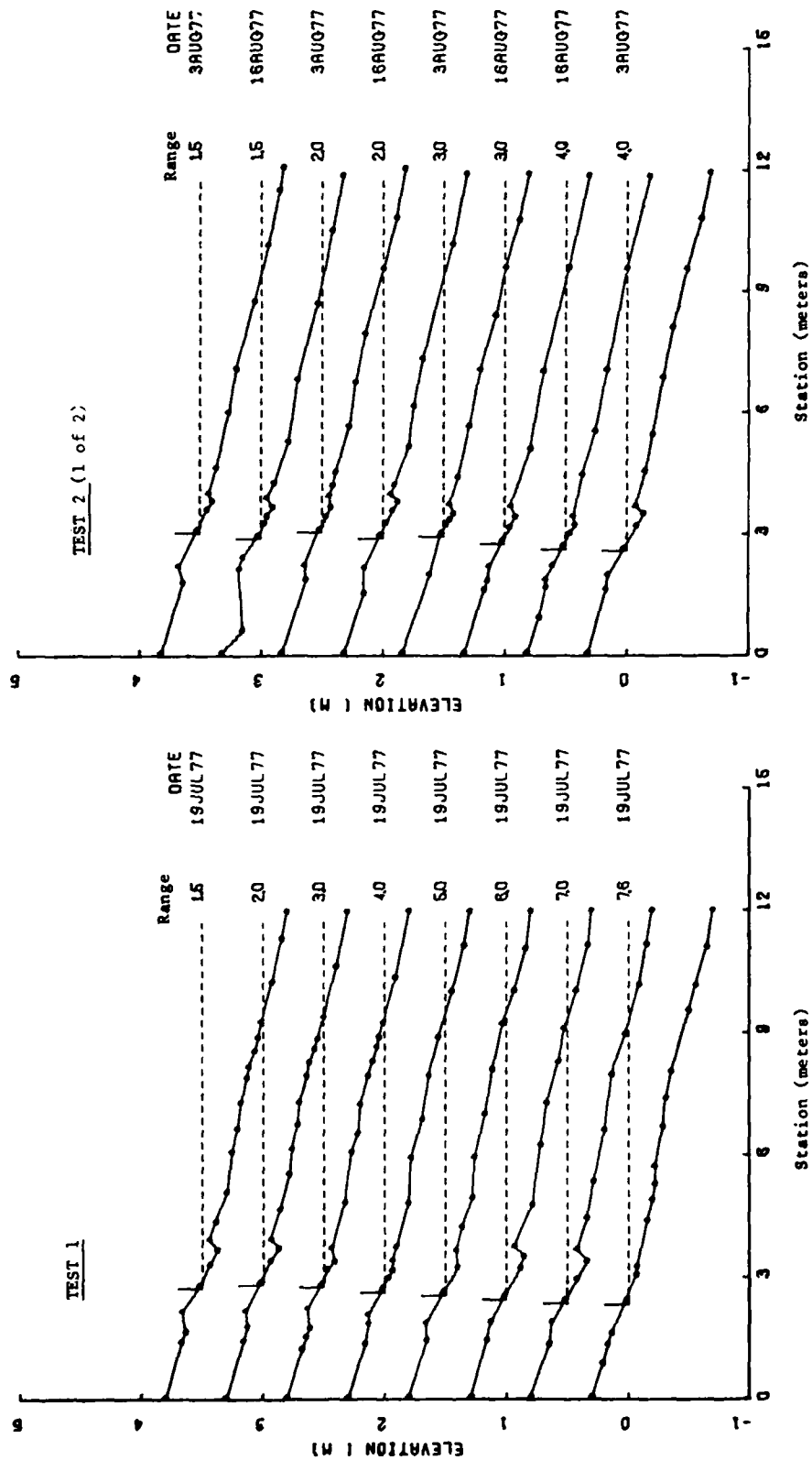
## TEST 15

RANGE 1.5		RANGE 2.0		RANGE 3.0		RANGE 4.0		RANGE 5.0		RANGE 6.0		RANGE 7.0		RANGE 7.6	
STA	ELEV	STA	ELEV	STA	ELEV	STA	ELEV	STA	ELEV	STA	ELEV	STA	ELEV	STA	ELEV
(M)	(M)	(M)	(M)	(M)	(M)	(M)	(M)	(M)	(M)	(M)	(M)	(M)	(M)	(M)	(M)
0.00	.284	0.00	.285	0.00	.280	0.00	.285	0.00	.305	0.00	.285	0.00	.285	0.00	.300
1.10	.140	.85	.175	.63	.205	.85	.140	.80	.200	.96	.170	.95	.190	1.00	.180
1.15	.100	.85	.135	.63	.140	.85	.125	.80	.115	1.00	.125	1.36	.125	1.23	.140
1.34	.094	1.03	.010	1.83	0.000	1.13	.120	1.35	.110	1.60	.085	1.60	.105	1.65	.125
2.01	.030	2.46	.090	2.26	.061	1.77	.015	1.42	.095	2.61	0.000	2.60	.010	2.34	.080
2.80	.004	3.35	.230	2.51	.070	3.00	.085	2.80	.015	2.75	.015	2.40	.030	2.55	.005
3.35	.204	3.92	.231	2.95	.145	3.10	.155	3.15	.075	3.54	.070	3.34	.080	3.20	.070
4.20	.235	4.60	.245	3.48	.145	3.95	.165	3.63	.120	3.73	.120	3.62	.090	3.75	.125
5.50	.290	4.05	.300	4.25	.245	3.78	.110	3.82	.080	3.40	.090	3.65	.125	3.95	.170
6.75	.310	4.95	.320	5.17	.305	3.80	.140	4.04	.090	4.04	.095	4.04	.105	4.35	.120
7.75	.344	7.95	.400	6.20	.305	4.85	.220	4.15	.130	4.90	.155	4.25	.150	4.70	.180
8.75	.404	8.60	.455	6.90	.310	6.00	.280	4.78	.105	6.91	.230	5.05	.180	6.91	.205
10.07	.540	10.05	.505	7.75	.370	6.91	.310	9.00	.270	7.80	.325	7.80	.325	8.00	.350
11.15	.580	11.10	.450	6.70	.405	7.62	.340	8.88	.255	7.75	.420	7.67	.330	7.76	.450
11.93	.705	11.93	.605	0.00	.535	0.75	.420	7.78	.315	10.10	.600	0.78	.615	0.90	.575
				10.07	.625	10.02	.575	0.75	.420	11.20	.601	10.10	.601	11.07	.630
				11.93	.705	11.08	.600	0.78	.370	11.93	.705	11.20	.600	11.93	.700
						11.93	.700	11.83	.600			11.93	.700		

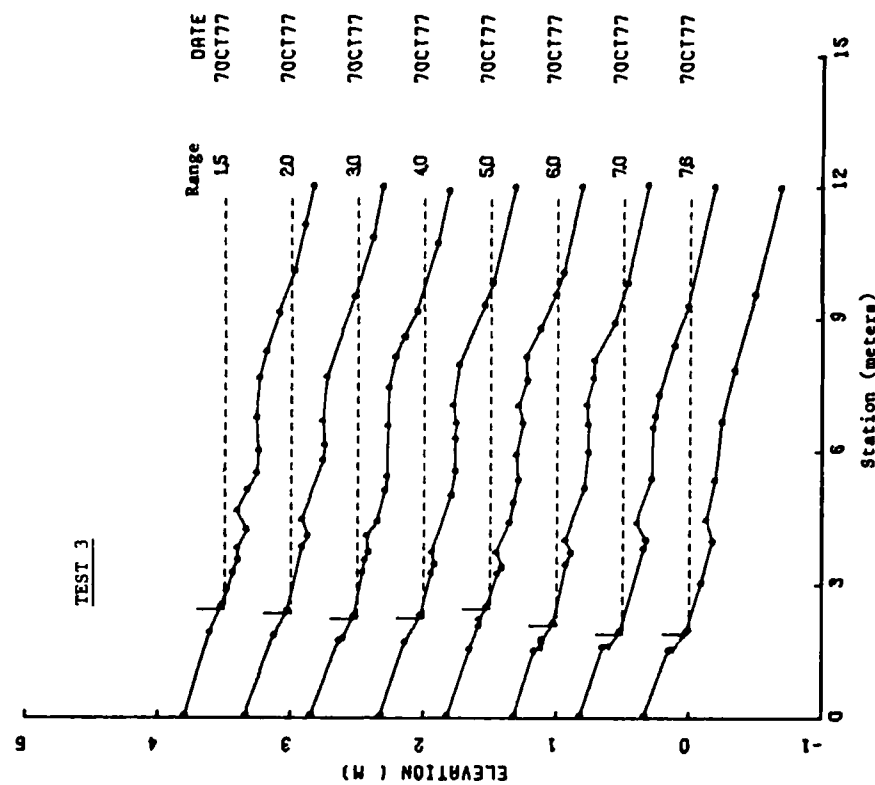
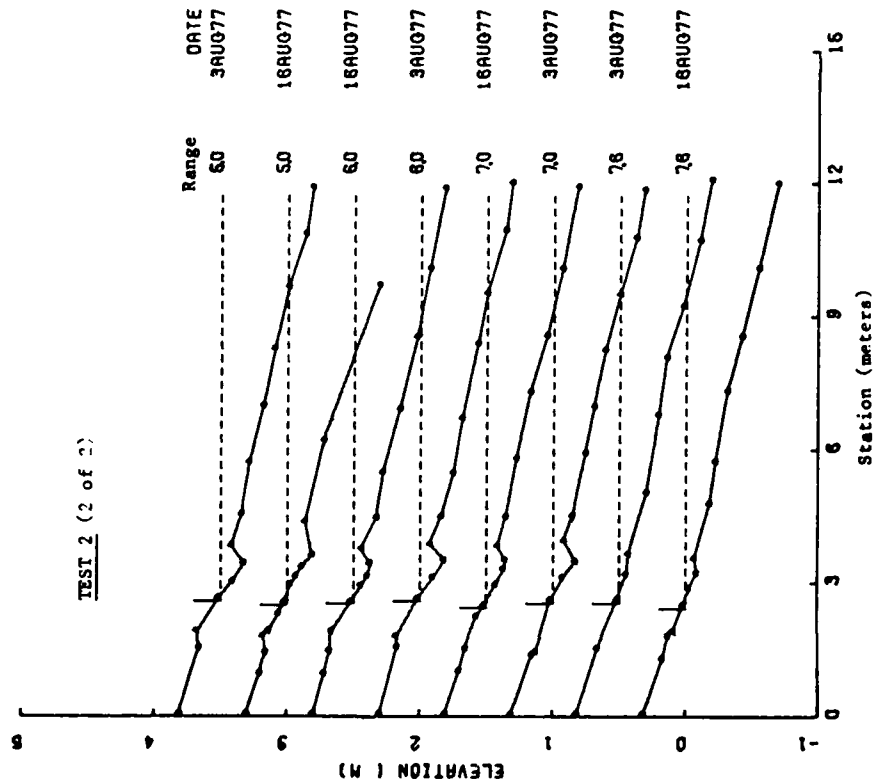
APPENDIX C

PLOTTED BEACH PROFILES

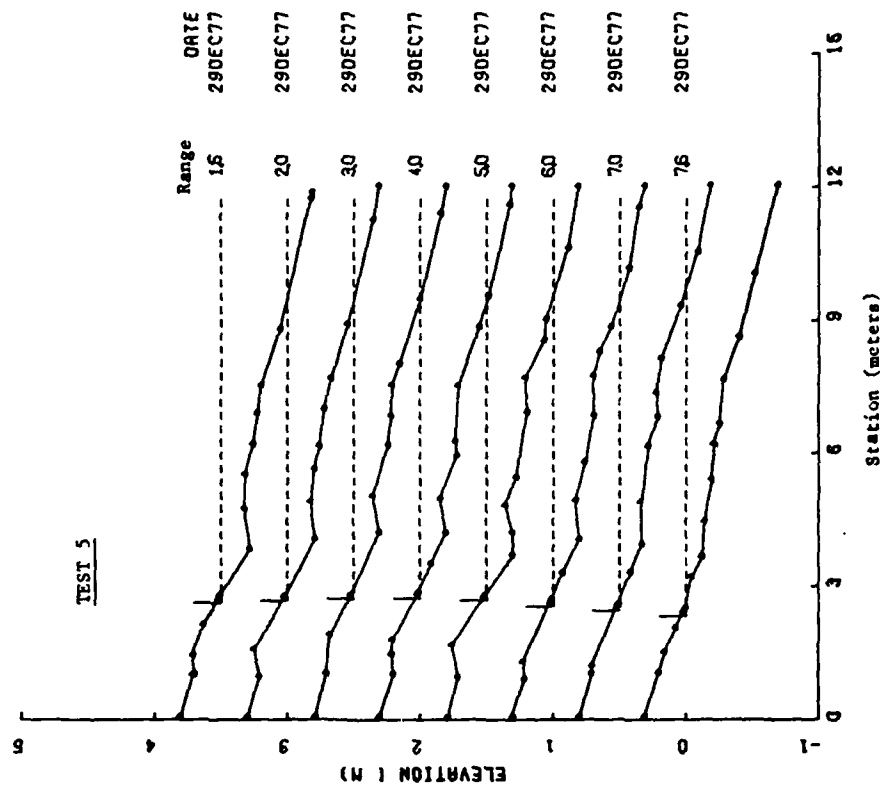
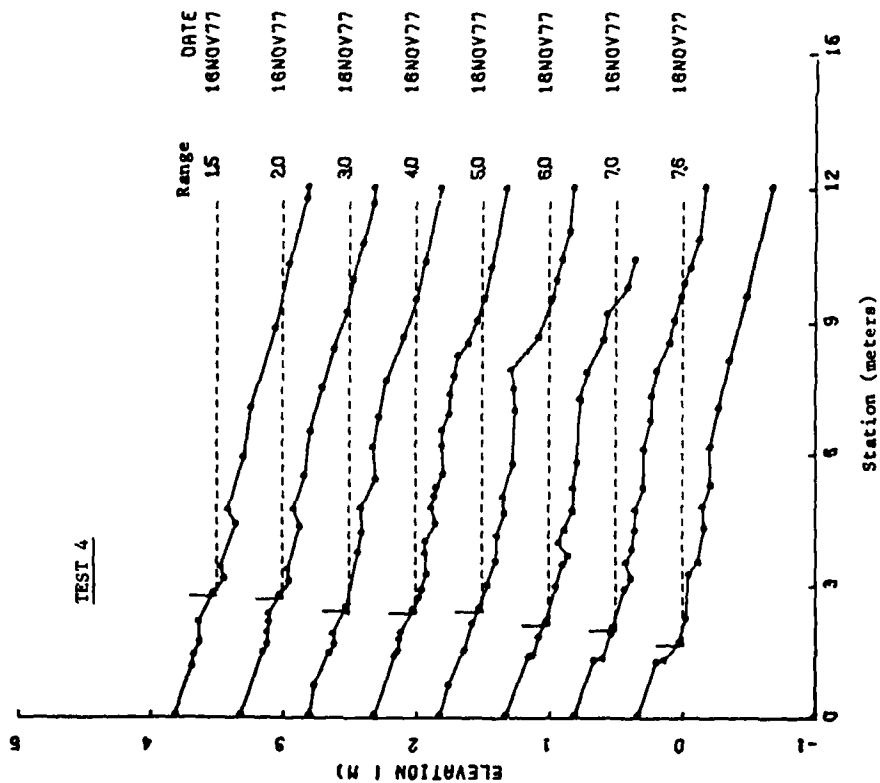
SHORELINE POSITION  
 VERTICAL DATUM IS SWL  
 HORIZONTAL DATUM IS  
 STATION 0



SHORELINE POSITION  
 VERTICAL DATUM IS SWL  
 HORIZONTAL DATUM IS  
 STATION 0

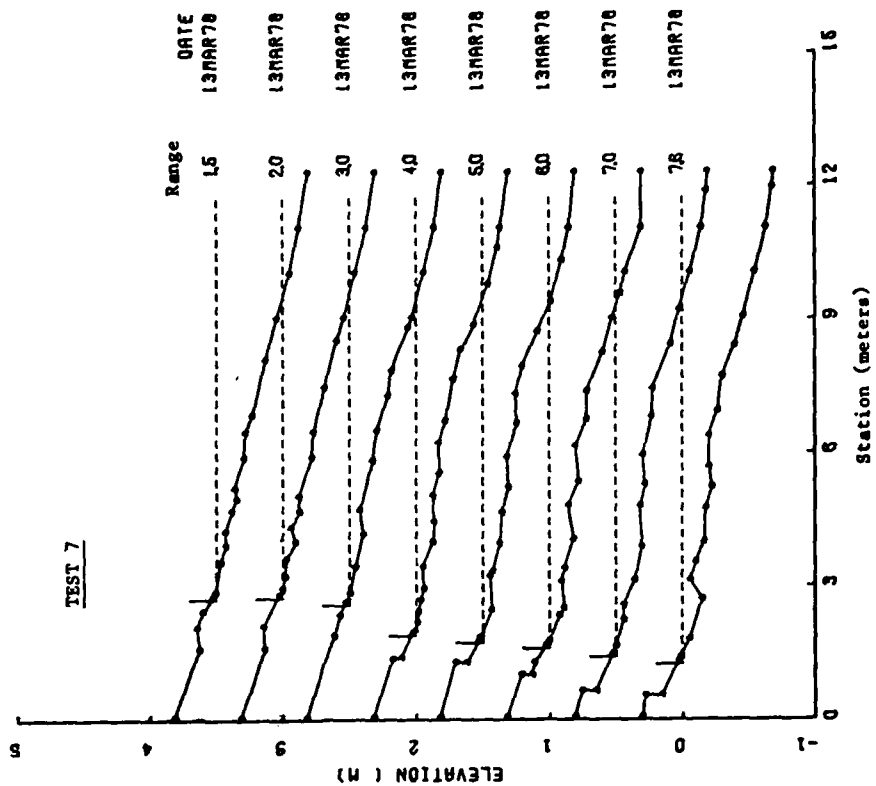
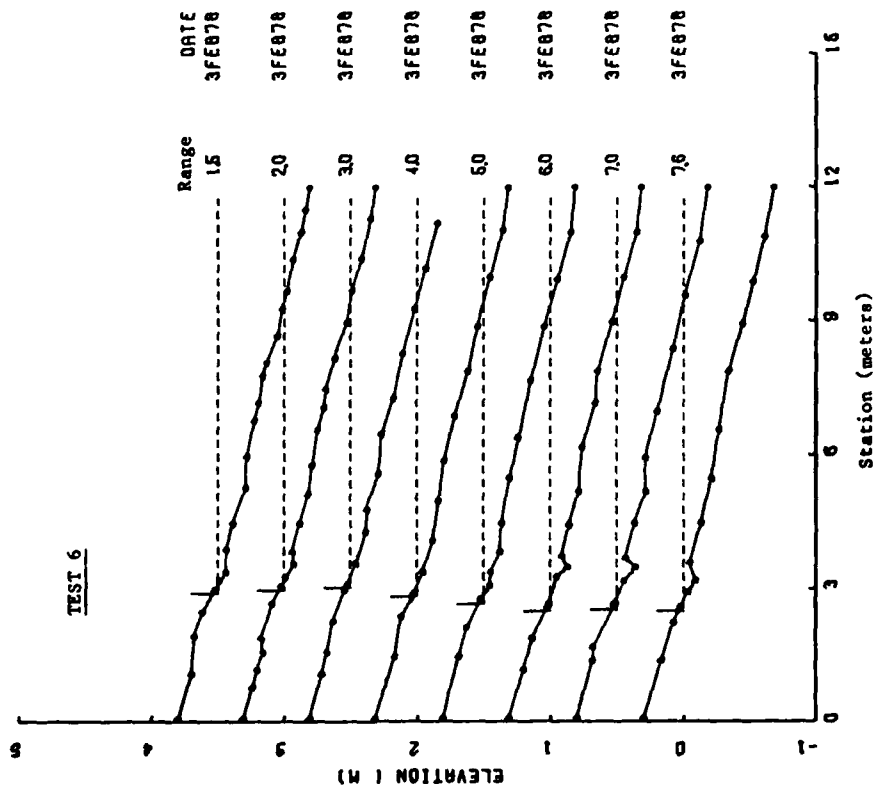


SHORELINE POSITION  
 VERTICAL DATUM IS SWL  
 HORIZONTAL DATUM IS  
 STATION 0

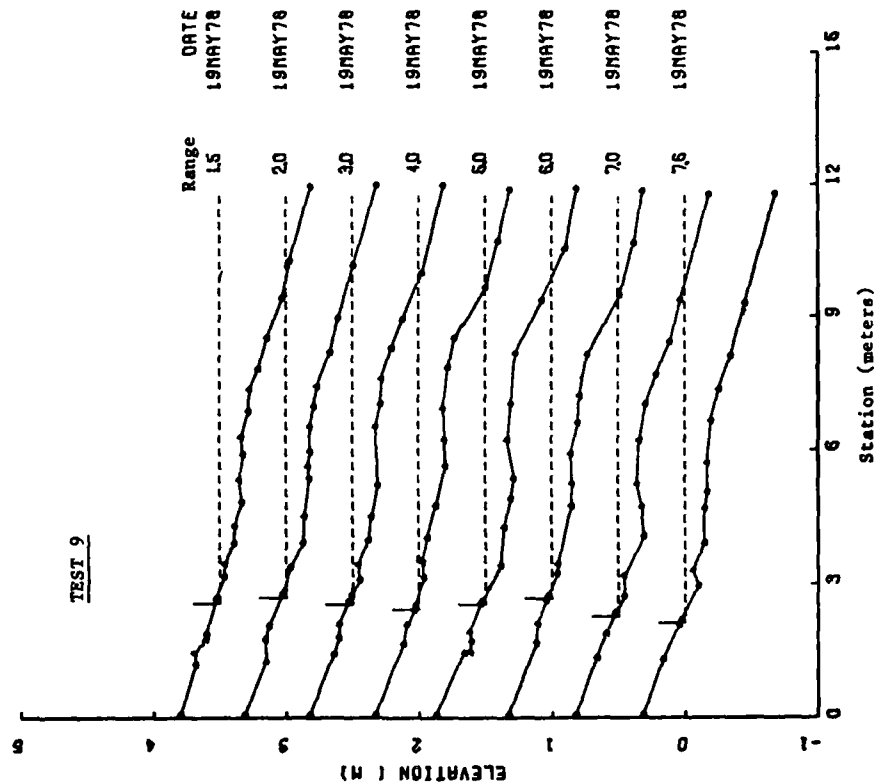
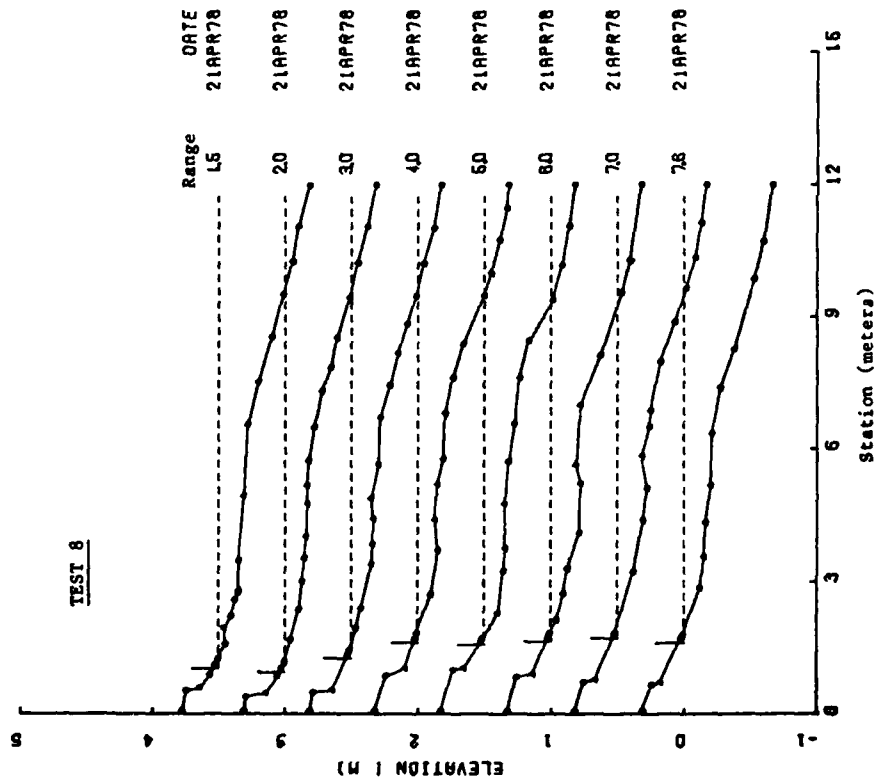




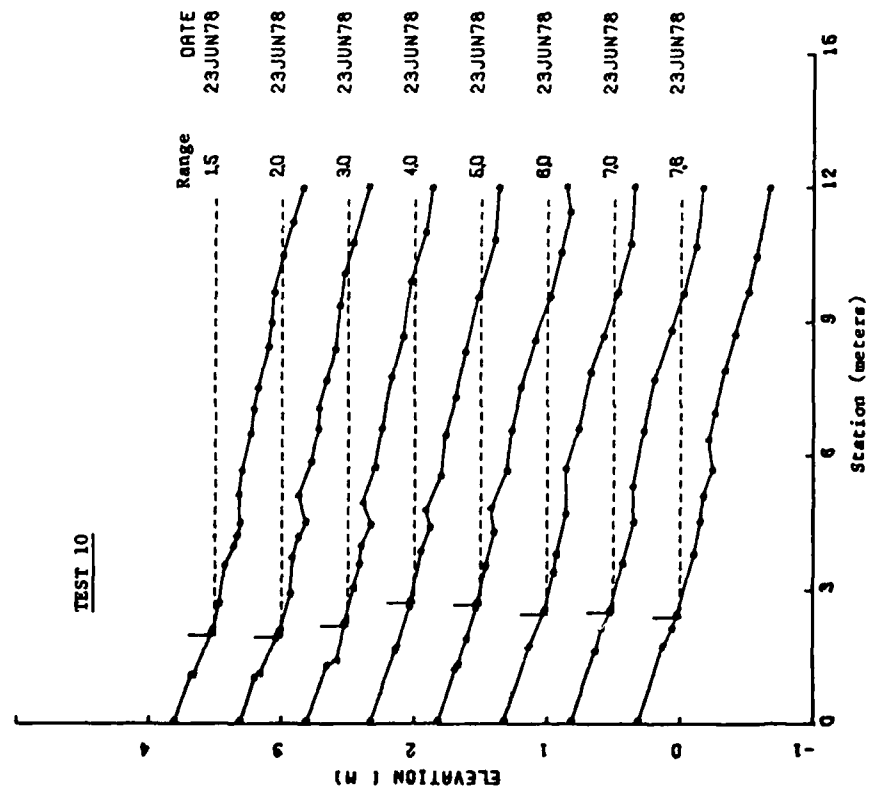
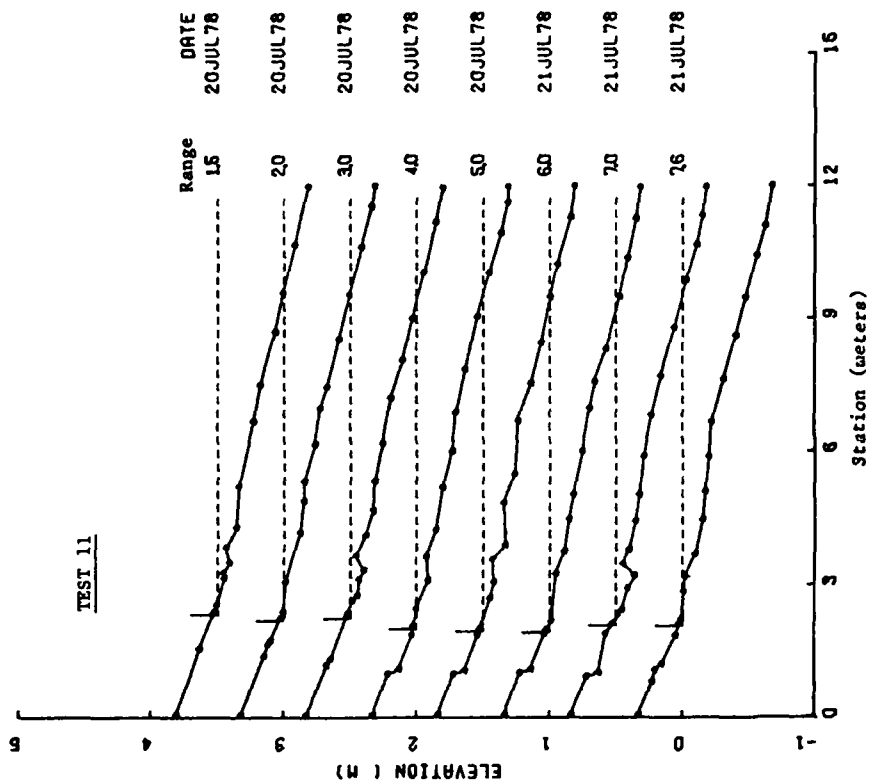
X- SHORELINE POSITION  
 VERTICAL DATUM IS SML  
 HORIZONTAL DATUM IS  
 STATION 0



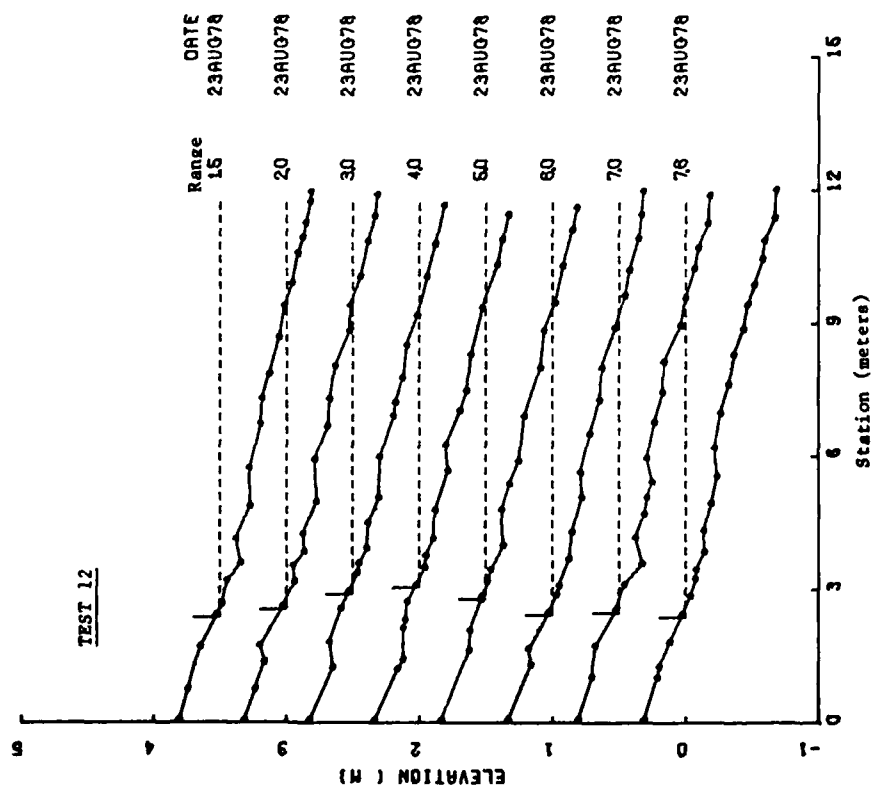
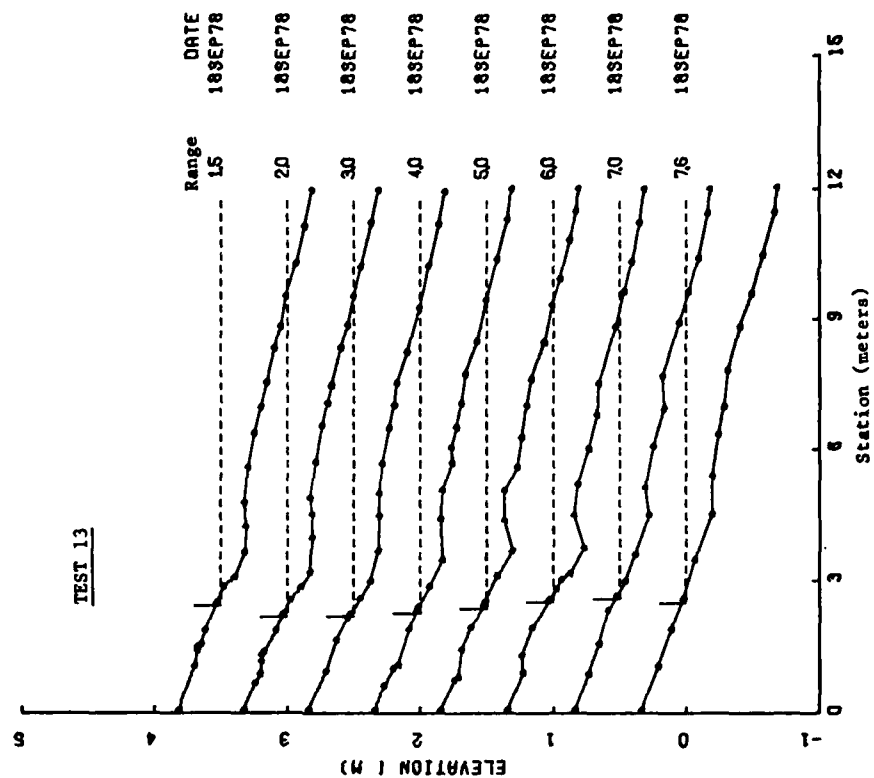
✓ SHORELINE POSITION  
 VERTICAL DATUM IS SWL  
 HORIZONTAL DATUM IS  
 STATION 0



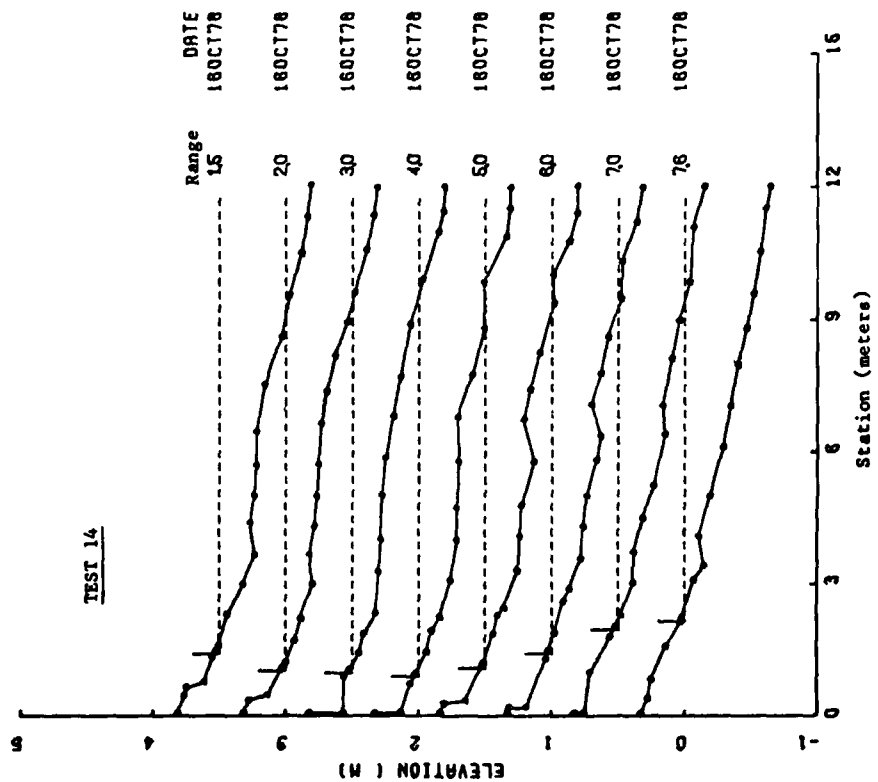
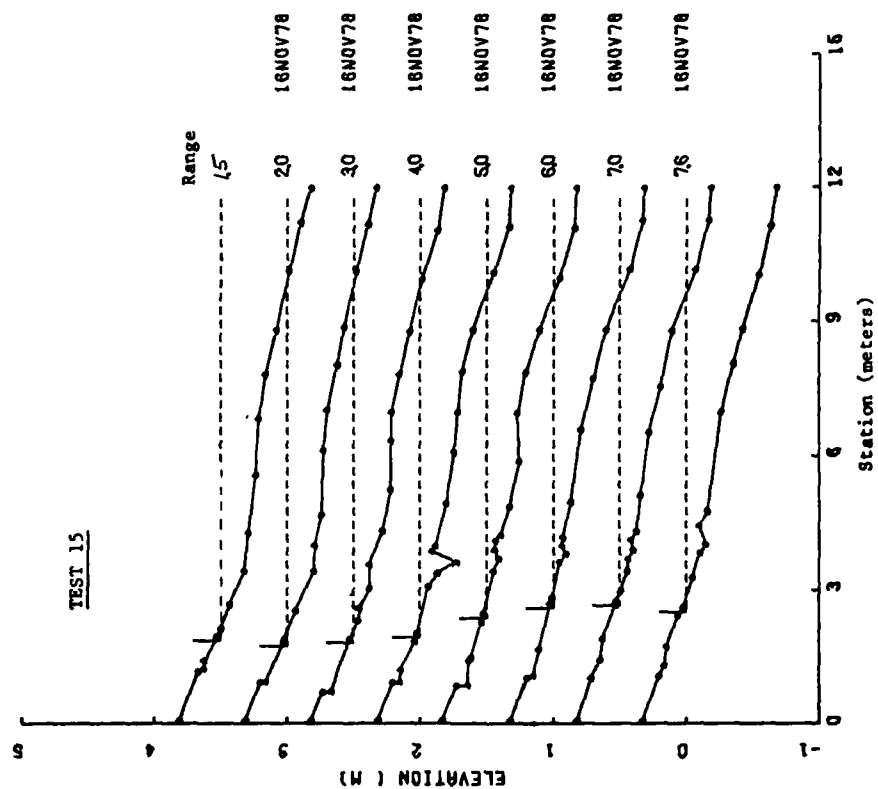
- SHORELINE POSITION  
 VERTICAL DATUM IS SWL  
 HORIZONTAL DATUM IS  
 STATION 0



SHORELINE POSITION  
VERTICAL DATUM IS SWL  
HORIZONTAL DATUM IS  
STATION 0



-- SHORELINE POSITION  
 VERTICAL DATUM IS SWL  
 HORIZONTAL DATUM IS  
 STATION 0



## APPENDIX D

### SELECTED BREAKER BAR AND WATERLINE PHOTOS

The following photos from 35-millimeter slides were taken at approximate run-hours 01, 08, 16, and 24. Figure 15 provides an explanation of features. The complete set of slides is available from CEIAC.



Figure D-1a.



Figure D-1b.



Figure D-1c.



Figure D-1d.

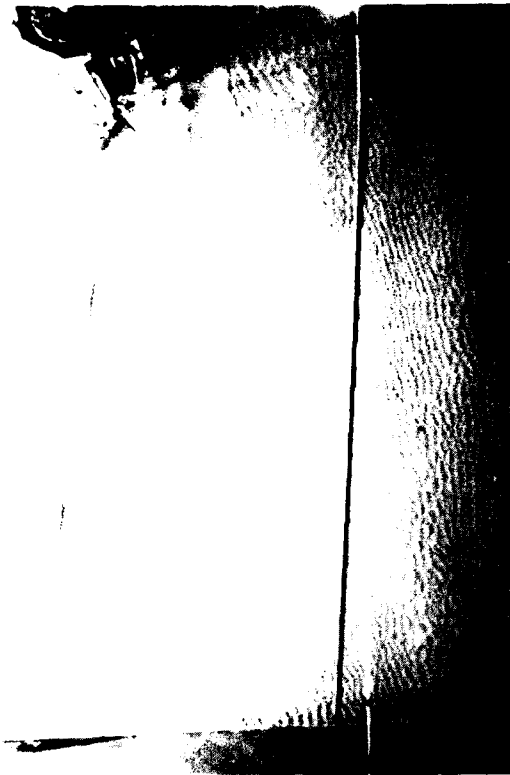


Figure D-2b.



Figure D-2d.



Figure D-2a.



Figure D-2c.





Figure D-3a.



Figure D-3b.



Figure D-3c.



Figure D-3d.

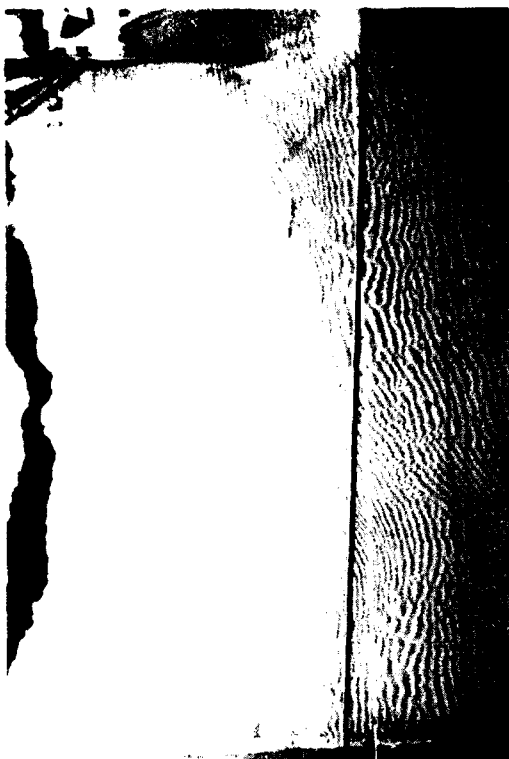


Figure D-4b.



Figure D-4d.



Figure D-4a.



Figure D-4c.



Figure D-5b.



Figure D-5d.



Figure D-5a.

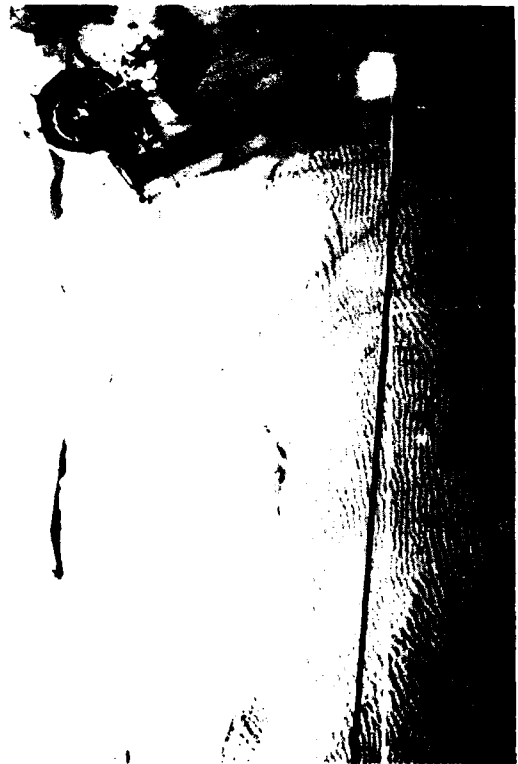


Figure D-5c.



Figure D-6b.

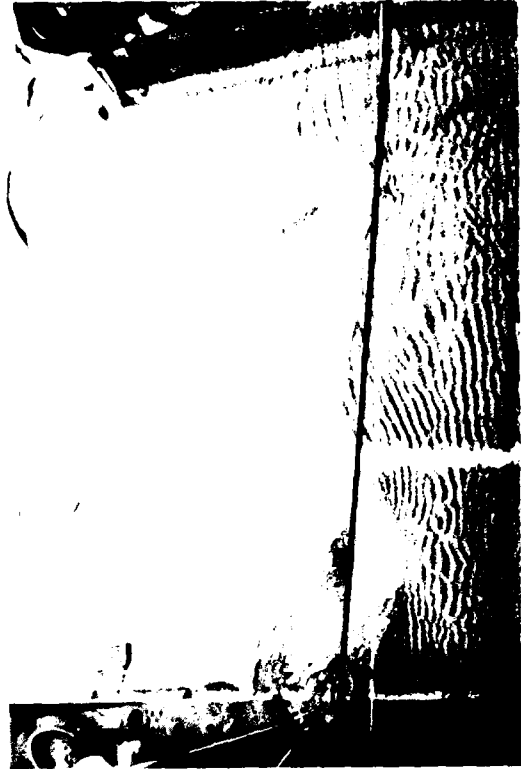


Figure D-6d.



Figure D-6a.

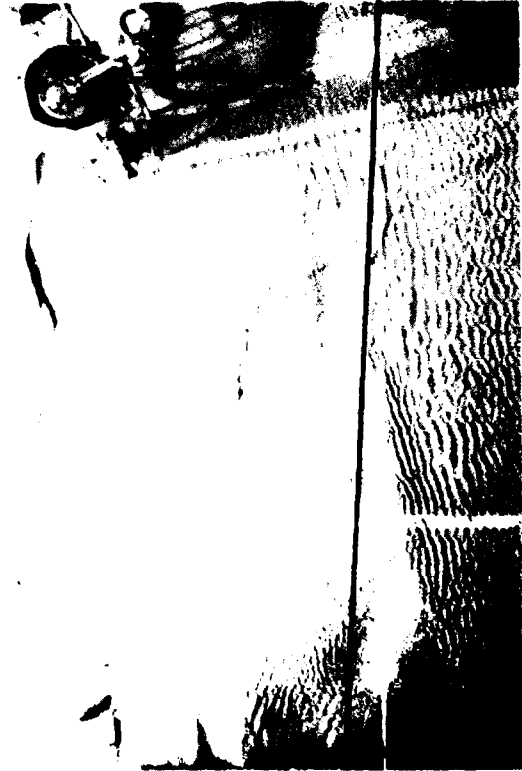


Figure D-6c.



Figure D-7b.



Figure D-7d.



Figure D-7a.

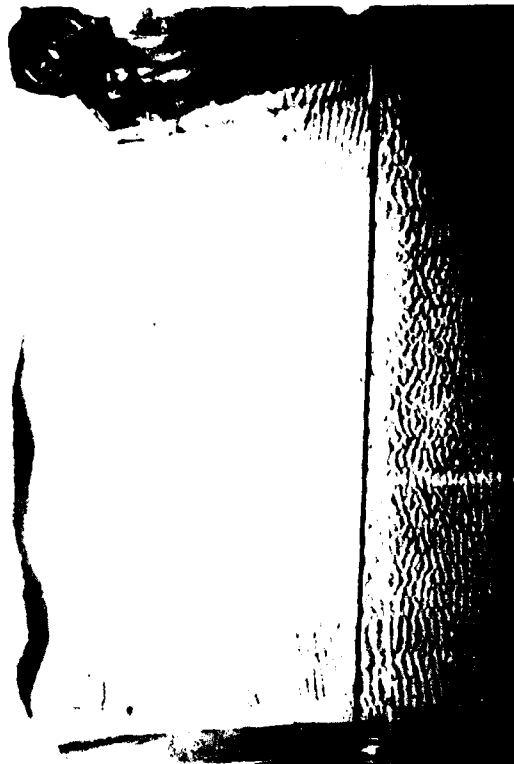


Figure D-7c.



Figure D-8a.

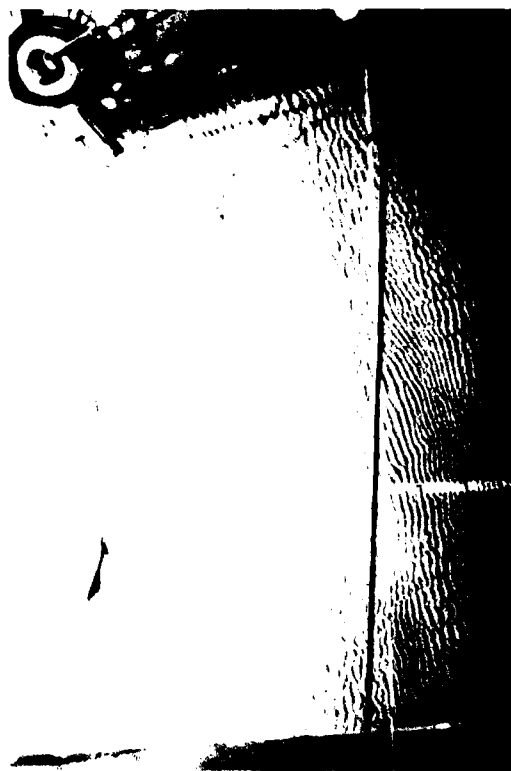


Figure D-8c.

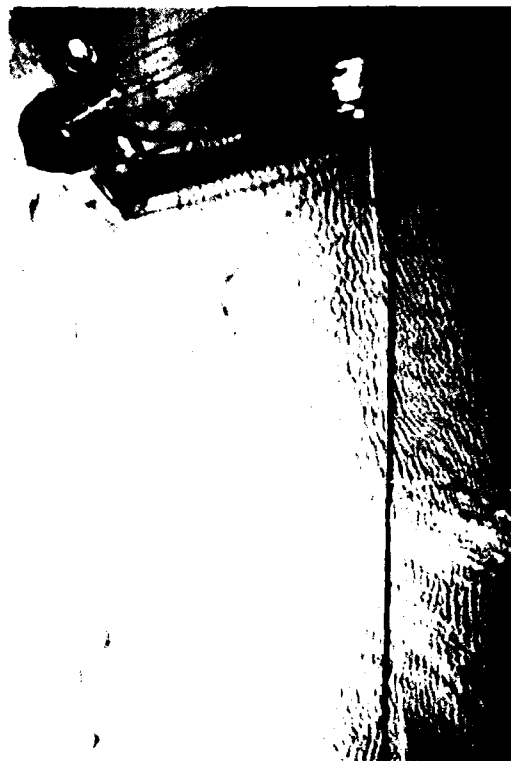


Figure D-8d.



Figure D-9a.

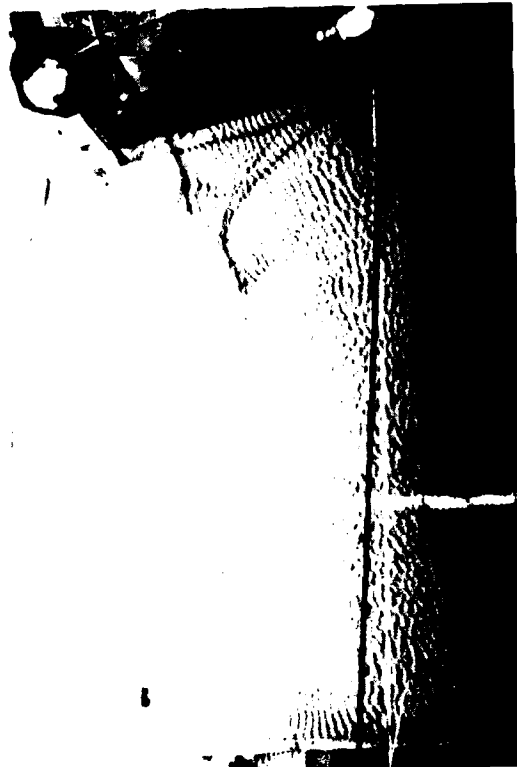


Figure D-9b.

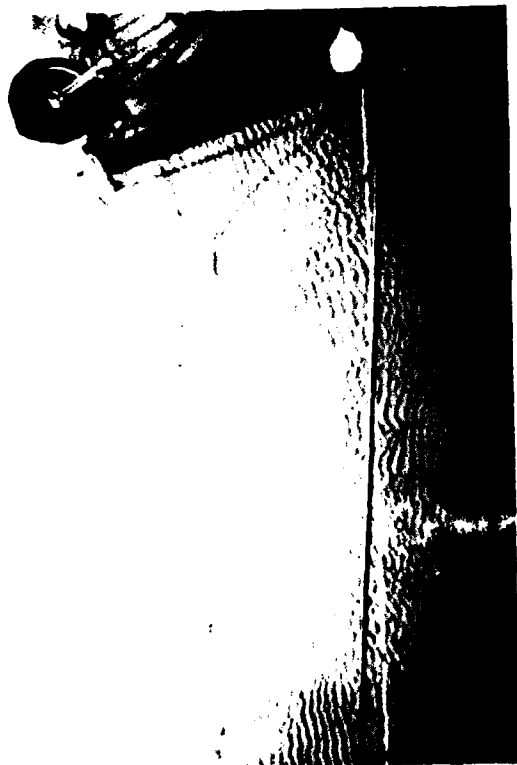


Figure D-9c.

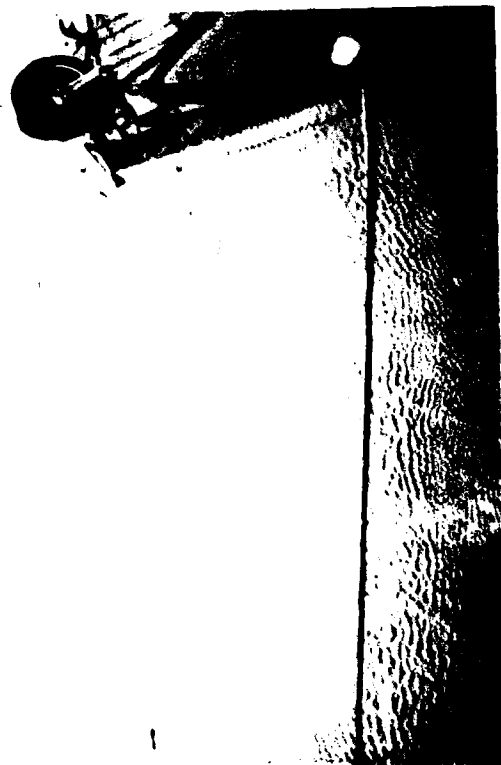


Figure D-9d.



Figure D-10b.

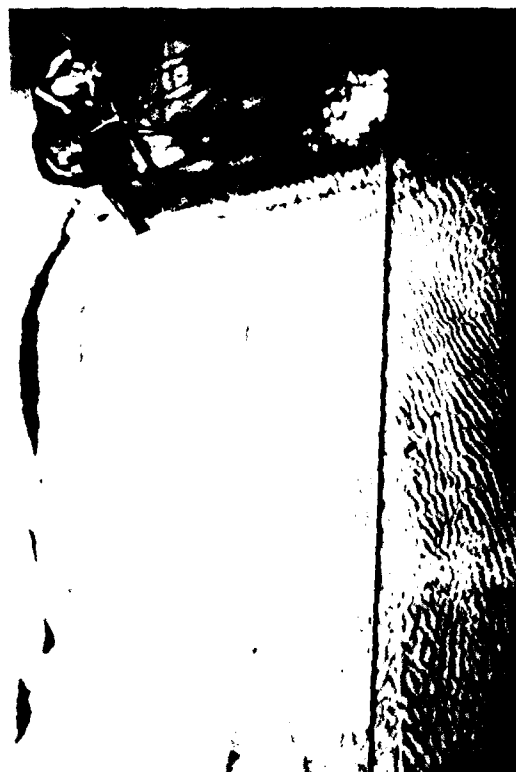


Figure D-10a.



Figure D-10d.



Figure D-10c.



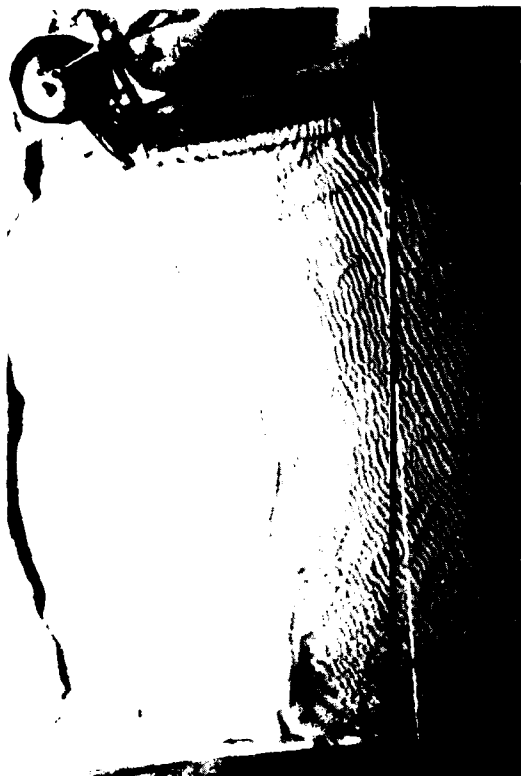


Figure D-11b.



Figure D-11d.



Figure D-11a.



Figure D-11c.

## APPENDIX E

### HOURLY CYCLE CALCULATIONS

A listing of the program which calculates the values in this appendix, using the data in Appendix A, is available from CEIAC.

HOURLY CYCLE CALCULATIONS

TEST	DATE	TIME	MR	HN	WAVE	HEIGHT	BREAKER	SKY	PLB	TEST	DATE	TIME	MR	HN	WAVE	HEIGHT	BREAKER	SKY	PLB
					CM	CM	DEGREES	N/M	J/M/S						CM	CM	DEGREES	N/M	J/M/S
1	1	0	40	10	0	6.4	8	9	1.185	1	1	0	30	13	2	12.3	8	2.268	3.703
1	1	1	32	10	0	6.4	9	9	1.100	1	1	1	30	13	2	11.6	8	2.128	3.559
1	1	2	32	10	0	6.4	8	8	1.156	1	1	2	30	13	2	12.4	8	2.197	3.903
1	1	3	32	10	0	6.6	8	8	1.244	1	1	3	30	12	4	15.1	9	2.638	4.959
1	1	4	30	9	0	7.0	8	10	1.128	1	1	4	30	13	1	14.6	9	2.076	4.750
1	1	5	40	8	4	6.4	10	8	1.065	1	1	5	30	13	2	14.7	8	2.715	4.541
1	1	6	40	9	2	6.4	8	8	1.128	1	1	6	30	12	6	13.3	8	2.376	3.727
1	1	7	30	10	2	6.4	8	7	1.214	1	1	7	28	13	6	12.9	7	2.849	3.587
1	1	8	30	10	2	6.4	7	9	1.100	1	1	8	30	11	0	13.9	7	2.162	2.039
1	1	9	30	9	4	7.2	9	8	1.156	1	1	9	30	9	7	15.3	2	2.180	1.828
1	1	10	30	9	4	7.2	8	8	1.214	1	1	10	30	11	3	14.4	6	2.394	2.758
1	1	11	30	10	2	5.6	9	9	1.100	1	1	11	30	11	3	14.0	5	2.232	2.338
1	1	12	30	10	0	6.2	9	7	1.156	1	1	12	30	11	3	15.0	5	2.612	2.577
1	1	13	30	10	6	6.2	7	8	1.244	1	1	13	30	13	2	13.2	5	2.431	2.292
1	1	14	30	10	6	6.2	6	6	1.304	1	1	14	30	11	4	10.6	4	1.680	1.592
1	1	15	30	9	6	7.4	6	6	1.274	1	1	15	30	12	6	14.5	5	2.599	3.607
1	1	16	30	9	6	7.4	6	8	1.274	1	1	16	30	12	6	14.5	5	2.603	3.617
1	1	17	30	10	6	6.2	8	8	1.304	1	1	17	30	12	1	11.6	7	1.959	2.869
1	1	18	30	10	6	6.4	8	8	1.244	1	1	18	30	12	6	12.2	7	2.111	2.872
1	1	19	30	10	6	6.0	8	8	1.214	1	1	19	30	12	6	11.8	6	2.111	3.530
1	1	20	30	10	6	5.6	9	7	1.072	1	1	20	30	12	1	11.2	10	2.612	3.788
1	1	21	30	10	6	7.0	7	7	1.128	1	1	21	30	12	1	11.3	11	1.910	2.229
1	1	22	30	10	6	6.6	7	7	1.244	1	1	22	30	12	0	11.8	8	2.128	2.229
1	1	23	30	10	6	5.8	7	8	1.100	1	1	23	30	12	0	11.8	8	2.128	2.229
1	1	24	30	10	6	6.0	8	6	1.214	1	1	24	30	13	2	13.6	2	2.509	1.576
2	2	0	30	10	4	5.8	7	7	1.156	2	2	0	30	9	6	11.5	8	1.793	3.290
2	2	1	30	10	4	5.8	7	7	1.156	2	2	1	30	10	4	13.2	8	2.243	3.624
2	2	2	30	10	4	6.4	7	8	1.244	2	2	2	30	11	1	13.4	6	2.497	3.481
2	2	3	30	10	4	6.4	7	8	1.244	2	2	3	30	11	1	15.4	6	2.806	4.510
2	2	4	30	10	4	6.4	6	6	1.185	2	2	4	30	11	0	16.2	6	3.179	5.109
2	2	5	30	10	4	6.4	6	6	1.304	2	2	5	30	11	0	14.2	6	2.557	4.109
2	2	6	30	10	4	6.4	6	6	1.244	2	2	6	30	10	6	13.4	6	2.437	4.194
2	2	7	30	10	4	5.8	7	9	1.045	2	2	7	30	11	6	12.5	6	2.130	3.170
2	2	8	30	10	4	6.2	9	7	1.274	2	2	8	30	11	2	12.5	6	2.378	4.092
2	2	9	30	10	4	6.2	9	7	1.045	2	2	9	30	10	0	12.7	9	2.397	4.399
2	2	10	30	10	4	6.2	7	7	1.045	2	2	10	30	10	0	13.7	7	2.075	3.571
2	2	11	30	10	4	6.6	7	7	1.156	2	2	11	30	10	3	12.3	7	2.262	3.893
2	2	12	30	10	4	6.6	7	6	1.156	2	2	12	30	10	3	12.3	7	2.057	3.774
2	2	13	30	10	4	6.6	6	6	1.128	2	2	13	30	10	3	12.5	9	2.057	4.008
2	2	14	30	10	4	6.6	6	6	1.128	2	2	14	30	9	4	12.0	8	1.844	3.384
2	2	15	30	10	4	6.4	6	6	1.114	2	2	15	30	9	5	12.8	8	2.002	3.975
2	2	16	30	10	4	6.4	6	6	1.128	2	2	16	30	9	4	13.3	8	2.167	3.977
2	2	17	30	10	4	6.4	7	7	1.128	2	2	17	30	9	4	11.8	8	1.815	3.115
2	2	18	30	10	4	6.4	7	7	1.114	2	2	18	30	8	8	11.8	7	2.746	2.746
2	2	19	30	10	4	6.4	7	6	1.100	2	2	19	30	8	8	12.4	7	1.810	2.761
2	2	20	30	10	4	6.4	7	7	1.128	2	2	20	30	10	4	13.7	6	1.810	2.761
2	2	21	30	10	4	6.4	7	7	1.072	2	2	21	30	10	4	13.7	6	2.339	3.223
2	2	22	30	10	4	6.4	7	7	1.072	2	2	22	30	10	4	13.7	6	2.339	3.223
2	2	23	30	10	4	6.4	7	7	1.045	2	2	23	30	10	4	13.7	6	2.093	3.264
2	2	24	30	10	4	6.4	7	7	1.045	2	2	24	30	10	4	13.7	6	2.093	3.264
2	2	25	30	10	4	6.4	7	7	1.045	2	2	25	30	10	4	13.7	6	1.579	2.897
2	2	26	30	10	4	6.4	7	7	1.045	2	2	26	30	10	4	13.7	6	1.579	2.897
2	2	27	30	10	4	6.4	7	7	1.045	2	2	27	30	10	4	13.7	6	1.579	2.897
2	2	28	30	10	4	6.4	7	7	1.045	2	2	28	30	10	4	13.7	6	1.579	2.897
2	2	29	30	10	4	6.4	7	7	1.045	2	2	29	30	10	4	13.7	6	1.579	2.897
2	2	30	30	10	4	6.4	7	7	1.045	2	2	30	30	10	4	13.7	6	1.579	2.897

## HOURLY CYCLE CALCULATIONS

[illegible]

# HOURLY CYCLE CALCULATIONS

TEST	WAVE DATA RUN TIME HR	WAVE HEIGHT GAGE1 CM	BREAKER ANGLES DEGREES	SVY N/M	PLB J/M/8	TEST	WAVE DATA RUN TIME HR	WAVE HEIGHT GAGE1 CM	BREAKER ANGLES DEGREES	SVY N/M	PLB J/M/8
9	0 30	9.8	12.0	3.115	4.920	12	0 30	9.7	5.3	2.511	4.339
9	1 30	11.7	9.4	2.918	4.308	12	1 30	9.5	9.4	2.477	4.175
9	2 30	12.0	13.3	3.002	4.121	12	2 30	10.3	4.5	2.444	3.737
9	3 30	12.1	10.5	3.348	4.942	12	3 30	10.6	4.7	2.661	3.669
9	4 30	11.2	9.5	2.809	4.291	12	4 30	10.3	10.3	4.735	7.617
9	5 30	11.7	9.6	2.974	4.390	12	5 30	10.3	10.3	4.735	8.732
9	6 30	11.1	9.9	2.822	3.871	12	6 30	9.5	9.5	4.028	6.798
9	7 30	10.6	9.6	2.675	3.944	12	7 30	10.3	10.3	4.735	7.429
9	8 30	10.6	8.6	2.667	3.602	12	8 30	9.6	5.7	2.612	4.305
9	9 30	11.0	9.1	2.648	4.046	12	9 30	11.0	4.7	2.750	4.096
9	10 30	9.8	7.6	1.945	3.032	12	10 30	10.5	4.9	2.646	4.361
9	11 30	10.2	8.6	2.317	3.420	12	11 30	10.3	5.2	2.661	4.943
9	12 30	11.2	8.7	2.596	3.698	12	12 30	11.3	4.3	2.716	4.260
9	13 30	11.6	9.4	2.946	4.349	12	13 30	10.1	4.9	2.511	3.537
9	14 30	11.7	9.0	2.809	4.146	12	14 30	9.9	4.9	2.965	4.686
9	15 30	10.6	8.9	2.609	4.336	12	15 30	9.9	5.3	2.578	4.654
9	16 30	11.2	11.2	3.299	4.685	12	16 30	9.3	6.4	2.750	4.965
9	17 30	11.3	10.0	3.974	4.697	12	17 30	9.2	6.1	2.612	4.305
9	18 30	11.4	10.1	3.010	5.251	12	18 30	9.6	6.0	2.578	4.147
9	19 30	12.1	9.0	2.918	4.908	12	19 30	9.7	6.0	2.621	4.671
9	20 30	11.5	7.8	2.442	3.656	12	20 30	9.7	6.5	2.928	4.942
9	21 30	11.4	8.3	2.544	4.018	12	21 30	9.5	5.8	2.612	4.098
9	22 30	11.1	9.8	2.663	4.522	12	22 30	9.4	4.8	2.156	3.296
9	23 30	12.2	10.2	3.289	5.363	12	23 30	9.5	5.0	2.346	3.774
10	0 30	14.9	18.3	8.092	11.725	13	0 30	6.9	7.6	2.406	3.113
10	1 30	15.3	18.0	8.392	13.591	13	1 30	6.7	8.0	2.578	3.661
10	2 30	14.3	17.1	7.491	12.084	13	2 30	6.1	7.6	2.239	3.273
10	3 30	15.3	18.2	8.493	14.715	13	3 30	6.2	7.6	2.339	3.516
10	4 30	14.7	18.0	8.092	14.932	13	4 30	7.2	7.0	2.406	3.916
10	5 30	13.8	17.4	7.367	13.594	13	5 30	6.7	6.9	2.174	2.905
10	6 30	15.5	17.7	8.241	15.670	13	6 30	6.8	6.9	2.239	2.423
10	7 30	15.0	17.0	8.493	16.148	13	7 30	7.1	6.8	2.305	2.788
10	8 30	15.0	17.0	8.493	16.148	13	8 30	6.3	6.8	2.207	2.655
10	9 30	14.2	18.5	8.341	14.923	13	9 30	6.2	7.3	2.079	3.125
10	10 30	14.4	18.2	8.043	13.935	13	10 30	6.6	7.0	2.079	3.039
10	11 30	13.8	18.3	7.798	13.951	13	11 30	6.6	6.6	2.239	2.898
10	12 30	14.7	17.9	8.043	14.349	13	12 30	7.2	6.7	2.174	2.996
10	13 30	15.3	17.3	8.043	15.292	13	13 30	7.1	6.8	2.207	3.226
10	14 30	14.4	18.0	7.944	15.549	13	14 30	7.0	6.6	2.305	3.169
10	15 30	15.0	21.0	9.808	17.547	13	15 30	6.8	6.8	2.079	2.948
10	16 30	13.7	19.5	8.341	14.453	13	16 30	6.8	6.8	2.079	2.426
10	17 30	14.2	19.2	8.392	14.066	13	17 30	6.5	6.7	1.995	2.401
10	18 30	14.4	18.8	8.341	14.453	13	18 30	6.2	6.7	1.995	3.321
10	19 30	14.1	19.8	8.697	16.048	13	19 30	6.8	7.0	2.272	3.041
10	20 30	13.7	20.7	8.955	16.525	13	20 30	6.5	7.1	2.207	2.518
10	21 30	15.5	19.5	8.241	15.207	13	21 30	5.9	7.6	2.239	2.550
10	22 30	14.3	19.2	8.493	16.148	13	22 30	5.8	8.2	2.339	2.194
10	23 30	14.7	18.5	7.846	14.919	13	23 30	5.7	7.6	2.110	2.194
10	24 30	14.0	18.0	8.043	14.349	13	24 30	6.2	7.9	2.372	2.263

# HOURLY CYCLE CALCULATIONS

TEST	WAVE DATA RUN TIME HR	WAVE DATA GAGE CM	WAVE HEIGHT GAGE CM	BREAKER ANGLES DEGREES	SV M/M	PLR J/M/S
13	0	30	13.2	27 28	11.172	25.790
14	1	30	15.0	28 28	12.065	28.318
15	2	30	15.6	28 21	10.934	23.576
16	3	30	15.6	23 28	12.065	25.968
17	4	30	14.1	28 29	11.392	27.176
18	5	30	14.4	28 29	11.764	28.512
19	6	30	14.4	29 31	13.151	32.673
20	7	30	15.6	31 31	13.230	34.067
21	8	30	14.0	31 29	12.448	31.115
22	9	30	14.7	29 30	11.839	29.145
23	10	30	14.7	30 30	12.914	32.282
24	11	30	14.4	30 32	11.614	29.905
25	12	30	14.1	32 31	10.882	28.019
26	13	30	14.6	30 32	10.454	26.917
27	14	30	14.6	32 29	10.882	27.611
28	15	30	14.7	32 29	10.667	26.259
29	16	30	13.8	30 30	11.172	27.926
30	17	30	15.8	30 32	11.989	30.672
31	18	30	15.1	32 31	12.065	32.409
32	19	30	14.3	33 33	11.540	31.422
33	20	30	13.2	33 32	9.089	24.414
34	21	30	15.2	32 28	12.680	31.696
35	22	30	14.3	28 31	11.099	27.324
36	23	30	15.0	31 31	10.736	27.649
37	0	30	13.8	19 16	10.311	14.199
38	1	30	15.6	16 16	10.053	12.690
39	2	30	15.6	16 20	9.299	13.160
40	3	30	13.7	20 18	9.116	13.590
41	4	30	14.0	18 16	9.055	12.123
42	5	30	13.4	17 17	9.423	12.256
43	6	30	13.4	17 19	9.055	12.613
44	7	30	14.6	19 19	10.053	14.988
45	8	30	13.2	19 19	9.299	13.664
46	9	30	13.7	19 19	9.610	14.327
47	10	30	13.8	19 20	9.299	14.215
48	11	30	13.4	20 19	9.299	14.215
49	12	30	12.6	19 19	9.055	13.500
50	13	30	13.2	19 20	8.614	13.199
51	14	30	14.4	20 18	10.053	14.988
52	15	30	13.2	18 18	10.117	14.317
53	16	30	12.5	18 18	8.753	12.387
54	17	30	12.6	18 23	8.613	14.134
55	18	30	13.4	23 18	8.224	13.189
56	19	30	13.1	18 14	9.423	12.616
57	20	30	13.1	15.8 16 19	8.516	11.727
58	21	30	12.0	16.5 19 20	8.282	12.660
59	22	30	12.8	18.1 20 21	9.662	15.616
60	23	30	13.2	15.6 21 21	8.457	13.679

## APPENDIX F

### DAILY CYCLE CALCULATIONS

A listing of the program which calculates the values in this appendix, using the data in Appendix A, is available from CEIAC.

DAILY CYCLE CALCULATIONS

TEST	RUN TIME FROM HR	SKY	PLM	IL	MS	KP	TEST	RUN TIME FROM HR	SKY	PLR	IL	MS	KP
		N/W	J/M/S	N/S	M/S				N/W	J/M/S	N/S	M/S	
1	0 1	1.185	2.031	.0008	.3753	.1830	A	0 4	1.010	3.675	.7117	.2364	.1937
1	1 2	1.100	2.254	.0000	.0027	.2256	A	4 4	2.657	3.460	.3781	.1423	.1062
1	1 2	1.170	2.141	.0007	.0019	.2401	A	12 16	1.127	3.417	.3280	.1049	.0800
1	5 0	1.102	2.149	.0001	.0074	.2601	A	12 16	1.182	3.417	.2273	.0714	.0515
1	9 14	1.174	2.287	.0198	.0078	.2710	A	16 20	2.953	3.081	.1853	.0028	.0466
1	14 20	1.269	2.244	.0726	.0001	.2905	A	20 24	1.192	4.059	.2372	.0745	.0545
1	20 24	1.152	1.044	.0634	.0073	.3354	0	0 4	1.096	4.573	.6530	.2109	.1428
2	0 6	1.215	2.127	.0697	.0512	.3109	0	4 4	2.770	4.125	.4895	.1695	.1138
2	6 0	1.095	2.075	.0771	.0186	.3235	0	4 12	2.334	3.535	.5062	.2332	.1646
2	6 14	1.123	1.925	.0775	.0079	.3779	0	12 16	2.700	4.157	.4446	.1665	.1118
2	14 20	1.116	1.865	.0775	.0069	.3633	0	16 20	1.053	4.845	.4565	.1695	.0934
2	20 24	1.120	2.225	.0728	.0273	.3158	0	20 24	2.493	3.937	.4967	.1993	.1262
2	24 0	1.169	2.071	.0805	.0045	.3266	0	22 24	1.076	4.043	.4967	.1615	.1005
3	0 4	2.308	4.054	.0624	.3737	.3217	10	0 12	1.071	14.138	1.0045	.1245	.0710
3	4 12	2.654	4.152	.0501	.4324	.2097	10	12 16	1.534	15.710	1.0494	.1277	.0894
3	12 16	2.242	2.241	.0422	.4158	.4190	10	16 20	1.536	15.273	1.0984	.1278	.0719
3	16 20	2.053	2.555	.0475	.3275	.2926	10	20 24	1.574	15.166	1.1614	.1424	.0766
3	20 24	2.056	3.172	.0411	.3946	.2537	12	0 4	2.524	4.029	1.1593	.0545	.2877
4	0 4	2.219	3.219	.0447	.3725	.2591	12	4 12	0.559	4.044	1.0794	.3684	.2197
4	4 12	2.335	3.711	.0290	.3123	.1904	12	12 16	2.692	4.672	1.0480	.4204	.3770
4	12 16	2.576	4.148	.0484	.2545	.1612	12	16 20	2.600	4.572	1.7481	.6572	.3667
4	16 20	1.990	3.040	.0557	.2593	.1481	12	20 24	2.311	4.027	1.7434	.7105	.4029
4	20 24	1.874	3.135	.0679	.3244	.1939	13	0 4	2.300	3.591	1.3694	.4724	.3441
5	0 4	1.953	2.999	.0513	.2806	.1772	13	4 12	2.153	2.990	1.3057	.5365	.3845
5	4 12	1.803	2.482	.0459	.5937	.0602	13	12 16	2.115	3.000	1.1497	.5365	.3624
5	12 16	1.944	2.031	.0260	.4920	.12405	13	16 20	2.144	2.866	1.1015	.5065	.3424
5	16 20	1.998	2.066	.0412	.7913	.0300	13	20 24	2.204	2.853	1.1222	.5234	.4038
5	20 24	1.902	1.123	.0412	.7913	.0300	13	0 4	2.241	2.853	1.1704	.5189	.4103
5	0 4	1.907	1.225	.0900	.7095	.5712	13	4 12	1.564	25.913	1.1614	.5182	.5212
6	0 4	2.003	2.511	.1014	.5000	.3988	14	0 4	1.338	30.657	3.1000	.2766	.1234
6	4 12	1.992	2.245	.0990	.4761	.4104	14	4 12	1.204	30.612	3.1000	.2503	.1011
6	12 16	1.984	1.924	.0236	.4041	.4800	14	12 16	1.0721	27.201	3.2469	.2693	.1074
6	16 20	1.913	1.893	.0236	.4041	.4800	14	16 20	1.652	30.557	3.3034	.3119	.1229
6	20 24	2.155	2.167	.1009	.5534	.5120	14	20 24	1.691	30.557	3.1014	.2687	.1055
7	0 4	1.906	1.805	.1051	.5269	.5590	15	0 4	0.995	13.010	3.0925	.3387	.1711
7	4 12	1.951	1.251	.1251	.2961	.2245	15	4 12	0.337	14.156	2.2938	.2263	.1630
7	12 16	1.911	1.034	.0934	.2514	.1968	15	12 16	0.405	14.032	2.4492	.2612	.1730
7	16 20	2.777	4.066	.0414	.4527	.1766	15	16 20	0.803	13.082	2.6632	.2814	.1902
7	20 24	3.084	4.511	.0512	.2932	.1974	15	20 24	0.779	13.082	2.9209	.3318	.2233
7	0 4	3.084	4.511	.0512	.2932	.1974	15	0 4	0.779	13.082	2.9209	.3318	.2233
7	4 12	3.084	4.511	.0512	.2932	.1974	15	4 12	0.779	13.082	2.9209	.3318	.2233
7	12 16	3.084	4.511	.0512	.2932	.1974	15	12 16	0.779	13.082	2.9209	.3318	.2233
7	16 20	3.084	4.511	.0512	.2932	.1974	15	16 20	0.779	13.082	2.9209	.3318	.2233
7	20 24	3.084	4.511	.0512	.2932	.1974	15	20 24	0.779	13.082	2.9209	.3318	.2233
7	0 4	3.084	4.511	.0512	.2932	.1974	15	0 4	0.779	13.082	2.9209	.3318	.2233
7	4 12	3.084	4.511	.0512	.2932	.1974	15	4 12	0.779	13.082	2.9209	.3318	.2233
7	12 16	3.084	4.511	.0512	.2932	.1974	15	12 16	0.779	13.082	2.9209	.3318	.2233
7	16 20	3.084	4.511	.0512	.2932	.1974	15	16 20	0.779	13.082	2.9209	.3318	.2233
7	20 24	3.084	4.511	.0512	.2932	.1974	15	20 24	0.779	13.082	2.9209	.3318	.2233



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