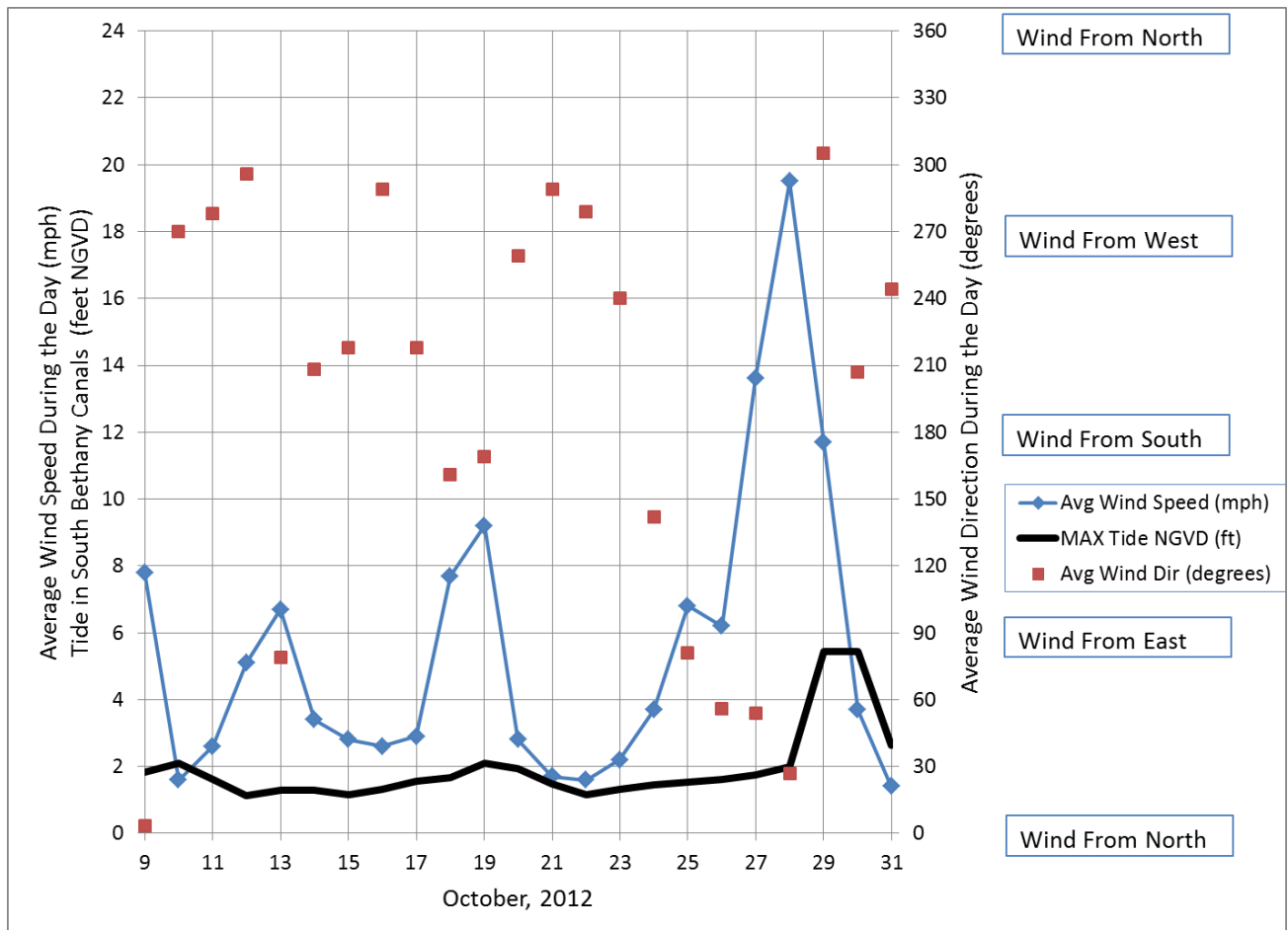


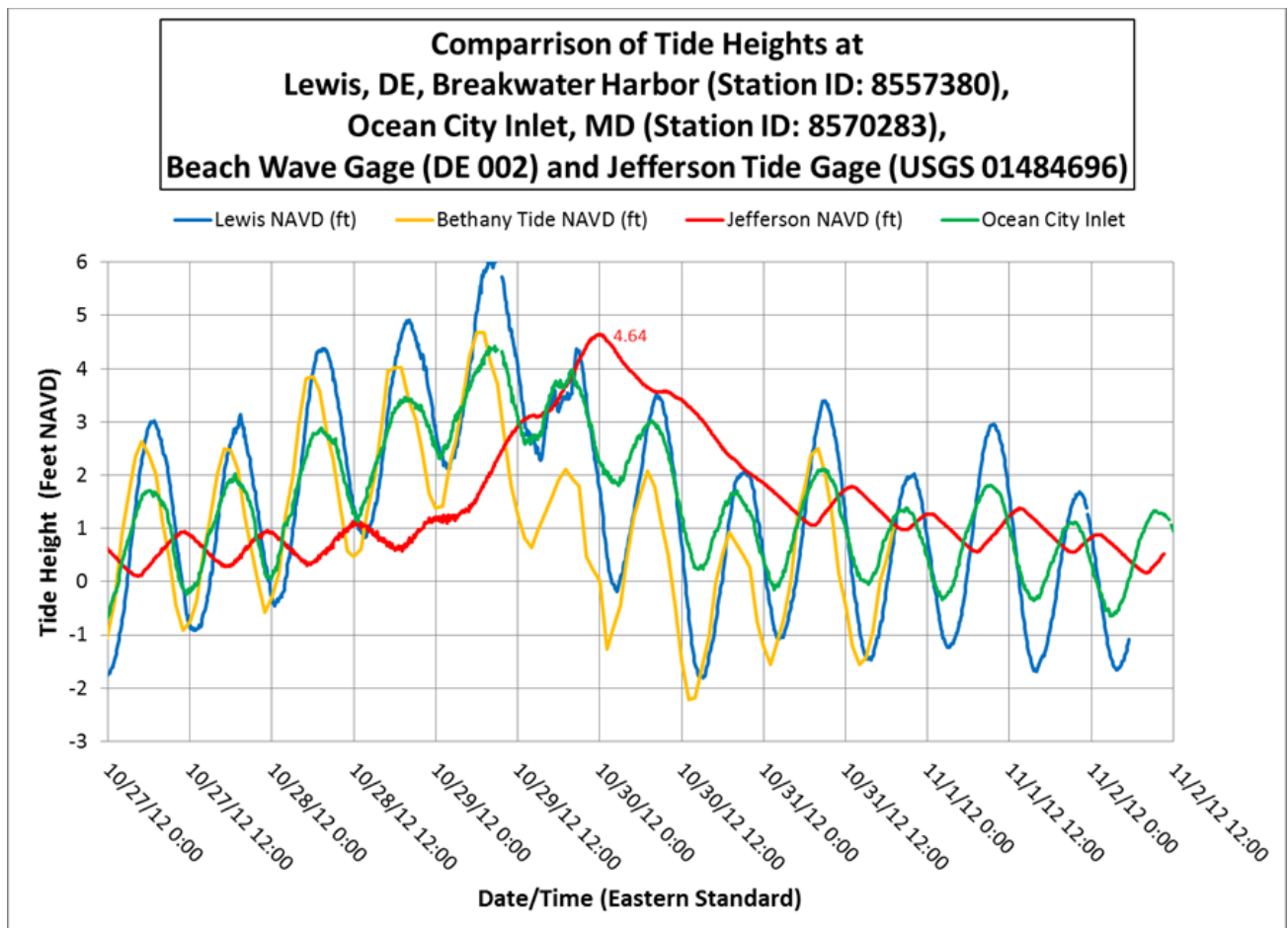
Storm of the Century Floods Bay Side in South Bethany

While the 1962 Nor'easter was the storm of the century for the ocean side in South Bethany, the October 29/30, 2012 Hurricane Sandy was the storm of the century for the bay side in South Bethany. Sandy started as a tropical depression in the Caribbean on October 22, 2012. It followed the coast similar to many other hurricanes that had done minimal damage to South Bethany until it met up with two other storm systems from the north on October 29 which caused Sandy to make a sharp turn to the west just north of Wilmington. (See Appendix for more details from the NOAA report on Sandy.) As can be seen from the chart below there were high winds coming from the northeast, similar to a typical Nor'easter, on the days just before the storm headed west. If Sandy had stayed on its northeast path, the damage to South Bethany would have been on the ocean side. There would have been more damage to the dunes and to the beach restoration. However Sandy did make that significant turn to the west. This caused the winds to shift and now come from the west, as can be seen from the chart below. The wind from the west caused the water in the Little Assawoman Bay to be blown into the South Bethany Canals and resulted in the highest canal tides ever recorded in the canals, 5.44 feet NGVD. (NGVD means National Geodetic Vertical Datum, established in 1929. There are many different vertical references. NGVD is the one used for the canal tide gage.) The record before Sandy had been 3.52 feet NGVD, recorded on 9/19/2003; almost 2 feet lower than that which was recorded for Sandy. The 1962 Nor'easter did not flood the bayside. The winds came from the northeast, blowing water away from our canals.

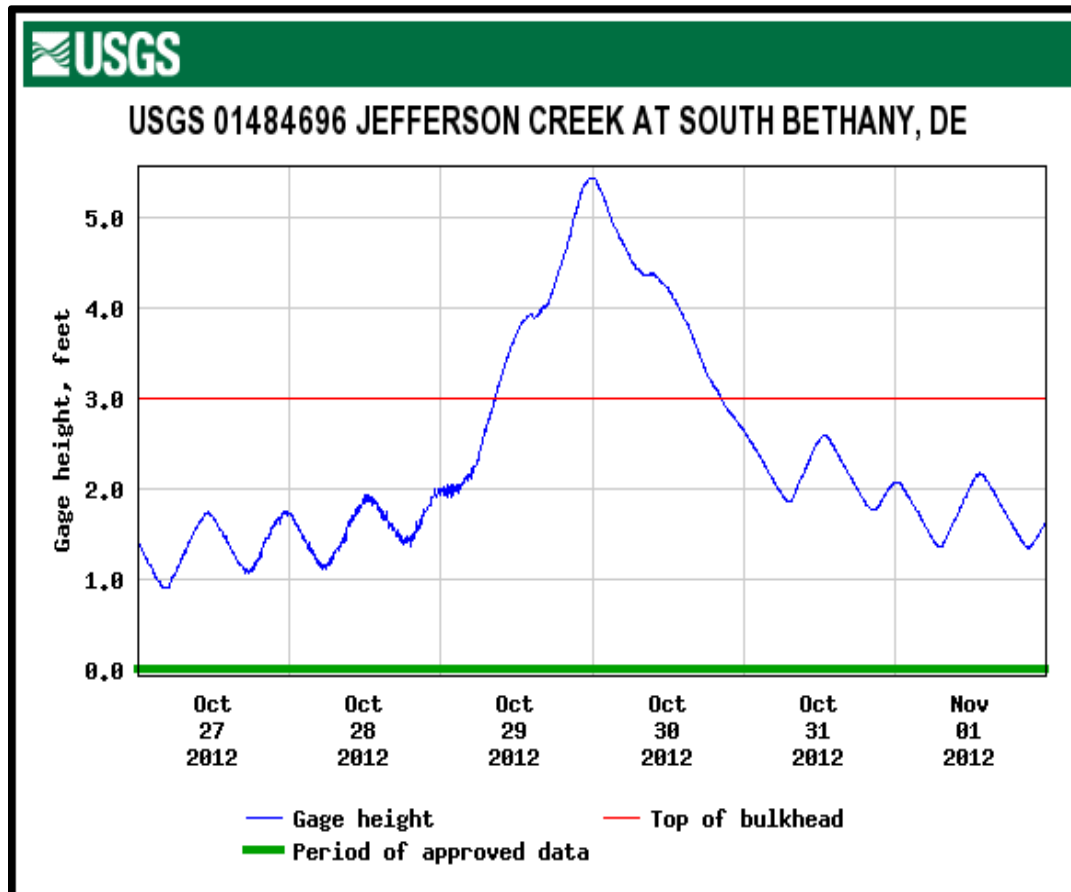


The chart below shows tide data from different sources near South Bethany. The data is plotted relative to NAVD. (The North American Vertical Datum was established in 1988. Near South Bethany NGVD - 0.80 feet = NAVD.) NAVD is used since it is the newer datum and the tide gages at Lewes and Ocean City will report their data relative to NAVD but not NGVD.

The highest tide in the canals, shown in red, was 4.64 feet NAVD (5.44 feet NGVD). It occurred about 15 hours after the high tide in the ocean. Usually the high tide in the canals occurs about 6 hours after the high tide in Ocean City (the green curve). (Note the time spacing of the red and green peaks before there as a significant increase in the canal tides.) This is because it takes quite a while for the water to flow through the Assawoman Bay, through the ditch at Route 54 in Fenwick Island, Through the Little Assawoman Bay, through the “Narrows” at the boat ramp just south of South Bethany and then through Little Bay into our canals. If you look at the red curve at about 10/29/12 1800 hours you see that a low tide is “missed” by the canals. That is because the water at the Ocean City Gage is too high to let water out of Assawoman Bay. The Ocean City Tide is going up again and thus pushes the canal tide even higher. The blue curve is for the Lewes Tide Gage and the yellow curve actually comes from a wave gage off the coast of Bethany Beach that was placed by the US Army Corps of Engineers. The Bethany Wave Gage shows the correct timing for the high and low tides. The relative tide heights are correct, but the exact vertical location of the curve may be slightly displaced since the gage is not tied directly to a vertical datum.



Canal waters were about three feet above the York Canal bulkhead at the maximum high tide. The top of many bulkheads were exceeded for almost 36 hours. The tide chart below together with the bulkhead elevation chart below the tide chart shows that all bulkheads were exceeded at maximum tide. Time on the chart is EST, height is NGVD.

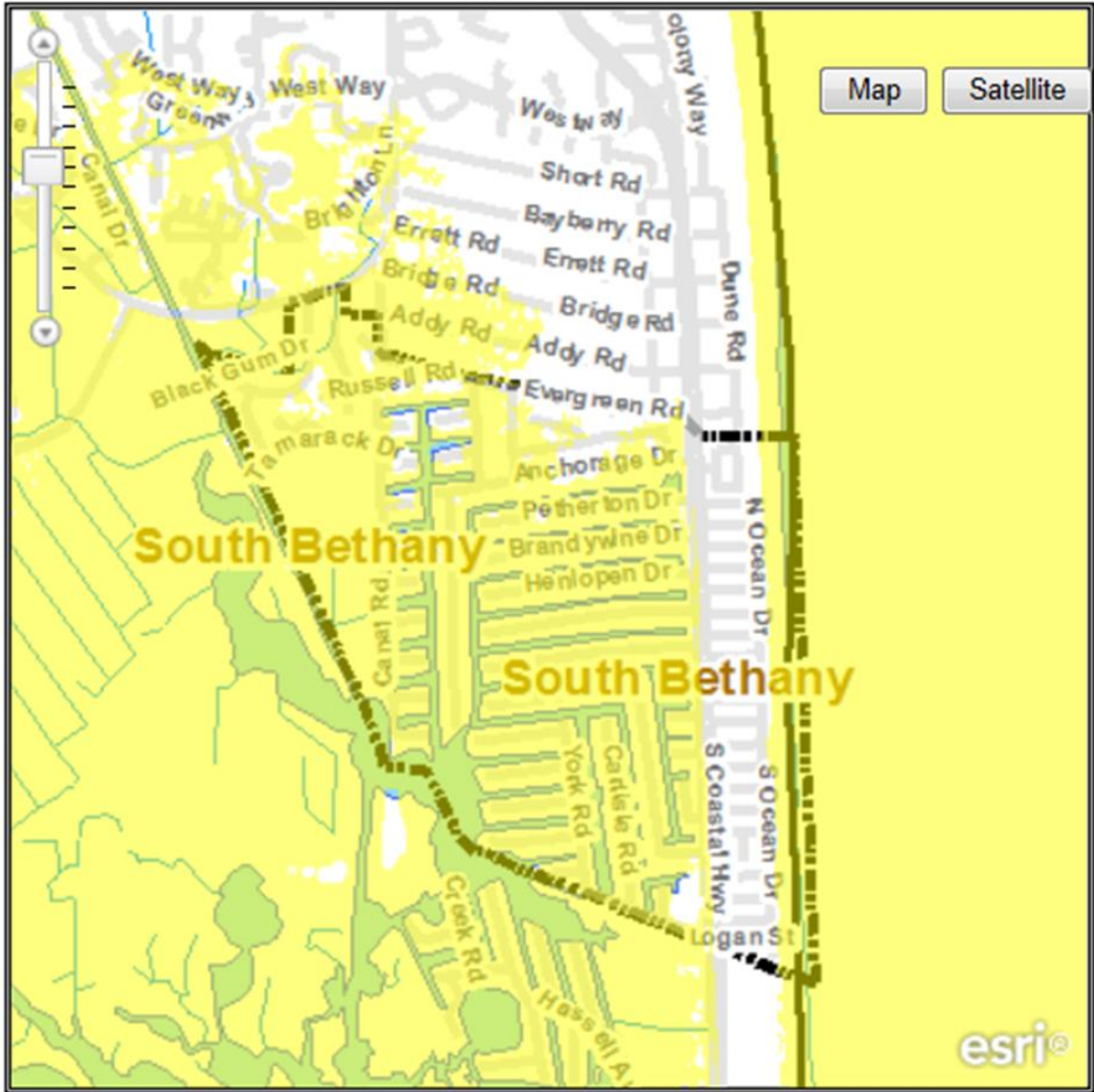


Street End	Elevation of Bulkhead (feet NGVD)	Flood over Bulkhead on 8/28/2011 (feet)	Flood over Bulkhead on 9/19/2003 (feet)	Flood over Bulkhead on 10/29/2012 (feet)	Canal End	Elevation of Bulkhead (feet NGVD)	Flood over Bulkhead on 8/28/2011 (feet)	Flood over Bulkhead on 9/19/2003 (feet)	Flood over Bulkhead on 10/29/2012 (feet)
Tide Gage		3.12	3.52	5.44	Tide Gage		3.12	3.52	5.44
Plymouth					W. 2nd	2.86	0.26	0.66	2.58
Bristol					W. 3rd	2.77	0.35	0.75	2.67
Victotia					W. 4th	3.02	0.10	0.50	2.42
Kimberly					W. 5th	3.61	-0.49	-0.09	1.83
Rebecca	3.46	-0.34	0.06	1.98	W. 6th	3.11	0.01	0.41	2.33
W. Bayshore	2.88	0.24	0.64	2.56	W. 7th	3.19	-0.07	0.33	2.25
Layton	2.72	0.40	0.80	2.72	W. 8th	3.61	-0.49	-0.09	1.83
New Castle	3.08	0.04	0.44	2.36	W. 9th	3.86	-0.74	-0.34	1.58
Henlopen	3.34	-0.22	0.18	2.10	W. Russell	3.36	-0.24	0.16	2.08
Brandywine	3.66	-0.54	-0.14	1.78	E. Russell	4.00	-0.88	-0.48	1.44
Petherton	4.43	-1.31	-0.91	1.01	W. 10th	4.00	-0.88	-0.48	1.44
Sussex					W. 11th	3.92	-0.80	-0.40	1.52
Kent					Anchorage	3.42	-0.30	0.10	2.02
Godwin	3.19	-0.07	0.33	2.25	Petherton	4.19	-1.07	-0.67	1.25
107 Godwin	2.86	0.26	0.66	2.58	Brandywine	3.36	-0.24	0.16	2.08
W. Anchorage	3.58	-0.46	-0.06	1.86	S. Highway	3.19	-0.07	0.33	2.25
W. 11th	4.50	-1.38	-0.98	0.94	York	2.52	0.60	1.00	2.92
W. 10th	4.51	-1.39	-0.99	0.93	Rebecca	3.94	-0.82	-0.42	1.50
W. 9th	3.28	-0.16	0.24	2.16	Kimberly	2.69	0.43	0.83	2.75
W. 8th	4.13	-1.01	-0.61	1.31	Victoria	2.86	0.26	0.66	2.58
W. 7th	4.06	-0.94	-0.54	1.38	Bristol	2.69	0.43	0.83	2.75
W. 6th	3.60	-0.48	-0.08	1.84	Boone	4.02	-0.90	-0.50	1.42
W. 5th	3.68	-0.56	-0.16	1.76	N. Highway	2.78	0.34	0.74	2.66
W. 4th	3.69	-0.57	-0.17	1.75	W. May	3.04	0.08	0.48	2.40
W. 3th	3.61	-0.49	-0.09	1.83	E. May	3.52	-0.40	0.00	1.92
W. 2th	2.78	0.34	0.74	2.66	Layton	2.71	0.41	0.81	2.73
W. 1th	2.79	0.33	0.73	2.65					

The tide rose high enough that the water almost reached the crown in the Route 1 south bound lane. The crown of the south bound lane is at an elevation of about 5.5 +/- feet NGVD. The maximum tide was 5.44 feet NGVD. The picture below from the Wilmington New Journal is an aerial view of South Bethany taken about 7 hours after the maximum high tide that occurred at midnight EST on 10/29/2012.



**“South Bethany Relieved Damage Not Worse,
Ground-level houses on west flooded, but none are floating”**
***News Journal* October 31, 2012 - Photo by Robert Craig**



Area Flooded by Sandy on 10/29/2012 – Shown in Yellow

The water in the canals rose to 5.44 feet NGVD on the South Bethany Tide Gage at about midnight EST on 10/29/2012. This flooded many ground floors to a depth of about 2 feet. See the following pictures.

Note water level line shown on homes.





10-30-2012 About 8:30 AM EDT



10-30-2012 About 8:30 AM EDT



10-30-2012 About 8:30 AM EDT



10-30-2012 About 8:30 AM EDT



10-30-2012 About 8:30 AM EDT



10-30-2012 About 8:30 AM EDT



10-30-2012 About 8:30 AM EDT



10-30-2012 About 8:30 AM EDT



10-30-2012 About 8:30 AM EDT



10-30-2012 About 8:30 AM EDT

In the final analysis South Bethany certainly did not have as much damage as our neighbors to the north in New Jersey and New York. However the damage to South Bethany was not insignificant. Damages in the tens of thousands of dollars were incurred by around XXX hundred of South Bethany's homeowners. YYY tons of damaged materials had to be removed from South Bethany. South Bethany streets on the west side looked like a war zone. See a typical scene in the picture below.



APPENDIX The following is from the NOAA report on Hurricane Sandy

noaa National Oceanic and Atmospheric Administration

NOAA Water Level and Meteorological Data Report HURRICANE SANDY

Silver Spring, Maryland

January 24, 2013

U.S. DEPARTMENT OF COMMERCE

National Ocean Service Center for Operational Oceanographic Products and Services

Colleen Fanelli, Paul Fanelli, David Wolcott

January 24, 2013

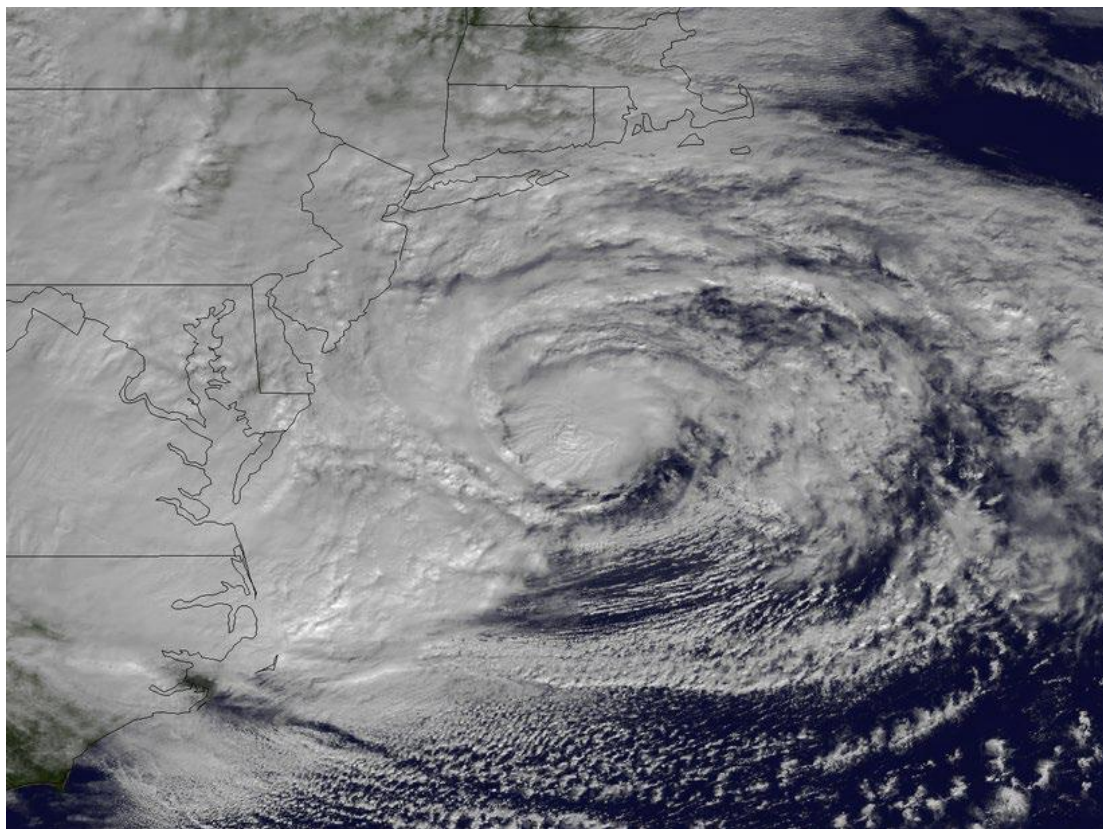


Photo Credit: NOAA National Environmental Satellite, Data & Information Service GOES

U.S. DEPARTMENT
OF COMMERCE
Rebecca Blank
Acting Secretary

National Oceanic and
Atmospheric Administration
Dr. Jane Lubchenco
Administrator

National Ocean Service
Dr. Holly Bamford
Assistant Administrator

Center for Operational Oceanographic Products and Services
Director, Richard Edwing

Summary

Sandy initially formed as a tropical depression in the southwestern Caribbean, about 320 miles south-southwest of the Kingston, Jamaica on October 22st 2012. Sandy followed a generally northward track over the coming days, moving over eastern Jamaica, eastern Cuba and the Bahamas (not shown). As Sandy moved over the Bahamas, the storm curved slightly to the west. While Sandy remained well offshore of Florida as a category 1 hurricane on October 26th (see Figure 2a), tropical storm force winds began to affect the U.S. Atlantic coast. Hurricane Sandy then began to take a more northeasterly track, following the coastline of North and South Carolina from October 27th to October 29th while remaining 250 to 300 miles offshore (see Figure 2a). Although Sandy remained a category 1 hurricane, the storm continued to grow in size. As Sandy moved offshore of the Outer Banks of North Carolina, the storm began to curve back to the northwest and head towards the mid-Atlantic coast as it picked up speed on October 29th (see Figures 2b and 2c). Despite the fact that Sandy had transitioned to a post-tropical cyclone just prior to making landfall near Atlantic City, NJ around 00:00 GMT on October 30th (October 29th 20:00 EDT), the storm still exhibited winds equivalent to a category 1 hurricane at landfall. Following landfall, the storm continued west-northwestward through Pennsylvania on October 30th, continuing to impact areas with tropical storm force winds and heavy rainfall before eventually curving northward into Canada the following day.

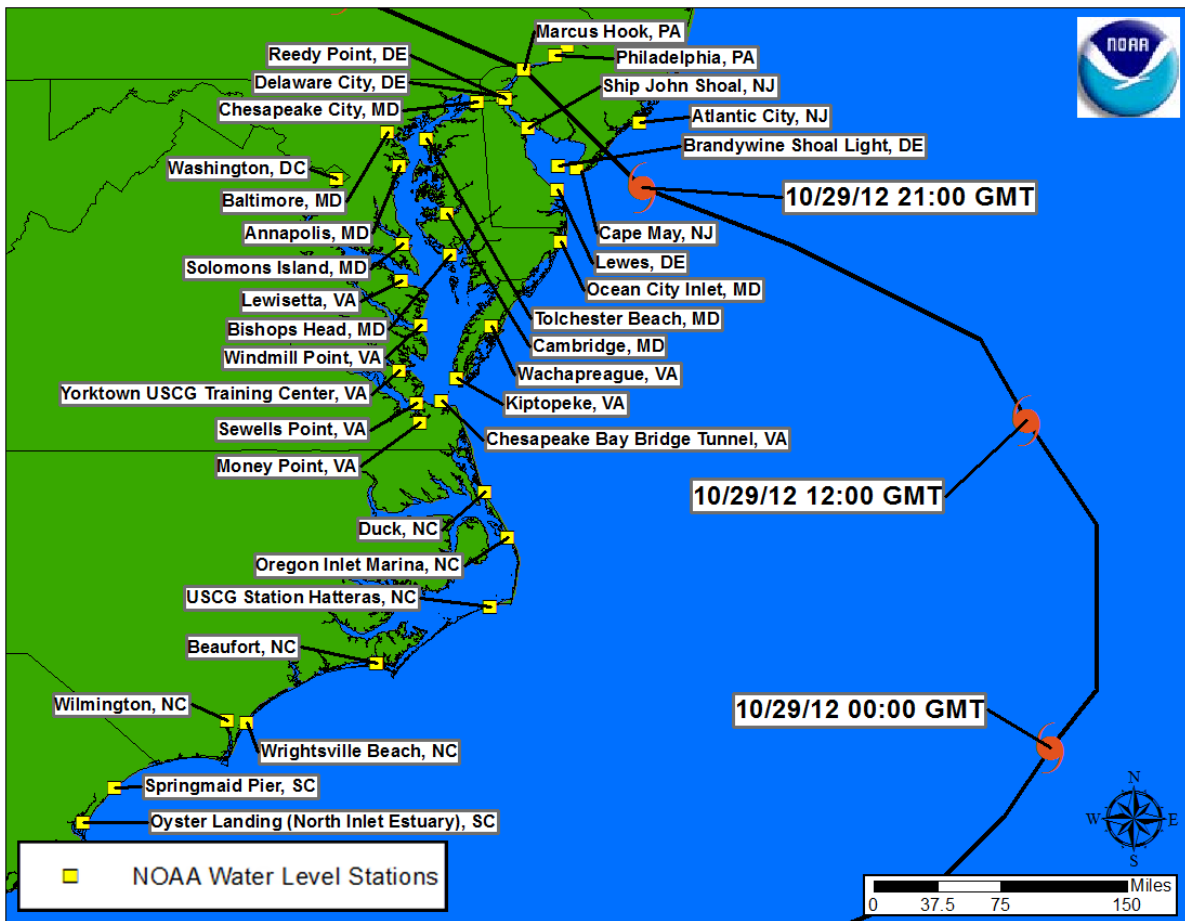
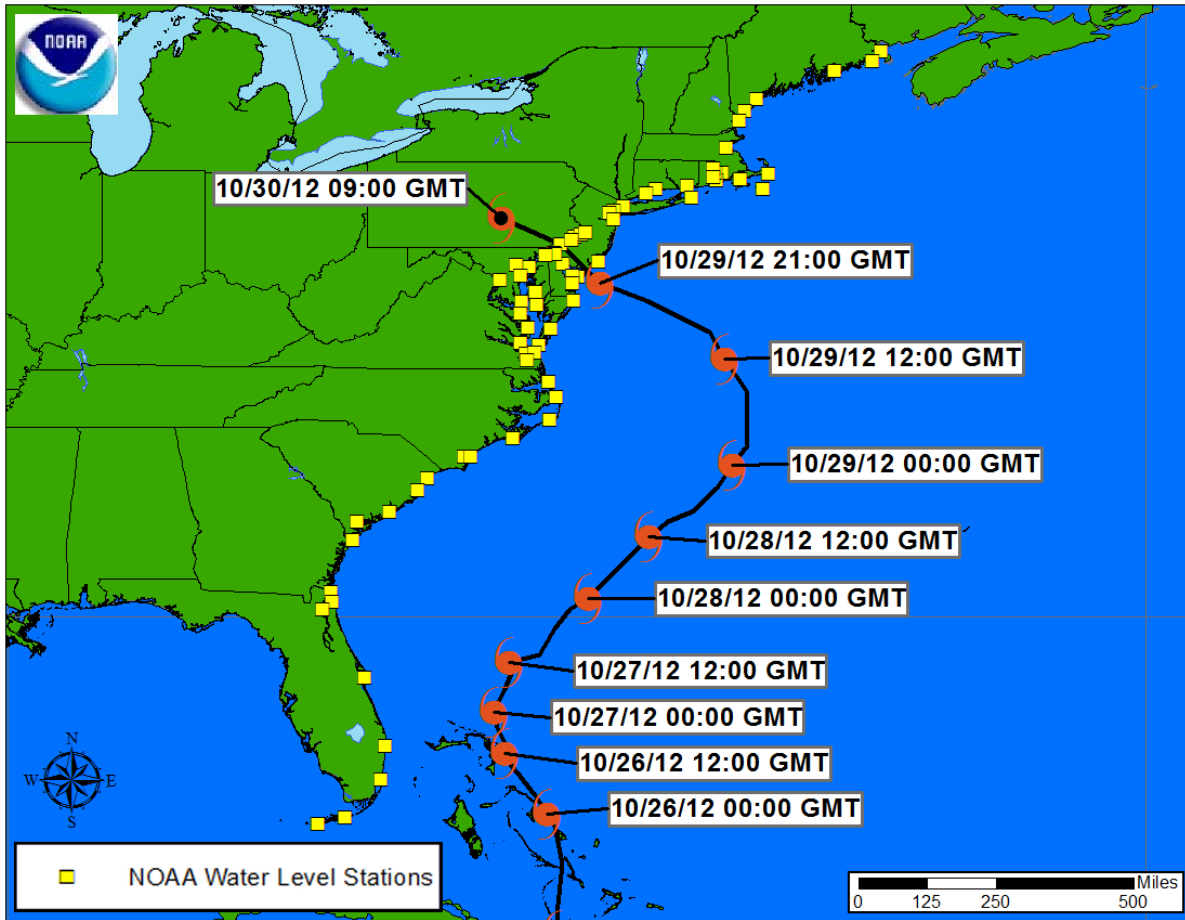
As Sandy passed offshore of Florida, Georgia and South Carolina, the maximum storm tide measured was 3.045 m (9.99 ft) above Mean Lower Low Water (MLLW) at Clarendon Plantation, SC on October 28 13:54 GMT. The maximum storm surge/residual across this region was also measured at Clarendon Plantation, SC and reached 1.082 m (3.55 ft) above tidal predictions on October 28 18:00 GMT. Maximum storm surge/residuals from Florida to South Carolina ranged from 0.28 to 1.08 m (0.9 to 3.6 ft) during Sandy. The highest wind speed and gust across this region were both measured at Lake Worth Pier, FL with a speed of 38.7 kts (44.5 mph) and a gust of 48.6 kts (55.9 mph). The minimum barometric pressure recorded from Florida to South Carolina was also at Lake Worth Pier, FL and measured 997.2 mb.

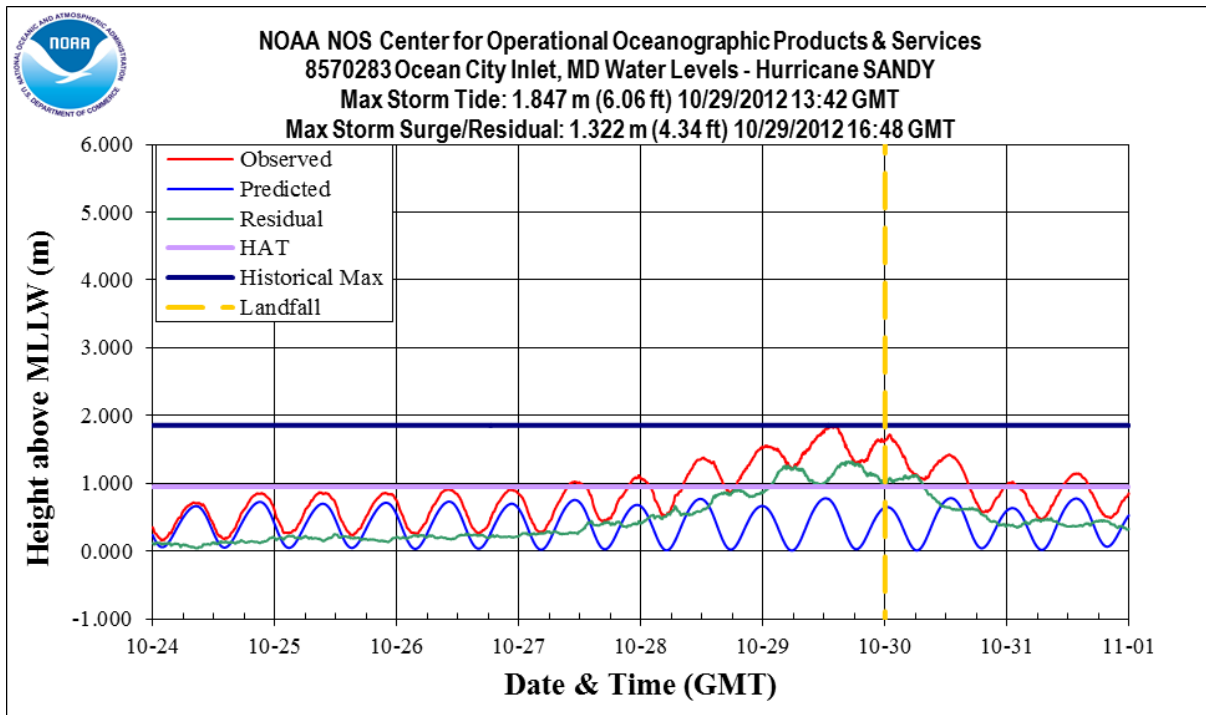
As Hurricane Sandy made a turn towards the mid-Atlantic coast and continued to grow in size, much more significant storm effects were observed from North Carolina northward to New England, especially across New Jersey, New York and Connecticut. The maximum observed storm tide along the coast from North Carolina to New Hampshire was 4.444 m (14.58 ft) above MLLW at Bergen Point West Reach, NY on October 30 01:24 GMT, shortly after landfall. The maximum storm surge/residual across this region was measured at Kings Point, NY and reached 3.856 m (12.65 ft) above tidal predictions on October 29 23:00 GMT, which was an hour prior to landfall. During Sandy, maximum storm surge/residuals along the mid-Atlantic coast from North Carolina to Delaware ranged from 0.63 to 1.63 m (1.8 to 5.3 ft). Within the Chesapeake Bay, maximum storm surge/residuals ranged from 0.75 to 1.46 m (2.5 to 4.9 ft). Within the Delaware Bay and River, maximum storm surge/residuals ranged from 1.62 to 1.96 m (5.3 to 6.4 ft). From New Jersey to Connecticut, maximum storm surge/residuals ranged from 1.57 to 4.44 m (5.2 to 12.7 ft). Along the New England coast from Rhode Island to Massachusetts, maximum storm surge/residuals ranged from 1.28 to 4.44 m (6.2 to 12.2 ft). Across the coast of New Hampshire and Maine, maximum storm surge/residuals ranged from 0.69 to 1.08 m (2.3 to 3.5 ft).

The highest wind speed recorded at CO-OPS and partnership stations from North Carolina to New England due to Hurricane Sandy was 51.9 kts (59.7 mph), at Cape May, NJ on October 30

00:00 GMT as Sandy made landfall. The highest wind gust also was recorded at Cape May, NJ and measured 65.3 kts (75.1 mph) on October 30 00:00 GMT. The minimum barometric pressure recorded from North Carolina to New England measured 945.5 mb at Atlantic City, NJ on October 29 22:24 GMT.

More information, data and storm reports can be found at the CO-OPS website, <http://tidesandcurrents.noaa.gov>. Storm reports are located under the Publications section of the webpage.





Figure

30: Water levels above Mean Lower Low Water (MLLW) at Wachapreague, VA. Lines denoting Highest Astronomical Tide (HAT) and Historical Maximum Water Level are displayed. Sandy made final landfall near Atlantic City, NJ on 10/30/2012 00:00 GMT as a Category 1 hurricane.

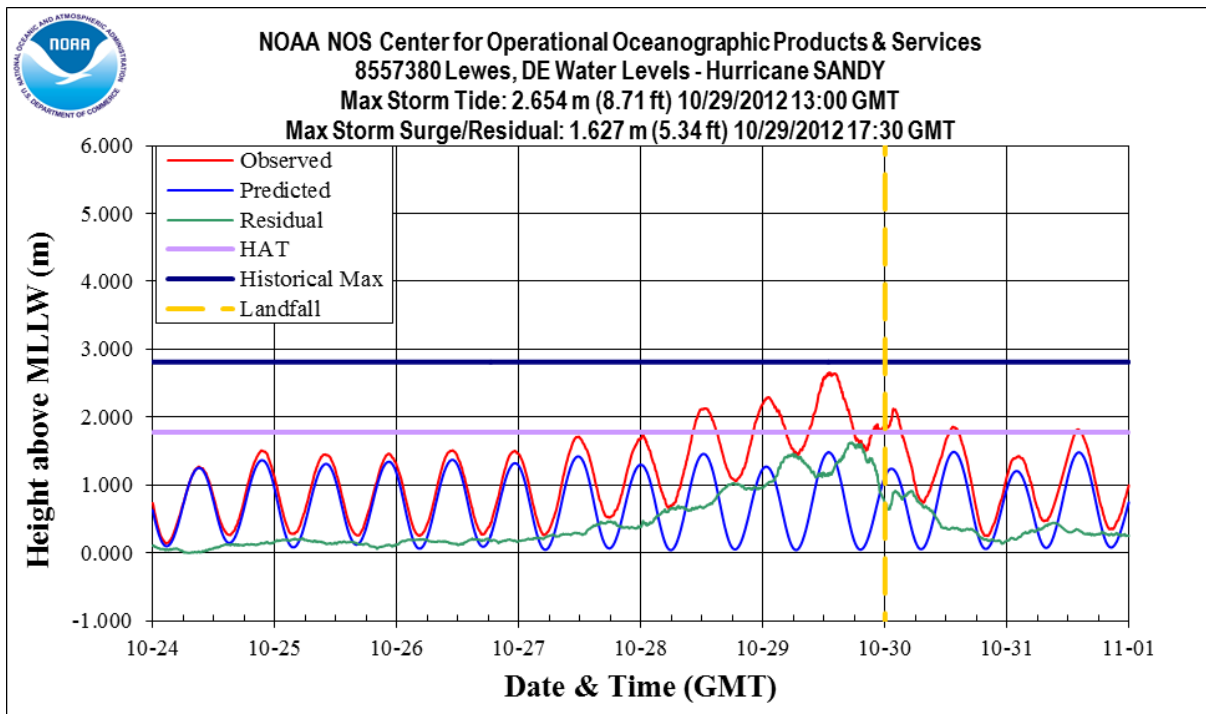


Figure 40: Water levels above Mean Lower Low Water (MLLW) at Lewes, DE. Lines denoting Highest Astronomical Tide (HAT) and Historical Maximum Water Level are displayed. Sandy made final landfall near Atlantic City, NJ on 10/30/2012 00:00 GMT as a Category 1 hurricane.