US Army Corps of Engineers
Waterways Experiment Station

Preliminary Data Summary for May 1994 CERC Field Research Facility

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Coastal Engineering Research Center

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May 1994
Preliminary Data Summary

by Field Research Facility

U.S. Army Corps of Engineers
Waterways Experiment Station
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Contents

Preface iv
1 — Introduction 1
2 — Meteorological Data 7
3 — Wave Data 12
4 — Current Data 17
5 — Visual Observations 20
6 — Water Levels 22
7 — Bathymetry 24
8 — Special Events 27

List of Figures

No.
1 FRF Location Map 2
2 Month at a Glance 3
3 Instrument Locations at FRF 6
4 Meteorological Monthly Summary 8
5 Time History of Wave Heights and Periods 16
6 Water Level Time History 22
7 CRAB Profiles 24
8 CRAB Profile Envelope 25
9 FRF Bathymetry (6 April 94) 26

List of Tables

No.
1 Instrument Status/Data Availability 4
2 Gauge Locations 5
3 Meteorological Data 9
4 Wave Data 13
5 Current Meter Data 18
6 Visually Observed Current Data 19
7 Visual Observations 21
8 Water Levels 23

Preface

This report provides a summary of basic oceanographic, meteorological and bottom profile data for the month. The data were obtained as part of the Measurements and Analysis work units at the U.S. Army Engineer Waterways Experiment Station, Coastal Engineering Research Center's Field Research Facility (FRF) in Duck, North Carolina. The FRF staff collected and analyzed these data. These summaries are intended to make the data readily available to all FRF users, and comments on their content and usefulness are invited.

1 Introduction

The U.S. Army Engineer Waterways Experiment Station, Coastal Engineering Research Center's (CERC) Field Research Facility (FRF) is located on the Outer Banks of North Carolina, near the village of Duck (Figure 1).

The FRF research program provides a means for obtaining high-quality field data, particularly during storms, in support of the U.S. Army Corps of Engineers' coastal engineering research missions. The research pier is a reinforced concrete structure supported on 0.9-m-diam steel piles spaced 12.2 m apart along the pier's length and 4.6 m apart across the width. The pier deck is 6.1 m wide and extends from behind the duneline to about the 6-m water depth contour at a height of 7.75 m above the National Geodetic Vertical Datum (NGVD) of the year 1929.

One of the responsibilities of the FRF research program is the collection, analysis and dissemination of data on local bathymetric, oceanographic, and meteorological conditions. This summary is intended to provide basic data as soon as possible after they are obtained. Questions and/or comments concerning the data may be directed to Mr. Clifford F. Baron at (919) 261-3511.

Chapter 2 presents the meteorological data; Chapters 3 through 6 present oceanographic data; Chapter 7 presents nearshore profiles and bathymetry; and Chapter 8, if included, documents special events that occurred at the FRF during the month.

Table 1 is a list of instruments used and their operational status during the month. Figure 2 shows weather and ocean conditions for the month. Table 2 and Figure 3 identifies the location of the instruments. The water depths at the wave gauges and current meters vary and may be determined from information contained in Figure 9. Other installation information is contained in Table 1.

Times given in the report are referenced to eastern standard time (EST).

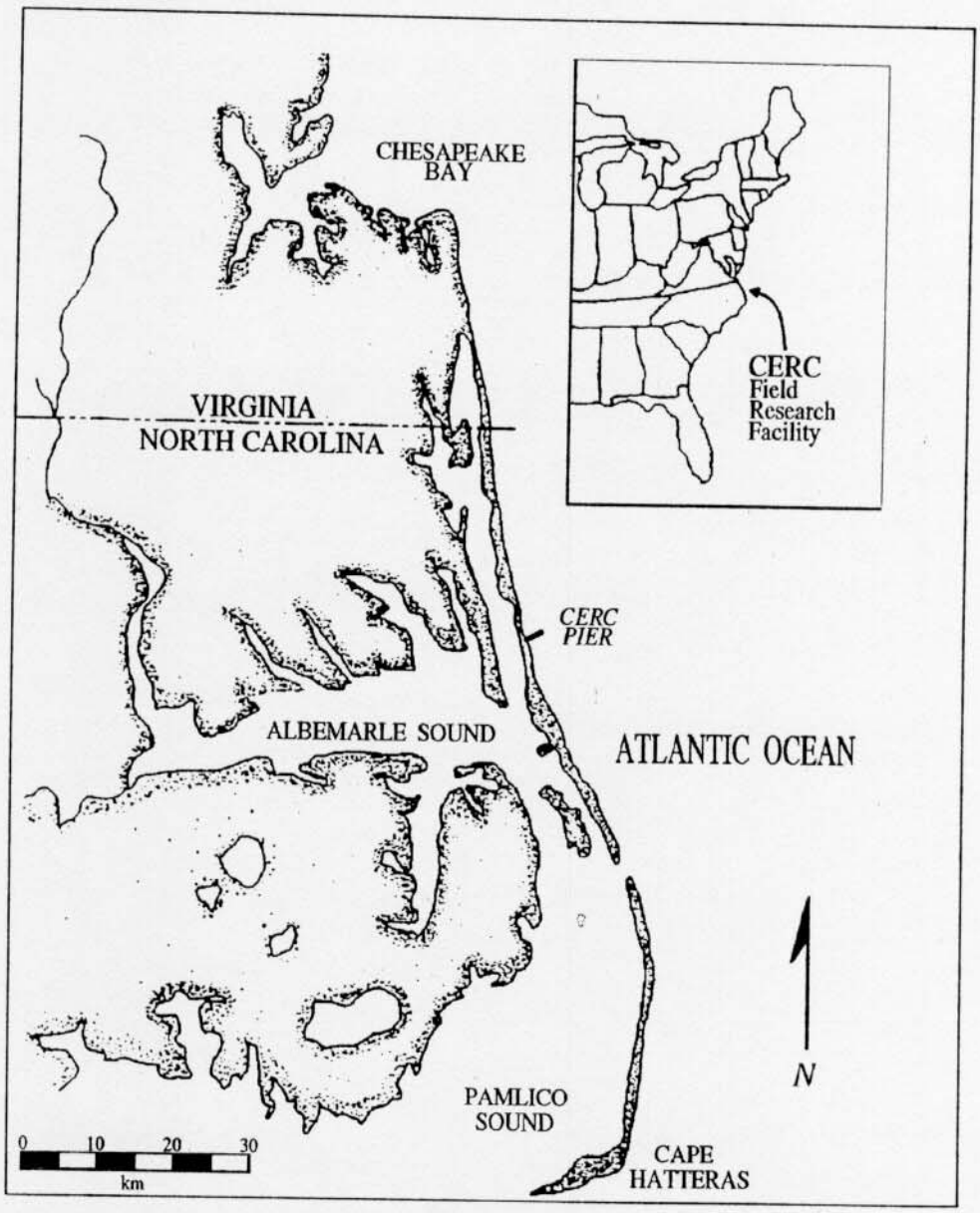

Figure 1. FRF Location Map

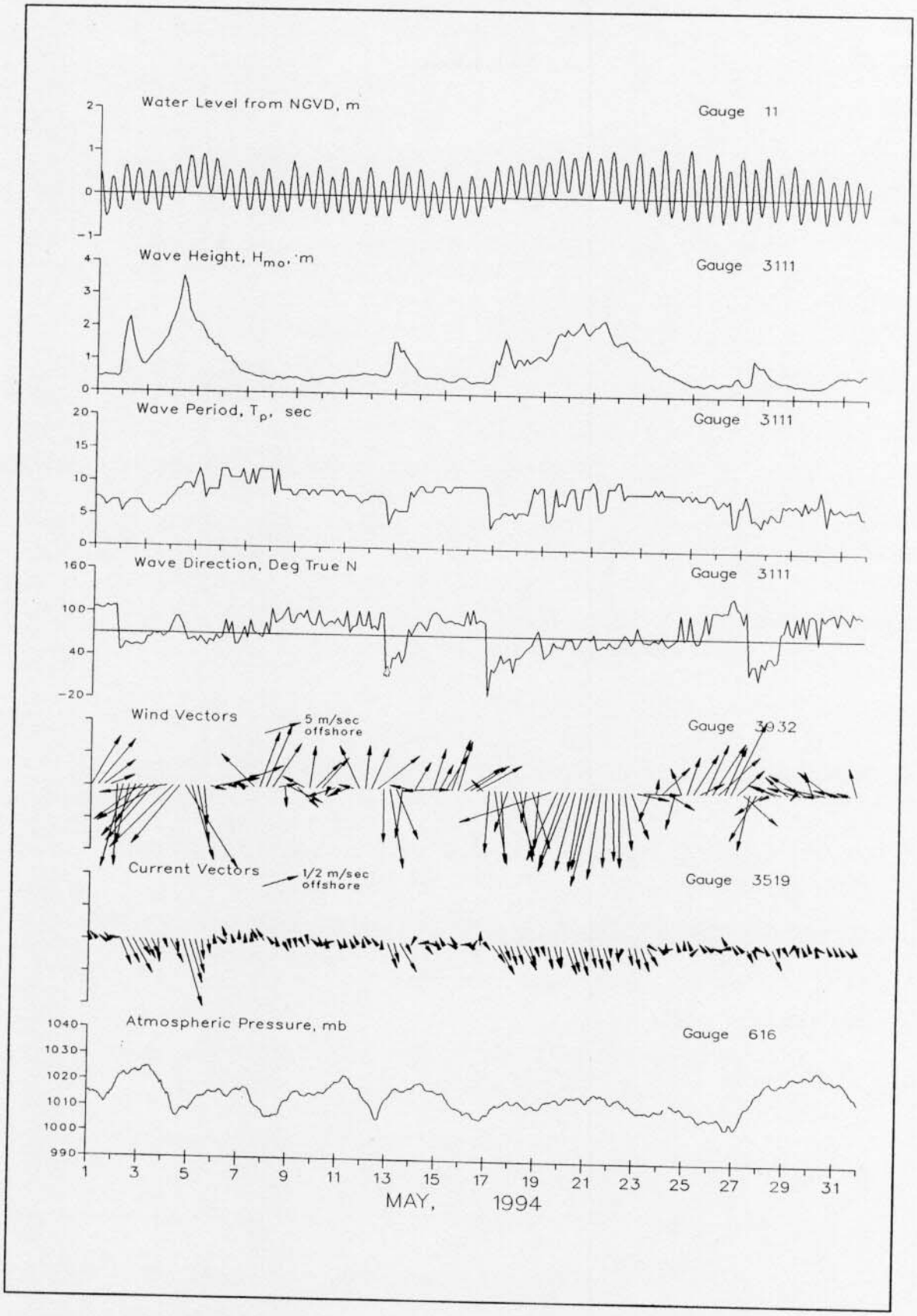

Figure 2. Month at a Glance

Table 1
Instrument Status/Data Availability

May 1994

Day of the month

Gauge ID	Description/Remarks		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
616	Atmospheric Pressure	Gauge Status	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
		Data Collected	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
604	Precipitation	Gauge Status	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
		Data Collected	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
624	Air Temperature	Gauge Status	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
		Data Collected	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
932	Anemometer	Gauge Status	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
		Data Collected	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
641	Pressure Gauge on FRF pier	Gauge Status	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
		Data Collected	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
625	Baylor staff on FRF pier	Gauge Status	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
		Data Collected	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
3111	8 Meter Array 309 m north of FRF	Gauge Status	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
		Data Collected	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
111	Pressure Gauge center of 8 Meter Array	Gauge Status	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
		Data Collected	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
630	Waverider buoy 4.0 km offshore	Gauge Status	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
		Data Collected	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
519	Current meter 434 m north of FRF pier (0.9 km offshore)	Gauge Status	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
		Data Collected	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
11	NOAA tide gauge at end of pier	Gauge Status	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
		Data Collected	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
	Visual Observations (daily oceanographic and meteorological observations)	Daily observation	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*

Gauge Status * = Operational / = Partial - = Non-Operational
Data Collected * = All / = Partial - = None
Visual Observations * = Complete / = Partial - = None

Table 2
Gauge Locations

Gauge ID	Description	Latitude Degrees N	Longitude Degrees W	FRF Coordinates Crosshore m	FRF Coordinates Longshore m	Gauge Depth NGVD, m	Water Depth NGVD, m
616	Atmospheric Pressure	36 10′ 45.48"	75 44′ 37.39"	11.60	569.00	-----	-----
3932	Anemometer	36 11′ 2.64"	75 44′ 46.50"	585.20	517.30	19.50	-----
641	Pressure Gauge	36 10′ 51.96"	75 44′ 42.21"	239.11	516.64	-1.64	-1.96
625	Baylor Staff	36 11′ 2.10"	75 44′ 46.31"	568.00	516.64	Surface	-8.36
3111	8 Meter Array North	36 11′ 17.59	75 44′ 32.62"	915.23	990.16	-7.50	-7.90
	8 Meter Array South	36 11′ 14.98	75 44′ 42.30"	914.20	735.37	-7.42	-7.90
	8 Meter Array East	36 11′ 16.88	75 44′ 40.32"	954.51	800.58	-7.62	-8.13
	8 Meter Array West	36 11′ 13.18"	75 44′ 38.84"	834.66	800.37	-6.98	-7.44
111	Pressure Gauge in center of 8 M Array	36 11′ 15.90"	75 44′ 38.88"	914.43	825.52	-7.76	-8.08
630	Waverider Buoy	36 12′ 16.44"	75 47′ 19.23"	3934.96	-2400.81	Surface	-17.00
3519	Current Meter	36 11′ 17.17"	75 44′ 34.15"	914.76	950.00	-5.30	-7.90
11	NOAA Tide Gauge	36 11′ 2.95"	75 44′ 46.76	596.49	514.20	Surface	-7.62

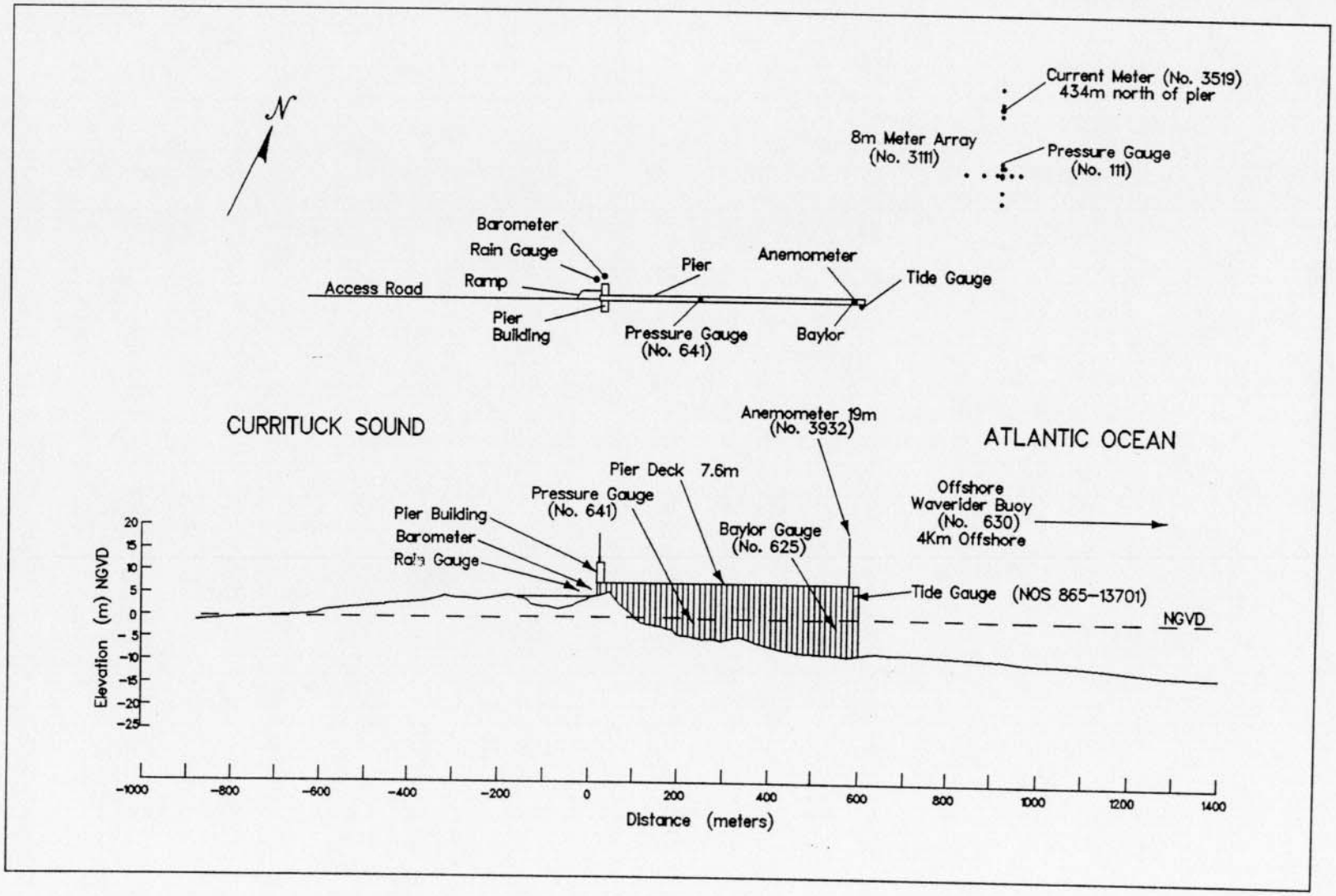

Figure 3. Instrument Locations, Elevations From NGVD

2 Meteorological Data

A variety of instruments have been installed at the FRF (Figure 3) to monitor the meteorological conditions. The data presented in Table 3 are collected and stored using a Digital Equipment Corporation VAX 11/750. For each instrument identified in Table 1, a log is maintained and the records are stored for future reference.

Winds were measured at the end of the pier at an elevation of 19 m (Figure 4) using a WeatherMeasure Skyvane anemometer. Monthly resultant wind speeds and directions are determined by vector averaging the data. Wind directions indicate where the wind is coming from. Temperature and atmospheric pressure means are the average of the values presented for the month. Total precipitation is the sum for the month.

The following may be useful for converting the data in Table 3 to other frequently used units of measurement:

1. Millimeters (mm) to inches (in.) -
   mm x .03937 = in.

2. Millibars (mb) to inches of mercury (in. Hg) -
   mb x 0.02953 = in. Hg

3. Degrees Celsius (C) to degrees Fahrenheit (F) -
   (C x 9/5) + 32 = F

4. Meters per second (m/s) to knots (kn) -
   m/s x 1.943 = kn

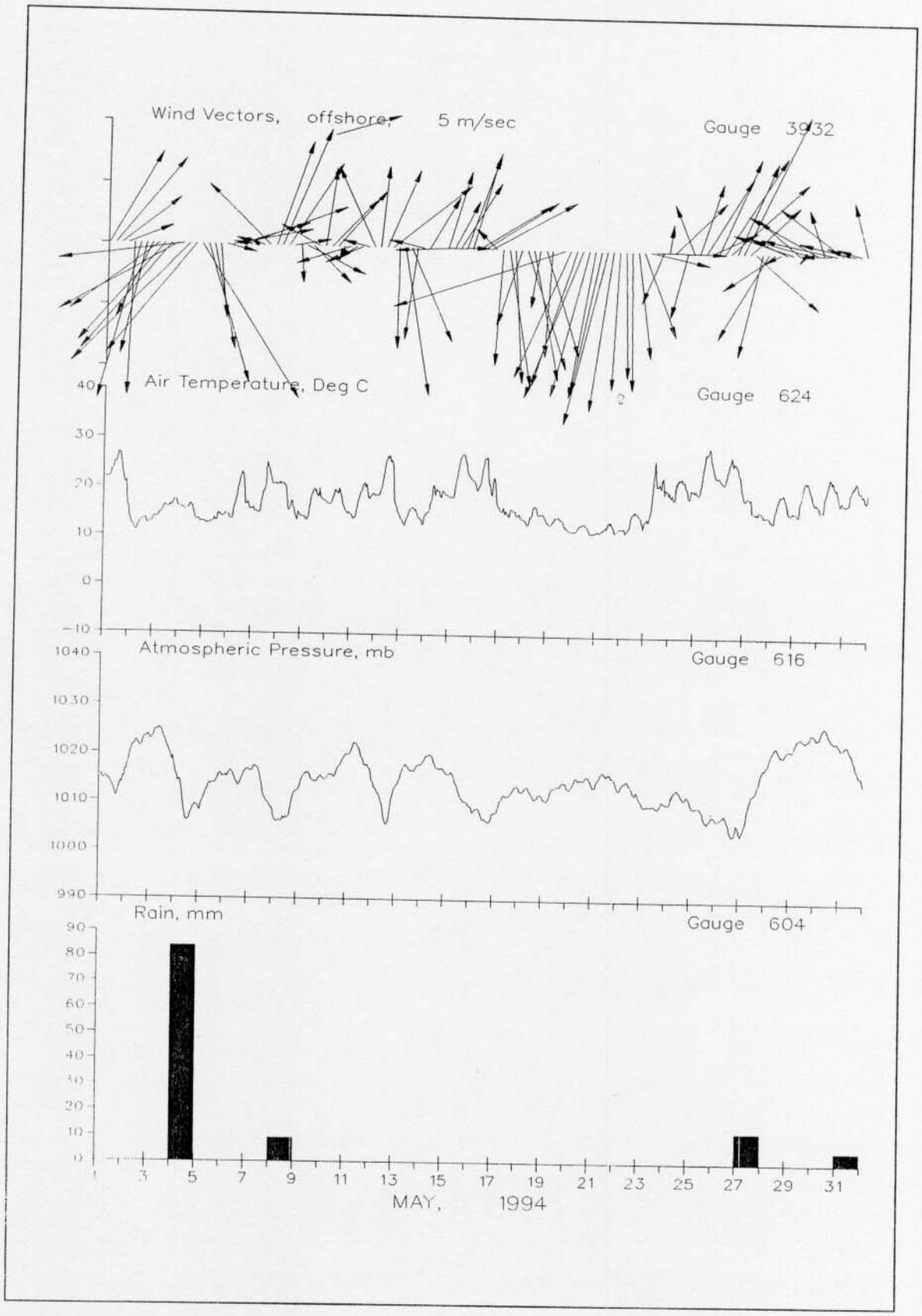

Figure 4. Meteorological Monthly Summary

Table 3
Meteorological Data

May 1994

Day	Hour	Wind Speed m/sec	Wind Direction deg TN	Temperature deg C	Atm Pressure mb	Precipitation mm
1	100	8	206	21.8	1015.4	0
	700	9	215	22.4	1015.0	0
	1300	6	227	25.5	1013.1	0
	1900	3	245	22.4	1012.6	0
2	100	12	1	14.5	1016.1	0
	700	13	12	11.0	1020.8	0
	1300	9	11	13.2	1022.1	0
	1900	7	22	12.4	1022.8	0
3	100	8	48	13.7	1023.2	0
	700	10	37	14.7	1024.8	0
	1300	11	36	16.0	1024.2	0
	1900	10	56	16.4	1021.0	0
4	100	9	81	16.1	1017.2	0
	700	13	40	15.3	1014.0	56
	1300	11	34	16.6	1006.4	28
	1900	14	339	13.4	1008.8	0
5	100	12	344	13.0	1008.3	0
	700	9	349	12.7	1011.8	0
	1300	6	355	13.3	1013.7	0
	1900	2	285	14.1	1014.7	0
6	100	6	257	14.5	1015.3	0
	700	5	249	16.3	1016.3	0
	1300	8	246	22.3	1014.1	0
	1900	1	100	16.8	1015.1	0
7	100	1	127	15.9	1016.7	0
	700	2	105	15.0	1017.4	0
	1300	7	137	20.2	1014.3	0
	1900	9	196	22.0	1010.1	0
8	100	10	199	20.6	1007.8	0
	700	8	209	20.6	1006.3	0
	1300	3	258	16.1	1006.6	9
	1900	3	355	13.8	1010.2	0
9	100	5	298	14.2	1012.5	0
	700	4	317	14.6	1015.7	0
	1300	3	121	19.9	1015.5	0
	1900	6	186	18.2	1014.5	0
10	100	5	220	17.3	1015.1	0
	700	6	217	18.1	1015.7	0
	1300	1	18	20.1	1015.5	0
	1900	4	69	15.6	1018.0	0

Table 3
Meteorological Data (continued)

May 1994

Day	Hour	Wind Speed m/sec	Wind Direction deg TN	Temperature deg C	Atm Pressure mb	Precipitation mm
11	100	2	53	14.7	1020.0	0
	700	3	1	17.1	1022.1	0
	1300	2	105	21.0	1021.0	0
	1900	7	157	18.1	1017.8	0
12	100	7	184	18.8	1015.0	0
	700	7	200	20.6	1012.1	0
	1300	8	227	26.7	1007.5	0
	1900	8	1	17.9	1008.5	0
13	100	12	351	14.3	1013.6	0
	700	8	338	14.1	1016.7	0
	1300	8	6	16.4	1017.3	0
	1900	3	1	14.2	1016.8	0
14	100	5	206	15.0	1017.9	0
	700	4	268	17.7	1019.8	0
	1300	3	86	20.3	1019.5	0
	1900	6	194	20.0	1017.2	0
15	100	4	204	18.7	1016.6	0
	700	6	208	20.8	1016.5	0
	1300	8	197	27.1	1013.5	0
	1900	8	193	23.9	1010.6	0
16	100	6	234	22.2	1009.6	0
	700	7	233	21.3	1009.0	0
	1300	7	237	26.5	1007.6	0
	1900	2	136	19.2	1006.4	0
17	100	9	2	16.8	1008.1	0
	700	11	351	15.7	1010.6	0
	1300	11	356	16.2	1011.7	0
	1900	6	15	15.0	1012.5	0
18	100	10	343	14.2	1013.6	0
	700	11	350	13.7	1013.1	0
	1300	5	7	17.1	1012.5	0
	1900	9	344	15.4	1011.4	0
19	100	9	2	13.4	1011.3	0
	700	10	15	13.8	1011.1	0
	1300	13	1	14.5	1013.4	0
	1900	11	20	12.6	1014.3	0
20	100	12	15	11.7	1013.4	0
	700	13	18	12.6	1014.5	0
	1300	12	12	13.5	1015.3	0
	1900	12	8	11.5	1015.6	0

Table 3
Meteorological Data (concluded)

May 1994

Day	Hour	Wind Speed m/sec	Wind Direction deg TN	Temperature deg C	Atm Pressure mb	Precipitation mm
21	100	12	9	11.9	1014.2	0
	700	15	11	12.1	1015.1	0
	1300	13	6	13.8	1016.4	0
	1900	11	2	11.8	1016.1	0
22	100	10	358	12.5	1013.7	0
	700	11	359	12.3	1014.4	0
	1300	9	353	15.9	1014.3	0
	1900	7	341	15.1	1012.1	0
23	100	4	283	14.4	1010.7	0
	700	5	271	18.7	1009.9	0
	1300	4	19	21.4	1010.0	0
	1900	2	187	19.8	1009.9	0
24	100	5	221	19.4	1010.5	0
	700	4	304	20.9	1011.7	0
	1300	5	12	22.4	1013.0	0
	1900	4	160	18.9	1011.2	0
25	100	6	195	20.5	1010.4	0
	700	7	207	22.1	1009.7	0
	1300	4	241	28.3	1008.2	0
	1900	8	200	24.5	1006.9	0
26	100	9	209	23.1	1007.3	0
	700	8	223	23.1	1007.4	0
	1300	8	200	26.6	1006.5	0
	1900	12	202	24.4	1003.9	0
27	100	5	222	18.7	1004.0	12
	700	6	315	19.1	1007.5	0
	1300	9	10	15.7	1012.2	0
	1900	8	26	15.4	1014.7	0
28	100	5	50	14.9	1017.8	0
	700	1	60	16.8	1020.6	0
	1300	3	117	19.9	1021.5	0
	1900	5	109	16.2	1020.3	0
29	100	4	134	16.2	1021.5	0
	700	1	36	19.0	1023.5	0
	1300	5	106	22.5	1023.9	0
	1900	6	121	18.7	1023.9	0
30	100	4	163	17.2	1024.6	0
	700	2	1	20.2	1025.6	0
	1300	6	102	22.5	1025.4	0
	1900	6	130	19.7	1023.3	0
31	100	2	112	18.2	1022.5	0
	700	4	103	20.7	1022.8	0
	1300	2	1	22.8	1020.4	5
	1900	4	166	20.3	1016.5	0
		Resultant		Mean	Mean	Total
		2	354	17.7	1014.6	110

3 Wave Data

Wave data are collected from three different sets of instruments, as shown in Table 1 and Figure 3. The first is an array of fifteen pressure gauges, collectively referred to as gauge 3111 (gauge 111 being one of them). Directional information is computed from these gauges using a iterative maximum liklihood estimator. The second is a Baylor staff gauge (625) and a pressure gauge (641), both attached to the pier. The third is a Waverider buoy (630). The data are collected, analyzed, and stored on optical disc using a Digital Equipment Corporation VAX 4100 programmed to sample the gauges for two hour and forty-eight minute time frames. The sampling rate is two times per second which equals five contiguous 34 minute records per collection period. This report reflects the data collection periods of 0100, 0700, 1300, and 1900 EST. The results are based only on the first 34 minute record. The exception is the 8 Meter Array (3111) which condenses the first four records into one statistical value.

Wave height H_{mo} is an energy-based statistic equal to four times the standard deviation of the sea surface elevations. Wave height reported from the pressure gauge has been compensated for hydrodynamic attenuation using linear wave theory. Wave period is identified from the computation of a variance (energy) spectrum with 60 degrees of freedom calculated from a 34-min record. Peak wave period T_p is defined as the period associated with the maximum energy in the spectrum. When this analysis is complete, the data are written to optical disc.

Table 4 presents the wave heights and periods for each wave record obtained at 6 hr intervals during the month. The monthly means and standard deviations from the means shown in Table 4 are average values computed from this data. Figure 5 is a time history of all H_{mo} and T_p values obtained for all gauges.

Differences in wave periods between wave gauges (Table 4 and Figure 5) may be the result of wave breaking, wave reformation, the presence of multiple wave trains containing nearly equal energy, and statistical variations in spectral estimations.

Table 4
Wave Data

May 1994

		641 Pressure Gage		625 Baylor Gauge		3111 8 Meter Array			630 Waverider	
Day	Hour	Hmo,m	Tp,sec	Hmo,m	Tp,sec	Hmo,m	Tp,sec	Dir,N	Hmo,m	Tp,sec
1	0100	0.32	7.6	0.39	7.6	0.45	7.6	106	0.59	7.4
	0700	0.36	5.9	0.43	12.2	0.52	7.1	104	0.68	6.8
	1300	0.37	6.6	0.43	6.8	0.47	6.6	108	0.56	5.6
	1900	0.34	6.6	0.43	6.6	0.44	7.1	108	0.61	7.4
2	0100	0.88	4.4	1.11	4.4	1.52	5.3	46	1.26	4.2
	0700	0.69	6.8	2.06	6.8	2.28	6.6	56	2.47	7.0
	1300	0.85	6.3	1.20	6.0	1.32	7.1	52	1.55	5.9
	1900	0.41	6.5	0.75	7.0	0.85	7.1	54	1.25	6.3
3	0100	0.52	5.9	0.86	5.5	0.95	5.6	54	1.09	6.0
	0700	0.53	5.0	1.19	5.0	1.21	5.0	64	1.33	5.1
	1300	0.68	4.9	1.24	5.2	1.40	5.6	68	1.53	5.4
	1900	0.65	5.0	1.51	6.6	1.70	6.2	64	1.86	6.1
4	0100	0.89	7.2	2.07	7.2	2.21	7.6	72	2.53	7.6
	0700	0.78	8.9	2.45	8.9	2.94	8.9	94	3.08	8.9
	1300	1.10	10.3	2.87	9.2	3.22	9.8	84	3.58	9.9
	1900	0.90	9.5	2.19	9.9	2.33	9.8	60	2.43	9.2
5	0100	0.95	10.7	1.88	9.5	2.12	10.8	64	2.36	8.9
	0700	0.79	7.4	1.86	11.2	1.86	10.8	66	1.96	7.2
	1300	0.82	5.3	1.43	8.9	1.59	8.9	54	1.79	8.1
	1900	0.63	9.5	1.20	9.5	1.45	8.9	58	1.47	8.6
6	0100	0.45	12.9	1.08	9.2	1.22	12.0	62	1.32	12.2
	0700	0.42	12.2	1.08	11.7	1.10	12.0	90	1.11	11.7
	1300	0.37	12.2	0.79	10.7	0.86	10.8	86	0.96	11.2
	1900	0.28	8.6	0.58	10.7	0.64	10.8	56	0.63	10.3
7	0100	0.24	12.2	0.57	10.3	0.58	9.8	80	0.62	9.9
	0700	0.28	12.9	0.47	10.3	0.51	12.0	90	0.56	12.2
	1300	0.25	12.2	0.47	8.6	0.49	12.0	70	0.56	8.9
	1900	0.25	8.9	0.41	12.2	0.45	12.0	66	0.59	12.2
8	0100	0.24	8.9	0.39	12.2	0.41	12.0	70	0.60	12.2
	0700	0.35	8.1	0.44	9.5	0.47	12.0	86	0.62	9.2
	1300	0.25	6.8	0.40	9.2	0.47	8.9	92	0.53	9.2
	1900	0.35	8.1	0.43	8.6	0.46	8.9	108	0.59	8.9
9	0100	0.28	4.2	0.40	8.3	0.46	8.2	86	0.63	4.2
	0700	0.27	8.6	0.36	9.5	0.37	8.9	100	0.52	8.3
	1300	0.21	8.1	0.34	8.6	0.41	8.2	104	0.46	8.6
	1900	0.31	8.9	0.41	8.6	0.40	8.9	84	0.48	8.6
10	0100	0.20	7.0	0.39	9.5	0.44	8.9	104	0.47	8.6
	0700	0.33	8.6	0.41	8.9	0.49	8.9	82	0.52	8.1
	1300	0.24	8.3	0.38	8.3	0.46	8.9	90	0.47	7.8
	1900	0.34	8.3	0.46	8.3	0.54	8.9	94	0.68	8.1

Table 4
Wave Data (continued)

May 1994

Day	Hour	641 Pressure Gage Hmo,m	Tp,sec	625 Baylor Gauge Hmo,m	Tp,sec	3111 8 Meter Array Hmo,m	Tp,sec	Dir,N	630 Waverider Hmo,m	Tp,sec
11	0100	0.27	8.3	0.47	7.8	0.55	8.2	82	0.62	8.1
	0700	0.30	8.3	0.48	8.3	0.55	8.2	74	0.67	8.3
	1300	0.28	8.6	0.52	7.8	0.58	7.6	84	0.65	7.8
	1900	0.42	8.1	0.59	7.6	0.61	7.6	84	0.73	7.0
12	0100	0.31	8.6	0.51	7.8	0.58	8.2	104	0.69	8.6
	0700	0.40	8.1	0.52	8.1	0.58	8.2	84	0.70	8.1
	1300	0.35	4.9	0.47	8.3	0.53	8.2	102	0.62	8.1
	1900	0.38	8.6	0.50	8.3	0.76	3.8	12	0.67	8.3
13	0100	0.69	6.0	1.49	6.3	1.61	6.2	40	1.88	6.1
	0700	0.77	5.7	1.08	6.0	1.34	5.9	48	1.42	5.9
	1300	0.52	5.2	0.91	6.0	1.02	5.9	44	1.17	6.5
	1900	0.49	4.9	0.71	8.6	0.78	8.2	72	0.94	6.3
14	0100	0.24	8.9	0.48	9.9	0.53	9.8	90	0.58	8.6
	0700	0.26	8.9	0.43	9.2	0.50	8.9	84	0.53	8.9
	1300	0.22	8.3	0.42	8.3	0.49	8.9	94	0.51	8.9
	1900	0.32	8.9	0.51	9.5	0.51	9.8	104	0.63	9.5
15	0100	0.22	10.3	0.40	9.9	0.41	9.8	92	0.53	9.5
	0700	0.25	9.2	0.40	9.9	0.40	8.9	92	0.50	9.5
	1300	0.28	9.9	0.49	9.9	0.51	9.8	90	0.69	9.9
	1900	0.35	9.5	0.49	9.9	0.51	9.8	88	0.71	9.9
16	0100	0.24	9.5	0.34	9.9	0.37	9.8	106	0.53	9.5
	0700	0.26	5.6	0.36	9.9	0.40	9.8	108	0.50	9.5
	1300	0.30	9.9	0.36	9.9	0.40	9.8	94	0.51	9.9
	1900	0.28	7.6	0.35	9.5	0.41	8.9	90	0.48	9.5
17	0100	0.80	4.6	0.94	4.5	1.11	4.6	26	1.21	4.5
	0700	0.60	4.5	0.87	4.6	1.27	5.0	30	1.16	4.5
	1300	0.93	5.7	1.22	5.7	1.48	5.9	34	1.56	5.7
	1900	0.57	5.1	0.85	5.9	0.86	5.9	42	1.17	5.6
18	0100	0.85	6.1	1.06	5.6	1.12	5.9	42	1.45	5.4
	0700	0.63	5.6	1.05	5.7	1.15	5.9	46	1.19	5.4
	1300	0.61	5.5	0.82	7.4	0.98	9.5	77	1.03	6.0
	1900	0.52	9.9	1.12	9.5	1.24	8.9	70	1.34	9.5
19	0100	0.60	9.2	1.06	9.9	1.11	9.8	62	1.18	8.9
	0700	0.63	4.7	1.20	8.3	1.35	4.6	46	1.34	4.9
	1300	0.95	5.5	1.69	5.4	1.91	9.8	64	1.93	9.9
	1900	0.70	6.1	1.68	7.6	1.86	7.6	58	1.93	7.2
20	0100	1.01	6.5	1.72	7.4	1.94	8.9	68	2.11	7.2
	0700	0.71	6.0	1.77	5.6	2.02	9.8	68	2.15	8.6
	1300	1.02	6.8	1.98	7.0	2.28	6.6	58	2.56	7.2
	1900	0.74	6.0	1.72	10.3	1.89	9.8	72	2.21	10.3

Table 4
Wave Data (concluded)

May 1994

Day	Hour	641 Pressure Gage Hmo,m	Tp,sec	625 Baylor Gauge Hmo,m	Tp,sec	3111 8 Meter Array Hmo,m	Tp,sec	Dir,N	630 Waverider Hmo,m	Tp,sec
21	0100	0.94	10.7	1.90	10.3	2.12	10.8	68	2.17	9.5
	0700	0.77	5.7	1.98	6.8	2.25	6.2	56	2.31	6.5
	1300	0.91	6.1	1.89	6.3	2.09	6.6	60	2.39	6.1
	1900	0.80	9.2	1.53	9.5	1.66	9.8	66	1.77	10.7
22	0100	0.80	10.7	1.46	9.5	1.66	10.8	58	1.74	7.8
	0700	0.79	5.3	1.54	5.5	1.72	8.2	68	1.86	5.5
	1300	0.78	4.7	1.38	8.6	1.46	8.9	72	1.71	7.4
	1900	0.76	8.6	1.17	9.2	1.29	8.9	68	1.49	9.5
23	0100	0.58	9.2	1.14	9.2	1.21	8.9	74	1.42	9.2
	0700	0.49	9.2	0.89	9.2	0.99	8.9	66	0.98	8.1
	1300	0.40	9.2	0.76	6.8	0.93	9.8	68	1.02	9.5
	1900	0.49	8.9	0.78	9.2	0.81	9.8	66	0.97	9.2
24	0100	0.32	8.3	0.63	8.3	0.70	8.9	64	0.81	8.3
	0700	0.42	8.9	0.59	8.1	0.56	8.8	89	0.76	8.9
	1300	0.31	8.6	0.49	8.6	0.53	8.9	70	0.62	8.9
	1900	0.32	8.3	0.42	8.1	0.43	8.9	68	0.49	7.8
25	0100	0.20	8.1	0.34	8.1	0.39	8.2	104	0.49	8.6
	0700	0.27	7.8	0.34	8.3	0.37	8.2	64	0.52	7.8
	1300	0.23	7.6	0.34	7.6	0.38	8.2	82	0.45	9.2
	1900	0.38	5.5	0.43	8.3	0.44	8.9	80	0.58	8.9
26	0100	0.28	7.4	0.35	7.6	0.37	7.1	108	0.62	8.1
	0700	0.38	7.6	0.38	8.1	0.43	8.2	106	0.57	7.4
	1300	0.34	7.2	0.42	9.2	0.44	8.2	108	0.55	8.6
	1900	0.51	6.3	0.58	5.2	0.64	4.2	128	0.88	4.2
27	0100	0.34	6.1	0.38	8.9	0.38	7.1	110	0.51	8.9
	0700	0.35	8.3	0.36	7.8	0.46	7.6	110	0.52	7.4
	1300	0.54	5.3	1.06	5.6	1.04	5.3	34	1.20	5.6
	1900	0.70	5.3	0.85	5.3	0.96	4.1	14	1.10	5.3
28	0100	0.52	4.9	0.72	4.8	0.66	5.0	32	0.81	5.5
	0700	0.42	5.4	0.55	5.5	0.55	5.9	46	0.72	5.7
	1300	0.33	5.5	0.47	5.3	0.47	5.3	42	0.53	7.4
	1900	0.31	6.3	0.45	5.5	0.46	7.1	82	0.51	5.6
29	0100	0.27	7.0	0.42	7.4	0.39	7.1	82	0.49	6.8
	0700	0.26	5.9	0.40	6.8	0.39	7.1	102	0.45	7.0
	1300	0.23	7.4	0.35	6.5	0.34	8.2	106	0.39	6.1
	1900	0.28	7.8	0.43	7.6	0.34	7.6	104	0.46	7.4
30	0100	0.27	7.2	0.32	8.6	0.34	7.6	102	0.42	8.3
	0700	0.30	4.9	0.37	8.3	0.40	7.6	106	0.45	7.4
	1300	0.50	4.7	0.49	5.5	0.53	7.6	104	0.63	5.1
	1900	0.51	6.1	0.60	6.3	0.65	6.6	108	0.74	6.6
31	0100	0.56	7.2	0.60	7.4	0.65	6.6	110	0.77	6.8
	0700	0.46	6.0	0.62	6.0	0.66	6.6	102	0.77	5.9
	1300	0.55	6.1	0.58	6.6	0.61	6.6	110	0.71	7.0
	1900	0.52	6.0	0.64	5.9	0.73	5.6	106	0.90	5.9
Mean		0.49	7.5	0.84	8.0	0.93	8.1	76	1.05	7.8
Std dev		0.23	2.0	0.55	1.8	0.63	1.9	23	0.65	1.8

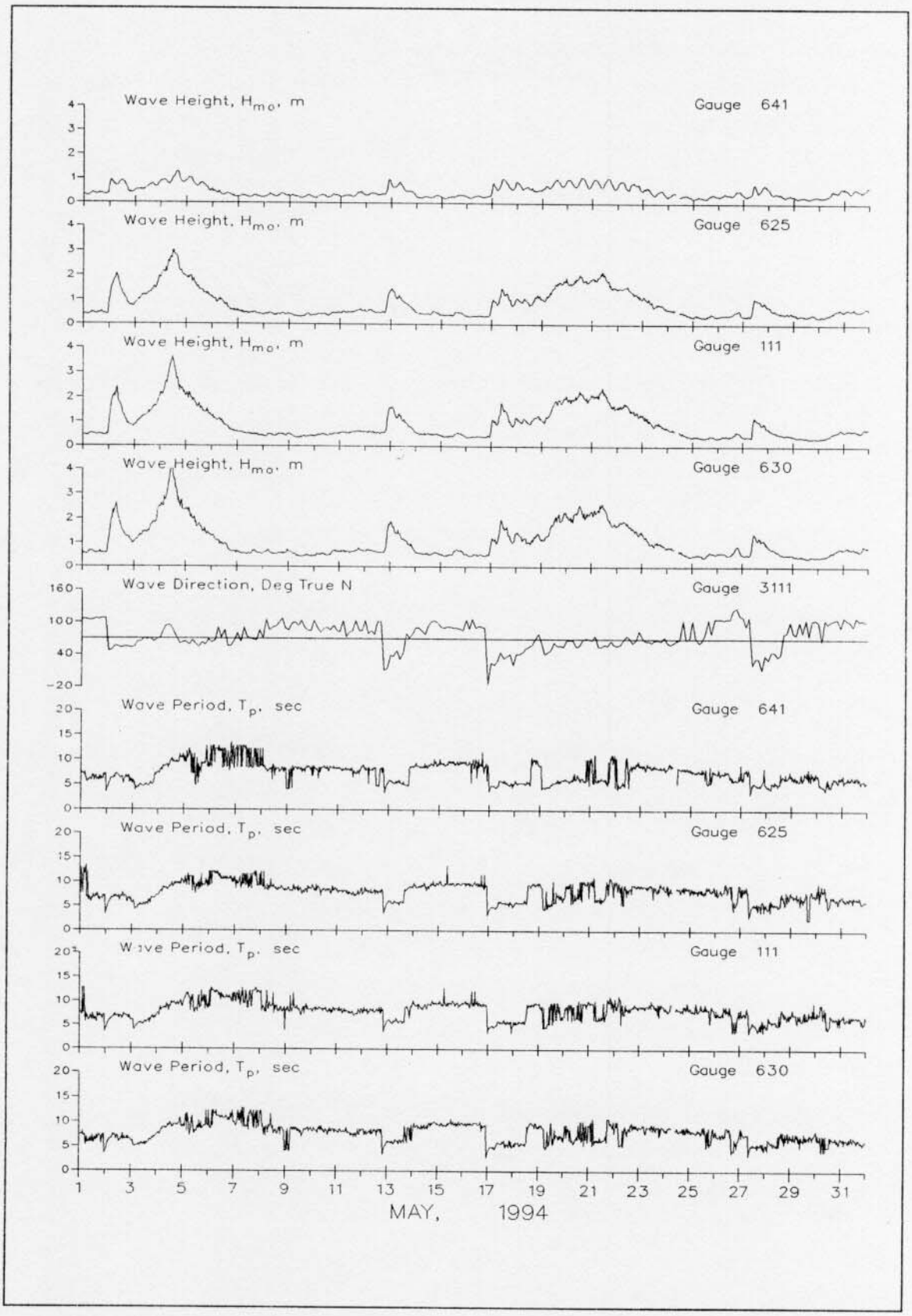

Figure 5. Wave Heights and Periods

4 Current Data

Current data (Table 5) are collected from a Marsh-McBirney electromagnetic biaxial current meter and by visually observing the movement of small drogues on the water surface in the surf and at the seaward end of the pier, as well as 500 m updrift of the pier, approximately 12 m offshore (Table 6).

Since the shoreline orientation is approximately N20W, longshore currents flow either toward 340 deg (i.e. northward) or toward 160 deg (i.e. southward). Similarly, cross-shore currents are either onshore (westward) or offshore (eastward). All current speeds are given in centimeters per second (cm/sec). Resultant speeds and directions are determined by vector averaging the cross-shore and longshore data. Current directions indicate the direction that the current is moving towards. Current data are plotted in Figure 2.

Table 5
Current Meter Data - Gauge 519

MAY 1994

Day	Time	Cross Shore	Long Shore	Speed	Dir
1	100	0	-9	10	342
	700	-3	-10	12	320
	1300	-1	-3	5	309
	1900	-1	-8	9	324
2	100	7	3	8	91
	700	0	45	45	161
	1300	3	42	42	156
	1900	6	59	60	154
3	100	5	31	31	150
	700	2	34	34	158
	1300	0	29	29	160
	1900	-10	36	37	177
4	100	0	15	15	164
	700	3	41	41	155
	1300	-3	20	20	172
	1900	-9	106	107	166
5	100	-5	70	70	165
	700	-6	54	55	167
	1300	-7	31	32	174
	1900	-4	22	22	172
6	100	2	-7	8	352
	700	-2	-4	6	309
	1300	1	-20	21	343
	1900	0	-9	10	342
7	100	5	-13	15	360
	700	3	-9	10	355
	1300	3	-10	12	356
	1900	-2	-18	19	332
8	100	-3	-19	21	328
	700	-2	-6	8	321
	1300	0	-4	5	345
	1900	2	18	18	153
9	100	0	11	11	165
	700	0	10	10	164
	1300	2	9	10	150
	1900	0	4	4	169
10	100	-1	-3	5	311
	700	0	-6	7	339
	1300	1	-3	4	349
	1900	3	0	3	72
11	100	0	-3	4	334
	700	1	-5	6	351
	1300	0	-3	4	333
	1900	0	-9	10	334
12	100	1	-5	6	353
	700	-3	-10	12	321
	1300	-2	-7	9	322
	1900	1	-3	4	355
13	100	0	41	41	162
	700	-2	31	31	165
	1300	6	49	50	153
	1900	2	18	18	155
14	100	-1	3	3	203
	700	0	0	0	
	1300	5	19	20	145
	1900	-2	-1	4	283
15	100	0	-4	5	336
	700	0	-10	11	334
	1300	-1	-1	3	297
	1900	-2	-12	14	327
16	100	0	0	0	
	700	-1	-2	3	307
	1300	7	-4	8	32
	1900	8	-19	21	1
17	100	3	9	9	142
	700	7	30	31	147
	1300	5	49	49	154
	1900	0	24	24	160
18	100	-2	31	31	165
	700	0	29	29	162
	1300	4	41	41	154
	1900	0	30	30	163
19	100	0	17	17	163
	700	0	15	15	163
	1300	-4	35	35	169
	1900	-2	34	34	165
20	100	-8	29	31	176
	700	-1	44	44	162
	1300	-3	39	39	166
	1900	-2	45	45	164
21	100	-4	21	21	173
	700	-4	32	32	168
	1300	-3	33	33	167
	1900	-2	36	36	165
22	100	-3	15	15	176
	700	-3	22	22	170
	1300	-9	13	17	196
	1900	-3	26	26	168
23	100	-3	32	33	168
	700	0	37	37	162
	1300	4	29	29	152
	1900	3	4	5	119
24	100	0	-2	4	318
	700	2	-7	8	357
	1300	0	0	0	
	1900	0	-9	10	342
25	100	3	-11	12	354
	700	0	-11	12	338
	1300	1	0	1	41
	1900	-2	-8	9	322
26	100	-3	-7	9	311
	700	-3	-3	6	290
	1300	-2	0	3	256
	1900	-1	-20	21	334
27	100	0	-6	7	328
	700	-3	-8	10	316
	1300	1	20	20	157
	1900	0	14	14	161
28	100	5	5	7	116
	700	0	-5	6	335
	1300	2	33	33	157
	1900	-1	10	11	169
29	100	1	9	9	152
	700	-2	3	4	210
	1300	-1	10	10	170
	1900	0	-5	6	337
30	100	1	-10	11	342
	700	1	-4	5	348
	1300	2	2	3	116
	1900	0	-6	7	335
31	100	0	-6	7	335
	700	0	-6	7	333
	1300	0	-2	4	316
	1900	0	-6	7	338
	1900	0	-6	7	338

KEY:

+cross-shore = offshore, cm/sec
-cross-shore = onshore, cm/sec
+longshore = south, cm/sec
-longshore = north, cm/sec
Speed = Resultant speed, cm/sec
Dir = Resultant direction, degrees true north

Table 6
Visually Observed Current Data

May 1994

	Pier End				Mid-Surf Zone				Beach		
Day	Cross Shore	Long Shore	Speed	Dir	Cross Shore	Long Shore	Speed	Dir	Location	Speed	Dir
1	25	-28	37	22	16	-27	31	11	South	10	S
2	0	47	47	160	0	76	76	160	North	91	S
3	0	28	28	160	0	23	23	160	North	43	S
4	0	32	32	160	0	51	51	160	North	36	S
5	0	61	61	160	0	87	87	160	North	49	S
6	0	11	11	160	20	-20	29	25	North	0	
7	3	-21	21	349	20	-44	48	4	South	9	N
8	11	-17	21	13	9	-20	22	4	South	8	N
9	0	32	32	160	6	16	17	138	North	7	S
10	11	-19	22	11	0	-12	12	340	South	0	
11	0	18	18	160	0	0	0		South	9	S
12	0	-51	51	340	21	-28	35	17	South	25	N
13	0	47	47	160	0	61	61	160	North	46	S
14	0	11	11	160	0	15	15	160	North	10	N
15	19	-32	37	11	17	-17	25	25	South	5	N
16	30	-14	33	46	11	-11	16	25	South	11	N
17	0	44	44	160	0	87	87	160	North	55	S
18	0	47	47	160	11	38	40	143	North	61	S
19	0	41	41	160	0	41	41	160	North	8	S
20	0	6	6	160	0	12	12	160	South	53	S
21	0	102	102	160	0	152	152	160	North	30	S
22	0	68	68	160	0	47	47	160	North	36	S
23	0	55	55	160	0	17	17	160	North	9	N
24	0	21	21	160	0	0	0		North	5	S
25	8	-27	28	357	0	-11	11	340	South	15	N
26	17	-18	25	22	10	-17	20	11	South	20	N
27	0	0	0		0	-27	27	340	South	0	
28	0	0	0		0	0	0		North	5	N
29	10	20	23	70	0	0	0		South	3	N
30	0	-16	16	340	0	-12	12	340	South	8	N
31	0	-34	34	340	0	-44	44	340	South	8	N

KEY:
+cross-shore = offshore, cm/sec
-cross-shore = onshore, cm/sec
+longshore = south, cm/sec
-longshore = north, cm/sec
Speed = Resultant speed, cm/sec

5 Visual Observations

Visual wave direction measurements (Table 7) of both the primary wave train (i.e. that having the higher wave heights) and the secondary wave train (which must be clearly distinguishable as a wave train separate from the primary waves but not surface chop or capillary waves) are taken daily at the seaward end of the pier. The direction of the primary wave train just north of the seaward end of the pier is also determined using a Raytheon Marine Pathfinder radar and measuring the alignment of the wave crests at approximately the same location as the visual measurements. The pier axis (considered perpendicular to the beach at the FRF) is oriented 70 deg east of true north; consequently, wave angles greater than 70 deg indicate that the waves were coming from the south side of the pier.

The width of the surf zone (seawardmost breaker position to shoreline) is determined from the pier deck.

Measurements of surface water temperature, density, and visibility are also taken daily at the seaward end of the pier. A Bucket Thermometer is lowered about 0.3 m into the water and allowed to remain for at least one minute. The temperature is then read, and a hydrometer is used to determine the density. A Secchi disc is used to determine the depth of visibility.

Table 7
Visual Observations

May 1994

Day	Time	Wave Approach Angle at Pier End deg from True N Primary	Secondary	Radar Wave Angle deg from True N	Width of Surf Zone,m	Water Characteristics at Pier End Temp.,C	Density g/cc	Secchi Vis.,m
1	1100	100			10	13.3	1.0260	1.2
2	0735	50		Gauge	350	12.8	1.0261	1.2
3	0730	50	90		130	14.4	1.0175	1.2
4	1000	50			790	15.6	1.0165	0.6
5	0800	60		inoperative	220	15.0	1.0180	0.6
6	0705	55	90		110	13.3	1.0208	0.3
7	0853	90			60	14.4	1.0216	1.2
8	0845	70	130		10	15.0	1.0240	0.6
9	0755	85	20	until	20	13.9	1.0240	1.5
10	0710	95			10	14.4	1.0234	1.5
11	0705	90	50		10	16.1	1.0200	2.4
12	0705	95		18 May	0	17.2	1.0200	1.5
13	0720	50	80		120	15.0	1.0231	0.6
14	0840	90	50		20	16.1	1.0200	2.7
15	1130	90			10	16.7	1.0220	2.7
16	0700	90			10	16.7	1.0228	3.0
17	0720	45			110	17.8	1.0229	5.5
18	0720	50		45	140	16.7	1.0170	1.8
19	0715	30		50	140	16.9	1.0015	1.2
20	0715	30		55	230	15.3	1.0200	0.3
21	0950	50			240	14.4	1.0200	0.3
22	1110	50	90		260	15.0	1.0210	0.3
23	0725	60		65	140	15.0	1.0180	0.9
24	0735	90	50		20	17.5	1.0175	1.8
25	0735	105			10	18.3	1.0175	2.4
26	0725	105			10	15.3	1.0244	1.8
27	0715	105		105	10	15.0	1.0244	3.0
28	0850	35			10	16.1	1.0238	3.4
29	0838	100			10	18.3	1.0187	3.4
30	0840	110			20	17.2	1.0220	3.4
31	0715	105		105	140	17.2	1.0224	3.0

6 Water Levels

Since 1978, the National Oceanic and Atmospheric Administration (NOAA)/National Ocean Service (NOS) has operated a primary tide station (No. 865-1370) at the seaward end of the FRF pier. A NOS acoustic tide gauge (Next Generation Water Level Measurement System, NGWLMS) is used to collect water level data every 6 minutes throughout the month.

The variation in water level during the month is shown in Figure 6 along with a list of means and extreme values. This presentation is useful in identifying effects of both meteorological and astronomical forces on the open coast water level. Table 8 contains the range, high, low, and mean water level for each 12.42-hr tidal cycle.

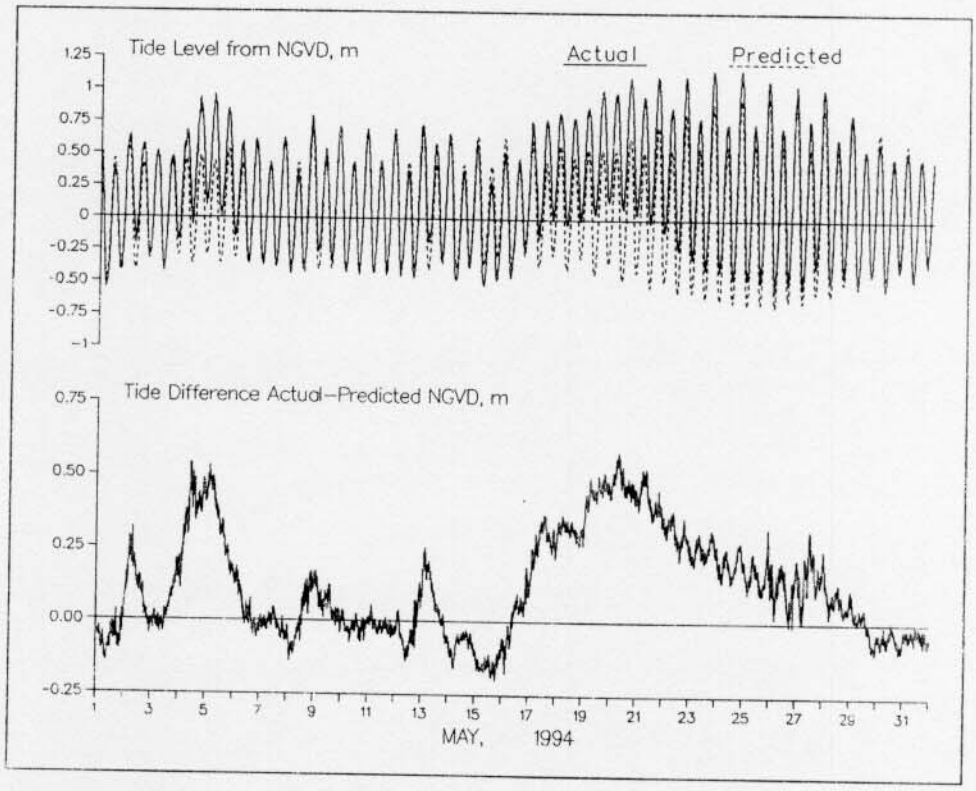

Figure 6. Water Level Variation

Table 8
Water Levels, m NGVD

MAY 1994 Tide Levels

	High			Low		Mean	Range		High			Low		Mean	Range
Day	Time	m	Day	Time	m	m	m	Day	Time	m	Day	Time	m	m	m
1	1206	0.39	1	0536	-0.56	-0.07	0.94	16	2230	0.76	16	1654	-0.24	0.24	1.00
2	0100	0.64	1	1824	-0.41	0.09	1.06	17	1148	0.77	17	0524	-0.16	0.33	0.93
2	1300	0.57	2	0642	-0.22	0.21	0.78	17	2324	0.83	17	1742	0.00	0.43	0.82
3	0124	0.51	2	1942	-0.29	0.12	0.81	18	1236	0.79	18	0648	-0.04	0.38	0.83
3	1442	0.47	3	0748	-0.42	0.05	0.89	19	0124	0.87	18	1836	-0.01	0.45	0.88
4	0254	0.67	3	2030	-0.17	0.24	0.85	19	1406	1.01	19	0736	0.04	0.52	0.97
4	1430	0.93	4	0836	-0.06	0.46	1.00	20	0218	0.99	19	2018	0.13	0.57	0.85
5	0318	0.96	4	2106	0.09	0.52	0.87	20	1500	1.10	20	0906	0.08	0.59	1.02
5	1530	0.85	5	0948	0.01	0.43	0.84	21	0336	0.96	20	2048	0.04	0.52	0.92
5	1748	0.63	5	2200	-0.15	0.25	0.78	21	1542	1.11	21	0912	-0.03	0.54	1.14
6	1554	0.61	6	1054	-0.36	0.12	0.97	22	0436	0.87	21	2230	-0.09	0.40	0.96
7	0442	0.43	6	2336	-0.37	0.05	0.80	22	1642	1.11	22	1054	-0.24	0.43	1.35
7	1706	0.60	7	1030	-0.38	0.11	0.98	23	0548	0.79	22	2330	-0.30	0.27	1.08
7	1930	0.38	8	0006	-0.43	-0.02	0.81	23	1736	1.16	23	1112	-0.38	0.39	1.54
8	1800	0.79	8	1224	-0.42	0.16	1.22	24	0636	0.74	24	0000	-0.39	0.22	1.14
9	0624	0.54	9	0036	-0.26	0.15	0.80	24	1848	1.16	24	1218	-0.45	0.34	1.61
9	1842	0.71	9	1206	-0.35	0.18	1.06	25	0700	0.75	25	0106	-0.46	0.17	1.21
10	0700	0.43	10	0124	-0.41	0.02	0.84	25	1930	1.08	25	1254	-0.48	0.30	1.56
10	1924	0.69	10	1248	-0.44	0.12	1.13	26	0742	0.72	26	0136	-0.56	0.13	1.28
11	0730	0.45	11	0118	-0.42	0.02	0.87	26	2036	1.04	26	1342	-0.50	0.25	1.54
11	2006	0.67	11	1324	-0.44	0.13	1.11	27	0824	0.78	27	0254	-0.53	0.13	1.31
12	0812	0.37	12	0200	-0.45	-0.02	0.82	27	2048	1.02	27	1424	-0.36	0.32	1.38
12	2036	0.73	12	1336	-0.46	0.13	1.19	28	0912	0.63	28	0342	-0.47	0.11	1.10
13	0842	0.58	13	0248	-0.19	0.17	0.77	28	2206	0.83	28	1536	-0.43	0.20	1.25
13	2036	0.66	13	1500	-0.31	0.16	0.97	29	1024	0.55	29	0448	-0.51	0.05	1.06
14	0924	0.38	14	0348	-0.47	-0.07	0.85	29	2242	0.61	29	1618	-0.43	0.09	1.03
14	2106	0.58	14	1536	-0.38	0.09	0.96	30	1200	0.47	30	0506	-0.54	-0.02	1.00
15	1006	0.29	15	0442	-0.52	-0.12	0.81	31	0018	0.53	30	1800	-0.39	0.07	0.92
15	2230	0.52	15	1548	-0.48	0.02	1.00	31	1148	0.48	31	0618	-0.46	0.02	0.94
16	1124	0.47	16	0424	-0.46	0.01	0.93	31	2348	0.43	31	1842	-0.35	-0.05	0.78

7 Bathymetry

A. Nearshore Profiles. In order to document profile response away from the pier, surveys of four profile lines extending 900 to 1,000 m from shore and located 489 and 581 m north and 517 and 608 m south of the FRF pier are conducted bi-weekly, after storms, and during more complete bathymetric surveys.

These profiles are obtained using the CRAB-Geodimeter surveying system; a Geodimeter 140-T self-tracking, electronic theodolite, distance meter, in combination with the Coastal Research Amphibious Buggy (CRAB), a 10.7 m high, self-powered, mobile tripod on wheels.

Figure 7 shows the last survey in April 1994 and the survey(s) in May 1994 on profile line 188, located 517 m south of the pier.

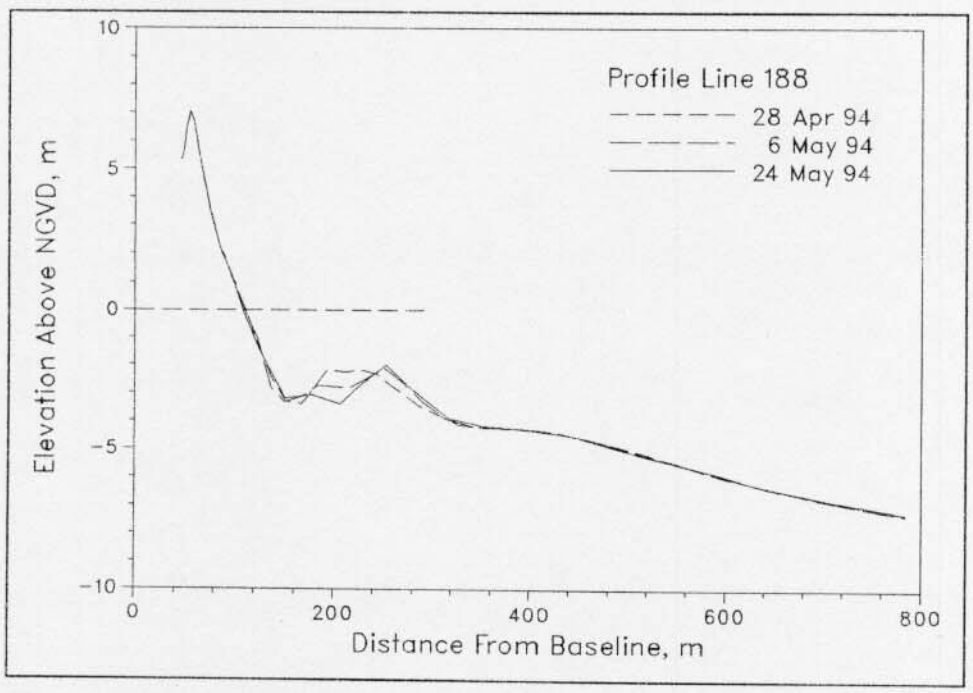

Figure 7. Monthly CRAB Profiles on Profile Line 188.

The profile envelope (Figure 8) reflects the maximum changes that occurred on the profile during 1994. Cross-hatched areas indicate changes to the annual envelope which occurred in May.

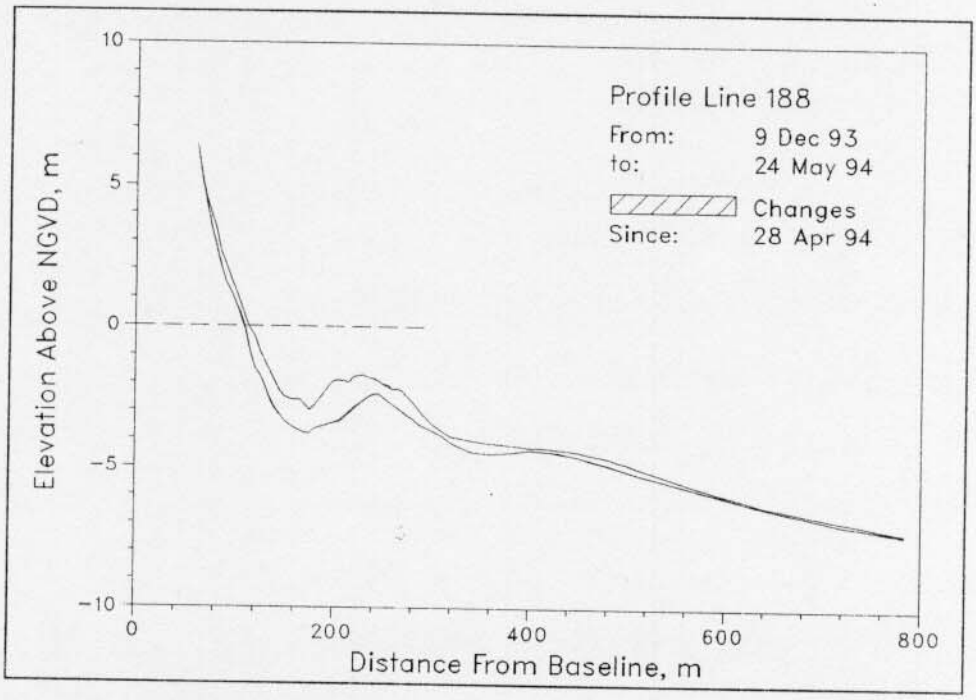

Figure 8. Profile Envelope - Profile Line 188.

B. Bathymetry. Figure 9 includes a two- and three-dimensional contour map and a change plot derived from the bathymetric survey on 6 April. Wide contour lines on the change diagram represent eroded areas; thin lines indicate deposition. There was no bathymetric survey in May. Figure 9 is included for reference only.

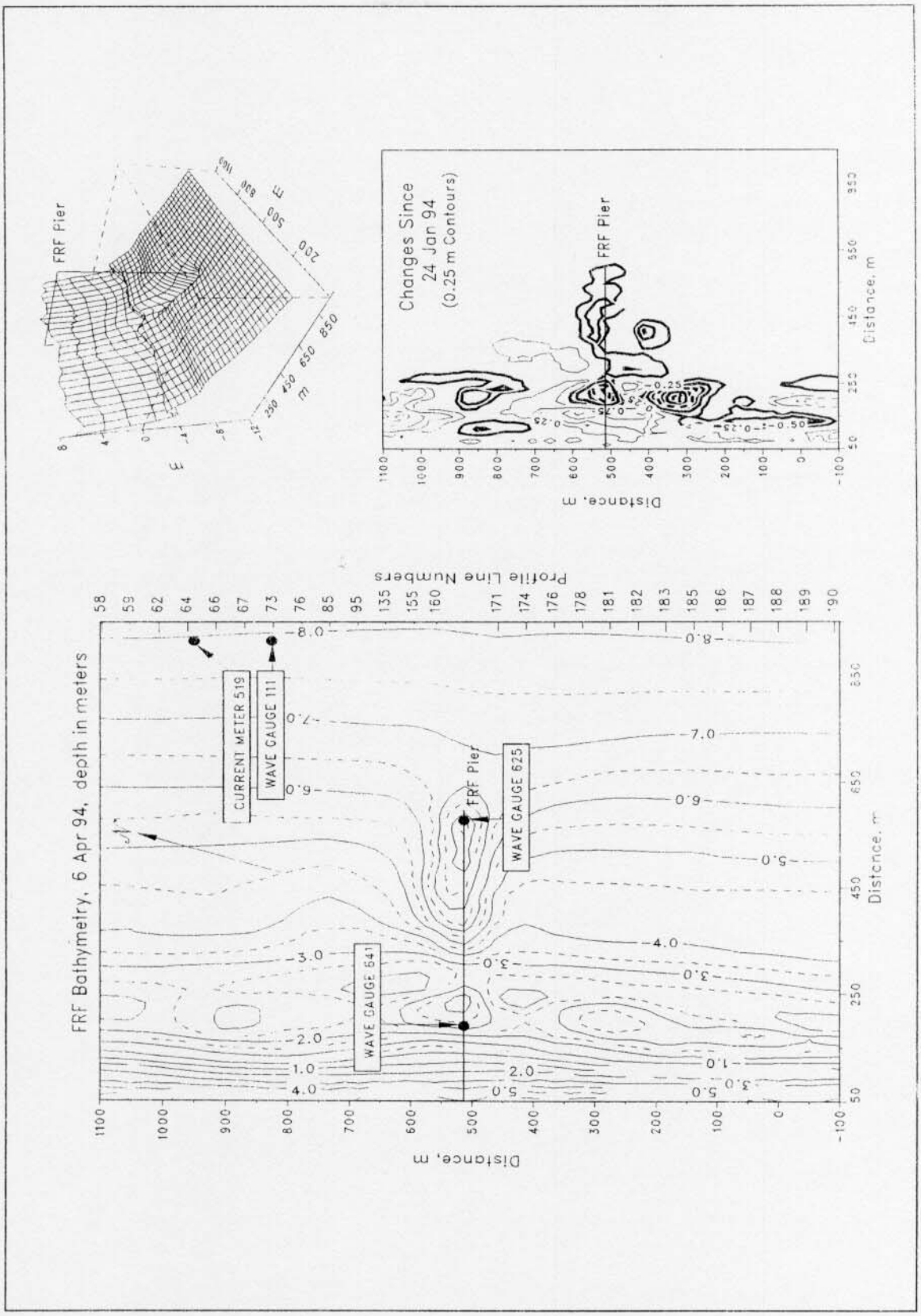

Figure 9. FRF Bathymetry, Depths Relative to NGVD

8 Special Events

A. Storm Data Collection. The following list identifies times when the wave height H_{mo} at the seaward end of the pier exceeded 2 m.

Start	End
4 May (1100)	4 May (2200)
20 May (1142)	21 May (1216)

B. Storm Synopsis.

4 May Forming over the North Carolina coast on the morning of 4 May, this storm moved to the northeast, quickly out to sea. The minimum atmospheric pressure was 1006 mb. Maximum onshore winds (NE) reached 19 m/s at 1000 EST. The maximum H_{mo}, at gauge 630, reached 4.11 m (T_p=9.1 s) at 1034 EST. There was 84 mm of precipitation.

20-21 May Winds associated with a high pressure system reached 15 m/s (NE) at 0808 EST on 21 May. The maximum H_{mo}, at gauge 625, reached 2.19 m (T_p=6.0 s) at 1000 EST on 21 May. There was no precipitation.

Distribution List

Government Agencies:

Back Bay National Wildlife Refuge
USACE-OCE
USACE-SAD
USACE-NAP
USACE-SAW
USACE-WES
NAVSAC
NOAA/NOS/OMS
National Marine Fisheries
U.S. Geological Survey
U.S. Library of Congress
U.S. National Park Service
U.S. National Weather Service
U.S. Naval Academy
U.S. Naval Civil Eng. Lab
U.S. Naval Oceanographic Off.
U.S. Naval Research Lab

Colleges/Universities:

Bucknell University
California Inst. of Tech.
Duke Marine Lab
East Carolina University
Florida Inst. of Tech.
M.I.T.
Naval Post Graduate School
NC State University
Old Dominion University
Oregon State University
Prince George's College
Scripps Institution of Oceanography
Stockton State College
University Calif-Berkeley
University of Florida
University of Maryland-College Park
University of Maryland-Baltimore
University of North Carolina
University of N C-Seagrant Program
University of Virginia
Va. Inst. of Marine Science
Rutgers University

Others:

Allied Signal Aerospace Co.
Applied Physics Lab
Cape Hatteras Nat. Seashore
Coastal and Est. Res., Inc.
Coastal Science & Eng., Inc.
Dr. Cy Galvin
GEOMET Tech., Inc.
Mr. Hodges
Dr. Hylton
Mr. Mason
Mr. Rodgers
WCTI-TV
MEC Systems Corporation
Moffatt & Nichol, Eng.
N.C. Div. Coastal Management
Oregon Inlet & Waterways Commis.
Raleigh-Durham Airport
Mr. Rowland
Mr. Savage
Science Application Int'l. Corp
Sherwood Industries
SEASUN Power Systems

Foreign:

Christchurch, Barbados
Ministry of Works, Bahamas
Dalhousie University, Halifax Nova Scotia
Queen's University, Ontario (Canada)
Ministry of Construction, Coastal Division (Japan)
Norwegian Hydrodynamic Laboratories (Norway)
University of Sydney (Australia)