

**FINAL REPORT FOR 2018
ON THE CONDITION OF THE MUNICIPAL OCEANFRONT BEACHES
THE BOROUGH OF AVALON, CAPE MAY COUNTY, NEW JERSEY**



View of the Avalon oceanfront April 21, 2018, a year following the US Army Corps of Engineers maintenance beach nourishment sediment that was put between 9th and 26th Streets restoring the project to the initial design specifications. This expanse shows the relationship among all the development and the beach/dune areas representing protection for that development from severe storms. PHOTO by Ted Kingston.

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**ANNUAL REPORT FOR 2018 - 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 1984. This annual report provides the results and analyses from the fall 2017 to fall 2018 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 fourth year of evaluation of conditions in the ebb-tidal shoals of Townsends Inlet.

Avalon undertook its own restoration of the north end engineered beach in 2015. 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. 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 the Borough undertook a sand back passing operation that moved about 50,000 cubic yards of sand from the 35th Street area to the vicinity of 15th Street as a central spot for deposition.

In 2017 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 lose material to the southern beaches during the winter of 2018 and again during the fall of 2018 with minor accumulations occurring during the spring and summer months.

Monitoring Program:

The CRC monitored the ten oceanfront cross sections four times in 2018, 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 144 December 4 & 6, 2017; 4th Quarter
- Survey 145 April 5 & 8, 2018; 1st Quarter
- Survey 146 June 1 - 6, 2018; 2nd Quarter
- Survey 147 September 5 & 6, 2018; 3rd Quarter
- Survey 148 December 6 & 7, 2018; 4th Quarter

Winter Storm Impacts:

The 2018 winter months started cold and dry without storm events. This dramatically changed in early March with a 7-storm series of mild to moderate events occurring every week into April, then twice in May; Mother's Day and the day prior to the Memorial Day weekend. The quarterly summary in Table 2, below provides an overview of the four surveys with the final municipal sand volume change recorded. Almost three hundred

thousand cubic yards of sand were removed from the beaches by April 5, 2018 with modest recovery seen by June (+14,578 cy), and added to by September (+57,430 cy). Erosion resumed during the fourth quarter of 2018 with 148,796 cy taken. The loss for the year amounts to 371,155 cubic yards as determined by adding up the 4 seasonal volume changes. The annual comparison (Dec. 2017 to Dec. 2018) yielded 347,947 cy. The USACE and nature placed 1,210,687 cubic yards on the beaches in 2017, so the 2018 loss rate was 30.7% of the total of the placed fill. Sand volumes were reported by the Federal project manager at 944,000 cy. The southern beaches contributed the remaining 264,000 cubic yards.

Summary of Sand Back-passing Projects:

There were further sand relocation efforts conducted in 2018 to enhance the federal maintenance effort completed by May 2017. Approximately 50,000 cubic yards of 35th Street area sand were truck-hauled north. Additional work is being contemplated for the spring of 2019.

Quarterly Beach Changes in 2018:

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 1 below shows the individual profile site trends in sand volume change by quarter for 2018.

**Table 1
2018 Oceanfront Beach Profile
Quarterly Sand Volume Changes at Each Survey Line Location**

Profile Number	Winter 12/17 - 4/18 (yds³/ft)	Spring 4/18 - 6/18 (yds³/ft)	Summer 6/18 - 9/18 (yds³/ft)	Fall 9/18 - 12/18 (yds³/ft)
8th Street Jetty				
AV-9	-24.67	7.05	-16.53	-22.07
AV-12	-64.02	7.16	-3.48	-21.99
AV-17	-53.94	-22.73	18.92	-21.79
AV-23	-15.55	-20.58	15.32	-22.32
AV-28	-23.78	23.22	-12.47	-23.07
AV-35	-8.94	-21.14	13.17	-3.66
AV-44	6.53	7.34	5.24	3.21
AV-58	3.25	8.59	-7.31	1.66
AV-70	-15.24	13.24	-0.91	1.64
AV-78	-13.51	-10.38	16.82	-5.54
Quarterly Volume Change (yds³) =	-294,367	14,578	57,430	-148,796

The storm frequency was responsible for the high volume losses seen at all but two locations in the early part of the year. Spring recovery was modest at 14,578 cy concentrated in the mid-municipal shoreline. Exceptions were seen at 9th and 12th Streets where gains occurred. The summer sand volume was higher and distributed across a wider area. The fall quarter sand volume loss was larger than the storm events would predict, perhaps due to the relatively small gains seen from 35th Street south. Also, the loss pattern was uniformly distributed from 9th to 28th Streets.

Table 2 below shows the fourth quarter changes at each profile location following the fall 2018 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. The 9th, 12th, 17th, 23rd, and 28th Street sites showed double-digit losses accumulating to a total of 148,796 cubic yards of sand moved elsewhere, either further offshore or into Stone Harbor.

Table 2
2018 Oceanfront Beach Profile
Fourth Quarter Sand Volume Change

Profile Number	Shoreline Change (feet)	Volume Change (yds³/ft)	Avg. Volume Change (yds³/ft)	Cell Distance (yds³/ft)	Net Volume Change (yds³/ft)	Cumulative Volume (yds³/ft)
8th Street Jetty						
			-22.073	500	-11,037	-11,037
AV-9	-39.9	-22.07				
			-22.031	840	-18,506	-29,542
AV-12	-22.0	-21.99				
			-21.887	1400	-30,642	-60,184
AV-17	-38.5	-21.79				
			-22.051	1680	-37,046	-97,230
AV-23	-13.1	-22.32				
			-22.694	1400	-31,771	-129,001
AV-28	10.9	-23.07				
			-13.366	2025	-27,066	-156,067
AV-35	14.3	-3.66				
			-0.228	2510	-572	-156,639
AV-44	41.7	3.21				
			2.434	3925	9,553	-147,085
AV-58	49.5	1.66				
			1.650	3360	5,542	-141,543
AV-70	-14.2	1.64				
			-1.952	2240	-4,372	-145,916
AV-78	15.5	-5.54				
			-5.540	520	-2,881	-148,796
Volume Change for Beaches Between the Jetty & 78th St. =					-148,796	(yds³)

Table 3 on the following page shows the annual volume change for 2018. Here the starting point was the December 2017 (Survey 144) versus the December 2018 survey (#148). A year of change summarized in the

table allows a review over 12 months as compared to Table 1 which documents quarter to quarter beach changes.

Table 3
Oceanfront Beach Profile
Annual Sand Volume Change December 2017 to December 2018

Profile Number	Shoreline Change (feet)	Volume Change (yds ³ /ft)	Avg. Volume Change (yds ³ /ft)	Cell Distance (yds ³ /ft)	Net Volume Change (yds ³ /ft)	Cumulative Volume (yds ³ /ft)
8th Street Jetty						
			-58.094	500	-29,047	-29,047
AV-9	-94.6	-58.09				
			-70.681	840	-59,372	-88,419
AV-12	-124.7	-83.27				
			-80.987	1400	-113,381	-201,800
AV-17	-149.9	-78.71				
			-60.597	1680	-101,802	-303,602
AV-23	-32.8	-42.49				
			-39.123	1400	-54,772	-358,374
AV-28	-88.4	-35.76				
			-27.784	2025	-56,262	-414,636
AV-35	-53.9	-19.81				
			0.732	2510	1,837	-412,798
AV-44	130.3	21.27				
			17.641	3925	69,239	-343,559
AV-58	72.2	14.01				
			6.134	3360	20,609	-322,951
AV-70	-21.3	-1.74				
			-7.897	2240	-17,689	-340,640
AV-78	4.8	-14.05				
			-14.052	520	-7,307	-347,947
Annual Volume Change for Oceanfront Beaches =					-347,947	

The annual sand volume loss was 347,947 cubic yards and the sum of the individual quarterly changes was -371,155 cubic yards. The difference is in the closed end volume calculations where the two adjacent survey sites have their sand volume changes averaged and multiplied by the distance between them. These are summed along the Avalon shoreline to yield the total sand volume change. Differences in survey ending distances among the four seasonal surveys make for some differences in contrast to a direct year to year comparison (about 23,000 cy in this case).

Avalon; A Review of the Worst Times:

Every so often it is important to see where we were and how far we have come with shore protection. In this small segment the CRC presents two views of the engineered oceanfront from before any beach nourishment had occurred. Stockton was asked in 1981 to come to the Borough and inspect what was becoming a serious erosion issue in the 12th to 17th Street area in spite of there being over 450 feet of vegetated dunes between the upper beach and individual homeowner seaside property lines. Primarily, this erosion was occurring during the

summer season with cliffs cut into the dunes and several ancient timber pole structures emerging from long burial in the beach. The 1981 air photograph presented as Figure 11 illustrates these dunes and a rapidly building sand spit deposited inside Townsend's Inlet along the Avalon inlet shoreline. While the inlet home owners were pleased with a sand beach in front of their properties for the first time in anyone's memory, the sand had to be coming from someplace.



Figure 1. On the left is an October 1986 view north from 20th Street showing the exposed support pilings for the boardwalk that once extended further north of its present ending street. There were no more dunes and homes were within easy reach of larger waves even at a normal high tide. To provide some economic insight as to the value of shore protection; one house in this section sold in early 1987 on the beach for \$82,000. The new owner held it until after the 1987 beachfill, then sold it in October for \$365,000 without doing a single improvement.

On the right is a February 1987 view from the end of the seaside bulkhead that ended at 17th Street with erosion approaching the oceanfront home on the south side of 17th Street. The white bags were placed earlier that winter, filled with concrete to protect the buried sewage service line running just seaward of the private property lines (formerly over 500 feet from the water's edge in 1981). By April 1987 the posts supporting the second floor deck were at the edge of the sand scarp with the resident's doghouse sitting at the very edge of the scarp leaving a 4-foot jump down if the dog wished to use the house. The 1987 2.35 million cubic yard initial beachfill came in time to save this property from total loss, and by 1997 it had been torn down and replaced by a much more expensive structure.

Relief came in 1987 with a NJ State/locally sponsored beach restoration project covering the oceanfront beach from the 8th Street jetty, south to 30th Street. The project included a dune erected just landward on the timber bulkhead that started at 8th Street, and ended at 17th Street, and continued south to merge with dunes remaining south of 28th Street. There was no dune system between the jetty and 25th Street by April 1987.



Figure 2. This pair of photographs are from late 2009 following the worst erosion seen since 1987. Multiple storms produced beach retreat, dune erosion which triggered the purchase of quarry sand by the Borough to bolster the dunes in the right side

picture taken from the sand covering the rock seawall at 17th Street. On the left is a view north from 23rd Street including the boardwalk to the extreme left 22 years after waves washed under the structure at mid-tide every day.

Avalon has been the most proactive municipality along the entire New Jersey coastline in terms of beach management, project implementation, and execution with a history of action going back to 1981.

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 2018 was the frequent spring season storms plus the fall losses observed.

AV-9 - Ninth Street

In 2017, the US Army Corps of Engineers returned to Avalon to conduct a much needed beach maintenance. 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.

The April 2018 cross section followed a month of weekly northeast storms in March 2018. Sand was added to the beach in May (7.05 yds³/ft.), with additional berm growth during the summer. However, sand was removed offshore lowering the seafloor elevation by almost a foot. This produced a net loss of 16.53 yds³/ft. by summer's end. Between September 5 and December 6, 2018 the berm was reduced to that present in April with minor additional losses offshore (-22.07 yds³/ft.) The annual sand loss was 58.09 yds³/ft. combined with a 95-foot shoreline retreat. After a year and a half in place, 86 cubic yards of the USACE placement volume remains on the beach or nearshore seafloor.



1a. April 5, 2018



1b. September 10, 2018



1c. December 6, 2018

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

View 1a shows the beach and seaward dune slope after the majority of the sequence of weekly northeast storms. Little dune damage occurred, but the beach was flattened to the toe of the dunes.

View 1b was taken in September following berm development showing sand restored to the beach and added to the seaward dune slope.

View 1c This view from early December shows the storm debris washed up to the seaward dune toe once again with the beach flattened by wave activity.

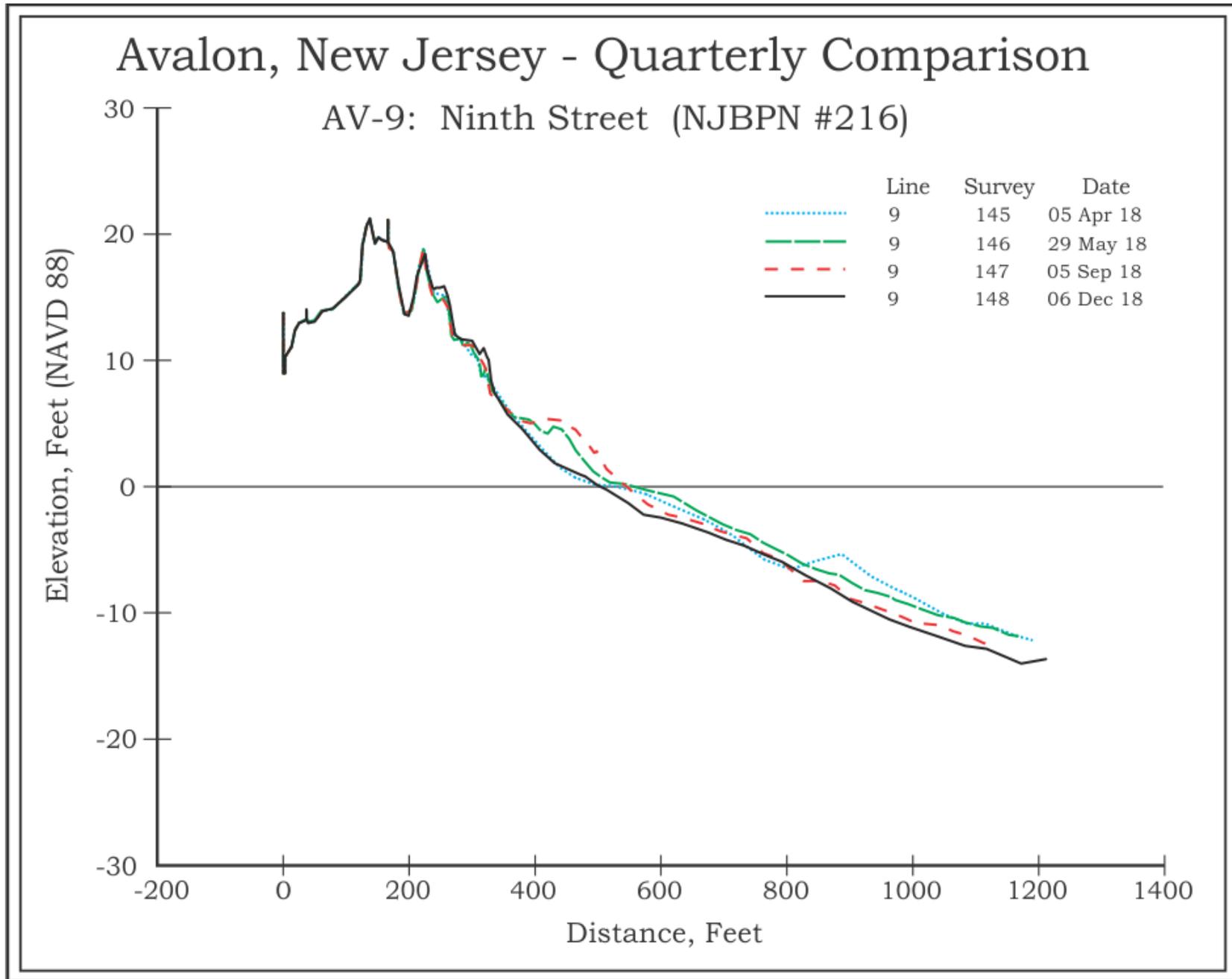


Figure 3. At 9th Street conditions ended in December 2018 approximately where they were as of April 2018. The summer accumulation built a significant beach berm and deposited sand offshore close to the beach, which eroded away between September and December 2018. Sand was minimally added to the dunes by the wind.

AV-12 - Twelfth Street

Sand placed by the USACE by March 2017 added 259 yds³/ft. expanding the beach width by 385 feet. The site has been the worst loss rate location in Avalon since 1983. As of April 2018 the loss was 64.02 yds³/ft., but during the spring 7.16 yds³/ft. returned as a beach berm. The beach and nearby offshore continued to gain during the summer, but at the expense of sand previously deposited offshore by April, making the September sand volume a minor loss of 3.48 yds³/ft. The beach eroded somewhat by December 2018, but not to the position it held in April 2018. Sand was also deposited in a tiny foredune at the seaward toe of the main dune. The fall sand volume loss was 21.99 yds³/ft., largely from the beach and near shore parts of the profile.

The annual sand volume loss was 83.27 yds³/ft., with a 125-foot shoreline retreat. The USACE placement volume minus this loss leaves 176 cubic yards of sand remaining on this profile location.



2a. April 6, 2018



2b. May 29, 2018



2c. December 6, 2018

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

View 2a shows 12th Street following the series of northeast storms that reduced the beach width, but did not impact the new seaward dune slope that had been newly planted with grass.

View 2b was taken just after Memorial Day with a small foredune developed at the fencing seaward of the new dune grass plants.

View 2c was taken after the summer season where minor storm activity had reached the toe of the new fore dune developed at the fence line. The season produced almost 2 feet of deposition from wind transport since the project was complete in March/April 2017.

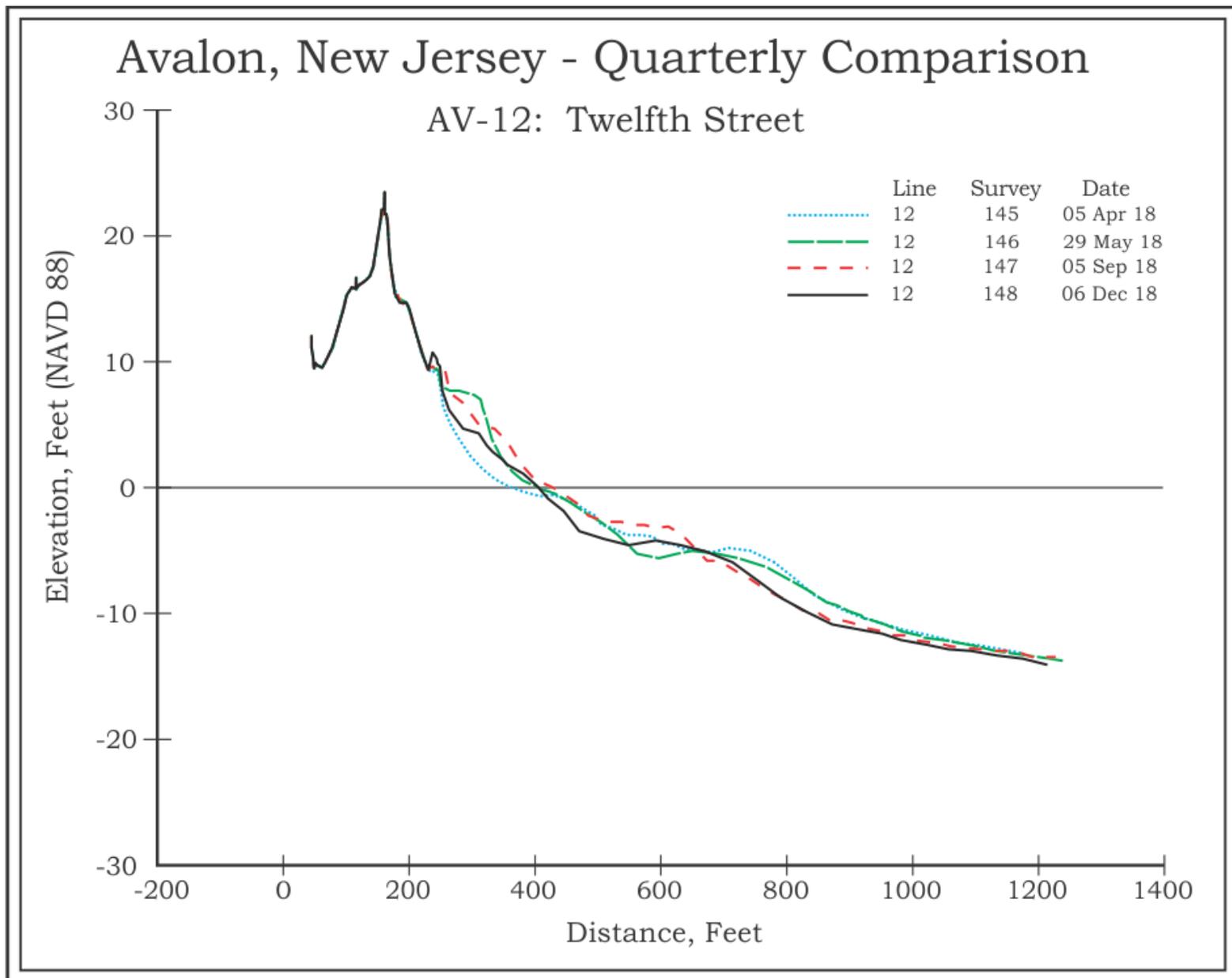


Figure 4. April 2018 survey revealed the smallest beach volume of sand. The spring and summer conditions added sand to the beach as material offshore moved landward. Sand was added to the dune toe as the early winter events cut into the berm built up over the summer. This year was not the most erosional ever seen at 12th Street, with conditions relatively consistent, but still in the loss column.

AV-17 - Seventeenth Street

The profile is located at the southern terminus of a rock revetment which continues north to 8th Street. The April 2018 beach reflected the weekly series of northeast storms impacting Avalon between March 2nd and April 8th. The winter survey completed in April found that 53.94 yds³/ft. in sand volume had been removed from the cross section. By June 18th, an additional 22.73 yds³/ft. had been eroded, mostly from the lower beachface. The summer season restored 18.92 yds³/ft. as a berm and bar system appeared close to the shoreline. By December 2018 the beach eroded somewhat reducing the sand volume by 21.79 yds³/ft.

The shoreline position was landward of the April and September location, but seaward of the May 29th position, essentially in the middle between the two extremes for the year.

The annual sand volume loss was 78.71 yds³/ft. The USACE placed 219.18 yds³/ft. by May 2017, so the remaining volume is 140 cubic yards, with material transferred to the dune 's seaward toe this summer by the wind.



3a. April 5, 2018



3b. September 6, 2018



3c. Summer 2018

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

View 3a Following a series of northeast events, the beach remained wide with sand accumulating along the two rows of fencing.

View 3b By September, the grass had advanced into the ridge between the fences. The beach remained in decent condition as the new dune ridge continued to grow.

View 3c The aerial view is from the summer of 2018 showing the dune pathway to the beach. The beach width is approximately equal to that of the dune with a broad intertidal beach as well. Bars had formed in the surf zone by the mid-summer.

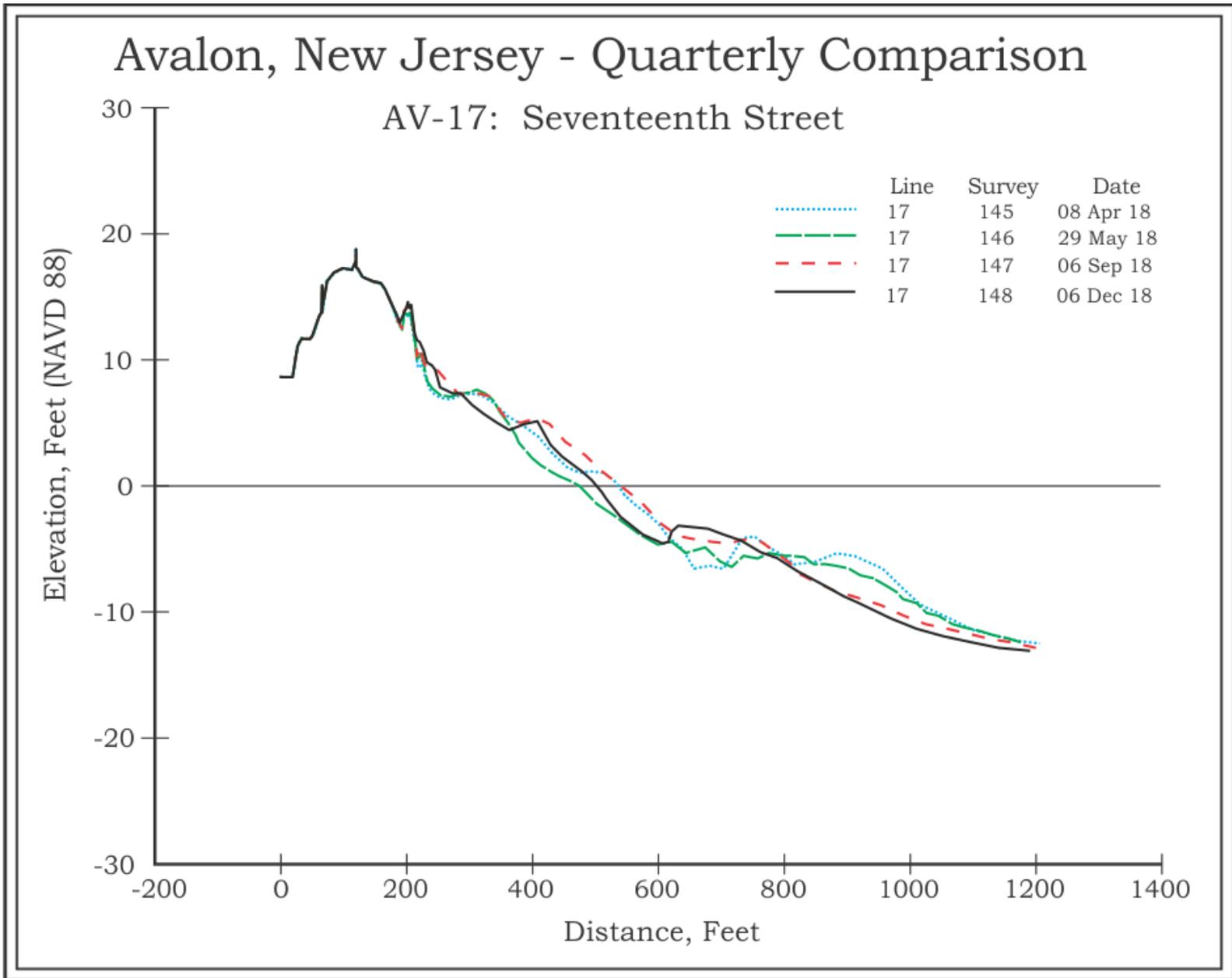


Figure 5. The April 2018 beach was negatively impacted by the weekly northeast storms by May 29th. The loss was on the beachface and nearby offshore. Sand returned abundantly to this area of the cross section by September 2018 provided by sand moved onto the beach from offshore. By December 2018 the beach had been reduced somewhat, but an offshore bar was poised to add to the beach from the nearby offshore region. The seaward dune toe gained material over the summer months.

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. The 2017 project complete as of May 2017 provided a 235-foot wider berm at an 8-foot elevation. The project added 120.69 yds³/ft. to this part of the Avalon oceanfront.

The April 2018 comparison showed 15.55 yds³/ft. in sand volume was lost due to the spring northeast events. Losses continued between April and June with another 20.58 yds³/ft. eroded. Conditions reversed during the summer as 15.32 yds³/ft. returned to the beach. As of December 2018, another loss of 22.32 yds³/ft. had occurred.

The annual beach volume change was 42.49 yds³/ft. with a 33-foot shoreline retreat. The difference leaves 79 cubic yards of the 2017 project sand left on the 23rd Street beachfront.



4a. April 5, 2018



4b. September 6, 2018



4c. December 6, 2018

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

View 4a The April view shows the fencing installed after the 2017 federal project was complete. Sand has gathered at the fence in the initial year. The beach remained wide with the 21st Street stormwater pipeline still buried.

View 4b By September the fence was two-thirds buried and plants were starting to colonize the new dune toe. The stormwater pipeline was still buried.

View 4c In December, only the top foot of the 4-foot fence was visible. The stormwater pipeline can be seen on the lower beachface to the extreme right side of the view.

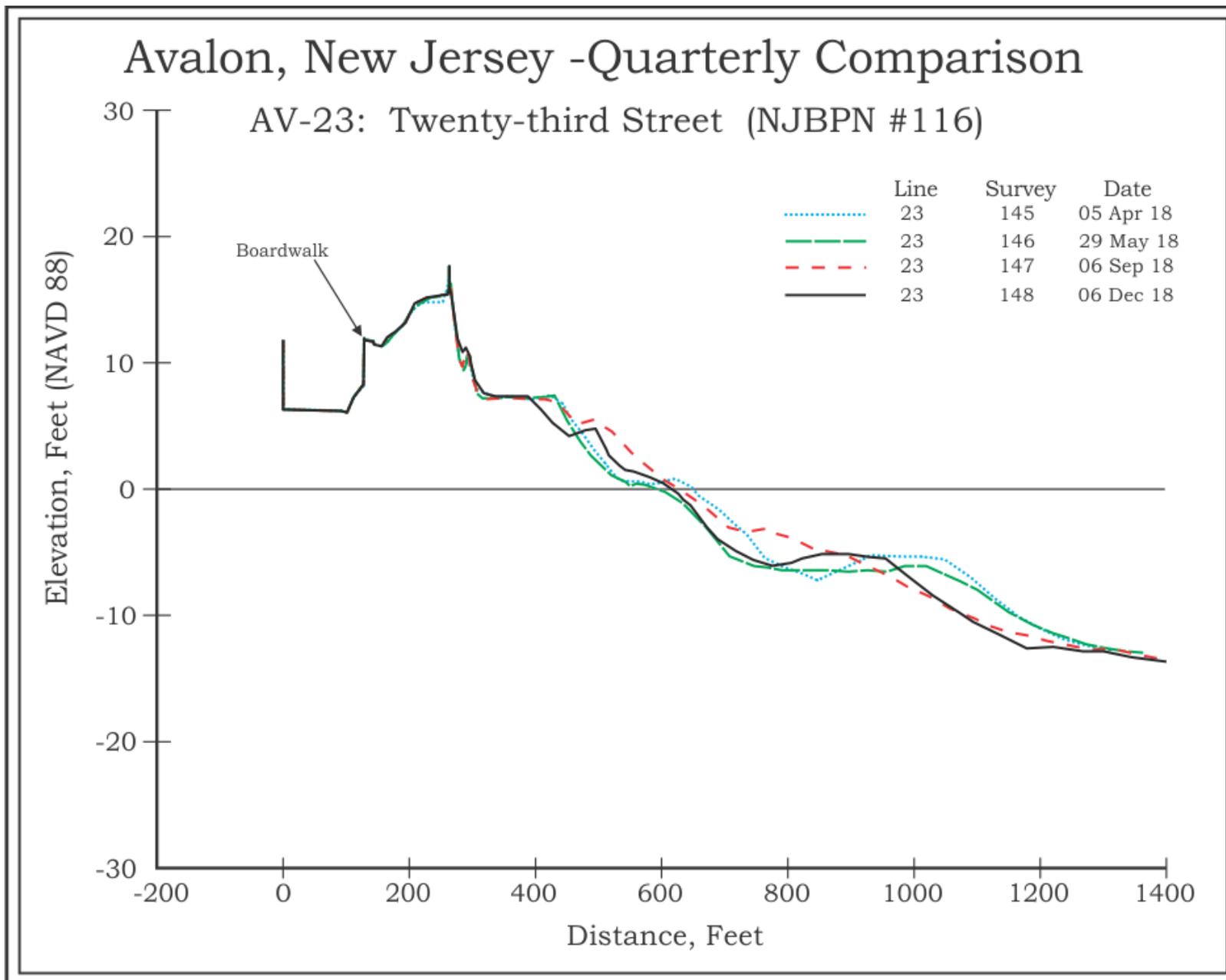


Figure 6. The April survey shows that the spring losses occurred offshore near sea level at 23rd St. However, the summer months brought offshore sand back to the beach building a significant berm. The fall losses were confined to the lower beachface and nearby offshore areas with the annual shoreline retreat just 33 feet.

AV-28 - Twenty Eighth Street

The 28th Street location is generally just south of the nodal point between chronic erosion and regular sand deposition in Avalon. This beach only received 37.41 yds³/ft., largely from sand moving to this location from the southern limit of pumping.

The April 2018 comparison showed that 23.78 yds³/ft. in sand volume was eroded, followed by the deposition of 23.22 yds³/ft. by May 29th. This return of sand was seen on the lower beachface and nearby offshore regions, likely from sand transported south from the beachfill template. During the summer, 12.47 yds³/ft. were lost in a balance between a large berm added on the upper beachface at the expense of the shore just below low tide. By December 2018 an additional 23.07 yds³/ft. were lost from the berm as it was reduced.

The annual change was a loss of 35.76 cubic yards of sand with an 88-foot shoreline retreat. The beach ended the year just 2 cubic yards of sand left from the material that moved into the area immediately following the 2017 USACE project.



5a. April 5, 2018



5b. September 6, 2018



5c. December 4, 2017

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

View 5a shows the beach following multiple northeast storms. The dune toe received a row of fencing in the spring.

View 5b shows the 28th Street beach following the summer season where the wind transported sand to the new fence building a small foredune.

View 5c is a view December 6, 2018. The sand fencing has been buried as the seaward dune slope accumulated wind transported material. The summer berm has been leveled out so that the wet/dry line on the beach is closer to the dunes.

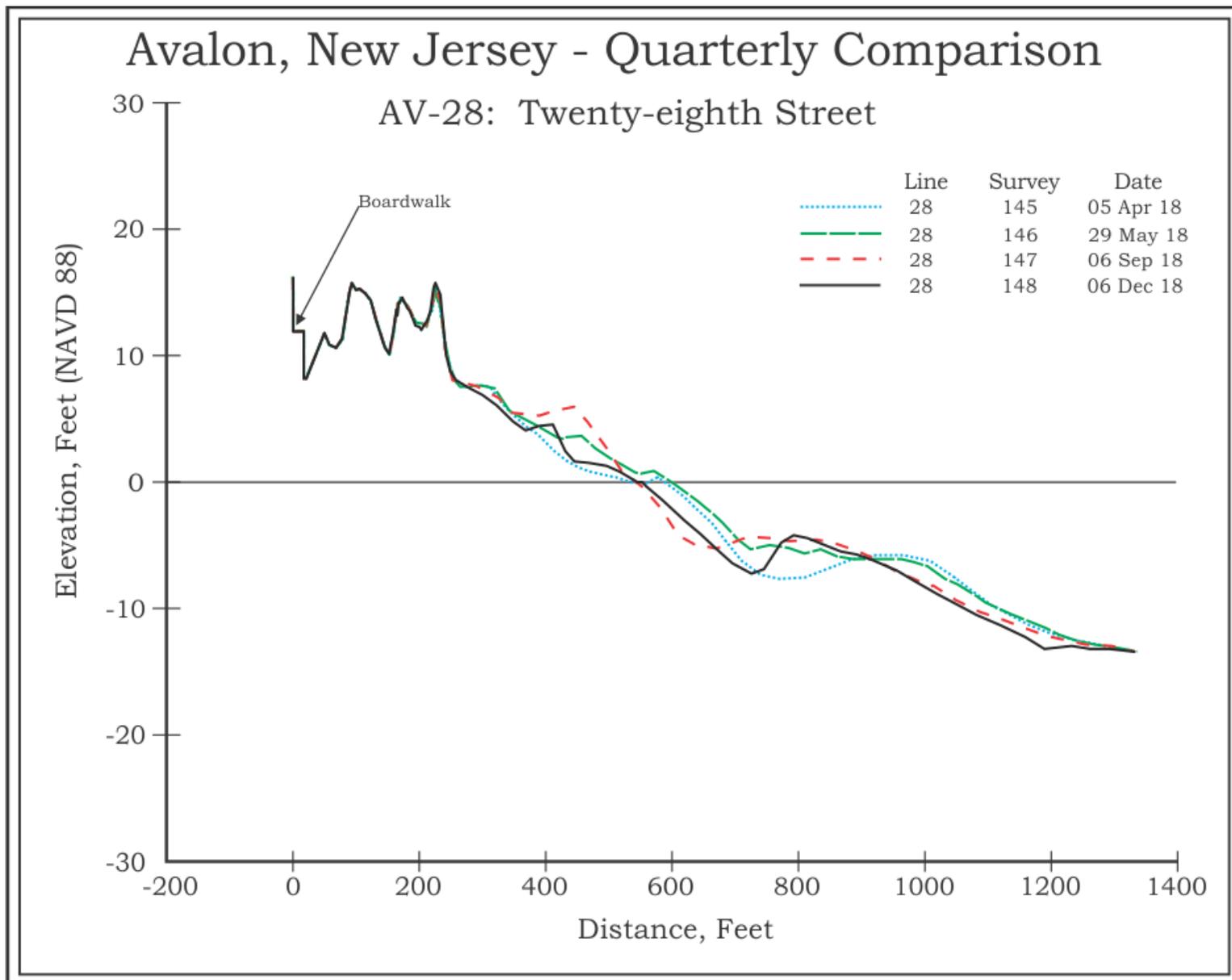


Figure 7. The 28th Street site was just south of the USACE sand template for 2017. Sand did move to the area from the deposit with the April survey showing some loss. The spring and summer seasons saw the beach develop into a sizable berm by Sept 6th. This berm was reduced by December 2018, but a bar was building offshore at the 670-foot distance from the reference.

AV-35 - Thirty Fifth Street

35th Street has been a depositional zone for decades and recently has been used as a sand source to augment the erosional beaches in the 12th to 15th Street area. The “borrowing” area is the lower beachface and any nearby bar exposed at low tide that harvesting of sand can occur.

The spring storms produced an 8.94 yds³/ft. sand volume loss that continued into the early summer with an additional 21.14 yds³/ft. removed. The summer months produced a 13.17 yds³/ft. sand volume gain that was reduced by 3.66 yds³/ft. by December 6th.

The annual change was a loss of 19.81 yds³/ft. with a 54-foot shoreline retreat. No sand has been placed this far south on the Avalon beachfront since such activities commenced in 1987.



6a. April 5, 2018



6b. September 6, 2018



6c. December 6, 2018

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

View 6a As of April 2018, the storms had reached the dune toe, but did not cause damage. The beach was flatter and narrower.

View 6b By September the berm had re-developed and a wide, dry beach resulted as the plot for this date shows below.

View 6c The seaward dune slope did accumulate a little sand during the fall season. The wide beach allows material to be continuously added to the dune stockpile any time a sea breeze exceeds 10 MPH.

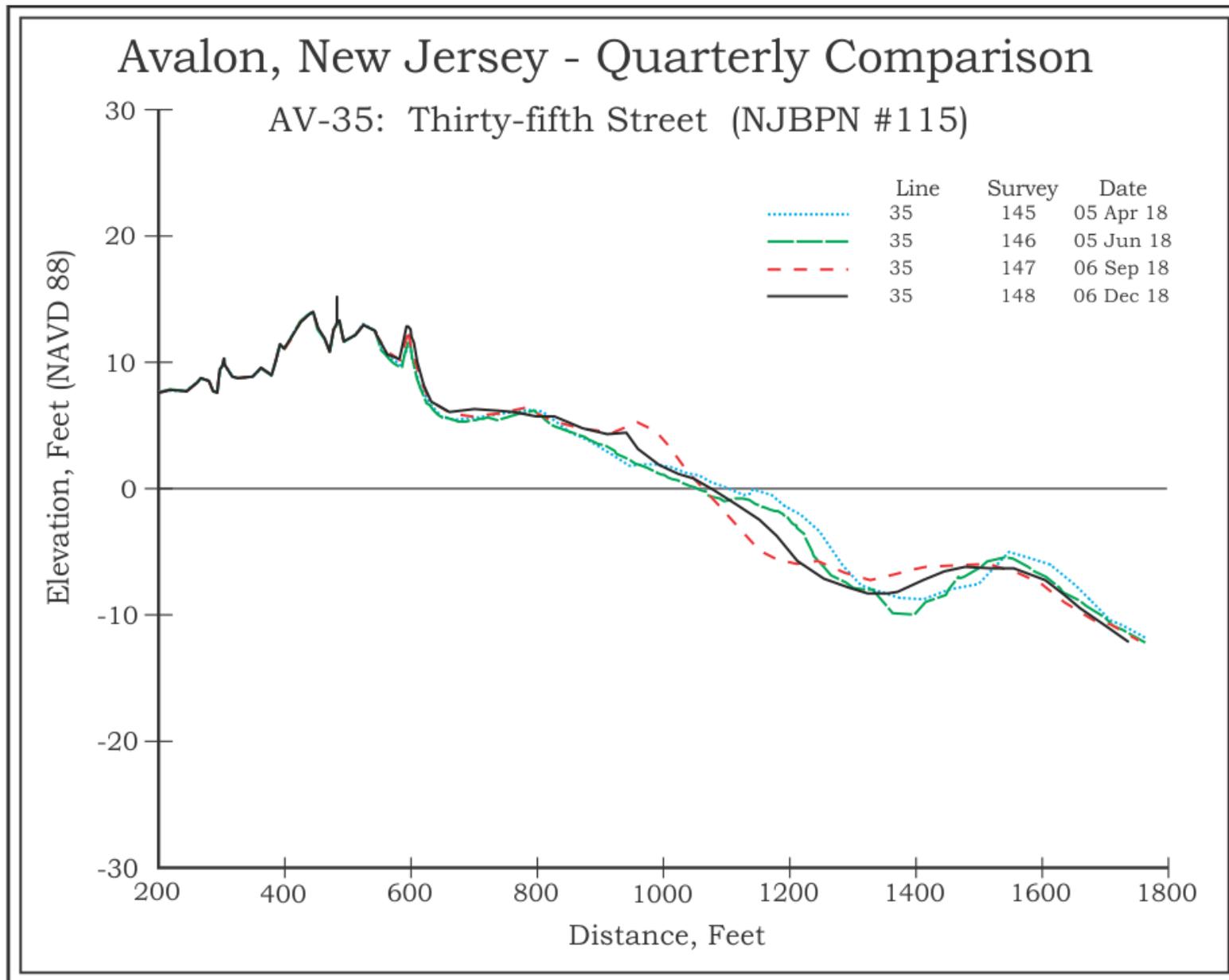


Figure 8. 35th Street location usually contains a substantial offshore bar which is the source of the material adding to the beach and dunes. The December 2018 beach is enhanced relative to the cross section present in April 2018. Offshore the slope into the bar trough is closer to the shoreline than it was in April generating the majority of the sand volume loss. The bar itself remained in position.

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. Their 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 spring survey in April 2018 showed that the site gained 6.53 yds³/ft. in spite of the northeast storm events occurring weekly. Another 7.34 yds³/ft. accumulated by June 1st. 5.24 yds³/ft. were added over the summer months with a final 3.21 yds³/ft. appearing by December 6th.

The annual accumulation of sand amounted to 21.27 yds³/ft. with a 130-foot shoreline advance. The April shoreline position was the most landward location for the year of surveys and each subsequent survey showed a seaward advance in the shoreline location.



7a. April 5, 2018



7b. September 7, 2018



7c. December 6, 2018

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

View 7a shows the view to the north across the wide beach and gentle seaward dune toe slope that is constantly growing.

View 7b is the same view in September, this dry beach is favored by piping plovers largely due to the width and the sparser regions among the dune grass plants.

View 7c shows the seaward dune toe slope with grass plants migrating down the slope. The Borough was in process of debris raking at the time. This plant waste is placed on the slope where any migratory seeds might germinate next season.

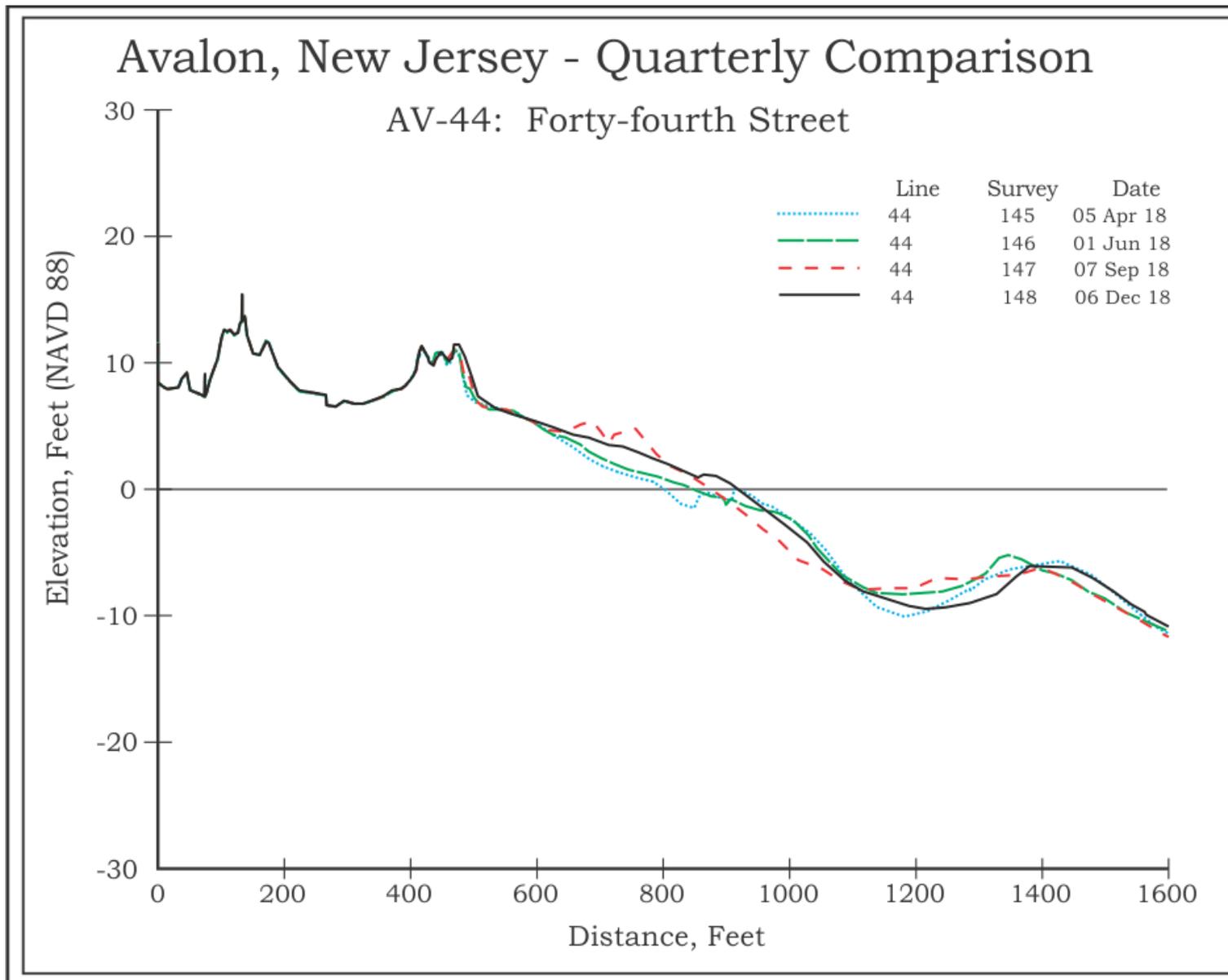


Figure 9. Dune growth was substantial at the seaward dune slope. The zero elevation shoreline position advanced steadily seaward over the year moving 130 feet altogether. The late summer profile shows two berm ridges developed on the beach which were leveled out by December without producing net beach slope elevation loss.

AV-58 - Fifty Eighth Street

The 58th Street site continued to accumulate sand on the dune and add to the general beach width over the past year. No sand was harvested from the southern back-pass borrow zone in the past two cycles.

The beach cross section gained 3.25 yds³/ft. by April; gained 8.59 yds³/ft. by June; then shed 7.31 yds³/ft. by September; finally adding 1.66 yds³/ft. in December 2018. For the year the site gained 14.01 yds³/ft. with a 72-foot shoreline advance.

The dune ridgeline closest to the beach has grown substantially since the June survey.



8a. April 5, 2018



8b. September 7, 2018



8c. December 6, 2018

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

View 8a Sand accumulates at the fence lines adding height and width to the dune system here. Storm activity did not reach into the dunes.

View 8b is a view along the fence with a berm-top pond present on the beach due to the summer berm development (see plot below).

View 8c The December view shows that the wind can essentially bury a four-foot fence in a season if the beach is sufficiently wide. This ensures that the dune continues to grow upward and seaward with time.

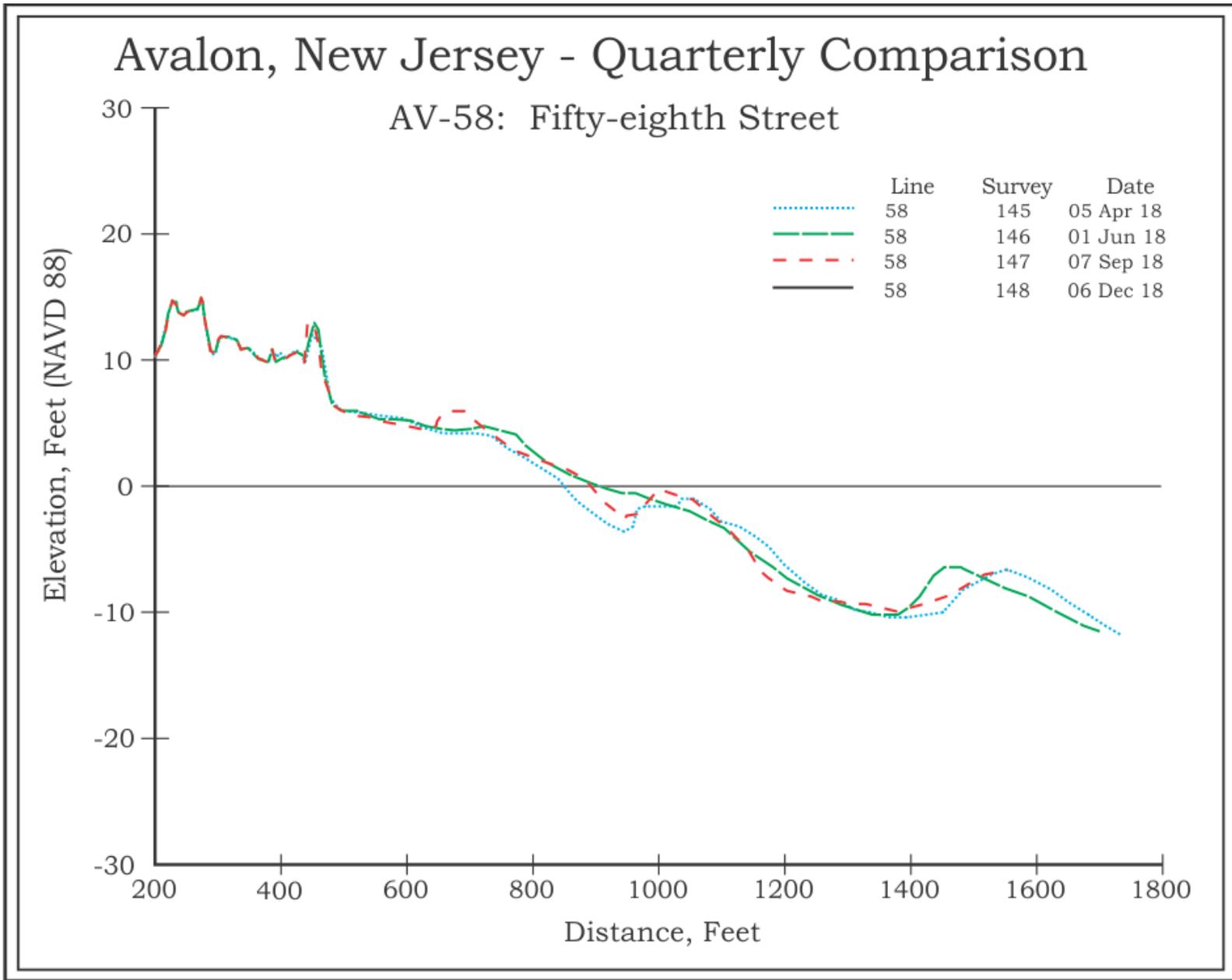


Figure 10. Sand was added to the seaward dune ridge in significant quantities. The beach's shoreline position advanced 72 feet seaward during the year as well. The bar system offshore shifted central position, but did not migrate toward the shoreline. Smaller bars did materialize and move landward in December 2017 and September 2018.

AV-70 - Seventieth Street

The 70th Street dune also saw significant sand deposited in the seaward ridge raising its elevation by a foot, extending inland up the main dune seaward slope.

The spring survey comparison saw a $-15.24 \text{ yds}^3/\text{ft.}$ sand volume loss by April 2018, followed by a $13.24 \text{ yds}^3/\text{ft.}$ recovery by June. The summer passed with a $-0.91 \text{ yds}^3/\text{ft.}$ sand volume loss, but a $1.64 \text{ yds}^3/\text{ft.}$ sand volume gain by December 6, 2018.

The annual sand volume decreased by $1.74 \text{ yds}^3/\text{ft.}$ as the shoreline retreated 21 feet from its December 2017 position.



9a. April 5, 2018



9b. September 5, 2018



9c. December 6, 2018

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

View 9a shows the dune toe and beach conditions following the majority of the spring 2018 northeast storms. No dune damage occurred.

View 9b is a view along the dune toe with two public works vehicles working in the area.

View 9c The beach at the access pathway is open at the dune toe with wind deposition filling in the gap to some extent. This access point has developed a significant dune system since the site was established back in 1992.

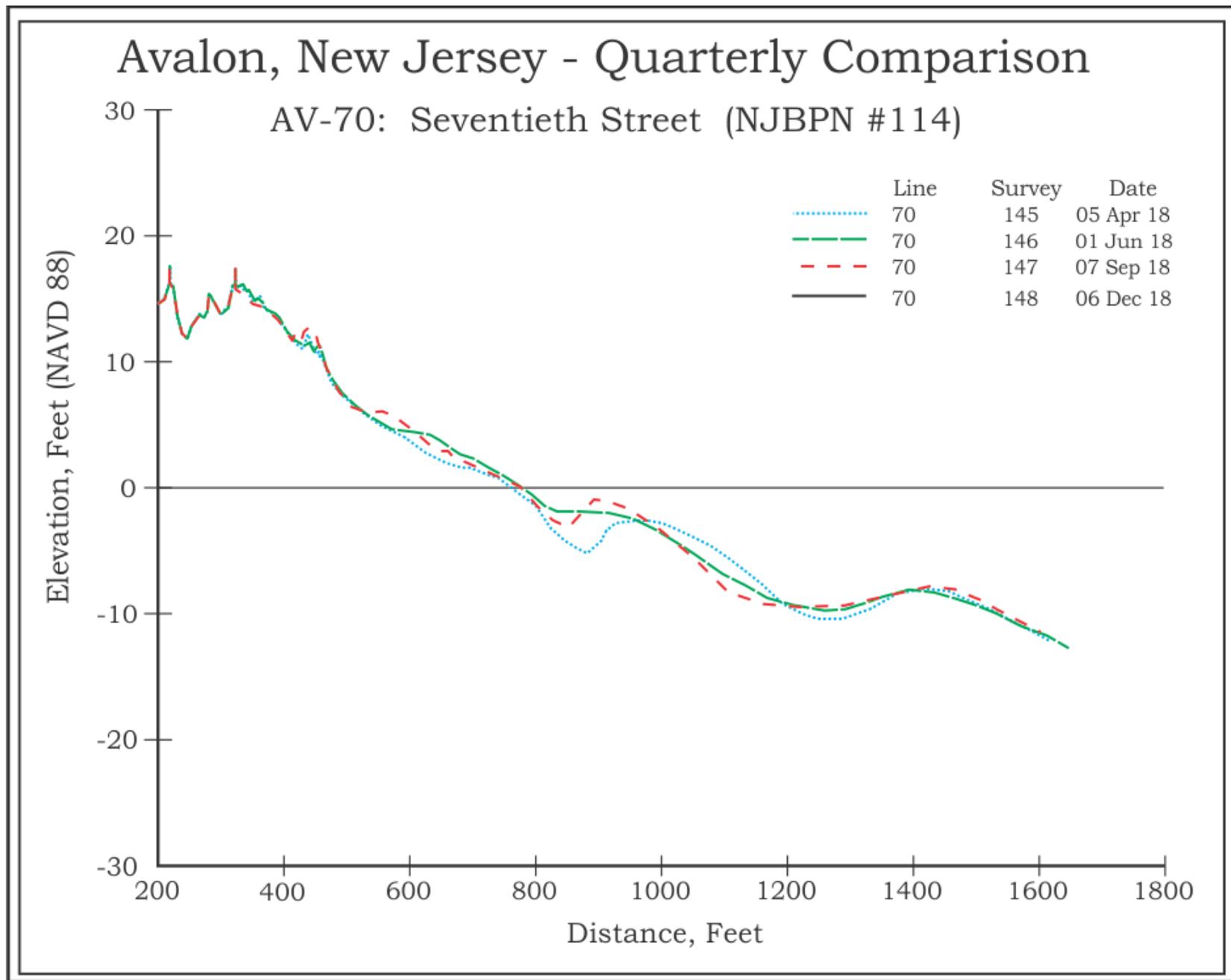


Figure 11. This site gained sand in the dunes at the seaward dune ridgeline. The beach had its largest berm ridge in December 2018 in spite of a summer of sand accretion. The offshore region remained active, particularly close to the zero elevation location. The distant bar changed little.

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. Since the project was complete, the beach lost sand volume three of the four comparisons. The April survey saw a loss of 13.51 yds³/ft., likely storm related; followed by a 10.38 yds³/ft. loss by June 2018. The summer months produced a gain of 16.82 yds³/ft., but the fall season saw loss return at the rate of 5.54 yds³/ft.

The annual result was a sand volume loss of 10.38 yds³/ft. with a shoreline retreat of 14 feet.

This dune had a thin veneer of sand added to the seaward slope, but seldom the width of the pen line on the plot in terms of actual visible accumulation on a very large seaward dune slope.



10a. April 5, 2018



10b. September 18, 2018



10c. December 6, 2018

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

View 10a demonstrates that the southern beaches are minimally affected by mild to moderate storms due to the extensive width of the beach.

View 10b is a mid-September view of the summer beach showing the dune width to the homes as well as the dry sand beach to the water's edge.

View 10c is a December view of the dunes, beach and oceanfront expanse of the protection these extensive features provide Avalon residents.

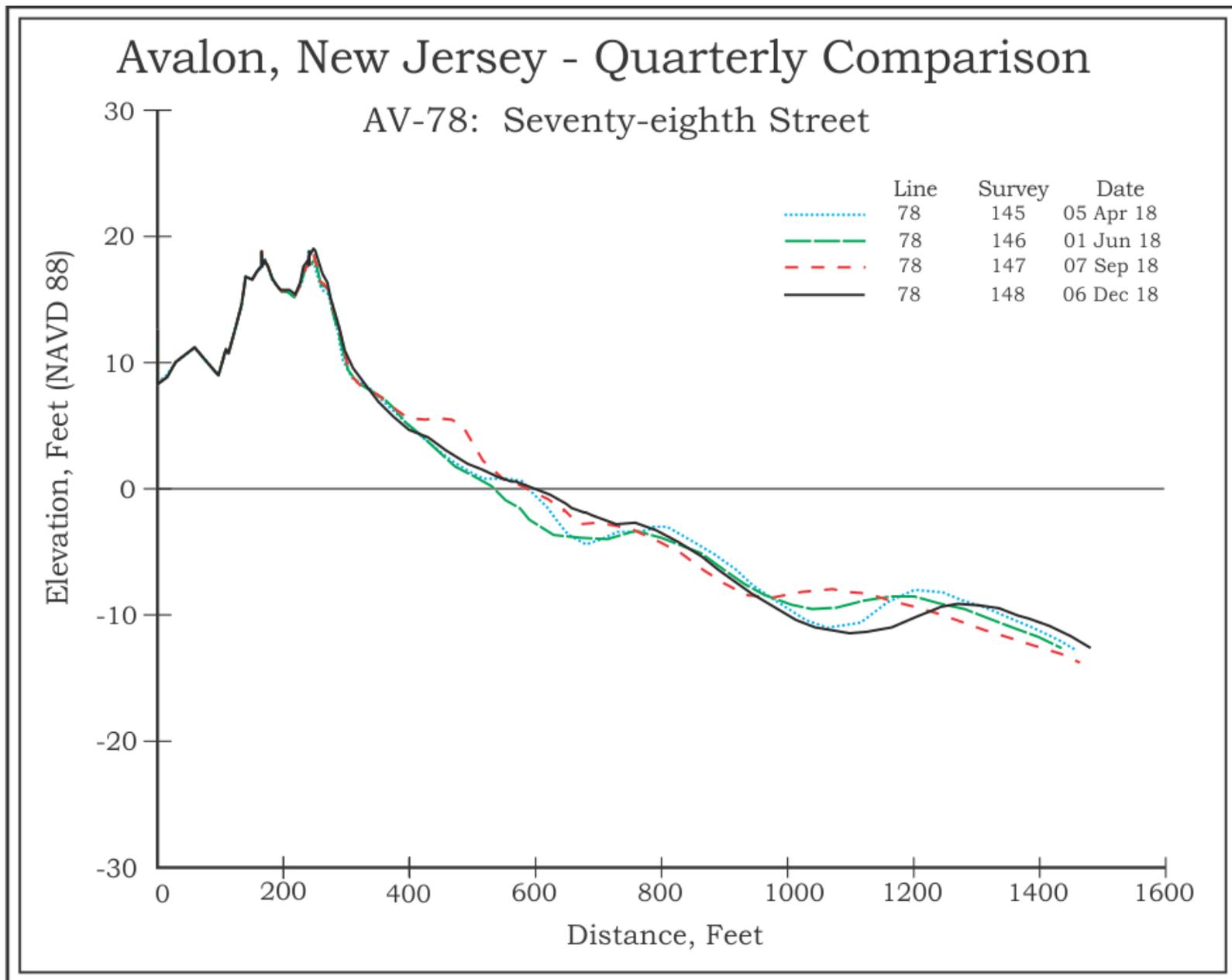


Figure 12. Sand did add to the dune, but as a thin sheet extending to the main seaward dune crest. The beach saw a summer berm that was flattened out by December. Sand moved landward from bars located close to the shoreline, but the offshore bar system changed position marginally.

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.

March began with a weekly series of storms of mild to moderate strength. The frequency tapered off in May with a mild storm Mother's Day and the day prior to Memorial Day. Damage was limited to the beachface retreat and loss of sand in the nearby offshore regions. The summer season did not produce extensive berm growth or substantial offshore bar migration onto the beach. The down-beach sand gains were limited to 44th and 56th Street locations, with those being limited to single digit or teen numbers. During the spring of 2018, approximately 50,000 cubic yards of sand back-passing was completed to augment the USACE project the year previous with deposition in the 12th Street region.

Sand volume losses were significant at 348,000 cubic yards, across the entire Borough oceanfront. However, if Avalon chooses to move sand from the back-passing areas this spring, the suggestion would be to place it between 11th and 15th Streets to provide the best distribution of the material over the 2019 bathing season.

Townsend's Inlet Bathymetric Survey:

During the fall of 2018, the CRC continued the series of bathymetric surveys of Townsend's Inlet including 1,500 feet of the Sea Isle City and Avalon adjacent beaches. This year represents the fourth annual survey of the inlet and it follows the USACE project in 2017 that removed over a million cubic yards of sand from the inlet's authorized borrow zone. The larger than normal volume taken was due to the US Fish & Wildlife Service refusing to consider allowing the USACE to pump sand from Hereford Inlet's authorized borrow zone for Stone Harbor in 2017. This is part of a continuing Coastal Barrier Resource Area (CBRA) issue related to legal interpretation of the legislation governing use of federal funds within a CBRA. Therefore, the State of NJ Dept. of Coastal Engineering funded some of the Stone Harbor project with the USACE taking the balance of the Stone Harbor sand from Townsend's Inlet along with the sand needed in Avalon. The impact on the Townsend's sand supply plus the additional cost made the project excessively expensive to complete. Effort continues to alter these decisions at all levels, federal, state and the three affected municipalities.

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 the 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. Now, 2.5

years following this project, the beaches in Sea Isle City have adjusted to the point where the sand flow to Townsend's Inlet has decreased toward previous rates of supply. Supply continues to add material to the inlet shoals, but not at the accelerated rate seen immediately following the federal project.

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. Four annual surveys have been conducted starting in 2015 as an earlier 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 3. June 1981 aerial photograph of the northern Avalon beachfront and Townsend's Inlet 3 years after the initial sand dredging in the inlet to supply material to Sea Isle City. The main tidal channel shifted to follow the dredge cut along the Sea Isle City shoreline. This significant change in the ebb-tidal flow along the Avalon shoreline allowed the flood tide to assume dominance. This produced the new sand spit seen attached to the 8th Street jetty extending almost to Dune Drive along the inlet shoreline. There were still substantial offshore bars present between the jetty and 18th Street. However, erosion of the dry beach to the dune vegetation was becoming a problem that summer. The 17th Street access pathway wandered for 465 feet through the dunes to the beach (red arrow), where the beach was now narrowing to cut into the dune toe. In 3 more years all the sand was gone into the inlet leaving the homes directly exposed south of 17th Street. The 1987 municipal/state beach restoration was the first of 9 leading to the current USACE project in 2002. The inlet geometry is critical to long term stability in Avalon. In the past 25 years there have never been offshore bars seaward of the beach between the jetty and 18th Street where waves broke on these shoals.

Figure 3 above is an aerial photograph taken in 1981 that shows shoaling conditions and configurations changed by inlet dredging contributing to major changes to the Avalon shoreline. The introduction of sand

onto Ludlam Island from offshore deposits in 2015 and 2016 was anticipated to introduce sharply increased deposition into the Townsend's Inlet shoal system.



Figure 14. View into Townsend's Inlet April 21, 2018 on a very calm day showing some of the Sea Isle City shoals near the beach, but little if any evidence of shoals on the Avalon side. The sand spit along the Avalon inlet shoreline is long gone with tiny pocket beaches at the points where the three finger groins intersect the seawall.

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. So to retard development pressures, the Congress determined that federal money was not permitted to be utilized in any form of federal expenditures or financial assistance in the CBRA areas. Previously, the US Fish and Wildlife Service (USFWS) 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.

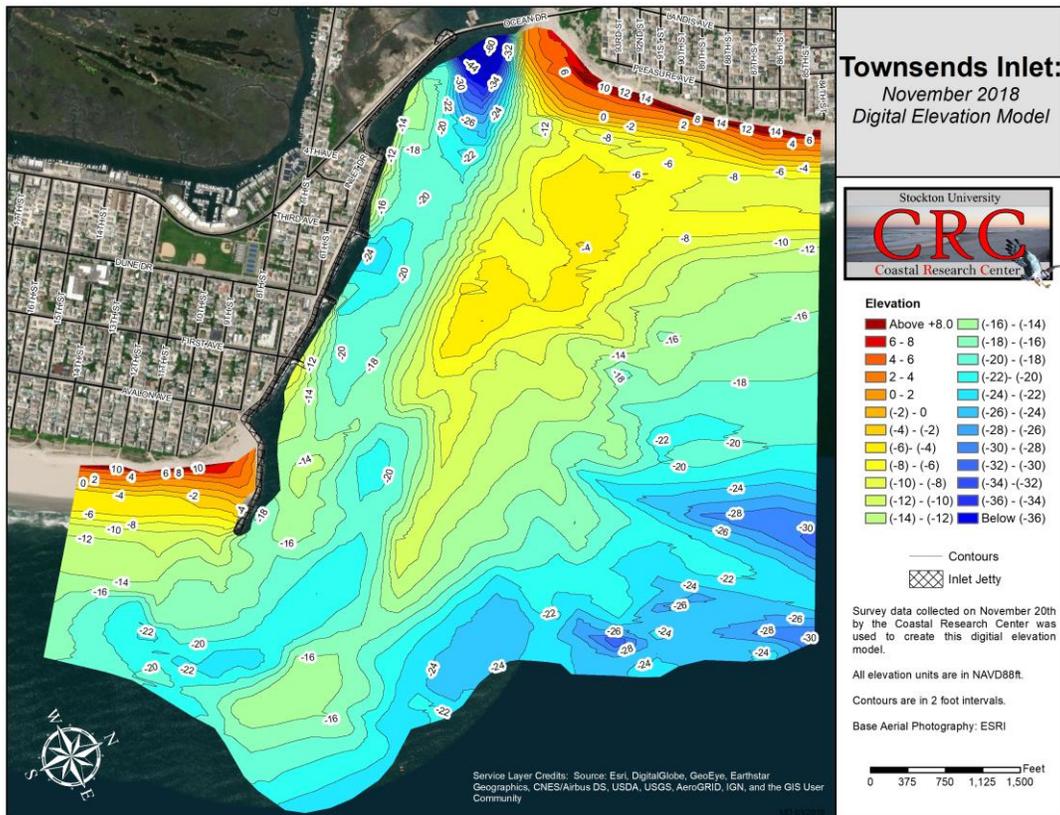
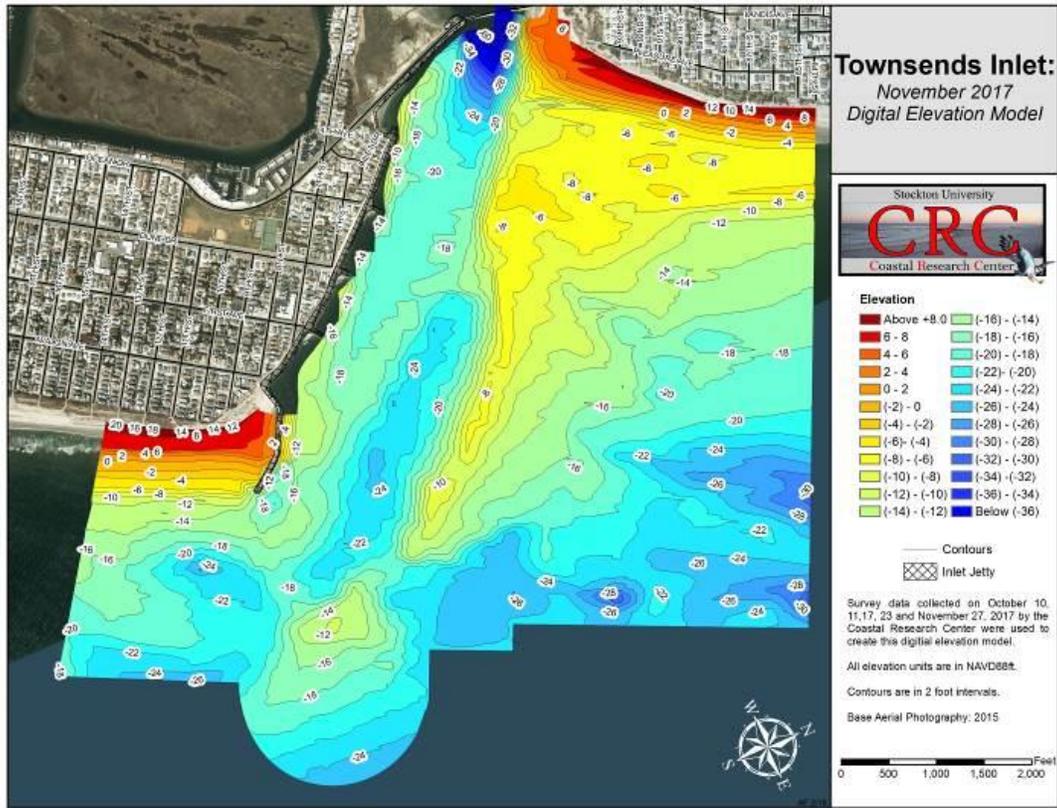


Figure 15. The Digital Elevation Map on the top shows elevation conditions in November 2017, following the extensive dredging by the USACE for beach nourishment material. The red and orange colors represent the beach and dunes while blues are the lowest elevations, contour intervals are shown at two foot intervals. The excavation within the authorized borrow zone shows as a linear blue area with a maximum depth over 24 feet. The DEM on the bottom was done November 2018 where the same zone shows extensive deposition expanding the shoals attached to the Sea Isle beach and a depth reduction of most of the blue zone to much less than 20 feet.

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.

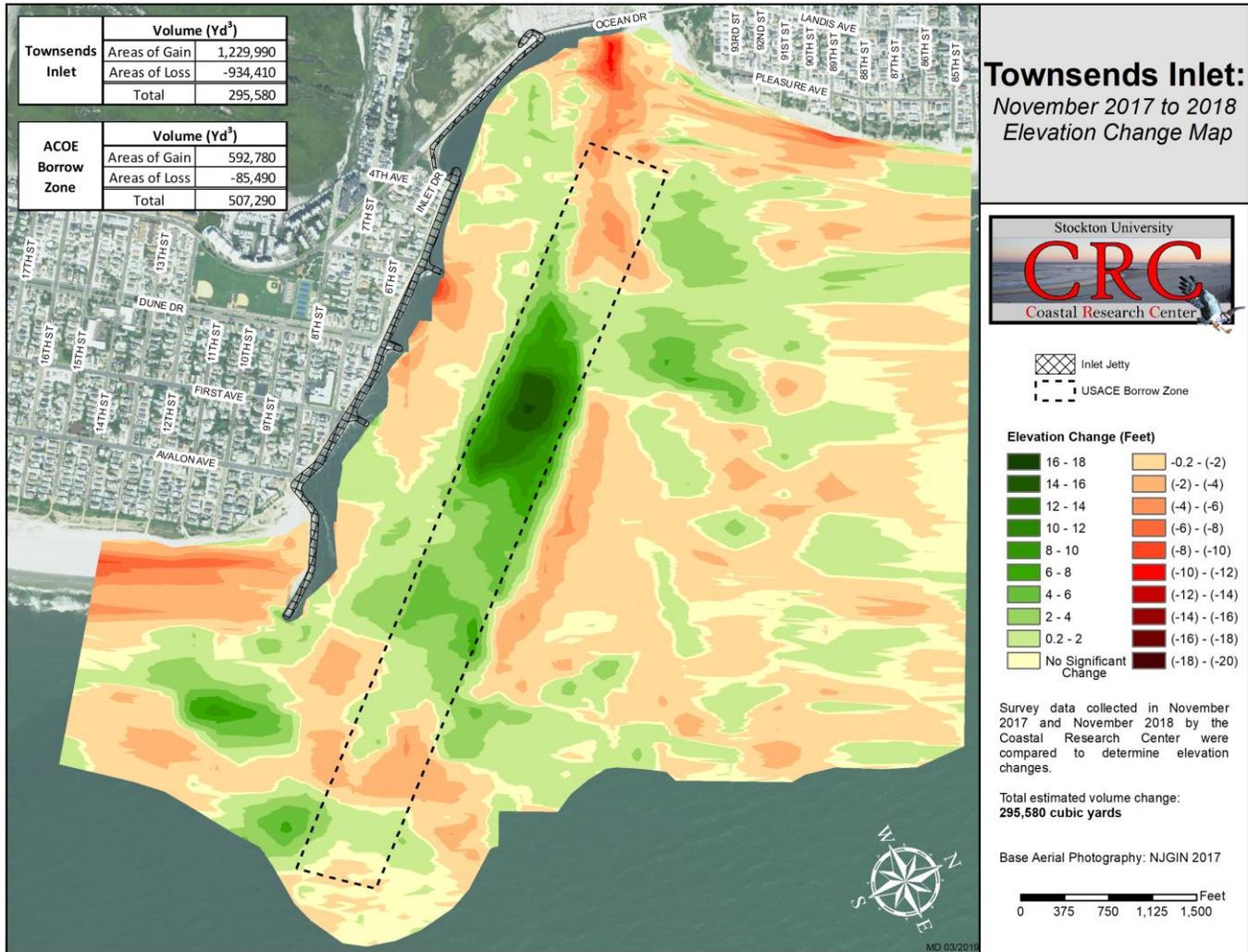


Figure 16. The map above is an elevation change map between surveys conducting November 2017 and November 2018. Green colored regions are areas of elevation gains while orange and red are regions where the elevation decreased. Yellow shaded areas are regions of no significant elevation change. The black dashed rectangle demarks the approved borrow zone used for each cycle of the federal nourishment maintenance efforts on Avalon's north end. The central area of the borrow zone gained 18 feet vertically in new sand filling in the excavation made a year earlier. A minor zone of accumulation has appeared just east of the inlet jetty in Avalon (8 feet vertically in the center). The beach area did lose sand as was shown in the 9th Street cross sections (Figure 3).

Figure 16 above is an elevation change map between the November 2017 and the November 2018 survey of the inlet. The map clearly shows extensive regions of sand accumulation on the shoal and areas of loss from both island beaches adjacent to the inlet. Other areas of gain or loss are measured in 0.2 to 2.0-foot increments over wide areas. An assumption for the loss observed along the northeast margin of the borrow zone is thought to come from sluffing of the cut bank into the excavation as it was filling in.

Since November 2017, the entire zone surveyed accumulated 592,780 cubic yards of sand while shedding 85,940 cubic yards, mostly on the municipal beaches. Word reaching us from the Army Corps project manager confirms that they feel that there is insufficient sand present in the borrow zone to allow a repetition of the 2017 beach fill project including Stone Harbor. The CRC agrees with this assessment in spite of generous sediment influx in the past year. There is sufficient material for a 400,000 cubic yard fill in Avalon, with more likely to arrive during 2019, making 2020 a good time for continued work.

Townsend's Inlet Conclusions:

The impact of the USACE beach restoration maintenance is clearly seen in the borrow zone DEM from 2017 where the central borrow area is linear and over 24 feet in depth. This zone filled in nicely during 2018 with over 500,000 cubic yards of sand added from a variety of sources. The majority came from the beaches of Sea Isle City, but the ebb tidal currents can move sand from the bay areas landward of the bridge back out into the shoals of the ebb-tidal delta.

Townsend's Inlet sand supply depends on losses from Sea Isle City. The USACE derived the Sea Isle beach sand from offshore which is a net benefit to the current NJ beach environment, but the supply transferred to the inlet is a function of northeast storm frequency and intensity, neither of which has been present at severe levels since NE Storm Jonas in January 2016.