

State of Delaware  
DELAWARE GEOLOGICAL SURVEY  
Robert R. Jordan, State Geologist

**OPEN FILE REPORT NO. 36**

**SUMMARY REPORT**  
**THE STORM OF JANUARY 4, 1992**

By

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## **PREFACE**

The DGS (Delaware Geological Survey) regularly compiles and evaluates a variety of water resources data. Special efforts are made to obtain detailed measurements, sometimes under difficult conditions, during and following extreme events such as storms, floods, droughts, and earthquakes. Through rapid collection and dissemination of data, the DGS assists those agencies with emergency response responsibilities in evaluating and predicting conditions during specific events. Following such events, the DGS routinely compiles information and prepares reports and maps to help assess the nature and effects of events and to predict the impact of future ones. Although most such reports and maps are not formally published, they are available and are used by officials and citizens.

A DGS "Storm Report" was issued immediately following the storm of January 4, 1992 for use by interested agencies. Because of the magnitude of this storm and the many requests for quantitative data, the DGS has published the report in Open File Report format.

The DGS encourages the exchange of data about such storms collected by various agencies so that as complete record as possible may be assembled for use by each unit.

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## CLIMATIC CONDITIONS FOR THE STORM OF JANUARY 4, 1992

### Summary of Storm Activity<sup>1</sup>

On January 4, 1992 an intense storm moved from the east across the Delmarva Peninsula and the Chesapeake Bay. Its track was the result of the low pressure being pulled westward by a strong cold-cored upper low moving across Georgia and South Carolina. The storm exhibited tropical/subtropical characteristics on radar. Satellite photos indicate that an "eye" to the storm formed just prior to landfall. Landfall occurred over the southern Delmarva Peninsula just prior to the time of high tide (0648 at Ocean City, Md). The storm weakened rapidly as it moved over land areas with a secondary area redeveloping farther out to sea later in the day on the 4th. Approximate locations of the storm's track are given on Figure 1.

As the storm moved across the Delmarva Peninsula perpendicular to the coast, Delaware was in the right-foreward quadrant to the north of the "eye" of the storm. This position typically produces the highest winds associated with a tropical storm. These winds created high waves that in conjunction with an astronomical high tide (new moon) produced strong surf and abnormally high tides along the shore. Rainfall from the storm in Delaware was not heavy enough to cause flooding of streams. Coastal flooding of marshes and low-lying areas did occur along the Inland Bays and along Delaware Bay.

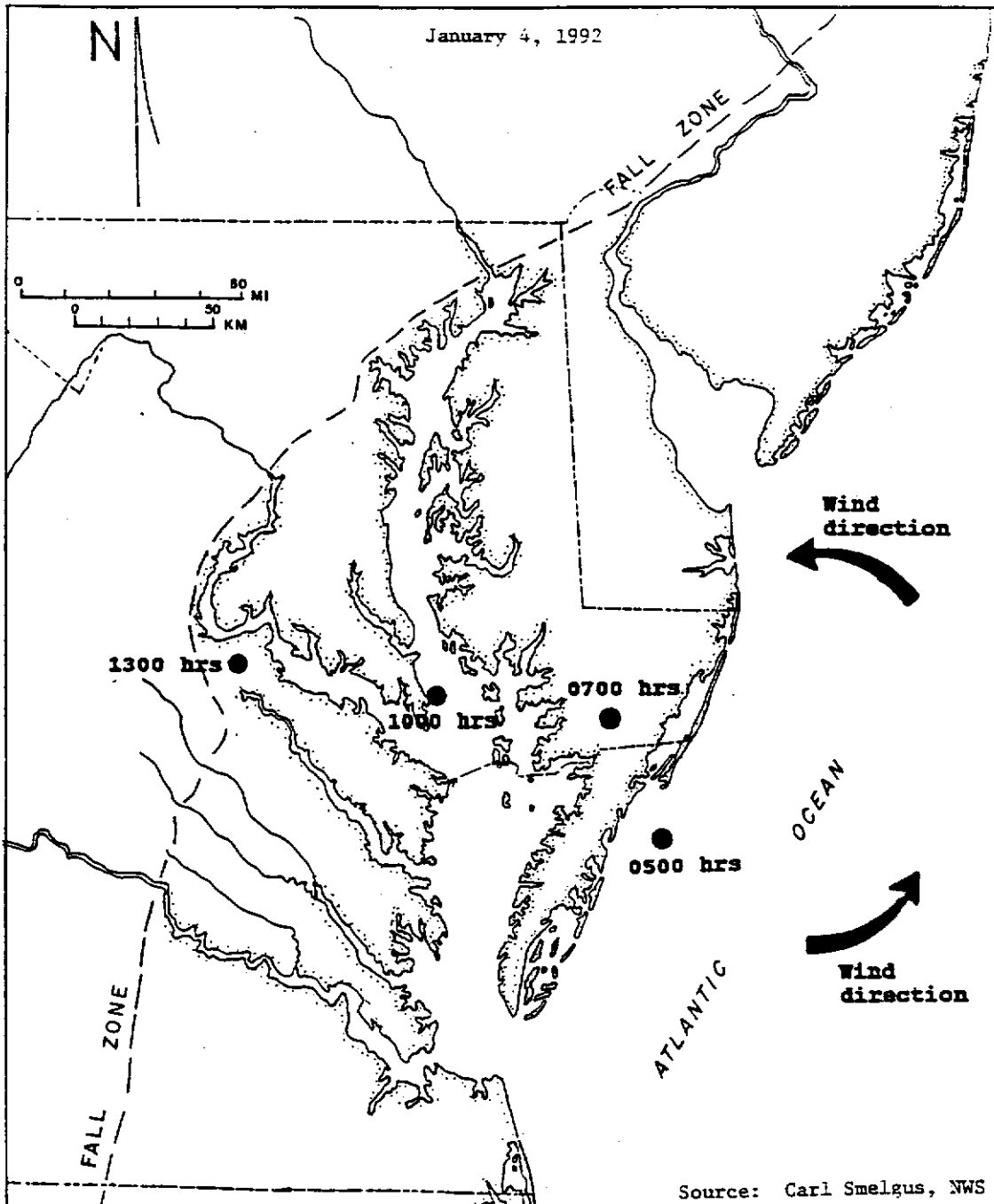
### Precipitation Data - January 3-5, 1992

<u>Location</u>	<u>January</u>			<u>Total</u> <u>(inches)</u>
	<u>3</u>	<u>4</u>	<u>5</u>	
	<u>(inches)</u>			
Old Coast Guard Stat.	0.01	0.66	0.00	0.67
Lewes, DE	0.00	0.26	0.03	0.29
Georgetown, DE (U of D)	0.00	1.06	0.00	1.06
Greenwood, DE	0.02	0.74	0.00	0.76
Dover Air Force Base	0.04	0.51	0.01	0.56
Dover, DE (DeIDOT)	0.00	0.34	0.08	0.42
New Castle, DE (NWS)	0.00	0.16	0.00	0.16

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<sup>1</sup> Source of information: National Weather Service (NWS)

Figure 1. Track of Storm - January 4, 1992.



● Approximate location of storm center.

0500 SE of Wallops Island, VA, moving NW  
0700 20 miles S of Salisbury, MD, moving WNW  
1000 Over Chesapeake Bay just SE of Patuxent River, MD  
1300 Stalled over northern VA, 40 miles W of Patuxent River, MD

Figure 2. Location of Weather and Tide Gage Stations.

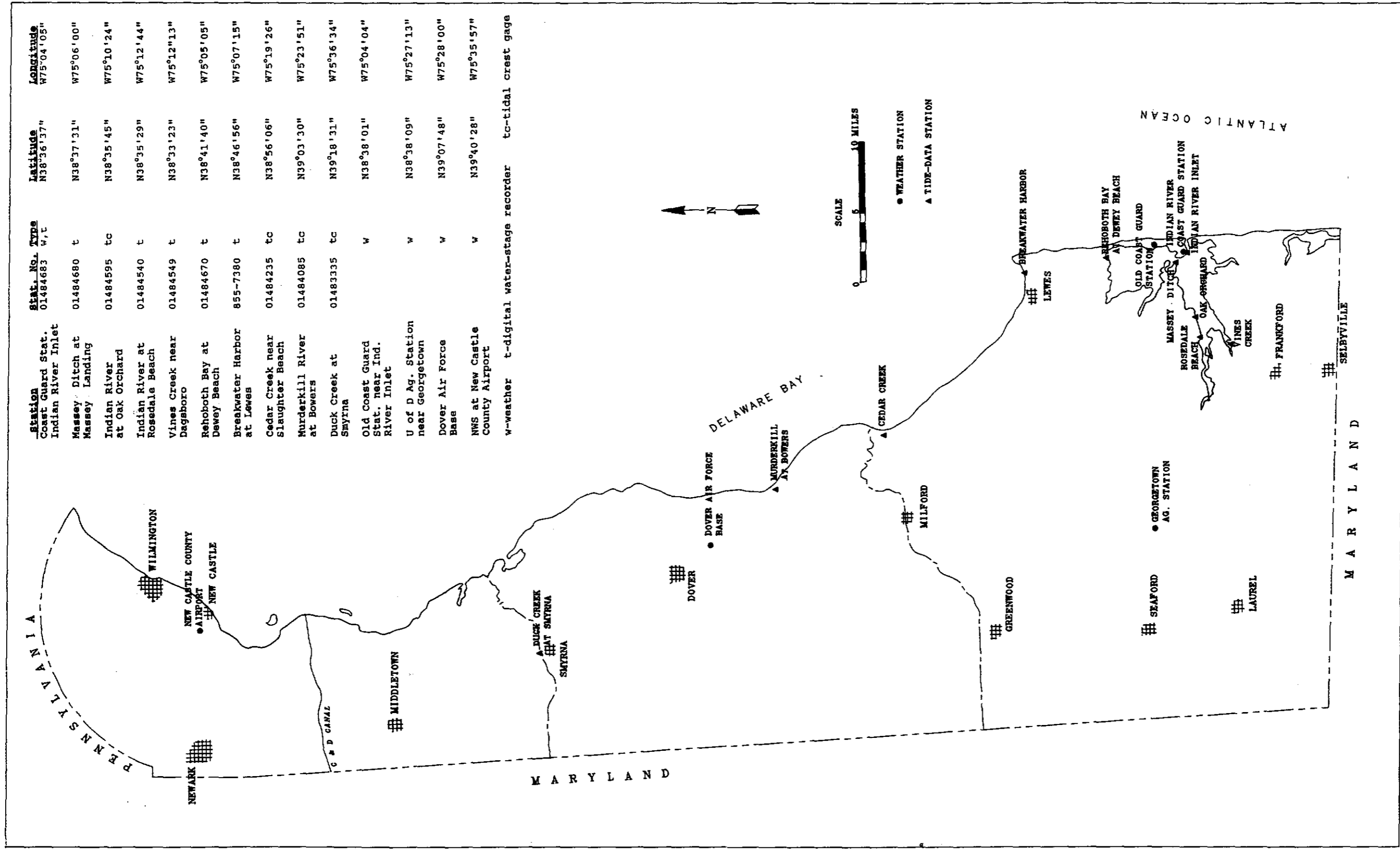


Table 1. Wind and Barometric Pressure Data - January 3-5, 1992

U. S. Coast Guard Station  
Indian River, DE

Old Inlet Coast Guard Station  
North of Indian River, DE

Date	Time (EST)	Wind Direction	Wind Velocity (mph)	Maximum Gusts (mph)	Barometric Pressure	Date	Time (EST)	Wind Direction	Wind Velocity (mph)	Maximum Gusts (mph)	Barometric Pressure
Jan 3	0100	-	-	-	-	Jan 3	0100	S71°E	17	19	30.22
	0400	-	-	-	-		0400	S68°E	18	20	30.17
	0700	NE	21	-	30.14		0700	S70°E	21	25	30.15
	1000	NE	23	-	30.06		1000	S77°E	21	25	30.12
	1300	NE	17	-	30.01		1300	S85°E	21	25	30.02
	1600	NE	26	-	29.94		1600	S85°E	22	26	29.98
	1900	NE	26	-	29.92		1900	N84°E	28	34	29.94
2200	NE	29	-	29.90	2200	N75°E	21	31	29.88		
Jan 4	0100	-	-	-	-	Jan 4	0100	N70°E	21	29	29.78
	0400	-	-	-	-		0400	N55°E	46	54	29.59
	0700	NNE	35	58	29.38		0700	N66°E	39	58	29.44
	1000	NE	17	-	29.52		1000	S68°E*	14	22	29.53
	1300	E	12	-	29.60		1300	S77°E	7	9	29.61
	1600	SE	10	-	29.61		1600	S73°E	6	8	29.63
	1900	SE	10	-	29.61		1900	S48°E	0.5	3	29.67
2200	S	12	-	29.64	2200	N80°E	16	21	29.70		
Jan 5	0100	-	-	-	-	Jan 5	0100	N77°E	6	13	29.70
	0400	-	-	-	-		0400	N66°E	3	9	29.72
	0700	N	23	-	29.70		0700	N60°E	6	11	29.75
	1000	NNW	17	-	29.78		1000	N46°E	6	13	29.79
	1300	N	14	-	29.76		1300	N41°E	8	13	29.73
	1600	N	12	-	29.76		1600	N43°E	5	11	29.72
	1900	N	12	-	29.75		1900	N60°E	5	8	29.77
2200	NNW	13	-	29.80	2200	N46°E	6	14	29.79		

\* Anemometer aerial bent during maximum gusts. Wind direction afterward inaccurate. Wind velocity data are questionable.

University of Delaware Agricultural Station  
Georgetown, DE

Date	Time (EST)	Wind Direction	Wind Velocity (mph)	Maximum Gusts (mph)	Barometric Pressure	Date	Time (EST)	Wind Direction	Wind Velocity (mph)	Maximum Gusts (mph)	Barometric Pressure
Jan 3	0100	N88°E	4	7	-	Jan 5	0100	N41°E	11	18	-
	0400	N78°E	3	5	-		0400	N35°E	10	16	-
	0700	S70°E	6	11	-		0700	N28°E	9	16	-
	1000	S69°E	12	21	-		1000	N26°E	11	26	-
	1300	S70°E	16	27	-		1300	N11°E	14	21	-
	1600	S74°E	16	26	-		1600	N17°E	14	23	-
	1900	S83°E	13	25	-		1900	N23°E	10	20	-
2200	N86°E	14	25	-	2200	N04°E	9	14	-		
Jan 4	0100	N79°E	15	33	-						
	0400	N62°E	22	37	-						
	0700	N67°E	28	50	-						
	1000	S70°E	20	38	-						
	1300	S46°E	12	22	-						
	1600	S66°E	9	15	-						
	1900	N89°E	6	3	-						
2200	N62°E	8	14	-							

Table 1 (continued).

Dover Air Force Base Dover, DE						National Weather Service Office New Castle, DE					
Date	Time (EST)	Wind Direction	Wind Velocity (mph)	Maximum Gusts (mph)	Barometric Pressure	Date	Time (EST)	Wind Direction	Wind Velocity (mph)	Maximum Gusts (mph)	Barometric Pressure
Jan 3	0052	N50°E	10	-	30.26	Jan 3	0100	N80°E	8	-	30.195
	0352	N60°E	10	-	30.22		0400	N70°E	9	-	30.145
	0652	N50°E	14	-	30.20		0700	N70°E	12	-	30.125
	0953	N50°E	13	-	30.22		1000	N80°E	15	-	30.110
	1253	N50°E	16	-	30.10		1300	N80°E	20	29	30.005
	1550	N50°E	16	23	30.06		1600	N80°E	17	23	29.970
	1851	N60°E	15	25	30.05		1900	N70°E	14	23	29.940
	2151	N50°E	16	22	29.99		2200	N70°E	17	24	29.895
Jan 4	0056	N40°E	20	26	29.91	Jan 4	0100	N40°E	17	-	29.800
	0352	N50°E	23	36	29.82		0400	N30°E	22	33	29.660
	0654	N40°E	29	41	29.71		0700	N40°E	30	41	29.540
	0951	N60°E	31	38	29.69		1000	N50°E	26	38	29.530
	1252	N60°E	20	25	29.65		1300	E	20	25	29.580
	1553	N40°E	16	25	29.66		1600	N80°E	15	-	29.600
	1851	N50°E	14	23	29.74		1900	N50°E	6	-	29.665
	2152	N10°E	16	-	29.77		2200	N20°E	14	-	29.695
Jan 5	0050	N	13	-	29.76	Jan 5	0100	N	13	-	29.685
	0353	N	14	-	29.76		0400	N	13	-	29.715
	0651	N30°W	13	-	29.78		0700	N10°W	10	-	29.735
	0952	N10°W	15	-	29.81		1000	N10°W	13	-	29.775
	1254	N10°W	18	26	29.75		1300	N10°W	15	-	29.700
	1551	N30°W	21	26	29.75		1600	N10°W	15	-	29.700
	1851	N20°W	18	-	29.80		1900	N30°E	13	-	29.755
	2151	N30°W	9	-	29.82		2200	N10°W	15	-	29.755

Table 2. Selected Predicted High and Low Tides -January 3-5, 1992

	Ocean City, MD (fishing pier)		Indian R. Inlet (C. G. Station)		Breakwater Harbor		Mispillion River (entrance)		Murderkill River at Bowers		Woodland Beach	
	Time	Height	Time	Height	Time	Height	Time	Height	Time	Height	Time	Height
Jan 3												
Low			0031	0.05	0045	-0.1	0136	-0.1	0157	-0.1	0251	-0.3
High	0609	3.8	0718	2.3	0727	4.6	0750	5.1	0807	5.1	0851	6.2
Low	1228	-0.05	1313	-0.05	1346	0.0	1437	0.0	1458	0.0	1535	-0.3
High	1830	3.0	1939	1.8	1944	3.3	2007	3.7	2024	3.1	2111	5.2
Jan 4												
Low	0031	0.1	0116	0.05	0128	-0.1	0219	-0.1	0240	-0.1	0335	-0.4
High	0648	3.8	0757	2.3	0807	4.6	0830	5.1	0840	5.0	0933	6.1
Low	1311	-0.2	1356	-0.1	1425	0.0	1516	0.0	1537	0.0	1617	-0.3
High	1909	3.1	2018	1.8	2022	3.4	2045	3.8	2102	3.7	2154	5.1
Jan 5												
Low	0114	0.1	0123	0.05	0207	-0.1	0258	-0.1	0319	-0.1	0417	-0.3
High	0726	3.8	0822	2.3	0842	4.6	0905	5.1	0922	5.0	1013	6.1
Low	1351	-0.2	1436	-0.1	1500	0.0	1551	0.0	1612	0.0	1656	-0.2
High	1946	3.1	2055	1.8	2058	3.4	2121	3.8	2142	3.7	2233	5.1

Datum is mean lower low water. Times are EST.

Numbers derived from U. S. Department of Commerce, "Tide Tables, 1992, East Coast of North and South America including Greenland."



Figure 3. Tide Gage Data.

BREAKWATER HARBOR, LEWES, DE January 3-6, 1992

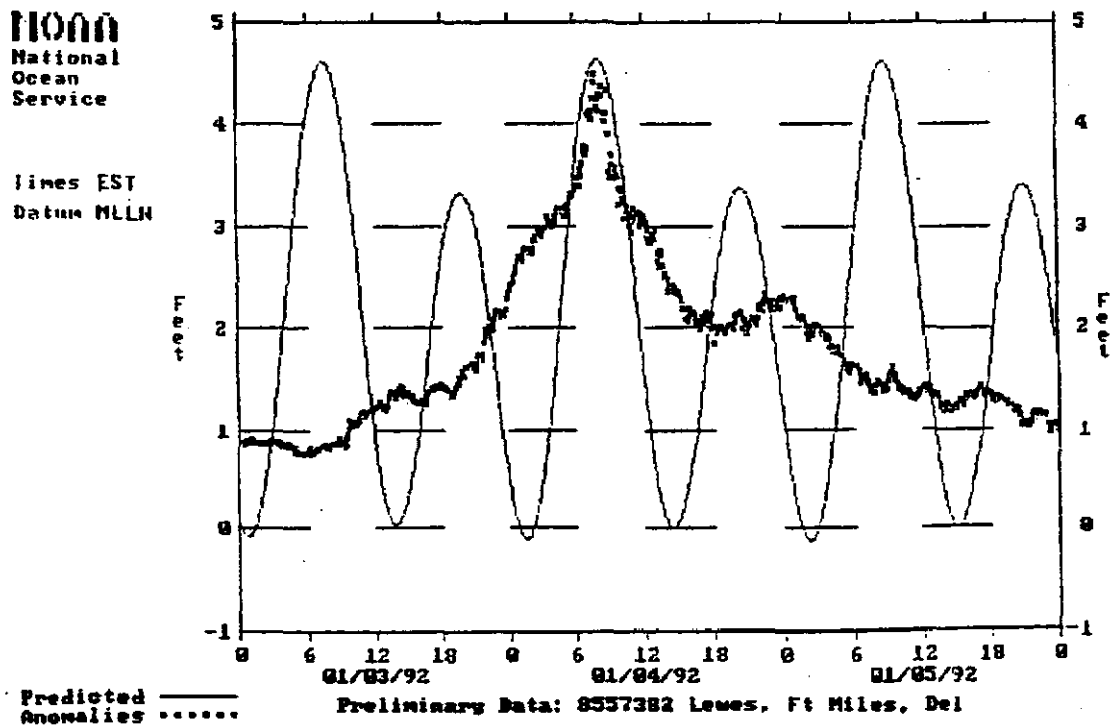
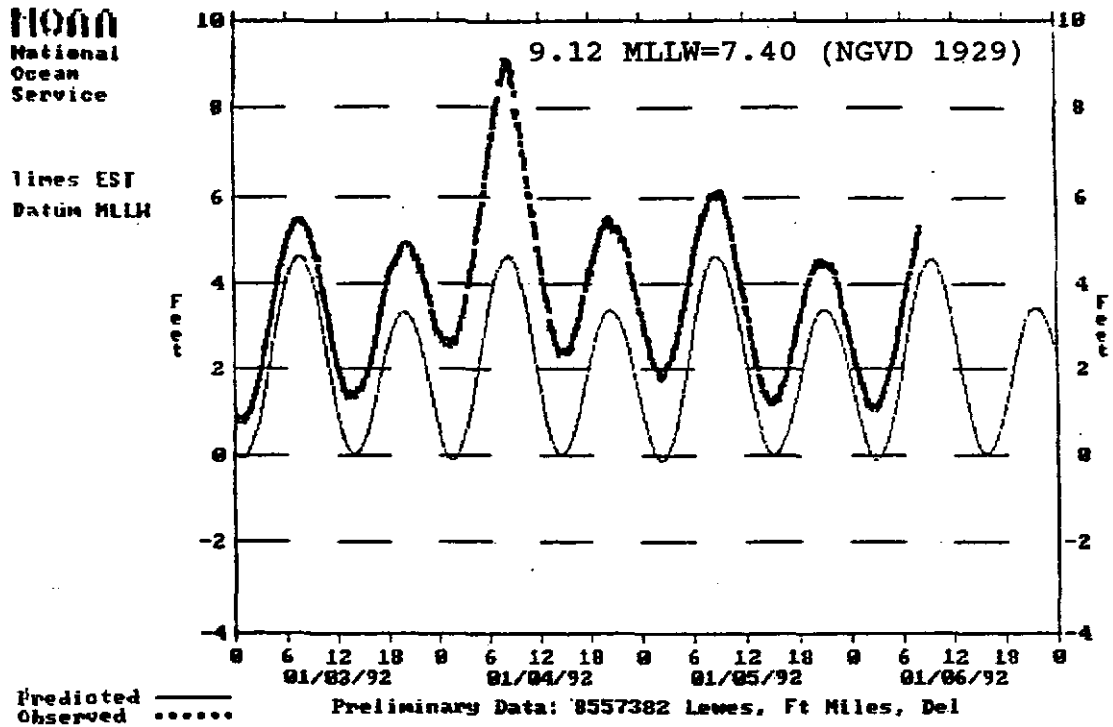


Table 3A. Maximum Heights of Tide  
Breakwater Harbor, Lewes, DE

Twenty Highest Stages, 1919 TO 1992<sup>2</sup>

<u>Rank</u>	<u>Date</u>	<u>Stage (ft.)</u>	<u>Storm type</u>
1	03/06/1962	8.05	NE
2	<b>01/04/1992</b>	<b>7.40</b>	NE
3	09/27/1985	6.61	HUR
4	10/25/1985	6.56	NE
5	10/22/1961	6.56	HUR
6	03/29/1984	6.52	NE
7	10/14/1977	6.29	HUR
8	10/23/1953	6.24	NE
9	12/22/1972	6.14	NE
10	01/13/1964	6.03	NE
11	12/09/1973	6.03	NE
12	01/10/1956	5.91	NE
13	01/02/1987	5.89	NE
14	11/10/1969	5.87	NE
15	12/12/1960	5.77	HUR
16	01/29/1922	5.75	NE
17	10/05/1948	5.69	HUR
18	05/24/1967	5.69	NE
19	05/03/1939	5.68	NE
20	11/15/1981	5.65	NE

NE-northeaster: HUR-hurricane

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<sup>2</sup> National Geodetic Vertical Datum 1929. Data are incomplete for 1990 and 1991; does not include storm of Oct. 31, 1991 that will rank in the top twenty. Source: U. S. Army Corps of Engineers.

Table 3B. Selected Tidal Stations - October 31, 1991 & January 4, 1992.

Data provided by U.S. Geological Survey, Water Resources Division.  
Provisional Data.

<u>Station</u>	<u>Date</u>	<u>Heights (NGVD 1929, ft)</u>	<u>Station Type</u>
Coast Guard Station, Indian River Inlet	Oct. 31	5.21	b
	Jan. 4	4.83	
Vines Creek near Dagsboro	Oct. 31	4.83	a
	Jan. 4	5.35 <sup>3</sup>	
Indian River at Oak Orchard	Oct. 31	5.27	a
	Jan. 4	5.84	
Indian River at Rosedale Beach	Oct. 31	5.21	b
	Jan. 4	5.75 <sup>4</sup>	
Massey Ditch at Massey Landing	Oct. 31	4.56	b
	Jan. 4	3.76 <sup>5</sup>	
Rehoboth Bay at Dewey Beach	Oct. 31	4.54	b
	Jan. 4	3.82 <sup>6</sup>	
Cedar Creek near Slaughter Beach	Oct. 31	5.66	a
	Jan. 4	6.61	
Murderkill River at Bowers	Oct. 31	6.03	a
	Jan. 4	8.76	
Duck Creek at Smyrna	Oct. 31	4.93	a
	Jan. 4	4.70	

a = Tidal Crest-Stage Gage

b = Digital Water-Stage Recorder

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<sup>3</sup> Three additional high-water marks were surveyed at the site to check the crest-stage gage and were found to be at 5.30 ft., 5.37 ft., and 5.42 ft.

<sup>4</sup> A high water mark for the March 1962 storm was shown to U. S. Geological Survey personnel by John Rogers and was surveyed to N.G.V.D. 1929 on May 13, 1991 and found to be at 6.73 ft. The Rosedale Beach tide gage is on the same property at Gulls Point.

<sup>5</sup> High water marks were surveyed to N.G.V.D. 1929 for the storm of Jan. 4, 1992 to verify the elevation recorded by the tide gage. They were at 3.86 ft., 3.80 ft., and 3.78 ft.

<sup>6</sup> Two high water marks of 6.94 ft. and 7.04 ft. for the storm of March 1962 were shown to U.S.G.S. personnel by I. G. Burton. They are in his beach house at the tide gage site. They were surveyed to N.G.V.D. 1929 on August 6, 1984.

Table 3C. Tidal Crest Stations  
 (Maximum recorded heights of tide 1966 to 1992)

Indian River at Oak Orchard

Elevation NGVD 1929 (ft)		Date	
8.25	Between	06-Mar-62	& 07-Mar-62
5.84		04-Jan-92	
5.34		12-Nov-68	
5.27		31-Oct-91	
5.23		29-Mar-84	
5.01		27-Apr-67	
5.01		25-Oct-80	
4.82		01-Dec-74	
4.76		14-Oct-77	
4.70		08-Apr-88	
4.68	Between	28-Jul-67	& 18-Sep-67
4.60		19-Oct-89	
4.56		19-Dec-77	
4.52	(Gloria)	27-Sep-85	
4.47		25-Oct-80	
4.45	Between	11-Feb-83	& 12-Feb-83
4.34		15-Nov-81	
4.30	Between	18-Nov-86	& 04-Dec-86
4.30	Between	06-Oct-87	& 17-Nov-87
4.28		04-Feb-87	
4.27		06-Apr-71	
4.25	Between	05-Oct-83	& 09-Nov-83
4.20		26-Feb-79	

Cedar Creek at Slaughter Beach

Elevation NGVD 1929 (ft)		Date	
6.61		04-Jan-92	
6.46		29-Mar-84	
6.14	Between	18-Nov-86	& 04-Dec-86
5.91		25-Oct-80	
5.66		31-Oct-91	
5.59		01-Dec-74	
5.56	Between	25-Sep-89	& 24-Oct-89
5.18	Between	02-Oct-83	& 07-Nov-83
5.07	Between	04-Nov-91	& 15-Nov-91
5.06	Between	07-Sep-89	& 25-Sep-89
4.96		14-Oct-77	
4.96	Between	23-Feb-82	& 17-Mar-82
4.94		15-Nov-81	
4.93		08-Apr-88	
4.91	Between	07-Oct-83	& 02-Nov-83
4.87	Between	26-Nov-90	& 27-Dec-90
4.85	Between	30-Mar-84	& 19-Apr-84
4.85	Between	15-Nov-81	& 05-Jan-82
4.82		24-Apr-83	
4.81	Between	20-Dec-77	& 30-Jan-78
4.80	Between	14-Oct-82	& 26-Oct-82
4.78	Between	01-Feb-90	& 28-Feb-90
4.76	Between	16-Feb-83	& 23-Mar-83

Table 3C (continued).

Murderkill River at Bowers, DE

Elevation NGVD 1929 (ft)		Date	
8.76		04-Jan-92	
8.74		06-Mar-62	
8.19		29-Mar-84	
8.13		25-Oct-80	
7.18		14-Oct-77	
7.10	(Gloria)	27-Sept-85	
6.91		19-Oct-89	
6.81	Between	18-Nov-86	& 04-Dec-86
6.68		09-Dec-73	
6.64	Between	20-Dec-77	& 30-Jan-78
6.63		18-Aug-89	
6.53	Between	15-Nov-83	& 07-Dec-83
6.48		23-Dec-72	
6.47		26-Dec-79	
6.35	Between	17-Dec-86	& 04-Feb-87
6.26		24-May-67	
6.24		15-Nov-81	
6.22		24-Apr-83	
6.22	Between	07-Apr-87	& 08-May-87
6.21	Between	29-Aug-79	& 09-Oct-79
6.19		13-Dec-85	
6.16	Between	26-Jan-67	& 30-Mar-67
6.16		10-Nov-69	
6.13		19-Feb-72	
6.10		12-Nov-68	

A plaque attached to a door frame at Paskey's Wharf marks the high tide location for the storm of March 1962. This mark was surveyed to National Geodetic Vertical Datum (N.G.V.D.) of 1929 on December 16, 1980 and was found to be at an elevation of 8.75 ft.

At the residence of Donald Wujtewicz at Bowers, DE, a high water mark is shown in a photo for the March 1962 storm. The mark is on a garage near the fire station and at the house next door to the Bowers Maritime Museum. The photo shows the 1962 storm to be about 2 inches higher than the January 4, 1992 storm.

Table 3C (continued).

Duck Creek (Smyrna River) at U.S. Rt. 13

Elevation NGVD 1929 (ft)		Date	
6.82		23-Jun-72	
5.86		29-Mar-84	
5.55		26-Feb-79	
5.53		29-Jul-80	
5.33	Between	29-Jul-80	& 04-Aug-80
5.11		01-Dec-74	
5.00		18-Aug-89	
4.93		31-Oct-91	
4.88		12-Nov-68	
4.80	(Gloria)	27-Sep-85	
4.74		18-Mar-83	
4.73		19-Oct-89	
4.72	Between	22-Jul-69	& 23-Aug-69
4.70		03-Nov-85	
4.70		04-Jan-92	
4.57	Between	12-Oct-82	& 15-Oct-82
4.54		28-Aug-71	
4.53		23-Dec-72	
4.50	Between	10-Nov-86	& 08-Dec-86
4.48	Between	08-Dec-86	& 06-Jan-87
4.44	Between	21-Aug-79	& 04-Oct-79
4.44	Between	16-Apr-90	& 18-Jun-90
4.43	Between	22-Jan-88	& 14-Mar-88
4.43	Between	04-Jan-84	& 10-Feb-84
4.42	Between	15-Nov-82	& 20-Dec-82

(References supplied by R. H. Simmons, USGS, WRD.)

Figure 4. Digital Tide Gage Station Records - January 1-6, 1992.

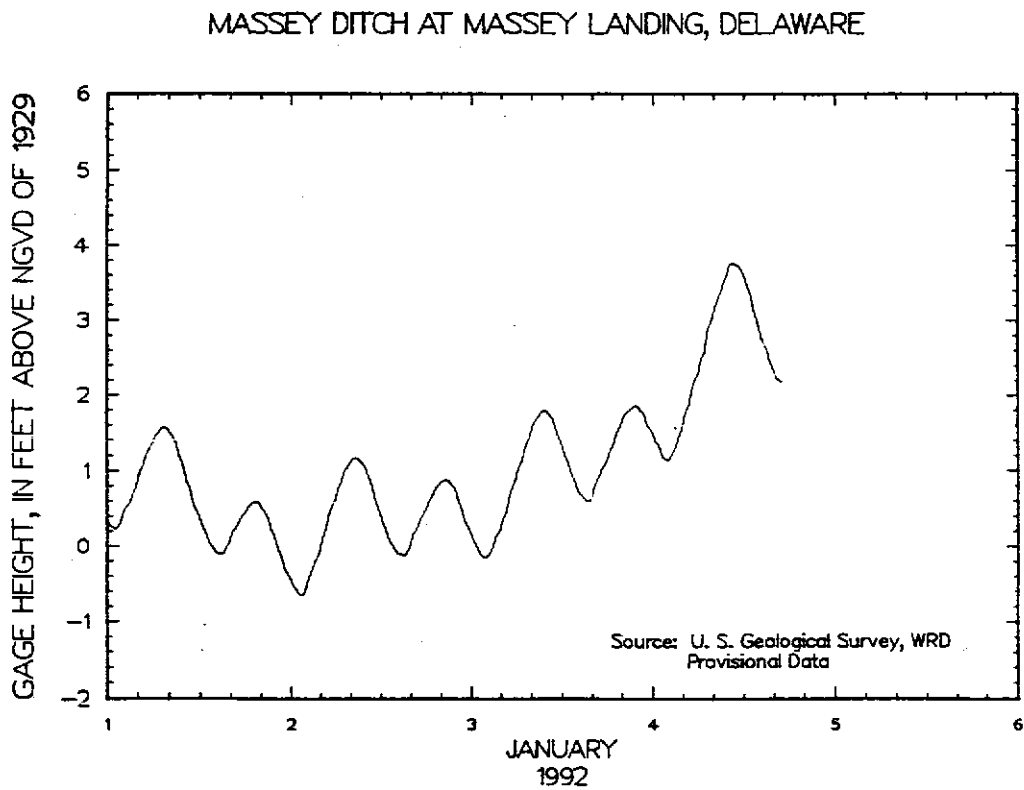
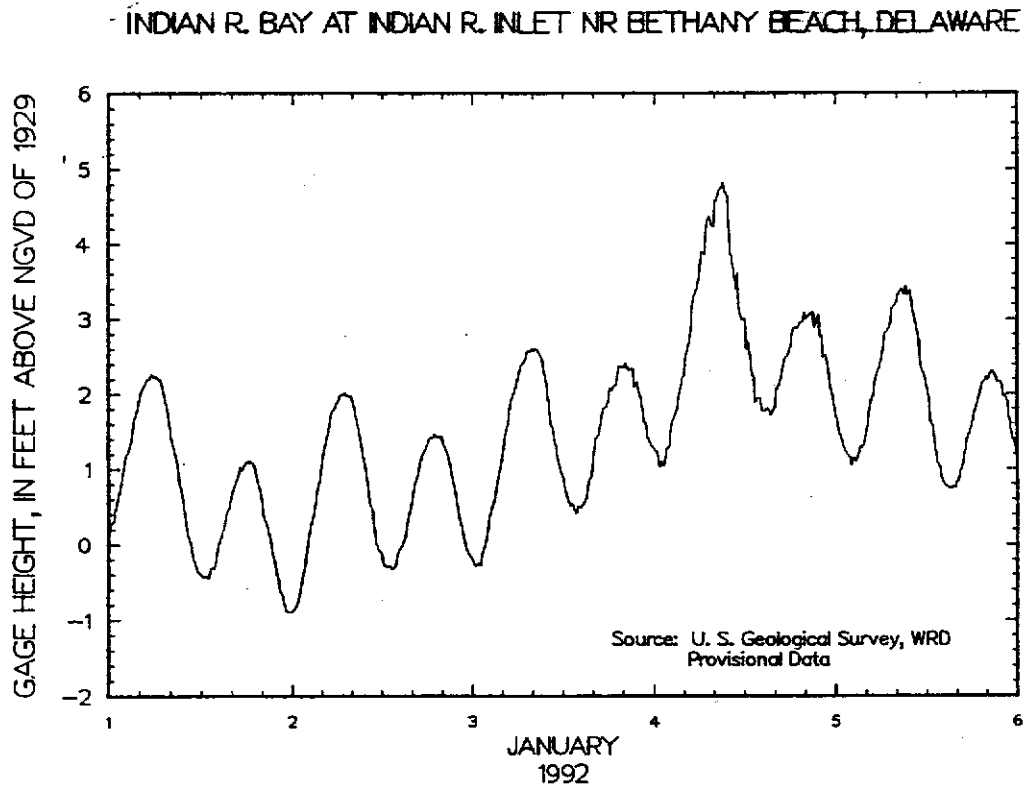
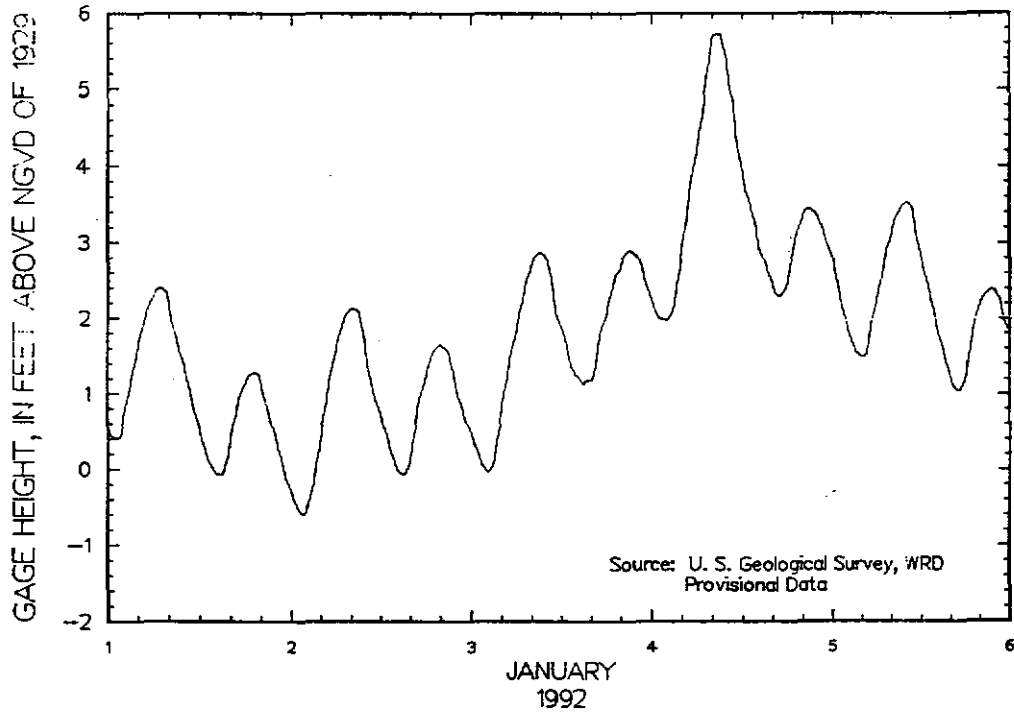
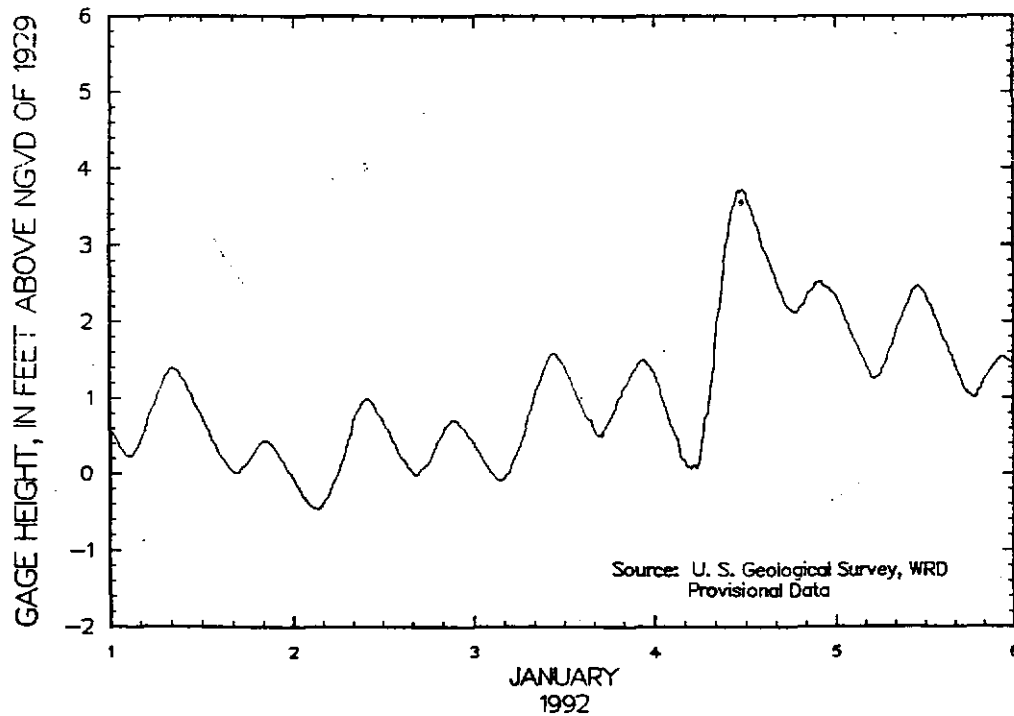


Figure 4 (continued).

INDIAN RIVER AT ROSEDALE BEACH, DELAWARE



REHOBOTH BAY AT DEWEY BEACH, DELAWARE





## GEOLOGIC OBSERVATIONS

Observations are based on reconnaissance of the area by Kelvin W. Ramsey and John H. Talley of the Delaware Geological Survey on January 6, 1992 and by Kelvin W. Ramsey on January 7, 1992.

1. Washovers and breaches in the dune system occurred at scattered locations along the Atlantic Coast.
  - The dunes in the central and north end of Fenwick were breached along most of the area. Little remained of the dunes in this area. The southern end of Fenwick near the Maryland line experienced marked scarping of the dunes, but not complete removal. This is in the area of the tie-in of beach replenishment from the Ocean City, Maryland project. Much of the beach replenishment sand had been removed offshore. As of January 6, 1992, an offshore bar and runnel system was being built in the surf zone. Large numbers of sea stars (starfish) were observed on the beach.
  - The dunes in the Fenwick Island State Park were breached in several spots. The parking lot at the park pavilion was covered with one to two feet of sand. Sand in this area did not reach Route 1.
  - Washovers were common in South Bethany. Scarping and erosion of the road behind the first row of houses was common. Sewer lines and well heads were exposed and damage to wells was common.
  - Washovers were common in Bethany Beach. Damage to the boardwalk was observed. The dunes were completely removed and much of the sand on the beach was removed offshore. Pilings and well casings from houses destroyed by the March, 1962 storm were observed on the beach and in the surf zone. No breaches were observed in the dunes north of Ocean Village up to Indian River Inlet.
  - No observations were made along the Inland Bays. According to unconfirmed reports, Routes 58 and 26 were closed due to flooding for a period of time. Some local flooding was also reported along Indian River Bay. Flooding in Rehoboth Bay appears to have been minor.
  - Breaches in the dunes were noted south of the Old Coast Guard Station in Delaware Seashore State Park. The washovers extended across Route 1 and closed the road due to sand and debris.

- Minor breaches in the dunes were noted north of the Old Coast Guard Station. Washovers barely extended into the dune field.
  - Washovers occurred throughout much of the extent of Dewey Beach. The most severe washovers appear to have been in the vicinity of Read Street. The dunes throughout this area were removed; damage to some buildings was noted.
  - Some washover occurred in Rehoboth Beach. The boardwalk was damaged, especially north of Rehoboth Avenue (Rd. 14A). Much of the sand on the beach was removed. A bar and runnel system was forming in the surf zone as of January 6, 1992.
  - The dunes on the Atlantic side of Cape Henlopen were scarped, but not severely damaged. One breach was noted along which water passed from one side of the Cape to the other. Sand was moved by the wind and had covered much of the vegetation. According to John Wehmiller from the Department of Geology of the University of Delaware, on January 4 at approximately 1400 hrs much of the Lewes Marsh was covered by water and water was rapidly draining off of the dune field on the Cape.
2. Washovers and breaches in the dunes occurred at scattered locations along Delaware Bay.
- Minor flooding occurred along Lewes Beach.
  - Washovers were noted at the south end of Broadkill Beach. The dunes were generally intact with some minor scarping as of January 7, 1992.
  - The dunes were flattened between the north end of Primehook Beach and the south end of Slaughter Beach. Washovers were observed to extend 20 to 30 feet into the marsh throughout this area. An artificial earthen berm that originally stood approximately 8 to 10 feet high at the end of Rd. 199 at Fowler Beach was almost completely removed. Based on the relative position of a concrete structure at the south end of Fowler Beach to the beach profile after the October 31, 1991 storm and the January 4, 1992 storm, beach retreat in this area may be as much as 20 feet inland.
  - Minor washovers occurred at the south end of Slaughter Beach and at N. Delaware Avenue.
  - Damage occurred on the north side of the jetties of the Mispillion River. Waves reported to be 8 feet high crossed the breach north of the jetties and

severely damaged the marina and buildings at the Mispillion River light. The north end of the island between the jetties and the breach rotated inland and a spit prograded approximately 50 to 60 feet into the Mispillion River across from the marina. The orientation of the spit suggests that the waves were coming from an almost due east direction. A large prefabricated building was lifted from the dock area and moved approximately 1000 ft down Rd. 203 where it rested against the bridge railing.

- The dunes were flattened from the north end of the Mispillion Inlet to north of Bennetts Pier. Damage occurred to most of the houses at Big Stone Beach, especially to those that were not on piers. According to an eyewitness (Frank Schwinn) who was at Big Stone Beach during the storm, waves 8 to 10 feet high were common during the peak of the storm between 0900 and 1000. Washovers carried sand into the marsh 50 to 60 feet beyond its previous extent.
- Washovers occurred along the southern end of South Bowers up to about the 5th house in South Bowers. Sand waves were measured in the roadway that were approximately 5 feet from crest to crest. At the very end of the road in South Bowers, a sand pile indicated that the water level had been approximately 3 feet higher than the present land surface.
- No observations were made north of South Bowers.

## SUMMARY

A combination of factors made the storm of January 4, 1992 severe, even though it was of relatively short duration. The major contributing factor was that the storm made landfall on the southern Delmarva Peninsula. This location of the storm placed the Delaware coast in the storm's northeast quadrant with high winds coming from almost due east. The time of landfall was also at the time of high tide along the Delaware Coast during the highest tides of the month (new moon) and was at the time that the lowest barometric pressures were recorded. The high winds (up to 46 to 50 mph in gusts) generated waves that built on top of the astronomical high tide to create large waves and severe surf along the shore. Precipitation associated with the storm was light; the highest recording station was Georgetown with 1.06 inches. The storm moved inland rapidly, so it created problems during a single tidal cycle.

The wind direction also allowed additional wave fetch from the east to build up from the Atlantic across Delaware Bay to the Delaware side of the Bay. The areas that lie directly in this path are from Primehook to Bowers. These areas experienced the most severe flooding, more severe than along the Atlantic Coast based on the record or near record high tides recorded.

The tides in the Inland Bays were less than those recorded for the October 31, 1991 storm at the Indian River Inlet, Massey Ditch, and Rehoboth Bay at Dewey Beach, but were higher up Indian River Bay at Oak Orchard, Rosedale Beach, and Vines Creek. This probably indicates an additional fetch across Indian River Bay associated with high winds that piled the water up along the western end of the Bay. The tide at Oak Orchard was the second highest recorded, but was still 2.4 feet below the March 1962 storm level.

Tides at Breakwater Harbor were the second highest of record behind the March 1962 storm. Unfortunately, no data were obtained for the October 31, 1991 storm for this station.

Tides were the highest ever recorded for Cedar Creek at Slaughter Beach and for the Murderkill River at Bowers. The station at Bowers recorded a level just above that for the March 1962 storm. Levels at Duck Creek at Smyrna, however, were much lower and ranked as the 15th highest recorded.

### CONCLUSIONS AND PREDICTIONS.

As has been noted for previous storms, the severity of the storm was due primarily to strong winds from the east to northeast. These "northeasters" have been the major cause of coastal flooding and damage along the Delaware Coast. The storm of January 4, 1992 may be a model of the location and severity of damage to be expected from a tropical storm that could create severe damage to the Delaware coast. The January 4 storm had an "eye" and typical counter-clockwise wind circulation as it encountered the coast of the southern Delmarva. The easterly winds created allowed for a direct approach to the Delaware Coast and the building of significant waves, especially in the area of the longest fetch across the mouth of Delaware Bay and the Bay itself. The conditions also occurred at an astronomical high tide, but only existed for one tidal cycle.

In a worst-case scenario based on this storm, the following would likely create severe and life-threatening conditions.

1. A slow-moving storm with tropical- to hurricane-force winds.
2. Landfall over the southern Delmarva Peninsula that places the Delaware Coast in the storm's northeast quadrant.
3. Continuation of the storm over several tidal cycles.
4. Landfall during high tide or an astronomical high tide.

Based on the distribution of damage in this storm, the areas most likely to sustain severe property damage would be:

1. The entire Atlantic Coast, with damage most severe at the northern end of Fenwick, South Bethany and Bethany Beaches, and Dewey Beach. Likely places for new inlets to form are just north of Fenwick and near the Old Coast Guard Station north of Indian River Inlet.
2. Along the western side of Delaware Bay, with damage most severe from Primehook to Bowers.

It must be recognized that no two storms are identical and that decisions regarding each storm must be based on the existing conditions and the experience of the results of previous storms.

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