

# Storm Tide and Wind Impact of Hurricane Sandy Along the Hudson River

Extended Abstract # 40

**Paul A. Eisen, CCM, Principal Scientist**

Roux Associates, Inc., 209 Shafter Street, Islandia, NY 11749-5074

## INTRODUCTION

This paper begins by briefly summarizing recently reported changes in the intensity, damage costs, and frequency of major weather events such as droughts and hurricanes. These events are reviewed because it is important to understand whether there are clear changes or even trends occurring. It is also important to understand whether recent changes are consistent with the anticipated pace of changing climate and its predicted impacts. Ultimately, it is reasonable to postulate that future predictions regarding climate change will have some direct relationship with the potential for change in insured losses and insurance claims from major weather events.

In order to illustrate significant issues that may need to be addressed more frequently if predictions about climate change are correct, a case study is presented that elaborates on some of the widespread impacts from Hurricane Sandy. In this instance, substantial property damage (from a storm that made landfall in southern New Jersey) extended from the Battery, in lower Manhattan, to areas beyond 30 miles north along the Hudson River. This property damage created a need to distinguish between damage caused by wind and damage caused by storm surge, in order to resolve an insurance claim. Weather and storm tide data for Sandy are assessed from available stations to specifically examine how weather and tide conditions deteriorated, and eventually led to a damaging 7.8-foot storm surge (7.8 feet above predicted tide) at a riverside location, 30 miles north of Manhattan. Once the data are assembled and other observations are considered, it is possible to reach conclusions regarding the specific cause of the property damage.

## Body

Trends in the intensity, damage costs, and frequency of major weather events such as droughts, floods, severe weather, and hurricanes are closely monitored. A recent comprehensive report<sup>1</sup> summarized worldwide statistics on these subjects, which are sometimes evaluated from the additional perspective of global climate change. With respect to natural disaster events<sup>a</sup>, there were 295 separate events in 2012 which combined to cause economic losses of \$200 billion, just above the ten-year average of 257 natural disaster events with an average cost of \$187 billion. The disasters caused insured losses of \$72 billion, well above the ten-year average of \$53 billion. The two largest global events of 2012 occurred in the US: Hurricane Sandy and a prolonged year-long drought in the mid-western U.S. Hurricane Sandy was the costliest single event of the

---

<sup>a</sup> An event must have met at least one of the following criteria to be classified as a “natural disaster”: economic loss of \$50 Million, insured loss of \$25 Million, 10 fatalities, 50 injured, or 2,000 homeless or displaced.

year causing an estimated \$28.2 billion in insured losses (combined private and government sponsored insurance programs), and approximately \$65 billion in economic losses across the United States, the Caribbean, the Bahamas, and Canada. These costs remain subject to update, since they are still undergoing change as repairs proceed to completion.

With respect to global climate change, 2012 was reported<sup>2</sup> to be the 36<sup>th</sup> consecutive year of above average global temperatures. Using official data provided by the National Climatic Data Center, combined land and ocean temperature for the earth in 2012 averaged 0.57 degrees C (1.03 degrees F) above the long-term mean, making 2012 the tenth warmest year since global temperatures began being kept back in 1880. In spite of this warming trend, 2012 marked the fourth year in a row with below average tropical cyclone development across the globe. Based on data from the National Hurricane Center and the joint Typhoon Warning Center since 1980, the average number of named storms is 85 and the average number of Category 1 and above storms is 47. In 2012, only 82 named storms were recorded. For the seventh consecutive year, the number of hurricanes, typhoons, and cyclones were below the longer term average, with a total of only 44. So, while climate change (as indicated by global temperatures and other indicators) continues to proceed at a steady pace, the trend in intensity and frequency of major storms such as hurricanes, is not yet exhibiting a clearly discernible trend. This is not particularly surprising, given the many complex factors that ultimately determine the outcome of any particular tropical cyclone season in terms of the number of named storms and their intensity.

Even though current trends are unclear, in terms of frequency and intensity of major weather events as a result of climate change, this topic was addressed recently in an “Information Statement” on Climate Change<sup>3</sup> issued by The American Meteorological Society (AMS). The “Information Statement” is based on peer-reviewed scientific literature and is consistent with the vast weight of the current scientific understanding as expressed in assessments from the Intergovernmental Panel on Climate Change, the U.S. National Academy of Sciences, and the U.S. Global Change Research Program. The AMS “Information Statement” reports:

*“Weather patterns will continue to vary from day to day and from season to season, but the frequency of particular patterns and extreme weather and climate events may change as a result of global warming. Model simulations project an increased proportion of global hurricanes that are in the strongest categories, namely 4 and 5 on the Saffir-Simpson scale, although the total counts of hurricanes may not change or may even decrease.”*

*“... Drier conditions in summer, such as those anticipated for the southern United States and southern Europe, are expected to contribute to more severe episodes of extreme heat. Critical thresholds of daily maximum temperature, above which ecosystems and crop systems (e.g., food crops such as rice, corn, and wheat) suffer increasingly severe damage, are likely to be exceeded more frequently.”*

Thus, if one accepts this prevailing and scientifically supported prediction, we would be well advised to carefully examine extreme weather events as they occur in the coming years. By

doing this, we will be collecting information that may eventually allow us to improve our assessments and, ultimately, the outcome of such events.

Another aspect of climate change is that it holds the potential to increase property losses dramatically if it causes more severe (or frequent) damage from hurricanes, typhoons, floods, fires, etc. A long-term impact of increased severity (or frequency) of damaging weather events could be to drive up the cost of property and flood insurance in the areas where climate change is most likely to manifest itself, such as in communities that have coastal exposure or connections.

Also, there has been a recent trend for damage claims to be filed against companies that emit greenhouse gases in substantial quantities. The presumption is that certain site specific impacts that can be linked to climate change can also theoretically be linked to those emissions. Companies facing such damage claims may turn to their comprehensive general liability (CGL) policies for coverage. However, insurance companies may take the position that claims under CGL coverage are excluded, due to the common CGL exclusion for pollution related damage. The regulatory support for such a position has been evolving rapidly in recent years.

More specifically, in the often cited 2007 U.S. Supreme Court (Court) case (Massachusetts v. Environmental Protection Agency – 549 U.S. 1438 (2007)), the Court made a landmark decision that EPA's previous decision not to regulate carbon dioxide emissions under the Clean Air Act was arbitrary and capricious. In resolving that question, the Court addressed whether pollution includes greenhouse-gas emissions. In a 5 to 4 decision, the Court held that greenhouse gases, including CO<sub>2</sub>, are indeed air pollutants within the meaning of the Clean Air Act. As a result, the Court determined that the U.S. EPA "has statutory authority to regulate emission of such gases" (549 U.S. at 1443). In subsequent regulatory actions spurred by this decision, EPA has determined that emissions of greenhouse gases do cause endangerment of public health and welfare and, based upon that determination, EPA has begun to treat emission of greenhouse gases as pollution. This categorization opens the door for exclusion of such claims under CGL policies.

All in all, the potential insurance related aspects of climate change are very interesting. The case study that is presented below illustrates an issue that may become more common if the number and value of property insurance claims were to increase dramatically due to climate change. More specifically, the typical property insurance policy covers damage from wind, but excludes damage from flooding such as a storm tide. Property owners may choose not to purchase separate flood insurance, believing that they are far removed from the ocean coastline and that any property damage that they might incur is more likely to be caused by wind, or other non-flood related conditions. However, as this case study illustrates, remarkable damage from storm tide flooding is possible, even though a property is far removed from the ocean coastline.

### ***Case Study - Storm Tide and Wind Impact of Hurricane Sandy along the Hudson River***

This following is a case study regarding storm tide and wind impact of Hurricane Sandy along the Hudson River. The case study was initiated after an insurance claim was filed for property damage coverage in association with the damage from the storm. The question to be addressed in this instance was whether the specific property damage was caused by the wind or by the

storm tide. Insurance coverage in such circumstances can be complicated, since insurance coverage is often determined based upon the underlying cause of the damage.

The property damage in this instance involved a dock and related structures that were located on the Hudson River, some 30 miles north of the southern tip of Manhattan. According to the homeowner of this property (hereinafter, primary residence), the dock (Figure 1) was allegedly struck and damaged by a rogue watercraft (a fiberglass sailboat, estimated to be about 40 feet in length) belonging to a neighbor during Hurricane Sandy. The sailboat was securely moored offshore at a nearby boat club, approximately 0.6 miles north of the homeowner's residence at the onset of Sandy's effects. Ultimately, sections of the sailboat were found partially submerged adjacent to damaged sections of the dock (Photo 1). There were no witnesses to the damage due to the storm's severity, and the nighttime conditions (including lack of lighting) during the height of the storm.



**Figure 1. Detailed location map. Primary residence and adjacent properties.**





**Photo 1. Primary Residence (Looking Northeast). Remnants of Fiberglass Sailboat that Allegedly Struck Primary Residence Dock.**

### ***Review of Weather and Storm Tide Data.***

A summary of relevant storm tide data and hourly weather conditions from 2 PM on October 29 through 7 AM on October 30, 2012 is provided in Table 1. This was the period of time when the storm made landfall in Southern New Jersey, and initiated a storm tide that traveled far up the Hudson River. The data in Table 1 includes:

- predicted and actual observed tides, as well as the storm surge (difference between the predicted tide and the observed tide) at the National Oceanic and Atmospheric Administration (NOAA) station located on the Hudson River at The Battery in New York City; and
- Estimated predicted and actual tides, as well as the estimated storm surge at the primary residence. Estimated tide conditions at the primary residence were based on publically available data from locations in the vicinity, including Alpine, New Jersey (approximately 7 miles to the south; and, Piermont, New York, located approximately 10 miles to the south).

Observed hourly weather (wind direction, wind speed, wind gust) is displayed for the three closest observation points to the primary residence with quality assured data (from the National Climatic Data Center). These stations are White Plains, NY (Westchester County Airport),

which is 11 miles ESE of the primary residence; Teterboro, NJ (Teterboro Airport), which is 18 miles SSW of the primary residence; and, Newburgh, NY, (Stewart Airport) which is 30 miles NNW of the primary residence.

From review of Table 1, it is clear that the storm tide reached its peak at the primary residence between 9 and 11 PM on October 29, 2012 and corresponded with the predicted high tide. The storm surge (tidal departure above predicted tide) at the primary residence is estimated to have reached a peak height of 7.8 feet. Winds were from the east southeast and southeast during this period, blowing steadily between 24 and 43 miles per hour, with gusts as high as 66 miles per hour. Winds continued to blow from the southeast and south southeast during the remainder of the night at speeds generally ranging from 15 to 25 miles per hour, with gusts as high as 40 miles per hour.

**Table 1.****Summary of Tide and Wind Conditions on October 29 and 30, 2012 during Superstorm Sandy**

Date	Time	The Battery (NOAA Station #8518750)			Primary Residence			White Plains, New York (Westchester County Airport) 11 Miles ESE			Teterboro, New Jersey (Teterboro Airport) 18 Miles SSW			Newburgh, New York (Stewart Airport) 30 Miles NNW		
		Predicted Tide (Feet) <sup>1</sup>	Actual Tide (Feet) <sup>1</sup>	Actual Storm Surge Above Predicted Tide Due to Storm (Feet) <sup>1</sup>	Predicted Tide (Feet) <sup>2</sup>	Estimated Actual Tide (Feet) <sup>3</sup>	Estimated Storm Surge Above Predicted Tide Due to Storm (Feet) <sup>3,4,5</sup>	Wind Direction	Wind Speed (MPH)	Gust Speed (MPH)	Wind Direction	Wind Speed (MPH)	Gust Speed (MPH)	Wind Direction	Wind Speed (MPH)	Gust Speed (MPH)
10/29/2012	2:00 PM	-2.72	2.87	5.59	-1.09	2.79	3.9	NNE	28	49	NNE	23	55	NE	34	48
10/29/2012	3:00 PM	-2.25	4.14	6.39	-1.69	2.27	4.0	NE	25	51	NNE	25	45	NE	34	46
10/29/2012	4:00 PM	-1.17	5.58	6.75	-2.01	2.70	4.7	NE	21	48	NNE	23	44	NE	34	58
10/29/2012	5:00 PM	0.02	6.96	6.94	-1.69	3.70	5.4	ENE	31	54	NE	29	52	NE	40	58
10/29/2012	6:00 PM	1.04	8.61	7.57	-0.79	4.90	5.7	N/A	N/A	N/A	ENE	25	58	N/A	N/A	N/A
10/29/2012	7:00 PM	1.74	10.53	8.79	0.21	6.06	5.9	N/A	N/A	N/A	E	44	73	ESE	43	61
10/29/2012	8:00 PM	1.96	11.21	9.25	0.91	7.29	6.4	N/A	N/A	N/A	ESE	40	56	ESE	36	59
10/29/2012	9:00 PM	1.55	10.69	9.14	1.61	9.02	7.4	N/A	N/A	N/A	ESE	43	66	ESE	34	53
10/29/2012	10:00 PM	0.57	8.68	8.11	1.88	9.68	7.8	N/A	N/A	N/A	SE	24	43	ESE	34	53
10/29/2012	11:00 PM	-0.57	5.66	6.23	1.61	9.32	7.7	N/A	N/A	N/A	SE	32	44	SE	37	54
10/30/2012	12:00 AM	-1.53	3.69	5.22	0.91	7.75	6.8	N/A	N/A	N/A	SE	20	40	N/A	N/A	N/A
10/30/2012	1:00 AM	-2.28	2.30	4.58	-0.09	5.16	5.3	SE	25	39	SE	24	38	N/A	N/A	N/A
10/30/2012	2:00 AM	-2.63	1.10	3.73	-1.09	3.31	4.4	SE	22	34	SE	18	36	SE	23	40
10/30/2012	3:00 AM	-2.19	1.02	3.21	-1.59	2.27	3.9	SE	21	36	SE	23	33	SE	18	37
10/30/2012	4:00 AM	-1.01	2.03	3.04	-1.99	1.16	3.1	SE	16	25	SE	15	25	SE	17	29
10/30/2012	5:00 AM	-0.35	3.44	3.79	-1.59	1.12	2.7	SE	15	24	SSE	18	29	SE	17	29
10/30/2012	6:00 AM	1.48	4.15	2.67	-0.79	1.77	2.6	SE	15	N/A	SSE	14	32	SE	17	32
10/30/2012	7:00 AM	2.24	4.38	2.14	0.61	3.81	3.2	SE	20	32	SE	16	32	SE	17	32

1. Predicted and actual tidal date for The Battery (NOAA station # 8518750) was obtained from <http://tidesandcurrents.noaa.gov/geo.shtml?location=8518750>.

2. Predicted tide data for Alpine, NJ was obtained from <http://tides.mobilegeographics.com/locations/125.html?y=2012&m=10&d=29>.

3. Actual tide elevation and magnitude of storm surge above predicted tide were estimated based on the predicted tide at a gauging station located on the Hudson River in Alpine, NJ (located 10 miles south of the Primary Residence), and a USGS high water mark during Sandy, observed in Piermont, NY (located 2.7 miles to the south of Primary Residence). Both sets of data used for the estimates were referenced to the North American Vertical Datum 1988 (NAVD 88). The high tide at the Alpine Station on October 29, 2012 was predicted to occur at 9:59 PM, and this timing coincided with the peak of the storm surge. The predicted height variation between low and high tide at the Alpine Station for October 29 was approximately 4 feet. The high water mark observed in Piermont, NY was 9.68 feet above NAVD 88. Data regarding the high water mark in Piermont, NY was obtained from <http://water.usgs.gov/floods/events/2012/sandy/sandymapper.html>.
4. The timing of the peak storm surge was estimated in two ways: (1) based on the predicted high tide at the Alpine, NJ site, which was 9:59 pm on October 29, 2012; and (2) based on the actual time of the peak storm surge (approximately 8 pm on October 29, 2012) observed at The Battery ( NOAA station # 8518750), and the actual time that the peak storm surge was observed (approximately 5 am on October 30, 2012) at the USGS gauging station on the Hudson River in Albany (USGS station # 01359139). The difference between the timing of the two peaks is approximately 9 hours. The time of the peak storm surge at the Primary Residence was estimated to be approximately 10 pm on October 29, 2012 based on multiplying the time between the surges by the ratio of the distance between the station at The Battery and the Primary Residence (27.8 miles) and the distance between the station at The Battery and the USGS station in Albany, NY (approximately 135 miles) and adding that number to the time of the storm surge at The Battery. Actual tide data for the USGS station in Albany, NY was obtained from [http://nwis.waterdata.usgs.gov/usa/nwis/uv/?cb\\_00010=on&cb\\_62619=on&format=gif\\_default&period=&begin\\_date=2012-10-29&end\\_date=2012-10-30&site\\_no=01359139](http://nwis.waterdata.usgs.gov/usa/nwis/uv/?cb_00010=on&cb_62619=on&format=gif_default&period=&begin_date=2012-10-29&end_date=2012-10-30&site_no=01359139).
5. The National Hurricane Center has estimated that the riverfront areas in the Hudson River Valley experienced inundations ranging from 3 to 5 feet. Inundation is the total water level that occurs on normally dry ground as a result of the storm tide, and expressed in terms of height above ground level. Normally dry land is roughly defined as areas higher than the normal high tide line, or Mean Higher High Water. This information is reported on page 8 of the National Hurricane Center's report on Hurricane Sandy which may be found at: [http://www.nhc.noaa.gov/data/tcr/AL182012\\_Sandy.pdf](http://www.nhc.noaa.gov/data/tcr/AL182012_Sandy.pdf).

N/A Data Not Available



During this same nighttime period, the neighbor's sailboat was set free from its moored location due to the effects of Sandy. The boat was broken apart into several pieces and, ultimately, portions of the bow and stern were found partially submerged in the water adjoining the northeast corner of the homeowner's property (Photo 1). The final location of the remainder of the boat (including the central portion of the hull, the keel and the mast) is not known.

### *Site Visits*

On March 4, 2013, well after the effects of Sandy had been experienced, the author traveled to the primary residence and met the homeowner to conduct an inspection. The homeowner provided a tour to the area of his property adjoining the Hudson River (retaining wall, in-ground pool, gazebo, sea wall, fence, and the portions of dock that were not destroyed). During the inspection, it was observed that very little of the walking surface of the dock remained in place (Photo 2). Properties to the north of the residence (second property to the north) had a lawn and sea wall that were several feet lower than the sea wall at the primary residence (Figure 1). Photos (3 and 4) show details of the second property to the north of the primary residence, where substantial portions of dock walking surface remnants were found after the storm. The distance from the original dock location at the primary residence and the two main locations where the dock remnants were observed ranged from 300 to 450 feet to the northwest.



**Photo 2. From Original Dock Location: Remnants of Primary Residence Dock Looking East.**



**Photo 3. From Second Property North of Primary Residence Looking East:  
Substantial Portions of Dock Walking Surface Found.**



**Photo 4. From Second Property North of Primary Residence Looking Northeast:  
Substantial Portions of Dock Walking Surface Found.**



Subsequent to completing the visit to the primary residence, the Boat Club where the sailboat had been securely moored prior to the arrival of Sandy was visited. Boat Club personnel reported that approximately 34 of the boats moored or stored at the Boat Yard were declared a total loss as a result of storm damage. Approximately 15 to 19 boats broke free of their moorings, even though the Boat Club had enforced strict requirements for securing boats to their moorings prior to Sandy's arrival.

### *Summary*

- Sandy was a powerful storm, and the damage it caused was widespread throughout the New York and New Jersey region<sup>4</sup>. The storm's low central pressure created a large circulation that generated a truly remarkable storm tide. The Hudson River is an estuary from the lower New York City harbor (the Battery) northward past Albany to Troy, NY, 153 miles from the Battery. The storm tide generated by Sandy traveled from the Battery all the way north on the Hudson River to Troy, as the Hurricane made its landfall in southern New Jersey. A storm surge of approximately five feet above predicted tide was observed at a NOAA station in Albany, NY (approximately 135 miles from the station located in the Battery).
- While the storm tide reached a peak at the Battery at 8 PM (9.25 feet above predicted tide), it took a few hours for that peak storm tide to reach the primary residence, at only a slightly diminished height (estimated at 7.8 feet above predicted tide).
- The winds in the vicinity of the primary residence were very strong, blowing steadily from the east southeast and southeast at between 24 and 43 miles per hour during the height of the storm, with gusts as high as 66 miles per hour.
- The location where the remnants of the primary residence dock were deposited (Figure 1) is consistent with the estimated height and direction of the storm tide that appears to have deposited the remnants at that location. The dock was clearly picked up and moved into this location by the storm surge, which moved from south to north over the neighbor's adjoining seawall and lawns. By 5 PM on October 29, 2012, the storm surge was already five feet above the predicted tide and almost two feet above a normal high tide and was steadily rising. The highest point of the surge occurred at about 10 PM, after which the flow of the water would begin ebbing and turn southward. The location of the dock remnants are also consistent with the wind direction from the east-southeast observed during the period between 7 PM and 10 PM, which would have pushed the dock to the northwest. Therefore the dock most likely had broken loose and had been deposited on the neighbor's lawn before about 10 PM.
- It is very unlikely that the moored sailboat would have been set free from its mooring by strong winds alone, prior to the arrival of the peak storm tide<sup>b</sup>. The winds from the northeast during the early part of the storm (2 PM to 5 PM) were high (25-30 mph with gusts up to 50 mph) but not unlike other storms encountered in this area. These winds

---

<sup>b</sup> According to basic Newtonian physics, force is proportional to mass. The ratio of the mass of water to the mass of air is over 780 to 1. Hence, the force of the storm tide would be much larger than the force of the wind.

alone were unlikely to have broken the sailboat free. Since the peak storm tide is estimated to have reached the vicinity of the primary residence by about 10 PM, this is estimated to be the approximate time that the boat was set free from its mooring, give or take an hour or so. Once free, the boat would move with the flow of surge water and wind to the north and west, away from the primary residence dock. Once the direction of flow of surge water changed to the south at about 10 PM, the boat would have changed direction and moved southward with the water. Winds from the southeast probably pushed the sailboat up against the primary residence seawall as it traveled southward with the ebbing tide sometime after 10 PM. By that time, however, the dock must have already been deposited on the neighbor's lawn.

- Even if one considers the very unlikely event of the sailboat being set free from its mooring by strong winds alone, prior to the arrival of the peak storm tide, the observed conditions do not support the theory that the boat wrecked the dock for three reasons. First, the boat would have had to float southward, pushed by the northeast wind against the strong incoming tide on the Hudson River for about a mile, prior to about 6 PM, when the wind shifted from the northeast to the east-south-east. The boat would then have to have been brought northwestward by Hurricane Sandy's east-south-east wind field and storm tide prior to about 10 PM. This theoretical movement could conceivably have resulted in the boat being present at the Primary Residence dock at the same time as the peak storm surge. However, in such circumstances, one would expect that the storm surge would carry at least some remnants of the boat (if not the whole boat) to the same location where the remnants of the deck were found. No boat pieces were reported to be found near the dock remnants. Finally, fiberglass boats usually take the brunt of impacts with docks. It is considered unlikely that impacts with a fiberglass sailboat of this estimated size could cause the complete destruction of the dock.
- The most likely scenario is that the storm tide set both the dock and the boat free at about the same time, and initially brought the boat northward away from primary residence's dock, due to the movement of water and wind. The dock would also have been pushed northward onto the neighbor's lawn. After the storm tide began to slacken, the sailboat would begin its southward movement, being carried by the southward (ebbing) flow of the Hudson River. The strong east-south-east winds late in the storm pushed the sailboat up (or its remnants) against the primary residence seawall, near the location where it meets the seawall of the neighboring property immediately to the north, which is approximately 60 feet to the north of where the dock originally connected to the seawall.
- The final location of sailboat remnants (Figure 1), and the battered condition of those remnants (Photo 1) is indicative of repeated collisions having occurred with the sea wall and remaining dock structures at or near the primary residence.

To a reasonable degree of scientific certainty, the dock at the primary residence was torn loose and destroyed due to the force of the storm tide that was associated with Hurricane Sandy. The sailboat that was found near the dock's former location arrived at that location after the storm surge had receded. Even in the very unlikely event that the sailboat did impact the dock prior to the dock being carried away by the storm surge, it is more likely that the dock damaged the boat than the boat destroyed the dock.

## **Acknowledgments**

This author gratefully acknowledges the assistance in data review and analysis provided by Noelle Clark, Principal Engineer, and Chris Geraghty, Project Scientist, at Roux Associates, Inc.

## **REFERENCES**

1. Aon Benfield. Annual Global Climate and Catastrophe Report – Impact Forecasting -2012.
2. *Ibid.* page 11.
3. *Information Statement on Climate Change*; American Meteorological Society: Boston, MA, 2012
4. Blake, E.S.; Kimberlain, T.B.; Berg, R.J.; Cangialosi J.P.; and Beven, J.L. II. *Tropical Cyclone Report, Hurricane Sandy (AL182012) 22 – 29 October, 2012; U.S. Dept. of Commerce; National Oceanographic and Atmospheric Administration; National Hurricane Center; 12 February 2013.*

## **KEY WORDS**

Climate Change, insurance, Hurricane Sandy, Hudson River