

**FINAL REPORT FOR 2017
ON THE CONDITION OF THE MUNICIPAL OCEANFRONT BEACHES
THE BOROUGH OF AVALON, CAPE MAY COUNTY, NEW JERSEY**



View of the Avalon oceanfront July 2, 2017 following the US Army Corps of Engineers maintenance beach nourishment put between 9th and 26th Streets restoring the project to the initial design specifications. The view also illustrates the 100-acre dune park that is unparalleled as a municipally-owned open space on the mid-Atlantic coastline (photo by Ted Kingston for the CRC). The origin of the offshore bar system just north of the fishing pier is a possible answer to where the beach nourishment sand migrates to as the wave climate chronically redistributes it away from 9th to 26th Street beaches.

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**ANNUAL REPORT FOR 2017 - TO THE BOROUGH OF AVALON
ON THE
CONDITION OF THE MUNICIPAL BEACHES**

Introduction:

The Avalon municipal shoreline has been studied by the Stockton University Coastal Research Center (CRC) since work initially began back in 1984. This annual report provides the results and analyses from the fall 2016 to fall 2017 survey datasets of that program. This report will examine the changes since the recent US Army Corps of Engineers-sponsored beach restoration, the post-project sand redistribution, and the third year of evaluation of conditions in the ebb-tidal shoals of Townsends Inlet.

During the summer of 2015, Avalon undertook its own restoration of the north end engineered beach. This project followed the 2013 USACE (US Army Corps of Engineers) emergency maintenance due to impacts from Hurricanes Irene and Sandy, when the USACE placed a reported 336,359 cubic yards (CY) of sand on the engineered beach. With no federal funding available Avalon undertook a massive project on its own to restore the severely eroded federal project beach. The 2015 project placed 740,000 cubic yards of sand, dredged from Townsends Inlet, to between 9th and 23rd Streets to restore the federal beach design.

In 2016, to restore safe beach access and shore up storm protection the Borough undertook another sand back-pass project during spring 2016. The newest and 4th round of sand back-pass projects by the Borough harvested and placed approximately 50,000 cy of sand from the northern borrow zone transferred to the engineered beach.

This year the municipal effort took a well-deserved pause as the US Army Corps of Engineers (USACE) returned to provide a much needed maintenance of the engineered beach. Great Lakes Dredge and Dock Co.(GLDD) placed approximately 944,000 cubic yards (cy) of sand on the engineered beach from the 8th Street Jetty to 30th Street as reported (Erik Rourke, USACE & Chris Constantino, NJDEP). This project restored the full USACE beach template design within the federal project area by May 24, 2017. The restored beach continued to function with modest loss to the critical beach between 9th and 17th Streets. South of 23rd Street the shoreline gained material at all profile locations fed primarily by the past three years of loss in the critical zone.

Monitoring Program:

The CRC monitored the ten oceanfront cross sections four times in 2017 on a seasonal timeline. These surveying activities continue a monitoring program dating back to 1981. The five northern sites are located within the engineered beach project area while the southern five sites cover the accretional region including the natural exclusion area and sand back-passing borrow zones. Monitoring provides details on natural sediment movement along the Borough's Atlantic shoreline and surveying has continued through multiple beach restoration projects starting in 1987 with a local/state sponsored project that gathers data for project performance evaluation. Each topographic beach profile starts at a fixed reference position landward of the dune. The repetitive surveys for each profile include changes to the dune, beach and nearshore.

The following is a list of quarterly studies included in this report and the dates of the surveys:

- Survey 139 December 19 & 23, 2016; 4th Quarter
- Survey 140 March 15 & 16, 2017; 1st Quarter
- Survey 141* April 17 & May 24, 2017 following Federal sand placement*
- Survey 142 June 13 - 14, 2017; 2nd Quarter
- Survey 143 September 5 & 7, 2017; 3rd Quarter
- Survey 144 December 4 & 6, 2017; 4th Quarter

**Note: Survey 141 followed completion of the federal maintenance of the engineered beach only, and was included as a separate sub-section.*

Winter Storm Impacts:

A northeast storm occurred January 23, 2017 on the anniversary of Jonas in 2016. This storm was less severe than Jonas and was followed by a mild event March 14, 2017, which ended the recorded northeast storms for the year. Periods of northeast winds did occur from time to time, but no coast impacting hurricanes passed by the NJ coast during 2017 in spite of catastrophic events in Texas, Florida, Puerto Rico and the US Virgin Islands.

Table 1
Oceanfront Shoreline and Volume Changes
Related to USACE Work on the Engineered Beach as of May 2017

Profile Number	Shoreline Change (feet)	Volume Change (yds³/ft)	Avg. Volume Change (yds³/ft)	Cell Distance (feet)	Net Volume Change (yds³)
8th Street Jetty					
			5.140	500	2,570
AV-9	17	5.14			
			132.370	840	111,191
AV-12	385	259.60			
			225.825	1400	316,155
AV-17	306	192.05			
			155.795	1680	261,736
AV-23	209	119.54			
			78.965	1400	110,551
AV-28	40	38.39			
Total Volume Change for Oceanfront Engineered Beaches in cubic yards =					802,202

This summary based on surveys comparing March 17, 2017 data to that obtained in mid-April and May 24, 2017 following project completion agrees fairly well with the reported sand volumes from the project contractor via the Federal project manager (944,000 cy). The “as-built” surveys contain 10 times the number of survey cross sections which were taken as each 100-foot segment of the beach was completed moving south. The data in the table above represents 5 cross sections measured after all work was complete and the project demobilized.

Summary of Sand Back-passing Projects:

There were no further sand relocation efforts conducted in 2017 due to the federal maintenance effort completed by May 2017.

Quarterly Beach Changes in 2017:

Oceanfront beaches were surveyed quarterly to depict both seasonal and annual changes, erosional and recovery rates and to assist in storm damage assessments and project performance assessments. Table 2 below shows the individual profile site trends in sand volume change by quarter for 2017. The large northern site changes are due to the beach restoration effort by the USACE.

Table 2
2017 Oceanfront Beach Profile
Quarterly Sand Volume Changes at Each Survey Line Location

Profile	Winter	Spring	Summer	Fall
Number	12/15 - 3/16	3/16 - 6/16	6/16 - 9/16	9/16 - 12/16
	(yds³/ft)	(yds³/ft)	(yds³/ft)	(yds³/ft)
8th Street Jetty				
AV-9	144.20	5.14	-1.72	-47.99
AV-12	38.12	259.60	-39.20	-57.64
AV-17	4.49	192.05	-15.74	-15.03
AV-23	-17.00	119.54	-3.53	17.51
AV-28	-21.54	38.39	10.16	33.70
AV-35	-1.98	-6.83	19.89	24.36
AV-44	-14.57	17.98	8.60	-5.18
AV-58	-13.90	7.11	4.68	10.02
AV-70	-6.20	18.97	35.39	10.78
AV-78	-15.74	35.91	5.75	10.14
Quarterly Volume Change (yds³) =	-25,967	1,021,342	140,580	74,732

The seasonal total sand volume change along the Avalon oceanfront shoreline during 2017 was a very substantial gain of 1,210,687 cy as the Corps project dominated the situation. However, the additions to the federal sand volume totaled over 250,000 cubic yards of sand added to the municipal shoreline south of 23rd Street. The only quarter showing regional losses was the winter between December 2016 and March 2017. The federal project was underway in March, with the 9th Street site receiving the initial sand deposit.

Table 3 below shows the fourth quarter changes at each profile location following the fall 2017 seasonal changes. Shoreline position changes (zero datum NAVD88) are measured in feet. Profile volume changes were averaged with adjacent sites to calculate an average volume change then multiplied by the distance between sites to determine a net cell volume change in cubic yards. Summation of each cell volume change provides the total change in sand volume for the Avalon oceanfront beaches during the fourth quarter. 9th, 12th and 17th Street sites showed double-digit losses accumulating to a total of 50,000 cubic yards of sand moved elsewhere.

Table 3
2017 Oceanfront Beach Profile
Fourth Quarter Sand Volume Change

Profile Number	Shoreline Change (feet)	Volume Change (yds³/ft)	Avg. Volume Change (yds³/ft)	Cell Distance (feet)	Net Volume Change (yds³)
8th Street Jetty					
			-47.987	500	-23,994
AV-9	-73.0	-47.99			
			-52.813	840	-44,363
AV-12	-89.6	-57.64			
			-36.336	1400	-50,870
AV-17	7.5	-15.03			
			1.237	1680	2,078
AV-23	1.2	17.51			
			25.606	1400	35,848
AV-28	86.0	33.70			
			29.034	2025	58,793
AV-35	46.0	24.36			
			9.592	2510	24,076
AV-44	-22.1	-5.18			
			2.422	3925	9,506
AV-58	-20.2	10.02			
			10.404	3360	34,956
AV-70	30.4	10.78			
			10.460	2240	23,430
AV-78	7.0	10.14			
			10.137	520	5,271
Total Volume Change for Oceanfront Beaches in cubic yards =					74,732

Fall 2017 fourth quarter changes show the chronic loss between the 8th Street jetty and 23rd Streets, with an otherwise successful gain to the beaches excepting the 44th Street location.

Table 4 on the following page shows the annual volume change for 2017. Here the starting point was December 2016 (Survey 139) versus the December 2017 survey (#144). A year of change summarized in the table allows a review over 12 months as compared to Table 2 which documents quarter to quarter beach changes.

Table 4
Oceanfront Beach Profile
Annual Sand Volume Change March to December 2017

Profile Number	Shoreline Change (feet)	Volume Change (yds³/ft)	Avg. Volume Change (yds³/ft)	Cell Distance (feet)	Net Volume Change (yds³)
8th Street Jetty					
			99.605	500	49,803
AV-9	163.2	99.61			
			148.587	840	124,813
AV-12	259.9	197.57			
			183.156	1400	256,418
AV-17	261.1	168.74			
			142.632	1680	239,621
AV-23	131.5	116.52			
			88.154	1400	123,415
AV-28	123.2	59.79			
			47.397	2025	95,978
AV-35	112.3	35.01			
			20.971	2510	52,637
AV-44	-25.5	6.94			
			8.103	3925	31,802
AV-58	-1.2	9.27			
			29.878	3360	100,390
AV-70	40.7	50.49			
			42.368	2240	94,904
AV-78	32.8	34.25			
			34.248	520	17,809
Total Volume Change for Oceanfront Beaches in cubic yards =					1,187,590

As is clearly seen, the annual beach improvement was over a million cubic yards. The quarterly survey review found 1,210,687 cy in added sand while the annual comparison revealed 1,187,590 cubic yards in added material. If one subtracts the summation of sand added between the jetty, south to 28th Street from the total a balance of 297,543 cubic yards of sand was added south of 28th Street. This material represents a fraction of the sand eroded from the engineered beach zone since 2015 when Avalon funded an interim beach restoration, but is likely material derived from southerly movement on the beachface as well as along the offshore bar system. All but two shoreline position advanced seaward with the winners located in the direct USACE placement zone. However, over 100 feet of shoreline position advance was seen as far south as 35th Street with an odd shift into the negative column at 44th and 58th Street sites, normally places were advances in the shoreline position is an annual affair. The smallest sand volume gains were seen here as well. 70th and 78th Streets may be the beneficiaries of the Stone Harbor federal maintenance project last year. Some sand was directly placed as the blending taper into the Avalon beach including the likelihood that some sand moved north into Avalon following the project in Stone Harbor.

Individual Site Review:

This section describes the changes documented at each of the cross-section locations. The objective is to show with cross sections and photographs how the individual sites performed. The dominating theme in 2017 was the

federal project and a relatively beneficial storm frequency that also saw no significant hurricane impacts to the Avalon shoreline.

AV-9 - Ninth Street

Beach conditions at the north end had deteriorated rapidly requiring the Borough of Avalon to undertake a full scale beach restoration project in 2016, 159.22 yds³/ft. of new sand was placed at 9th Street. In 2017, the US Army Corps of Engineers returned to conduct a much needed beach maintenance in Avalon. The US Army Corps contractor placed 144 yds³/ft. on the 9th Street profile as of the first quarter survey in March 2017. Since the project started at the north end of the oceanfront beach, the progress of work moved south completing the effort by May 24, 2017 when the southern project profile sites were surveyed for post-project conditions.

Over the past months since this site was completed, the rate of sand volume change was positive at the end of the second quarter (5.14 yds³/ft.), minimal during the third quarter (-1.72 yds³/ft.), but increased to -47.99 yds³/ft. by December 2017. The 8th Street jetty tends to protect this site and the nearby beach from direct wave erosion, so retreat of the berm and sand loss is slower than at the critical site located at 12th Street.



1a. January 20, 2017



1c. December 4, 2017



1b. March 16, 2017

Photographs 1a to 1c. 9th Street view to the south.

View 1a shows the beach and seaward dune slope prior to sand placement in 2017. The dry beach is very narrow with wrack material deposited at the dune toe indicating storm wave run-up reached the fence line. However, from 10th Street south the revetment was exposed.

View 1b was taken in March as the beachfill was underway. The width of the dry beach is now several hundred feet wider. The project proceeded south, finishing in May.

View 1c This view from early December shows that the majority of the sand was still present, but loss commenced between the September and December surveys (-47.99 yds³/ft.). The shoreline retreated 73 feet.

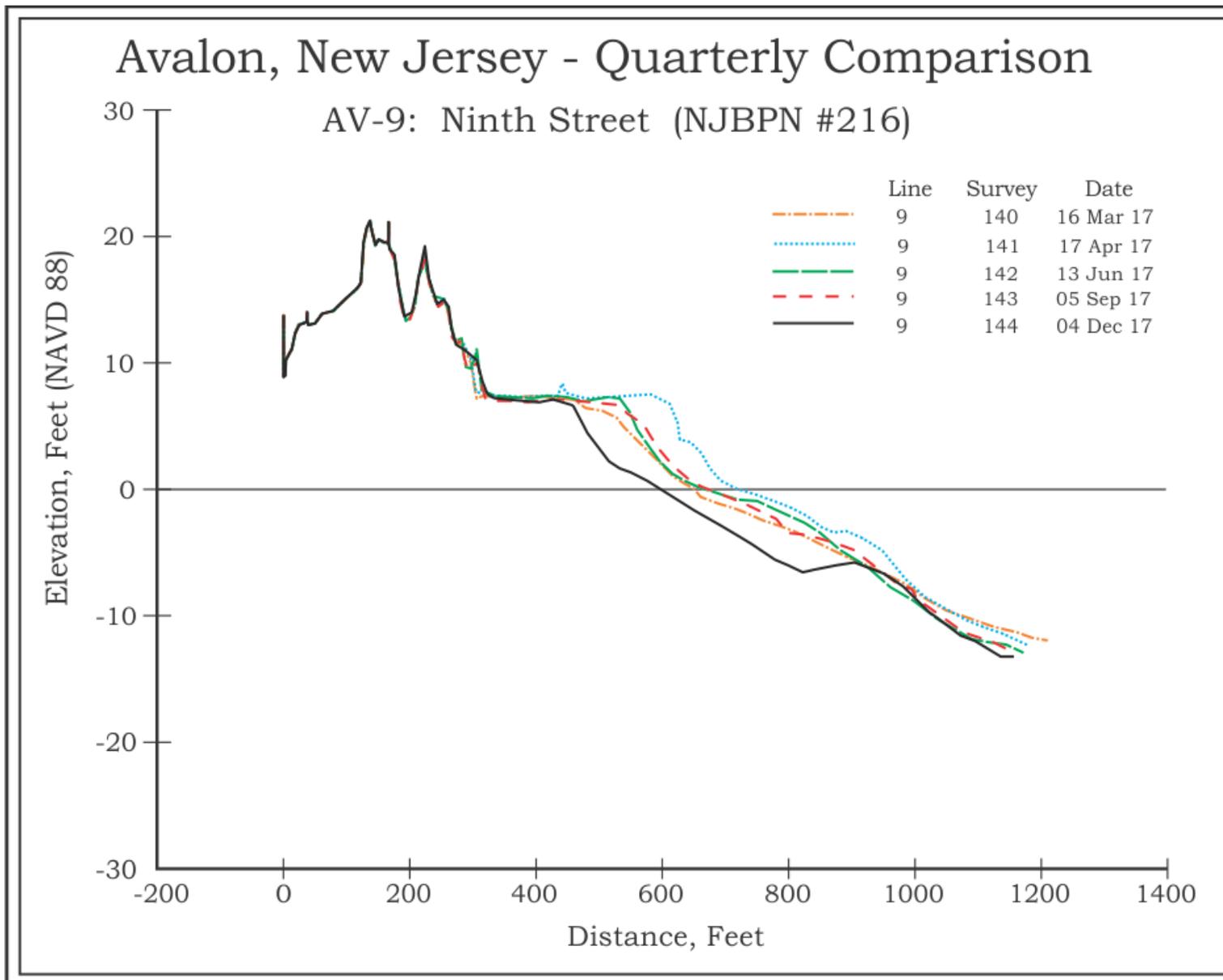


Figure 1. At 9th Street the CRC has provided five cross sections to reflect the conditions as the beach restoration had taken place as of March 16, 2017, followed by a final profile from April. There was adjustment by June with the next six months showing little change up until September 2017. By the December survey, sand had moved seaward forming a bar approximating the offshore slope present earlier, but with an erosional trough between the berm and a point 400 feet further seaward.

AV-12 - Twelfth Street

The Borough's 2015 beach nourishment project added 209.12 yds³/ft. in new sand to this site and restored the recreational beach berm. The loss rate between 2015 and early 2017 was extraordinary and alarming. The USACE did return by March 2017 and added 259 yds³/ft. expanding the beach width by 385 feet. This situation has occurred multiple times since 1987 and occurs at the point where erosion is at its worst. The March 2017 survey profile accurately demonstrates the loss situation as the federal project got underway. By May 2017 the beach had been restored. Each subsequent quarterly survey showed berm retreat totaling 120 feet accompanied by a 100.97 yds³/ft. sand volume loss, largely shed to the south as seen previously. The percentage change by year's end was a loss of 38.98% in sand volume and a retreat of 31.17% of the added beach width.

This material removed moves rapidly south, limiting losses for a time at 17th Street and adding to the beach at 23rd Street to the point where all the easily available sand is gone, whereupon losses begin to accelerate at 17th moving toward the 23rd Street site.



2a. March 16, 2017



2b. June 13, 2017



2c. December 4, 2017

Photographs 2a to 2c. 12th Street Views to the south.

View 2a shows 12th Street following the winter just prior to the onset of the federal beach project. Some dune loss occurred above the timber bulkhead and the beach was passable at low tide.

View 2b was taken following completion of the federal project showing the 385-foot wide beach to the zero elevation position.

View 2c was taken after some minor northeast events with a total shoreline retreat of 120 feet and sand losses totaling 100.91 yds³/ft. from June to December.

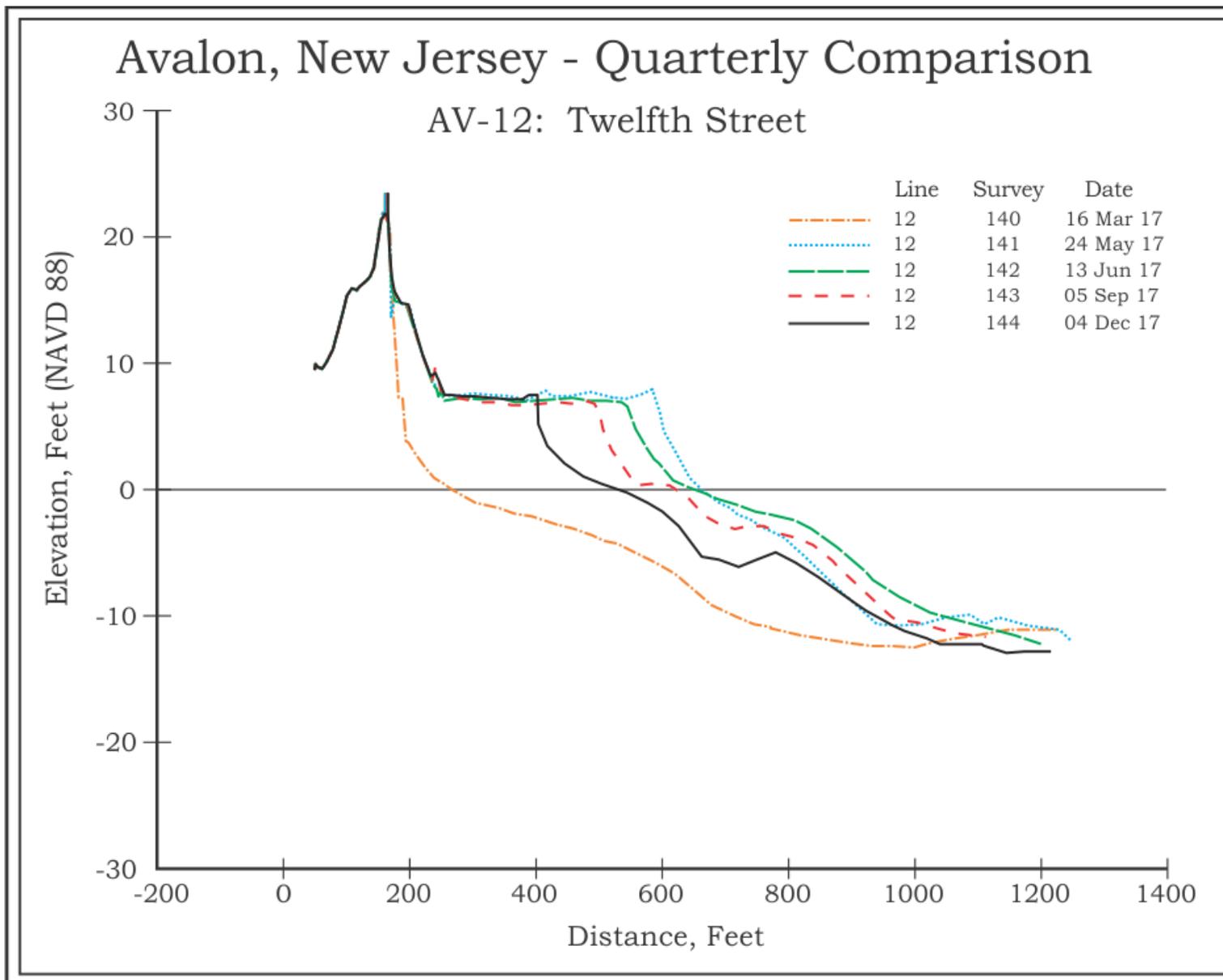


Figure 2. The initial survey of 2017 started at the revetment rocks and showed that the beach was wet at low tide to the rocks. The May survey defined the widest berm. The net change in beach sand volume during the May to June period was relatively small in spite of a berm becoming less steep. Sand moved seaward adjusting the profile slope. Between June and September loss did occur (-39.20 yds³/ft.), a problem that accelerated by December 4, 2017 (-57.64 yds³/ft.). These losses were not substantially storm driven due to low storm frequencies and low intensity of individual events.

AV-17 - Seventeenth Street

The profile is located at the southern terminus of a rock revetment which continues north to 8th Street. No rock exposure occurred at this site by the time work commenced on the federal project. However, the remaining beach sloped from the dune toe immediately toward the swash line only a few feet seaward. By May of 2017 a 420-foot wider beach berm had been added. By the June survey, minor berm retreat (40 feet) had occurred as sand adjusted to a more gentle slope seaward. Early September produced another small retreat (50 feet) in the berm, with sand deposited offshore as a bar. By December the bar was further seaward and the berm had retreated another 90 feet leaving 240 feet remaining of the original width to the berm crest. (All measurements above were made from the May 2017 cross sectional berm width. The computer software counts shoreline positions from the zero elevation position which was 150 feet further seaward in May 2017 from where the new berm at 8-foot elevation started.). Sand did move seaward offshore, but only by a small amount. The group of cross section profile plots all come together at the 1,200 foot distance seaward of the reference location indicating that sand movement is primarily south parallel to the shoreline, not seaward further offshore.



3a. March 15, 2017



3b. June 13, 2017



3c. December 4, 2017

Photographs 3a to 3c. 17th Street, view to the south.

View 3a shows that storm damage has impacted the seaward dune toe leaving a 3-foot scarp. While the rocks remained buried, exposure was seen two city blocks to the north.

View 3b Following the beach restoration, this view to the south shows the wide beach and new sand in place as of June.

View 3c The December view does not illustrate the berm retreat since the width remains substantial.

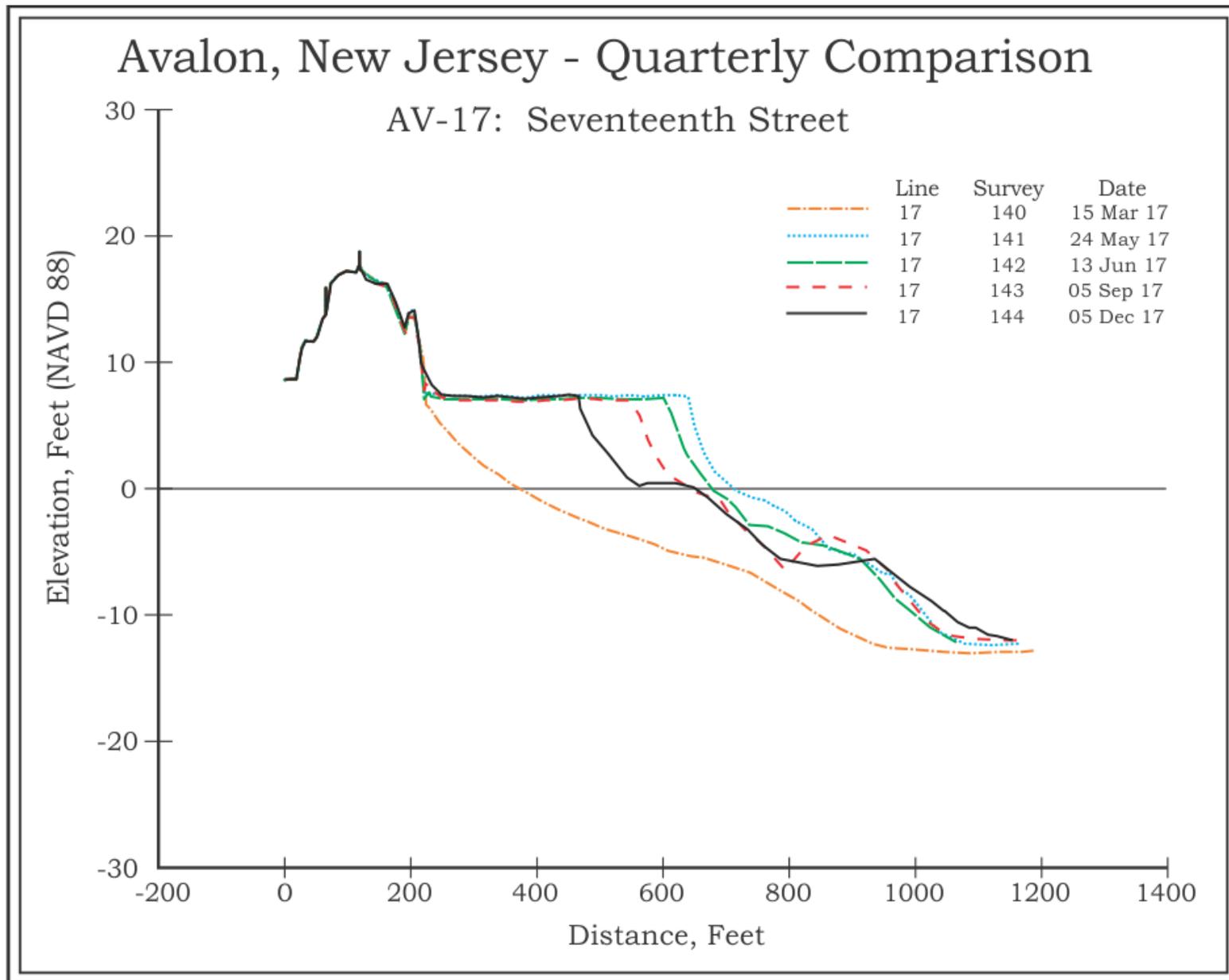


Figure 3. The five surveys show the dramatic process of adding a large volume of sand to the Avalon shoreline. The May cross section represents the maximum deposit that adjusted slowly to a more gentle slope during the summer. Between September and December erosion cut into the berm, but sand moved offshore leaving the zero elevation position practically the same as it was in May (-52 feet) Very little sand was moved seaward of the initial profile (May 2017). Lost sand volume moves south rather than offshore.

AV-23 - Twenty Third Street

The 23rd Street cross section is located seaward of the Avalon boardwalk near the southern end of the engineered beach and federal project. Sand placement in July 2015 created an extensive berm as 123.36 yds³/ft. in new sand was added. The shoreline advanced 216 feet in the process. However, the losses mounted as a result of storms to the point where the seaward dune slope was scarped into an 8-foot cliff. The 2017 project complete as of May 2017 provided a 235-foot wider berm at an 8-foot elevation that adjusted slowly until September 2017. Sand appeared offshore as a bar system that developed by September and grew larger, further seaward by December 2017.

The sand volume changes were relatively minor because material was arriving from the northern beach as fast as it moved away to the south. Between June and September the sand volume declined by 3.53 yds³/ft., and the shoreline retreated 20 feet; by December the sand volume increased by 17.51 yds³/ft. while the shoreline advanced 1.2 feet. Sand moved across the shoreline at this site as contrasted with the three northern sites where material primarily moved south parallel to the coastline. This beach did lose 1.89 yds³/ft. above the zero datum between September and December while it gained 19.40 yds³/ft. below the zero datum.



4a. March 15, 2017



4b. June 13, 2017



4c. December 4, 2017

Photographs 4a to 4c. 23rd Street, views to the north.

View 4a shows the dune erosion at this site caused by winter storms. The stormwater outfall pipeline (distance) is exposed nearly to the dune and the beach is flattened and narrow.

View 4b was taken immediately following sand placement during the recent federal maintenance project. The storm pipeline is now buried again as the restored beach extends to the outfall end. Sand also accumulated along the toe of the dune scarp.

View 4c was taken in late fall, showing the new fencing with minor accumulated sand. The stormwater pipeline remains buried.

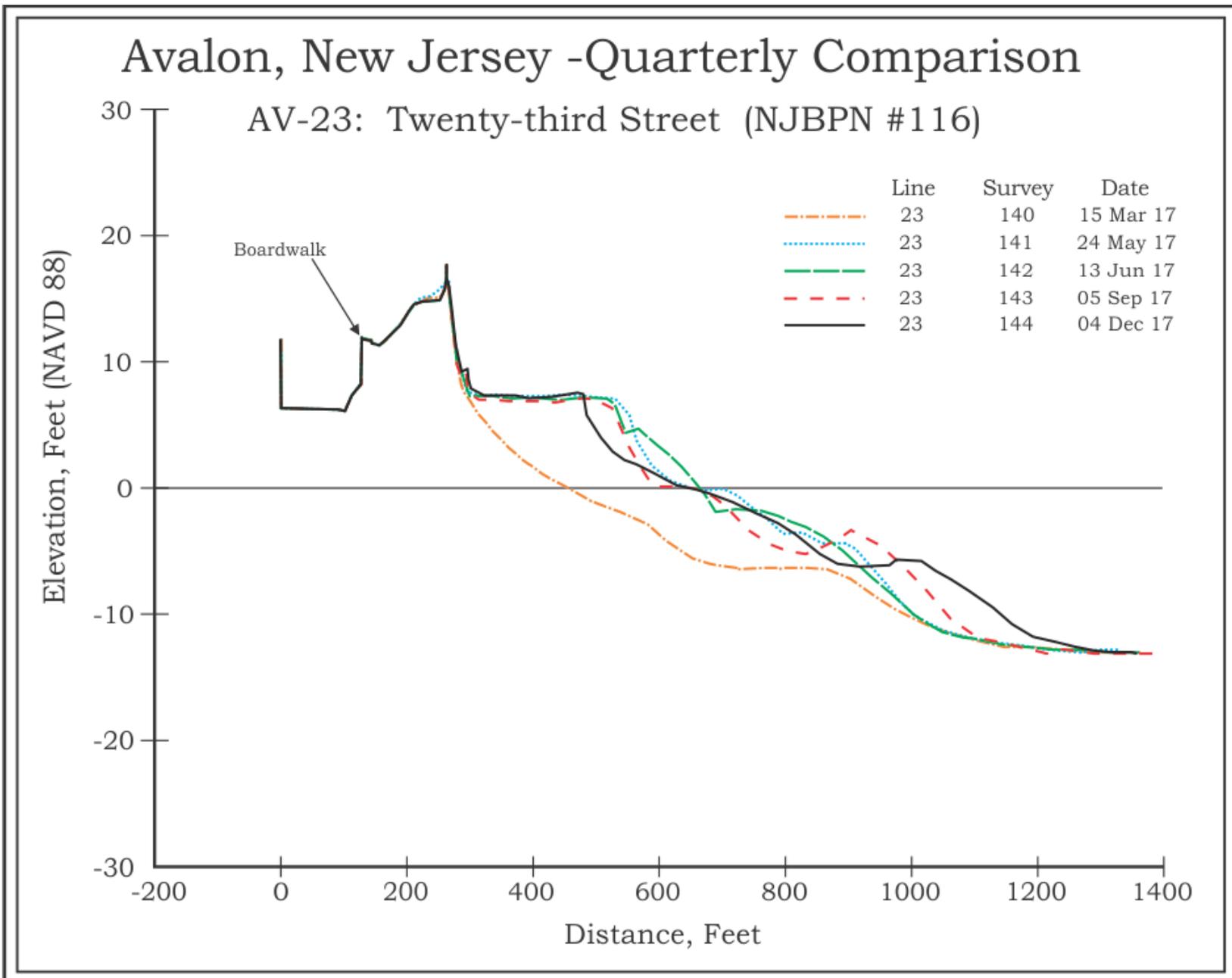


Figure 4. The impact of the 2017 federal maintenance work shows dramatically between March and May of 2017. Adjustments since have resulted in sand deposited offshore creating a bar system while minor retreat occurred in the berm. This site is presently the nodal area between erosion to the north and deposition to the south along the Avalon coast.

AV-28 - Twenty Eighth Street

The 28th Street location is generally south of the nodal point between chronic erosion and regular sand deposition in Avalon. The site is situated seaward of a large parking area for beach users and presently has a multi-crested dune system that has developed since 1987 when the boardwalk was protected by a row of sand hills. The site gained sand during 2017 between March and December as sand moved onto the site from the north. Between March and May of 2017 the beach developed a berm at the dune toe and added sand in a bar offshore. This indicates influx of material not derived from direct placement, and in fact direct placement has ended north of 28th Street since the initial federal beachfill in 2002.



5a. March 15, 2017



5b. June 13, 2017



5c. December 4, 2017

Photographs 5a to 5c. 28th Street, views to the north.

View 5a was taken prior to federal beach work reaching the area as can be seen in the far distance where the 21st Street stormwater pipeline can be seen.

View 5b shows the 28th Street beach following sand being added as far south as 23rd Street, but not directly on this beach.

View 5c is a view December 4, 2017. No sand fencing has been installed as yet, but the dune toe shows evidence of wind transport into the immediate vicinity of the dune grass.

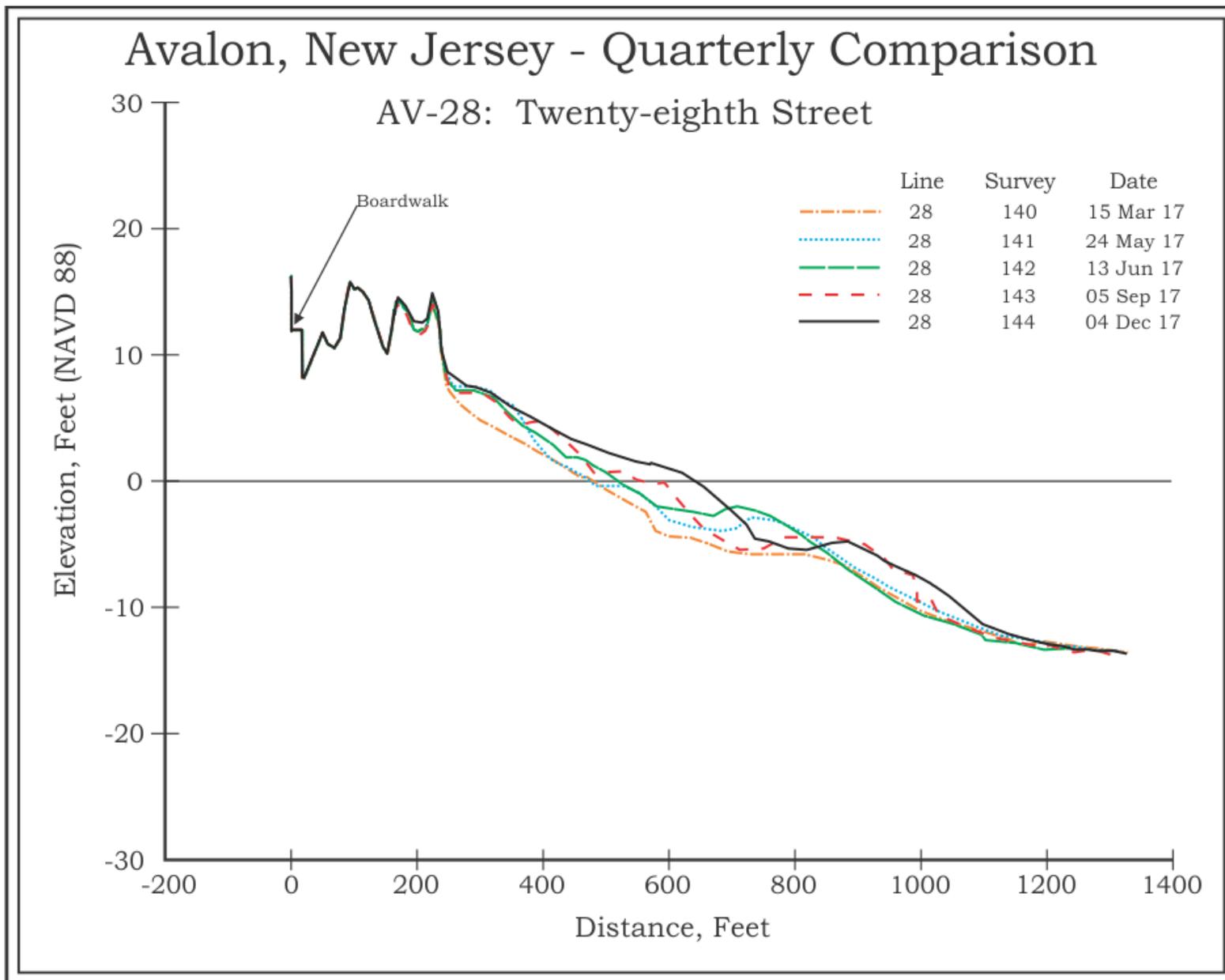


Figure 5. The 28th Street site was deficient in sand as of March 2017, and material was not directly added to the site, but moved in rapidly as the federal project approached from the north. By May, a mound of sand had appeared at the toe of the dunes and was added offshore as a bar system. This bar grew larger and seaward by September. Sand also added to the beach raising its elevation over that seen in March. By December the site had gained 81.32yds³/ft. as the shoreline advanced 162 feet seaward. This represents a significant addition to the area's sand supply.

AV-35 - Thirty Fifth Street

Sand accumulation has been dramatic here where the current primary dune marks approximately the old shoreline position in 1987. As a result of this remarkable natural accumulation of sand this section of shoreline was designated as the northern borrow zone for Avalon sand backpassing projects.

Multiple occasions where sand has been excavated locally to provide emergency material to the northern beaches, the sand volume on a cross section after the sand was excavated exceeds the sand volume present prior to the backpassing excavation process. On all four occasions, the beach recovered the sand volume excavated within 4 months of the project completion.

Every major beach nourishment effort sees material arrive within a few months of the project finishing on the northern beaches. For the next year, material adds to the berm, dune toe and offshore bar systems.

For example during the 2016 backpass project, by December 19th the excavation area was completely filled with an excess of material forming a 320-foot wide beach berm at elevation 5ft. NAVD88, six feet vertically above the post-harvest excavation beach grade. Another 16.65 yds³/ft. of sand was added the beach bringing the accumulated volume onshore following harvesting to 37.39 yds³/ft. of sand, or 103% of the sand volume excavated just six months earlier.

The current situation has benefitted from the recent USACE project by adding 43.64 yds³/ft. between June and December 2017 accompanied by a 71-foot shoreline advance. As of the most recent survey, the berm is wide enough for a repetition of dune development seaward of the existing dunes. The original 1987 survey reference post lies west of the profile plot by 200 feet, so all the dune development showing on the plots has grown up, moving seaward with time since then.



6a. March 15, 2017



6b. June 14, 2017



6c. December 5, 2017

Photographs 6a to 6c. 35th Street, views to the north.

View 6a shows the conditions following the winter of 2016-2017 where some wave action reached the dune toe but without damage.

View 6b photo taken in June 2017 shows deposition of a higher berm on the dry beach as summer got underway.

View 6c was taken from the seaward dune crest across the outer dune field toward the newly extended Avalon fishing pier. The beach width is evident as sand moves in from the recent federal maintenance fill.

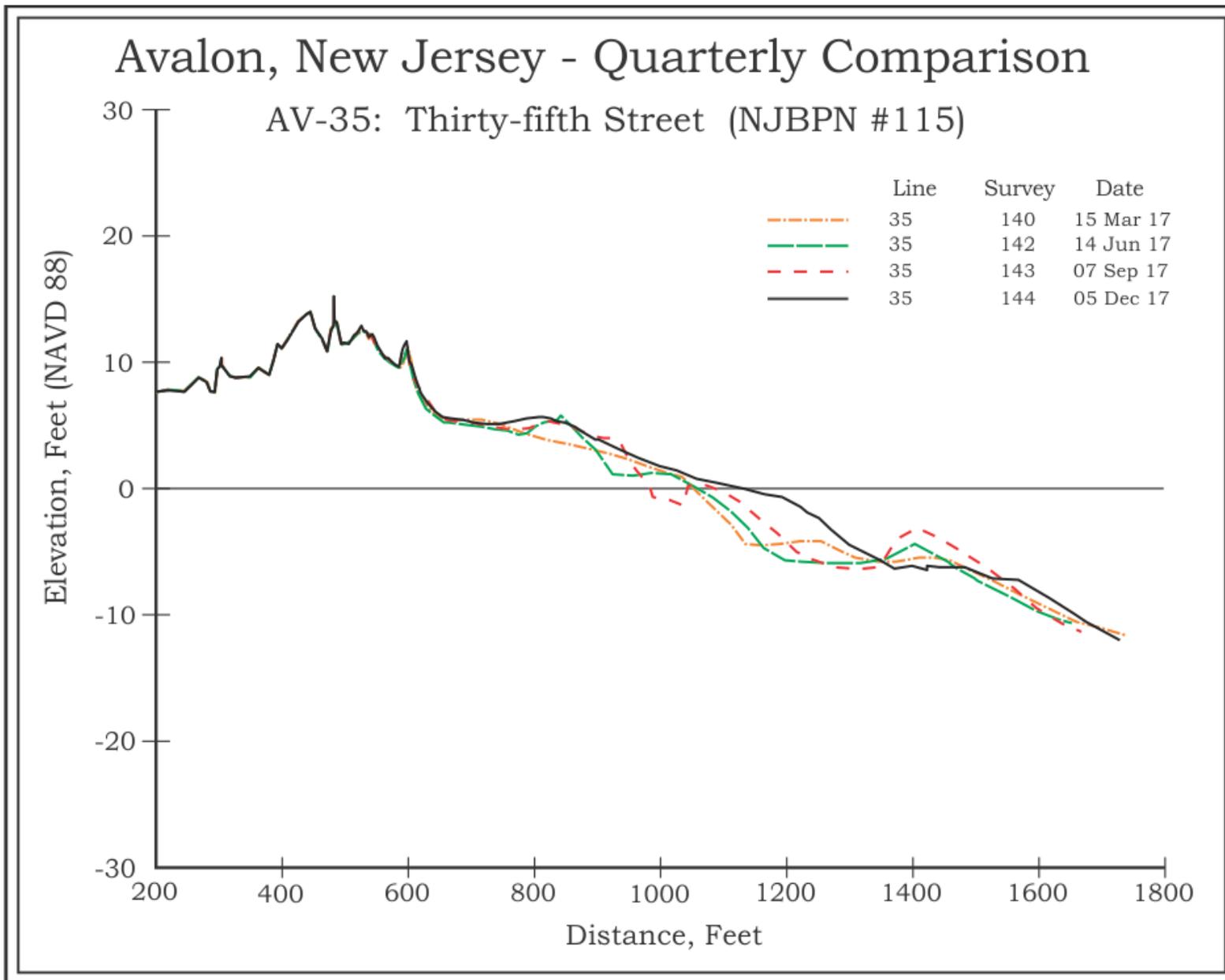


Figure 6. 35th Street is located centrally within an area accepted for sand harvesting for back pass operations. The beach since March 2017 has developed a significant berm and high beach where dune growth is favored. Offshore, the bar system added to the submerged part of the beachface slope creating a very wide berm at the close of 2017.

AV-44 - Forty Fourth Street

This site is located within an exclusion zone in the Avalon “High Dune Area” established by the NJ Endangered Species Program to govern how and where Avalon could harvest beach sand for back pass operations. The goal was to create a habitat not under repetitive excavation that could impact food sources for piping plover chicks hatching in the spring of the year. As a result and despite the abundance of available sand accumulating in this region annually no sand has been harvested from this region during the Borough’s multiple sand back-passing programs including 2016. The high dunes comprise of over 100 acres of premier coastal dunes along the New Jersey shoreline now dedicated open space. This dune system is a 1,000-foot wide zone that extends seaward from the 50-foot elevation primary dune along Dune Drive and is populated by multiple ridges of lower elevation that have accumulated and expanded quickly over many decades as the beach rapidly accreted seaward. In recent decades the sand feeding this expansion has come from the north end erosional zone.

The March survey showed a flat beach leading into a deep offshore trough. Spring deposition rapidly added to the berm, which continued to move seaward as more material appeared. This site did not perform as well as 35th Street to the north or the three sites south of 44th Street. The shoreline retreated 22 feet and the site lost 5.18 yds³/ft. during the 4th quarter of 2017. Between December 2016 and December 2017, the site did gain 6.94 yds³/ft., but the shoreline retreated 25 feet. Beach elevation increased over the summer months and sand was deposited offshore as a bar system, but without serious increases in quantity showing on the profile plots.



7a. March 16, 2017



7b. June 14, 2017



7c. December 5, 2017

Photographs 7a to 7c. 44th Street, views to the north.

View 7a is a view northeast across the foredune area and beach. Located within the exclusion zone rapid dune growth still occurs without dune fencing as the region continues to accumulate sand and the dune expands seaward through natural aeolian processes.

View 7b is the same view in June, the dry beach is favored by piping plovers as are the sparser regions among the dune grass plants.

View 7c shows the winter beach at the end of 2017 where the ocean waves have reached within 100 feet of the dune toe, but the width of the shore area prevents dune erosion.

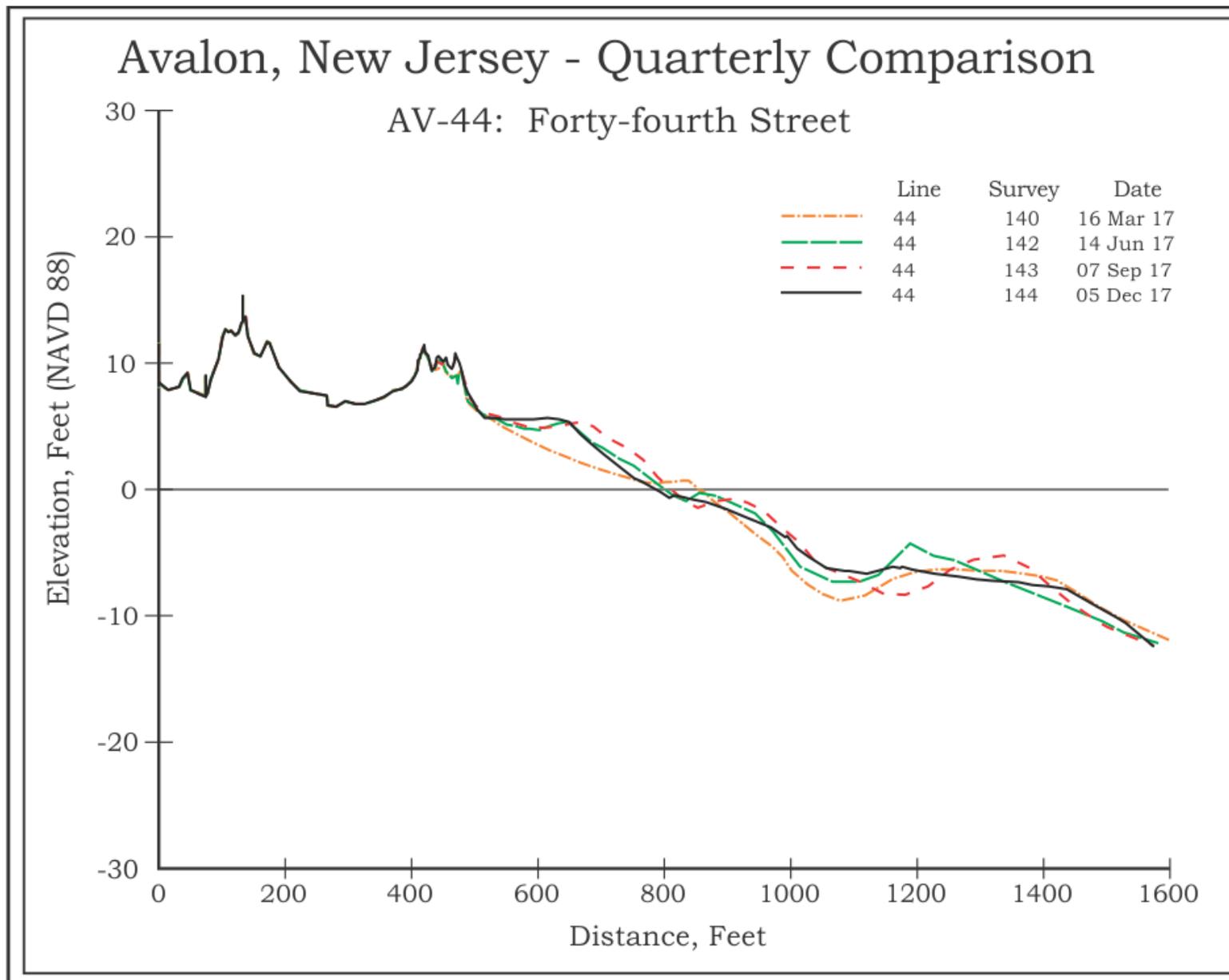


Figure 7. Dune growth is a nearly continuous process along this section of the Avalon shoreline. Beach sand moves inland driven by the on-shore winds and develop on the seaward edge of the existing dune field. The beach developed a seasonal berm early in 2017 and maintained the configuration throughout the year. Offshore the bar system remained relatively consistent with sand shifting in elevation and position. The trough landward of the bar was the deepest in March of 2017.

AV-58 - Fifty Eighth Street

The 58th Street site has shown a long term accretional trend over the monitoring history. This site lies at the southern margin of the Avalon high dune area and natural area exclusion zone. Currently, 350 feet of dune width protects oceanfront properties in this region. With an additional 300 feet of beach width to support dune growth shore protection continues to be enhanced.

The impact of sand placement either on the northern beaches of Avalon or south of the site in Stone Harbor during 2017 did not have direct influence on the beach at this location. However, minor shoreline position shifts were accompanied by dune growth and sand accumulation on the beach and in the offshore trough landward of the bar system. A minor foredune present over several years grew wider and higher right at the seaward limit of the dunes and if it continues will easily become the next significant addition to the dunes.



8a. March 17, 2017



8b. June 17, 2017



8c. December 6, 2017

Photographs 8a to 8c. 58th Street, views to the south along the seaward dune toe.

View 8a Sand continues to accumulate at the fence lines adding height and width to the dune system here.

View 8b Shows the broad expanse of dry beach between the water's edge and the dunes.

View 8c The December view of the dune toe looking south indicates vertical growth on the fence as sand was added this year. The older fence line in 8a, above, is buried completely.

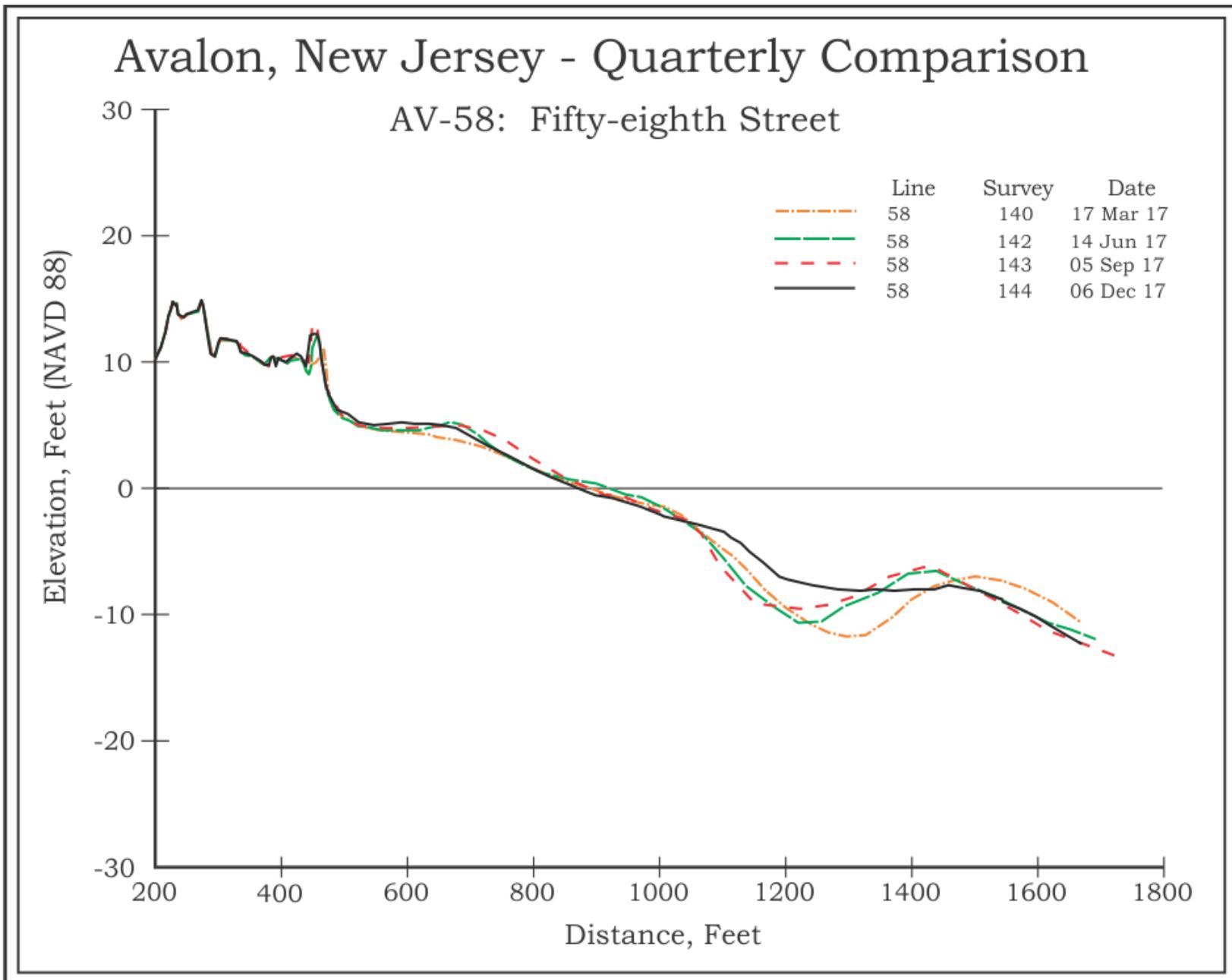


Figure 8. Sand was added to the dunes, the beach and filled in the offshore bar trough over the course of 2017. The annual change was the addition of 9.27 yds³/ft. in sand volume all below the zero datum, and a 1-foot shoreline retreat.

AV-70 - Seventieth Street

The 70th Street dune grew substantially at the seaward limit of the dune zone. The beach slope became flatter as the variety of bars and troughs were filled in or planed off as of December 2017. The major shift was the filling of the offshore bar trough. Sand is likely to have migrated north onto this site from the USACE sand placement completed in Stone Harbor. This part of the Seven-Mile-Island shore protection project includes the southern few blocks of Avalon as the taper zone and direct fill zone south of 78th Street.



9a. March 17, 2017



9b. June 14, 2017



9c. December 6, 2017

Photographs 9a to 9c. 70th Street, views to the south along the dune toe.

View 9a shows the dune toe and beach conditions near the end of the winter of 2017.

View 9b shows a near identical view as the grass begins to grow for the summer season. Note there are three horizontal fence wires in the foreground fence.

View 9c shows the view to the south at the same location, but now there are just two wires showing as sand accumulation has buried more of the fence placed in 2015.

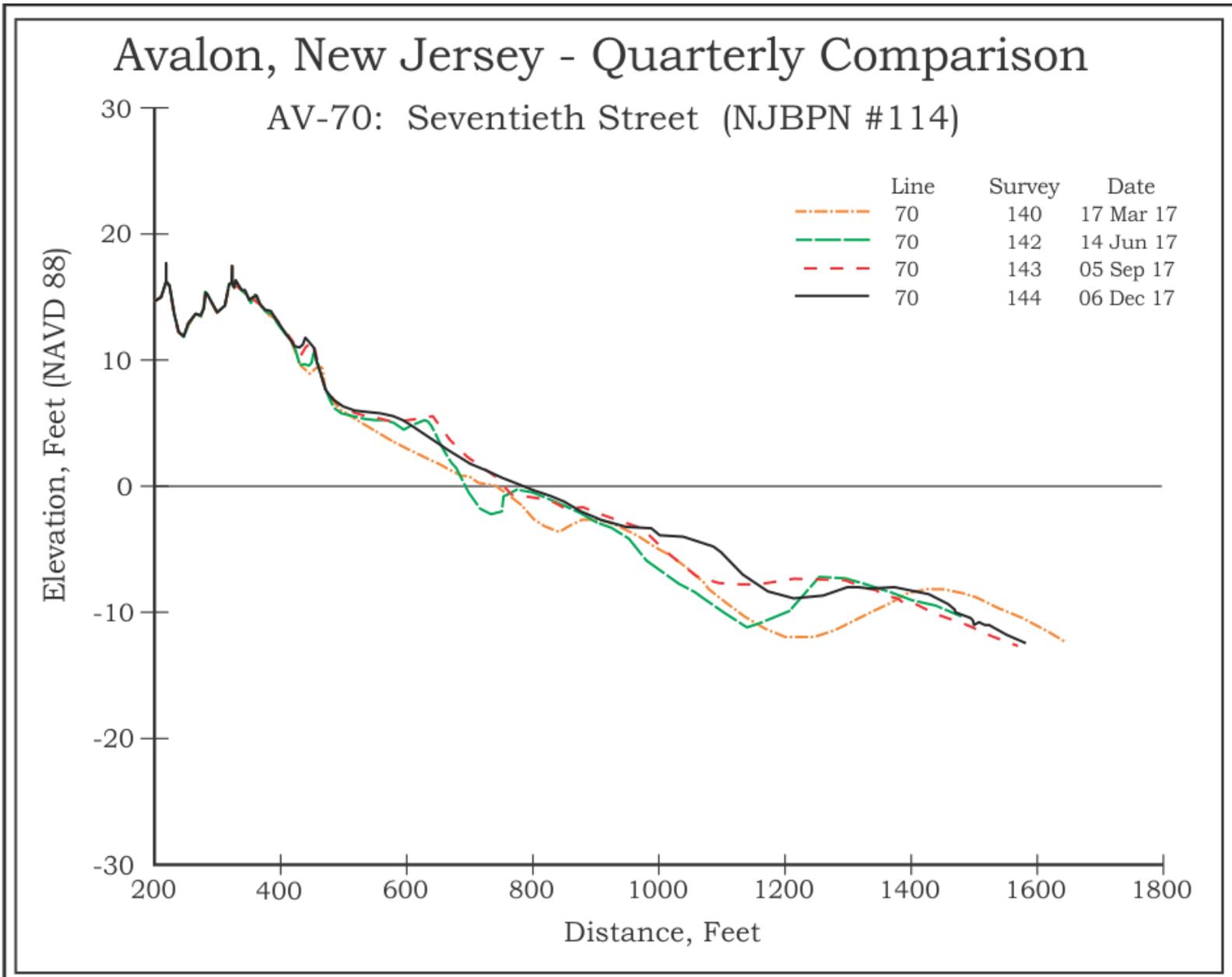


Figure 9. This site did change configuration substantially on the beach and especially offshore. The annual sand volume grew by 50.49 yds³/ft. with all but 9.6 yds³/ft. being added offshore. The shoreline position advanced 41 feet seaward as the beach added sand as well.

AV-78 - Seventy Eighth Street

This site is located near the boundary with Stone Harbor and is within the placement taper for the Stone Harbor federal nourishment project. The site did receive direct sand placement during 2017, probably between the March and June surveys. The sand volume added was 35.91 yds³/ft. and the shoreline moved 38 feet seaward. Material continued to accumulate in the offshore and berm during the summer, but material moved from the berm to the offshore by December. The annual change was the addition of 34.25 yds³/ft. with a 33-foot shoreline advance seaward.



10a. March 17, 2017



10b. June 14, 2017



10c. December 6, 2017

Photographs 10a to 10c. 78th Street, views to the north.

View 10a shows the dune and beach from the end of the beach access path. Sand has accumulated along the seaward fence line and on the beach.

View 10b shows sand adding to the foredune area at the fence line following sand placement for Stone Harbor.

View 10c shows continued dune growth, but a wetter beach as the berm had flattened out somewhat as shown in the figure below.

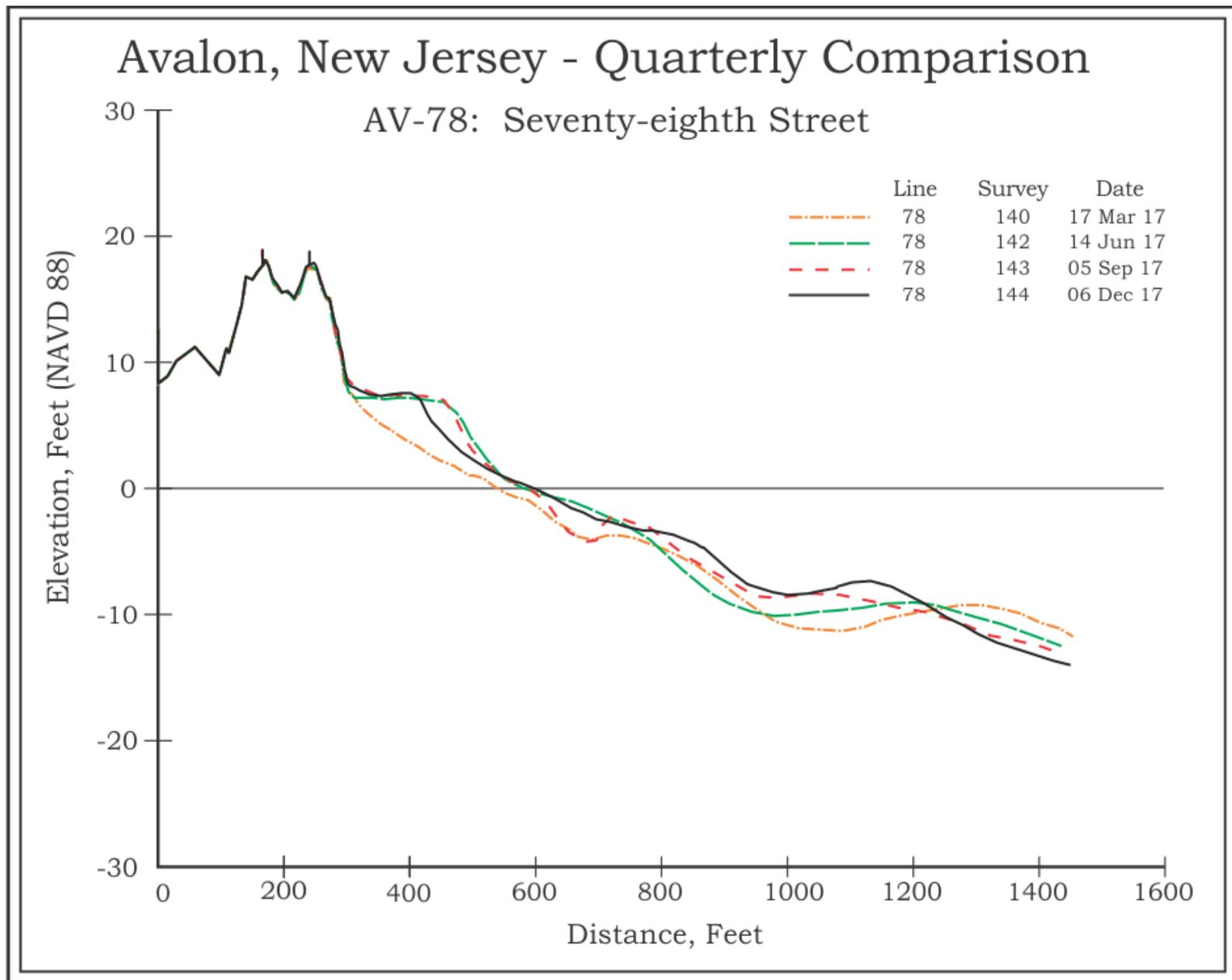


Figure 10. While sand did not add substantially to the dune beyond the seaward toe, the beach did gain sand and material accumulated offshore. The net sand volume change was more evenly balanced between the beach and the bar system at 78th Street likely due to direct sand placement by the USACE in the spring.

Summary of Avalon's Oceanfront Beaches:

The Borough of Avalon placed 740,000 cubic yard of sand on the beaches between 9th and 23rd Streets tapering to zero around 25th Street in 2015 in an effort to restore the engineered federal beach design. The USACE performed a maintenance effort in 2017 adding 940,000 cubic yards of sand between 9th and 23rd Streets with sand moving onto the 28th Street site by June. Storm activity was demonstrably less during 2017 with a January northeaster, and one storm in mid-March and a few minor northeast wind events over the fall months. No significant hurricane activity occurred along the mid-Atlantic coastline this year in spite of three US impacting storms in Texas, Florida, Puerto Rico and the US Virgin Islands.

Between the USACE project and natural accretion, the Borough shoreline gained 1.2 million cubic yards of sand as of December 2017 when compared to the previous year. The lion's share of the added sand volume is related to the federal project completed in the Borough. None of the 10 locations saw a sand volume loss, but 44th Street did have the least sand volume gain (6.94 yds³/ft.).

Townsend's Inlet Bathymetric Survey:

Avalon's north end is susceptible to erosion even during modest and moderate storm events due to its orientation to the northeast and prevailing southerly longshore currents that moves sand rapidly away from the engineered beaches. Currently, there is little to no source to feed sand to this region to naturally replenish these erosional losses at the north end. Natural inlet sand bypassing has effectively been disrupted and limited by frequent dredging of the inlet, construction and extension of the 8th Street jetty and a lack of sand entering Townsends Inlet from Ludlum Island. Consequently, the rate of dredging has exceeded the natural replenishment rate to the ebb shoal needed for sand bypassing to occur. Additionally, the 1987 permit conditions attached allowing sand harvesting from Townsend's Inlet required the approved borrow zone be located 1,000 feet north of the Avalon Inlet rock revetment shoreline due to resident owner complaints during the permitting process. This action insured the location of replenishment sand supplies accumulating within Townsend's Inlet be positioned seaward of the extreme south end of Ludlam Island rather than more medially within the inlet entrance where northeast wave events could transfer some material toward the Avalon shoreline and eventually onto the north end beaches. Permitting agencies need to re-visit this design to the official borrow zone and define a site more in harmony with the 1949 to 1978 aerial photographic history of Townsend's Inlet ebb-tidal delta shoaling patterns.

The inlet ebb tidal shoals are the natural reservoirs of accumulated sediment which alter nearshore wave patterns, affect inlet tidal channel configuration and influence the adjacent beaches. These sediment accumulations may continue to grow with time depending upon influx of available sediments until a maximum equilibrium volume is reached that allows sand by-passing to begin from the up-drift to down-drift barrier island shoreline. Avalon is on the down-drift side of Townsend's Inlet, and the past 25 years have demonstrated that this process is no longer occurring at Townsends Inlet in quantities required to naturally nourish and stabilize the north end beaches in Avalon. The ebb-tidal flow deposits sand into the ocean outside the inlet where the waves then mold the material into the typical spoon-shape shoal with the main channel located somewhere within these shoals. In the Townsend's Inlet case, the main channel lies medially with the lion's share of the shoal sand to the northeast of the channel closer to Sea Isle City. This situation has been true for several decades since beach nourishment has been using the inlet as the sand source. Dredging the material from a zone starting over 1,000 feet northeast of the Avalon shoreline has maintained this location since 1978.

The USACE completed construction of a massive nourishment project for southern Ocean City and all of Ludlam Island in 2016. This project introduced approximately 4 million cubic yards of sand derived from the NJ jurisdictional continental shelf waters (to the 3-mile limit) into the nearshore littoral system. The introduction of this sand, never previously present on any historical beach, into the system will dramatically

alter the rate of sediment entering Townsend's Inlet and the ebb shoals and could potentially restore natural sand bypassing rates to Avalon. The Borough approved an annual bathymetric survey of Townsend's to quantify and document this influx of sand from Ludlam Island into the inlet system. Comparison between annual surveys will provide data to determine rates of accumulation and potential implications this deposition may have on initiating natural sand bypassing from the ebb shoals to the Avalon beaches.

These topographic and bathymetric surveys of Townsend's Inlet cover the inlet system from the southern segment of Sea Isle City to about 12th Street in Avalon back to the Townsend's Inlet Bridge. The bathymetric data is collected using Hypack software, RTK-GPS and an Echo-Trac digital depth sounder combined on the RV Osprey, a 24-foot research vessel. Three annual surveys have been conducted starting in 2015 as the USACE project was nearing completion. Surveys cover both the Sea Isle City and Avalon inlet shorelines, channel and borrow zone and the entire ebb shoal system into water of under 3-foot depths at high tide. The survey lines start at the dune and cross the beach into the water using traditional land surveying methods, where the vessel continues to cover the ocean floor to depths of 30 feet offshore.



Figure 11. 1971 aerial photograph of Townsend's Inlet after construction of the 8th Ave. jetty, the rock revetment and 3 short finger groins in the inlet. The main channel lies next to the revetment with vast shoals exposed at low tide immediately northeast of the channel. Note that the seaward parts of the shoal wrap around the inlet mouth and contributed large slugs of sand to the beach lying between the jetty and 17th Street in Avalon. At this time there was a 465-foot wide vegetated dune system seaward of the end of 17th Street before reaching the dry, high tide beach. Flood tidal currents and storm wave action moved sand over the jetty into the inlet where the ebb-tidal currents carried it back out to the shoals for eventual return to the north end beach. A stable cycle of sediment was in place. The jetty was also lower in elevation and shorter so that sand did move back into the inlet from Avalon generating a feed-back loop process. Deposits of sand washed over the jetty or around it were rapidly re-positioned by the ebb-tidal currents to the offshore bar and eventually back onto the Avalon ocean beach. The bar at the extreme lower right in the photograph is the point of attachment for sand moving landward from the offshore ebb-delta deposit.

Figure 11 above is an aerial photograph taken in 1971 that shows shoaling conditions and configurations ideal for sand bypassing and wave sheltering to the Avalon shoreline. This discussion is included again in 2017 to demonstrate shoal conditions beneficial to Avalon. Sand shoals are emergent over a wide area in the ebb-tidal zone and form a crescent shape towards Avalon in this photograph. These shoal deposits have slowly disappeared due to their excavation for beach restoration in both municipalities since 1978 and a diminished sand supply entering the system as the Ludlam Island beaches deteriorated. The introduction of sand onto Ludlam Island from offshore deposits in 2015 and 2016, longshore transport from project beaches should restore larger ebb-tidal shoal deposits that may, hopefully, duplicate these pre-1978 situation.

The 2017 USACE beach restoration project was complicated by a conflict over utilizing federal dollars to derive sand for beach work on Seven-Mile-Island taken from Hereford Inlet's ebb tidal shoals. Hereford Inlet is part of the Coastal Barrier Resources Act (CBRA) in New Jersey (NJ-09 & NJ-09P). Created by the John Chafee Coastal Barrier Resources System of 1882, these special areas were determined to be of natural value and to retard development pressures, the Congress determined that federal money was not permitted to be utilized in promoting any form of federal expenditures or financial assistance in the CBRA areas. Previously, the US Fish and Wildlife Service (USF&WS) that has jurisdiction over the CBRA sites, had allowed the USACE to remove sand from the established borrow area within the Hereford Inlet ebb-tidal delta seaward of the inlet opening. In 2015, new legal opinions emerged ending the practice of federal funding including all sand mining for beach restoration, even on the adjacent barrier island shorelines. The result was that the NJDEP Division of Coastal Engineering (DCE) agreed to pump sand from Hereford Inlet for the Stone Harbor portion of Seven-Mile-Island beach restoration, and the USACE would utilize Townsend's Inlet ebb-tidal shoals for the Avalon portion of this maintenance effort. However, the DCE ran short of money to complete the Stone Harbor project forcing the USACE contractor to complete it using Townsend's Inlet sand pushed the length of the Avalon shoreline into Stone Harbor. As a result a million cubic yards of sand was extracted from the Townsend's Inlet borrow zone depleting any recent recovery input from the Ludlam Island nourishment utilizing the offshore sediment discussed above.

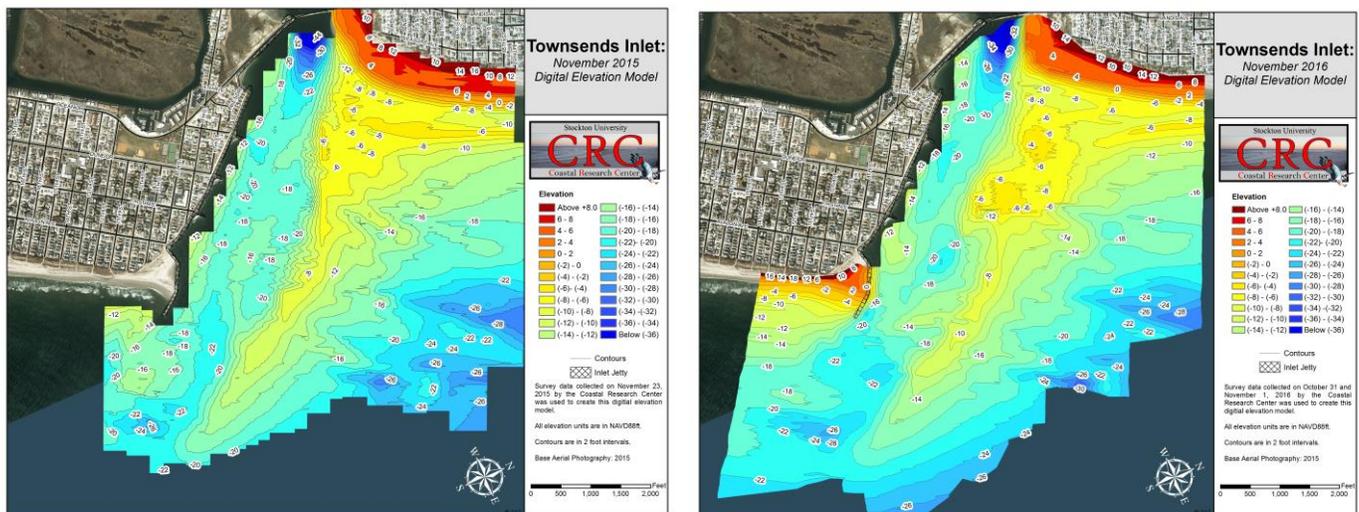


Figure 12. The DEM on the left shows elevation conditions in November 2015, red and orange colors represent the beach and dunes while blues are the lowest elevations, contour intervals are shown at two foot intervals. The light blue to green area shows the extent of the ebb shoal before sand placement was completed on Ludlam Island. The DEM on the right shows elevation conditions on November 1, 2016, about one year after the initial survey. Again, light blue to green colors represent higher elevations while dark blues are the lowest elevations, contour intervals are at two foot intervals. These two images provide the historical perspective leading to this year's survey after the most recent USACE maintenance beach restoration effort.

It was anticipated that the 3.4 million cubic yards of sand added to Ludlam Island during 2016 would rapidly restore this shoal system to its pre-dredging conditions.

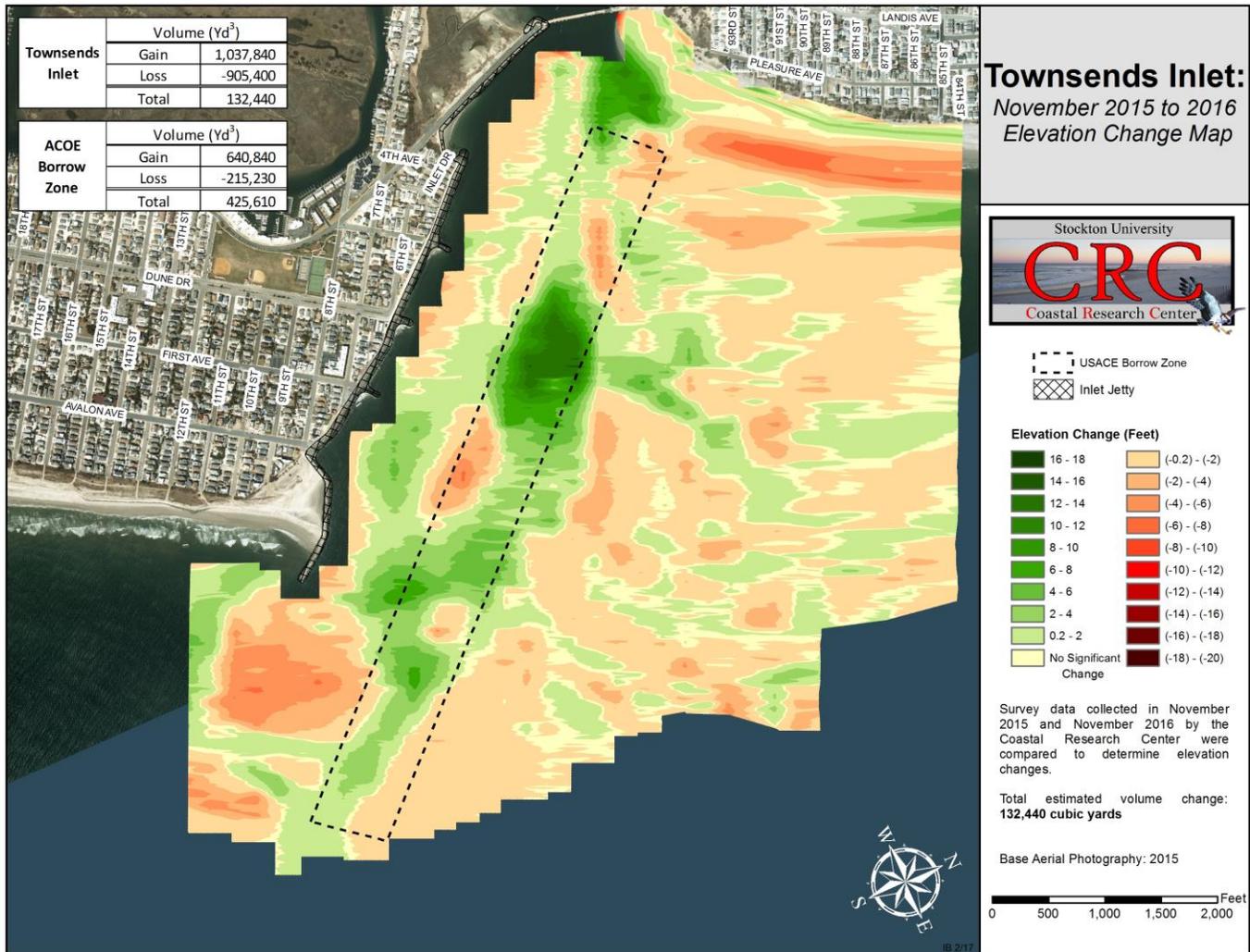


Figure 13. The map above is an elevation change map between surveys conducting November 2015 and November 2016. Green colored regions are areas of elevation gains while orange and red are regions where the elevation decreased. Yellow shaded areas are regions of no significant elevation change. The black dashed rectangle demarks the approved borrow zone used for each cycle of the federal nourishment maintenance efforts on Avalon's north end. The most depositional zone in the inlet appears to have been centrally located within the designated sand borrow zone.

Figure 13 above is an elevation change map between the November 2015 and the November 2016 survey of the inlet. The map clearly shows regions of sand accumulation on the shoal and an area of loss from an extensive linear area along Sea Isle City's shoreline into the nearshore region, extending north from 93rd Street to the northern limits of the survey. A second area of loss occurred in the inlet channel mouth off Avalon seaward of the 8th Street jetty. The changes in elevations are associated with a change in sand volume. Within the borrow zone the areas of gains accumulated 640,840 cy of sand within a year. There were pockets of sand loss within the borrow zone area focused along the channel margin where -215,230 cy of sand moved away between 2015 to 2016. The net volume change within the borrow zone was a gain of 425,610 cy of sand. This exceeds the annual anticipated recharge rate of just over 300,000 cy of sand. The volume change analysis indicates that within the first year 1,037,840 cy of sand accumulated in regions throughout the inlet system. Areas of loss were significant with -905,440 cy moved mostly from the two regions of loss described above, Sea Isle City beaches and the mouth of the inlet. The net inlet change was a modest gain of 132,440 cy of sand.

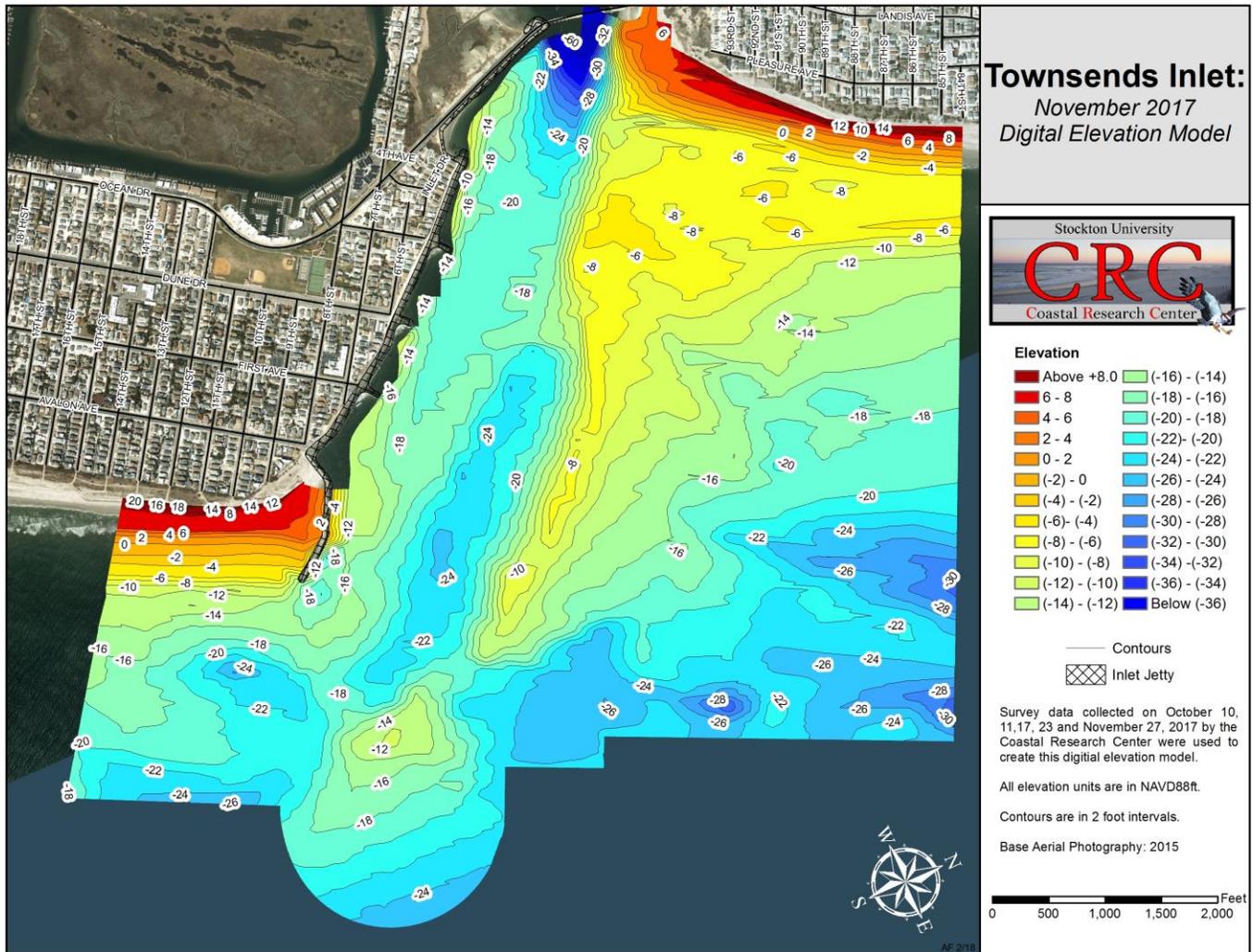


Figure 14. Digital elevation map of Townsends Inlet representing conditions existing in November 2017 using the same color and contour patterns. The USACE excavation in the borrow zone area can be clearly seen as 22 to 24-foot depths where the depth was 14 feet in 2016. The beach in Avalon received the majority of this sand, but 320,000 cubic yards were sent south into Stone Harbor to complete that part of the project.

The second elevation change map compares the data from 2016 with the 2017 information and shows that across the entire area surveyed, the inlet shoal system lost 886,550 cubic yards of sand. The areas of loss amounted to 1.7 million cubic yards, while within the defined borrow zone the net loss was 494,230 cubic yards because sand was added on the inner quarter while excavation for the beach projects concentrated on the central half. Sand also was deposited in the seaward quarter of the zone. The deposition on the Avalon beach clearly shows up as accumulation. Additional material was obtained outside the rectangular outline of the traditional borrow zone to the south and east of the seaward segment to obtain extra FCCE sand for Stone Harbor to complete the 2017 maintenance effort. That area in red color on Figure 15 below contributed 375,630 cubic yards in the digital comparison with the survey from fall 2016. Combined the 832,550 cy plus the 375,630 cy totals 1,208,180 cubic yards of material derived from Townsend's Inlet ebb-tidal delta for both Avalon and part of the Stone Harbor work. The balance of the Stone Harbor material came from Hereford Inlet funded by state and local money.

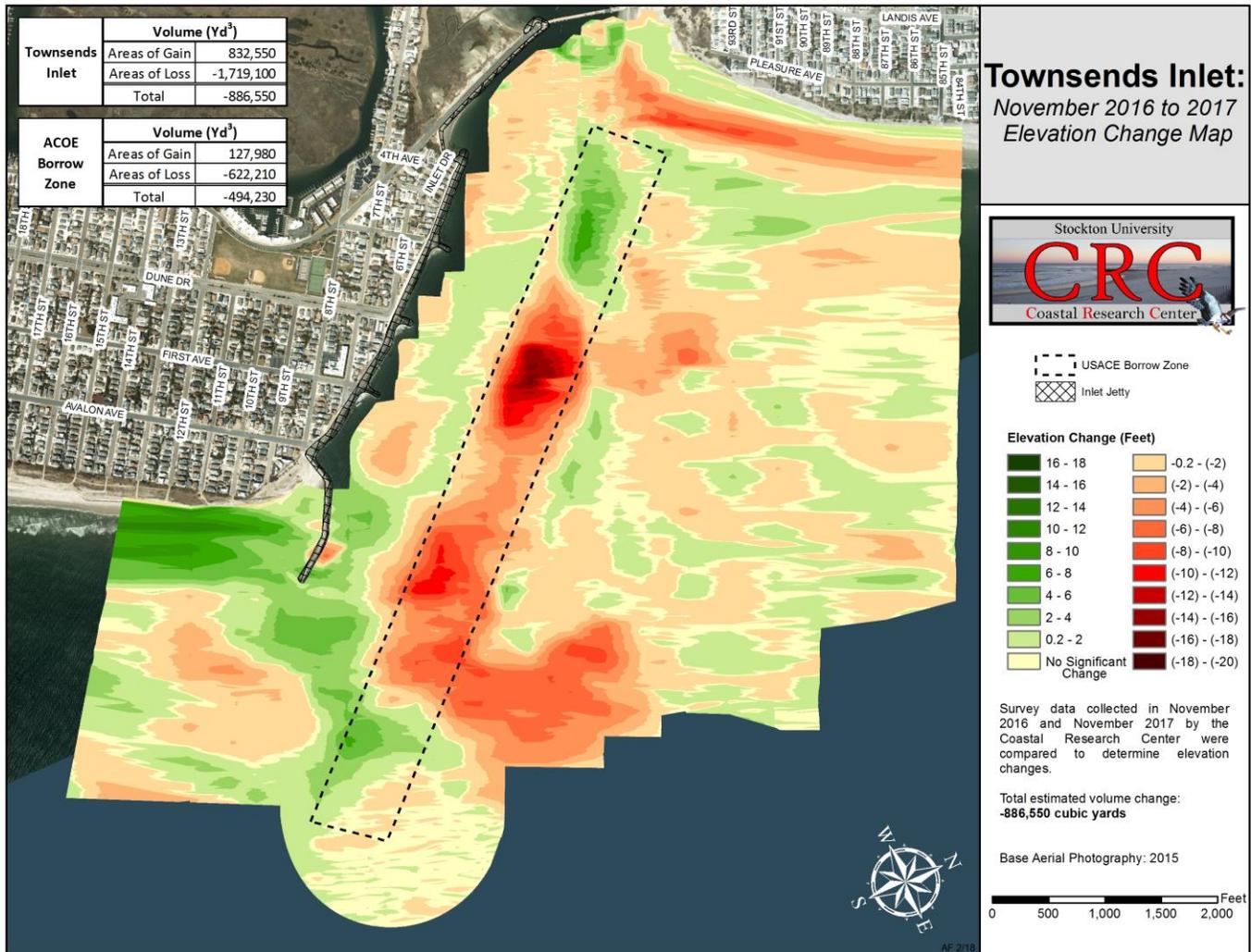


Figure 15. Elevation change map for 2016 to 2017 at Townsends Inlet ebb-tidal shoals. The red zone of loss represents the sand excavation undertaken during the spring of 2017 to serve the needs of the Avalon and part of the Stone Harbor USACE shore protection maintenance project. Sand did accumulate naturally by 4 to 6-foot elevation rise of the sea floor immediately east of the 8th Street jetty, extending into the outermost borrow zone region where a 10-foot elevation rise was recorded. This represents sand that might migrate to the Avalon side of the inlet. The USACE sand placement on the Avalon beach near the jetty also shows as a wide green zone to 13th Street. The 24-foot deep excavation will need to fill in before large scale cross inlet sand transfer can occur, with that sand derived from Ludlam Island’s USACE project.

Townsend’s Inlet Conclusions:

Tidal currents and the ever-changing wave climate act to generate a large shoal system east of the Townsend’s Inlet Bridge to points seaward of the Avalon inlet jetty. Sand normally enters this area as littoral processes move it southwest along the Sea Isle City beach and nearshore zone to Townsend’s Inlet. Some material is transported inland under the drawbridge, while ebb tides arrange it along the channel margins where waves mold the shoals seen at low tide or when waves are larger than normal showing areas of white water in the breakers. Storms accelerate the rate of sediment movement and may even act to force some to “by-pass” the inlet to the Avalon side as beach material.

The impact of the USACE beach restoration maintenance is clearly seen in the borrow zone where the red color denotes excavation as change in the order of 10 to 16 feet vertically. The survey was completed over 6 months following the dredging to produce the sand for beach restoration. The work was complete as of the May 24, 2017 survey of the engineered beach in Avalon. Tidal current infilling of the project excavation certainly reduced the depth of digging as well as muted the side slopes into the borrow zone removal area.

Since over a million cubic yards of sand was removed, the prospect for its replacement plus a need for increases sufficient to promote large scale sand by-passing of the inlet to Avalon remain at best a wish for future development. The prospect of inlet processes establishing an ebb-tidal shoal system at Townsend's Inlet depend on developing an annual average sand extraction limit that is substantially less than the sediment volume arriving from the Ludlam Island beaches. Right now, that volume coming to the inlet is as high as it will ever get given that the USACE introduced over 3.5 million cubic yards of sand from offshore onto the island's oceanfront beaches and the transfer process will simply diminish over time, returning to pre-project levels. The evaluation of a more Avalon-beneficial borrow zone placement is important as this zone of repetitive extraction of sand has implications for sand supplies and their distribution throughout the inlet ebb-dominated region. The pre-inlet dredging location of the main ebb-tidal channel was historically closely associated with the Avalon side of the inlet to the point of causing the loss of the Avalon cross streets numbered 1st through 6th since 1900. The inlet channel proximity to Avalon determined where the main ebb-tidal delta shoal seaward of the inlet would be positioned, and that position was once, more beneficial in allowing sand to reach the Avalon beachfront in a by-passing of the inlet opening from Ludlam Island (Figure 11, 1971, seaward ebb shoal).