US Army Corps of Engineers
Waterways Experiment Station

Preliminary Data Summary for April 1994 CERC Field Research Facility

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Coastal Engineering Research Center

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April 1994
Preliminary Data Summary

by Field Research Facility

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

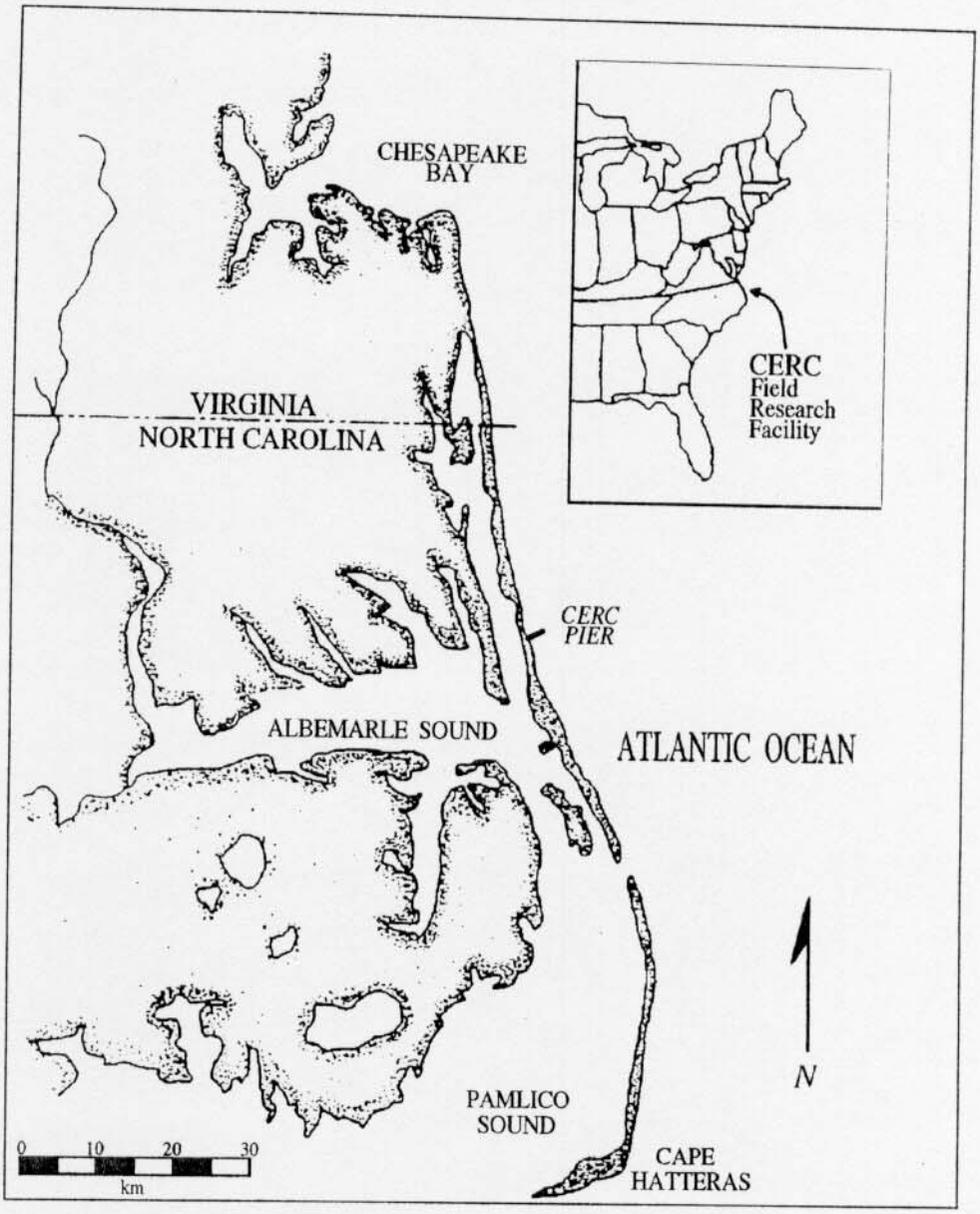

Figure 1. FRF Location Map

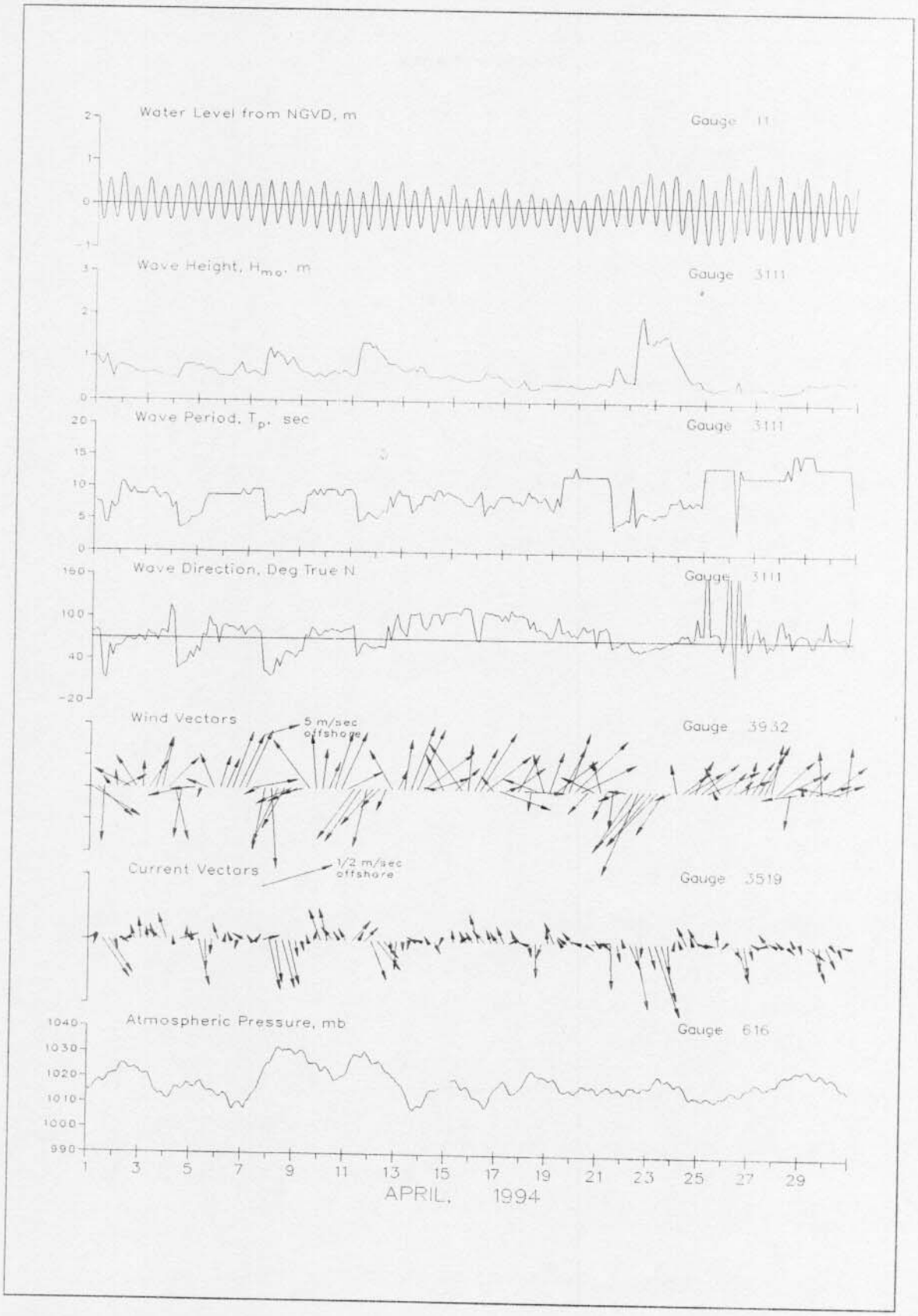

Figure 2. Month at a Glance

Table 1
Instrument Status/Data Availability

April 1994

Day of the month

Gage 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
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

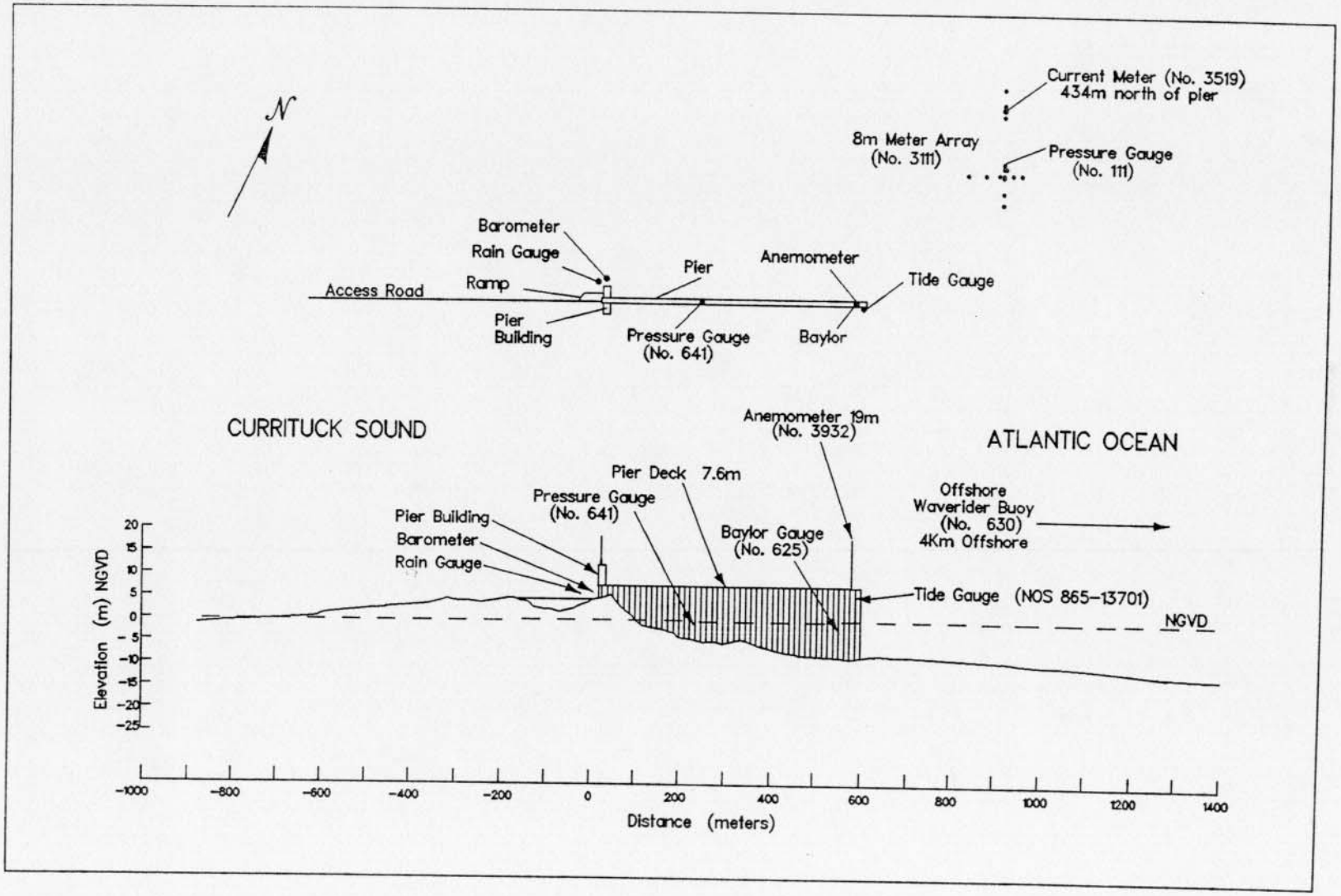

Figure 3. Instrument Locations, Elevations From NGVD

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

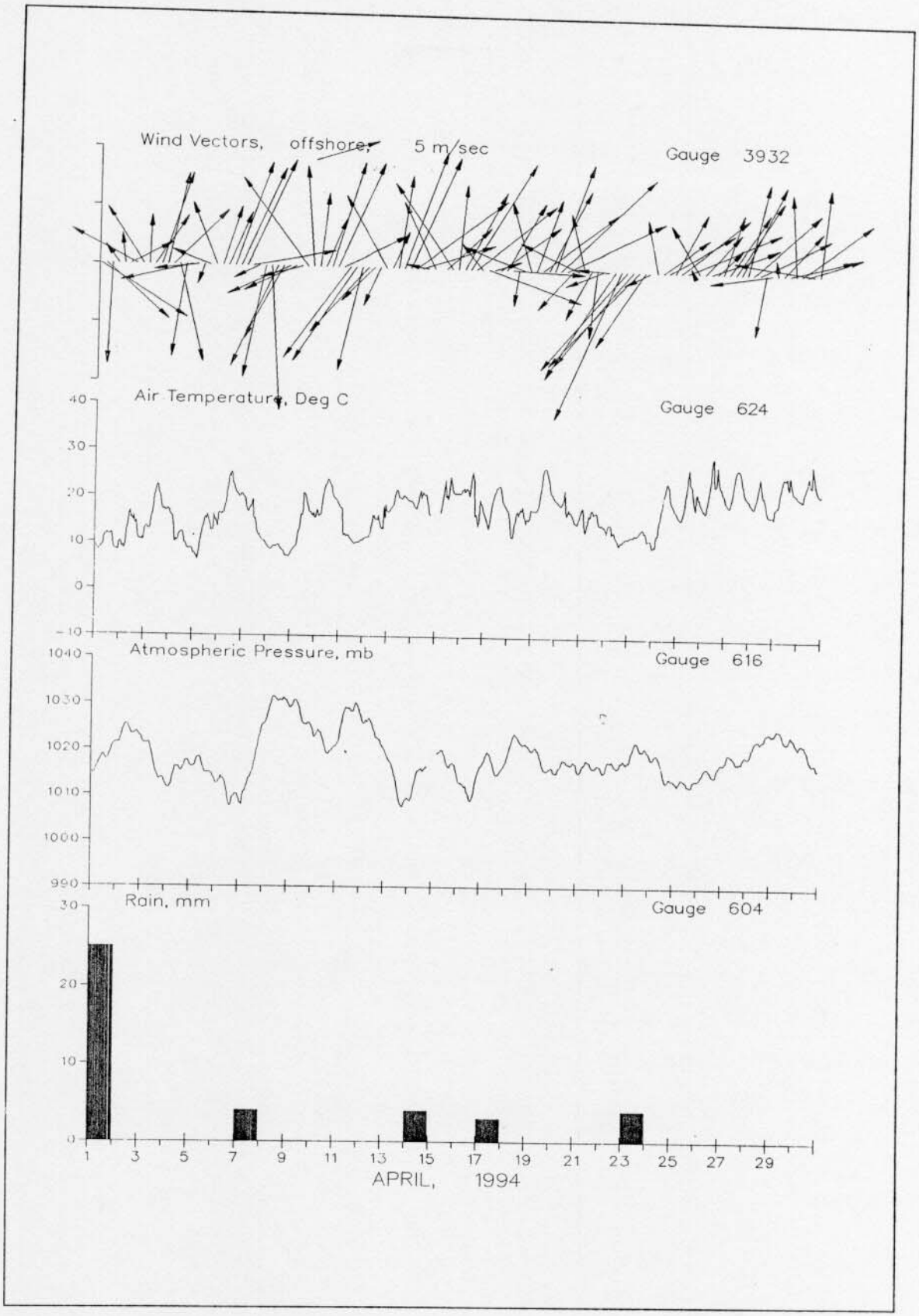

Figure 4. Meteorological Monthly Summary

Table 3
Meteorological Data

Apr 1994

Day	Hour	Wind Speed m/sec	Wind Direction deg TN	Temperature deg C	Atm Pressure mb	Precipitation mm
1	100	8	305	9.4	1014.9	0
	700	7	315	9.2	1016.8	25
	1300	9	2	11.8	1018.4	0
	1900	2	146	8.8	1019.5	0
2	100	3	173	10.1	1021.5	0
	700	4	1	12.5	1024.3	0
	1300	6	119	14.8	1024.6	0
	1900	6	149	10.7	1023.5	0
3	100	4	181	13.2	1022.7	0
	700	5	210	15.1	1021.5	0
	1300	8	195	22.4	1016.9	0
	1900	8	190	17.0	1013.4	0
4	100	6	220	17.0	1012.1	0
	700	8	347	10.5	1013.2	0
	1300	8	7	12.4	1016.2	0
	1900	6	74	8.7	1016.4	0
5	100	3	82	7.8	1016.4	0
	700	2	17	10.1	1017.7	0
	1300	3	112	15.6	1016.4	0
	1900	6	160	12.8	1014.8	0
6	100	5	195	16.0	1013.0	0
	700	5	200	16.9	1014.1	0
	1300	9	196	24.2	1010.4	0
	1900	9	201	20.8	1009.7	0
7	100	10	201	20.4	1008.8	0
	700	6	257	16.9	1010.9	4
	1300	2	60	15.4	1014.8	0
	1900	10	9	11.0	1020.7	0
8	100	12	356	9.5	1025.7	0
	700	9	21	9.4	1029.2	0
	1300	7	24	9.4	1031.3	0
	1900	5	61	7.4	1030.7	0
9	100	4	61	8.4	1030.0	0
	700	3	72	11.7	1030.6	0
	1300	9	146	17.4	1028.5	0
	1900	9	175	16.9	1025.6	0
10	100	6	185	15.7	1024.6	0
	700	4	199	17.6	1024.5	0
	1300	9	194	23.9	1020.9	0
	1900	10	200	20.1	1019.8	0

Table 3
Meteorological Data (continued)

Apr 1994

Day	Hour	Wind Speed m/sec	Wind Direction deg TN	Temperature deg C	Atm Pressure mb	Precipitation mm
11	100	6	239	18.1	1021.2	0
	700	9	32	11.9	1026.8	0
	1300	9	30	10.8	1029.1	0
	1900	9	11	10.5	1029.6	0
12	100	7	37	11.4	1027.8	0
	700	4	40	12.3	1026.4	0
	1300	4	1	15.5	1025.3	0
	1900	7	152	13.5	1022.4	0
13	100	3	201	17.1	1020.0	0
	700	8	187	18.8	1017.3	0
	1300	10	197	20.1	1012.2	0
	1900	10	201	20.2	1007.7	0
14	100	9	229	19.3	1009.1	0
	700	6	249	19.1	1012.9	4
	1300	2	101	21.1	1015.9	0
	1900	6	156	16.6	1016.4	0
15	100		Hardware Error			0
	700	5	223	18.7	1019.6	0
	1300	8	148	20.0	1018.7	0
	1900	7	184	21.3	1017.0	0
16	100	7	205	21.2	1014.6	0
	700	10	207	22.0	1012.5	0
	1300	8	227	25.2	1010.0	0
	1900	3	143	15.0	1012.4	0
17	100	8	291	16.7	1016.8	0
	700	2	249	16.3	1019.7	3
	1300	6	230	22.0	1016.7	0
	1900	6	206	20.6	1015.0	0
18	100	5	273	17.2	1017.2	0
	700	3	6	15.0	1021.7	0
	1300	5	112	17.9	1023.2	0
	1900	6	165	15.7	1021.4	0
19	100	6	196	17.6	1020.7	0
	700	7	229	18.6	1020.9	0
	1300	8	204	26.8	1017.7	0
	1900	10	197	21.9	1015.5	0
20	100	11	221	19.7	1015.6	0
	700	9	240	19.5	1016.4	0
	1300	4	38	18.0	1017.8	0
	1900	5	117	15.2	1017.0	0

Table 3
Meteorological Data (concluded)

Apr 1994

Day	Hour	Wind Speed m/sec	Wind Direction deg TN	Temperature deg C	Atm Pressure mb	Precipitation mm
21	100	5	167	17.3	1015.5	0
	700	5	24	14.9	1016.9	0
	1300	6	5	17.9	1017.6	0
	1900	3	64	14.8	1016.3	0
22	100	3	95	14.3	1015.9	0
	700	11	29	14.7	1017.6	0
	1300	14	20	11.5	1017.1	0
	1900	11	37	11.2	1016.7	0
23	100	10	35	12.1	1017.2	0
	700	11	39	12.8	1019.7	4
	1300	7	29	13.7	1021.7	0
	1900	2	60	11.5	1020.3	0
24	100	5	170	10.3	1018.8	0
	700	5	229	15.6	1019.2	0
	1300	6	235	21.9	1016.2	0
	1900	6	205	19.7	1013.5	0
25	100	7	226	17.2	1013.4	0
	700	8	243	17.7	1013.4	0
	1300	1	158	27.0	1013.3	0
	1900	5	151	18.3	1012.6	0
26	100	4	217	19.1	1013.8	0
	700	6	246	20.0	1015.9	0
	1300	3	220	29.5	1015.6	0
	1900	5	196	23.7	1015.3	0
27	100	6	209	20.2	1017.3	0
	700	7	209	20.8	1019.5	0
	1300	8	203	27.2	1018.4	0
	1900	8	191	22.5	1017.7	0
28	100	7	223	19.9	1019.0	0
	700	6	239	20.4	1021.1	0
	1300	5	8	22.4	1022.8	0
	1900	5	79	17.3	1023.4	0
29	100	1	173	16.7	1024.1	0
	700	5	217	21.9	1025.1	0
	1300	5	252	25.2	1023.1	0
	1900	7	176	23.2	1022.7	0
30	100	7	229	21.1	1022.4	0
	700	4	247	22.0	1022.0	0
	1300	6	99	24.1	1020.3	0
	1900	8	185	23.0	1017.5	0
		Resultant		Mean	Mean	Total
		2	196	16.9	1018.8	40

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

Apr 1994

Day	Hour	641 Pressure Gage Hmo,m	641 Pressure Gage Tp,sec	625 Baylor Gauge Hmo,m	625 Baylor Gauge Tp,sec	3111 8 Meter Array Hmo,m	3111 8 Meter Array Tp,sec	3111 8 Meter Array Dir,N	630 Waverider Hmo,m	630 Waverider Tp,sec
1	0100	0.67	7.2	0.87	8.1	1.04	8.2	78	1.16	7.8
	0700	0.48	3.5	0.77	7.4	0.79	7.6	78	1.00	7.4
	1300	0.65	4.7	0.83	4.8	0.80	4.4	12	0.96	4.5
	1900	0.30	7.0	0.68	7.0	0.73	6.6	44	0.81	7.2
2	0100	0.26	7.6	0.66	9.9	0.79	10.8	58	0.88	7.4
	0700	0.27	8.3	0.64	10.3	0.74	9.8	66	0.79	9.5
	1300	0.22	8.9	0.62	9.5	0.65	9.8	66	0.74	8.6
	1900	0.20	8.6	0.55	8.3	0.62	8.9	72	0.71	8.3
3	0100	0.28	8.6	0.54	9.2	0.62	8.9	64	0.64	9.2
	0700	0.24	9.2	0.59	8.6	0.63	9.8	74	0.63	9.5
	1300	0.26	8.6	0.48	8.3	0.57	8.2	66	0.58	8.3
	1900	0.22	8.3	0.46	8.9	0.48	8.9	80	0.55	8.9
4	0100	0.36	6.5	0.42	8.6	0.54	6.6	116	0.58	7.2
	0700	0.32	6.3	0.50	8.1	0.66	3.8	26	0.65	8.6
	1300	0.55	3.9	0.80	4.0	0.83	4.1	34	0.93	4.1
	1900	0.36	4.3	0.86	5.4	0.83	5.3	50	1.03	5.4
5	0100	0.50	4.8	0.77	5.3	0.80	5.6	58	0.90	5.3
	0700	0.28	9.2	0.59	8.9	0.69	7.6	76	0.83	6.3
	1300	0.32	8.6	0.59	8.3	0.73	8.9	100	0.78	8.1
	1900	0.30	8.9	0.55	9.2	0.57	8.9	88	0.69	8.9
6	0100	0.29	8.9	0.48	9.2	0.55	8.9	86	0.59	8.3
	0700	0.29	8.9	0.52	9.2	0.56	8.9	86	0.58	8.6
	1300	0.52	5.7	0.62	8.6	0.73	8.9	84	0.79	8.9
	1900	0.44	7.4	0.62	9.5	0.65	9.8	88	0.81	9.5
7	0100	0.46	7.6	0.63	9.9	0.65	8.9	82	0.76	9.2
	0700	0.45	7.8	0.58	9.5	0.63	9.8	88	0.70	9.2
	1300	0.34	9.5	0.51	9.2	0.55	9.8	78	0.57	8.6
	1900	0.80	5.4	1.29	5.2	1.22	5.6	22	1.34	5.5
8	0100	0.57	5.0	1.11	5.3	1.12	5.3	20	1.41	5.3
	0700	0.60	5.6	0.94	5.6	0.99	5.9	30	1.33	5.6
	1300	0.41	5.5	0.85	5.7	0.90	5.9	52	1.03	5.6
	1900	0.42	5.7	0.77	6.8	0.82	6.2	48	0.94	6.5
9	0100	0.25	2.7	0.64	6.5	0.66	6.2	52	0.76	6.3
	0700	0.31	9.5	0.62	6.1	0.63	8.9	76	0.74	6.3
	1300	0.28	9.2	0.60	8.9	0.56	9.8	86	0.67	8.6
	1900	0.33	9.5	0.51	9.2	0.58	9.8	74	0.67	10.3
10	0100	0.29	4.8	0.52	8.6	0.61	9.8	82	0.63	9.2
	0700	0.41	9.9	0.60	9.5	0.68	9.8	84	0.77	4.9
	1300	0.38	5.4	0.54	9.2	0.64	8.9	82	0.75	8.9
	1900	0.51	5.5	0.57	5.6	0.68	9.8	82	0.81	5.7

Table 4
Wave Data (continued)

Apr 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	0.36	6.0	0.51	9.5	0.56	9.8	84	0.63	8.9
	0700	0.63	8.9	0.94	3.9	1.11	4.8	46	1.03	4.2
	1300	0.44	5.1	1.33	5.4	1.34	5.3	64	1.43	5.4
	1900	0.69	5.5	1.18	5.9	1.23	5.9	60	1.36	6.0
12	0100	0.48	4.9	1.10	5.2	1.12	5.3	58	1.31	6.0
	0700	0.53	5.7	0.92	5.4	0.99	6.6	60	1.11	6.8
	1300	0.47	5.7	0.73	7.8	0.84	8.9	90	0.97	5.9
	1900	0.59	9.2	0.73	8.3	0.80	8.9	92	0.91	6.0
13	0100	0.43	9.2	0.63	8.9	0.69	8.9	86	0.80	8.9
	0700	0.47	8.6	0.65	8.9	0.75	8.9	74	0.83	9.5
	1300	0.46	6.1	0.65	9.9	0.68	6.6	104	0.88	6.8
	1900	0.63	7.6	0.70	8.6	0.79	7.6	108	1.03	7.2
14	0100	0.40	7.6	0.50	9.2	0.55	8.9	84	0.64	9.5
	0700	0.43	8.9	0.48	9.9	0.56	8.2	106	0.63	9.5
	1300	0.38	9.5	0.47	9.9	0.54	9.8	106	0.65	9.5
	1900	0.45	8.1	0.50	9.5	0.61	9.5	107	0.68	8.6
15	0100				Hardware Error					
	0700	0.34	8.1	0.44	7.8	0.51	8.6	109	0.55	7.8
	1300	0.41	7.6	0.47	9.2	0.47	7.6	115	0.65	7.6
	1900	0.36	6.6	0.49	9.5	0.50	7.4	114	0.59	7.0
16	0100	0.31	7.2	0.49	7.2	0.50	8.9	70	0.62	8.9
	0700	0.48	5.9	0.65	5.3	0.69	5.9	102	0.92	5.6
	1300	0.45	7.4	0.51	7.4	0.58	7.6	108	0.74	7.6
	1900	0.51	7.4	0.59	7.6	0.60	8.2	106	0.74	8.6
17	0100	0.39	8.3	0.47	8.3	0.48	8.9	98	0.69	8.9
	0700	0.22	8.1	0.32	8.9	0.37	8.9	98	0.46	8.9
	1300	0.23	8.1	0.32	8.1	0.35	8.2	106	0.42	8.1
	1900	0.31	6.8	0.48	8.6	0.53	7.6	106	0.72	7.0
18	0100	0.21	7.0	0.29	8.3	0.32	9.8	102	0.44	8.6
	0700	0.16	8.9	0.28	9.5	0.32	8.9	98	0.39	8.3
	1300	0.28	7.8	0.42	8.9	0.42	8.2	86	0.58	8.3
	1900	0.23	6.0	0.43	8.3	0.42	8.2	82	0.58	8.1
19	0100	0.26	9.2	0.41	7.2	0.43	6.6	74	0.53	7.6
	0700	0.20	8.3	0.35	7.6	0.42	7.6	104	0.48	8.3
	1300	0.25	8.1	0.34	8.6	0.39	12.0	82	0.46	8.3
	1900	0.25	5.5	0.37	12.2	0.38	12.0	78	0.54	12.2
20	0100	0.23	7.4	0.32	12.9	0.36	12.0	76	0.54	2.1
	0700	0.21	7.0	0.29	12.2	0.39	12.0	92	0.47	12.2
	1300	0.29	6.8	0.41	11.7	0.39	12.0	86	0.53	12.2
	1900	0.27	5.0	0.45	11.2	0.47	12.0	62	0.59	3.6

Table 4
Wave Data (concluded)

Apr 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	0.29	8.9	0.44	11.7	0.45	12.0	86	0.53	11.2
	0700	0.25	11.2	0.44	11.2	0.46	10.8	84	0.55	11.2
	1300	0.45	4.3	0.82	4.5	0.85	4.6	64	1.03	5.0
	1900	0.22	3.9	0.52	5.2	0.53	5.0	68	0.66	5.2
22	0100	0.22	10.7	0.46	5.6	0.50	5.3	70	0.57	5.3
	0700	0.51	3.7	0.82	3.7	1.31	4.4	56	1.06	3.5
	1300	0.81	6.0	1.70	6.5	2.03	6.6	54	2.48	6.3
	1900	0.74	5.9	1.28	6.5	1.45	6.2	58	1.75	6.0
23	0100	0.65	5.5	1.30	5.9	1.49	5.6	62	1.80	5.9
	0700	0.64	5.7	1.38	6.0	1.52	6.2	62	1.71	6.0
	1300	0.61	5.7	1.44	6.6	1.51	6.6	66	1.74	5.7
	1900	0.53	4.7	1.04	9.2	1.12	8.2	68	1.32	8.9
24	0100	0.44	7.2	0.88	7.6	0.88	8.9	72	1.05	8.9
	0700	0.28	8.3	0.55	7.6	0.59	7.6	78	0.65	9.2
	1300	0.22	7.8	0.42	8.1	0.48	7.6	70	0.59	7.8
	1900	0.33	8.3	0.46	7.8	0.53	8.2	104	0.67	7.8
25	0100	0.19	5.3	0.30	7.6	0.35	13.6	80	0.41	8.9
	0700	0.19	14.3	0.26	14.3	0.30	13.6	80	0.38	13.5
	1300	0.14	15.1	0.28	13.5	0.34	13.6	82	0.33	13.5
	1900	0.24	13.5	0.33	13.5	0.36	13.6	58	0.40	13.5
26	0100	0.15	7.6	0.30	13.5	0.36	13.6	226	0.39	12.9
	0700	0.20	7.6	0.29	12.9	0.55	3.2	20	0.39	12.9
	1300	0.16	4.9	0.31	12.9	0.33	12.0	64	0.36	12.2
	1900	0.24	7.2	0.40	12.9	0.39	12.0	58	0.49	12.2
27	0100	0.17	7.2	0.30	12.2	0.36	12.0	86	0.47	12.2
	0700	0.23	7.2	0.32	12.2	0.36	12.0	72	0.51	7.0
	1300	0.22	4.9	0.33	12.2	0.36	12.0	58	0.52	12.2
	1900	0.20	7.4	0.29	11.7	0.30	12.0	62	0.44	11.7
28	0100	0.14	15.1	0.25	11.7	0.26	12.0	100	0.38	12.2
	0700	0.18	6.6	0.25	7.2	0.29	13.6	80	0.32	14.3
	1300	0.16	16.0	0.26	13.5	0.32	15.7	62	0.36	12.2
	1900	0.31	7.4	0.44	15.1	0.37	13.6	80	0.50	7.4
29	0100	0.24	16.0	0.47	16.0	0.50	15.7	80	0.64	4.1
	0700	0.25	4.1	0.44	15.1	0.47	15.7	64	0.51	14.3
	1300	0.22	14.3	0.39	15.1	0.46	13.6	80	0.46	14.3
	1900	0.29	14.3	0.49	13.5	0.49	13.6	76	0.56	13.5
30	0100	0.29	13.5	0.47	14.3	0.52	13.6	74	0.60	13.5
	0700	0.24	7.4	0.47	13.5	0.55	13.6	76	0.58	12.9
	1300	0.27	7.8	0.43	13.5	0.47	13.6	78	0.52	12.9
	1900	0.35	7.6	0.50	12.9	0.54	13.6	68	0.70	7.2
Mean		0.36	7.6	0.59	9.0	0.65	9.1	76	0.76	8.4
Std dev		0.15	2.6	0.28	2.8	0.31	2.9	25	0.35	2.7

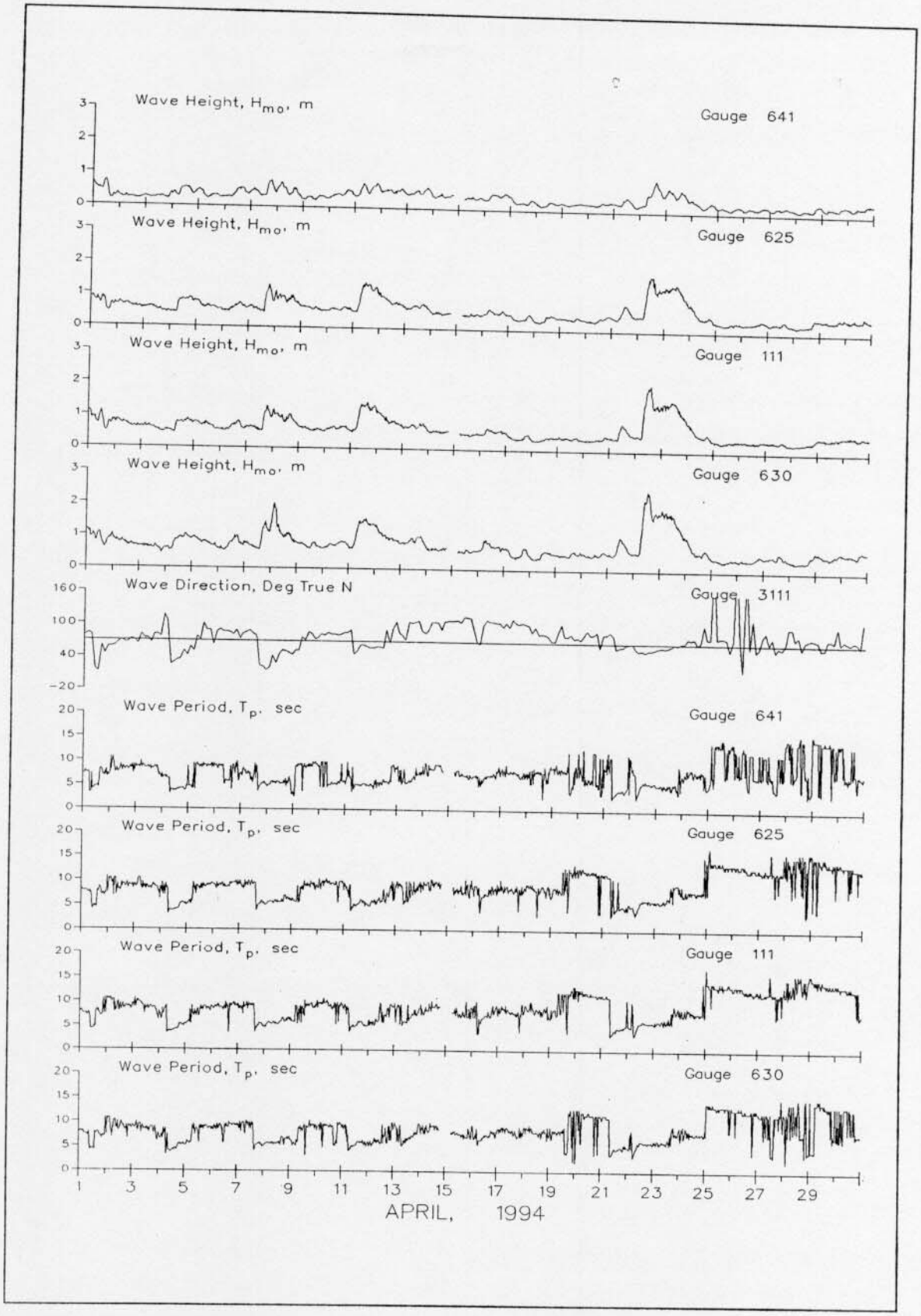

Figure 5. Wave Heights and Periods

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

APRIL 1994

Day	Time	Cross Shore	Long Shore	Speed	Dir
1	100	0	0	0	
	700	-2	4	5	196
	1300	7	35	36	149
	1900	6	31	31	149
2	100	0	9	9	167
	700	3	5	6	127
	1300	-3	1	4	242
	1900	1	-10	11	345
3	100	4	-15	16	354
	700	2	-8	9	354
	1300	2	-11	12	349
	1900	-4	-8	10	309
4	100	1	-19	20	343
	700	1	-1	2	353
	1300	13	1	13	72
	1900	4	-8	10	4
5	100	1	-5	6	350
	700	-4	37	37	168
	1300	-7	24	25	178
	1900	-4	11	12	185
6	100	1	-12	13	343
	700	2	-3	5	8
	1300	0	-5	6	338
	1900	-3	7	8	191
7	100	-4	-6	9	302
	700	0	-3	4	327
	1300	4	-2	5	31
	1900	12	1	12	73
8	100	-5	39	39	169
	700	-6	33	34	172
	1300	-4	38	38	167
	1900	-4	35	36	168
9	100	-2	13	14	171
	700	0	9	9	168
	1300	0	-3	4	343
	1900	5	-6	9	13
10	100	1	-24	25	342
	700	4	-24	25	348
	1300	-3	-11	13	322
	1900	0	-7	8	330
11	100	-1	-10	11	332
	700	17	-9	20	39
	1300	6	-5	8	26
	1900	12	-6	14	39
12	100	0	32	32	161
	700	7	27	28	145
	1300	5	16	17	142
	1900	-1	9	9	173
13	100	-8	20	22	183
	700	-1	7	7	178
	1300	-2	5	6	191
	1900	-3	-4	7	301
14	100	-4	-3	7	286
	700	0	-4	5	330
	1300	1	10	10	155
	1900	-1	2	3	201
15	100	inoperative			
	700	3	-9	10	355
	1300	8	-1	9	55
	1900	0	-9	10	332
16	100	0	-9	10	332
	700	2	-22	23	344
	1300	-3	-11	13	320
	1900	0	-10	11	342
17	100	-1	-9	10	330
	700	0	-13	14	340
	1300	0	0	0	
	1900	0	-10	11	341
18	100	-1	-1	3	291
	700	-1	10	11	171
	1300	-7	25	26	178
	1900	-6	10	12	197
19	100	3	-10	11	354
	700	0	-17	18	338
	1300	0	-3	4	331
	1900	-3	-6	8	311
20	100	-3	-10	12	322
	700	-3	-2	5	290
	1300	4	6	7	131
	1900	12	3	13	86
21	100	0	-3	4	322
	700	2	5	6	137
	1300	-10	33	35	179
	1900	-2	13	14	171
22	100	0	-4	5	345
	700	1	20	20	158
	1300	-8	50	51	170
	1900	-3	8	9	186
23	100	-1	19	19	166
	700	-2	58	58	163
	1300	-4	44	45	166
	1900	-6	23	24	176
24	100	2	-2	3	7
	700	0	-3	4	340
	1300	0	-15	16	336
	1900	1	-6	7	344
25	100	-2	-14	16	330
	700	-4	-3	6	288
	1300	2	1	3	97
	1900	3	-11	13	355
26	100	-2	2	3	221
	700	4	12	13	141
	1300	-1	30	30	164
	1900	-3	23	23	170
27	100	0	11	11	167
	700	-2	-3	5	301
	1300	-3	0	4	255
	1900	-2	-11	12	325
28	100	-3	-3	5	298
	700	-1	-4	6	319
	1300	3	7	8	139
	1900	0	-5	6	335
29	100	0	5	5	169
	700	9	13	16	127
	1300	0	28	28	162
	1900	-5	18	19	179
30	100	1	18	18	158
	700	1	4	4	144
	1300	0	9	9	163
	1900	-1	0	2	284

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

Apr 1994

	Pier End				Mid-Surf Zone				Beach		
Day	Cross Shore	Long Shore	Speed	Dir	Cross Shore	Long Shore	Speed	Dir	Location	Speed	Dir
1	0	32	32	160	9	16	18	129	North	46	N
2	0	0	0		0	-12	12	340	South	3	N
3	29	-29	41	25	0	-36	36	340	South	10	N
4	0	24	24	160	0	30	30	160	North	61	S
5	0	87	87	160	0	20	20	160	North	36	N
6	5	-17	18	357	0	-28	28	340	South	15	N
7	16	16	23	70	4	-15	15	357	South	0	
8	0	44	44	160	0	55	55	160	North	107	S
9	0	0	0		5	9	10	129	North	5	S
10	13	-44	45	357	0	-47	47	340	South	10	N
11	-29	20	35	250	0	27	27	160	North	61	S
12	0	47	47	160	0	23	23	160	North	46	S
13	8	-28	29	357	0	-47	47	340	South	23	N
14	26	-17	31	36	7	-12	14	11	South	10	N
15	7	-23	24	357	0	-20	20	340	South	20	N
16	8	-28	29	357	0	-28	28	340	South	20	N
17	4	-12	13	357	5	-17	18	357	South	3	N
18	0	38	38	160	0	10	10	160	North	11	S
19	10	-34	35	357	0	-22	22	340	South	18	N
20	38	30	49	70	17	-9	19	43	South	9	N
21	0	20	20	160	0	0	0		North	16	S
22	0	34	34	160	-10	34	35	177	North	36	S
23	0	51	51	160	0	51	51	160	North	36	S
24	22	17	28	70	17	-29	34	11	South	10	N
25	23	23	33	70	17	-8	19	43	South	5	N
26	0	34	34	160	0	0	0		North	20	S
27	18	-30	36	11	5	-17	18	357	South	23	N
28	28	-14	31	43	0	0	0		South	3	N
29	0	0	0		0	0	0		South	0	
30	0	0	0		15	-51	53	357	South	20	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
Dir = Resultant direction, degrees true north

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

Apr 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	0715	95	55		85	8.9	1.0200	1.2
2	0815	50	90		67	9.4	1.0192	1.8
3	0800	90			12	8.9	1.0208	1.5
4	0850	40	90		18	7.8	1.0250	2.1
5	0730	45	90	Radar	12	10.0	1.0160	1.8
6	0720	100			12	10.6	1.0200	1.2
7	0800	110			12	7.8	1.0256	1.5
8	0720	35			98	11.1	1.0170	1.5
9	0930	50	90	inoperative	21	11.1	1.0151	1.5
10	0830	95			12	10.6	1.0220	1.2
11	0800	50	80		94	11.1	1.0239	2.7
12	0850	95	50		110	11.1	1.0165	1.2
13	0750	95		all	21	11.7	1.0175	2.1
14	0715	100			21	7.2	1.0258	1.8
15	0720	95			12	7.8	1.0262	1.5
16	1020	90			8	8.3	1.0262	1.2
17	0850	85		month	9	13.3	1.0243	3.0
18	0720	90			3	11.1	1.0210	2.7
19	0755	100	85		6	12.2	1.0201	1.8
20	0710	95			6	10.0	1.0262	1.5
21	0730	90	50		9	11.7	1.0263	1.2
22	0715	45			12	15.0	1.0151	1.5
23	0945	50			162	12.8	1.0170	0.9
24	0930	70	110		82	13.3	1.0140	1.2
25	0805	100			5	13.9	1.0246	2.4
26	0705	100			12	14.4	1.0180	2.1
27	0705	100			6	13.3	1.0225	2.1
28	0700	105			9	12.8	1.0256	1.8
29	0705	45	85		11	16.1	1.0242	3.4
30	0830	95	50		12	15.6	1.0239	1.2

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 Leupold-Stevens digital recording float-type tide gauge is used to collect instantaneous 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.

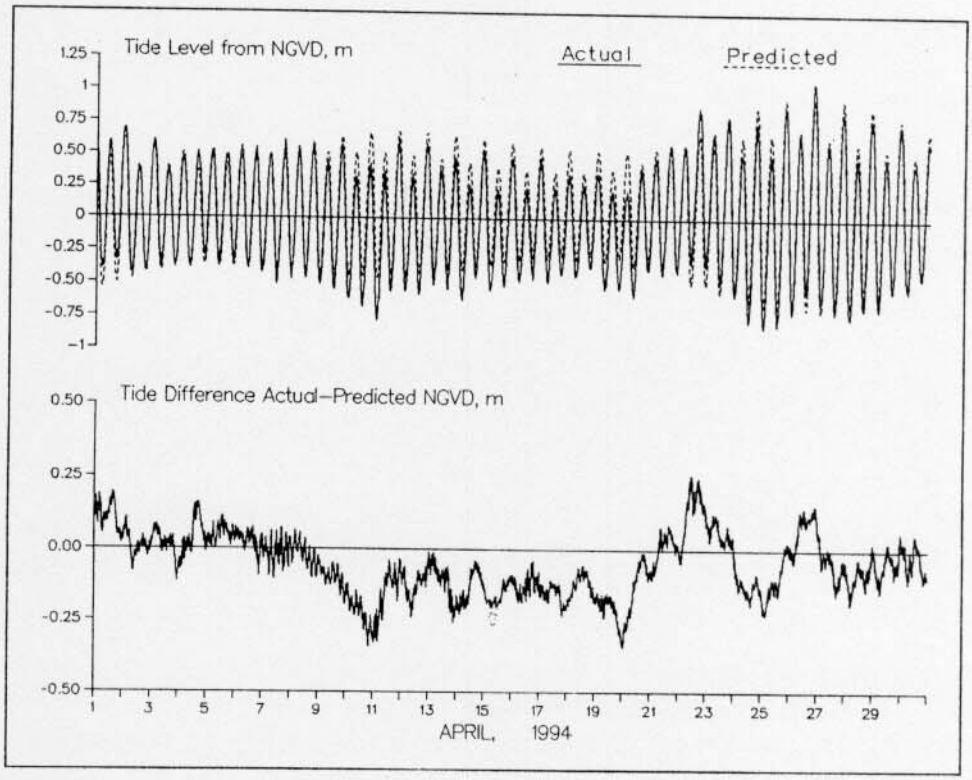

Figure 6. Water Level Variation

Table 8
Water Levels, m NGVD

APR 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	1054	0.58	1	0506	-0.40	0.09	0.98	16	1030	0.25	16	0500	-0.49	-0.13	0.73
1	2336	0.69	1	1724	-0.34	0.17	1.03	16	2248	0.47	16	1642	-0.47	0.01	0.94
2	1136	0.37	2	0630	-0.44	-0.02	0.81	17	1054	0.24	17	0536	-0.49	-0.13	0.73
3	0036	0.60	2	1830	-0.43	0.08	1.02	17	2336	0.34	17	1654	-0.43	-0.05	0.77
3	1300	0.39	3	0730	-0.37	0.02	0.76	18	1154	0.26	18	0530	-0.44	-0.09	0.70
4	0142	0.47	3	1930	-0.38	0.03	0.84	19	0036	0.35	18	1830	-0.38	-0.02	0.73
4	1424	0.51	4	0830	-0.39	0.05	0.90	19	1312	0.21	19	0712	-0.54	-0.16	0.75
5	0236	0.52	4	2100	-0.30	0.11	0.82	20	0212	0.21	19	1918	-0.54	-0.16	0.75
5	1618	0.48	5	0918	-0.37	0.08	0.85	20	1430	0.39	20	0754	-0.60	-0.08	0.99
6	0406	0.55	5	2136	-0.36	0.10	0.91	21	0254	0.47	20	2106	-0.39	0.04	0.86
6	1630	0.54	6	1036	-0.39	0.07	0.93	21	1542	0.58	21	0906	-0.41	0.10	0.99
7	0436	0.49	6	2154	-0.43	0.04	0.92	22	0348	0.56	21	2136	-0.40	0.10	0.96
7	1730	0.60	7	1054	-0.51	0.04	1.12	22	1612	0.87	22	0954	-0.35	0.27	1.22
8	0506	0.55	7	2324	-0.47	0.05	1.02	23	0448	0.68	22	2230	-0.36	0.17	1.04
8	1742	0.58	8	1136	-0.47	0.05	1.05	23	1730	0.80	23	1042	-0.49	0.16	1.29
9	0624	0.43	9	0000	-0.51	-0.03	0.94	24	0536	0.50	23	2330	-0.58	-0.03	1.08
9	1830	0.57	9	1212	-0.55	-0.01	1.12	24	1748	0.75	24	1130	-0.79	-0.02	1.54
10	0624	0.32	10	0106	-0.62	-0.14	0.94	25	0636	0.49	25	0030	-0.82	-0.16	1.32
10	1912	0.42	10	1236	-0.68	-0.13	1.10	25	1854	0.87	25	1236	-0.81	0.04	1.69
11	0724	0.35	11	0124	-0.79	-0.22	1.14	26	0736	0.69	26	0106	-0.72	0.00	1.41
11	1930	0.62	11	1318	-0.57	0.01	1.18	26	1924	1.07	26	1306	-0.56	0.25	1.63
12	0754	0.34	12	0154	-0.56	-0.11	0.90	27	0800	0.59	27	0154	-0.66	-0.01	1.25
12	2006	0.57	12	1342	-0.59	0.01	1.16	27	2012	0.83	27	1400	-0.72	0.06	1.55
13	0906	0.37	13	0212	-0.51	-0.05	0.88	28	0912	0.48	28	0306	-0.77	-0.14	1.25
13	2054	0.47	13	1442	-0.55	-0.02	1.02	28	2124	0.77	28	1518	-0.69	0.06	1.46
14	0918	0.26	14	0330	-0.63	-0.17	0.88	29	0942	0.47	29	0418	-0.69	-0.09	1.16
14	2130	0.53	14	1506	-0.46	0.04	0.99	29	2218	0.74	29	1606	-0.55	0.10	1.30
15	0936	0.23	15	0354	-0.55	-0.18	0.78	30	1048	0.43	30	0536	-0.56	-0.03	0.98
15	2212	0.47	15	1536	-0.52	-0.01	0.99	30	2248	0.61	30	1706	-0.44	-0.01	1.05

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 March 1994 and the survey(s) in April 1994 on profile line 188, located 517 m south of the pier.

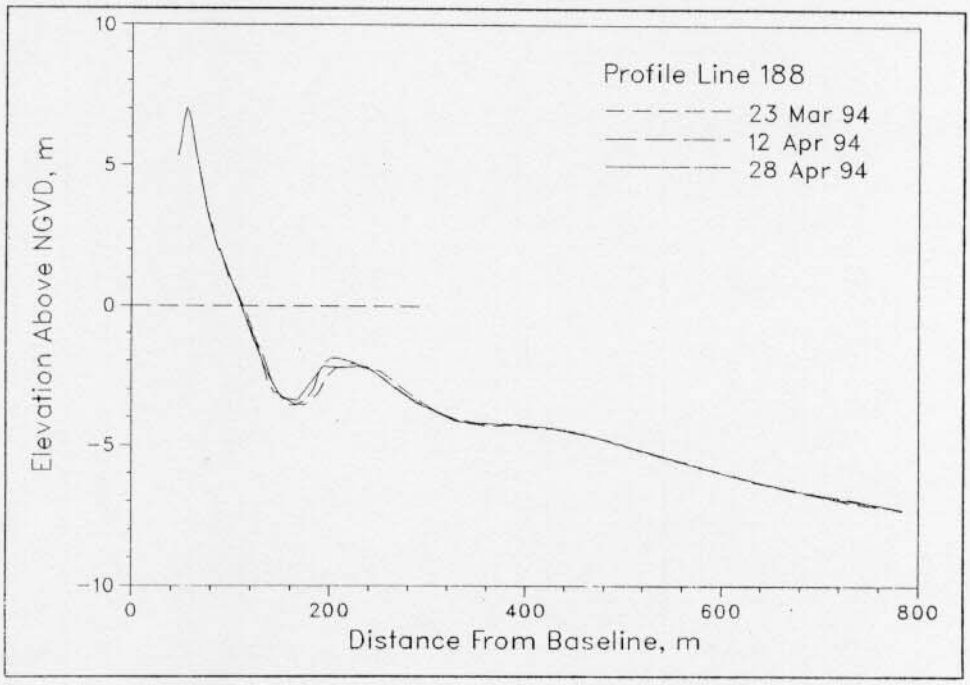

Figure 7. Monthly CRAB Profiles on Profile Line 188.

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 April.

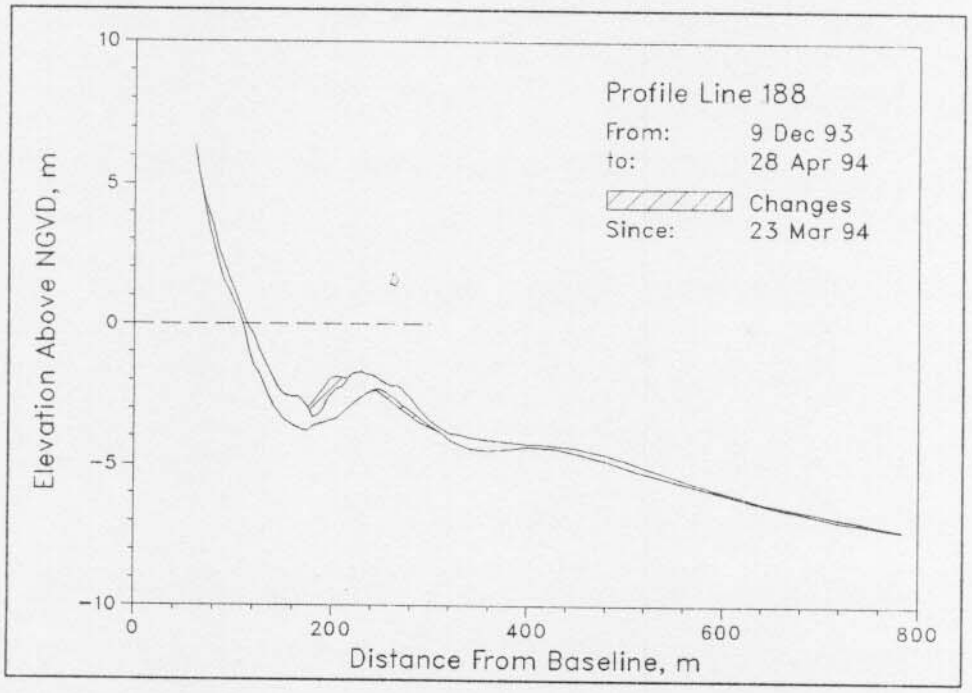

Figure 8. Profile Envelope - Profile Line 188.

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.

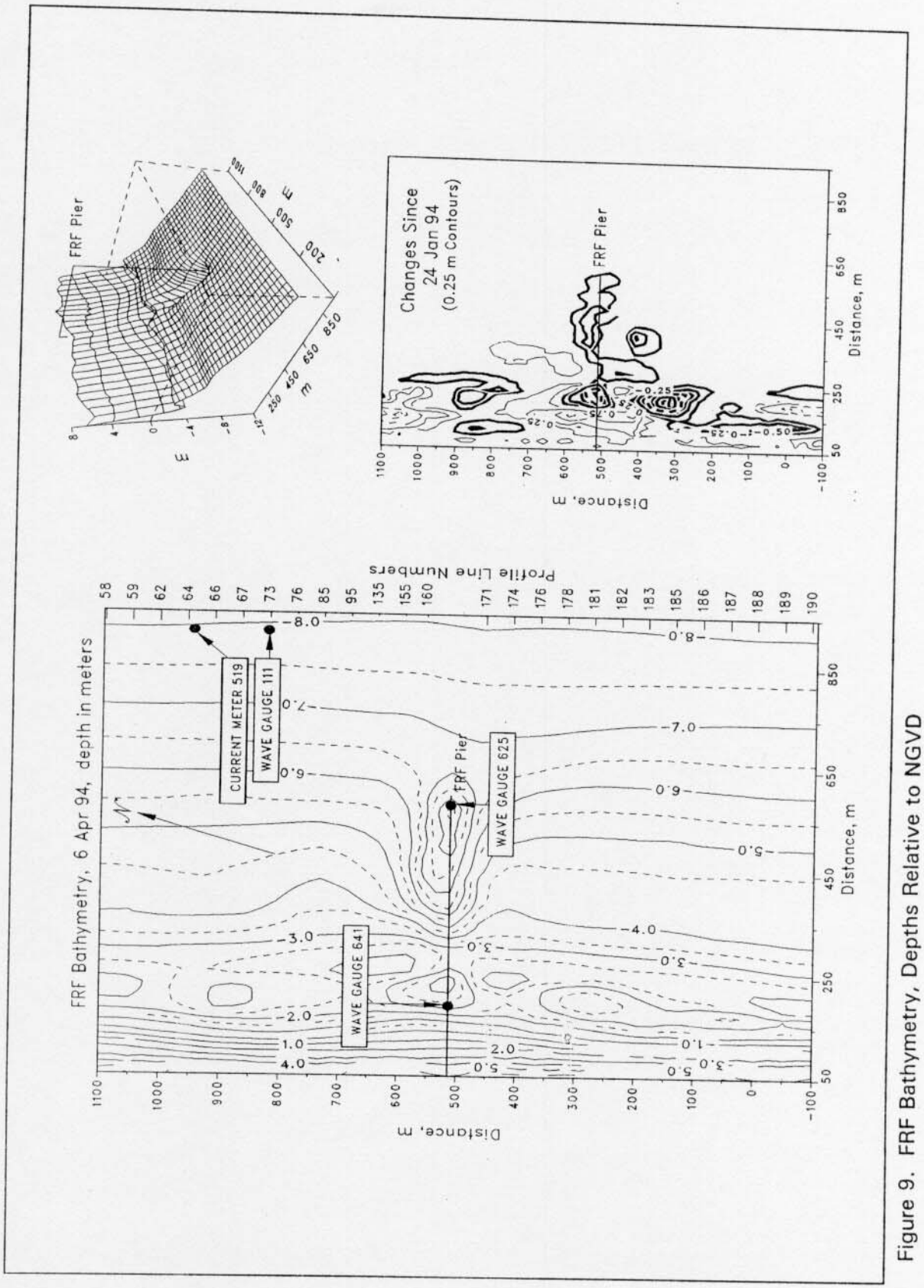

Figure 9. FRF Bathymetry, Depths Relative to NGVD

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)