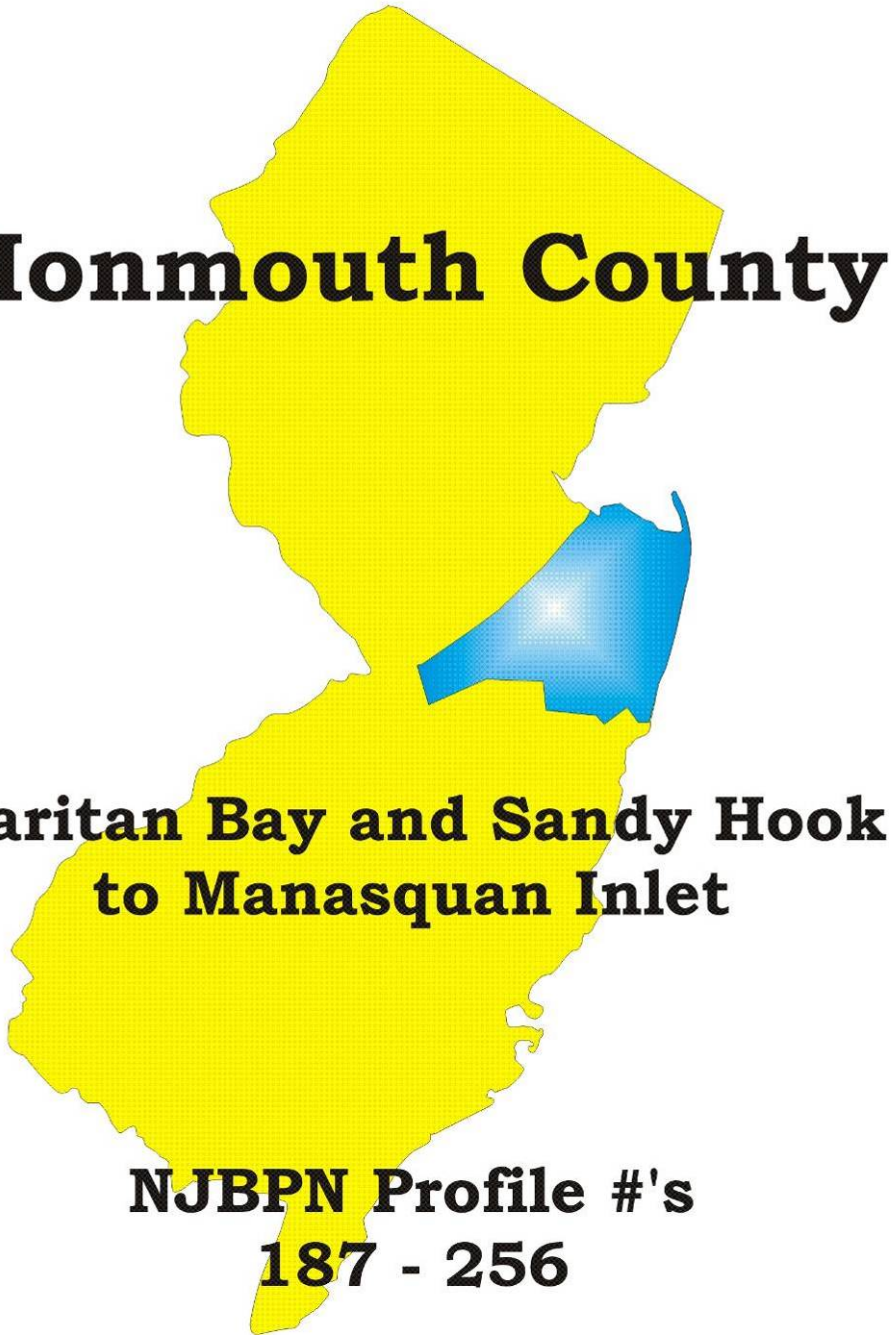
New Jersey Beach Profile Network

Monmouth County

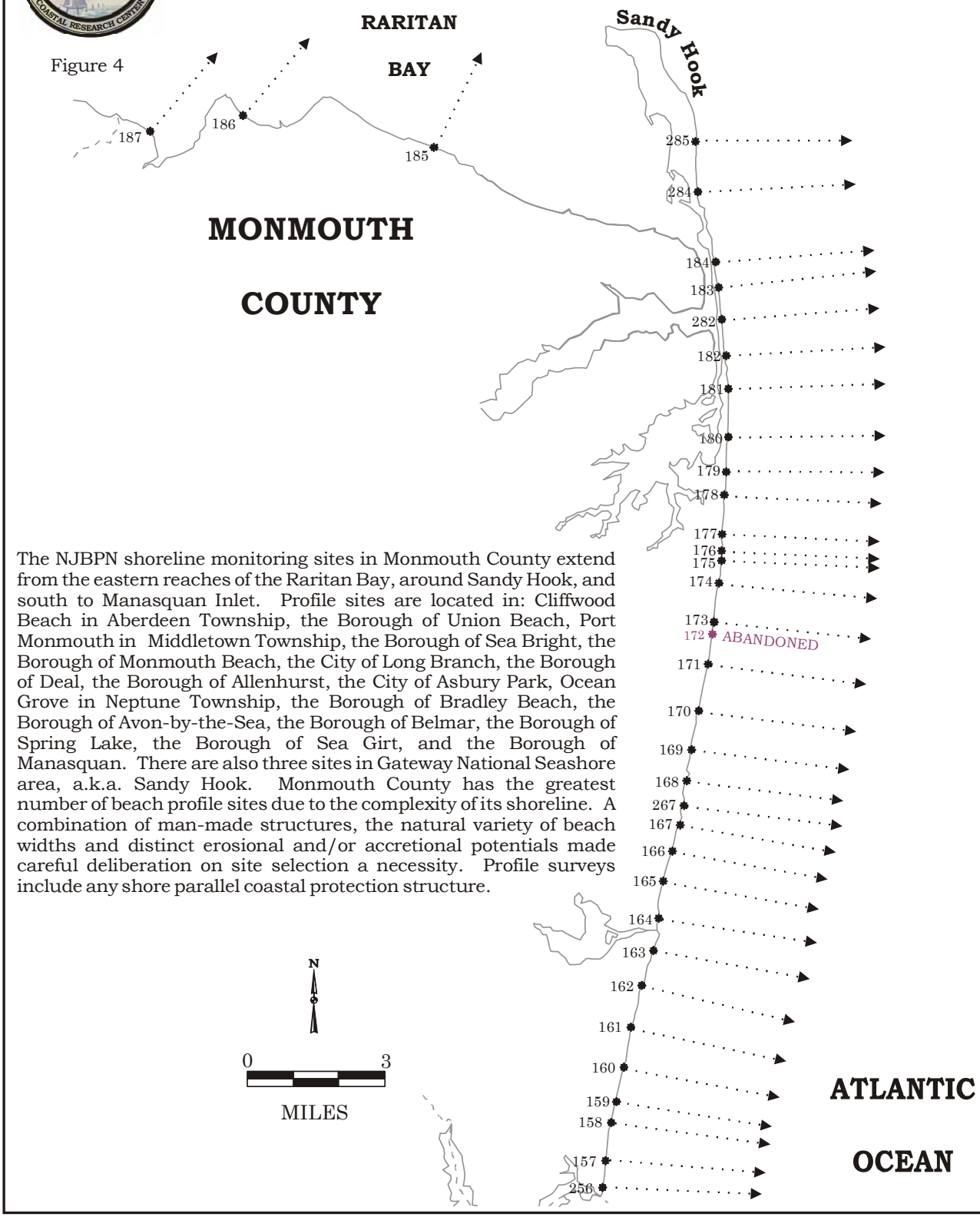


Raritan Bay and Sandy Hook to Manasquan Inlet

NJBPN Profile #'s 187 - 256

New Jersey Beach Profile Network
Monmouth County Profile Site Locations

Figure 4



The NJBPN shoreline monitoring sites in Monmouth County extend from the eastern reaches of the Raritan Bay, around Sandy Hook, and south to Manasquan Inlet. Profile sites are located in: Cliffwood Beach in Aberdeen Township, the Borough of Union Beach, Port Monmouth in Middletown Township, the Borough of Sea Bright, the Borough of Monmouth Beach, the City of Long Branch, the Borough of Deal, the Borough of Allenhurst, the City of Asbury Park, Ocean Grove in Neptune Township, the Borough of Bradley Beach, the Borough of Avon-by-the-Sea, the Borough of Belmar, the Borough of Spring Lake, the Borough of Sea Girt, and the Borough of Manasquan. There are also three sites in Gateway National Seashore area, a.k.a. Sandy Hook. Monmouth County has the greatest number of beach profile sites due to the complexity of its shoreline. A combination of man-made structures, the natural variety of beach widths and distinct erosional and/or accretional potentials made careful deliberation on site selection a necessity. Profile surveys include any shore parallel coastal protection structure.

Interpreting the Data

A 20-year analysis of each site location in Monmouth County is presented in the following pages. The analysis for each site includes: a 20-year shoreline trend graph designed to show yearly changes (fall) in the position of the shoreline with respect to the survey monument for each site plus a cumulative summation of the change over time to 2006 with a power function trend line generated by the data. Next there is a cross-section plot for each site comparing 1986 and 2006 data, with two comparison photographs with text.

Shoreline Trend Graph
The shoreline trend graph includes several useful pieces of information. The red and green bars on each graph show the annual shoreline change for each year. The red bars indicate a shoreline retreat and the green bars indicate a shoreline advance. The blue line towards the top of each graph shows the summation of all shoreline positions throughout the 20-year study period. The black line shows the median trend for the profile's annual shoreline position changes. The reference position for each profile is variable resulting in a variety of scaling options used to represent the changes in feet from reference position for each graph. This may result in the graph bars appearing smaller or larger depending on the required scale for each location. This does not affect the value for the shoreline change calculated for each site since this is simply the difference between the distances from the reference position to the shoreline point for each survey.

Comparison Photographs
At least two photographs were selected for each profile location. An early photograph (usually taken between 1986 and 1991) and a more recent photograph taken in 2006 is included for each profile. The photographs are then followed by text explaining what is seen in each photograph along with the year in which it was taken.

Cross-section Plot
The cross-section plots compare data collected in 1986 to 2006 data. They provide a visual comparison of changes that occurred over the study period both above and below the shoreline position (zero datum, NGVD 29). Profiles that were added to the project at a later date only compare 1995 data to 2006 data. The solid black line shows the data that was collected during the fall 2006 survey. The red-dotted line, except in cases where the profile was added at a later date, shows the data that was collected during the fall 1986 survey.

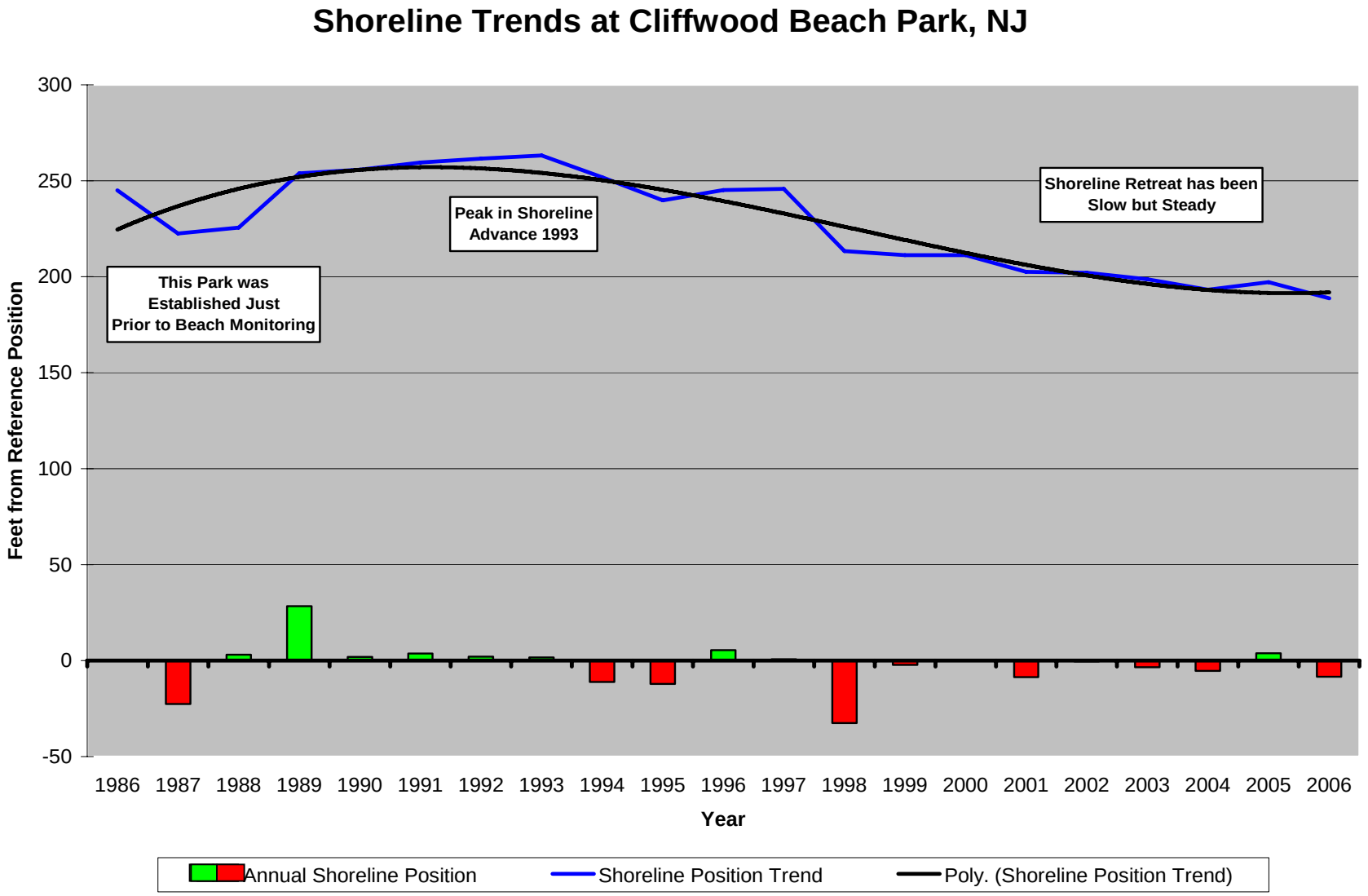


Figure 5 – Site 187. The Monmouth County Cliffwood Beach Park was established just prior to the establishment of the beach surveying project in 1986. Selected because the site represented an opportunity to track changes at a natural beach with a dune located on Raritan Bay, the location has seen the dune system grow over the years, while undergoing a long-term shoreline retreat from the peak seaward position observed in 1993. Since then the shoreline has been forced back from a 263-foot distance from the reference position to a 188-foot distance.

The loss in beach width has made up most of the 75-foot retreat. The Raritan Bay fetch limits the maximum size of the waves generated by either northeast storms or northwest winds to less than 5 second periods and 4 feet in height. The energy in these types of waves is insufficient to have any impact on the sea bottom offshore from the beach. All the surveys from the past 20 years have not diverged in any significant fashion from the depths ranging from 0 to 4 feet of water within 1,000 feet of the shoreline. There are never any offshore bars and little sediment appears to have moved onto the site or left for other locations along the shoreline. The shoreline retreat appears to be due to sand moved into the dunes and perhaps a spreading of the park beach alignment toward the west into an embayment.

20-Year Comparison Photographs – Site 187, Cliffword Beach Park

The Cliffwood Beach shoreline developed a well vegetated dune around the fencing visible in the 1987 photograph (left) and is an excellent example of a bay beach where wave energies are relatively low. Northeast and northwest winds generate up to 4-foot waves, but they do not possess the power of oceanic waves. A combination of storm surge and waves will produce dune erosion, but recovery is usually fairly rapid. The cross sectional plot below shows the initial survey plotted against the same line in 2006. Over the past 20 years, the dune has continued to grow much larger expanding seaward from the toe of the original dune. Sand moved from the beach into the dunes and the shoreline retreated because new sand is not available from any source offshore or nearby.

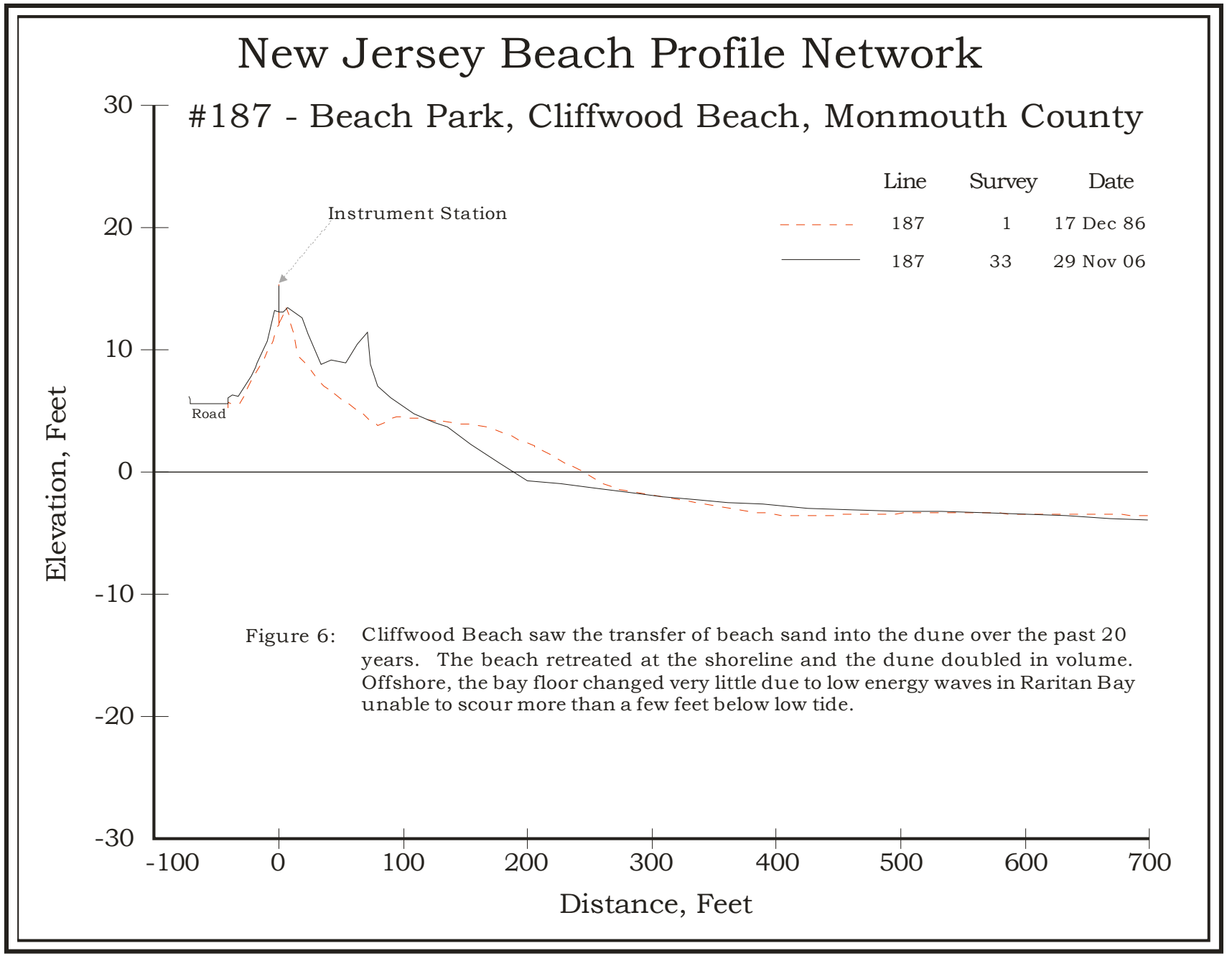


Figure 6: Cliffwood Beach saw the transfer of beach sand into the dune over the past 20 years. The beach retreated at the shoreline and the dune doubled in volume. Offshore, the bay floor changed very little due to low energy waves in Raritan Bay unable to scour more than a few feet below low tide.

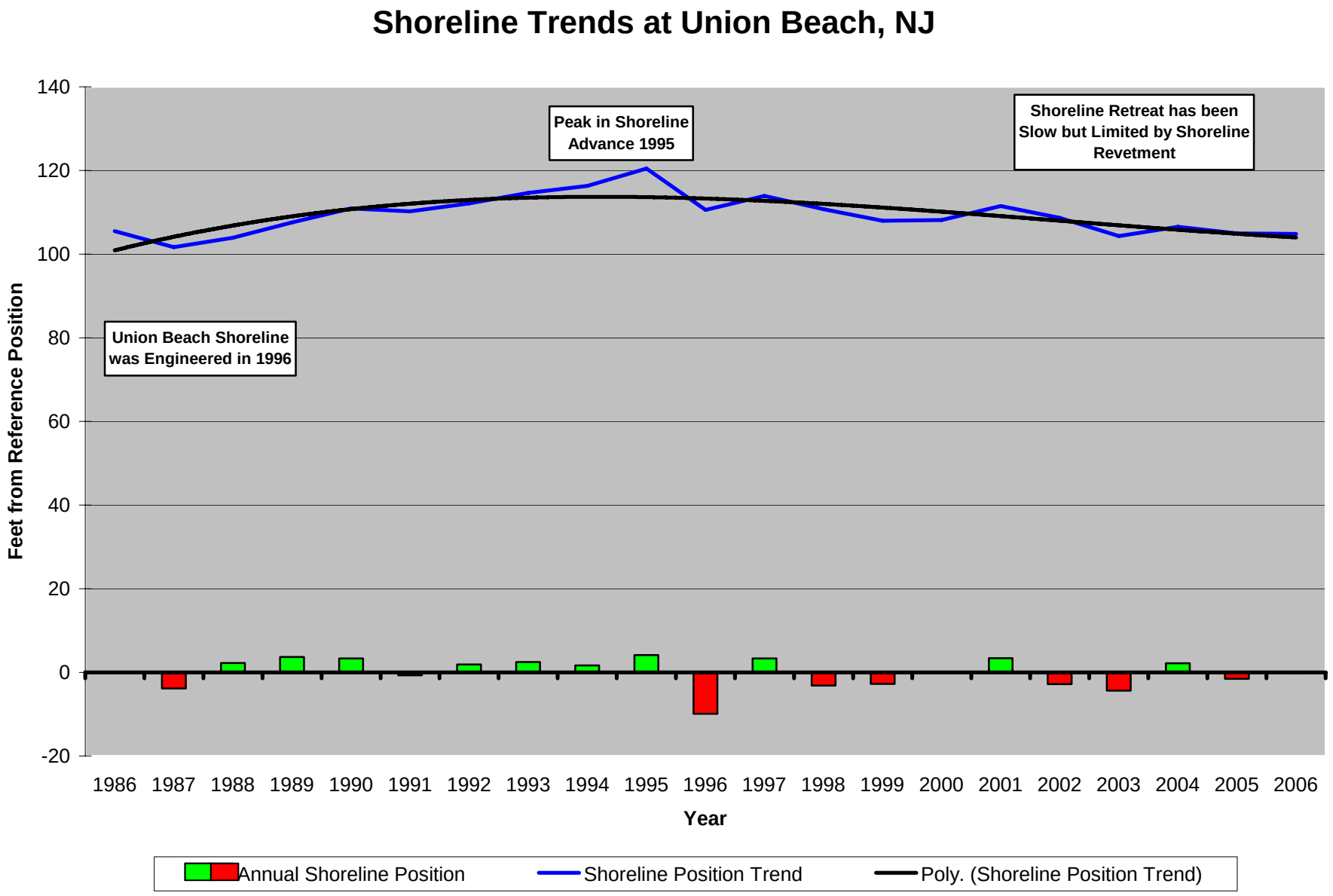
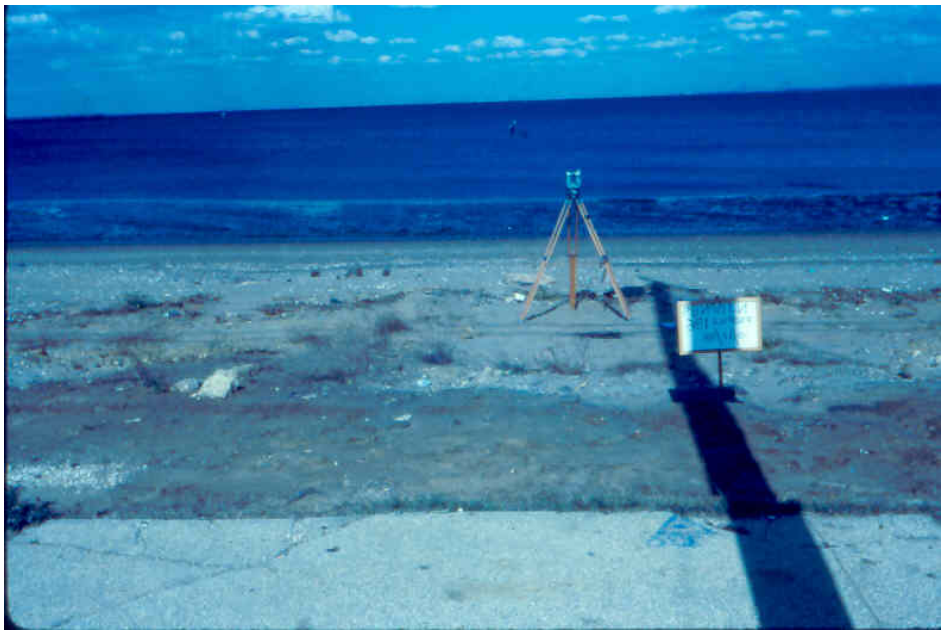


Figure 7 – Site 186. Union Beach is basically an engineered shoreline with a rock revetment constructed during the 1990's and a small wet to dry beach at the base of the rocks. There is no dune and prior to the rock wall construction by the State, there were sections of the

shoreline where erosion had created a bluff in the older sediments of Monmouth County. Shoreline changes have been rather small with no changes to the submerged part of the profile in the bay. Since 1995 the trend has been slightly negative with very little distance to cover to the base of the rocks.



20-Year Comparison Photographs – Site 186, Union Beach

Engineering a stable shoreline produced the majority of the change at this site over 20 years. The left photograph was taken in 1988 showing the original narrow beach that ended at the sidewalk along the road at the shoreline. In the far distance stands the rod-man in about 3.5 feet of water some 600 feet out into the bay from the shoreline. The bulkhead and rock apron on the beach have precluded an alteration of the profile to the water's edge. Low wave energy on the bay has meant that little occurs below low tide. The site monitoring continued in the hope that sand might migrate parallel to the shoreline and bury the rocks.

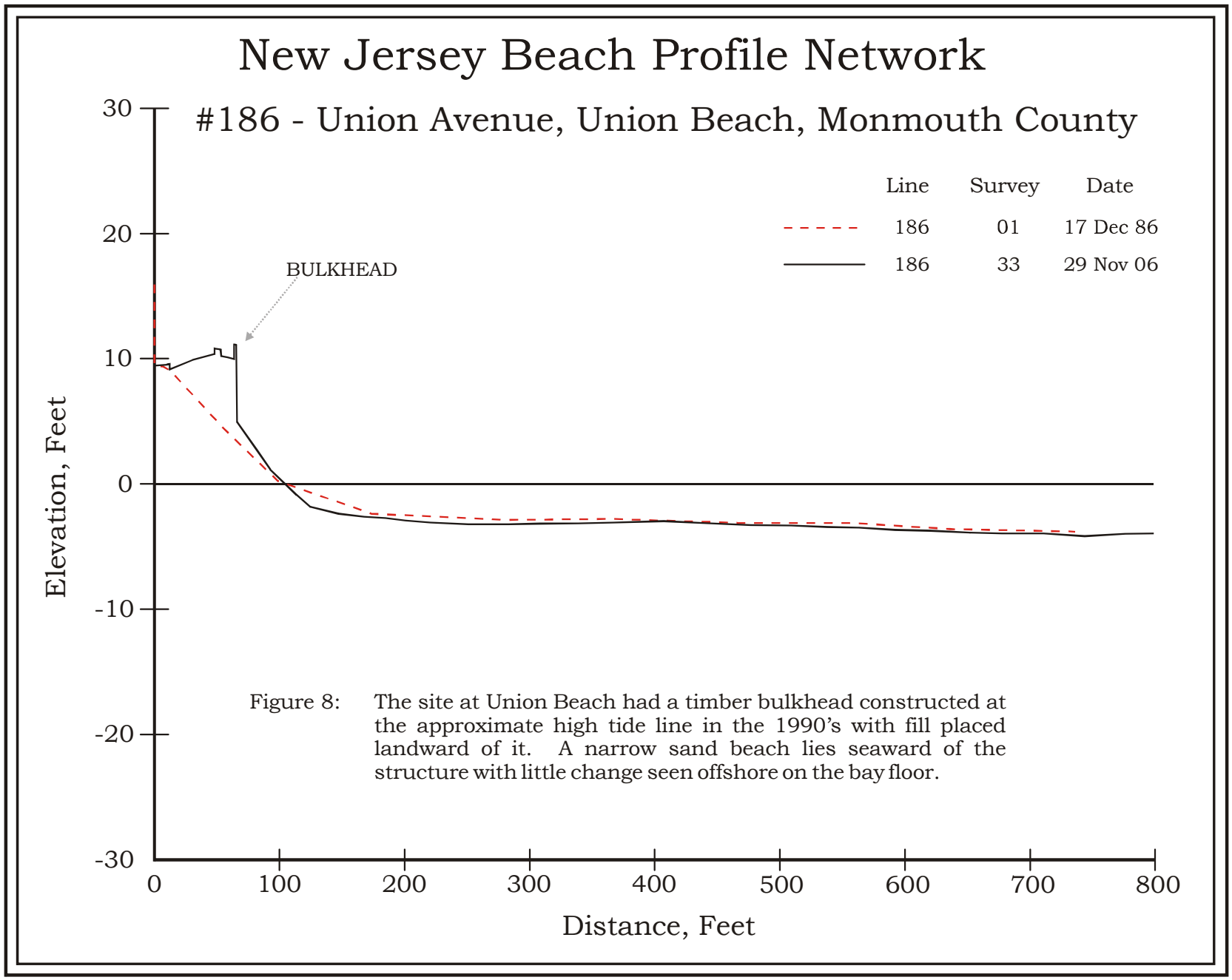


Figure 8: The site at Union Beach had a timber bulkhead constructed at the approximate high tide line in the 1990's with fill placed landward of it. A narrow sand beach lies seaward of the structure with little change seen offshore on the bay floor.

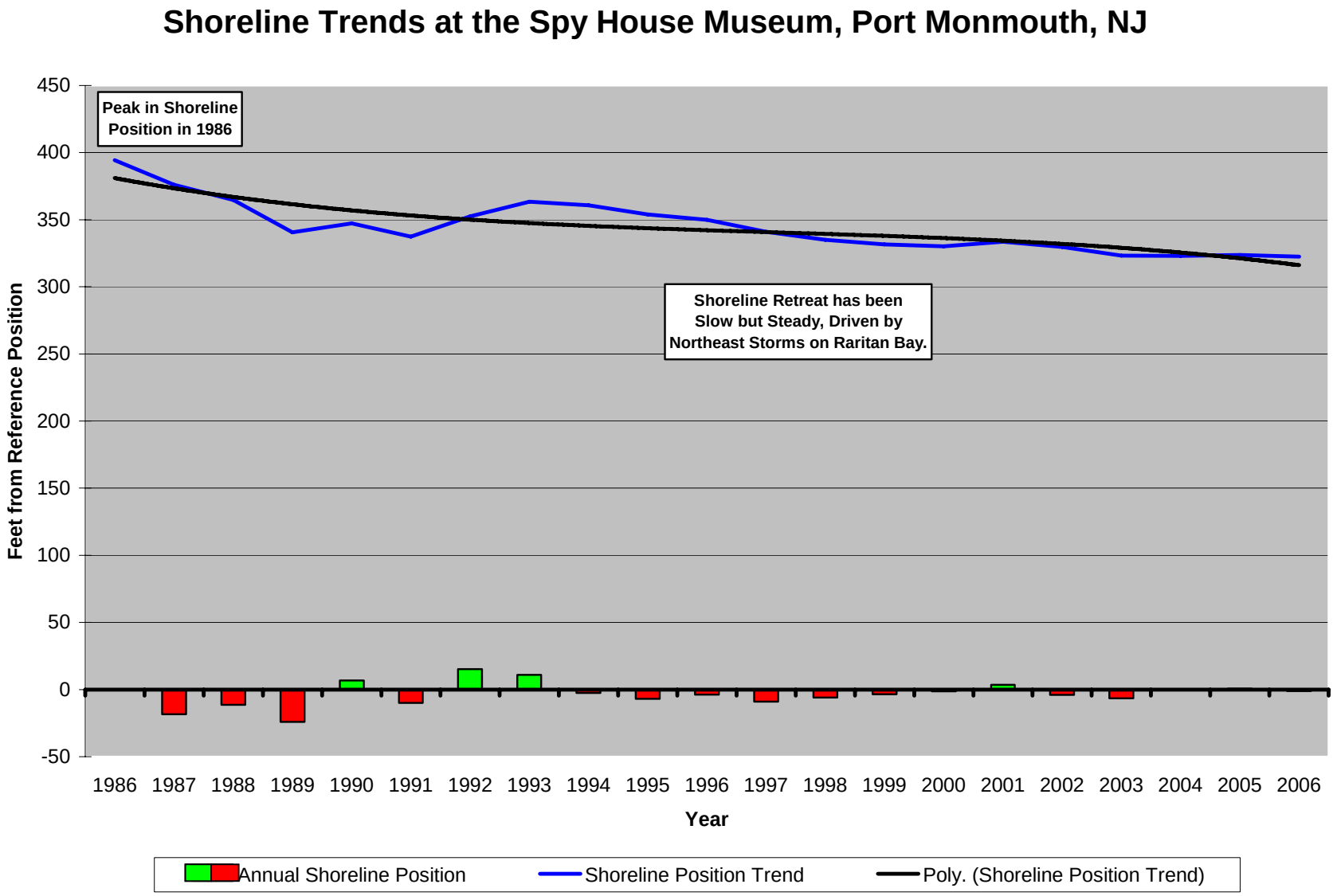


Figure 9 – Site 185. This is the easternmost cross section along the northern bay shoreline established in Monmouth County. This site experienced dune and bluff erosion from minor northeast storms that generated a scarp at the edge of the uplands leading down to the beach. The shoreline retreated about 72 feet in 20 years with the largest loss seen in 1989. There is a tiny dune perched on the edge of the bluff that is periodically restored by the county and as beach sand blows up the scarp cut into the older sediments. This dune vegetates and if left

untouched would resemble a seaward dune slope. A lack of adequate beach width inhibits dune/bluff stability at this site. The same Raritan Bay pattern of no offshore bar development and little change offshore in sea bed elevation occurs at the Spy House locality.

20-Year Comparison Photographs – Site 185, Spy House Museum, Port Monmouth

At the Spy House site, the bluff has been eroding for years as northeast storms generate waves across Raritan Bay. The material in the bluff has a component that is not suitable for beaches, but gets cleaned up from time to time. Offshore the bay floor is flat and not subject to much change. As seen below, the bluff has retreated over 80 feet in the 20 year study period with a nearly uniform pattern mimicking the bluff retreat on the beach and within the zone of wave influence. The pictures above show the similarity and contrast between 1989 (left) and 2006 (right).

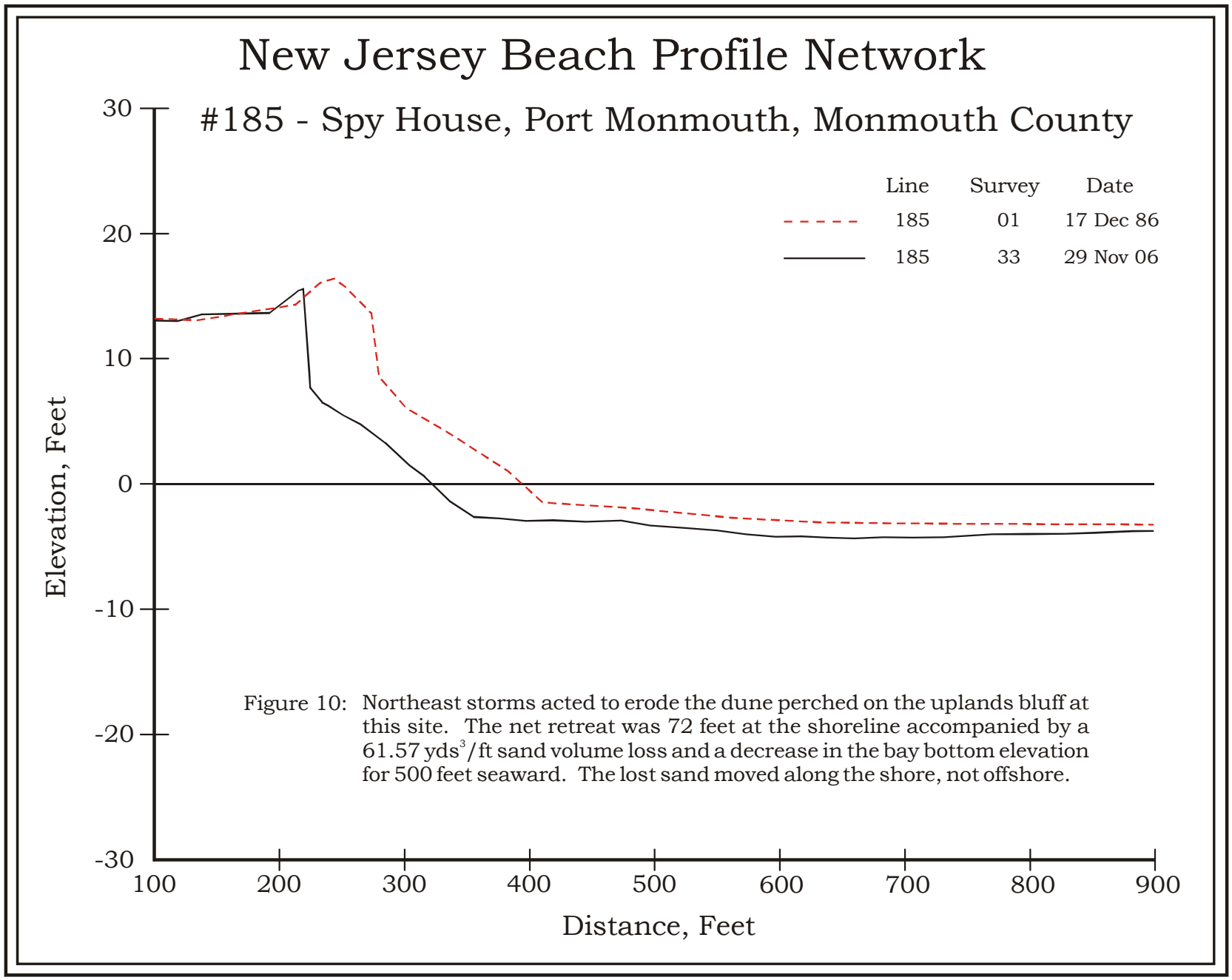


Figure 10: Northeast storms acted to erode the dune perched on the uplands bluff at this site. The net retreat was 72 feet at the shoreline accompanied by a 61.57 yds^3/ft sand volume loss and a decrease in the bay bottom elevation for 500 feet seaward. The lost sand moved along the shore, not offshore.

Shoreline Trends at the Gateway National R.A. Gunnison Beach, NJ

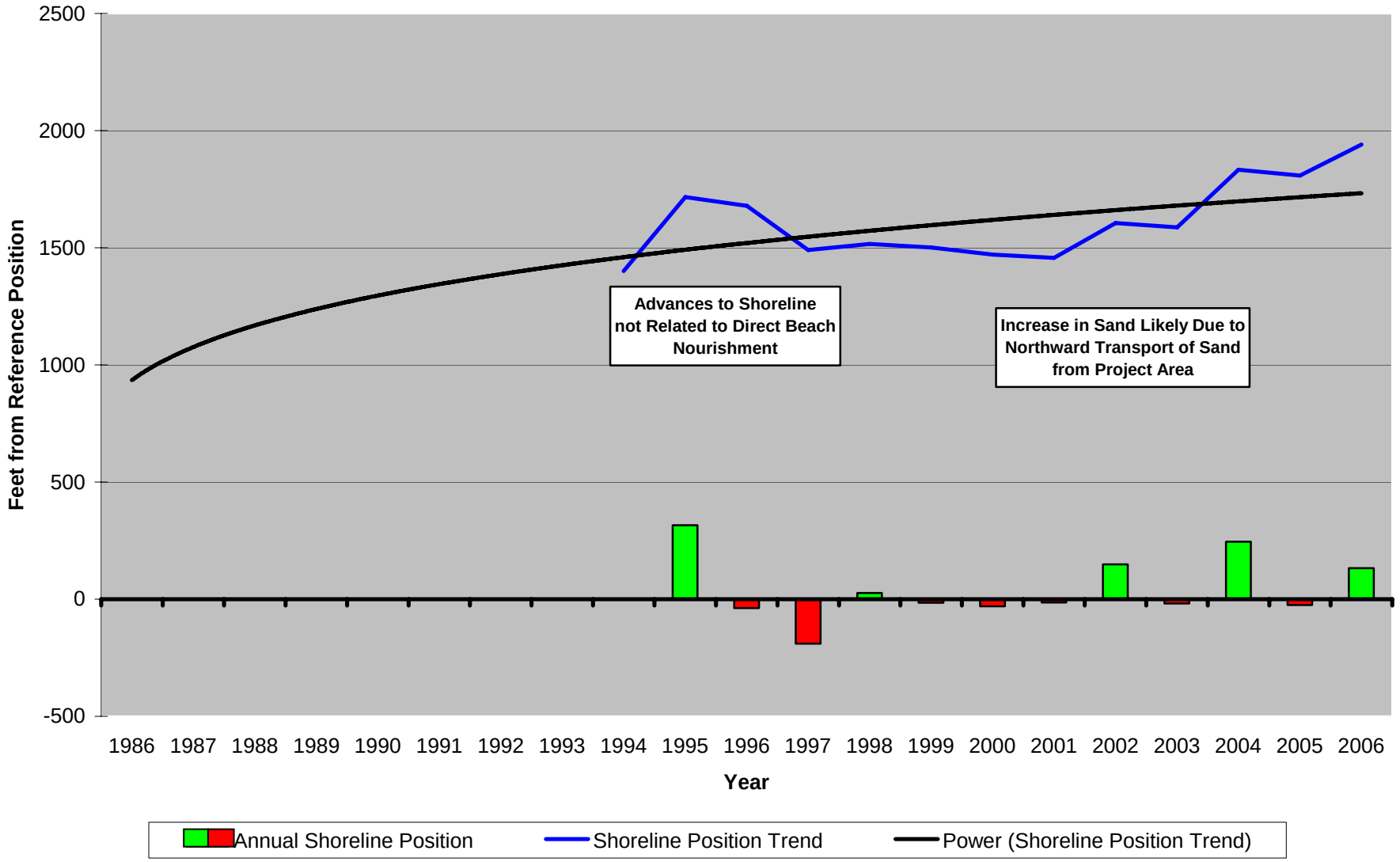


Figure 11 – Site 285. This site was established in 1994 following expansion of the program. Two new sites were placed on the Sandy Hook National Seashore to follow changes anticipated as the Monmouth County shore protection project got started. Initially, the northern site saw a substantial advance in the shoreline position (317 feet in 1995) that was not related to the start up of beach nourishment. The shoreline position retreated in 1997 by 190 feet, and then remained stable for four years. Accretion in 2002, 2004 and 2006 produced an advance totaling 540 feet leaving a very wide dry beach with massive offshore bars moving slowly north appearing like small sand spits as they attached to the beach. This beach is over 1,400 feet wide between the seaward toe of the dune and the berm crest.

20-Year Comparison Photographs – Site 285, Gunnison Beach, Gateway National Seashores, Sandy Hook
The Gunnison Beach is very wide from the dune toe to the berm crest. Sand migrates to the area from the south and welds to the beach as large bars move north along the shoreline. The water deepens rapidly offshore so that one reaches 12 – 15 feet of water within 200 feet of the shoreline at low tide. The pictures above show the contrast between 1995 (left) and 2006 (right).

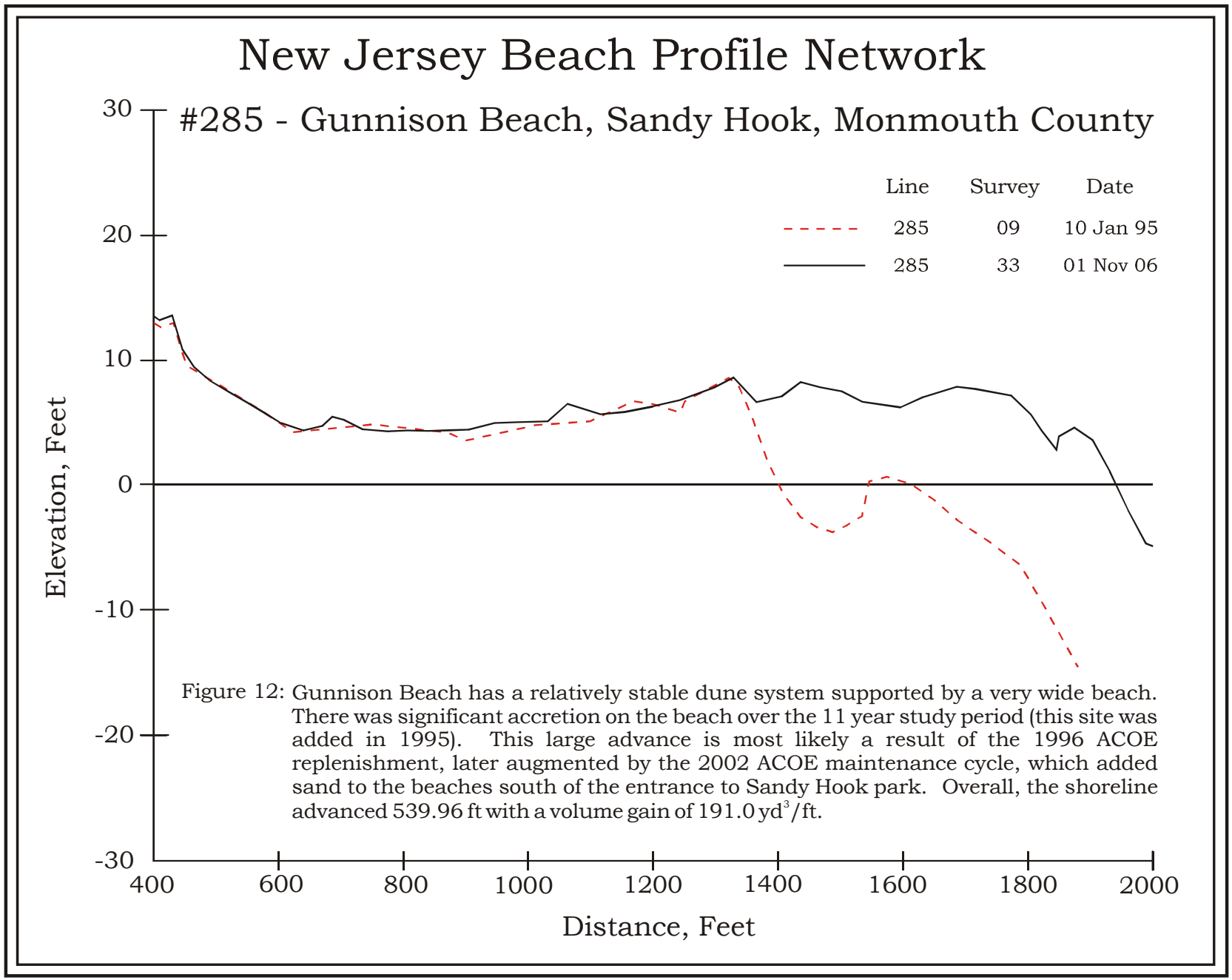


Figure 12: Gunnison Beach has a relatively stable dune system supported by a very wide beach. There was significant accretion on the beach over the 11 year study period (this site was added in 1995). This large advance is most likely a result of the 1996 ACOE replenishment, later augmented by the 2002 ACOE maintenance cycle, which added sand to the beaches south of the entrance to Sandy Hook park. Overall, the shoreline advanced 539.96 ft with a volume gain of 191.0 yd^3/ft.

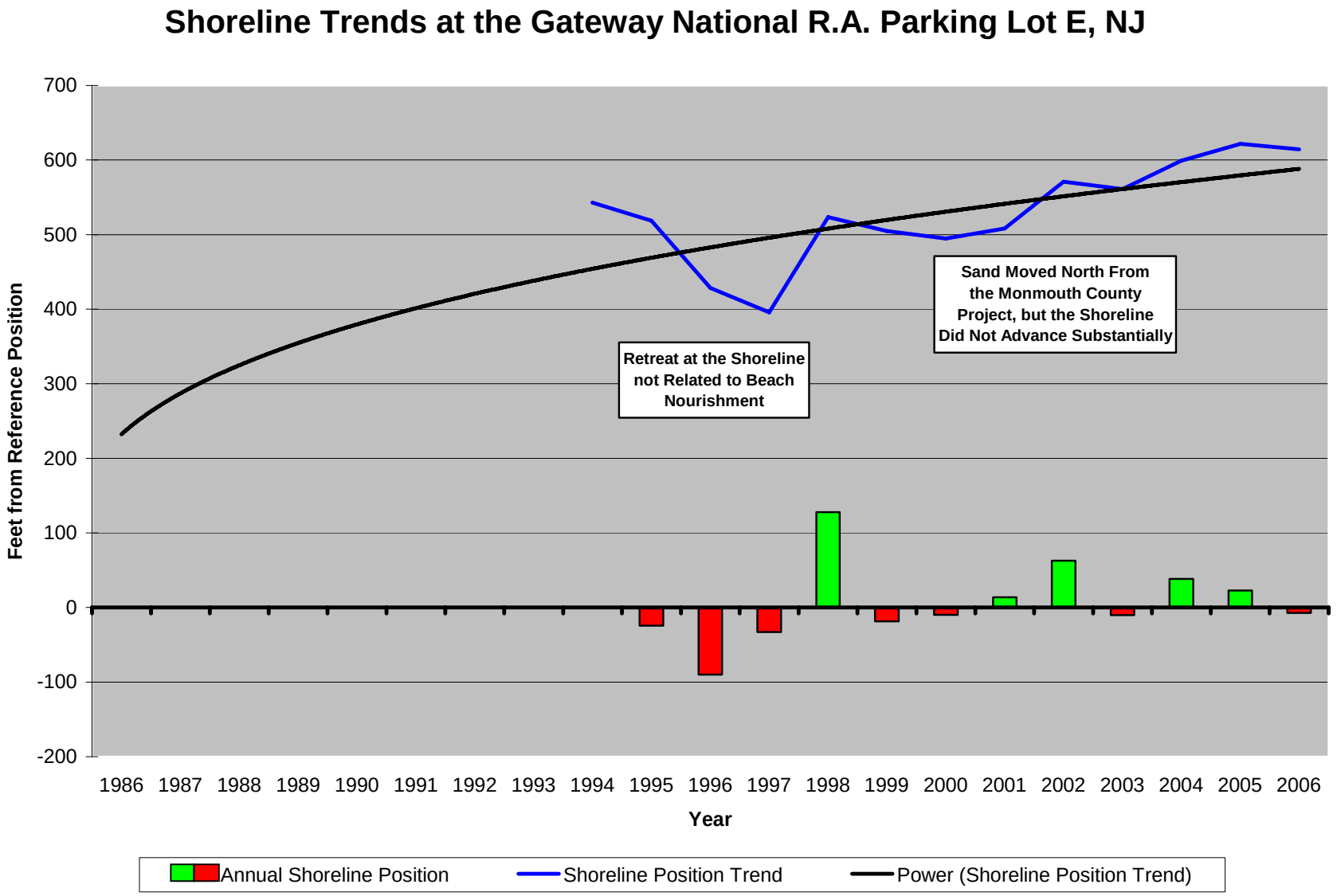


Figure 13 – Site 284. This profile was positioned about half way between the park entrance site (#184) and Gunnison Beach (#285). This location shows a shoreline retreat between 1994 and 1997 that indicates that the ACOE project sand did not immediately appear along this shoreline. By 1998, an advance of over 100 feet is most likely related to the arrival of sand moved north from Sea Bright. The advances in 2001, 2004, and 2005 continued the trend in 2002 sand was placed directly during 2006 for a net shoreline advance totaling 120 feet. This

site was influenced by earlier efforts at shoreline stabilization conducted by a partnership between the US Park Service and the NY District Corps of Engineers pumping sand from Raritan Bay onto the shoreline south of this site. Erosion had threatened several times to breach the base of the spit cutting Sandy Hook off from the peninsula or wiping out the access highway due to severe overwash into the Navesink/Shrewsbury River tidal channel.

20-Year Comparison Photographs – Site 284, Parking Lot E, Gateway National Seashores, Sandy Hook
The view to the south shows the width of the berm from the position of the crest. There was a significant ridge and runnel present in 2006 with the dunes quite distant on the extreme right (2006 photo is on the right). While the cross section below does not show extensive shoreline advance due to the beach fill project, the growth in the dunes has been quite extensive. The pictures above show the contrast between 1995 (left) and 2006 (right).

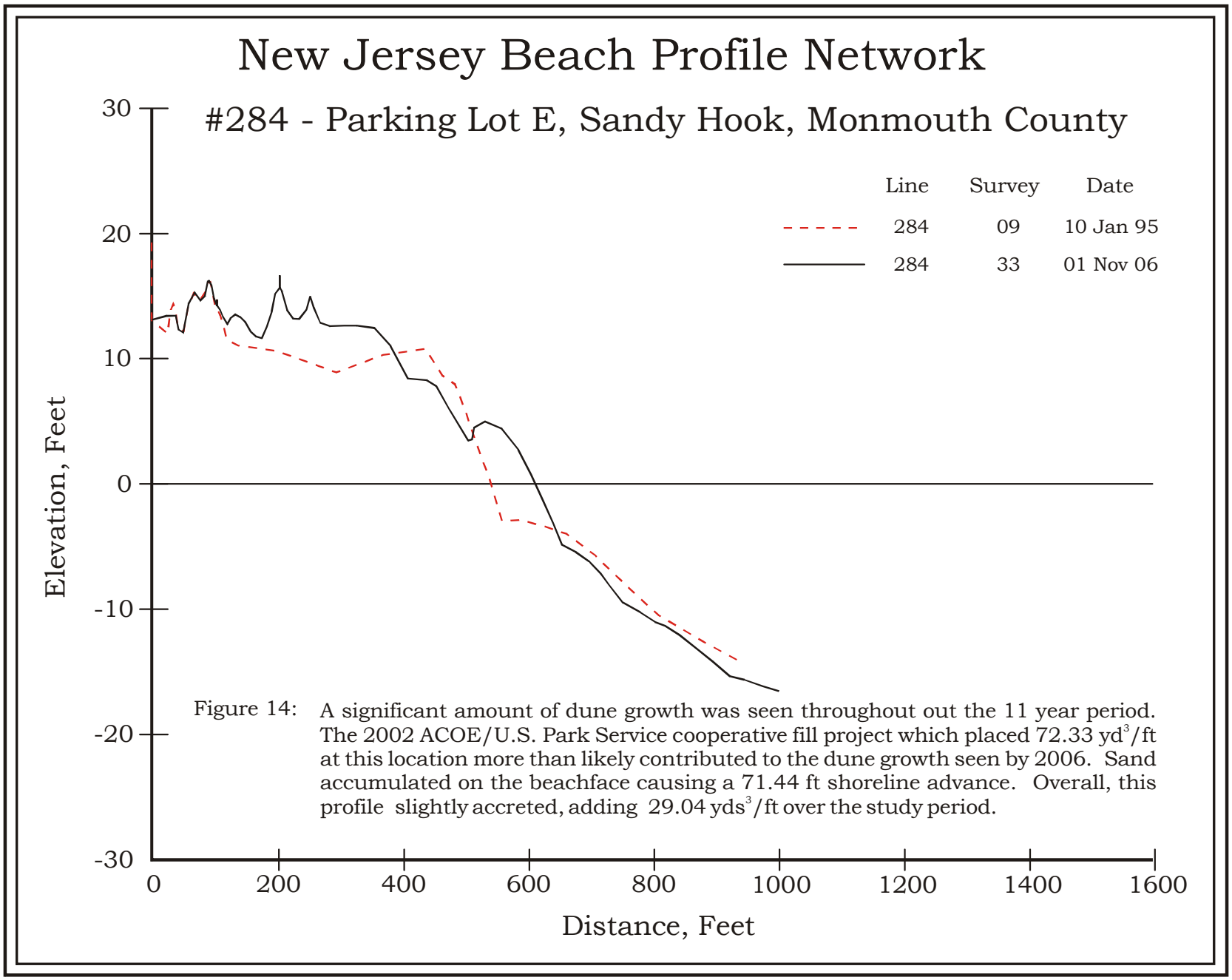


Figure 14: A significant amount of dune growth was seen throughout out the 11 year period. The 2002 ACOE/U.S. Park Service cooperative fill project which placed 72.33 yd^3/ft at this location more than likely contributed to the dune growth seen by 2006. Sand accumulated on the beachface causing a 71.44 ft shoreline advance. Overall, this profile slightly accreted, adding 29.04 yds^3/ft over the study period.

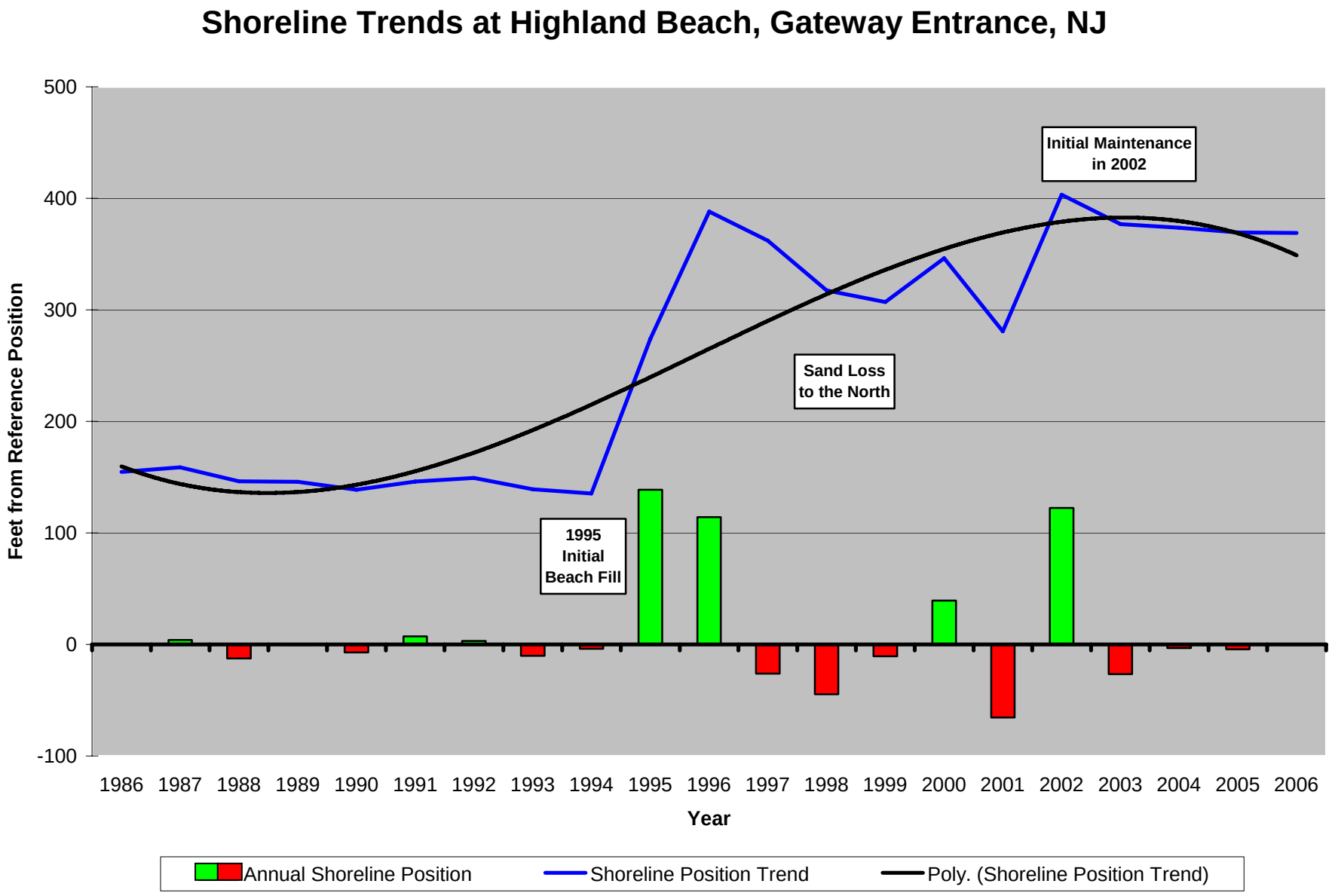


Figure 15 – Site 184. This profile was an example of how the Sea Bright seawall provided the only protection from storm damage along the northern 13 miles of Monmouth County prior to beach nourishment. There was no dry beach and surveys went from the rocks of the seawall

into the water limiting shoreline changes. Dramatic changes occurred in 1995 as sand began to accumulate along the rocks. By 1996 the shoreline had advanced seaward by 253 feet as hundreds of cubic yards of sand were pumped onto the profile shoreline from a source offshore. The profile location saw subsequent erosion as sand moved north over the next few years bringing the shoreline landward by 108 feet. An ACOE funded maintenance fill in 2002 restored the shoreline position to 403 feet distant from the reference position (+123 feet). Losses over the past four years have been relatively minor. The initial sand loss rate may be lower in the recent past due to low storm frequency or the fact that the loss previously has made for wider beaches to the north and therefore, lower open end loss rates. Northeast storm wave directions should transport sand south along the shoreline. Since northeast winds are limited by the presence of Long Island, NY to the north and east, the southerly waves dominate the sand transport direction generally producing sand transport to the north.

20-Year Comparison Photographs – Site 184, Highlands Beach, Near Entrance of Gateway National Seashores, Sandy Hook
The extreme difference made by the sand volume placed along this shoreline shows in the next series of sites along the Sea Bright shoreline. Located near the north end of the rock seawall, this location did have a narrow wet beach in 1986 (shown in the 1987 photograph on the left). Now in 2006 (photo of right) the beach remains reasonably wide with a natural dune system developing on the dry beach. No effort was expended in designing a dune, so growth is dependant on natural plant succession and spreading.

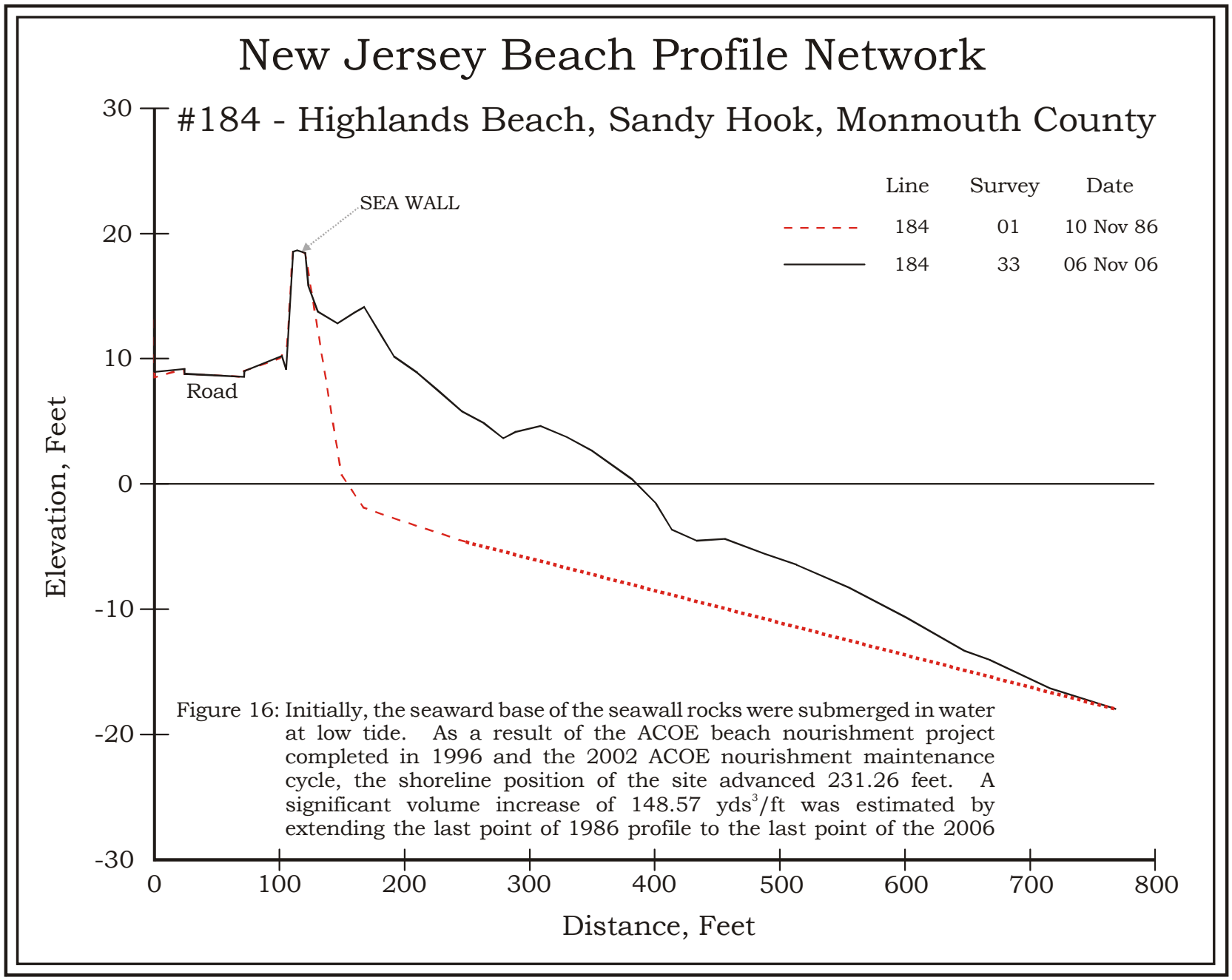


Figure 16: Initially, the seaward base of the seawall rocks were submerged in water at low tide. As a result of the ACOE beach nourishment project completed in 1996 and the 2002 ACOE nourishment maintenance cycle, the shoreline position of the site advanced 231.26 feet. A significant volume increase of 148.57 yds^3/ft was estimated by extending the last point of 1986 profile to the last point of the 2006

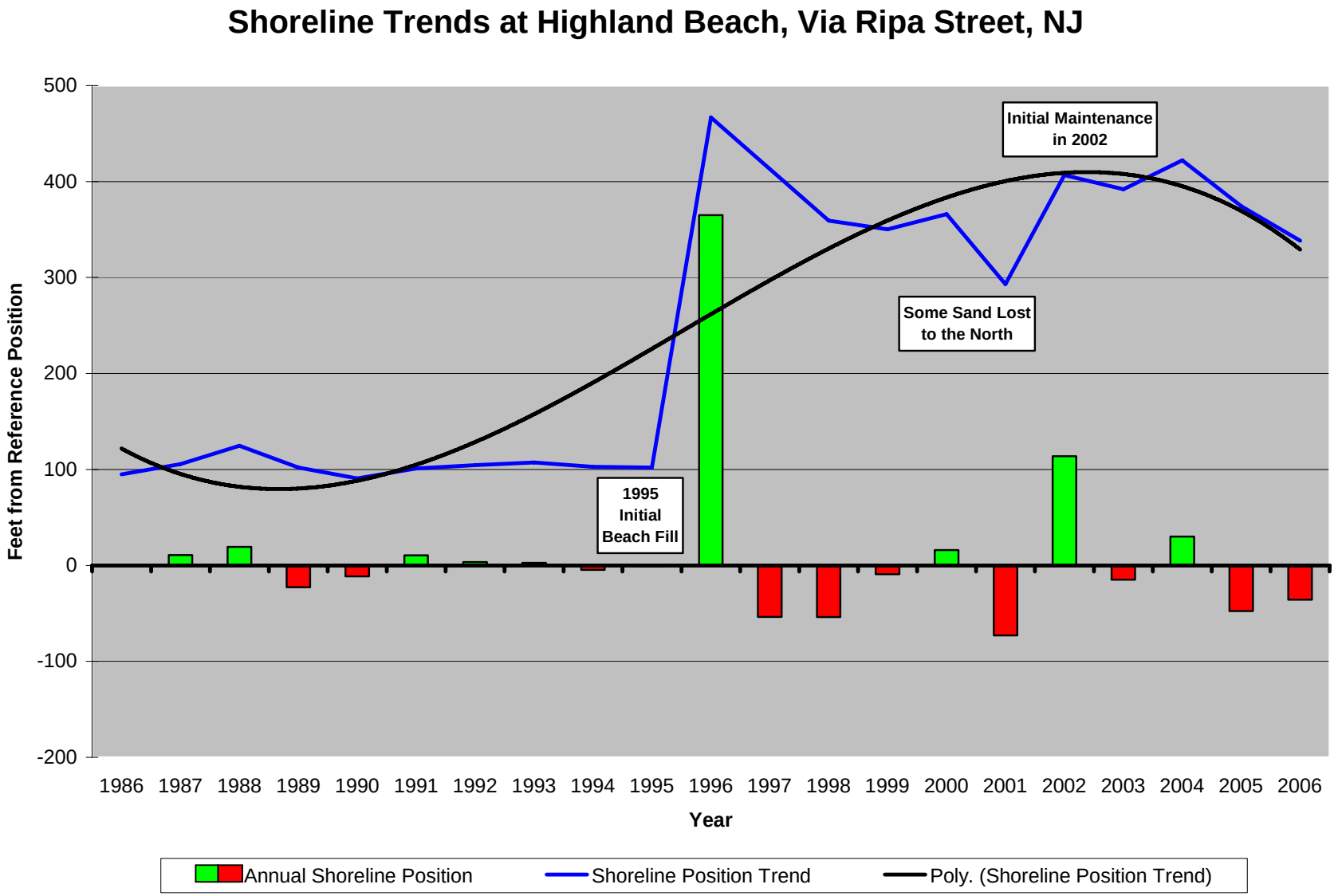


Figure 17 – Site 183. Slightly further south along the Sea Bright seawall, there was no beach and the rocks were reached by the waves at all but the lowest tides. Between 1986 and 1995 the shoreline varied slightly over 9 years, then the NY District Corps of Engineers added enough sand to produce a 365-foot advance in the shoreline position. Modest incremental retreats followed causing 173 feet of landward

movement by 2001. The maintenance fill pushed the shoreline seaward again by over a hundred feet. Minor fluctuations between gains and losses since have left this shoreline with a net advance of 237 feet over that present in 1995 prior to the project.

20-Year Comparison Photographs – Site 183, Via Ripa Street, Sea Bright

In 1986, the water reached the rocks at low tide and the profile could not be carried far into the water. The left photograph was taken in 1986 and shows the waves washing to the rocks at low tide with the groin trapping a tiny beach in the corner. The 2006 view looking south shows the beach, a small dune near the rocks and the relationship between the dunes, beach and offshore. The photographer in this shot was standing in about the same position as the 1986 photograph. By 2006, a sizable ridge and runnel developed on the cross section. The cross section below shows the huge wedge of sand lying above the dashed line representing the 1986 profile data. The heavier dotted line was added to extend the data to the same ending point present on the 2006 plot to allow a close approximation of the sand volume added to the beach and seafloor. The assumption made at all the Monmouth County sites where sand was added is that the 2006 ending position was at least the same elevation (not higher, but likely lower) as it would have been in 1986 had the early limited budgets and technolgy permitted the survey to run that far out to sea.

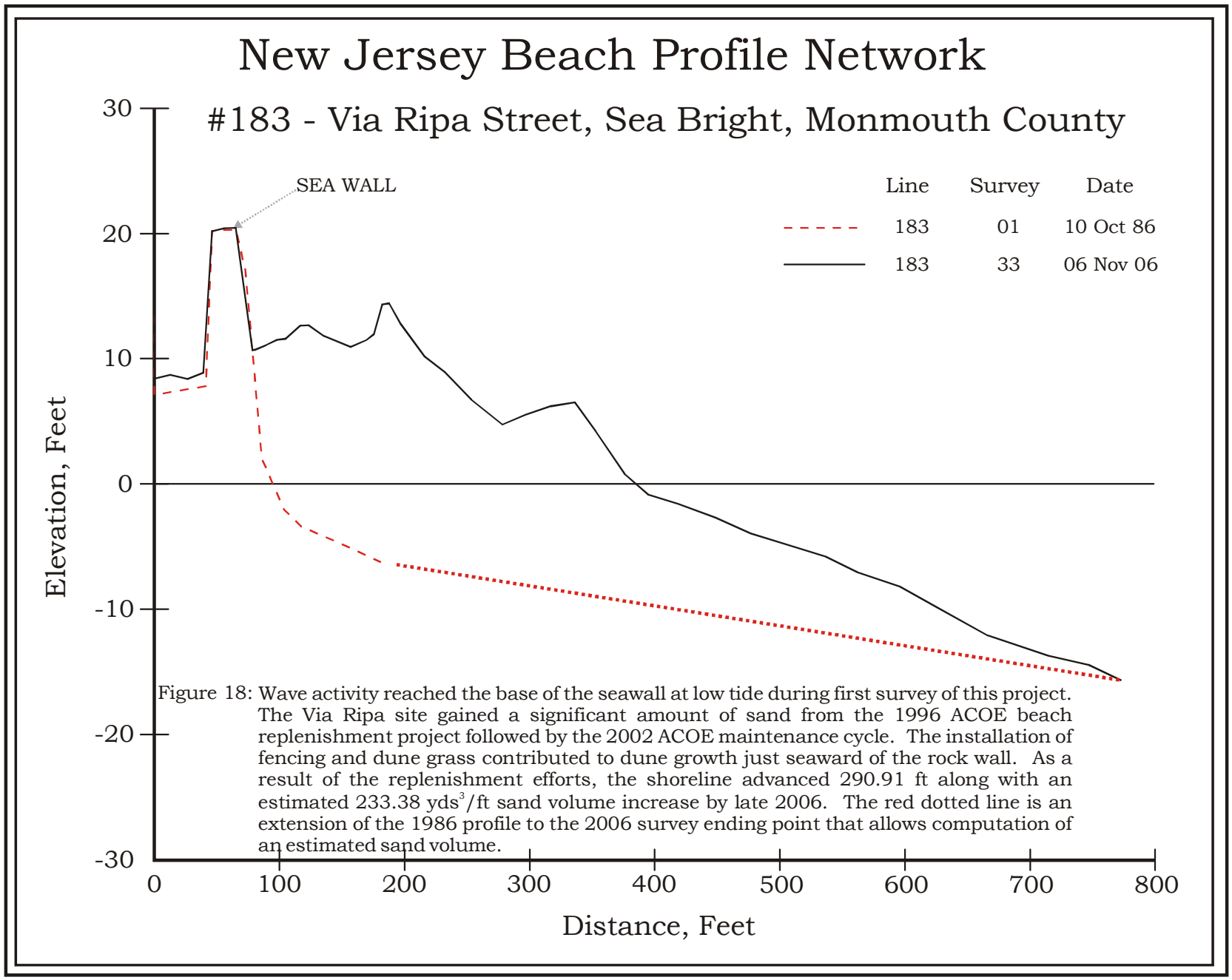


Figure 18: Wave activity reached the base of the seawall at low tide during first survey of this project. The Via Ripa site gained a significant amount of sand from the 1996 ACOE beach replenishment project followed by the 2002 ACOE maintenance cycle. The installation of fencing and dune grass contributed to dune growth just seaward of the rock wall. As a result of the replenishment efforts, the shoreline advanced 290.91 ft along with an estimated 233.38 yds^3/ft sand volume increase by late 2006. The red dotted line is an extension of the 1986 profile to the 2006 survey ending point that allows computation of an estimated sand volume.

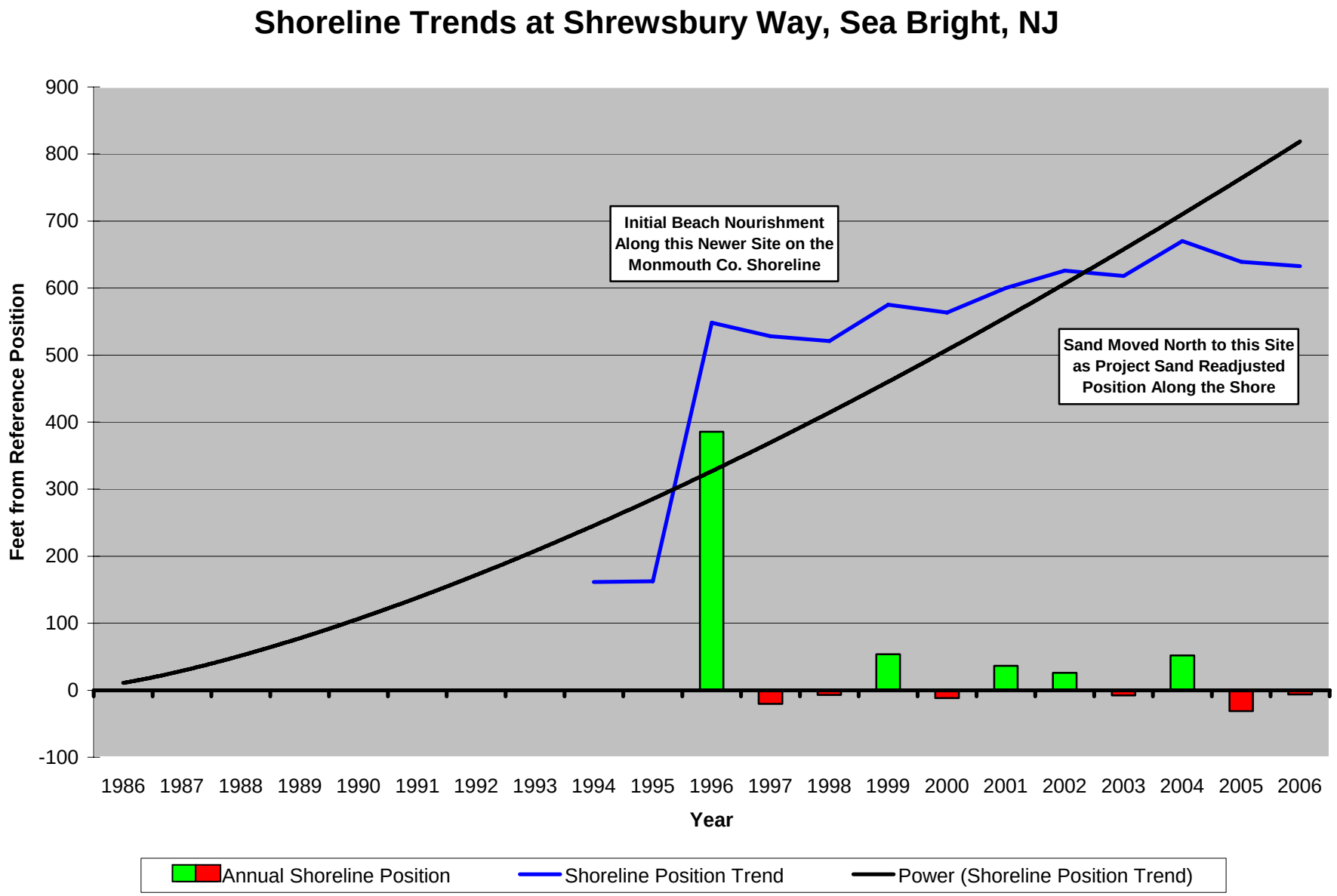


Figure 19 – Site 282. The early years are not represented because this site was established just prior to the commencement of the Monmouth County beach nourishment project. The fill produced an advance in the shoreline of 375 feet that continued to grow wider by another 85 feet

by 2006 without additional sand placement. Acquired by the State of New Jersey as public use beachfront, the location has a dune and a substantial beach for recreational purposes.

A. 

B. 

C. 

20-Year Comparison Photographs – Site 282, Shrewsbury Way, Sea Bright

In early 1995 the beach was a wet strip of sand against the rocks with little or no recreational utility at that time. This can be seen in the photo taken in early 1995 (A). A view of the dune width present during the spring 2006 survey is shown in the top right photograph (B). The 2006 photograph on the bottom (C) shows the width and size of a ridge and runnel deposit that was common along this section of beach that fall.

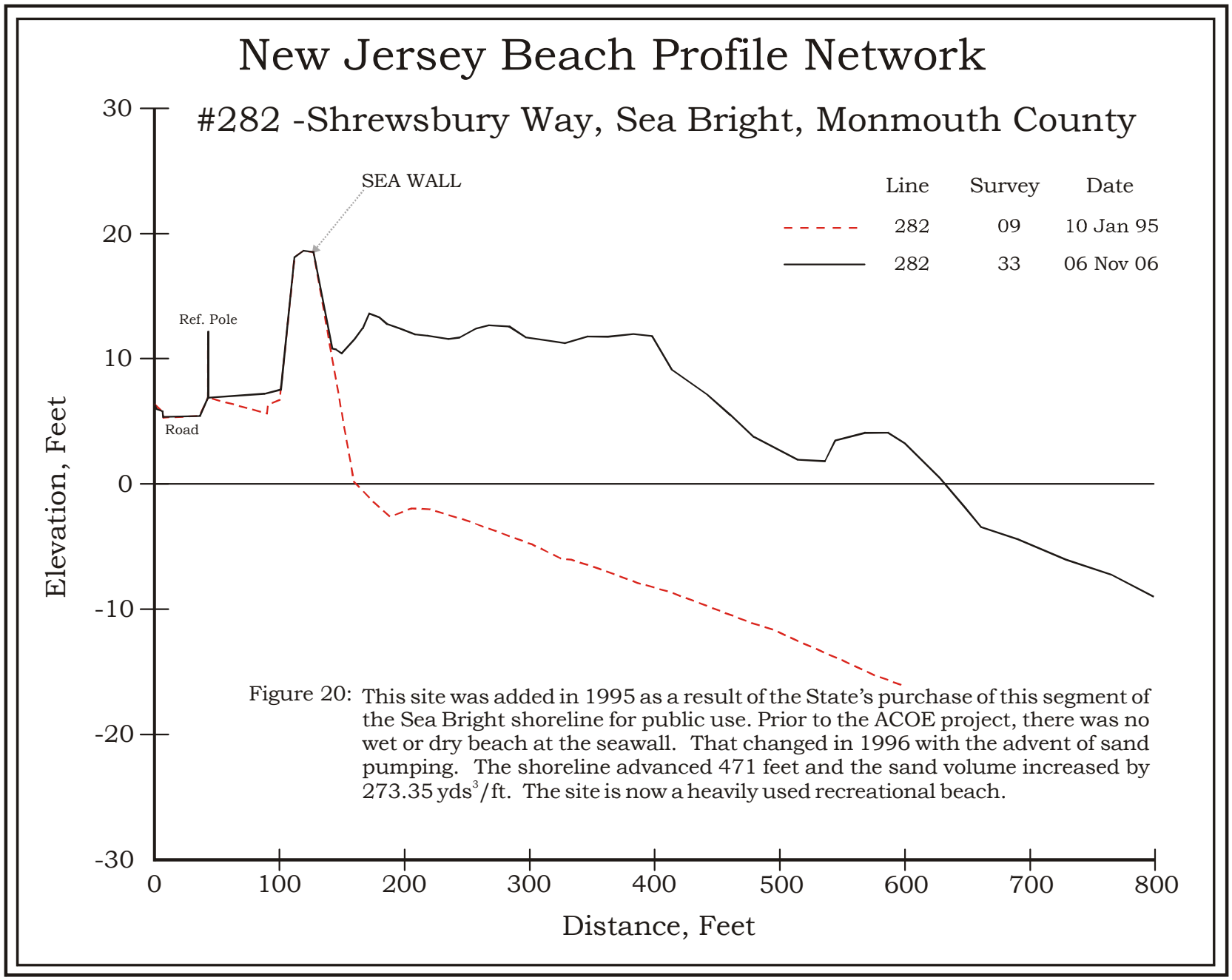


Figure 20: This site was added in 1995 as a result of the State's purchase of this segment of the Sea Bright shoreline for public use. Prior to the ACOE project, there was no wet or dry beach at the seawall. That changed in 1996 with the advent of sand pumping. The shoreline advanced 471 feet and the sand volume increased by 273.35 yds^3/ft. The site is now a heavily used recreational beach.

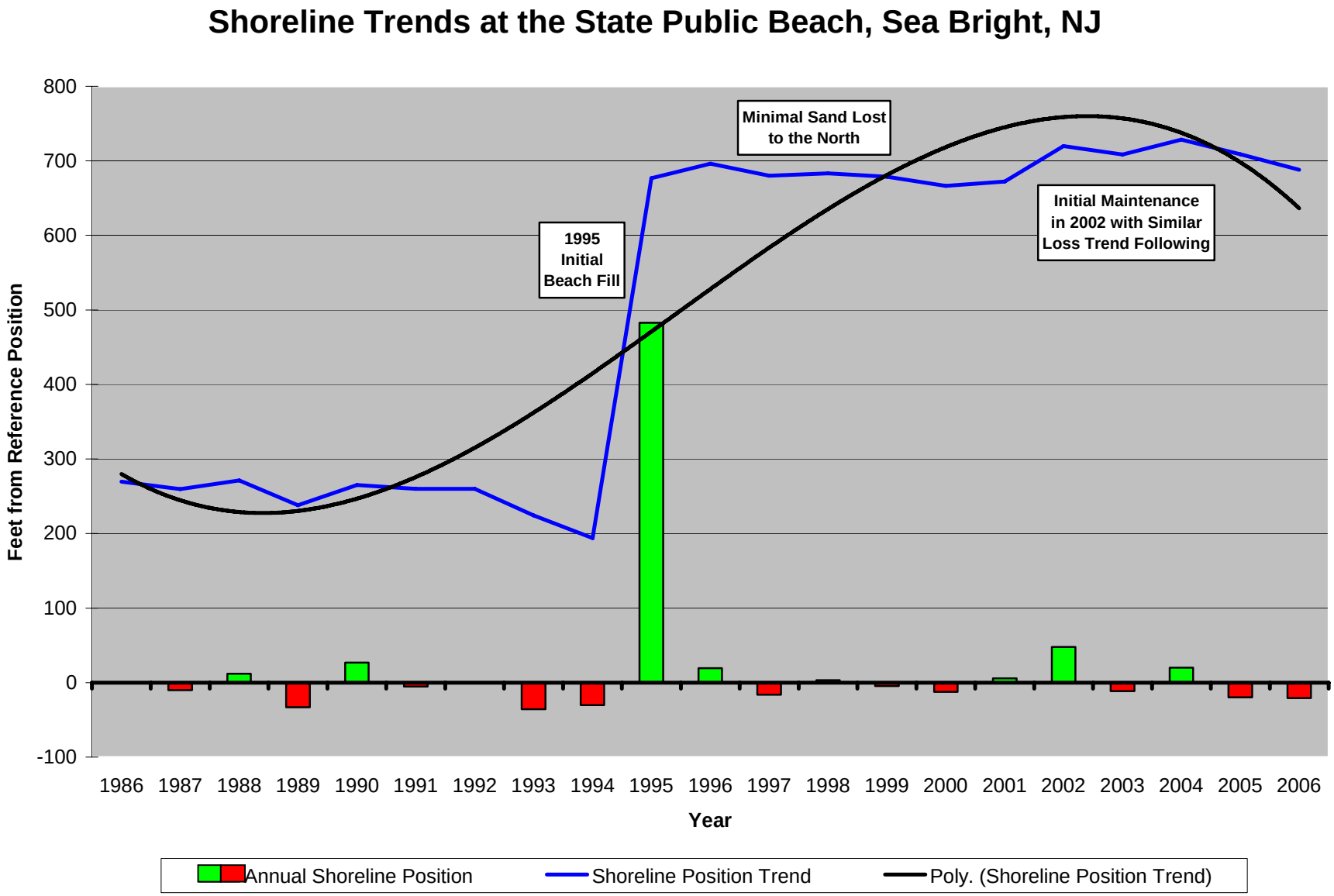


Figure 21 – Site 182. This profile is located between groins and as a result a beach did exist prior to the beach nourishment. The shoreline position shifted within a narrow range prior to 1995 and a trend of very minor shoreline retreat appears to be consistent following both the initial fill and the 2002 maintenance nourishment effort. The beach is heavily used recreationally during the season.


20-Year Comparison Photographs – Site #182, Public Beach Lot, Sea Bright

The 2006 beach shows a substantial ridge and runnel out beyond the location of the high tide line. There is a dune and back-dune region that did not exist in 1986. The white buildings shown center/left in the 2006 (right) photograph are those shown next to the low water line in the 1988 photograph (left). The beach did exist in 1986, but dropped into the sea immediately seaward of the seawall. The 2006 cross section below shows a 250-foot wide vegetated region now in position in front of the rocks, followed by a foredune, then the beach with the shoreline position about 400 feet seaward of the 1986 location in reference to the starting point for the surveys. The red dashed line was added to the 1986 survey to reach the 2006 survey end point to allow an approximate sand volume for a comparison to the end of the 2006 survey. Clearly the seafloor elevation at that point in 1986 may have been different, but technology did not permit surveying that far offshore at that time.

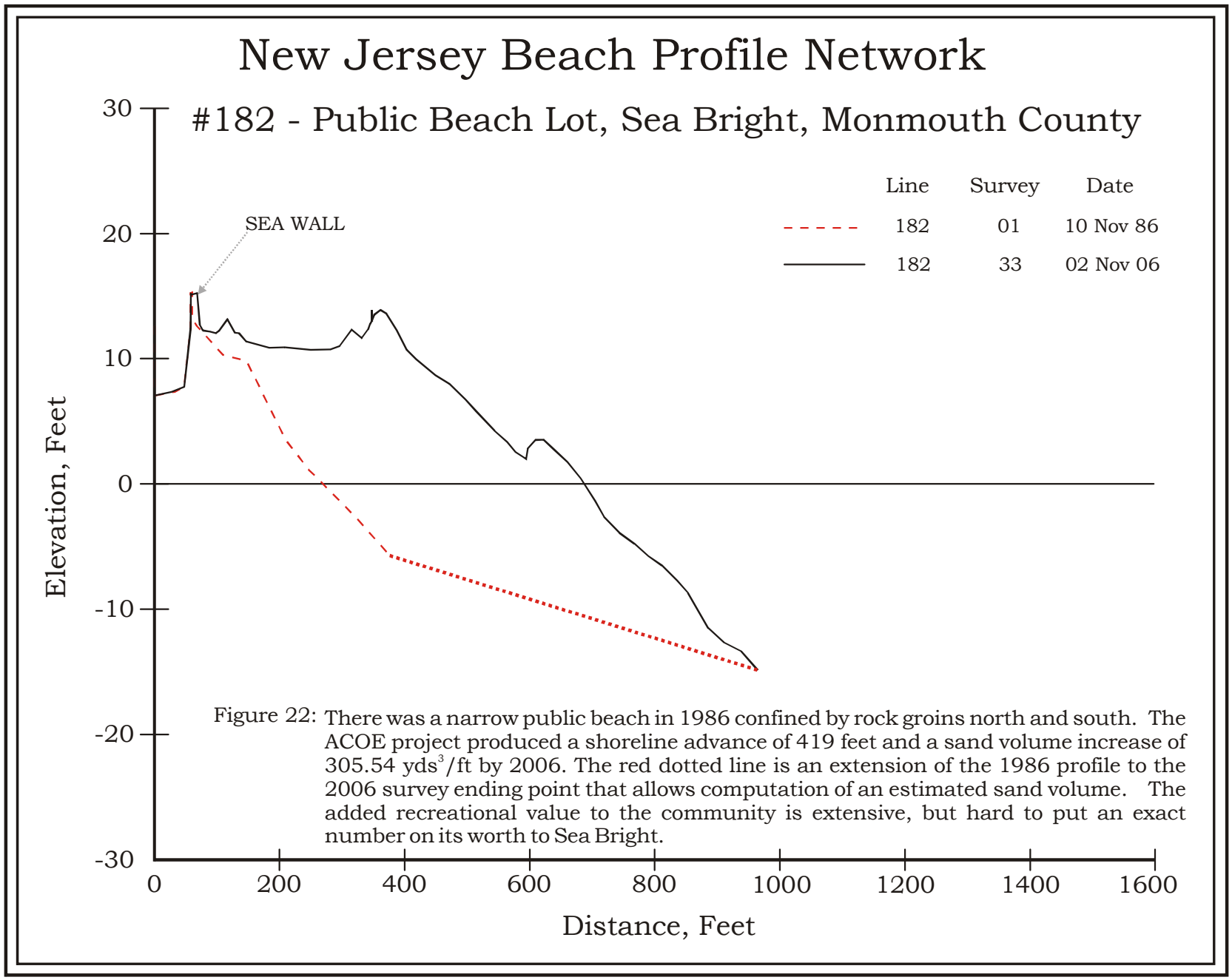


Figure 22: There was a narrow public beach in 1986 confined by rock groins north and south. The ACOE project produced a shoreline advance of 419 feet and a sand volume increase of 305.54 yds^3/ft by 2006. The red dotted line is an extension of the 1986 profile to the 2006 survey ending point that allows computation of an estimated sand volume. The added recreational value to the community is extensive, but hard to put an exact number on its worth to Sea Bright.

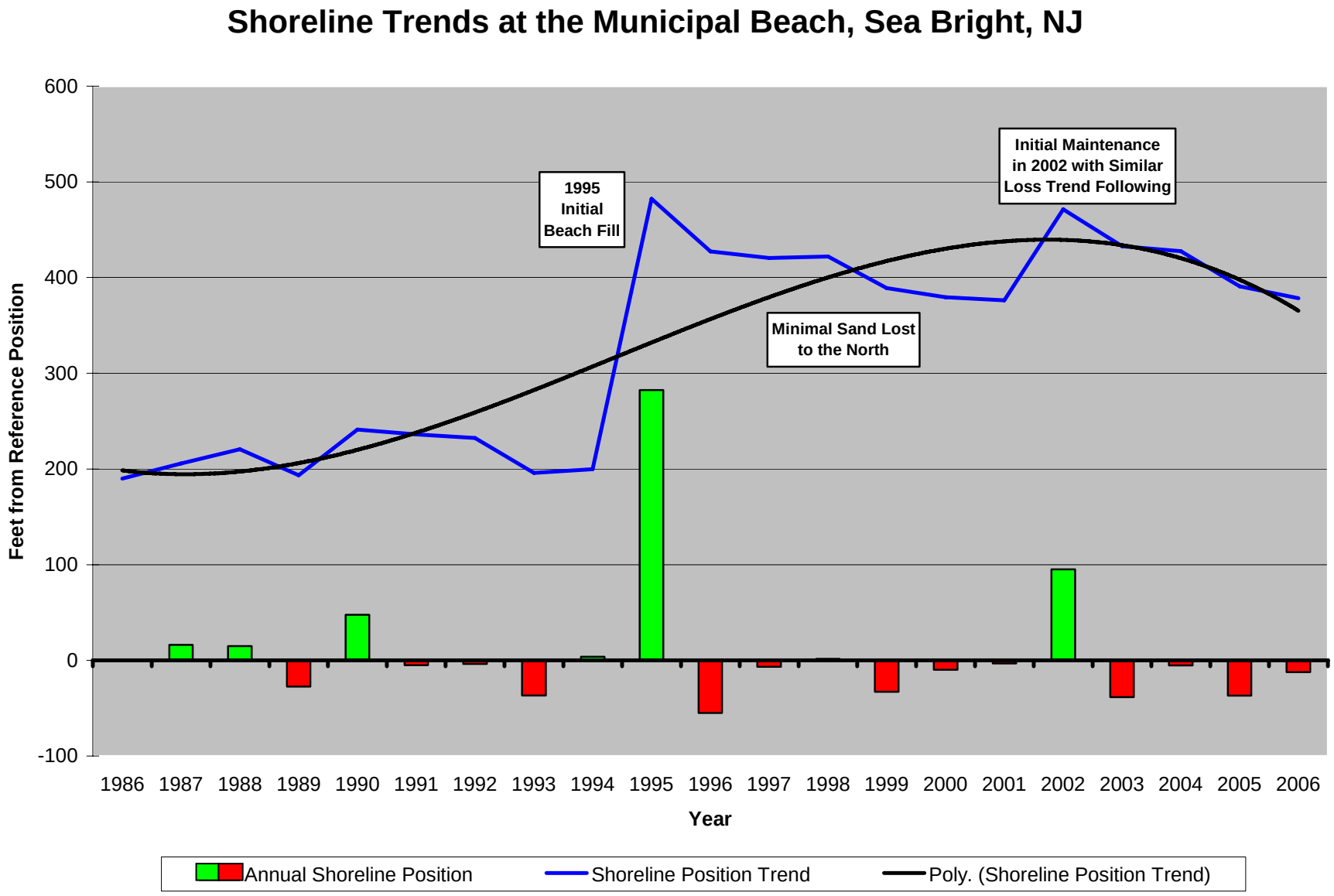


Figure 23 – Site 181. The Sea Bright municipal beach was significantly enhanced by the Federal project, but a beach was present for recreational use prior to the fill. Loss rates following both the initial work and the maintenance effort appear to be similar.

20-Year Comparison Photographs – Site 181, Municipal Lot, Sea Bright

The 2006 beach is 165 feet further seaward than it was in 1986. That cross section started in the parking lot (bulkhead in the left photograph in 1988). The timber bulkhead was to keep storm waves out of the municipal downtown area. The current dune crest sits almost exactly in the location of the berm crest in 1986. The beach and an offshore bar that had moved onto the lower beach slope that year extend the 2006 shoreline to the 370-foot distance from the reference position. The extended 1986 profile sand volume calculation produced a 130.95 yds^3/ft increase that is more representative of the change than the direct 1986 to 2006 profile volume change because the calculation always terminates at the end of the shortest profile. However, because that calculation represents factual data, it is the number used in the tables of values for all profiles. This additional calculation was done in Monmouth County due to the dramatic increase in beach width related to the Federal Shore Protection Project. Each ending point in the 2006 survey was added to the 1986 data to force a sand volume calculation to that ending distance. It can be assumed that the offshore depth at the 2006 ending distance was always deeper in 1986 than it was in 2006.

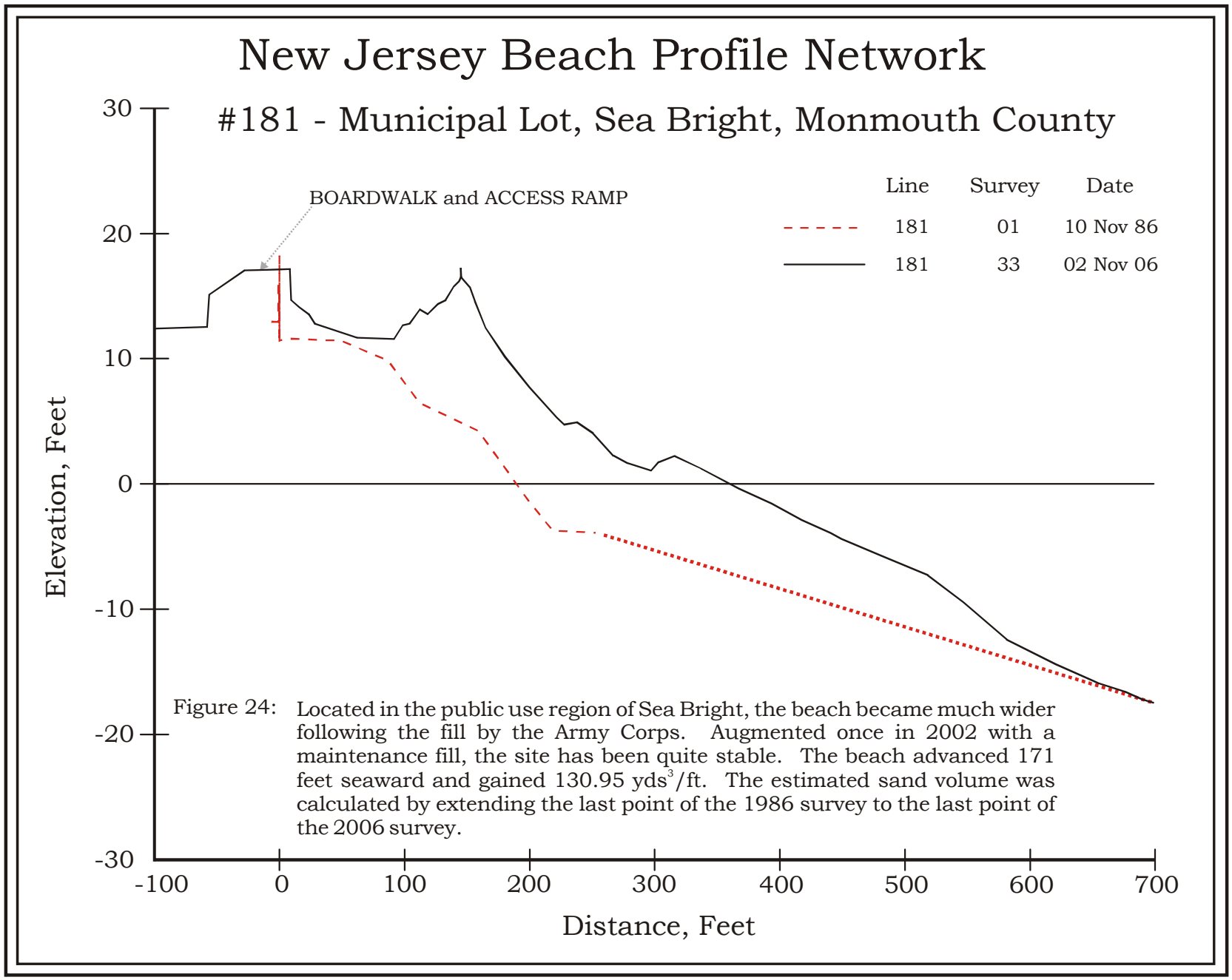


Figure 24: Located in the public use region of Sea Bright, the beach became much wider following the fill by the Army Corps. Augmented once in 2002 with a maintenance fill, the site has been quite stable. The beach advanced 171 feet seaward and gained 130.95 yds^3/ft. The estimated sand volume was calculated by extending the last point of the 1986 survey to the last point of the 2006 survey.

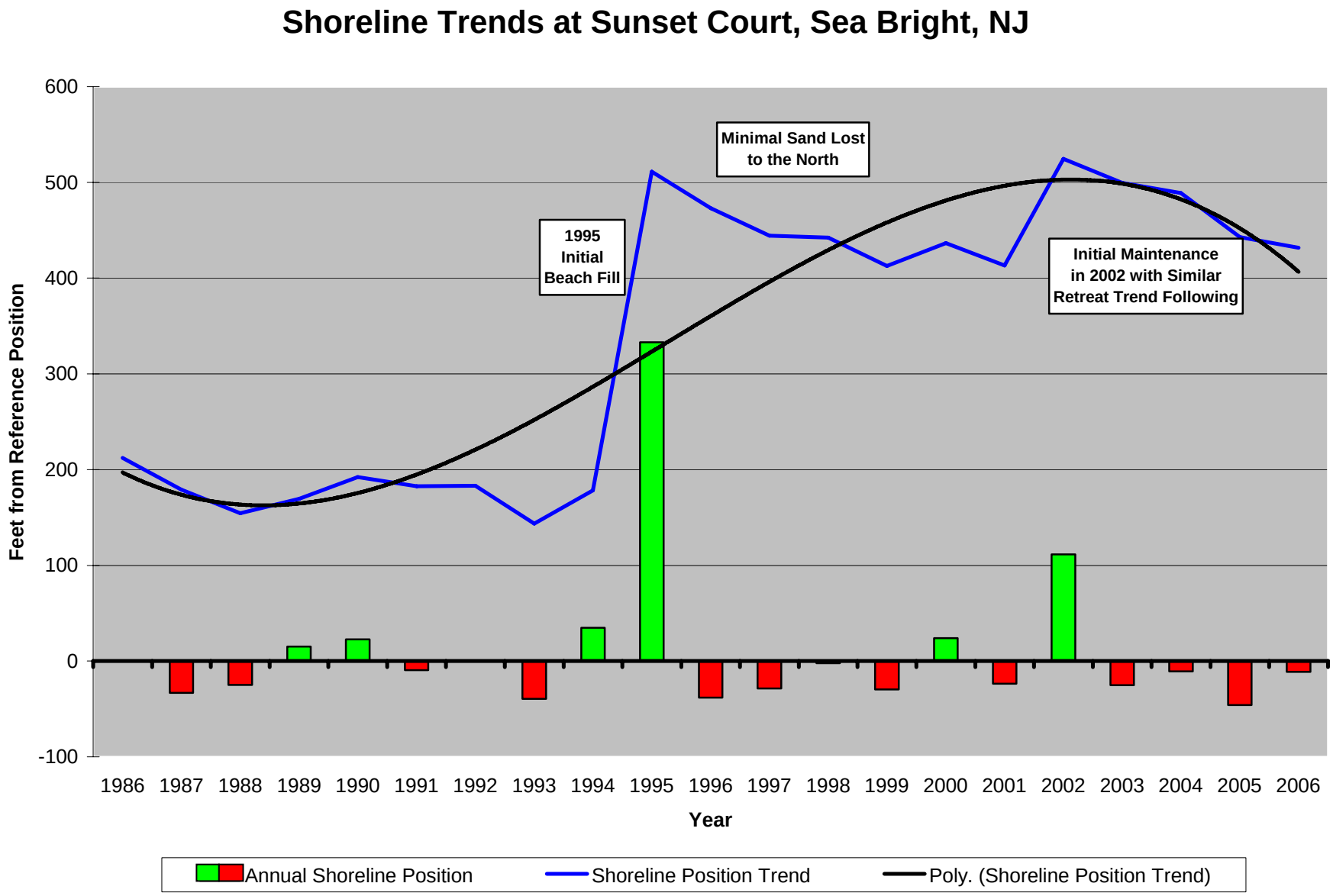


Figure 25 – Site 180. Further south along the Sea Bright shoreline the beach was very narrow in 1986 with sand banked up against the rocks and a beachface slope that began immediately seaward to the zero elevation line at a distance of 200 feet from the reference. Storms in 1991 and 1992 reduced this distance by 50 feet prior to the initial beach replenishment.

20-Year Comparison Photographs – Site 180, Sunset Court, Sea Bright
Comparing this 1988 view to the north with this 2006 view from the top of the seawall shows a dramatic contrast with the wide, vegetated dune field that extends beyond the zero elevation line from 1986. The building roof to the left of the figure in the left photograph is the same peak on the left side of the 2006 view. The sand volume calculation from 2006 to 1986 yielded a 183.85 yds^3/ft increase from that present in 1986.

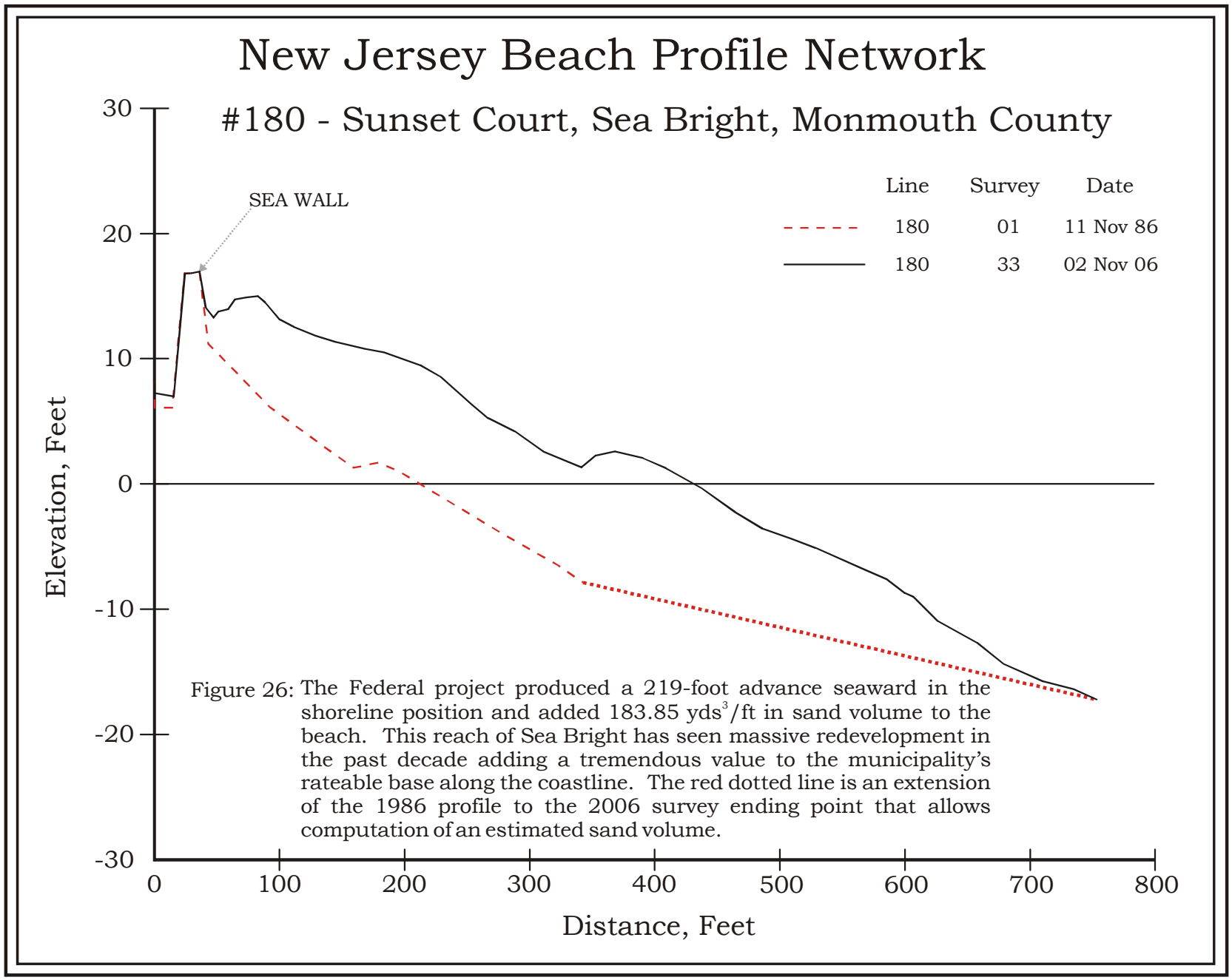


Figure 26: The Federal project produced a 219-foot advance seaward in the shoreline position and added 183.85 yds^3/ft in sand volume to the beach. This reach of Sea Bright has seen massive redevelopment in the past decade adding a tremendous value to the municipality's rateable base along the coastline. The red dotted line is an extension of the 1986 profile to the 2006 survey ending point that allows computation of an estimated sand volume.

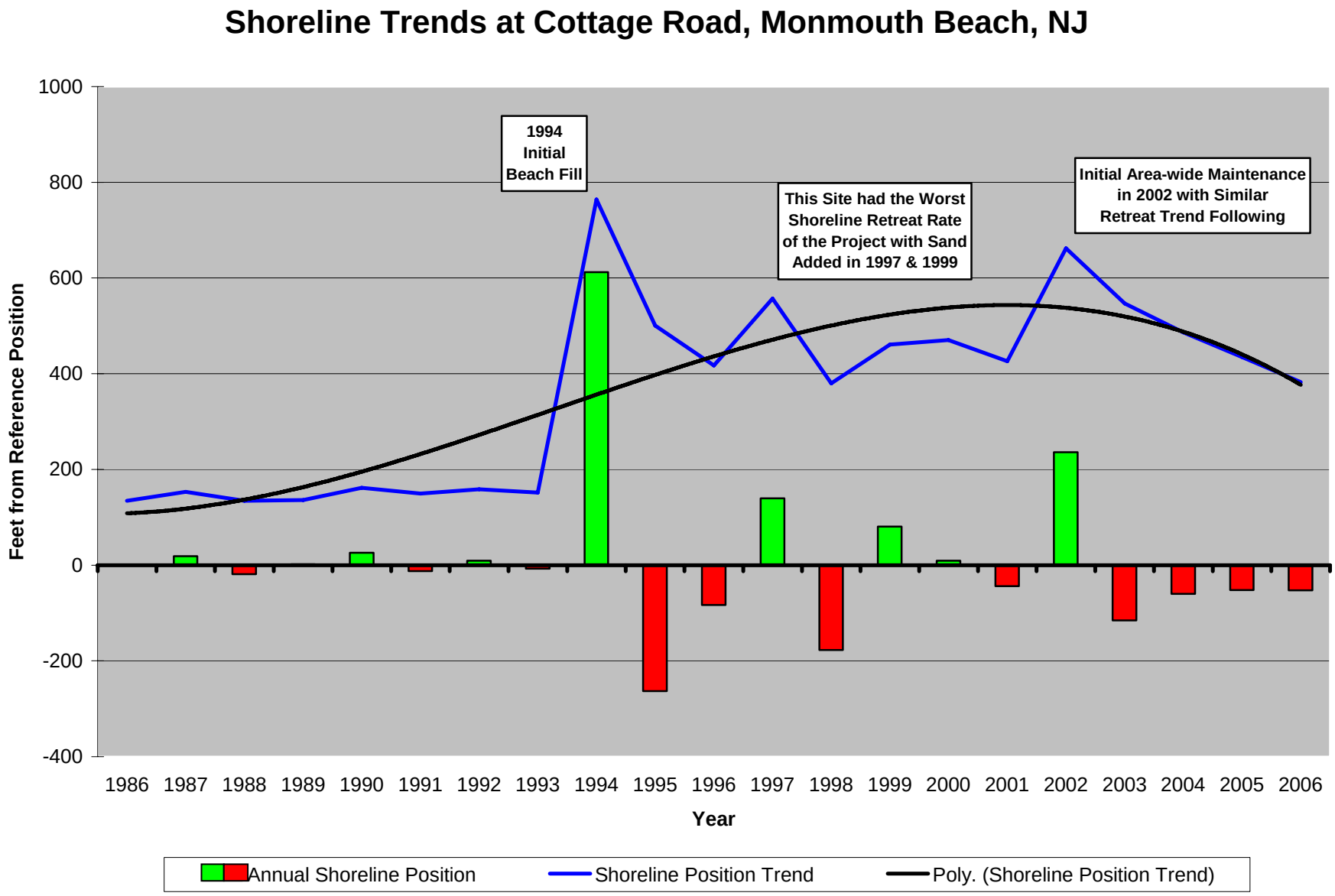


Figure 27 – Site 179. The Cottage Road site lies just north of a vintage beach club that was built seaward of the highway and protected by moving the seawall seaward around the structure. This geometry appears to enhance the erosion rate at this beach. The trend shows a substantially greater rate of retreat in the shoreline than at other Sea Bright sites. The dredge added sand in 1997 and 1999 as it was involved

in working other portions of the project. The maintenance fill in 2002 reversed the loss, but the rate of retreat continued. From 1986 to 1994 there was no beach of any kind at the base of the seawall rocks. Water depth at the rock wall's toe would vary yearly, but on the best of survey dates, the crew left the rocks directly into the water.

A.

B.

C.

20-Year Comparison Photographs – Site 179, Cottage Road, Monmouth Beach

The left photograph (B) shows the geometry of the seawall from the survey site instrument position. The bottom right picture (C) shows the scarp present Oct. 11, 2006 indicating that shoreline retreat was impacting the dunes on a mildly rough day. However, compared to the situation present prior to the project, this beach is infinitely superior to any observed between 1986 and 1994. The top photo shows the conditions of the beach in 1989 (A).

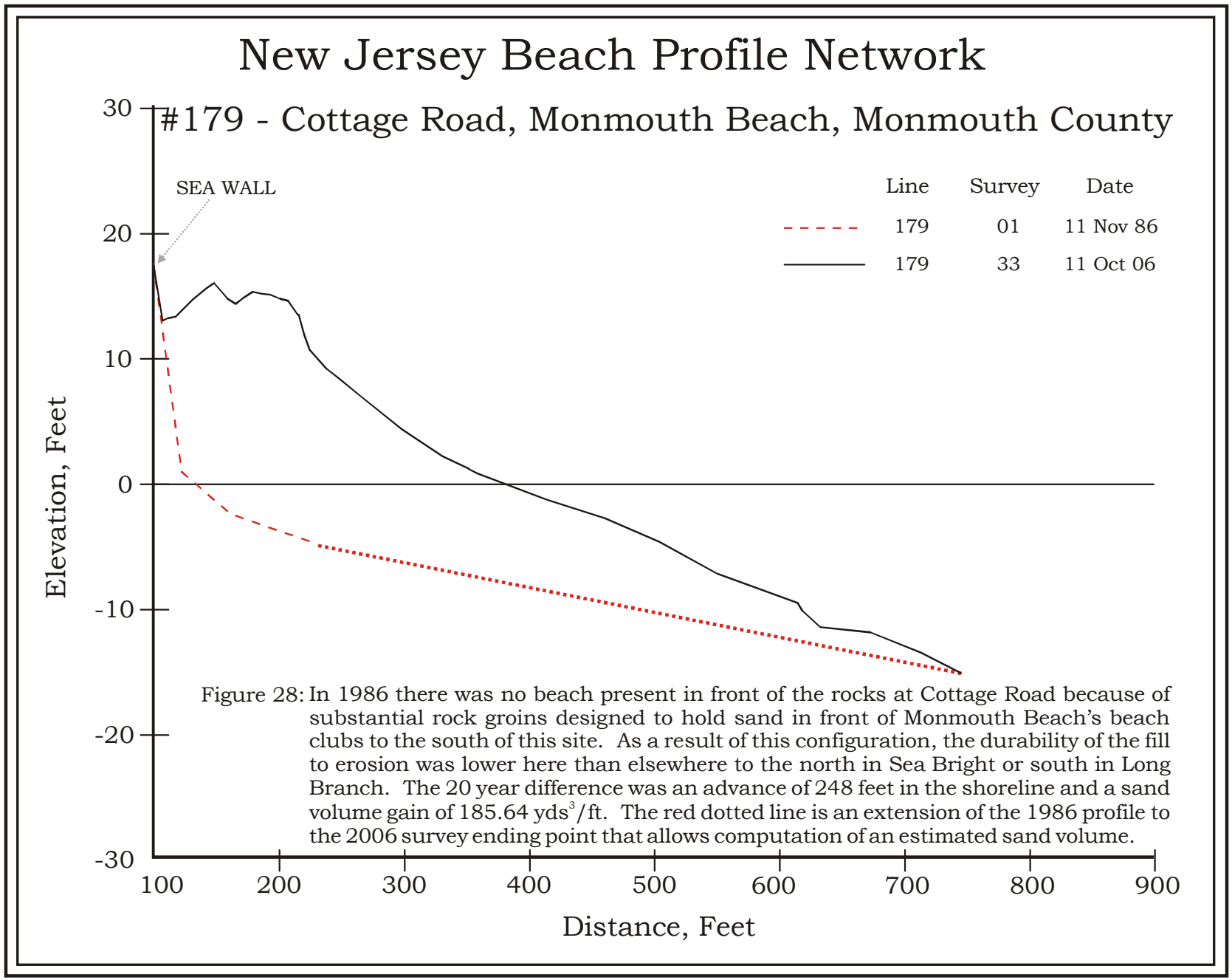


Figure 28: In 1986 there was no beach present in front of the rocks at Cottage Road because of substantial rock groins designed to hold sand in front of Monmouth Beach's beach clubs to the south of this site. As a result of this configuration, the durability of the fill to erosion was lower here than elsewhere to the north in Sea Bright or south in Long Branch. The 20 year difference was an advance of 248 feet in the shoreline and a sand volume gain of 185.64 yds^3/ft. The red dotted line is an extension of the 1986 profile to the 2006 survey ending point that allows computation of an estimated sand volume.

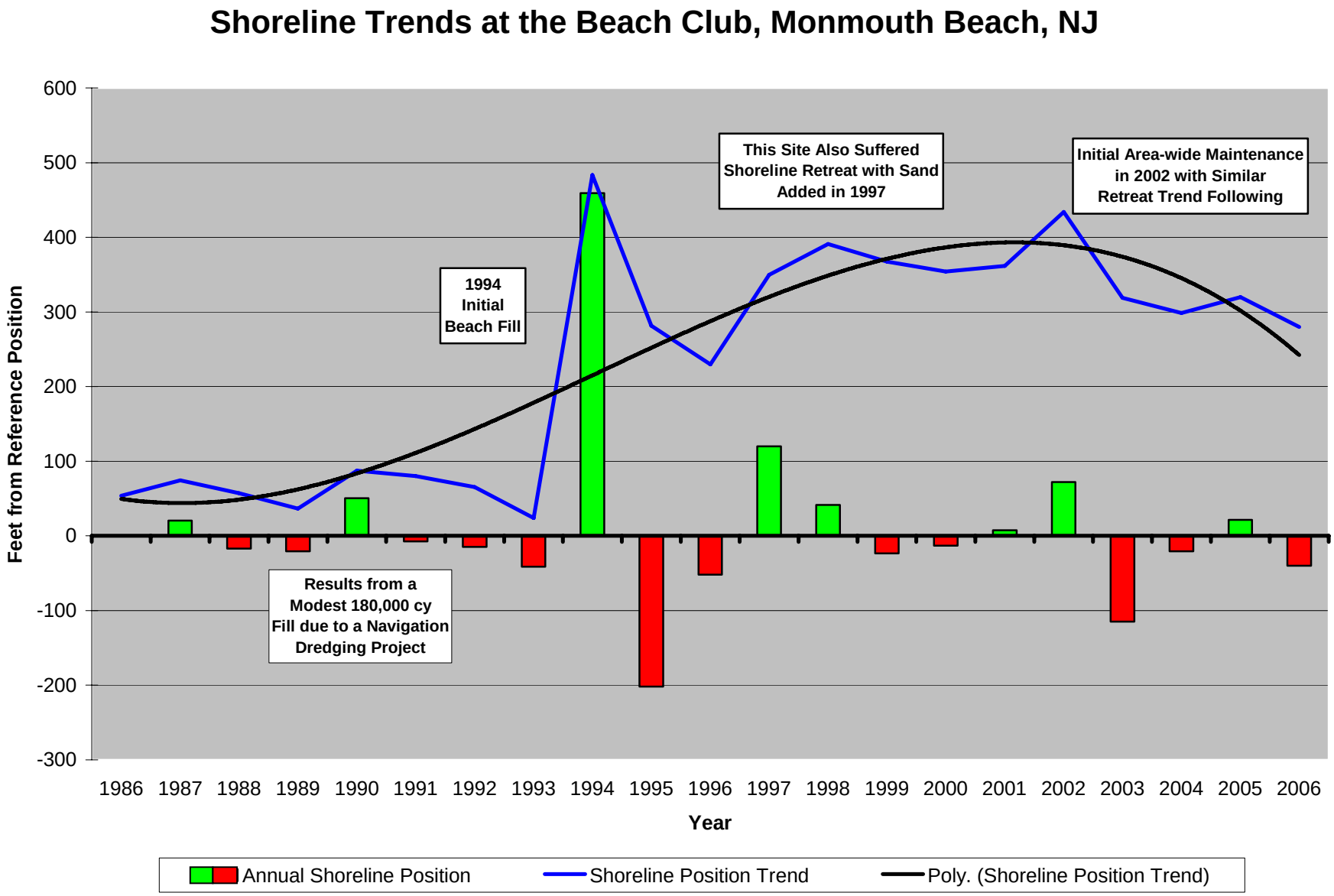


Figure 29 – Site 178. This profile, located at one of the Monmouth Beach clubs, also declined in sand volume more rapidly after the federal fill project than it did elsewhere between Long Branch and Sandy Hook. The rate of loss was less than that seen at Cottage Road to the north.

20-Year Comparison Photographs – Site 178, Monmouth Beach Club, Monmouth Beach
The dune seen in the 2006 photograph (right) did not exist in 1986 because the dry beach area was pushed directly to the bulkhead protecting the buildings. The beach sloped steeply seaward from the pavilion to the water. In the fall of 2006 that distance was 226 feet further seaward. The photo on the left depicts the conditions of this beach in 1991.

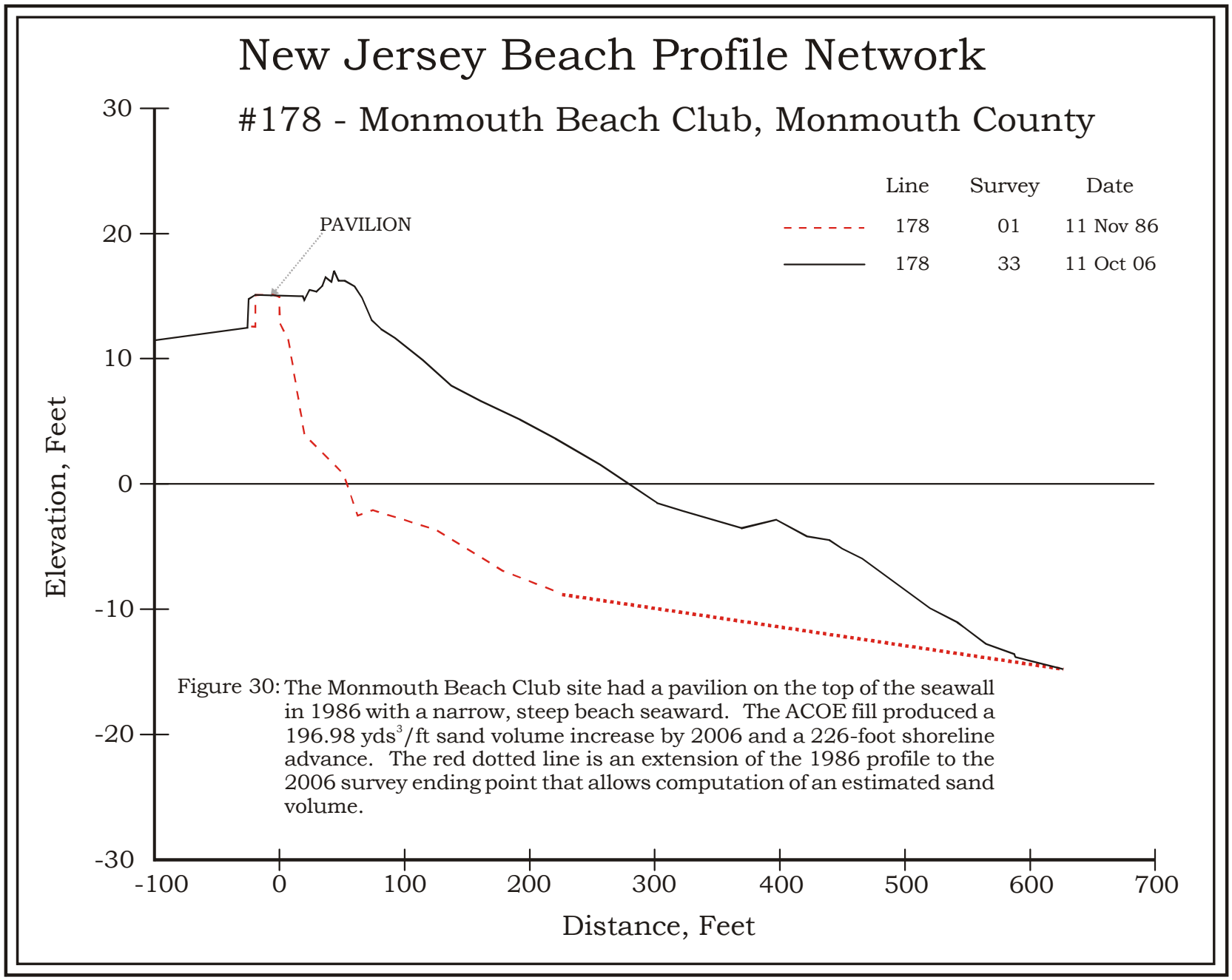


Figure 30: The Monmouth Beach Club site had a pavilion on the top of the seawall in 1986 with a narrow, steep beach seaward. The ACOE fill produced a 196.98 yds^3/ft sand volume increase by 2006 and a 226-foot shoreline advance. The red dotted line is an extension of the 1986 profile to the 2006 survey ending point that allows computation of an estimated sand volume.

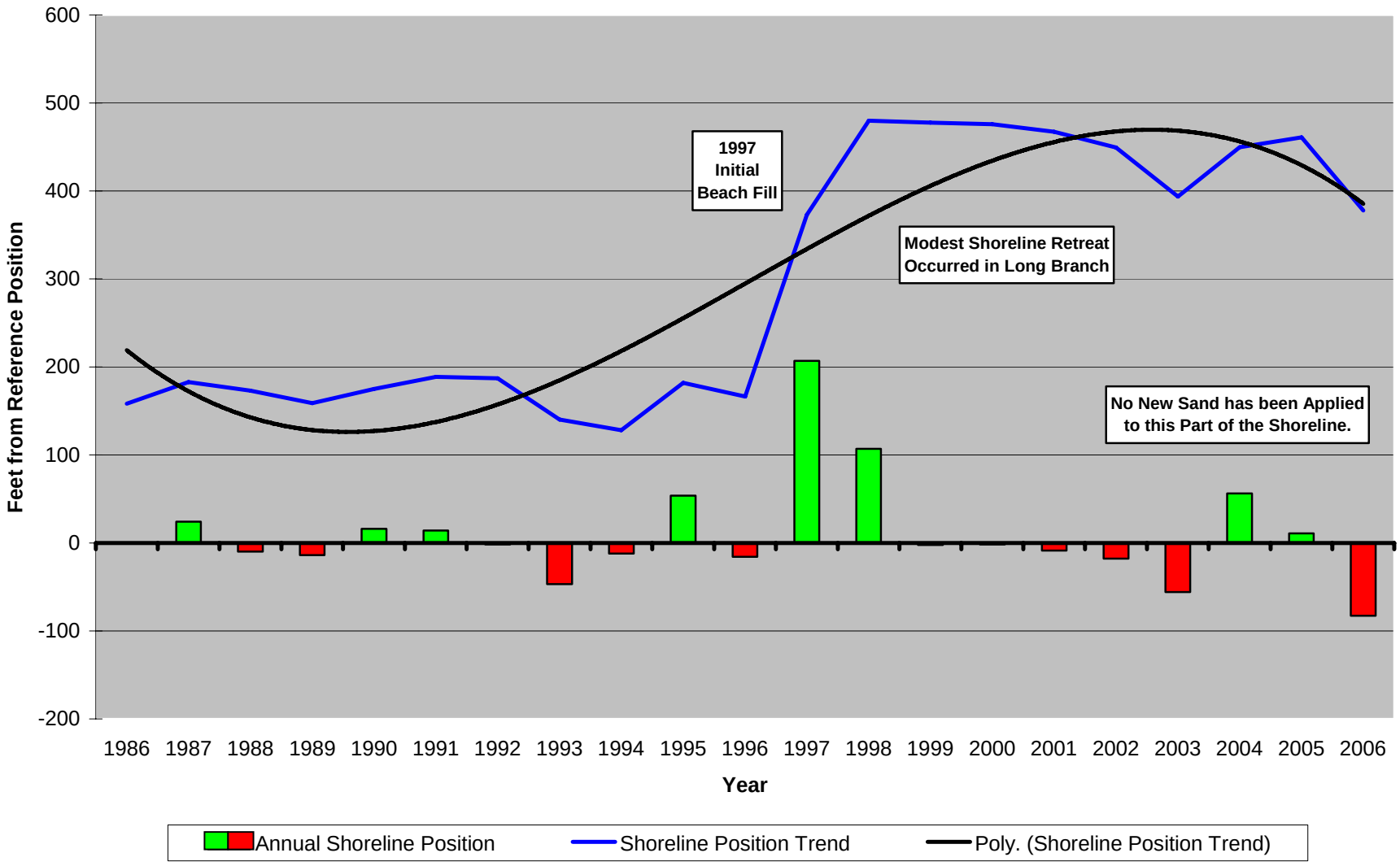


Figure 31 – Site 177. South of the seawall, this beach has remained relatively constant in width since the 1997 initial sand placement. There was no 2002 maintenance effort in Long Branch, so the retreat rate is not influenced by additional sand volumes since 1997.

20-Year Comparison Photographs – Site 177, 404 Ocean Avenue, Long Branch

This beach goes to Ocean Avenue to an ancient concrete wall that kept sand off the road. The beach never had a dune because of intense recreational activity. Formerly a military recreational site for Fort Monmouth personnel, the public beach is wider and higher than it was in 1996. Today the beach has been integrated into the Seven Presidents Park system for public use. The sand volume remaining from the Federal project is 192.40 yds^3/ft as of fall 2006. The wide beach in the right-hand photograph has been pushed up each winter for at least two decades. It shows on the 1986 cross section and was present each fall for many years. The picture on the left depicts the conditions of the beach in 1990.

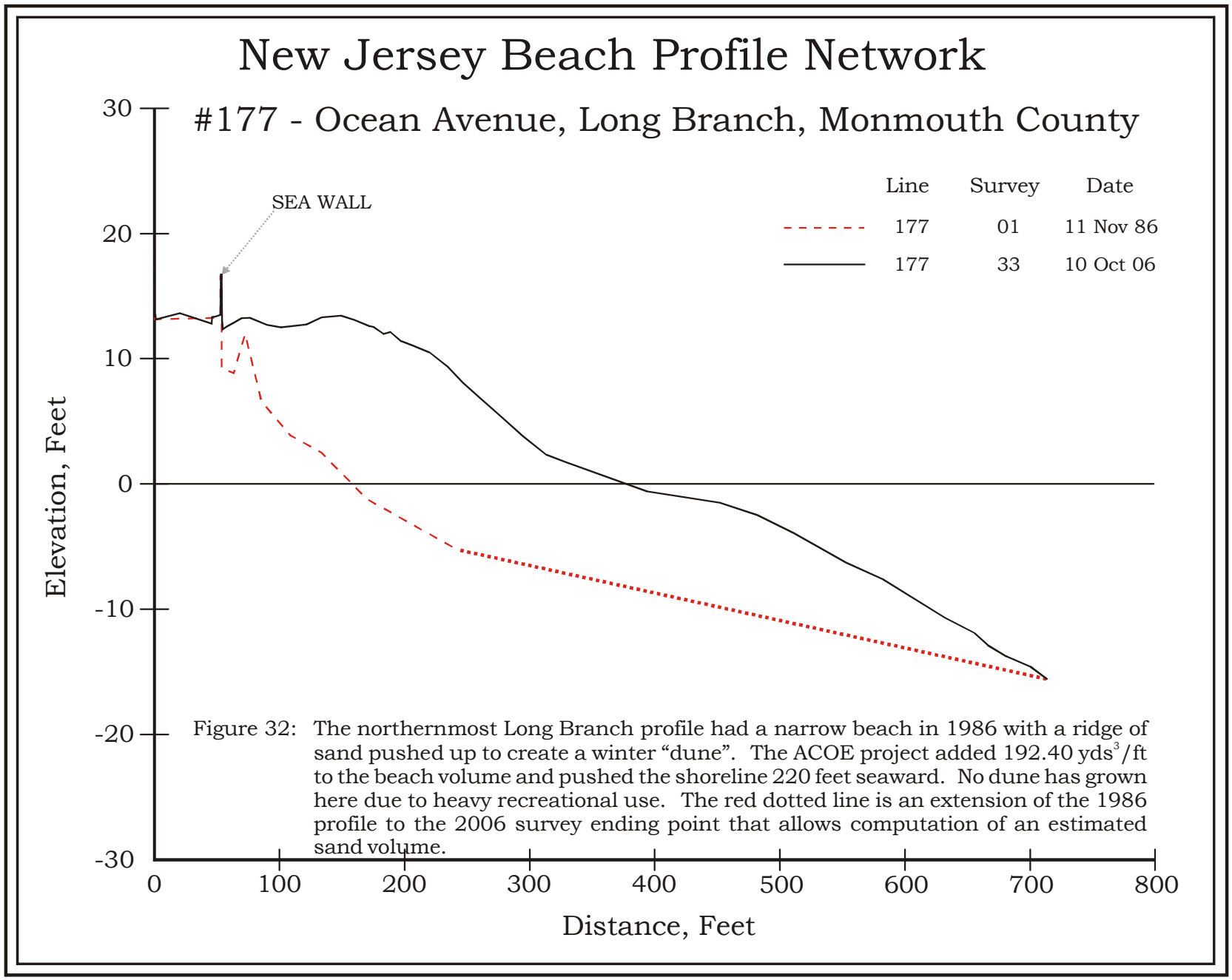


Figure 32: The northernmost Long Branch profile had a narrow beach in 1986 with a ridge of sand pushed up to create a winter "dune". The ACOE project added 192.40 yds^3/ft to the beach volume and pushed the shoreline 220 feet seaward. No dune has grown here due to heavy recreational use. The red dotted line is an extension of the 1986 profile to the 2006 survey ending point that allows computation of an estimated sand volume.

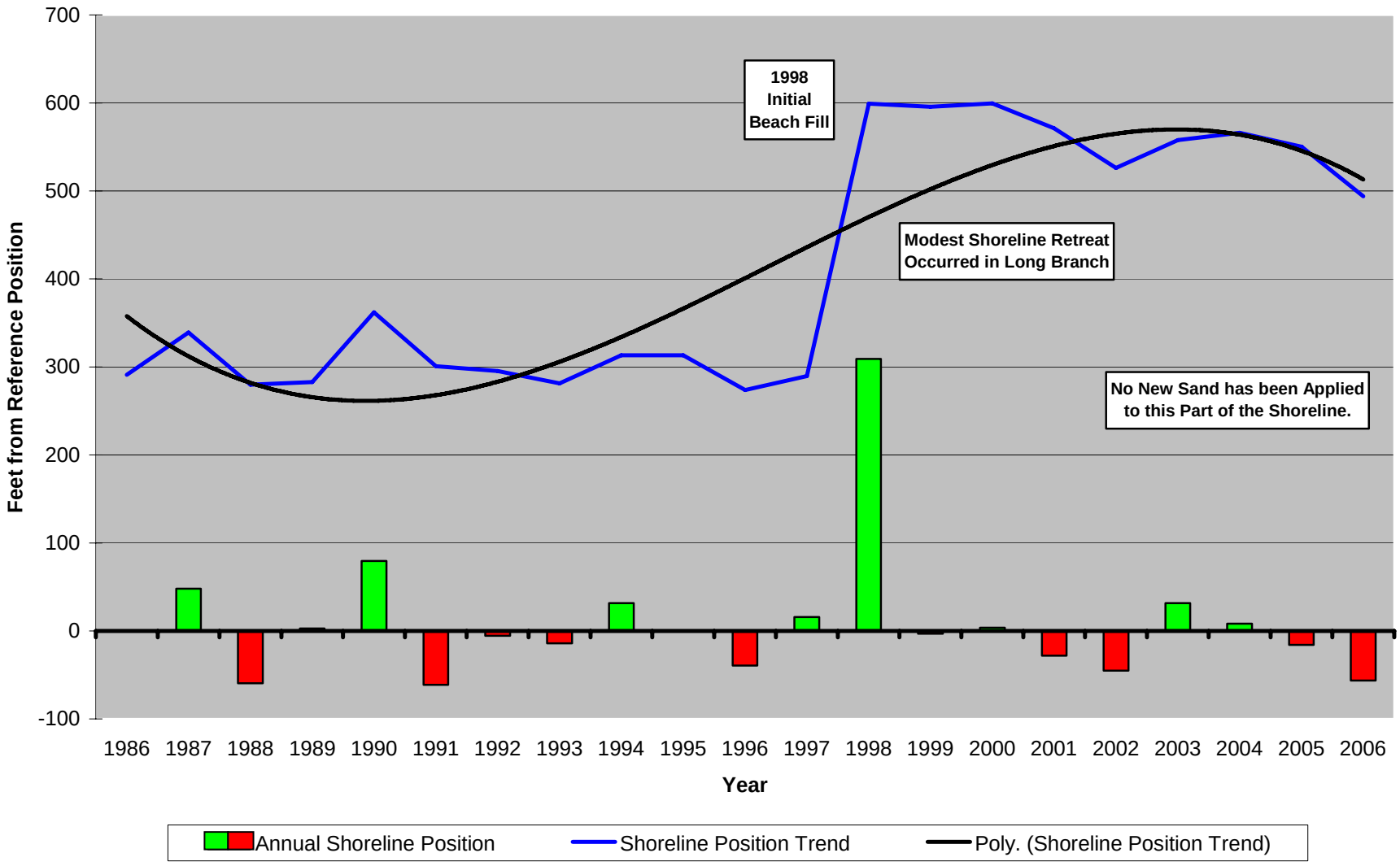


Figure 33 – Site 176. This Park location was assembled from multiple commercial and single family lots east of Ocean Avenue. It has become an extremely popular county recreational site since it opened. The beach nourishment project added 300 feet of width to the

shoreline with only 100 feet of retreat since 1998. There was no maintenance project done here in 2002 so the retention quantity exceeds that anticipated by the New York District engineers and far exceeded that expected by the project's detractors.

20-Year Comparison Photographs – Site 176, Seven Presidents Park, Long Branch

The October 1986 survey crossed a small dune that provided next to no real storm protection. This site is located at a major access way to the beach from the parking lot. There has been little growth to the dune along the profile line because of its location between a small playground and pump house, however, north and south of the site the dune has grown substantially and dune grasses flourish. The beach is currently 203 feet wider than it was in 1986. The above photographs show the contrast between 1989 (left) and 2006 (right).

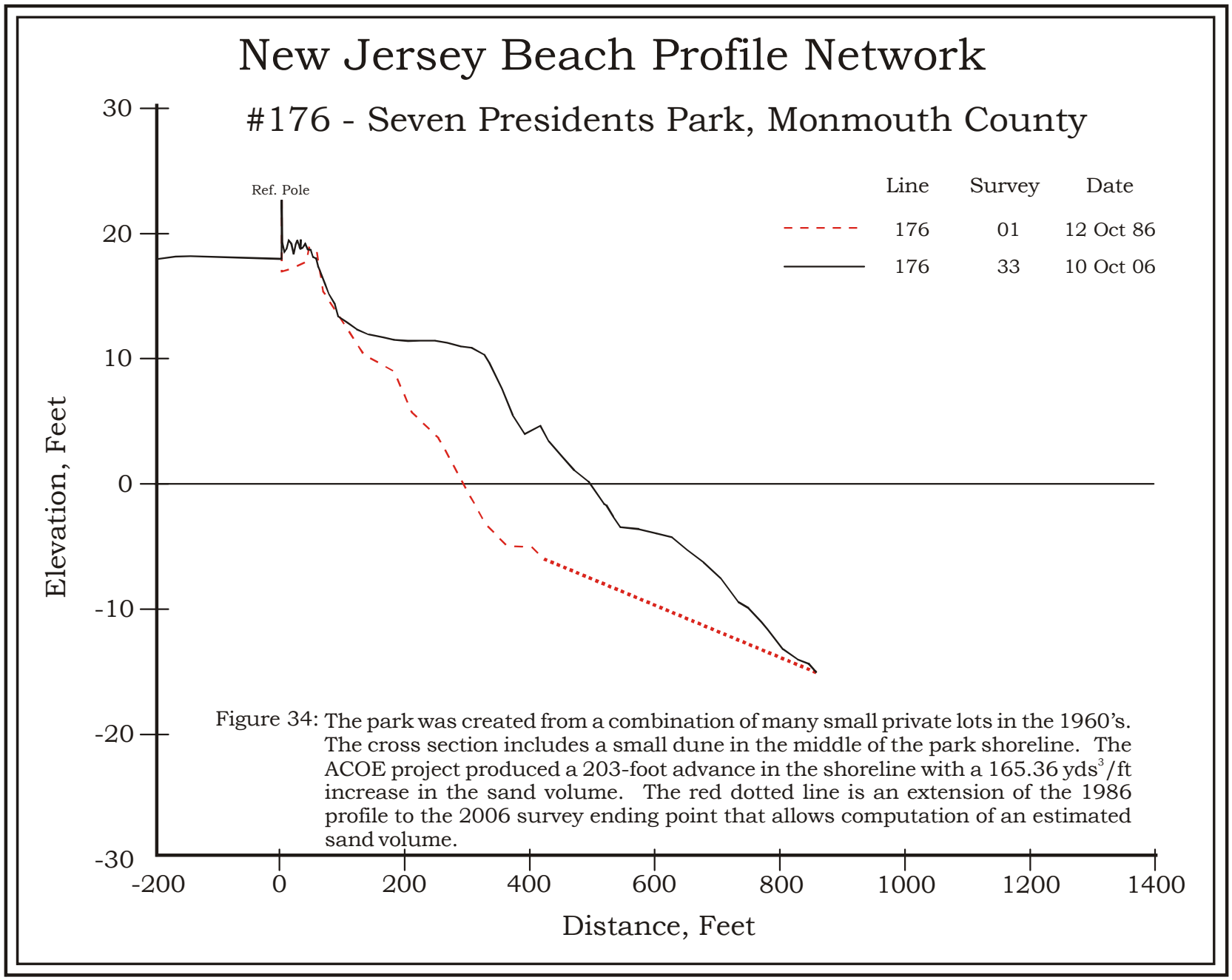


Figure 34: The park was created from a combination of many small private lots in the 1960's. The cross section includes a small dune in the middle of the park shoreline. The ACOE project produced a 203-foot advance in the shoreline with a 165.36 yds^3/ft increase in the sand volume. The red dotted line is an extension of the 1986 profile to the 2006 survey ending point that allows computation of an estimated sand volume.

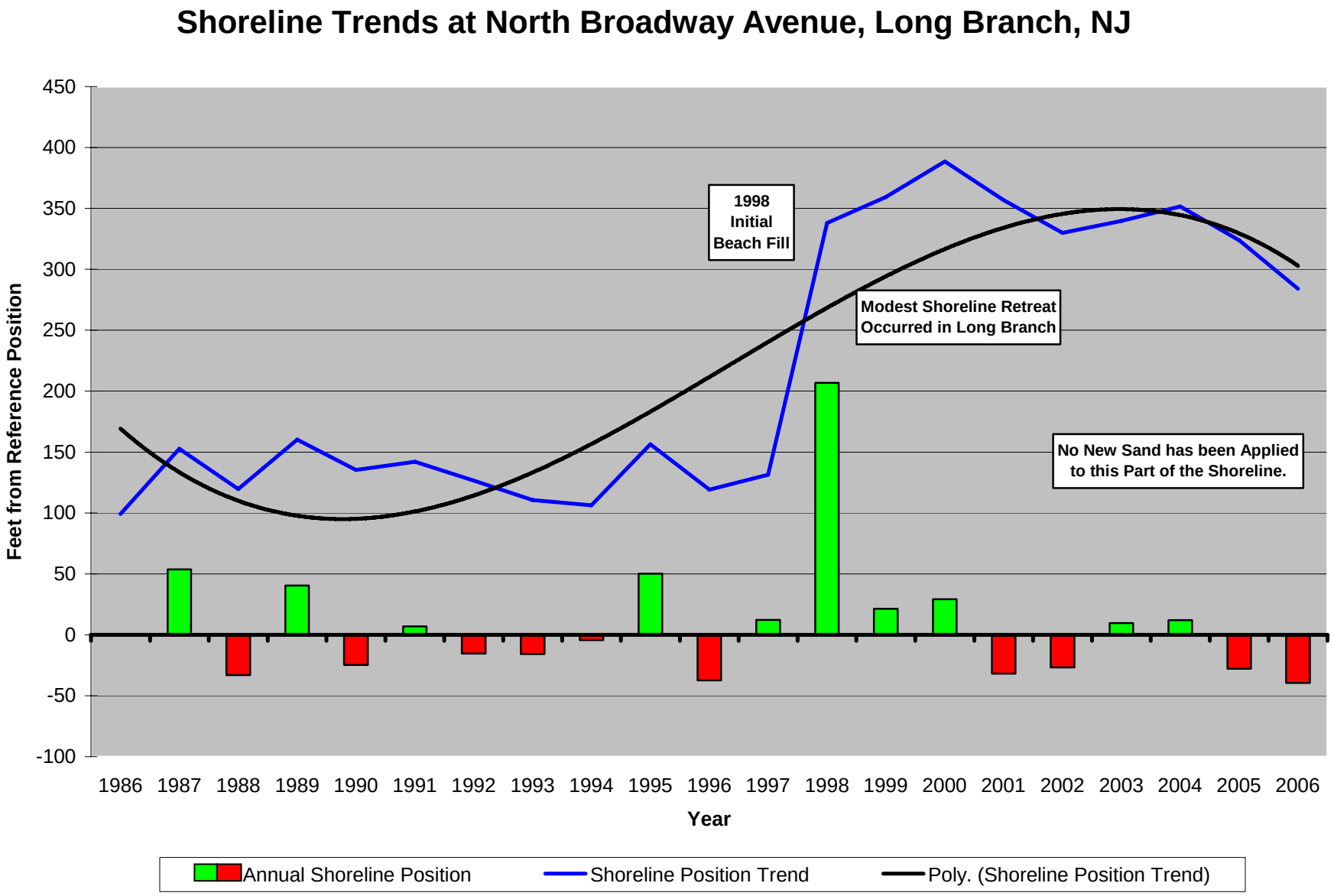


Figure 35 – Site 175. The major segment of the Long Branch shoreline is represented by cross sections #175 (this site), 174 and 173 where the uplands bluff was protected by a vertical steel bulkhead dating from the mid-twentieth century. Later the southern half was reinforced

with a rock seawall in front of the steel wall due to its deterioration. The Federal project had advanced beyond N. Broadway by fall 1998 creating a 207-foot advance in the shoreline position. Since then it has been relatively stable retreating by about 50 feet over eight years.

20-Year Comparison Photographs – Site 175, North Broadway Avenue, Long Branch

The Long Branch shoreline was in shambles prior to the Federal Shore Protection Project. While redevelopment started in the mid-1980's the rate of major project initiation was slow until following sand placement. After the project developers flocked to the area pouring hundreds of millions of dollars into massive residential and shopping-related projects. The 2006 photograph shows that sand has filled the zone directly in front of the old steel bulkhead nearly to its top elevation of 20 feet. In 1986 it was 14 feet from the top of the bulkhead to the sand below. The sand volume remaining since 1998 is 152.95 yds^3/ft, which has formed a 125 foot wide recreational beach seaward of the bulkhead.

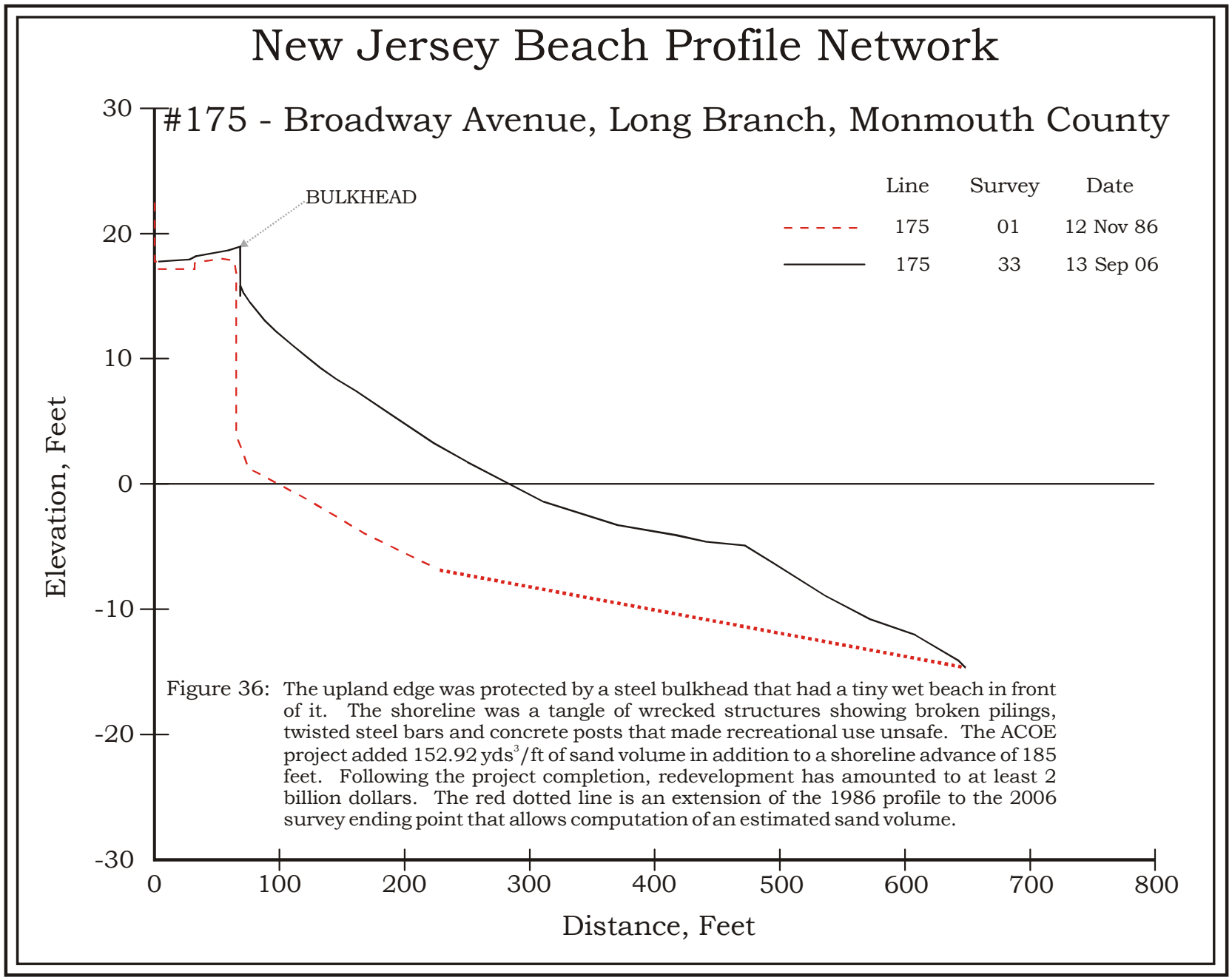


Figure 36: The upland edge was protected by a steel bulkhead that had a tiny wet beach in front of it. The shoreline was a tangle of wrecked structures showing broken pilings, twisted steel bars and concrete posts that made recreational use unsafe. The ACOE project added 152.92 yds^3/ft of sand volume in addition to a shoreline advance of 185 feet. Following the project completion, redevelopment has amounted to at least 2 billion dollars. The red dotted line is an extension of the 1986 profile to the 2006 survey ending point that allows computation of an estimated sand volume.

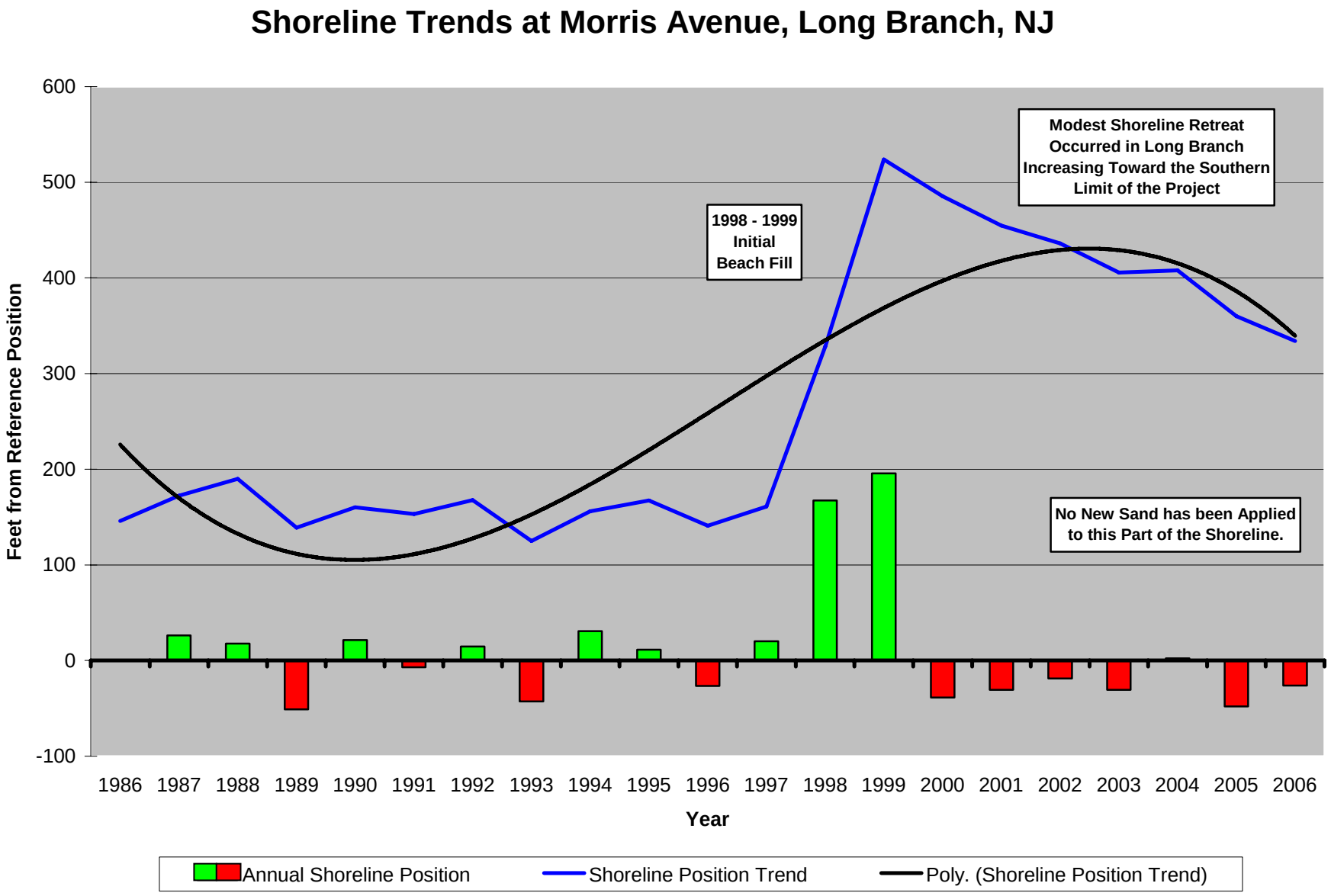


Figure 37 – Site 174. This profile in the middle of the Long Branch oceanfront begins to show an increased rate of shoreline retreat. The process is directly related to the fact that the initial project ended at the Long Branch southern boundary due to issues of real estate easements

to the beach. New Jersey was required to obtain easements in perpetuity on any privately-owned shoreline where there was ownership of the dune or dry beach. This was nearly universal in the municipalities of Elberon, Deal, Allenhurst and Loch Arbor so a major gap was left in sand placement along the Monmouth County shoreline.

20-Year Comparison Photographs – Site 174, Morris Avenue, Long Branch

The Long Branch bluff edge once supported a dual, two-lane Ocean Avenue with a grass island dividing the roads, and a grass border between the eastern curb and the boardwalk. The boardwalk was built on concrete pilings buried in the beach in front of the bluff and was over twice the width of the current boardwalk. Only the southbound highway exists in 2006, with the boardwalk now occupying the location for the mid-highway grass island. The northbound road and its 30-foot wide grass margin have been lost. The State cooperated with Long Branch several decades ago in building a rock seawall on the edge of the bluff to reduce erosion. Beach nourishment generated a much wider recreational beach seaward of the wall. The pictures above show the contrast between 1990 (left) and 2006 (right).

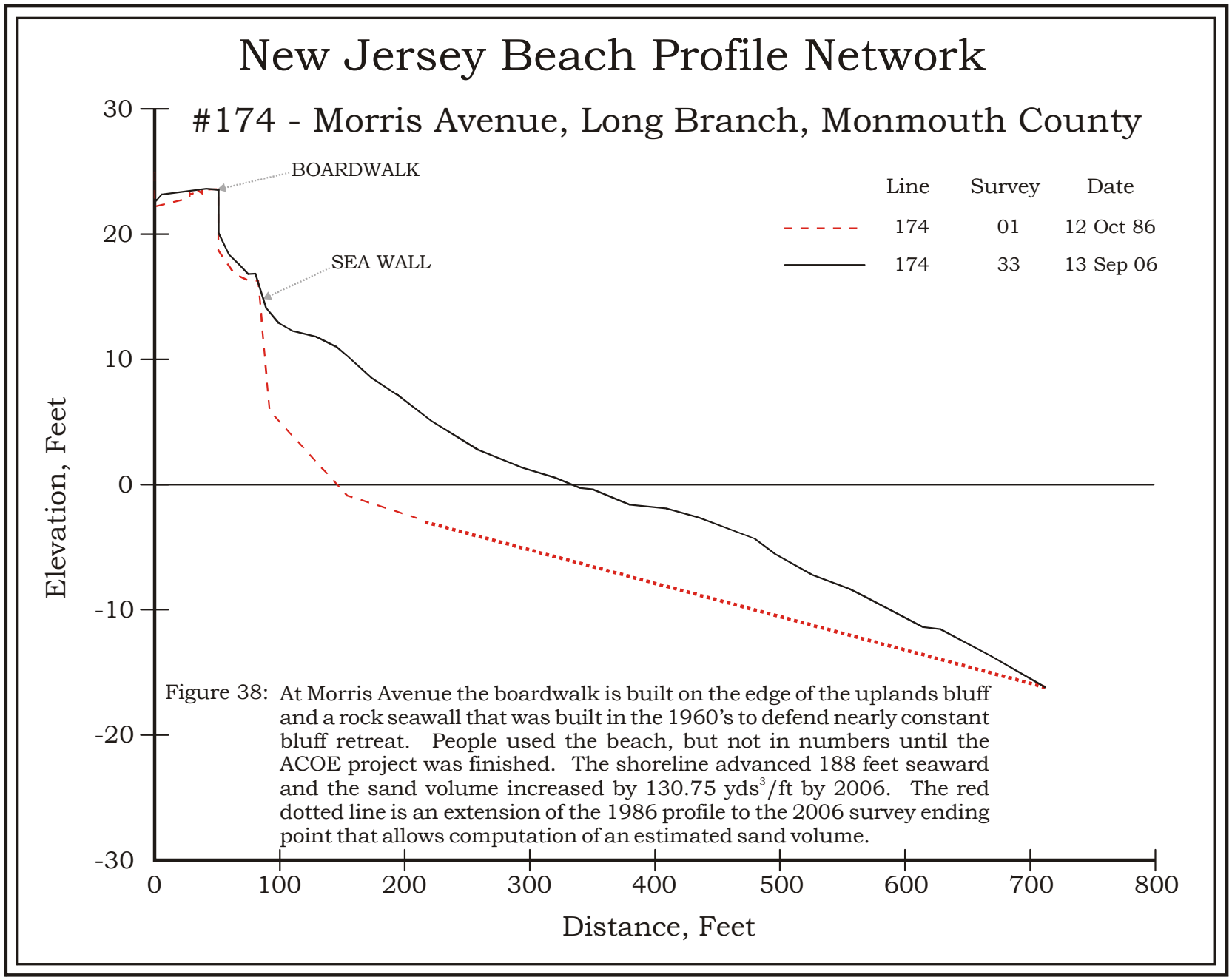


Figure 38: At Morris Avenue the boardwalk is built on the edge of the uplands bluff and a rock seawall that was built in the 1960's to defend nearly constant bluff retreat. People used the beach, but not in numbers until the ACOE project was finished. The shoreline advanced 188 feet seaward and the sand volume increased by 130.75 yds^3/ft by 2006. The red dotted line is an extension of the 1986 profile to the 2006 survey ending point that allows computation of an estimated sand volume.

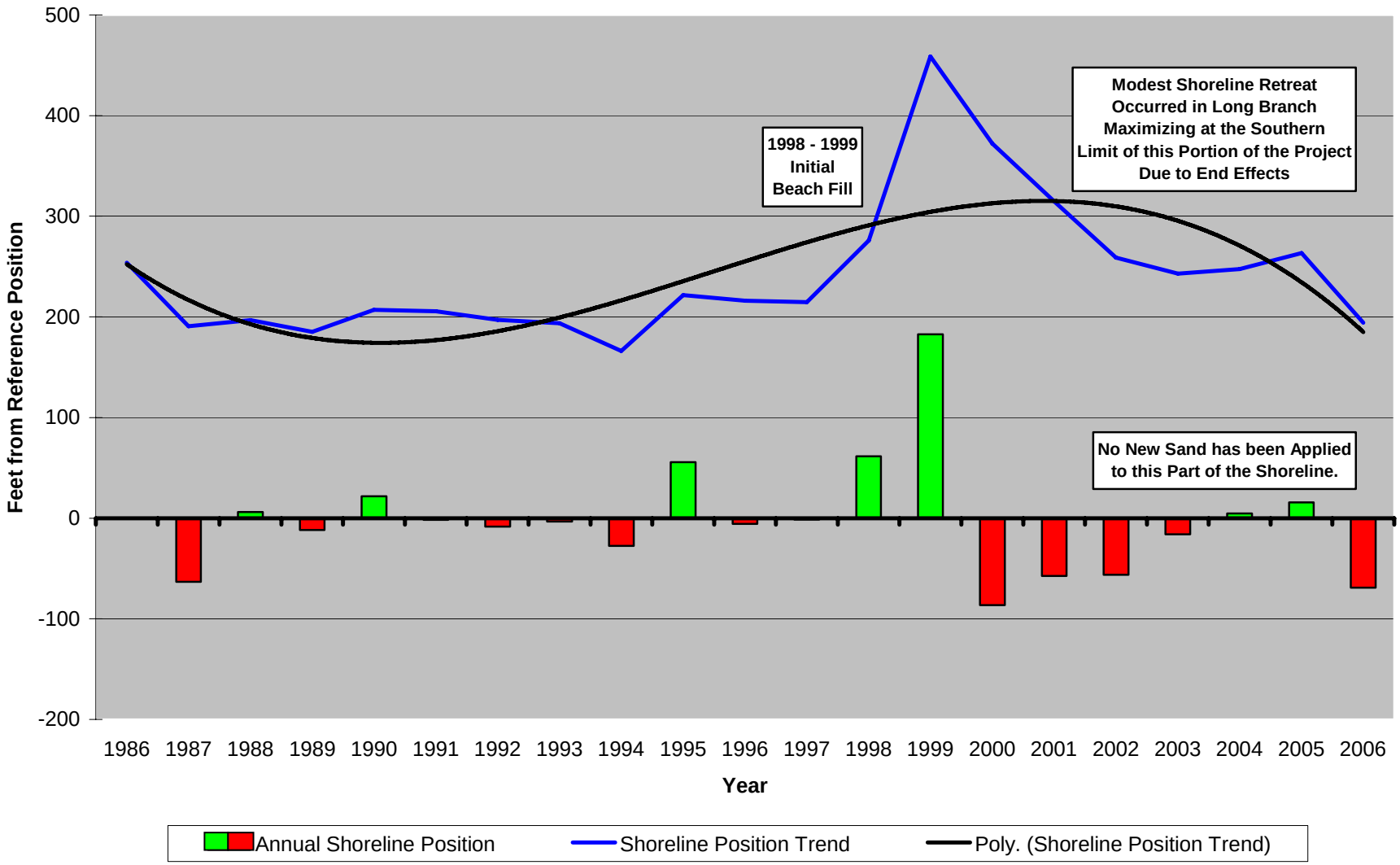


Figure 39 – Site 173. West End Avenue was essentially the southern limit of sand placement due to real estate issues blocking sand placement further south. The commencement of loss was immediate and continued at a constant pace until 2003 when a mild reversal

occurred. In 2006 the rate of loss returned to that seen earlier. In the final analysis the 1997 shoreline position was slightly seaward of the 2006 shoreline position (214 feet vs. 194 feet from the reference location).

20-Year Comparison Photographs – Site 173, West End Avenue, Long Branch

Viewing the beach from the top of the bluff at an elevation of 31 feet, the width of the beach appears sufficient to support bathing. However, when the ACOE project was completed the groins were all but buried with sand. The loss rates shown above exposed the tips of the groins, then eventually about half the original rock structures. The comparison profile plot below shows that the November 2006 survey was actually lower in elevation than that present in November twenty years earlier. The volume was 48.75 yds^3/ft less and the shoreline retreated 60 feet in spite of the impact of the beach nourishment. These erosional end effects seen at artificial ends to even massive projects are significant in terms of loss as sand is quickly redistributed to those end beaches were sand was not placed as the waves and currents work to create a equilibrium shoreline between the nourished (Long Branch) and non-nourished (Elberon) beach. Unfortunately, the next profile location lies a mile south of this site and may show only modest input from the sand supply lost from the southern Long Branch beaches. Had the project been completed as designed these dramatic losses would not have occurred and the shoreline would have been relatively stable throughout Long Branch. The pictures above show the contrast between 1989 (left) and 2006 (right).

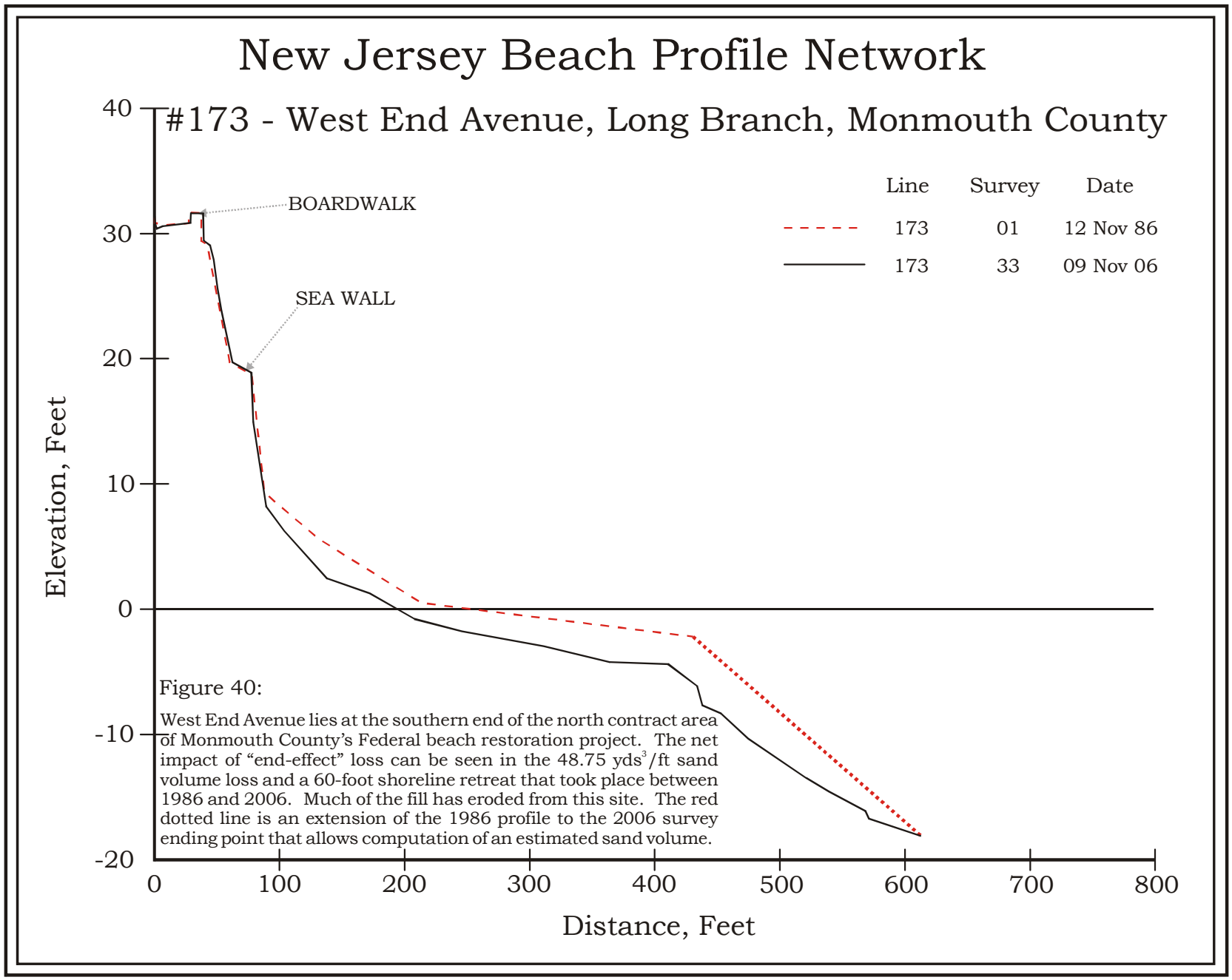


Figure 40:

West End Avenue lies at the southern end of the north contract area of Monmouth County's Federal beach restoration project. The net impact of "end-effect" loss can be seen in the 48.75 yds^3/ft sand volume loss and a 60-foot shoreline retreat that took place between 1986 and 2006. Much of the fill has eroded from this site. The red dotted line is an extension of the 1986 profile to the 2006 survey ending point that allows computation of an estimated sand volume.

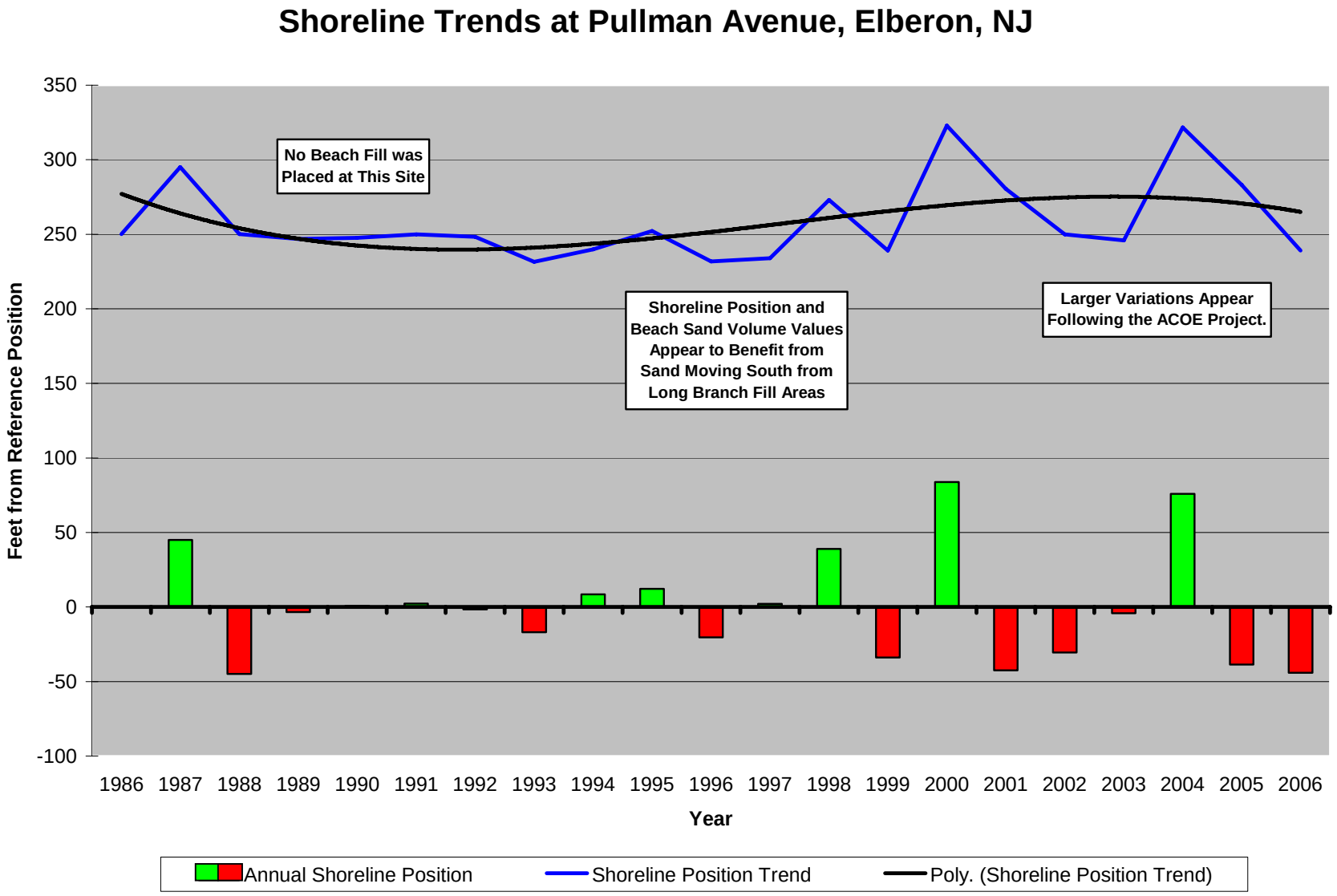


Figure 41 – Site 171. No sand was added to the Elberon beaches south of the West End Avenue site in Long Branch. The variability of the shoreline position grows dramatically larger in the years following the ACOE project to the north. The trend in position curves upward by about 20 feet in average shoreline position was influenced by two large sand volume input years (2000 and 2004).

A. 

B. 

C. 

D. 

20-Year Comparison Photographs – Site 171, Pullman Avenue, Elberon

Also positioned along the highest elevation part of the Monmouth County bluff, the Pullman Avenue site has never seen dry sand beaches at the toe of the rocks. Some years have had more sand on the beach than seen in 2006, but not with a significant width of dry sand. The upper bluff slope is vegetated and backfilled behind the bulkhead with sandy gravel (Photo D, taken in 1989). Occasionally, the water level is at the rocks at low tide (Photo C, taken in 1989 shows water at the rocks). The sand volume has improved substantially since the 1998 completion of the Long Branch segment of the project. Material has appeared and the most likely source is littoral transport from the north. Photos A and B show the contrast between 1988 (top left) and 2006 (top right).

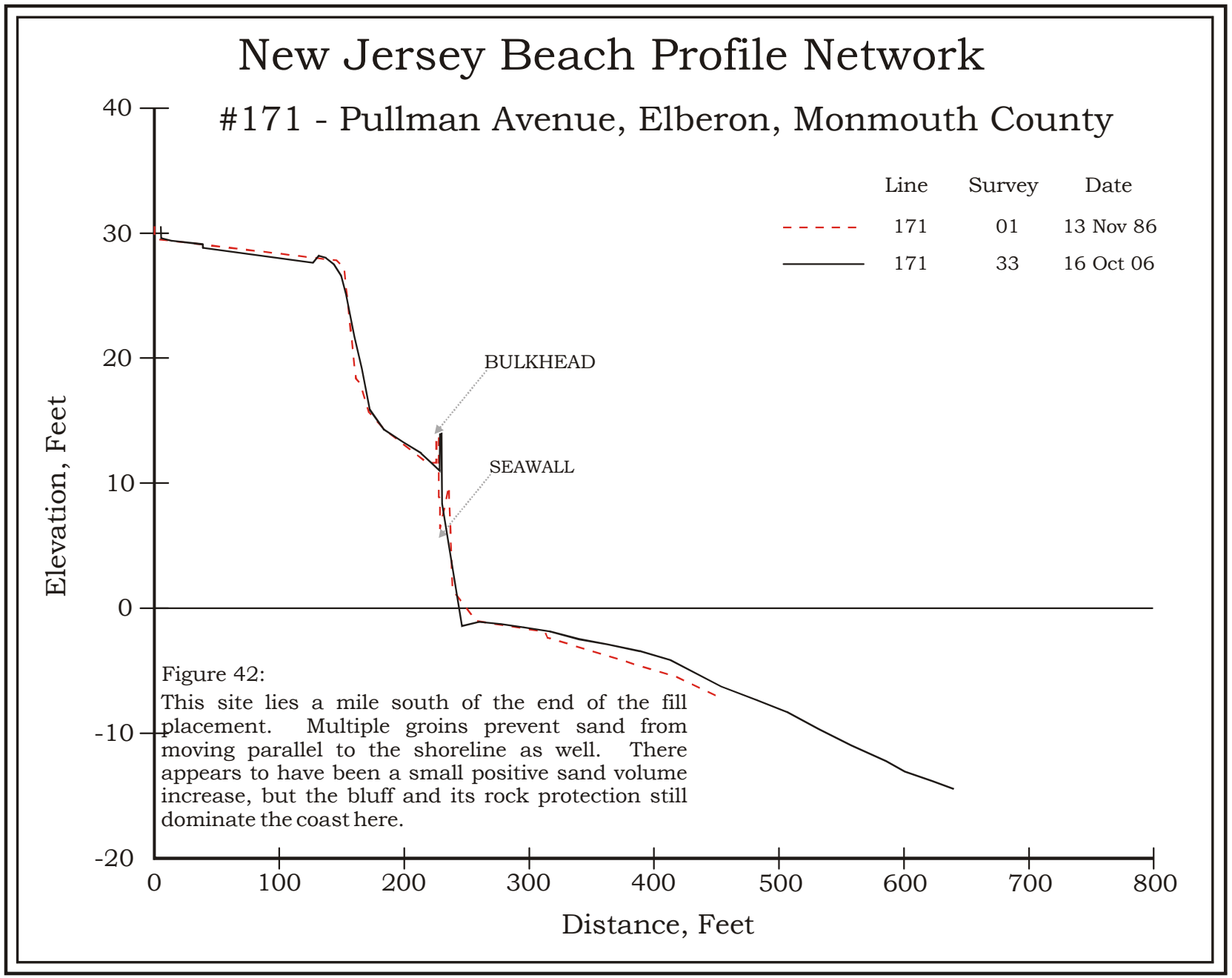


Figure 42:
This site lies a mile south of the end of the fill placement. Multiple groins prevent sand from moving parallel to the shoreline as well. There appears to have been a small positive sand volume increase, but the bluff and its rock protection still dominate the coast here.

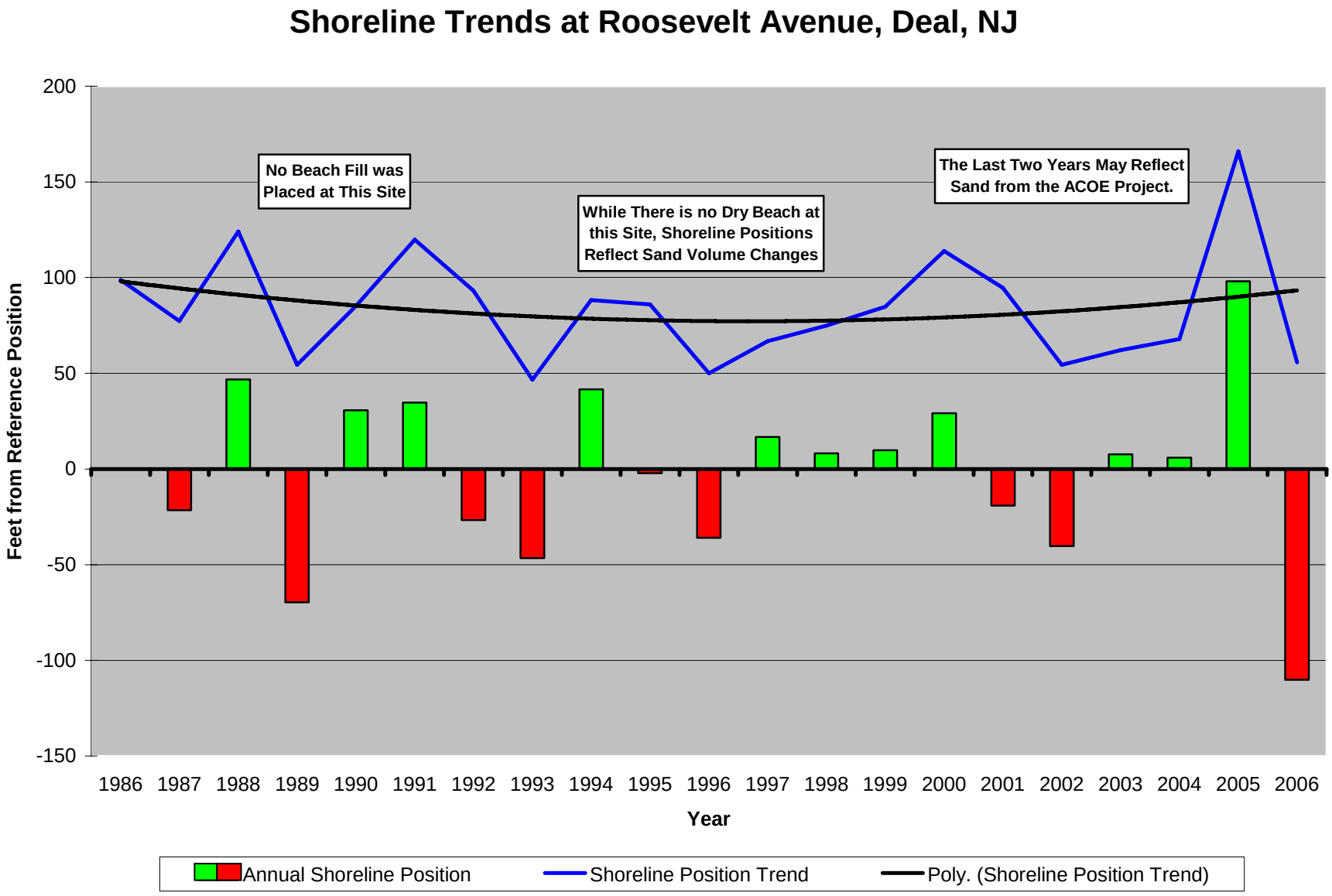


Figure 43 – Site 170. Located along the Deal shoreline, the site is typical of the bluff where timber and rock shore protection structures abound. Normally, there is no dry beach and frequently the transition from the rocks of the seawall to the sand surface is done in water even

at low tide. The data was variable from year to year with a trend toward shoreline retreat that appeared to reverse after 1999. There is a major fluctuation between 2005 and 2006 that will be interesting to investigate in the future for evidence of gains either from the south or north as sand is slowly distributed along the beach.

20-Year Comparison Photographs – Site 170, Roosevelt Avenue, Deal

The dry beach is very narrow on the best of site visits for the surveys. The rocks form a compartment for the beach severely restricting any sand transport along the shoreline using the littoral transport mechanism. There appears to be more sand in the system since the ACOE project was completed, but the convincing evidence is still not observable. The pictures above show the contrast between 1988 (right) and 2006 (left).

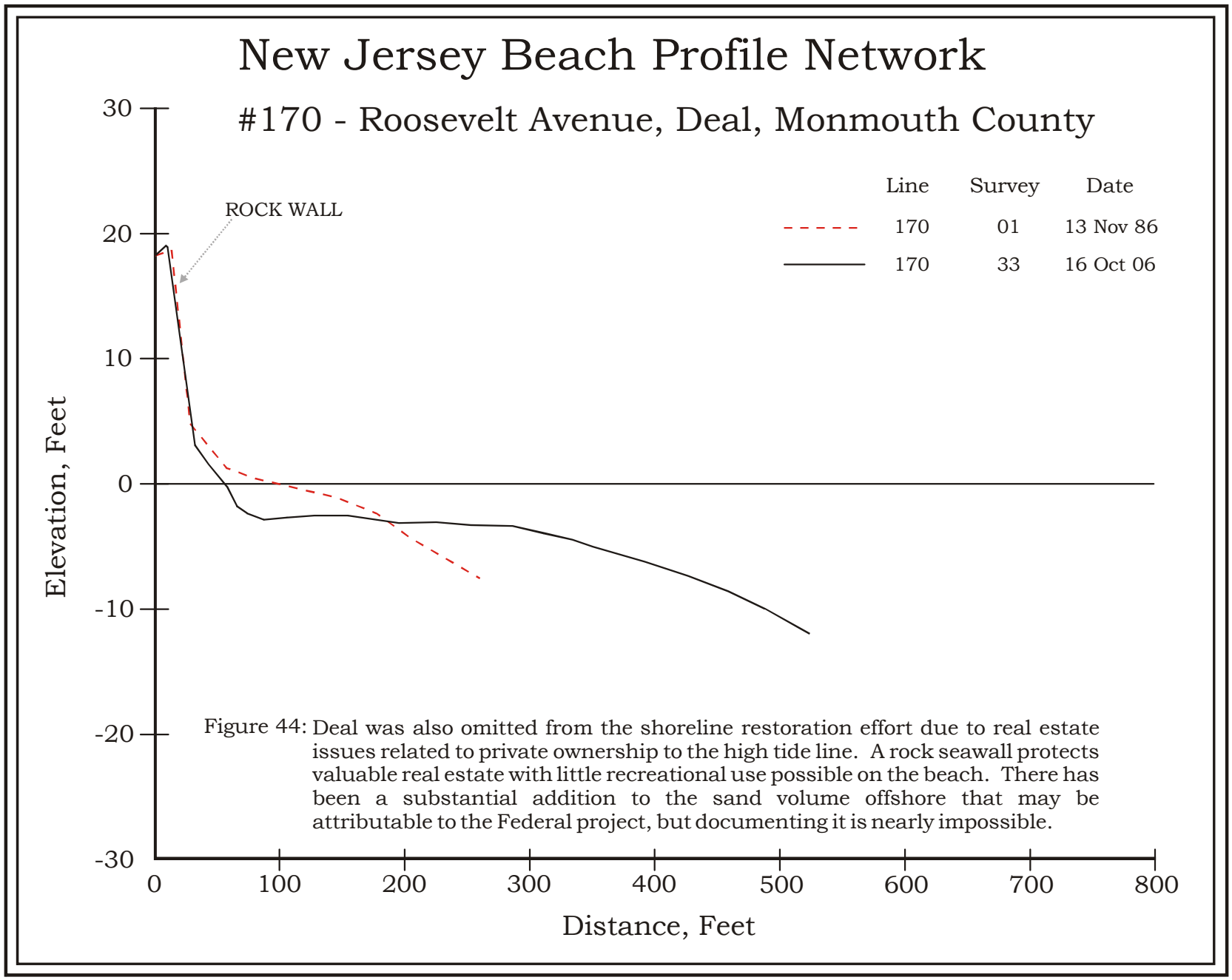


Figure 44: Deal was also omitted from the shoreline restoration effort due to real estate issues related to private ownership to the high tide line. A rock seawall protects valuable real estate with little recreational use possible on the beach. There has been a substantial addition to the sand volume offshore that may be attributable to the Federal project, but documenting it is nearly impossible.

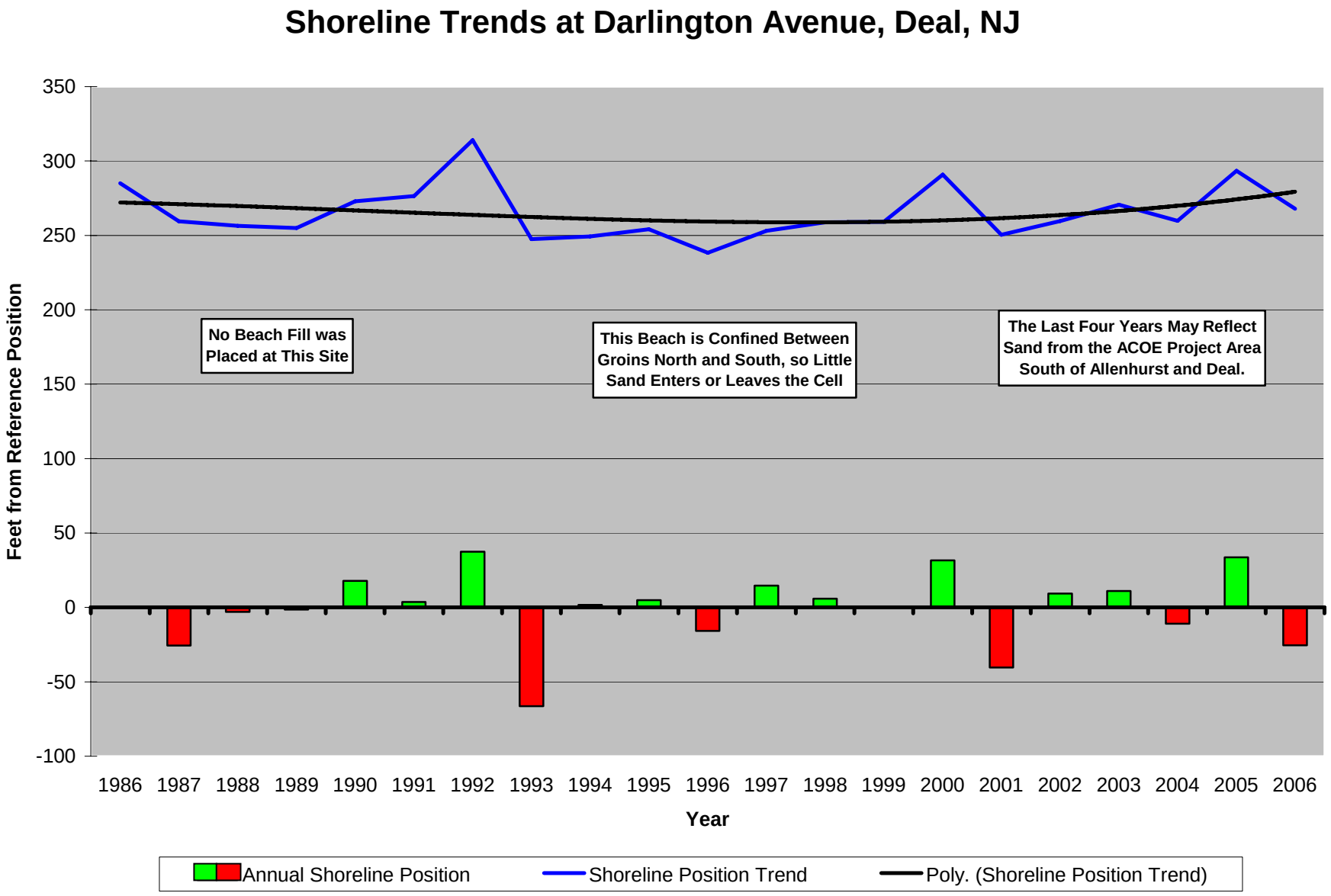


Figure 45 – Site 169. The Darlington Avenue site had more sand within the groin compartment than most other Deal shoreline segments. This is because the bluff was less protected from direct wave erosion, which over time introduces new sand to the system as the bluff

intermittently erodes and due to the presence of a large groin a block to the north at Roseld Avenue that traps sand from moving north. The variation in shoreline positions here has been less than that seen to the north, but the trend showing retreat that reverses following 1996 is similar. In spite of the similar shoreline retreat in 2006, the 20-year trend shows little net change to the beach over that time as sand moves around within the beach compartment formed by the two large groins.

20-Year Comparison Photographs – Site 169, Darlington Avenue, Deal

The beach extends to the base of the bluff where waste concrete mixed with the sand covers the upland stratigraphy comprising the bluff. The profile changed little over the 20-year surveying interval with no significant episodes of storm erosion to the bluff other than 1992. The pictures above show the contrast between 1989(left) and 2006(right).

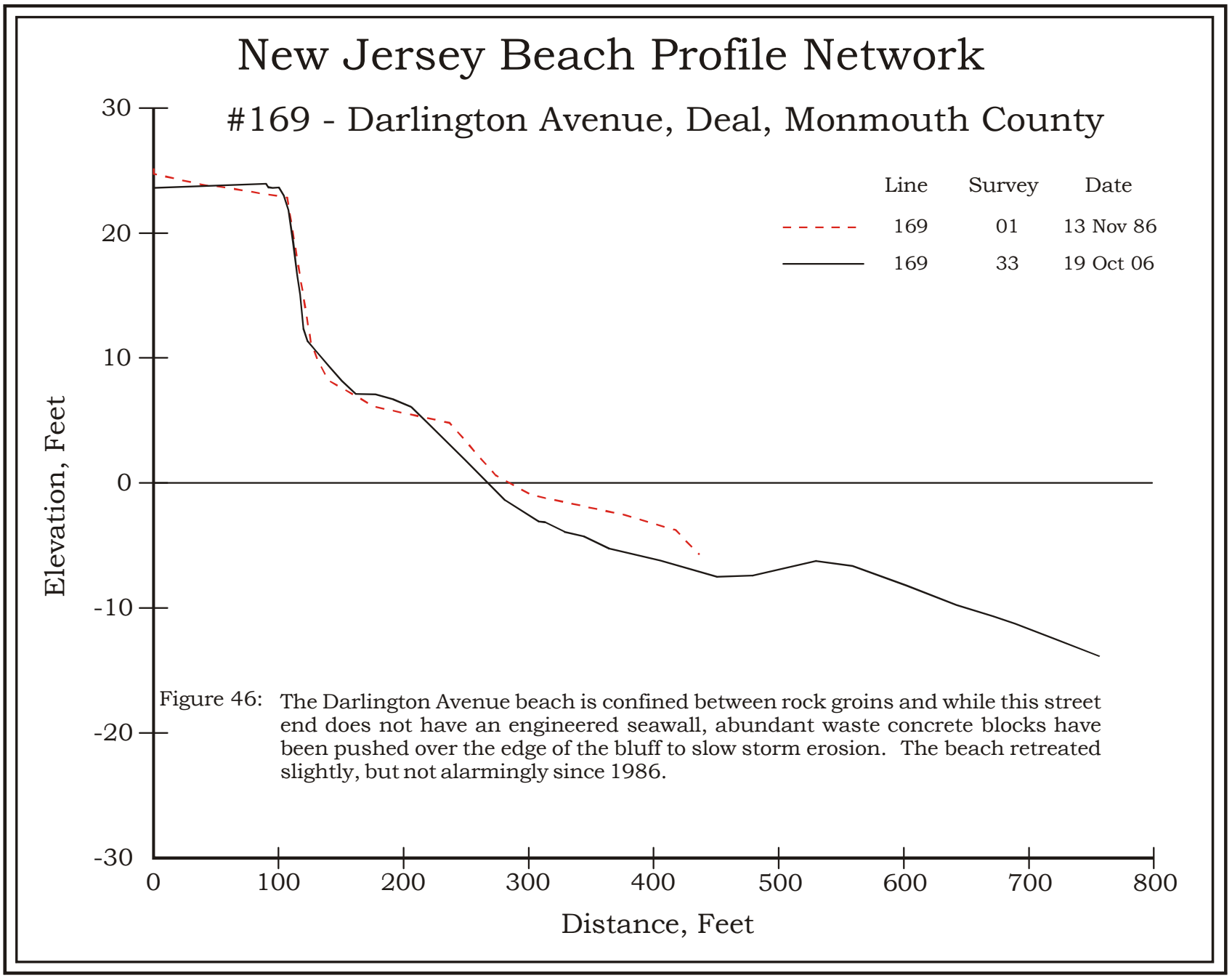


Figure 46: The Darlington Avenue beach is confined between rock groins and while this street end does not have an engineered seawall, abundant waste concrete blocks have been pushed over the edge of the bluff to slow storm erosion. The beach retreated slightly, but not alarmingly since 1986.

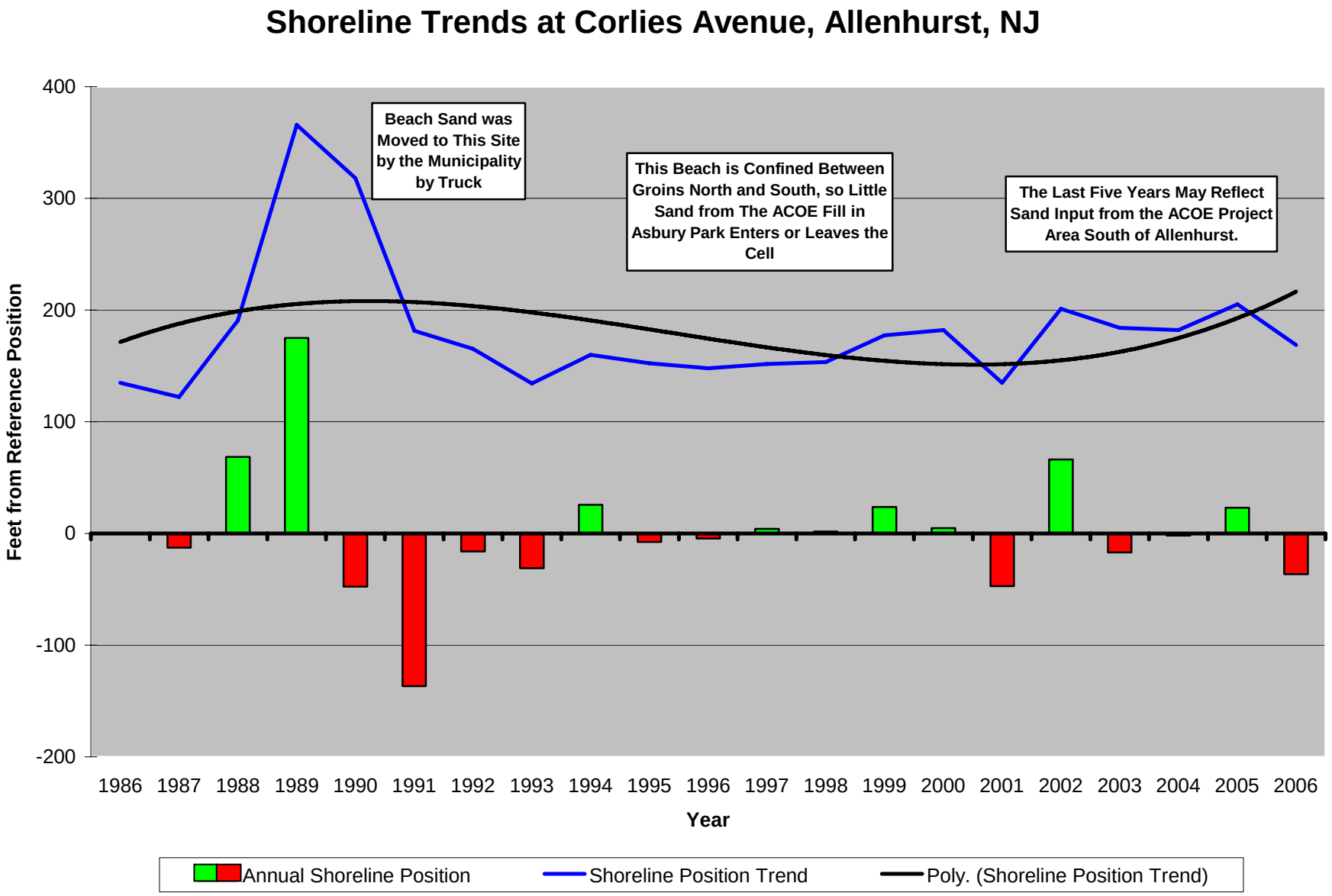


Figure 47 – Site 168. Positioned less than a mile north of Asbury Park where the ACOE project commenced south to the Manasquan Inlet, this Allenhurst site also shows a post-construction positive trend in shoreline position since 2000. The big spike in 1989 was due to the

municipality trucking in 180,000 cubic yards of sand placed directly onto this locally important recreational beach. The shoreline advanced almost 200 feet seaward, and then proceeded to retreat until 1993 where it stabilized. The net 50-foot increase seaward in shoreline position from this small project suffered a partial retreat in 2006. By 2006 the beach width was slightly wider but the elevation was higher providing more recreational area above the shoreline position as seen in the photos below.

20-Year Comparison Photographs – Site 168, Corlies Avenue, Allenhurst

The Allenhurst beach is entirely protected by an aging concrete wall at the edge of the bluff. Sand slowly appears to have migrated north around the Deal Lake groin and the flume exit that formed the northern boundary of Asbury Park. The tiny 2-block oceanfront shoreline of Loch Arbor separates Asbury Park from Allenhurst. The comparison cross section below shows that the beach, and especially the offshore region have gained substantially over the past 20 years, probably related to sand loss moving to the north from the southern segment of the ACOE project that ended in nearby Asbury Park. This site is poised to see substantial shoreline advances when this offshore sand eventually moves onshore. The pictures above show the contrast between 1991(left) and 2006(right).

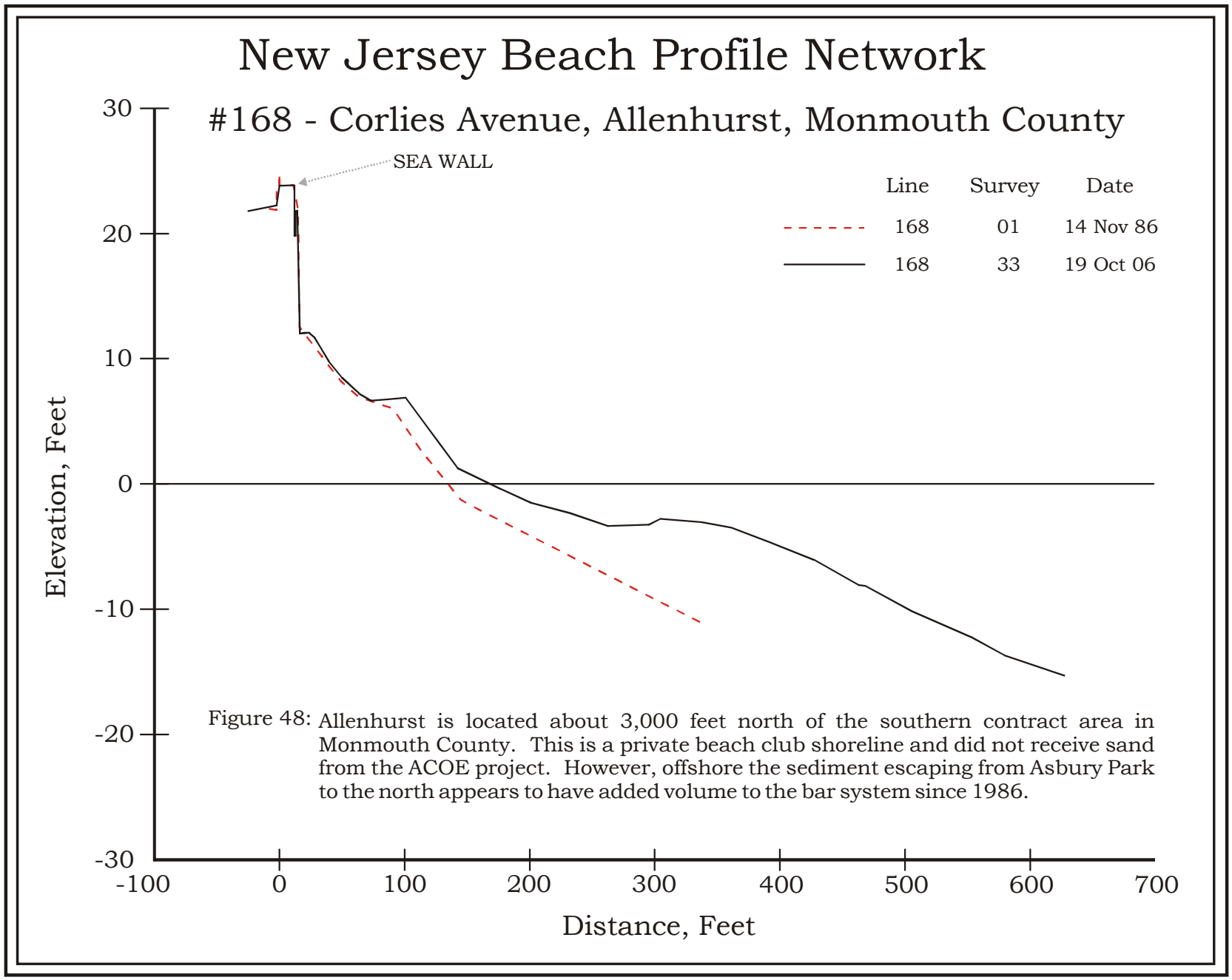


Figure 48: Allenhurst is located about 3,000 feet north of the southern contract area in Monmouth County. This is a private beach club shoreline and did not receive sand from the ACOE project. However, offshore the sediment escaping from Asbury Park to the north appears to have added volume to the bar system since 1986.

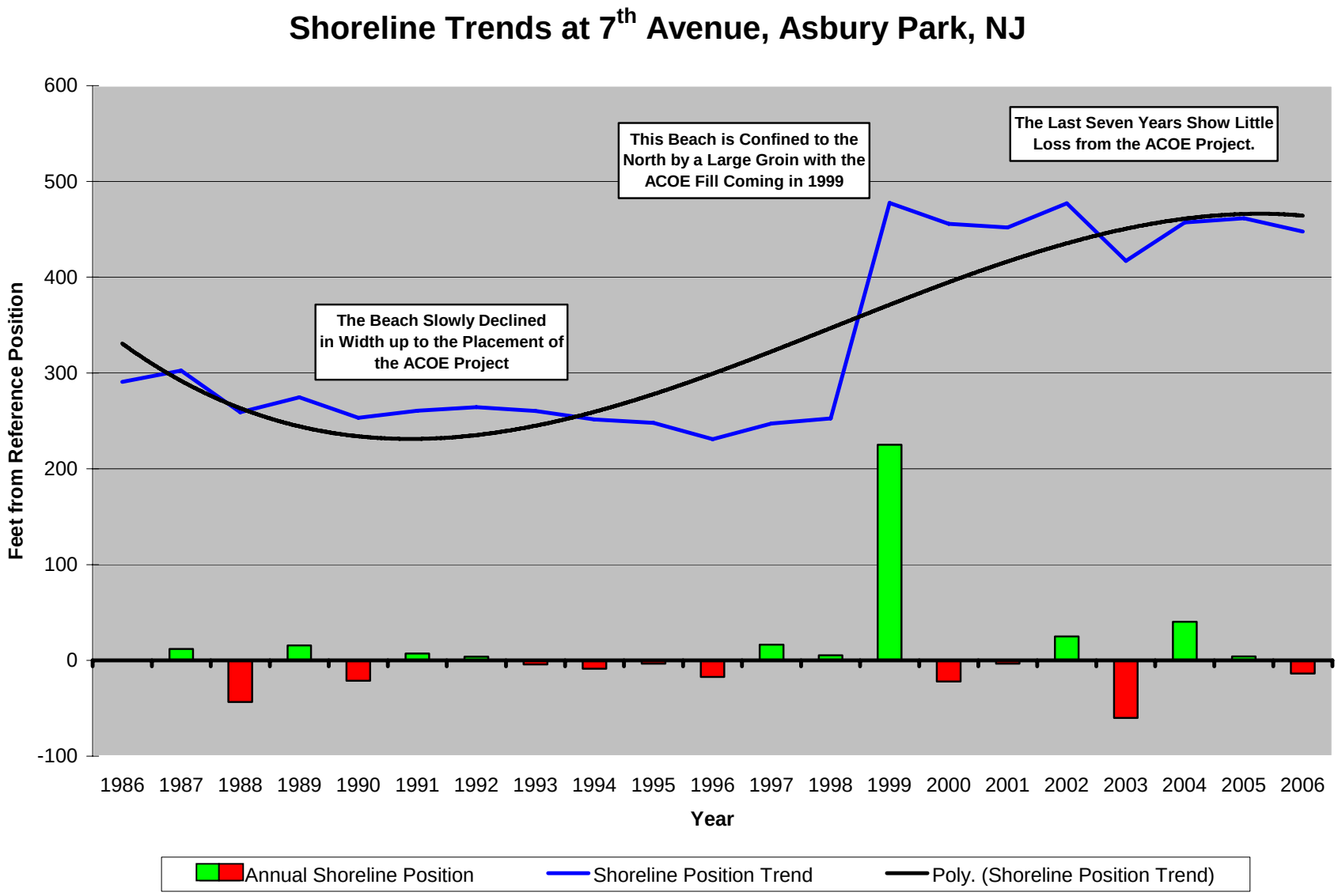


Figure 49 – Site 267. Located two blocks from Deal Lake in Asbury Park, the effects of the 1999 ACOE shore protection project are clear. In spite of the gains seen in Allenhurst offshore, the sand volume as shown by the shoreline position has remained fairly constant since 1999. No new sand has been added here since 1999.

20-Year Comparison Photographs – Site 267, 7th Avenue, Asbury Park

The ACOE project completed in 1999 delivered about 225 cubic yard of sand for each foot of ocean frontage. There were no dunes built due to intense recreational use, but sand was excavated from under the boardwalk in 2006 to prevent decay of the supporting structure (right photograph). The boardwalk was reduced in width after being damaged during storm events prior to the ACOE project that produced the wider beaches seen in 2006. The left photograph depicts the conditions of the beach in 1994.

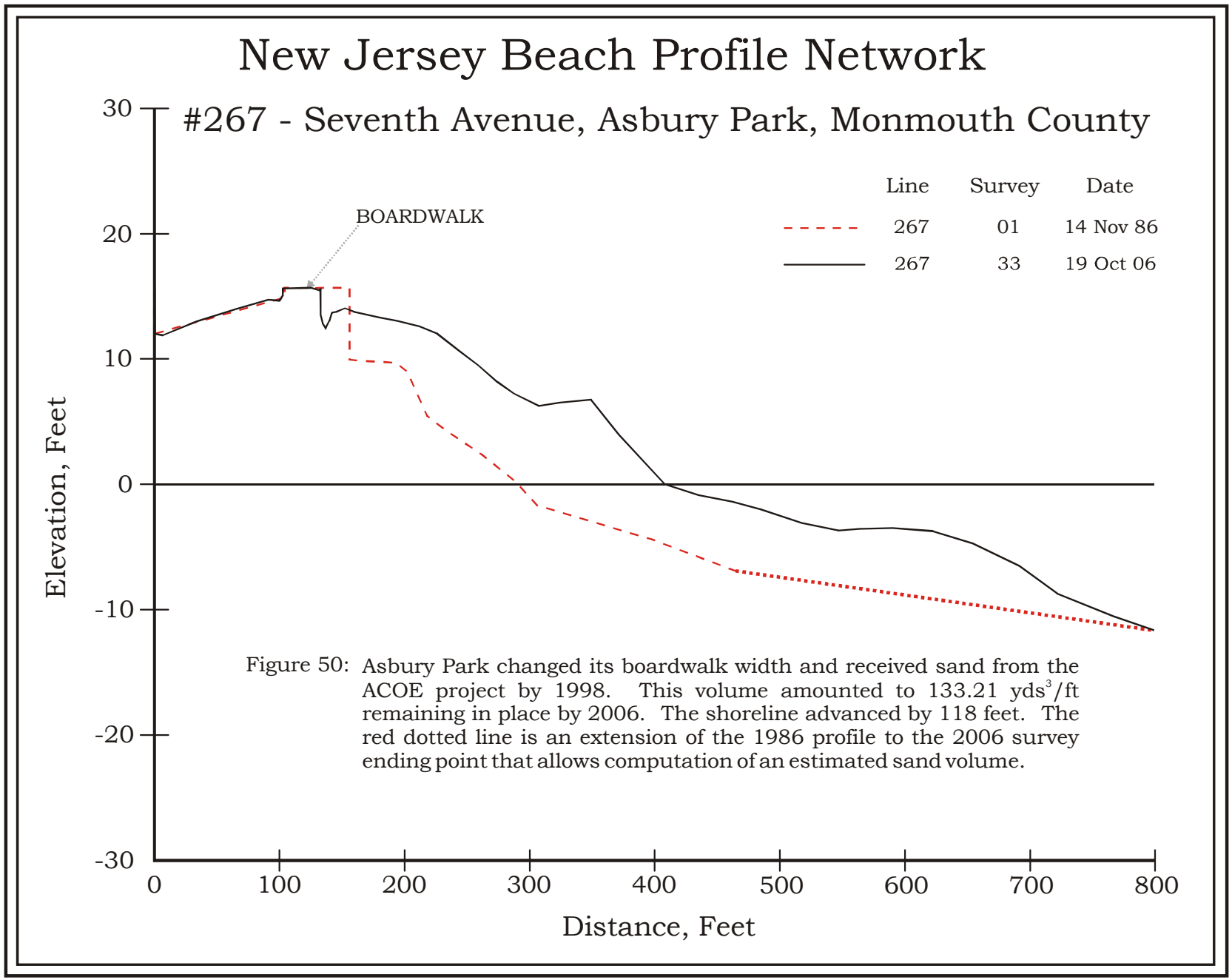


Figure 50: Asbury Park changed its boardwalk width and received sand from the ACOE project by 1998. This volume amounted to 133.21 yds^3/ft remaining in place by 2006. The shoreline advanced by 118 feet. The red dotted line is an extension of the 1986 profile to the 2006 survey ending point that allows computation of an estimated sand volume.

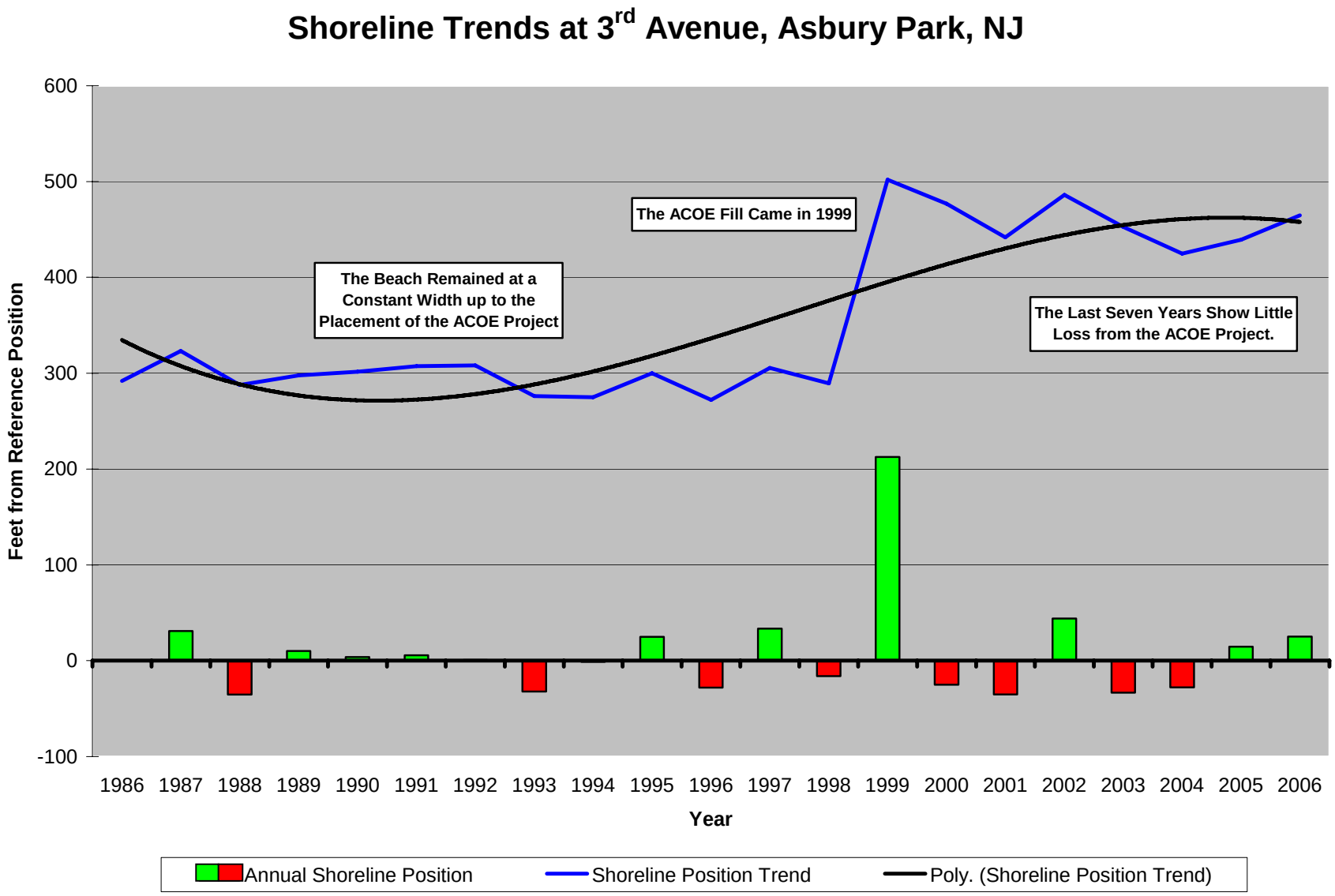


Figure 51 – Site 167. This profile is centrally located in Asbury Park, remained stable between 1986 and 1999. The 200-foot increase in shoreline width due to the fill has remained in place with only a 40-foot retreat in seven years. By 2006 the sand volume increase for the study period was 142.35 yds^3/ft.

20-Year Comparison Photographs – Site 167, 3rd Avenue, Asbury Park
The ACOE project increased the shoreline width by 134 feet in 1999. The post–construction sand volume has remained nearly at the project levels since completion, modest variations occurred in the shoreline position but the net changes were minimal. The beach has traditional experienced intense recreational use with blankets spread across nearly every square foot in the summer. Wind transport has packed sand under the boardwalk prompting the City to start removing it but no effort to establish a dune system is evident. The pictures above show the contrast between 1991(left) and 2006(right).

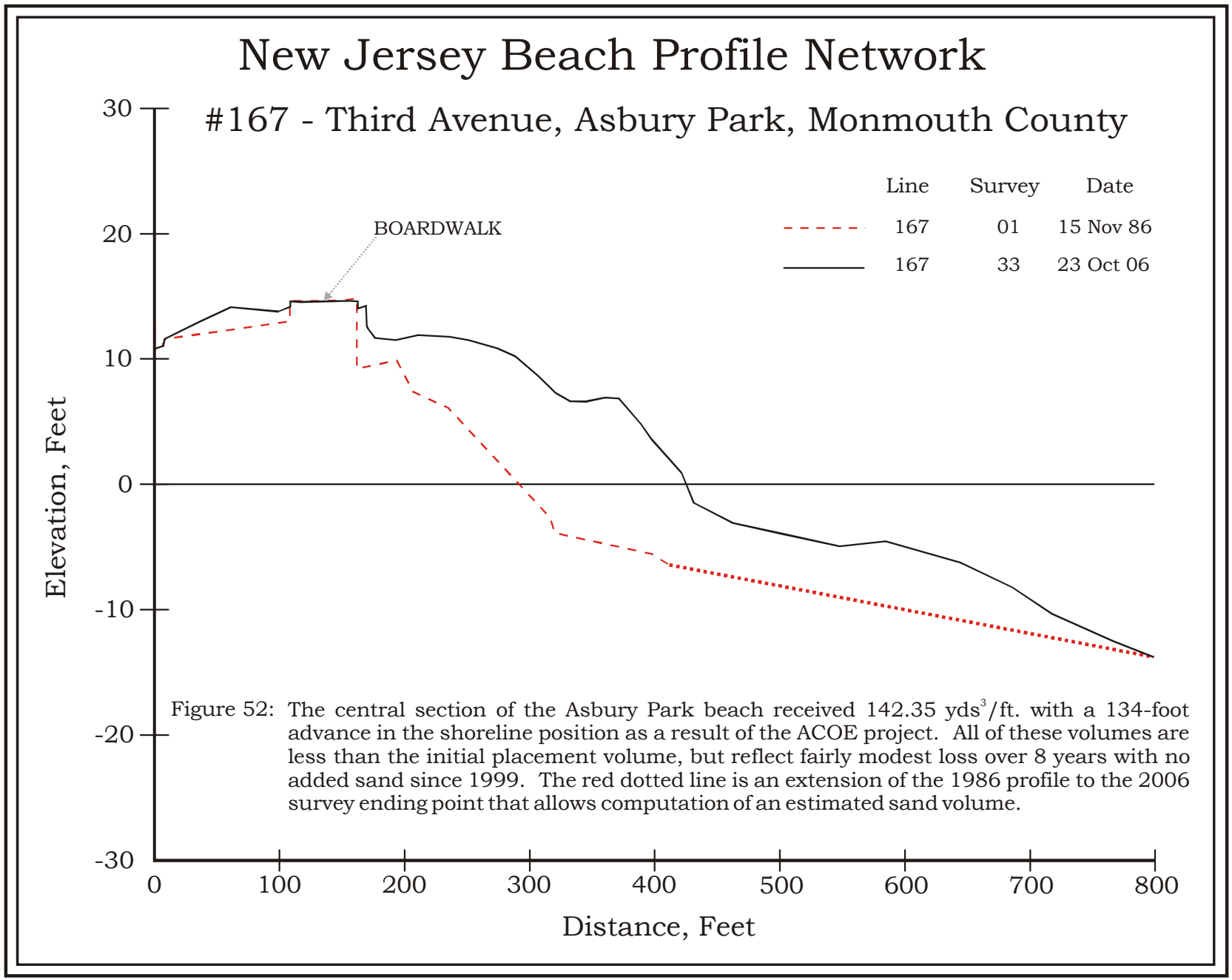


Figure 52: The central section of the Asbury Park beach received 142.35 yds^3/ft. with a 134-foot advance in the shoreline position as a result of the ACOE project. All of these volumes are less than the initial placement volume, but reflect fairly modest loss over 8 years with no added sand since 1999. The red dotted line is an extension of the 1986 profile to the 2006 survey ending point that allows computation of an estimated sand volume.

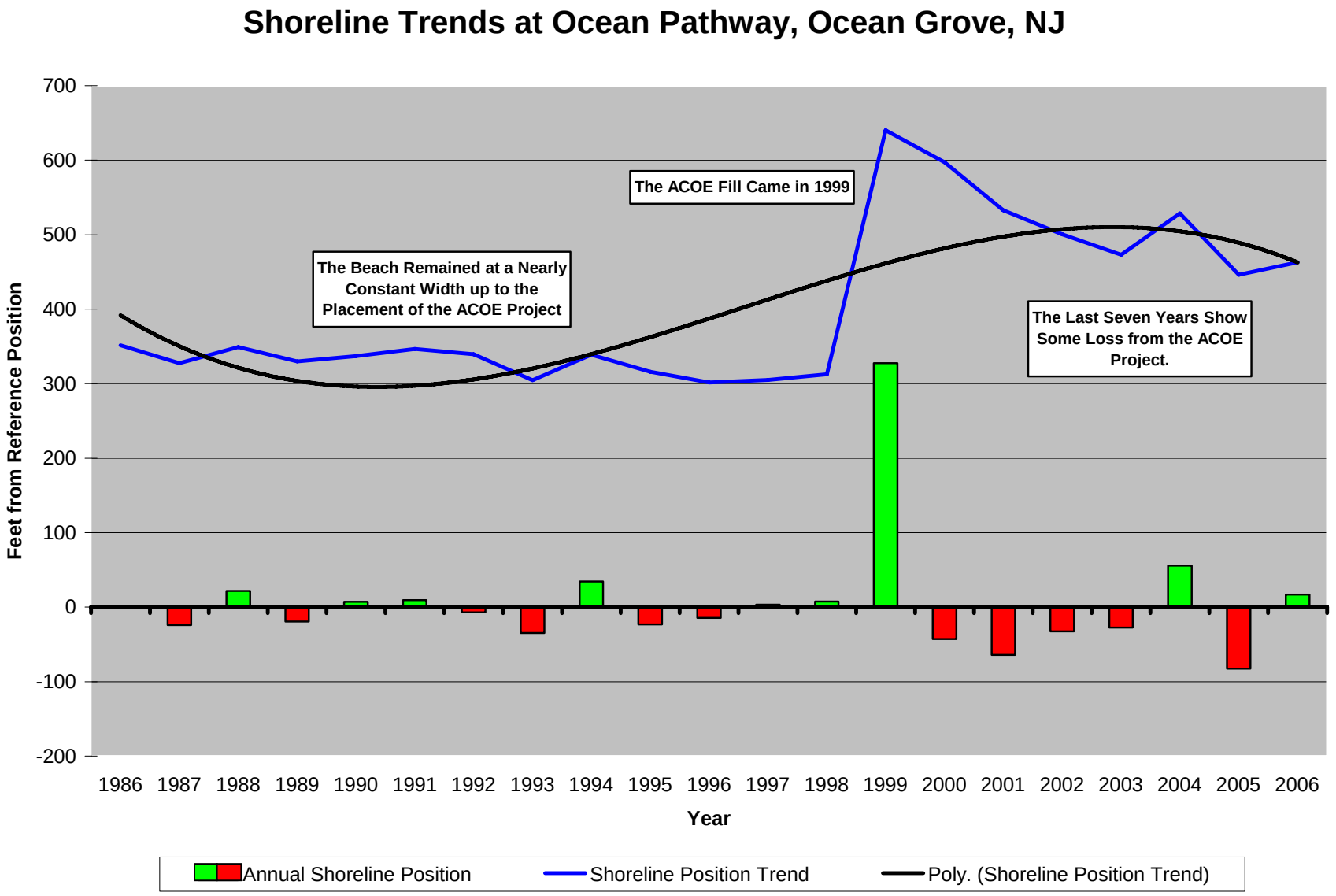


Figure 53 – Site 166. The extended period of slow shoreline retreat ended in 1999 with a better than 300-foot advance in the position with the fill project construction. Retreat occurred in 5 of the next 7 years to generate approximately 50% retreat in the 300-foot advance. The net change at this site since 1986 was an advance of 120 feet.


20-Year Comparison Photographs – Site 166, Ocean Pathway, Ocean Grove
The Ocean Grove site bisects the Pilgrim Pathway pavilion seaward of the boardwalk. The beach was fenced initially and planted, but never deliberately maintained for dune growth, so vegetation is somewhat random and in a naturally seeded state on the beach. There was a dry beach here in 1986, but with a far narrower width. Above is the comparison photographs between 1988(left) and 2006(right).

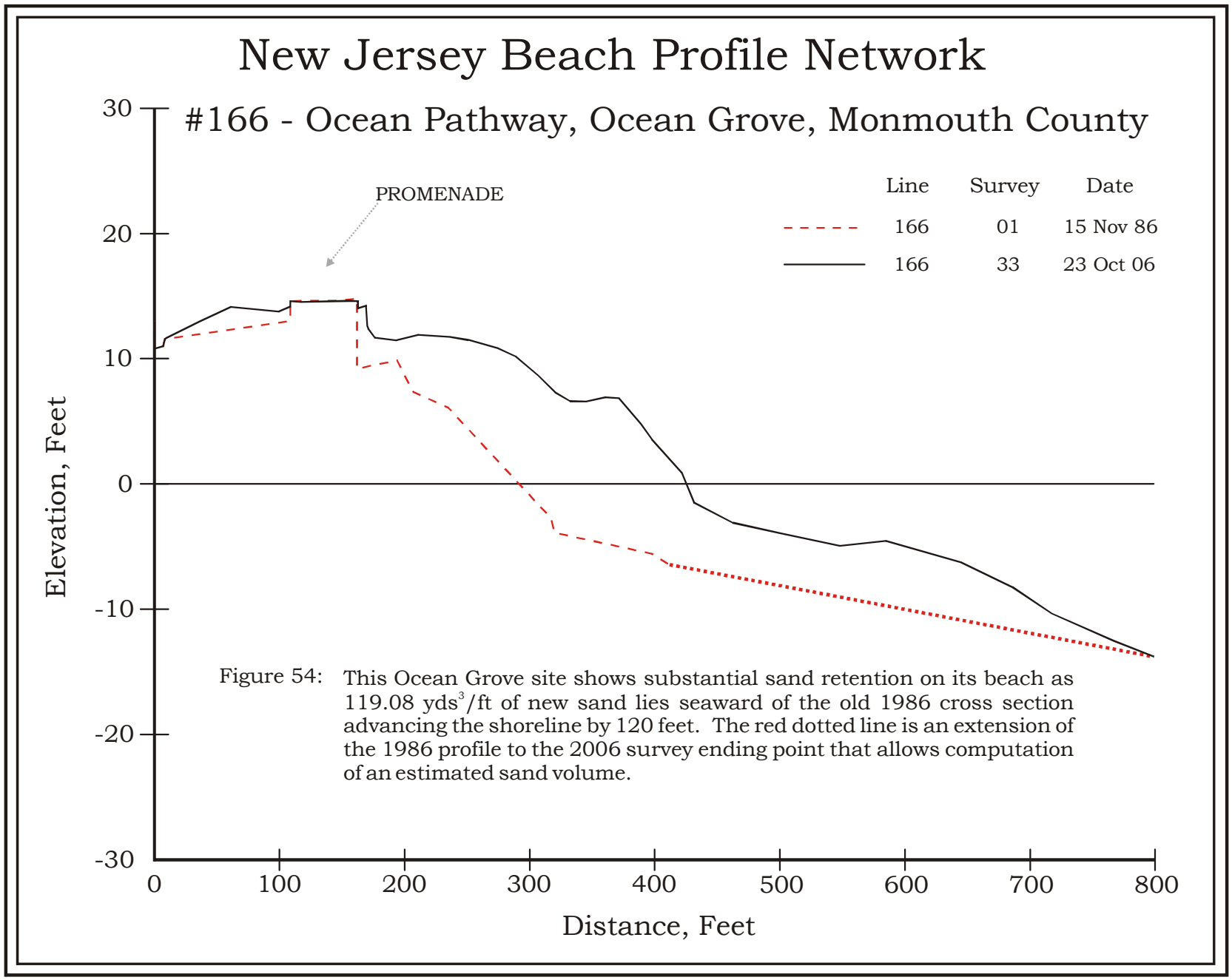


Figure 54: This Ocean Grove site shows substantial sand retention on its beach as 119.08 yds^3/ft of new sand lies seaward of the old 1986 cross section advancing the shoreline by 120 feet. The red dotted line is an extension of the 1986 profile to the 2006 survey ending point that allows computation of an estimated sand volume.

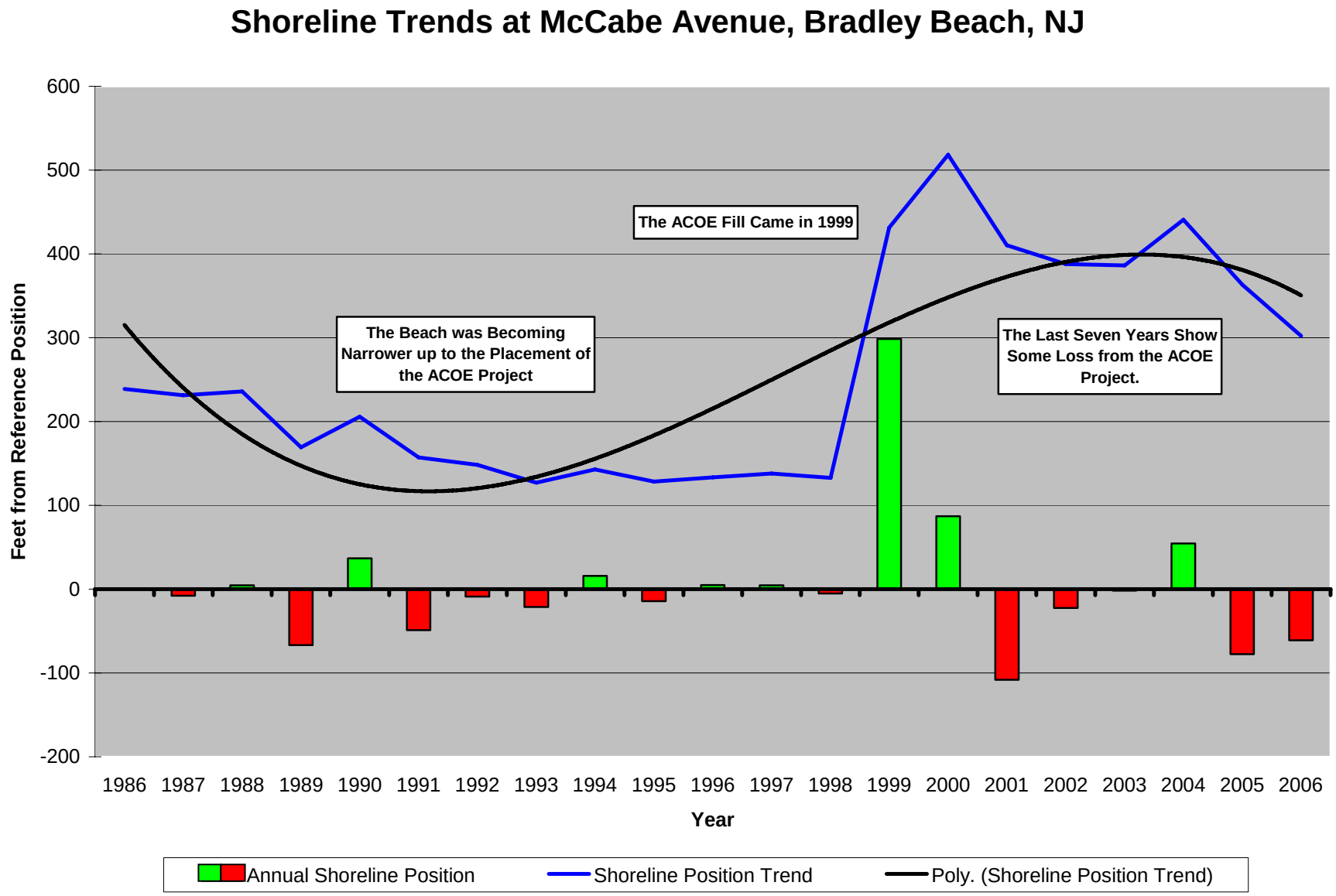


Figure 55 – Sit e165. The rate of shoreline retreat was greater in Bradley Beach than in Ocean Grove prior to the ACOE project. The 1992 storm forced the municipality to pull the boardwalk completely off the beach and move it onto the top edge of the bluff. This provided an

additional 40 feet of badly needed recreational beach area following the storm. The beachfill in 1999 added significant width to the beach and was followed by a further shoreline advances in 2000 with retreat in 4 of the 7 years since.

20-Year Comparison Photographs – Site 165, McCabe Avenue, Bradley Beach
The new promenade position is landward of the bulkhead that protects the bluff from erosion. The community keeps a 20-foot path clear of dune sand for emergency and maintenance access to the beach. The community has taken a more active role in maintaining the dunes, fencing the seaward toe and producing a meaningful barrier to storm onslaught. The photographs above contrast 1988 (left) and 2006 (right).

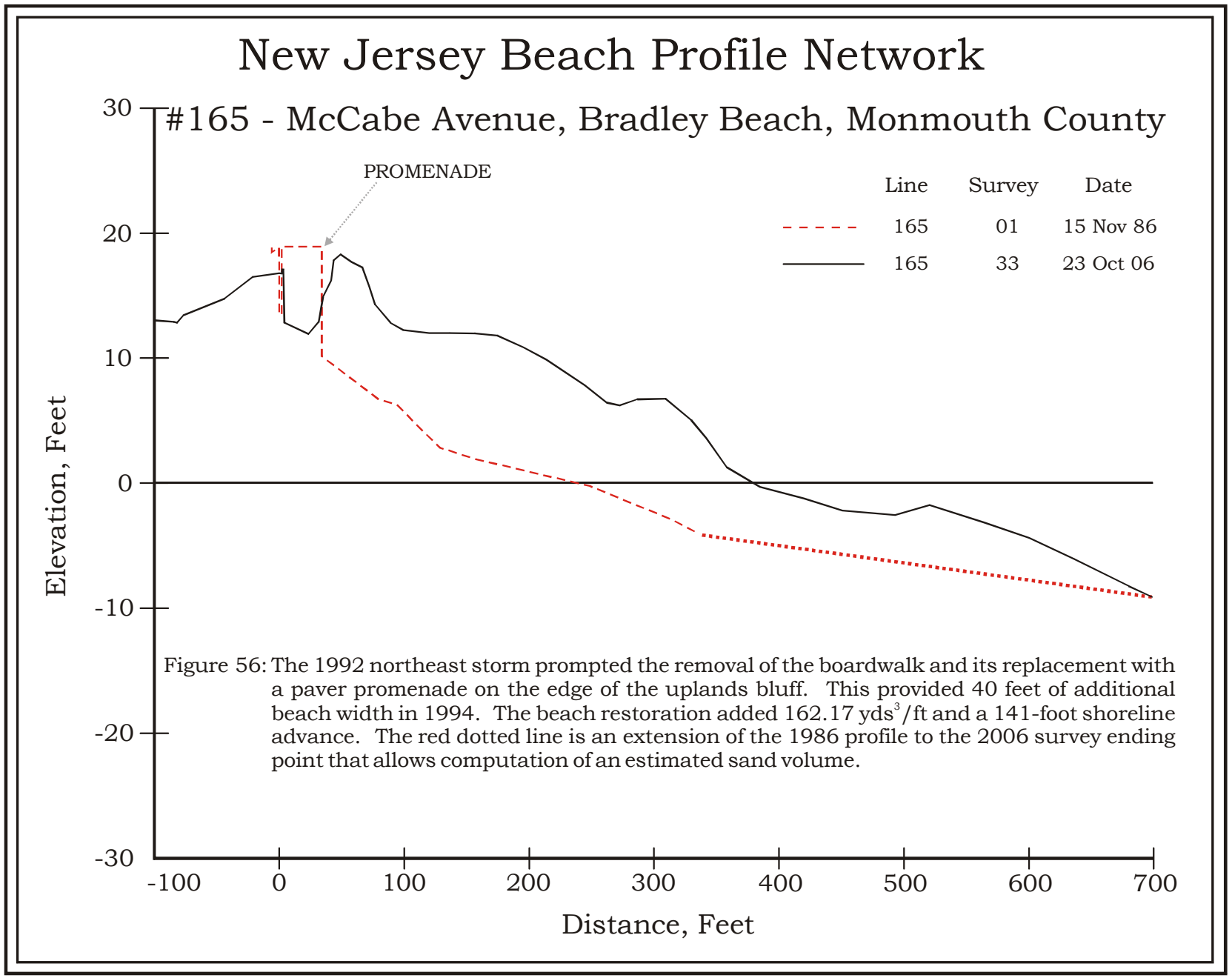


Figure 56: The 1992 northeast storm prompted the removal of the boardwalk and its replacement with a paver promenade on the edge of the uplands bluff. This provided 40 feet of additional beach width in 1994. The beach restoration added 162.17 yds^3/ft and a 141-foot shoreline advance. The red dotted line is an extension of the 1986 profile to the 2006 survey ending point that allows computation of an estimated sand volume.

Shoreline Trends at Sylvania Avenue, Avon-by-the-Sea, NJ

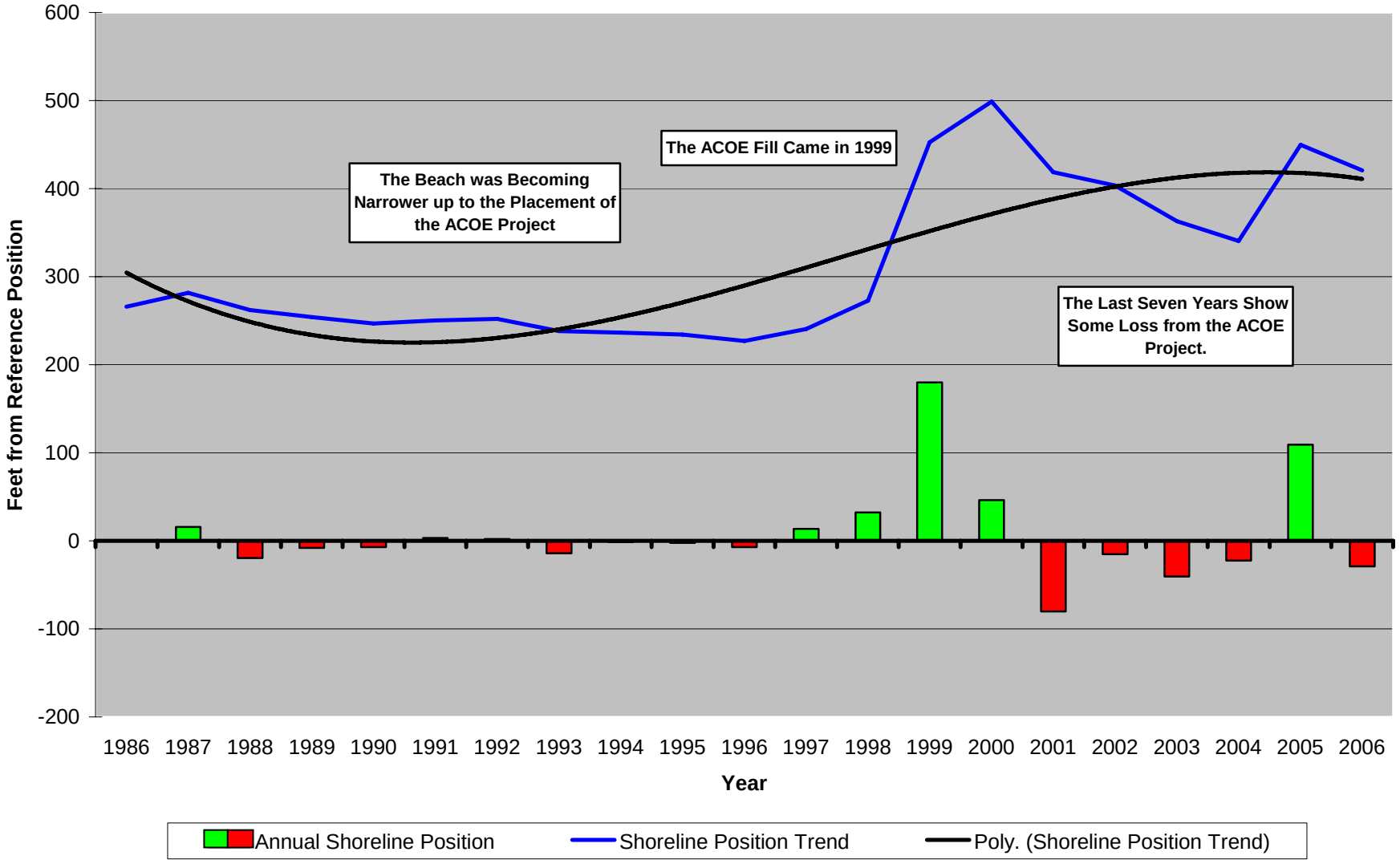


Figure 57 – Site 164. Between 1986 and 1996 the shoreline was slowly retreating as sand left the Avon beachfront. This trend reversed in 1997 for two years prior to the ACOE project was completed in 1999. Sand continued to accumulate advancing the shoreline another 40 feet by 2000. The next 6 years saw one significant advance in 2005 and 5 years with minor retreat.

20-Year Comparison Photographs – Site 164, Sylvania Avenue, Avon-by-the-Sea

The Avon beaches are extensively used for summer recreation; therefore no dune system was created. The municipality does install a sand fence each winter to reduce the wind transport landward onto Ocean Avenue or the boardwalk. The net shoreline position advanced 123 feet seaward between 1986 and 2006 largely due to the ACOE project. An older bulkhead landward of the boardwalk protects Ocean Avenue and oceanfront properties.

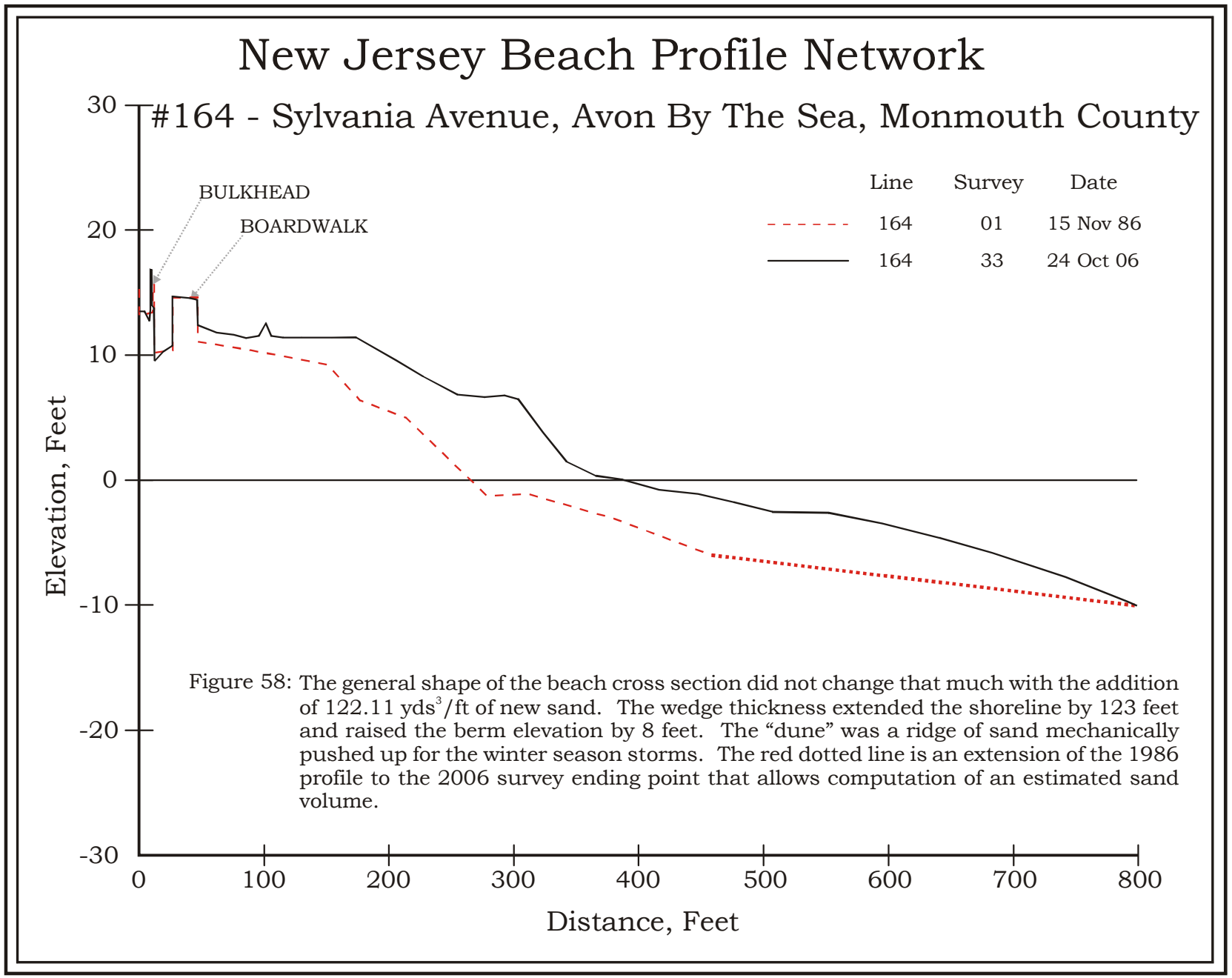


Figure 58: The general shape of the beach cross section did not change that much with the addition of 122.11 yds^3/ft of new sand. The wedge thickness extended the shoreline by 123 feet and raised the berm elevation by 8 feet. The "dune" was a ridge of sand mechanically pushed up for the winter season storms. The red dotted line is an extension of the 1986 profile to the 2006 survey ending point that allows computation of an estimated sand volume.

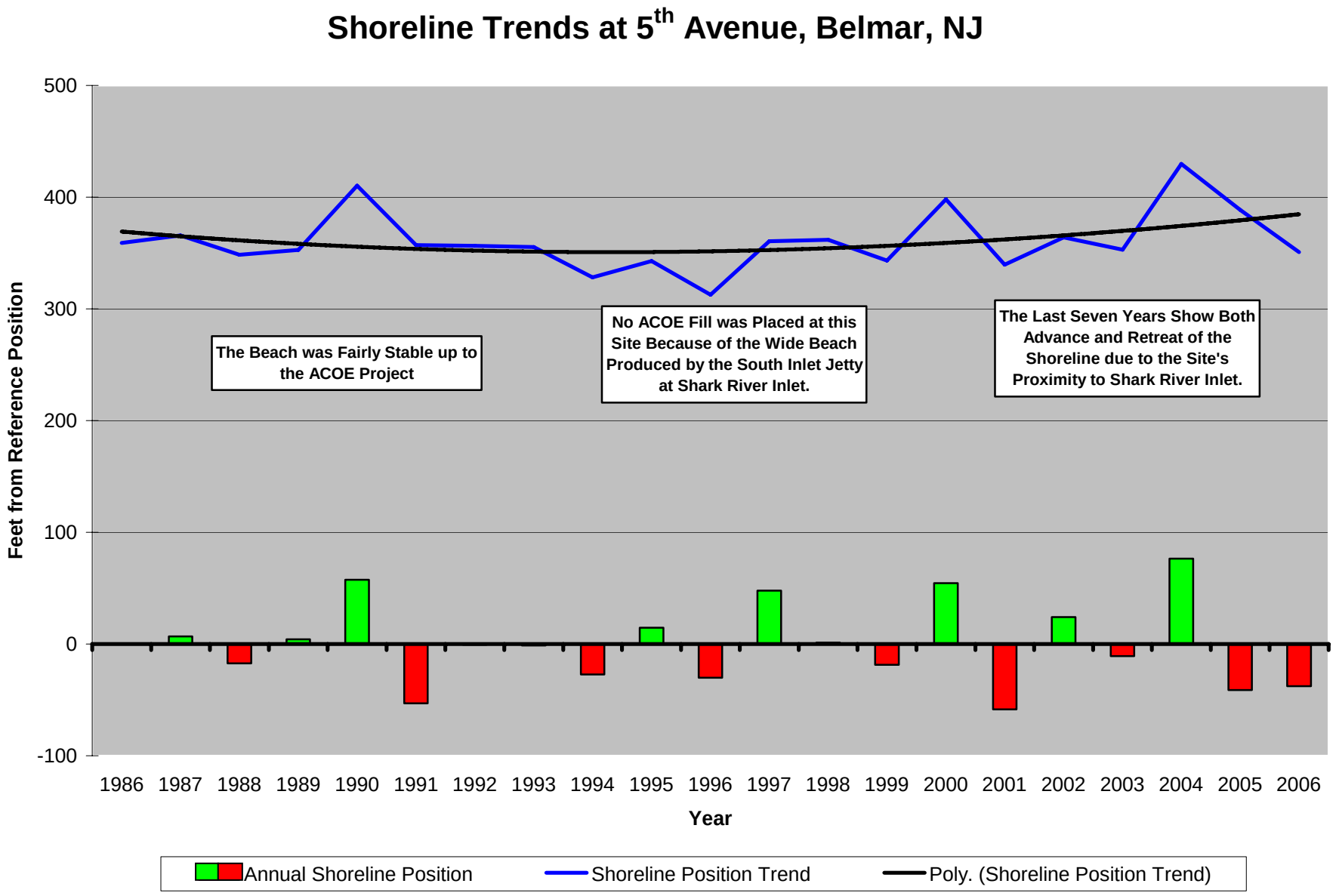

Shoreline Trends at 5th Avenue, Belmar, NJ
Feet from Reference Position
500
400
300
200
100
0
-100
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
Year
The Beach was Fairly Stable up to the ACOE Project
No ACOE Fill was Placed at this Site Because of the Wide Beach Produced by the South Inlet Jetty at Shark River Inlet.
The Last Seven Years Show Both Advance and Retreat of the Shoreline due to the Site's Proximity to Shark River Inlet.
Annual Shoreline Position
Shoreline Position Trend
Poly. (Shoreline Position Trend)

Figure 59 – Site 163. Fifth Avenue in Belmar is in proximity to Shark River Inlet. The south inlet jetty has accumulated sand and formed a substantial wide recreational beach for decades and the ACOE project manager determined that no sand would be added to regional beaches in proximity to the jetty. As a result the data on shoreline change reflects significant shifts in the balance of littoral sand transport. In 1990, 1997, 2000, and 2004 the advances recorded were due to dominant littoral sand movement north toward the jetty. In 1991, 2001 and 2005 the dominance favored transport to the south away from the jetty, so the shoreline retreated. The largest advance came in 2004 because there was abundant new sand south of this site to move toward the jetty. Correlation of the data with northeast storms occurs in 1991 (Halloween Storm) and 2001 (El Nino year). In 2004, there were no storms of any significance, so sand moved north producing shoreline advance.

20-Year Comparison Photographs – Site 163, 5th Avenue, Belmar

The 2006 photograph (right) shows the beach and the Belmar fishing pier located just south of the Shark River Inlet south jetty. These structures are barriers to sand transport parallel to the shoreline and largely responsible for the pattern in the shoreline position data shown above. The comparison plot shown below between the beach in 1986 and the survey from 2006 shows the least difference of all the sites in NJ. The shoreline advanced exactly 0.67 feet in 20 years. No significant dune was ever developed along this shoreline due to heavy recreational use. A very small dune has developed adjacent to the seaward side of the boardwalk but is not continuous across beach access stairs over which this profile crosses. A ridge is pushed up each winter as a barrier to wind transported sands.

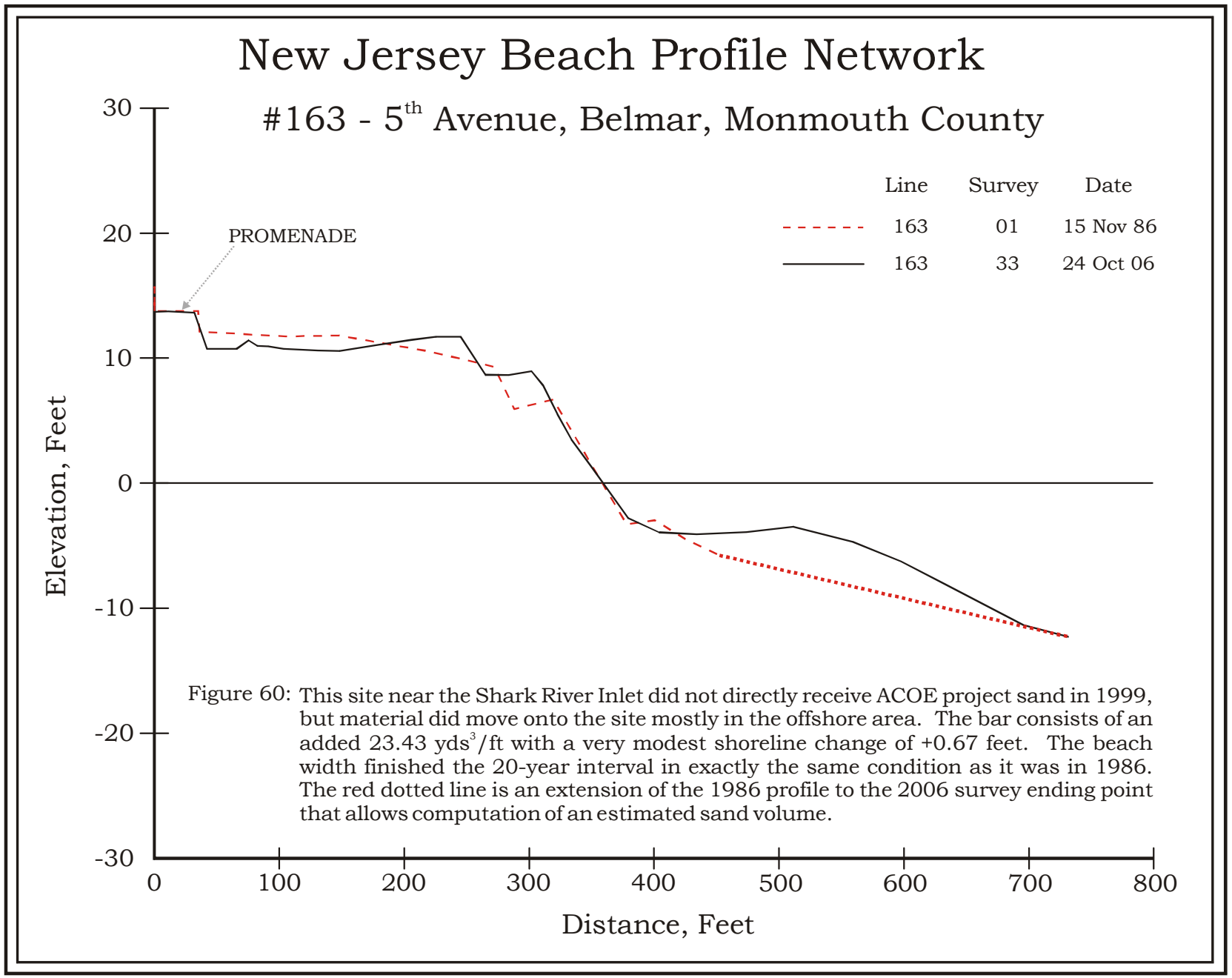


Figure 60: This site near the Shark River Inlet did not directly receive ACOE project sand in 1999, but material did move onto the site mostly in the offshore area. The bar consists of an added 23.43 yds^3/ft with a very modest shoreline change of +0.67 feet. The beach width finished the 20-year interval in exactly the same condition as it was in 1986. The red dotted line is an extension of the 1986 profile to the 2006 survey ending point that allows computation of an estimated sand volume.

Shoreline Trends at 18th Avenue, Belmar, NJ

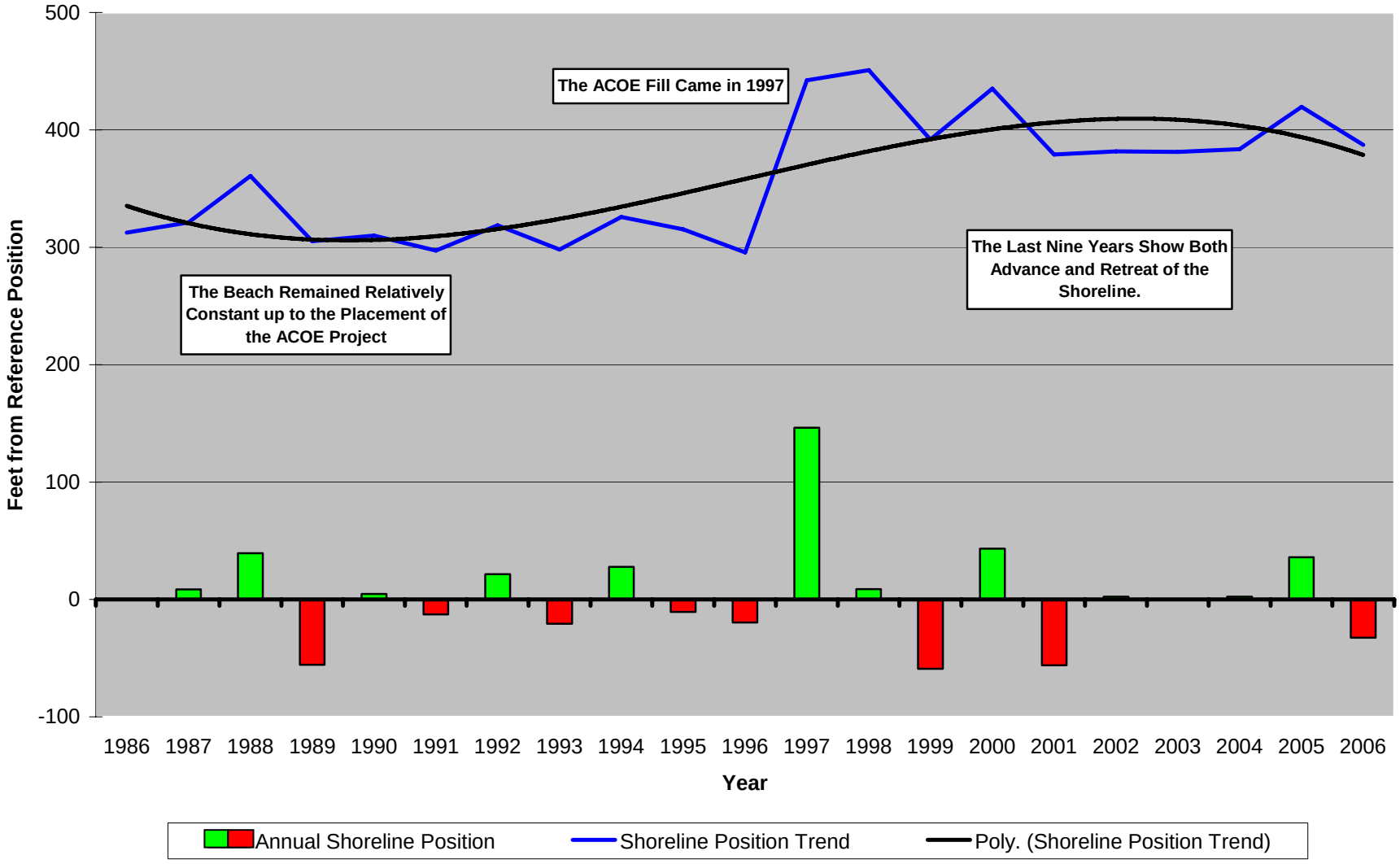


Figure 61 – Site 162. At the 18th Avenue beach, the ACOE project did provide a 150-foot advance to the shoreline position that was followed by small variable periods of retreat and advance over the next 9 years. The net change was modest with a retreat of 63 feet in the shoreline position.

20-Year Comparison Photographs – Site 162, 18th Avenue, Belmar
In 2006 (right photograph), there is a narrow zone of vegetation along the boardwalk separated from the beach with a plastic fence that is better designed to prevent wind transport into Ocean Avenue than it is to trap sand for the dune growth. The snow fence shown in the right photograph was placed to block additional wind transport that would get leveled out in the following spring. The photo on the left depicts the beach conditions at this site in 1989.

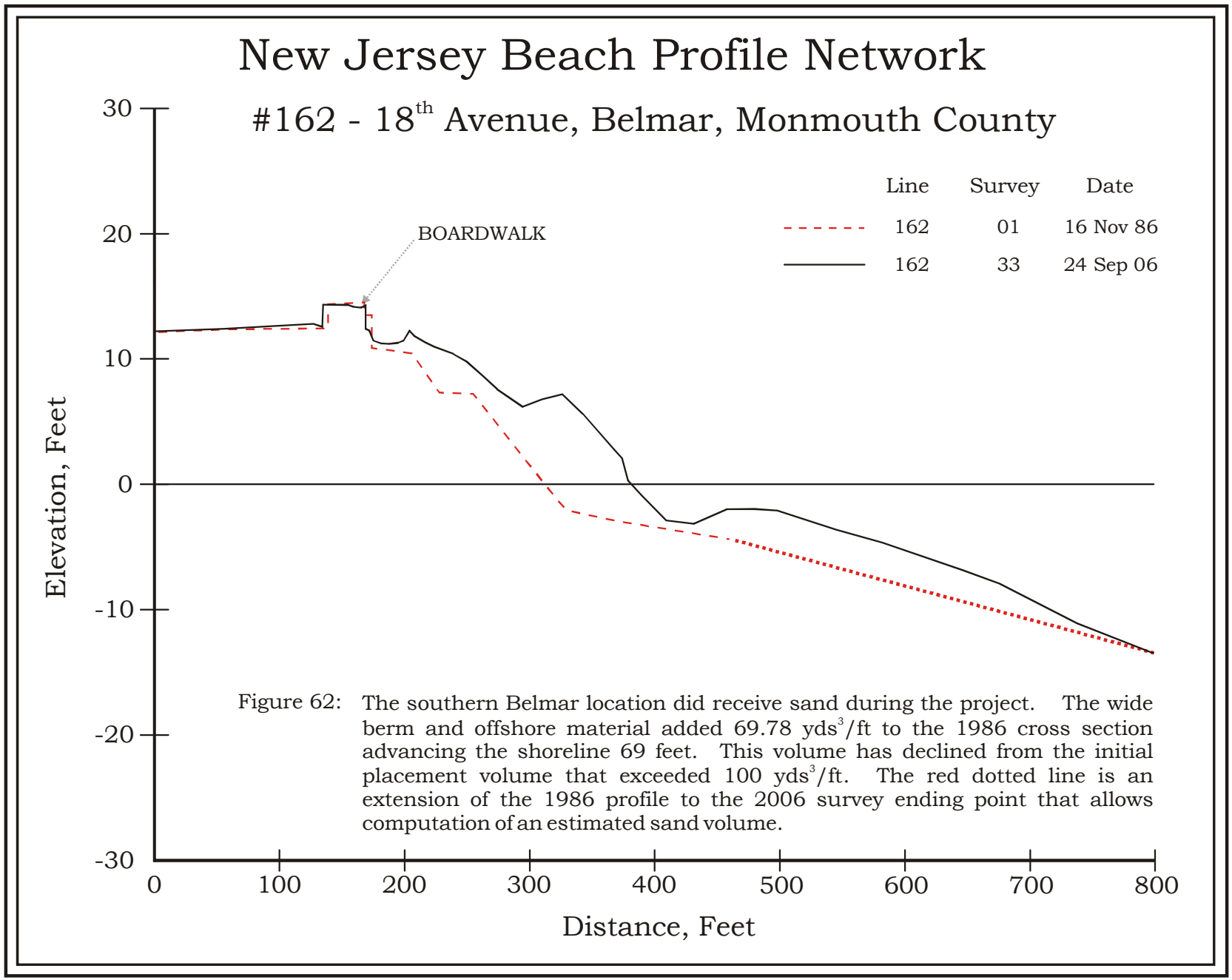


Figure 62: The southern Belmar location did receive sand during the project. The wide berm and offshore material added 69.78 yds^3/ft to the 1986 cross section advancing the shoreline 69 feet. This volume has declined from the initial placement volume that exceeded 100 yds^3/ft. The red dotted line is an extension of the 1986 profile to the 2006 survey ending point that allows computation of an estimated sand volume.

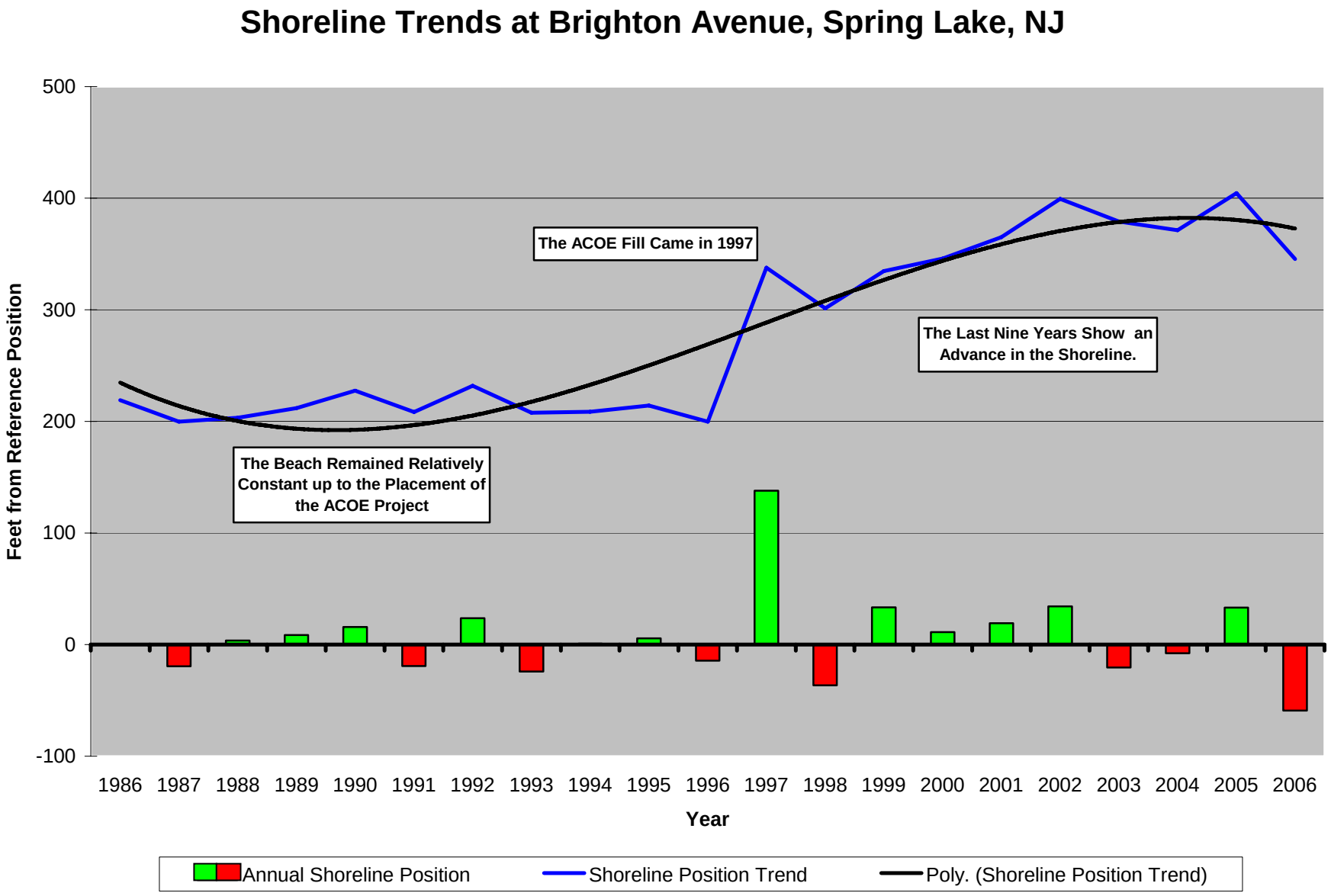
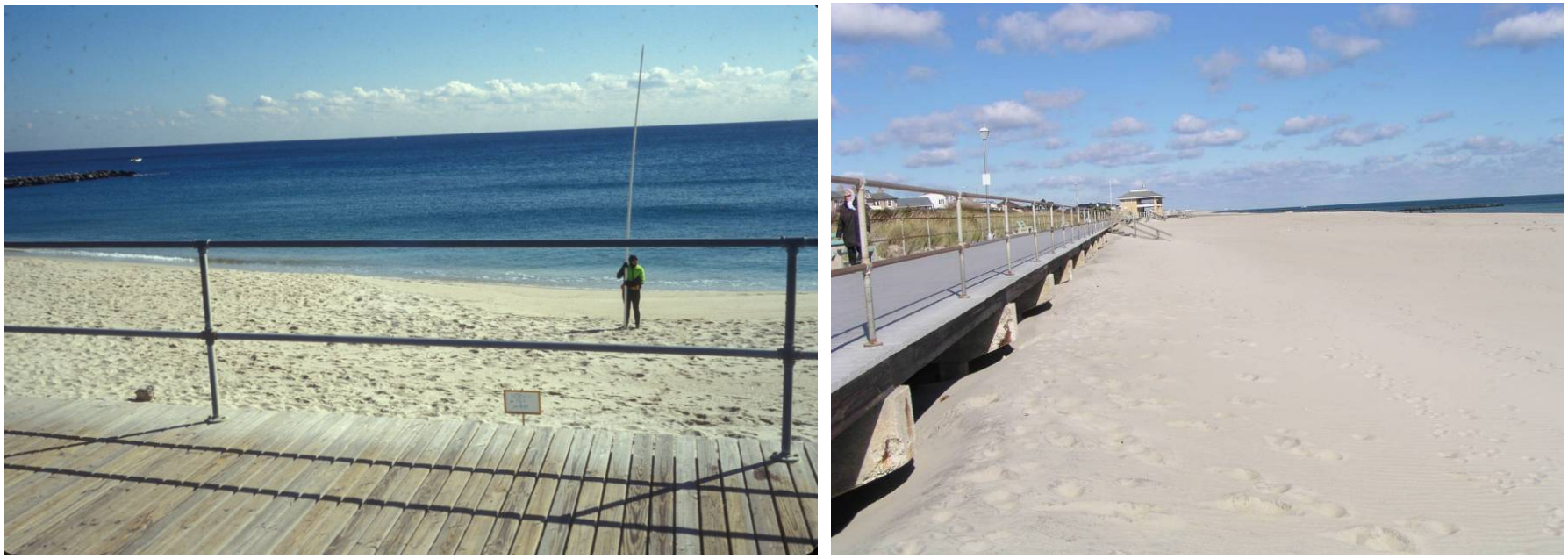


Figure 63 – Site 161. The northern Spring Lake site showed a marked trend toward continued accretion of the beach following the ACOE project in 1997. Over the next 9 years the shoreline advanced an additional 8 feet between 1997 and 2006 with a maximum advance of 63

feet (2005) beyond the “as-built” position. Prior to the project starting, the beach retreated about 20 feet in a decade, so erosion appears to be in check at Brighton Avenue, Spring Lake.



20-Year Comparison Photographs – Site 161, Brighton Avenue, Spring Lake
The boardwalk was built seaward of the dune decades previously. The community has two recreational buildings located at the boardwalk that serve the bathing public. The dunes saw extensive sand gain between the pre-construction toe and the boardwalk on the west side. The berm is much higher and wider than it was in 1996. The photographs above show the contrast between 1989 (left) and 2006 (right).

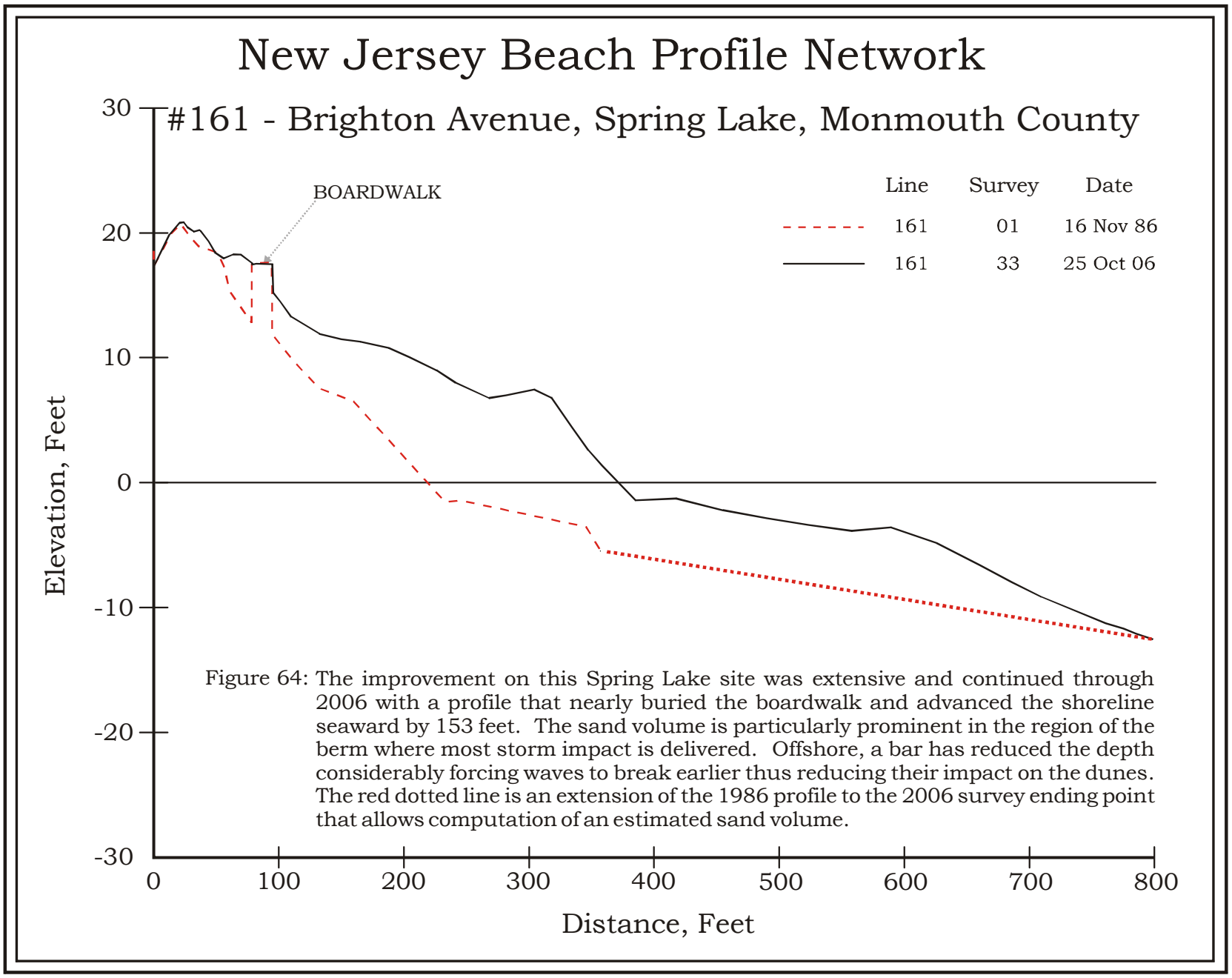


Figure 64: The improvement on this Spring Lake site was extensive and continued through 2006 with a profile that nearly buried the boardwalk and advanced the shoreline seaward by 153 feet. The sand volume is particularly prominent in the region of the berm where most storm impact is delivered. Offshore, a bar has reduced the depth considerably forcing waves to break earlier thus reducing their impact on the dunes. The red dotted line is an extension of the 1986 profile to the 2006 survey ending point that allows computation of an estimated sand volume.

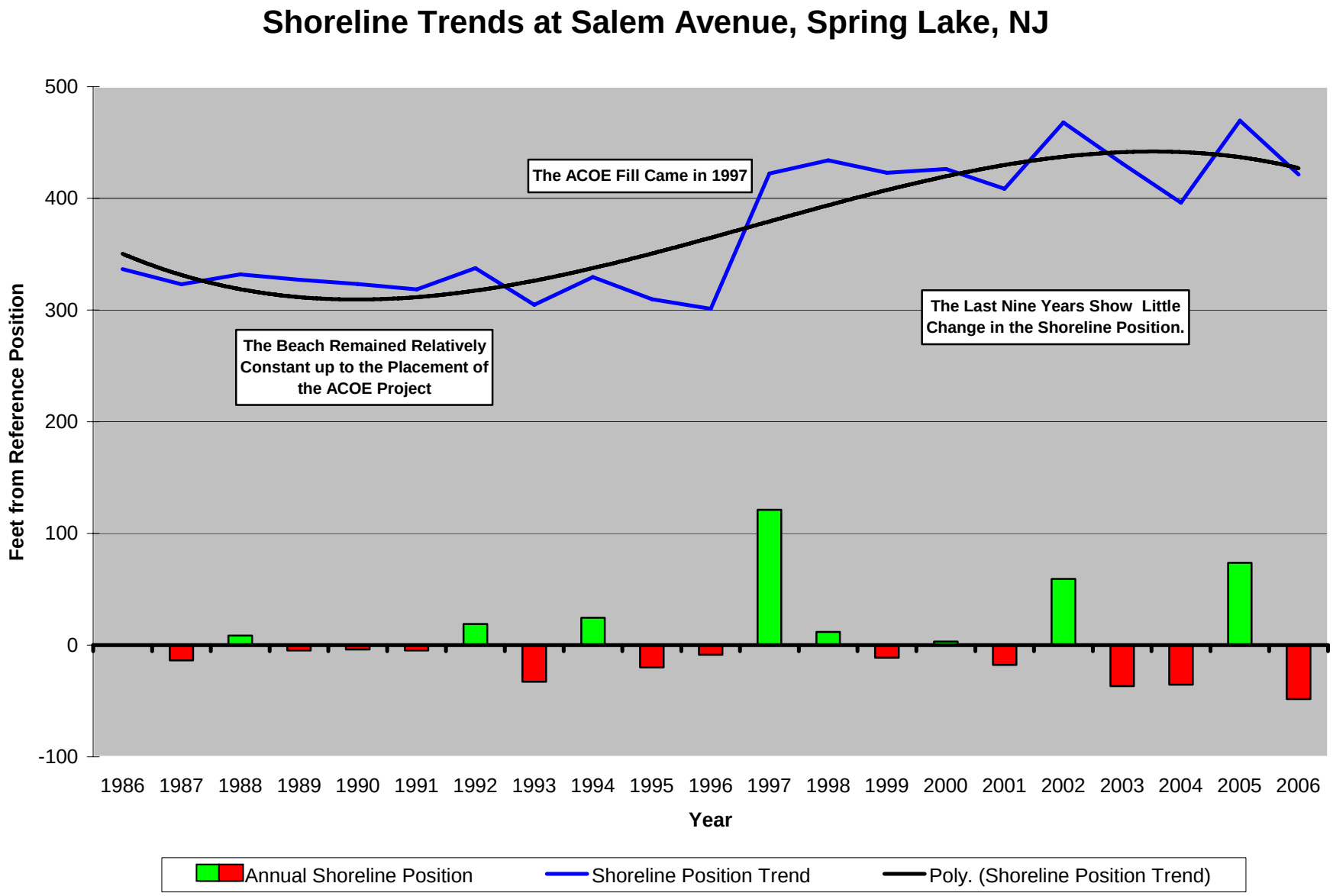


Figure 65 – Site 160. The Salem Avenue site demonstrated a very slow retreat in the shoreline between 1986 and 1996. The ACOE project produced a 120-foot advance that remained nearly constant until 2001 when a series of larger swings caused larger changes in the zero

elevation shoreline position. The 2006 retreat restored the shoreline position back to the conditions following construction of the beach for nearly a net zero change in 9 years. The shoreline has remained at or beyond the 1997 “as-built” position for 9 years.

20-Year Comparison Photographs – Site 160, Salem Avenue, Spring Lake
This view to the north from the base of the Spring Lake boardwalk shows the southern beach recreational structure built years ago and the wide berm still present nine years following the ACOE project finish. The dune system grew substantially in height and width since the project. The crest elevation was raised by 2 feet and the low area between the dune and the boardwalk filled in along with a wider beach and shallower bar system offshore. The area is heavily used for recreational use in the summer.

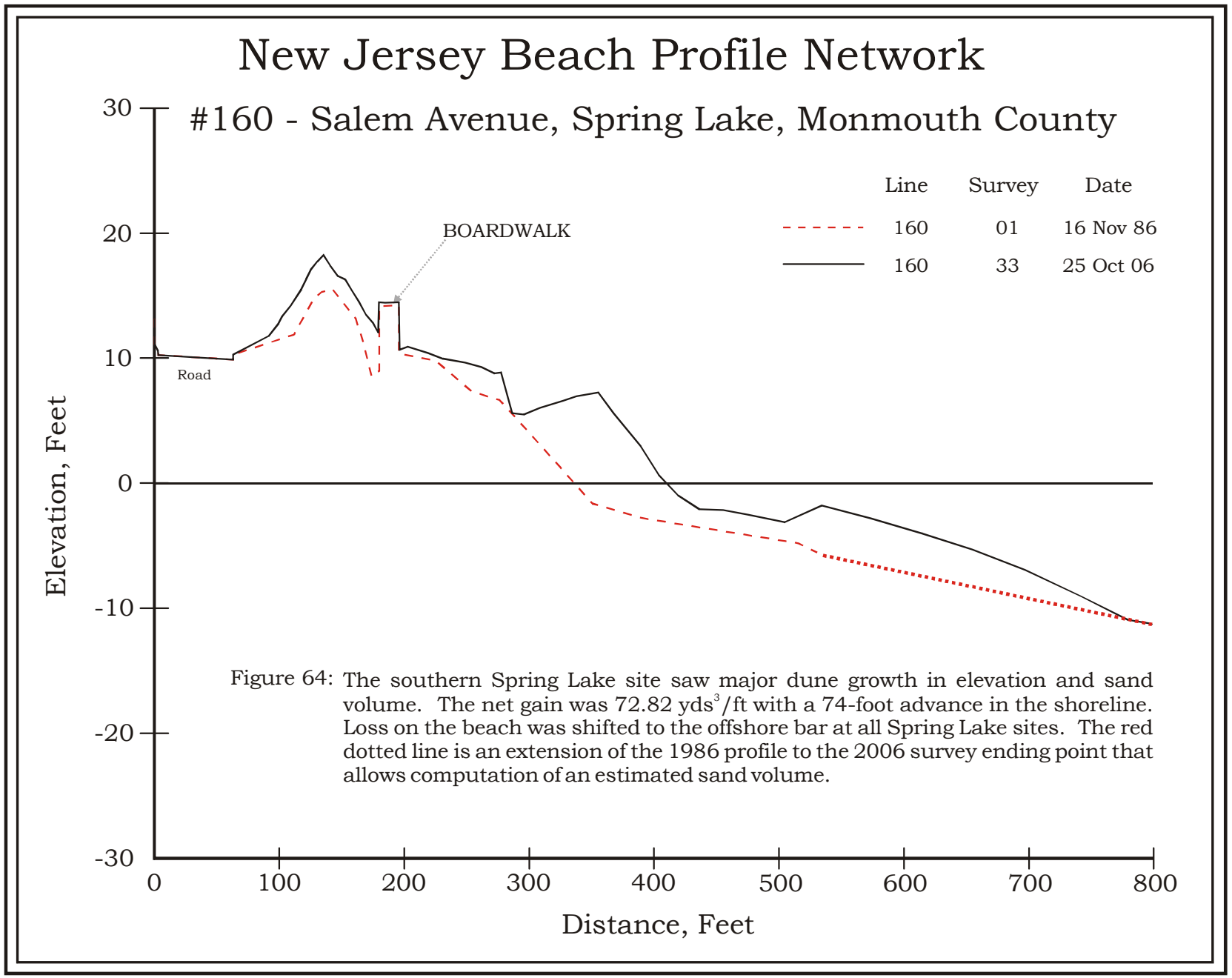


Figure 64: The southern Spring Lake site saw major dune growth in elevation and sand volume. The net gain was 72.82 yds^3/ft with a 74-foot advance in the shoreline. Loss on the beach was shifted to the offshore bar at all Spring Lake sites. The red dotted line is an extension of the 1986 profile to the 2006 survey ending point that allows computation of an estimated sand volume.

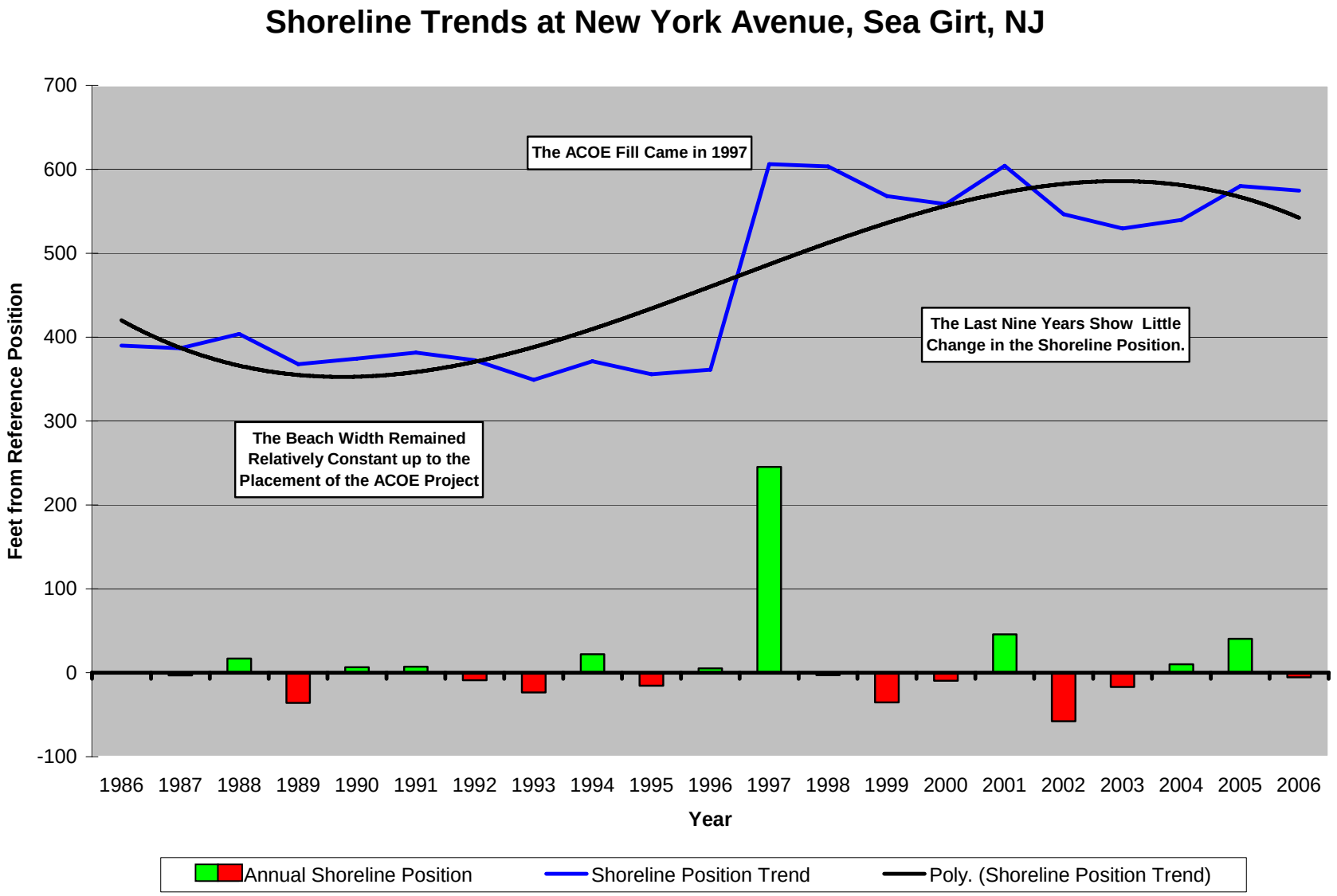


Figure 65 – Site 159. The 1997 fill produced over a 200-foot advance in the shoreline that has remained relatively stable for the last 9 years. The 2006 position is only 30 feet landward of the "as-built" location. The shoreline pattern fluctuated with 3 advances and 6 retreats post-construction, with relatively modest variations in width leaving the beach in excellent condition.

20-Year Comparison Photographs – Site 159, New York Avenue, Sea Girt

The heavy recreational use precluded developing a dune on this beach. To the south, ridges of sand were pushed up to block storm waves and reduce sand transport onto and across into Ocean Avenue. The Borough of Sea Girt is considering developing a dune system, but disagreements with the NJDEP have slowed their progress. The cross section shows a large wedge of sand on the berm as contrasted to the beach width and slope present in 1986. The photographs above show the contrast between 1991 (left) and 2006 (right).

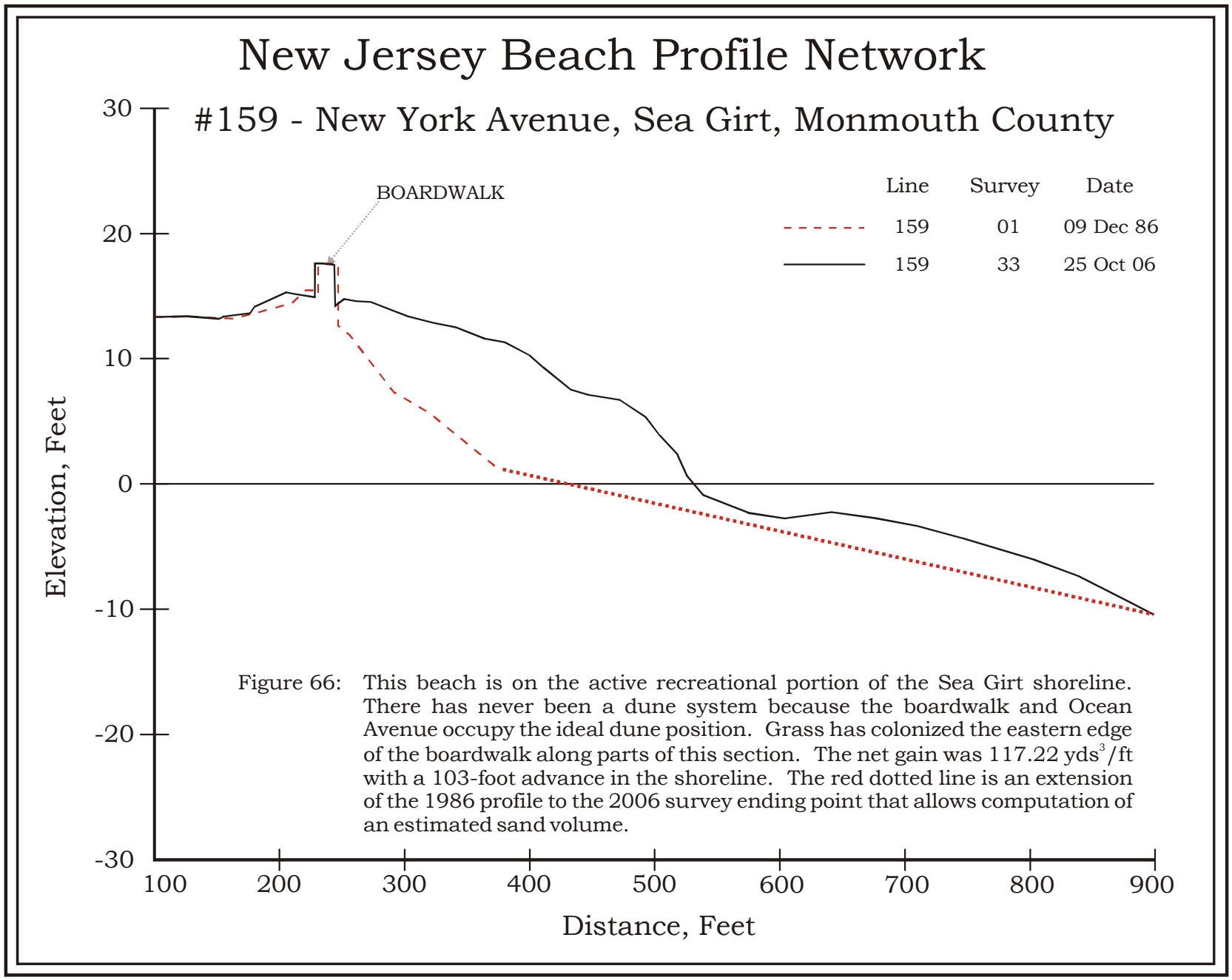


Figure 66: This beach is on the active recreational portion of the Sea Girt shoreline. There has never been a dune system because the boardwalk and Ocean Avenue occupy the ideal dune position. Grass has colonized the eastern edge of the boardwalk along parts of this section. The net gain was 117.22 yds^3/ft with a 103-foot advance in the shoreline. The red dotted line is an extension of the 1986 profile to the 2006 survey ending point that allows computation of an estimated sand volume.

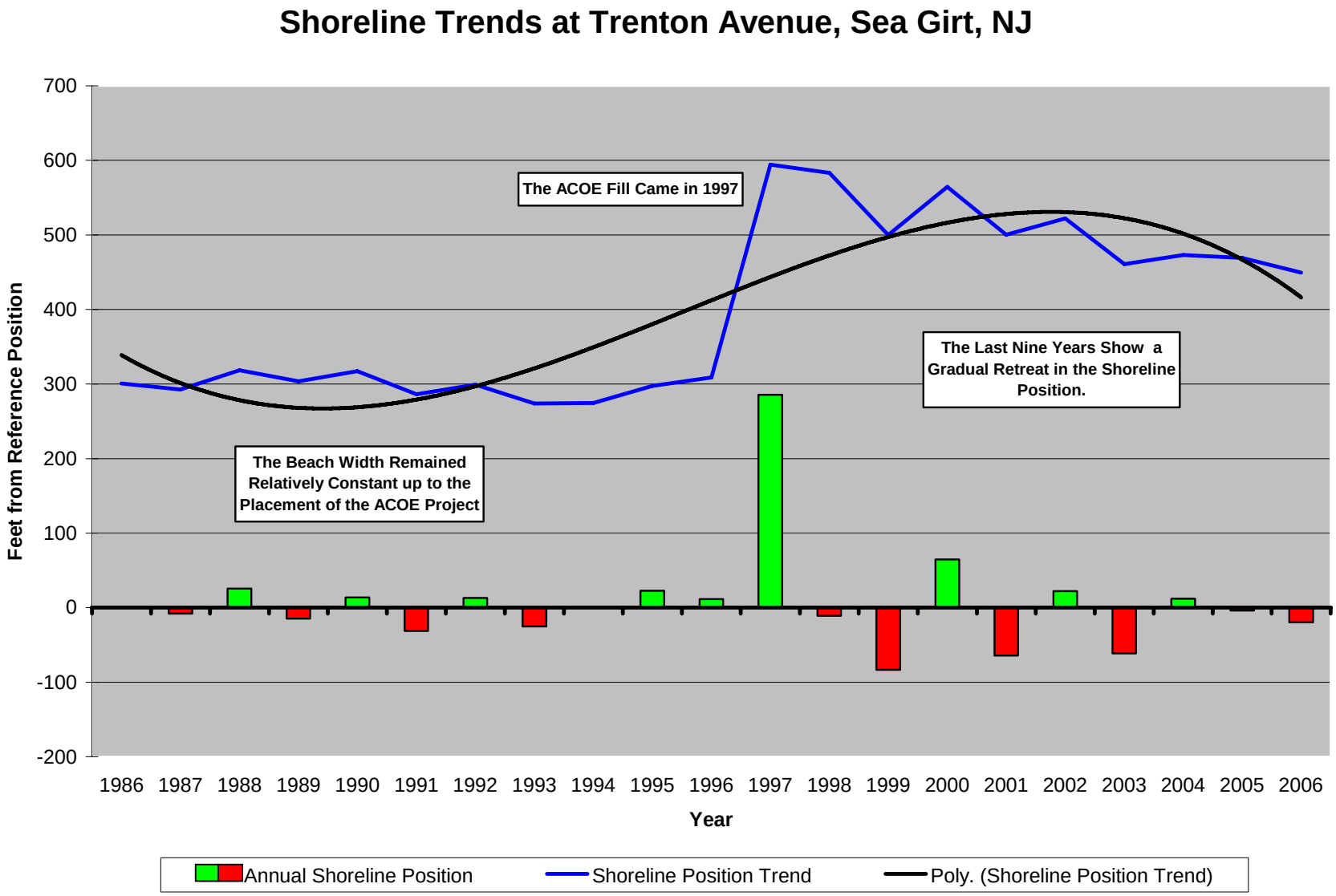


Figure 67 – Site 158. Toward the southern boundary of Sea Girt, the impact of the ACOE shore protection project showed a large shoreline advance. That advance did retreat 5 out of 9 years pulling the shoreline back about 150 feet.

20-Year Comparison Photographs – Site 158, Trenton Avenue, Sea Girt

The change at this location is very dramatic because the December 1992 northeast storm produced serious bluff erosion damage that required a bulkhead to assure nervous residents that further loss would be avoided. The high tide was always landward of the boardwalk, but advanced 300 feet further seaward after the project. Prior to The ACOE project it was possible to walk under the boardwalk at this location. After completion sand has filled under the boardwalk and was blown landward raising the dune elevation by several feet from the toe up to the crest. The cross section below shows the 1997 boardwalk position relative to the beach elevation as compared to the post construction situation in 2006.

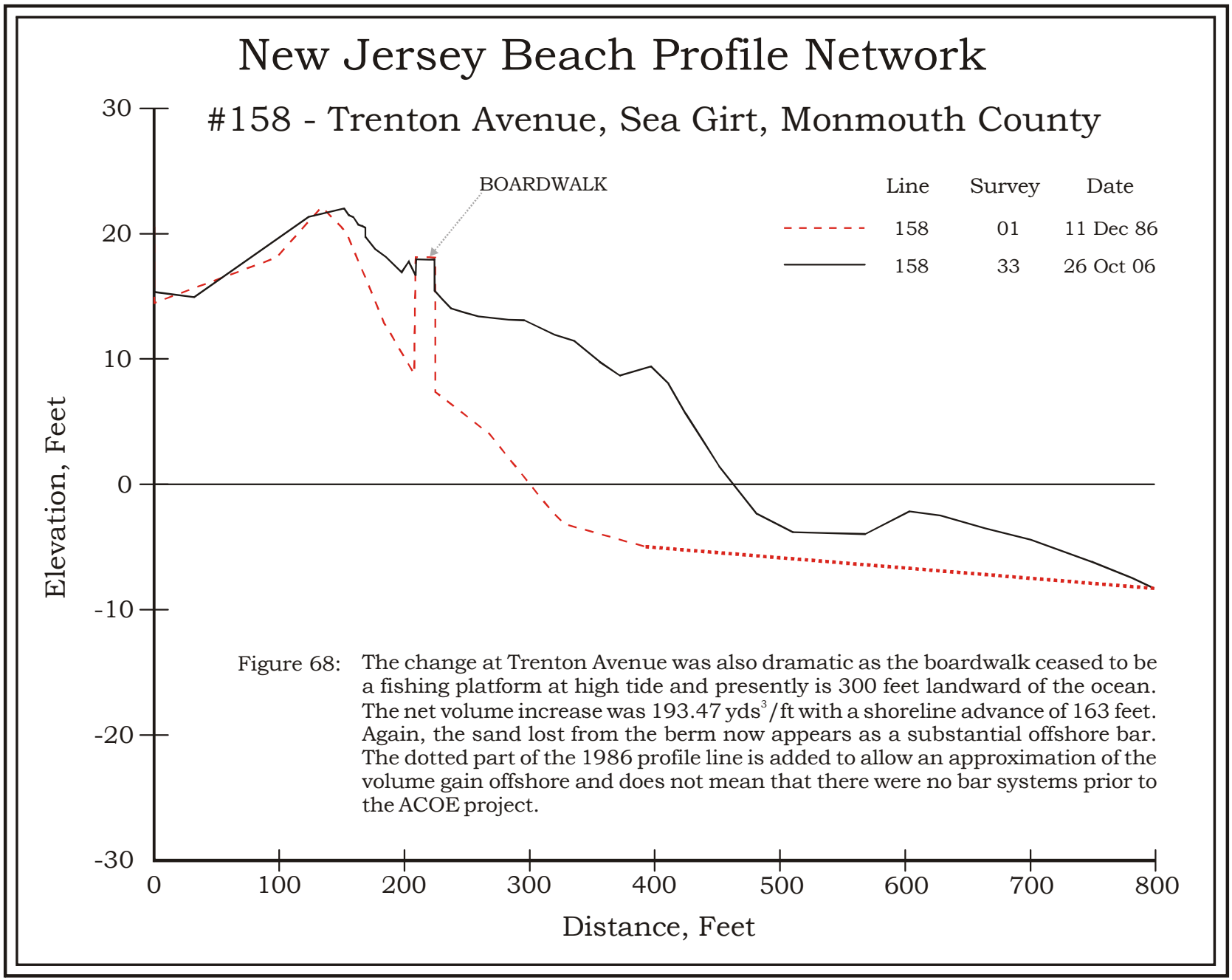


Figure 68: The change at Trenton Avenue was also dramatic as the boardwalk ceased to be a fishing platform at high tide and presently is 300 feet landward of the ocean. The net volume increase was 193.47 yds^3/ft with a shoreline advance of 163 feet. Again, the sand lost from the berm now appears as a substantial offshore bar. The dotted part of the 1986 profile line is added to allow an approximation of the volume gain offshore and does not mean that there were no bar systems prior to the ACOE project.

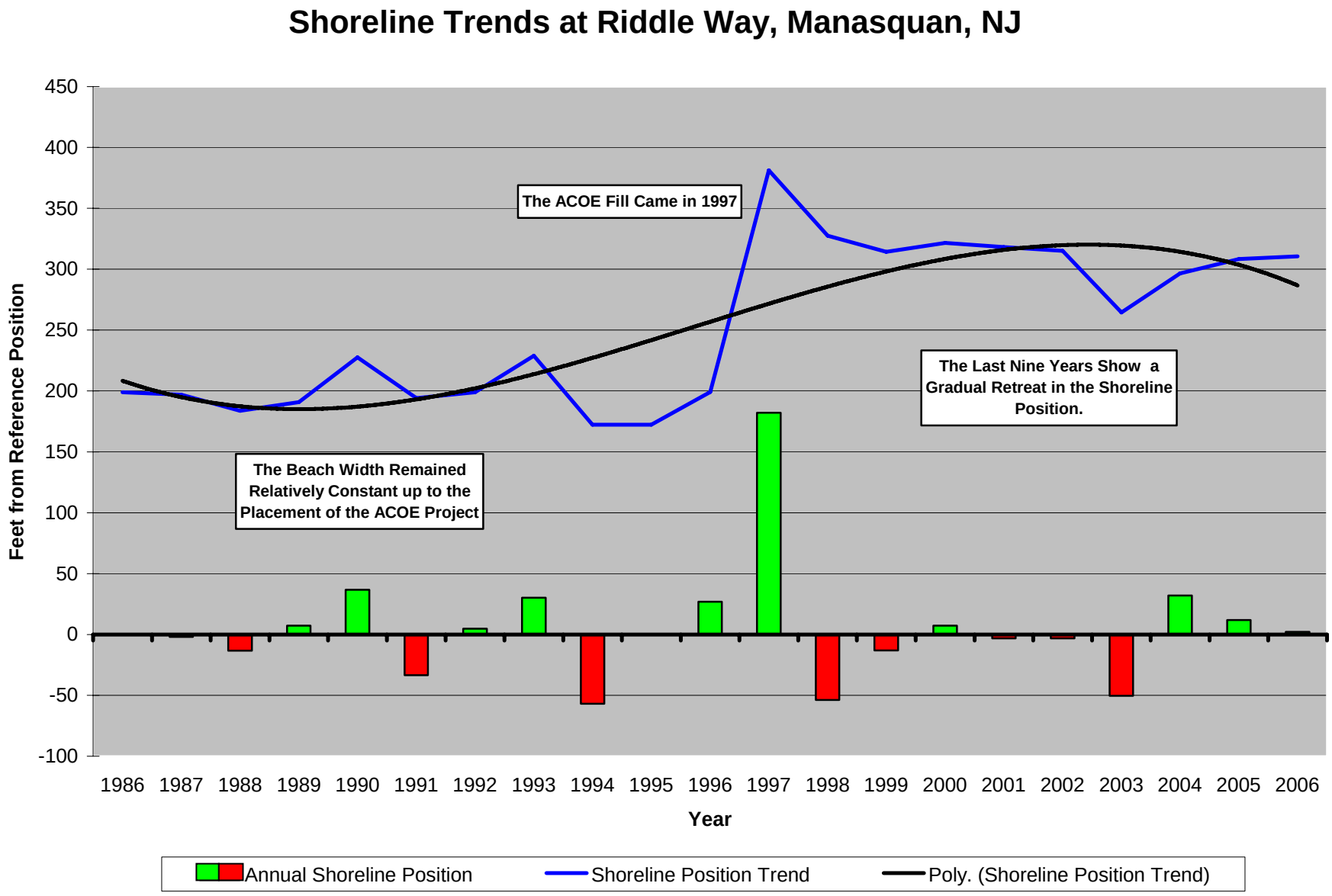


Figure 70 – Site 157. The Borough of Manasquan beach lies just north of the Manasquan Inlet. The two jetties produce substantial shoreline variations annually dependant on northeast storm frequency. The big spike in 1997 is the ACOE beach nourishment project that produced a

175-foot advance in the shoreline. The years 1998 and 2003 each caused a 50-foot retreat that was partially offset by advances in 2000, 2004 and 2005.

20-Year Comparison Photographs – Site 157, Riddle Way, Manasquan
The 2006 photograph (right) shows the asphalt promenade that lies just seaward of the residential homes that are protected by a moderately elevated dune system that has been the focus of considerable strife in Manasquan over the years. The beach remains wider than it was in 1996, but inlet-induced loss has been greater than that in Spring Lake and Sea Girt. The 1986 survey was taken prior to any dune development along the Manasquan oceanfront and its construction produced legal conflict over its potential to block views. This opposition continued in spite of the partial mitigation of the incipient dune (left) provided to 1992 northeast storm damage to the owners' properties at the promenade.

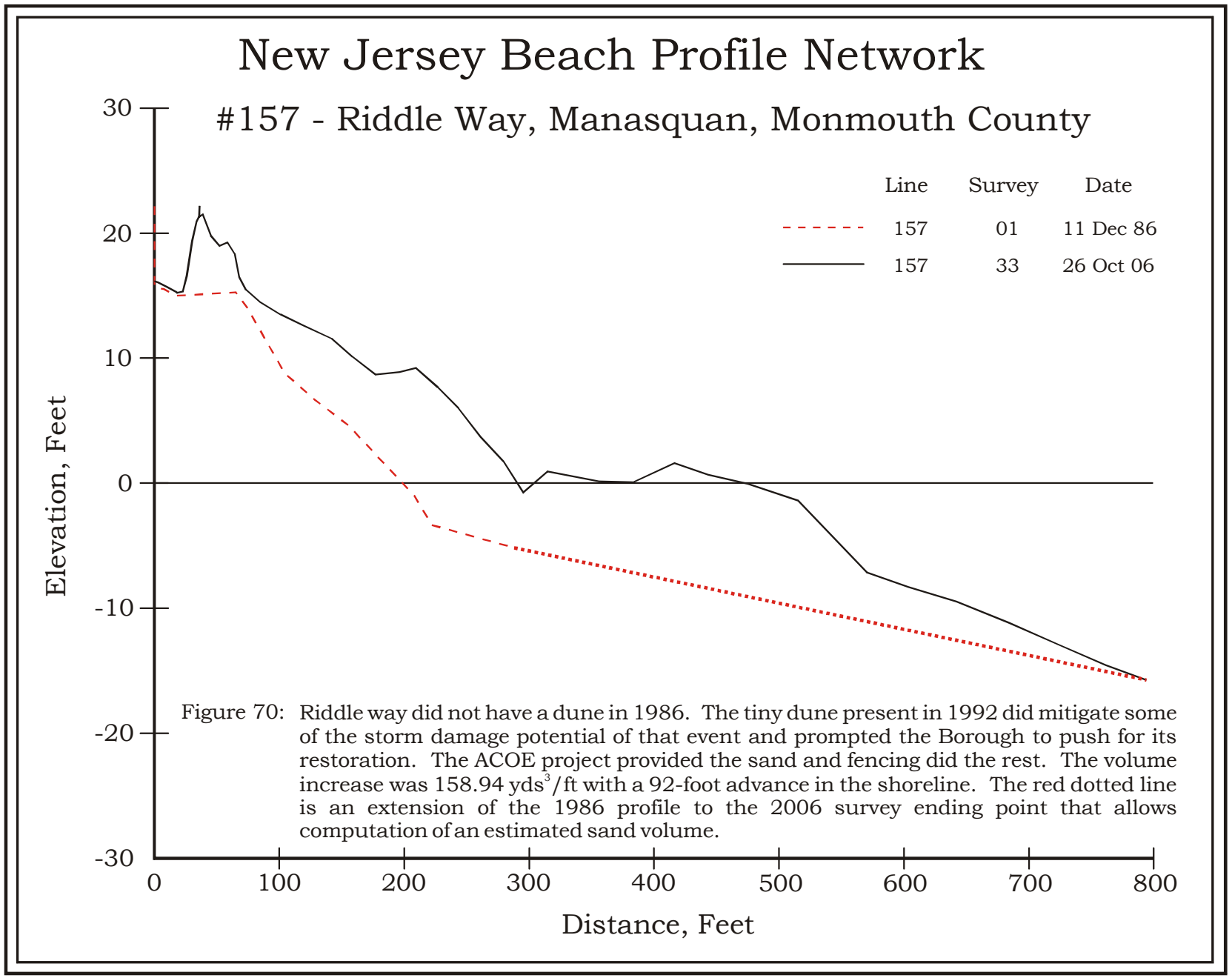


Figure 70: Riddle way did not have a dune in 1986. The tiny dune present in 1992 did mitigate some of the storm damage potential of that event and prompted the Borough to push for its restoration. The ACOE project provided the sand and fencing did the rest. The volume increase was 158.94 yds^3/ft with a 92-foot advance in the shoreline. The red dotted line is an extension of the 1986 profile to the 2006 survey ending point that allows computation of an estimated sand volume.

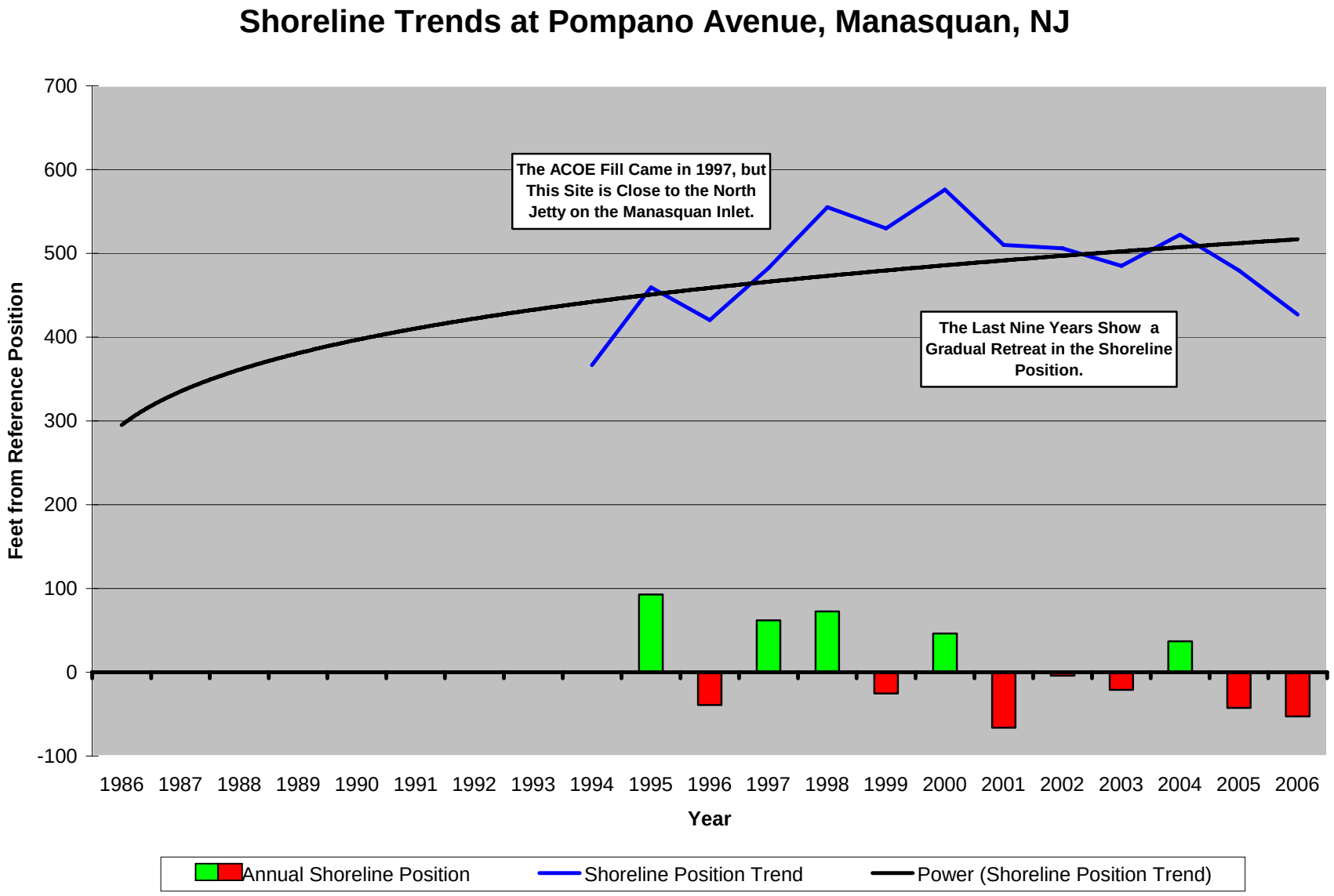


Figure 71 – Site 256. This profile was added in 1994 to provide closer coverage of the shoreline and sand volume changes on the north side of Manasquan Inlet. The sand volume added was reduced at the inlet because the jetties were shorter than necessary to retain the normal

volume being added elsewhere. Despite the taper in width, sand readily moves into the Manasquan Inlet channel requiring more frequent dredging. For several years after completion the shoreline width fluctuated with little net change but in the last two years shoreline retreat has gradually accelerated.

20-Year Comparison Photographs – Site 256, Pompano Avenue, Manasquan
The dune at this site has grown substantially since 1995. Unfortunately, some homeowners do not appreciate the greater storm protection they provide. The wider beaches now support both a larger dune footprint and provide ample recreational space. The photographs above show the contrast between 1995 (left) and 2006 (right).

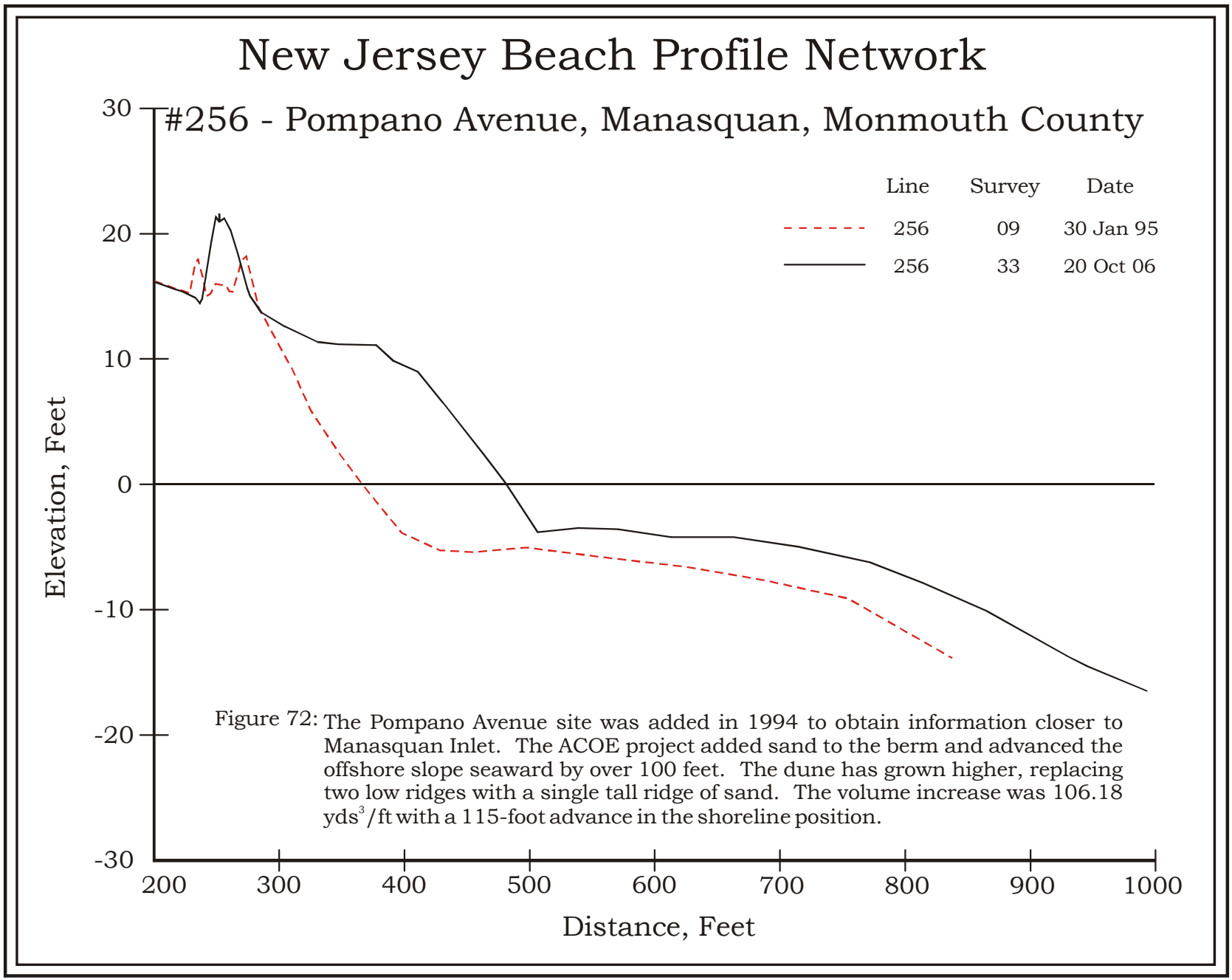


Figure 72: The Pompano Avenue site was added in 1994 to obtain information closer to Manasquan Inlet. The ACOE project added sand to the berm and advanced the offshore slope seaward by over 100 feet. The dune has grown higher, replacing two low ridges with a single tall ridge of sand. The volume increase was 106.18 yds^3/ft with a 115-foot advance in the shoreline position.

SUMMARY OF MONMOUTH COUNTY:

Intense development commenced along the Monmouth County shoreline by 1870 with the construction of the New York and Long Branch Railroad. This direct access to the County's coastline allowed tourism to develop and eventually permitted commuting to the urban north by full-time residents. The early tourist hotels built in Long Branch, Asbury Park, Ocean Grove and Spring Lake were set back from the edge of the bluff. The exact retreat rate of the bluff is unknown, but relatively soon; property owners began to construct wooden walls at the base of the bluff, parallel to the shoreline and added timber groins on the beach perpendicular to the shoreline. Improvements in engineering design and better technology allowed more durable and larger projects to essentially armor the bluff shoreline with walls of concrete timber and rock. This essentially shut off the re-supply of beach sand because waves could no longer mine the bluff during storms.

The same erosion control effort was also applied to dividing the beach into cells separated by rock groins sometimes spaced as close as 700 feet apart. Groin design knew no limits during the 1960's and every Monmouth County shorefront municipality built at least one of these structures. Frequently spaced at every other street-end, the groins severely reduced the meager sand supply's ability to move in any direction except directly offshore during bigger storm events.

Little by little the Monmouth County beaches became very narrow with miles of shoreline without a sand beach of any kind. The ultimate armored shoreline was found in Sea Bright where a seawall was started by a railroad company to protect tracks laid parallel to the dunes late in the 19th Century. This wall had been rebuilt ever stronger during the 20th Century. Groins were also included about every quarter mile along the 12-mile shoreline. The only bathing beaches were found in tiny pockets tucked into the corner made by the seawall and one of the groins. This condition was common from Sandy Hook National Seashore south to Allenhurst.

The situation was slightly better from Asbury Park to the south, but storm damage to boardwalk and other public infrastructure was commonplace. The 1991 Halloween and 1992 December storms did substantial damage to the entire Monmouth County shoreline, piling the boardwalk into Ocean Avenue as splintered debris in Belmar, Avon-by-the-Sea, and Spring Lake. Damage to homes occurred in Manasquan as the ocean easily overtopped the beach and modest dune along that oceanfront. Even the Sea Bright seawall was not sufficient to prevent sand, debris and millions of tons of seawater from landing in Ocean Avenue. Serious storm activity essentially ended with the December 1992 northeaster. Nothing since has approached its severity allowing many to forget what a true storm can do. Between 1992 and 2006, there have been storms of the magnitude that would be expected each and every year. Events with a recurrence interval of greater than each year have been fortuitously absent.

The majority of the Monmouth County shoreline consists of a Cretaceous and early Tertiary-aged sedimentary bluff, which lies under and landward of most of Monmouth County's beaches. This bluff rises to 35 feet above the ocean in Elberon and gradually drops in elevation until it reaches sea level at Manasquan. The bluff at the beach disappears south of Bay Head in Ocean County.

A sand spit, a geologically modern feature, extends to the north from Long Branch/Monmouth Beach ending at the tip of Sandy Hook enclosing part of Raritan Bay. This 16-mile long peninsula

developed over hundreds of years as the bluff-front coastline eroded and retreated due to wave attack during storms. Proximity to Long Island, New York creates a wind block that prevents maximum development of northeast storm waves that results in dominant sediment transport to the north from the rest of Monmouth County's shoreline. This transport direction can reverse with southeast winds over short periods of time, but in the long term the sand movement is largely from south to north ending at Sandy Hook.

By 1994 the State of New Jersey became serious about finding a solution to this shoreline loss and turned to a Federal project initially authorized in July of 1958 to undertake a Federal study to determine the best method of beach erosion control in Monmouth County. This work, modified under the Federal Water Resources Development Acts of 1986, 1988 and 1992 progressed through the three Federal phases (reconnaissance, feasibility, and planning and engineering design) leading to construction. The Federal lead agency is the New York District of the US Army Corps of Engineers with the local sponsor as the New Jersey Department of Environmental Protection. The NY Corps District carried the project through the Reconnaissance phase into the jointly sponsored Feasibility phase that chose a design plan. The State spent years in negotiations with local municipalities along the Monmouth County coast to generate detailed plans and define local and State financial and governance responsibilities. Real estate issues and public access to the federally funded project where likewise long, tedious and frequently frustrating. Finally the Army Corps approved the Planning and Engineering Design for construction and Congress authorized the funding to start construction of the nation's largest beach restoration project ever attempted.

The project consists of 21 miles of shoreline from the Sandy Hook gateway loop to the Manasquan Inlet in Monmouth County, New Jersey. The protection is provided by the construction of a 100-foot wide beach berm at an elevation of 10 feet above mean low water (MLW). The project also called for notching existing stone groins and extending storm water outfall pipelines. The project included periodic nourishment of the restored beaches on a 6-year cycle for a period of 50 years from the start of the initial construction.

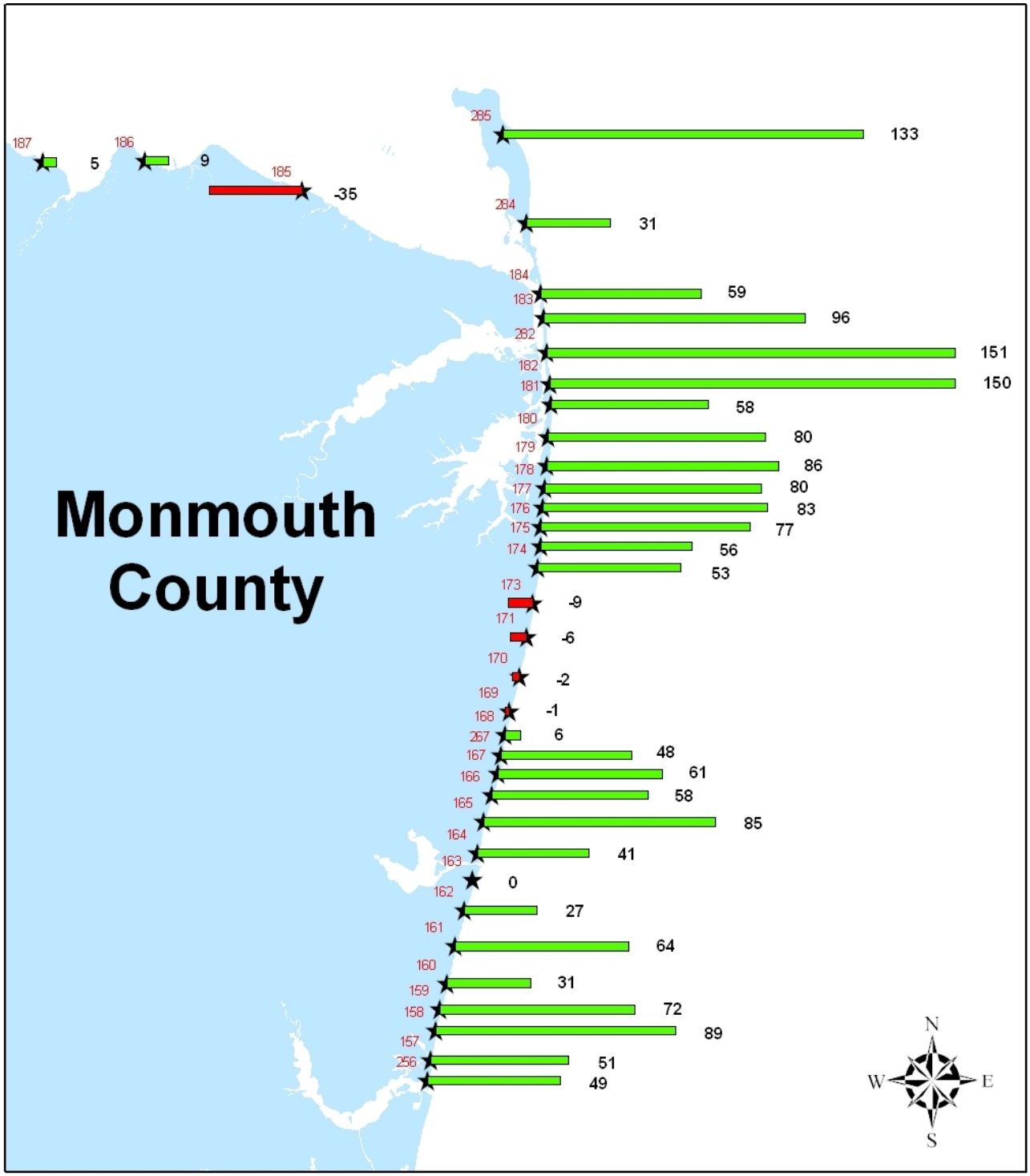
Construction commenced following the January 1994 award of the initial contract for Monmouth Beach. Over the next six years 24.9 million cubic yards of sand were pumped from about a mile offshore to the beach at a cost of $210,000,000. Beach nourishment efforts have provided a vast supply of new sediment to the beaches of 9 out of 12 oceanfront municipalities. The earliest sites with sand added have responded well, requiring little augmentation since the project started. Some early maintenance work was done at Monmouth Beach due to sand losses when material migrated south toward Long Branch in 1997. The initial general maintenance was complete in 2002 for the northern Monmouth County reach, placing less than 70 yds^3/ft. at most sites. Over the past eleven years, the extensive shoreline advances and large increases in sand volume have provided tremendous increases in shore protection, vastly increased ecologic habitat and new recreational opportunities to all municipalities involved.

As the graphics (pages 12 to 116) show, the general trend at all the Monmouth County sites receiving beach nourishment sand showed slow losses with many years of stability. The rate of loss calculated demonstrated that if nothing further were to be done, the beach at these sites would be back to pre-project condition in 65 years. Increased storm intensity or frequency would reduce this value, but the prediction was made by some that the vast majority of this sand would be gone in six months after the construction was completed. The most serious sites of loss were found in places where the project terminated due to impediments to sand placement involving public access and

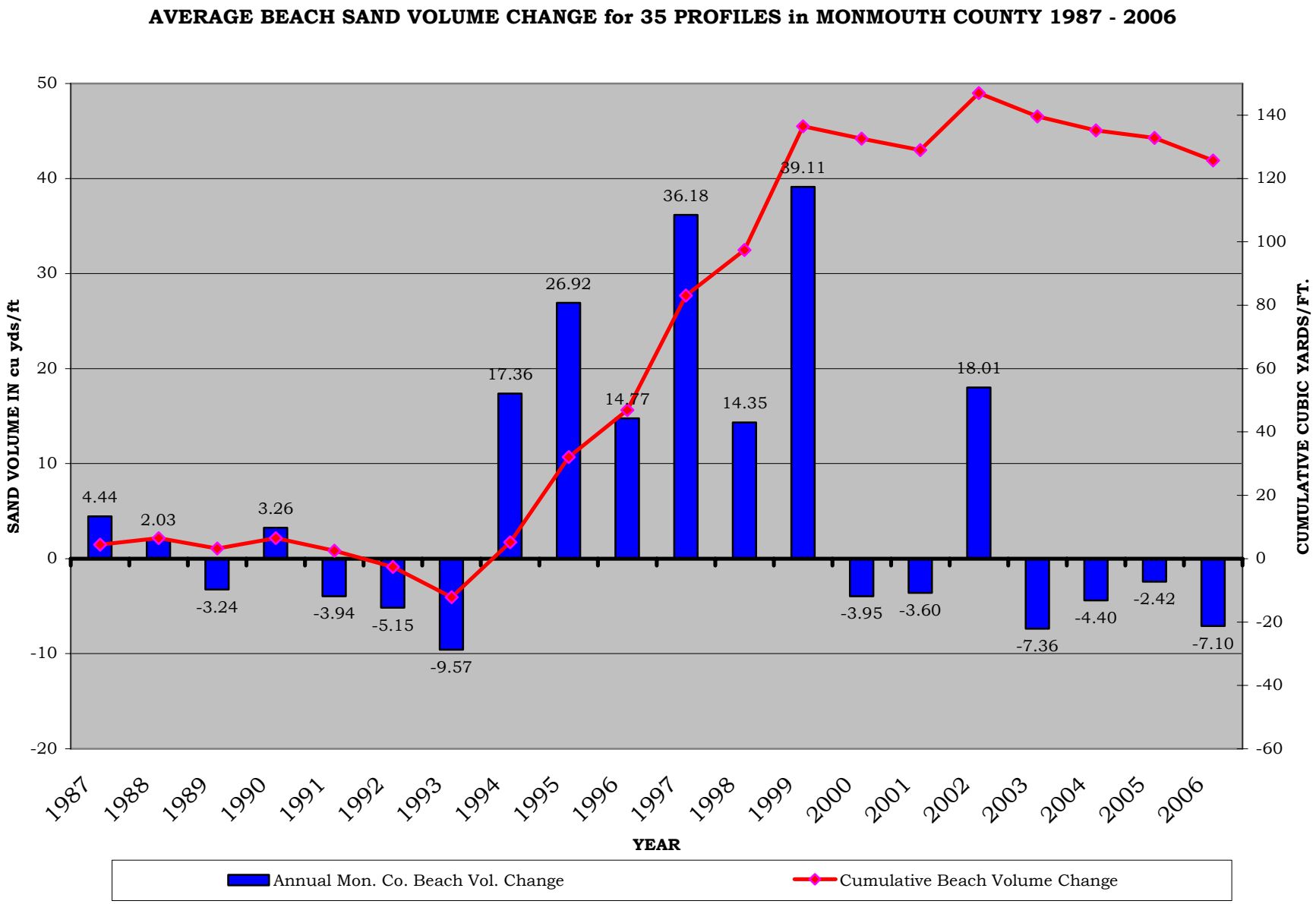
private property easements to proceed (the south end of Long Branch is the best example). The surveys show that very little sand moved into the Allenhurst, Deal and Elberon shoreline because of the large number of rock groins and the very narrow beach that has existed for many years. With the current mood of Congress toward funding future beach nourishment activity, the likelihood that this segment would receive subsequent project funding is not good. The issues related to public access and the easements necessary to proceed with any federally sponsored project make beach nourishment in this segment even less likely. Monitoring will continue to look to determine at what rate sand does move into the region should that happen.

Two summary illustrations were prepared, the first shows the average of each of the 35 Monmouth County profile shoreline changes as a green (advance in the shoreline position) or red (shoreline retreat) bar located on a map at the location in Monmouth County. The impact of the Federal beach restoration project presents an emphatic display of shoreline advances where the project was constructed as contrasted to those oceanfront communities where the real estate issues prevented sand placement (Elberon, Deal and Allenhurst/Loch Arbor).

The second illustration presents the average sand volume changes for all 35 profiles calculated for each fall between 1986 and 2006. Sand volume measures the quantity added to the profile cross section between the dune to a point about 400 feet offshore of the berm. The Federal project's impact is seen beginning in 1994 as millions of yards of new sand was added each year until 2000. The maintenance fill in 2002 also shows as added sand volume. The trend since 2002 has been relatively flat showing relatively minor losses as the sand adjusted for storms and moved to equilibrium. By 2006, the average Monmouth County Profile had a sand volume increase of 125.69 yds^3/ft compared to the initial year 1986.



Summary Illustration 1: Monmouth County's shoreline received the most extensive restoration project thus far co-sponsored by the State and Federal governments with local participation to add sand to 21 miles of the county shoreline. This effort clearly shows in the large advances seen to the shoreline position in all but the segment between Elberon and Allenhurst, NJ. Some sand has moved into the area not nourished, but not enough to change conditions at the pre-existing erosional beach within the un-nourished reach.



Summary Illustration 2: The average fall sand volume change for Monmouth County illustrates the commencement of the Federal beach restoration in 1994, continuing until 2000. The 2002 maintenance effort shows as added material as well (18.01 yds^3/ft). Loss rates since 2002 have been relatively minor. By 2006, the cumulative trend shows a 125.69 yds^3/ft average sand volume gain in Monmouth County.

Monmouth County New Jersey Beach Volume Changes
Fall 1986 to Fall 2006 for 36 Sites – Taken From NJBPN Reports

Site Number	Fall Beach Sand Volume Change Each Year																				86-06	Beach Only	
PROFILE	F 1987	F 1988	F 1989	F 1990	F 1991	F 1992	F 1993	F 1994	F 1995	F 1996	F 1997	F 1998	F 1999	F 2000	F 2001	F 2002	F 2003	F 2004	F 2005	F 2006	AVERAGE	(cu feet)/ft	PROFILE
187	-2.27	4.88	7.80	12.30	-1.33	0.36	-0.68	1.51	0.38	-0.01	0.75	-2.56	1.49	-0.47	-0.60	-0.29	-4.99	-0.44	-2.14	-2.97	0.54	4.90	187
186	-1.45	-0.03	-2.29	17.79	7.44	-1.27	0.52	-0.90	-5.89	-3.10	-0.66	-0.58	-1.32	-1.25	0.27	-1.51	-2.65	2.11	-2.54	-3.10	-0.02	8.66	186
185	-25.17	7.85	-10.91	-1.74	-30.41	27.97	13.80	-10.99	-4.66	-9.93	2.38	-5.74	-0.09	-2.20	2.88	-2.12	-2.79	2.96	-5.68	1.63	-2.65	-34.53	185
285									87.67	-4.75	-31.45	11.90	0.38	-12.76	17.89	42.28	-1.06	71.14	37.05	31.32	20.80	132.99	285
284									-42.67	-63.74	3.69	47.10	-12.60	5.51	11.45	56.19	-11.50	35.34	14.04	-12.19	2.55	30.94	284
184	4.16	-1.04	1.01	-6.91	2.47	-0.81	-4.55	8.90	108.57	103.36	-32.97	-31.10	-2.32	14.91	-22.23	79.83	-30.33	-12.41	4.02	-6.76	8.79	59.10	184
183	5.76	3.39	-3.77	0.33	-1.98	2.43	-2.33	-1.11	0.60	294.59	-0.30	-15.85	-21.92	0.72	-9.24	5.65	15.38	2.78	-14.95	-10.41	12.49	96.09	183
282									-11.47	288.26	3.21	12.25	26.32	-6.32	32.83	-8.09	14.91	21.65	-15.50	0.11	29.85	150.51	282
182	1.34	6.71	-9.47	9.35	-1.80	-6.92	3.25	-16.35	269.46	94.39	-10.23	-4.14	-1.42	-6.59	1.26	17.50	13.73	-0.67	-23.86	-4.71	16.54	149.57	182
181	9.52	3.54	-9.93	18.00	-10.01	5.33	-35.54	-28.43	232.33	-16.76	2.53	-5.88	-3.59	-15.37	-8.12	64.93	-9.54	-25.56	-24.42	-5.35	6.88	58.10	181
180	-3.55	1.29	-3.08	5.40	-4.35	1.25	-3.44	-0.94	223.41	-6.76	-13.53	-5.50	-15.00	8.82	-16.79	94.67	-10.28	-25.91	-34.42	-24.53	8.34	80.04	180
179	5.91	-4.15	0.32	7.19	-3.65	-1.41	-8.10	199.75	-178.17	-84.20	99.72	-93.12	31.67	-4.75	-25.94	219.04	-100.06	-66.77	-36.15	-36.47	-3.97	85.63	179
178	14.82	-1.47	-7.03	11.10	2.65	-19.23	-9.54	348.10	-173.53	-34.40	110.49	25.03	-14.15	-17.69	4.15	81.93	-84.23	-20.65	-13.82	-4.04	9.92	79.71	178
177	8.44	4.58	-7.22	10.15	0.58	0.52	-19.07	-17.60	38.70	-0.99	107.87	72.81	0.74	-1.21	1.98	-15.29	-3.98	15.59	-0.47	-31.36	8.24	82.69	177
176	28.64	-23.33	3.08	7.80	-15.02	-11.09	-6.94	6.45	27.66	-21.67	-10.13	203.22	-7.70	6.41	-14.59	-16.37	18.80	-10.09	-17.15	-20.38	6.38	77.06	176
175	19.79	-3.05	6.85	-1.85	-4.07	-9.26	-12.04	-7.88	29.61	9.81	-8.29	138.69	-2.11	33.13	-21.71	-28.05	17.22	-19.29	-18.96	2.42	6.05	55.83	175
174	6.78	1.27	-13.38	3.46	1.60	7.43	-7.17	-12.78	13.50	21.18	-11.79	114.59	124.59	-28.85	-12.50	-14.29	-17.31	-9.04	-34.12	-6.38	6.34	52.79	174
173	0.14	-0.96	-1.86	5.37	1.67	-7.21	5.08	-20.52	30.19	-15.21	7.24	51.50	145.01	-77.44	-48.84	-40.19	6.50	-15.41	-5.19	-24.96	-0.25	-8.79	173
172	2.27	14.90	-24.23	-10.12	19.89	0.11	SITE ABANDONED IN 1993														0.47	11.67	172
171	10.63	-8.25	-9.14	0.34	-1.30	0.24	-5.32	6.63	-11.05	10.11	-9.37	18.32	-16.96	42.28	-3.86	-16.57	4.84	20.37	-26.87	6.70	0.59	-5.88	171
170	-6.60	15.07	-21.52	16.95	-0.87	-13.42	-16.09	17.18	13.56	-23.64	-1.19	33.17	-16.20	-12.65	-1.60	-5.16	20.04	-22.98	34.80	-1.16	0.38	-2.46	170
169	-6.48	4.91	-10.75	5.85	5.18	0.50	-3.90	-10.16	5.89	-13.38	8.97	4.57	3.95	-12.21	-0.39	-7.62	31.92	-18.90	2.75	-6.80	-0.81	-1.46	169
168	-6.34	32.76	79.56	-25.43	-53.90	-27.81	-22.65	13.00	23.53	-14.18	4.18	-0.12	36.35	-52.56	8.49	22.17	23.88	-40.77	24.98	-10.04	0.76	5.52	168
267	-0.53	-8.32	-3.40	-4.42	4.27	-14.19	-1.60	-19.73	24.45	-14.78	8.92	5.81	191.90	-27.53	12.55	9.41	-8.33	-17.61	11.83	-13.62	6.75	47.93	267
167	17.93	-13.43	-2.29	8.52	7.06	-36.69	-18.31	3.98	20.73	-3.03	3.14	-14.71	166.69	-3.32	-11.80	20.19	-5.88	-44.32	25.82	-23.66	4.83	60.58	167
166	-12.00	11.65	-12.47	7.78	0.89	1.45	-30.25	18.76	-7.55	2.74	-0.25	-1.42	224.68	-35.02	-9.95	-8.36	-0.57	-13.20	7.20	-10.40	6.69	57.79	166
165	5.48	0.10	-13.32	5.54	-22.12	0.51	-11.51	-4.91	22.96	-1.56	-1.92	9.23	206.92	50.89	-21.58	6.52	-11.60	-13.55	23.80	-20.46	10.47	85.42	165
164	-5.13	-1.78	-7.58	7.40	-1.66	-21.42	-4.70	19.21	9.45	-17.53	-4.99	7.44	140.20	39.04	3.63	-19.33	-24.10	6.84	-4.53	6.65	6.36	41.20	164
163	-1.24	-5.25	2.60	-4.59	-5.62	-1.06	-12.72	-20.42	34.25	-10.90	11.16	4.74	24.29	3.70	6.82	6.33	-4.93	21.30	-18.06	4.21	1.73	-0.03	163
162	3.44	11.47	-7.24	0.17	-4.72	4.97	-8.96	9.21	6.09	-10.41	107.69	-22.83	-2.44	-4.78	-11.22	-1.17	-0.62	14.21	4.58	-3.42	4.20	26.67	162
161	-3.60	-1.56	2.20	8.28	-3.04	-2.57	-6.87	8.57	11.70	-6.17	81.53	-9.20	34.49	-0.40	-0.01	33.64	-3.70	3.47	-6.33	-0.30	7.01	63.72	161
160	3.44	4.74	-8.24	-2.02	-4.52	8.90	-4.22	8.48	-6.94	4.72	84.81	24.46	6.31	-16.00	-3.39	20.34	-17.29	-10.40	18.83	-13.80	4.91	30.89	160
159	2.42	4.14	-8.02	7.01	-1.37	-15.66	-26.46	12.32	20.97	4.90	172.16	-33.54	15.40	-3.14	12.36	-19.64	-0.70	5.94	19.23	-15.32	7.65	71.63	159
158	11.70	3.62	-3.51	-5.00	-7.13	5.43	-18.48	13.14	23.57	-1.70	232.09	-59.08	-3.60	-10.18	13.59	1.40	-32.69	18.71	-3.29	-10.61	8.40	88.62	158
157	11.67	7.23	-2.05	8.87	-13.51	0.34	24.37	-46.78	8.04	9.78	148.35	-50.02	2.76	-1.76	-1.21	6.34	-27.85	23.80	-8.97	39.92	6.97	50.62	157
256									6.06	-5.45	96.26	20.79	-11.05	18.69	2.63	-12.05	3.71	-14.26	0.79	-1.27	8.74	48.80	256

	F 1987	F 1988	F 1989	F 1990	F 1991	F 1992	F 1993	F 1994	F 1995	F 1996	F 1997	F 1998	F 1999	F 2000	F 2001	F 2002	F 2003	F 2004	F 2005	F 2006	86-06 AVERAGE	86-06 BEACH VOLUME TO THE ZERO ELEVATION
MONMOUTH AVERAGE	4.44	2.03	-3.24	3.26	-3.94	-5.15	-9.57	17.36	26.92	14.77	36.18	14.35	39.11	-3.95	-3.60	18.01	-7.36	-4.40	-2.42	-7.10	6.28	
CUMULATIVE VOLUME	4.44	6.47	3.23	6.49	2.55	-2.60	-12.18	5.18	32.11	46.88	83.05	97.40	136.51	132.56	128.96	146.96	139.60	135.20	132.79	125.69	131.97	51.18

Table 1 - Each of these tables is designed to provide the reader/viewer with all the information distilled from 20 years of beach surveys at the 100 NJBPN sites along the coast of New Jersey. The red columns represent the site locations, which are presented in the County Site Map (Figure 4). The data are the calculated dune, beach and offshore sand volume changes for each site for each year. These data are averaged across time at the right-hand, black-typeface column (labeled "86-06 AVERAGE") to give the average sand volume for each site over 20 years time. The blue column is the sand volume change for just the beach to the zero elevation datum (NGVD29). A set of new sites was added in 1995 to fill gaps in coverage or cover beaches close to each NJ inlet.

The two bottom rows of numbers represent:

a) The average annual Monmouth County sand volume change.
b) The cumulative sum of these averaged changes.

Monmouth County New Jersey Shoreline Changes
Fall 1986 to Fall 2006 for 36 Sites – Taken From NJBPN Reports

Site Number — Fall Shoreline Position Change Each Year — 86 to 06 change in the shoreline

PROFILE	F 1987	F 1988	F 1989	F 1990	F 1991	F 1992	F 1993	F 1994	F 1995	F 1996	F 1997	F 1998	F 1999	F 2000	F 2001	F 2002	F 2003	F 2004	F 2005	F 2006	AVERAGE	(feet)	PROFILE
187	-22.54	3.08	28.27	1.91	3.71	2.01	1.62	-11.21	-12.10	5.41	0.65	-32.50	-2.19	0.00	-8.58	-0.52	-3.45	-5.32	3.81	-8.44	-2.82	-56.14	187
186	-3.87	2.24	3.70	3.35	-0.68	1.88	2.50	1.68	4.14	-9.86	3.33	-3.17	-2.78	0.18	3.37	-2.83	-4.37	2.21	-1.56	-0.17	-0.04	-0.71	186
185	-18.40	-11.31	-24.07	6.76	-9.93	15.13	10.83	-2.58	-6.88	-3.93	-8.98	-5.95	-3.48	-1.37	3.46	-3.99	-6.47	-0.14	0.59	-1.23	-3.60	-71.95	185
285									316.21	-37.73	-189.35	26.75	-15.38	-30.30	-14.02	148.56	-17.89	245.20	-24.58	132.50	45.00	539.96	285
284									-24.38	-90.07	-32.72	127.71	-18.70	-10.06	13.65	62.79	-10.15	38.12	22.66	-7.42	5.95	71.44	284
184	4.16	-12.57	-0.35	-7.19	7.43	3.24	-10.22	-3.95	138.79	114.17	-26.07	-44.61	-10.51	39.39	-65.61	122.51	-26.42	-3.31	-4.23	-0.41	10.71	231.26	184
183	10.63	19.13	-22.66	-11.43	10.52	3.46	2.78	-4.67	-0.75	364.92	-53.77	-53.80	-9.07	15.92	-73.11	113.83	-15.04	30.19	-47.70	-35.83	12.18	290.91	183
282									1.19	385.81	-20.27	-6.95	53.90	-11.62	36.48	25.91	-7.67	51.95	-30.99	-6.37	39.28	471.38	282
182	-10.17	11.74	-33.13	26.87	-5.12	0.01	-35.57	-30.28	482.79	19.31	-16.12	3.26	-4.49	-12.32	5.70	47.69	-11.41	20.13	-19.71	-20.67	20.93	418.53	182
181	16.04	14.84	-27.24	47.71	-5.01	-3.64	-36.56	3.72	282.53	-54.91	-6.83	1.53	-32.83	-9.65	-3.32	95.17	-38.46	-5.29	-36.93	-12.21	9.43	171.26	181
180	-33.13	-24.72	15.12	22.70	-9.59	0.34	-39.43	34.67	332.85	-38.13	-28.57	-2.18	-29.63	23.93	-23.45	111.40	-25.07	-10.63	-45.97	-11.13	10.97	219.36	180
179	19.07	-18.96	1.60	25.82	-12.38	9.19	-7.01	612.32	-263.19	-83.38	139.70	-176.99	80.80	9.49	-44.19	235.98	-115.32	-60.29	-51.83	-52.35	12.40	248.07	179
178	20.44	-16.90	-20.65	50.66	-7.29	-14.89	-41.19	459.22	-201.77	-51.83	119.95	41.34	-23.59	-13.16	7.38	72.25	-114.77	-20.48	21.27	-39.90	11.30	226.07	178
177	24.23	-9.84	-13.90	15.99	13.97	-1.80	-46.84	-12.11	53.79	-15.70	206.88	106.83	-2.39	-1.84	-8.57	-17.80	-55.79	56.25	11.02	-82.89	10.97	219.51	177
176	47.94	-59.37	2.84	79.48	-61.14	-5.46	-14.06	31.66	0.25	-39.38	15.79	309.23	-3.27	3.81	-28.15	-45.17	31.62	8.39	-15.88	-56.30	10.14	202.84	176
175	53.61	-33.01	40.45	-24.82	6.79	-15.52	-15.93	-4.30	50.18	-37.44	12.21	206.79	21.34	29.12	-31.81	-26.74	9.72	11.95	-27.95	-39.60	9.25	185.06	175
174	26.23	17.59	-51.03	21.41	-7.07	14.59	-42.68	30.83	11.49	-26.59	20.17	167.29	195.59	-38.55	-30.54	-18.69	-30.53	2.31	-47.93	-26.02	9.39	187.89	174
173	-63.23	6.08	-11.58	21.83	-1.52	-8.37	-3.42	-27.59	55.59	-5.60	-1.46	61.40	182.67	-86.29	-57.34	-56.09	-15.96	4.56	15.74	-69.01	-2.98	-59.61	173
172	-38.14	40.63	-60.82	-4.90	31.75	9.21	SITE ABANDONED IN 1993														-3.71	-31.47	172
171	44.91	-44.88	-3.28	0.80	2.24	-1.55	-16.90	8.52	12.18	-20.26	2.09	39.07	-33.91	83.78	-42.39	-30.55	-4.11	75.92	-38.62	-44.00	-0.55	-10.95	171
170	-21.56	46.78	-69.61	30.67	34.69	-26.67	-46.50	41.58	-2.18	-36.00	16.76	8.12	9.81	29.13	-19.15	-40.25	7.60	5.84	97.99	-110.17	-2.16	-43.10	170
169	-25.65	-3.08	-1.44	17.91	3.62	37.46	-66.35	1.73	4.86	-15.82	14.63	5.89	0.29	31.63	-40.34	9.23	11.02	-10.92	33.64	-25.51	-0.86	-17.22	169
168	-12.80	68.58	175.06	-47.60	-136.68	-16.23	-31.02	25.69	-7.57	-4.59	4.00	1.79	23.79	4.84	-47.19	66.07	-17.01	-1.86	22.97	-36.43	1.69	33.81	168
267	11.79	-43.40	15.65	-21.38	7.20	3.83	-4.15	-8.74	-3.34	-17.33	16.37	5.38	225.04	-22.00	-3.57	25.05	-60.08	40.30	4.12	-52.66	5.90	118.06	267
167	31.04	-35.34	10.08	3.84	5.72	0.80	-32.05	-1.17	25.06	-27.99	33.51	-16.08	212.56	-25.09	-35.01	44.14	-33.45	-27.89	14.67	-13.68	6.68	133.69	167
166	-24.03	21.61	-19.35	7.25	9.56	-7.14	-34.72	34.28	-23.02	-14.37	3.29	7.66	327.61	-42.88	-64.38	-32.56	-27.29	55.70	-82.50	25.23	6.00	119.95	166
165	-7.72	4.60	-66.62	36.70	-48.73	-8.88	-21.29	15.91	-14.38	4.94	4.49	-5.10	298.49	87.11	-107.97	-22.53	-1.70	54.59	-77.59	16.83	7.06	141.16	165
164	15.87	-19.53	-8.04	-7.23	3.24	2.00	-14.06	-1.56	-2.30	-7.28	13.62	32.16	179.87	46.34	-80.25	-15.27	-40.50	-22.52	109.27	-60.79	6.15	123.04	164
163	6.82	-17.21	4.21	57.48	-53.06	-0.64	-1.26	-27.10	14.59	-30.14	47.90	1.32	-18.47	54.62	-58.30	24.22	-10.86	76.60	-41.13	-28.90	0.03	0.67	163
162	8.68	39.52	-55.54	4.78	-12.74	21.63	-20.76	27.75	-10.46	-19.57	146.41	8.76	-59.14	43.26	-55.97	2.47	-0.27	2.40	35.98	-37.78	3.47	69.39	162
161	-19.31	3.62	8.56	15.71	-19.28	23.65	-24.16	0.89	5.51	-14.41	137.87	-36.37	33.40	11.21	19.20	34.33	-20.39	-7.70	33.16	-32.51	7.65	152.98	161
160	-13.54	8.72	-4.78	-3.79	-4.69	18.97	-32.74	24.66	-19.72	-8.56	121.06	11.91	-11.28	3.33	-17.57	59.27	-36.58	-35.25	73.62	-59.13	3.70	73.92	160
159	-3.16	16.95	-35.94	6.62	7.10	-9.03	-23.48	22.13	-15.39	5.29	245.36	-2.99	-35.28	-9.45	45.67	-57.72	-17.03	10.03	40.54	-48.34	7.09	103.09	159
158	-8.09	25.78	-14.68	13.61	-31.10	12.96	-25.24	0.65	22.74	11.40	285.49	-11.02	-83.44	64.64	-64.21	22.03	-61.46	12.13	-3.91	-5.56	8.14	162.72	158
157	-1.97	-13.19	7.21	36.73	-33.50	4.71	30.19	-56.84	0.03	26.87	182.10	-53.69	-13.16	7.19	-3.29	-3.24	-50.43	32.02	11.85	-19.49	4.51	92.07	157
256									92.86	-39.03	61.95	72.75	-25.18	46.30	-66.17	-3.98	-20.95	37.18	-42.55	2.11	9.61	115.29	256
AVERAGE	2.03	-0.20	-8.27	14.35	-10.52	1.59	-23.38	42.78	32.22	6.14	46.14	26.16	44.23	10.06	-29.93	29.76	-25.83	20.80	-2.86	-32.78	7.13	134.23	AVERAGE

Table 2 - The individual change in the position of the zero elevation point along each survey profile at each site shows the variation in shoreline location with time and as a result of major beach restoration efforts or storm events. This position is derived from the topography on the beach relative to the location of the site reference monument. This "shoreline" is located where the surveyed profile line crosses the zero datum elevation defined by the National Geodetic Vertical Datum of 1929 (the datum used when NJBPN was established in 1986). The red columns are the site location numbers, the black columns are each year's shoreline position movement landward (-) or seaward (+) from the previous year. The last black type column is the average shoreline movement over the 20-year period, and the blue column is a direct comparison of the shoreline position in 1986 with that present in 2006. This shoreline change comparison covers the entire 20 years in one table.

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