

Dead Neck Beach Nourishment Monitoring and Data Analysis Osterville, Massachusetts

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1. Background

Since the completion of a 225,000 cubic yard nourishment in the first quarter of 2000, the movement of the Dean Neck shoreline has been monitored annually through the use of Differential GPS (DGPS) shoreline surveys and cross-shore profile measurements. These two data sets were used to determine shoreline change rates and volume loss in the 1999-2000 nourishment area, as well as shoreline change rates for the entire seaward shoreline of the island.

In order to enhance the storm protection capability of the eastern end of Dead Neck, two major beach nourishments have been placed on the island, adjacent to West Bay inlet. This segment of the Dead Neck shoreline has historically been the most erosive area of the island, due to its proximity to West Bay inlet. The inlet, with its jetties, effectively interrupts littoral transport from updrift beaches. This has been the case since the opening of the inlet in the first half of the 20th century. Net transport along the Dead Neck shoreline is directed toward the Cotuit Bay entrance from the West Bay entrance. Therefore, as it is cut off from the natural source of sediment to the east, the east end of the island continues to erode (apparent as shoreline retreat and lowering of the island), further inhibiting its ability to adequately serve as storm protection for the area directly landward of the island (in the Seapuit River) and in West Bay.

1.A 1985 Nourishment

For the first nourishment in 1985, 120,000 cubic yards of sand were placed along the section of beach starting at West Bay inlet and extending 2,400 feet westward (Wood, et al., 1996). Beach compatible material dredged from the West Bay inlet entrance channel was the source of sand used for this project. The design template of the nourishment had a berm elevation of +12.0 ft NGVD and a width of 100 ft. On average, the fill template required 50 to 60 cubic feet of sand per foot length of beach and had a stated design life of 10 years.

The performance of the 1985 nourishment was monitored on a semi-annual basis up to 1993. In 1993 approximately 7% of the nourishment volume remained in the template area. The average volume loss rate for the 7.5-year monitoring period is 14,880 cubic yards per year. Erosion rates along the template were higher than average at the completion of the nourishment as the beach fill profile equilibrated. Toward the end of the monitoring period, erosion rates were again accelerated due to a series of severe storms which impacted this shoreline during this time, including Hurricane Bob (August, 1991), the "no-name" northeast storm of October, 1991 and the Blizzard of 1993.

1.B 1999 Nourishment

The second nourishment project commenced in the first half of 1999 and was completed in winter 2000 (Woods Hole Group, 2001). The fill template for this nourishment had an elevation of +13 MLW, and a berm crest width of 150 feet. The sand used for the fill was available from channel maintenance dredging at Cotuit and West Bay Inlets. For this nourishment, 187,300 cubic yards were initially placed along a 2,000 foot-length of the Dead Neck shoreline, starting at the West Bay inlet. This

resulted in an average fill volume of 95 cubic yards per foot of shoreline. In 2000, the fill was supplemented with an additional 25,100 cubic yards of sand, placed over the easternmost 1,000 feet of the island. The total volume of sand for the 1999-2000 nourishment project was therefore 212,400 cubic yards.

Monitoring of this nourishment is an ongoing effort. As of winter 2005, five cross-shore and three GPS surveys have been performed on Dead Neck. The following sections present an analysis of the survey data, and performance of the 1999 fill to date.

2. GPS Shoreline Surveys

Annual monitoring of the Dead Neck shoreline was started in November of 2002. Along-shore shoreline surveys are performed as an adjunct to the cross-shore profile surveys. GPS shoreline surveys are a relatively easy method to monitor shoreline trends between measured cross-shore survey transects and also well beyond the alongshore limits of the 1999 beach fill. These surveys are carried out using a Trimble DGPS unit carried in a purpose-built backpack (Figure 1). As the surveyor walks along the Mean High Water (MHW) line of the beach, position data are collected at one-second intervals and recorded in a hand-held data logger. After the survey, the data are uploaded to a desktop PC and imported into a shoreline analysis extension created for the ESRI ARC-MAP GIS software program.



Figure 1. Collecting Dead Neck shoreline position data using a Trimble Backpack DGPS unit.

At the time of the first shoreline survey in November 2002, the filled beach profile already had eroded noticeably. This was made most evident by the steep scarp-face of the filled area and also by the failure of sections of sand fencing that had been placed on the crest of the fill at the time of the nourishment (Figure 2). By the time of the October 2004 survey, most of the sand fencing was gone, though the scarp face remained.



Figure 2. At the time of the November 2002 shoreline survey of Dead Neck, sand fencing set-up in the nourishment area had begun to fail due to erosion of the beach fill.

Plots showing the three measured shorelines overlaid on 1994 aerial photographs are presented in Figures 3 and 4, for the western end (Sampsons Island) and Eastern end (the nourishment area) of Dead Neck, respectively. In Figure 3, it can be seen clearly that since the time of the 1994 photographs, the westernmost 1,000 feet of the island have been accretional. The greatest area of accretion is at the western tip. Between 1994 and 2002 the Sampsons Island spit grew approximately 50 feet into Cotuit Bay Inlet. Since 2002, the spit has grown another 20 feet, for a total spit growth of 70 feet over ten years.

Some lengths of shoreline in the Samsons Island area of Dead Neck are clearly erosional, even within the two-year span of available shoreline survey data. Recently, the greatest shoreline erosion has occurred at a section of shoreline that is about 1,750 feet from the inlet to Cotuit Bay. Another section about 2,500 feet from the inlet has eroded more than 60 feet since 1994. However, since the 2002 shoreline survey there has been much less change in the position of the shoreline.

In the shoreline plot of the eastern end of Dead Neck, there is a dramatic difference between the recent shorelines and that of the 1994 photo, of course due to the placement of the 1999 nourishment. The 2002 shoreline is approximately 120 feet seaward of the 1994 shoreline. Between 2002 and 2004 the shoreline had receded about 45 feet. All of the shorelines converge at a spot that is about 2,400 feet west of the West Bay inlet. The area loss along this 2,400 foot length of shoreline is 1.6 acres between 2002 and 2004.

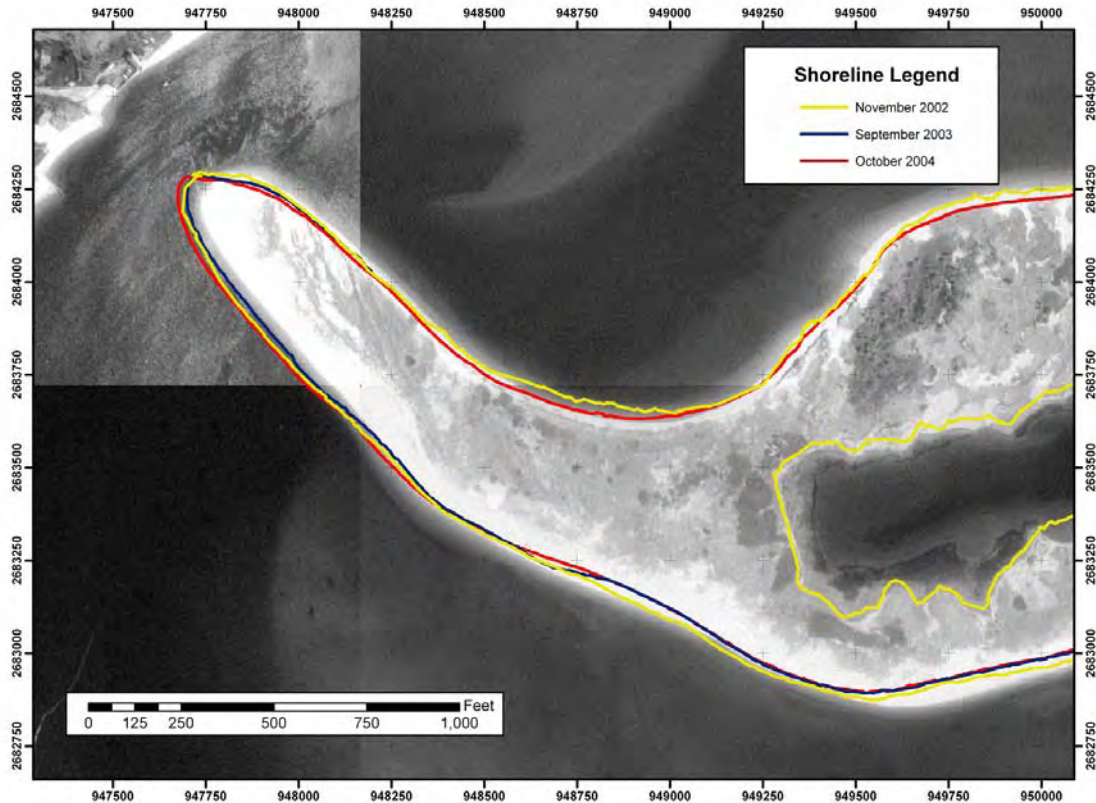


Figure 3. Measured GPS shorelines overlaid on a composite 1994 aerial orthophoto (MassGIS, 2005) of the Sampsons Island region of Dead Neck. Cotuit Inlet is seen in the upper left portion of the photo. Positions are given in Massachusetts State Plane (NAD83, feet).

On the Seapuit River shoreline of Dead Neck, the 2002 line shows that there are areas of accretion compared to the 1994 aerial photo. This accretional area is likely due to wave overwash from the Nantucket Sound side of the island, and may have occurred prior to the 1999 nourishment. An area 500 feet west of the inlet has the greatest accretion since 1994, where the shoreline has expanded approximately 100 feet into the river.

Shoreline erosion rates were computed for the entire seaward shoreline of Dead Neck. The 2002 and 2004 shorelines were used for this analysis. These two survey years were chosen because the change rates resulting from the shoreline analysis are likely more representative of longer term rates, as opposed to the shorter one-year periods that are possible using the 2003 shoreline. The results of the change analysis are presented in Figure 5 and 6.

In Figure 5, shoreline erosion rates are indicated by color bars along the Dead Neck shoreline. For the whole seaward facing shoreline the maximum erosion rate was computed to be -23.4 feet per year (ft/yr). This maximum rate occurred about 1100 feet west of the West Bay Inlet. The average change rate over the 2,000 foot length of the 1999 nourishment was -17.0 feet during this period. At the western end of Dead Neck, the westernmost 1,000 feet of shoreline from Cotuit Inlet was accretional, with an average change rate of +4.9 ft/yr.

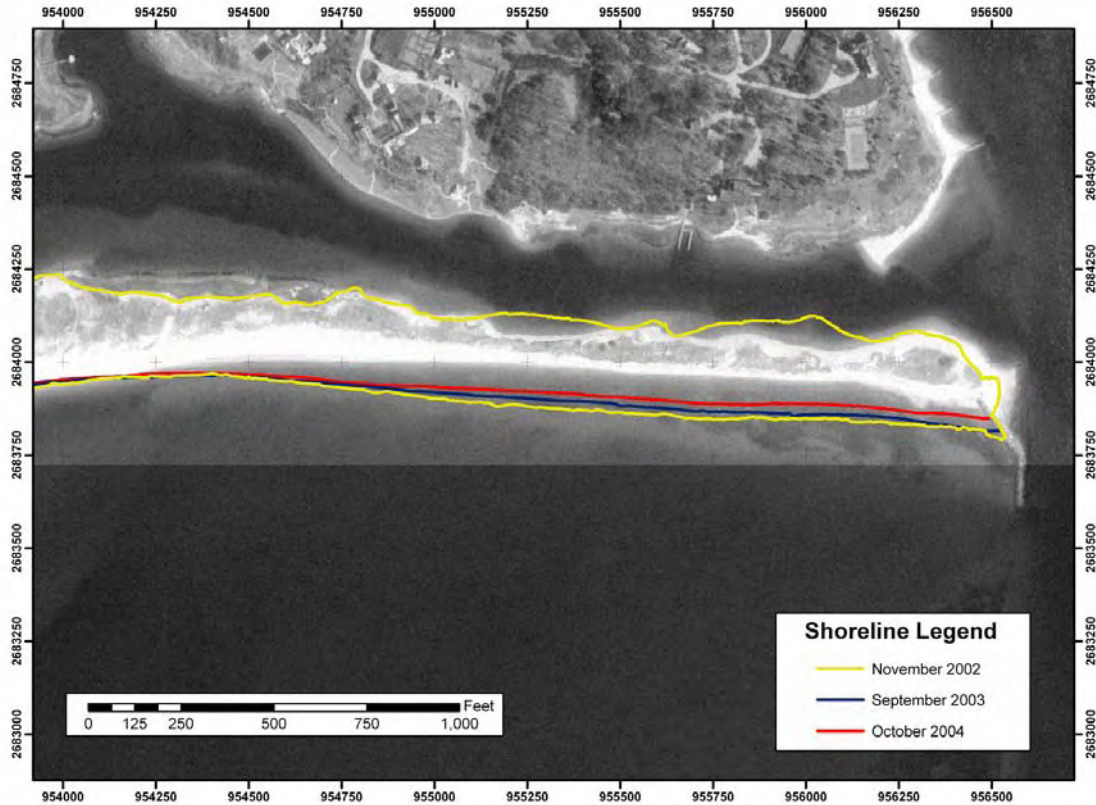


Figure 4. Measured GPS shorelines overlaid on a composite 1994 aerial orthophoto (MassGIS, 2005) of the eastern end of Dead Neck. West Bay Inlet and its western jetty are seen in the right side of the photo. Positions are given in Massachusetts State Plane (NAD83, feet).

Shoreline change statistics for the entire Dead Neck shoreline are presented in Figure 6. In this figure, a histogram plot of shoreline change rates shows the frequency distribution of rates for the entire seaward shoreline. Between 2002 and 2004, the mean change rate was -6.5 ft/yr, indicating that on average, the Dead Neck shoreline was erosional. These results are based on 103 total shore-normal computational transects spaced 90 feet along the shoreline.

3. Cross-shore Profile Surveys

Cross-shore profile surveying of the Dead Neck shoreline has been the principal method of monitoring the performance of both the 1985 and 1999 nourishments. In contrast to the more recent GPS monitoring efforts, cross-shore surveys have been limited to the easternmost 2,400 feet of Dead Neck. For the 1985 nourishment, profiles were measured semi-annually up to 1993. Since the completion of the 1999 nourishment, profiles generally have been surveyed annually. No survey was performed in 2003.

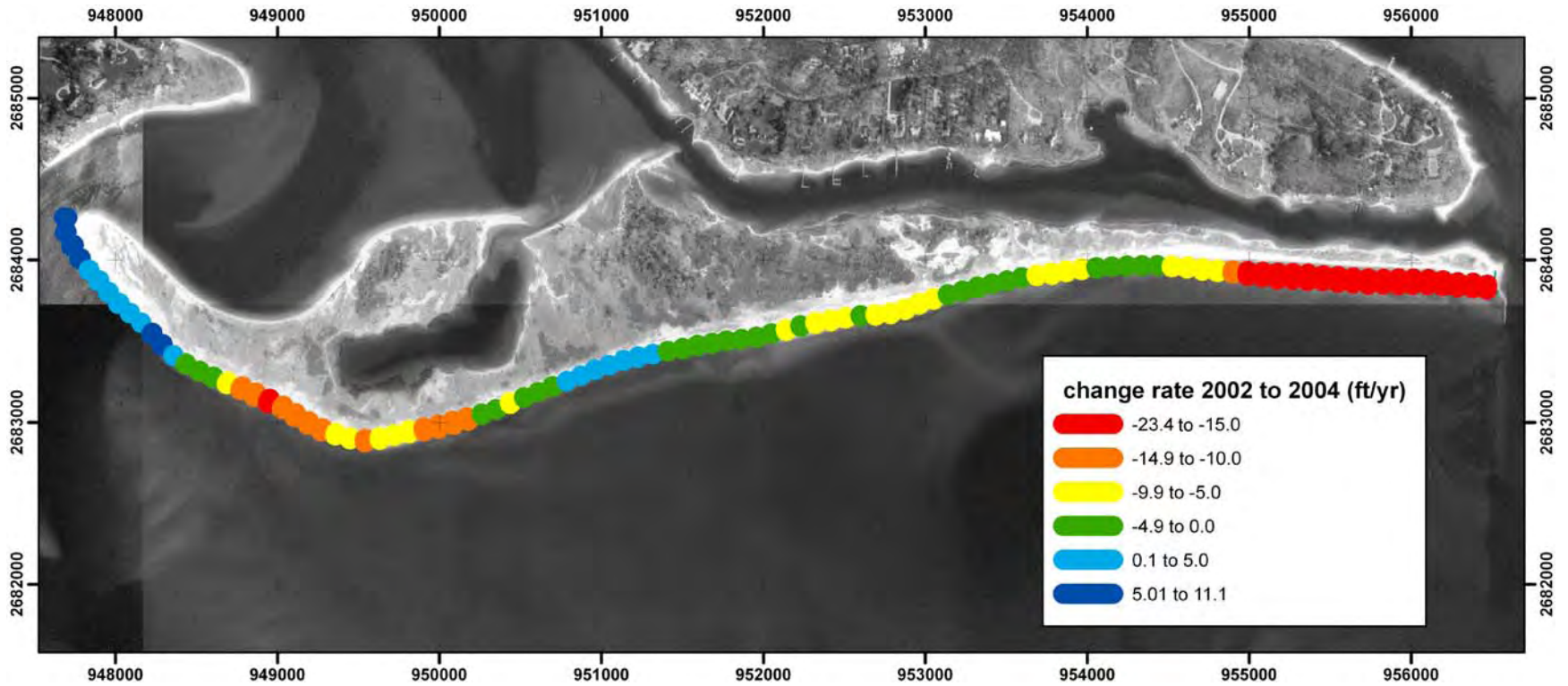


Figure 5. Results of shoreline change analysis using the 2002 and 2004 GPS shorelines. Color bars indicate a range of shoreline change computed along Dead Neck. Negative rates indicate erosion, and are represented by the colors green, yellow, orange and red. Areas of accreting shoreline are indicated by light and dark blue.

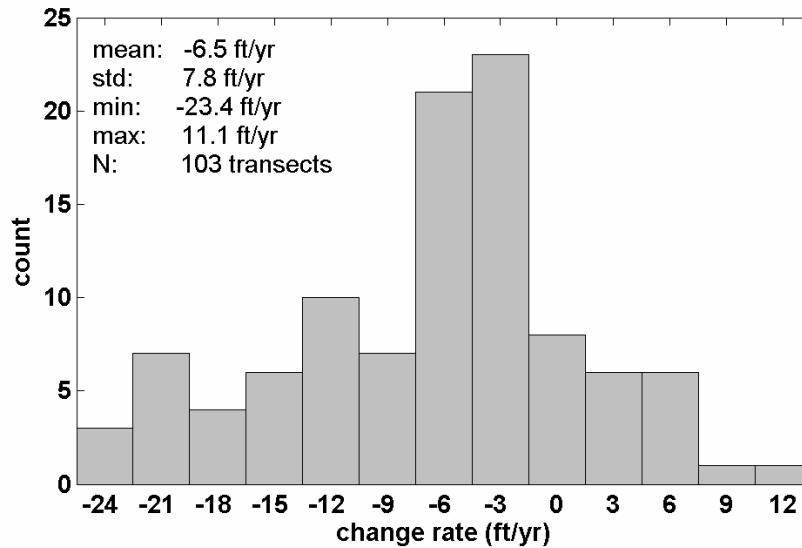


Figure 6. Histogram plot of annualized shoreline change rates between 2002 and 2004 GPS shorelines. Rates were computed along the entire seaward shoreline of Dead Neck, determined using a total of 103 shoreline transects, spaced 90 feet apart.

The particulars of each profile survey are presented in Table 1. Up until the 2004 survey, profiles were measured by CapeSurv at 100 foot intervals, and to a distance offshore limited by the wading depth of a person. In September 2004, 200-foot transect spacings were used by the surveyor, GBA. For this latest survey, the land-based profile survey was supplemented with a boat-based bathymetry survey. The boat extended the land survey seaward approximately 2,800 feet from the survey baseline by following the same transect lines of the land survey. The boat and land surveys overlapped near the shoreline, so the result was continuous cross-shore profile measurements that extend far offshore to depth of approximately -8 ft MLW.

Table 1. Available Dead Neck cross-shore survey data sets, since the 1999 nourishment. Station 24+00 is 2,400 feet from west of West Bay inlet, along the survey baseline.		
Survey	Shoreline coverage (stations)	Transect spacing
construction template	00+00 to 20+00	100 ft
pre-nourishment	00+00 to 14+00	100 ft
March 1999, post	00+00 to 20+00	100 ft
May 2000	00+00 to 24+00	100 ft
April 2001	00+00 to 24+00	100 ft
March 2002	00+00 to 24+00	100 ft
September 2004	00+00 to 24+00	200 ft

Plots of the profile data from the data listed in Table 1 are presented in the Appendix of this report. The construction template, pre-nourishment template and March 1999 survey profile data were digitized from plans created by GBA (1999). All other profile data sets were available in processed tabular formats.

Using the available profile data, volume change rates were computed along the length of the 1999 nourishment, between stations 00+00 (at West Bay inlet) and 20+00 (2,000 feet west of West Bay inlet). The results of these computations are shown in Figure 7. In this plot, the first three survey periods indicate accretion at the east end of Dead Neck. This accretion is due to the addition of 25,100 cubic yards of dredged sand in early 2000 on the first 1,000 feet of the beach (i.e., between stations 00+00 and 10+00).

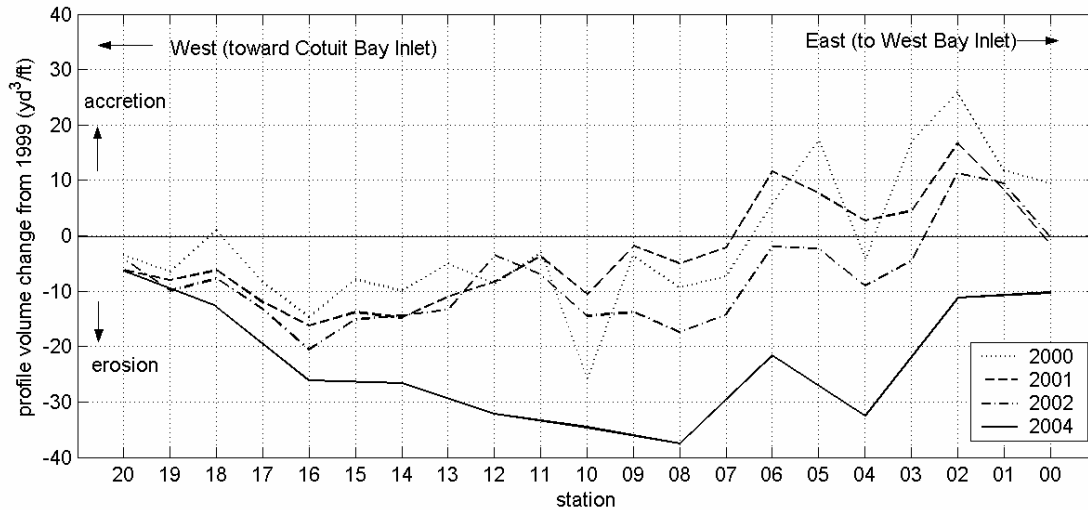


Figure 7. Profile volume loss from the 1999 measured profiles computed for each cross-shore survey transect in the nourishment area. The 2004 results are based on 200-ft transect spacings, while all other years' results are based on 100-ft transect spacing.

By September 2004, all profiles were indicating volume loss. The greatest volume loss had occurred in the vicinity of Station 08+00, where nearly 40 cubic yards per foot length of beach (yd^3/ft) of fill material had been lost from the profile. Volume losses are smaller at both ends of the nourishment. At the east end of the nourishment, losses are likely mitigated due to the availability of sand from the updrift (eastern) portion of the nourishment area. At the eastern end, volume losses only appear to be less than toward the center of the nourishment, again due to the additional 25,100 yd^3 of sand placed on this end of the beach in early 2000.

From the profile volume computations, the total nourishment volume remaining within the nourishment template area (stations 00+00 to 20+00) at the time of each profile survey can be determined. Figure 8 presents the nourishment volume remaining as a function of time. By this volume loss determination, and knowing that the total nourishment volume was 212,400 cubic yards, the percent remaining of the original volume is computed to be 64%. Expressed in another way, 36% of the fill volume has been lost from the nourishment area over the last five years. At the time of the September 2004 survey, there were 137,000 yd^3 of sand remaining.

Finally, the total volume loss rate for the nourishment between each cross-shore pile survey is presented in Table 2. The volume loss rate is shown to vary over time, with the maximum rate occurring in the first year after the nourishment. This is expected as the nourishment template profile equilibrated during this initial period. Over the approximate five-year period since the bulk of the 1999 nourishment was completed, the average rate of volume loss has been $-13,700 \text{ yd}^3/\text{yr}$.

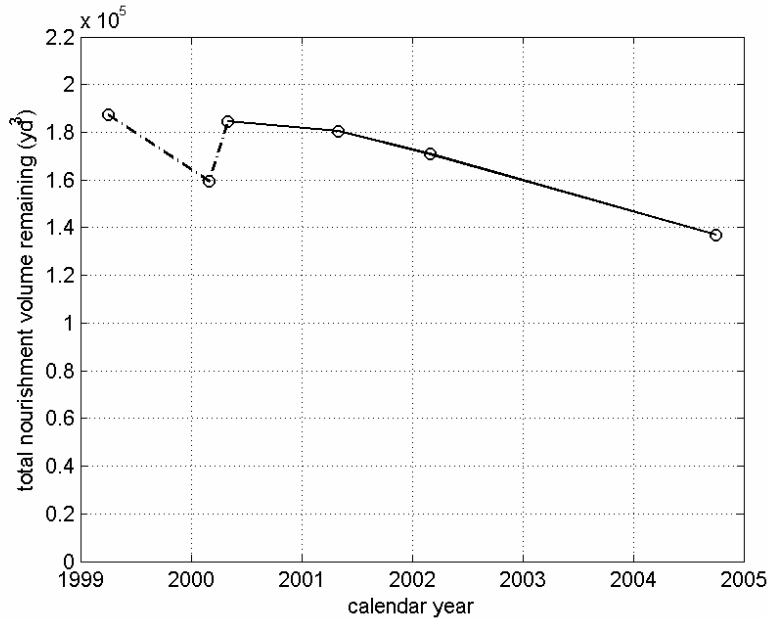


Figure 8. Volume of the Dead Neck nourishment remaining as a function of time. The first point is the nourishment volume as completed in 1999. The second point indicates the total volume of the nourishment before the addition of 25,100 cubic yards of sand in winter 2000.

Table 2. Total volume loss and resulting volume loss rate for the 1999 Dead Neck nourishment, between surveys and for the entire span of time between 1999 and 2004.

period	net volume loss (cu yd)	volume loss rate (cu yd/yr)
1999 to 2000 ^a	-27,900	-30,400
2000 to 2001 ^b	-4,000	-4,000
2001 to 2002	-9,600	-11,500
2002 to 2004	-33,900	-13,100
1999 to 2004	-75,400	-13,700

^a to just prior to addition of 25,100 cubic yards in winter 2000
^b from just after the completion of the nourishment in 2000

3. References

Gahagen and Bryant Associates (1999). "West Bay and Cotuit Bay Dredging, Dead Neck Beach Nourishment". Cross-section plan.

Wood, Jon D., John S. Ramsey, and Lee L. Weishar (1996). "Beach Nourishment Along Nantucket Sound: A Tale of Two Beaches." Proceedings of the 9th Annual National Conference on Beach Preservation Technology. Florida Shore and Beach Preservation Association.

Woods Hole Group (2001). "2000 Annual Survey of Dead Neck Barrier Island". Technical report.

Appendix: Cross Shore Profile Plots

