THE RICHARD STOCKTON COLLEGE OF NEW JERSEY
COASTAL RESEARCH CENTER

Central Mantoloking, NJ October 31, 2012 following Hurricane Sandy looking north from the bridge to the Borough. The former shoreline along Barnegat Bay ran through the center of the photograph. This is where the tidal inlet breached through the barrier spit entered the bay.

New Jersey Beach Profile Network 2012 Annual Report on Shoreline Changes in New Jersey's Four Coastal Counties Raritan Bay to Delaware Bay Spring of 2011 Through Fall of 2012

Prepared for:
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July 31, 2013

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New Jersey Beach Profile Network
2012 Annual Report
On
Shoreline Changes In New Jersey
In the Four Coastal Counties
Raritan Bay to Delaware Bay

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Division of Construction and Engineering
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EXECUTIVE SUMMARY

The New Jersey Department of Environmental Protection (NJDEP) authorized the New Jersey Beach Profile Network (NJBPN) project in 1986. The report is divided into four coastal county segments and provides a summary of beach changes for that county. This year is unique in that Hurricane Sandy had such a profound impact on the beach/dune systems of the State, especially in Monmouth and Ocean Counties. Therefore, most of the traditional remarks have been set aside in favor of a focus on what worked, how well things did or did not work to protect or defend public and private development in each county.

All major beach restoration or hard structure projects were reviewed for performance and effectiveness. The seasonal changes are included, but largely in table form in the appendix. The individual site cross sections will show the four surveys, but include a short, immediate post-Sandy survey done between one and 15 days following the storm. Each segment of the coastline was individually published on the Coastal Research Center (CRC) website as soon as it was complete. This report attempts to combine all six Sandy reports plus a review of the seasonal changes prior to Sandy in a summary of this extraordinary event.

The photographs, cross sections, trend charts, and text focus on the impacts of Sandy but will review seasonal and year to year changes observed since the previous report. The report is also found on the website at www.stockton.edu/crc. Past reports are linked to the site so comparisons can be made to the **2011-2012** observations along the New Jersey coastline. .

The survey data was analyzed and evaluated to show changes in the four county shorelines and sand volume changes for the 18-month study interval. The three-month seasonal average sand volume changes for each county plus the 18-month summary are shown below. Beach nourishment projects in Atlantic County produced the extensive sand volume increases over this study period. Keep in mind that these average sand volume changes and the corresponding shoreline position shifts reflect conditions prior to Hurricane Sandy since the fall 2012 surveys were essentially complete by October 29, 2012.

	S 11 – F 11 Cu. yds/ft.	F 11 – S 12 Cu. yds/ft.	S 12 – F 12 Cu. yds/ft.	S 11 – F 12 Cu. yds/ft.
Monmouth County	**-0.68**	**7.91**	**-5.14**	**1.44**
Ocean County	**2.70**	**3.99**	**1.72**	**8.12**
Atlantic County	**17.29**	**10.19**	**13.83**	**35.31**
Cape May County	**-9.99**	**4.83**	**-1.77**	**-8.25**

The shoreline change values represent the derived difference in horizontal distance to the zero elevation position (NAVD88) from the reference monument on the two profiles being compared. Advances seaward are positive and retreats landward are negative. Each number shown below is the average change for all the sites in each county.

	S 11 – F 11 Feet	F 11 – S 12 Feet	S 12 – F 12 Feet	S 11 – F 12 Feet
Monmouth County	**10.61**	**20.29**	**0.32**	**31.22**
Ocean County	**17.16**	**20.56**	**-4.24**	**34.00**
Atlantic County	**17.29**	**10.19**	**13.83**	**35.31**
Cape May County	**-10.58**	**7.97**	**-13.66**	**-8.68**

Beach nourishment in Atlantic County produced the large average seaward advances in the zero elevation position (shoreline). Work on LBI at Brant Beach also increased the average shoreline position due to several 250-foot advances factored into the averages while the sand volume was more diluted across the entire county.

ACKNOWLEDGEMENTS

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INTRODUCTION:

The New Jersey Beach Profile Network (NJBPN) project provides local and regional information on coastal zone changes and is designed to document seasonal and storm-related damage assessments of the New Jersey shoreline. Each site has been visited annually in the fall since 1986. Semiannual visits, each spring and fall, began in 1994 following the passage of Public Law 93. The program was expanded to take surveys every spring following the winter northeasters and in the fall following summer beach accretion. In addition, new sites were established in the gaps of coverage and adjacent tidal inlet shorelines. The information collected consists of photographs of the beach/dune system at each site, a topographic profile of the dune, beach and seafloor to a minimum depth of 14-16 feet, and field notes on significant geologic changes. Also, construction activity is noted and necessary information regarding quantity and duration of such activity is gathered. The field data are used to generate graphical cross section plots, which can be used for comparison across the width of the active coastal zone. The cross section is also used to calculate sand volume and shoreline position changes. The 2012 report follows an in-depth analysis in 2011 looking across the 25-year history of the project and is the latest in a series of annual reports prepared for the New Jersey Department of Environmental Protection (NJDEP) that began in 1987. The information is arranged by county and sequential profile site location, and includes the survey cross sections, site photographs, and the description of significant changes. The tables of beach volume and shoreline change data are found after the county site descriptions for Cape May County. A summary of each county's coastal zone activities follows the county profile site location diagram.

THE NEW JERSEY COASTAL ZONE:

The northern coast in Monmouth County is considered a headland beach (carved into older geologic sedimentary units that created a sandy beach backed by a bluff of the older sediments) which erode during serious storm events. As a matter of fact, the erosion loss to the armored bluff between 1962 and 2012 was very minimal due to the abundance of timber, rock, steel and concrete used to prevent it. The impact of Hurricane Sandy changed much of this by producing over 30-foot breaking waves that damaged or destroyed multiple levels of revetment or bulkhead construction frequently exposing the old sediments of the uplands to erosion. Several locations saw retreat in the order of 30 to 50 feet with the sediment distributed along the shoreline just as it has for thousands of years. Centuries of this sort of erosion had created two major sand spits, one to the north from Long Branch (Sandy Hook), and the other to the south from Bay Head (Mantoloking to Barnegat Inlet). To the south of Barnegat Inlet, barrier islands compose the remainder of the NJ coastline where individual islands are separated from the mainland by a series of bays and tidal lagoons. These islands provide no local sand supply to the beach and as a result the shoreline moves landward with rising sea level.

Sandy's impact strongly reinforced the time-honored thesis known to coastal geologists that time, storms and sea level rise all result in landward migration of the sand shoreline due to storm impacts. Sand is transported across the barrier beach into the bay or lagoon adding to the landward edge of the barrier and moving the entire coastal landform up the existing coastal plain slope that comprises the four coastal New Jersey counties. New inlets formed, overwash buried the salt marshes on Long Beach Island, and Barnegat Bay received tens of thousands of cubic yards of sand and debris that removed sediments from the beaches and dunes and transported them westward into the bays. Early recovery efforts as the CRC survey crews conducted the post-storm work were focused on removing this sand from the roads and properties on the islands and returning as much as possible to the beaches.

STORM EVENTS IN 2009-2012

Between December 1992 and November 2009, the New Jersey shoreline received just one Federal Presidential Disaster Declaration due to a northeast storm February 6, 1998 (applied only to Cape May and Atlantic Counties). Since the "Nor-Ida" combination storm of November 11, 2009 there have been three northeast disaster declarations and two hurricanes (Irene 2011 and Sandy 2012). The three northeast storms preceded Hurricane Irene, which made landfall in New Jersey as a strong tropical-storm in late August. There was an additional northeaster October 29, 2011, but no declaration for that event.

Hurricane Sandy crossed the New Jersey coastline exactly a year later, also as the combination of a late season hurricane that was fading into a tropical storm and a strong cold front that wrapped around the hurricane circulation generating an enhanced wind field that extended across a 1,200 mile diameter in the western Atlantic. A blocking high pressure cell over Greenland forced an unusual left-hand turn to the west and allowed Sandy to make an abnormal shoreline-perpendicular crossing just north of Atlantic City during the evening of Sunday October 29, 2012. This crossing point created two differing impacts between limited shoreline damage due to waves in Cape May and Atlantic Counties (flooding in the back bays excepted) and catastrophic shoreline losses in Ocean and Monmouth Counties extending into New York Harbor and Long Island. This extreme damage was compounded by storm surge flood tide elevations of up to 14 feet NAVD88 in NY Harbor and wave run up on dunes in Long Branch, NJ of 24 foot elevation. The type of approach meant that the southern counties did not have a second high tide accompanied by 80 MPH on-shore winds because the wind reversed direction as the storm center came on land. The northern counties saw the second high tide Sunday night slash through battered dunes and pour waves and water across the barrier beaches and over most all protective structures. The tidal surge flooded areas surrounding Barnegat Bay and pushed into Shark River, Manasquan River, Navesink and Shrewsbury Rivers plus opened several coastal fresh water lakes to marine flooding for the first time in decades (Wreck Pond, Lake Como, Wesley Lake, Deal Lake, and Tackanassee Lake, all in Monmouth County).

Barnegat Bay was especially impacted by the disaster. Tide elevation gauges in the bay showed that the strong northeast winds were pushing bay water south, away from Bay Head, the Toms River, Mantoloking, etc with successive high tides in the bay actually slightly lower each cycle as the storm approached land. Water flow at a USGS stream gauge in the Manasquan Canal showed nearly constant in-flow with almost no ebb-tidal flow during the two days just prior to the landfall. The tide elevation shot up 5+ feet in two hours as the breach and overwash occurred on October 29-30th and the stream flow dramatically reversed in the Manasquan Canal to all ebb-directed flow that continued for two days after the storm. It also took the same two days for the tide elevation to return to a normal high tide range at the Herbert Street gauge site.

The Richard Stockton College of NJ Coastal Research Center (CRC) initiated a post-storm survey and assessment of the New Jersey shoreline in response to severe beach erosion resulting from the impact and landfall of Hurricane Sandy. The field work started October 31, 2012 in Cape May County and continued northward into northern Monmouth County by November 26, 2012 as clean-up work continued to remove debris. Any sand excavated from roadways was being returned to the beach and is included in the survey cross section since it is now part of the post-Sandy beach.

Each of the other surveys was completed within the seasonal windows used for this study. The cross sections all show the spring of 2011, fall of 2011, spring of 2012, the SANDY survey, and fall of 2012. As fate would have it all the sites in Cape May, Atlantic and Ocean Counties had been surveyed prior to October 29, 2012. Work had been completed in southern Monmouth County as well, leaving only the sites in Raritan Bay, on Sandy Hook and north of Long Branch to be surveyed to normal depths following Sandy.

Hurricane Sandy:

The coastal segment between Long Branch to Sandy Hook was the shoreline where the New York District Army Corps of Engineers conducted its Phase I Shore Protection Project between 1994-1996 (initial contract for Monmouth Beach to Sea Bright) and 1997-1999 (for Monmouth Beach to Long Branch). There have been several maintenance contracts conducted in this reach to address erosional "hotspots" (1997, 1999, 2002, 2010 and currently in Monmouth Beach December 2012). The 2011 Coastal Center 25-year report evaluated the sand quantity remaining within this reach at the 12 sites within the project extent at between 14% and 116% of the initial placement volume. The phase I reach between Sandy Hook National Seashore and the Elberon/Long Branch border did have several maintenance fills (1997, 1999, 2002, 2009, a minor addition in 2010 and the current project underway in late 2012). However, there are two significant points of erosion that have hampered the overall project success. There is a large rock groin at the Cottage Road site (#179) that blocks sand movement along the beach. Since sand moves north, this site is perpetually starved for sand moving into the area from the south. The second location is #173 at West End in Long Branch where the project ends moving south. Elberon and Deal did not participate in the initial project, so sand leaves West End moving north leaving erosion the only option. No sand arrives from the north except during a northeaster. The best evidence for this was the limited success for the 2009 maintenance project focused on the West End site that declined by over 50% between 2009 and 2011. The Morris Avenue location 5,000 feet north benefited substantially within 6 months however.

Another issue with the Long Branch to Sea Bright segment of the Army project was the failure to include a significant dune system in the original plan. The presence of the 28-foot high Sea Bright seawall and a 20+foot high natural bluff in Long Branch armored with rock and steel meant that the dune was more or less an after thought to the project's effectiveness. Initially, two lines of sand fence were erected in Sea Bright with grass planted between them. No initial ridge of sand was designed or built, so the dune system evolved naturally as grass spread and the wind transported material toward the fencing. As a result after 12 years, the dune was irregular, varied greatly in width and elevation and was positioned a considerable distance from the rock wall. There was no dune system in Long Branch due to a very high tourism usage. Grass plants did colonize at the toe of the rock revetment, but no consequential dunes developed.

The major observation was that Sandy's waves were dramatically higher upon breaking than they were further south, especially south of the center of rotation for the storm. Damage seen in Deal and Elberon demanded that waves exceeded 30 feet in NAVD 88 elevation levels on breaking on the bluff. The Pullman Avenue site saw two homes with foundation elevations at +28 feet destroyed and a third of the lot transformed into empty space where the land once stood. The Lake Tackanassee site was obliterated and the entire Long Branch boardwalk on the top of the bluff was destroyed. These huge breakers essentially bulldozed the berm, beach and irregular dune system to the base of the massive Sea Bright seawall, and then ramped up that slope, over the wall and slammed down onto the space between the highway and the wall. The gaps in the seawall were exploited in a devastating manner in the Borough of Sea Bright especially in the town center where the municipal public beach is located in a gap in the rock seawall. Sandy just blasted through this gap with awful consequences. Lake Tackanassee remained closed to tidal flow until a northeast storm March 6, 2013 opened this small estuary lake back to tidal circulation. Sandy toppled over a row of concrete barrier wall segments that remain in an irregular pattern along the beachface, but the ebb-flow drainage from the lake is restricted by an ancient corroded steel bulkhead that was long buried in sand landward of the concrete sections by about 150 feet. High tide submerges the entire entry with flow limited by the elevation difference between high and low tide. At low tide a drainage stream flows down a gradient from the remnants of the steel bulkhead to the low tide elevation at the ocean. This inlet will close naturally as sand is transported into the opening and generates a bay-mouth barrier above the average high tide elevation.

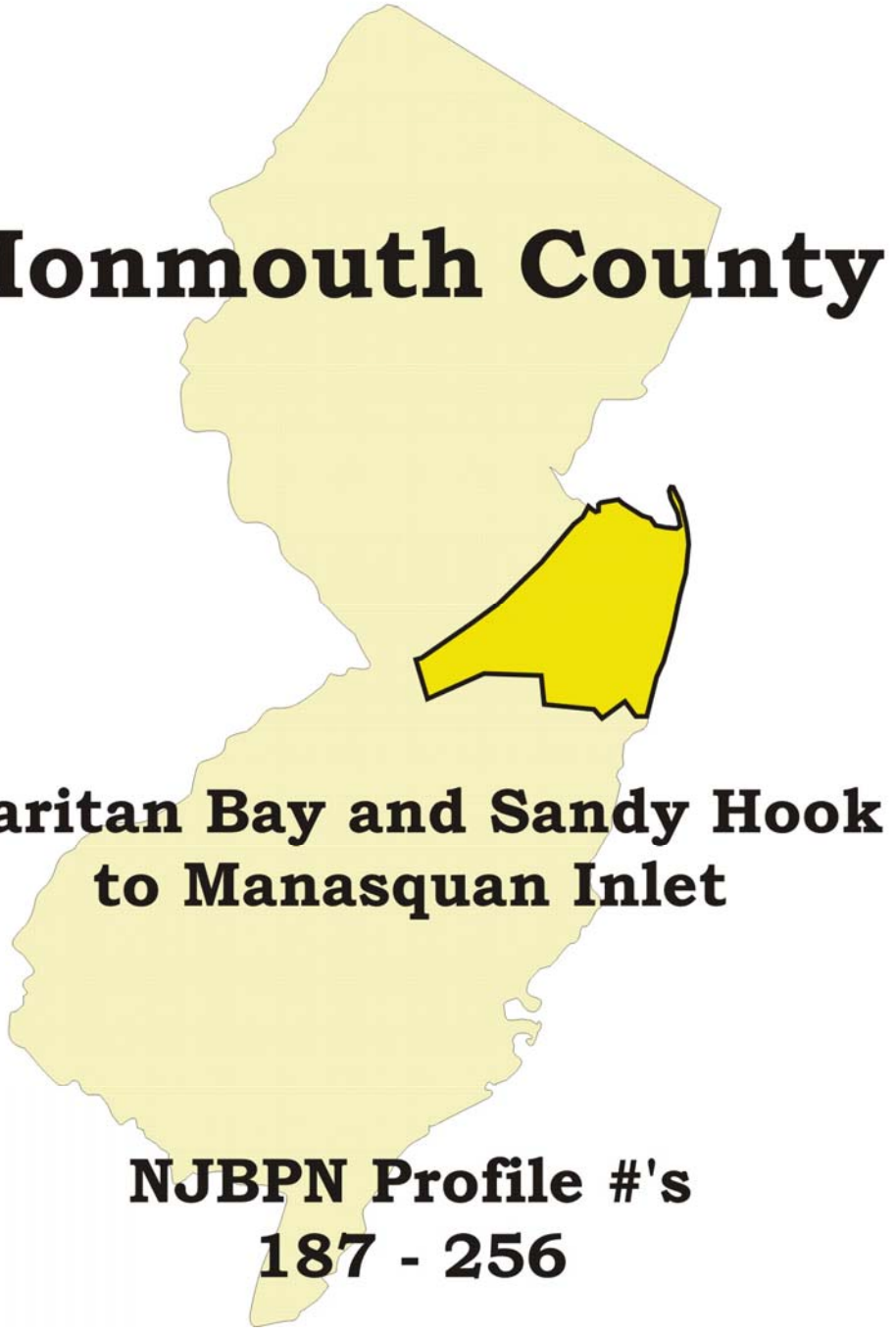
Beach/Dune Damage Assessment by Municipal Island Segment:

To measure the erosion, pre-existing New Jersey Beach Profile Network (NJBPN) monitoring sites were used to provide an accurate comparison and assessment of storm related shoreline and beach volume changes. Using the data from those sites surveyed for fall 2012 NJBPN survey, completed in Monmouth County by October 12, 2012, provides a good baseline for damages that occurred during the hurricane. For those sites not yet surveyed, data from spring 2012 was used for comparison. Data collected at the 15 oceanfront beach profile locations was done November 12-26, 2012 using RTK GPS and extending from the reference location, across the dunes, beach and into the surf to wader depth and by traditional survey methods (swimmers going to -16 feet of water) at those sites not yet surveyed during NJBPN fall 2012 survey. By the 12th, it was clear that sand recovery was well under way as a berm had been deposited on the erosional surface generated by Sandy with a substantial offshore bar present in water less than 5 feet deep offshore. However, in some locations massive amounts of sand had been transported inland and were being returned to the beach. Very little sand was transported over the bluff or steel wall in Long Branch, but wave damage was evident from moving water. Substantial sand volumes were moved over the Sea Bright seawall and through the gaps in the rock wall. This was being hauled back to the beach.

Profile Locations: Site locations in Deal, Elberon, Monmouth Beach and Sea Bright were not surveyed during fall 2012 prior to the arrival of Sandy, the Long Branch sites were surveyed on October 5 & 8, 2012 and all sites again post-Sandy through November 26, 2012 (Figure 1). This report covers the New York District Corps of Engineers Monmouth County Shore Protection project's initial Phase I where sand was placed from the border with the National Sea Shore, south through Sea Bright, Monmouth Beach, and Long Branch, NJ late in the 20th Century into the first two years of the 21st Century. Maintenance work was done on Phase I beaches in places, but none has been preformed on the southern segment (Phase II) between Asbury Park and Manasquan Inlet. Based on the performance of the fill project, clearly the dune system's design needs to be evaluated and a new approach implemented along this pair of Monmouth County reaches as the post-storm data is processed and analyzed.

New Jersey Beach Profile Network

Monmouth County



Raritan Bay and Sandy Hook to Manasquan Inlet

NJBPN Profile #'s 187 - 256

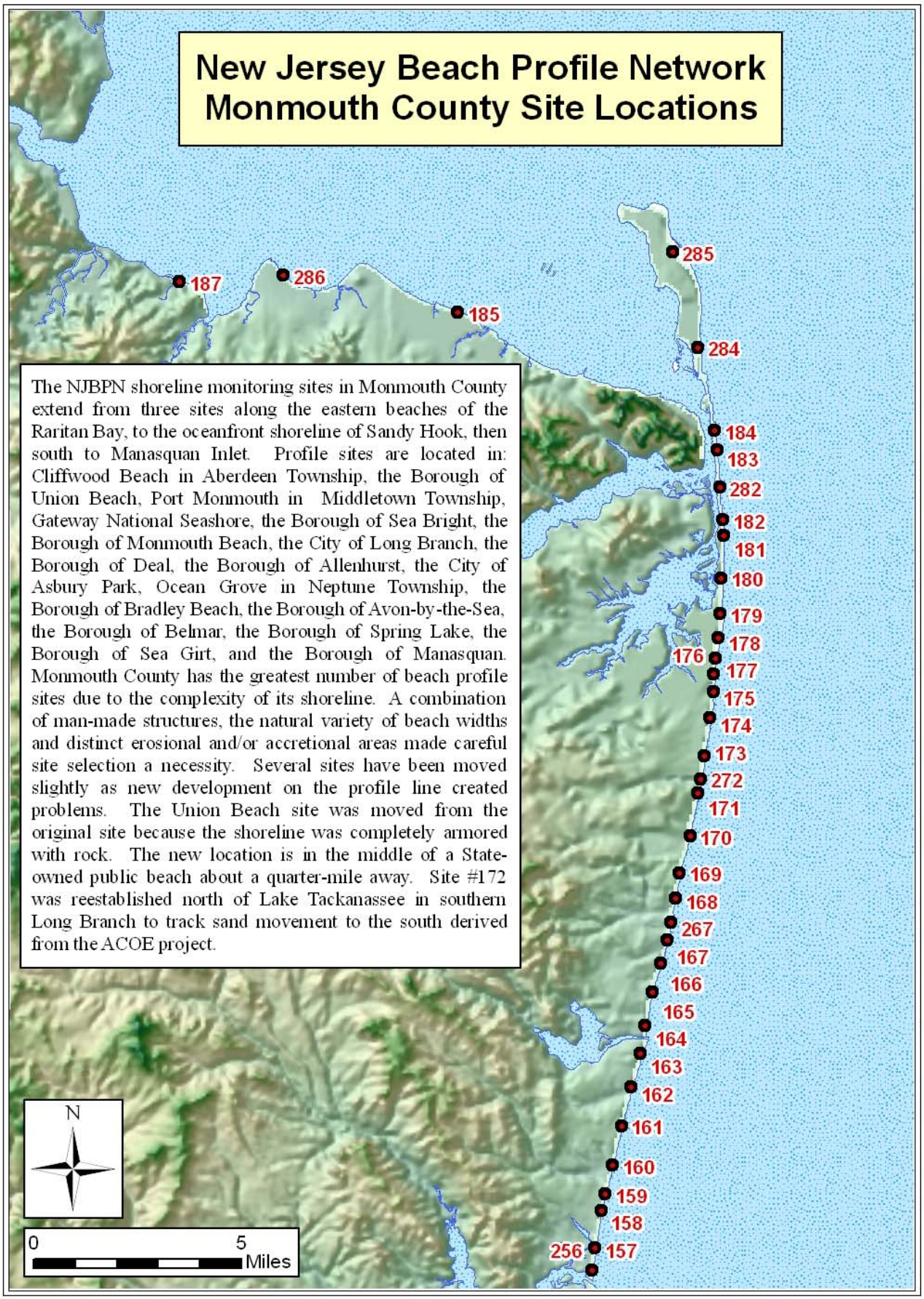


Figure 1. Survey site locations in Monmouth County.

Individual Site Descriptions:

Locations in along the Monmouth County oceanfront were surveyed following Hurricane Sandy on November 12 and 13, 2012. The profile line was covered using RTK-GPS with data points on the dune, beach and shallow offshore regions. In all cases, the very visible offshore bar could not be reached due to water depth and wave action. The sand loss calculations compared the fall 2012 pre-storm data to the post-Sandy survey and apply to the dune/beach system only and do not account for a percentage of sand dragged offshore by Sandy's waves, to return later in time. This recovery process was clearly underway by early November. A berm and small bars had already attached to the shoreline above low tide in multiple locations. All sites were either surveyed to normal depths offshore, the majority prior to Sandy, a few following the immediate post-disaster surveys (Sandy Hook for example).

Cliffwood Park, Aberdeen; #187

This is a small County Park, established shortly before surveying commenced in 1986. The shoreline faces north, northeast into Raritan Bay and is subject to a significant wave fetch across the bay.

Union Beach; #286

The Union Beach site is now located in the middle of the municipal bathing beach on Raritan Bay. Formerly, positioned about 1,000 feet south along the bayshore, the old site was hardened with rock revetment over ten years ago and this effort virtually eliminated any change above low tide. The site was moved to provide more meaningful data on bay beach changes.

Spy House Museum, Port Monmouth; #185

The easternmost site along the Monmouth County Raritan Bay shoreline is positioned west of Highlands and Atlantic Highlands at a Monmouth County Park site dedicated to an historic building dating to the revolution. Significant shore rehabilitation work preceded Hurricane Sandy and served to absorb some of the impact.

Gunnison Beach, Sandy Hook National Seashore; #285

Three additional cross sections were established 18 years ago to collect data on sand volumes being added to the National Seashore. Gunnison Beach is the northernmost site, but still a substantial distance south of the tip of Sandy Hook spit. Access to the shoreline further north is restricted by limited roads.

Parking Lot E, Sandy Hook National Seashore; #284

This public bathing beach was selected because it was located in the middle of Sandy Hook and represented both a public use area and an easy access point to conduct surveys.

Highlands Beach, Sandy Hook National Seashore; #184

The southern site was initially established as the terminal location for the oceanfront beaches because it was felt that the Federal shoreline was not a State responsibility. After almost a decade of work it seemed obvious that the rest of Sandy Hook needed to be covered if only to understand what transpired along the Sea Bright beach section. Sand was being lost, so where was it going. The two new sites on Sandy Hook have answered that question ever since.

Via Ripa, Sea Bright; #183

This northern location lies just south of the bridge to Atlantic Highlands across the entrance into the Shrewsbury and Navesink Estuaries. The beach was at 74% of the initial Federal project placement sand volume and waves ran up and over the wall, but in a lower magnitude based on the sand found landward of the wall. Also, there was a much smaller ramp leading to the top of the wall on the sea side. Located closer to the fetch limit produced by Long Island, perhaps the waves were simply smaller.

Shrewsbury Way, Sea Bright; #282

This site was the only northern Monmouth County site along Phase I Federal project that had exceeded the initial sand volume placed on the beach (116%). Even so, the storm waves broke over the Sea Bright seawall as they ramped up the sand against the rocks allowing wave run-up to crest the 28-foot wall. The beach profile was reduced in elevation and width.

Sea Bright Public Beach, Sea Bright; #182

The next location north was obtained by NJ State purchase 25 years ago and converted into a public bathing area with some off-street parking. There was a modest dune at the toe of the rocks, but the waves ramped up and over the rocks using that sand as a deposit forming the ramp. In addition there was a timber bulkhead protecting a 20-foot wide gap in the rock seawall at this location. Sandy blew through the timber section and poured into Ocean Avenue with sand, debris and lots of salt water. This compounded the water coming in from Raritan Bay making flooding the worst ever recorded. This beach contained 98% if the initial Federal project's fill material as of fall 2011. No dune existed other than grass growing at the toe of the rock seawall. The post-Sandy survey showed a narrower and lower elevation beach with an as yet unknown ratio of sand lost offshore versus sand transported through the gap or over the seawall.

Sea Bright Municipal Beach; #181

The peninsula widens here to include commercial businesses on both sides of Ocean Avenue plus parking for the beach. However, no rock seawall extended across a several hundred foot gap at the municipal beach. An ancient timber bulkhead was the back shot position for the survey and it had gaps cut in it to allow easy public access to the beach. The resulting storm wave damage and tidal flooding was intense and destruction was wide spread and devastating. The situation was made worse because both the fire company and the police station were located between the municipal beach and Ocean Avenue. Both were gutted by waves. Debris impacted businesses on the west side of Ocean Avenue while the storm surge flooding into Raritan Bay flowed up the Shrewsbury and Navesink River Estuaries compounding the disaster. While the beach is still present, it is narrower and lower in elevation with a massive amount of sand moved landward into Sea Bright Borough.

Sunset Court, Sea Bright; #180

The next location north of Cottage Road maintained 45% of the initial sand volume placed in 1999. The repeated deposition of maintenance material at Cottage Road moved north through this location. There was no dune, other than grass here and there among the rocks of the seawall. Storm waves over-topped the wall in quantity and caused flooding and debris damage that kept the highway closed for weeks to general traffic. A lower, narrower beach remains, but the restoration process is underway just to the south.

Monmouth Beach Club, Monmouth Beach; #178

Monmouth Beach has two survey sites, one at the Beach Club along Ocean Avenue between Vista Court and Valentine Street and the second located at Cottage Avenue near an offset in the seawall and extended groin that protects the Private Beach Club located along Ocean Avenue between Beach Road and Cottage Avenue.

The Valentine Street site is located on the premises of the venerable Monmouth Beach Club with the survey starting point in the landward segment of the timber deck overlooking the seawall. On the day of the post-Sandy visit, three excavators were picking apart the ruins of the entire facility and transferring the debris into huge dumpster vehicles for transport to the staging area. The beach was much lower and narrower because only 53% of the initial sand volume was still present from the Federal project. In addition, no dune had been designed into the project, but irregular sand dunes had appeared over time by natural growth processes. These dunes failed to stop the wave attack.

Cottage Road, Monmouth Beach; #179

The Cottage Road location has been the poster for "Hot Spot" erosion in an otherwise very successful Federal beach restoration project. Here a massive stone groin was privately built decades ago to restrict sand movement north from the beach fronting an equally venerable coastal recreational edifice from the 19th Century. The groin obviously serves its intended purpose, but to the detriment of the Federal beach project's durability just north of the groin. The Cottage Road site commenced losing sand as soon as it was completed. Losses were replaced in 1997, 1999, 2001, and modest sand volume was added in 2010 from Shrewsbury River dredging. Currently a contractor has the site closed to anyone not involved in the construction project as a 2012 restoration starting here and moving northward is underway. There is only a narrow, dry beach that gets wet to the rocks under normal wave action at high tide. Sandy barreled over the seawall, dumping many thousands of tons of seawater into the highway making storm surge flooding worse. The beach is in the process of being replaced by sand dredged from the approved borrow sites as this is being written.

Ocean Avenue Long Branch; #177

This site was once a USO non-commissioned officer's beach recreation area for Fort Monmouth personnel. Presently part of the Seven-Presidents Park system belonging to Monmouth County, this site was part of the Federal Project and retained 72% of the initial fill sand volume. However, Sandy rolled across the beach to Ocean Avenue and transported abundant sand into the roadway. Clearing was nearly complete so traffic was moving slowly by, but more work needed to be completed. Nearby businesses were flooded by the combination of storm surge and wave overwash.

Seven Presidents Park, Long Branch; #176

This site was converted into open parkland space 20 years ago with the purchase of all commercial and private buildings near the waterfront. The area has 25 foot dunes with several prominent gaps to allow public easy access to the beach. The Federal project was completed here in 1999 and 74% of the initial sand placed was still present in October 2011. The cross section is located at the southern gap in the dunes, so storm damage in the form of abundant sand washed landward into the parking lot was evident. Park employees were busy scraping up the sand and returning it to the beach to clean up. The park public use buildings were inundated, but built to take impacts, so remained standing, if wet. The remarkable event was the discovery that wave run-up on the immediately adjacent dunes went to their crest. The GPS elevation of the dune crest was 24.6 feet

NAVD88, so Sandy's waves registered over 10 vertical feet more run-up elevation than measured in Avalon or Atlantic City south of the hurricane eye. This is strong evidence of the massive difference in storm damage seen in Ocean, Monmouth Counties in NJ (plus NY) as compared to Cape May and Atlantic Counties south of the landfall point for the center of storm rotation.

Broadway Avenue, Long Branch; #175

Here the Corps project beach was at 79% of the as-built sand volume in the fall of 2011. Sandy's waves rolled across this beach as well and impacted the steel wall protecting the bluff. Water crashed down on the paved promenade without incident and cascaded into the new development causing minor flooding and damage. The high-grade railing along the edge of the promenade was bent landward and would need replacing along much of the distance. The beach was lower and narrower, but still in place with a sizable offshore bar just offshore.

Morris Avenue, Long Branch; #174

The City was in the process of hauling sand to Morris Avenue where it was being sieved to remove debris and returned to the beach. The beach was reduced in elevation, width and ramped up against the revetment somewhat. There was a significant offshore bar moving landward that almost reached the low tide position and was included in the wading survey.

West End Avenue, Long Branch; #173

Located near the southern end of Phase I within the NY District Corps of Engineers Monmouth County beach restoration project, this site has a rock revetment protecting the base of the bluff, with the boardwalk positioned at the edge of the bluff some 15 feet above the revetment. The former Ocean Avenue was a four-lane highway with a grass median and a grass strip between the roads and the bluff edge before the boardwalk that was located on the beach perched on concrete supports. During the 1950's hurricanes and northeasters carved away at the bluff, destroyed the old boardwalk and reduced Ocean Avenue to the southbound two lane roadway with a tiny grass plot seaward of it. Long Branch abandoned the old Ocean Avenue in the 1970's; locating a modern highway a block inland and parallel with Ocean Avenue extending south into Elberon. The rock revetment was built and the boardwalk was placed on the narrow remnant of grass east of the southbound roadway. In 1999 the initial beach replenishment was completed giving this location a 250-foot wide beach, but no dune was included. Sandy rolled over the beach and struck the revetment with massive force tearing out the bluff under and the boardwalk over the grass strip. The erosion extended to the concrete curbing bordering the old roadway. Water damage existed on properties landward of the roadway as evidenced by debris and sand deposits.

Lake Tackanassee, Long Branch; #272

This new cross section designed to replace original site #172 abandoned years ago was positioned just south of a series of major condominium complexes between West End Avenue and the Lake. This is the northernmost "estuary lake" along the Monmouth County shoreline and, like the others has a fresh water drainage system buried under a bay-mouth barrier. There is no bluff here, so the storm waves simply rolled over everything in their path to the lake where Ocean Avenue crosses it on a bridge structure. An historic life-saving station converted to a bathing complex was utterly destroyed. All traces of the beach survey established two years ago were gone, so the site was navigated to using the GPS coordinates for the reference monuments. The profile ran up-grade to a point where the slope reversed down-grade seaward into the water. An offshore bar was present

as well. Multiple individuals with metal detectors were busy finding coins long buried by sand now washed landward toward the lake. The abundance of metal artifacts was such that this author picked up two silver 25¢ coins on the beach surface while doing the post-storm survey. The sand loss was extensive and the structural damage was total.

Pullman Avenue, Elberon; #171

The single cross section located in Elberon at Pullman Avenue demonstrated the susceptibility of even the high bluff located here (28 feet NAVD88) to major erosion from the storm surge and waves generated by Hurricane Sandy. Homes built at the bluff edge were destroyed by waves with about a third of each lot's width inland gone. The rock revetment and timber wall account for about 40% of the bluff height and were unaffected. Apparently waves broke on the revetment with crests at least 35 feet high because both homes were smashed in on the seaward side. This was not from wave spray on impact with the fortifications. The end of Pullman Avenue was eroded landward by about 50 feet.

Roosevelt Avenue, Deal #170;

The Roosevelt Avenue site is located north of the Deal sewage pumping station built in 1906 at the base of the sedimentary bluff. It is essentially a three-story building with just the top story presented at the end of Roosevelt Avenue. South of this street is a series of private homes built on the bluff with a decent sand beach seaward of the dune-mantled bluff edge. Phillips Avenue is the location of a public bathing complex that was totally destroyed by the loss of the Phillips Avenue fishing pier built decades ago over the rock groin at the end of Phillips Avenue. North of Roosevelt Avenue there is essentially no dry beach between closely-spaced groins. Site #170 has a 26-year history of a wet beach against the rocks. Occasional offshore bars have migrated to the shoreline yielding a temporary dry beach less than 25 feet in width. Sandy's waves over-topped the rock wall and scoured deeply into the soil, fill debris (bricks etc.) and bluff sediments. Water poured landward flooding both Roosevelt and Ocean Avenues to 3-foot depths as seen in debris lines on nearby properties. The tile roof was torn off the seaward side of the sewer plant pumping station and all three floors of the facility were filled with seawater. Deal's $650,000 investment in rehabilitation of the facility last year was in ruins.

Southern Deal;

Deal is divided from Allenhurst by a massive boxed pair of groins that retain all sand on the Allenhurst beach, letting none past to the north. The Darlington Avenue site is about a mile north into Deal and was picked because there was a pocket beach centered at Darlington Avenue extending several blocks in either direction. The sediment bluff, once exposed 25 years ago had been armored by individual property owners over time with timber bulkhead "seawalls". The beach varied little over time. The wave forces over-matched the newer timber structures smashing them to rubble and exposing an erosional scarp in the bluff sediments. In 50 years, I have never observed so much of the Cretaceous sediments that comprise the Monmouth County uplands exposed to view. The retreat at the top of the bluff was about 25 feet of loss to the oceanfront property owners in a very irregular pattern. Those who chose to build a beach cabana at or near the sand at the base of the bluff lost it to splintered wood. One was concrete and suffered the same fate because the storm undermined its foundation. Old structural relicts, never seen earlier were exposed on the lower beach with a bar offshore where the sand had been carried and deposited. With the erosion noted in the bluff, this little beach likely gained sand volume the time-honored way by storm erosion of the bluff sediments.

Allenhurst – Loch Arbor;

The site #168 at Allenhurst sits on top of an ancient concrete wall that drops vertically to the sand beach. There is a wooden walk elevated above the road just landward of the concrete wall. It was at this site that we came to realize the power of Hurricane Sandy's wave forces. The boardwalk is 20 feet above sea level, behind a vertical concrete wall located about 100 feet from the low tide line on the beach. About 50 feet of the boardwalk was stripped from the supports and shifted toward the roadway with ample evidence that waves had moved across the lawns of the major houses further landward. A well-clipped hedge was pushed over landward with debris threaded through it and the grass landward was dying from salt water with loads of small debris all over it. Down below, the beach was present, ramped up to the wall's base. Two massive slabs of concrete had settled downward and slightly outward at the base indicating that failure was threatened during the height of the storm. There was a recovery berm and offshore bar along the entire segment between the Deal boundary groin and the Deal Lake flume. Loch Arbor is only a two-block shoreline with half public beach and half in private ownership. There has been a long history of storm waves washing through the private beach club into Deal Lake. This clearly had occurred as the road across the "estuary" lake bay mouth barrier was still closed. Deal Lake is the largest of the now-closed stream estuaries along the Monmouth County Shoreline. It has been mapped as open to the tide flow as late as 1880, but closed by 1889. There was no paved road across the bay mouth sand bar until after 1920 according to the earliest aerial photography. There is a sizable weir and boxed flume carrying freshwater seaward to drain the lake. This was still functioning though sand had spilled into the lake at the seaward end. No Federal Project sand was deposited along this short segment, but over the past 13 years material has escaped by the large terminal groin in Asbury Park enhancing this small reach.

Asbury Park;

The Federal project beach in Asbury Park had no dune, but the sand was ramped up to the elevation of the boardwalk. As a consequence, at both survey sites there was minor decking damage, some railings destroyed and the majority of the wave energy passed over the boardwalk into Ocean Avenue. Sand was in front of business establishments on the landward side of the boardwalk with flow at each street end. Sand was being hauled to the 7th Avenue site where sieving equipment was separating debris from the sand prior to it being returned to the beach. Sand recovery from offshore was also well underway.

Ocean Grove;

The southern half of Ocean Grove was still in the process of having Ocean Avenue cleared of a thick sand deposit with the material being hauled back to the beach. The boardwalk was broken up and the dune system was gone. To the north of Main Street, things improved with remnant dunes in place, little sand in the street and an intact boardwalk. At Ocean Pathway the dune remained as did the large, open, but roofed over seating area seaward of the boardwalk. The dune remained with the instrument monument about 1.5 feet from the scarp.

Bradley Beach;

The McCabe Avenue site had some damage, but fared better than most locations. The dunes did survive in places and kept the worst of wave impacts out of the City. Storm surge flooding did occur with damage to some structures and boardwalk sections. Sand was being hauled back to the beach which was recovering with a berm and bar close to the shoreline.

Avon-by-the-Sea;

Avon has one site located at Sylvania Avenue where damage to the boardwalk was extensive extending to the structures adjacent to the boardwalk. Sand occupied Ocean Avenue with evidence of wave damage to businesses on the far side of the roadway. Avon had a "landscaped" dune that did little to protect the infrastructure, so once the waves crossed the beach, there was little to prevent them from dissipating their energy on the infrastructure. The same offshore bar and recovery berm was present on the beach here as everywhere else.

Belmar;

Belmar has two survey sites, one at 18th Avenue and the second at 5th Avenue near Shark River Inlet. The Belmar beach has a boardwalk between it and Ocean Avenue that suffered damage but was still largely present. Sand was in Ocean Avenue and was partially cleared. Belmar would push up a sand ridge in the late fall to act as a minor storm barrier, but it is not known if that had been accomplished prior to Sandy. The beach width had been reduced, but berm growth was underway with offshore bars present at all locations along this reach. Shark River Inlet separates Belmar from Avon-by-the-Sea and was a major source of storm surge flooding to low-lying parts of all communities surrounding this estuary. This was clearly in evidence by the rows of debris piled along the streets, observed in some detail since both highway drawbridges were up and out of service requiring the crew to detour to Highway 35 inland.

Spring Lake;

Two cross sections located in Spring Lake showed that the dune, developed decades ago landward of the boardwalk, was also insufficient to protect the town landward of it. Storm wave up-rush went under the boardwalk, hit the dunes, was force upward and lifted the entire Spring Lake boardwalk off excellent concrete supports and eventually deposited most of it in Ocean Avenue. Hurricane Irene had previously damage some of the structure the August previously in 2011, and the walk had recently been re-surfaced with composite decking. The CRC observed that the steel tie-down pieces had rusted to nearly nothing since 1944 (?) and as a result meant that the entire boardwalk deck assembly was held in place essentially by gravity. Large quantities of sand had been transported onto Ocean Avenue and down many side streets. Large scale damage to homes was not evident; however flooding by the water level was evident. The "estuary" lake (Lake Como) between Spring Lake and Belmar was likewise being both pumped out and excavated to locate and clear the drainage weir to the ocean.

Sea Girt Borough;

Sea Girt is divided into two parts, each with a profile site. The southern site at Trenton Avenue typifies the coastal bluff with major homes and a wide, reasonably high dune landward of the boardwalk that protected the bluff face from erosion and kept the overwash out of the street ends. Some overwash had occurred at Trenton Avenue, but was well on its way to clean-up. The boardwalk had been damaged at Trenton Avenue, but otherwise survived. A dune had grown seaward of the boardwalk since the ACOE project, but it had been eroded away.

The northern half is represented by the New York Avenue site where a shore-parallel Ocean Avenue allows vehicle access to the boardwalk and beach for public access. Homes exist across Ocean Avenue. Here there were no dunes, Sandy's waves washed over the beach, across the boardwalk and down the streets a block

inland. Tidal flooding also entered by way of Wreck Pond, the second "estuary" lake north of Manasquan Inlet. Crews were at work trying to clear a vast sand deposit from the tidal weir gate and were pumping flood water out of Wreck Pond. This "estuary" still retains a small aspect of the old, natural bay-mouth barrier inlets once common to Monmouth County. That aspect had clearly been utilized by the Hurricane Sandy forces.

Manasquan Borough;

Manasquan is located at the southern limit of the NY District's massive Monmouth County beach restoration project and positioned just north of the Manasquan Inlet. Developed at the turn of the 20th Century, many small homes populate the former primary dune between the ocean and First Avenue. Prior to the ACOE project, the Borough had established a small dune system seaward of the paved promenade that is in front of the oceanfront homes This was primarily in response to the December 1992 northeast storm that last damaged the community. Litigation over the dune height, width and access pathways limited the enthusiasm for enlarging the dune's footprint in spite of the Borough's winning the litigation. Sandy broke through the dune line and passed over the promenade into the initial row of homes. Since there are frequently more than one dwelling between the promenade and First Avenue, a great deal of moderate damage was done as water, sand and debris were forced between the narrow passages between buildings. Vast amounts of sand and debris clogged First Avenue such that the oceanfront area was still closed to the public and barely passable on November 12th. There was a substantial offshore bar and a new recovery berm in the process of building. The sand was very coarse and contained abundant pebbles originally derived from bluff erosion over the centuries. There are two cross sections in Manasquan. No promenade remained at Pompano Avenue with tiny remnant dunes present at Riddle Way. A ridge of excavated sand had been built along the alignment of the promenade at the south end of the Borough Beach.

NJBPN 187 – Beach Park, Cliffwood Beach

This is the westernmost NJBPN site located on Raritan Bay. The photograph on the left shows the shoreline on November 30, 2011. The photo on the right, taken at low tide shows the lag deposits from Sandy (taken on December 13, 2012).

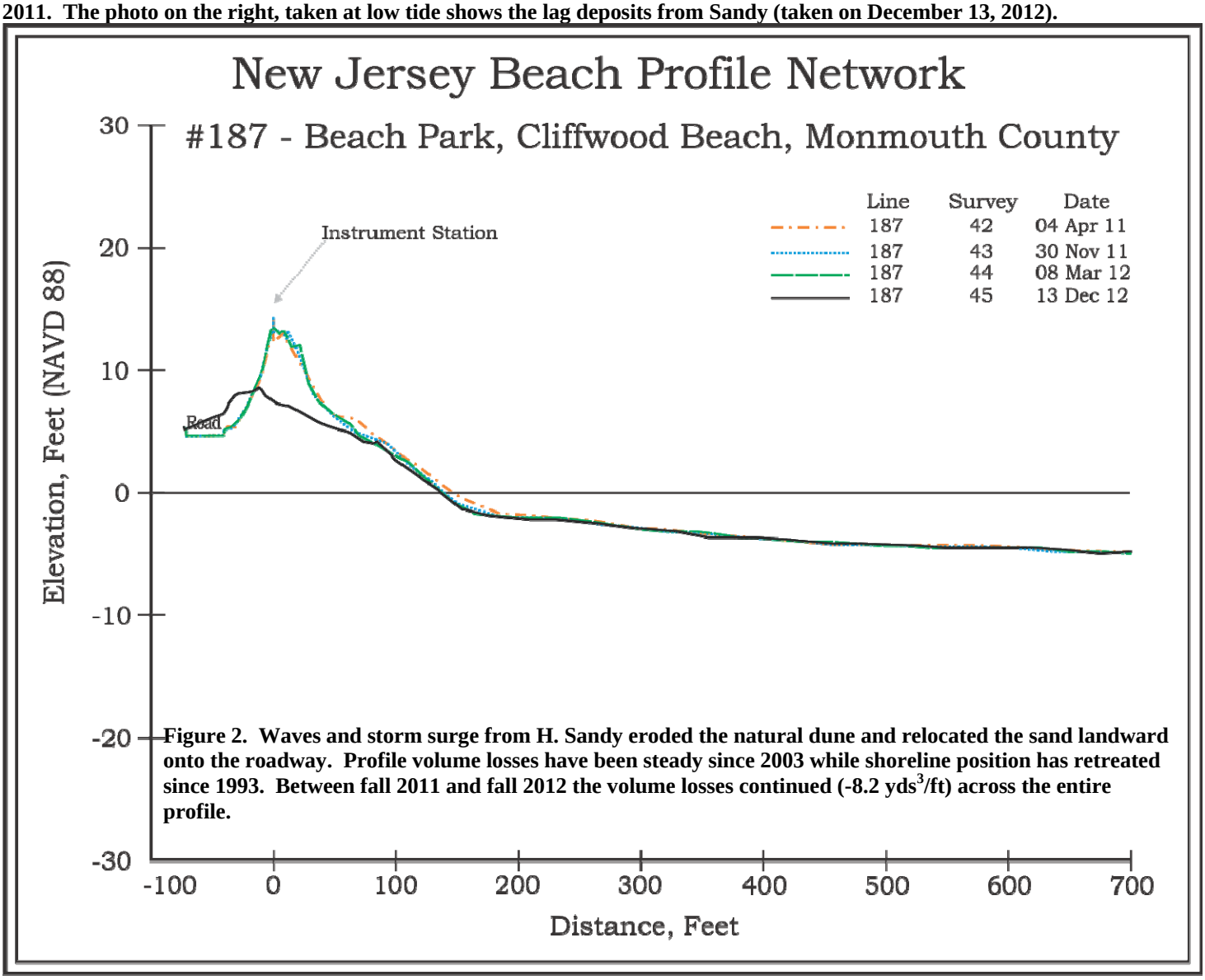


Figure 2. Waves and storm surge from H. Sandy eroded the natural dune and relocated the sand landward onto the roadway. Profile volume losses have been steady since 2003 while shoreline position has retreated since 1993. Between fall 2011 and fall 2012 the volume losses continued (-8.2 yds^3/ft) across the entire profile.

NJBPN 286 – Beach Street, Union Beach

This site is located at the public bathing beach and was established in 2009. The photograph on the left shows the shoreline on November 30, 2011. The photo on the right shows the municipalities efforts in replacing lost sand following Sandy (taken on December 13, 2012).

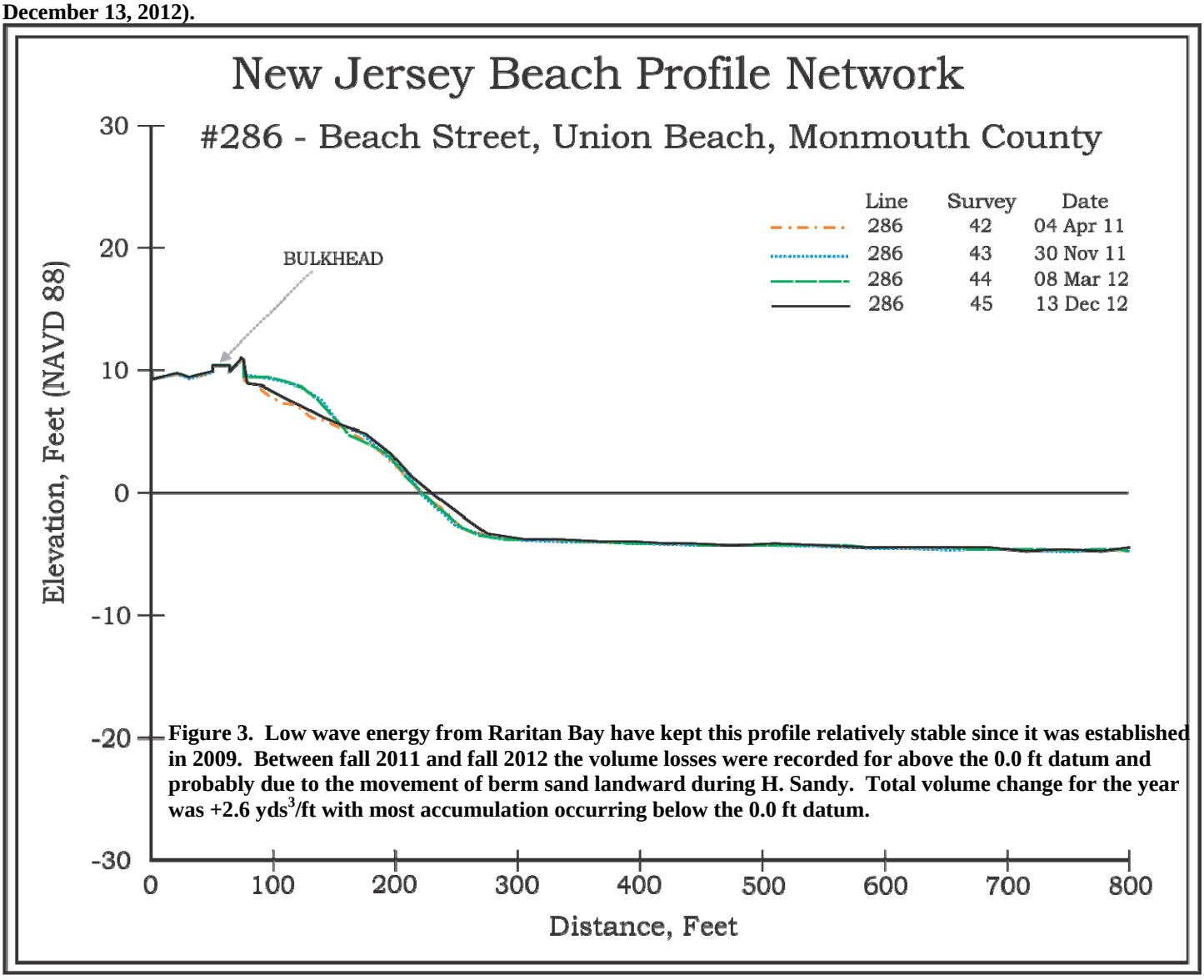


Figure 3. Low wave energy from Raritan Bay have kept this profile relatively stable since it was established in 2009. Between fall 2011 and fall 2012 the volume losses were recorded for above the 0.0 ft datum and probably due to the movement of berm sand landward during H. Sandy. Total volume change for the year was +2.6 yds^3/ft with most accumulation occurring below the 0.0 ft datum.

NJBPN 185 – Spy House, Port Monmouth

This site was damaged during H. Irene in 2011 which led to municipal efforts to harden the shoreline with an interlocking block revetment. The photograph on the left shows the shoreline on November 30, 2011. The photo on the right shows the revetment post Sandy (taken on December 13, 2012).

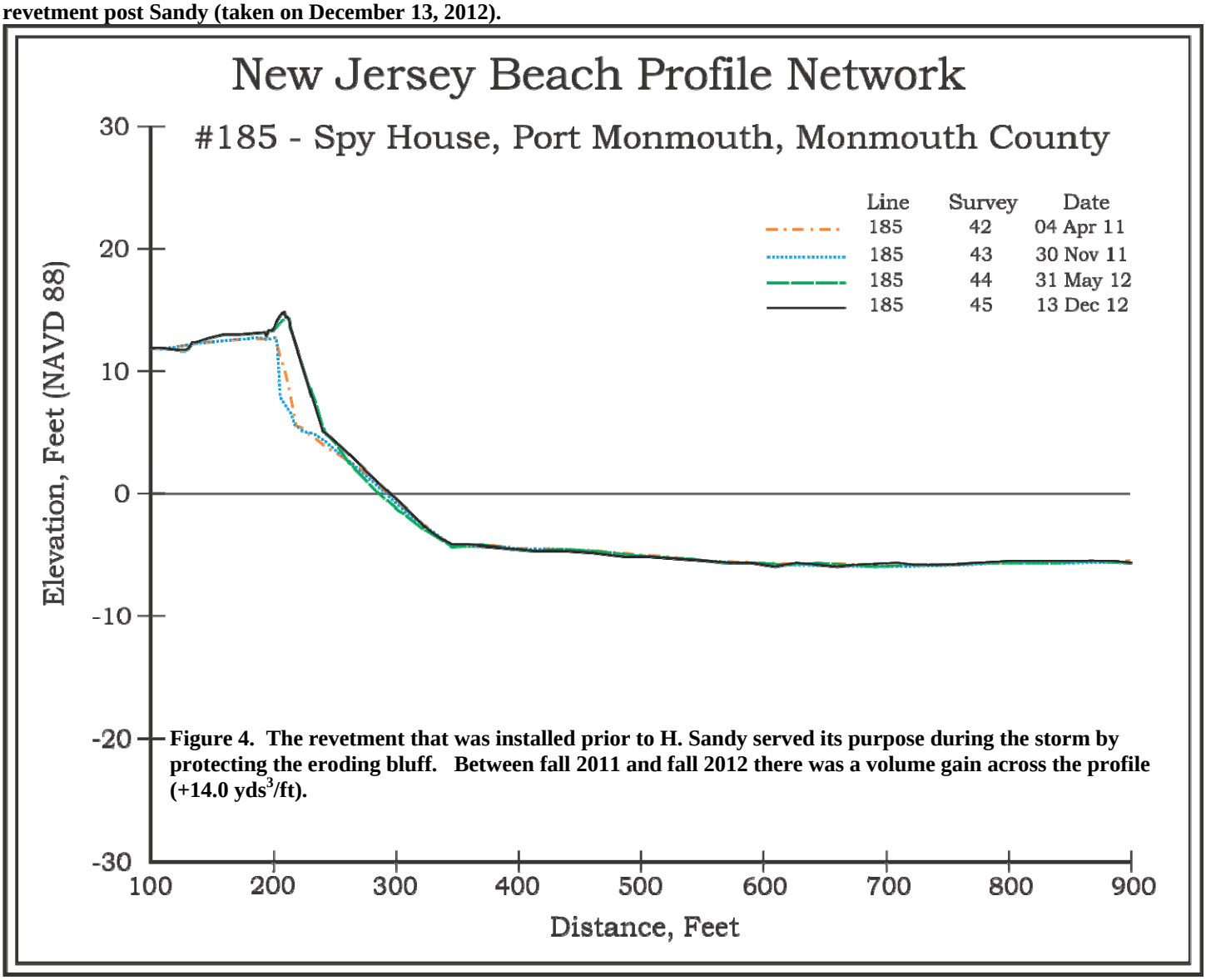


Figure 4. The revetment that was installed prior to H. Sandy served its purpose during the storm by protecting the eroding bluff. Between fall 2011 and fall 2012 there was a volume gain across the profile (+14.0 yds^3/ft).

NJBPN 285 – Gunnison Beach, Sandy Hook National Seashore

This is the northernmost ocean NJBPN survey site that has shown advances in the berm position since 1999. The photograph on the left shows the shoreline on October 6, 2011. The photo on the right shows the runnel and high water line post Sandy (taken on January 22, 2013). The park was closed following H. Sandy due to the presence of ordnance delaying the fall survey.

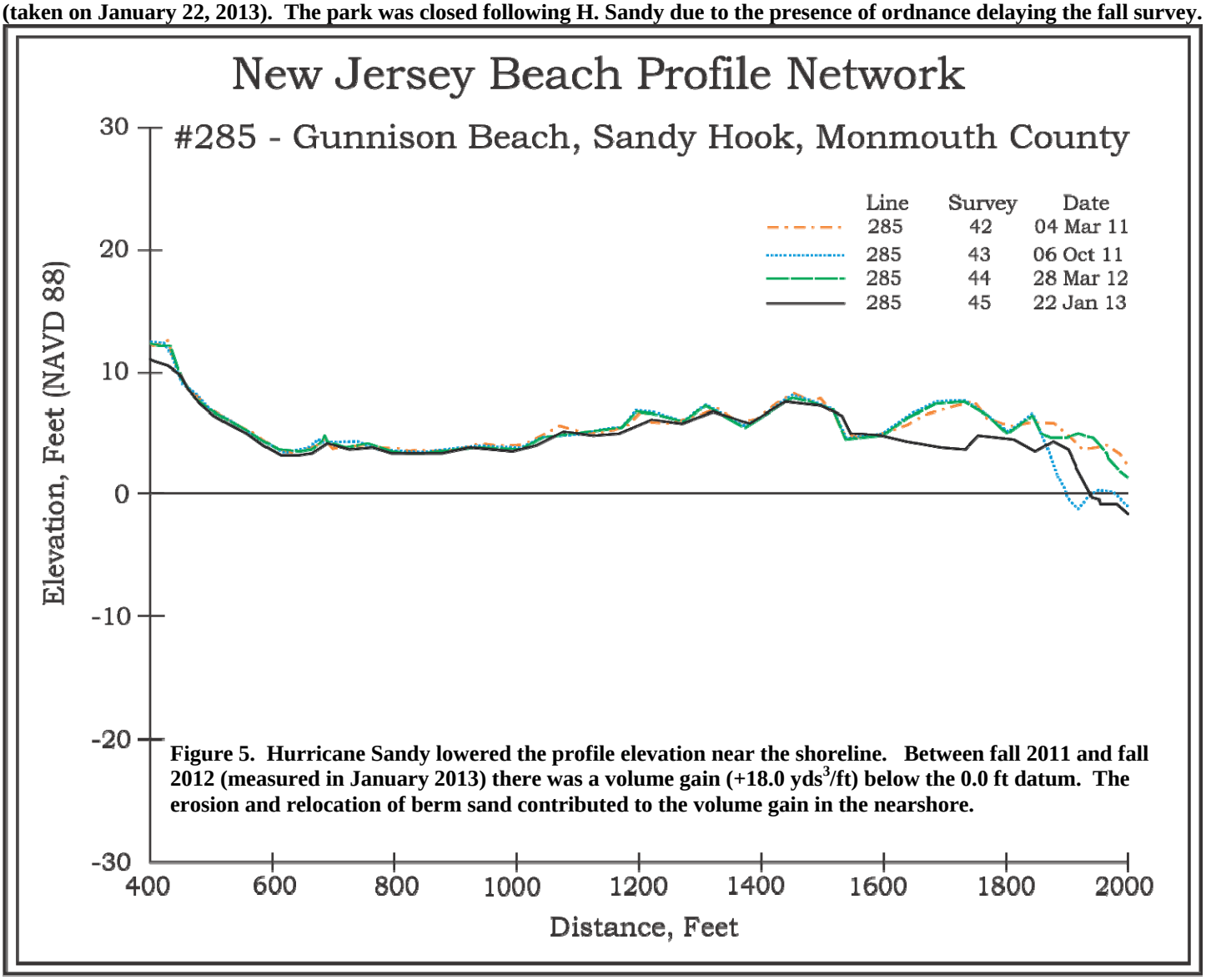


Figure 5. Hurricane Sandy lowered the profile elevation near the shoreline. Between fall 2011 and fall 2012 (measured in January 2013) there was a volume gain (+18.0 yds^3/ft) below the 0.0 ft datum. The erosion and relocation of berm sand contributed to the volume gain in the nearshore.

NJBPN 284 – Parking Lot E, Sandy Hook National Seashore

This Sandy Hook site has been eroding since 2010. The photograph on the left shows the shoreline on October 6, 2011. The photo on the right shows the post Sandy (taken on January 22, 2013) profile where there was considerable loss of the dune.

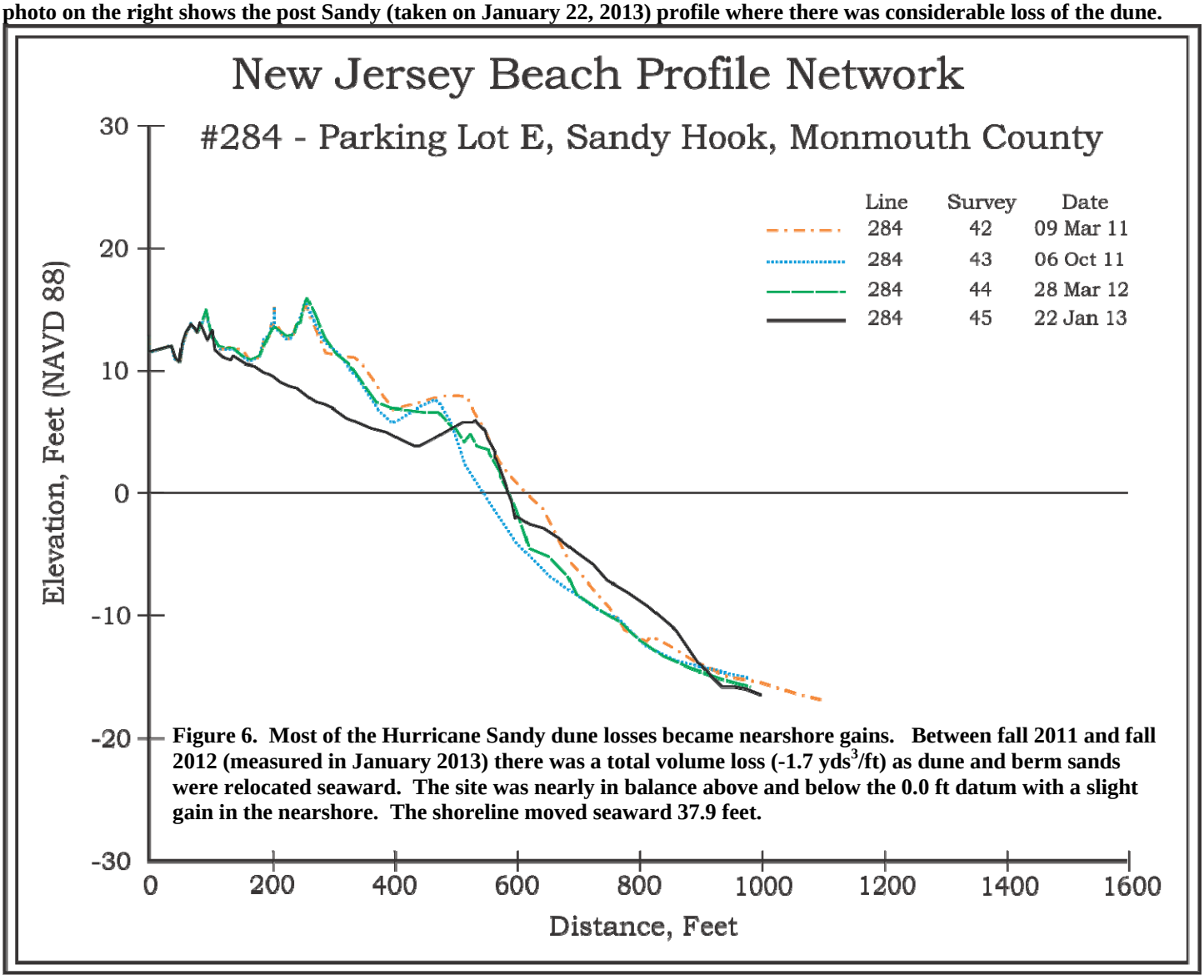


Figure 6. Most of the Hurricane Sandy dune losses became nearshore gains. Between fall 2011 and fall 2012 (measured in January 2013) there was a total volume loss (-1.7 yds^3/ft) as dune and berm sands were relocated seaward. The site was nearly in balance above and below the 0.0 ft datum with a slight gain in the nearshore. The shoreline moved seaward 37.9 feet.

NJBPN 184 – Highlands Beach, Sandy Hook National Seashore

This southern Sandy Hook site is located near the entrance to the park and has gained in volume since the placement of nourishment and maintenance sands from the Federal Monmouth Co. shore protection project. The photograph on the left shows the shoreline on October 6, 2011. The photo on the right shows the post Sandy (taken on January 22, 2013) profile where there was considerable loss of the dune and exposure of the rock revetment at the base of the seawall.

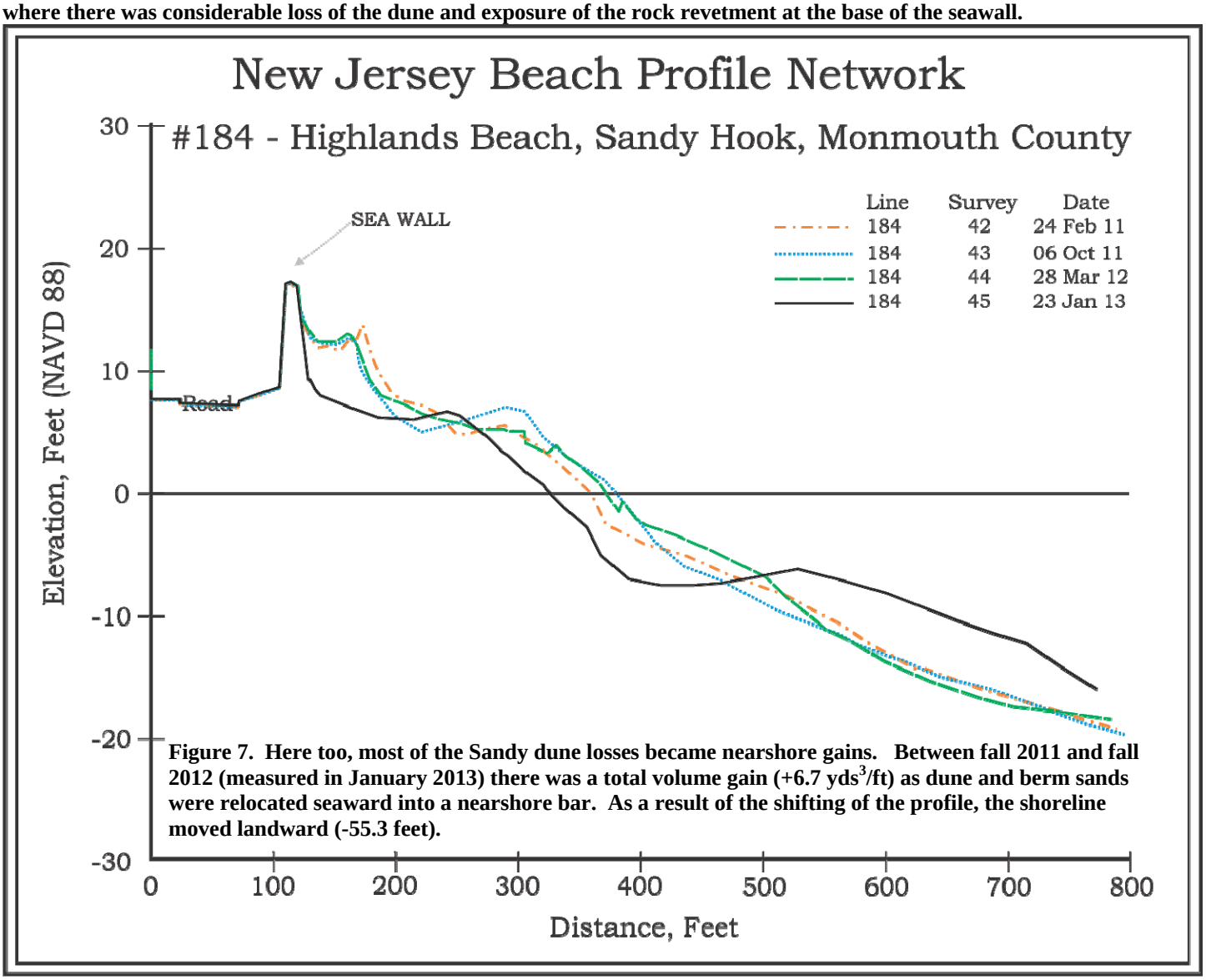


Figure 7. Here too, most of the Sandy dune losses became nearshore gains. Between fall 2011 and fall 2012 (measured in January 2013) there was a total volume gain (+6.7 yds^3/ft) as dune and berm sands were relocated seaward into a nearshore bar. As a result of the shifting of the profile, the shoreline moved landward (-55.3 feet).

NJBPN 183 – Via Ripa Street, Sea Bright

This site was near the northern limit of the initial Federal shore protection project and has experienced only moderate sand losses since that time. An engineered dune was not constructed due to the presence of the seawall. More sand was placed in the berm to compensate the absence of the dune. A low dune established naturally between two parallel rows of sand fence. The left photograph was taken on March 22, 2012 during the spring survey. The right photo was taken November 26, 2012.

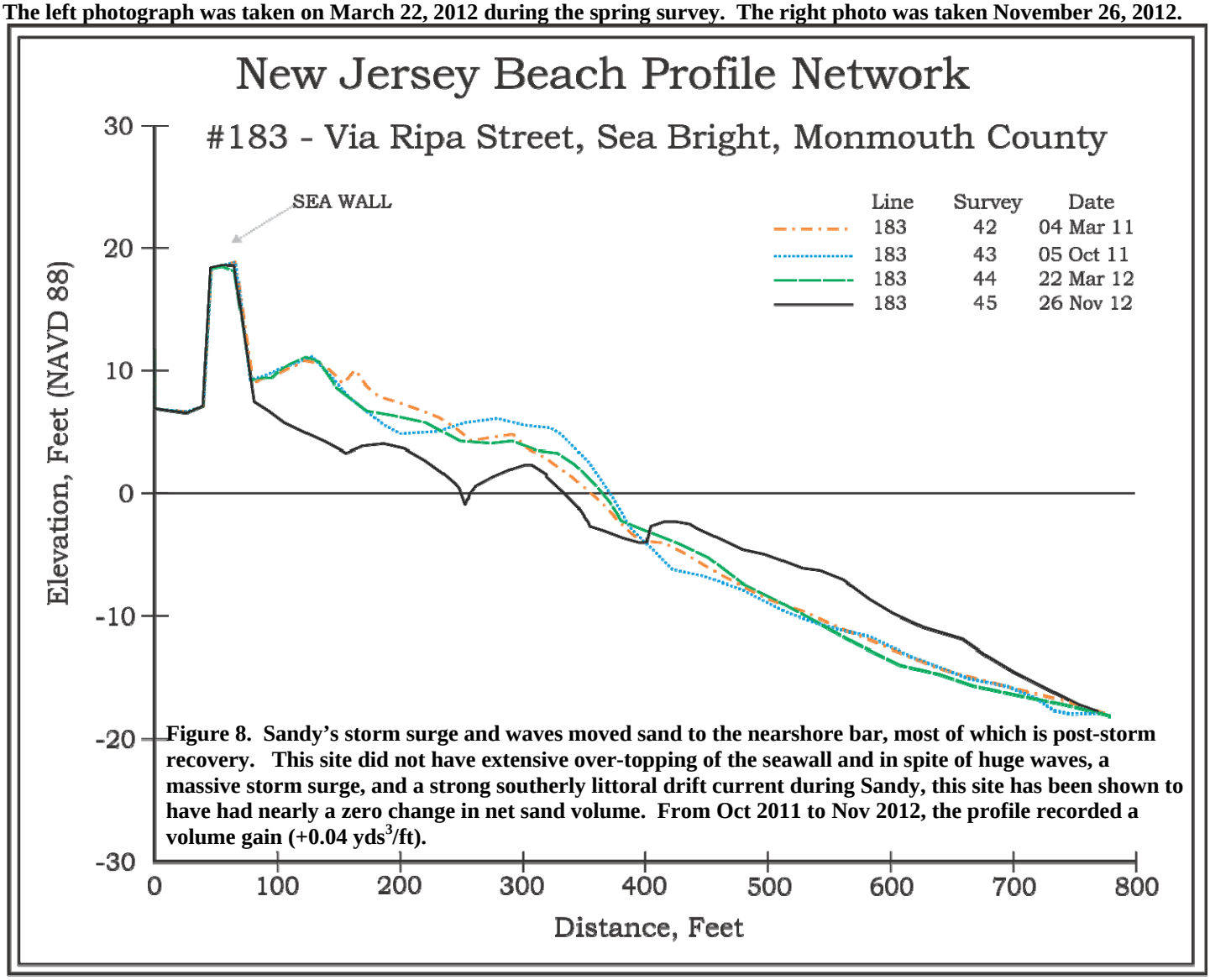


Figure 8. Sandy's storm surge and waves moved sand to the nearshore bar, most of which is post-storm recovery. This site did not have extensive over-topping of the seawall and in spite of huge waves, a massive storm surge, and a strong southerly littoral drift current during Sandy, this site has been shown to have had nearly a zero change in net sand volume. From Oct 2011 to Nov 2012, the profile recorded a volume gain (+0.04 yds^3/ft).

NJBPN 282 – Shrewsbury Way, Sea Bright

This site was included in the initial Federal beach nourishment project but did not include an engineered dune. A low, wide dune field was established surrounding a pair of fence rows built immediately following beach restoration and planted with grass between them. The left photograph (taken on March 28, 2012) shows the natural development of the dune system over the past 12 years. On the right, only remnants of the sand fence remained following the storm (taken November 26, 2012).

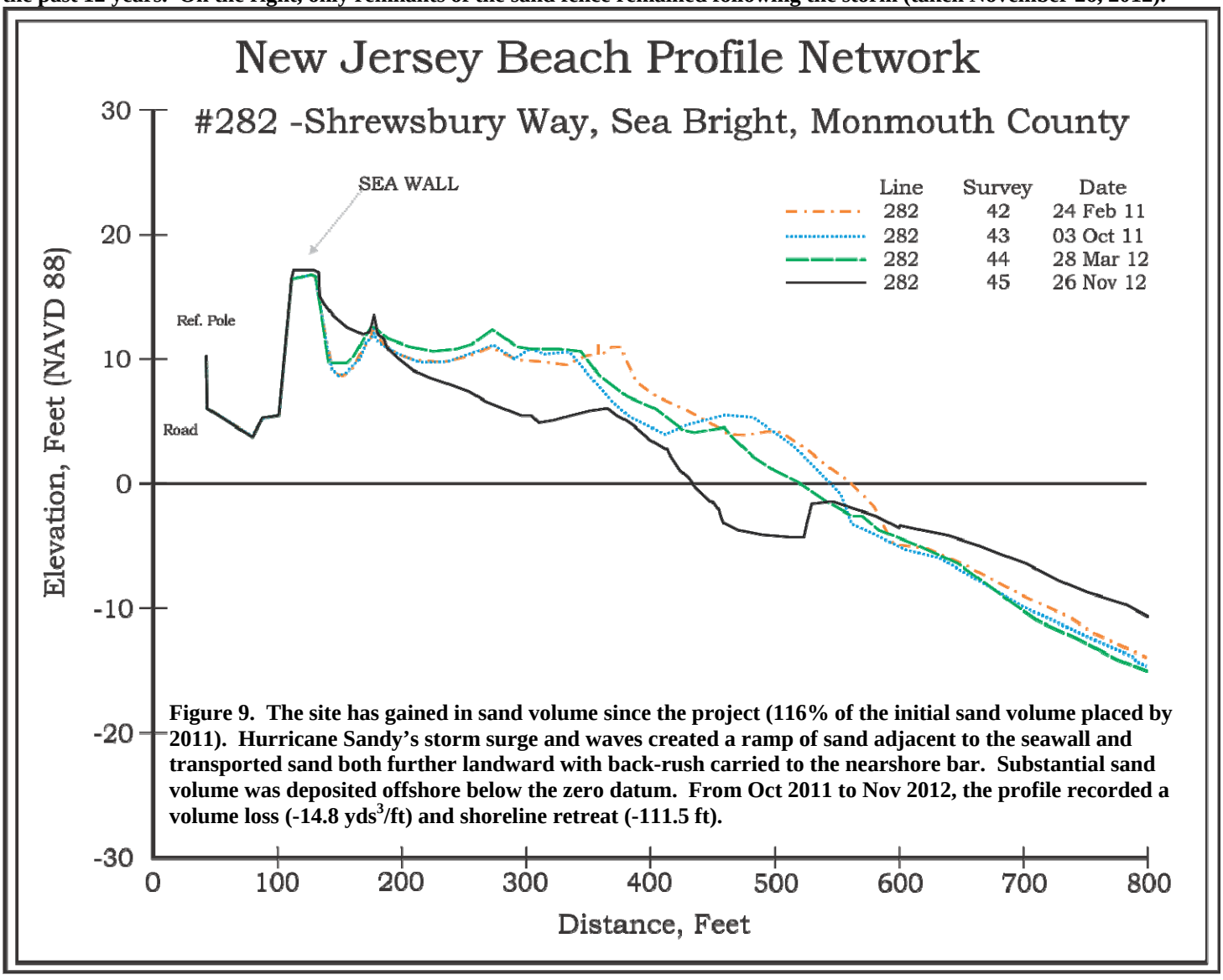


Figure 9. The site has gained in sand volume since the project (116% of the initial sand volume placed by 2011). Hurricane Sandy's storm surge and waves created a ramp of sand adjacent to the seawall and transported sand both further landward with back-rush carried to the nearshore bar. Substantial sand volume was deposited offshore below the zero datum. From Oct 2011 to Nov 2012, the profile recorded a volume loss (-14.8 yds^3/ft) and shoreline retreat (-111.5 ft).

NJBPN 182 – Public Beach, Sea Bright

Low, wide dunes established naturally following the initial Federal beach nourishment project. Sand volumes have been relatively stable since that time (left photo taken March 22, 2012). Sandy's storm surge and waves relocated sand from the dune and berm to both landward to the rocks and over the rocks, and to the nearshore (right photo November 21, 2012).

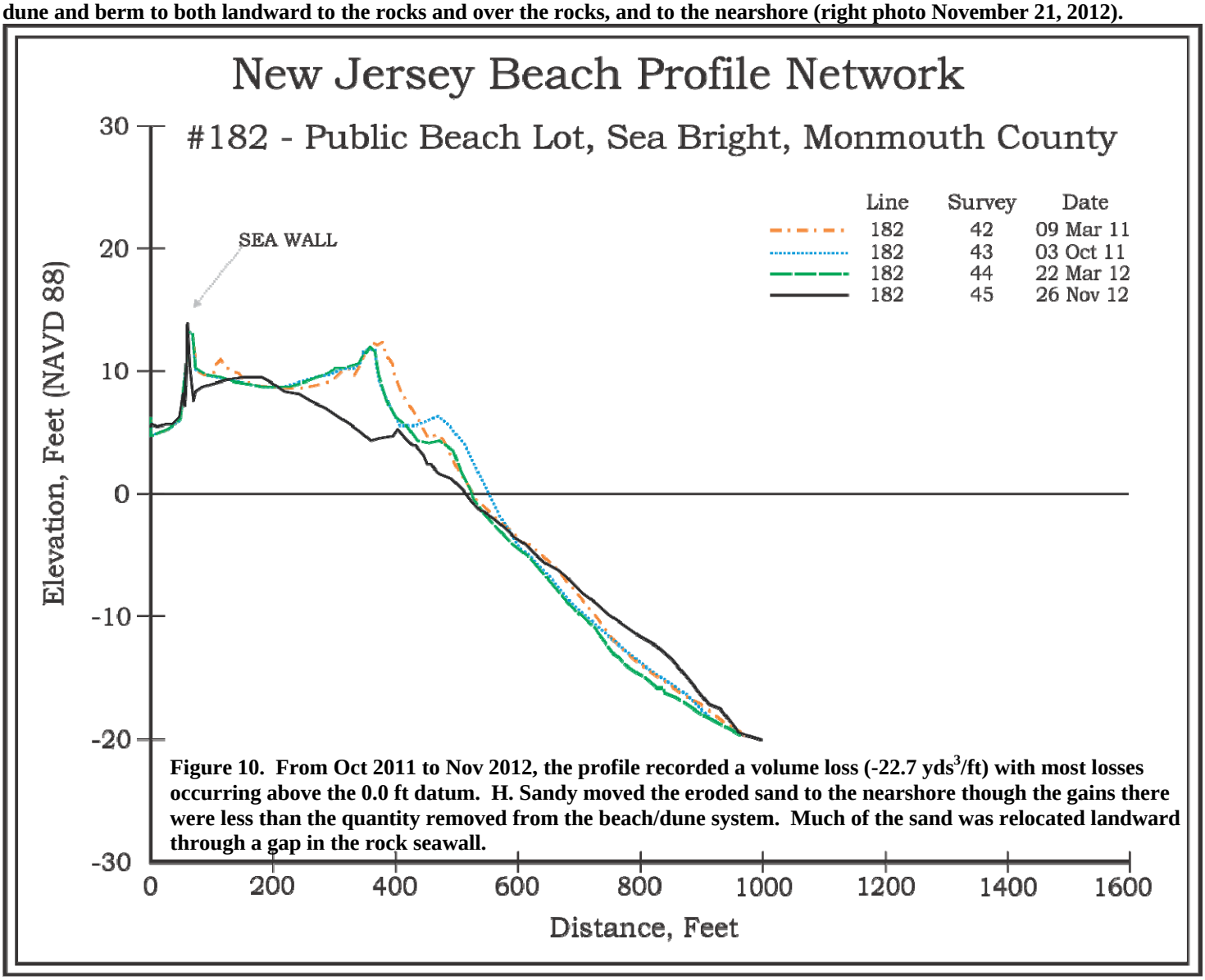


Figure 10. From Oct 2011 to Nov 2012, the profile recorded a volume loss (-22.7 yds^3/ft) with most losses occurring above the 0.0 ft datum. H. Sandy moved the eroded sand to the nearshore though the gains there were less than the quantity removed from the beach/dune system. Much of the sand was relocated landward through a gap in the rock seawall.

NJBPN 181 – Municipal Beach, Sea Bright

This site received sand during the Federal beach nourishment and maintenance projects (left photo taken May 30, 2012). This site was the most heavily damaged along the northern Monmouth County shoreline from Hurricane Sandy because there was a gap in the rock seawall and large grade-level pedestrian gaps in the small dunes (right photo taken).

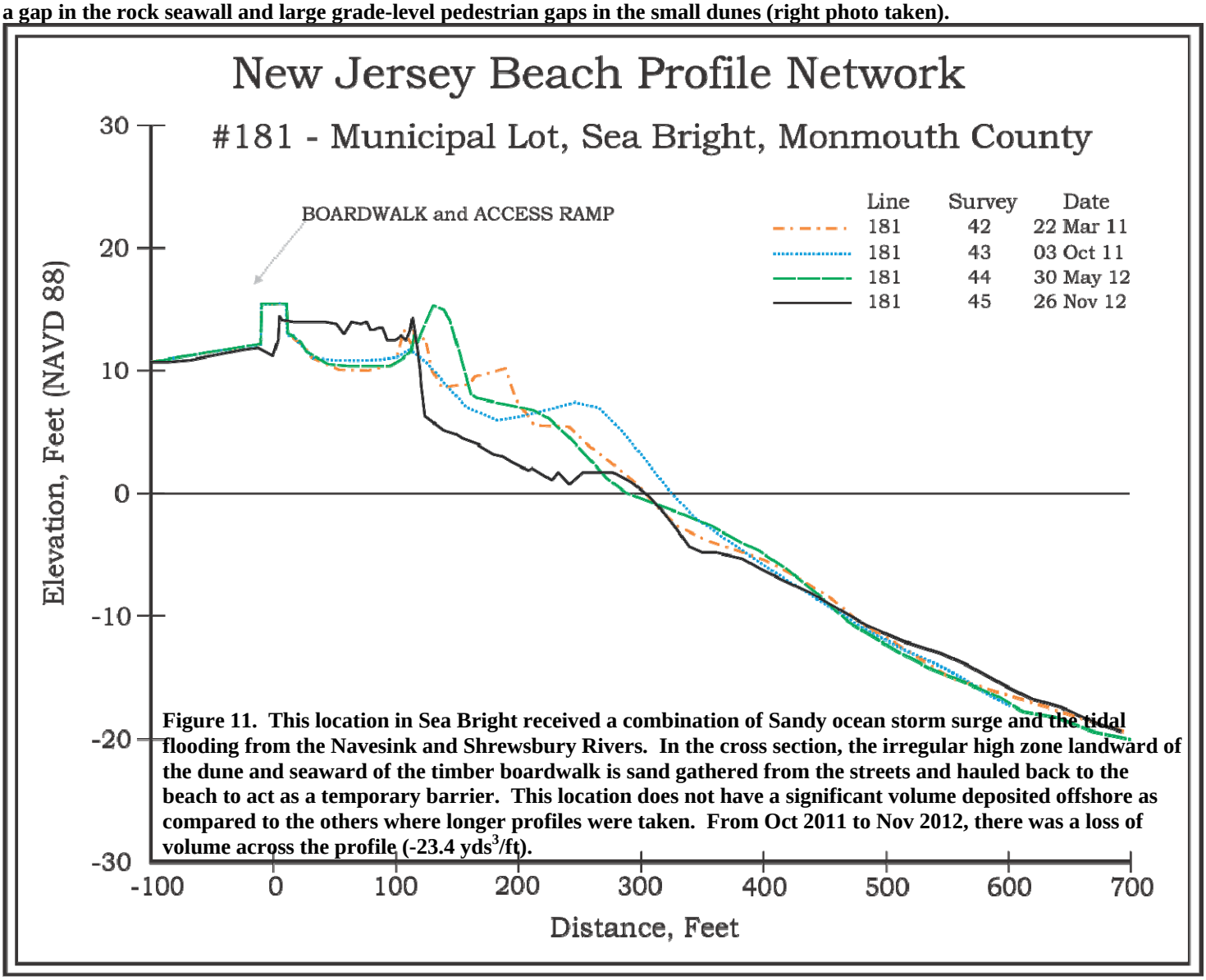


Figure 11. This location in Sea Bright received a combination of Sandy ocean storm surge and the tidal flooding from the Navesink and Shrewsbury Rivers. In the cross section, the irregular high zone landward of the dune and seaward of the timber boardwalk is sand gathered from the streets and hauled back to the beach to act as a temporary barrier. This location does not have a significant volume deposited offshore as compared to the others where longer profiles were taken. From Oct 2011 to Nov 2012, there was a loss of volume across the profile (-23.4 yds^3/ft).

NJBPN 180 – Sunset Court, Sea Bright

This site was the recipient of sand from the initial Federal beach nourishment project. The left photograph (May 30, 2012) shows the variety in height, width and vegetation density associated with the naturally developed dunes seaward of the seawall. Sandy's waves pushed sand into a gentle ramp up the seaward rock slope and allowed the wave bores to pour over the wall into Ocean Avenue and associated properties (right photo taken November 21, 2012).

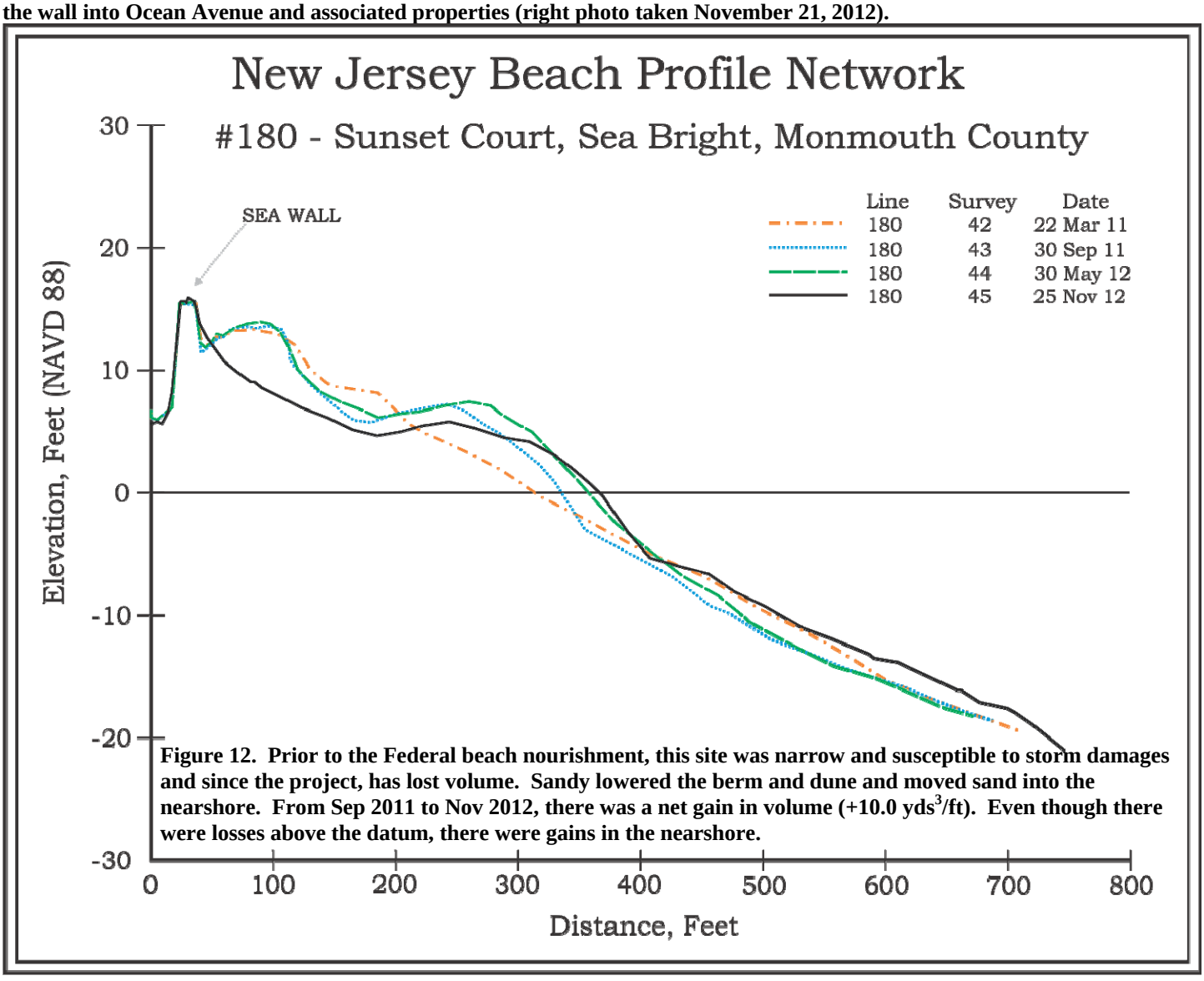


Figure 12. Prior to the Federal beach nourishment, this site was narrow and susceptible to storm damages and since the project, has lost volume. Sandy lowered the berm and dune and moved sand into the nearshore. From Sep 2011 to Nov 2012, there was a net gain in volume (+10.0 yds^3/ft). Even though there were losses above the datum, there were gains in the nearshore.

NJBPN 179 – Cottage Road, Monmouth Beach

This site has the worst erosion history of any site in Monmouth County. Chronic volume losses have been recorded over the years because the rock groins adjacent to the site block sand transport from the south. The spring 2012 survey (left photo taken May 31, 2012) recorded a high 300-ft wide berm following a renourishment fill that was completed in Jan 2012. Most of that sand was moved to the nearshore or over the seawall during Sandy. The right photograph (Nov 21, 2012) shows the renourishment activities following the storm.

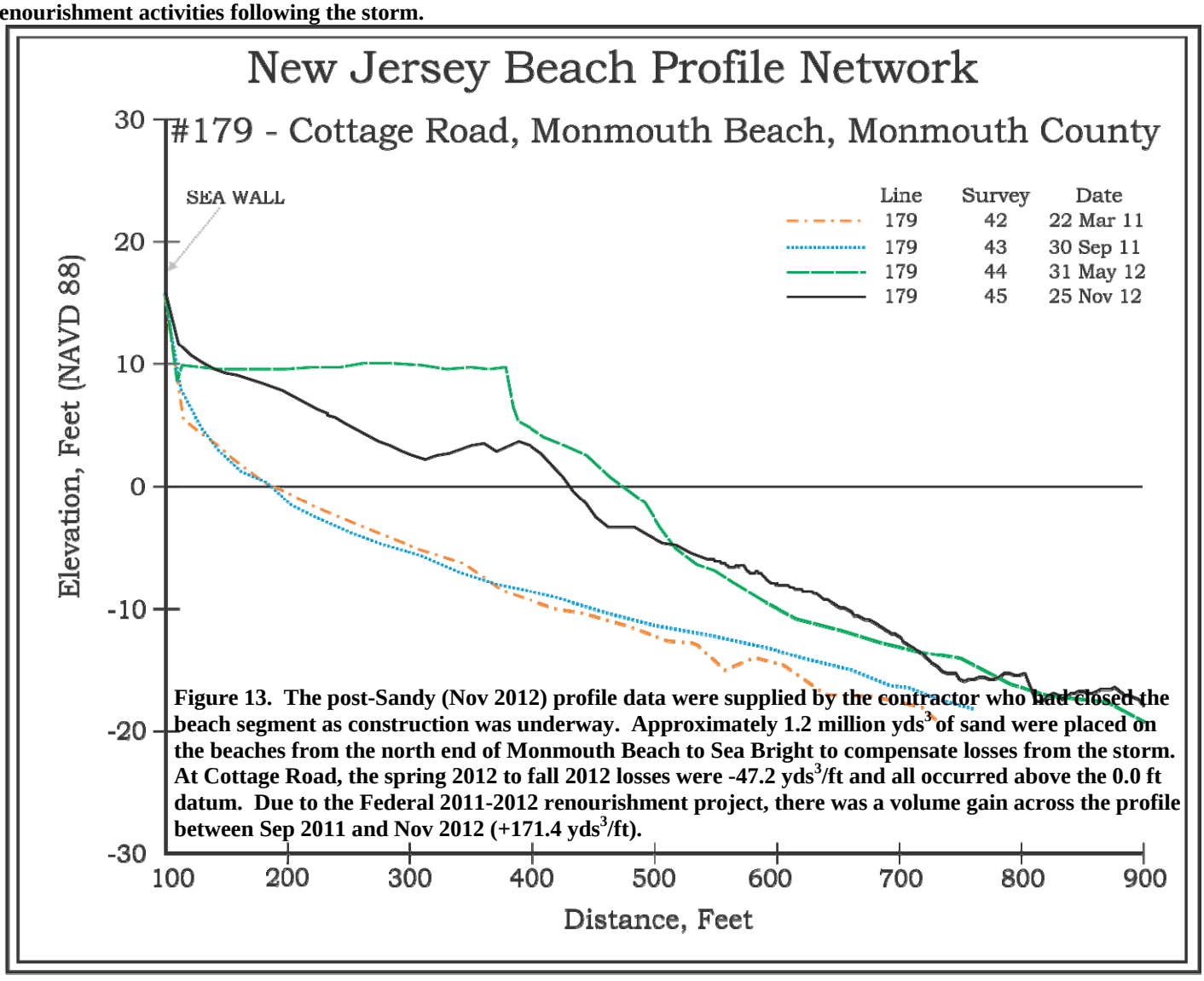


Figure 13. The post-Sandy (Nov 2012) profile data were supplied by the contractor who had closed the beach segment as construction was underway. Approximately 1.2 million yds^3 of sand were placed on the beaches from the north end of Monmouth Beach to Sea Bright to compensate losses from the storm. At Cottage Road, the spring 2012 to fall 2012 losses were -47.2 yds^3/ft and all occurred above the 0.0 ft datum. Due to the Federal 2011-2012 renourishment project, there was a volume gain across the profile between Sep 2011 and Nov 2012 (+171.4 yds^3/ft).

NJBPN 178 – Monmouth Beach Club, Monmouth Beach

This profile was the recipient of the initial Federal beach nourishment project and the winter 2011 to 2012 renourishment (left photo taken May 31, 2012). Hurricane Sandy removed significant amounts of sand from the berm, destroyed a moderate-sized dune and badly damaged the buildings associated with the facility (right photo taken November 25, 2012).

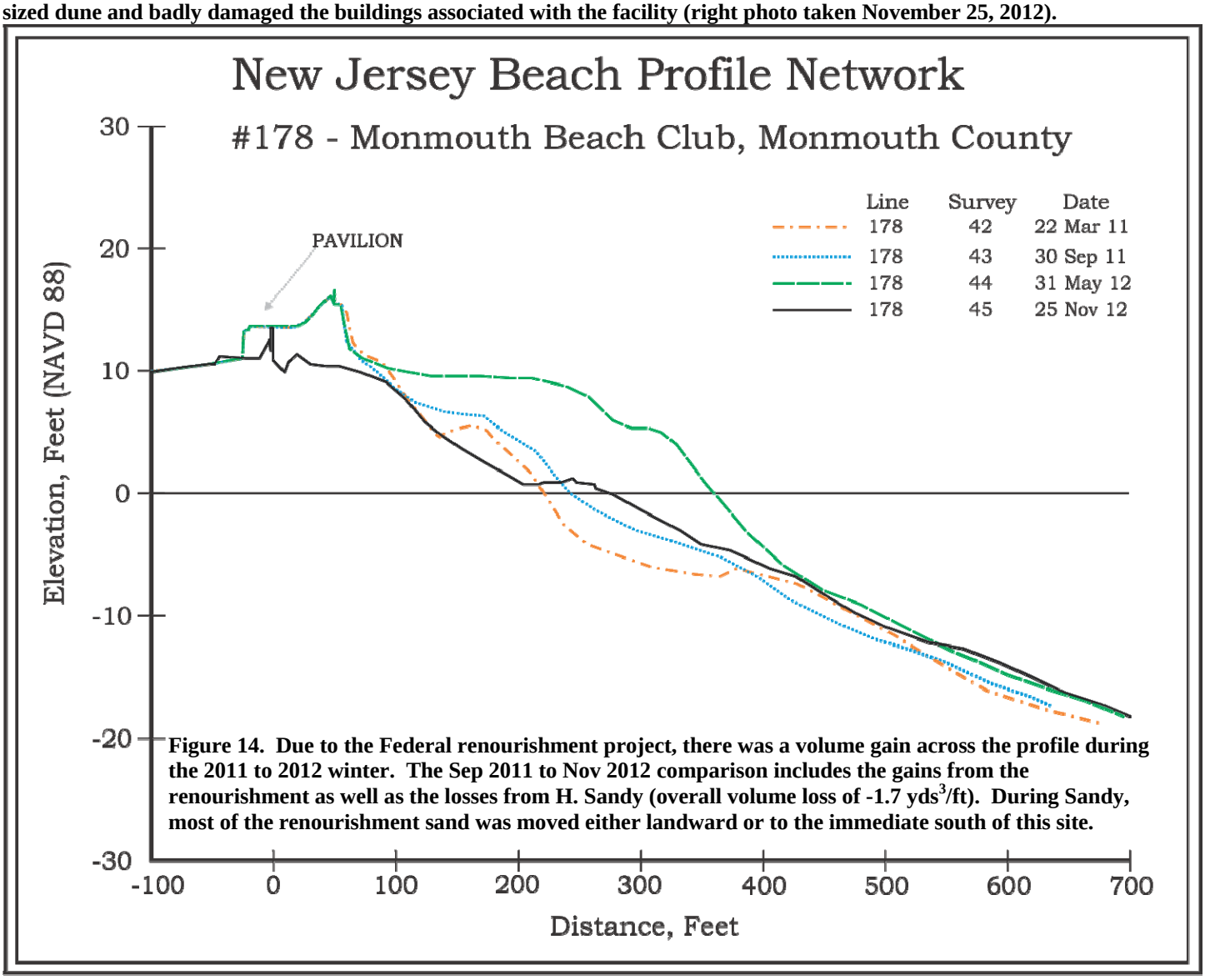


Figure 14. Due to the Federal renourishment project, there was a volume gain across the profile during the 2011 to 2012 winter. The Sep 2011 to Nov 2012 comparison includes the gains from the renourishment as well as the losses from H. Sandy (overall volume loss of -1.7 yds^3/ft). During Sandy, most of the renourishment sand was moved either landward or to the immediate south of this site.

NJBPN 177 – 404 Ocean Avenue, Long Branch

This site was the recipient of sand from the initial Federal beach nourishment project. The ridge of sand that was present in the February 2011 survey was removed during H. Irene in August 2011. This site was the southernmost one NOT surveyed prior to Sandy, so the pre-storm profile is from the spring of 2012 (left photo taken May 14, 2012). After Sandy, the berm was reduced in elevation and pushed landward. Sand was also deposited offshore beyond the normal 16-foot ending depth for NJBPN surveys (right photo taken November 25, 2012).

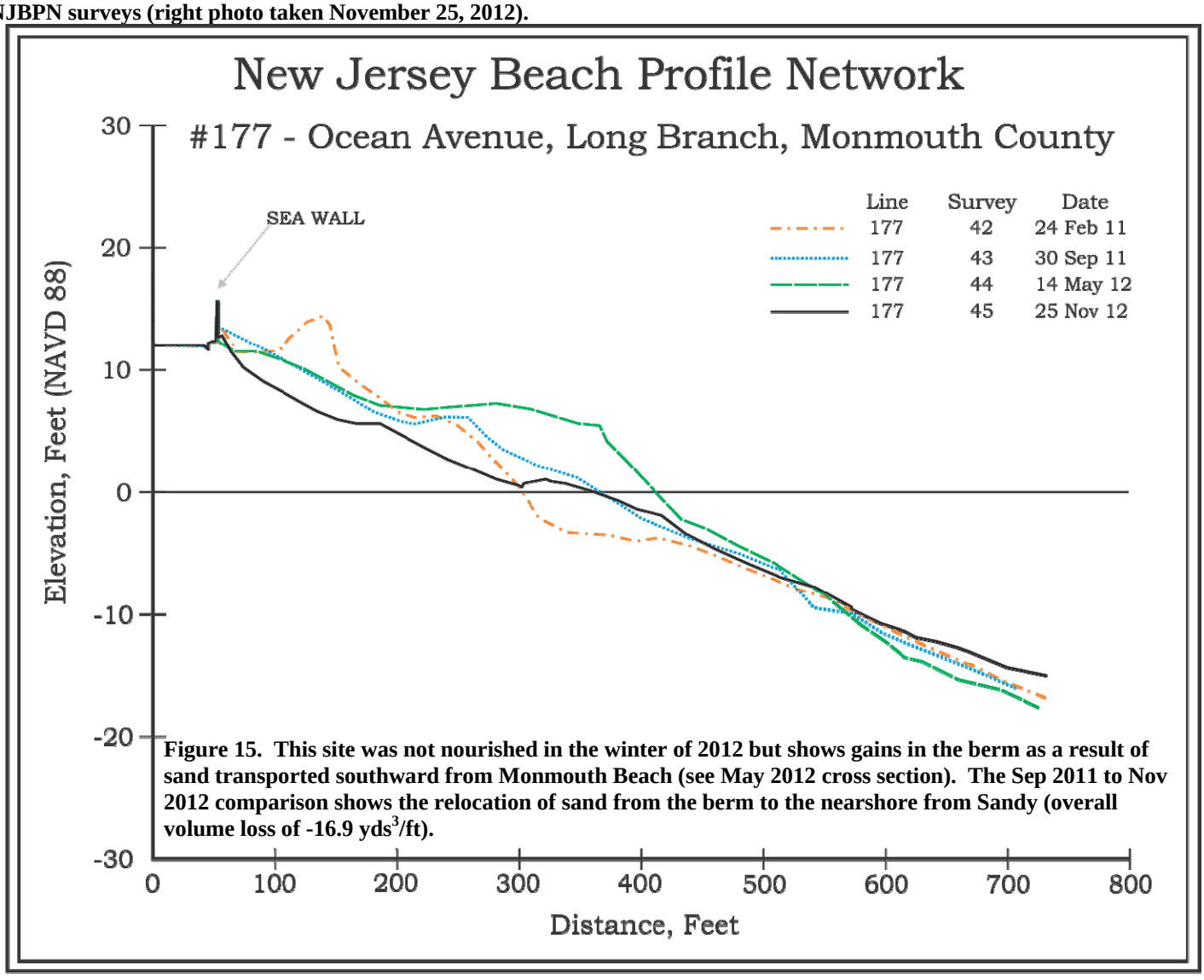


Figure 15. This site was not nourished in the winter of 2012 but shows gains in the berm as a result of sand transported southward from Monmouth Beach (see May 2012 cross section). The Sep 2011 to Nov 2012 comparison shows the relocation of sand from the berm to the nearshore from Sandy (overall volume loss of -16.9 yds^3/ft).

NJBPN 176 – Seven President's Park, Long Branch

This site is a popular recreational park with a partial ridge of 25-foot elevation dunes and an expansive berm that has undergone variable volume changes through the years (left photo taken October 8, 2012). During Hurricane Sandy, the grade-level public access points created channeled flow from the storm waves and washed sand landward into the parking lots (right photo taken November 13, 2012).

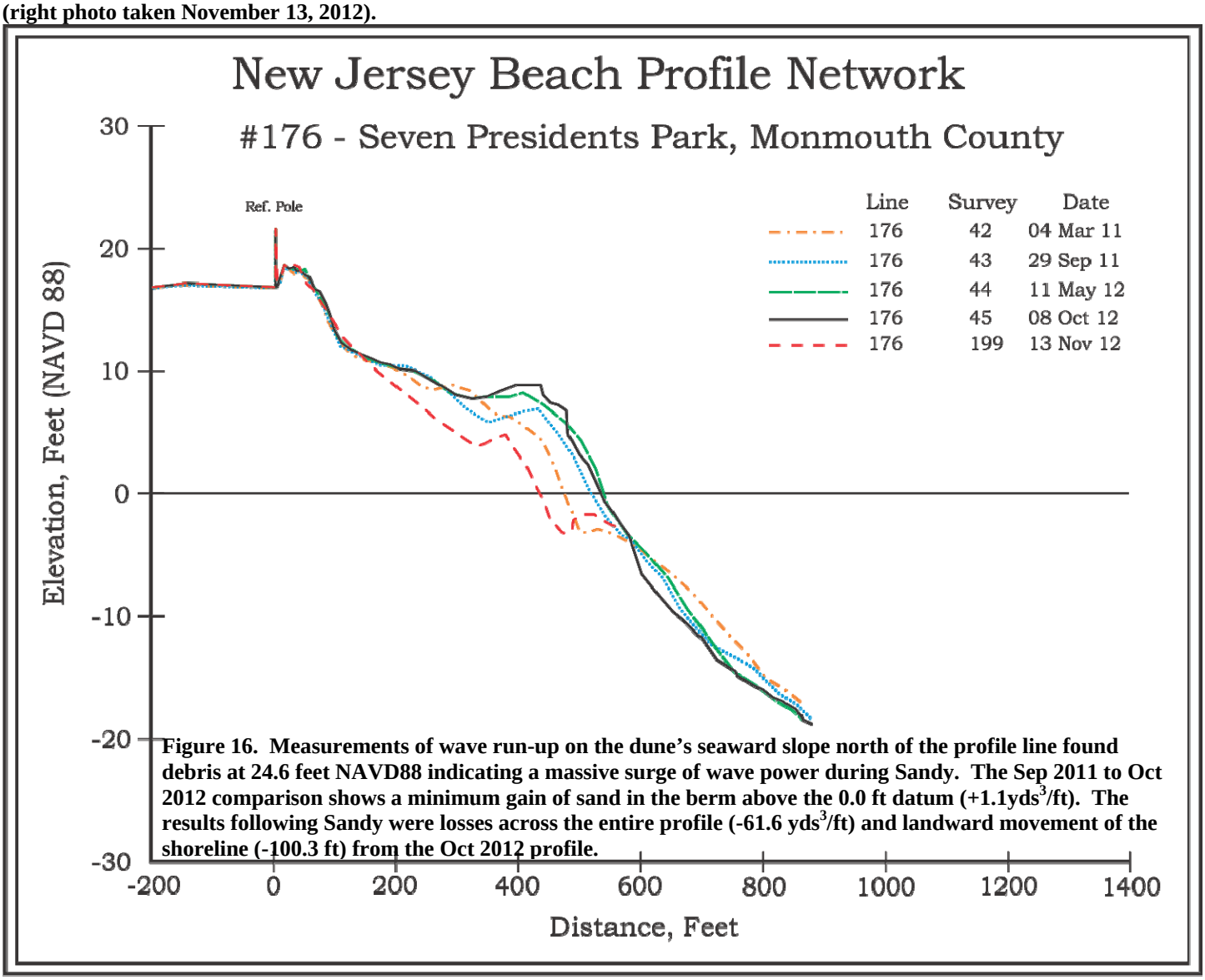


Figure 16. Measurements of wave run-up on the dune's seaward slope north of the profile line found debris at 24.6 feet NAVD88 indicating a massive surge of wave power during Sandy. The Sep 2011 to Oct 2012 comparison shows a minimum gain of sand in the berm above the 0.0 ft datum (+1.1yds^3/ft). The results following Sandy were losses across the entire profile (-61.6 yds^3/ft) and landward movement of the shoreline (-100.3 ft) from the Oct 2012 profile.

NJBPN 175 – Broadway Avenue, Long Branch

This site has benefitted from the Federal shore protection project and renourishment activities (left photo taken October 8, 2012). H. Sandy relocated the berm sand over the vertical steel wall, but the vast majority of sand was deposited offshore beyond the reach of the wading profile survey. The railing on the right photograph was bent landward by wave action 17 feet above the zero datum elevation (November 13, 2012).

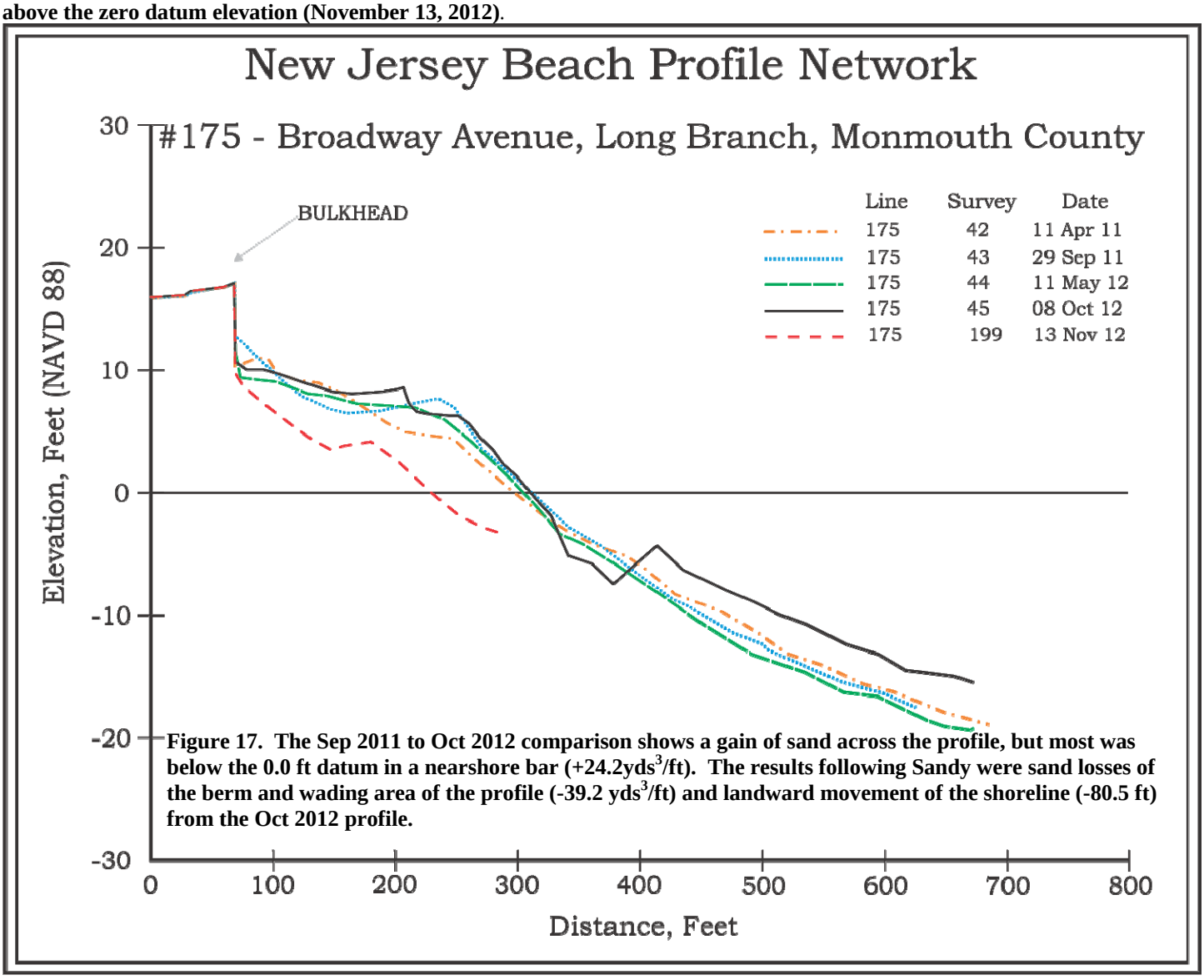


Figure 17. The Sep 2011 to Oct 2012 comparison shows a gain of sand across the profile, but most was below the 0.0 ft datum in a nearshore bar (+24.2yds^3/ft). The results following Sandy were sand losses of the berm and wading area of the profile (-39.2 yds^3/ft) and landward movement of the shoreline (-80.5 ft) from the Oct 2012 profile.

NJBPN 174 – Morris Avenue, Long Branch

This site also was the recipient of the Federal beach nourishment project and was a direct beneficiary from the 2010 maintenance fill completed to the south. Strong northerly littoral sand transport moved abundant sand from that project into this segment (left photo taken October 8, 2012). Hurricane Sandy removed the sand from on top of the seawall, eroded into the upper bluff sediments and destroyed the boardwalk (right photo taken November 13, 2012).

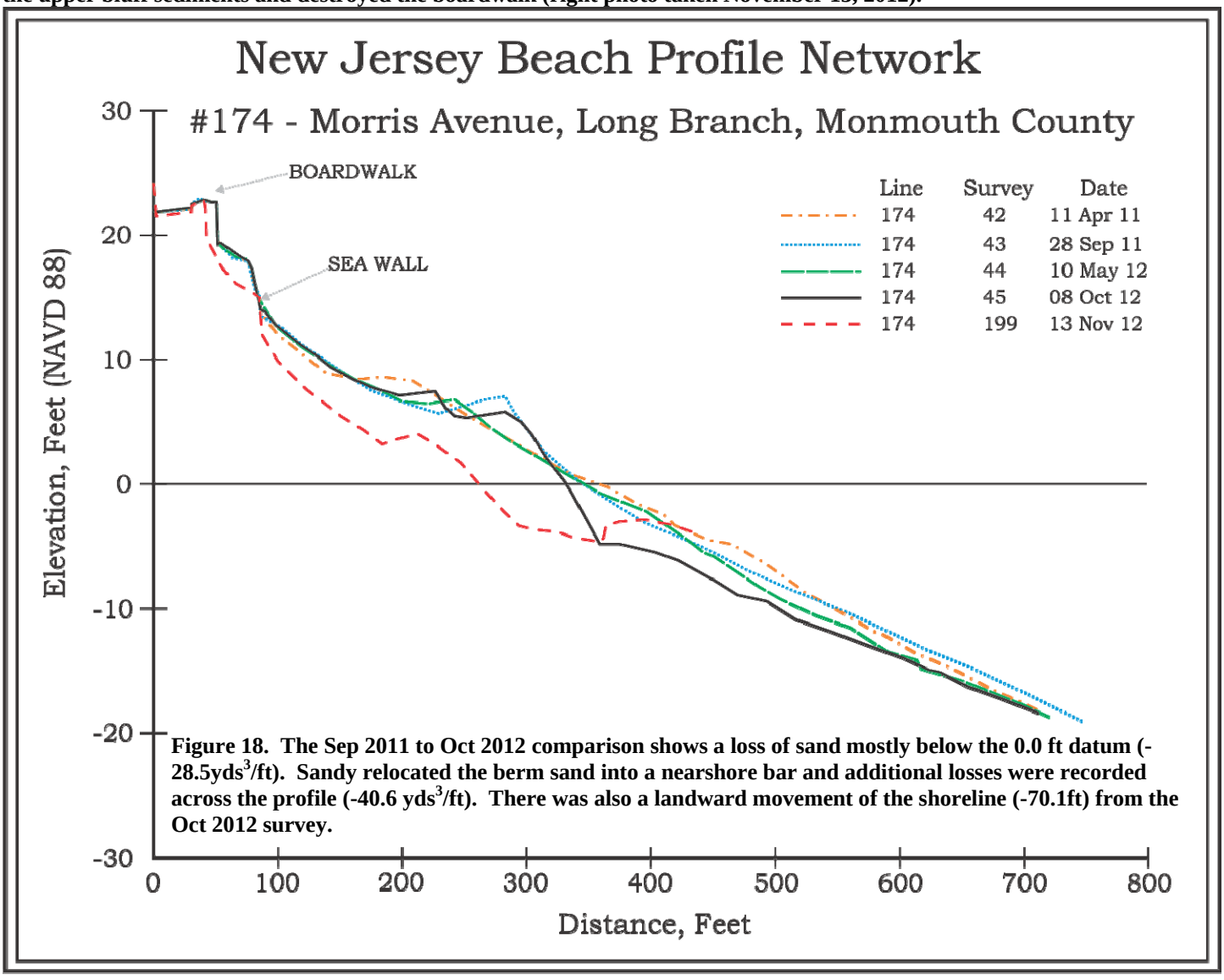


Figure 18. The Sep 2011 to Oct 2012 comparison shows a loss of sand mostly below the 0.0 ft datum (-28.5yds^3/ft). Sandy relocated the berm sand into a nearshore bar and additional losses were recorded across the profile (-40.6 yds^3/ft). There was also a landward movement of the shoreline (-70.1ft) from the Oct 2012 survey.

NJBPN 173 – West End Avenue, Long Branch

This site is located near the southern limit of the Federal beach nourishment project. Long Branch did not include the construction of a protective dune. It was decided at the time of project planning that the bluff elevation and the presence of the rock revetment was enough protection for landward properties and the sand was put into the berm (left photo taken October 5, 2012). While the revetment held in place during H. Sandy, the boardwalk built on the upper bluff sediments was destroyed when the bluff retreated to the edge of the old southbound Ocean Ave. roadway (right photo taken November 13, 2012). Storms in the 1950's took the center grass island and the northbound roadway plus the old boardwalk.

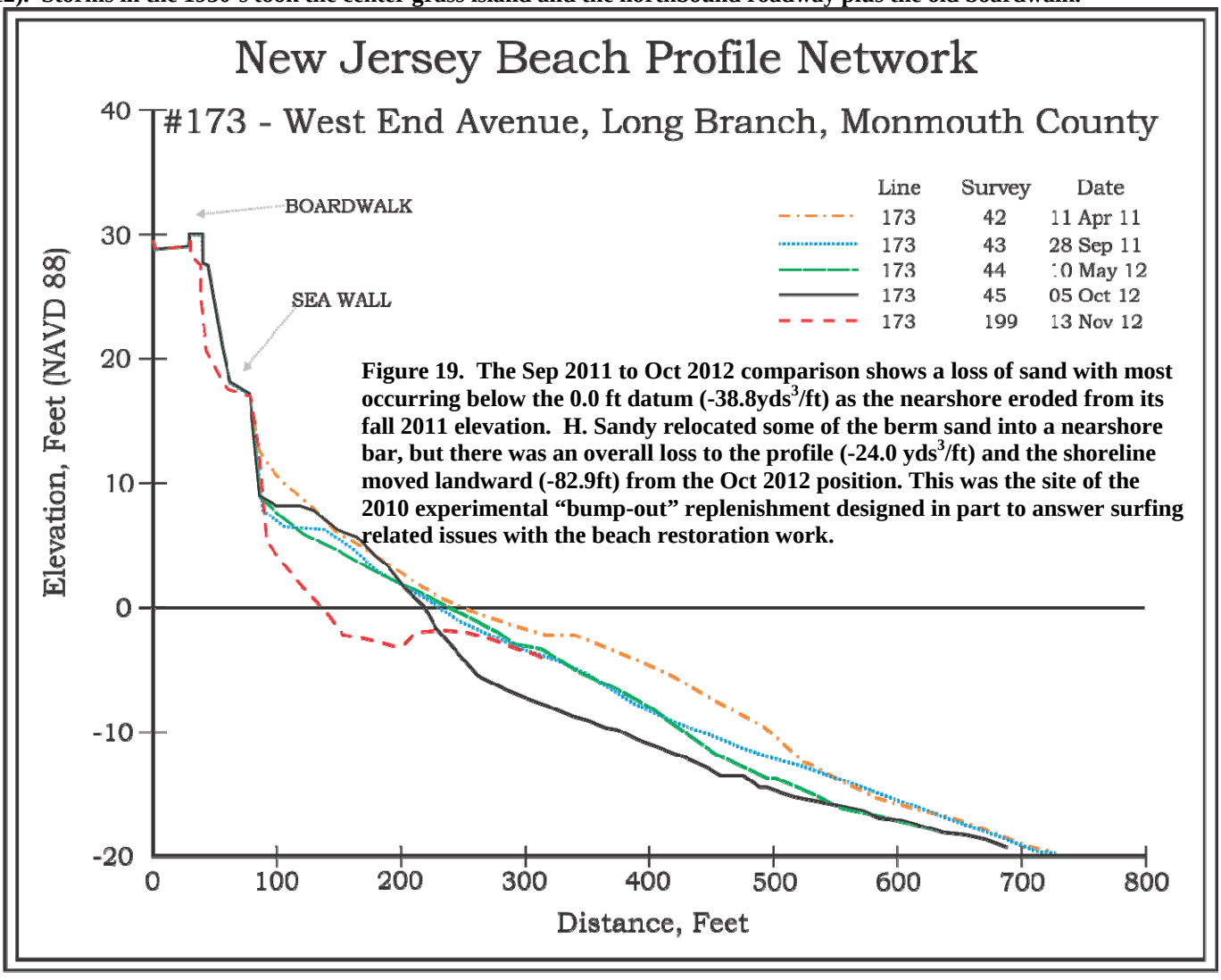


Figure 19. The Sep 2011 to Oct 2012 comparison shows a loss of sand with most occurring below the 0.0 ft datum (-38.8yds^3/ft) as the nearshore eroded from its fall 2011 elevation. H. Sandy relocated some of the berm sand into a nearshore bar, but there was an overall loss to the profile (-24.0 yds^3/ft) and the shoreline moved landward (-82.9ft) from the Oct 2012 position. This was the site of the 2010 experimental "bump-out" replenishment designed in part to answer surfing related issues with the beach restoration work.

NJBPN 272 – 805 Ocean Ave, Long Branch

This site, established in 2010, is located on the northeastern edge of Lake Takanassee and within a groin compartment. The left photo (taken October 5, 2012) shows the relatively stable conditions of the berm prior to H. Sandy. The photo on the right (taken November 13, 2012) shows the lowered berm and debris from structures that were destroyed in the storm.

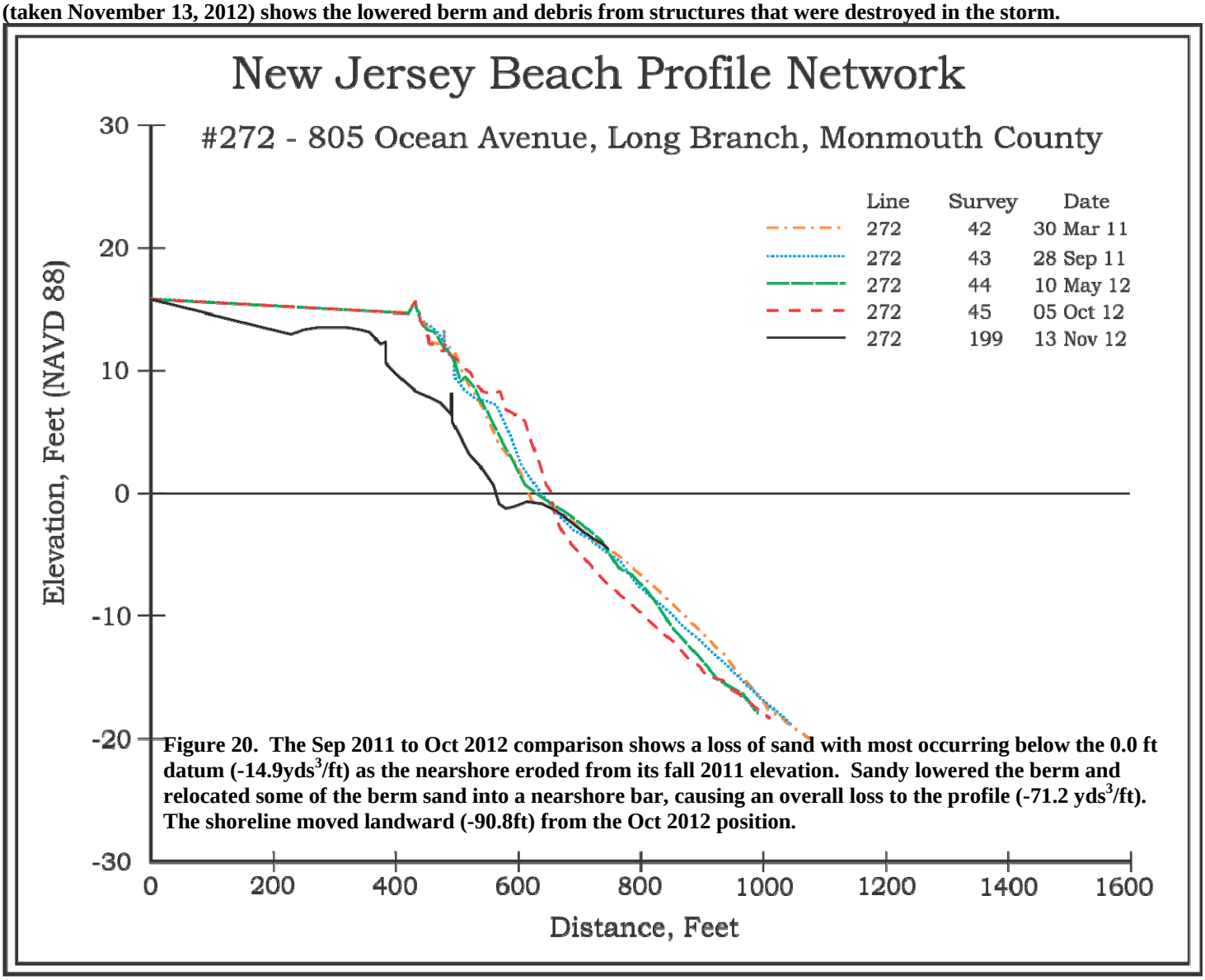


Figure 20. The Sep 2011 to Oct 2012 comparison shows a loss of sand with most occurring below the 0.0 ft datum (-14.9yds^3/ft) as the nearshore eroded from its fall 2011 elevation. Sandy lowered the berm and relocated some of the berm sand into a nearshore bar, causing an overall loss to the profile (-71.2 yds^3/ft). The shoreline moved landward (-90.8ft) from the Oct 2012 position.

NJBPN 171 – Pullman Avenue, Elberon

This site is located on the highest point along the bluff shoreline and in the past, has had very little sub-aerial beach as this community was not included in the Federal beach nourishment projects (left photo taken May 13, 2012). Prior to Sandy, the private properties were separated from the shoreline by a bulkhead and rock revetment which rises 12 feet in elevation and was undamaged. However, waves apparently broke over the rock revetment, attacked upper un-armored bluff sediments and pushed the edge back 40 feet (right photo taken November 13, 2012).

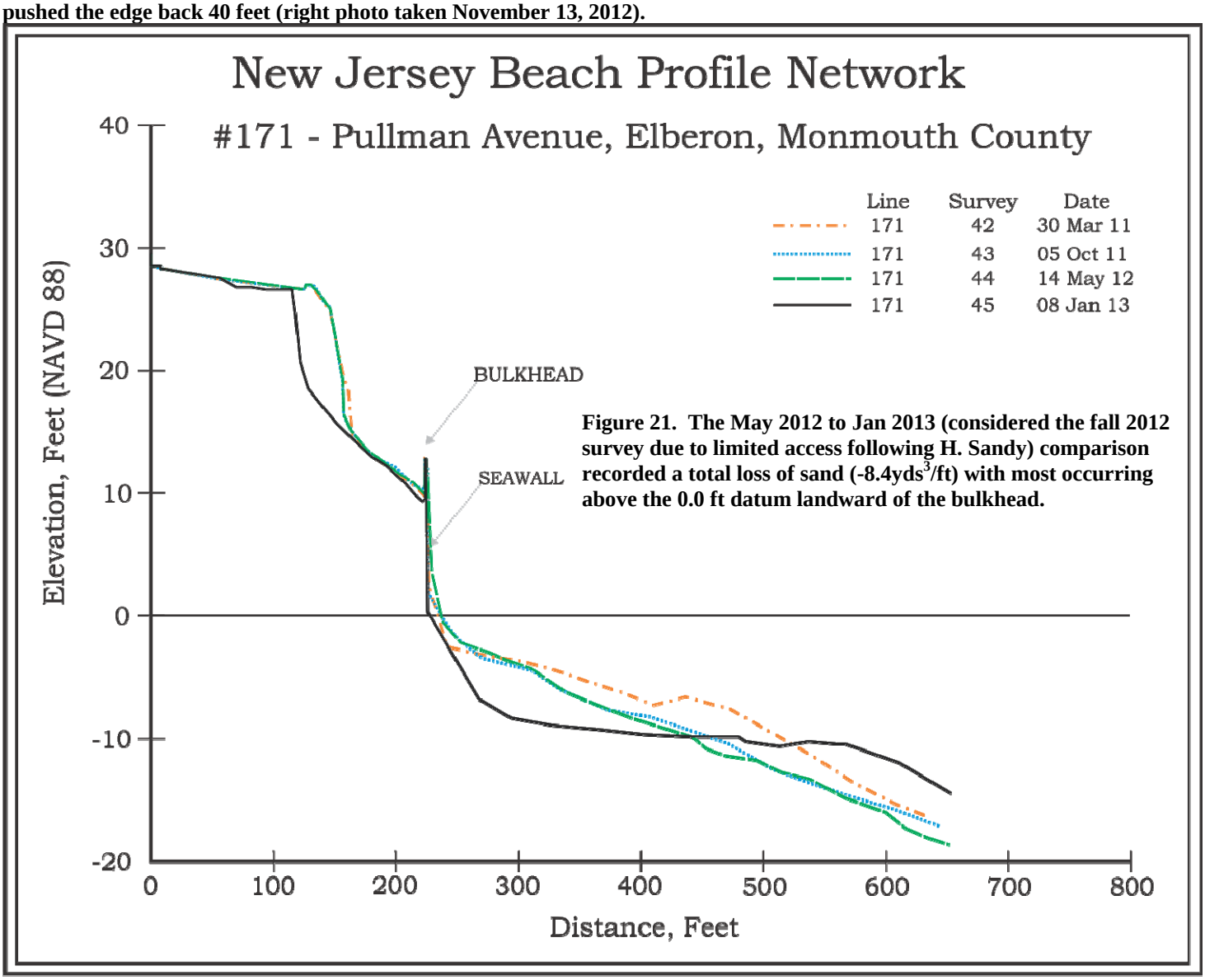


Figure 21. The May 2012 to Jan 2013 (considered the fall 2012 survey due to limited access following H. Sandy) comparison recorded a total loss of sand (-8.4yds^3/ft) with most occurring above the 0.0 ft datum landward of the bulkhead.

NJBPN 170 – Roosevelt Avenue, Deal

This profile is located between two rock groins that limit sediment movement. This area has never received sand from direct beach nourishment and has never benefited from the addition of sand from the littoral system derived from the Federal beach fills. Here the bluff is 20 feet higher than the beach and armored with rocks (left photo taken May 13, 2012). The photo on the right (taken November 13, 2012) shows the impacts of Sandy where waves crashed over the rocks and dug deeply into the area just landward of the rock revetment. Ocean Avenue was flooded at least 3 feet deep and the Deal sewage pumping station at the seaward end of Roosevelt Avenue was destroyed.

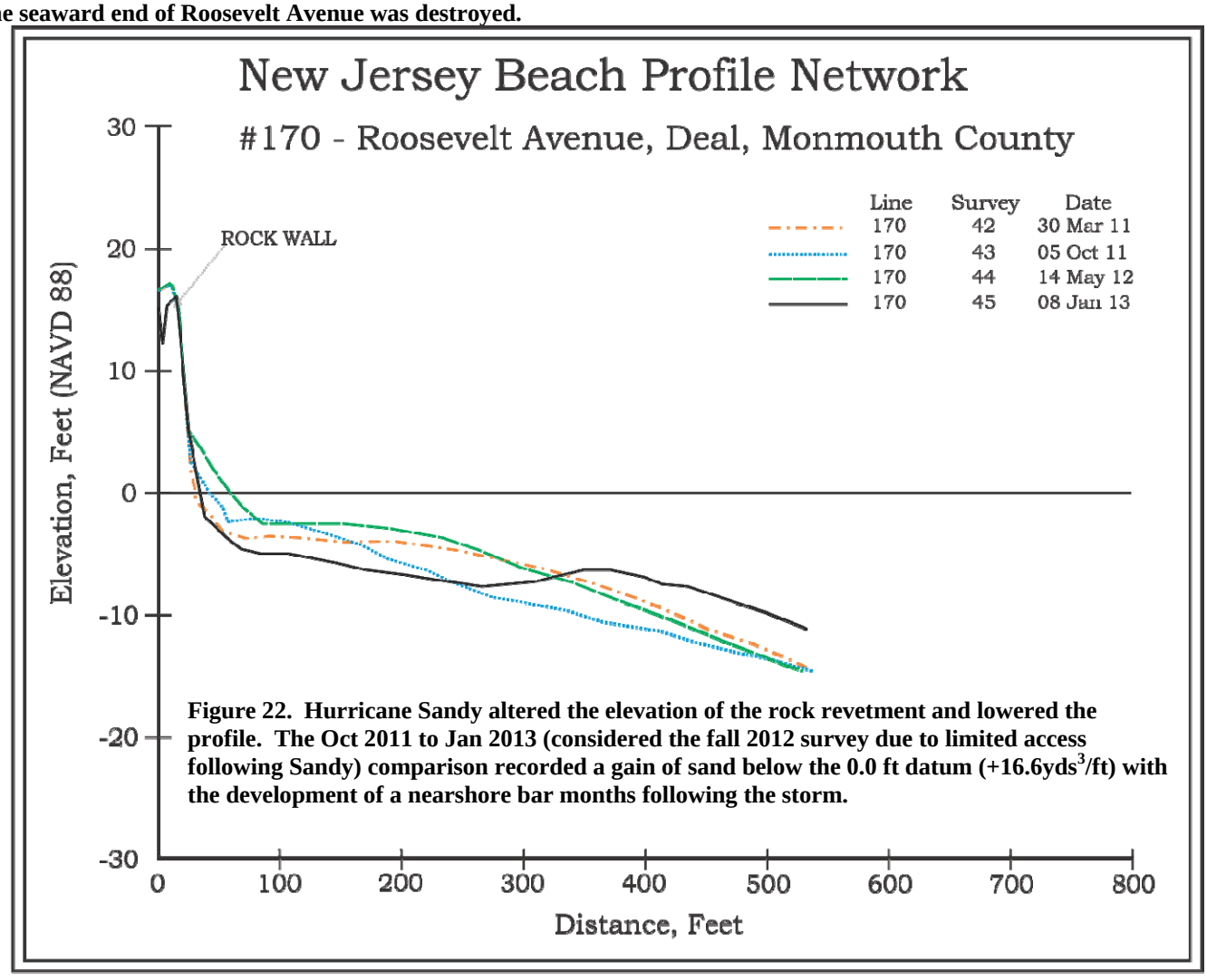


Figure 22. Hurricane Sandy altered the elevation of the rock revetment and lowered the profile. The Oct 2011 to Jan 2013 (considered the fall 2012 survey due to limited access following Sandy) comparison recorded a gain of sand below the 0.0 ft datum (+16.6yds^3/ft) with the development of a nearshore bar months following the storm.

NJBPN 169 – Darlington Avenue, Deal

The Darlington site has a small subaerial beach contained between two larger groins. The upland bluff is partially exposed and partially protected by various types of armor. The left photo (taken on October 5, 2012) shows the pre-Sandy conditions. This site was completely inundated by storm surge and waves during Sandy (right photo taken November 13, 2012).

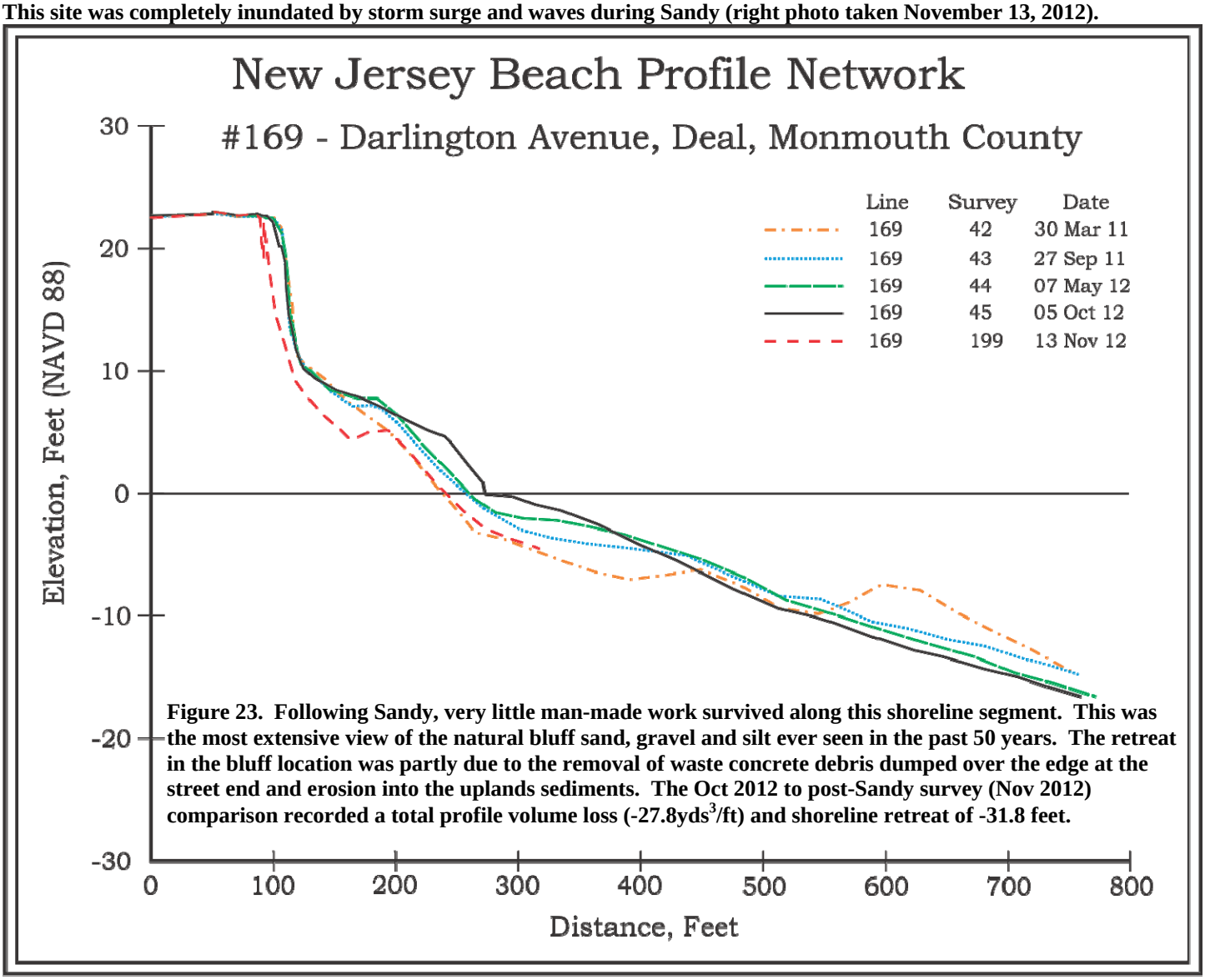


Figure 23. Following Sandy, very little man-made work survived along this shoreline segment. This was the most extensive view of the natural bluff sand, gravel and silt ever seen in the past 50 years. The retreat in the bluff location was partly due to the removal of waste concrete debris dumped over the edge at the street end and erosion into the uplands sediments. The Oct 2012 to post-Sandy survey (Nov 2012) comparison recorded a total profile volume loss (-27.8yds^3/ft) and shoreline retreat of -31.8 feet.

NJBPN 168 – Corlies Avenue, Allenhurst

This site in Allenhurst also represents the shoreline conditions for Loch Arbor's 2-block shoreline. Here an old concrete wall protects the sedimentary bluff (left photo taken on October 5, 2012). Age and decay has had an effect, but Sandy's waves clearly broke over the top of the wall with sufficient force to dislodge about 50 feet of the boardwalk (right photograph in front of the white truck, taken November 13, 2012) and negatively impact the landscaping across the street. Note that nothing remains of the white cabaña complex at the north end of the Allenhurst beach and note the bent railing in the foreground.

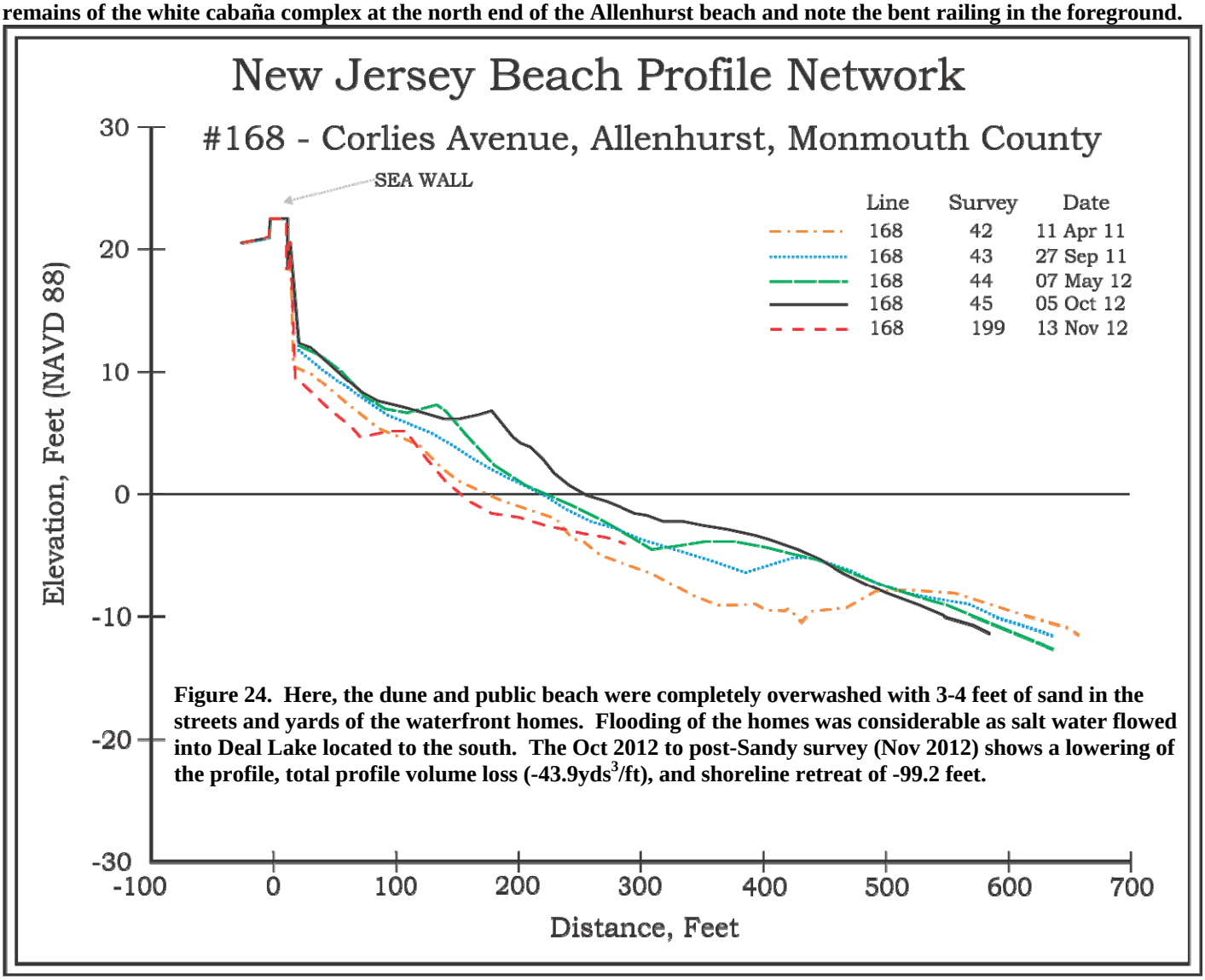
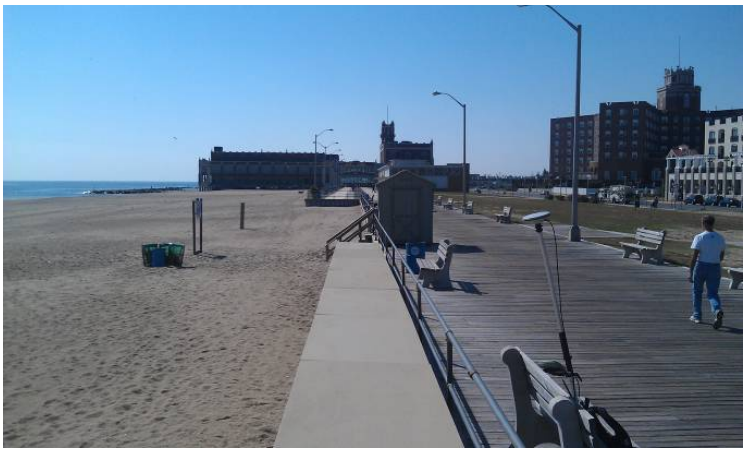


Figure 24. Here, the dune and public beach were completely overwashed with 3-4 feet of sand in the streets and yards of the waterfront homes. Flooding of the homes was considerable as salt water flowed into Deal Lake located to the south. The Oct 2012 to post-Sandy survey (Nov 2012) shows a lowering of the profile, total profile volume loss (-43.9yds^3/ft), and shoreline retreat of -99.2 feet.

NJBPN 267 – 7th Avenue, Asbury Park



This site was included in the Federal shore protection project. The left photo (taken on October 5, 2012) shows the wide beach and no dune. Hurricane Sandy stripped sand from the beach, pushed the berm landward with sand washed up to the boardwalk as a ramp allowing the waves to pass over the structure inland. The smaller structures showing on the left photograph are missing after Sandy, but the boardwalk had minor damage as waves forced sand under and upward raising decking in an irregular pattern (right photo November 13, 2012).

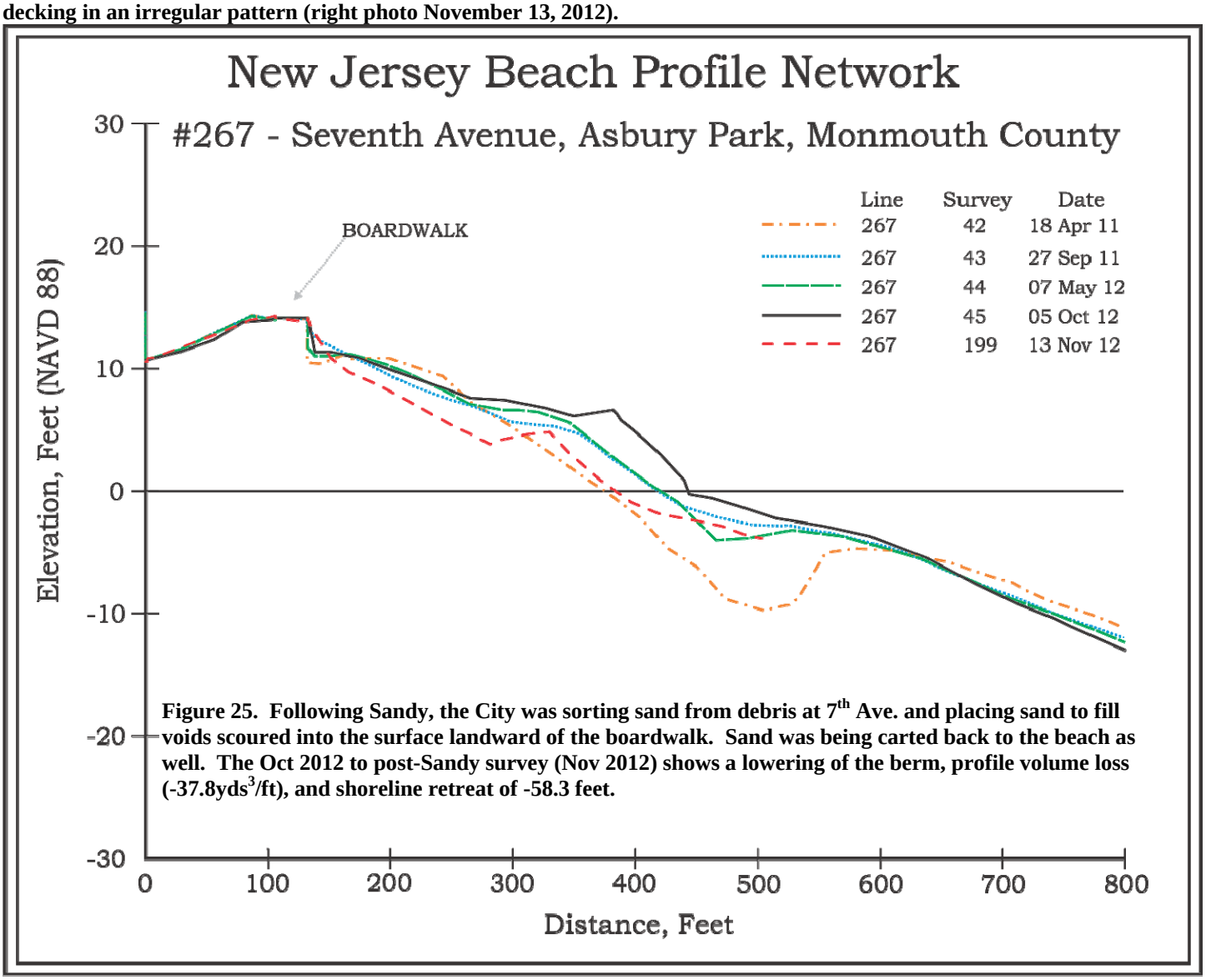


Figure 25. Following Sandy, the City was sorting sand from debris at 7th Ave. and placing sand to fill voids scoured into the surface landward of the boardwalk. Sand was being carted back to the beach as well. The Oct 2012 to post-Sandy survey (Nov 2012) shows a lowering of the berm, profile volume loss (-37.8yds^3/ft), and shoreline retreat of -58.3 feet.

NJBPN 167 – 3rd Avenue, Asbury Park

Asbury Park experienced a broad leveling of the profile as a result of Hurricane Irene and had made gains by the Oct 2012 survey (left photo October 5, 2012). After Sandy, this site at 3rd Avenue the sand, stripped from the beach, was ramped up to the boardwalk allowing the waves to pass over the structure without destroying it (right photo taken November 13, 2012). The small building to the left side of the left photograph was gone, but boardwalk damage was limited to raised sections of decking.

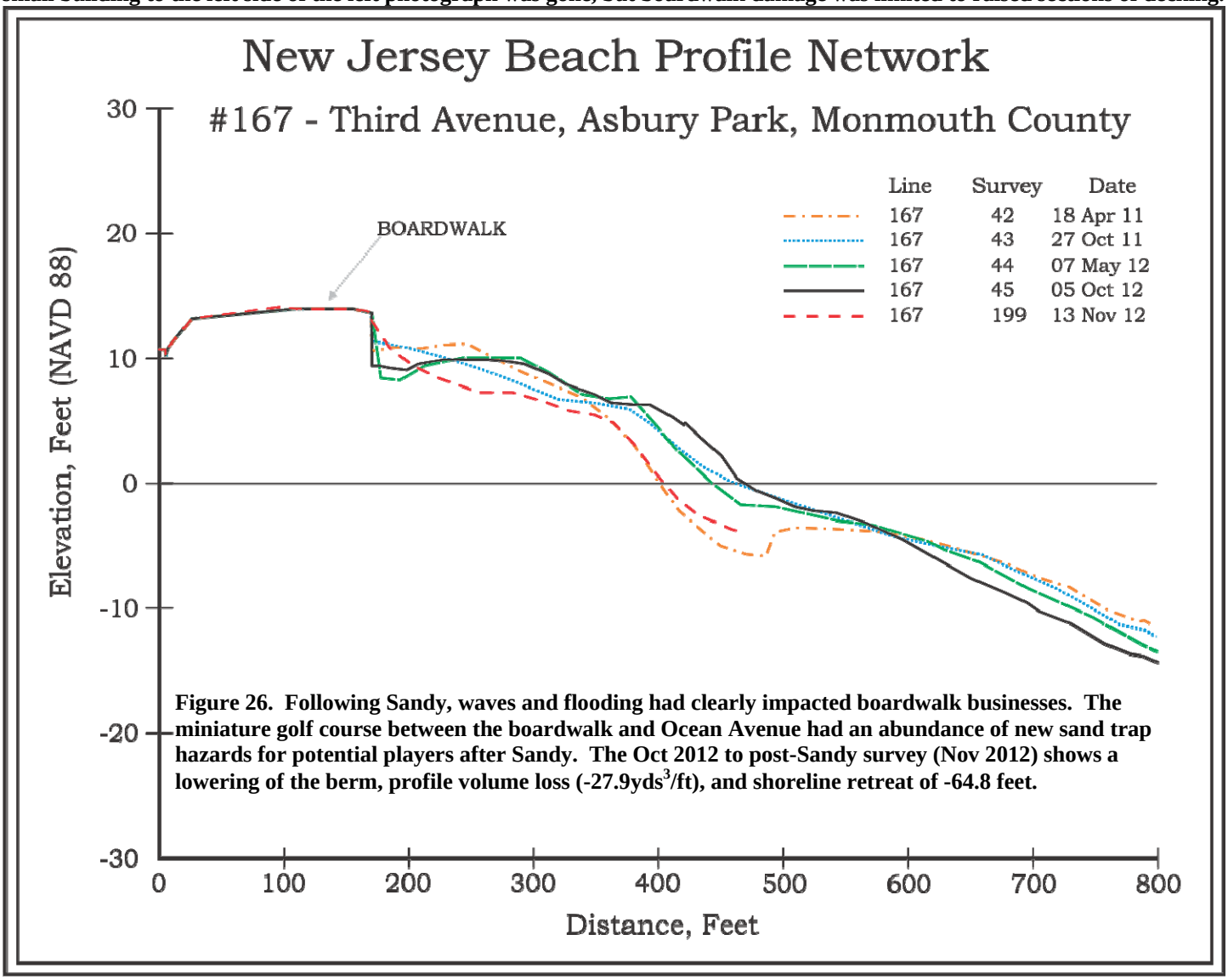


Figure 26. Following Sandy, waves and flooding had clearly impacted boardwalk businesses. The miniature golf course between the boardwalk and Ocean Avenue had an abundance of new sand trap hazards for potential players after Sandy. The Oct 2012 to post-Sandy survey (Nov 2012) shows a lowering of the berm, profile volume loss (-27.9yds^3/ft), and shoreline retreat of -64.8 feet.

NJBPN 166 – Ocean Pathway, Ocean Grove

This site was included in the Federal shore protection project in 1999 and experienced slow sand volume loss (left photo taken on October 4, 2012). Following Sandy, the dunes along the northern Ocean Grove shoreline survived in partial sections, example below, but were removed south of Main Street. Sand was being excavated from Ocean Avenue and carted back to the beach (vehicle in right photo November 13, 2012).

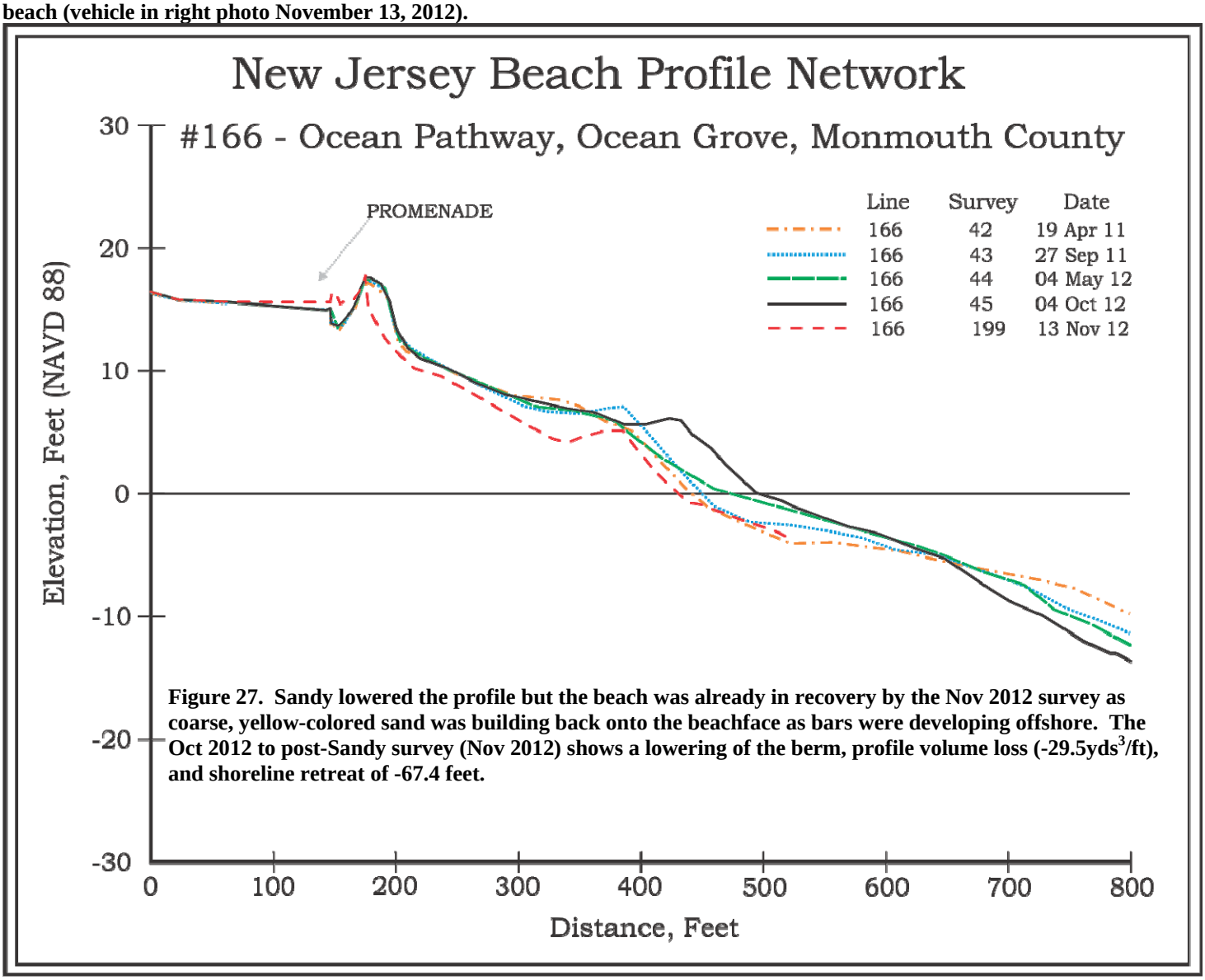


Figure 27. Sandy lowered the profile but the beach was already in recovery by the Nov 2012 survey as coarse, yellow-colored sand was building back onto the beachface as bars were developing offshore. The Oct 2012 to post-Sandy survey (Nov 2012) shows a lowering of the berm, profile volume loss (-29.5yds^3/ft), and shoreline retreat of -67.4 feet.

NJBPN 165 – McCabe Avenue, Bradley Beach

This site saw few changes following Irene in 2011 (left photo taken on October 4, 2012). Following Sandy, dune damage was extensive, but their effect was to reduce the damages landward. The promenade was impacted, but not destroyed but abundant sand was still present in Ocean Avenue. The swale between the dune system and the promenade was filled with sand and the volume lost was significant from the beach (right photo taken Nov 12, 2012).

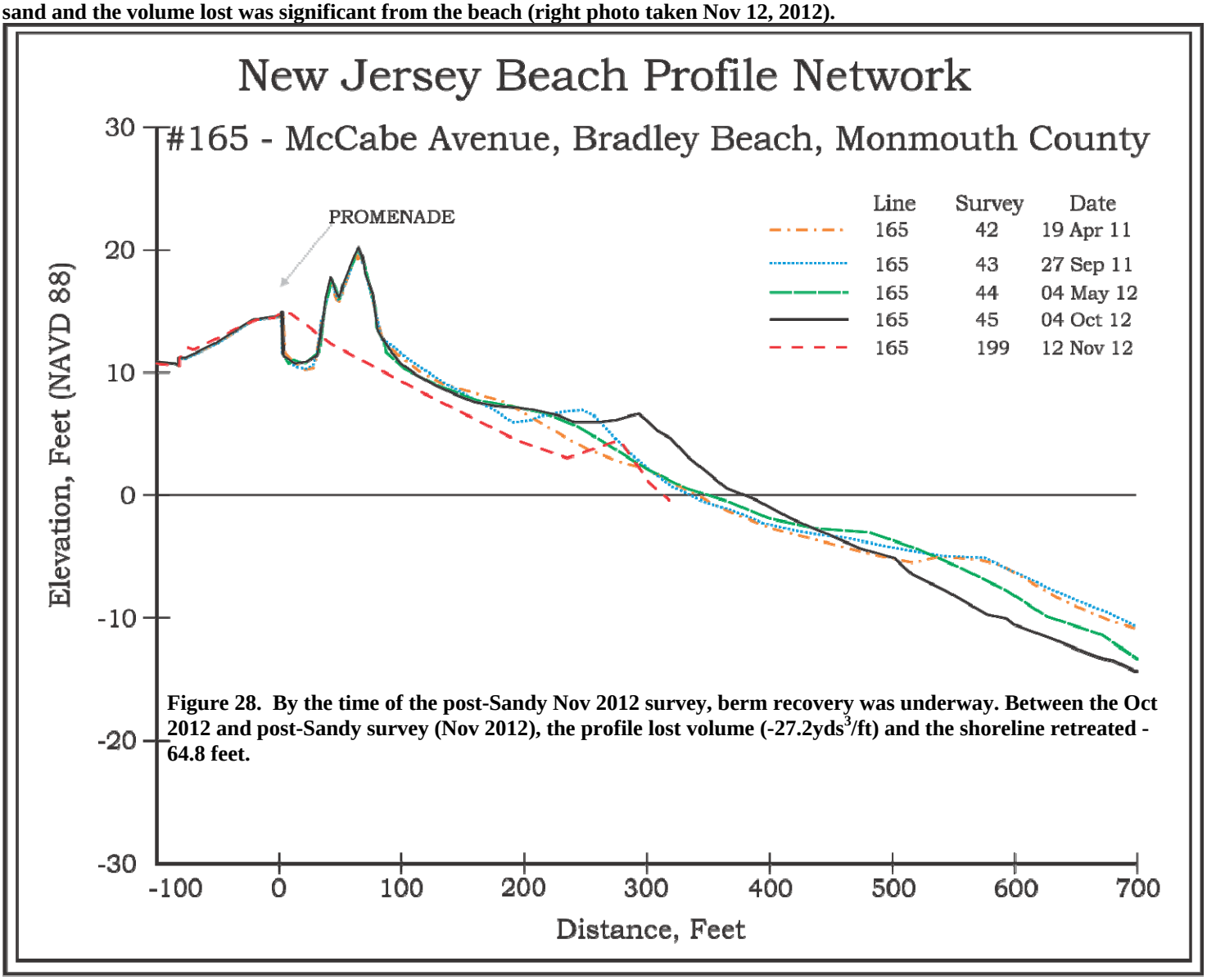


Figure 28. By the time of the post-Sandy Nov 2012 survey, berm recovery was underway. Between the Oct 2012 and post-Sandy survey (Nov 2012), the profile lost volume (-27.2yds^3/ft) and the shoreline retreated -64.8 feet.

NJBPN 164 – Sylvania Avenue, Avon-by-the Sea

This site is located north of the Shark River inlet and was nourished in the 1999 Federal shore protection project (left--pre-Sandy photo, taken on October 4, 2012). During Sandy, the beach had been totally submerged and sand was washed inland well beyond Ocean Avenue. The swale between Ocean Avenue and the boardwalk was filled in. Damage to the building just north of the profile line was extensive. The small lakes were also impacted with sand burying the drainage system as well as raising lake levels with salt water. Efforts were underway to excavate the drainage and lower lake level (right photo taken November 12, 2012).

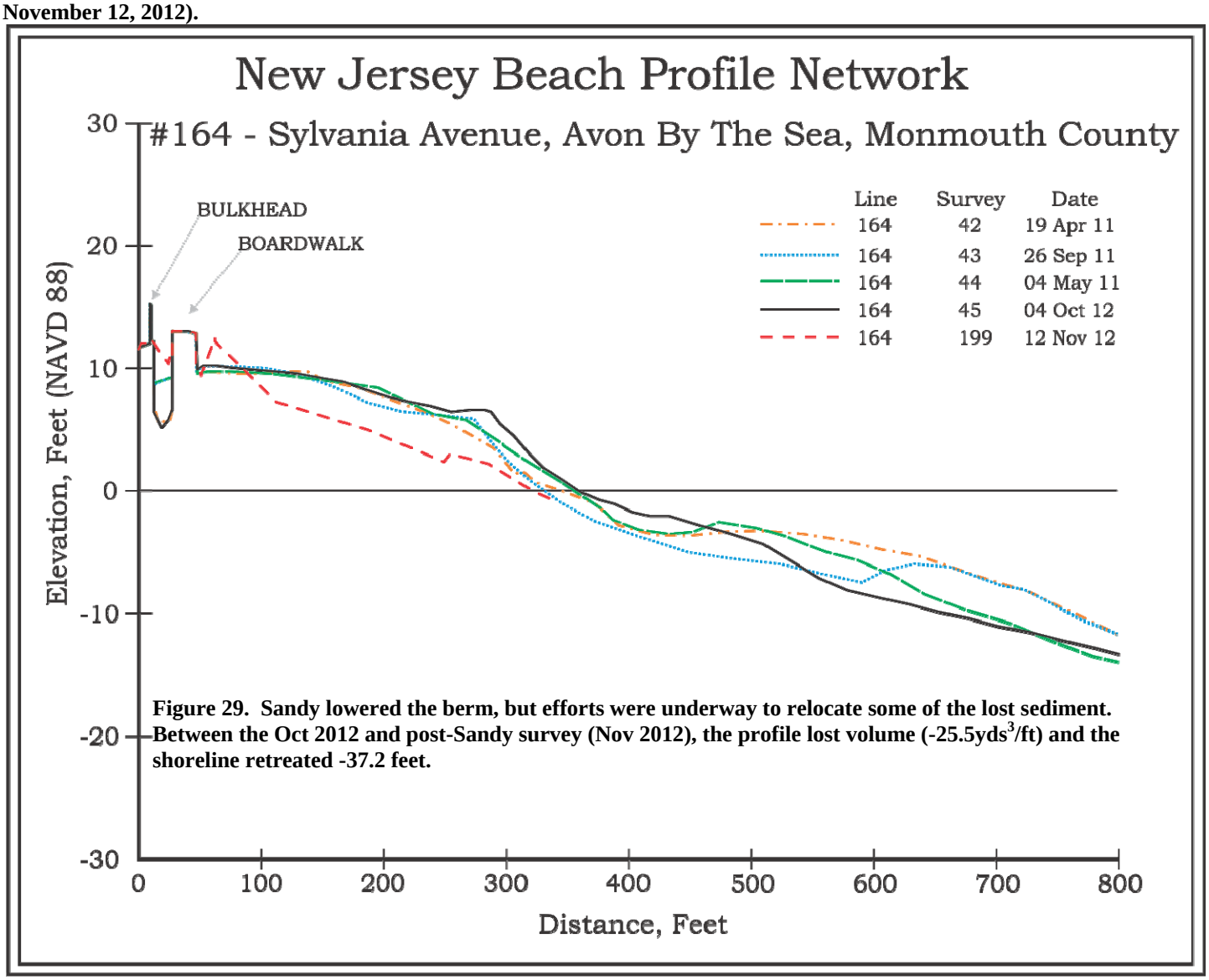


Figure 29. Sandy lowered the berm, but efforts were underway to relocate some of the lost sediment. Between the Oct 2012 and post-Sandy survey (Nov 2012), the profile lost volume (-25.5yds^3/ft) and the shoreline retreated -37.2 feet.

NJBPN 163 – 5th Avenue, Belmar

This site did not have a dune prior to Sandy but had a wide, dry beach (left photo taken on October 2, 2012). During Sandy, the dry beach was submerged by the storm surge. Sand was carried landward onto Ocean Avenue accompanied by extensive flooding (right photo taken November 12, 2012).

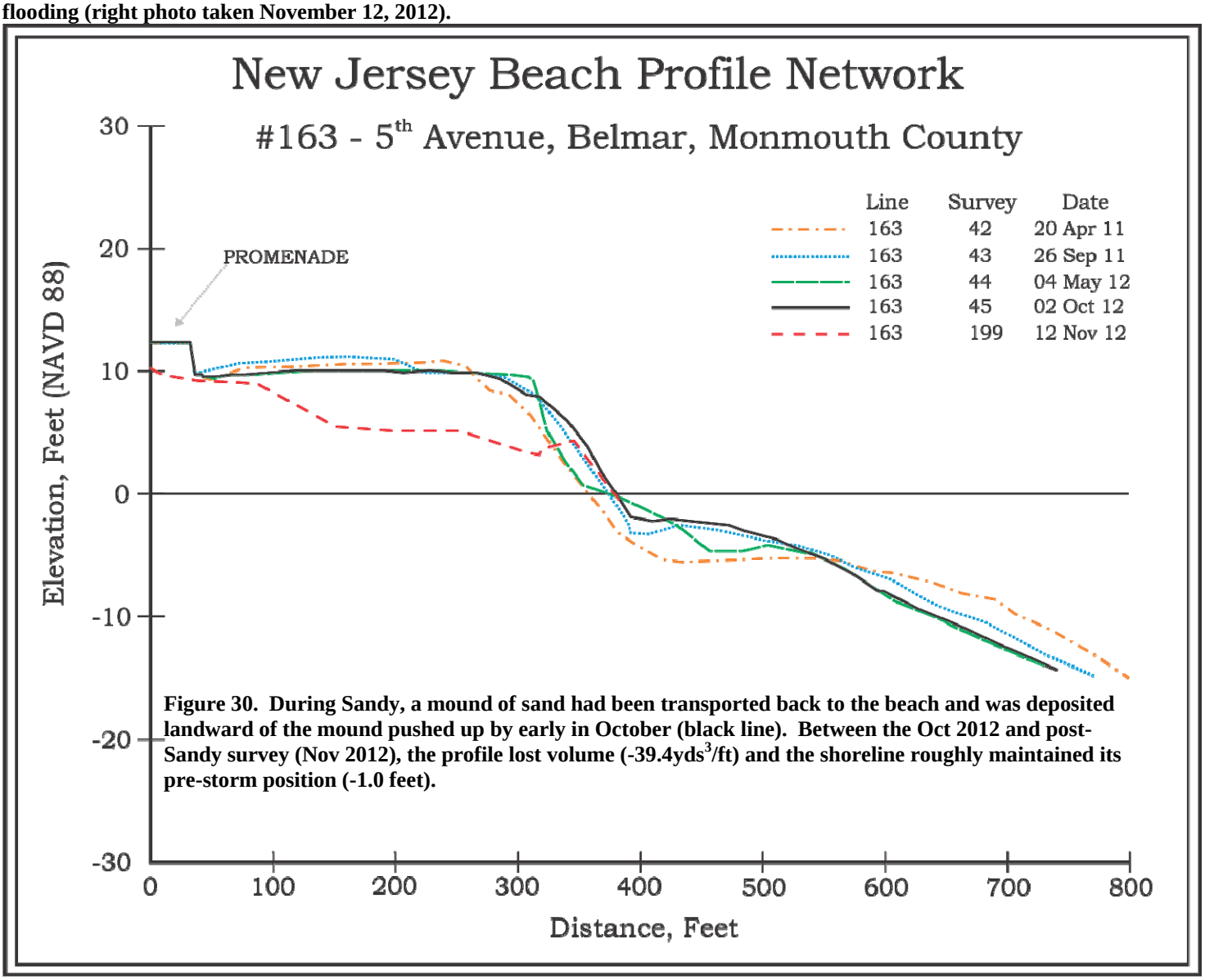
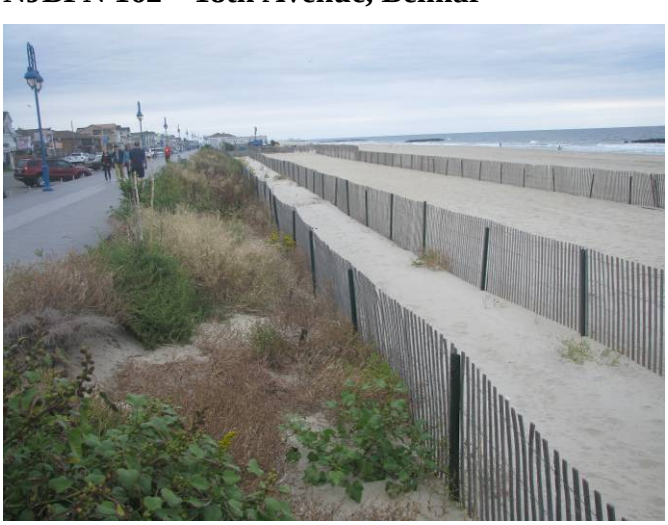


Figure 30. During Sandy, a mound of sand had been transported back to the beach and was deposited landward of the mound pushed up by early in October (black line). Between the Oct 2012 and post-Sandy survey (Nov 2012), the profile lost volume (-39.4yds^3/ft) and the shoreline roughly maintained its pre-storm position (-1.0 feet).

NJBPN 162 – 18th Avenue, Belmar



Sand was placed at this location in the 1997 Federal shore protection project and has remained relatively stable (left photo taken October 2, 2012). The southern Belmar shoreline was completely overrun by the force of Hurricane Sandy. The Lake Como segment was closed to traffic because multiple pumping pipelines were in place moving lake water back to the sea. Excavators were digging to clear the normal drainage system as well. Nothing but the supports remained from the boardwalk, with the small dune and all the fencing swept away (right photo taken November 12, 2012).

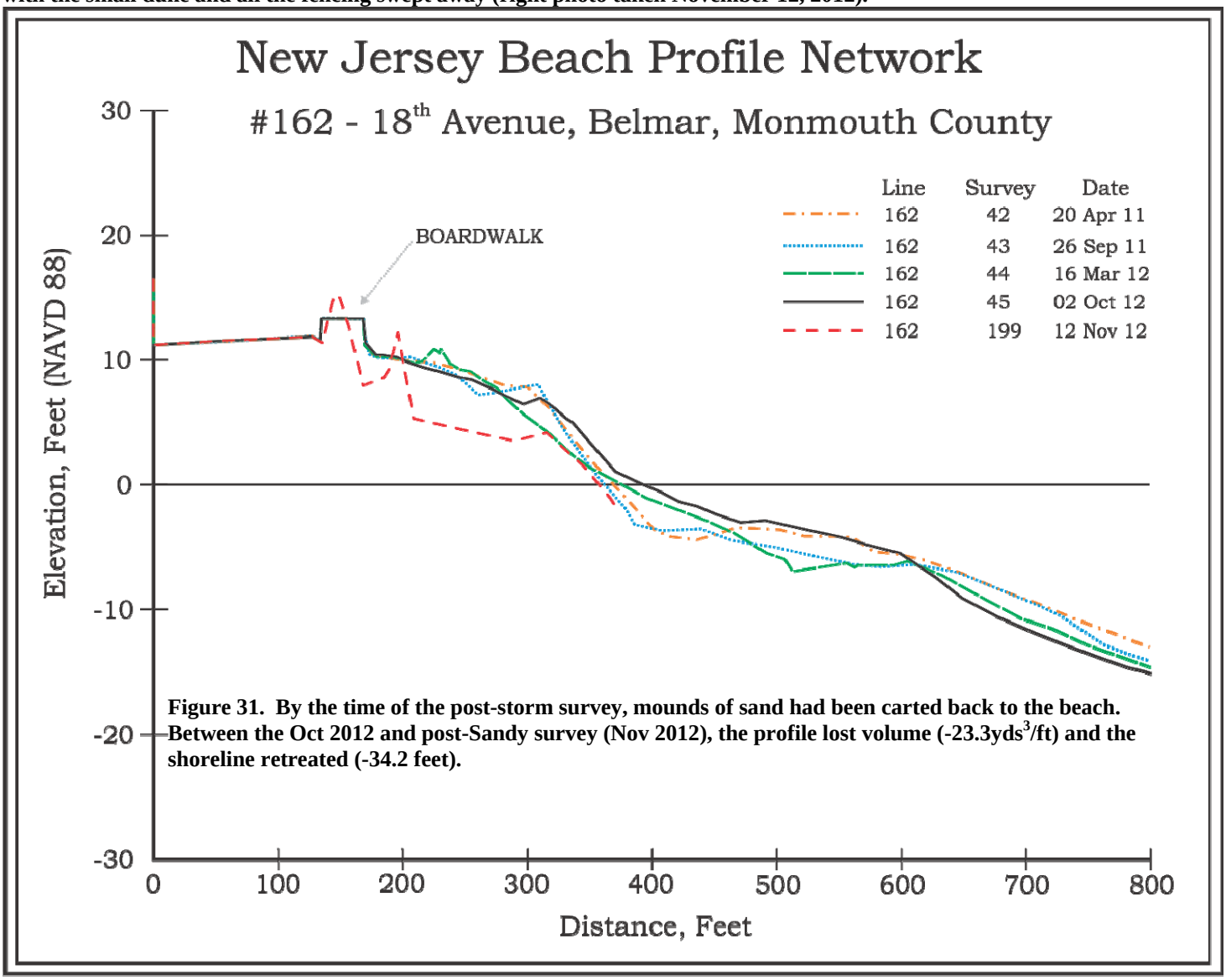


Figure 31. By the time of the post-storm survey, mounds of sand had been carted back to the beach. Between the Oct 2012 and post-Sandy survey (Nov 2012), the profile lost volume (-23.3yds^3/ft) and the shoreline retreated (-34.2 feet).

NJBPN 161 – Brighton Avenue, Spring Lake

This site received sand during the 1997 Federal shore protection project and has had modest volume gains (left photo taken on October 2, 2012). During Sandy, Spring Lake lost the entire boardwalk deck. Extensive damage occurred at the ocean-side bathing buildings with most of the dunes breached and some segments removed entirely. Since the boardwalk had been seaward of the dunes for over 70 years, the waves impacting the dunes acted to lift the boardwalk deck sections from the concrete supports. The fact that the steel deck retainers were rusted away by decades of neglect did not help matters in terms of boardwalk survival (right photo taken November 12, 2012).

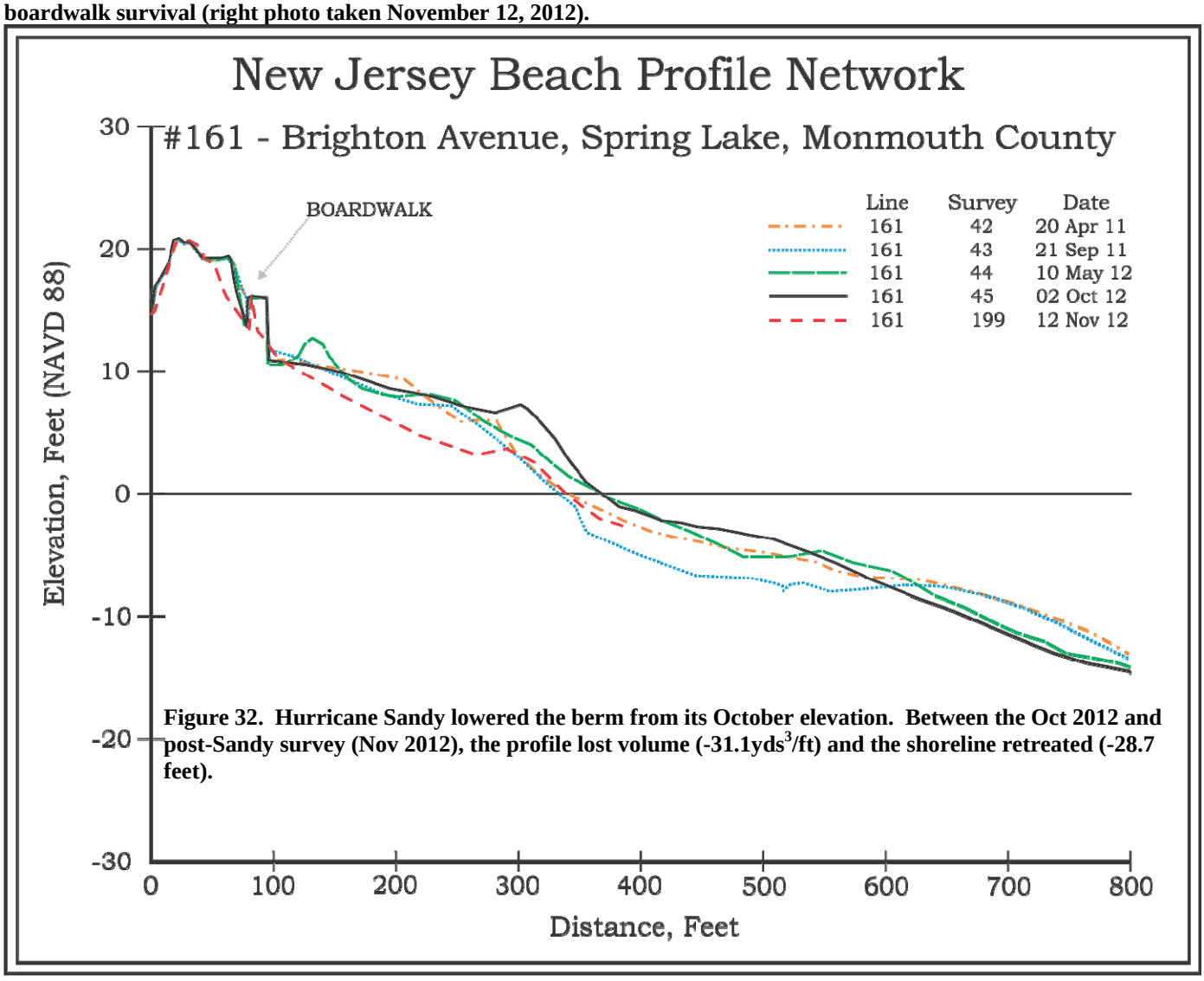


Figure 32. Hurricane Sandy lowered the berm from its October elevation. Between the Oct 2012 and post-Sandy survey (Nov 2012), the profile lost volume (-31.1yds^3/ft) and the shoreline retreated (-28.7 feet).

NJBPN 160 – Salem Avenue, Spring Lake

The dunes at this site also were located landward of the boardwalk (left photo taken October 1, 2012). Sandy caused serious dune erosion that allowed waves to move sand into Ocean Avenue and strip the boardwalk deck from the supports. A ridge of sand had been carted back to the beach as the feature showing on the beach on the November 12th survey line (right photo taken November 12, 2012).

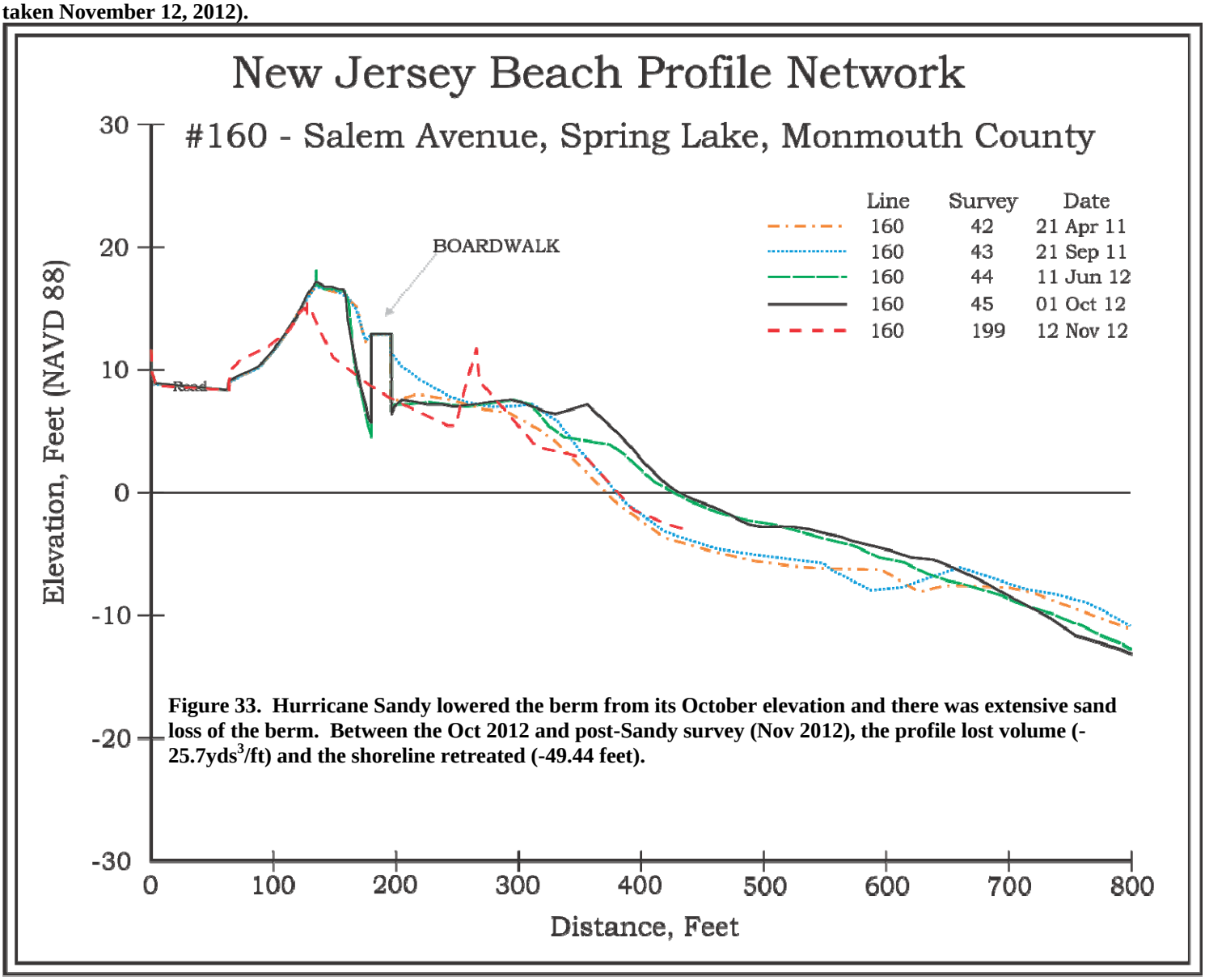


Figure 33. Hurricane Sandy lowered the berm from its October elevation and there was extensive sand loss of the berm. Between the Oct 2012 and post-Sandy survey (Nov 2012), the profile lost volume (-25.7yds^3/ft) and the shoreline retreated (-49.44 feet).

NJBPN 159 – New York Avenue, Sea Girt

Sand was added to this site in the 1997 Federal shore protection project and has remained relatively stable since that time (left photo taken on October 1, 2012). Sandy caused damages along the northern Sea Girt shoreline and impacted the infrastructure more intensely than at locations further south. The boardwalk was damaged and washed over completely. Sand was being carted back the beach as a sizable ridge (right photo taken November 12, 2012).

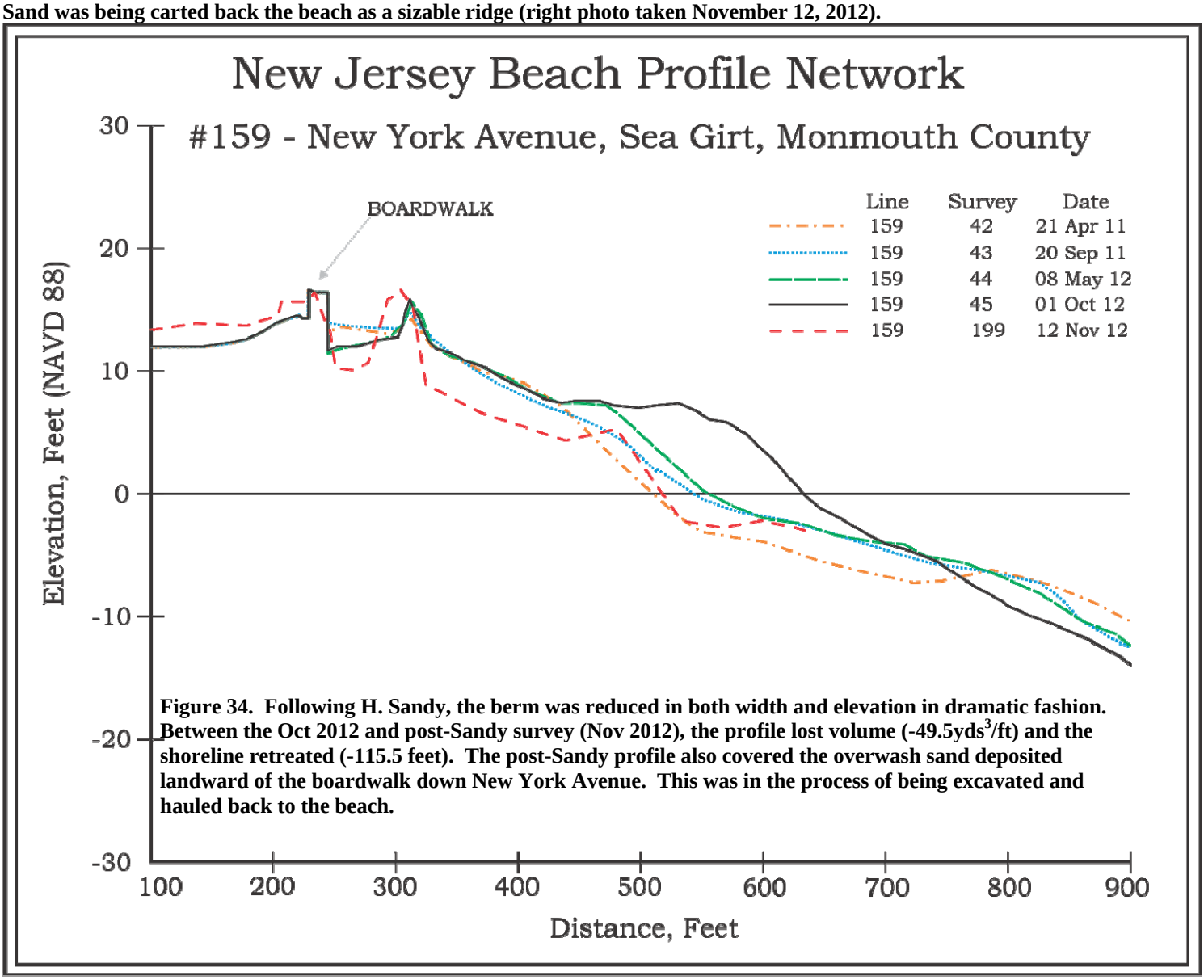


Figure 34. Following H. Sandy, the berm was reduced in both width and elevation in dramatic fashion. Between the Oct 2012 and post-Sandy survey (Nov 2012), the profile lost volume (-49.5yds^3/ft) and the shoreline retreated (-115.5 feet). The post-Sandy profile also covered the overwash sand deposited landward of the boardwalk down New York Avenue. This was in the process of being excavated and hauled back to the beach.

NJBPN 158 – Trenton Avenue, Sea Girt

Sand was added to this location in the 1997 Federal shore protection project and dunes formed on their own (left photo taken on October 1, 2012). H. Sandy reduced the elevation and width of the berm and the sand from the street end was carted back to the beach (see the ridge shown in the right photo taken November 12, 2012). Ocean Avenue does not continue south to this location. The beach to the north suffered dune loss, but no waves reached the homes because both the dune was substantial and the homes sit on top of the Monmouth County bluff.

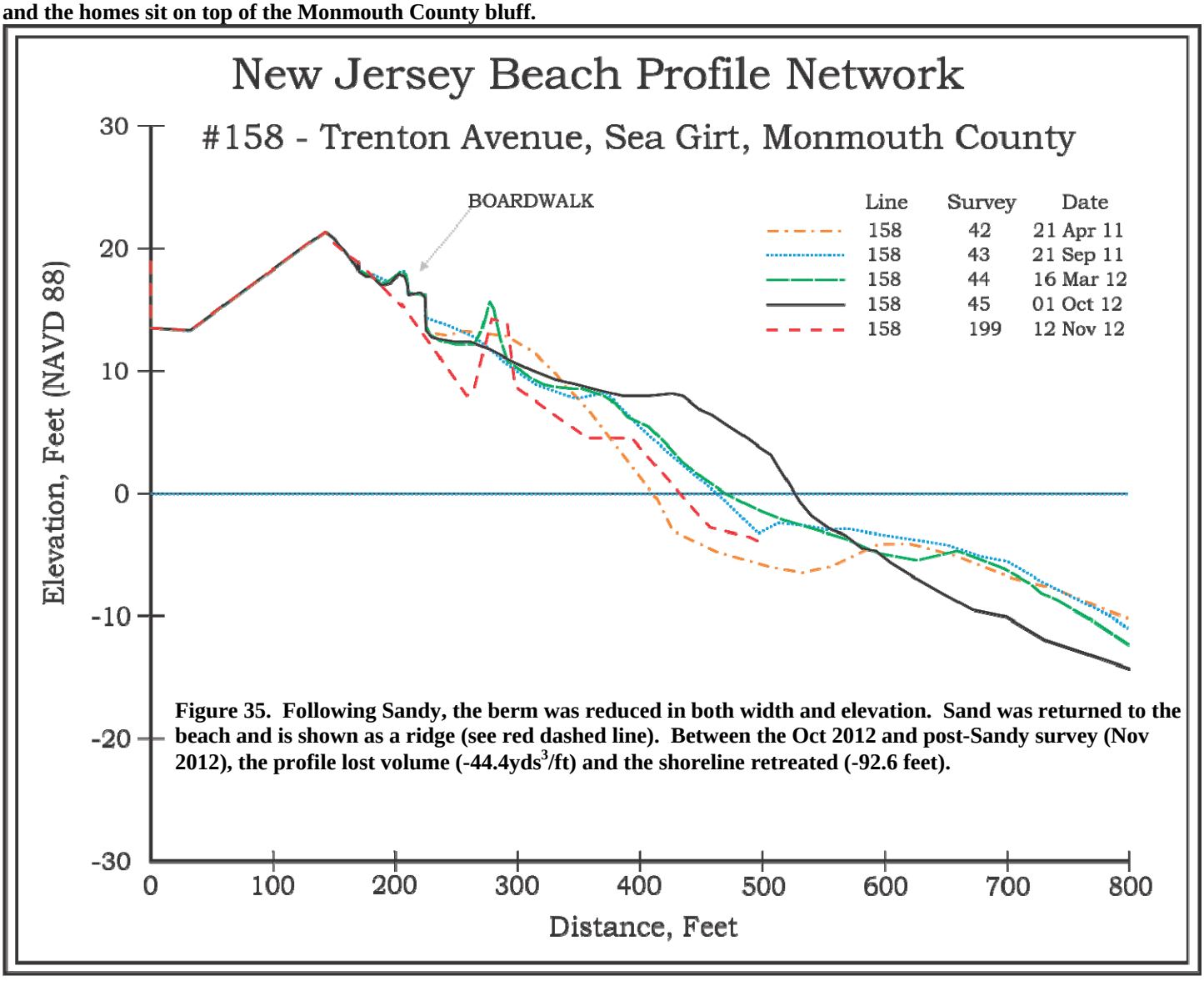


Figure 35. Following Sandy, the berm was reduced in both width and elevation. Sand was returned to the beach and is shown as a ridge (see red dashed line). Between the Oct 2012 and post-Sandy survey (Nov 2012), the profile lost volume (-44.4yds^3/ft) and the shoreline retreated (-92.6 feet).

NJBPN 157 – Riddle Way, Manasquan

This site lies north of the Manasquan Inlet and within influence of the inlet jetties that can create substantial shoreline variations (left photo taken on September 21, 2012). Both Manasquan sites were heavily damaged with massive waves and flooding that transported sand among the homes and into First Avenue. The promenade survived at Riddle Way, but the dune was removed and washed landward. The public access up from First Avenue to the beach at Riddle Way had been a giant white water flume discharging into Manasquan's beachfront development. Work was proceeding to move sand back to the beach as seen in the piles showing on the right photograph (taken November 12, 2012).

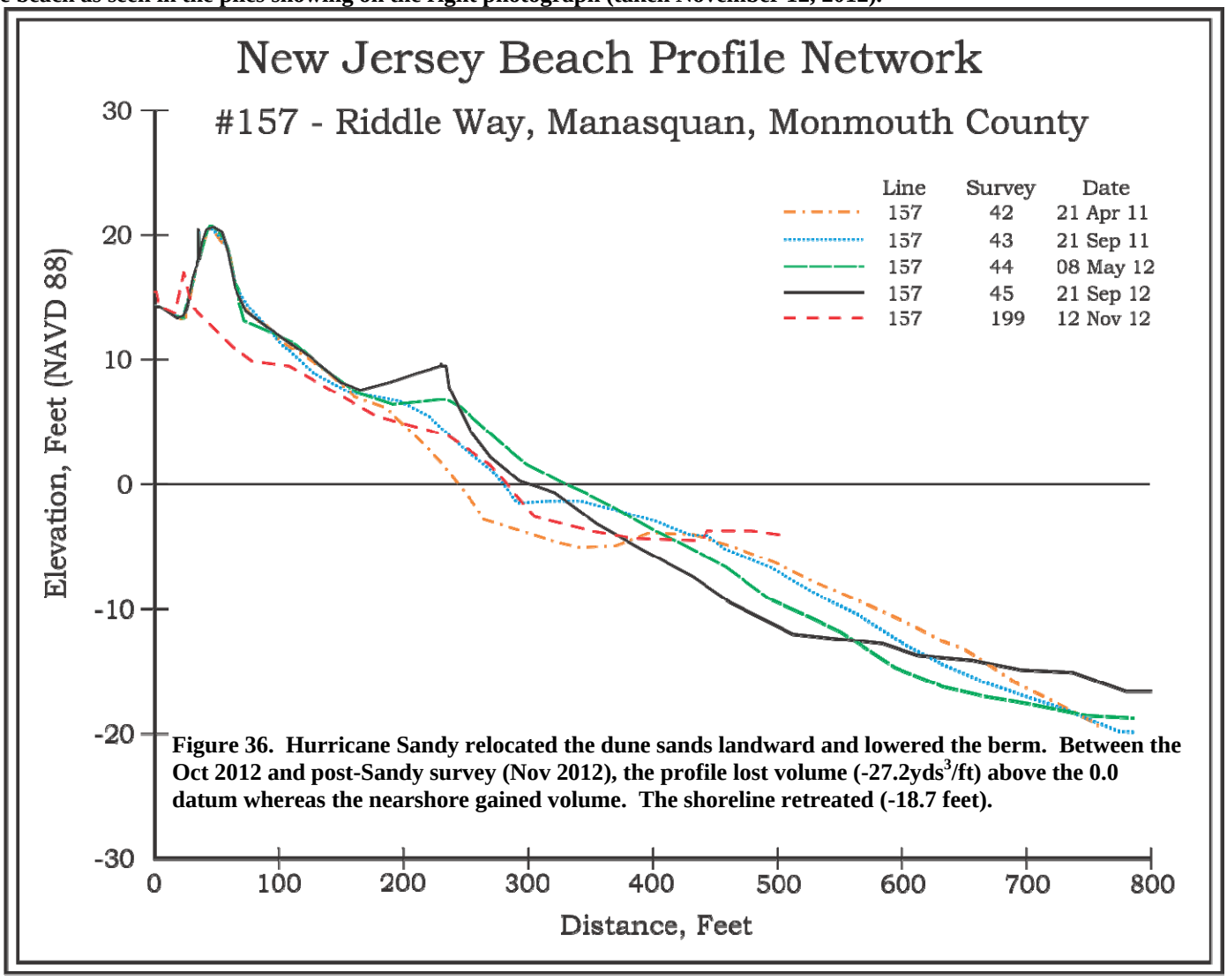


Figure 36. Hurricane Sandy relocated the dune sands landward and lowered the berm. Between the Oct 2012 and post-Sandy survey (Nov 2012), the profile lost volume (-27.2yds^3/ft) above the 0.0 datum whereas the nearshore gained volume. The shoreline retreated (-18.7 feet).

NJBPN 256 – Pompano Avenue, Manasquan

This site is located just north of the Manasquan Inlet. Sand was added in the 1997 Federal shore protection project and profile volume has steadily declined since (left photo taken on September 21, 2012). Following Sandy, damages were worse at this location than to the north. The promenade was removed, as were the dunes and all the berm sand had been transported through the homes into First Avenue in the Borough. Multiple homes had been "red-stickered" with "unfit for habitation" tags with some clearly off their foundations (right photo taken November 12, 2012).

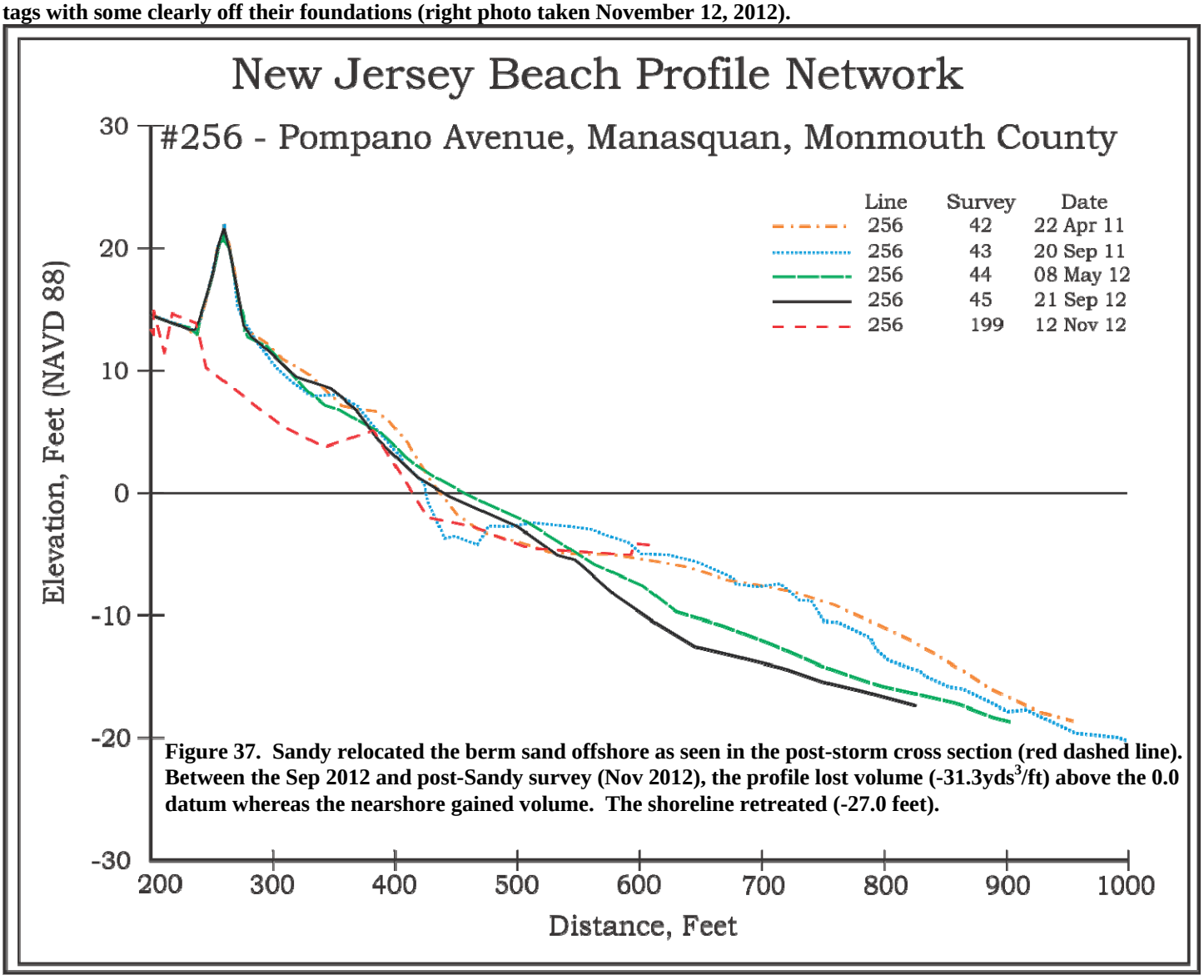


Figure 37. Sandy relocated the berm sand offshore as seen in the post-storm cross section (red dashed line). Between the Sep 2012 and post-Sandy survey (Nov 2012), the profile lost volume (-31.3yds^3/ft) above the 0.0 datum whereas the nearshore gained volume. The shoreline retreated (-27.0 feet).

Roosevelt Ave. Deal to Via Ripa St. Sea Bright Post-Sandy Site Volume Changes

Site Location and Number		Site Sand Volume Change (cu yds/ft)	Dune Failure (Y or N)	Date of Recent Beach Fill
Deal	170	No Data Yet	Bluff Retreat	Never
Elberon	171	-13.60	Bluff Retreat	Never
Long Branch	272	-71.38	Y	Never
Long Branch	173	-23.97	Bluff Retreat	1999
Long Branch	174	-40.72	Bluff Retreat	1999
Long Branch	175	-46.76	No Dune	1998
Long Branch	176	-62.07	No Dune	1998
Long Branch	177	-45.87	No Dune	1997
Monmouth Beach	178	-69.38	Y	1994
Monmouth Beach	179	-48.83	No Dune	1994
Sea Bright	180	-22.60	Y	1995
Sea Bright	181	-16.70	Y	1995
Sea Bright	182	-31.20	Y	1995
Sea Bright	282	-37.13	Partial	1996
Sea Bright	183	-34.10	Y	1996

Figure 38 shows a table of sand loss volumes per foot of shoreline at each of the Northern Monmouth County sites. No beach nourishment was done at the three southern sites because Allenhurst/Loch Arbor, Deal and Elberon declined to participate in the project. The hightide ownership issues were the major stumbling block. Because there was a high sediment bluff in Long Branch fronted with a rock revetment and a very high bathing use demand on the beach space, no dune was designed into this project. Sea Bright's shoreline was defended soley by a 28-foot rock wall that had served as the only form of shore protection during the decades prior to the NY District Corps Project, and this zone was not designated as needing dunes. Fencing was installed along the Sea Bright section and planted between the rows of fence. Natural processes served to allow dunes to develop over 12 years, but with no general design specifications, the process was pretty random. A significant recommendation would be to re-assess the view on creating a wide, double ridge of sand to provide a higher level of storm protection to serve as a blocker for wave run-up that went over the seawall. More importantly, efforts must be made to close the two gaps in the rock wall in the central section of Sea Bright with huge dunes or extend the wall with a serious barrier to seal these two entry points from future waves.

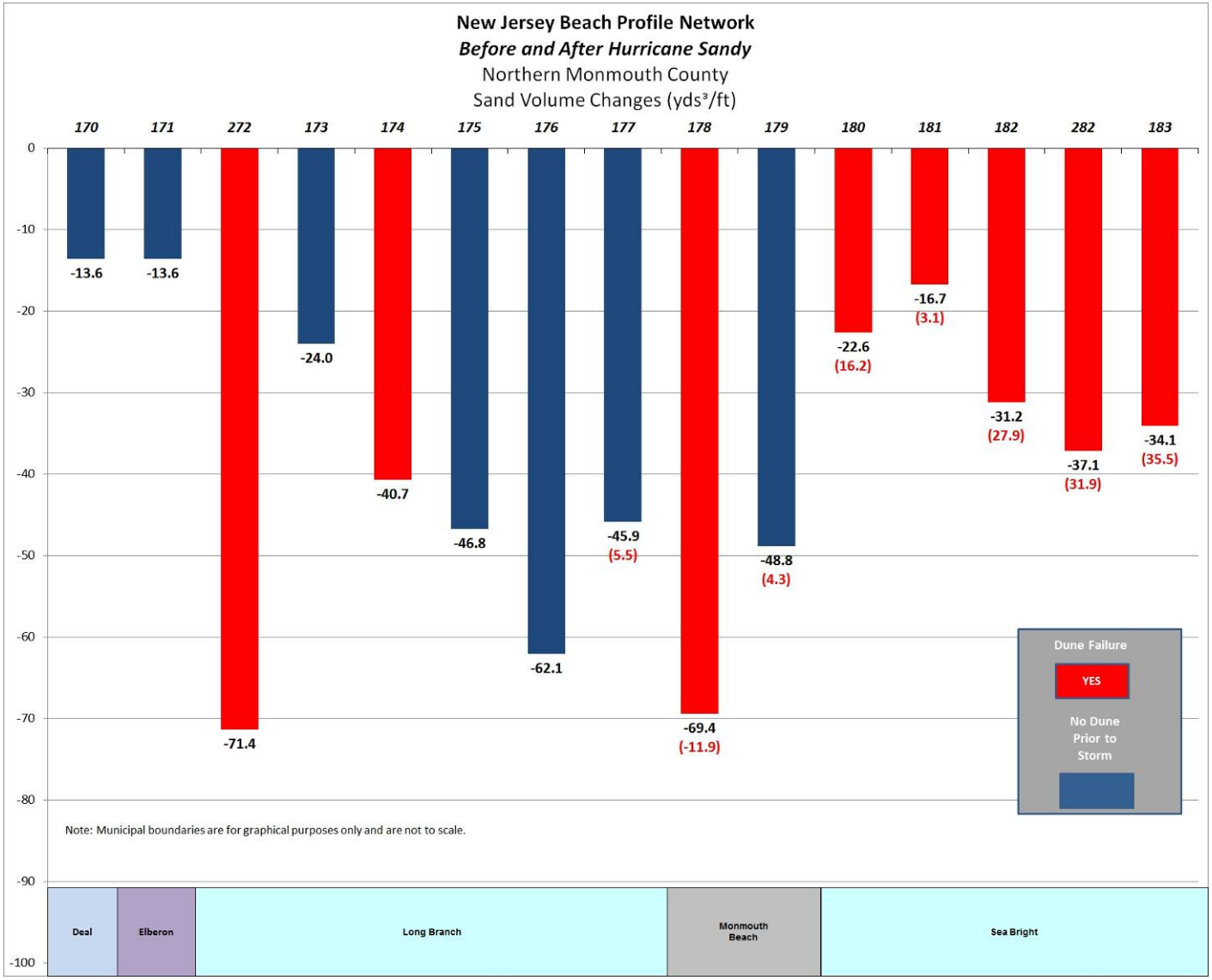


Figure 39. This is a graphical display of the sand volume lost at each site combined with an indication of the presence, absence or failure of the dune system along the Northern Monmouth County shoreline. The natural area north of Sea Bright (Sandy Hook National Seashore) has three cross sections that will be surveyed before December 21, 2012. The sand volume losses are expressed in cubic yards of sand per foot of shoreline. For comparison, the Federal placement volumes were between 225 and 300 cubic yards of sand per foot of shoreline.

All the sand volumes presented and in the two tables above related to the immediate impact on the beach by Hurricane Sandy reflect loss within the dune, beach and shallow offshore reached by wading with a GPS unit. From site 177 north to #183, each location had not been surveyed prior to Sandy, so the regular fall survey was conducted that goes well offshore to 16 to 18-foot depths (NAVD88). On those 8 sites, the deposition of sand offshore is readily apparent. The quantity of sand deposited offshore for those sites is shown in (red) below the loss number for the beach/dune system. For the two northern profiles, the offshore volume nearly equals the loss on the beach. The final depth reached appears to contain the envelope of change termed "closure". Closure appears to extend to water depths up to 20 feet (98% of the change observed) while the normal NJBPN surveys cover from 93 to 96% of the sand volume changes at the 16-foot water depths offshore.

Northern Monmouth County Post Sandy Volume Changes

MUNICIPALITY	NJBPN Site#	Shoreline Change in the Zero Elev. Position Since Initial Fill	Vol Change cu yds per ft	Average of Sand Loss Between Adjacent Sites (cy/ft)	Dune Failure	Recent Beach Fill	Distance Between Sites (FEET)	Vol Change - Cubic Yards Between Profiles (South to North)	Cumulative Volume Change - Cubic Yards (South to North)
Deal *No Survey Yet*	**170**	**no project**	**-13.60**	**-17.23**	**Seawall**	**Never**	**4868**	**-66,207**	**-66,207**
Elberon	171	no project	-13.60	-13.60	Bluff Retreat	Never	5527	-75,172	-141,379
Long Branch	272	no project	-71.38	-42.29	Failed	Never	1418	-101,185	-242,564
Long Branch	173	-362	-23.97	-47.68	Bluff Retreat	1999	3283	-78,695	-321,259
Long Branch	174	-216	-40.72	-32.35	Bluff Retreat	1999	4886	-198,973	-520,232
Long Branch	175	-97	-46.76	-43.74	No Dune	1998	3353	-156,767	-676,999
Long Branch	176	-83	-62.07	-54.42	No Dune	1998	2192	-136,066	-813,065
Long Branch	177	7	-45.87	-51.25	No Dune	1997	2096	-96,130	-909,194
Monmouth Beach	178	-198	-69.38	-59.87	Failed	1994	2647	-183,648	-1,092,842
Monmouth Beach	179	-309	-48.83	-61.92	No Dune	1994	2949	-143,976	-1,236,818
Sea Bright	180	-124	-22.60	-25.48	Failed	1995	4559	-103,044	-1,339,863
Sea Bright	181	-111	-16.70	-10.03	Failed	1995	5382	-89,873	-1,429,735
Sea Bright	182	-106	-31.20	-8.47	Failed	1995	1937	-60,437	-1,490,172
Sea Bright	282	-95	-37.13	-4.28	Partial	1996	4206	-156,159	-1,646,331
Sea Bright	183	-86	-34.10	-1.93	Failed	1996	4742	-161,702	-1,808,032

Figure 40. This table provides a summary of all the individual site sand volume losses from the dune and beach to the limit of the post-Sandy survey. The shoreline change data is the distance in feet that the zero elevation position has moved landward since the Federal project was completed (1994 to 1999). This coastal segment contains the northern phase of the NY District Corps of Engineers massive Monmouth County Shore Protection Project with the exception of the Deal and Elberon sites (#170, 171 & 272) where no sand was ever placed. The totals for sand loss is derived by adding the two adjacent site losses and dividing by two, then multiplying by the distance in feet between the two sites. This is known in the dredging industry as "closed-end averaging" to obtain dredged volume along a channel. It is acknowledged that sand resources reside seaward of the short post-storm surveys in the form of growing offshore sand bars, but the need for speed dictated that taking additional time to survey to 15-16 feet of water offshore would not add significantly to the losses seen within the beach/dune system. In this report, the sites north of #176 were surveyed to the normal -16-foot elevations because these sites were not surveyed in the fall of 2012 prior to Sandy. These were compared to the spring 2012 surveys done earlier in the year. It is also acknowledged that the large distances between sites limits the precision of the sand loss total volume for restoration purposes, but it gives a decent approximation. Longer surveys will be repeated in due course however. A percentage of the sand carried offshore by Sandy will move back toward the beach over time in the absence of future storms. All sand lost from the dunes will require human intervention to replace, groom and re-vegetate in order to have the protection in place quickly.

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New Jersey Beach Profile Network

Ocean County

Manasquan Inlet to Little Egg Inlet

NJBPN Profile #'s 156 - 234

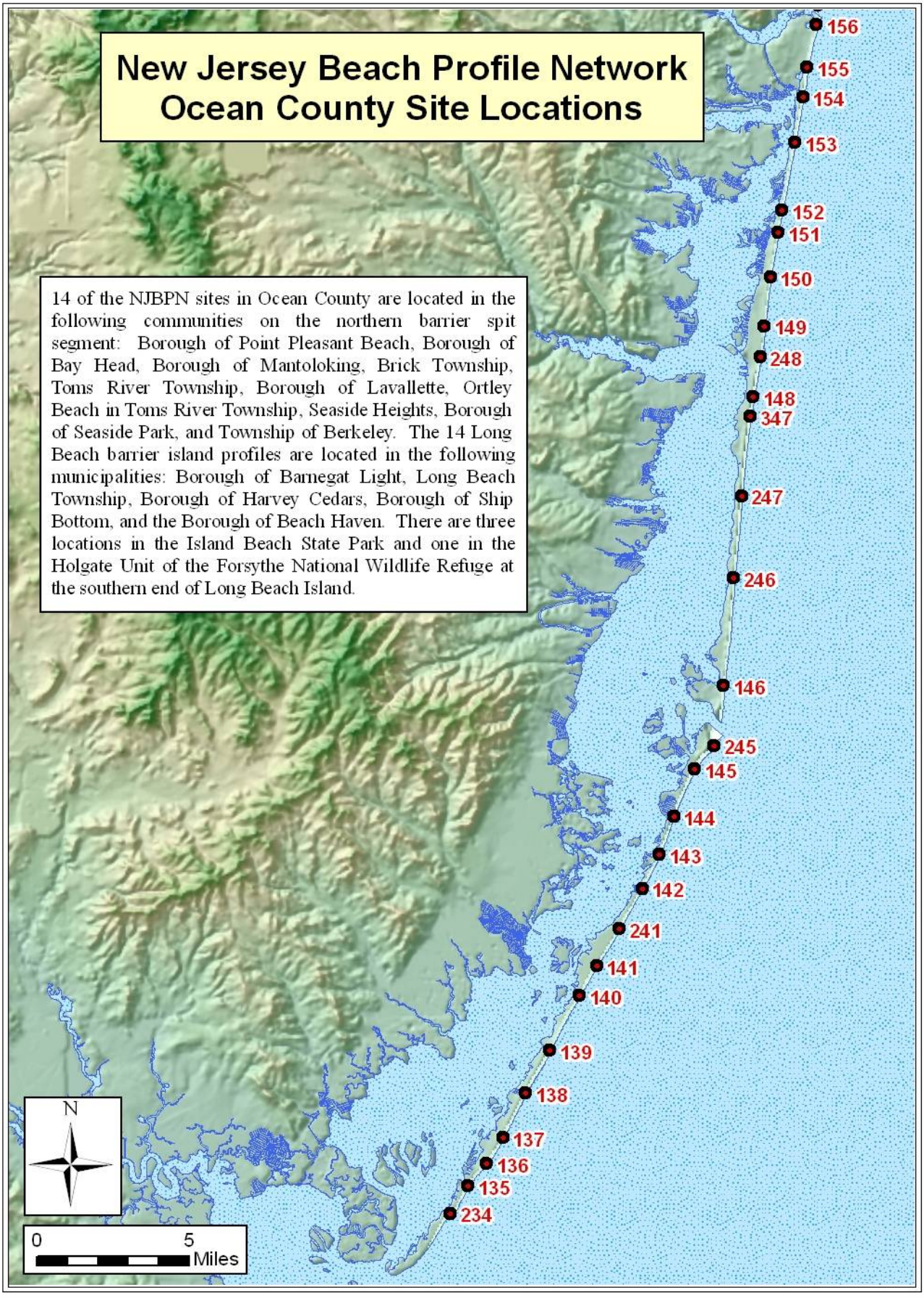


Figure 41. Locations of the 28 NJBPN profile stations in Ocean County, NJ.

Hurricane Sandy's Impact on the Ocean County Shoreline;

In general terms, all forms of damage to beaches, dunes and public or private property was significantly worse on the north side of the storm's zone of coastal landfall in Atlantic County. Southern Cape May County faired best with limited overwash, dune scarping and loss of beach elevation. Many Cape May coastal communities were beneficiaries of either USACE or NJ State co-sponsored Shore Protection Projects that yielded wider beaches and dunes designed with specific storm resistance in terms of elevation and width. Damages increased towards the region of landfall with moderate dune breaches, especially in southern Ocean City area, and damages to southern Absecon Island's oceanfront properties. Dune breaches, loss and scarping of dunes, beach width and elevation continued north into Brigantine. From the natural area of Holgate on Long Beach Island, north along the remainder of the Jersey coast the intensity dramatically increased for dune breaching and overwash and/or complete erosion of the dunes, drastic lowering of the elevation on beaches with substantial sand transport onto and across Long Beach Island or Northern Ocean County's spit. Damage to oceanfront property (public and private) increased dramatically culminating in one major breach across to Barnegat Bay in the Borough of Mantoloking generating a new inlet pathway to the bay. Two additional near breaches occurred just north of the Herbert Street cut resulting in substantial loss in private residences. Overwash decimated Ortley Beach and had severe impacts between Mantoloking and Seaside Park. Two dune cuts in Island Beach State Park swept sand across the park access highway almost to the bay. The wide beach in Point Pleasant Beach mitigated the wave damage, but the absence of any dune system along the boardwalk section allowed seawater unlimited access to the community adjoining the oceanfront. Even the large dune at Maryland Avenue saw the public access pathway used as a means of overwash into the interior depositing over 3 feet of sand on the properties and in the streets.

Individual segments of the dunes did prevent wave access, but the general trend was one where the dune eventually failed because of narrow beaches, a low pedestrian access path to the beach, or a minimal width/height of the dune itself. The erosion rate in the dunes could be gauged in Mantoloking where the southern properties in the Borough had a dune system with dunes over 24 feet in elevation and over 100 feet wide at a 20-foot elevation. These dunes survived with between 15 and 20% of the initial sand volume remaining and some sand overwash through public access pathways (Albertson Street). Elsewhere scraps of dune remained providing just enough protection to allow the residence landward of the surviving segment to escape destruction declining to situations where the inlet was cut entirely through the barrier to Barnegat Bay.

Beach/Dune Damage Assessment by Municipal Island Segment:

The 28 Ocean County New Jersey Beach Profile Network (NJBPN) monitoring sites were surveyed to provide an accurate comparison and assessment of storm related shoreline and beach volume changes. The data from the fall 2012 NJBPN survey, completed along the developed portion of Ocean County's shoreline by September 21st, provides an excellent indication of beach and dune conditions against which to show damages that occurred during the hurricane. Data collected at the 14 oceanfront beach profile locations on Long Beach Island cover the municipal beaches from Barnegat Light to the entrance of the Holgate Forsythe National Wildlife Refuge (including the three constructed USACE engineered beaches in Harvey Cedars, Surf City and Brant Beach). Volume losses from the hurricane were calculated from surveys that were conducted within days

following the storm. At the sites where the post-storm survey did not reach to the 0.0 foot (NAVD88) datum, the profile was extended seaward at a 1:20 slope to obtain the best estimate of volume losses.

It should be noted that no areas along the northern Ocean County barrier-spit shoreline have seen movement toward construction of the USACE design plan for regional shore protection. There have not been any NJ State, County or local beach replenishment projects completed prior to Hurricane Sandy. Previous storm damage has been addressed by importing mainland quarry sand in piecemeal repairs to minor breaches or beach elevation loss on a local basis. Quarry sand has been delivered to Long Beach Island accumulating vast quantities over decades. Unfortunately no comprehensive records were maintained as to how much, where it was placed or how much the cost was. The Borough of Mantoloking obtained permits to place sand mined from the Ambrose Channel leading into New York Harbor in the 1990's, but that project failed to materialize.

Point Pleasant Beach;

The two cross sections in Point Pleasant Beach demonstrated that with no dune system or a smaller, poorly vegetated dune system, there would be little resistance from the tidal surge and the associated waves to cross inland from the ocean. The entire beach and dune system along this segment of northern Ocean County experienced wide-scale overwash and breaching of dunes. The northern profile located at Water Street had no dune in front of the boardwalk, which was damaged and a large amount of sand from the beach was carried inland from wave action. Damage would have been more severe had there not been a 600-foot wide berm in front of the boardwalk. The southern profile at Maryland Avenue was significantly eroded (dune breach) with sand losses totaling 45.7 yds^3/ft. along the profile due to the storm. By the time of the post-storm survey, the municipality had begun relocating sand from the berm to the former dune location.

Bay Head;

The entire beach and dune system along this segment of northern Ocean County experienced wide-scale overwash and breaching of dunes. Approximately 5,500 feet of this 9,500-foot municipal shoreline had a rock revetment constructed following the storm 50 years ago that did comparable damage to the State's shoreline. Since 1992 the rocks have been buried as the core of a continuous dune line fronting the development. The 1992 northeast storm over-topped the wall of rocks and put sand into the street ends without significant property damage. Restored shortly afterward, no storm until Sandy approached stripping the sand from the rocks. Hurricane Sandy treated the rock revetment as if it were a speed bump. Sand and water poured down each street end to the tidewater several blocks inland. The beachfront homes were still standing, but had suffered substantial structural damage in many cases ranging up to the deposition of 2+ feet of sand on the building's lot without damage to the building. Sand was being excavated from the streets two blocks inland. Where there was no rock revetment, there was greater structural damage to homes and their surroundings. Accelerated erosion occurred surrounded the larger groins present in the northern part of Bay Head due to wave energy reflecting off the north side of the structure and adding to the incident wave coming onto the beach directly. Small segments of dune remained either between the revetment and the homes or where no revetment was built. Dense vegetation or a significantly wider cross section at a high elevation seemed to make the difference in the amount of overwash seen.

Mantoloking;

The Borough of Mantoloking extends for over two miles further south and has no regional shore protection hard structures on the beach. Individual owners have constructed private rock or timber structures across the front of private homes over time. The dunes have been maintained meticulously over the past decade in an effort to maximize the municipal shore protection they afford. The crest elevation exceeded 14 feet with some as high as 25 feet. The major problem was that insufficient sand was on the coastline to provide both a major dune system and a wide beach to force waves to break early and not get close enough to break on the dune slope. By late September a municipally-sponsored dune evaluation revealed that this year the Borough's situation was about as good as it was possible to make it without a major beach nourishment project. The highest, widest dunes (24 feet elevation and over 100 feet of width at a 20-foot elevation) served to protect homes on the southern segment of the Borough from damage, but a declining width of the dune base combined with lower average elevations allowed massive failure along the remainder of the municipality. The Borough's mid-section was the most heavily impacted with three channels cut across the entire peninsula into Barnegat Bay. The worst was seen at Herbert Street where a new bridge connects with mainland Ocean County. Here a tidally flowing inlet was generated that allowed in the storm surge flood and permitted several days of tidal flow erasing at least 12 properties. A second, small cut occurred at 1117 Ocean Avenue and a third occurred at Lyman Street all mostly due to narrow, lower elevation dunes with no significant beach width to absorb some of the wave attack.

Brick Township;

The wider, higher dunes existing just north of the municipal boundary in Mantoloking continued south into Brick Township. Here there was little municipal oversight of dune maintenance so elevations, low spots and placement of access stairways to the beach were at the option of individual owners. At the municipal beach #3, the dune failed to the south on the property and waves directly impacted a multi-family building that was built very close to the beach. Overwash was evident, especially to the south toward Normandy Beach.

Toms River Township (Normandy Beach, Ortley Beach);

The northern Township shoreline fared better than did the Ortley Beach section to the south, but significant overwash occurred in this section and many oceanfront and landward homes were damaged. This was due to beach-dune widths and elevations not adequate to withstand the tidal surge and wave action produced by Hurricane Sandy. Site #151 had losses of the dune and berm where 46.1 yds^3/ft. of sand were removed during the storm. The Ortley Beach cross section (site #149) was centered in the zone completely destroyed with over 5 feet of elevation stripped away in the center of Ocean Avenue. There was no evidence that the survey site was ever there. The GPS unit took the team to a spot on flat sand with only the masonry utility access column standing 5 feet above the sand surface indicating where Ocean Avenue had been. Ortley Beach had a 25-year history of shoreline retreat and sand volume loss as determined by the Coastal Center's 8^{th} Avenue survey site. Site #149 located at 8^{th} Avenue showed a sand volume loss of 68.7 yds^3/ft. with the dune removed and pushed landward and deposited as overwash deposits. Everything was stripped away leaving a flat, featureless beach sloping into the sea.

Lavallette;

Lavallette had no dunes and suffered damage from Hurricane Gloria in 1985. The municipality developed a dune system between the paved promenade and the beach, but areas where beach accessways were carved

through the dune system created low areas allowing the intense waves riding on the evening storm surge to easily erode those areas and create a number of serious breaches. While some remnants of dunes remained following the storm in the northern portion of the municipality (proximal to site #150), beach-dune widths and elevations in areas to the south were not adequate and wide-scale overwash and breaching occurred. This caused severe damage to infrastructure and property. Following Hurricane Sandy, Site #150 had sand volume loss of 51.7 yds^3/ft.

Seaside Heights;

This segment of the shoreline experienced damage to infrastructure and property as a result of having no dune system and an approximate berm width of 250-feet. The boardwalk and piers sustained heavy damage and in some places were completely destroyed. The cross-section located at Franklin Avenue (site #248) showed a sand volume loss of 39.3 yds^3/ft of the beach in front of the boardwalk.

Seaside Park;

The pre- and post-storm analysis for site #148 at 4th Avenue showed that a portion of the foredune was removed during the storm; however, the remainder of the dune provided protection to the landward structures. No overwash occurred at the profile location. The dune's approximate 25-foot elevation (NAVD88) and 150-foot width (at the base) combined with a 150-foot wide beach provided adequate protection from tidal surge and wave action. As has been noted in other areas along the northern Ocean County barrier-spit, areas where beach accessways were carved through the dune system created low areas that were more easily eroded, resulting in wave overwash and sand being transported landward of the beach-dune system into the streets and private properties. While homes sustained flood damage in this segment from Barnegat Bay, loss of infrastructure and homes was minimized due to the larger beach-dune system hindering the waves that were crossing over land.

Midway Beach (Berkeley Township);

Site 347 in Midway Beach showed significant sand losses to the beach and dune but a portion of the dune remained to protect the landward homes and infrastructure. While overwash covered some of the streets and properties with sand, much of the overwash was limited to the areas proximal to street ends. These beach accessways were carved through the dune system, creating low areas that were more easily eroded, resulting in wave overwash. While homes sustained flood damage in this segment, loss of infrastructure and homes was minimized due to the larger beach-dune system.

Island Beach State Park;

At the three locations within the state park, the storm eroded sand from the foredune and berm and moved the sand into the nearshore. No dune breaching occurred at any of the sites due to the wide beaches and dune elevations that in some areas exceeded 20 feet NAVD88. There were several dune breaches with sand transported landward covering the highway serving the natural area, but no complete pathways were carved into Barnegat Bay.

Barnegat Light Borough;

The two profile sites in Barnegat Light Borough demonstrated that with a much larger than average dune system, there would be little impact from the tidal surge and the associated waves. The structure responsible for

this hefty dune system was the 1988 to 1991 reconstruction of the south jetty to Barnegat Inlet parallel to the north jetty instead of the older "arrowhead" design originally built. The result was an accumulation of sand on the south side of the new jetty advancing the shoreline seaward by 2,400 feet at the jetty. This deposit tapers narrower to the south, but still produced a 450-foot shoreline advance at site 145 located at 26th Street in the Borough. The shoreline orientation is also a factor since the wave approach was almost parallel with the beach, not perpendicular to it. As a result there was no overwash, no sand in the streets, and no direct wave impact on any home. Water reached into the dunes with the only damage done to dune fencing closest to the shoreline.

Long Beach Township (Loveladies);

The La Baia Street profile site did have dunes that survived, but at this location the public access pathway was at least 6 feet lower than the adjacent dune crests. The waves found the gap, cut it at least two house lots wider and water and sand flowed landward to the boulevard. This scenario was repeated many places where the simple expedient of having public works place sand and grade a dune cross over to the adjacent elevations could have prevented this particular overwash. Dune failure was likely related to individual access pathways to the beach from individual homes excavated below the average dune elevation. Along this segment of LBI, the dune width was higher than average.

Harvey Cedars;

Two cross sections located in Harvey Cedars crossed the 2009 Federal Shore Protection Project. In both cases the dune built seaward of the native dune experienced substantial erosion, but the crest was still intact. The wider beach helped by forcing the waves to break earlier in the approach to the dune. The sand elevation on the beach was substantially reduced with all of it retained on the shoreline, but deposited offshore. Recovery by mild weather waves pushing material back toward the shoreline was already underway within days of the storm. Since there were no direct losses due to overwash transport onto the island, there should be enough sand left to push a wedge of recovered sand up toward the dune scarp for enhanced protection from the coming winter northeast storms.

Long Beach Township (North Beach);

This segment of the township shoreline is not covered by NJBPN, but damage was apparent with overwash between homes extending landward to the Boulevard. There was no direct benefit from the fill activity on either side of this beach. Indirect sand migration along the beach did provide a measure of added width, but no enhancement to the dunes.

Surf City;

Surf City was the location of the initial Army Corps project effort in 2007. This was completed and in spite of the problems associated with including illegally dumped munitions parts in the fill sands, the net result was a survival of the dune with the crest elevation in place, but narrower in total dune width. The beach fill was reduced in width from the design plan, but sufficient to help prevent wave overwash and damage to public and private infrastructure. In spite of the fact that these fill segments had abrupt starting and stopping points creating what are called "end-effects", each was very successful in limiting damages to private and public property located landward of the fill project.

Ship Bottom;

While no fill was placed along the Ship Bottom shoreline, the loss from the Surf City section did improve the beach width along this reach. The dunes were wider as well and the combination prevented most overwash. The 8th Street site suffered removal of the seaward slope nearly to the crest, but a wide crest and minimal low spots allowed an excellent performance of this coastal segment of the island.

Long Beach Township (Brant Beach, Beach Haven Crest, Spray Beach);

Brant Beach was the most recent segment of LBI to receive the Army Corps beach replenishment project completed in early 2012. This site showed similar results as seen in Harvey Cedars and Surf City where the dune and beach took the impact with losses to the beach width and elevation and erosion to the seaward dune slope. No overwash or wave damage was observed.

The story was different at Beach Haven Crest where the dune failed at 81st Street. The pre-Sandy photograph depicts a narrow dune with a 16-foot crest elevation. This proved insufficient to stop the wave assault and extensive damage resulted. Both beach width and dune mass are essential, working as a team to protect from wave damage because both are essentially piles of sand which do erode at fairly rapid rates. If a dune were to erode at a 10 feet per hour rate, then it would need to be 100 feet thick to withstand a 10-hour duration of a steady intense storm activity. This approximates Sandy's level of violence over two high tide intervals on Monday October 29th.

The site at Old Whaling Road was different in Spray Beach due to a wider, higher dune. About a third of the dune was eroded taking the entire seaward slope, but the height prevented overwash and the properties landward were spared.

Beach Haven;

Both survey sites in Beach Haven suffered dune failure. Overwash covered streets and properties with sand. House damage was evident at both sites. Observations north and south of both sites found remnants of dunes that remained, but in general overwash was common and extensive in its penetration across the island.

Long Beach Township (Holgate);

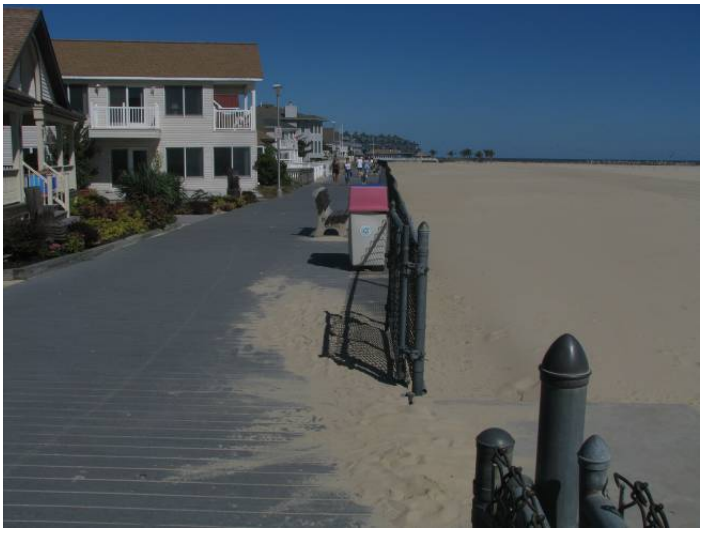
The site #135 at Webster Avenue was typical of the wholesale damage done as the dune system was essentially erased and washed across the island into Barnegat Bay in many cases. Sand thicknesses of 3 to 4 feet were observed on Long Beach Island Boulevard and down the side streets to the bay. Low elevation homes were destroyed and even some larger structures showed serious impacts. The practice of oceanfront owners closing in the ground level area under the first habitable floor level with a concrete floor, insulated walls, and installing the furnace, hot water heater, the air conditioner compressor, and storing a myriad of possessions in an area designated as open space to allow waves to pass under the building with minimal impact, vastly increased the damage to individual properties as the wave of debris piled up against landward structures and penetrated into other ground level spaces. Individuals found that their space under the house now contained an intertwined complex of debris densely filling the entire area under the house. Clearly the dunes were too thin, too low and the beach too narrow to block Sandy in any meaningful way.

Among all the destruction, there were several oceanfront homes that had developed a wider, higher dune that hung together allowing the survival of the house including the landscaping.

Forsythe Wildlife Refuge site;

In an effort to develop data on the NJ natural areas along the coastline the NJ Beach Profile Network includes surveys of all these natural areas. The Holgate Unit site in the Forsythe natural area was established in 1994 near the start of the spit extending a mile to the south. The entire spit has been moving landward as sand is held to the north by the pair of groins guarding the beach at the south end of development in the Township. Sandy transported sand westward across the spit into Barnegat Bay causing about a hundred feet of shoreline retreat. This retreat has been documented over the past 18 years in spite of meager efforts to stabilize the immediate shoreline with waste concrete and geo-textile bags filled with sand. This retreat will ultimately produce a similar situation to that of Longport south of 11th Street (Atlantic County) where very expensive homes have minimal beach/dune protection and depend on a low rock wall that failed to protect them. The possibility of a new inlet through the spit at Holgate always exists since there is an historical record of three breakthroughs, the last of which happened in 1920 during a severe northeast storm. Tucker's Beach became Tucker's Island and the "New Inlet" proceeded to migrate south erasing the newly formed island by 1940. The net result was a 500 to 700-foot retreat in the southern LBI shoreline landward that if repeated would render most of the Holgate section of Long Beach Township as part of the Atlantic Ocean. The solution will require both structural and sand volume enhancement to stop or slow the changes that are driven by exceptional storms.

NJBPN 156 – Water Street, Point Pleasant



The photograph on the left was taken on September 21, 2012. The one on the right shows no noticeable change to the backbeach elevation following the storm (taken November 12, 2012). This urban beach did not have a dune system but was spared from more severe damages by the over 600-foot protective berm.

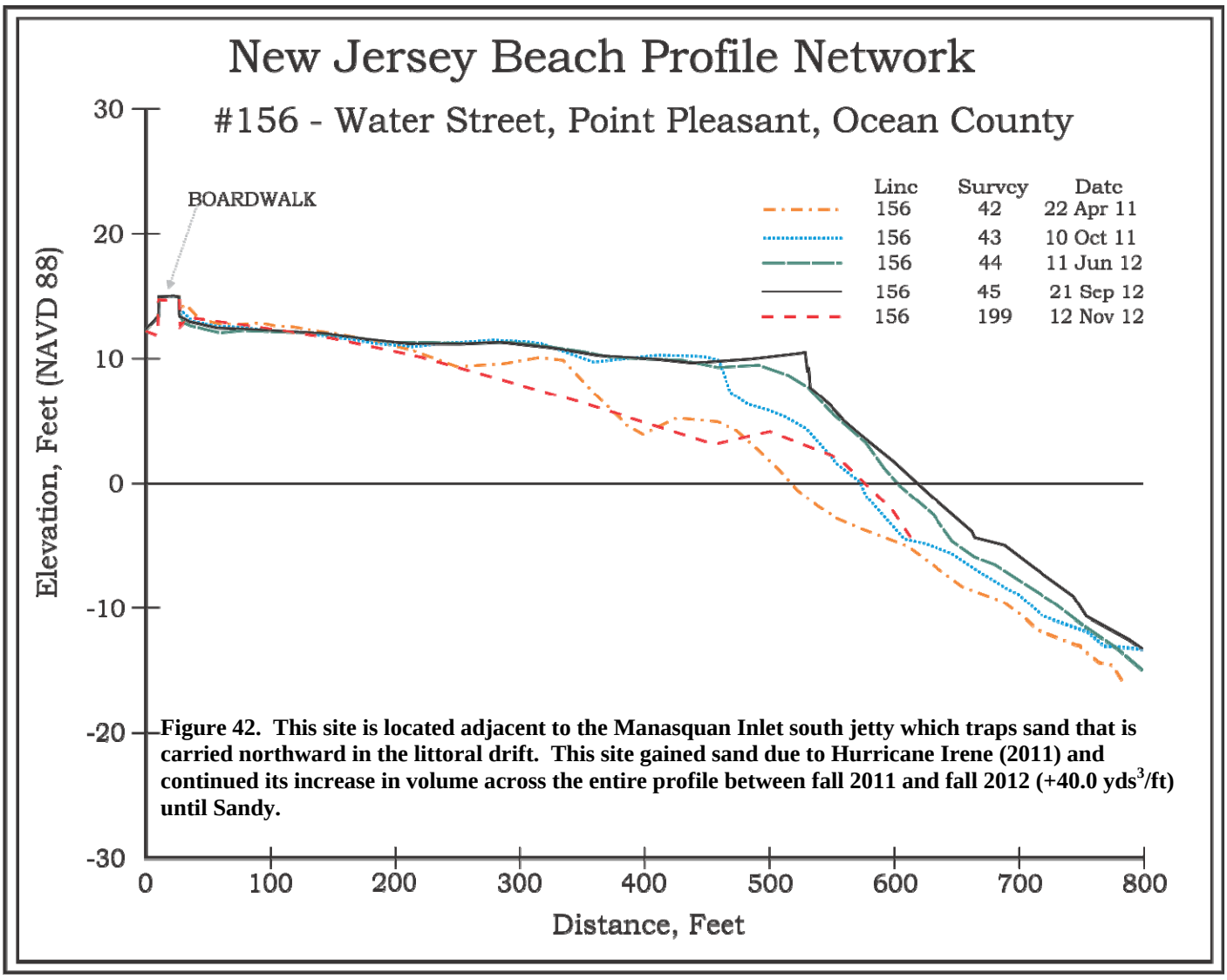


Figure 42. This site is located adjacent to the Manasquan Inlet south jetty which traps sand that is carried northward in the littoral drift. This site gained sand due to Hurricane Irene (2011) and continued its increase in volume across the entire profile between fall 2011 and fall 2012 (+40.0 yds^3/ft) until Sandy.

NJBPN 155 – Maryland Avenue, Point Pleasant

The photograph on the left shows the dune that has occurred at this site for 25 years (taken on September 17, 2012) and on the right, the damages and local restoration efforts of the former dune (taken on November 12, 2012). Lower elevation shore-perpendicular access ways may have channeled wave activity landward. The plot depicts the changes caused by the storm and the losses of the berm and poorly vegetated dune system where 45.7 yds^3/ft. of sand were removed during the storm. By the time of the post-storm survey, the municipality had begun relocating sand from the berm to the former dune location.

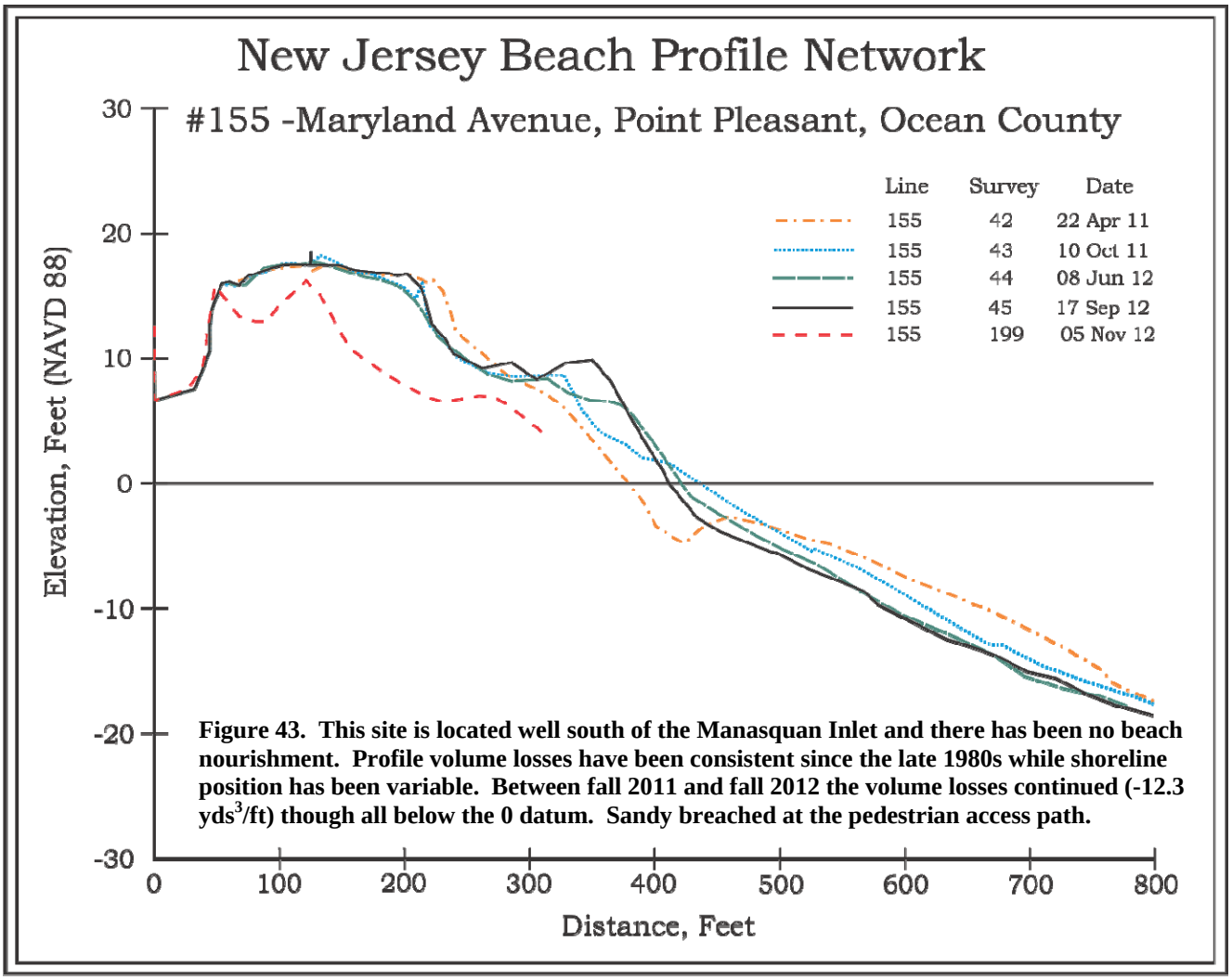


Figure 43. This site is located well south of the Manasquan Inlet and there has been no beach nourishment. Profile volume losses have been consistent since the late 1980s while shoreline position has been variable. Between fall 2011 and fall 2012 the volume losses continued (-12.3 yds^3/ft) though all below the 0 datum. Sandy breached at the pedestrian access path.

NJBPN 154 – Johnson Avenue, Bay Head

The photograph on the left (September 17, 2012) shows the low dunes before Sandy and on the right, post-storm conditions (November 12, 2012). The plot depicts the changes and the losses of the berm and moderate dune where 36.8 yds^3/ft. of sand were removed during the storm (calculated from extending the November 2012 survey to the datum at a 1:20 slope). The dune seaward of the homes was obliterated during the storm and exposed a base rubble-mound revetment layer. The beach was lowered, and sand was overwashed between the oceanfront homes and carried landward to the backbarrier.

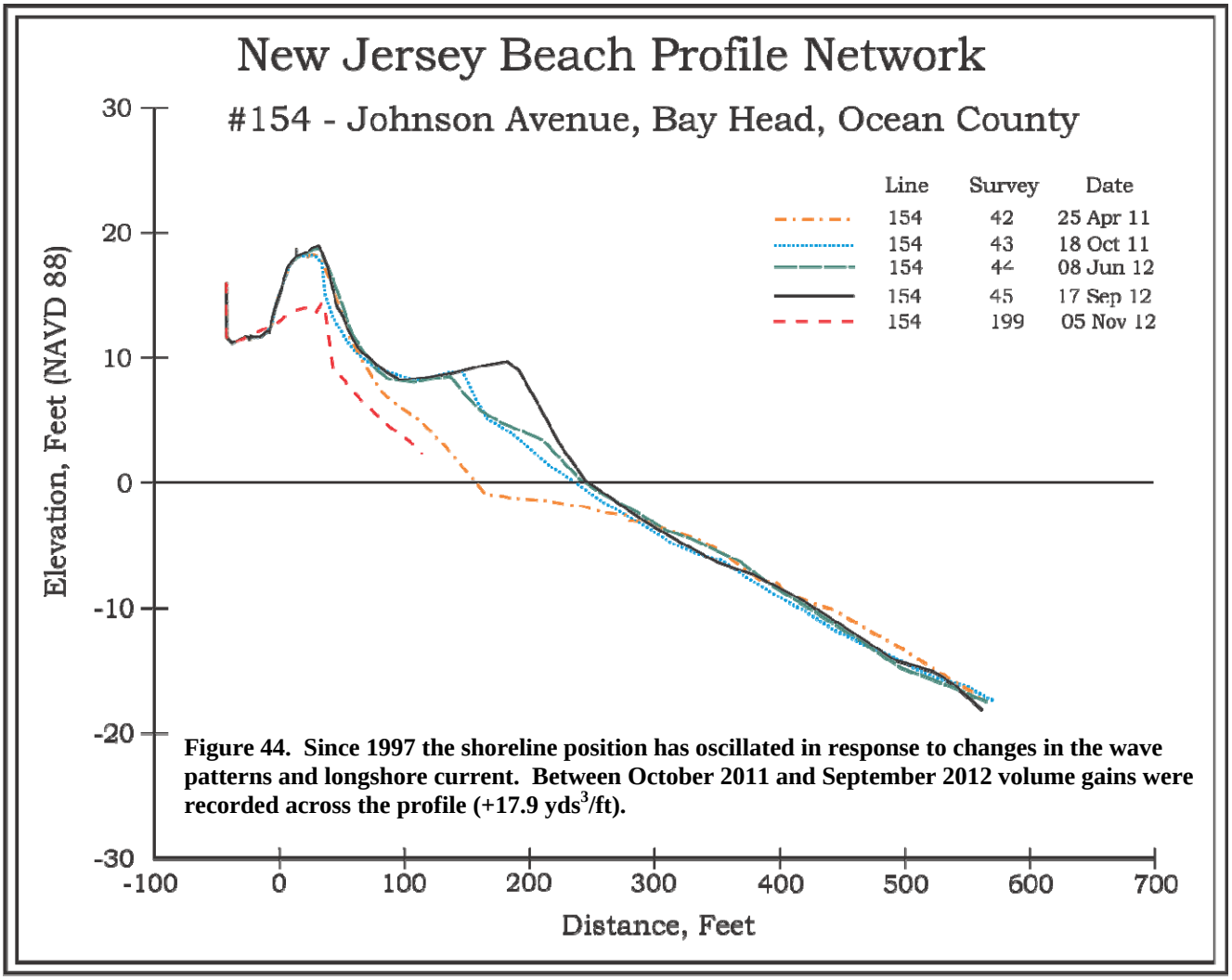


Figure 44. Since 1997 the shoreline position has oscillated in response to changes in the wave patterns and longshore current. Between October 2011 and September 2012 volume gains were recorded across the profile (+17.9 yds^3/ft).

NJBPN 153 – 1117 Ocean Avenue, Mantoloking

Pre-storm conditions of the modified dune are shown in the September 17, 2012 (left). This view shows the results of the restoration effort following Hurricane Irene (August 2011). The November 5, 2012 (right) was taken at the same location. This profile location is within 300 feet from the temporary breach that opened during Sandy. The home at 1117 Ocean Avenue was completely removed from its location and the residence in the photograph was also destroyed.

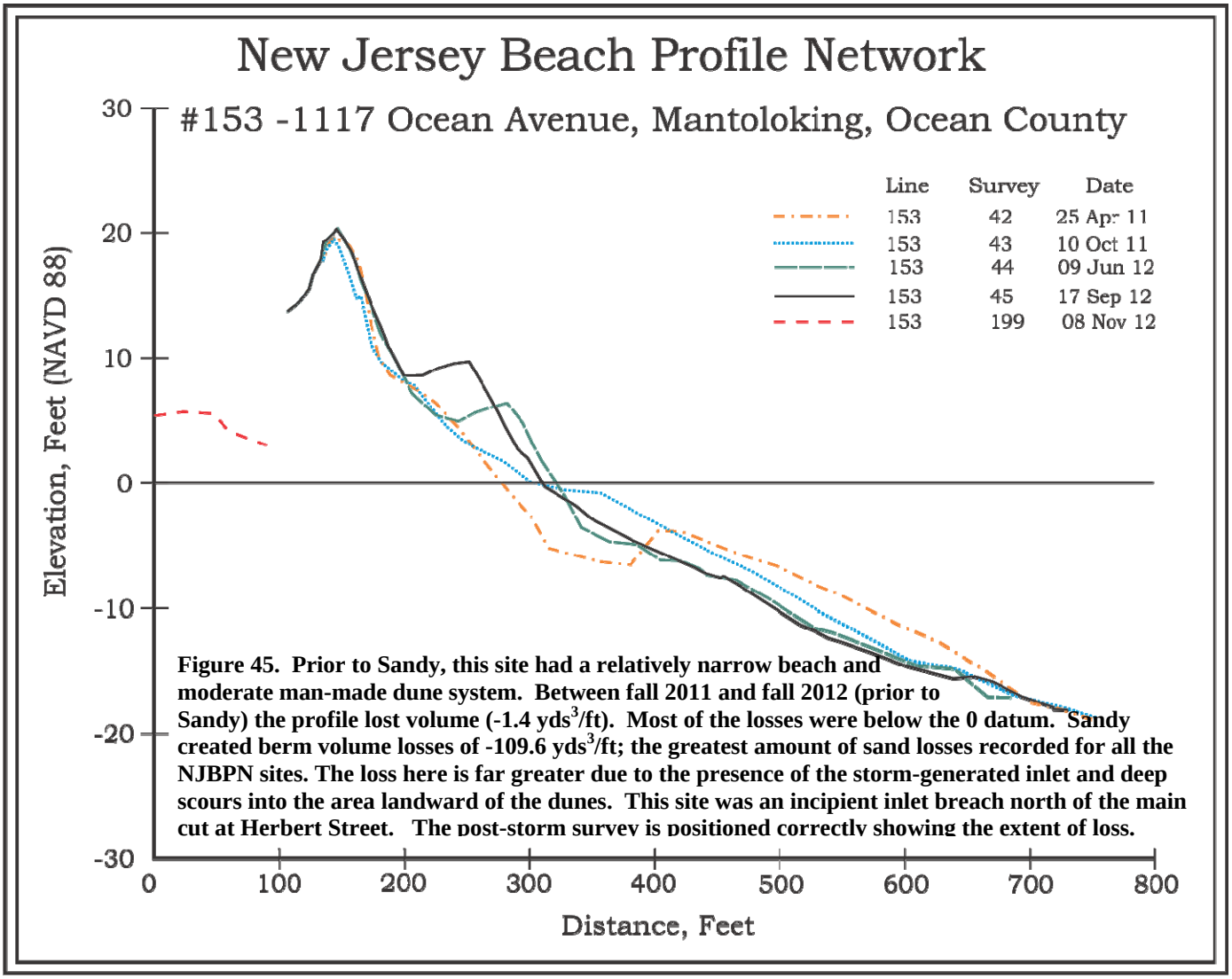


Figure 45. Prior to Sandy, this site had a relatively narrow beach and moderate man-made dune system. Between fall 2011 and fall 2012 (prior to Sandy) the profile lost volume (-1.4 yds^3/ft). Most of the losses were below the 0 datum. Sandy created berm volume losses of -109.6 yds^3/ft; the greatest amount of sand losses recorded for all the NJBPN sites. The loss here is far greater due to the presence of the storm-generated inlet and deep scours into the area landward of the dunes. This site was an incipient inlet breach north of the main cut at Herbert Street. The post-storm survey is positioned correctly showing the extent of loss.

NJBPN 152 – Public Beach #3, Brick Township

The photograph on the left shows the public access way, dune, and moderate berm on September 14, 2012. The post-storm photo on the right (November 8, 2012) shows municipal efforts in protecting what was left of the former dunes.

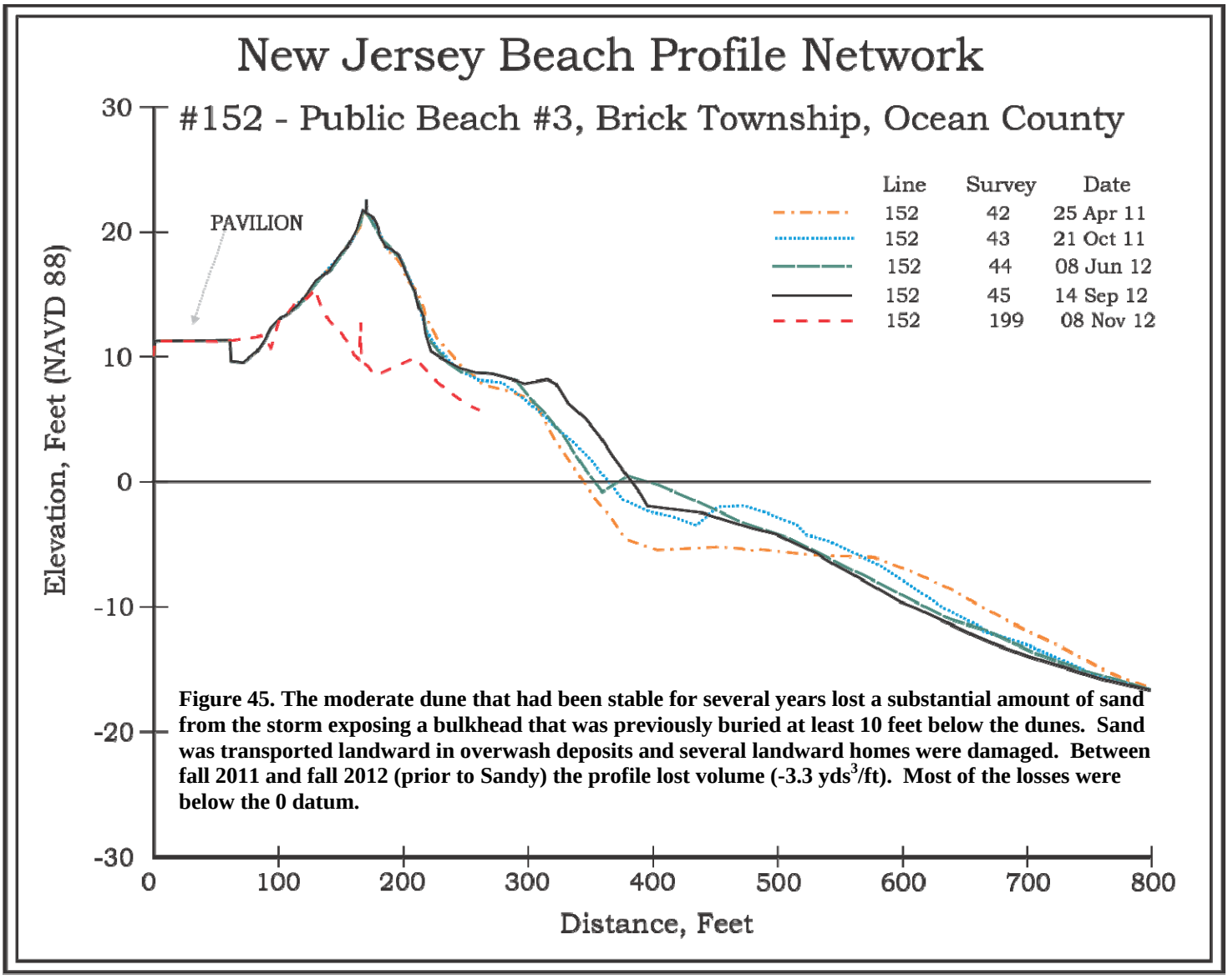


Figure 45. The moderate dune that had been stable for several years lost a substantial amount of sand from the storm exposing a bulkhead that was previously buried at least 10 feet below the dunes. Sand was transported landward in overwash deposits and several landward homes were damaged. Between fall 2011 and fall 2012 (prior to Sandy) the profile lost volume (-3.3 yds^3/ft). Most of the losses were below the 0 datum.

NJBPN 151 – 1st Avenue, Normandy Beach

The photograph on the left (September 14, 2012) shows the limited dune system and minimal berm prior to Sandy. On the right (November 8, 2012), the photo shows damages to structures and exposure of once-buried bulkheads following the storm. Significant overwash occurred at this site and many oceanfront and landward homes were damaged.

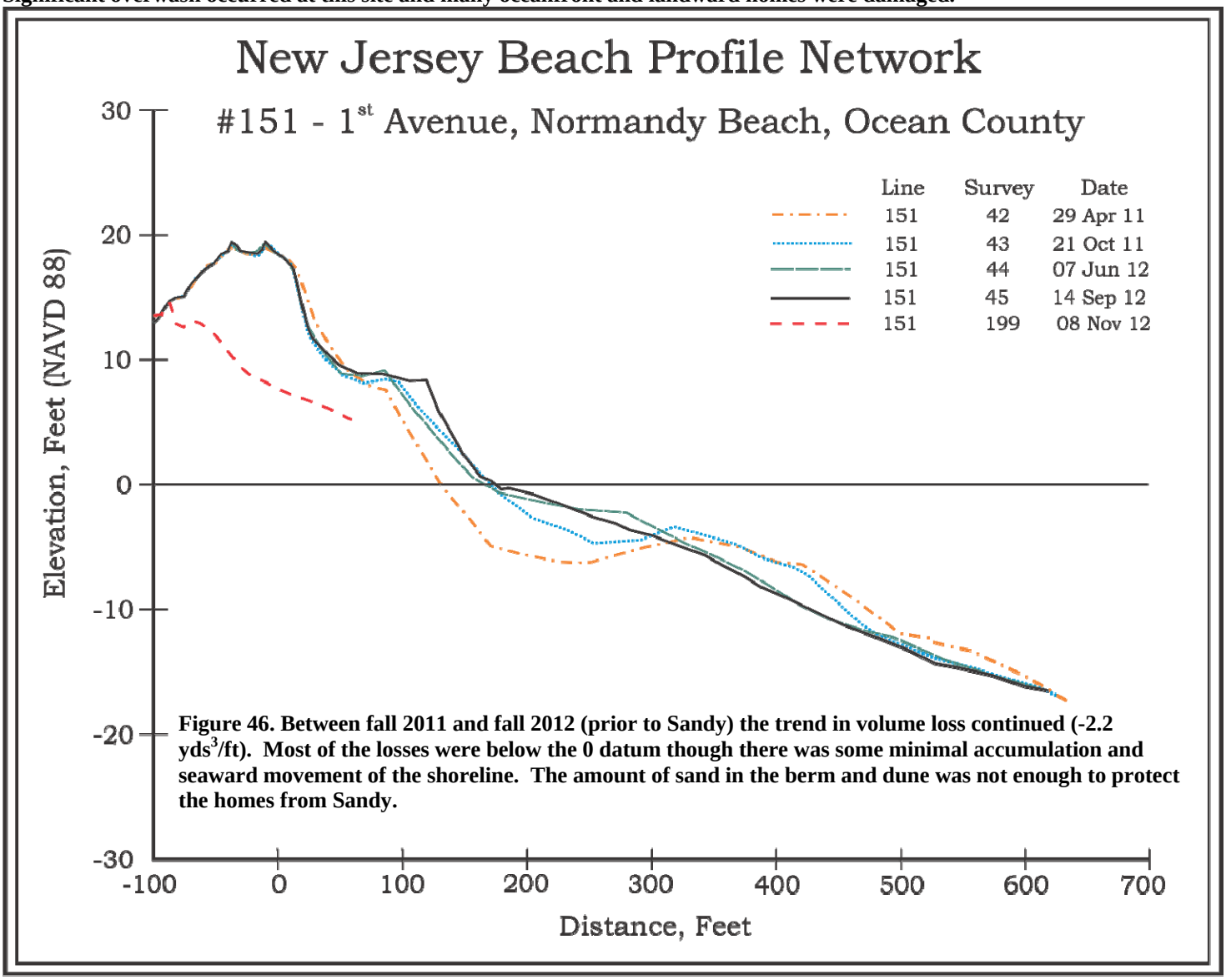


Figure 46. Between fall 2011 and fall 2012 (prior to Sandy) the trend in volume loss continued (-2.2 yds^3/ft). Most of the losses were below the 0 datum though there was some minimal accumulation and seaward movement of the shoreline. The amount of sand in the berm and dune was not enough to protect the homes from Sandy.

NJBPN 150 – White Avenue, Lavallette

The photograph on the left (September 14, 2012) shows the dune that was created over time through municipal efforts. On the right (November 8, 2012), the photo shows the losses of the berm and dune where 51.1 yds^3/ft. of sand were removed during the storm. This location experienced beach and dune erosion; however, overwash only occurred where the dune was lower and breached.

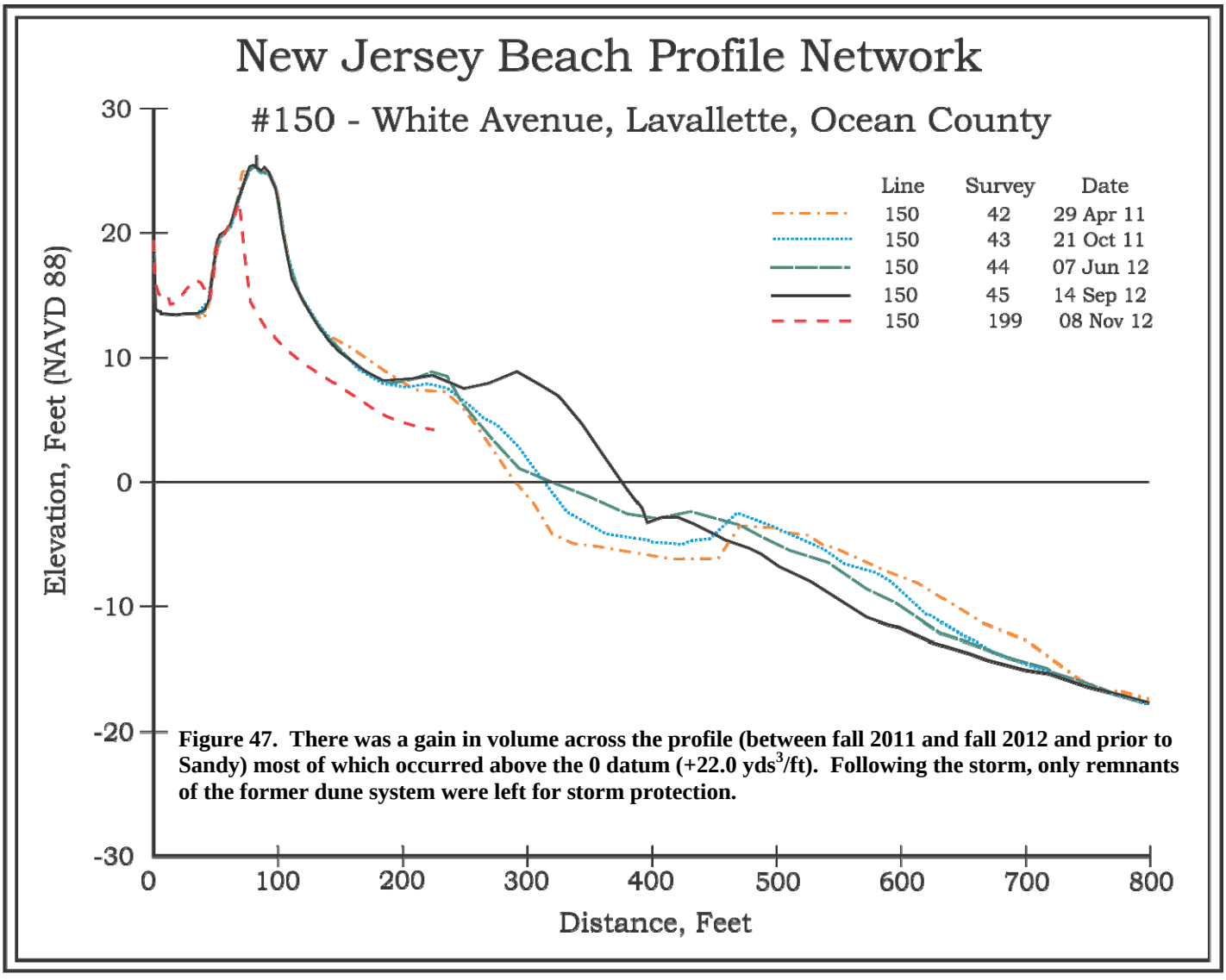


Figure 47. There was a gain in volume across the profile (between fall 2011 and fall 2012 and prior to Sandy) most of which occurred above the 0 datum (+22.0 yds^3/ft). Following the storm, only remnants of the former dune system were left for storm protection.

NJBPN 149 – 8th Avenue, Ortley Beach

The photograph on the left (September 14, 2012) shows a modest berm and the municipal dune present prior to the storm. On the right (November 8, 2012), 68.7 yds^3/ft of berm and dune were removed during the storm. Over 10 feet of dune height was pushed landward in overwash deposits. The boardwalk was located landward of the dunes (left) Ocean Avenue was destroyed as well as several homes. The photo on the right shows a classic flat beach created by the large waves.

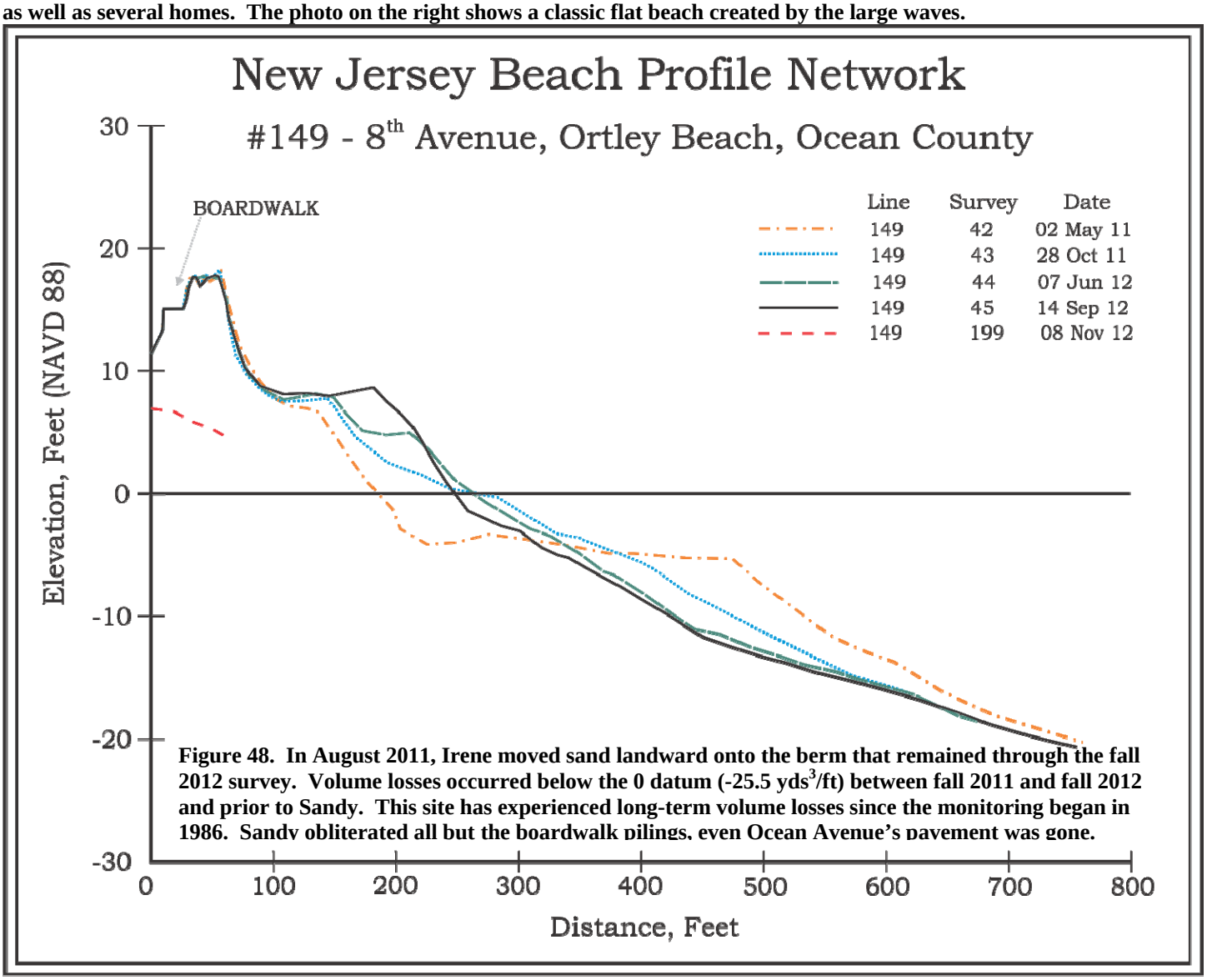


Figure 48. In August 2011, Irene moved sand landward onto the berm that remained through the fall 2012 survey. Volume losses occurred below the 0 datum (-25.5 yds^3/ft) between fall 2011 and fall 2012 and prior to Sandy. This site has experienced long-term volume losses since the monitoring began in 1986. Sandy obliterated all but the boardwalk pilings, even Ocean Avenue's pavement was gone.

NJBPN 248 – Franklin Avenue, Seaside Heights

The September 13, 2012 photo on the left shows the bathing beach prior to Hurricane Sandy. The photo on the right shows the November 8, 2012 post-storm beach. This urban beach did not have a dune system and the photo on the right shows the obvious damages to the pier and amusements.

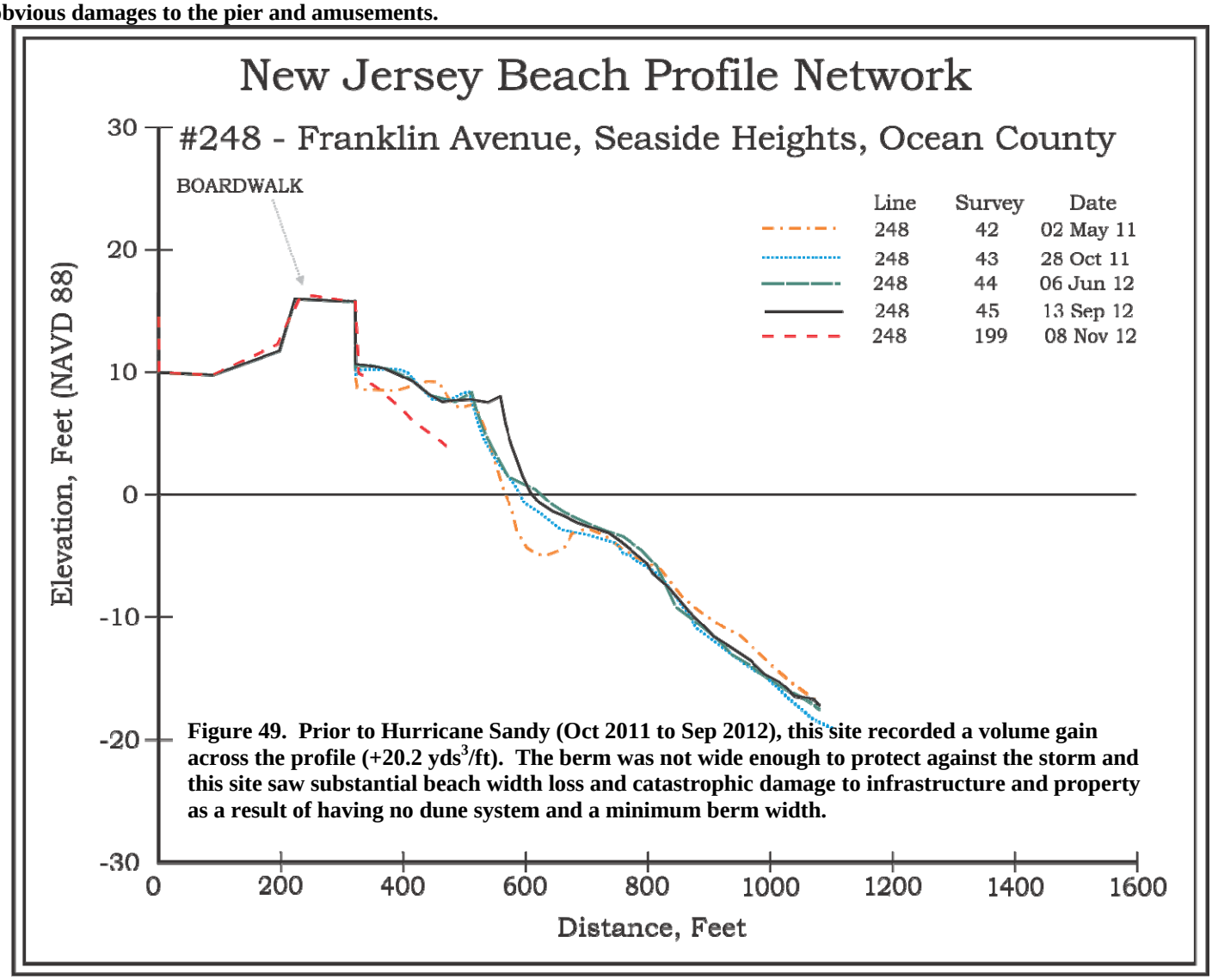


Figure 49. Prior to Hurricane Sandy (Oct 2011 to Sep 2012), this site recorded a volume gain across the profile (+20.2 yds^3/ft). The berm was not wide enough to protect against the storm and this site saw substantial beach width loss and catastrophic damage to infrastructure and property as a result of having no dune system and a minimum berm width.

NJBPN 148 – 4th Avenue, Seaside Park

The left photograph was taken on September 13, 2012 and shows the extensive dune prior to Hurricane Sandy. On the right (taken November 8, 2012), a northeast storm had dumped snow on the shoreline nearly a week after Sandy's landfall. Although there was loss of dune from the storm, no overwash occurred at this location.

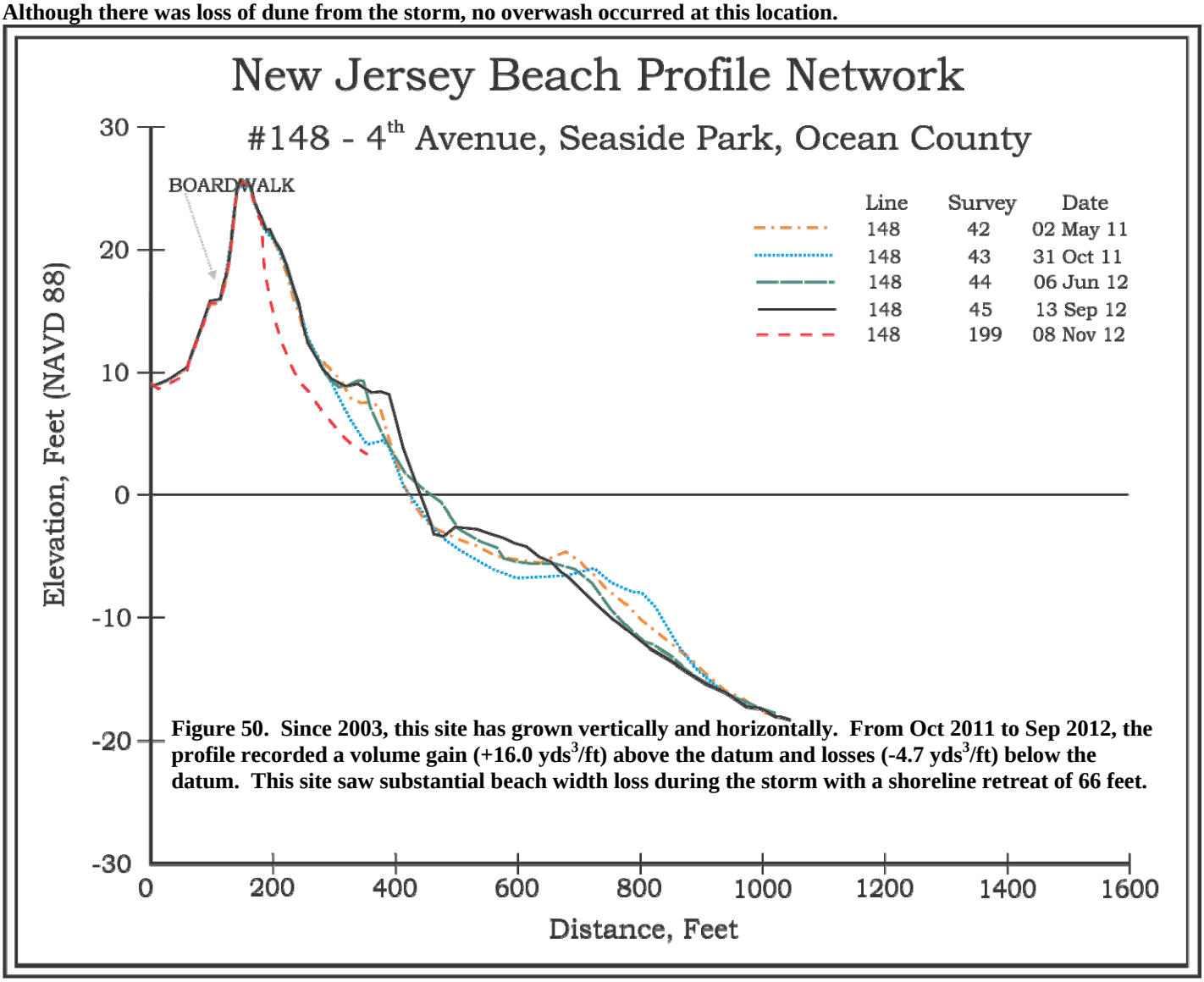


Figure 50. Since 2003, this site has grown vertically and horizontally. From Oct 2011 to Sep 2012, the profile recorded a volume gain (+16.0 yds^3/ft) above the datum and losses (-4.7 yds^3/ft) below the datum. This site saw substantial beach width loss during the storm with a shoreline retreat of 66 feet.

NJBPN 347 – 6th Lane, Midway Beach

The left photograph was taken on September 13, 2012 and on the right (taken November 8, 2012), a northeast storm had dumped snow on the shoreline nearly a week after Sandy's landfall. The figure below depicts the changes caused by the storm and the losses of the berm and dune where 48.7 yds^3/ft. of sand were removed during the storm. Though there were measured losses of the berm and dune, enough dune remained to protect the landward homes and infrastructure.

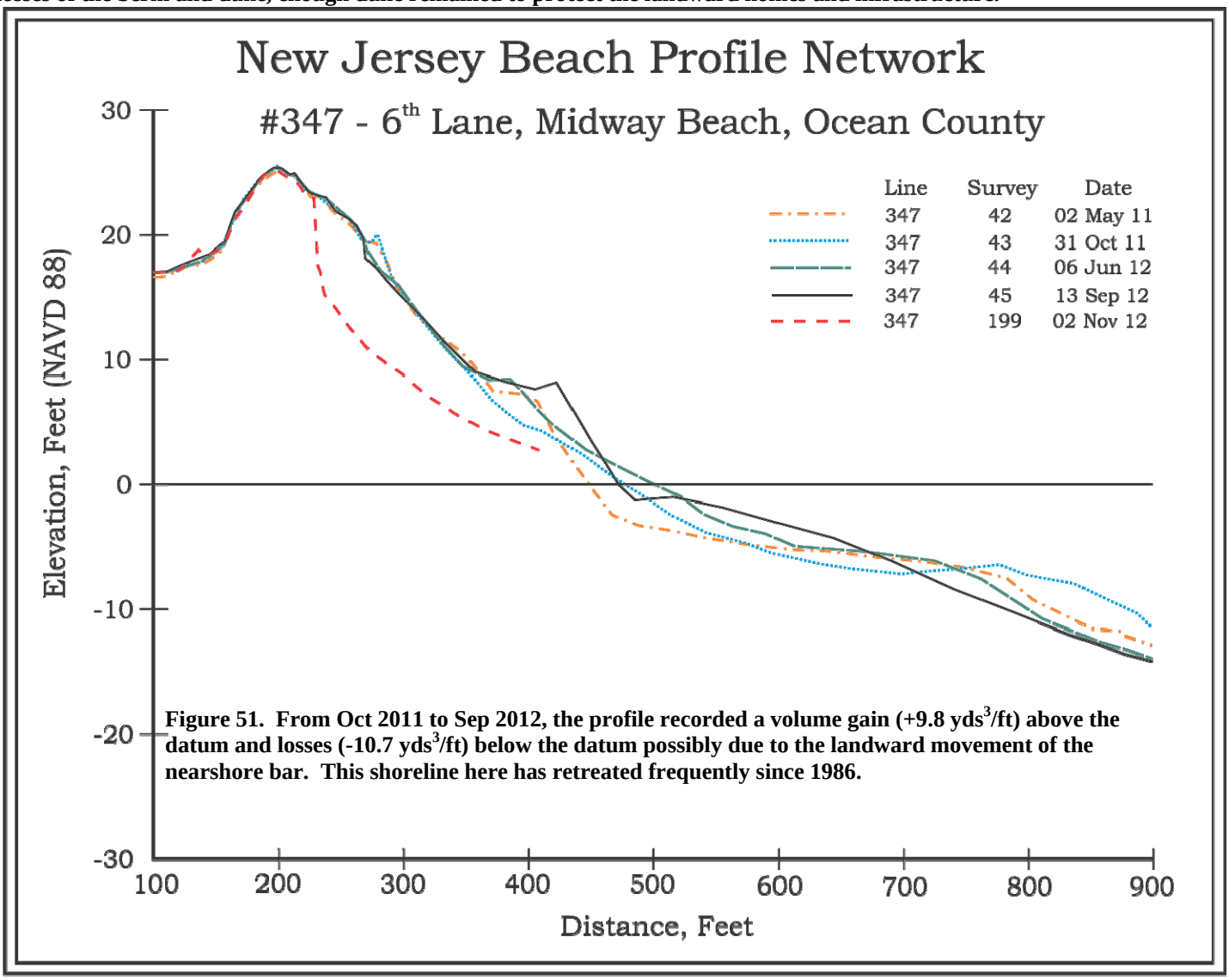


Figure 51. From Oct 2011 to Sep 2012, the profile recorded a volume gain (+9.8 yds^3/ft) above the datum and losses (-10.7 yds^3/ft) below the datum possibly due to the landward movement of the nearshore bar. This shoreline here has retreated frequently since 1986.

NJBPN 247 – North End, Island Beach State Park

The left photograph was taken on November 8, 2011 and shows a wide natural dune system. The right photo (taken December 12, 2012) shows the condition of the dune system nearly six weeks after Sandy's landfall.

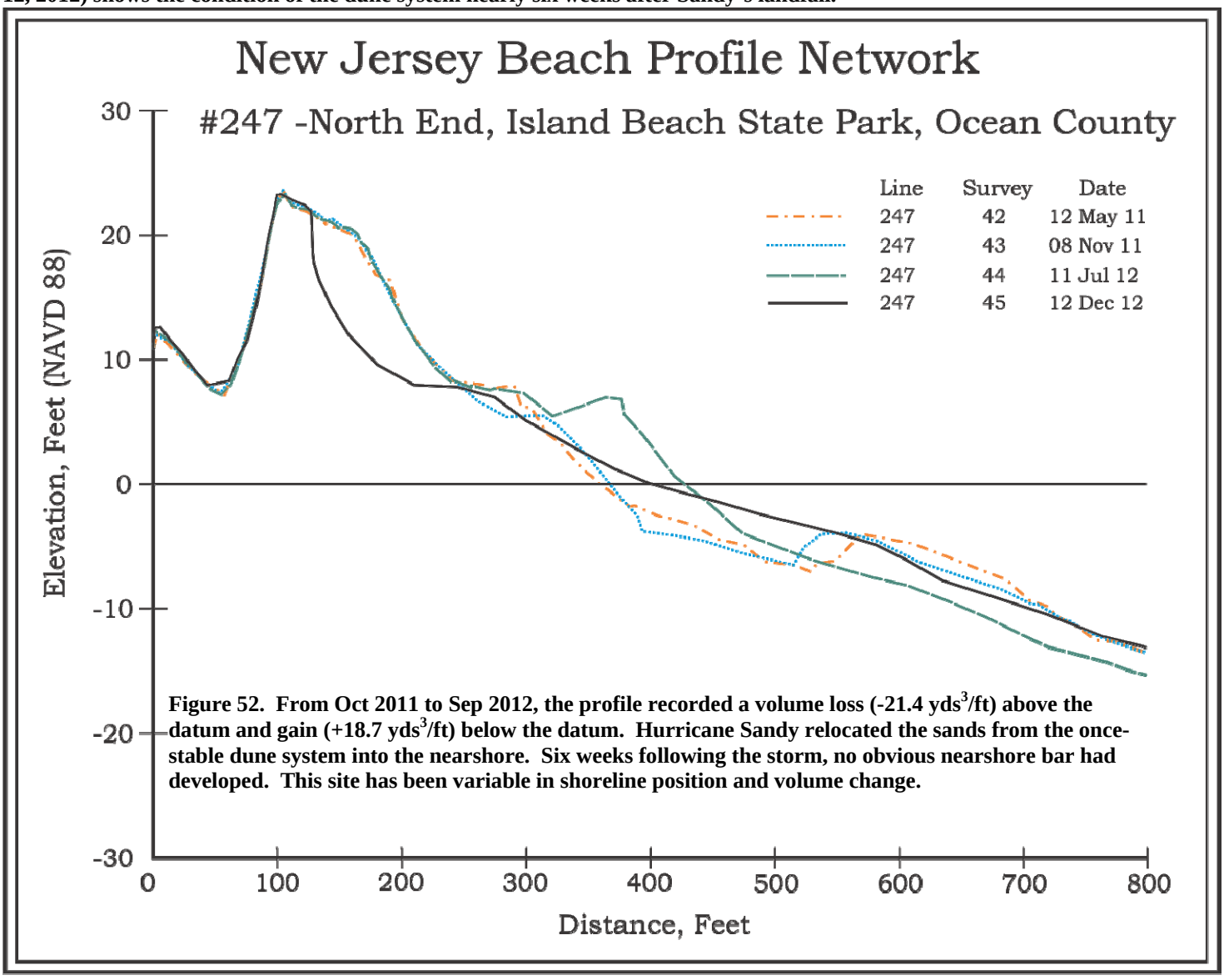


Figure 52. From Oct 2011 to Sep 2012, the profile recorded a volume loss (-21.4 yds^3/ft) above the datum and gain (+18.7 yds^3/ft) below the datum. Hurricane Sandy relocated the sands from the once-stable dune system into the nearshore. Six weeks following the storm, no obvious nearshore bar had developed. This site has been variable in shoreline position and volume change.

NJBPN 246 – Parking Lot A7, Island Beach State Park

The left photograph was taken on November 8, 2011 and shows a wide natural dune system. Six weeks after Sandy, (right photo taken December 12, 2012) the dune and berm had eroded and sand was moved into a nearshore bar.

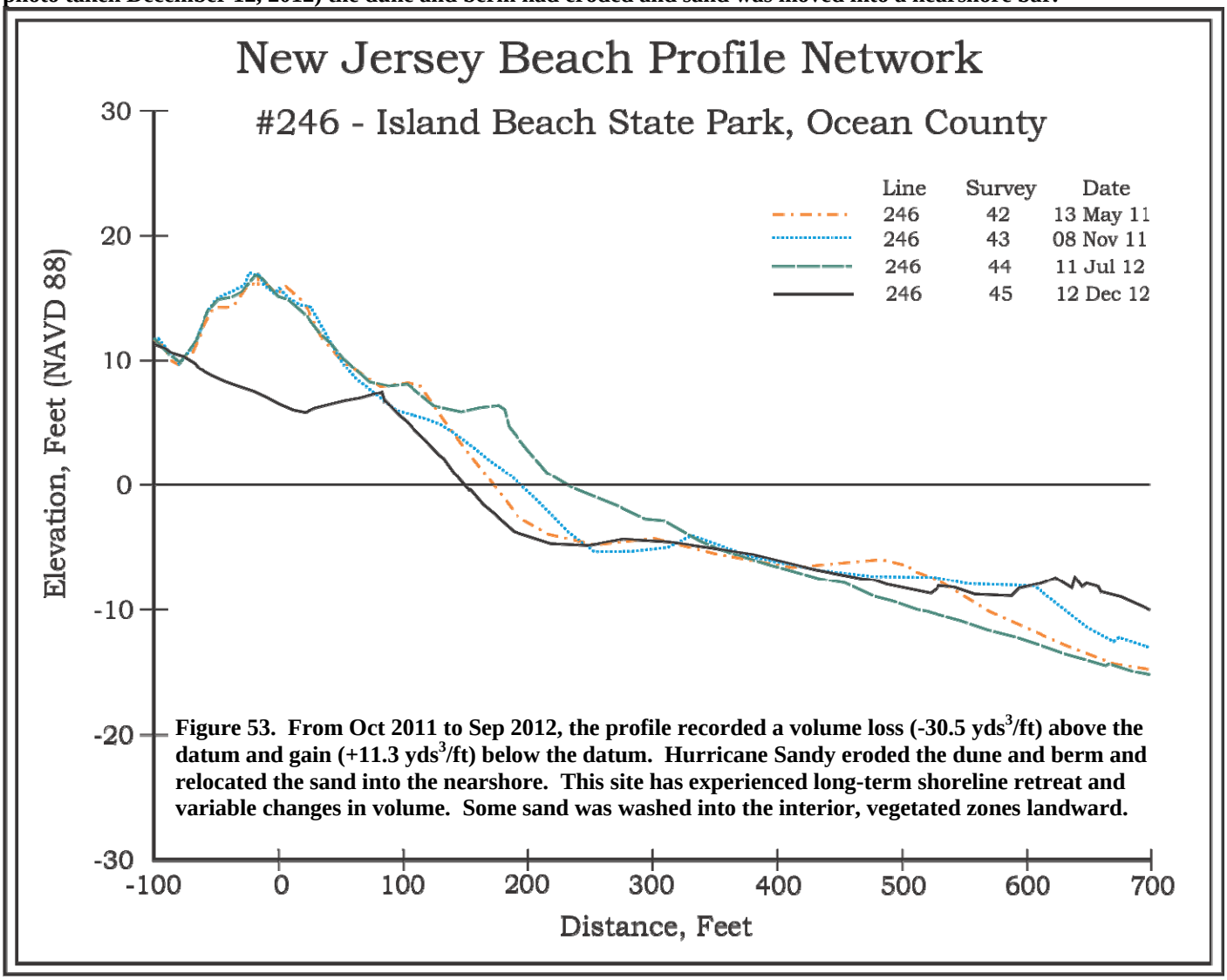


Figure 53. From Oct 2011 to Sep 2012, the profile recorded a volume loss (-30.5 yds^3/ft) above the datum and gain (+11.3 yds^3/ft) below the datum. Hurricane Sandy eroded the dune and berm and relocated the sand into the nearshore. This site has experienced long-term shoreline retreat and variable changes in volume. Some sand was washed into the interior, vegetated zones landward.

NJBPN 146 – Parking Lot A7, Island Beach State Park

This site within the state protected area is less than a mile from the north Barnegat Inlet jetty. The left photograph was taken on November 8, 2011 and shows the wide beach and natural dunes. The photo on the right, six weeks after Sandy (December 12, 2012) shows the conditions of the dune and berm.

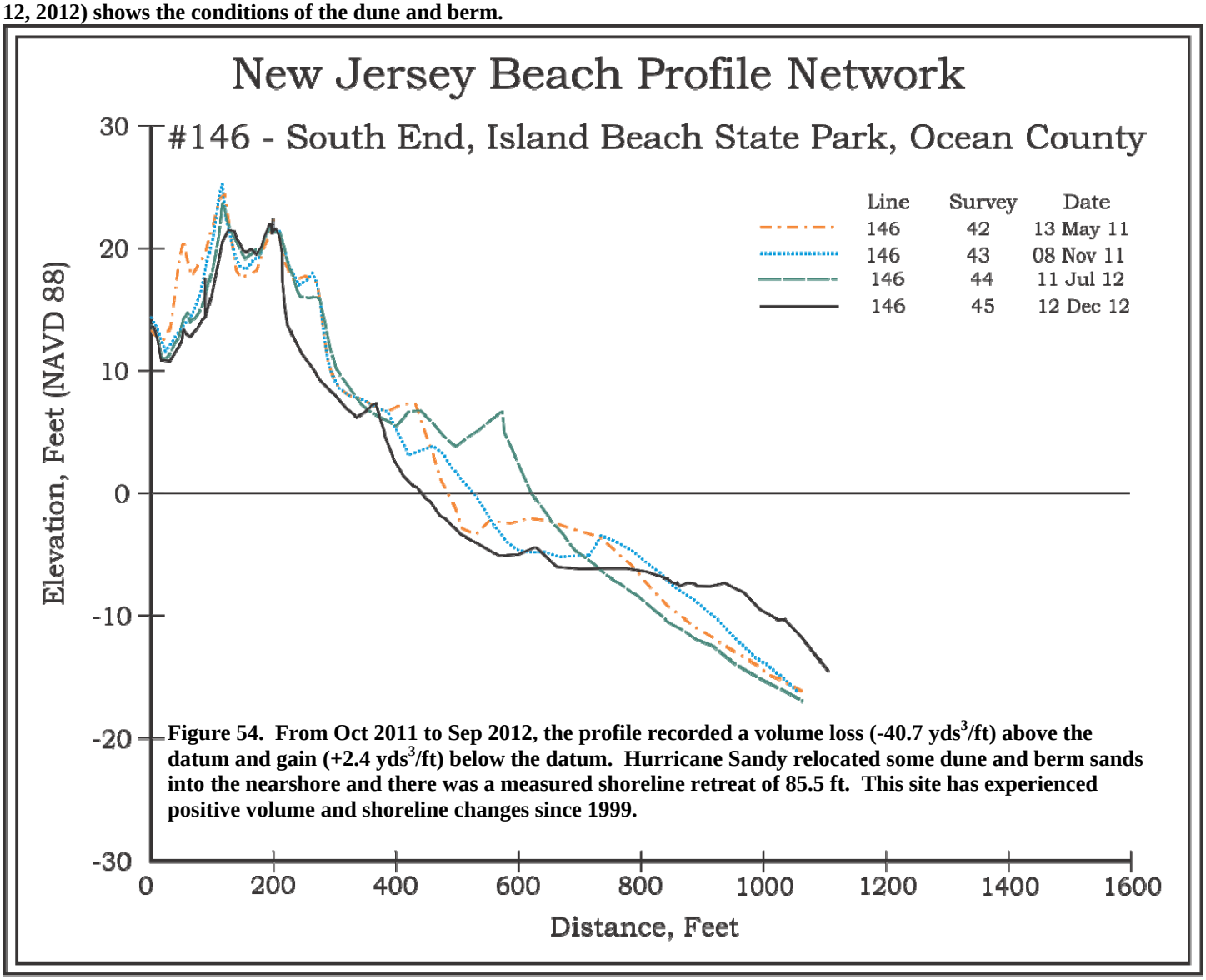


Figure 54. From Oct 2011 to Sep 2012, the profile recorded a volume loss (-40.7 yds^3/ft) above the datum and gain (+2.4 yds^3/ft) below the datum. Hurricane Sandy relocated some dune and berm sands into the nearshore and there was a measured shoreline retreat of 85.5 ft. This site has experienced positive volume and shoreline changes since 1999.

NJBPN 245 – 10th Street, Barnegat Light

This site is located approximately 1500 feet south of the Barnegat Inlet south jetty and was established to monitor the changes at the inlet. The left photo (taken on September 12, 2012) shows the dune and beach conditions before Sandy and the dense vegetation along the landward dune slope. The photo on the right (taken on November 2, 2012) shows the impact of Sandy where sand was overwashed and blown landward across the dune burying but not killing the vegetation.

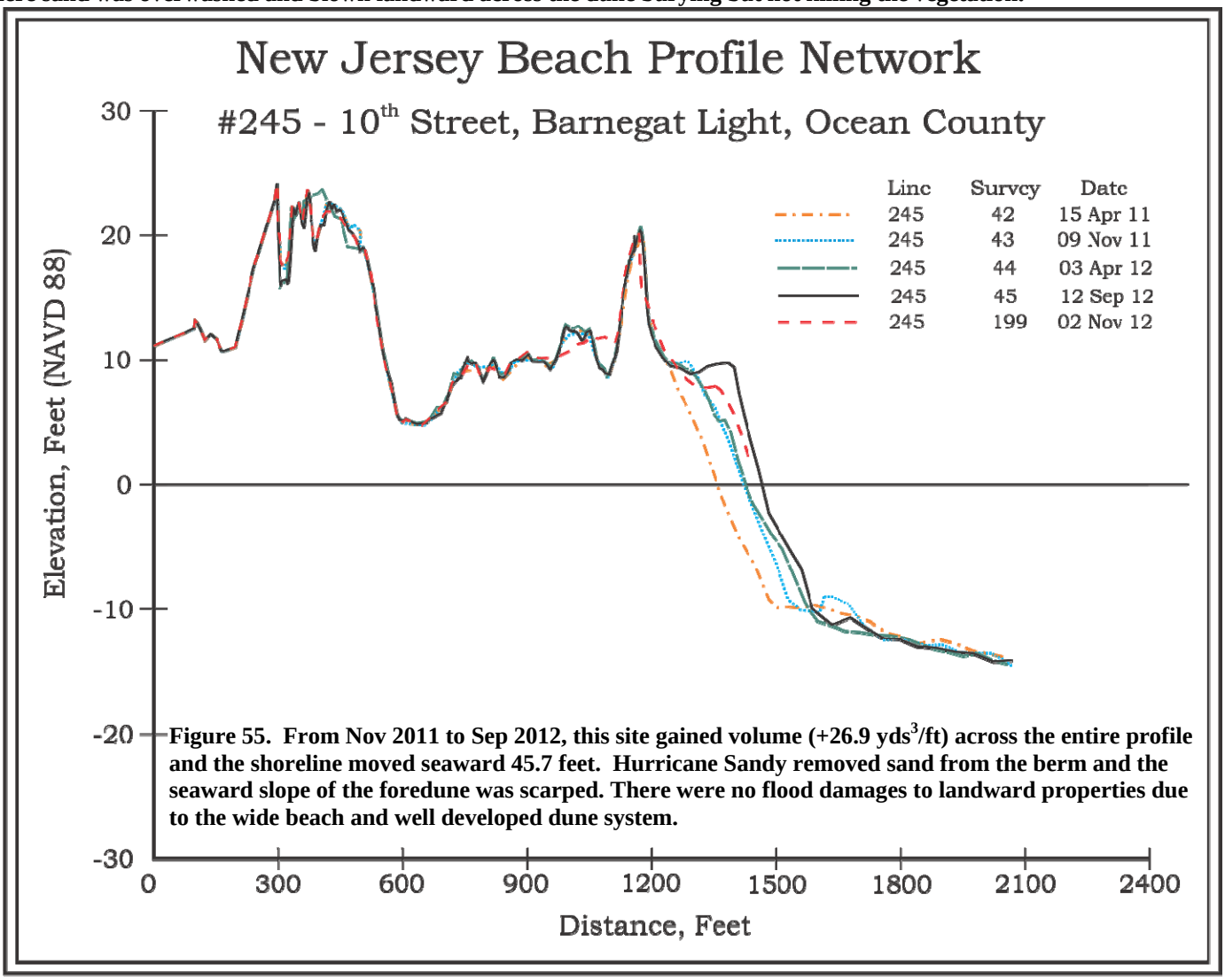


Figure 55. From Nov 2011 to Sep 2012, this site gained volume (+26.9 yds^3/ft) across the entire profile and the shoreline moved seaward 45.7 feet. Hurricane Sandy removed sand from the berm and the seaward slope of the foredune was scarped. There were no flood damages to landward properties due to the wide beach and well developed dune system.

NJBPN 145 – 26th Street, Barnegat Light

The photo on the left was taken on September 12, 2012 and shows the dune and beach conditions and dense vegetation before Sandy. In the photo on the right taken on November 2, 2012 from a similar location looking south post-Sandy the impact of the storm is evident from the sand overwashed and blown landward across the dune burying the dense vegetation seen in the September picture and by the narrower beach width.

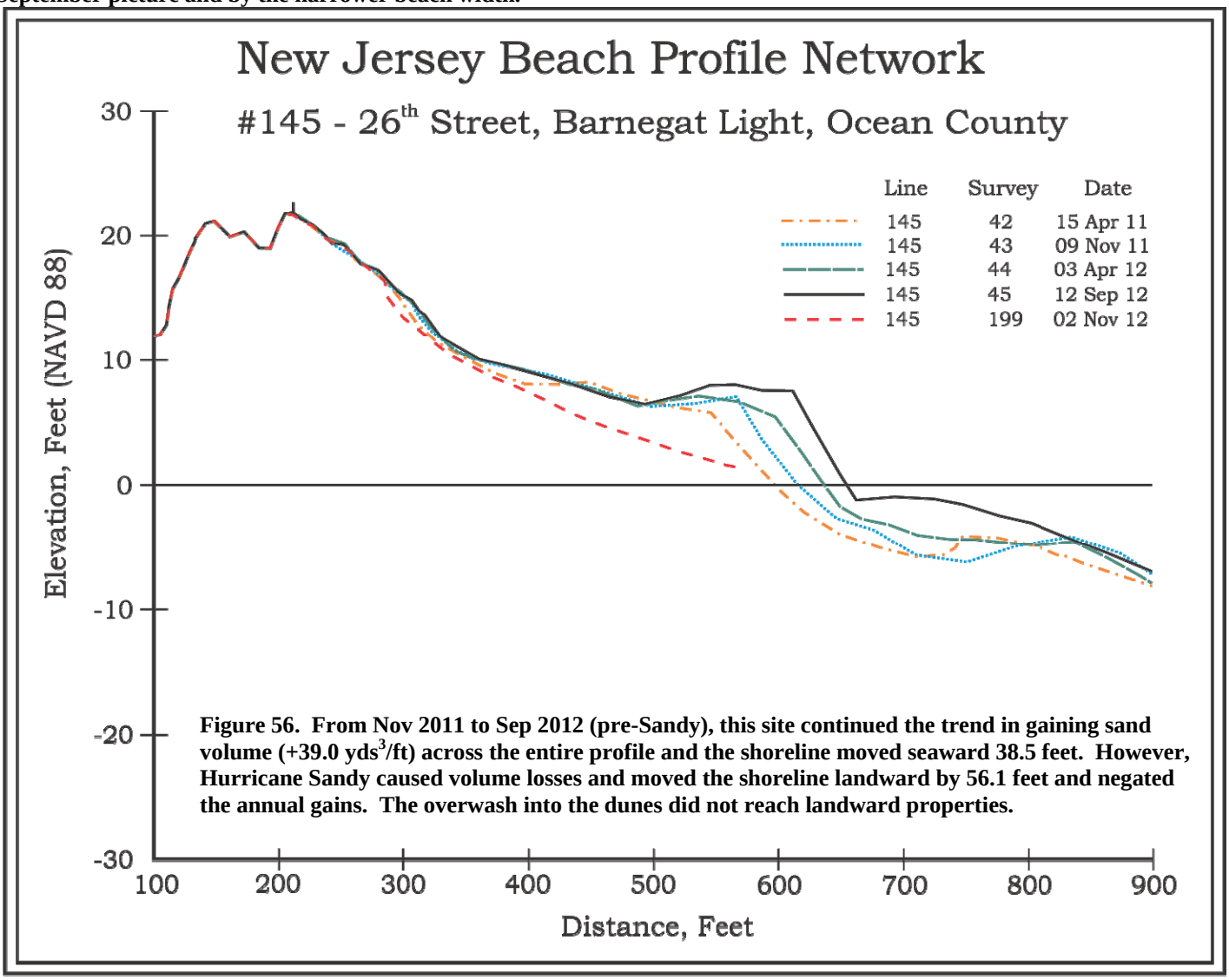


Figure 56. From Nov 2011 to Sep 2012 (pre-Sandy), this site continued the trend in gaining sand volume (+39.0 yds^3/ft) across the entire profile and the shoreline moved seaward 38.5 feet. However, Hurricane Sandy caused volume losses and moved the shoreline landward by 56.1 feet and negated the annual gains. The overwash into the dunes did not reach landward properties.

NJBPN 144 – La Baia Street, Loveladies

Above are two photos taken at La Baia Street before and after Hurricane Sandy. The photo on the left (taken September 12, 2012) shows the dune and beach conditions prior to the storm. In the photo on the right (taken November 2, 2012) the impact of the storm is evident. The former dune was removed and the shoreline moved 110.1 feet landward. Sand was overwashed between the oceanfront homes and carried landward to the road.

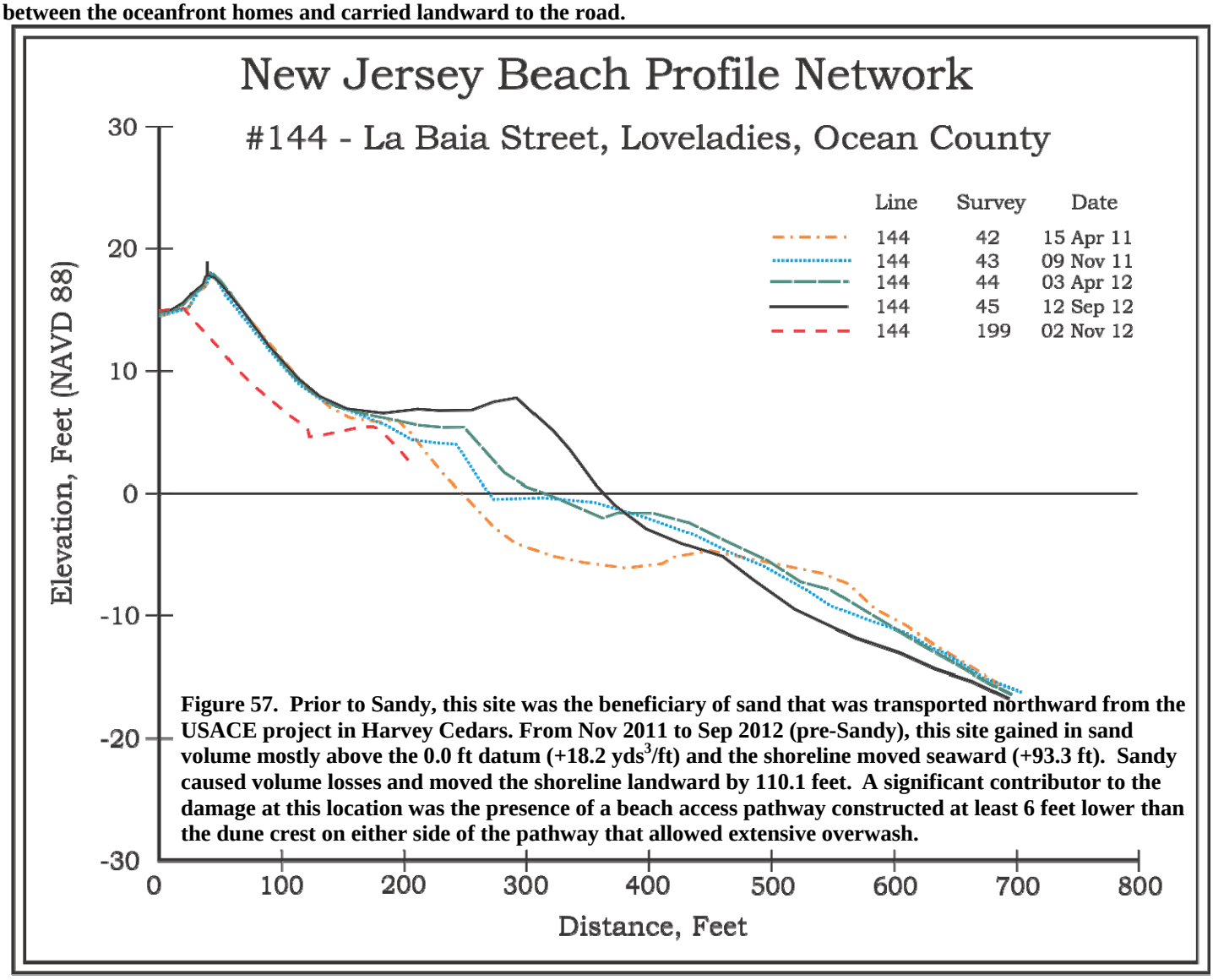


Figure 57. Prior to Sandy, this site was the beneficiary of sand that was transported northward from the USACE project in Harvey Cedars. From Nov 2011 to Sep 2012 (pre-Sandy), this site gained in sand volume mostly above the 0.0 ft datum (+18.2 yds^3/ft) and the shoreline moved seaward (+93.3 ft). Sandy caused volume losses and moved the shoreline landward by 110.1 feet. A significant contributor to the damage at this location was the presence of a beach access pathway constructed at least 6 feet lower than the dune crest on either side of the pathway that allowed extensive overwash.

NJBPN 143 – 73rd Street, Harvey Cedars

The photo on the left was taken on September 11, 2012 while the photo on the right was taken on November 2, 2012 from a similar location looking north. This site had received sand as part of the 2010 USACE beach nourishment project for Long Beach Island. The project provided ample dune and beach width enhancement and storm protection for the oceanfront properties. The post-Sandy photo shows the impact of the storm with a significant dune scarp at the seaward crest and a narrow, lower-elevation beach remaining. However there was no evidence that sand overwashed the dune at this location.

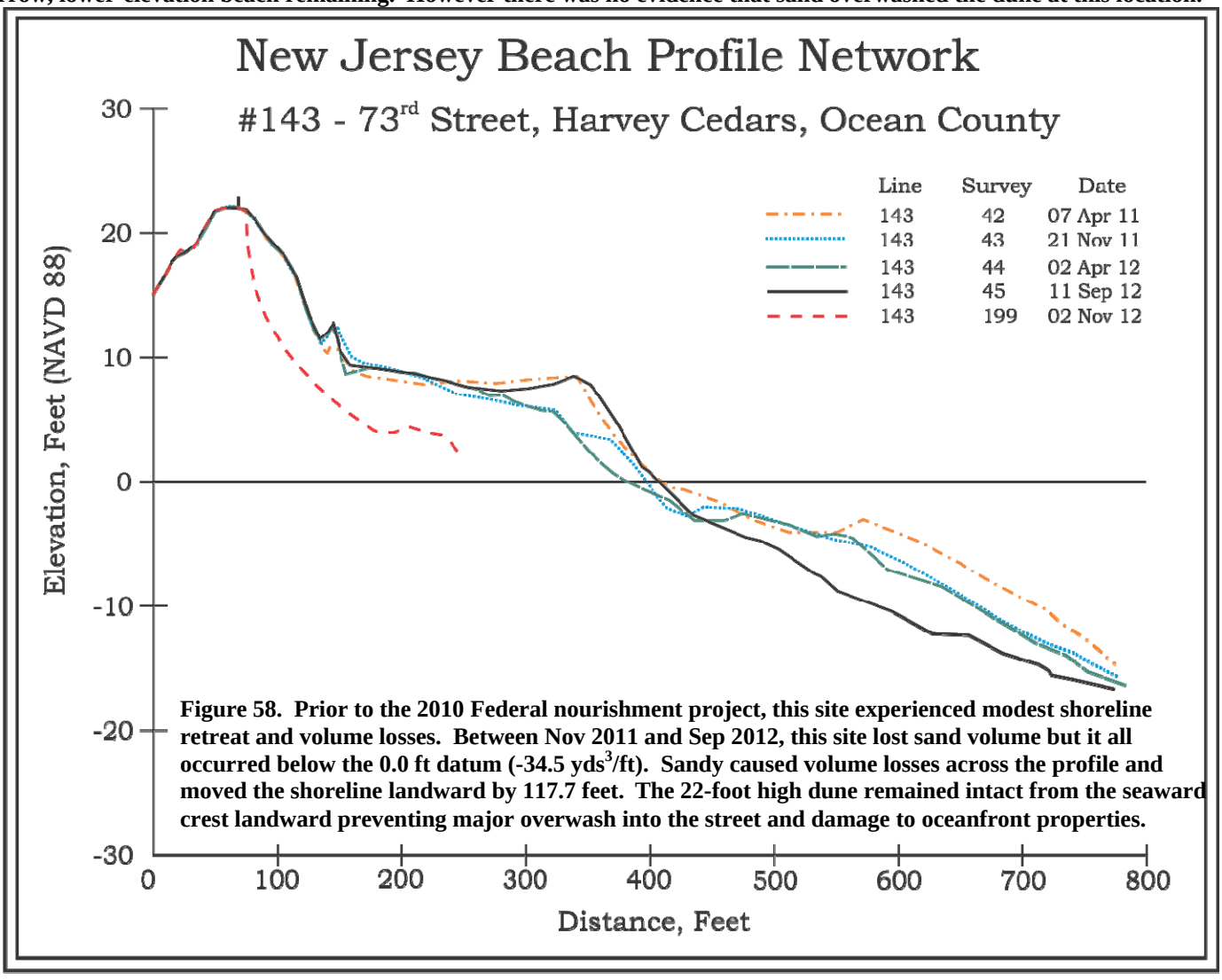


Figure 58. Prior to the 2010 Federal nourishment project, this site experienced modest shoreline retreat and volume losses. Between Nov 2011 and Sep 2012, this site lost sand volume but it all occurred below the 0.0 ft datum (-34.5 yds^3/ft). Sandy caused volume losses across the profile and moved the shoreline landward by 117.7 feet. The 22-foot high dune remained intact from the seaward crest landward preventing major overwash into the street and damage to oceanfront properties.

NJBPN 142 – Tranquility Drive, Harvey Cedars

The Tranquility Drive site was included in the 2010 USACE beach nourishment project. The photo on the left was taken on September 11, 2012 and shows the dune and beach conditions of the USACE engineered beach before Sandy. On the right, the photo (taken on November 2, 2012 - post-Sandy) shows the impact of the storm by the significant loss of dune seaward of the homes and the lower and narrower beach. Despite the significant loss of dune, overwash did not occur and the oceanfront properties were protected from wave damages.

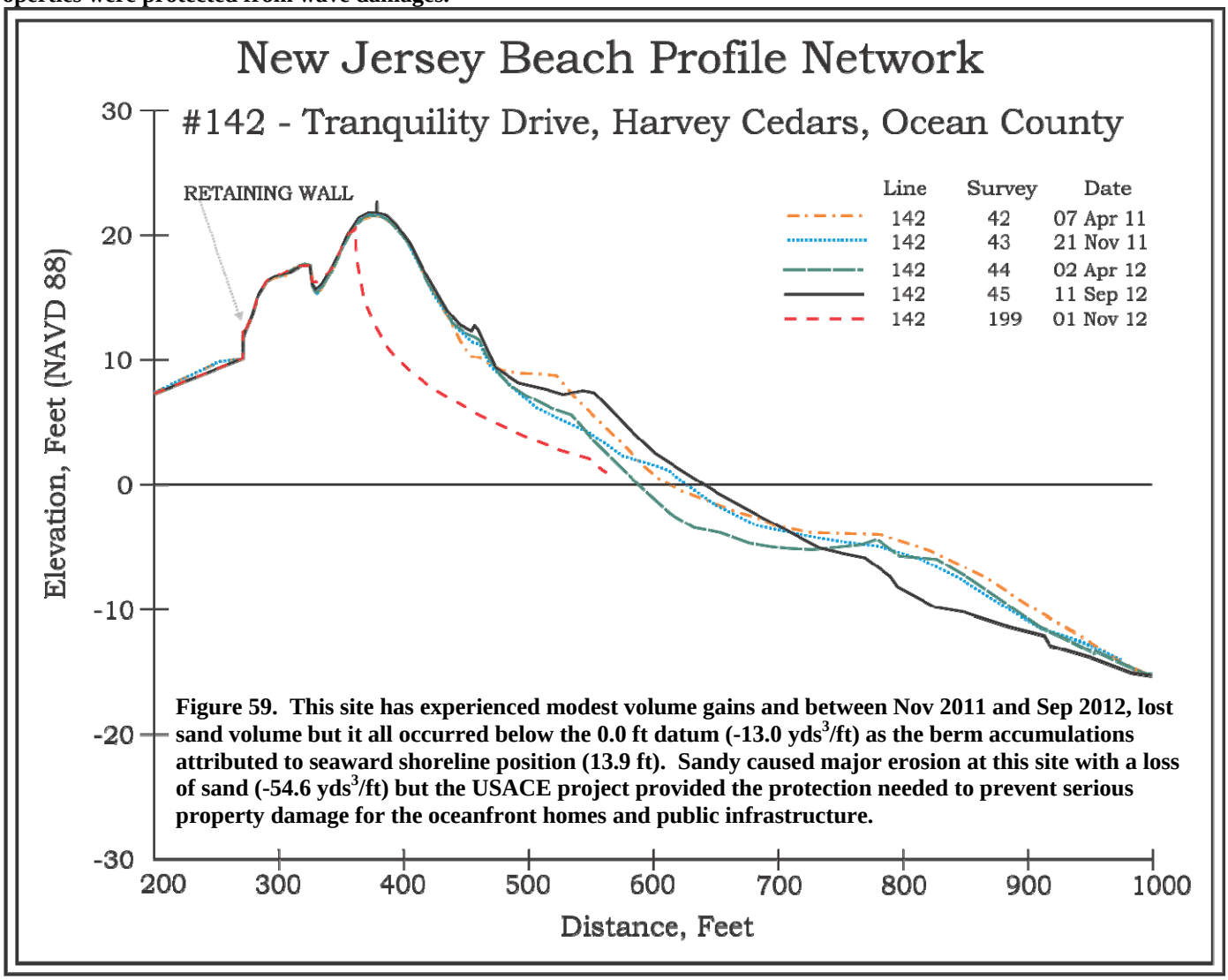


Figure 59. This site has experienced modest volume gains and between Nov 2011 and Sep 2012, lost sand volume but it all occurred below the 0.0 ft datum (-13.0 yds^3/ft) as the berm accumulations attributed to seaward shoreline position (13.9 ft). Sandy caused major erosion at this site with a loss of sand (-54.6 yds^3/ft) but the USACE project provided the protection needed to prevent serious property damage for the oceanfront homes and public infrastructure.

NJBPN 241 – 20th Street – Surf City

The photographs above were taken on September 11th, 2012 (left) and November 1st, 2012 (right). Both images show the view of 20th Street (site 241) looking south. This location in Surf City received a beach replenishment in 2007, which increased the sand volume and width of the dune and berm. The dune and berm both experienced substantial erosion; however no overwash occurred at this location.

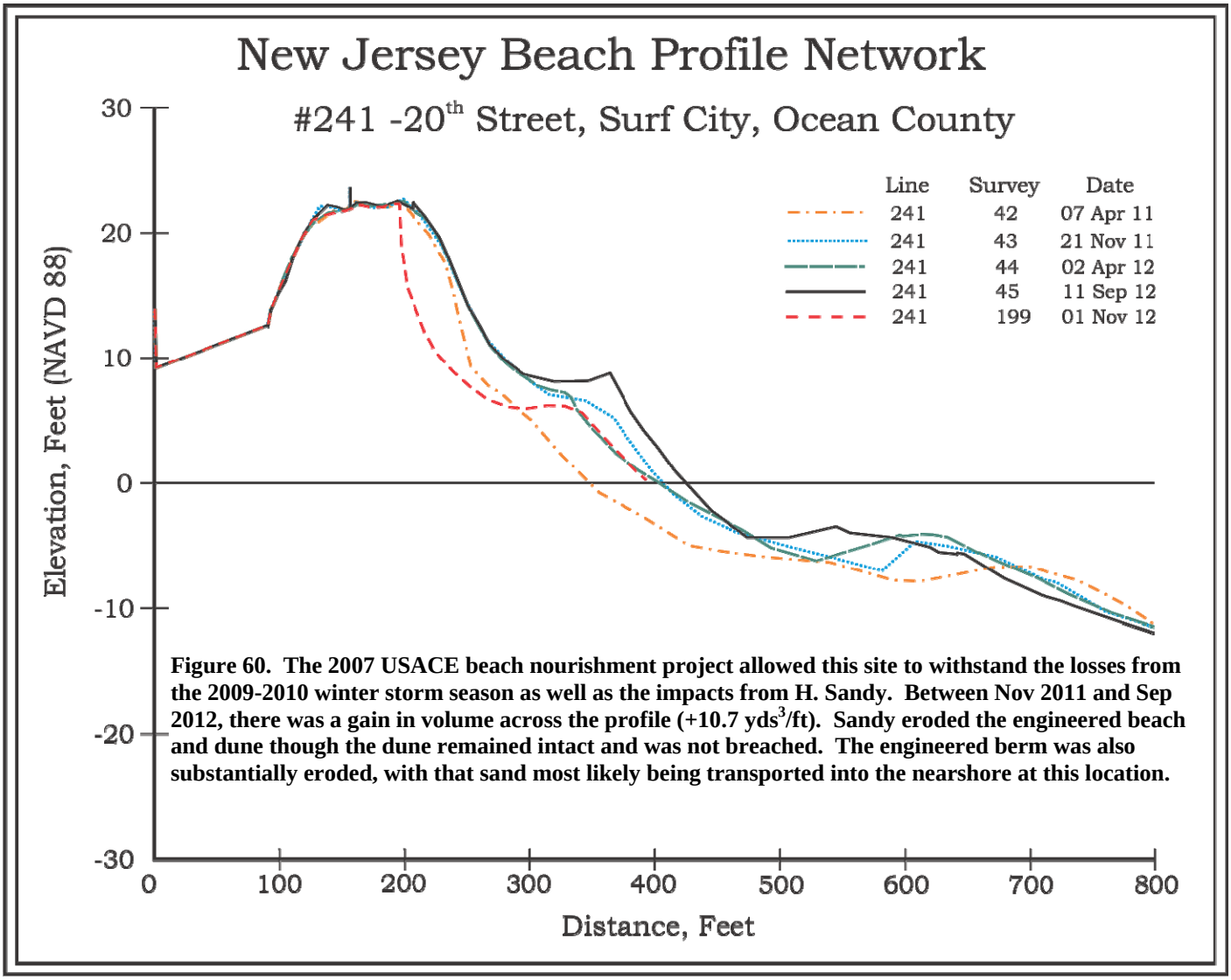


Figure 60. The 2007 USACE beach nourishment project allowed this site to withstand the losses from the 2009-2010 winter storm season as well as the impacts from H. Sandy. Between Nov 2011 and Sep 2012, there was a gain in volume across the profile (+10.7 yds^3/ft). Sandy eroded the engineered beach and dune though the dune remained intact and was not breached. The engineered berm was also substantially eroded, with that sand most likely being transported into the nearshore at this location.

NJBPN 141 – 8th Street, Ship Bottom

The photographs above were taken on September 10th, 2012 (left) and November 1st, 2012 (right). Both images show the view of 8th street (site 141) looking north. This location in Ship Bottom experienced erosion of the beach and dune from Sandy, however the dune was not breached and no overwash occurred at this location.

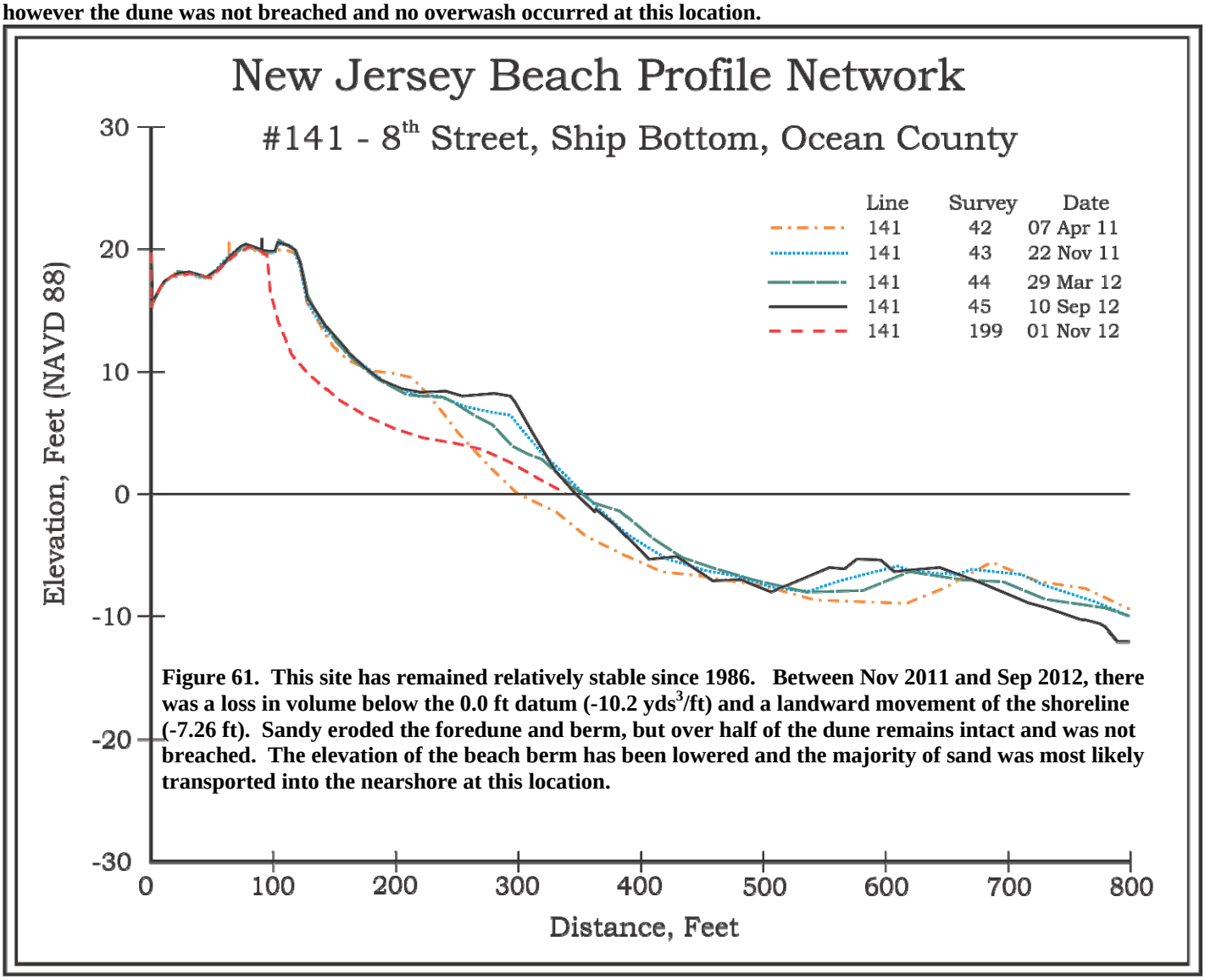


Figure 61. This site has remained relatively stable since 1986. Between Nov 2011 and Sep 2012, there was a loss in volume below the 0.0 ft datum (-10.2 yds^3/ft) and a landward movement of the shoreline (-7.26 ft). Sandy eroded the foredune and berm, but over half of the dune remains intact and was not breached. The elevation of the beach berm has been lowered and the majority of sand was most likely transported into the nearshore at this location.

NJBPN 140 – 32nd Street, Long Beach Township

The photographs above were taken on September 10th, 2012 (left) and November 1st, 2012 (right). Both images show the view of 32nd street (site 140) looking north. This location in the Brant Beach section of Long Beach Township received beach replenishment in spring 2012, which increased the sand volume and width of the dune and berm. The foredune slope experienced minor erosion during Sandy, while the berm was severely eroded. No overwash occurred at this location. The park bench remained in its original position.

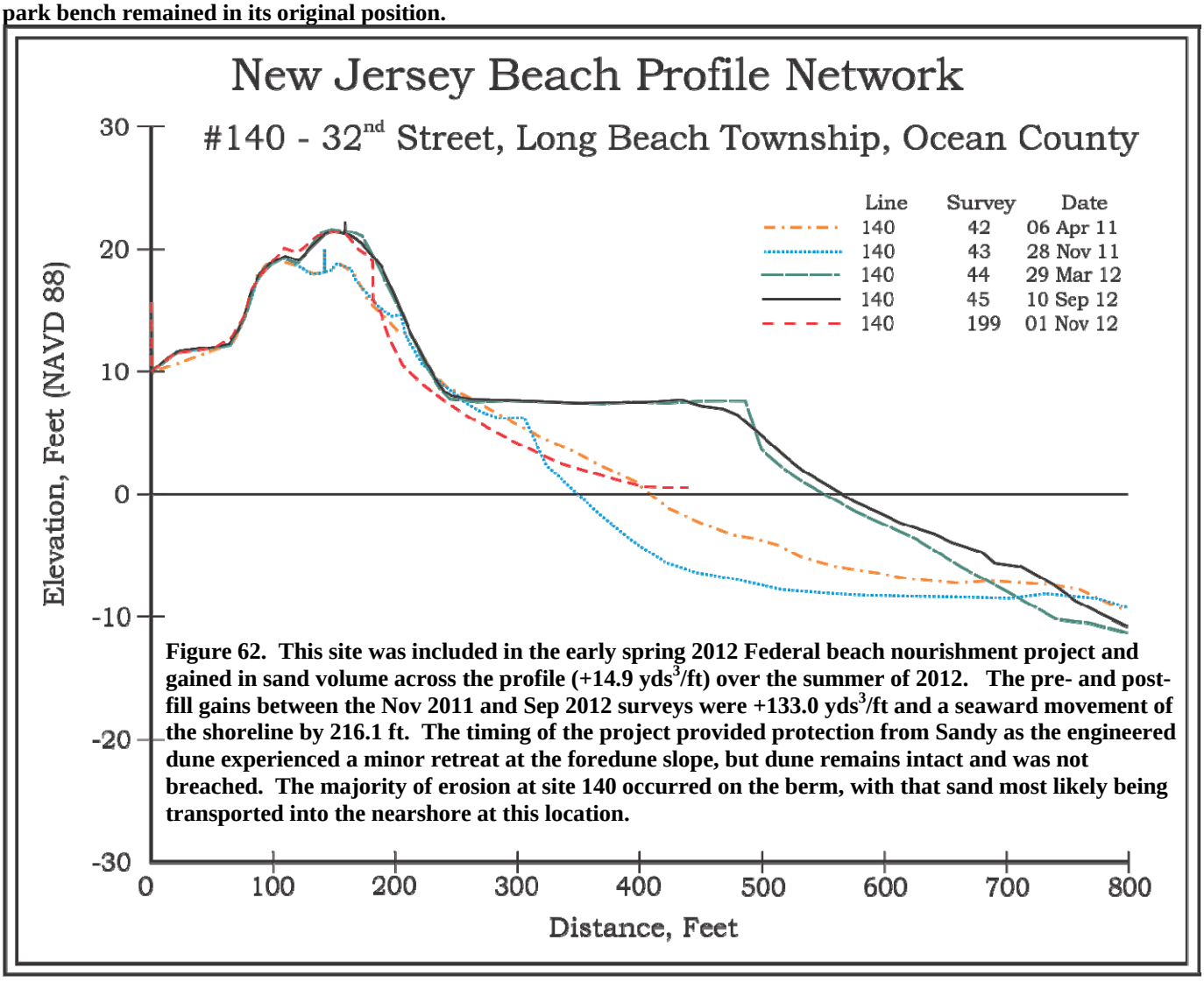


Figure 62. This site was included in the early spring 2012 Federal beach nourishment project and gained in sand volume across the profile (+14.9 yds^3/ft) over the summer of 2012. The pre- and post-fill gains between the Nov 2011 and Sep 2012 surveys were +133.0 yds^3/ft and a seaward movement of the shoreline by 216.1 ft. The timing of the project provided protection from Sandy as the engineered dune experienced a minor retreat at the foredune slope, but dune remains intact and was not breached. The majority of erosion at site 140 occurred on the berm, with that sand most likely being transported into the nearshore at this location.

NJBPN 139 – 81st Street, Long Beach Township

The photographs above were taken on September 10th, 2012 (left) and November 1st, 2012 (right). Both images show the view of 81st street (site 139) looking south. It is evident in the photographs that the existing dune was completely eroded away and overwash occurred, with waves pushing water and sand under the oceanfront homes and into the streets landward of them. The dune elevation was about 16 feet.

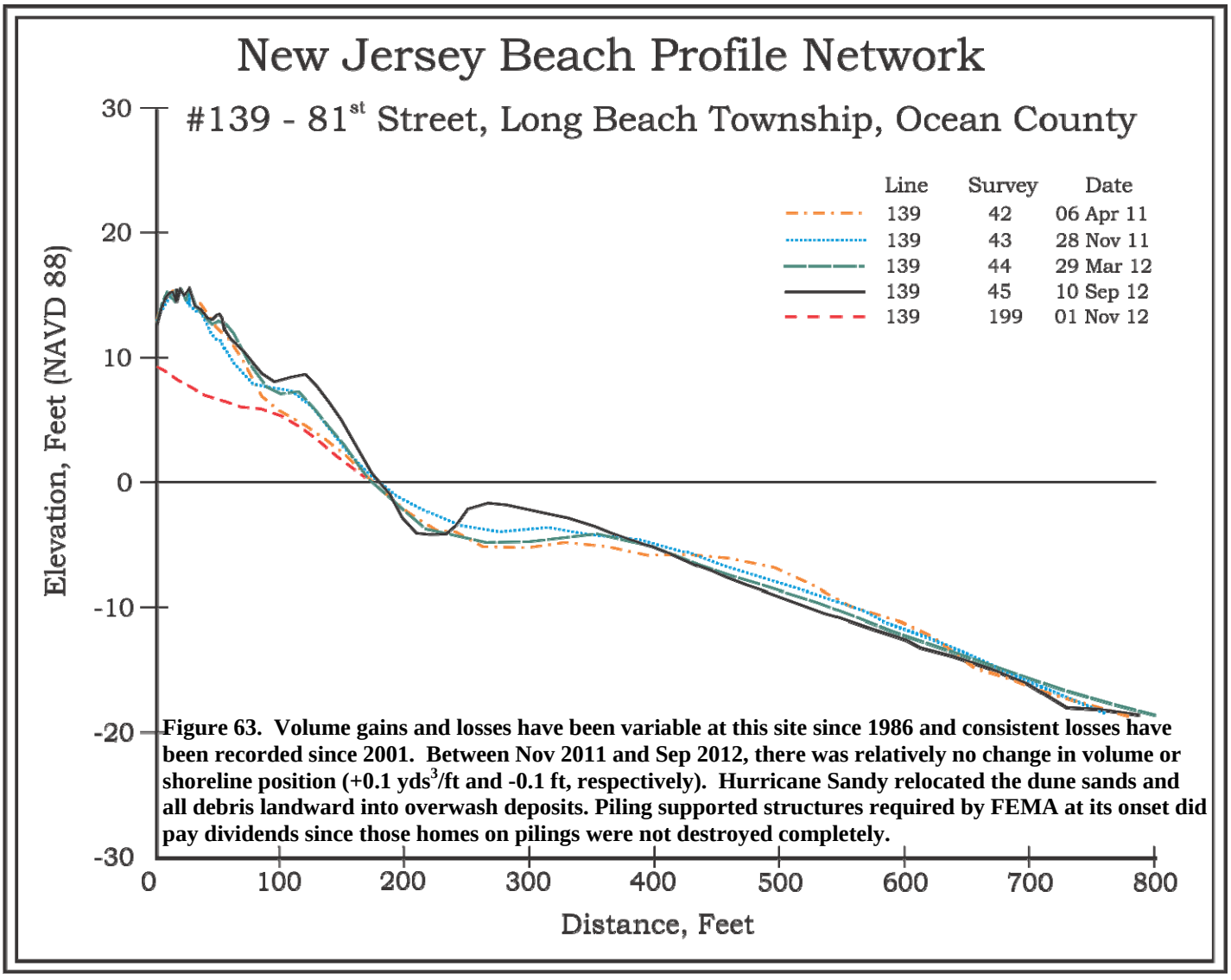


Figure 63. Volume gains and losses have been variable at this site since 1986 and consistent losses have been recorded since 2001. Between Nov 2011 and Sep 2012, there was relatively no change in volume or shoreline position (+0.1 yds^3/ft and -0.1 ft, respectively). Hurricane Sandy relocated the dune sands and all debris landward into overwash deposits. Piling supported structures required by FEMA at its onset did pay dividends since those homes on pilings were not destroyed completely.

NJBPN 138 – Old Whaling Road (124th Street), Long Beach Township

The photographs above were taken on September 7th, 2012 (left) and November 1st, 2012 (right). Both images show the view of Old Whaling Road (site 138) looking south. The existing dune experienced erosion, however it was not completely removed and no overwash occurred at this location. Surprisingly, two blocks to the north a dune of comparable size and shape was eroded away and overwash occurred.

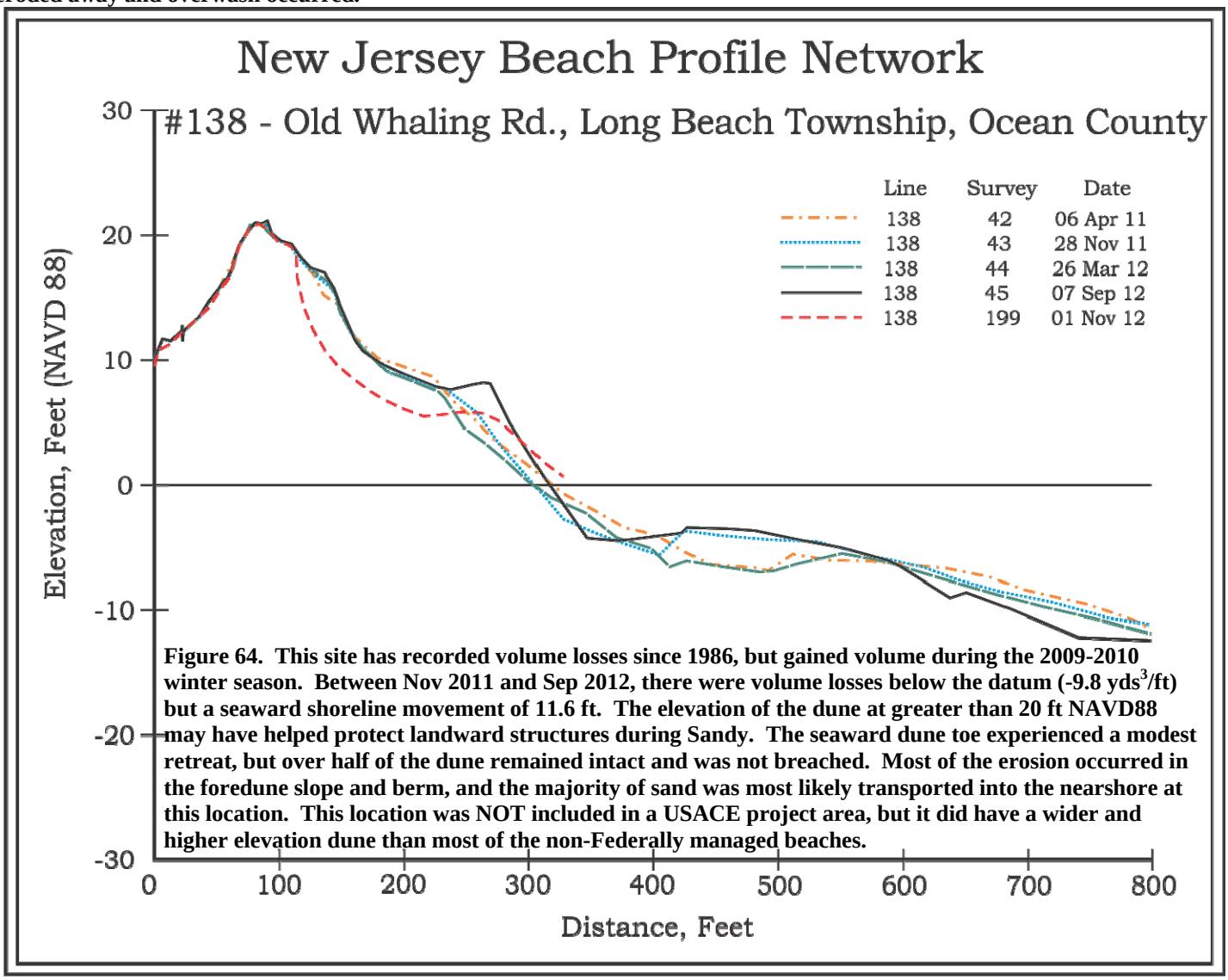


Figure 64. This site has recorded volume losses since 1986, but gained volume during the 2009-2010 winter season. Between Nov 2011 and Sep 2012, there were volume losses below the datum (-9.8 yds^3/ft) but a seaward shoreline movement of 11.6 ft. The elevation of the dune at greater than 20 ft NAVD88 may have helped protect landward structures during Sandy. The seaward dune toe experienced a modest retreat, but over half of the dune remained intact and was not breached. Most of the erosion occurred in the foredune slope and berm, and the majority of sand was most likely transported into the nearshore at this location. This location was NOT included in a USACE project area, but it did have a wider and higher elevation dune than most of the non-Federally managed beaches.

NJBPN 137 – Taylor Avenue, Beach Haven

The photographs above were taken on September 7th, 2012 (left) and November 1st, 2012 (right). Both images show the view of Taylor Avenue looking north. It is evident in the photographs that the existing dune was completely eroded away and overwash occurred, with waves pushing water and sand under the oceanfront homes and into the streets landward of them. The crib timber structure in the above right photograph was instrumental in saving the home from significant damage. The cribbing was back-filled with rocks and masonry debris and provided an effective barrier to direct wave impacts. The landward returns on the structure were critical in saving the property.

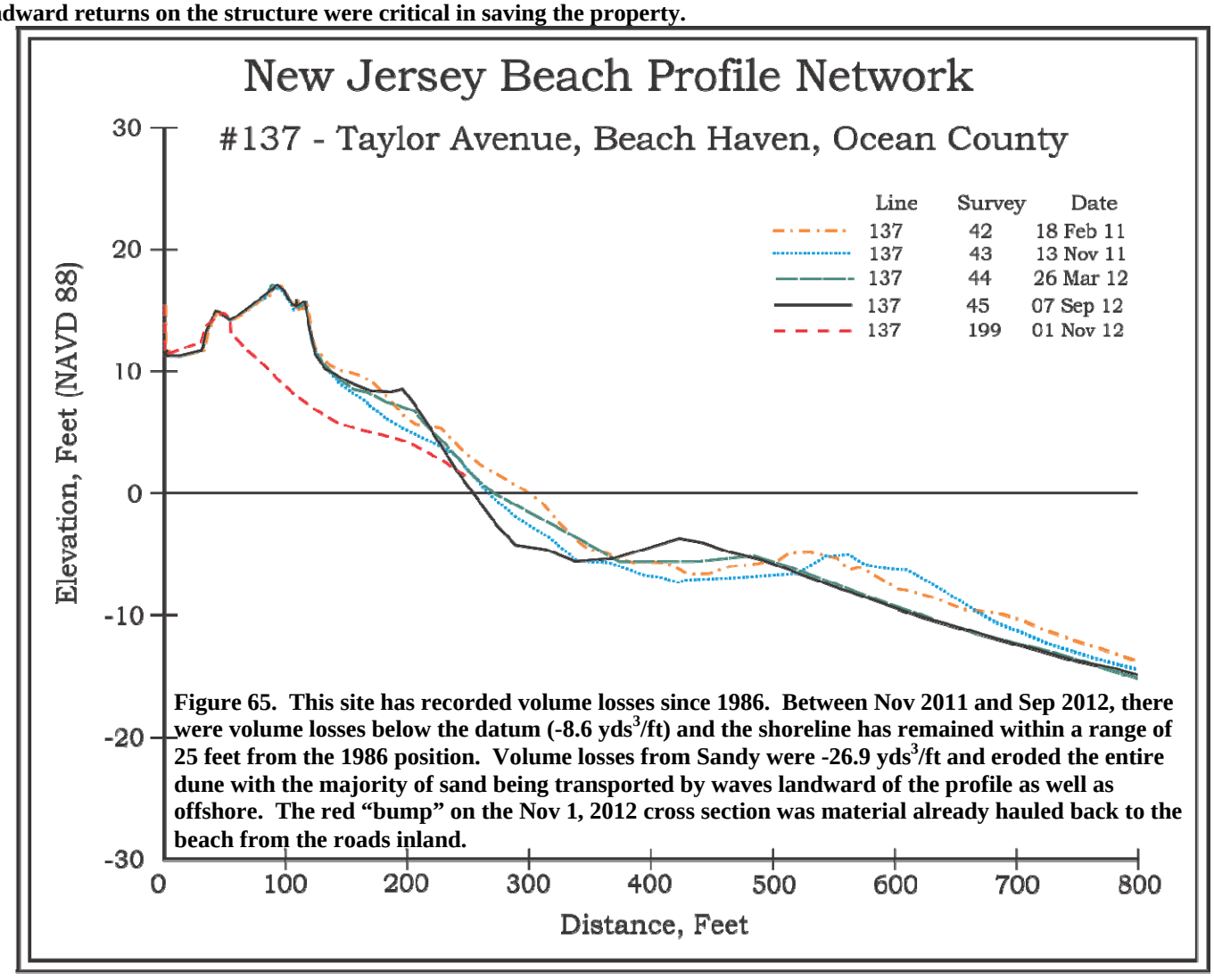


Figure 65. This site has recorded volume losses since 1986. Between Nov 2011 and Sep 2012, there were volume losses below the datum (-8.6 yds^3/ft) and the shoreline has remained within a range of 25 feet from the 1986 position. Volume losses from Sandy were -26.9 yds^3/ft and eroded the entire dune with the majority of sand being transported by waves landward of the profile as well as offshore. The red "bump" on the Nov 1, 2012 cross section was material already hauled back to the beach from the roads inland.

NJBPN 136 – Dolphin Avenue, Beach Haven

The photographs above were taken on September 6th, 2012 (left) and November 1st, 2012 (right). Both images show the view of Dolphin Avenue (site 136) looking north. It is evident in the photographs that the existing dune was completely eroded away and overwash occurred, with waves pushing water and sand under the oceanfront homes and into the streets landward of them. Damage was clear and very common.

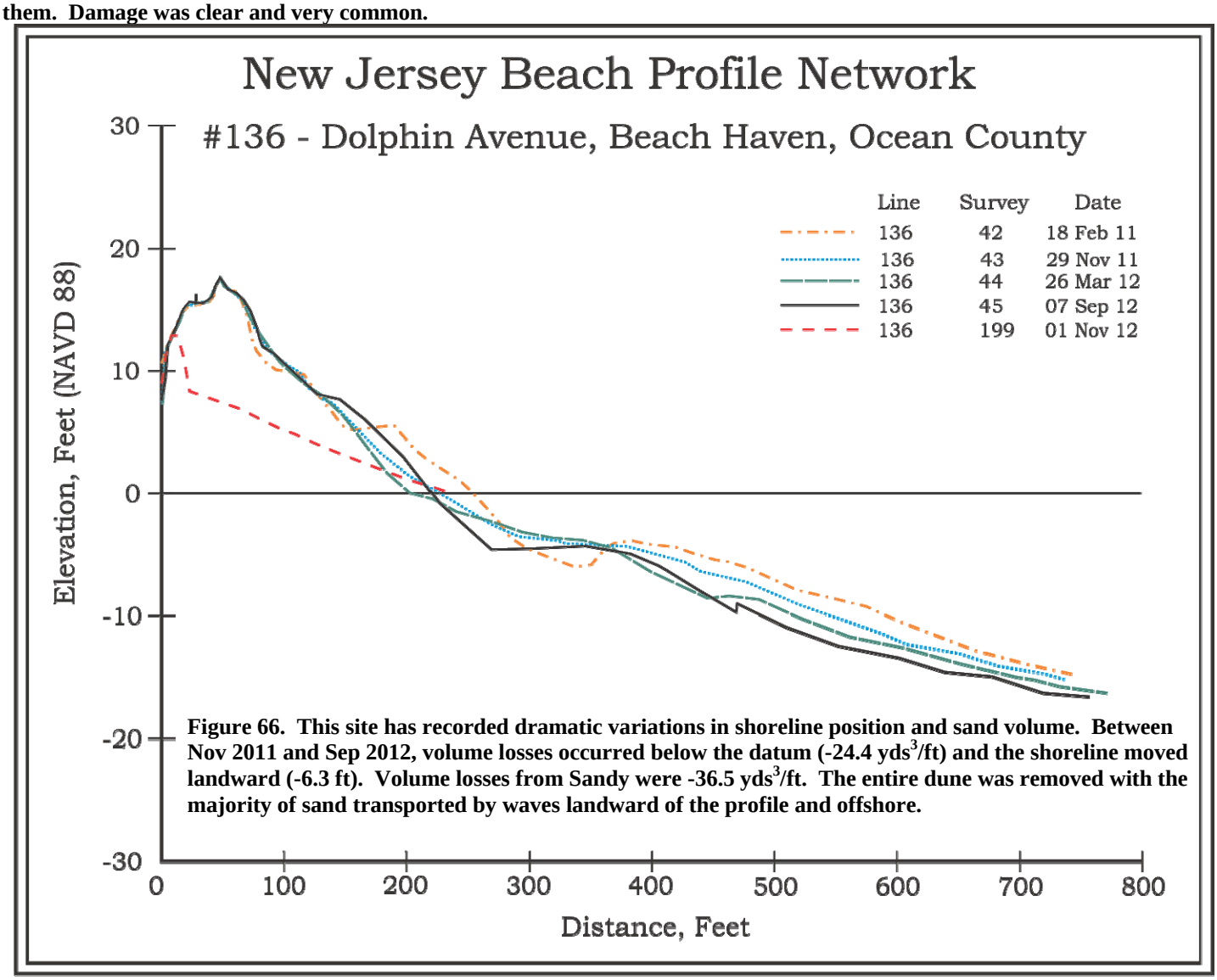


Figure 66. This site has recorded dramatic variations in shoreline position and sand volume. Between Nov 2011 and Sep 2012, volume losses occurred below the datum (-24.4 yds^3/ft) and the shoreline moved landward (-6.3 ft). Volume losses from Sandy were -36.5 yds^3/ft. The entire dune was removed with the majority of sand transported by waves landward of the profile and offshore.

NJBPN 135 – Webster Avenue, Long Beach Township

The photographs above were taken on September 6th, 2012 (left) and November 1st, 2012 (right). Both images show the view of Webster Avenue in Beach Haven (site 135) looking south. It is evident in the photographs that the existing dune was completely eroded away and overwash occurred, with waves pushing water and sand under the oceanfront homes and into the streets landward of them exposing the timber section of an old groin that was not exposed prior to the storm.

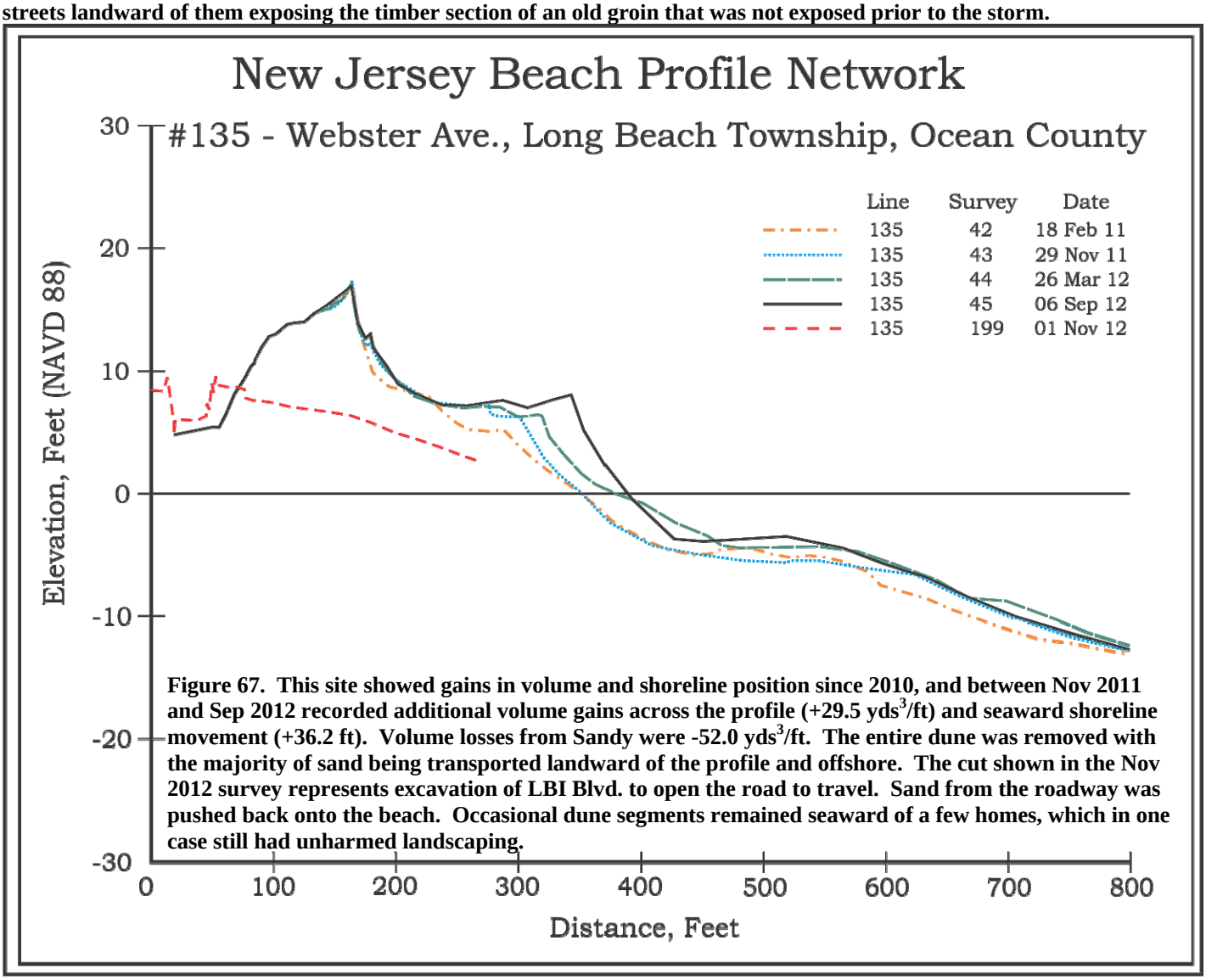


Figure 67. This site showed gains in volume and shoreline position since 2010, and between Nov 2011 and Sep 2012 recorded additional volume gains across the profile (+29.5 yds^3/ft) and seaward shoreline movement (+36.2 ft). Volume losses from Sandy were -52.0 yds^3/ft. The entire dune was removed with the majority of sand being transported landward of the profile and offshore. The cut shown in the Nov 2012 survey represents excavation of LBI Blvd. to open the road to travel. Sand from the roadway was pushed back onto the beach. Occasional dune segments remained seaward of a few homes, which in one case still had unharmed landscaping.

NJBPN 234 – Forsythe National Wildlife Refuge, Holgate Entrance, Long Beach Township

The photographs above were taken on September 6th, 2012 (left) and November 1st, 2012 (right). Both images show the view looking north at the beach-buggy entrance to the Forsythe Refuge (site 234). Wide-scale overwash occurred that extended to Barnegat Bay at this location due to the effect of Hurricane Sandy. All traces of a dune system in the natural area were flattened and moved landward as an overwash deposit.

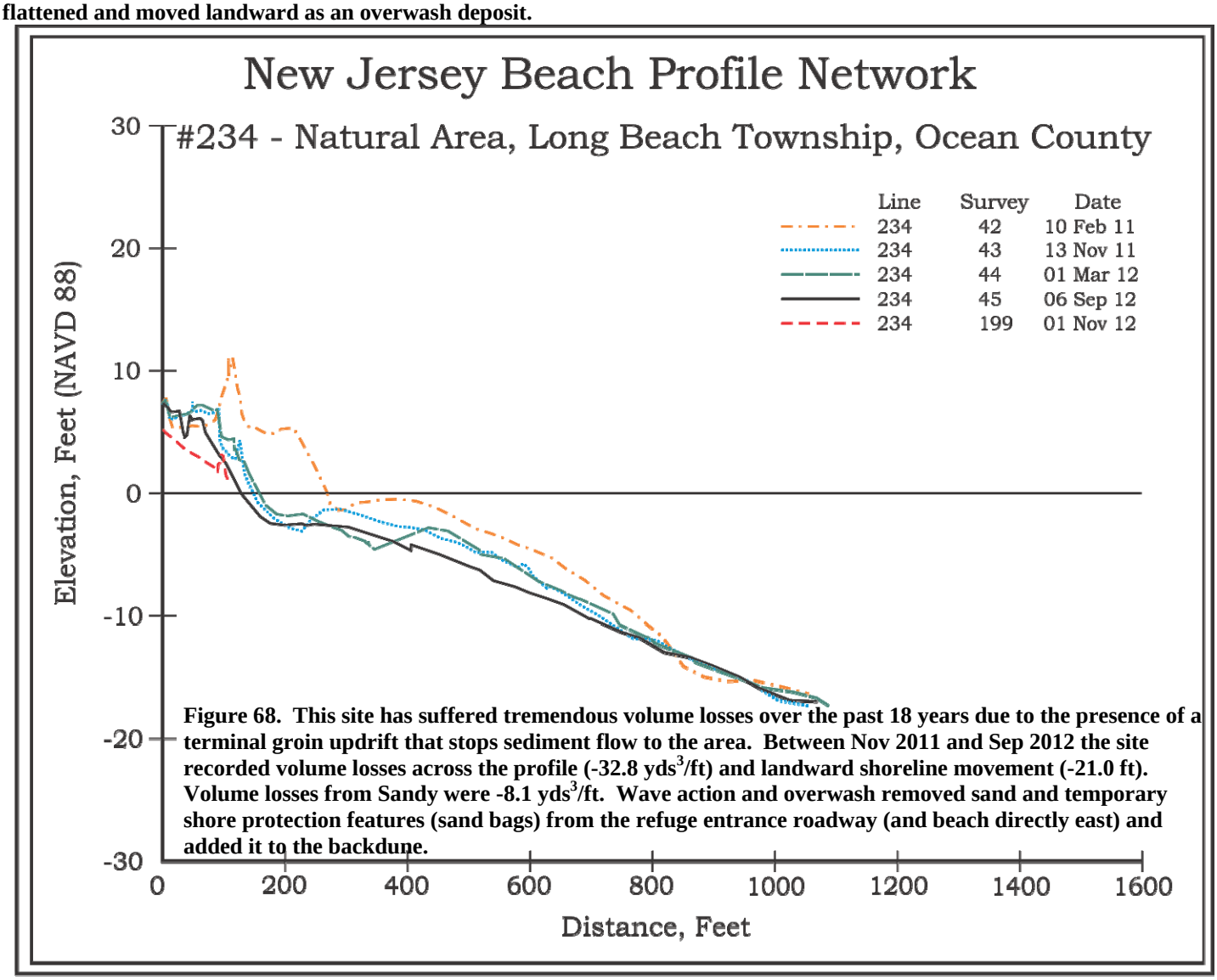


Figure 68. This site has suffered tremendous volume losses over the past 18 years due to the presence of a terminal groin updrift that stops sediment flow to the area. Between Nov 2011 and Sep 2012 the site recorded volume losses across the profile (-32.8 yds^3/ft) and landward shoreline movement (-21.0 ft). Volume losses from Sandy were -8.1 yds^3/ft. Wave action and overwash removed sand and temporary shore protection features (sand bags) from the refuge entrance roadway (and beach directly east) and added it to the backdune.

Northern Ocean County
Post Sandy Volume Changes

Site	Vol Change cu yds per ft	Dune Failure	Recent Beach Fill
347	-48.673	N	N
148	-43.722	N	N
248	-39.327	Y	N
149	-68.744	Y	N
150	-51.687	Y	N
151	-46.139	Y	N
152	-42.014	Y	N
153	-109.595	Y	N
154	-19.576	Y	N
155	-45.752	Y	N
156	-62.677	Y	N

Long Beach Island
Post Sandy Volume Changes

Site	Vol Change cu yds per ft	Dune Failure	Recent Beach Fill
234	-7.8	Y	N
135	-37.9	Y	N
136	-24.1	Y	N
137	-27.3	Y	N
138	-19.1	N	N
139	-29.5	Y	N
140	-40.4	N	Y
141	-40.3	N	N
241	-36.4	N	Y
142	-48.2	N	Y
143	-33	N	Y
144	-21.6	Y	N
145	-28.6	N	N
245	-5.2	N	N

Figure 69 shows a table of values for the 11 developed shoreline profile site locations in northern Ocean County (left) and the 14 profile sites on Long Beach Island (right). The sand volume lost per foot of shoreline represents loss from the dune and the beach and does not include changes in the offshore region. These surveys were completed as rapidly as possible so no swimmers were brought to these sites. The swimming portion of the survey takes 75% of the time at each site and the crew was trying to cover as many sites as possible each day following Sandy. There are 105 sites to cover statewide. Full surveys completed in the spring of 2013 and later in the fall of 2013 should provide information as to sand volume recovery occurring naturally since Sandy.

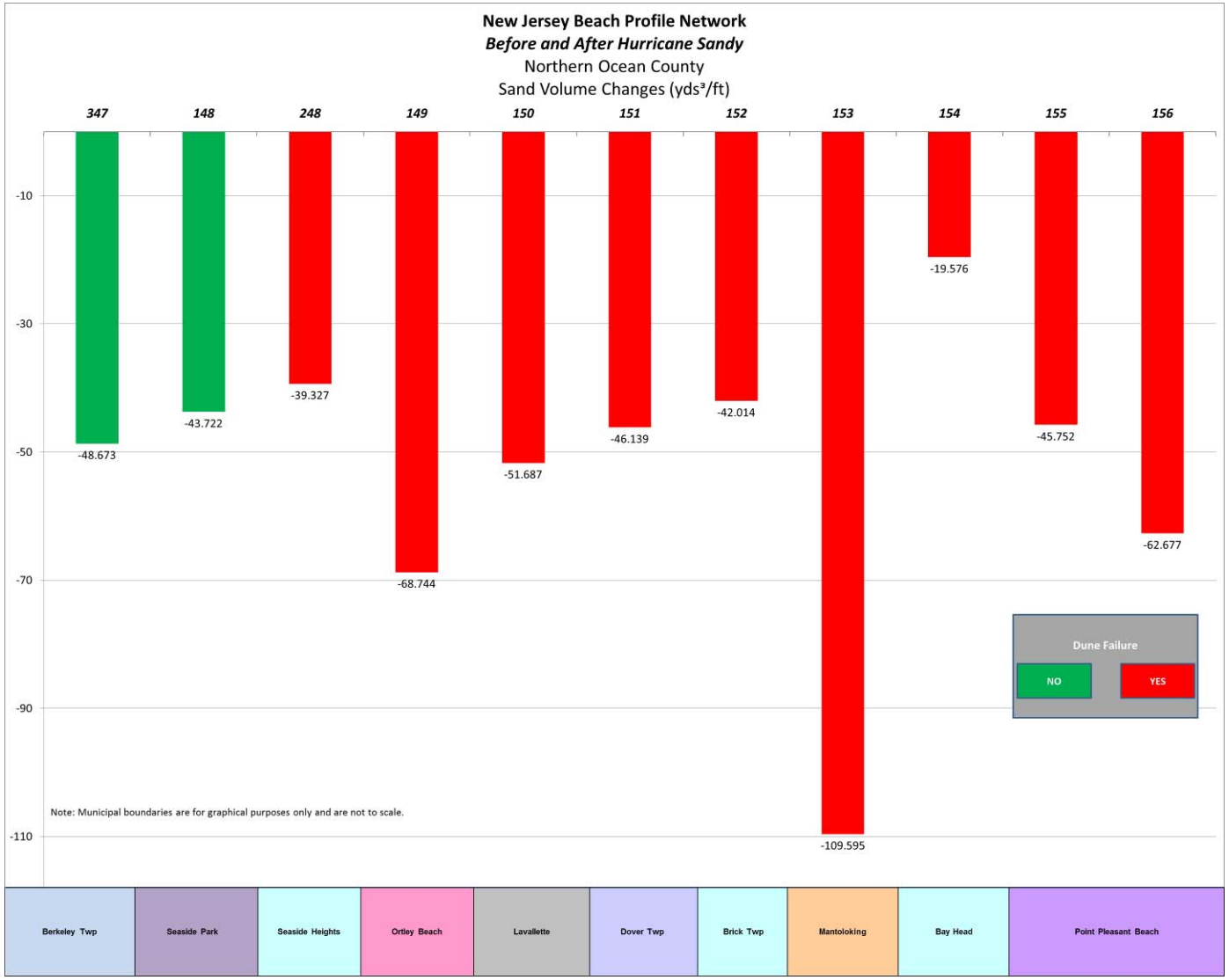


Figure 70. This graphic shows the sand volume loss figures for each of the communities within the developed sections of the northern Ocean County Atlantic shoreline. No Federal shore protection projects have occurred along this portion of the New Jersey shoreline. All sites experienced berm erosion and dune losses. Sites 347 and 148 contained a greater dune volume prior to the storm and though dune losses were recorded, there was no dune failure. The losses measured at Site 153 were enhanced due to the presence of a newly-opened inlet (with depths measured at approximately 18 feet). The dune at Site 154 contained a rock/timber core that was included in the pre-storm dune volume calculation.

Northern Ocean County Post Sandy Volume Changes

MUNICIPALITY	Site	Vol Change cu yds per ft	Average Volume Between Sites	Dune Failure	Recent Beach Fill	REF POINT Distance (FEET)	Vol Change - Cubic Yards Between Profiles (South to North)	Cumulative Volume Change - Cubic Yards (South to North)
Berkely Township	347	-48.673		N	N	0.00	0.00	0
Seaside Park	148	-43.722	-46.20	N	N	4,607.59	-212,859.05	-212,859.05
Seaside Heights	248	-39.327	-41.52	Y	N	9,074.11	-376,798.01	-589,657.06
Ortley Beach	149	-68.744	-54.04	Y	N	7,154.30	-386,586.18	-976,243.25
Lavallette	150	-51.687	-60.22	Y	N	11,087.76	-667,654.81	-1,643,898.06
Dover Twp	151	-46.139	-48.91	Y	N	10,393.85	-508,394.46	-2,152,292.51
Brick Twp	152	-42.014	-44.08	Y	N	5,184.78	-228,527.02	-2,380,819.53
Mantoloking	153	-109.595	-75.80	Y	N	15,628.24	-1,184,691.26	-3,565,510.79
Bay Head	154	-19.576	-64.59	Y	N	10,487.40	-677,333.97	-4,242,844.76
Point Pleasant Beach	155	-45.752	-32.66	Y	N	6,800.90	-222,144.64	-4,464,989.40
Point Pleasant Beach	156	-62.677	-54.21	Y	N	9,971.70	-540,610.46	-5,005,599.86
						Total Volume Loss for Northern Ocean County =	-5,005,599.86	

Figure 71. This table provides a summary of all the individual site sand volume losses from the dune and beach to the limit of the post-Sandy survey. The total is derived by adding two adjacent site losses and dividing by two, then multiplying by the distance in feet between the two sites. This is known in the dredging industry as "closed-end averaging" to obtain dredged volume along a channel. It is acknowledged that sand resources reside seaward of the short post-storm surveys, but the need for speed dictated that taking additional time to survey to 15-16 feet of water offshore would not add significantly to the losses seen within the beach/dune system. These longer surveys will be completed in due course however. No estimate was made for the sand loss values south of the Berkeley Township site (347) in the natural areas of Island Beach State Park. A percentage of the sand carried offshore by Sandy will move back toward the beach over time in the absence of future storms. All sand lost from the dunes will require human intervention to replace, groom and re-vegetate in order to have the protection in place quickly. A natural dune system developing from scratch would require 15 to 20 years to re-establish close to what was lost.

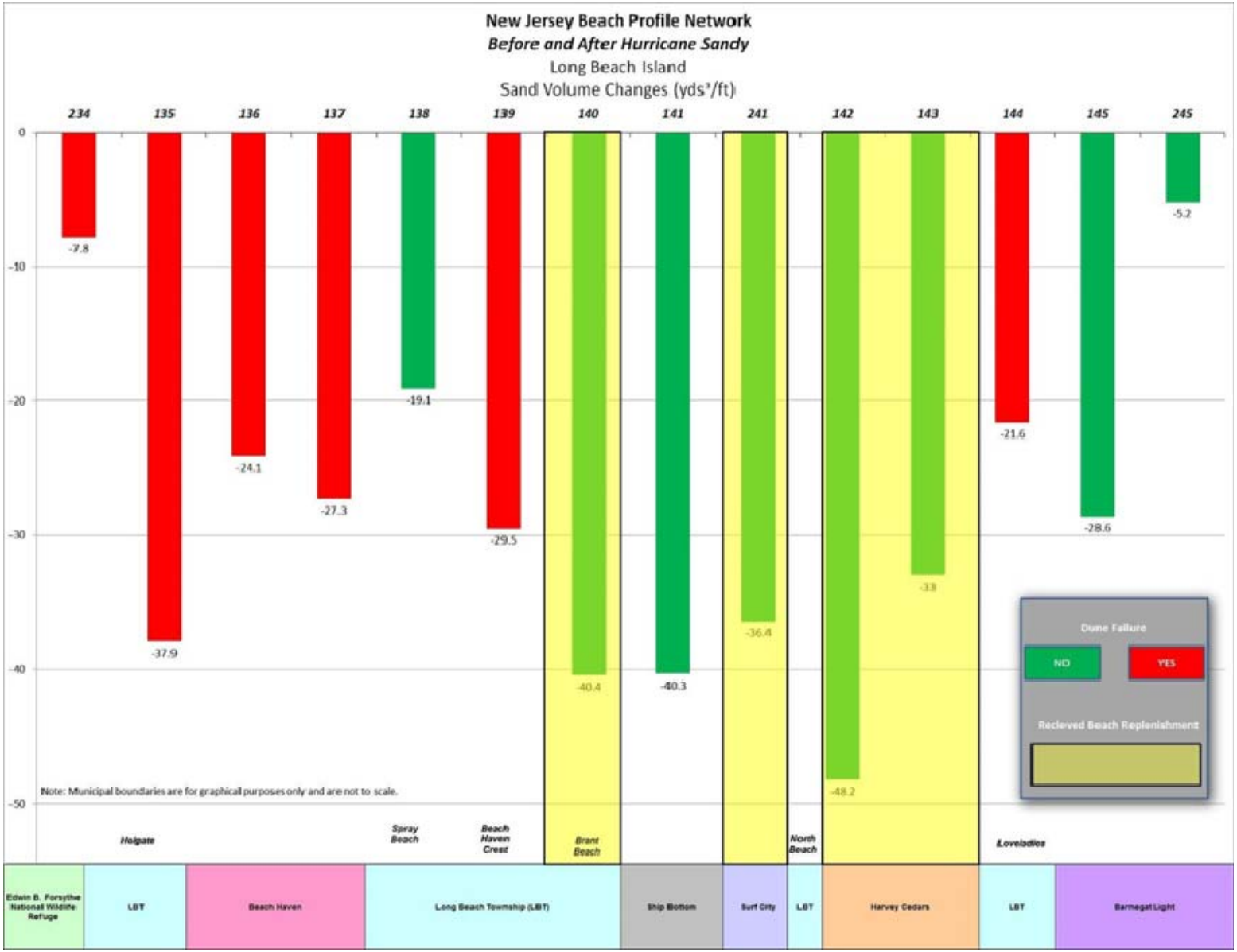


Figure 72. This graphic combines the loss figures with the presence or absence of the Federal Shore Protection Project and the occurrence of dune failure. It became perfectly clear that the ACOE shore protection design was sufficient to preclude structural damage along the extent of the LBI coastal shoreline where it had been completed.

Long Beach Island

MUNICIPALITY	Site #	Vol Change (cu yds/ft)	Average Volume Between Sites	Dune Failure	Recent ACOE Beach Fill	REF POINT Distance (FEET)	Vol Change - Cubic Yards Between Profiles (South to North)
Forsythe Wildlife Refuge	234	-7.80		Y	N	0	0
Holgate - Long Beach Township	135	-37.90	-22.85	Y	N	5,643	-128,941
Beach Haven	136	-24.10	-31.00	Y	N	5,114	-158,543
Beach Haven	137	-27.30	-25.70	Y	N	5,268	-135,393
The Dunes - Long Beach Township	138	-19.10	-23.20	N	N	8,654	-200,780
Beach Haven Crest - Long Beach Township	139	-29.50	-24.30	Y	N	8,559	-207,972
Brant Beach - Long Beach Township	140	-40.40	-34.95	N	Y	10,774	-376,558
Ship Bottom	141	-40.30	-40.35	N	N	6,027	-243,205
Surf City	241	-36.40	-38.35	N	Y	7,522	-288,466
Harvey Cedars	142	-48.20	-42.30	N	Y	8,082	-341,858
Harvey Cedars	143	-33.00	-40.60	N	Y	6,618	-268,691
Loveladies - Long Beach Township	144	-21.60	-27.30	Y	N	7,018	-191,603
Barnegat Light	145	-28.60	-25.10	N	N	8,992	-225,688
Barnegat Light	245	-5.20	-16.90	N	N	5,155	-87,117
						Long Beach Island Sand Loss =	**-2,854,815**

Figure 73 is a summation of all the individual site sand volume losses from the dune and beach to the limit of the post-Sandy survey. The total is derived by adding two adjacent site losses and dividing by two, then multiplying by the distance in feet between the two sites. No estimate was made for the sand loss values south of the Forsythe Refuge site positioned a short distance from the terminal groin on LBI. Likewise there was a small additional sand loss north of site #245 in Barnegat Light Borough to the Barnegat Inlet south jetty, but at 5.2 cubic yards per foot, a 1000 feet distance yields only a 5,000 cy addition to the 2.85 million cubic yard total emerging from this study. Speculation on what percentage of the lost sand lies unrecoverable on LBI and in Barnegat Bay could range up to a million cubic yards that will need to come from offshore or mainland borrow zones/quarries. Perhaps as much as 500,000 cubic yards could be recovered over time as sand carried offshore by Sandy moves back toward the beach. All sand lost from the dunes will require human intervention to replace, groom and re-vegetate in order to have the protection in place quickly.

New Jersey Beach Profile Network

Atlantic County

Little Egg Inlet
to Great Egg Harbor Inlet

NJBPN Profile #'s
134 - 126

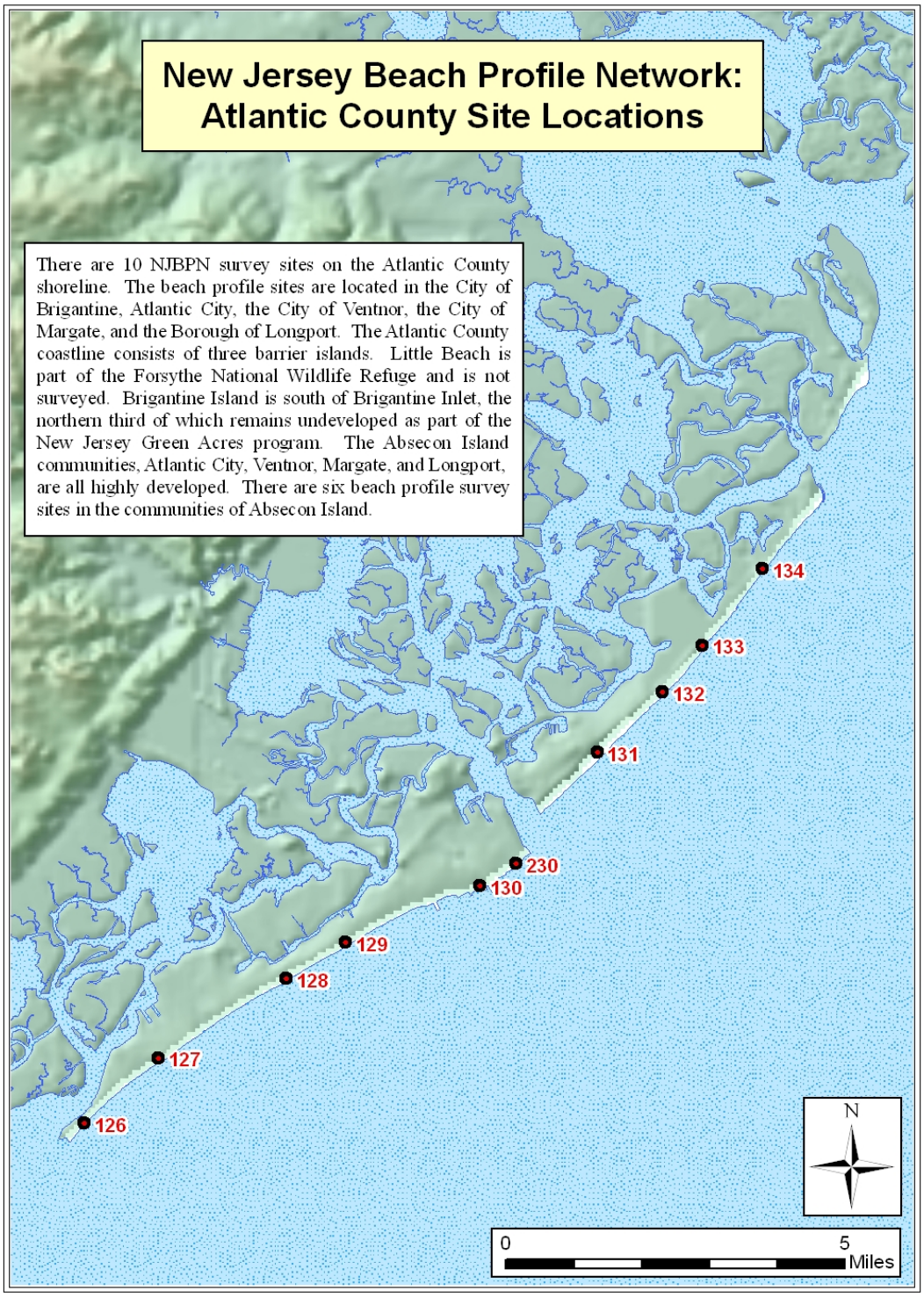


Figure 74. Location map for the 10 NJBPN profile sites in Atlantic County, NJ

Hurricane Sandy's Impact on the Atlantic County Ocean Shoreline;

In general terms, damage to beaches, dunes and public or private property was significantly worse on the north side of the storm's zone of coastal landfall in Atlantic County. Southern Cape May County faired best with limited overwash, dune scarping and loss of beach elevation. Damages increased towards the region of landfall with moderate dune breaches, especially in southern Ocean City area, and damages to southern Absecon Island's oceanfront properties. The wide beach in Brigantine combined with multi-ridged dune systems along half of the City's oceanfront precluded any wave damage. Backbay flooding was a major problem however. Further north in Brigantine, a narrow beach allowed waves to wash across Ocean Avenue and in the natural area north of development, overwash was a common natural process.

Beach/Dune Damage Assessment by Municipal Segment:

To measure the erosion, information previously collected at the 10 Atlantic County New Jersey Beach Profile Network (NJBPN) monitoring sites was used to provide the pre-storm view of existing shoreline conditions. On November 6, and 12, 2012 each site was visited and a GPS-based survey of the dune, beach and shallow offshore region was completed to provide an accurate comparison and assessment of storm related shoreline and beach volume changes. Data collected at the 10 oceanfront beach profile locations cover the municipal beaches from the City of Brigantine Beach to the Borough of Longport. Little Beach on Pullen Island to the north of Brigantine is a natural area and is not included in the NJBPN program. Aerial photography post-Sandy does show overwash of the Little Beach Island's central portion with shoreline retreat now at a dune system that first developed in the 1880's and had remained well inland since then.

Federal or NJ State Coastal Projects;

In 2004 the US Army Corps of Engineers, Philadelphia District, conducted a Shore Protection project from Absecon Inlet, south to the Ventnor City/Margate City boundary on Absecon Island. The design was for a 150-foot wide beach in Atlantic City and a 100-foot beach width in Ventnor backed up by a 14.5-foot elevation at the crest dune that was vegetated and fenced with sand fencing and pedestrian access pathways to the beach. Since Margate and Longport declined to participate, their municipal shorelines did not receive direct sand placement. The maintenance cycles were delayed until 2011 when the ACOE return to place sand on the northern portion of the Atlantic City shoreline. Fortunately, this task was very recently completed when Sandy came ashore (June 2012). A second maintenance cycle is set to begin in 2013. An Absecon Inlet project to rebuild the inlet rock revetment to a uniform standard and remove over a century of accumulated debris from earlier shore protection efforts along the inlet sand beach is moving toward construction under ACOE jurisdiction.

The ACOE project for Brigantine was focused on the northern third of the developed shoreline. A feeder beach was designed into the project at the southern 1,600 feet of the natural area north of development. The project extends south to 5th Street South in the City. In 2006 the initial Federal beach restoration was completed and extended to the south the footprint of two prior State and local projects from 1997 and 2001. In 2011 an emergency maintenance was completed under the Flood Control and Coastal Emergencies funding program using trucked-in sand. Restoration plans are in process to complete the Brigantine beach replenishment as well.

Brigantine;

The northern-most profile site on the Island of Brigantine is located on the undeveloped northern end of the island now in the possession of the State of New Jersey. This location was overwashed by waves from the ocean to the bay marshes by Sandy. The vegetation survived behind the dune ridge, so re-growth is assured, but at a more landward location. The northeast storm of 1992 was the last time this occurred.

Where development begins, the beach has been erosional due to the orientation difference between the physical infrastructure and the long-term changes in the shoreline. The Federal project includes a part of the natural shoreline where sand is placed to act as a feeder beach to the worst of the erosional segment. Waves crashed over the promenade and flooded Brigantine Boulevard. Prior to Sandy, the beach was wet to the toe of the rock revetment, so provided little protection. Dunes and a dry beach appear near the southern end of the promenade where steep scarps were in evidence going south to approximately 25th Street South. The dune-defended section did much better in stopping the storm waves except at 15th Street South where a large, multistory building occupies the footprint of the dune. Both the 15th and 14th Street ends and the building's parking lot were overrun by waves and sand was transported into Ocean Avenue.

However, south of 15th Street South, the ever-widening beach absorbed the storm surge and the wave energy with no ill effects on any public or private property. The berm was eroded and sand pushed landward into the seaward-most part of the dune area.

Atlantic City;

Absecon Island has been under development since 1852 when Atlantic City was founded. Beach nourishment has been a part of the shoreline management strategy since the 1930's with a Federal project in place since 2003. Most of the material has been placed between Absecon Inlet and Iowa Avenue. In 2003 the ACOE placed sand between Absecon Inlet and the Ventnor City/Margate City boundary. The towns of Margate and Longport declined to participate in the Federal project and the last beach material applied to either was 190,000 cubic yards deposited in Longport in 1990. The dunes were constructed to an elevation of 14.5 feet NAVD88 and were just high enough to withstand the wave run-up during Sandy. Post storm surveys encountered large dimensioned timber debris on the crest of the dune at North Carolina Avenue and among the lower dunes in Ventnor. The lack of consistent shore protection allowed significant wave damage to occur along the Absecon Inlet shoreline in the City. One source of debris causing damage was the decking from the inlet boardwalk that was destroyed. Slated for demolition, the decayed structure came apart during the storm and large sections of decking washed into the City along the inlet. The oceanfront beach lost width and elevation, but the dunes prevented damage to the City's famous boardwalk.

Ventnor City;

Ventnor chose to participate in the 2003-2004 Federal beach restoration project. The Dorset Avenue site saw no serious impact from Sandy other than beach elevation loss and a narrower berm width. Further south toward Margate, the end-effect losses to the Federal project allowed waves to reach the timber bulkhead protecting the upland development and water came over the bulkhead at a variety of locations.

Margate City;

Margate City had significant amounts of water wash over the timber bulkhead at the development limit and inundate the streets and properties immediately landward. At the Benson Avenue site a lack of dunes, but a very wide beach permitted wave energy to deposit sand to the very top of the bulkhead, over it and into the street. Workers were busy shoveling it into wheelbarrows and rolling it out of the restaurant kitchen that backs up to the bulkhead at the street end. The berm supplied most of the material transported landward. Some spots did have "island" dunes that acted to protect from the overwash process, but in many cases the water came into the City.

Borough of Longport;

The southern community has an old concrete seawall protecting some of the development with a narrow, low elevation beach to the seaward. Waves crashed into the wall and poured over it down most of the Borough streets into Atlantic Avenue. Since the homes are very close to the wall, house damage was evident as well. Flooding was apparent and structural damage was wide spread. Many oceanfront properties had expensive landscaping with outside structures in abundance. These were destroyed. Longport also has a southern tip with no beach and a rock revetment seaward of a timber bulkhead with homes pressed right up to the top of the timber structure. Each of these expensive properties had the first floor of each residence ripped open and flooded with enough force to transport the electric distribution substation into the street. The homes can be restored, but the price will be high.

A seldom discussed issue emanating from Hurricane Sandy damage that is not included in any recovery program was the destruction of tens of thousands of high-quality, and therefore, expensive landscaping projects surrounding homes subject to either wave overwash or flooding from the bayside storm surge. Salt water percolating into the soil killed or is the process of killing millions of plants that will need replacing at each owner's expense.

Individual Site Locations in Atlantic County:

All Atlantic County sites had been visited earlier in the fall of 2012, so required site visits as soon as possible following the storm. The photographs show the fall, pre-Sandy beach conditions as compared to the photographs taken on the day the site was surveyed following the storm. As the post-storm surveys progressed, the natural sand volume recovery on the beach was easily observed and can be seen in the cross sections. The early November time frame of Atlantic County shows a small step-berm built near the low tide line as the initial wave transport moved sand transported offshore during the storm began moving landward, back to the beach. Therefore, only minimal recovery had occurred by the 11th of November 2012.

The normal activity showed that just prior to Hurricane Sandy, the county beaches all had decent width berms with as wide a beach as could be expected following a benign summer of constructional waves. There had been no storm activity for exactly one year between events that resulted in Federal Disaster declarations.

NJBPN 134 – Green Acres Area, Brigantine

The photographs above were taken on October 26, 2012 (left) and November 11, 2012 (right). The dune on the left started from nothing in January 1993, and was washed flat by Sandy (right). It is likely that the posts in the right picture date from the original 1992 post-storm effort to re-create the dune along this open-space beach.

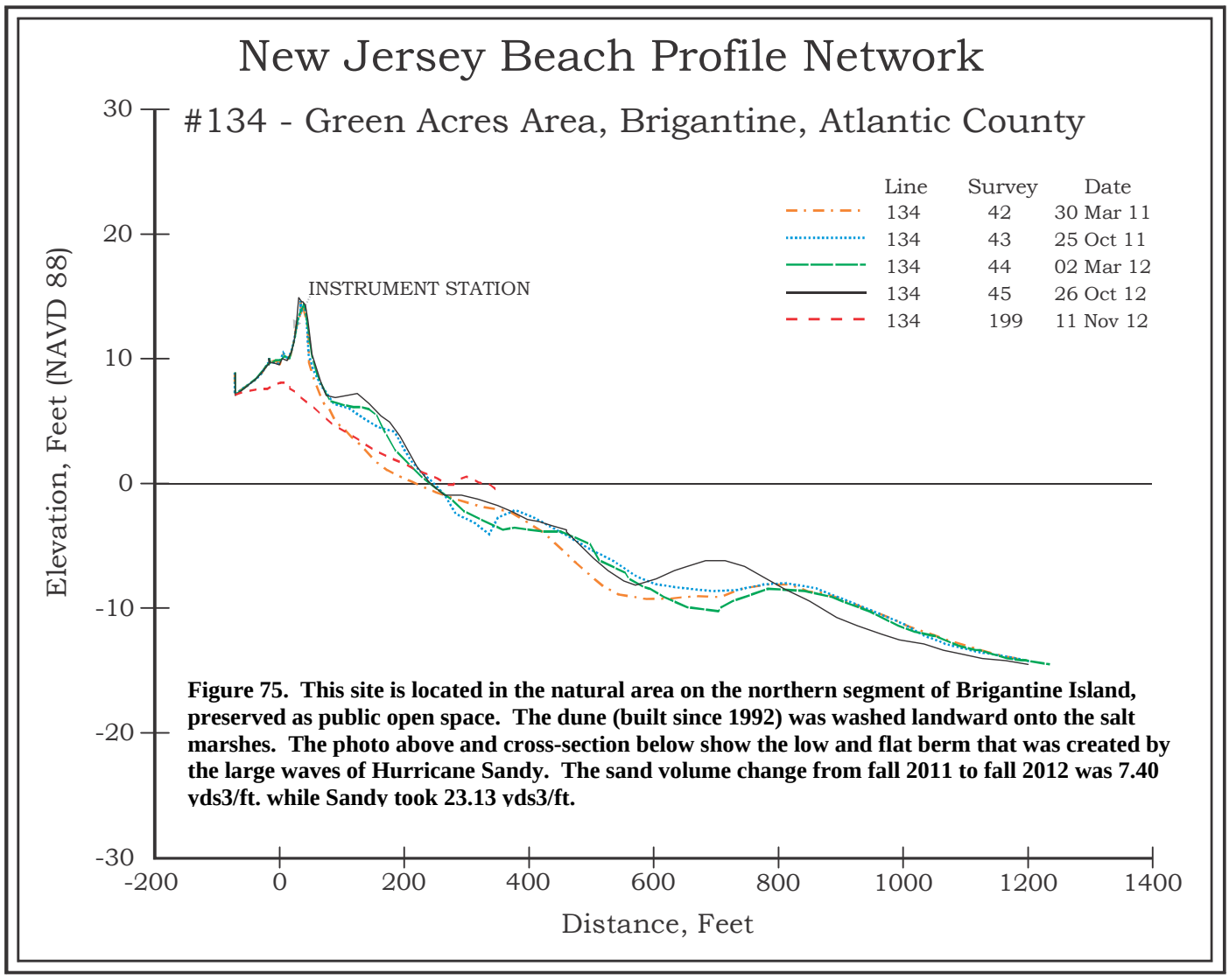


Figure 75. This site is located in the natural area on the northern segment of Brigantine Island, preserved as public open space. The dune (built since 1992) was washed landward onto the salt marshes. The photo above and cross-section below show the low and flat berm that was created by the large waves of Hurricane Sandy. The sand volume change from fall 2011 to fall 2012 was 7.40 yds3/ft. while Sandy took 23.13 yds3/ft.

NJBPN 133 – 4th Street North, Brigantine

The photographs above were taken on October 26, 2012 (left) and November 3, 2012 (right). The seaward slope of the dunes was truncated by Sandy with sand moved seaward. Minor overwash at street ends occurred in places, but wholesale damage was absent.

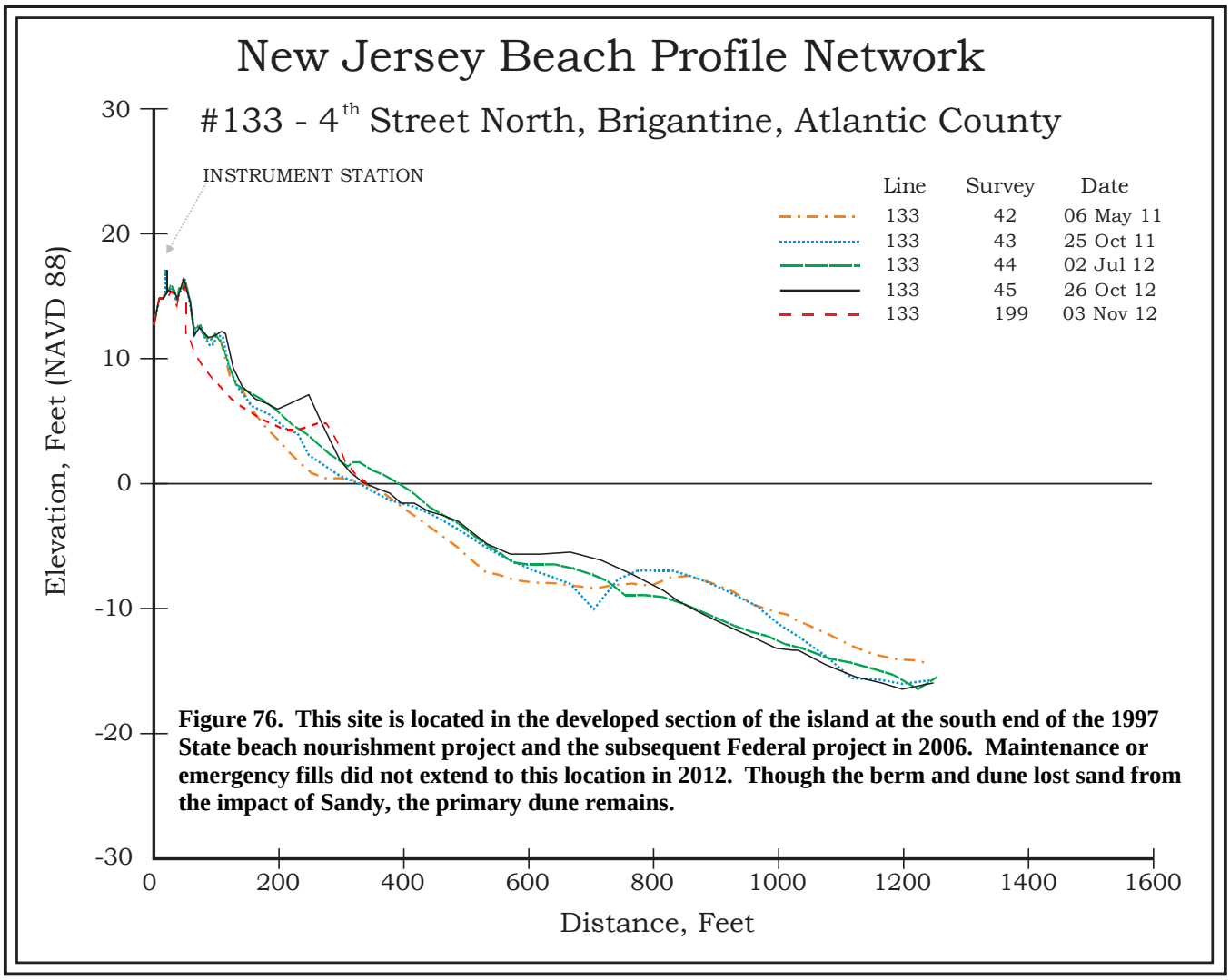


Figure 76. This site is located in the developed section of the island at the south end of the 1997 State beach nourishment project and the subsequent Federal project in 2006. Maintenance or emergency fills did not extend to this location in 2012. Though the berm and dune lost sand from the impact of Sandy, the primary dune remains.

NJBPN 132 – 15th Street South, Brigantine

The photographs above were taken on October 25, 2012 (left) and November 3, 2012 (right). This part of the beach lies in a zone where little erosion or accretion has occurred until beach nourishment started in 1997. Since then the shoreline has moved seaward by 200 feet. But the damage was caused by a lack of dunes in front of the parking lot and the building at 15th Street South.

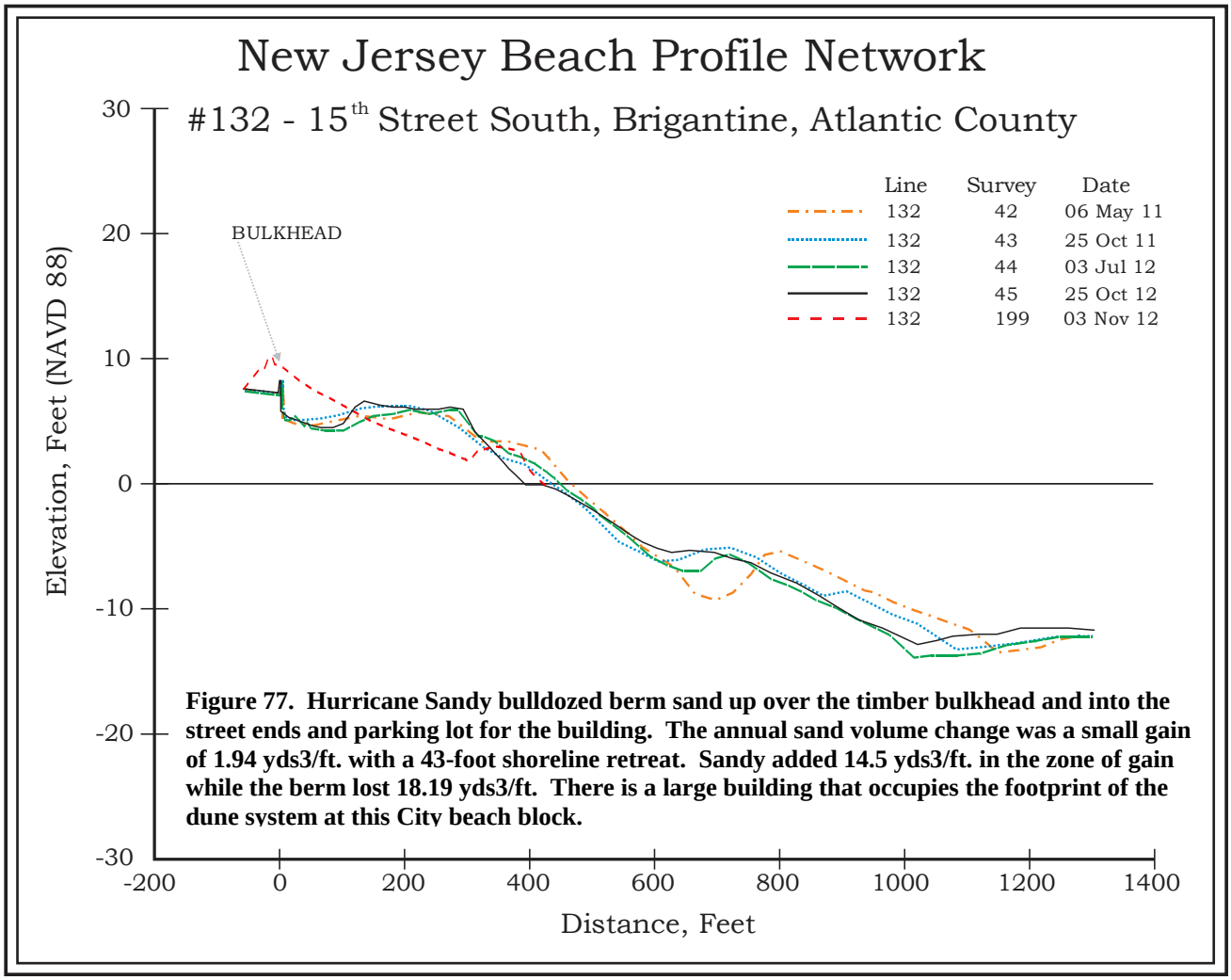


Figure 77. Hurricane Sandy bulldozed berm sand up over the timber bulkhead and into the street ends and parking lot for the building. The annual sand volume change was a small gain of 1.94 yds3/ft. with a 43-foot shoreline retreat. Sandy added 14.5 yds3/ft. in the zone of gain while the berm lost 18.19 yds3/ft. There is a large building that occupies the footprint of the dune system at this City beach block.

NJBPN 131 – 43rd Street South, Brigantine

The photographs above were taken on October 25, 2012 (left) and November 3, 2012 (right). The large building at 15th Street South shows in both pictures in the distance. From the large building at 15th Street, to a mile south of this site, the beach width is huge with multiple rows of vegetated dune ridges to the landward site. The storm surge and wave energy expended itself in the dunes closest to the back beach margin with no ill effect on the development.

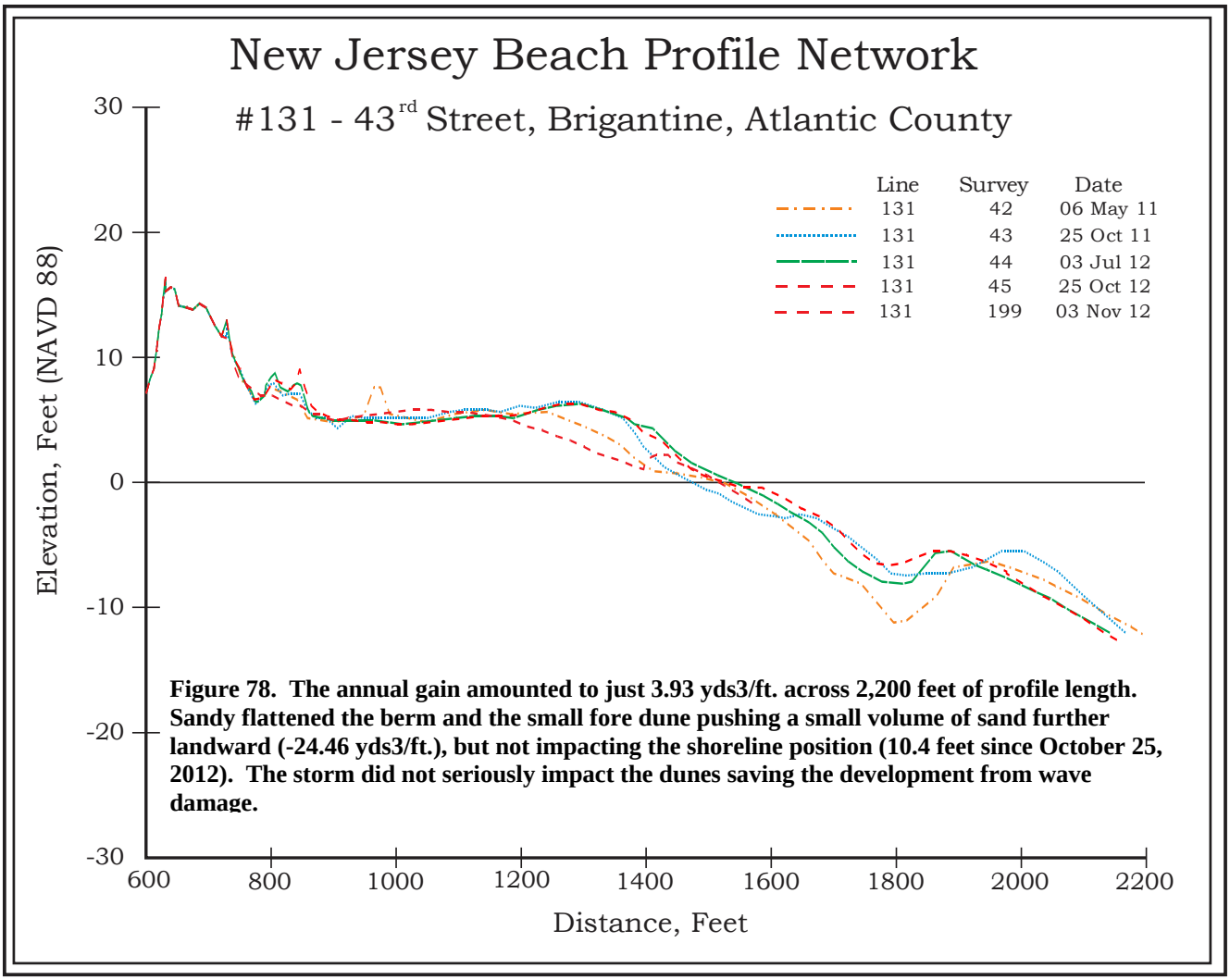


Figure 78. The annual gain amounted to just 3.93 yds3/ft. across 2,200 feet of profile length. Sandy flattened the berm and the small fore dune pushing a small volume of sand further landward (-24.46 yds3/ft.), but not impacting the shoreline position (10.4 feet since October 25, 2012). The storm did not seriously impact the dunes saving the development from wave damage.

NJBPN 230 – Rhode Island Avenue, Atlantic City

The photographs were taken on September 18, 2012 (left) and November 6, 2012 (right). Work was continuing on the rock sill being placed between the Massachusetts and Vermont Avenue groins in northern Atlantic City. The new Revel Entertainment casino was built here and a submerged, shore-parallel rock sill between the two groins was built to trap sand as a "perched" beach for a longer time period between the maintenance interval for the Federal beach project. Since the maintenance was just completed following hurricane Irene in 2011, the dune/beach system resisted the storm damage from Sandy with about three quarters of the dune surviving.

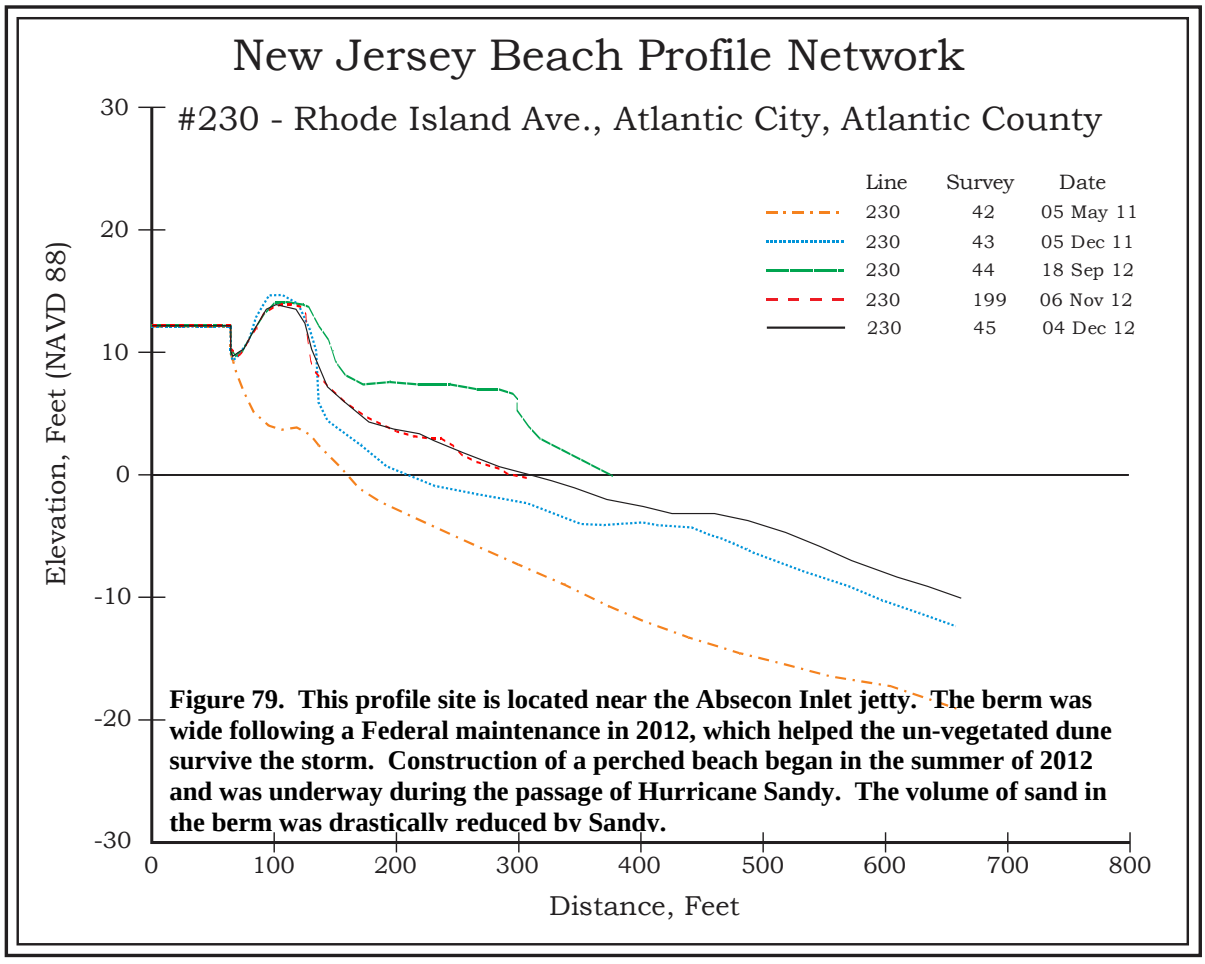


Figure 79. This profile site is located near the Absecon Inlet jetty. The berm was wide following a Federal maintenance in 2012, which helped the un-vegetated dune survive the storm. Construction of a perched beach began in the summer of 2012 and was underway during the passage of Hurricane Sandy. The volume of sand in the berm was drastically reduced by Sandy.

NJBPN 130 – North Carolina Avenue, Atlantic City

The photographs above were taken on June 4, 2012 (left) and November 6, 2012 (right). The beach lost much of the berm sand volume, but the dune survived by being just high enough. Note that there is abundant debris deposited near the crest of the dune and stream gullying was in evidence on the landward side of the dune indicating that sea water had crossed it in significant volume at the height of the storm.

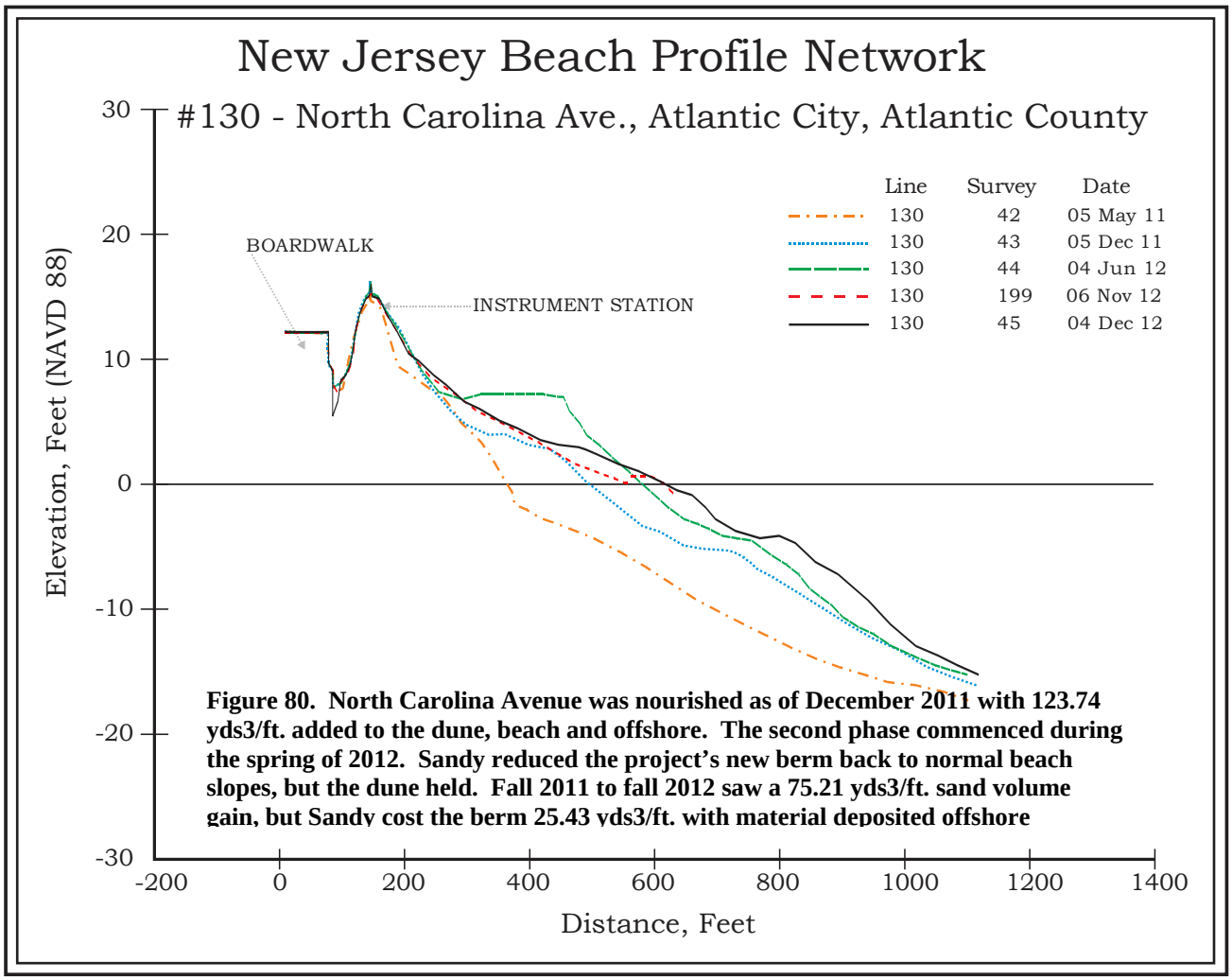


Figure 80. North Carolina Avenue was nourished as of December 2011 with 123.74 yds3/ft. added to the dune, beach and offshore. The second phase commenced during the spring of 2012. Sandy reduced the project's new berm back to normal beach slopes, but the dune held. Fall 2011 to fall 2012 saw a 75.21 yds3/ft. sand volume gain, but Sandy cost the berm 25.43 yds3/ft. with material deposited offshore

NJBPN 129 – Raleigh Avenue, Atlantic City

The photographs above were taken on April 13, 2012 (left) and November 6, 2012 (right). Raleigh Avenue lies in the middle of the Federal beach project and this meant that little damage was done. The dunes were invaded on the seaward slope depositing sand in the grass and knocking down an incipient foredune.

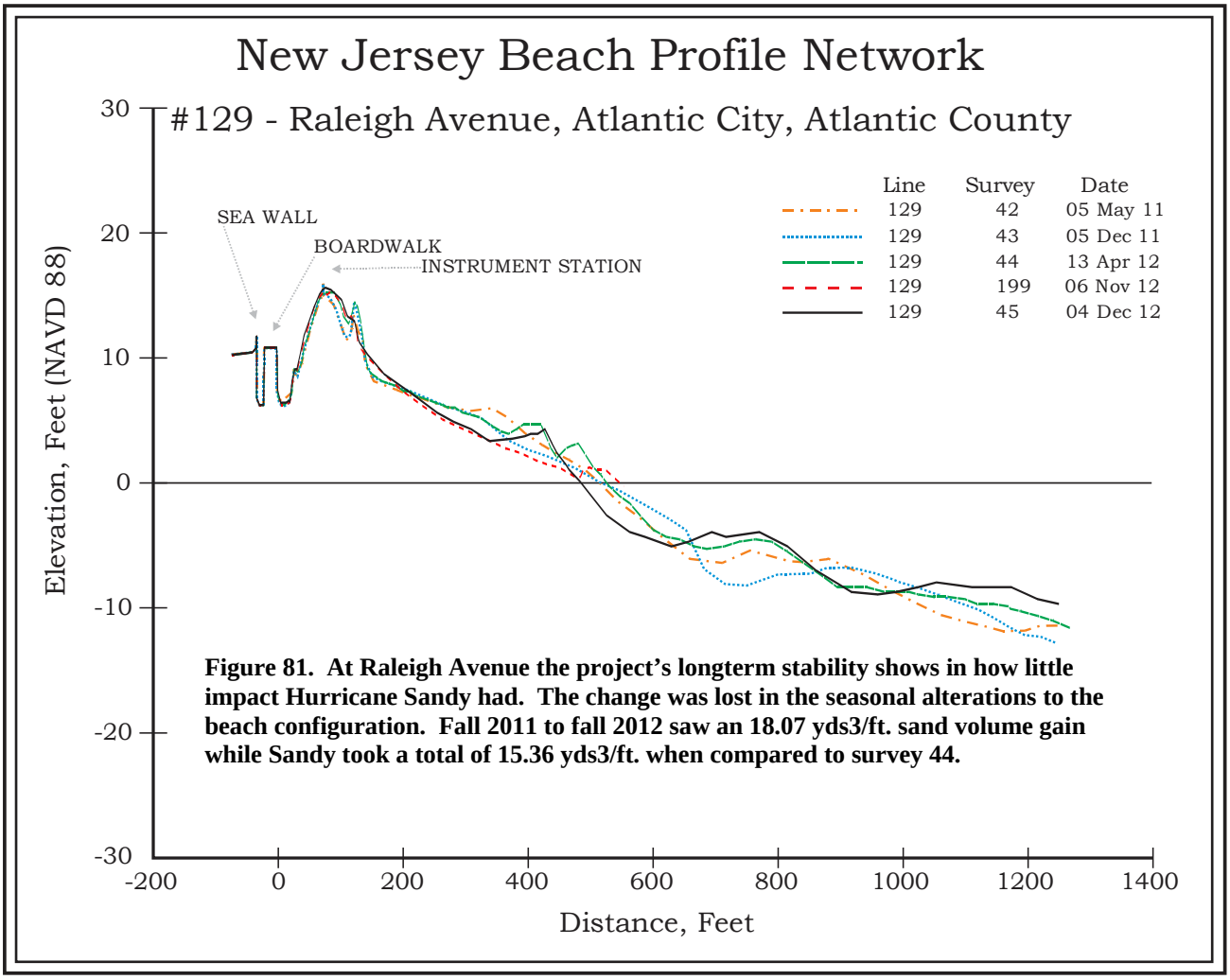


Figure 81. At Raleigh Avenue the project's longterm stability shows in how little impact Hurricane Sandy had. The change was lost in the seasonal alterations to the beach configuration. Fall 2011 to fall 2012 saw an 18.07 yds3/ft. sand volume gain while Sandy took a total of 15.36 yds3/ft. when compared to survey 44.

NJBPN 128 – Dorset Avenue, Ventnor City

The photographs above were taken on April 13, 2012 (left) and November 6, 2012 (right). Dorset Avenue in Ventnor City also is located in the middle of the Federal project with excellent retention of the sand placed in 2004.

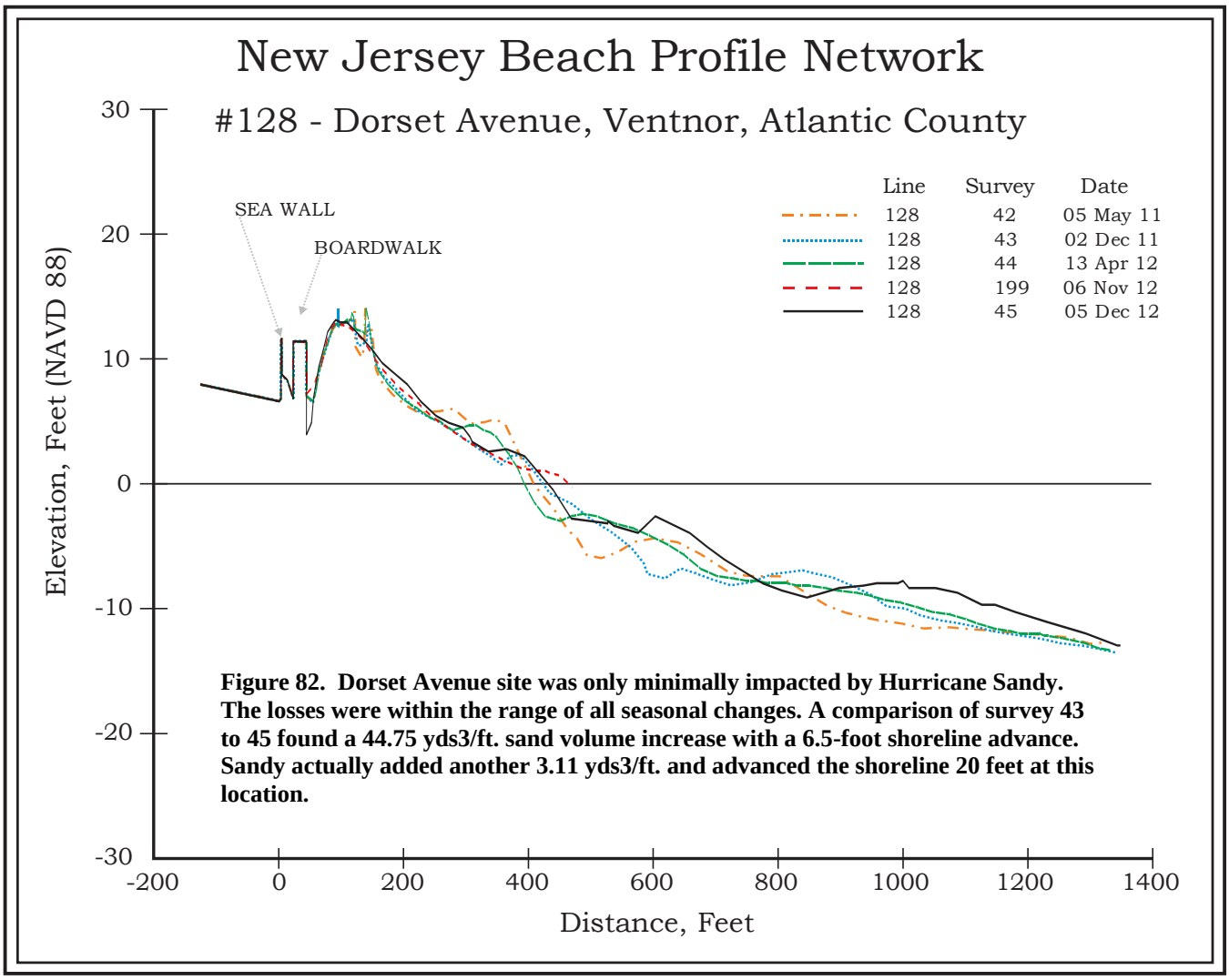


Figure 82. Dorset Avenue site was only minimally impacted by Hurricane Sandy. The losses were within the range of all seasonal changes. A comparison of survey 43 to 45 found a 44.75 yds3/ft. sand volume increase with a 6.5-foot shoreline advance. Sandy actually added another 3.11 yds3/ft. and advanced the shoreline 20 feet at this location.

NJBPN 127 – Benson Avenue, Margate City

The photographs above were taken on April 13, 2012 (left) and November 6, 2012 (right). The relatively robust berm was cut down and pushed landward as a substantial deposit that included Benson Avenue and environs. The work was underway to excavate the sand at the sea-side of the bulkhead to keep water from simply running over it.

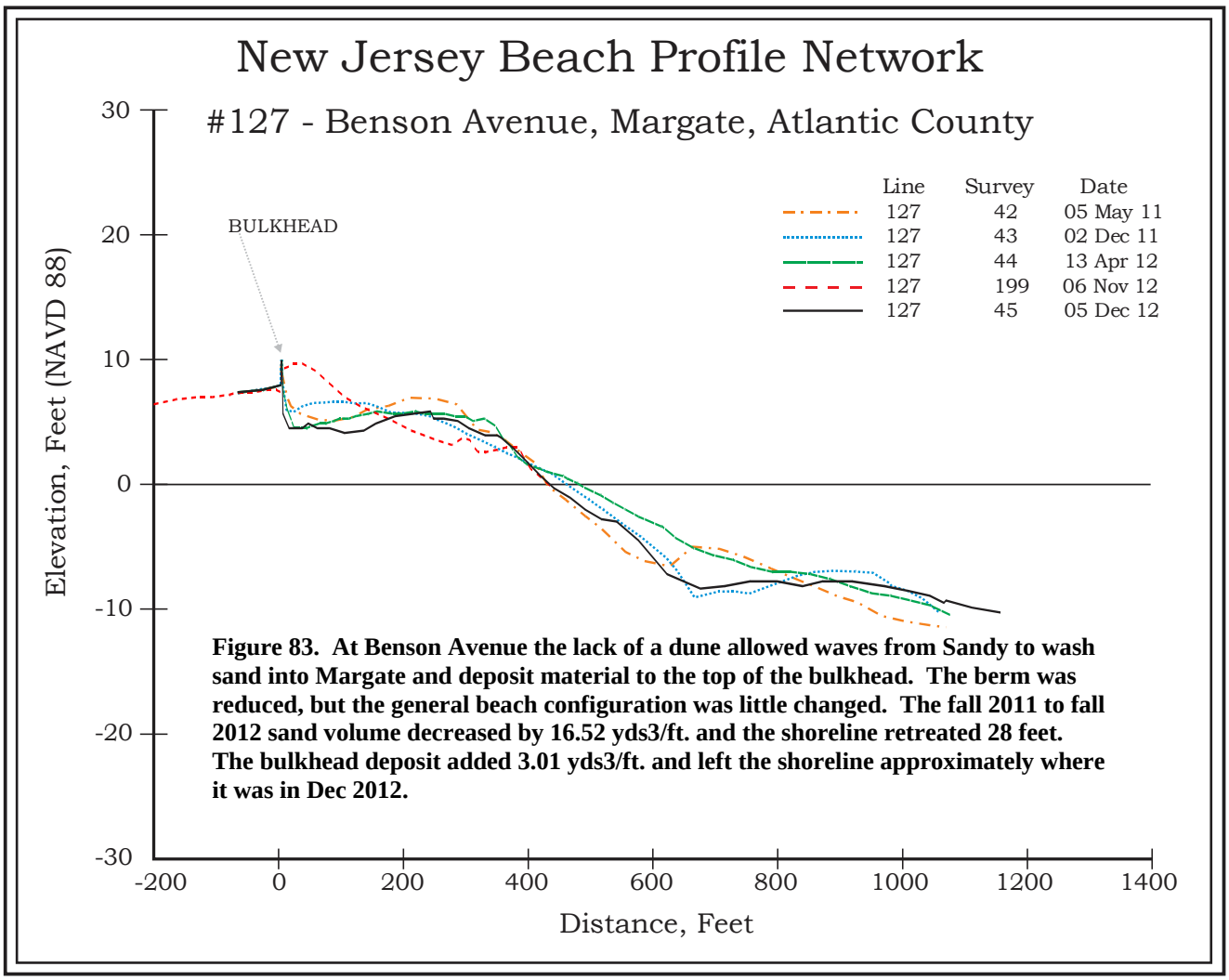


Figure 83. At Benson Avenue the lack of a dune allowed waves from Sandy to wash sand into Margate and deposit material to the top of the bulkhead. The berm was reduced, but the general beach configuration was little changed. The fall 2011 to fall 2012 sand volume decreased by 16.52 yds3/ft. and the shoreline retreated 28 feet. The bulkhead deposit added 3.01 yds3/ft. and left the shoreline approximately where it was in Dec 2012.

NJBPN 126 – 17th Street, Longport

The photographs above were taken on April 11, 2012 (left) and November 6, 2012 (right). The narrow beach allowed wave energy to explode on the seawall. The water bounced over it and crashed into the homes built at the base of the wall. Street end flooding, sand deposition to Atlantic Avenue and structural damage was spread along the shoreline.

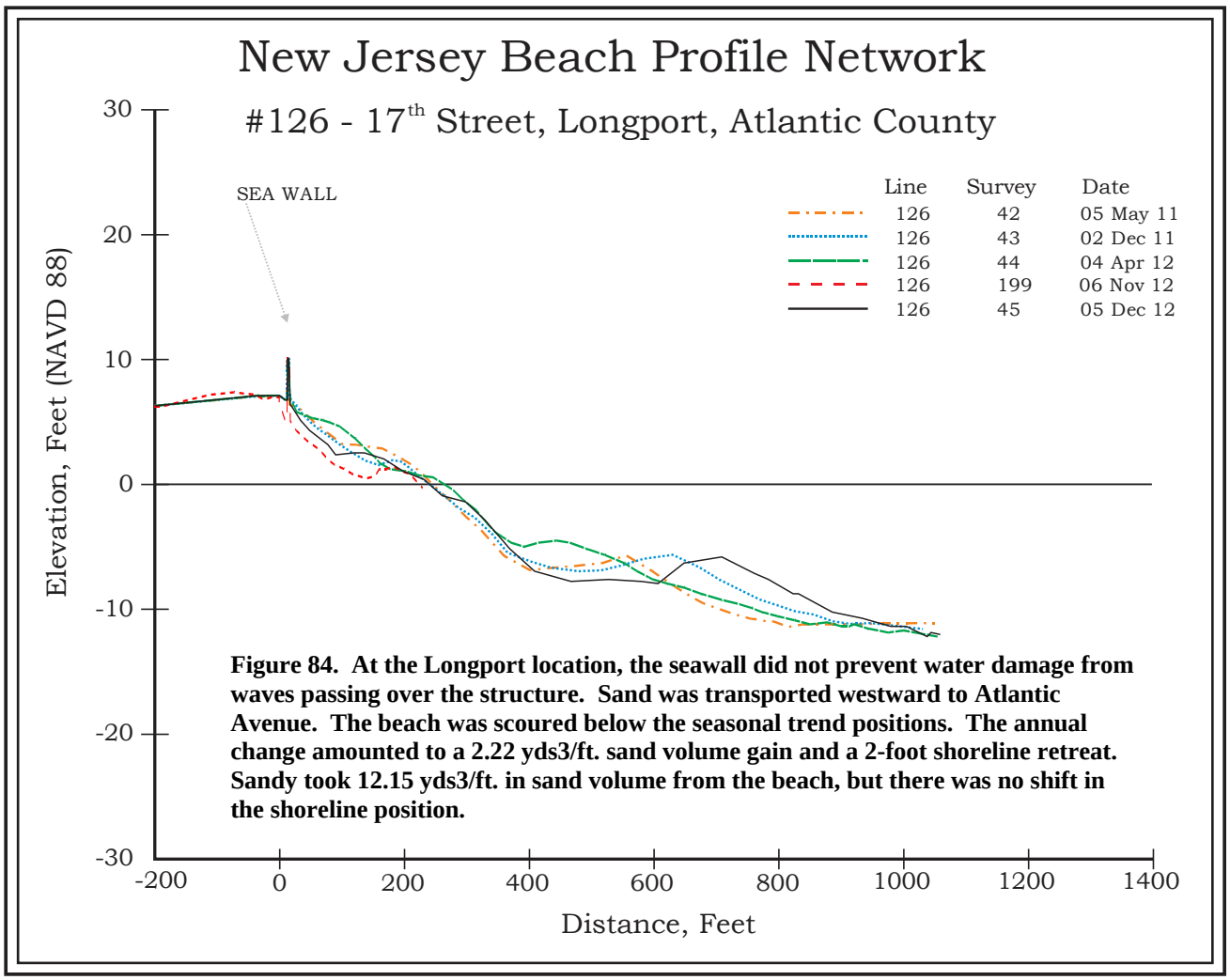


Figure 84. At the Longport location, the seawall did not prevent water damage from waves passing over the structure. Sand was transported westward to Atlantic Avenue. The beach was scoured below the seasonal trend positions. The annual change amounted to a 2.22 yds3/ft. sand volume gain and a 2-foot shoreline retreat. Sandy took 12.15 yds3/ft. in sand volume from the beach, but there was no shift in the shoreline position.

Summary & Conclusions

Atlantic County Post Sandy Volume Changes

Site	Volume Change (cu yds/ft)	Dates for Comparison	Dune Failure	Recent Beach Fill
134	-39.77	Oct 26, 2012 to Nov 11, 2012	Y	Never
133	-17.72	Oct 26, 2012 to Nov 3, 2012	N	2006 & 2011
132	-0.40	Oct 26, 2012 to Nov 3, 2012	No Dune	Never
131	-23.93	Oct 26, 2012 to Nov 3, 2012	N	Never
230	-30.27	Sep 18, 2012 to Nov 6, 2012	N	2011
130	-25.13	June 4, 2012 to Nov 6, 2012	N	2011
129	-15.36	Apr 13, 2012 to Nov 6, 2012	N	2004
128	-1.18	Apr 13, 2012 to Nov 6, 2012	N	2004
127	2.65	Apr 13, 2012 to Nov 6, 2012	No Dune	Never
126	-12.17	Apr 11, 2012 to Nov 6, 2012	No Dune	1990

Figure 85 shows a table of values for the 10 shoreline profile site locations in Atlantic County. The sand volume lost per foot of shoreline represents loss from the dune and the beach and does not include changes in the offshore region. These surveys were completed as rapidly as possible so no swimmers were brought to these sites. Dunes were damaged at some points, but performed in an excellent manner at sites numbered 131, 230, 130, 129 and 128.

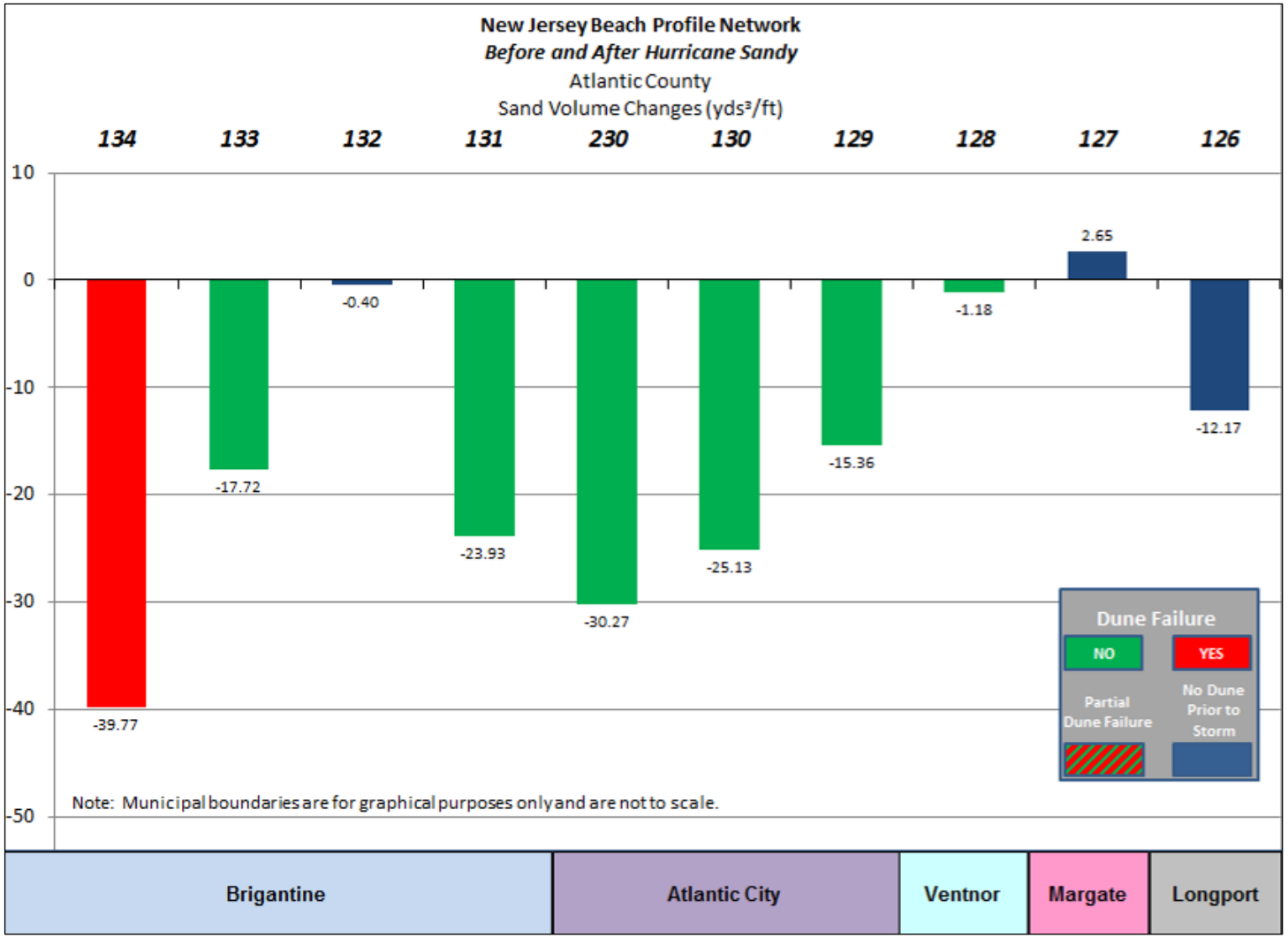


Figure 86. This graphic shows the sand volume loss figures for each of the communities within the developed sections of the Atlantic County shoreline. Federal shore protection projects have occurred along this portion of the New Jersey shoreline in Brigantine (northern portion), Atlantic City, and Ventnor. In Brigantine, prior to the storm the engineered had beach had been eroded away. Atlantic City and Ventnor's engineered beach and dune systems have been maintained by the USACE recently and withheld the storm generated waves from breaching the dunes. All sites experienced berm erosion and dune losses except for site 127 in Margate, where sand had accumulated in front of the bulkhead adjacent to the street end (No dune at this location). The only true dune failure occurred in the national area on the north end of Brigantine (site 134), however sites 132 (Brigantine), 127 (Margate) and 126 (Longport) did not have dune systems in place prior to the storm and all experienced overwash of waves with sand being transported landward of the beach.

Atlantic County Post Sandy Volume Changes

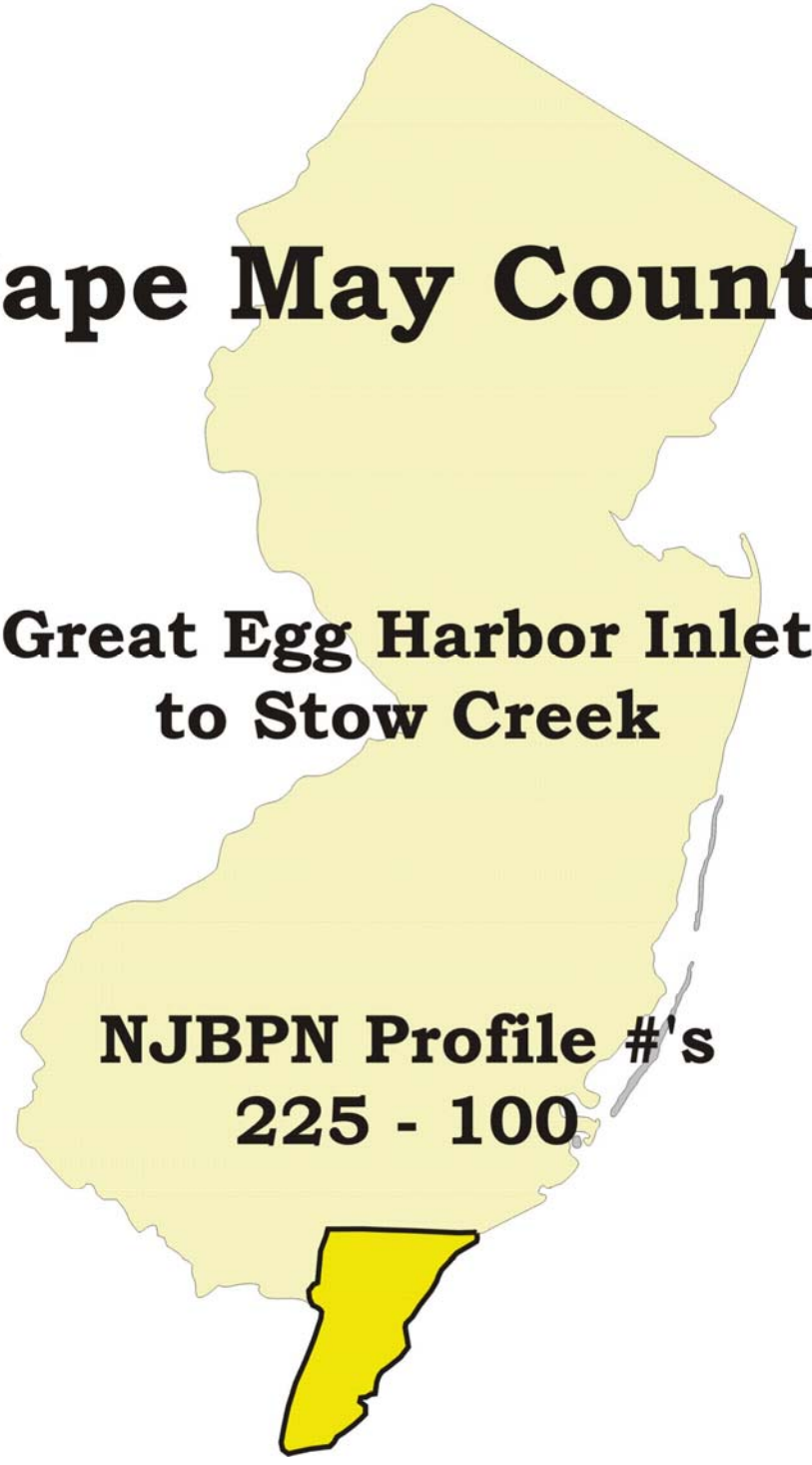
MUNICIPALITY	NJBPN Site#	Shoreline Change in the Zero Elev. Position Since Sandy	Vol Change cu yds per ft	Average of Sand Loss Between Adjacent Sites (cy/ft)	Dune Failure	Recent Beach Fill	Distance Between Sites (FEET)	Vol Change - Cubic Yards Between Profiles (North to South)	Cumulative Volume Change - Cubic Yards (North to South)
North Brigantine Natural Area	134	-25	-39.77	-39.77	Y	Never	2,000	-79,540	-79,540
4th St. No. Brigantine	133	-18	-17.72	-28.75	N	2006 & 2011	7,554	-217,128	-296,668
15th St. So. Brigantine	132	0	-0.40	-9.06	No Dune	Never	4,762	-43,145	-339,813
43rd St. So. Brigantine	131	-10	-23.93	-12.17	N	Never	7,042	-85,661	-425,474
Rhode Is. Ave. Atlantic City	230	-65	-30.27	-30.27	N	2011	850	-25,730	-451,203
No. Carolina Ave. Atlantic City	130	47	-25.13	-27.70	N	2011	3,265	-90,454	-541,657
Raleigh Ave. Atlantic City	129	58	-15.36	-20.25	N	2004	11,384	-230,468	-772,125
Dorset Ave. Ventnor	128	73	-1.18	-8.27	N	2004	5,419	-44,816	-816,941
Benson Ave. Margate	127	-92	2.65	0.74	No Dune	Never	11,753	8,639	-808,302
17th St. Longport	126	-31	-12.17	-4.76	No Dune	1990	7,737	-36,830	-845,132
						Total Volume Loss for Atlantic County =			-845,132

Figure 87. This table provides a summary of all the individual site sand volume losses from the dune and beach to the limit of the post-Sandy survey. The total is derived by adding two adjacent site losses and dividing by two, then multiplying by the distance in feet between the two sites. This is known in the dredging industry as "closed-end averaging" to obtain dredged volume along a channel. It is acknowledged that sand resources reside seaward of the short post-storm surveys, but the need for speed dictated that taking additional time to survey to 15-16 feet of water offshore would not add significantly to the losses seen within the beach/dune system. These longer surveys will be completed in due course however. A percentage of the sand carried offshore by Sandy will move back toward the beach over time in the absence of future storms. All sand lost from the dunes will require human intervention to replace, groom and re-vegetate in order to have the protection in place quickly. A natural dune system developing from scratch would require 15 to 20 years to re-establish close to what was lost.

New Jersey Beach Profile Network

Cape May County

Great Egg Harbor Inlet to Stow Creek



NJBPN Profile #'s 225 - 100

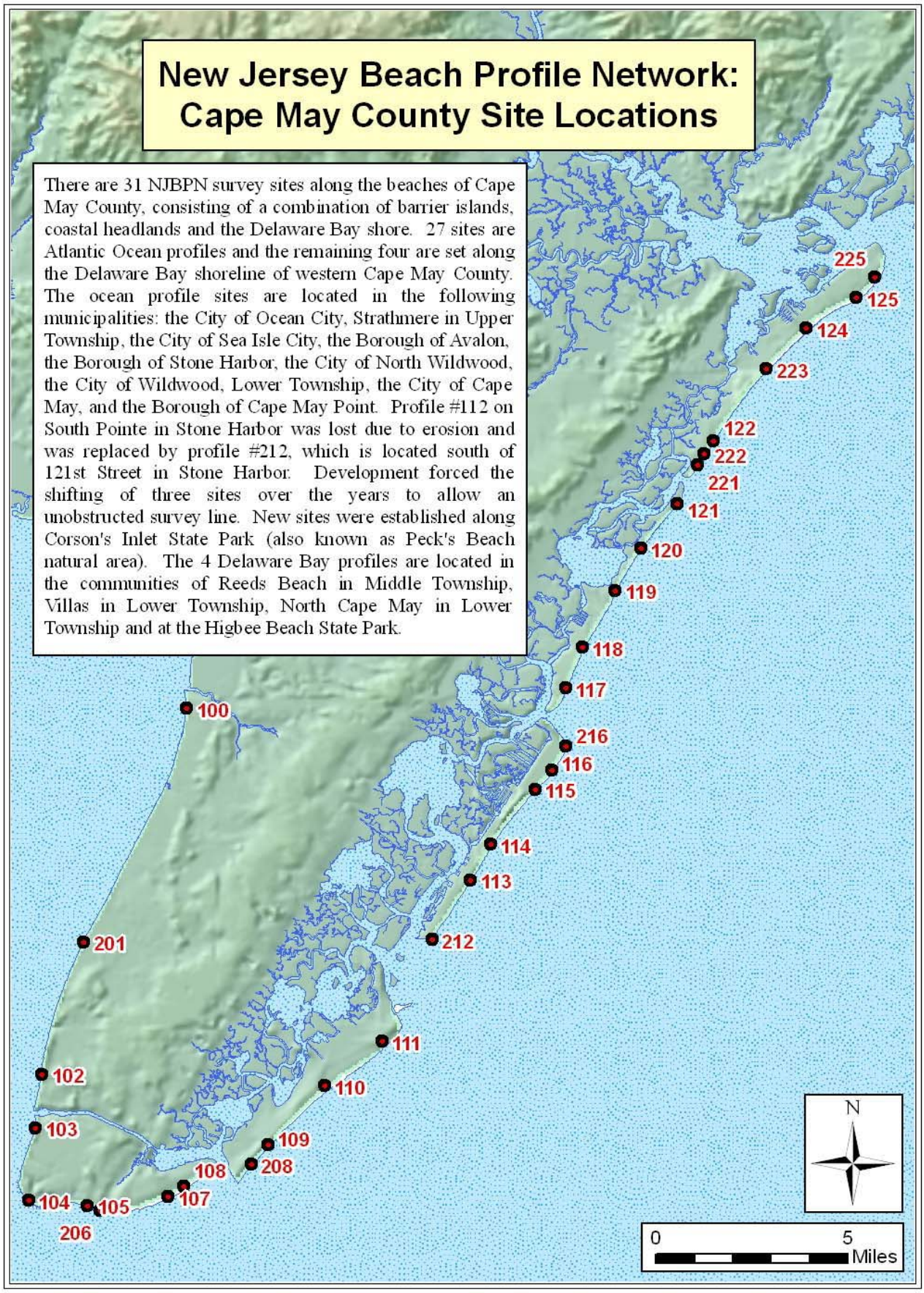


Figure 88. Map of Cape May County showing the locations of the 31 profile sites in the county.

Cape May County Storm Damage Report:

Cape May County has 31 survey stations between Reeds Beach on the Western Cape May County shoreline, around Cape May Point and up the ocean coastline to Great Egg Inlet in Ocean City. This county has five tidal inlets separating four barrier islands and a complex coastal geomorphic compartment that is the site of Cape May City, a US Coast Guard base and Cape May Point. The complexity is related to yet unknown geologic relationships among the sediments of the Cape May Formation comprising the county mainland, the older sand barrier deposits comprising the land at the west end of Cape May Harbor and the recent barrier segment used by the USCG base and most of the oceanfront portion of Cape May City.

Cape May County has been the focus of multiple US Army Corps of Engineers (ACOE) shore protection projects since 1989 and two major NJ State and local projects as well. The Federal project list includes Ocean City, Avalon, Stone Harbor and Cape May City. The State projects include Upper Township (Strathmere), Sea Isle City and North Wildwood. Both of these barrier islands are also authorized Federal projects working toward construction under Federal project status. The Federal project authorization also included an environmental restoration that included the Cape May Nature Conservancy plus the tip of Cape May Point to Lake Drive. Between 2002 and 2005 Cape May Point was also the location of a Federal 227 Experimental Project Design where different styles of submerged reef breakwaters were built in two Point groin cells. The placement of sand coincided with the construction of the experimental perched beach sills.

The reporting season commenced with the recovery following Hurricane Irene in August 2011. A northeast storm occurred near the end of October that garnered a Federal Disaster Declaration (DR-NJ-4021) due to significant beach erosion and some dune damage. Most projects subject to FEMA reimbursement rolled the Irene losses into the new declaration and took the combined loss as one payment. Some Federal money became available to cover the ACOE projects as well (Brigantine, Absecon Island and Seven-Mile Island). All was quiet from October 2011 through to Hurricane Sandy exactly a year later. The summer of 2012 saw excellent sand accumulation along the NJ oceanfront. Damage from the prior year was restored in many places to the limit of the regionally available sand in the offshore bar system. The coastal environment was in pretty good shape when Hurricane Sandy came ashore on Sunday October 29, 2012.

Using the data from the fall 2012 NJBPN survey, completed in Cape May County by October 19, 2012, provides a good baseline for damages that occurred during the hurricane. Data collected at the 31 beach profile locations was done between November 12 and 26, 2012 using RTK GPS and extended from the reference location, across the dunes, beach and into the surf to wader depth. By Nov. 12th, it was clear that sand recovery was well under way as a berm had been deposited on the erosional surface generated by Sandy with a substantial offshore bar present in water less than 5 feet deep offshore. Very little sand in the oceanfront locations had been washed inland beyond the dunes. Exceptions were found in Ocean City, Sea Isle City, and at the Reeds Beach site. A gap in the dunes at the point where Cape May City borders the Nature Conservancy lands also saw wave damage to a few structures.

Western Delaware Bay Shoreline of Cape May County;

Between Reeds Beach and Cape May Point, the western shoreline of Cape May County suffered from the back-side of Hurricane Sandy after the storm made landfall on the New Jersey shoreline. The wind direction reversed and came across the storm-surge flooded Delaware Bay with 4-foot waves with very short periods. Due to the high water levels these waves pounded dunes and made low-lying areas subject to inundation, wave damage and loss of some structures.

Reeds Beach was hit hard because there was no bluff, and a minimal dune system. The region is basically a narrow sand beach with a low dune acting as a barrier seaward of the salt marshes. Sand was pushed across the

road to Bidwell Creek and the majority of the dredge material pumped from the creek project two years ago was moved inland onto the salt marsh lying between Reeds Beach homes and the Cape May County mainland.

To the south, the bluff of the county uplands is mantled with dune sand and made a better barrier. Erosion took some dune and moved the zero elevation position toward the bay because the beach/dune slope was reduced in gradient allowing sand to deposit on the terrace that extends over 1,000 feet into the Delaware Bay from Villas and North Cape May. This wide terrace is the geological result of long, slow bluff erosion by bay waves.

Higbee Beach, a natural area, suffered bluff erosion and beach retreat, but on a minimal scale. Cape May Point had sand moved up onto the highest parts of the dry beach and suffered minimal dune losses from the bay side around to the oceanfront beach. The Borough shoreline actually gained 175,000 cubic yards of new sand as a result of Hurricane Sandy.

Separate site surveys in Cape May Point showed that over 175,000 cubic yards of sand were added to that community's beachfront between April 2012 and April 2013, making it the only shore community to benefit from Hurricane Sandy.

Cape May City;

The approach direction of the ocean waves, deflected somewhat by Cold Springs Inlet jetties and the south, southwest orientation of the shoreline acted to pile sand from the beachface landward onto the backshore beach into the dune vegetation. The Cape May beaches all gained berm sand at the expense of beachface retreat. Only the short segment between the Third Avenue groin and the Nature Conservancy suffered inundation largely because building a decent sized dune was resisted by the adjacent property owners.

The Wildwoods;

The same process appeared to be working at 3 of 4 cross sections between the natural area and North Wildwood, with the 15th Street site not performing as did the Wildwood site at Cresse Avenue. The Cresse berm became 2 feet higher with a ridge over 100 feet wide created from beachface sand pushed up on top of the back berm region of the beach. At the 15th Avenue site in North Wildwood another signature result from Sandy appeared with the deposition of a sand ramp deposited up the seaward slope of the primary dune. It appears that when the dry beach is deeply flooded by a storm surge, the waves break on the submerged beachface slope, excavating abundant sand that the broken wave bores transport across the berm, and deposit it where they run up the dune slope. If the waves do not breach the dunes, they deposit beach sand as a ramp at the seaward toe of the dune. Where a hard structure presents an effective wave barrier, this ramp was likewise deposited and in some cases effectively enabled the waves to run-up and over the hard structure. The example of this was seen at the Sea Bright seawall in Monmouth County.

Avalon & Stone Harbor;

These two communities have been leaders in shore protection by having successfully managed to have Federal shore protection projects constructed and have for years, promoted wider, higher dunes with coordinated development of pedestrian access pathways that do not make a breach easier at street end access points. No instance of dune breaching occurred in either Borough; no waves washed sand into streets or under homes. Dune erosion did occur, but in some cases, the extraordinary width of the dune area allowed Sandy's wave energy to be absorbed within the swales and vegetation of the foredunes arrayed along the mid-section of the barrier island. Elsewhere a wide, relatively high primary dune blocked wave over-topping by just enough to be successful. A major hard structure improvement to the Townsend's Inlet shoreline in Avalon paid dividends by reducing the damage from Sandy to considerably less than what occurred during the December 1992 northeast storm. The worst wave damage occurred to the highway leading to the Townsend's Inlet draw bridge to Sea

Isle City. Waves over-topped the rock revetment protecting the highway and ripped up the pavement, scouring the underlying road base.

Sea Isle City & Strathmere;

A 2009 NJ State and locally sponsored shore protection project saved these two communities substantial damage expense as well. Previous storms of far less intensity had made a shambles out of the Commonwealth Avenue highway leading through northern Sea Isle City into Strathmere. Sandy produced minor breaching and over-topping, but not nearly the extent of overwash seen previously (1998 for example). There were instances of dune breaching in Sea Isle City, extensive tidal flooding, but no catastrophic structural damage. The project protected Strathmere only allowing a couple of minor instances of waves cresting the dunes. The Corson's Inlet shoreline, a crisis situation in 2008, was un-damaged in spite of being flooded by tidal surge.

Ocean City;

The shore protection was a Federal project (Great Egg Inlet to 34th Street) and a local/State partnership (34th Street to the Corson's Inlet State Park). Two decades of sand redistribution produced results ranging from fantastic through fair to poor. The mid-section of the island had vegetation covering 450 feet of dunes before reaching the dry beach. These areas saw absolutely no wave damage with the storm's energy totally absorbed within the foredune region lying seaward of the primary dune. This was a welcome change from the October 1991 northeast storm where just the boardwalk suffered $4 million in damage in the 15th to 20th Street region. There has been no damage to this structure since (the initial fill was completed in the summer of 1992 and resulted in no damage in December of 1992 when a worse event than 1991 hit Ocean City).

To the north the recently maintained Federal project had a narrow beach between a dune system and the direct frontal assault of the northeast waves during Sandy. With little or no beach to break on, and roll across, the waves pounded with full fury on the dunes immediately. Eroding at rates up to 12 feet horizontally per hour, many sections lost the protection the dune afforded. Sand was washed into the streets; storm surge flooding was made worse by every wave crossing into the city. Structural damage occurred, but not at catastrophic levels. At the southern end of development, the beach had not been maintained as frequently and there was only one fairly narrow line of dunes protecting property. Sandy crossed this line easily and waves flowed against, around and beneath 10 blocks of homes. Damage was considerable with early clean-up focused on moving thousands of cubic yards of sand back to the beach in early November.

The Corson's Inlet State Park shoreline south of development in Ocean City suffered dune loss of considerable magnitude. These losses were major increases in the loss rate that had commenced in 2011 with the series of modest northeast storms that commenced in November 2009. The beach had been narrow with spring high tides reaching the near-vertical scarp in the dunes. This slow rate of retreat was greatly accelerated during Hurricane Sandy.

Individual Site Descriptions:

Each site will display a photograph from the earlier fall 2012 survey several weeks prior to Sandy. The second picture was taken during the survey at each site to show the extent and nature of storm damages. The profile cross section displays the longer, early fall survey and the post-Sandy assessment to illustrate where and the magnitude of storm erosion. Since the natural areas in the wildlife refuge, Corson's Inlet State Park and Higbee Beach State Park were left un-surveyed until after Sandy, those cross sections will be of normal length. The Cape May County natural areas performed quite well except for the Corson's Inlet Park shoreline on the Peck's beach side of the inlet.

Gardens Road, Ocean City, Cape May County, Site #225;

Between October 26 and November 6, 2012 Hurricane Sandy removed 125 feet of dune vegetation at elevation 12.0 NAVD 88 or higher. The beach was not wide and occupied just 50 feet between the seaward dune toe and the zero elevation position. The home in both pictures was impacted with water inside due to wave surges, but could be repaired. The large pine trees actually helped save the home.

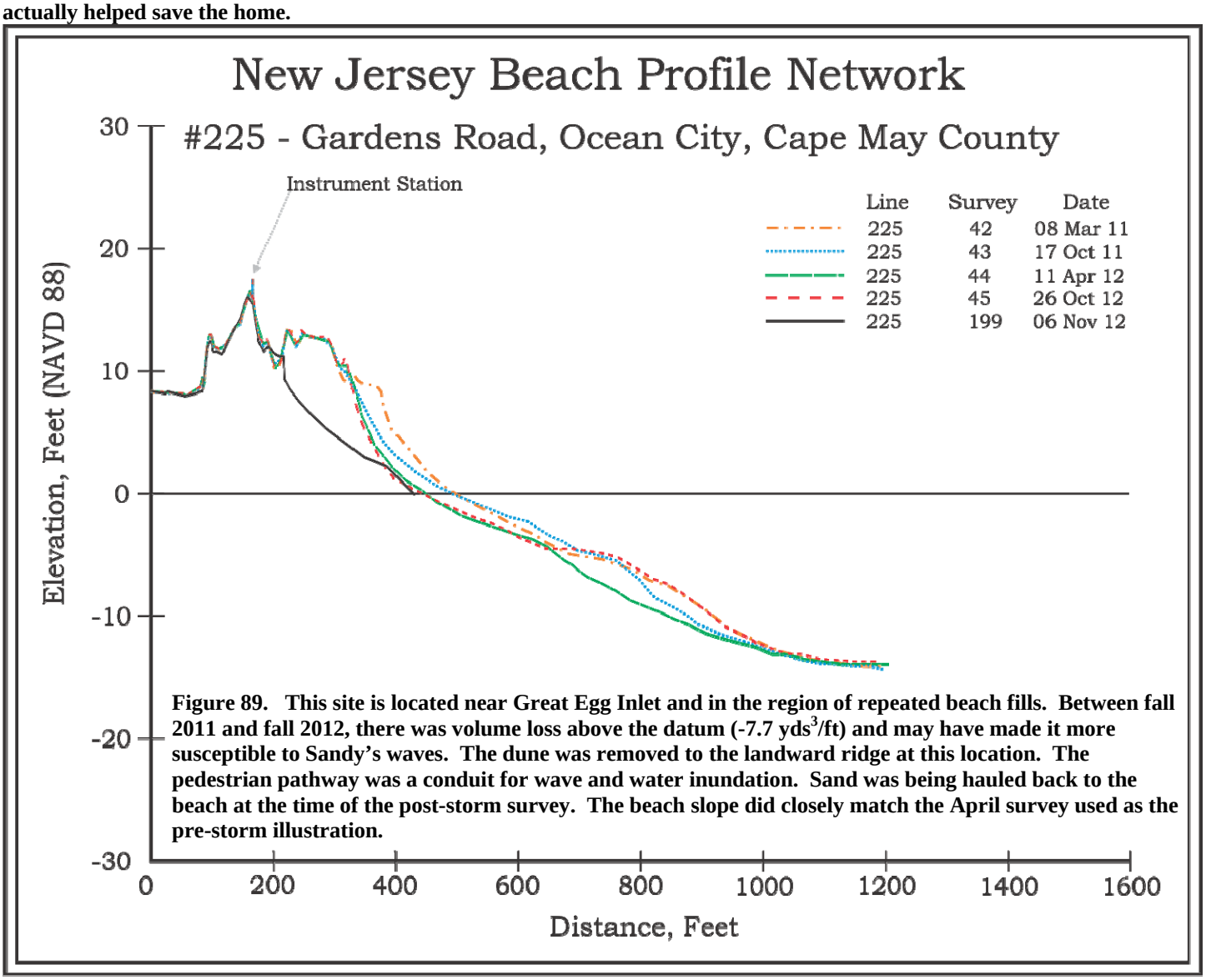


Figure 89. This site is located near Great Egg Inlet and in the region of repeated beach fills. Between fall 2011 and fall 2012, there was volume loss above the datum (-7.7 yds^3/ft) and may have made it more susceptible to Sandy's waves. The dune was removed to the landward ridge at this location. The pedestrian pathway was a conduit for wave and water inundation. Sand was being hauled back to the beach at the time of the post-storm survey. The beach slope did closely match the April survey used as the pre-storm illustration.

6th Street, Ocean City, Cape May County, Site #125;

The left photograph was taken October 26, 2012 just prior to the storm. The dune was intact, but the beach was extremely narrow so the initial storm action was able to attack the dune. The right photograph was taken November 6, 2012 from the back shot position standing on the street end paving that had been excavated of sand, looking seaward to the boardwalk about 120 feet distant. The sand had been deposited to the top of the timber by the storm surge. The wedge of sand was swept landward of the boardwalk and had spilled into the end of 6th Street.

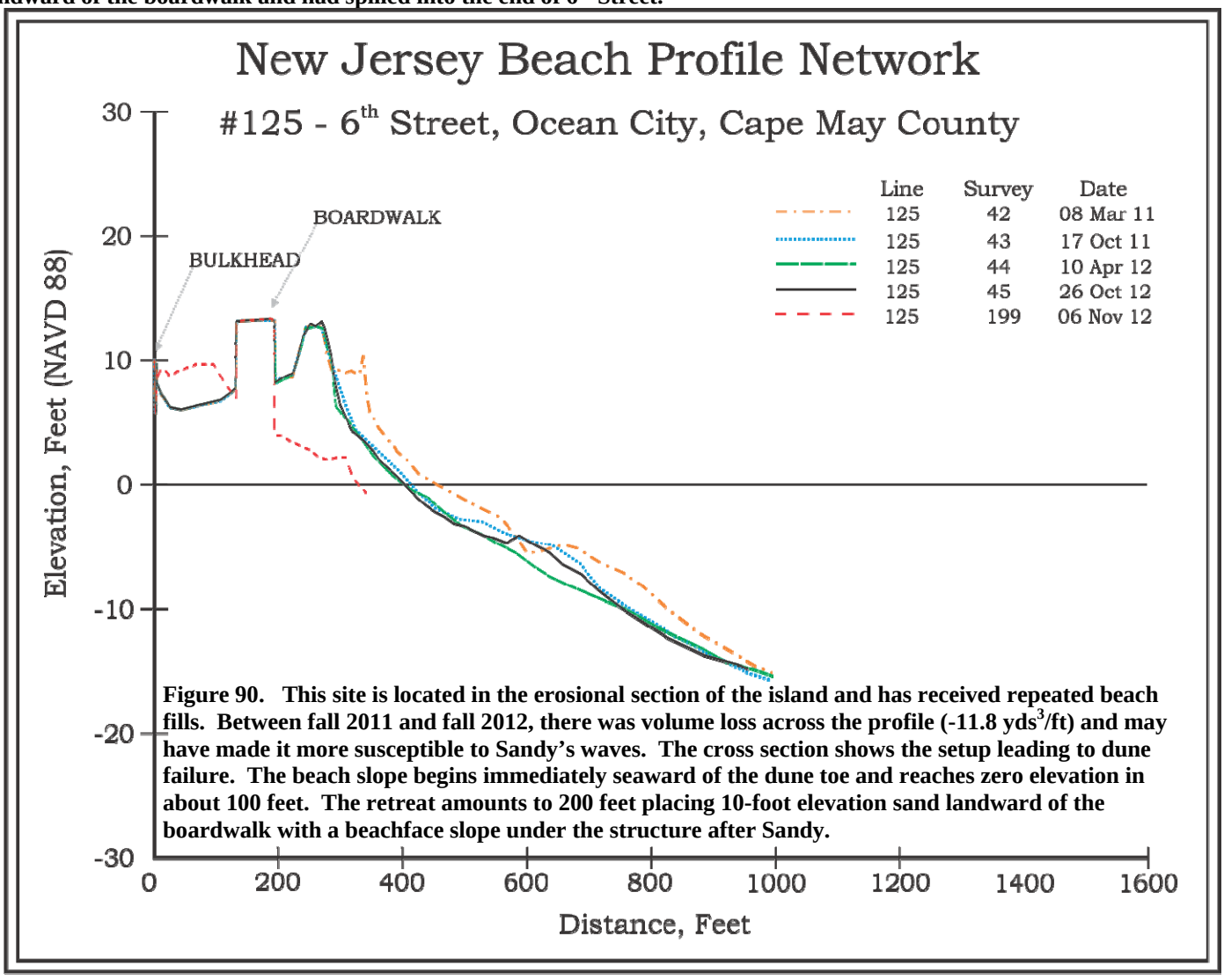


Figure 90. This site is located in the erosional section of the island and has received repeated beach fills. Between fall 2011 and fall 2012, there was volume loss across the profile (-11.8 yds^3/ft) and may have made it more susceptible to Sandy's waves. The cross section shows the setup leading to dune failure. The beach slope begins immediately seaward of the dune toe and reaches zero elevation in about 100 feet. The retreat amounts to 200 feet placing 10-foot elevation sand landward of the boardwalk with a beachface slope under the structure after Sandy.

20th Street, Ocean City, Cape May County, Site #124;

The 20th Street site is at the maximum retention of beach restoration sand anywhere along the oceanfront. This site has seen the shoreline move seaward by 600 feet since the 1980's with 460 feet of dunes. The photograph on the left was taken March 2, 2012 showing the beach and gentle gradient into the seaward-most dune ridge. Following Sandy on November 6, 2012 (right photo) the zone of about 150 feet in width had been inundated by the storm surge with sand pushed landward into the first major swale. The berm was lowered as would be expected without much shoreline retreat.

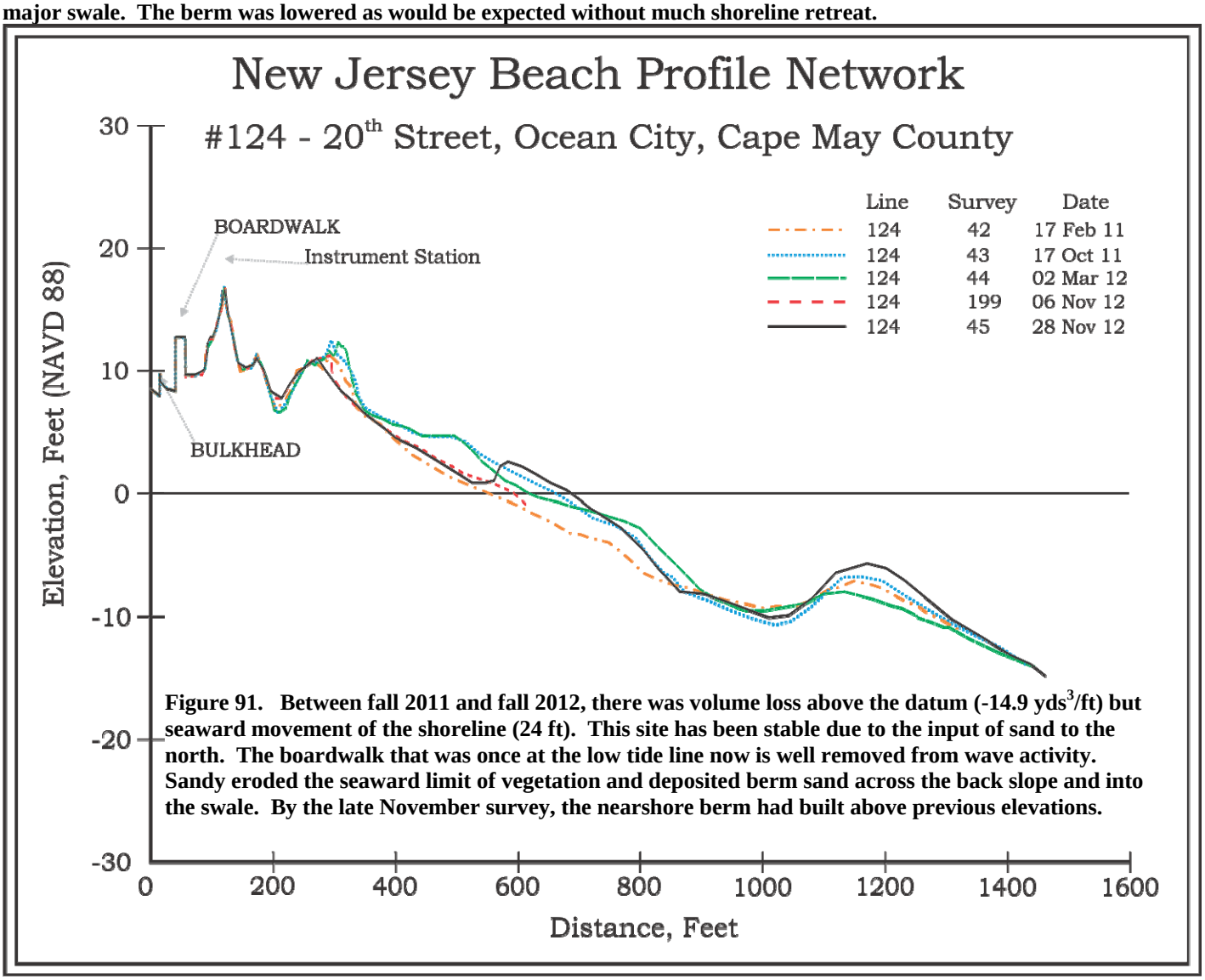


Figure 91. Between fall 2011 and fall 2012, there was volume loss above the datum (-14.9 yds^3/ft) but seaward movement of the shoreline (24 ft). This site has been stable due to the input of sand to the north. The boardwalk that was once at the low tide line now is well removed from wave activity. Sandy eroded the seaward limit of vegetation and deposited berm sand across the back slope and into the swale. By the late November survey, the nearshore berm had built above previous elevations.

34th Street, Ocean City, Cape May County, Site #223;

The 34th Street site has always possessed a low threshold dune that really is little more than a mound with a wide access path for both vehicles and pedestrians. The March 2, 2012 view (left) shows the relatively wide dunes north of the site, but the storm barreled through the pathway into 34th Street. The piles of sand on the right picture were transported back to the beach as of November 28th. The beach berm was cut back, but since this site was surveyed a month following the storm a new berm was in the process of reconstruction.

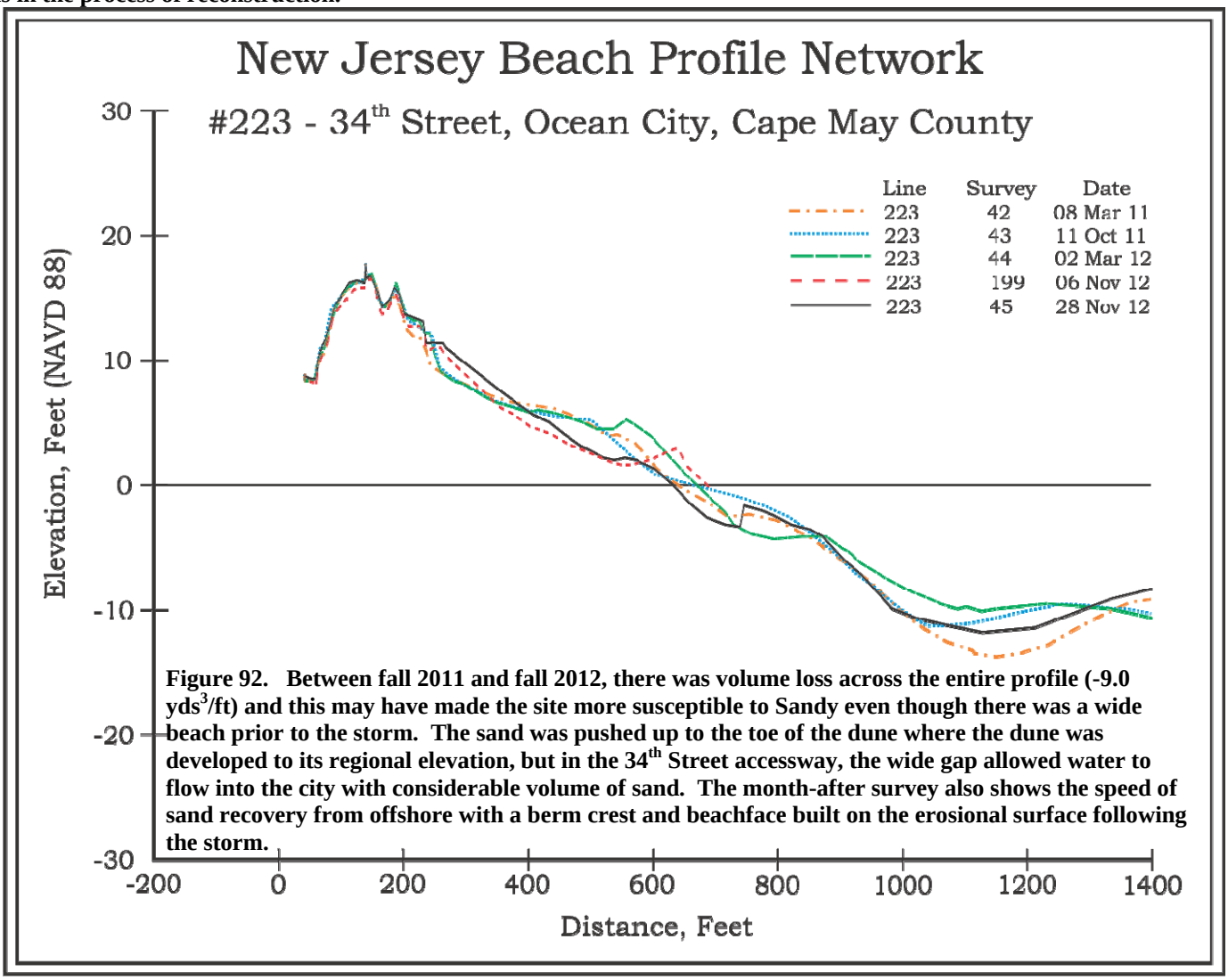


Figure 92. Between fall 2011 and fall 2012, there was volume loss across the entire profile (-9.0 yds^3/ft) and this may have made the site more susceptible to Sandy even though there was a wide beach prior to the storm. The sand was pushed up to the toe of the dune where the dune was developed to its regional elevation, but in the 34th Street accessway, the wide gap allowed water to flow into the city with considerable volume of sand. The month-after survey also shows the speed of sand recovery from offshore with a berm crest and beachface built on the erosional surface following the storm.

56th Street, Ocean City, Cape May County, Site #122;

The left photograph was taken October 26, as Sandy was approaching NJ. Machines were deployed pushing up a ridge of sand seaward of the existing dunes at this site. Sandy overwhelmed the shore protection, jumped the old bulkhead and washed well inland producing damage and flooding. The right picture was taken November 6th and shows recent bulldozing efforts to provide a small measure of protection for homes with nothing between them and the sea.

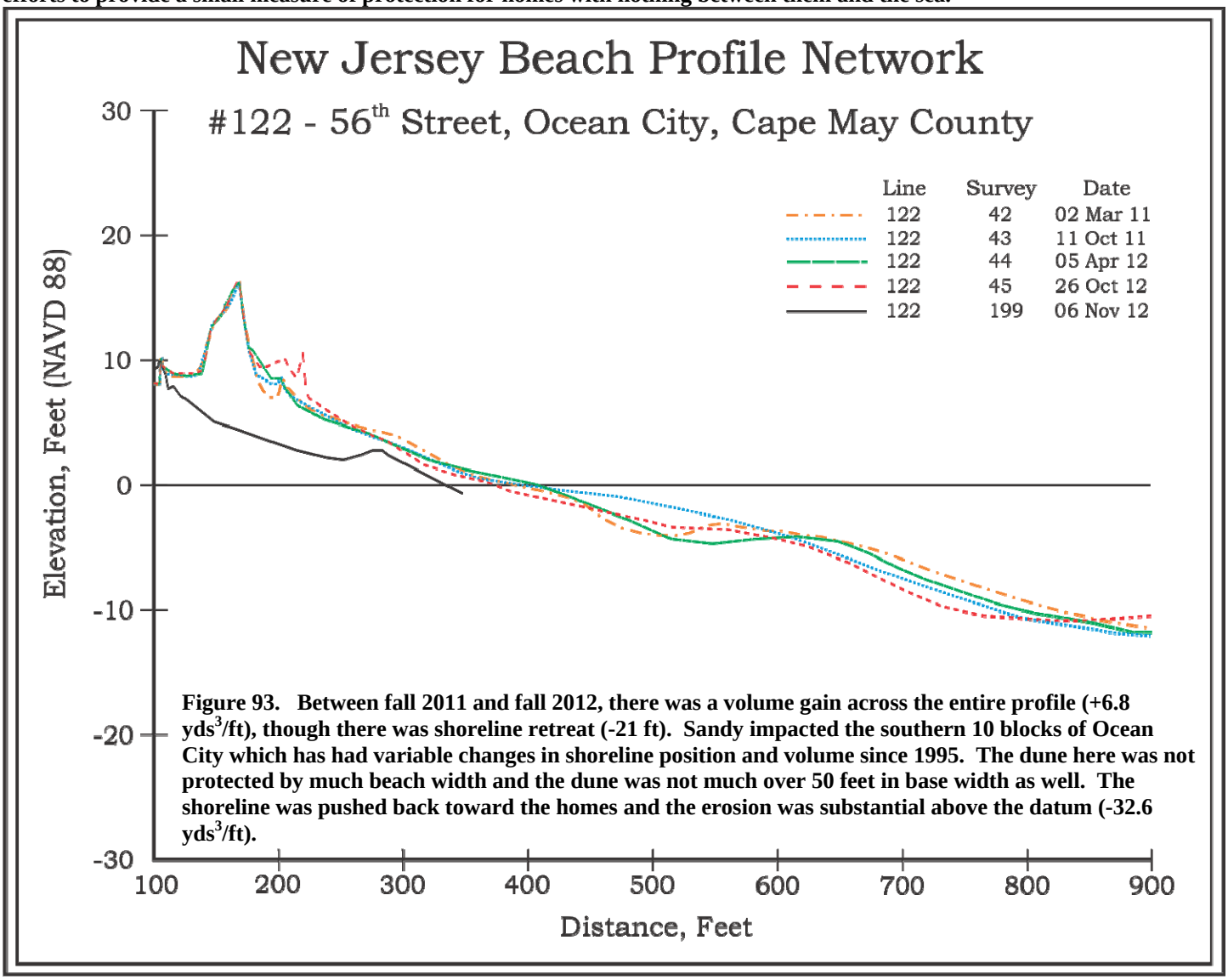


Figure 93. Between fall 2011 and fall 2012, there was a volume gain across the entire profile (+6.8 yds^3/ft), though there was shoreline retreat (-21 ft). Sandy impacted the southern 10 blocks of Ocean City which has had variable changes in shoreline position and volume since 1995. The dune here was not protected by much beach width and the dune was not much over 50 feet in base width as well. The shoreline was pushed back toward the homes and the erosion was substantial above the datum (-32.6 yds^3/ft).

59th Street, Ocean City, Cape May County, Site #222;

The left picture, taken March 9, 2012, shows an erosional scarp in the spring of 2012. This condition did not change during the summer and the waves during Sandy carved deeply into the remaining dunes. The erosion reflected up the beach into the southernmost development in Ocean City as well. The right picture was taken November 28, 2012 and shows large scale overwash and inundation of the lower sections of the dune system. The scarp was pushed landward a minimum of 155 feet with loss in elevation to the remaining dunes because the erosion passed the crest of the main dune ridge.

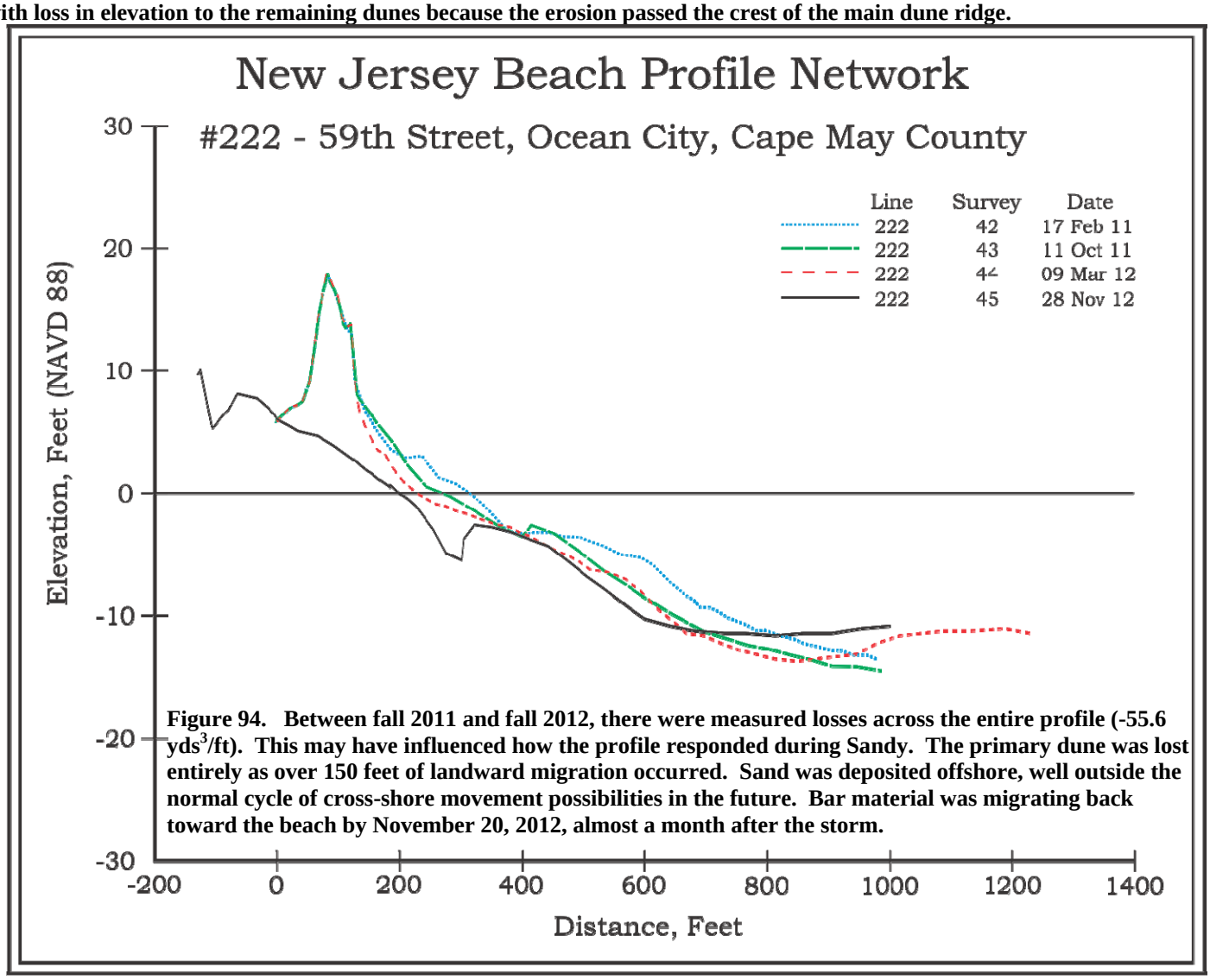


Figure 94. Between fall 2011 and fall 2012, there were measured losses across the entire profile (-55.6 yds^3/ft). This may have influenced how the profile responded during Sandy. The primary dune was lost entirely as over 150 feet of landward migration occurred. Sand was deposited offshore, well outside the normal cycle of cross-shore movement possibilities in the future. Bar material was migrating back toward the beach by November 20, 2012, almost a month after the storm.

Corson's Inlet State Park, Ocean City, Cape May County, Site #221;

Positioned about a half-mile south of the development in Ocean City, the dune has been repeatedly eroded since the spring of 2012. Sandy hit this site pretty hard as a result of a narrow, low elevation beach. The November 28, 2012 picture on the right shows that the higher elevation dune was removed and the water pushed inland over lower elevation vegetation. There is an older, vegetated dune line over a hundred feet further landward that finally stopped the storm surge.

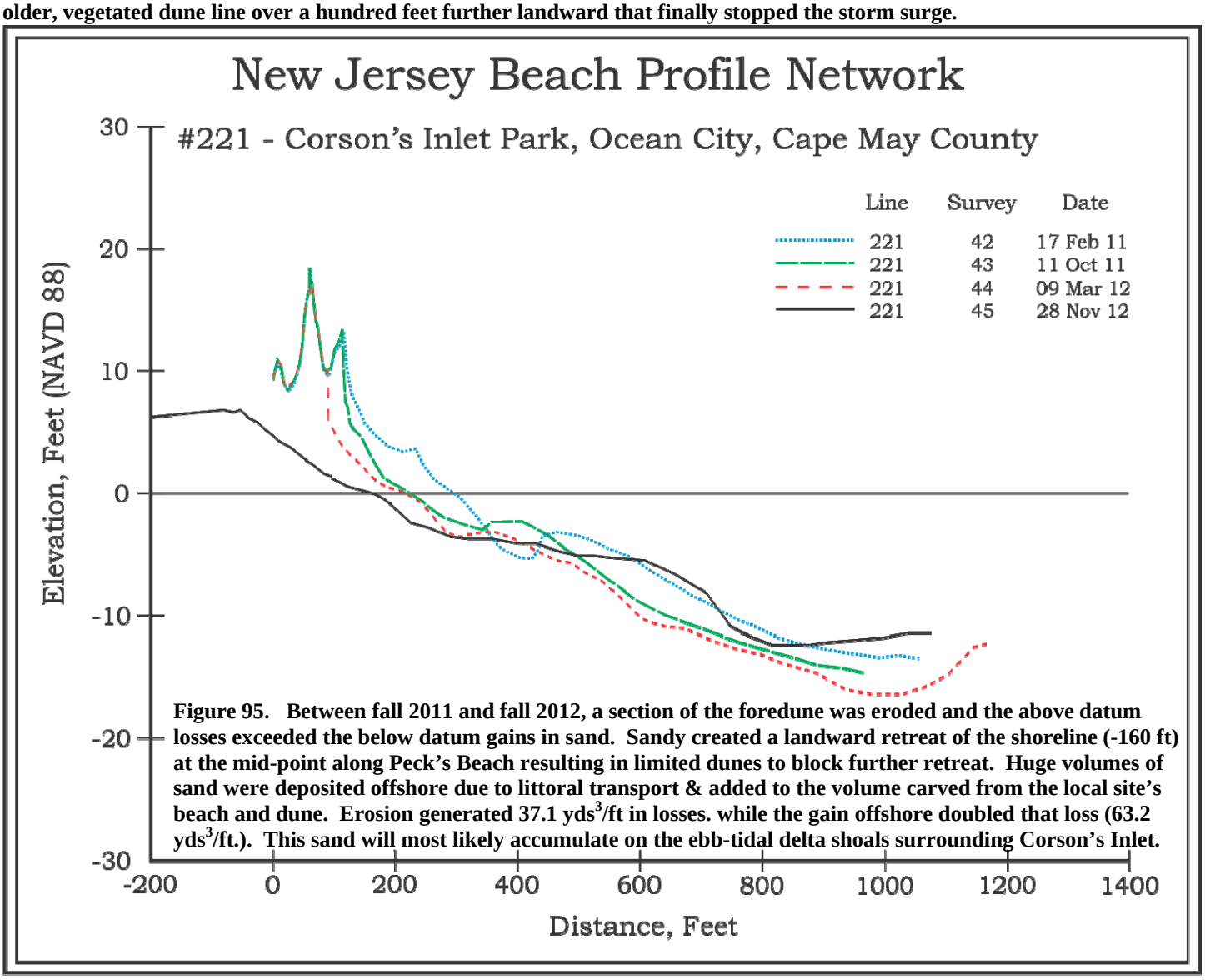


Figure 95. Between fall 2011 and fall 2012, a section of the foredune was eroded and the above datum losses exceeded the below datum gains in sand. Sandy created a landward retreat of the shoreline (-160 ft) at the mid-point along Peck's Beach resulting in limited dunes to block further retreat. Huge volumes of sand were deposited offshore due to littoral transport & added to the volume carved from the local site's beach and dune. Erosion generated 37.1 yds^3/ft in losses. while the gain offshore doubled that loss (63.2 yds^3/ft.). This sand will most likely accumulate on the ebb-tidal delta shoals surrounding Corson's Inlet.

Williams Road, Strathmere, Cape May County, Site #121;

The left picture was taken October 17, 2012 looking across the wide dune zone area seaward of the primary feature. On November 5, 2012 the same view following Sandy shows that the area was flooded by waves that knocked down the highest primary dune, but did not flood the immediate landward area. The beach was flattened by the storm surge. The dune removed was only three feet higher than the post-storm feature however.

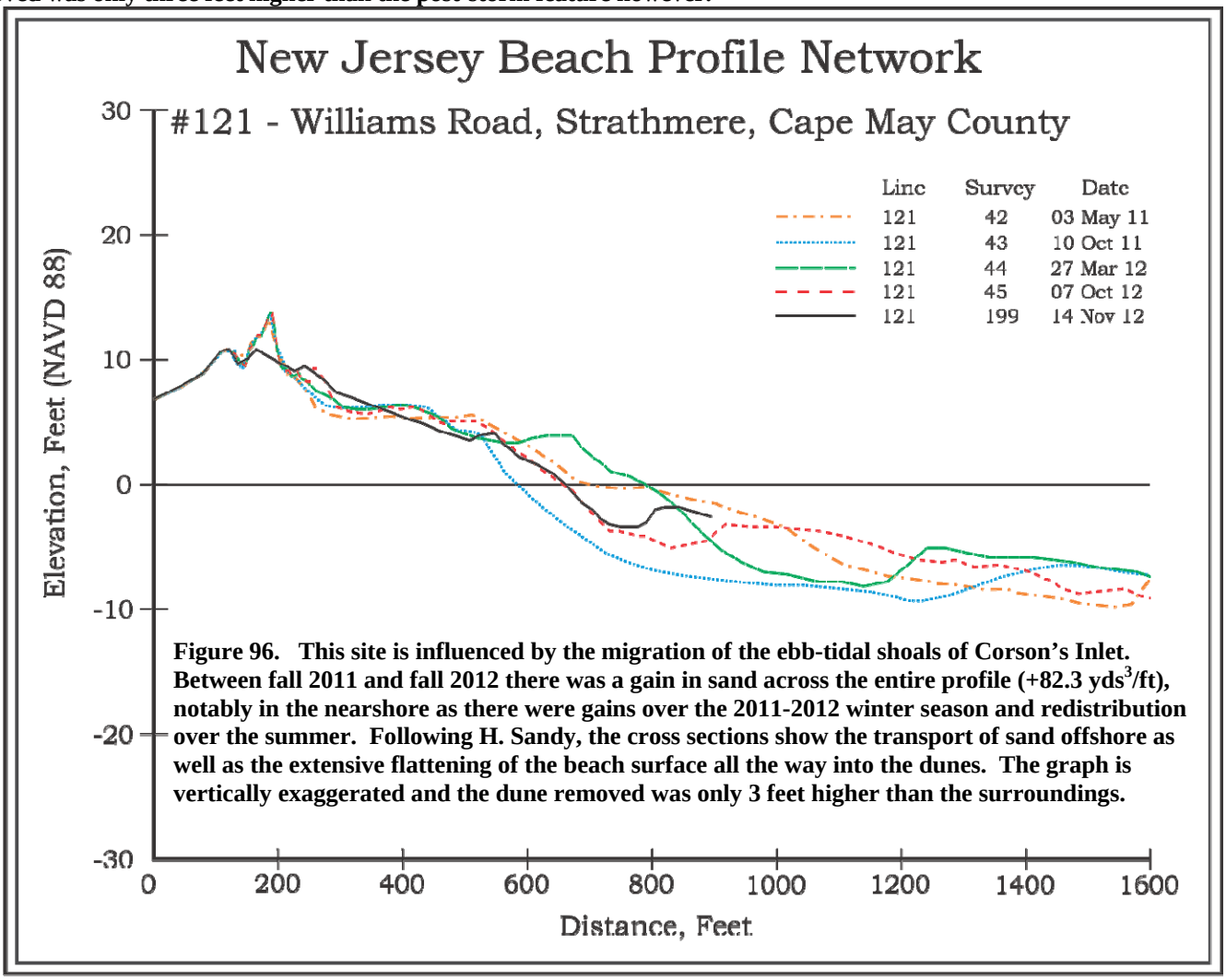


Figure 96. This site is influenced by the migration of the ebb-tidal shoals of Corson's Inlet. Between fall 2011 and fall 2012 there was a gain in sand across the entire profile (+82.3 yds^3/ft), notably in the nearshore as there were gains over the 2011-2012 winter season and redistribution over the summer. Following H. Sandy, the cross sections show the transport of sand offshore as well as the extensive flattening of the beach surface all the way into the dunes. The graph is vertically exaggerated and the dune removed was only 3 feet higher than the surroundings.

1st Street, Sea Isle City, Cape May County, Site #120;

This location is on the boundary between Sea Isle City and Strathmere along the main (and only) road parallel to the ocean. The sand transported into the dune by October 17, 2012 was washed across by Sandy as seen on the left picture on November 14, 2012. Some minor breaching occurred along Commonwealth Avenue, but the dune remained relatively intact.

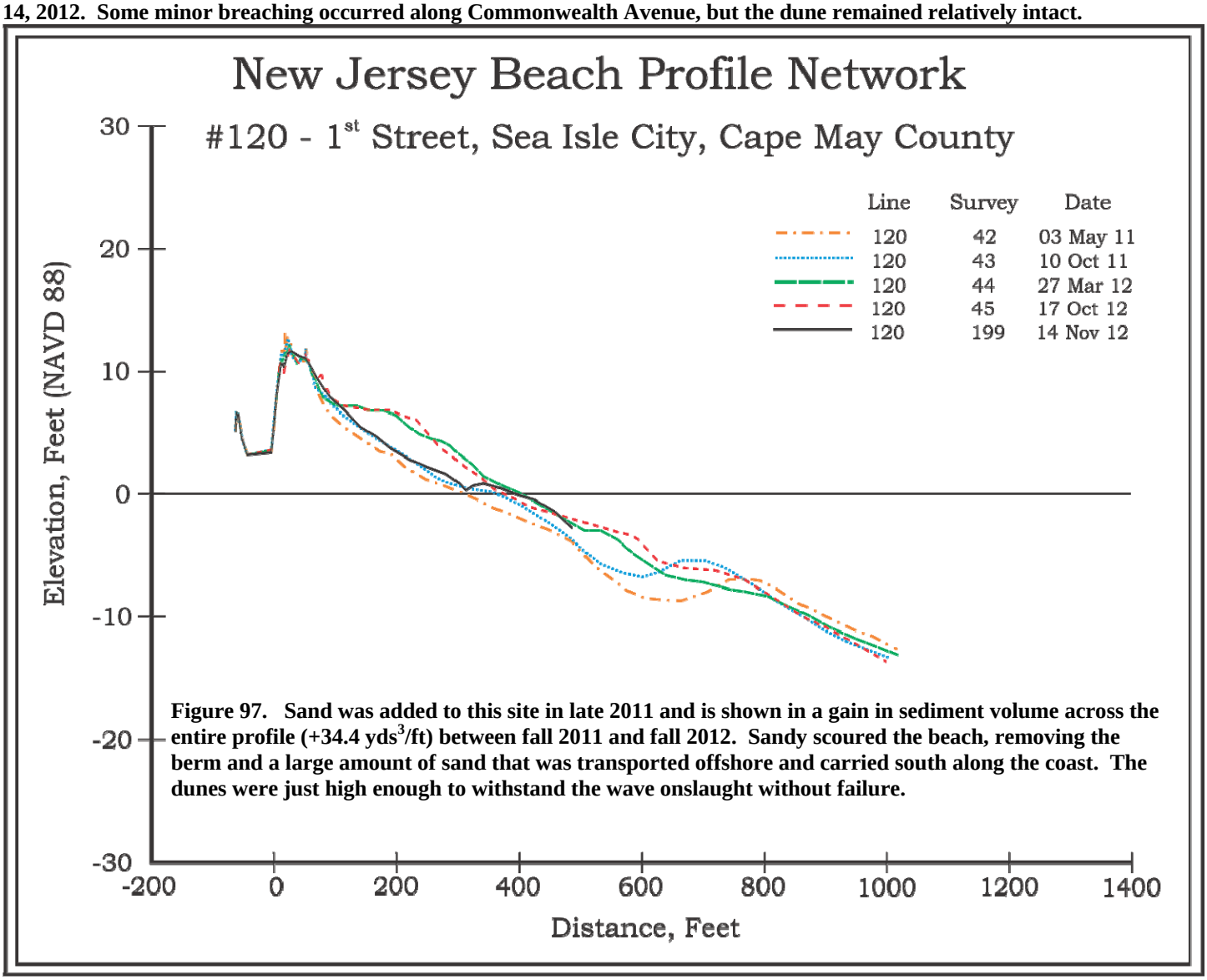


Figure 97. Sand was added to this site in late 2011 and is shown in a gain in sediment volume across the entire profile (+34.4 yds^3/ft) between fall 2011 and fall 2012. Sandy scoured the beach, removing the berm and a large amount of sand that was transported offshore and carried south along the coast. The dunes were just high enough to withstand the wave onslaught without failure.

25th Street, Sea Isle City, Cape May County, Site #119;

On October 22, 2012, the beach was relatively wide and dry with a decent new deposit of sand along the recent fencing installed at the seaward toe of the dune system. After Sandy on November 14, 2012 the beach was lower in elevation, all the fencing was missing and sand was pushed back into the dunes, up the seaward slope.

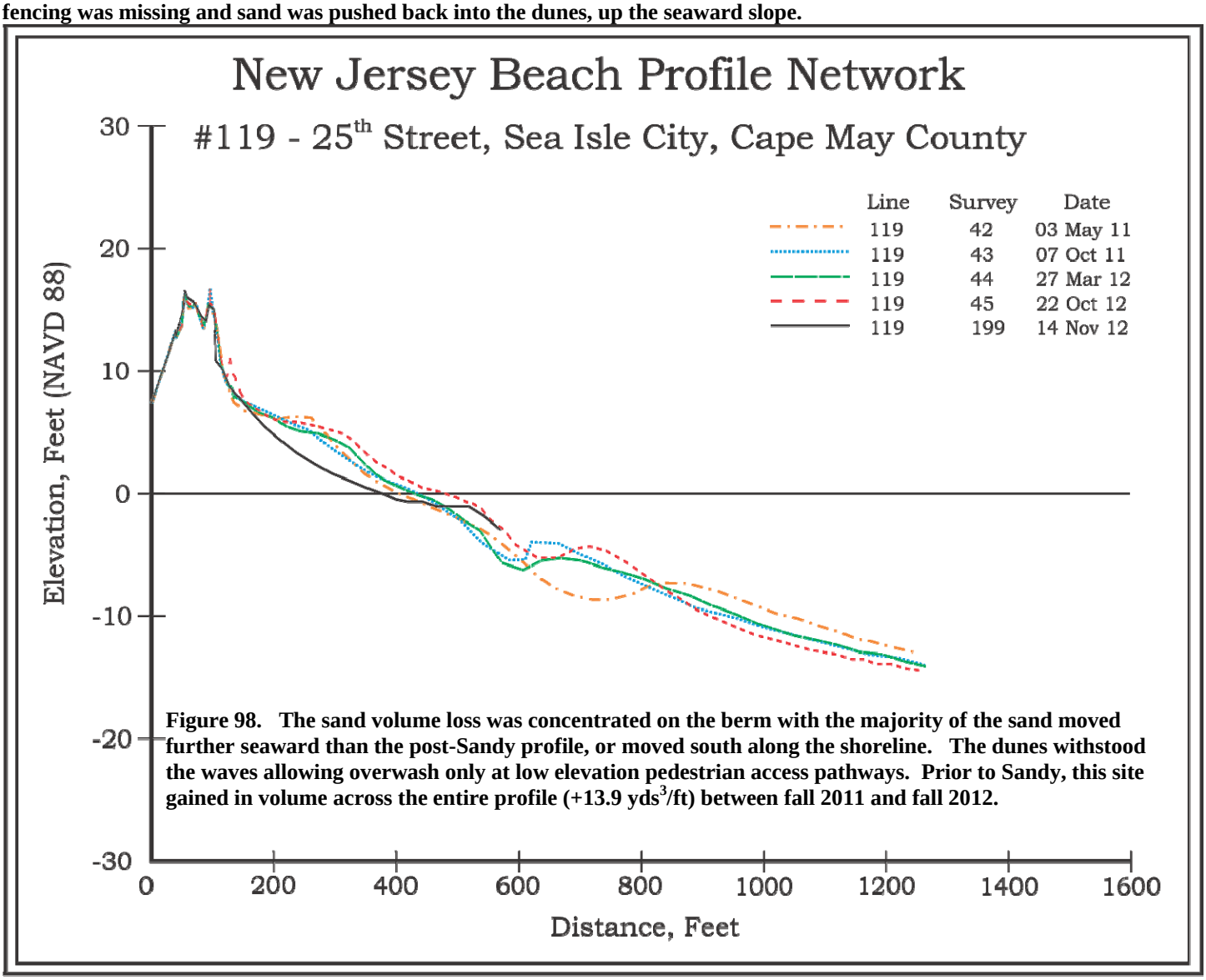


Figure 98. The sand volume loss was concentrated on the berm with the majority of the sand moved further seaward than the post-Sandy profile, or moved south along the shoreline. The dunes withstood the waves allowing overwash only at low elevation pedestrian access pathways. Prior to Sandy, this site gained in volume across the entire profile (+13.9 yds^3/ft) between fall 2011 and fall 2012.

57th Street, Sea Isle City, Cape May County, Site #118;

The left picture was taken October 22, 2012 and shows the dune system landward of a wide, dry beach. Following Sandy on November 14, 2012, the beach was much lower in elevation and the dune was carved away nearly to the crest. The scarp had slumped two weeks later, but the impact can clearly be seen in the cross section below.

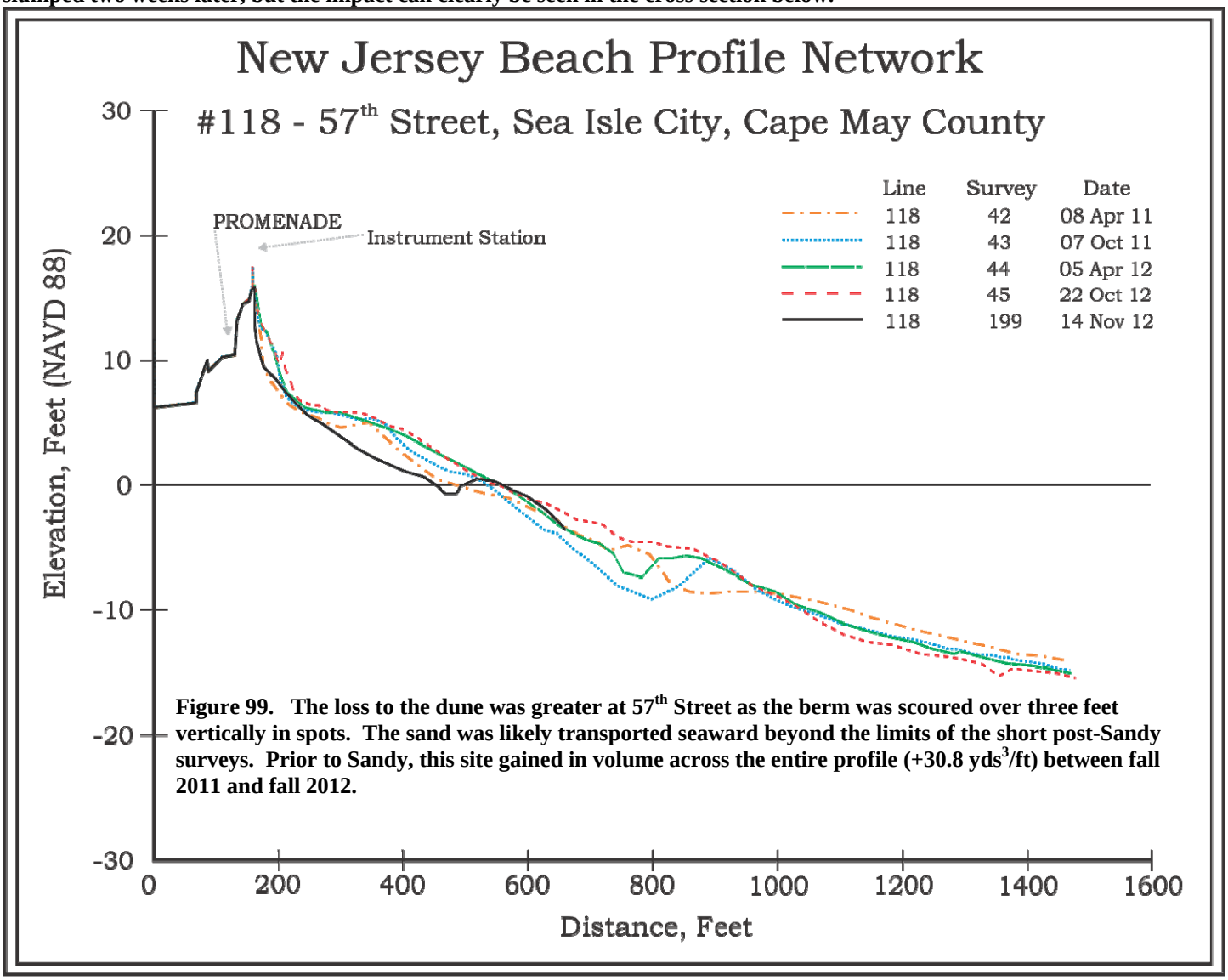


Figure 99. The loss to the dune was greater at 57th Street as the berm was scoured over three feet vertically in spots. The sand was likely transported seaward beyond the limits of the short post-Sandy surveys. Prior to Sandy, this site gained in volume across the entire profile (+30.8 yds^3/ft) between fall 2011 and fall 2012.

80th Street, Sea Isle City, Cape May County, Site #117;

On October 22, 2012 the beach possessed a recently deposited foredune developed at fencing installed in the past year. The beach was wider and higher than the scene following the storm. On the right, the post-Sandy clean-up was responsible for the deposition of sand, washed inland, having been hauled back to the beach to form a linear ridge to help with future storm protection.

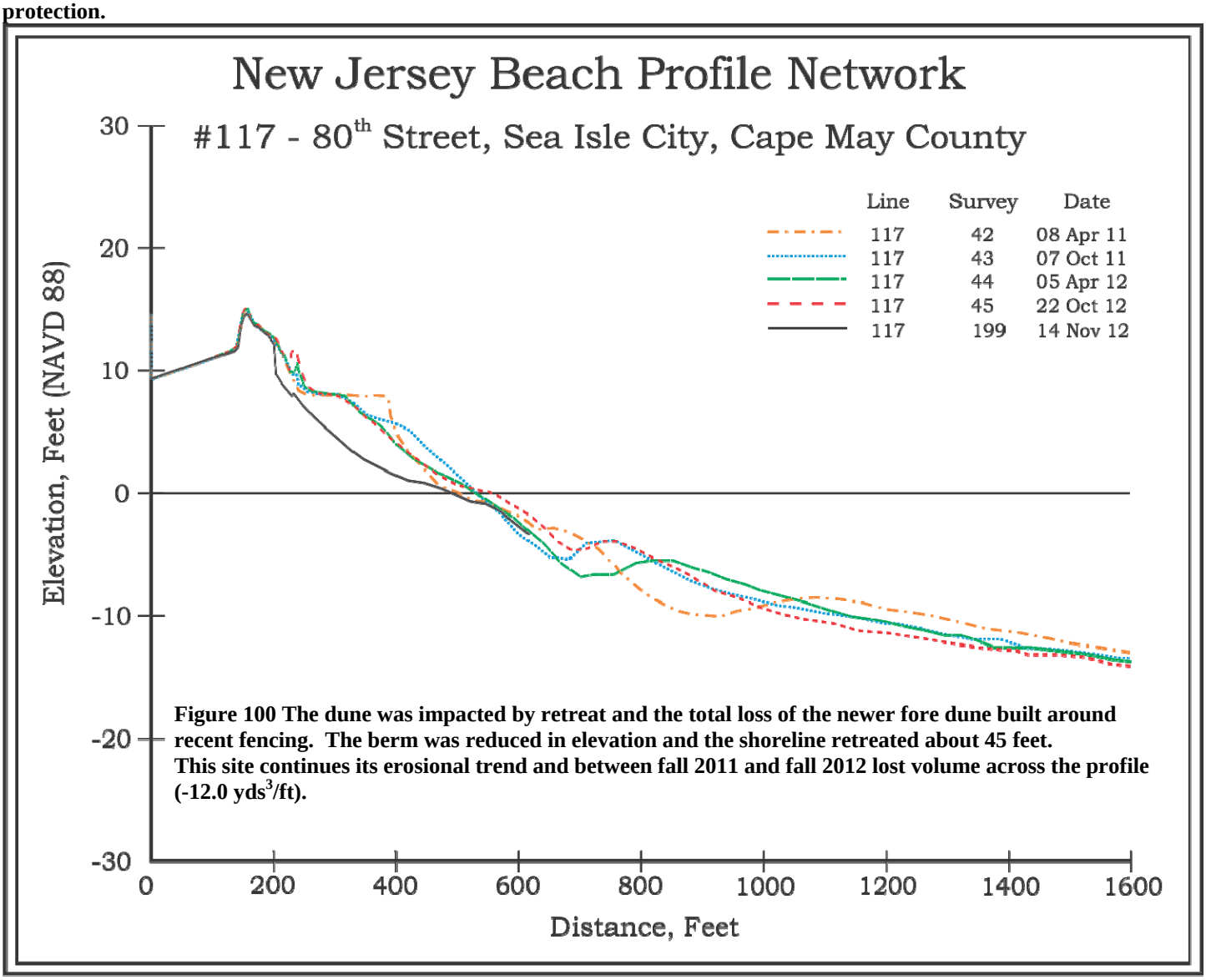


Figure 100 The dune was impacted by retreat and the total loss of the newer fore dune built around recent fencing. The berm was reduced in elevation and the shoreline retreated about 45 feet. This site continues its erosional trend and between fall 2011 and fall 2012 lost volume across the profile (-12.0 yds^3/ft).

9th Street, Avalon, Cape May County, Site #216;

The September 25th photograph shows the wide berm and seasonal plant growth at the 9th Street site. Following Sandy the fence was taken out as was the wide berm with erosion cutting into the seaward dune toe slope. The litter deposited on the dune slope shows the elevation to which the waves ran up the dunes (14.0 feet NAVD88 in Avalon).

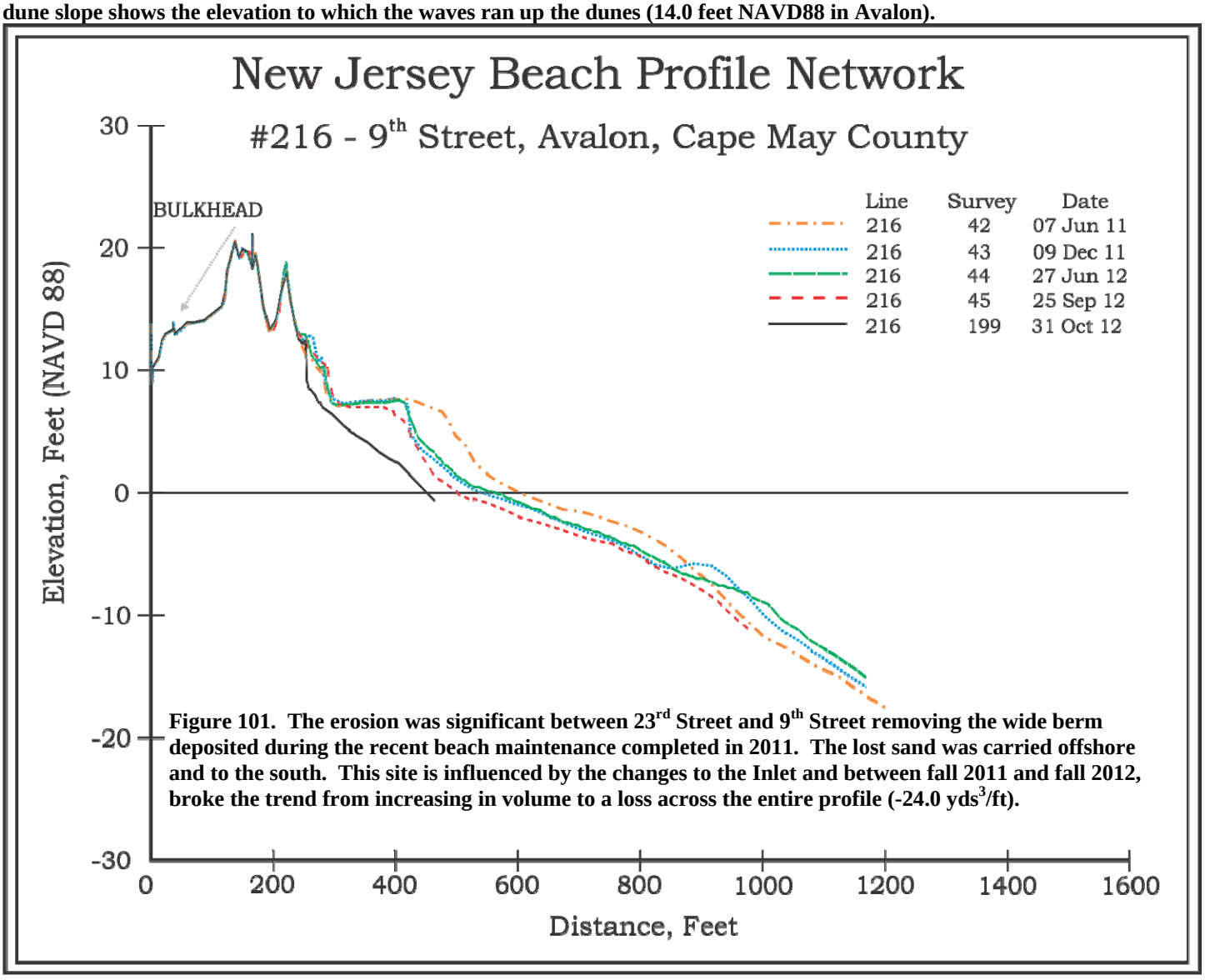


Figure 101. The erosion was significant between 23rd Street and 9th Street removing the wide berm deposited during the recent beach maintenance completed in 2011. The lost sand was carried offshore and to the south. This site is influenced by the changes to the Inlet and between fall 2011 and fall 2012, broke the trend from increasing in volume to a loss across the entire profile (-24.0 yds^3/ft).

23rd Street, Avalon, Cape May County, Site #116;

The left picture was taken September 25, 2012 and shows the beach late in the summer with a generous post-sand fill berm present and a healthy season's growth in new dune plants. By October 31st, the beach was much lower in elevation as sand was carried offshore and the dune's seaward slope was cut and sand washed into the grasses. The entrance pathway was truncated at most Avalon street-end entrances.

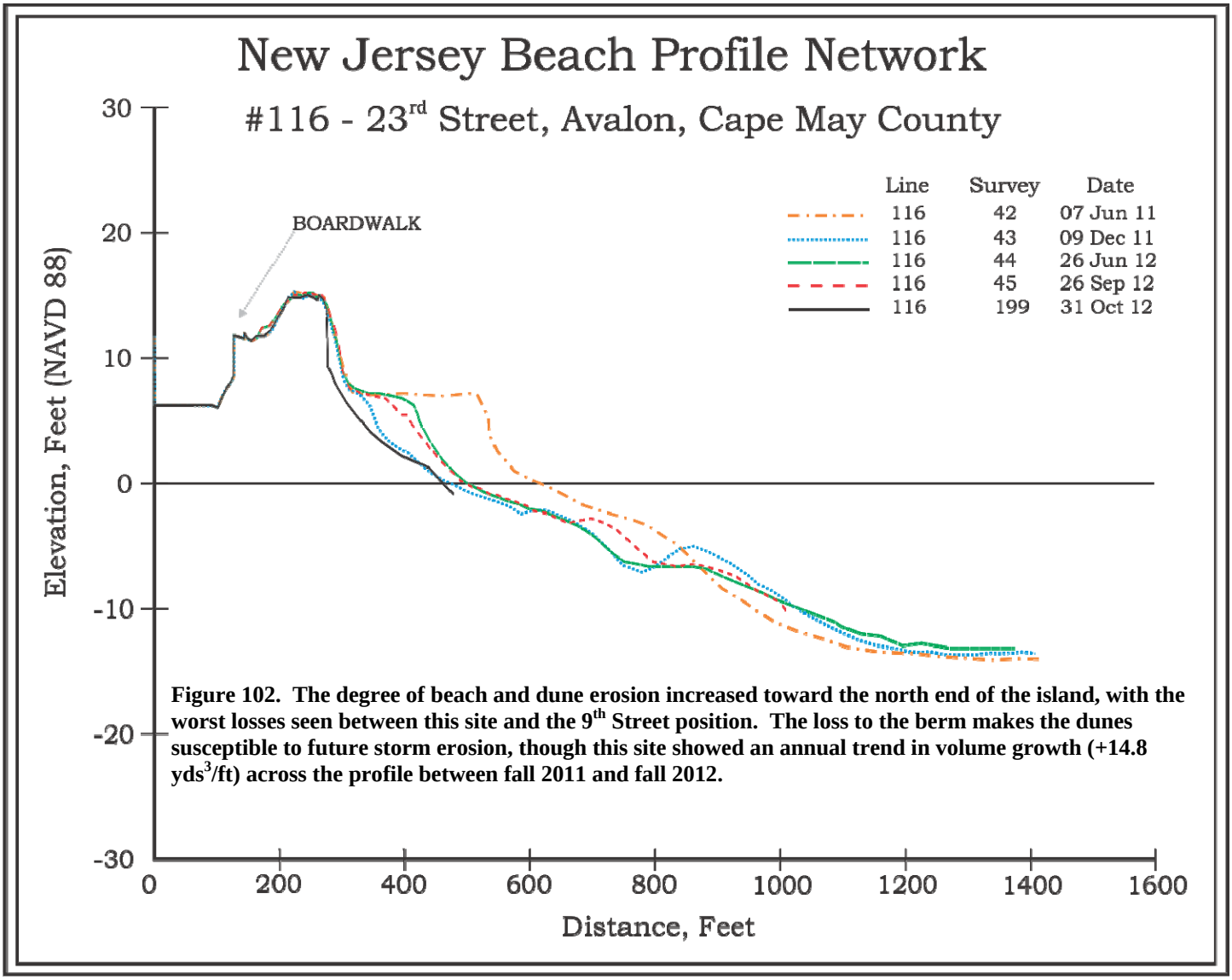


Figure 102. The degree of beach and dune erosion increased toward the north end of the island, with the worst losses seen between this site and the 9th Street position. The loss to the berm makes the dunes susceptible to future storm erosion, though this site showed an annual trend in volume growth (+14.8 yds^3/ft) across the profile between fall 2011 and fall 2012.

35th Street, Avalon, Cape May County, Site #115;

Between September 27th and October 31st, the beach at 35th Street suffered foredune flooding and minor erosion of the seaward toe. Sand was stripped from the berm and washed into the lower elevation dune field. The loss to individual plants can be determined by careful examination of the two photographs.

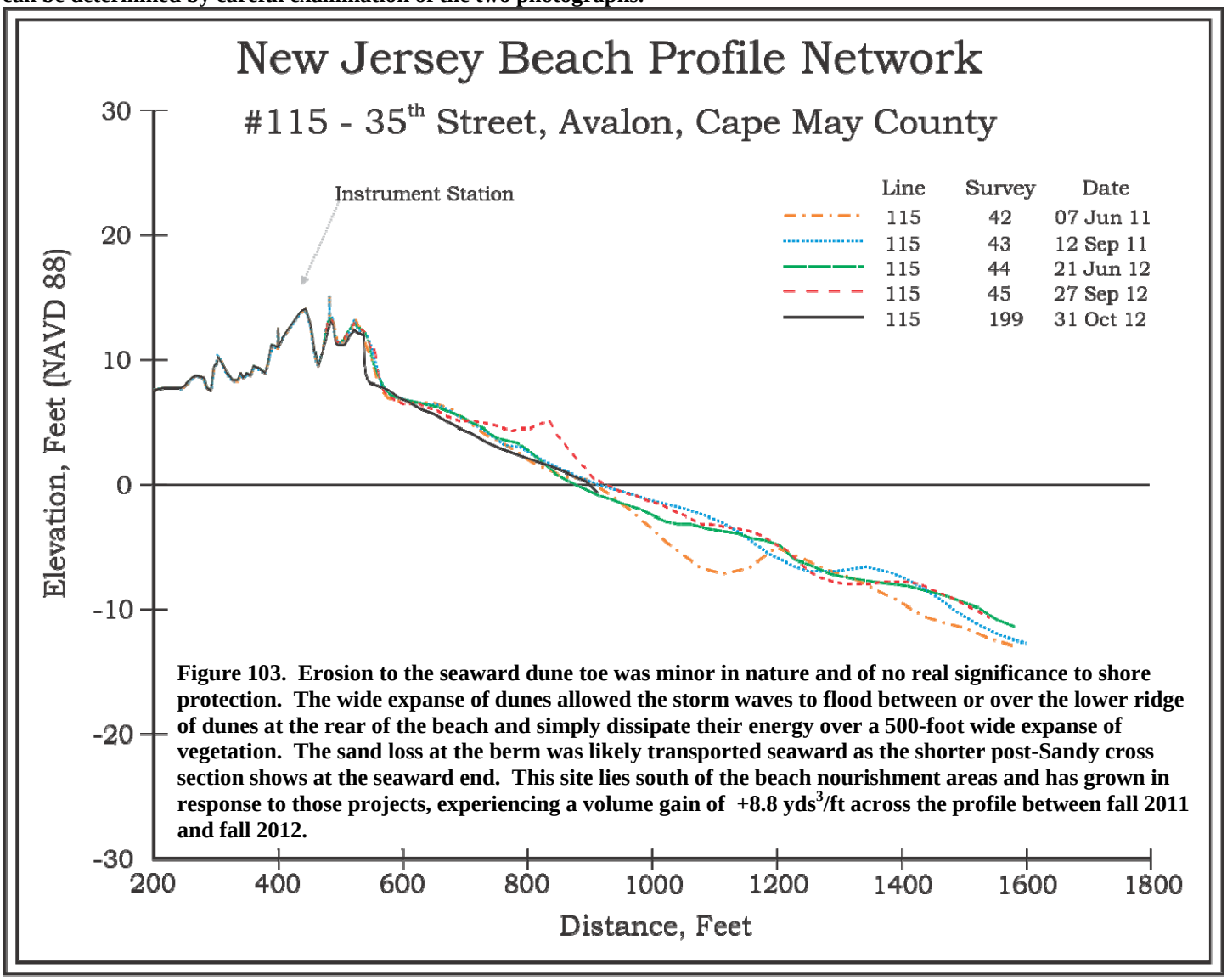


Figure 103. Erosion to the seaward dune toe was minor in nature and of no real significance to shore protection. The wide expanse of dunes allowed the storm waves to flood between or over the lower ridge of dunes at the rear of the beach and simply dissipate their energy over a 500-foot wide expanse of vegetation. The sand loss at the berm was likely transported seaward as the shorter post-Sandy cross section shows at the seaward end. This site lies south of the beach nourishment areas and has grown in response to those projects, experiencing a volume gain of +8.8 yds^3/ft across the profile between fall 2011 and fall 2012.

70th Street, Avalon, Cape May County, Site #114;

The left picture was taken September 28, 2012 during the late summer survey, and the nearly identical view was obtained October 31st just after Sandy. Note that there are two pairs of closely spaced fence posts that have a small angle between them in their vertical positions. The two pairs of posts are present in both photographs and show the loss in seaward dune toe grass and sand. The berm along the ocean's edge was also reduced in elevation.

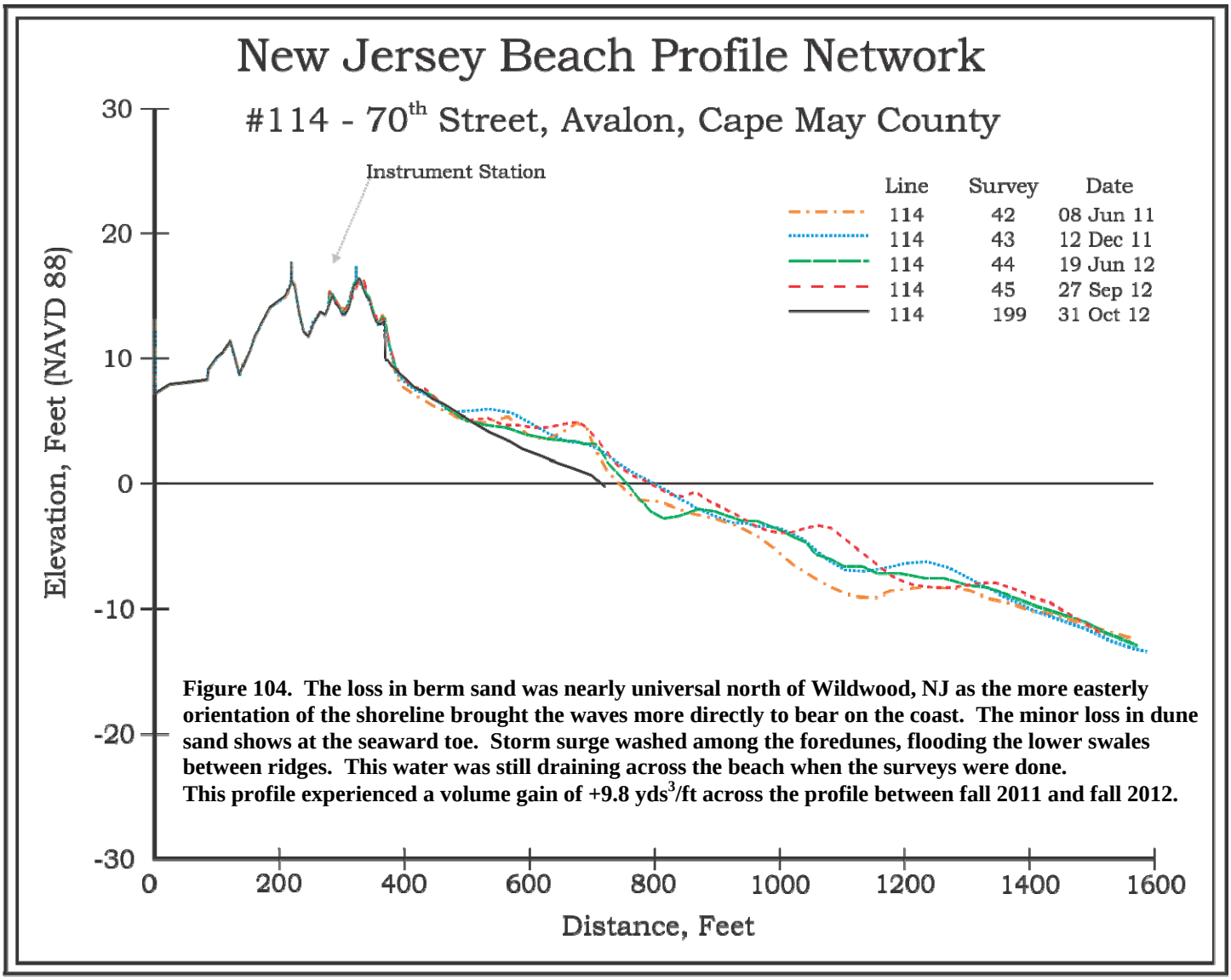


Figure 104. The loss in berm sand was nearly universal north of Wildwood, NJ as the more easterly orientation of the shoreline brought the waves more directly to bear on the coast. The minor loss in dune sand shows at the seaward toe. Storm surge washed among the foredunes, flooding the lower swales between ridges. This water was still draining across the beach when the surveys were done. This profile experienced a volume gain of +9.8 yds^3/ft across the profile between fall 2011 and fall 2012.

90th Street, Stone Harbor, Cape May County, Site #113;

The left photograph was taken October 24, 2012 just prior to Sandy. The right picture was taken October 31, 2012 and shows the effects of lowering the berm elevation and some minor dune toe erosion. This site did not suffer significant erosion damage and no overwash beyond the dune toe area.

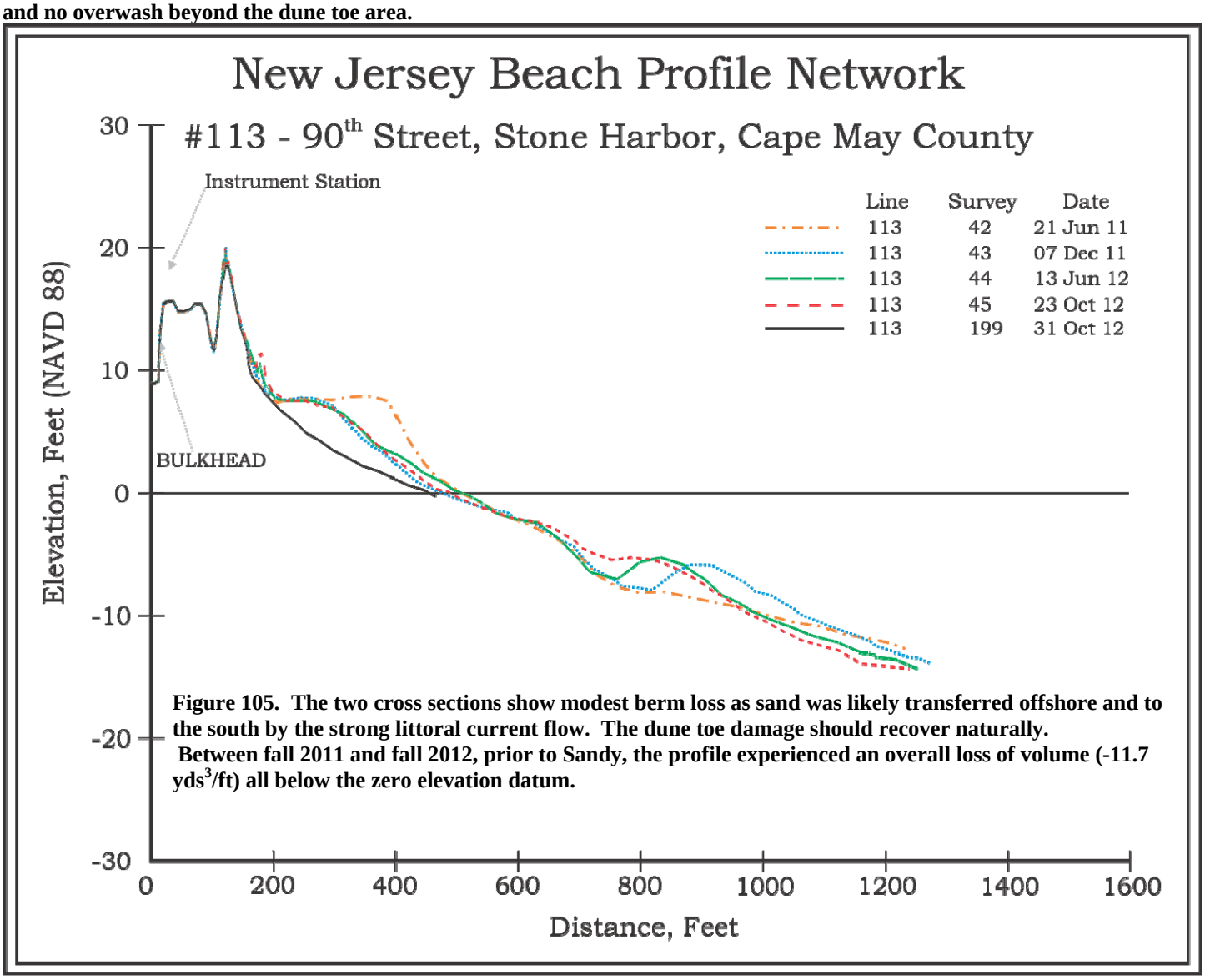


Figure 105. The two cross sections show modest berm loss as sand was likely transferred offshore and to the south by the strong littoral current flow. The dune toe damage should recover naturally. Between fall 2011 and fall 2012, prior to Sandy, the profile experienced an overall loss of volume (-11.7 yds^3/ft) all below the zero elevation datum.

121st Street, Stone Harbor, Cape May County, Site #212;

The southern cross section in Stone Harbor was re-established just north of the terminal rock groin along the Borough oceanfront following the loss of South Point in 1990. The left picture shows the conditions in June 2012 where sand had deposited seaward of an older scarp cut into the dunes, building out to the sand fencing. Sandy eliminated all the newly-deposited material moving the beach landward uniformly by 50 feet. The catamaran pilings show a closer proximity to the surf after Sandy than prior to the storm (Nov. 8, 2012). The erosional cut in the dunes returned to approximately the location of the cut made in November 2009.

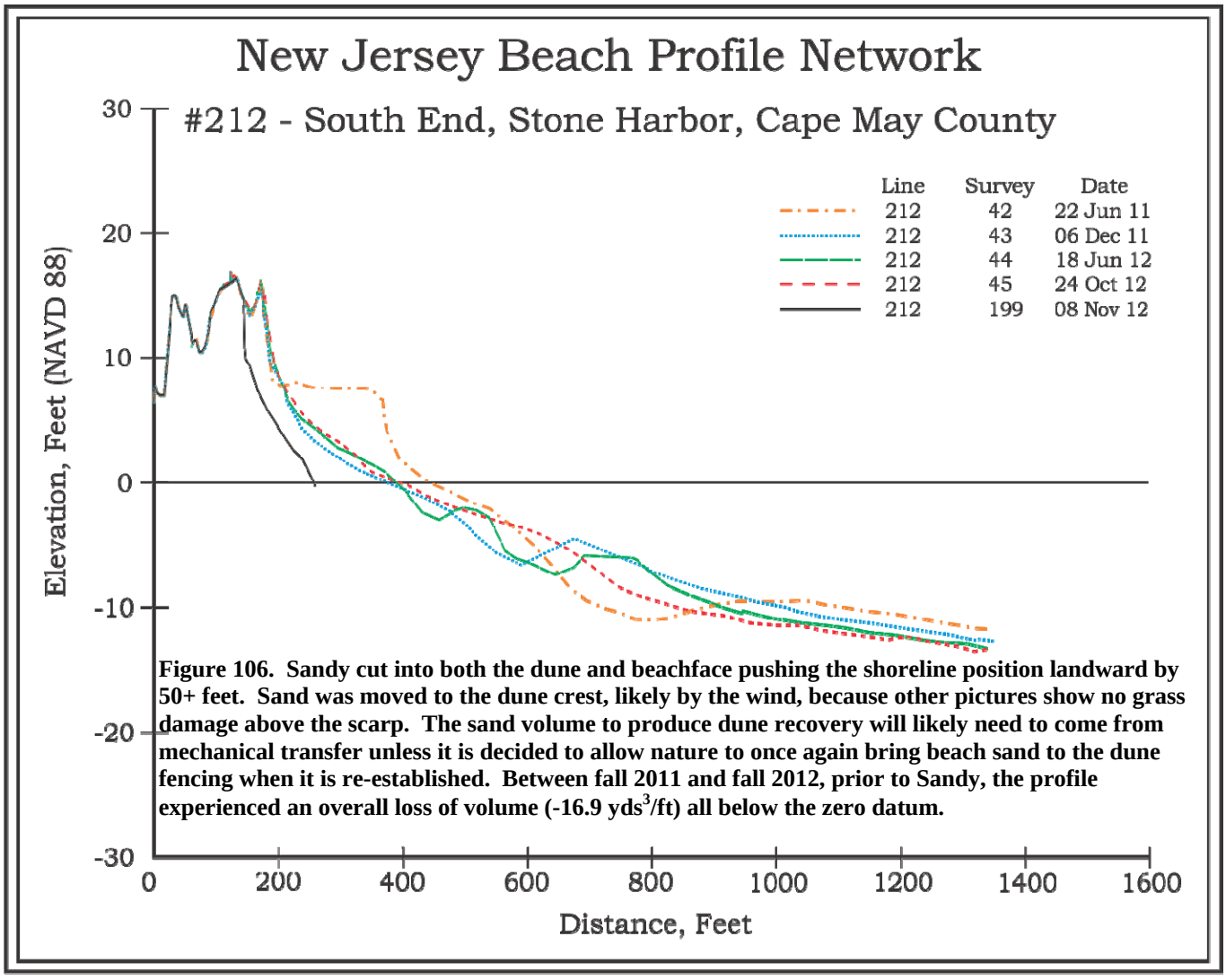


Figure 106. Sandy cut into both the dune and beachface pushing the shoreline position landward by 50+ feet. Sand was moved to the dune crest, likely by the wind, because other pictures show no grass damage above the scarp. The sand volume to produce dune recovery will likely need to come from mechanical transfer unless it is decided to allow nature to once again bring beach sand to the dune fencing when it is re-established. Between fall 2011 and fall 2012, prior to Sandy, the profile experienced an overall loss of volume (-16.9 yds^3/ft) all below the zero datum.

15th Avenue, North Wildwood, Cape May County, Site #111;

The view to the southeast from 15th Avenue dune crossover was taken April 4, 2012. The picture following Sandy was taken on November 29th and is on the right. Summer dune grass growth shows in spite of the storm. The waves did flow across the entire dry beach and ramped up a deposit onto the seaward dune toe. No dune breach occurred near this location. Further south at the piers, the dune was erased because it was built to pass seaward of the pier ends and was far more exposed to wave action. Erosion at the very northeast corner of the City also removed the dune south to 4th Avenue and over-topped the bulkhead revetment.

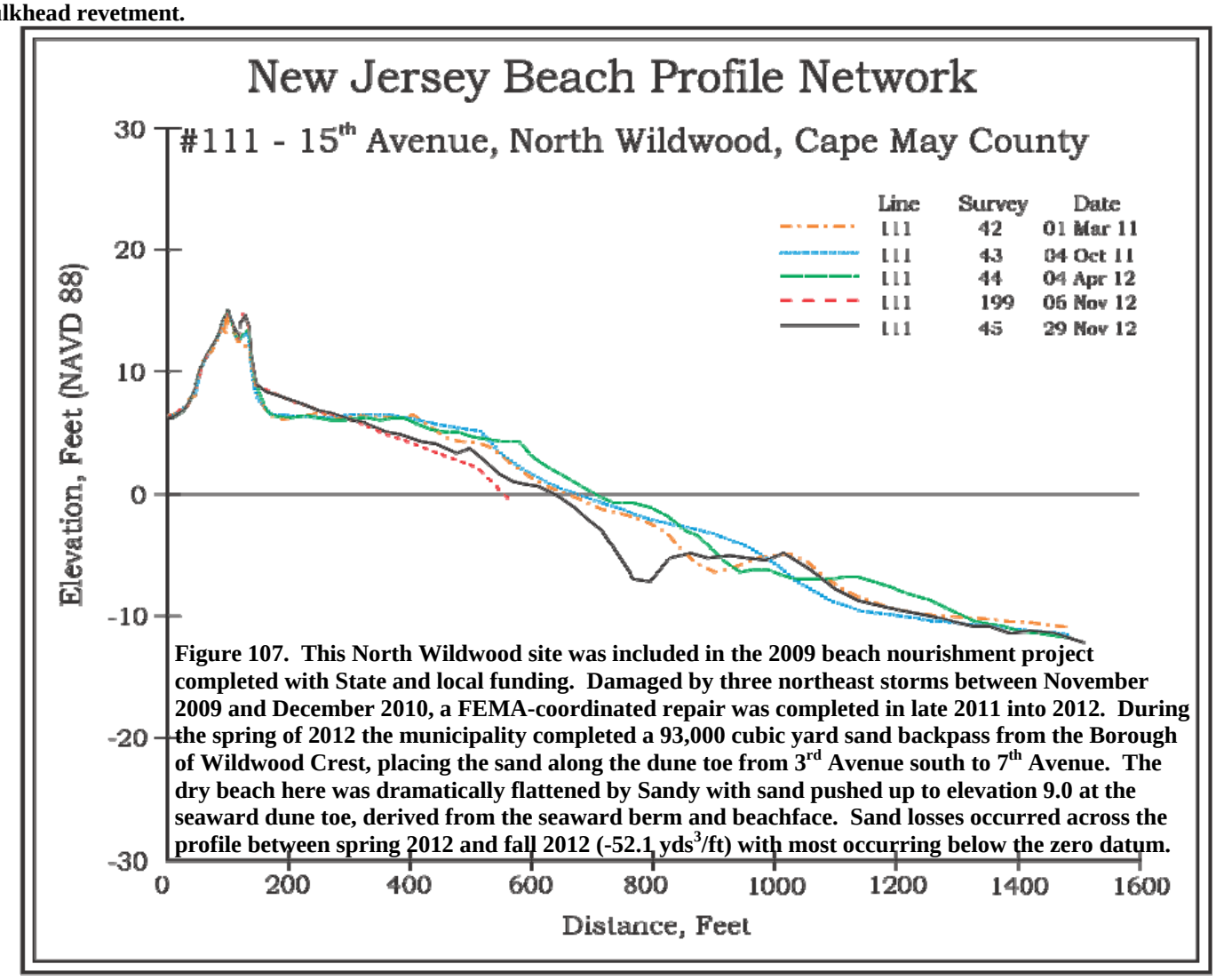


Figure 107. This North Wildwood site was included in the 2009 beach nourishment project completed with State and local funding. Damaged by three northeast storms between November 2009 and December 2010, a FEMA-coordinated repair was completed in late 2011 into 2012. During the spring of 2012 the municipality completed a 93,000 cubic yard sand backpass from the Borough of Wildwood Crest, placing the sand along the dune toe from 3rd Avenue south to 7th Avenue. The dry beach here was dramatically flattened by Sandy with sand pushed up to elevation 9.0 at the seaward dune toe, derived from the seaward berm and beachface. Sand losses occurred across the profile between spring 2012 and fall 2012 (-52.1 yds^3/ft) with most occurring below the zero datum.

Cresse Avenue, Wildwood, Cape May County, Site #110;

On April 4, 2012 the view across the beach in Wildwood was taken from the tiny dune in front of the boardwalk. The November 29th view on the right was taken from the same location, but minus the sign. The beach gained sand at the berm 600 feet seaward of the boardwalk. The sand deposit probably was derived from the erosion of the spring survey's berm.

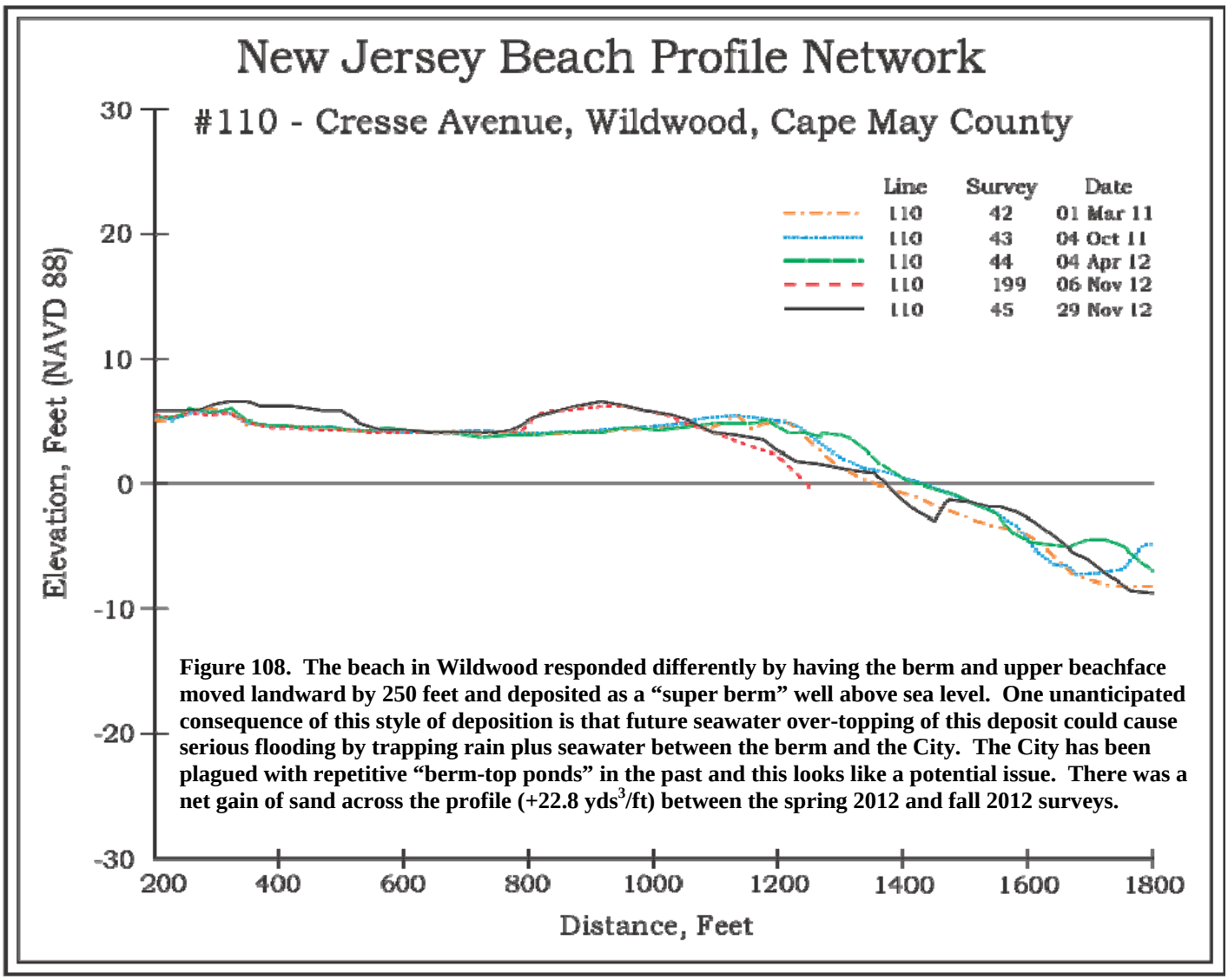


Figure 108. The beach in Wildwood responded differently by having the berm and upper beachface moved landward by 250 feet and deposited as a "super berm" well above sea level. One unanticipated consequence of this style of deposition is that future seawater over-topping of this deposit could cause serious flooding by trapping rain plus seawater between the berm and the City. The City has been plagued with repetitive "berm-top ponds" in the past and this looks like a potential issue. There was a net gain of sand across the profile (+22.8 yds^3/ft) between the spring 2012 and fall 2012 surveys.

Raleigh Avenue, Lower Township, Cape May County, Site #109;

The early spring photograph of the beach taken April 4, 2012 is shown on the left. The right-hand view was taken November 29th a month after the storm. Here sand was forced landward to the toe of the dunes where a deposit filled in a slightly lower part of the beach than the berm. The sand on the berm was likely the source of the deposit since the storm surge flooded the entire dry beach.

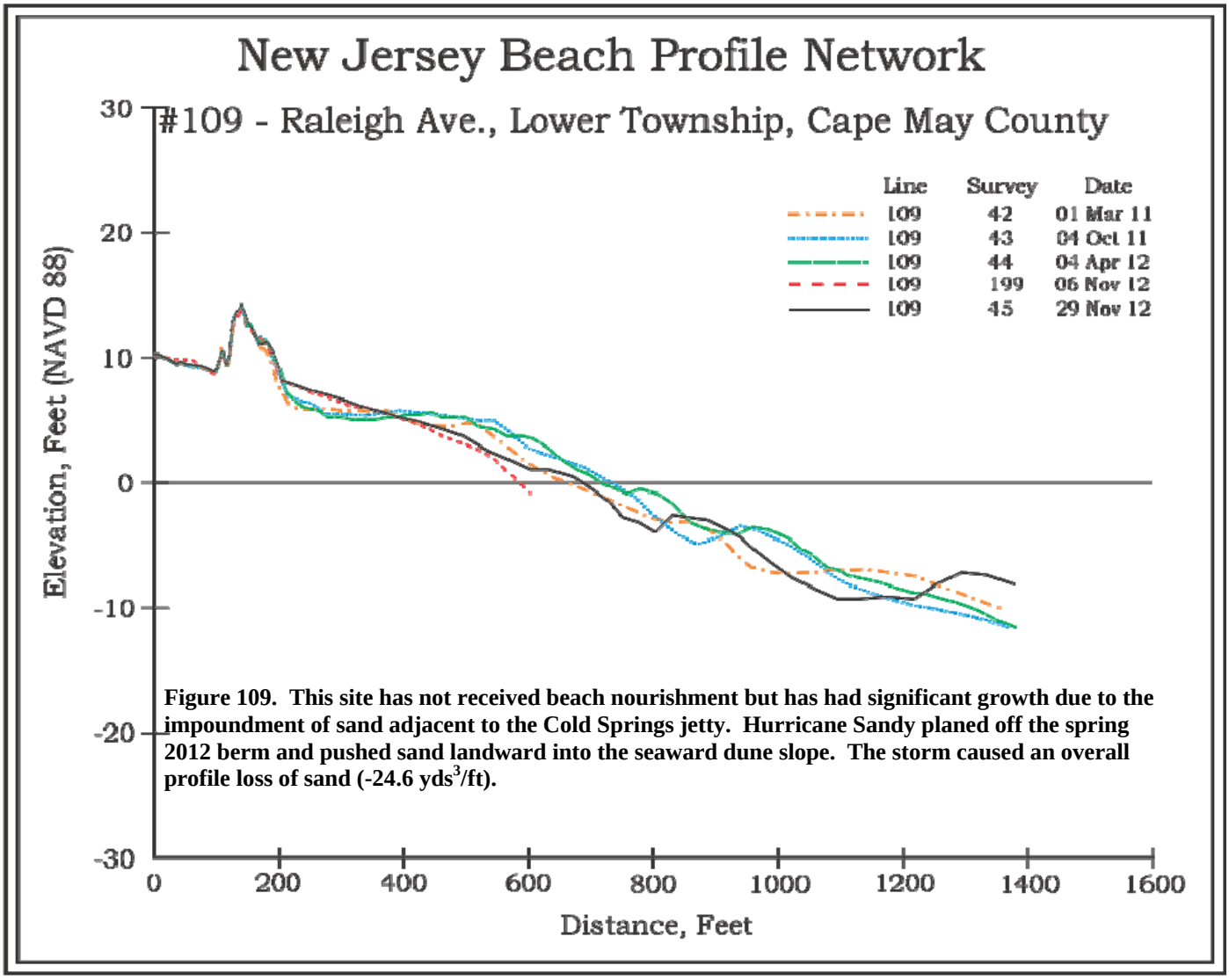


Figure 109. This site has not received beach nourishment but has had significant growth due to the impoundment of sand adjacent to the Cold Springs jetty. Hurricane Sandy planed off the spring 2012 berm and pushed sand landward into the seaward dune slope. The storm caused an overall profile loss of sand (-24.6 yds^3/ft).

US Coast Guard Base, Lower Township, Cape May County, Site #208;

The left picture was taken March 9, 2012 looking toward the sea. The natural areas were surveyed last and done with normal procedures, so the length of the surveys are equal and extend well off shore. The outfall line shows in both photographs (December 11th for the right side) and shows that little change in beach elevation occurred. The berm was eroded somewhat and transported toward the dunes. Water reached into the new foredune area directly landward of the vehicle and washed up into the second ridgeline. The new, white sand in the center of the right photo is not present on the left side.

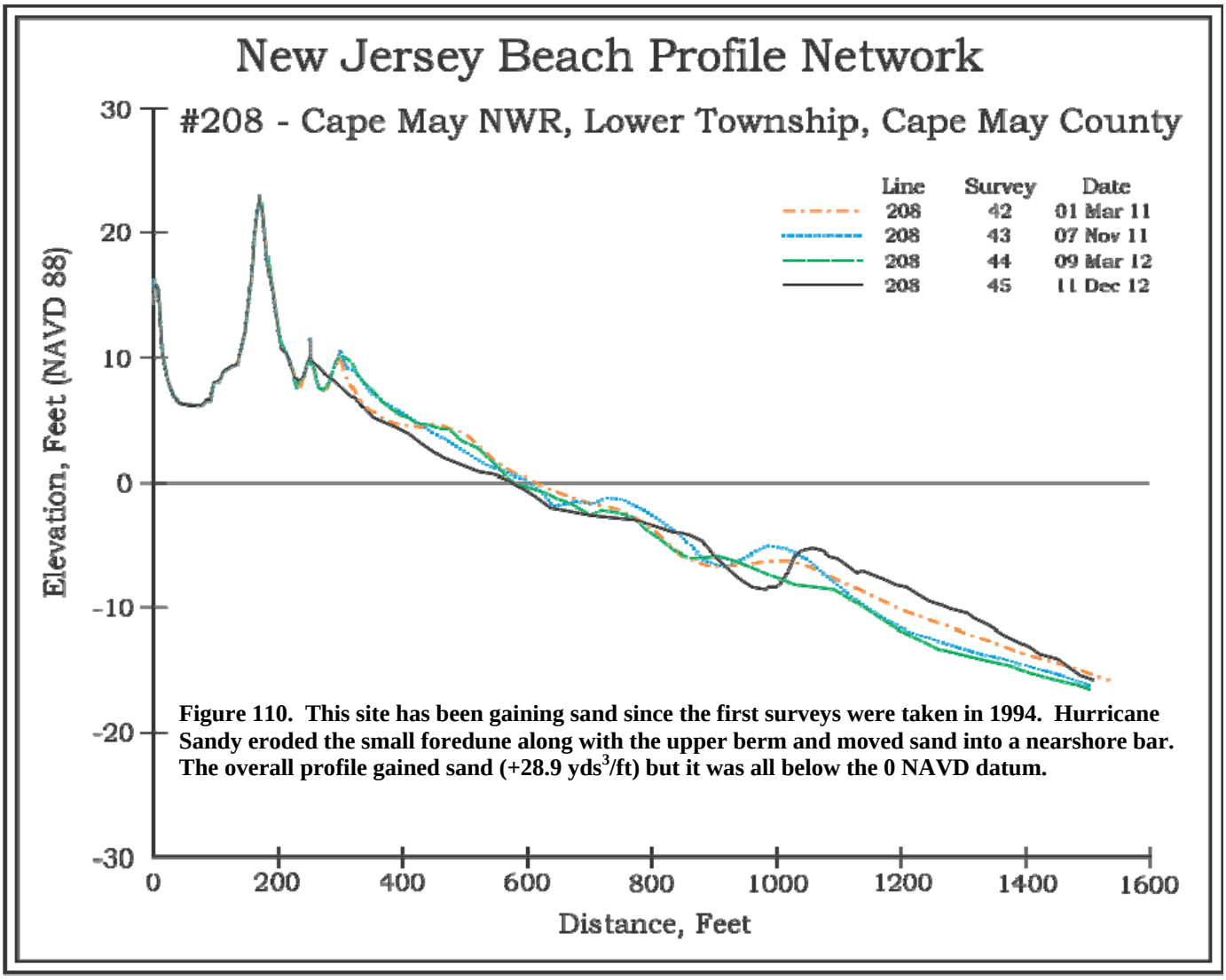


Figure 110. This site has been gaining sand since the first surveys were taken in 1994. Hurricane Sandy eroded the small foredune along with the upper berm and moved sand into a nearshore bar. The overall profile gained sand (+28.9 yds^3/ft) but it was all below the 0 NAVD datum.

Cape May Beach Club, Cape May City, Cape May County, Site #108;

On June 5, 2012, the beach was wide with the removable boardwalk ready for the summer. The post-storm picture on the right was taken November 9th at approximately the same spot looking southeast to the ocean. Assuming that the photographers are all about the same height and were standing when they took the shots, the berm elevation covers far more of the view of the ocean in November than it did in June. The cross section below shows why.

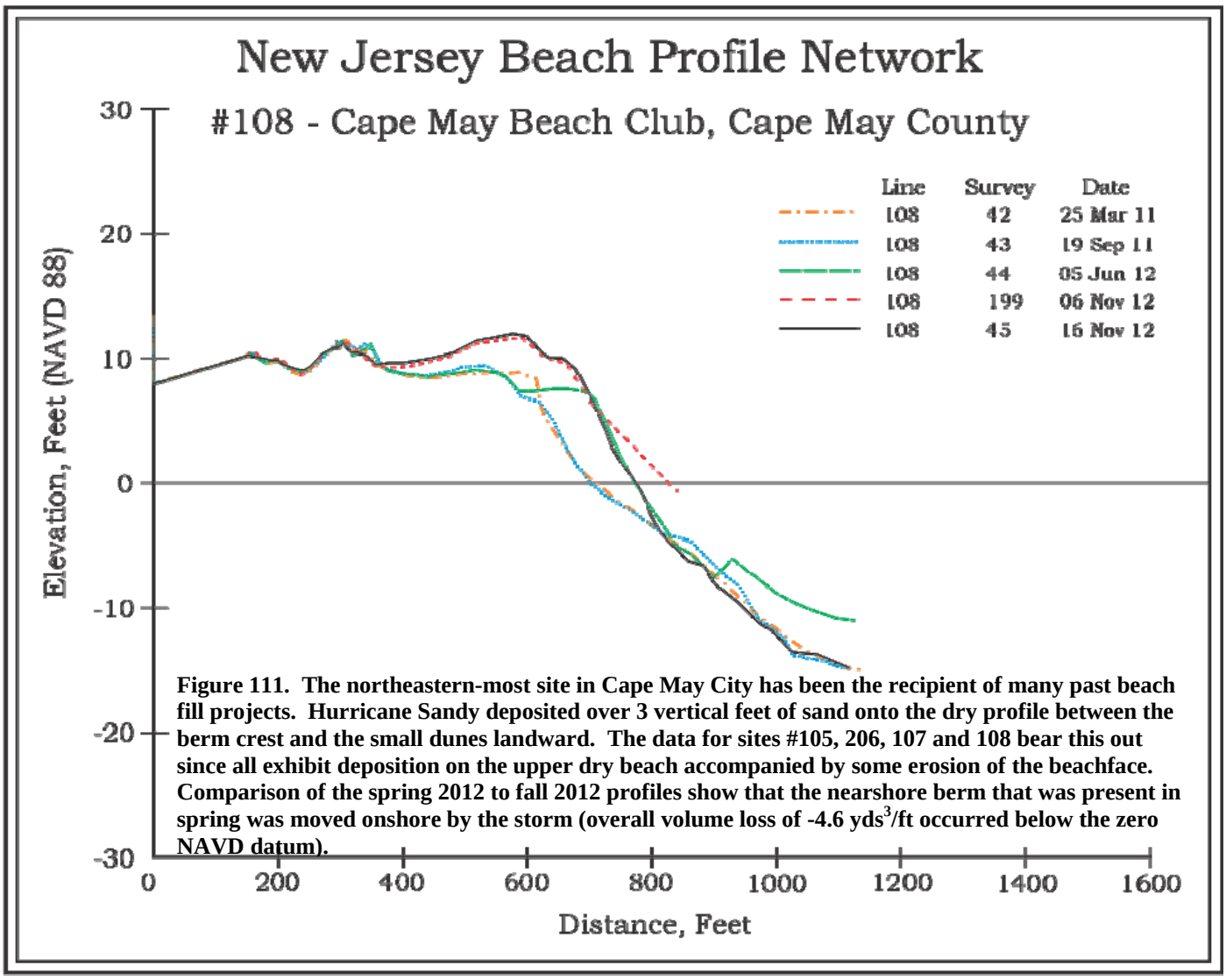


Figure 111. The northeastern-most site in Cape May City has been the recipient of many past beach fill projects. Hurricane Sandy deposited over 3 vertical feet of sand onto the dry profile between the berm crest and the small dunes landward. The data for sites #105, 206, 107 and 108 bear this out since all exhibit deposition on the upper dry beach accompanied by some erosion of the beachface. Comparison of the spring 2012 to fall 2012 profiles show that the nearshore berm that was present in spring was moved onshore by the storm (overall volume loss of -4.6 yds^3/ft occurred below the zero NAVD datum).

Baltimore Avenue, Cape May City, Cape May County, Site #107;

The left picture was taken in June 5, 2012 showing the beach toward the northeast. The post-storm shot on the right was taken November 9th. The sand can be seen deposited around the fencing leaving only two rows of wire above the sand while in June there were 5 rows of wire showing. Here the beach was also widened toward the zero elevation position.

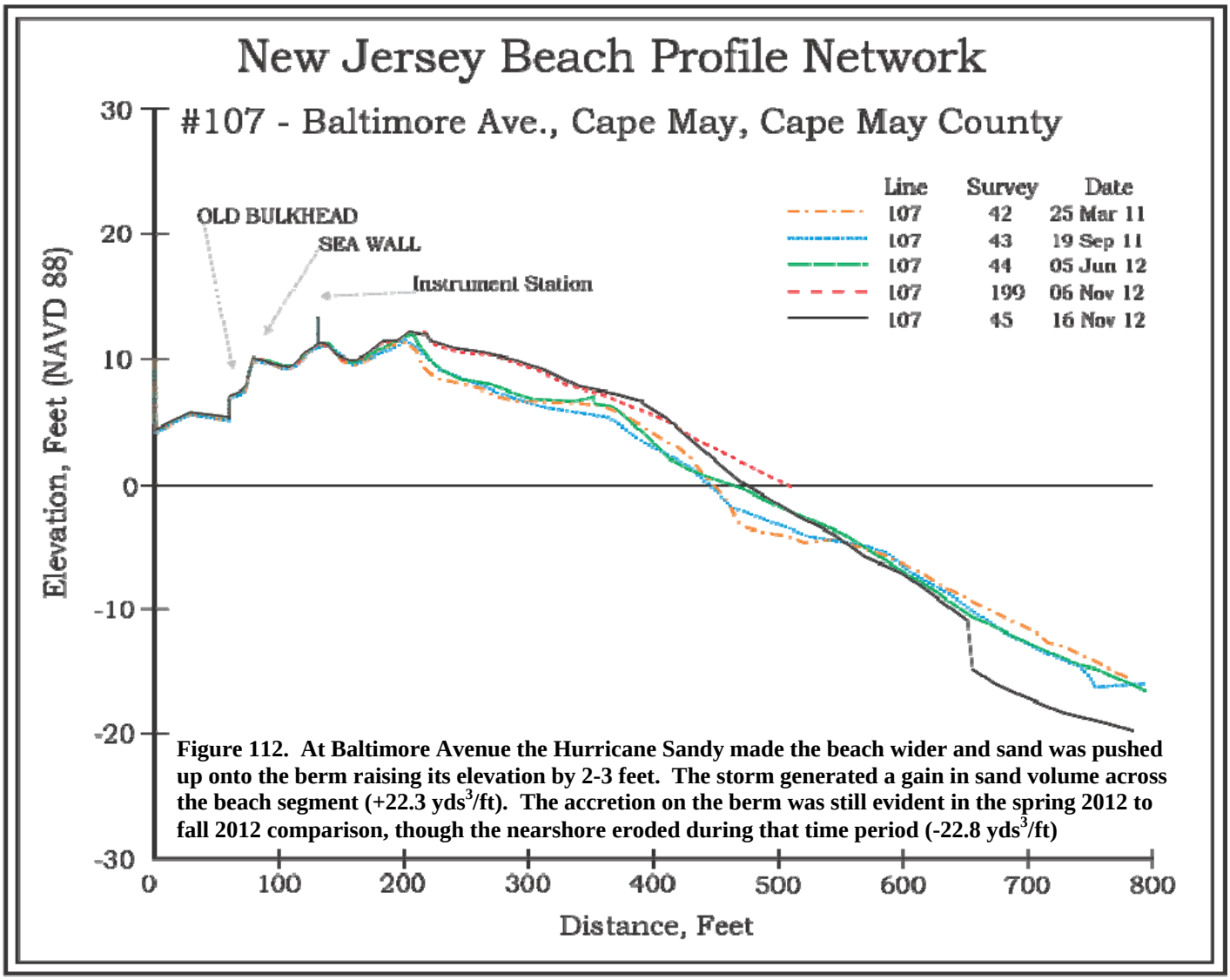


Figure 112. At Baltimore Avenue the Hurricane Sandy made the beach wider and sand was pushed up onto the berm raising its elevation by 2-3 feet. The storm generated a gain in sand volume across the beach segment (+22.3 yds^3/ft). The accretion on the berm was still evident in the spring 2012 to fall 2012 comparison, though the nearshore eroded during that time period (-22.8 yds^3/ft)

Broadway Avenue, Cape May City, Cape May County, Site #206;

The June 5, 2012 picture shows the popular bathing beach at the beginning of the last summer season. The right side shows the post-storm view on November 9th. The elevation increase shown below can be seen in the smaller slice of ocean in the right-hand view as compared to the left side. The seaward stair railings in both pictures have the same relative relationship to the horizon indicating that the view from the camera is almost the same elevation in both pictures.

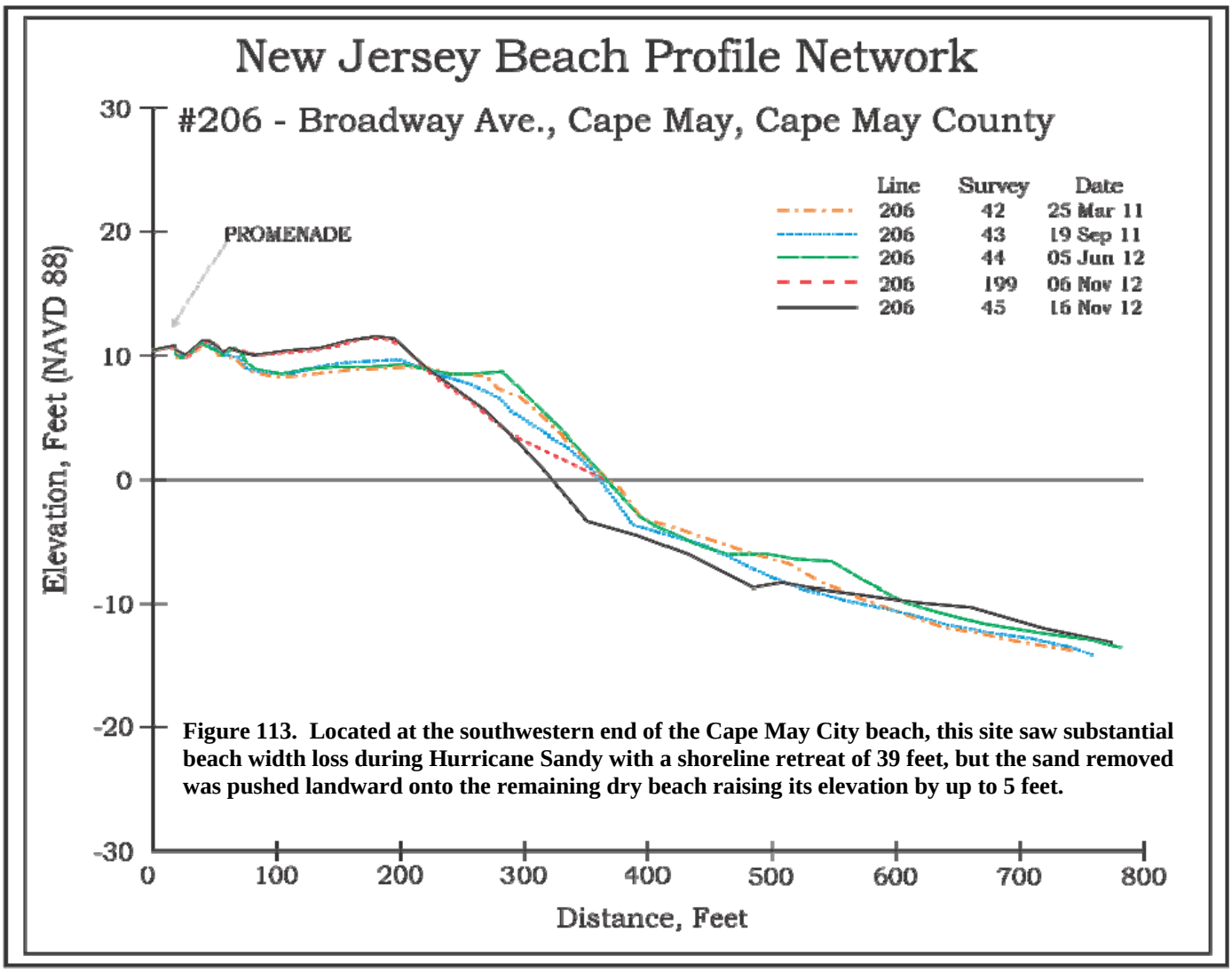


Figure 113. Located at the southwestern end of the Cape May City beach, this site saw substantial beach width loss during Hurricane Sandy with a shoreline retreat of 39 feet, but the sand removed was pushed landward onto the remaining dry beach raising its elevation by up to 5 feet.

Nature Conservancy, Cape May County, Site #105;

The left picture was taken March 5, 2012 looking toward the terminal groin in Cape May City. The left shot was done November 9th showing the dune erosion and overwash into the newer dune development that has occurred over the past 22 years since the initial beach restoration took place in Cape May City in 1990.

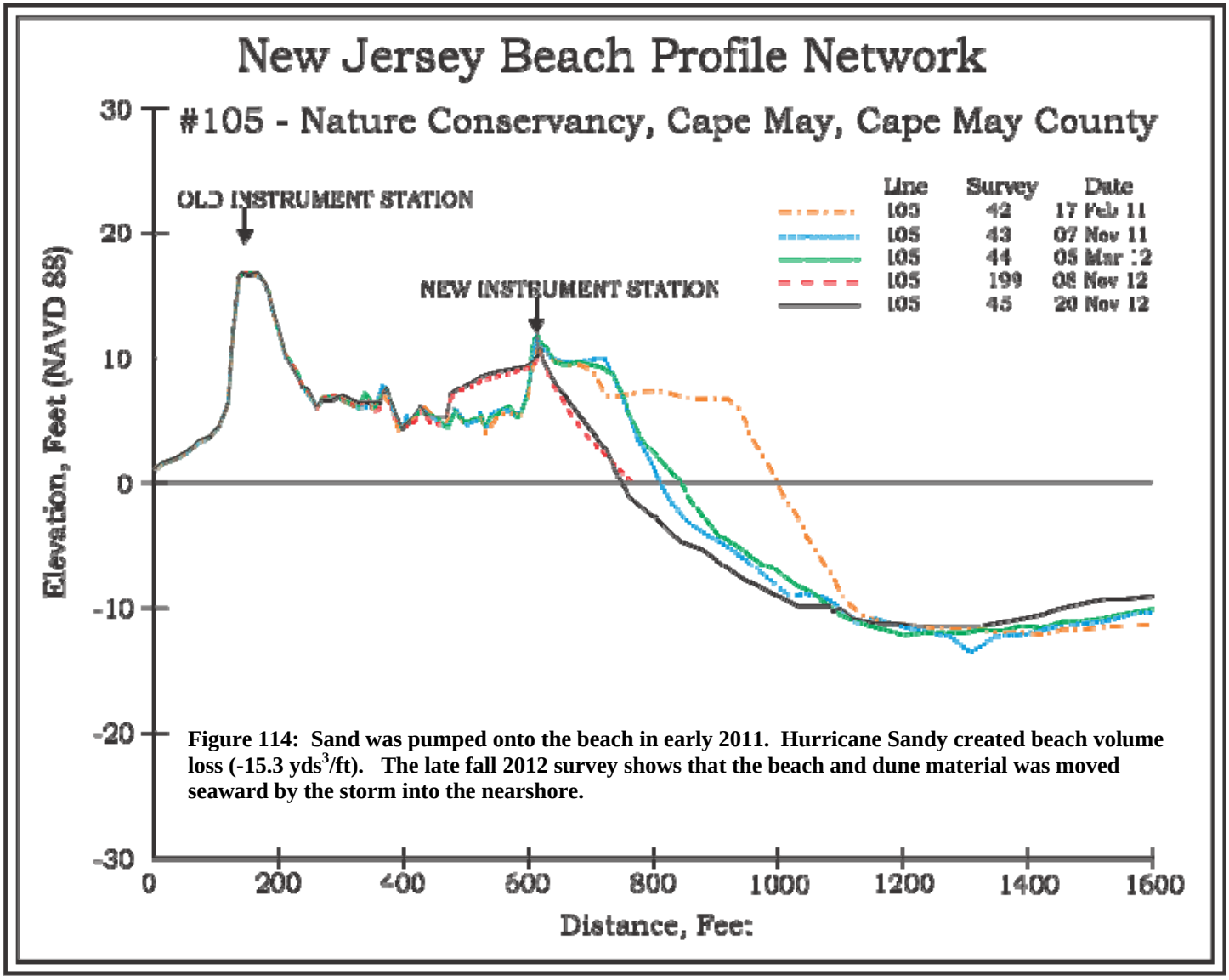


Figure 114: Sand was pumped onto the beach in early 2011. Hurricane Sandy created beach volume loss (-15.3 yds^3/ft). The late fall 2012 survey shows that the beach and dune material was moved seaward by the storm into the nearshore.

Lake Drive Cape May Point, Cape May County, Site #104;

The left picture was taken March 15, 2012 while the post-storm photograph was taken November 20th looking across the dunes to the bay. The beach was reduced in width somewhat, but no erosion occurred in the dunes. This location was essentially untouched by the storm.

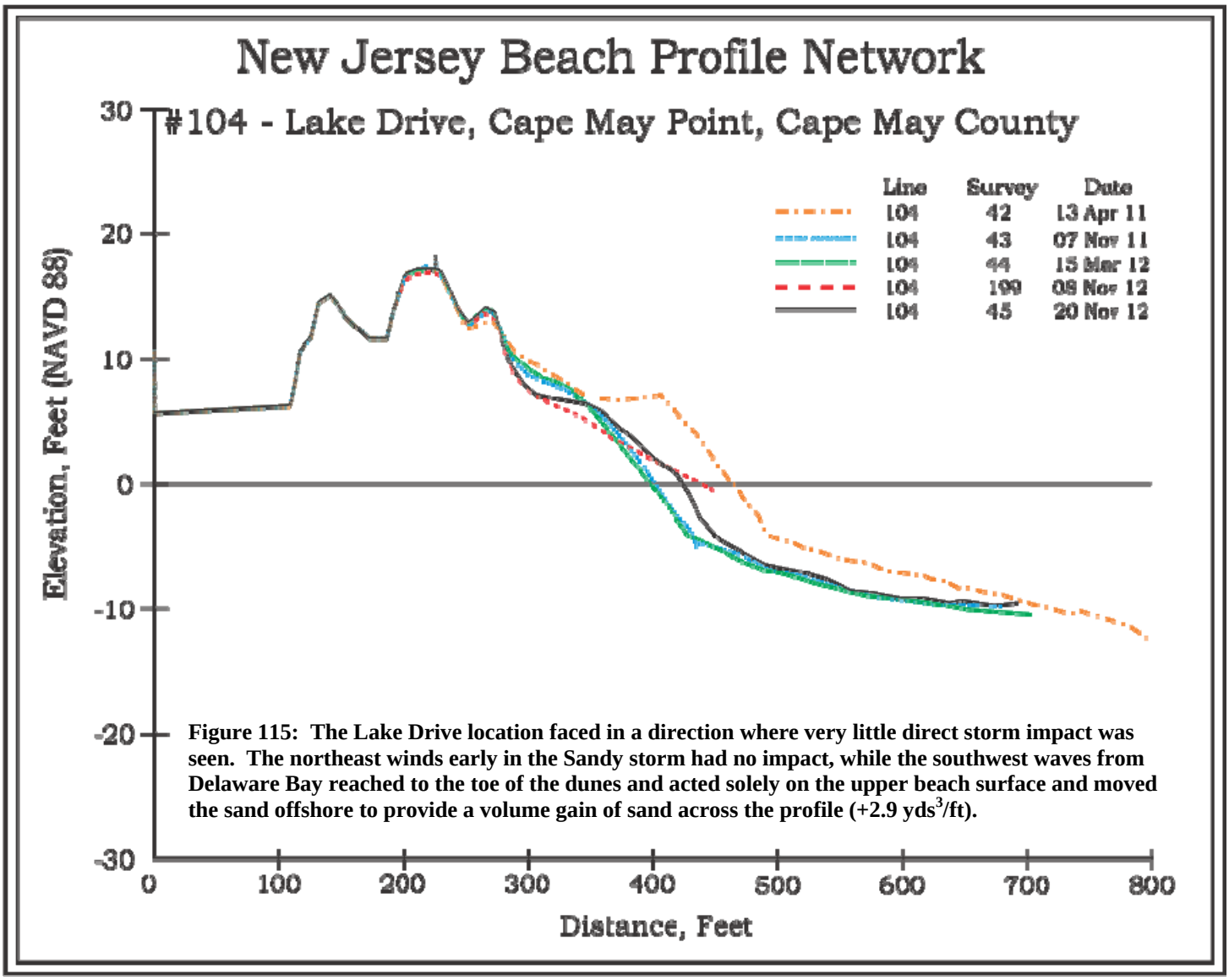


Figure 115: The Lake Drive location faced in a direction where very little direct storm impact was seen. The northeast winds early in the Sandy storm had no impact, while the southwest waves from Delaware Bay reached to the toe of the dunes and acted solely on the upper beach surface and moved the sand offshore to provide a volume gain of sand across the profile (+2.9 yds^3/ft).

Higbee Beach State Park, Cape May County, Site #103;

The left picture was taken March 5, 2012 while the post-storm picture on the right was taken November 20, 2012. The shoreline at the State Park, south of the Cape May Canal suffered bluff erosion into the mantle of wind-deposited sand that mantles the scarp. The incipient grasses were stripped away between the high tide line and the base of the bluff during Sandy. The beach was lower but wider with some sand moved into the bay.

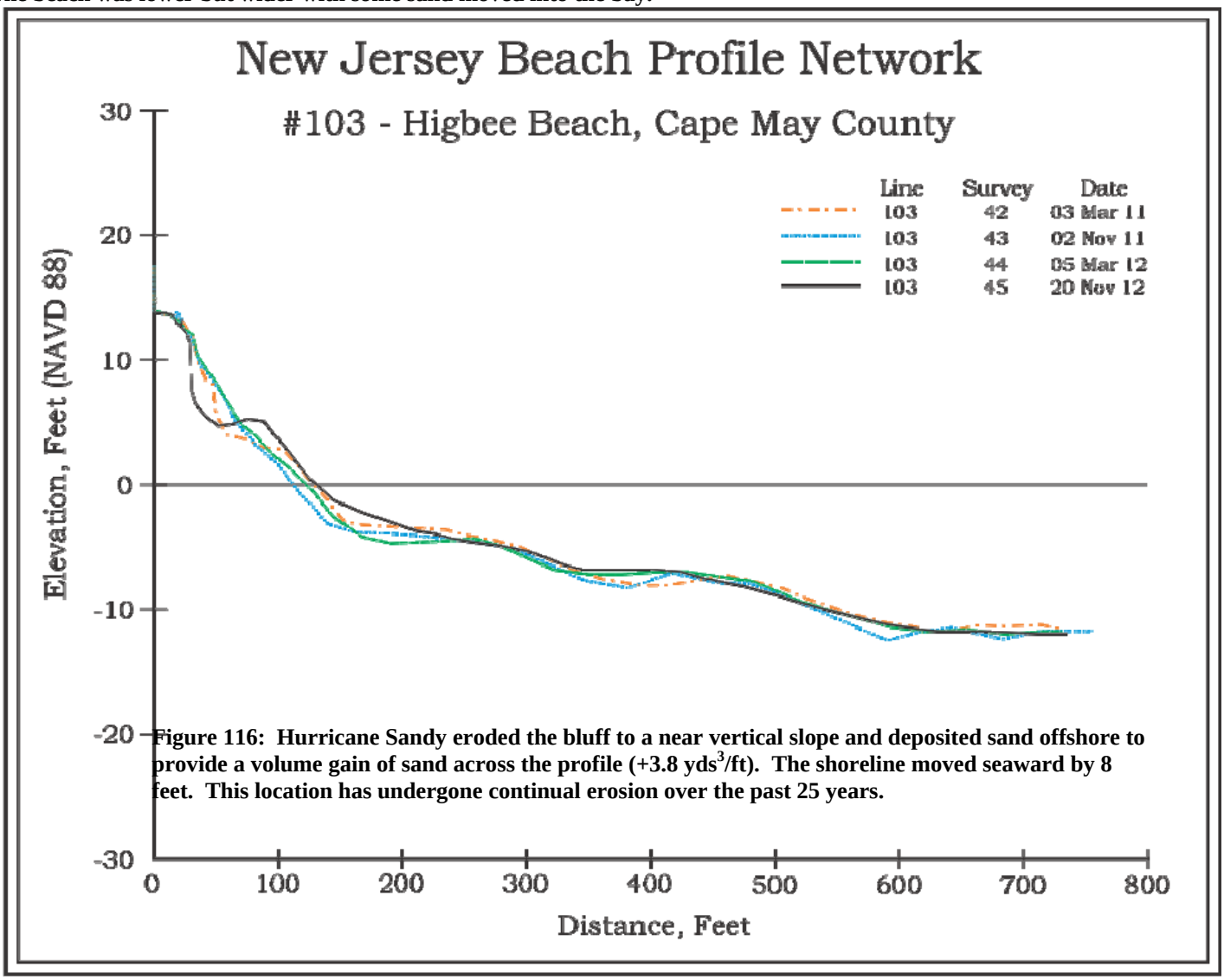


Figure 116: Hurricane Sandy eroded the bluff to a near vertical slope and deposited sand offshore to provide a volume gain of sand across the profile (+3.8 yds^3/ft). The shoreline moved seaward by 8 feet. This location has undergone continual erosion over the past 25 years.

Whittier Avenue, North Cape May, Cape May County, Site #102;

At Whittier Avenue the drainage line shows the extent of beach erosion between March 15, 2012 and after Sandy on November 9th. Sand was moved offshore onto the terrace, but the dune withstood the majority of the Delaware Bay wave assault on this shoreline.

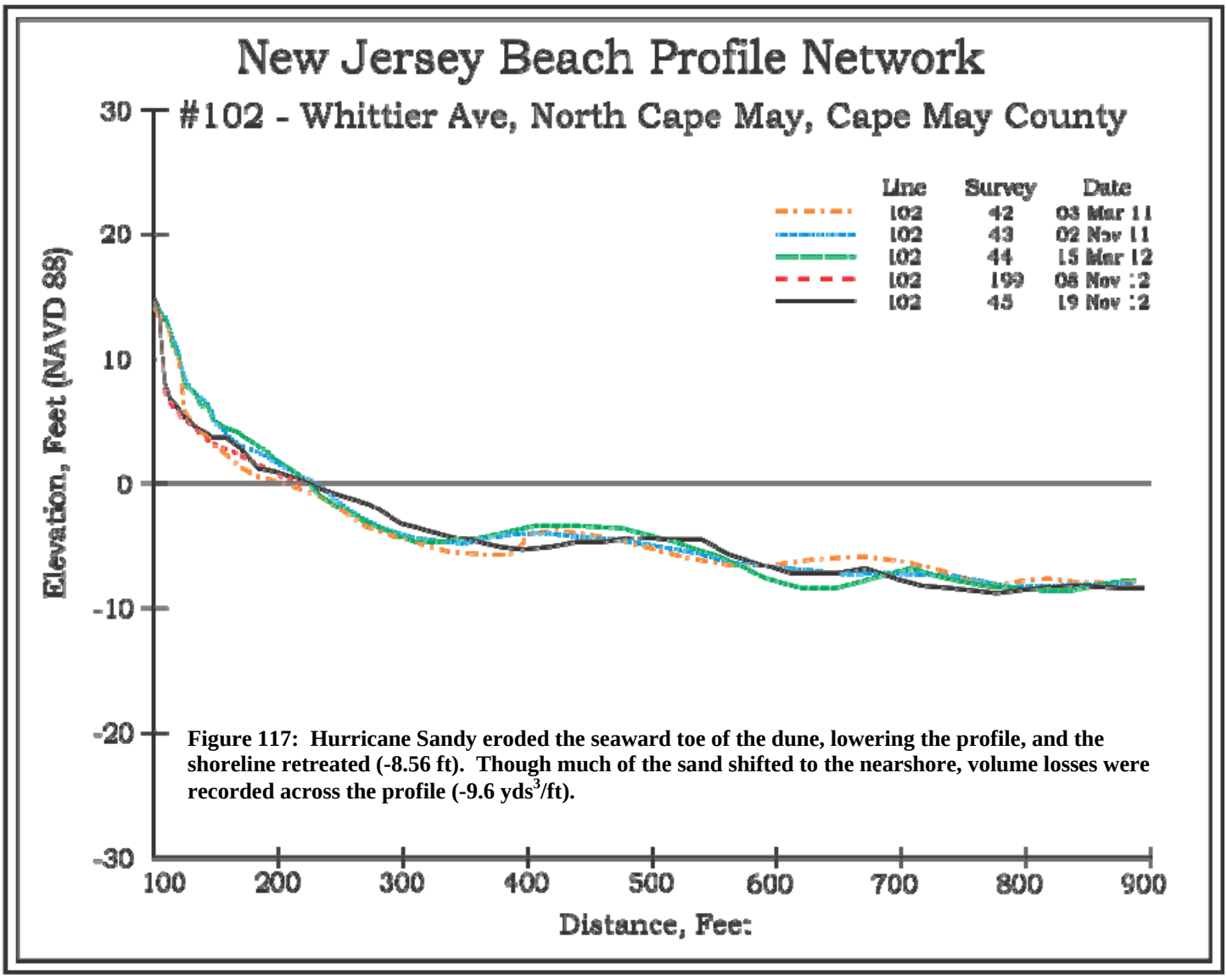
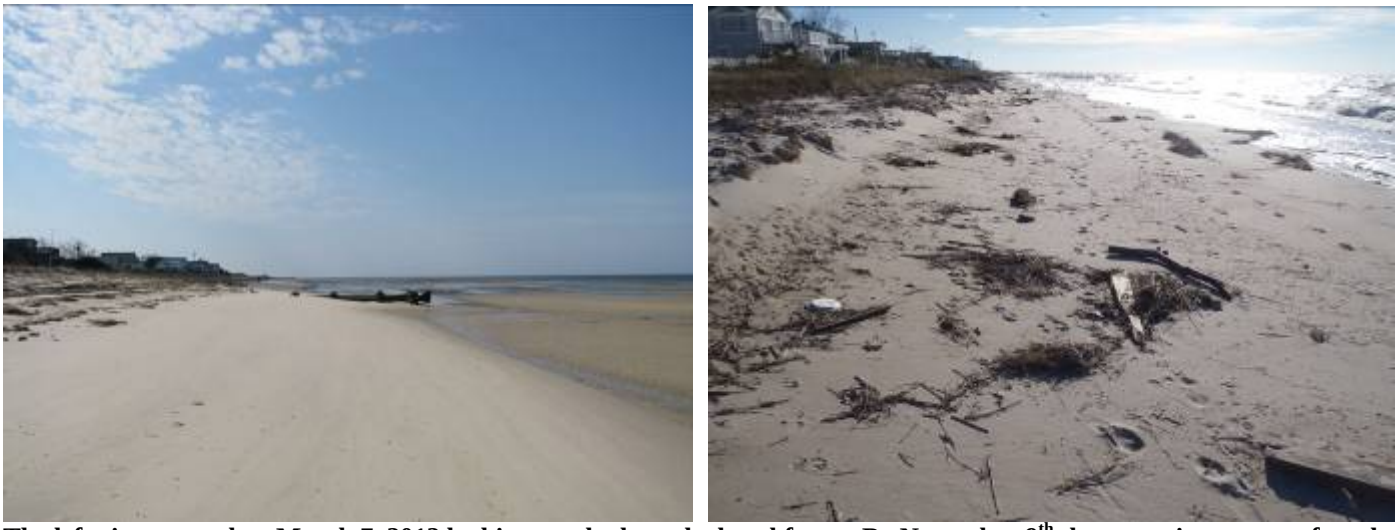


Figure 117: Hurricane Sandy eroded the seaward toe of the dune, lowering the profile, and the shoreline retreated (-8.56 ft). Though much of the sand shifted to the nearshore, volume losses were recorded across the profile (-9.6 yds^3/ft).

Pacific Avenue, Villas, Cape May County, Site #201;



The left view was taken March 7, 2012 looking south along the beachfront. By November 9th the storm impact was found to have eroded the beach into the toe of the dune reducing the beach elevation and creating a minor scarp. The height of the uplands bluff prevented local wave or tidal flooding.

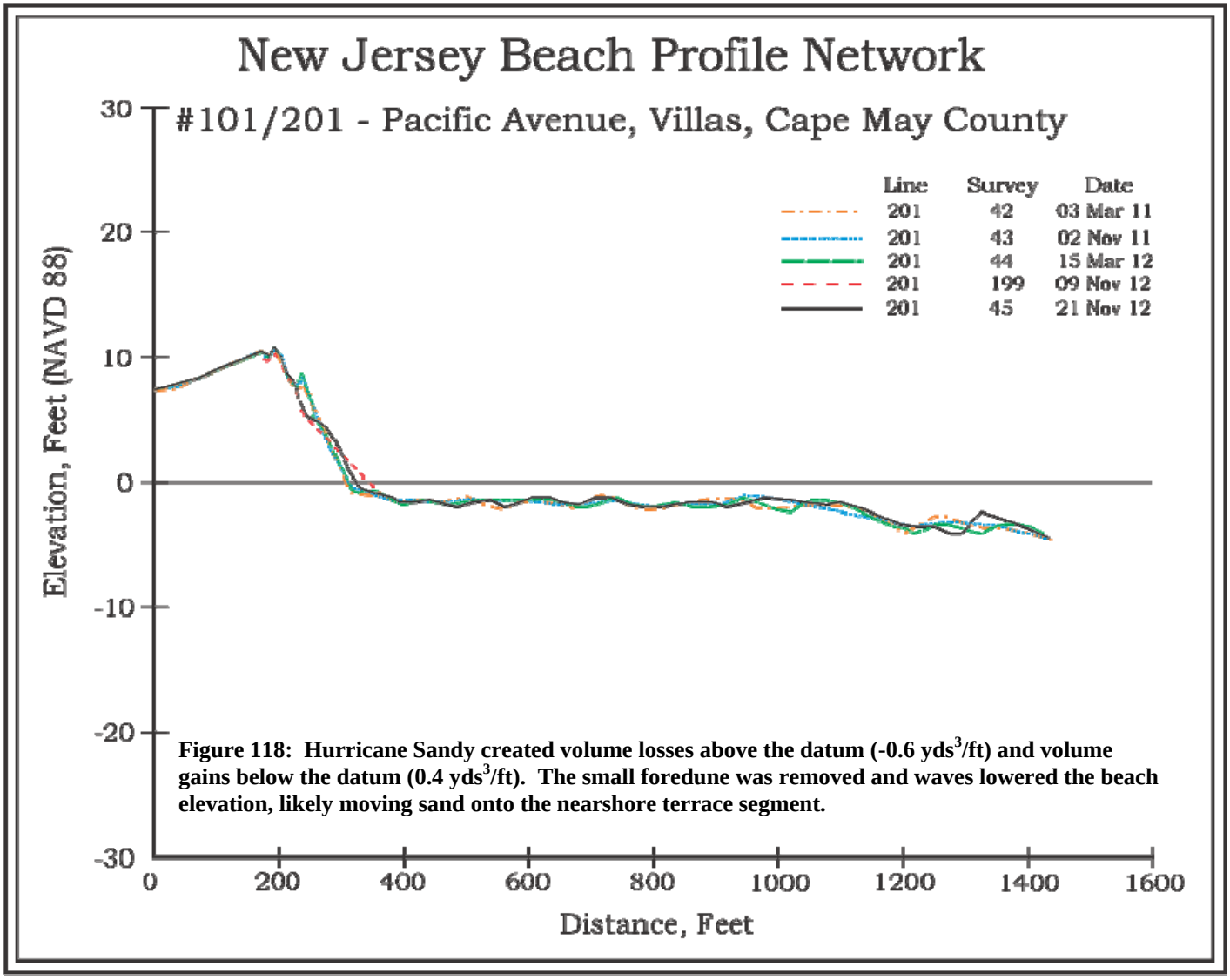


Figure 118: Hurricane Sandy created volume losses above the datum (-0.6 yds^3/ft) and volume gains below the datum (0.4 yds^3/ft). The small foredune was removed and waves lowered the beach elevation, likely moving sand onto the nearshore terrace segment.

Reeds Beach, Cape May County, Site #100;

The left photograph was taken March 5, 2012 looking south. The dune was vegetated and the beach was higher in elevation compared to the post-Sandy picture on the right taken November 8, 2012. The sand in the center of the right photo has been transferred from the roadway back to the beach as a series of piles.

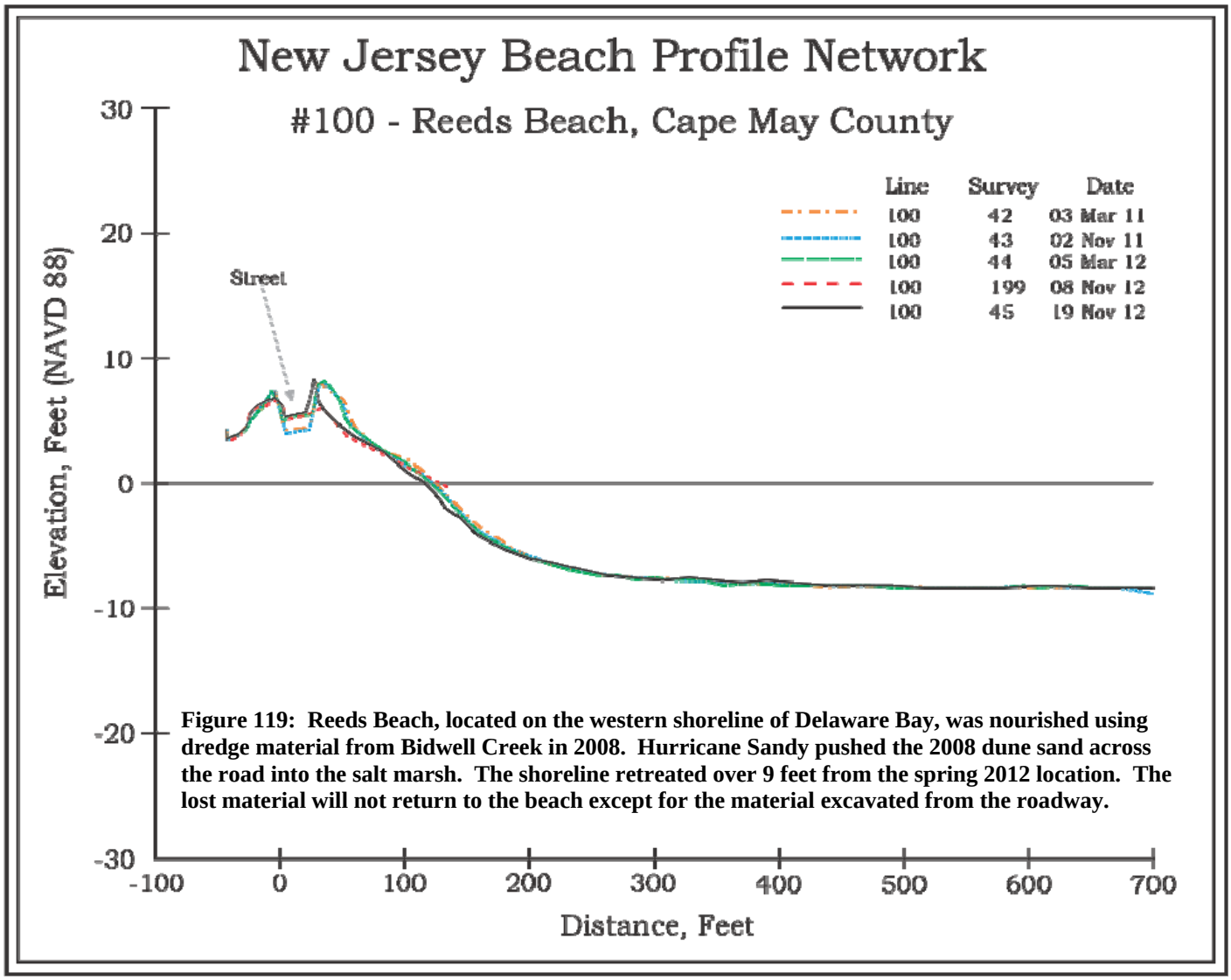


Figure 119: Reeds Beach, located on the western shoreline of Delaware Bay, was nourished using dredge material from Bidwell Creek in 2008. Hurricane Sandy pushed the 2008 dune sand across the road into the salt marsh. The shoreline retreated over 9 feet from the spring 2012 location. The lost material will not return to the beach except for the material excavated from the roadway.

Summary of Cape May County's Sandy impacts:

Cape May County's good fortune was greatly assisted by being located south of where the center of Sandy's rotation came ashore in New Jersey. The "eye" passed over northern Atlantic County about 9pm Monday night and produced a rapid change in the wind direction from the north-northeast to southwest. This acted to blunt the impact of the second high tide and reduce the wave height somewhat. Values of the elevation for wave run-up on dunes were between 13.5 and 14.5 feet NAVD 88 elevation. This was ten feet lower than similar measurements made in Long Branch, Monmouth County. In addition, many of the Cape May communities had been participants in the Philadelphia Army Corps Shore Protection projects starting in 1989 in Cape May City. Wide beaches with in-depth dune protection provided all the storm-stopping power needed to prevent wave damage and the flooding of the oceanfront streets with sand. A few places suffered mostly due to narrow beaches unable to limit wave impacts on the dunes. The horizontal erosion rates during Sandy were sufficient to cut through and produce overwash into Ocean City in spots, Sea Isle City in a few places, and in Wildwood where there was no dune to stop the water in spite of having the widest municipal beach in New Jersey. In 2009 a dune was incorporated into a beach restoration design for a NJ State – locally sponsored project with the City of North Wildwood. This dune served to demonstrate the difference in wave damage dunes can provide even for a community with an extremely wide natural beach.

The table below shows the sand volume change between either the earlier fall survey at each site or the spring 2012 survey (natural sites) and the post-Hurricane Sandy survey.

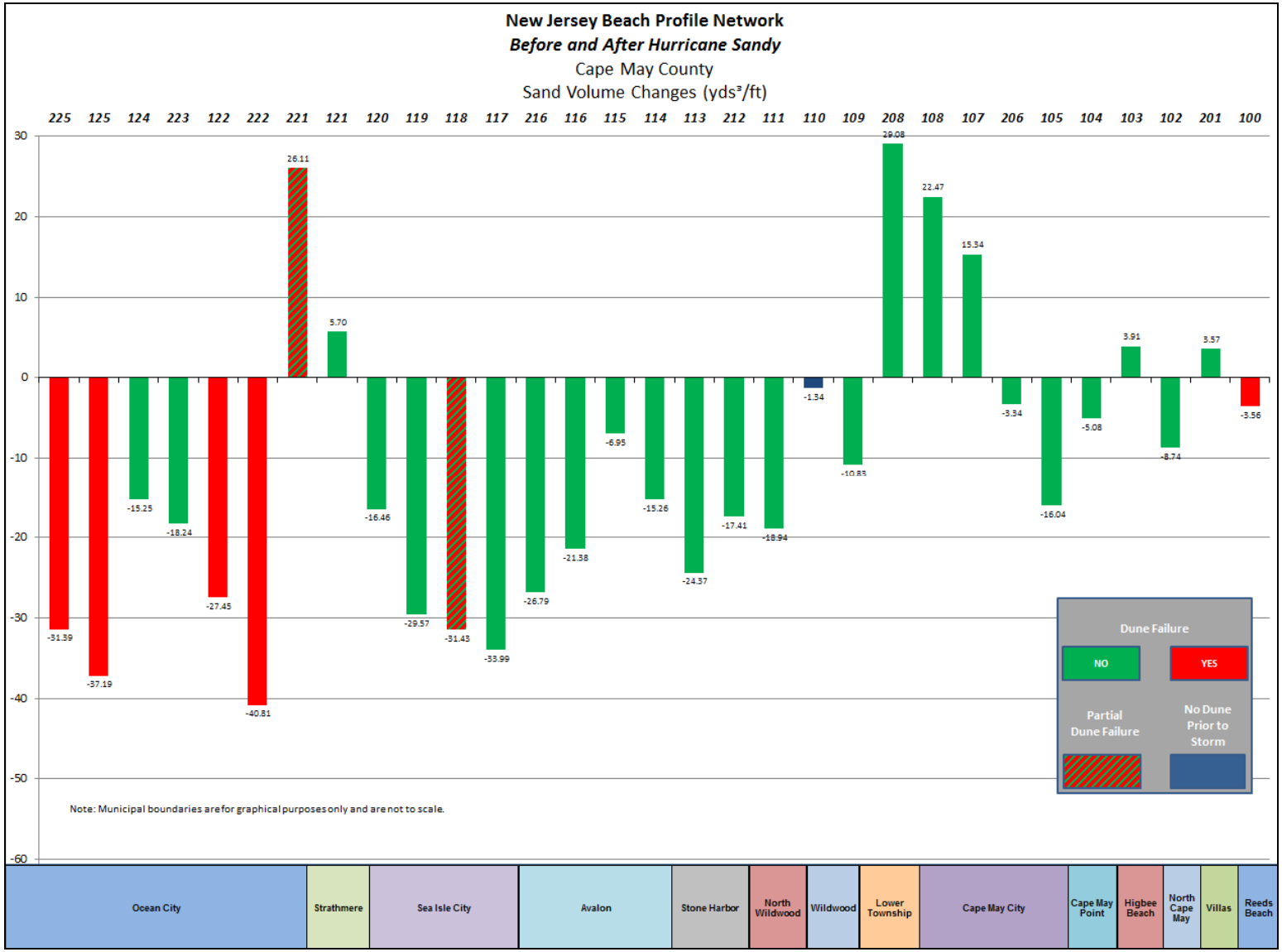


Figure 120. This graphic shows the sand volume loss figures for each of the communities within the developed sections of the Cape May County shoreline. Federal shore protection projects have occurred along this portion of the New Jersey shoreline in Ocean City, Strathmere, Sea Isle City, Avalon, Stone Harbor, North Wildwood, Cape May City, Cape May Point, and Reeds Beach. The engineered beach and dune systems have been maintained by the USACE recently and kept the storm generated waves from breaching the dunes. All sites experienced berm erosion and dune losses except for site 221 Corson's Inlet State Park, which is undeveloped, site 121 in Strathmere, which recently completed a beach nourishment project, sites 208 Cape May National Wildlife Refuge, sites 108 and 107 in Cape May City, where the orientation of the storm and location of landfall actually created long period swell waves that built up the beach. There were also moderate gains at site 103 in Higbee Beach State Park and site 201 in the Villas, which is located in the Delaware Bay. True dune failures occurred in Ocean City, where the greatest sand volume losses also occurred and overwash of waves transported sand landward of the beach.

Cape May County Post Sandy Volume Changes

MUNICIPALITY	NJBPN Site#	Vol Change cu yds per ft	Average of Sand Loss Between Adjacent Sites (cy/ft)	Dune Failure	Recent Beach Fill	Distance Between Sites (FEET)	Vol Change - Cubic Yards Between Profiles (South to North)	Cumulative Volume Change - Cubic Yards (South to North)
Ocean City	225	-31.39	To Inlet	Y	2010	1,006	-31,578	-31,578
Ocean City	125	-37.19	-34.29	Y	2010	3,820	-130,997	-162,576
Ocean City	124	-15.25	-26.22	N	2010	8,108	-212,591	-375,166
Ocean City	223	-18.24	-16.74	N	2010	7,885	-132,027	-507,193
Ocean City	122	-27.45	-22.85	Y	1995	12,271	-280,328	-787,521
Ocean City	222	-40.81	-34.13	Y	1995	2,264	-77,287	-864,808
Corson's Inlet S Park	221	26.11	-7.35	Y-Partial	Never	1,739	-12,786	-877,593
Strathmere	121	5.70	15.90	N	2012	1,241	19,733	-857,861
Sea Isle City	120	-16.46	-5.38	N	2012	7,961	-42,834	-900,694
Sea Isle City	119	-29.57	-23.02	N	2012	6,824	-157,057	-1,057,752
Sea Isle City	118	-31.43	-30.50	Y-partial	2009	9,078	-276,889	-1,334,641
Sea Isle City	117	-33.99	-32.71	N	2009	6,087	-199,107	-1,533,747
Avalon	216	-26.79	-30.39	N	2011	500	-15,195	-1,548,942
Avalon	116	-21.38	-24.08	N	2012	3,921	-94,442	-1,643,385
Avalon	115	-6.95	-14.16	N	Never	3,482	-49,314	-1,692,699
Avalon	114	-15.26	-11.10	N	2011	9,780	-108,606	-1,801,305
Stone Harbor	113	-24.37	-19.81	N	2011	5,633	-111,605	-1,912,910
Stone Harbor	212	-17.41	-20.89	N	2011	9,833	-205,405	-2,118,315
North Wildwood	111	-18.94	-18.17	N	2011	3,582	-65,099	-2,183,414
Wildwood	110	-1.34	-10.14	No Dune	Never	9,987	-101,239	-2,284,653
Lower Township	109	-10.83	-6.08	N	Never	11,296	-68,718	-2,353,371
Lower Township	208	29.08	9.12	N	Never	3,638	33,198	-2,320,174
Cape May City	108	22.47	25.78	N	2010	5,757	148,387	-2,171,787
Cape May City	107	15.34	18.91	N	2010	2,667	50,424	-2,121,363
Cape May City	206	-3.34	6.00	N	2010	9,470	56,841	-2,064,522
Cape May Nature Con	105	-16.04	-9.69	N	2011	1,736	-16,819	-2,081,341
Cape May Point	104	-5.08	-10.56	N	2010	8,393	-88,616	-2,169,957
Higbee Beach S Park	103	3.91	-0.58	N	Never	9,934	-5,801	-2,175,758
North Cape May	102	-8.74	-2.41	N	Never	7,008	-16,914	-2,192,672
Villas	201	3.57	-2.58	N	Never	19,154	-49,484	-2,242,156
Reeds Beach	100	-3.56	0.01	Y	2010	35,265	282	-2,241,874

Figure 121. This table illustrates the changes in sand volume for the 31 Cape May County beach sites with the sand volume for the beach/dune part of the profile in cubic yards of sand per foot of shoreline at that site. The distance between sites (not counting inlets) allows an estimate of sand volume lost between profile locations that are compiled for the entire county in the right-hand column. Local site sand volumes in RED denote locations where Sandy added sand to the beaches and dunes.

TABLE 1
MONMOUTH COUNTY
ANNUAL BEACH VOLUME CHANGES
SPRING 2011 - SPRING 2012 & FALL 2011 - FALL 2012

PROFILE SITE LOCATION		Survey 42 - 44 S2011-S2012 (volume expressed as cubic yards per foot)	Survey 43 - 45 F2011 - F2012 (volume expressed as cubic yards per foot)
187:	Cliffwood Beach Park	-4.76	-8.21
286:	Union Beach	3.46	2.68
185:	Port Monmouth, Spy House Museum	4.84	14.09
285:	Gateway National R. A., Gunnison Beach	13.15	18.05
284:	Gateway National R. A., Parking Lot E	-32.27	-1.76
184:	Highland Beach, Gateway Entrance	-0.52	6.80
183:	Highland Beach, Via Ripa St.	-3.43	0.05
282:	Sea Bright, Shrewsbury Way	-19.14	-14.85
182:	Sea Bright, North of Route 520	-22.90	-22.71
181:	Sea Bright, Municipal Beach	-2.12	-23.48
180:	Sea Bright, Sunset Court	9.39	10.04
179:	Monmouth Beach, Cottage Rd.	225.96	171.75
178:	Monmouth Beach, Beach Club	95.31	-1.77
177:	Long Branch, 404 Ocean Ave.	33.07	-16.90
176:	Long Branch, Seven Presidents Park	13.28	1.11
175:	Long Branch, North Broadway Ave.	-12.48	24.26
174:	Long Branch, Morris Ave.	-14.46	-28.54
173:	Long Branch, West End Ave.	-45.35	-38.86
272:	Long Branch 805 Ocean Ave.	-12.72	-14.99
171:	Elberon, Pullman Ave.	-23.98	-12.84
170:	Deal, Roosevelt Ave.	8.84	16.63
169:	Deal, Darlington Ave.	7.32	-2.62
168:	Allenhurst, Corlies Ave.	49.77	27.43
267:	Asbury Park, 7th Ave.	28.60	12.69
167:	Asbury Park, 3rd Ave.	5.07	-11.57
166:	Ocean grove, Ocean Pathway	-7.48	-3.49
165:	Bradley Beach, McCabe Ave.	-4.65	-23.33
164:	Avon-By-The-Sea, Sylvania Ave.	-22.10	-7.65
163:	Belmar, 5th Ave.	-4.24	-8.90
162:	Belmar, 18th Ave.	-20.20	7.15
161:	Spring Lake, Brighton Ave.	-3.61	25.62
160:	Spring Lake, Salem Ave.	21.05	17.33
159:	Sea Girt, New York Ave.	23.35	24.08
158:	Sea Girt, Trenton Ave.	10.96	-17.13
157:	Manasquan, Riddle Way	5.04	-2.50
256:	Manasquan, Pompano Ave.	-45.68	-51.38

TABLE 2
MONMOUTH COUNTY
ANNUAL SHORELINE CHANGES
SPRING 2011 - SPRING 2012 & FALL 2011 - FALL 2012

PROFILE SITE LOCATION		Survey 42 - 44 S2011-S2012 (shoreline change expressed in feet)	Survey 43 - 45 F2011 - F2012 (shoreline change expressed in feet)
187:	Cliffwood Beach Park	-9.0	-2.9
286:	Union Beach	-0.8	8.7
185:	Port Monmouth, Spy House Museum	-7.3	3.4
285:	Gateway National R. A., Gunnison Beach	7.8	168.0
284:	Gateway National R. A., Parking Lot E	-30.7	37.9
184:	Highland Beach, Gateway Entrance	11.4	-55.3
183:	Highland Beach, Via Ripa St.	11.9	-33.4
282:	Sea Bright, Shrewsbury Way	-40.7	-111.5
182:	Sea Bright, North of Route 520	-1.7	-38.9
181:	Sea Bright, Municipal Beach	-15.9	-22.4
180:	Sea Bright, Sunset Court	43.9	30.3
179:	Monmouth Beach, Cottage Rd.	285.9	244.0
178:	Monmouth Beach, Beach Club	138.9	30.7
177:	Long Branch, 404 Ocean Ave.	109.7	-4.2
176:	Long Branch, Seven Presidents Park	64.9	13.2
175:	Long Branch, North Broadway Ave.	6.8	-1.8
174:	Long Branch, Morris Ave.	-13.2	-14.1
173:	Long Branch, West End Ave.	-10.8	-12.4
272:	Long Branch 805 Ocean Ave.	10.91	16.3
171:	Elberon, Pullman Ave.	2.7	-9.5
170:	Deal, Roosevelt Ave.	28.9	-8.5
169:	Deal, Darlington Ave.	21.0	15.4
168:	Allenhurst, Corlies Ave.	46.5	33.2
267:	Asbury Park, 7th Ave.	45.4	23.6
167:	Asbury Park, 3rd Ave.	41.5	6.7
166:	Ocean grove, Ocean Pathway	32.2	47.6
165:	Bradley Beach, McCabe Ave.	9.4	42.6
164:	Avon-By-The-Sea, Sylvania Ave.	10.0	27.5
163:	Belmar, 5th Ave.	16.2	5.3
162:	Belmar, 18th Ave.	5.2	28.9
161:	Spring Lake, Brighton Ave.	25.4	34.5
160:	Spring Lake, Salem Ave.	54.0	50.5
159:	Sea Girt, New York Ave.	45.7	89.2
158:	Sea Girt, Trenton Ave.	60.5	63.0
157:	Manasquan, Riddle Way	86.7	21.2
256:	Manasquan, Pompano Ave.	19.2	15.6

TABLE 3
MONMOUTH COUNTY
SEASONAL BEACH VOLUME CHANGES

PROFILE SITE LOCATION	Survey	42-43 S11-F11	43-44 F11-S12	44-45 S1-F12	42-45 S11-F12
		(volume expressed as cubic yards per foot of beachfront)			
187:	Cliffwood Beach Park	-3.81	-0.94	-7.08	-11.92
286:	Union Beach	2.86	0.59	2.09	5.50
185:	Port Monmouth, Spy House Museum	-6.64	11.44	2.60	7.44
285:	Gateway National R. A., Gunnison Beach	-20.84	33.92	-0.92	-1.37
284:	Gateway National R. A., Parking Lot E	-45.10	12.83	-14.58	-47.45
184:	Highland Beach, Gateway Entrance	-1.31	0.73	6.41	5.71
183:	Highland Beach, Via Ripa St.	-2.08	-1.33	1.40	-2.01
282:	Sea Bright, Shrewsbury Way	-16.69	-2.62	-5.17	-32.49
182:	Sea Bright, North of Route 520	-3.35	-19.13	-2.77	-25.69
181:	Sea Bright, Municipal Beach	6.02	-5.54	-14.83	-16.90
180:	Sea Bright, Sunset Court	-5.36	14.74	-5.45	5.74
179:	Monmouth Beach, Cottage Rd.	12.73	217.08	-42.97	181.88
178:	Monmouth Beach, Beach Club	15.13	77.94	-79.17	15.96
177:	Long Branch, 404 Ocean Ave.	8.76	24.90	-40.28	-6.79
176:	Long Branch, Seven Presidents Park	3.13	10.11	-8.67	4.50
175:	Long Branch, North Broadway Ave.	1.63	-12.22	43.40	30.94
174:	Long Branch, Morris Ave.	-0.06	-14.63	-14.24	-28.69
173:	Long Branch, West End Ave.	-34.24	-11.61	-25.81	-72.88
272:	Long Branch 805 Ocean Ave.	-2.51	-9.86	-4.37	-17.78
171:	Elberon, Pullman Ave.	-21.16	-3.23	-8.45	-35.14
170:	Deal, Roosevelt Ave.	-21.62	30.42	-14.16	-4.93
169:	Deal, Darlington Ave.	6.80	0.44	-3.06	4.29
168:	Allenhurst, Corlies Ave.	40.65	9.12	16.56	69.83
267:	Asbury Park, 7th Ave.	32.42	-3.58	16.66	45.13
167:	Asbury Park, 3rd Ave.	15.43	-10.09	-2.71	4.18
166:	Ocean grove, Ocean Pathway	-3.74	-3.69	0.05	-7.23
165:	Bradley Beach, McCabe Ave.	12.83	-17.64	-6.33	-11.24
164:	Avon-By-The-Sea, Sylvania Ave.	-17.45	-4.53	-2.79	-24.99
163:	Belmar, 5th Ave.	10.21	-17.52	8.93	3.63
162:	Belmar, 18th Ave.	-13.89	-5.66	12.72	-6.55
161:	Spring Lake, Brighton Ave.	-26.80	23.21	2.36	-1.32
160:	Spring Lake, Salem Ave.	11.66	9.05	8.50	25.34
159:	Sea Girt, New York Ave.	17.61	6.45	17.22	40.79
158:	Sea Girt, Trenton Ave.	23.70	-12.88	-3.95	6.64
157:	Manasquan, Riddle Way	11.78	-5.79	3.03	6.15
256:	Manasquan, Pompano Ave.	-11.00	-35.81	-19.31	-56.47

TABLE 4
MONMOUTH COUNTY
SEASONAL SHORELINE CHANGES

PROFILE SITE LOCATION		Survey S11-F11	42-43 F11-S12	43-44 S1-F12	44-45 S11-F12	42-45
		(shoreline change expressed in feet)				
187:	Cliffwood Beach Park	-7.4	-1.7	-1.3	-10.3	
286:	Union Beach	-1.6	0.80	7.9	7.10	
185:	Port Monmouth, Spy House Museum	-1.9	-5.4	8.8	1.5	
285:	Gateway National R. A., Gunnison Beach	-47.2	55.0	113.0	120.8	
284:	Gateway National R. A., Parking Lot E	-70.1	39.3	-1.4	-32.1	
184:	Highland Beach, Gateway Entrance	20.4	-9.1	-46.3	-34.9	
183:	Highland Beach, Via Ripa St.	15.4	-3.5	-29.9	-18.0	
282:	Sea Bright, Shrewsbury Way	-17.2	-23.6	-88.0	-128.7	
182:	Sea Bright, North of Route 520	26.0	-27.8	-11.1	-12.9	
181:	Sea Bright, Municipal Beach	22.0	-37.9	15.5	-0.5	
180:	Sea Bright, Sunset Court	22.1	21.8	8.5	52.4	
179:	Monmouth Beach, Cottage Rd.	-1.9	287.8	-43.8	242.1	
178:	Monmouth Beach, Beach Club	22.0	117.0	-86.3	52.6	
177:	Long Branch, 404 Ocean Ave.	64.3	45.4	-49.5	60.1	
176:	Long Branch, Seven Presidents Park	44.1	20.7	-7.6	57.3	
175:	Long Branch, North Broadway Ave.	13.9	-7.1	5.3	12.1	
174:	Long Branch, Morris Ave.	-12.8	-0.4	-13.7	-26.9	
173:	Long Branch, West End Ave.	-19.7	8.9	-21.3	-32.1	
272:	Long Branch 805 Ocean Ave.	19.46	-8.55	24.9	35.8	
171:	Elberon, Pullman Ave.	3.1	-0.4	-9.2	-6.5	
170:	Deal, Roosevelt Ave.	12.1	16.8	-25.3	3.6	
169:	Deal, Darlington Ave.	19.3	1.8	13.7	34.7	
168:	Allenhurst, Corlies Ave.	44.1	2.4	30.8	77.2	
267:	Asbury Park, 7th Ave.	43.2	2.2	21.4	66.8	
167:	Asbury Park, 3rd Ave.	61.1	-19.6	26.4	67.9	
166:	Ocean grove, Ocean Pathway	8.2	24.0	23.6	55.8	
165:	Bradley Beach, McCabe Ave.	-5.0	14.4	28.3	37.6	
164:	Avon-By-The-Sea, Sylvania Ave.	-14.4	24.4	3.2	13.1	
163:	Belmar, 5th Ave.	16.5	-0.3	5.5	21.8	
162:	Belmar, 18th Ave.	-7.1	12.2	16.6	21.8	
161:	Spring Lake, Brighton Ave.	-7.7	33.1	1.4	26.8	
160:	Spring Lake, Salem Ave.	8.4	45.7	4.8	58.9	
159:	Sea Girt, New York Ave.	33.5	12.3	76.9	122.7	
158:	Sea Girt, Trenton Ave.	52.4	8.2	54.8	115.3	
157:	Manasquan, Riddle Way	35.8	50.9	-29.7	57.1	
256:	Manasquan, Pompano Ave.	-11.5	30.7	-15.2	4.0	

TABLE 5
OCEAN COUNTY
ANNUAL BEACH VOLUME CHANGES
SPRING 2011 - SPRING 2012 & FALL 2011 - FALL 2012

PROFILE SITE LOCATION		Survey 42 - 44 S2011-S2012 (volume expressed as cubic yards per foot)	Survey 43 - 45 F2011 - F2012 (volume expressed as cubic yards per foot)
156:	Point Pleasant, Water St.	80.41	40.08
155:	Point Pleasant, Maryland Ave.	-17.30	-12.32
154:	Bay Head, Johnson Ave.	25.09	17.90
153:	Mantoloking, 1117 Ocean Ave.	-5.11	-1.45
152:	Brick Townhsip, Public Beach	7.40	-3.37
151:	Normandy Beach, 1st Ave	10.97	-2.21
150:	Lavallette, White Ave.	4.57	12.29
149:	Ortley Beach, 8th Ave.	-12.09	-12.93
248:	Seaside, Franklin Ave.	13.33	20.22
148:	Seaside Park, 4th Ave.	-2.91	11.35
347:	Berkeley Township, 6th Ave.	-6.34	-0.91
247:	Island Beach State Park, North	-3.62	-2.70
246:	Island Beach State Park, Middle	10.89	-19.16
146:	Island Beach State Park, South	7.14	-38.29
245:	Barnegat Light, 10th St.	45.38	26.99
145:	Barnegat Light, 26th St.	26.37	39.07
144:	Loveladies, La Baia St.	34.79	18.22
143:	Harvey Cedars, 73rd St.	-36.73	-24.01
142:	Harvey Cedars, Tranquility Drive	-25.50	-1.85
241:	Surf City, 20th St.	41.65	10.77
141:	Ship Bottom, 8th St.	23.01	-6.67
140:	Long BeachTownship, 32nd St.	76.60	133.08
139:	Long Beach Township, 81st St.	2.08	0.10
138:	Long Beach Township, Old Whaling Rd.	-16.69	-2.78
137:	Beach Haven, Taylor Ave.	-26.31	-8.68
136:	Beach Haven, Dolphin Ave.	-34.49	-24.47
135:	Long Beach Township, Webster Ave.	36.40	29.53
234:	Long Beach Township, Border w/ Refuge	-71.99	-32.89

TABLE 6
OCEAN COUNTY
ANNUAL SHORELINE CHANGES
SPRING 2011 - SPRING 2012 & FALL 2011 - FALL 2012

PROFILE SITE LOCATION		Survey 42 - 44 S2011-S2012 (shoreline change expressed in feet)	Survey 43 - 45 F2011 - F2012 (shoreline change expressed in feet)
156:	Point Pleasant, Water St.	85.33	45.26
155:	Point Pleasant, Maryland Ave.	42.69	-24.81
154:	Bay Head, Johnson Ave.	87.59	10.11
153:	Mantoloking, 1117 Ocean Ave.	43.43	5.64
152:	Brick Township, Public Beach	51.08	18.37
151:	Normandy Beach, 1st Ave	35.31	3.52
150:	Lavallette, White Ave.	29.79	62.50
149:	Ortley Beach, 8th Ave.	77.89	-19.50
248:	Seaside, Franklin Ave.	57.99	19.83
148:	Seaside Park, 4th Ave.	36.55	17.27
347:	Berkeley Township, 6th Ave.	52.48	-5.67
247:	Island Beach State Park, North	67.98	34.14
246:	Island Beach State Park, Middle	59.51	-45.23
146:	Island Beach State Park, South	136.66	-85.57
245:	Barnegat Light, 10th St.	68.76	45.71
145:	Barnegat Light, 26th St.	39.07	38.59
144:	Loveladies, La Baia St.	67.52	93.35
143:	Harvey Cedars, 73rd St.	-28.06	9.84
142:	Harvey Cedars, Tranquility Drive	-25.36	13.95
241:	Surf City, 20th St.	55.56	17.68
141:	Ship Bottom, 8th St.	51.83	-7.28
140:	Long Beach Township, 32nd St.	141.97	216.12
139:	Long Beach Township, 81st St.	-0.79	-0.10
138:	Long Beach Township, Old Whaling Rd.	-15.47	11.67
137:	Beach Haven, Taylor Ave.	-29.05	-12.84
136:	Beach Haven, Dolphin Ave.	-50.05	-6.35
135:	Long Beach Township, Webster Ave.	27.71	36.29
234:	Long Beach Township, Border w/ Refuge	-111.60	-21.03

TABLE 7
OCEAN COUNTY
SEASONAL BEACH VOLUME CHANGES

PROFILE SITE LOCATION		Survey 42-43 S11-F11	43-44 F11-S12	44-45 S1-F12	42-45 S11-F12
		(volume expressed as cubic yards per foot of beachfront)			
156:	Point Pleasant, Water St.	54.65	20.78	18.64	96.01
155:	Point Pleasant, Maryland Ave.	-4.00	-13.60	2.25	-16.28
154:	Bay Head, Johnson Ave.	17.33	7.65	10.17	35.31
153:	Mantoloking, 1117 Ocean Ave.	1.67	-6.43	5.15	0.06
152:	Brick Townhsip, Public Beach	11.86	-4.46	1.09	8.48
151:	Normandy Beach, 1st Ave	13.99	-3.12	0.92	11.80
150:	Lavallette, White Ave.	2.59	1.64	10.63	15.12
149:	Ortley Beach, 8th Ave.	0.23	-9.27	-3.64	-18.09
248:	Seaside, Franklin Ave.	0.23	13.35	6.89	20.15
148:	Seaside Park, 4th Ave.	-11.82	8.80	2.42	-0.39
347:	Berkeley Township, 6th Ave.	-1.50	-1.55	0.70	-8.19
247:	Island Beach State Park, North	-3.24	-0.31	-2.43	-5.93
246:	Island Beach State Park, Middle	15.84	-4.95	-19.65	-8.72
146:	Island Beach State Park, South	-2.51	9.87	-46.40	-39.50
245:	Barnegat Light, 10th St.	41.45	3.93	22.98	68.35
145:	Barnegat Light, 26th St.	15.73	10.78	28.38	54.72
144:	Loveladies, La Baia St.	21.76	12.85	5.34	40.28
143:	Harvey Cedars, 73rd St.	-28.07	-8.69	-15.37	-52.03
142:	Harvey Cedars, Tranquility Drive	-13.81	-12.29	9.99	-15.51
241:	Surf City, 20th St.	42.95	-1.47	12.25	53.70
141:	Ship Bottom, 8th St.	30.10	-7.09	0.43	24.30
140:	Long BeachTownship, 32nd St.	-41.21	117.95	14.98	91.67
139:	Long Beach Township, 81st St.	9.02	-7.37	6.99	9.17
138:	Long Beach Township, Old Whaling Rd.	1.02	-17.71	14.84	-1.76
137:	Beach Haven, Taylor Ave.	-22.37	-4.03	-4.54	-30.87
136:	Beach Haven, Dolphin Ave.	-17.29	-16.93	-7.95	-42.16
135:	Long Beach Township, Webster Ave.	12.65	23.74	5.78	42.20
234:	Long Beach Township, Border w/ Refuge	-71.65	-0.30	-32.75	-104.56

TABLE 8
OCEAN COUNTY
SEASONAL SHORELINE CHANGES

PROFILE SITE LOCATION		Survey	42-43 S11-F11	43-44 F11-S12	44-45 S1-F12	42-45 S11-F12
			(shoreline change expressed in feet)			
156:	Point Pleasant, Water St.		55.92	29.42	15.88	101.21
155:	Point Pleasant, Maryland Ave.		57.54	-14.85	-9.96	32.73
154:	Bay Head, Johnson Ave.		79.78	7.81	2.30	89.89
153:	Mantoloking, 1117 Ocean Ave.		26.68	16.75	-11.11	32.32
152:	Brick Townhsip, Public Beach		19.98	31.10	-12.73	38.35
151:	Normandy Beach, 1st Ave		40.11	-4.81	8.33	43.64
150:	Lavallette, White Ave.		23.34	6.44	56.06	85.84
149:	Ortley Beach, 8th Ave.		81.88	-3.99	-15.51	62.38
248:	Seaside, Franklin Ave.		23.93	34.06	-14.23	43.76
148:	Seaside Park, 4th Ave.		1.87	34.67	-17.40	19.14
347:	Berkeley Township, 6th Ave.		29.05	23.42	-29.09	23.39
247:	Island Beach State Park, North		8.00	59.98	-25.84	42.15
246:	Island Beach State Park, Middle		21.86	37.65	-82.89	-23.37
146:	Island Beach State Park, South		42.16	94.50	-180.07	-43.41
245:	Barnegat Light, 10th St.		63.02	5.73	39.98	108.73
145:	Barnegat Light, 26th St.		18.48	20.60	18.00	57.07
144:	Loveladies, La Baia St.		22.39	45.13	48.22	115.74
143:	Harvey Cedars, 73rd St.		-12.69	-15.37	25.20	-2.85
142:	Harvey Cedars, Tranquility Drive		13.56	-38.91	52.86	27.50
241:	Surf City, 20th St.		59.01	-3.45	21.12	76.68
141:	Ship Bottom, 8th St.		53.72	-1.89	-5.37	46.46
140:	Long BeachTownship, 32nd St.		-59.68	201.65	14..47	156.44
139:	Long Beach Township, 81st St.		5.14	-5.94	5.83	5.04
138:	Long Beach Township, Old Whaling Rd.		-14.49	-0.99	12.66	-2.81
137:	Beach Haven, Taylor Ave.		-33.28	4.23	-17.07	-46.13
136:	Beach Haven, Dolphin Ave.		-27.42	-22.63	16.28	-33.77
135:	Long Beach Township, Webster Ave.		1.22	26.49	9.80	37.51
234:	Long Beach Township, Border w/Refuge		-120.55	8.95	-29.99	-141.59

TABLE 9
ATLANTIC COUNTY
ANNUAL BEACH VOLUME CHANGES
SPRING 2011 - SPRING 2012 & FALL 2011 - FALL 2012

PROFILE SITE LOCATION		Survey 42 - 44 S2011-S2012	Survey 43 - 45 F2011 - F2012
		(volume expressed as cubic yards per foot)	
134:	Brigantine, Green Acres	14.14	7.40
133:	Brigantine, 4th Street North	3.18	7.32
132:	Brigantine, 15th Street South	-13.72	1.94
131:	Brigantine, 43rd Street South	30.94	3.93
230:	Atlantic City, Rhode Island Ave.	95.21	45.28
130:	Atlantic City, North Carolina Ave.	177.96	75.21
129:	Atlantic City, Raleigh Ave.	19.47	18.07
128:	Ventnor City, Dorset Ave.	12.95	44.75
127:	Margate City, Benson Ave.	23.32	-16.52
126:	Longport, 17th St.	14.16	2.22

TABLE 10
ATLANTIC COUNTY
ANNUAL SHORELINE CHANGES
SPRING 2011 - SPRING 2012 & FALL 2011 - FALL 2012

PROFILE SITE LOCATION		Survey 42 - 44 S2011-S2012	Survey 43 - 45 F2011 - F2012
		(shoreline change expressed in feet)	
134:	Brigantine, Green Acres	24.6	-3.4
133:	Brigantine, 4th Street North	56.2	10.1
132:	Brigantine, 15th Street South	-10.7	-42.6
131:	Brigantine, 43rd Street South	25.9	50.4
230:	Atlantic City, Rhode Island Ave.	-160.1	99.4
130:	Atlantic City, North Carolina Ave.	214.1	124.1
129:	Atlantic City, Raleigh Ave.	11.3	-34.2
128:	Ventnor City, Dorset Ave.	15.2	6.5
127:	Margate City, Benson Ave.	51.0	-28.3
126:	Longport, 17th St.	17.7	-1.9

TABLE 11
ATLANTIC COUNTY
SEASONAL BEACH VOLUME CHANGES

PROFILE SITE LOCATION	Survey	42-43 S11-F11	43-44 F11-S12	44-45 S12-F12	42-45 S11-F12
		(volume expressed as cubic yards per foot of beachfront)			
134:	Brigantine, Green Acres	25.52	-11.38	18.78	32.92
133:	Brigantine, 4th Street North	1.39	1.79	5.51	8.72
132:	Brigantine, 15th Street South	-9.51	-3.97	5.89	-8.04
131:	Brigantine, 43rd Street South	38.82	-8.39	13.19	42.84
230:	Atlantic City, Rhode Island Ave.	141.35	48.58	-30.47	186.84
130:	Atlantic City, North Carolina Ave.	116.41	61.69	12.92	191.12
129:	Atlantic City, Raleigh Ave.	-1.00	20.45	-2.22	17.22
128:	Ventnor City, Dorset Ave.	3.39	9.62	34.83	47.52
127:	Margate City, Benson Ave.	5.76	17.00	-32.99	-9.84
126:	Longport, 17th St.	15.52	-0.73	2.95	17.11

TABLE 12
ATLANTIC COUNTY
SEASONAL SHORELINE CHANGES

PROFILE SITE LOCATION	Survey	42-43 S11-F11	43-44 F11-S12	44-45 S12-F12	42-45 S11-F12
		(shoreline change expressed in feet)			
134:	Brigantine, Green Acres	29.8	-5.1	1.7	26.3
133:	Brigantine, 4th Street North	-8.4	64.6	-54.5	1.7
132:	Brigantine, 15th Street South	-31.0	20.3	-62.9	-73.6
131:	Brigantine, 43rd Street South	-43.2	69.0	-18.6	7.3
230:	Atlantic City, Rhode Island Ave.	49.5	-209.6	309.0	148.9
130:	Atlantic City, North Carolina Ave.	131.9	82.2	41.9	256.0
129:	Atlantic City, Raleigh Ave.	2.6	8.7	-42.9	-31.6
128:	Ventnor City, Dorset Ave.	14.9	30.0	36.5	21.4
127:	Margate City, Benson Ave.	31.5	19.5	-47.8	3.2
126:	Longport, 17th St.	-4.5	22.2	-24.1	-6.4

TABLE 13
CAPE MAY COUNTY
ANNUAL BEACH VOLUME CHANGES
SPRING 2011 - SPRING 2012 & FALL 2011 - FALL 2012

PROFILE SITE LOCATION		Survey 42 - 44 S2011-S2012 (volume expressed as cubic yards per foot)	Survey 43 - 45 F2011 - F2012 (volume expressed as cubic yards per foot)
225:	Ocean City, Gardens Rd.	-43.74	-5.81
125:	Ocean City, 6th St.	-55.93	-11.86
124:	Ocean City, 20th St.	34.90	-2.80
223:	Ocean City, 34th St.	35.60	-9.04
122:	Ocean City, 56th St.	-2.32	6.89
222:	Ocean City, 59th St.	-53.02	-55.66
221:	Corson's Inlet Park, Ocean City	-97.52	-28.81
121:	Strathmere, Williams Rd.	16.91	82.33
120:	Sea Isle City, 1st St.	48.82	34.44
119:	Sea Isle City, 25th St.	-2.22	13.93
118:	Sea Isle City, 57th St.	10.06	30.82
117:	Sea Isle City, 80th St.	-8.92	-12.01
216:	Avalon, 9th St.	-11.99	-24.00
116:	Avalon, 23rd St.	-33.80	14.89
115:	Avalon, 35th St.	31.95	8.83
114:	Avalon, 70th St.	23.06	9.85
113:	Stone Harbor, 90th St.	-7.34	-11.78
212:	Stone Harbor, 121st St.	-39.42	-16.97
112:	Stone Harbor, South Pointe	** NO LONGER ACTIVE **	
111:	North Wildwood, 15th Ave.	21.81	-35.12
110:	Wildwood, Cresse Ave.	26.70	29.37
109:	Lower Township, Raleigh Ave.	24.46	-11.23
208:	Lower Township, U.S.C.G. Base	-29.81	7.53
108:	Cape May, Beach Club	52.25	44.54
107:	Cape May, Baltimore Ave.	-0.71	2.45
206:	Cape May, Broadway Ave.	11.29	-0.68
105:	Cape May, Nature Conservancy	-73.16	-8.62
104:	Cape May Point, Lake Dr.	-47.47	5.88
103:	Higbee Beach State Park	-4.27	10.71
102:	North Cape May, Whittier	6.81	-6.70
101:	Villas, Pacific Ave.	1.01	3.29
100:	Reeds Beach, Beach Ave.	-1.59	-0.58

TABLE 14
CAPE MAY COUNTY
ANNUAL SHORELINE CHANGES
SPRING 2011 - SPRING 2012 & FALL 2011 - FALL 2012

PROFILE SITE LOCATION		Survey 42 - 44 S2011-S2012 (shoreline change expressed in feet)	Survey 43 - 45 F2011 - F2012 (shoreline change expressed in feet)
225:	Ocean City, Gardens Rd.	-49.2	-49.1
125:	Ocean City, 6th St.	-54.2	-10.9
124:	Ocean City, 20th St.	68.5	24.0
223:	Ocean City, 34th St.	29.6	-34.7
122:	Ocean City, 56th St.	18.0	-21.4
222:	Ocean City, 59th St.	-86.7	-69.9
221:	Corson's Inlet Park, Ocean City	-78.5	-63.5
121:	Strathmere, Williams Rd.	88.6	72.1
120:	Sea Isle City, 1st St.	92.3	11.0
119:	Sea Isle City, 25th St.	23.0	46.8
118:	Sea Isle City, 57th St.	73.2	14.2
117:	Sea Isle City, 80th St.	26.4	21.7
216:	Avalon, 9th St.	-42.8	-41.6
116:	Avalon, 23rd St.	-115.1	24.8
115:	Avalon, 35th St.	34.9	11.8
114:	Avalon, 70th St.	13.7	-7.7
113:	Stone Harbor, 90th St.	-1.4	10.1
212:	Stone Harbor, 121st St.	-56.6	19.0
112:	Stone Harbor, South Pointe	** NO LONGER ACTIVE **	
111:	North Wildwood, 15th Ave.	46.0	-38.5
110:	Wildwood, Cresse Ave.	73.8	-62.1
109:	Lower Township, Raleigh Ave.	57.8	-47.8
208:	Lower Township, U.S.C.G. Base	-33.5	-25.2
108:	Cape May, Beach Club	61.0	72.7
107:	Cape May, Baltimore Ave.	12.7	27.7
206:	Cape May, Broadway Ave.	-2.9	-39.3
105:	Cape May, Nature Conservancy	-156.7	-62.9
104:	Cape May Point, Lake Dr.	-66.7	22.4
103:	Higbee Beach State Park	-6.2	18.6
102:	North Cape May, Whhittier	20.4	-5.3
101:	Villas, Pacific Ave.	4.0	13.3
100:	Reeds Beach, Beach Ave.	-4.5	-6.5

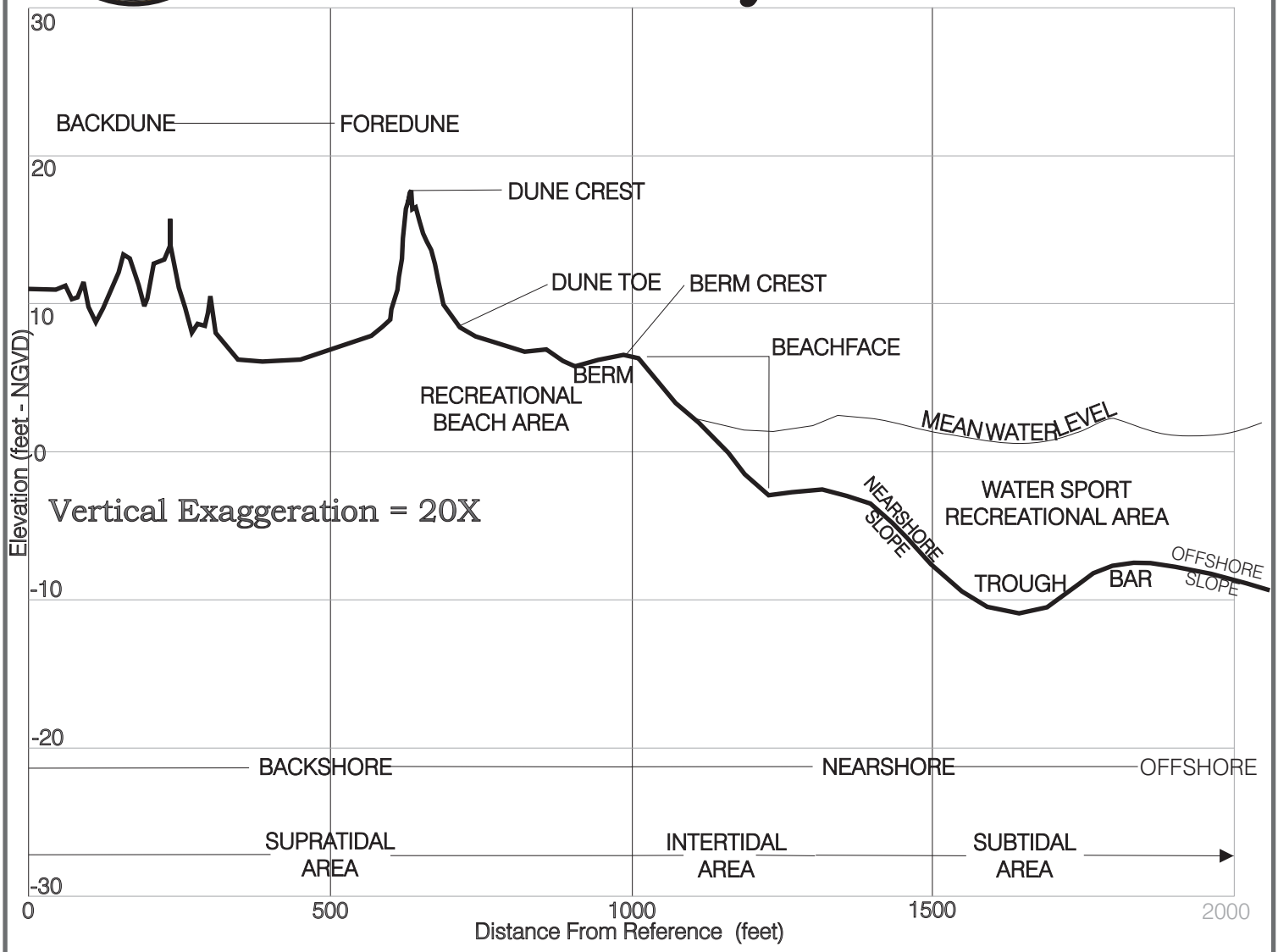
TABLE 15
CAPE MAY COUNTY
SEASONAL BEACH VOLUME CHANGES

PROFILE SITE LOCATION	Survey	42-43 S11-F11	43-44 F11-S12	44-45 S1-F12	42-45 S11-F12
		(volume expressed as cubic yards per foot of beachfront)			
225: Ocean City, Gardens Rd.		-13.72	-29.98	24.29	-19.49
125: Ocean City, 6th St.		-38.00	-17.92	6.64	-48.83
124: Ocean City, 20th St.		39.02	-4.19	1.43	36.15
223: Ocean City, 34th St.		25.95	9.59	-18.97	16.62
122: Ocean City, 56th St.		-7.41	2.64	2.16	2.12
222: Ocean City, 59th St.		-38.09	-14.31	-40.81	-94.68
221: Corson's Inlet Park, Ocean City		-50.79	-37.18	26.19	-73.93
121: Strathmere, Williams Rd.		-89.48	105.95	-24.03	-7.09
120: Sea Isle City, 1st St.		19.44	29.57	4.99	54.20
119: Sea Isle City, 25th St.		-2.90	0.67	13.26	11.14
118: Sea Isle City, 57th St.		-13.26	23.30	7.52	17.63
117: Sea Isle City, 80th St.		-2.57	-5.97	-6.14	-14.87
216: Avalon, 9th St.		-17.10	5.15	-23.31	-49.23
116: Avalon, 23rd St.		-49.93	16.76	4.34	-44.76
115: Avalon, 35th St.		40.39	-8.42	18.92	48.41
114: Avalon, 70th St.		36.55	-13.45	24.14	47.64
113: Stone Harbor, 90th St.		-0.05	-7.74	-4.38	-11.64
212: Stone Harbor, 121st St.		-26.28	-13.26	-3.62	-43.24
112: Stone Harbor, South Pointe		** NO LONGER ACTIVE **			
111: North Wildwood, 15th Ave.		4.77	17.00	-52.10	-30.51
110: Wildwood, Cresse Ave.		19.87	6.88	22.83	49.88
109: Lower Township, Raleigh Ave.		10.49	14.03	-24.67	-1.63
208: Lower Township, U.S.C.G. Base		-8.46	-21.49	28.95	-0.98
108: Cape May, Beach Club		2.09	48.39	-4.61	46.63
107: Cape May, Baltimore Ave.		-6.59	5.73	-3.42	-3.65
206: Cape May, Broadway Ave.		-8.26	20.23	-20.79	-9.80
105: Cape May, Nature Conservancy		-87.37	14.20	-22.84	-96.01
104: Cape May Point, Lake Dr.		-44.36	-2.22	8.39	-38.69
103: Higbee Beach State Park		-11.16	6.88	3.85	-0.41
102: North Cape May, Whittier Ave.		6.60	0.23	-6.95	-0.09
101: Villas, Pacific Ave.		2.46	-1.45	4.73	5.75
100: Reeds Beach, Beach Ave.		-1.49	0.06	-0.80	-2.41

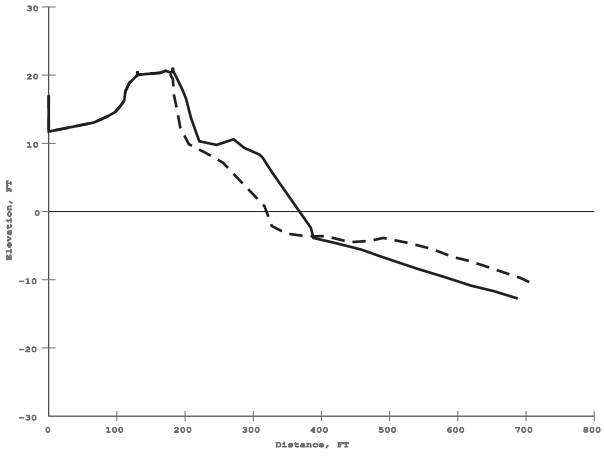
TABLE 16
CAPE MAY COUNTY
SEASONAL SHORELINE CHANGES

PROFILE SITE LOCATION	Survey	42-43 **S11-F11**	43-44 **F11-S12**	44-45 **S1-F12**	42-45 **S11-F12**
		(shoreline change expressed in feet)			
225: Ocean City, Gardens Rd.		-5.2	-44.0	-5.0	-54.3
125: Ocean City, 6th St.		-42.2	-12.0	1.1	-53.1
124: Ocean City, 20th St.		109.6	-41.1	65.1	133.6
223: Ocean City, 34th St.		24.9	4.7	-39.4	-9.8
122: Ocean City, 56th St.		5.8	12.1	-33.6	-15.6
222: Ocean City, 59th St.		-44.4	-42.3	-27.5	-114.2
221: Corson's Inlet Park, Ocean City		-72.2	-6.3	-57.2	-135.6
121: Strathmere, Williams Rd.		-117.3	205.9	-133.8	-45.2
120: Sea Isle City, 1st St.		52.9	39.4	-28.5	63.8
119: Sea Isle City, 25th St..		28.9	-5.9	52.8	75.8
118: Sea Isle City, 57th St..		52.0	21.2	-7.0	66.2
117: Sea Isle City, 80th St..		28.6	-2.2	23.9	50.3
216: Avalon, 9th St.		-62.5	19.7	-61.4	-104.2
116: Avalon, 23rd St.		-142.3	27.2	-2.4	117.5
115: Avalon, 35th St.		5.4	-40.3	52.1	17.2
114: Avalon, 70th St.		55.7	-41.9	34.2	47.9
113: Stone Harbor, 90th St.		-32.2	30.8	-20.7	-22.0
212: Stone Harbor, 121st St.		-68.3	11.7	7.3	-49.4
112: Stone Harbor, South Pointe			** NO LONGER ACTIVE **		
111: North Wildwood, 15th Ave.		16.1	29.9	-68.4	-22.5
110: Wildwood, Cresse Ave.		76.3	-2.4	-59.7	14.2
109: Lower Township, Raleigh Ave.		71.2	-13.5	-34.4	23.4
208: Lower Township, U.S.C.G. Base		-12.2	-21.2	-4.0	-37.4
108: Cape May, Beach Club		-9.9	70.9	1.7	62.7
107: Cape May, Baltimore Ave.		-2.9	15.5	12.2	24.8
206: Cape May, Broadway Ave.		-7.4	4.5	-43.8	-46.7
105: Cape May, Nature Conservancy		-186.0	29.3	-92.2	-248.9
104: Cape May Point, Lake Dr.		-63.2	-3.4	25.9	-40.8
103: Higbee Beach State Park		-16.5	10.4	8.2	2.1
102: North Cape May, Whittier Ave.		26.9	-6.5	1.2	21.6
101: Villas, Pacific Ave.		4.7	-0.7	14.0	18.0
100: Reeds Beach, Beach Ave.		-2.1	-2.4	-4.1	-8.5

Typical Beach Profiles in New Jersey



Above is a typical beach profile with major features and zones labeled. No beach will show every aspect of this diagram at all times, but it illustrates all important features that appear on the New Jersey shoreline..



Seasonal Variations

The pair of profiles to the left show some of the typical seasonal beach profile changes. The dashed line profile is the result of a winter season, where ocean conditions moved material offshore. The solid line profile is the result of a summer season, where ocean conditions moved sand onshore. The summer profile has a well developed berm and wider beach and dune, while the winter profile has this beach material present in the offshore region of the profile.

Coastal Research Center
Glossary of Coastal Terms

Accretion - The addition of material by natural processes.

Aeolian Accretion - The accretion that results from wind driven processes.

Backshore - The area of the beach profile landward of the berm and seaward of upland dunes or bluffs.

Beachface - Also known as foreshore. The area of the beach exposed to regular wave action.

Berm - The nearly horizontal portion of the beach formed at the high water line as waves deposit material. A beach may have no berm or multiple berms.

Bulkhead - A structure that is built to retain or prevent the slumping of land at the influence of water and wave action. Bulkheads are typically made of wood, steel, or aluminum.

Cross-shore Transport - The transfer of sand perpendicular to the shoreline, or along the profile. A bar migrating onto the beach is an example of cross-shore transport.

Current - The flow of water.

Downdrift - The dominant direction of movement of littoral materials.

Datum - A reference level from which elevations are measured.

Dry Beach - The area of beach between the water and dune toe that is commonly used for recreating. Also referred to as recreational beach.

Dune - Unconsolidated hills or mounds of sand. Dunes are the result of aeolian processes and may have vegetation ranging from sparse to dense. Vegetation greatly stabilizes a dune.

Eddy - A circular current running contrary to the main current.

Erosion - The removal of material by natural processes.

Foredune - The most seaward of the dune ridge along the profile.

Geotube - A geotextile fabric tube filled with sand, typically used to retain material or to dissipate wave energy.

Groin - A shore-perpendicular erosion control structure, usually made of wood or rock. This structure acts to slow the process of littoral transport.

Hurricane - A tropical cyclone in the Northern Hemisphere, with sustained winds over 74 mph.

Jetty - A shore-perpendicular erosion control structure similar to a groin, however it is used to control the movement of an inlet or channel.

Littoral Current - Current that moves parallel to shore, that results from the approach of waves not being perpendicular to the shoreline.

Littoral Drift - Also known as longshore transport. Movement of material in the longshore direction, resulting from the littoral currents.

Coastal Research Center
Glossary of Coastal Terms

Longshore Transport - Also known as littoral drift. Movement of material in the longshore direction, resulting from the littoral currents.

NGVD - (the datum of 1929) A common elevation reference developed from a specific model of the Earths' surface.

Onshore - In the direction of the shoreline; landward.

Offshore - In the direction opposite of the shoreline; seaward.
The region of the beach profile seaward of the first bar.

Neap Tide - A tide having significantly reduced variations from mean tide levels. Neap tides occur near quarter moon stages.

Nearshore - Region of beach profile extending from the berm seaward through the offshore.

Northeaster - Dominant type of coastal winter storm event experienced in New Jersey, with winds from the northeast that exceed 30 mph.

Revetment - Cover of stone placed on or along a shoreline to protect a slope or shore structure.

Ridge - A low elevation, near shore parallel continuous mound of sand, pushed onshore by wave action.

Riprap - Line of rocks placed randomly along a slope or structure for protection.

Runnel - A continuous area of lower elevation than, but parallel to and adjacent to, a ridge(s).

Scarp - A near vertical feature created through the erosion of material from the lower portion of a slope or bluff.

Scour - Underwater removal of material through currents and wave action.

Seawall - Structure that separates the land and water.

Shoreline - The narrow area of land in contact with the water. When referring to a profile plot, the point where the profile crosses the line representing the datum.

Spring Tide - Tide with the most extreme variations from mean tide levels. Spring tides occur at new or full moon stages.

Swale - A long, narrow, generally shallow depression between ridges.

Swash - The area of beachface exposed to breaking wave energy as waves come ashore.

Storm Surge - The abnormal rise in local sea level that accompanies a hurricane or other major storm event.

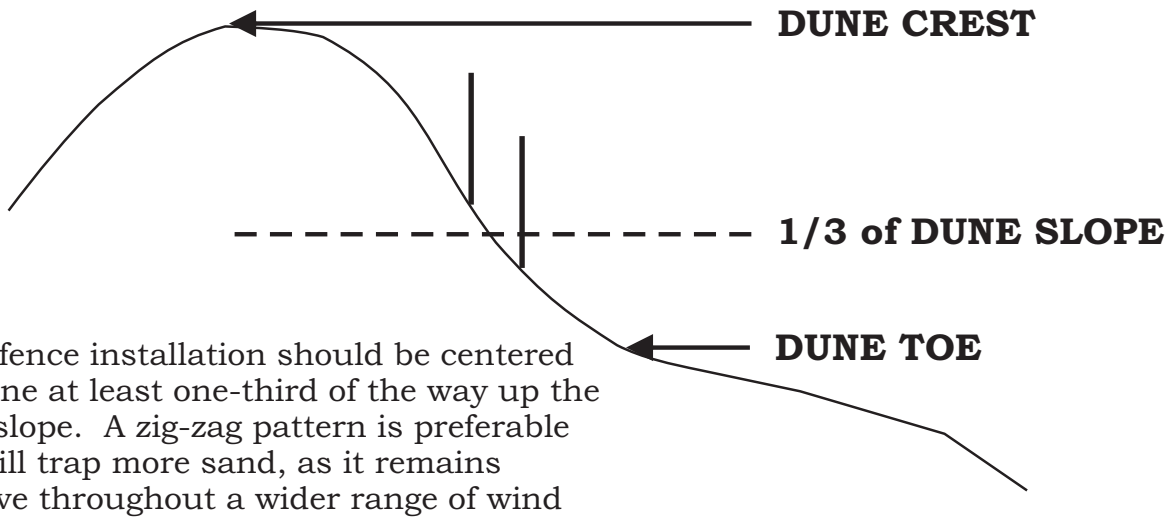
Updrift - In the direction opposite of the dominant movement of littoral materials.

Wrack - Debris deposited on the beach by wave action.

References: A.G.I., U.S.A.C.O.E., N.O.A.A., F.E.M.A., N.J.D.E.P.

Optimal Dune Fence Placement

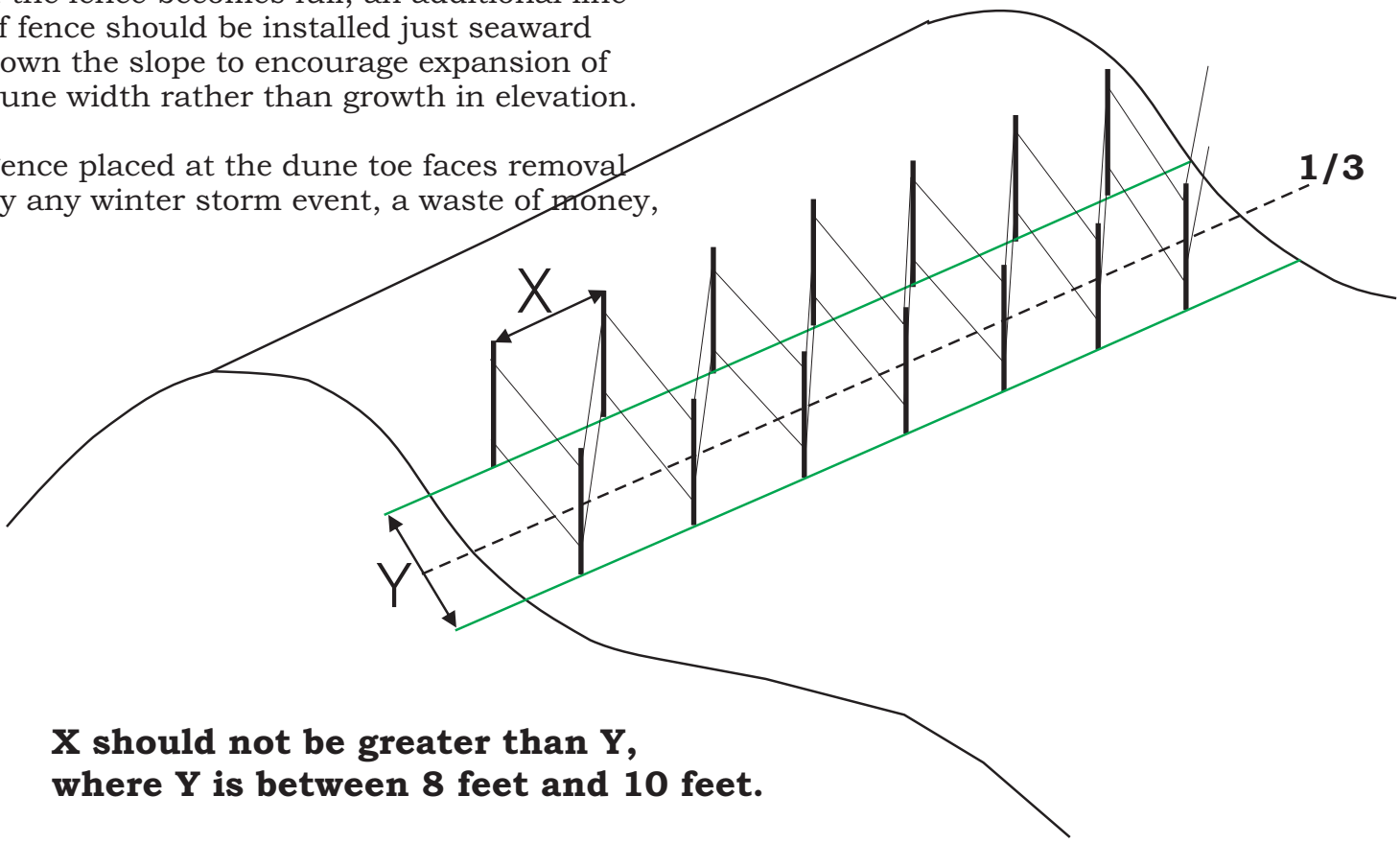
(Initial Fence Placement)



Dune fence installation should be centered on a line at least one-third of the way up the dune slope. A zig-zag pattern is preferable and will trap more sand, as it remains effective throughout a wider range of wind directions. The zig-zag pattern should be implemented as shown below.

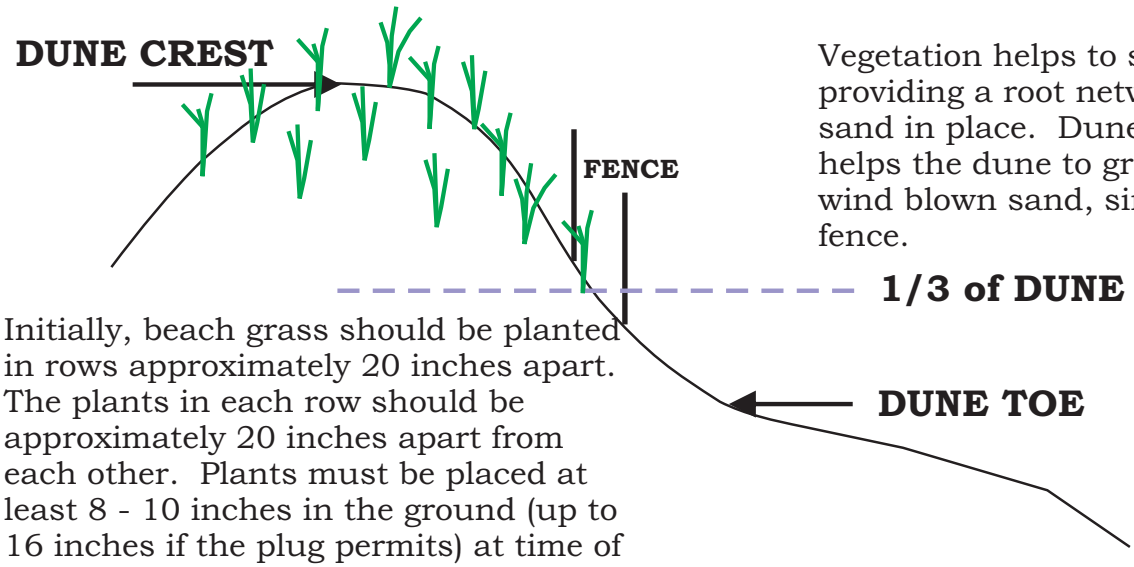
If the fence becomes full, an additional line of fence should be installed just seaward down the slope to encourage expansion of dune width rather than growth in elevation.

Fence placed at the dune toe faces removal by any winter storm event, a waste of money,



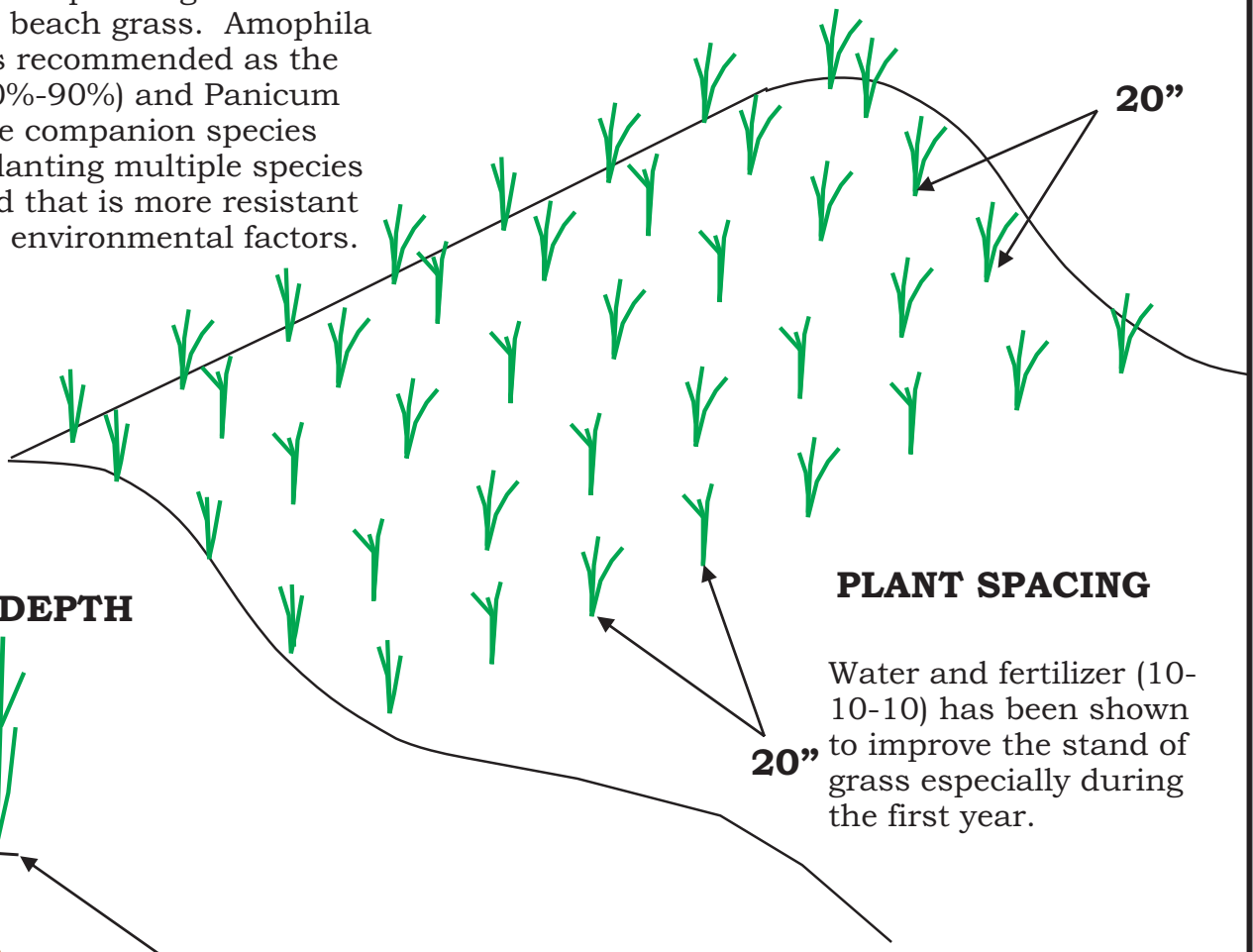
X should not be greater than Y, where Y is between 8 feet and 10 feet.

Optimal Beach Grass Planting
(Initial Planting)

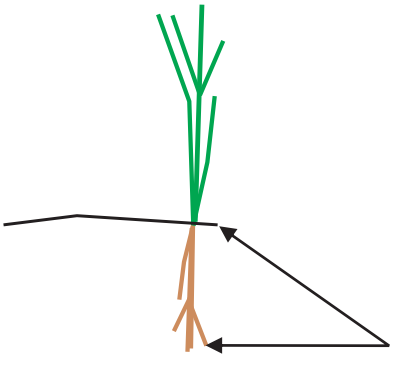


Vegetation helps to stabilize dunes by providing a root network to hold the sand in place. Dune vegetation also helps the dune to grow by trapping wind blown sand, similar to a dune fence.

Initially, beach grass should be planted in rows approximately 20 inches apart. The plants in each row should be approximately 20 inches apart from each other. Plants must be placed at least 8 - 10 inches in the ground (up to 16 inches if the plug permits) at time of planting. Shallow planting is the #1 cause of failed beach grass. Amophila breviligulata is recommended as the main plant (80%-90%) and Panicum amarum as the companion species (10%-20%). Planting multiple species creates a stand that is more resistant to disease and environmental factors.



Water and fertilizer (10-10-10) has been shown to improve the stand of grass especially during the first year.



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