Periodic Survey Evaluation: Ocean View Beach

Presented to:

City of Norfolk

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1. Executive Summary

In September 2012 Geodynamics, LLC conducted the fourteenth survey of the Ocean View shoreline. The study area extends from the western end of Willoughby Spit to the western edge of the Little Creek Inlet in East Ocean View. The periodic surveys are collected bi-annually in March/April and September/October to assess the condition of the shoreline and the state of existing shore protection projects. A baseline and transects were established with the first survey in September 2005 and have been used for each subsequent survey. Shoreline changes at Mean High Water (MHW) and volumetric changes above 0 ft NAVD88 and -15 ft NAVD88 are calculated at each transect. Differences in the region above 0 ft NAVD88 are indicative of changes to the dune and subaerial beach berm, while the differences above -15 ft NAVD88 indicate changes in the nearshore zone. Comparison of seasonal surveys (i.e. October 2011 to September 2012) eliminates seasonal variation of profiles in volumetric change analyses. Consecutive survey comparisons are useful to assess the direct impact of extreme events which may occur during the six month period between surveys. This report documents the data sources, methods, and results of a periodic surveying evaluation performed to compare the September 2012 survey data with previous surveys taken in October 2011 (fall to fall comparison) and March 2012 (most recent periodic survey comparison) in the Ocean View Beach area between Willoughby Spit and Little Creek Inlet.

Comparison	Parameter	Quantity
October 2011 vs. September 2012	Average Shoreline Change Rate at MHW (+0.98 ft NAVD88)	-1.98 ft/yr
	Cumulative Volume Change Rate Above 0 ft NAVD88	7,553 cy/yr
	Cumulative Volume Change Rate Above -15 ft NAVD88	-6,796 cy/yr
March 2012 vs. September 2012	Average Shoreline Change at MHW (+0.98 ft NAVD88)	-1.60 ft
	Cumulative Volume Change Above 0 ft NAVD88	-513 cy
	Cumulative Volume Change Above -15 ft NAVD88	-92,952 cy

The average shoreline change rate for the entire shoreline at MHW between the October 2011 and September 2012 surveys was -1.98 ft/yr, and the cumulative volume change above 0 ft NAVD88 was approximately 7,553 cy/yr. This indicates an overall volumetric gain in the dune and subaerial beach over the past year. The overall loss above -15 ft NAVD88 of -6,796 cy/yr indicates that while there were gains on the dune and subaerial beach, there was sediment loss across the nearshore system. The most recent period of comparison, from the March 2012 survey to the September 2012 survey depicts losses at the MHW line and significant sediment losses to the nearshore system.

While overall the shoreline showed losses for the year, there was variability within the various regions. The Willoughby Spit region shoreline has returned to a more typical state following the impacts of Hurricane Irene in August 2011. The most significant gains over the year occurred adjacent to the terminal groin and while portions of this area showed losses during the most recent survey period, as sediment moved offshore out of the system, some recovery of the dune system occurred.

In the 800 Block region, the previously detached tombolo has begun to form again and cut off sand to the downdrift areas. The relocation of this breakwater where this tombolo forms, as part of the Willoughby Spit Shoreline Improvement Project, is expected to permanently decrease the potential for tombolo formation at this location.

The patterns of sediment gains/losses in the West Ocean View region are related to the shoreline returning to equilibrium following Hurricane Irene in August 2011. The most recent period shows erosion being more severe offshore at the east end of the region. This area is closest to the 800 Block Breakwaters and the changes with the tombolo detachment and attachment may have an effect on this section of shoreline.

The Central Ocean View Breakwaters region showed gains in the MHW shoreline position as well as gains in sediment volume over the year. The smaller gains in volume above 0 feet NAVD88 in the most recent survey period, March 2012 to September 2012, indicate that majority of the gains occurred during the winter season, which is likely due to recovery from Hurricane Irene in August 2011.

Similar to the adjacent region, Central Ocean View has experienced an increase at the MHW shoreline and volumetric gains in sediment over the past year. The majority of the volumetric gain occurred during the period from October 2011 to March 2012 and is likely due to post-storm recovery.

As expected, due to the direction of sediment movement, there were continued volume losses to the beach in the East Ocean View region between the October 2011 and September 2012 period. During the most recent period there were increased losses overall; however, the dune and subaerial beach showed gains as compared to the overall year which is indicative of post-hurricane recovery. The east end of the region, adjacent to the jetty, is more erosive than most areas west in this region due to the lack of a sediment source. The profiles have a fairly steady pattern of accretion on the profiles landward of the breakwaters and erosion on the profiles between the breakwaters showing the influence of the breakwaters on decreasing the wave heights and retaining sediment along the shore.

In addition to regional assessments, comparison of the September 2012 survey was made against post-fill surveys from the East Ocean View beach nourishment and Willoughby Spit to Central Ocean View dune restoration which took place in March 2009 and January-March 2005 respectively.

Comparison	Average Shoreline Change	Average Volume Change Above 0 ft NAVD88	Cumulative Volume Change Above 0 ft NAVD88	Average Volume Change Above -15 ft NAVD88	Cumulative Volume Change Above -15 ft NAVD88
East Ocean View Nourishment vs. September 2012 Comparison	-4.26 ft	-14.98 cy/ft	-74,884 cy	-25.93 cy/ft	-134,607 cy
Central Ocean View Nourishment vs. September 2012 Comparison	-4.07 ft	-11.73 cy/ft	-217,462 cy	-10.80 cy/ft	-193,219 cy

The two design projects underway for the Willoughby Spit region and the West Ocean View region will help alleviate the concerns with these hot spots and provide additional protection in vulnerable areas; however, there are still other areas that may require nourishment to provide adequate storm protection.

The approximately 77,900 cy volumetric loss above 0 ft NAVD88 from the East Ocean View project is approximately 70% of the original amount placed in this dune and subaerial beach area. The

approximately 217,500 cy loss above 0 ft NAVD88 in the Central Ocean View project area is approximately 68% of the original amount placed above 0 ft NAVD88. Due to storm impacts and background erosion that has occurred, as anticipated, over the projects' design life, there are areas in both of these shoreline regions that should be targeted for nourishment. The East Ocean View project is likely to require a renourishment in the next two to three years.

2. Objective

The City of Norfolk, Virginia has maintained a program of periodic surveying of the Ocean View shoreline since 2005. The periodic surveying data collection dates are shown in Table 2-1. This report documents the data sources, methods, and results of a periodic surveying evaluation performed to compare the September 2012 survey data with previous surveys taken in October 2011 (fall to fall comparison) and March 2012 (most recent periodic survey comparison) in the Ocean View Beach area between Willoughby Spit and Little Creek Inlet. In addition, comparison of the most recent survey (September 2012) was made to pre-fill and post-fill surveys from the Central Ocean View beach nourishment project that took place in January-March 2005 and the East Ocean View beach nourishment project that was most recently renourished in March 2009.

Table 2-1: Surveyors and Collection Dates

Data Collection Date	Surveyor
September 2005	McKim & Creed
March 2006	McKim & Creed
October 2006	McKim & Creed
March 2007	McKim & Creed
October 2007	McKim & Creed
March 2008	McKim & Creed
October 2008	McKim & Creed
April 2009	McKim & Creed
October 2009	Geodynamics, LLC
March 2010	Geodynamics, LLC
October 2010	Geodynamics, LLC
April 2011	Geodynamics, LLC
October 2011	Geodynamics, LLC
March 2012	Geodynamics, LLC
September 2012	Geodynamics, LLC

3. Data Sources

Geodynamics, LLC, conducted the most recent survey of Ocean View Beach in September 2012. The baseline and transects established for the September 2005 survey were used for the most recent survey. Figure 3-1 shows the location of the baseline, transects and the stationing applied by Geodynamics for the surveying. As shown Figure 3-1, transects were stationed from west to east along the Ocean View shoreline. The survey data were provided in xyz and shapefile formats allowing for compatibility with multiple programs.

Geodynamics noted that typical survey accuracy along the hydrographic portions of the profiles is approximately ±1 cm. This 'margin of error', if applied over the entire length of the hydrographic profiles can potentially result in significant volumetric differences, in particular on the shallow and long profiles near Willoughby Spit. Therefore, volumetric changes discussed herein are analyzed with regard to potential volumetric margins of error.

Also in September 2012, the Virginia Institute of Marine Science (VIMS) flew aerial photography of the Ocean View shoreline, georectified the images, and digitized a shoreline position from the images. The September 2012 aerial photos with the digitized shoreline position are presented in Appendix A. Since these photos cover a limited portion of area landward and seaward of the shoreline, a previous image (2009) is underlain, for presentation purposes.

Pre- and post-fill survey data from the East Ocean View beach nourishment, collected in June 2003 and March 2009, respectively, were used as baseline data for assessing the current state of that nourishment project. Similarly, pre- and post-fill survey data from the Willoughby Spit to Central Ocean View dune restoration were utilized; these surveys were collected in December 2004 – February 2005 and March 2005, respectively. Pre-fill and post-fill data were available in xyz format from previous studies of these projects by Moffatt & Nichol.

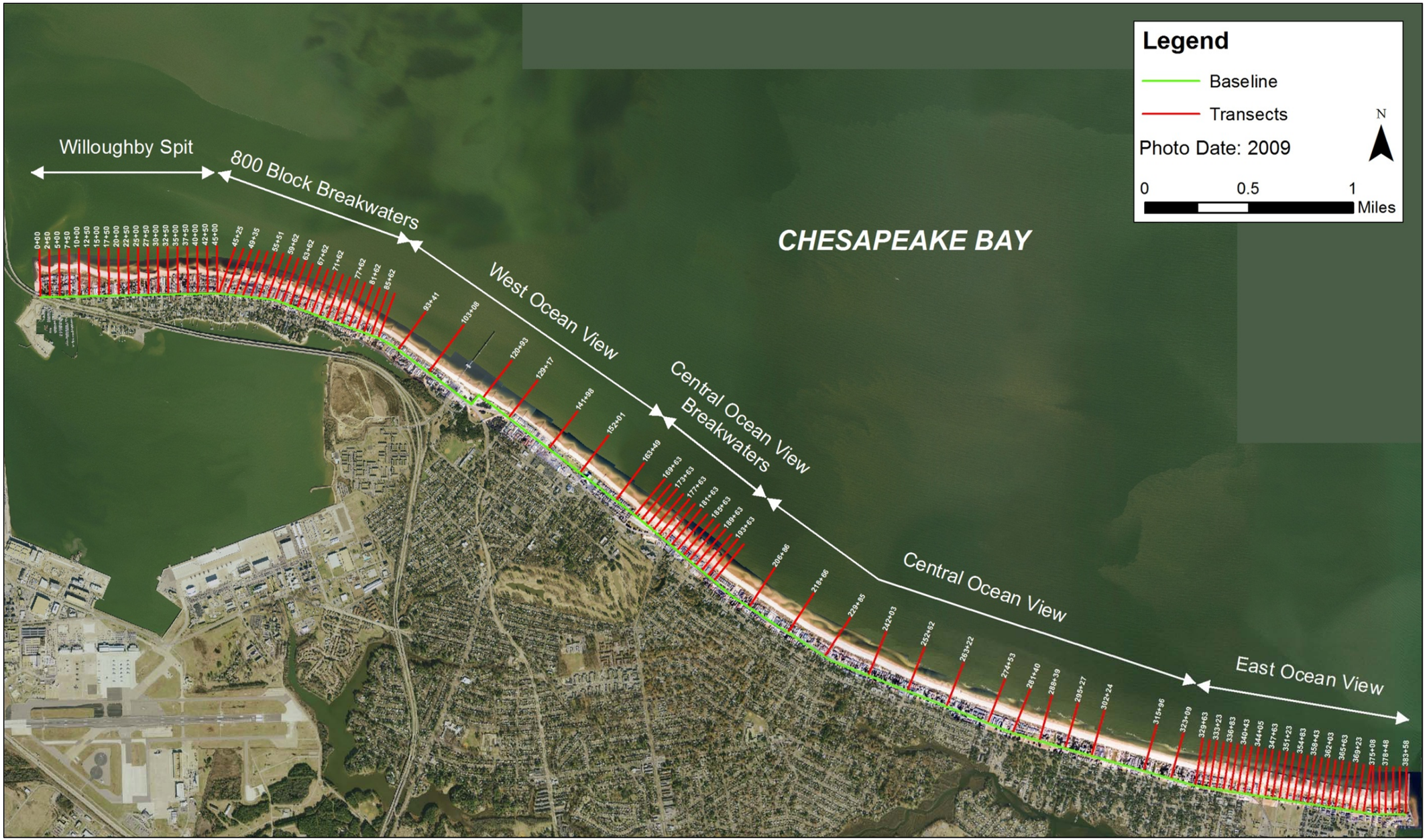

Figure 3-1: Survey Baseline and Transects

4. Methods

Survey comparisons and respective analysis were performed using a combination of Autodesk Civil 3D 2010 (Civil 3D), Microsoft Excel (Excel), Surfer and the USACE's Beach Morphology Analysis Package (BMAP). Civil 3D is an AutoCAD based program which allows the user to create and analyze Digital Terrain Models (DTMs). Surfer is a contouring and 3D surface mapping program utilized to create 3D surfaces for analysis. BMAP is a program developed by the USACE to analyze morphologic and dynamic properties of beach profiles.

All pertinent survey data were imported into Civil 3D in xyz format. The horizontal coordinate system used was Virginia South State Plane NAD 1983 (HARN), US Survey feet with a vertical datum of NAVD88. DTMs were created for each set of survey data, and a beach profile was extracted at each survey transect in station-elevation format. Individual profile plates showing the extracted profile at each transect for each date are presented in Appendix B. From the profiles, shoreline change and volumetric change were then calculated at each transect for the following time periods:

1. October 2011 to September 2012 (Entire Shoreline)
2. March 2012 to September 2012 (Entire Shoreline)
3. March 2009 (East Ocean View post-fill) to September 2012 (Sta 329+63 through Sta 383+58)
4. March 2005 (Central Ocean View post-fill) to September 2012 (Sta 15+00 through Sta 195+63)
5. December 2004-February 2005 (Central Ocean View pre-fill) to September 2012 (Sta 15+00 through Sta 195+63)

First, the change in shoreline position at mean high water (MHW) was calculated at each transect for each time period mentioned. MHW along Ocean View beaches is defined as +0.98 ft NAVD88 based on NOAA tidal benchmark at Sewells Point. The resulting value represents the shoreline change (ft) over the time period between surveys. The shoreline change rate (ft/yr) was then calculated by dividing by the amount of time between survey dates.

Representative volume changes were also calculated at each transect for all time periods. Volume changes were calculated for two different extents in order to better understand the processes occurring onshore and offshore of the Ocean View beach area. Calculations included volume change above -15 ft NAVD88 and volume change above 0 ft NAVD88. The results represent volume change per linear foot of shoreline (cy/ft) over the period of time between surveys. The volume change rate (cy/ft/yr) was then calculated by dividing by the amount of time between survey dates. In addition, the volume changes were converted to cumulative changes over the entire shoreline. This was done by applying the average end area method to the unit volume changes (cy/ft) and unit volume change rates (cy/ft/yr) computed at each transect and summing the total volume changes over the entire shoreline. The resulting value indicated the total loss or gain of material between surveys based on the applicable profile extents.

Volume changes calculated for portions of the profiles above 0 ft NAVD88 are representative of changes in the amount of material in the dune system and on the subaerial beach. These areas are highly influenced by the performance of coastal structures and the impact of storm activity.

5. Discussion of Periodic Surveying Evaluation

This section discusses differences observed between the noted surveys, overall shoreline trends, regional shoreline trends and the East Ocean View and Central Ocean View nourishment projects. The computed shoreline changes and volume changes at each individual transect for the time periods covered are tabulated in Appendix C.

5.1. Differences in Survey Comparisons

Profile variations in the surveys taken as part of the ongoing program of periodic surveying of the Ocean View shoreline (October 2011, March 2012 and September 2012) were minimal in the topographic portion of the survey due to use of the same baseline and transects put in place for the initial survey in September 2005. Profile extents and alignment were virtually the same when comparing the survey data. The only discrepancy which impacted calculations was the vertical margin of error in the hydrographic portion of the survey as mentioned in Section 3.

The pre-fill and post-fill surveys taken for the East Ocean View and Central Ocean View nourishment projects did not use the same baseline and transects or cover the same extents as the periodic surveys. Therefore, the profiles extracted from the DTMs in Civil 3D at the periodic surveying transects are interpolations between the actual pre- and post-fill data points. In addition, the surveys did not extend as far offshore as the periodic surveys, limiting computations and the ability to track the offshore movement of sand.

5.2. General Shoreline Trends

Key statistics were calculated to describe the average shoreline and volume changes over the entire shoreline as well as for each region of the shoreline as defined in Figure 3-1. The computed statistics include average shoreline change, average volume change, and cumulative volume change (e.g. total volume of material lost or gained along a section of shoreline). A summary of the resulting statistics for the October 2011 to September 2012 comparison are presented in Table 5-1. A summary of the resulting statistics for the March 2012 to September 2012 comparison are presented in Table 5-2. Evaluation of the computed statistics took into account volume changes computed for portions of the profile above 0 ft NAVD88 and above -15 ft NAVD88 in order to better understand onshore and offshore processes.

According to Table 5-1, the Ocean View shoreline has experienced overall losses at MHW over the past year. Most of this erosion occurred during the most recent survey period, as shown in Table 5-2. Hurricane Irene impacted the shoreline in August 2011 so recovery, and increases in sediment, would be expected in the months immediately following the storm. Once recovery occurred the shoreline appears to have suffered increased erosion.

While the overall trends over the past year are erosional, patterns vary within each region of the shoreline as defined in Figure 3-1. The calculated statistics with respect to each region will be discussed in more detail in the following section.

Table 5-1: Regional Shoreline and Volume Change Statistics (October 2011 to September 2012)

Region	Average Shoreline Change	Average Volume Change Rate Above 0 ft NAVD88	Cumulative Volume Change Rate Above 0 ft NAVD88	Average Volume Change Rate Above -15 ft NAVD88	Cumulative Volume Change Rate Above -15 ft NAVD88
	(ft/yr)	(cy/ft/yr)	(cy/yr)	(cy/ft/yr)	(cy/yr)
Willoughby Spit (0+00 to 45+00)	4.73	-1.78	-8,795	4.11	19,201
800 Block Breakwaters (45+25 to 87+62)	-2.63	-1.41	-6,275	-0.18	-531
West Ocean View (93+41 to 163+49)	-0.73	-0.80	-4,176	-2.49	-15,601
Central Ocean View Breakwaters (169+63 to 195+63)	1.02	0.98	5,357	2.52	10,887
Central Ocean View (206+86 to 323+09)	5.26	2.79	34,919	0.44	2,432
East Ocean View (329+63 to 383+58)	-26.06	-2.19	-13,478	-3.71	-23,186
OVERALL	Weighted Average (ft/yr)	Weighted Average (cy/ft/yr)	Total (cy/yr)	Weighted Average (cy/ft/yr)	Total (cy/yr)
	-1.98	0.14	7,553	-0.21	-6,796

Table 5-2: Regional Shoreline and Volume Change Statistics (March 2012 to September 2012)

Region	Average Shoreline Change	Average Volume Change Rate Above 0 ft NAVD88	Cumulative Volume Change Rate Above 0 ft NAVD88	Average Volume Change Rate Above -15 ft NAVD88	Cumulative Volume Change Rate Above -15 ft NAVD88
	(ft)	(cy/ft)	(cy)	(cy/ft)	(cy)
Willoughby Spit (0+00 to 45+00)	-0.47	-0.94	-4,857	-4.37	-18,596
800 Block Breakwaters (45+25 to 87+62)	-4.48	-0.24	-1,037	-2.54	-11,430
West Ocean View (93+41 to 163+49)	-1.53	-0.35	-2,684	-2.49	-19,808
Central Ocean View Breakwaters (169+63 to 195+63)	0.56	0.36	2,107	-0.37	127
Central Ocean View (206+86 to 323+09)	0.30	1.00	11,685	-1.17	-15,071
East Ocean View (329+63 to 383+58)	-5.78	-0.88	-5,728	-4.58	-28,172
OVERALL	Weighted Average (ft)	Weighted Average (cy/ft)	Total (cy)	Weighted Average (cy/ft)	Total (cy)
	-1.60	0.02	-513	-2.41	-92,952

5.3. Regional Shoreline Trends

Regional shoreline trends are discussed below for the defined regions between Willoughby Spit and Little Creek Inlet (see Figure 3-1). A summary of the information in Table 5-1 and Table 5-2 has

been created for each region of study. Figure 5-1 through Figure 5-4, following the discussion of regional shoreline trends, present the shoreline and volume change at each transect within the defined regions.

5.3.1. Willoughby Spit

The Willoughby Spit region (Sta 0+00 to Sta 45+00) includes two offshore breakwaters, timber groins and has historically been a stable and accreting region. A summary of average shoreline and volume change rates for the Willoughby Spit region between October 2011 and September 2012 and between March 2012 and September 2012 are presented in Table 5-3.

Table 5-3: Average Shoreline and Volume Change Rates for Willoughby Spit

Region	Average Shoreline Change	Average Volume Change Above 0 ft NAVD88	Cumulative Volume Change Above 0 ft NAVD88	Average Volume Change Above -15 ft NAVD88	Cumulative Volume Change Above -15 ft NAVD88
October 2011 vs. September 2012 Comparison					
Willoughby Spit (0+00 to 45+00)	(ft/yr)	(cy/ft/yr)	(cy/yr)	(cy/ft/yr)	(cy/yr)
	4.73	-1.78	-8,795	4.11	19,201
March 2012 vs. September 2012 Comparison					
Willoughby Spit (0+00 to 45+00)	(ft)	(cy/ft)	(cy)	(cy/ft)	(cy)
	-0.47	-0.94	-4,857	-4.37	-18,596

The information depicted in Table 5-3 shows the influence of the recent storm events on this region over the last year. For the year between the spring surveys (April 2011 and March 2012), this region experienced an average shoreline change rate of 4.73 ft/yr at MHW while showing an overall gain of sediment to the system. There were losses above 0 ft NAVD88 on the dune and subaerial beach, with the majority of sediment gain occurring between -15 ft NAVD88 and 0 ft NAVD88. Hurricane Irene impacted the shoreline in August 2011 and gains in the system in the period immediately following the storm are expected as the system recovers. While the year-long comparison shows gains, the loss of sediment in the most recent period is indicative of the shoreline returning to a more typical state of equilibrium once storm recovery had been completed. The most significant gains over the year occurred adjacent to the terminal groin as shown in Figure 5-2. While portions of this area showed losses during the most recent survey period, as sediment moved offshore out of the system, some recovery of the dune system occurred, as depicted in Figure 5-4.

5.3.2. 800 Block Breakwaters

The 800 Block Breakwaters region (Sta 45+25 to Sta 87+62) is characterized by a field of eight breakwaters. The easternmost breakwater was built in February 2006 along with removal of the pre-existing groin spur and toe extension. This new breakwater was built further offshore since the previous structural configuration caused the beach to fill out and impair natural sediment transport to the west. A summary of average shoreline and volume change rates for the 800 Block Breakwaters region between October 2011 and September 2012 and between March 2012 and September 2012 are presented in Table 5-4.

Table 5-4: Average Shoreline and Volume Change Rates for 800 Block Breakwaters

Region	Average Shoreline Change	Average Volume Change Above 0 ft NAVD88	Cumulative Volume Change Above 0 ft NAVD88	Average Volume Change Above -15 ft NAVD88	Cumulative Volume Change Above -15 ft NAVD88
October 2011 vs. September 2012 Comparison					
800 Block Breakwaters (45+25 to 87+62)	(ft/yr)	(cy/ft/yr)	(cy/yr)	(cy/ft/yr)	(cy/yr)
	-2.63	-1.41	-6,275	-0.18	-531
March 2012 vs. September 2012 Comparison					
800 Block Breakwaters (45+25 to 87+62)	(ft)	(cy/ft)	(cy)	(cy/ft)	(cy)
	-4.48	-0.24	-1,037	-2.54	-11,430

A previous borrow area for a 2010 dune restoration project was located landward of the easternmost breakwater. The removal of sediment allowed the tombolo that had formed at this breakwater to become detached. Hurricane Irene in August 2011 further decreased the salient formation. During the most recent period the tombolo has begun to form again and cut off sand to the downdrift areas as evidenced in Figure 5-4. The relocation of this breakwater as part of the Willoughby Spit Shoreline Improvement Project is expected to permanently decrease the potential for formation of a tombolo at this location.

5.3.3. West Ocean View

The West Ocean View area (Sta 93+41 to Sta 163+49), between the 800 Block and Central Ocean View breakwaters, is characterized by a series of timber groins. A summary of average shoreline and volume change rates for the West Ocean View region between October 2011 and September 2012 and between March 2012 and September 2012 are presented in Table 5-5.

Table 5-5: Average Shoreline and Volume Change Rates for West Ocean View

Region	Average Shoreline Change	Average Volume Change Above 0 ft NAVD88	Cumulative Volume Change Above 0 ft NAVD88	Average Volume Change Above -15 ft NAVD88	Cumulative Volume Change Above -15 ft NAVD88
October 2011 vs. September 2012 Comparison					
West Ocean View (93+41 to 163+49)	(ft/yr)	(cy/ft/yr)	(cy/yr)	(cy/ft/yr)	(cy/yr)
	-0.73	-0.80	-4,176	-2.49	-15,601
March 2012 vs. September 2012 Comparison					
West Ocean View (93+41 to 163+49)	(ft)	(cy/ft)	(cy)	(cy/ft)	(cy)
	-1.53	-0.35	-2,684	-2.49	-19,808

The October 2011 to September 2012 survey comparison showed a slight retreat of the MHW shoreline position, with overall volume losses to the system. Immediately updrift of the bulkhead and groin at the 200 Block of Ocean View the shoreline showed a loss of sediment which is characteristic

of the effects of the armoring structures in the area. Also, updrift of the Central Ocean View breakwaters the shoreline showed losses which is indicative of the end effects caused by these structures. The patterns of sediment shift are related to the shoreline returning to equilibrium following Hurricane Irene in August 2011. The most recent period shows erosion more severe offshore at the west end of the region. This area is closest to the 800 Block Breakwaters and the changes with the tombolo detachment and attachment may have an effect on this section of shoreline.

5.3.4. Central Ocean View Breakwaters

The Central Ocean View breakwater region covers the four offshore breakwaters at Central Ocean View and approximately 800 feet westward (Sta 169+63 to Sta 195+63). A summary of average shoreline and volume change rates for the Central Ocean View Breakwaters region between October 2011 and September 2012 and between March 2012 and September 2012 are presented in Table 5-6.

Table 5-6: Average Shoreline and Volume Change Rates for Central Ocean View Breakwaters

Region	Average Shoreline Change	Average Volume Change Above 0 ft NAVD88	Cumulative Volume Change Above 0 ft NAVD88	Average Volume Change Above -15 ft NAVD88	Cumulative Volume Change Above -15 ft NAVD88
October 2011 vs. September 2012 Comparison					
Central Ocean View Breakwaters (169+63 to 195+63)	(ft/yr)	(cy/ft/yr)	(cy/yr)	(cy/ft/yr)	(cy/yr)
	1.02	0.98	5,357	2.52	10,887
March 2012 vs. September 2012 Comparison					
Central Ocean View Breakwaters (169+63 to 195+63)	(ft)	(cy/ft)	(cy)	(cy/ft)	(cy)
	0.56	0.36	2,107	-0.37	127

The Central Ocean View Breakwaters region showed gains in the MHW shoreline position as well as gains in sediment volume above 0 ft NAVD88 and -15 ft NAVD88 over the year. The smaller gains in volume above 0 feet NAVD88 in the most recent survey period, March 2012 to September 2012, indicate that majority of the gains occurred during the winter season, which is likely due to recovery from Hurricane Irene in August 2011. The end effects of the breakwater field are apparent in the losses at MHW at Sta 175+63 and Sta 177+63 in Figure 5-1 and Figure 5-3 as well as sediment volume losses depicted in Figure 5-2 and Figure 5-4.

5.3.5. Central Ocean View

Central Ocean View (Sta 206+86 to Sta 323+09) is historically a stable region with slight accretion despite the absence of engineering interventions (e.g. beach fill or structures). A summary of average shoreline and volume change rates for the Central Ocean View region between October 2011 and September 2012 and between March 2012 and September 2012 are presented in Table 5-7.

Table 5-7: Average Shoreline and Volume Change Rates for Central Ocean View

Region	Average Shoreline Change	Average Volume Change Above 0 ft NAVD88	Cumulative Volume Change Above 0 ft NAVD88	Average Volume Change Above -15 ft NAVD88	Cumulative Volume Change Above -15 ft NAVD88
October 2011 vs. September 2012 Comparison					
Central Ocean View (206+86 to 323+09)	(ft/yr)	(cy/ft/yr)	(cy/yr)	(cy/ft/yr)	(cy/yr)
	5.26	2.79	34,919	0.44	2,432
March 2012 vs. September 2012 Comparison					
Central Ocean View (206+86 to 323+09)	(ft)	(cy/ft)	(cy)	(cy/ft)	(cy)
	0.30	1.00	11,685	-1.17	-15,071

As shown in Table 5-7, Central Ocean View has experienced an increase at the MHW shoreline and volumetric gains in sediment above 0 ft NAVD88 and -15 ft NAVD88 over the past year. The majority of the volumetric gain occurred during the period from October 2011 to March 2012. This is likely due to sediment that was moved offshore during the hurricane being pushed back onshore during the post-storm recovery. Assessment of Figure 5-2 and Figure 5-4 shows the majority of these gains occurred to the dune and subaerial beach berm above 0 ft NAVD88 which is in agreement with onshore movement of sediment.

5.3.6. East Ocean View

The East Ocean View region (Sta 329+63 to Sta 383+58) is characterized by 15 breakwaters of which the 5 westernmost were built in August of 2009. Prior to the breakwater construction, a beach renourishment project took place in March 2009, adding approximately 196,000 cy of material to the beach. A summary of average shoreline and volume change rates for the East Ocean View region between October 2011 and September 2012 and between March 2012 and September 2012 are presented in Table 5-8.

Table 5-8: Average Shoreline and Volume Change Rates for East Ocean View

Region	Average Shoreline Change	Average Volume Change Above 0 ft NAVD88	Cumulative Volume Change Above 0 ft NAVD88	Average Volume Change Above -15 ft NAVD88	Cumulative Volume Change Above -15 ft NAVD88
October 2011 vs. September 2012 Comparison					
East Ocean View (329+63 to 383+58)	(ft/yr)	(cy/ft/yr)	(cy/yr)	(cy/ft/yr)	(cy/yr)
	-26.06	-2.19	-13,478	-3.71	-23,186
March 2012 vs. September 2012 Comparison					
East Ocean View (329+63 to 383+58)	(ft)	(cy/ft)	(cy)	(cy/ft)	(cy)
	-5.78	-0.88	-5,728	-4.58	-28,172

As expected, due to sediment movement along the shoreline from east to west, there were continued volume losses to the beach in this this region between the October 2011 and September 2012 period. During the most recent period there were increased losses overall; however, the dune and subaerial beach showed gains as compared to the overall year. This is indicative of post-hurricane recovery with some sediment being moved onshore while the typical sediment losses due to sediment transport in the area were still experienced overall. The east end of the region, adjacent to the jetty, is more erosive than most areas west in this region due to the lack of a sediment source and the littoral sediment movement in this region going from east to west. The profiles have a fairly steady pattern of accretion on the profiles landward of the breakwaters and erosion on the profiles between the breakwaters showing the influence of the breakwaters on decreasing the wave heights and retaining sediment along the shore.

End effects of the ten easternmost breakwaters previously caused erosion to the western portion of East Ocean View (Bay Oaks hotspot). The five breakwaters constructed at Bay Oaks in 2009 were designed to help alleviate these end effects and create a more uniform shoreline response. As evidenced in Figure 5-1 and Figure 5-2, the erosion hotspot, which was apparent at the western end of the breakwater field in previous reports, has been adequately filled with new material and the newly constructed breakwaters have performed as expected, decreasing the end effects of the breakwater field on the shoreline. End effects of the breakwaters are apparent with some loss of material downdrift of the breakwater field, as evidenced in Figure 5-4; however, these impacts are likely due to Hurricane Irene, not typical background erosion, as the shoreline experienced less erosion during the most recent survey period.

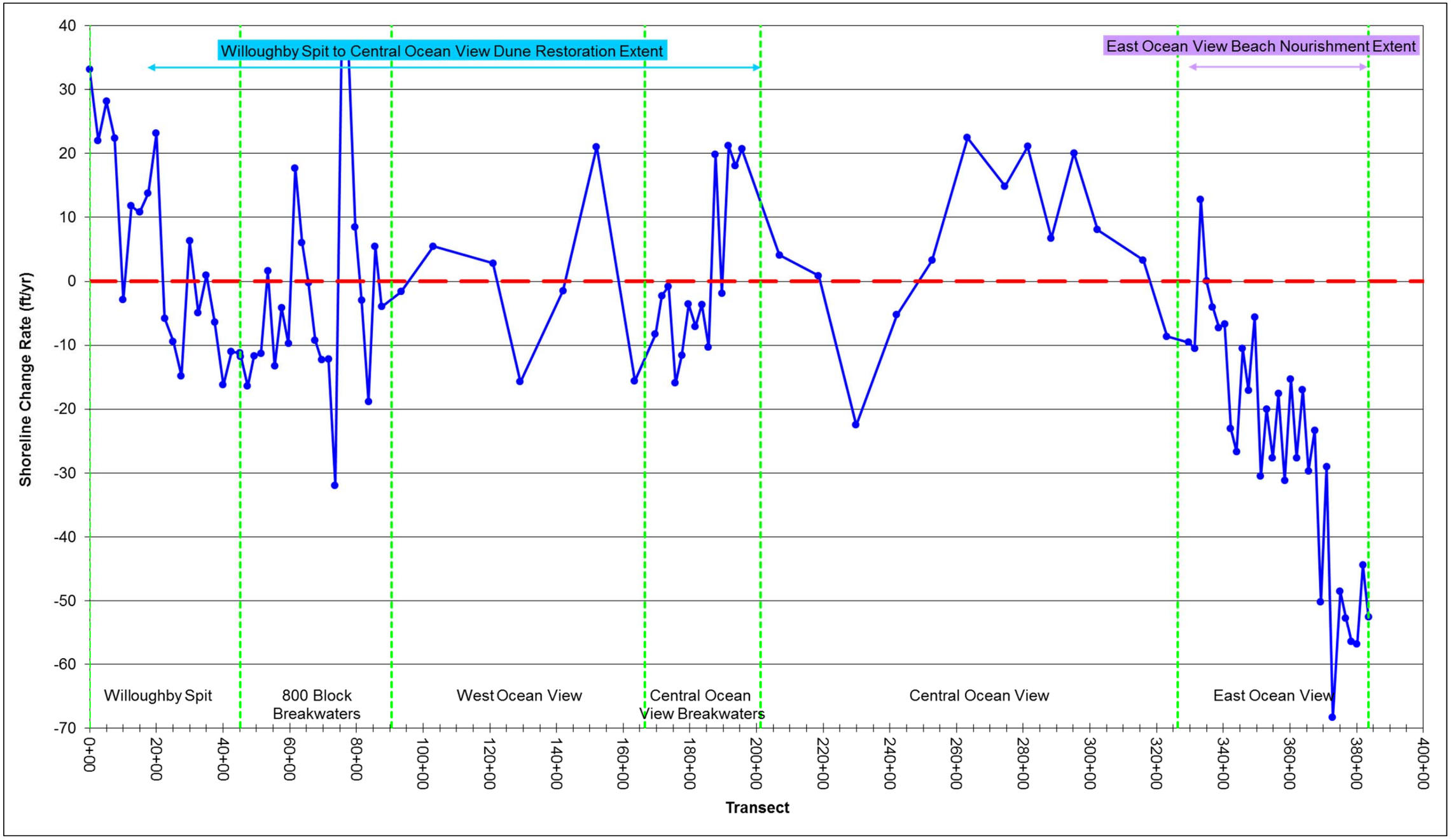

Figure 5-1: Shoreline Change Rate (ft/yr) at Mean High Water (+0.98 ft NAVD88) for October 2011 to September 2012 (Note: Positive = Accretion, Negative = Erosion)

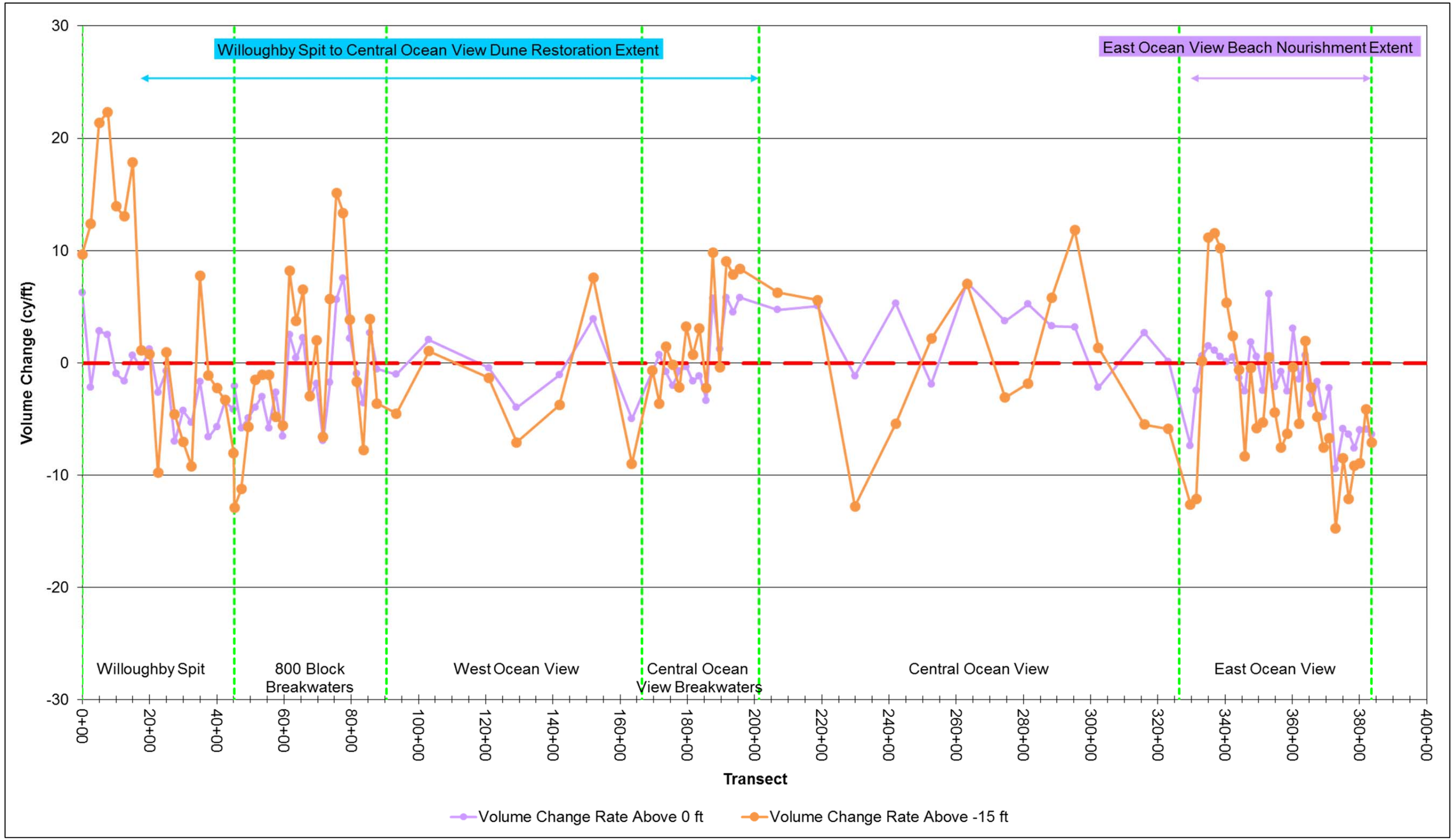

Figure 5-2: Volume Change Rate Above 0 ft NAVD88 (cy/ft) for October 2011 to September 2012 (Note: Positive = Accretion, Negative = Erosion)

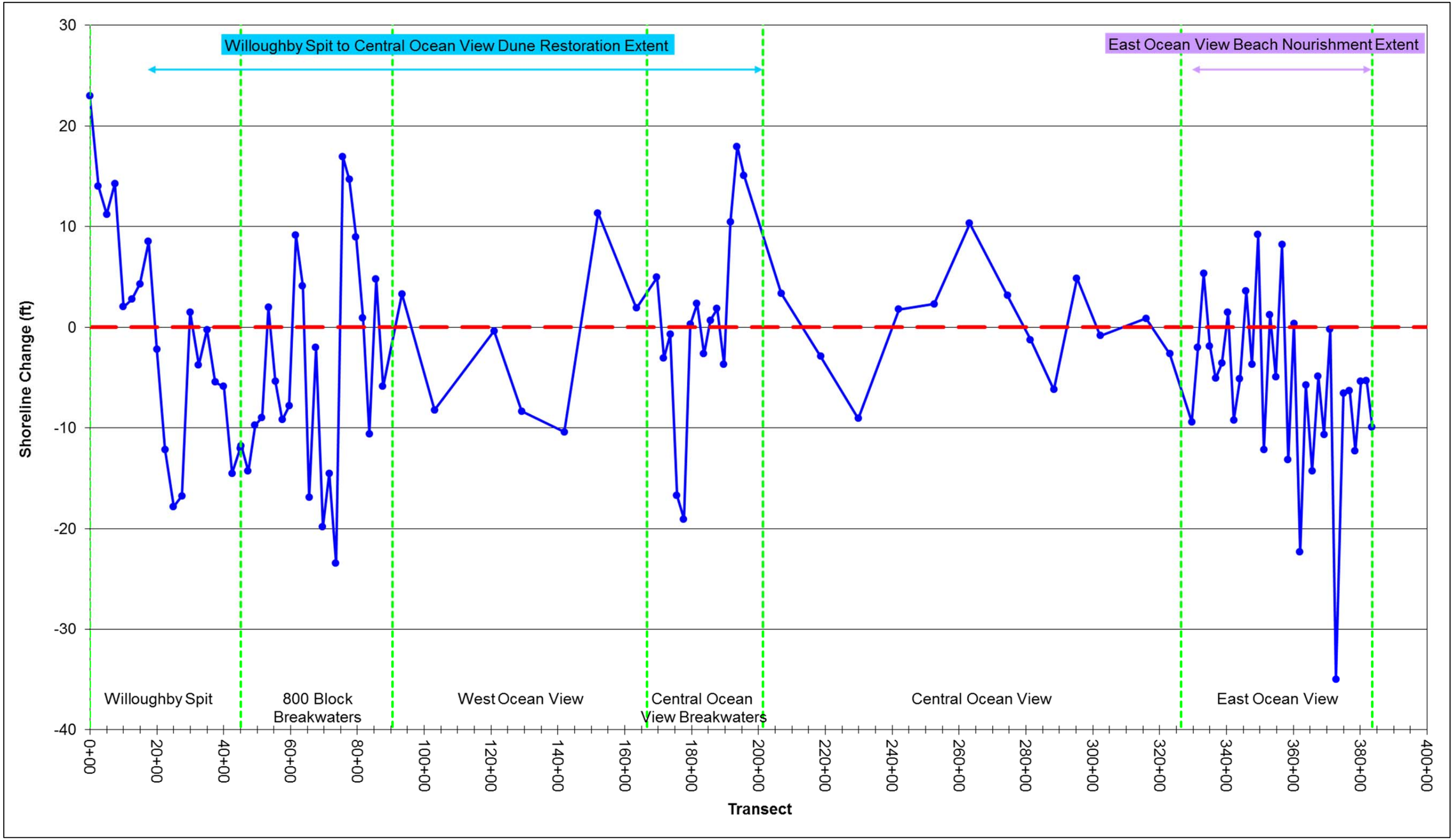

Figure 5-3: Shoreline Change (ft) at Mean High Water (+0.98 ft NAVD88) for March 2012 to September 2012 (Note: Positive = Accretion, Negative = Erosion)

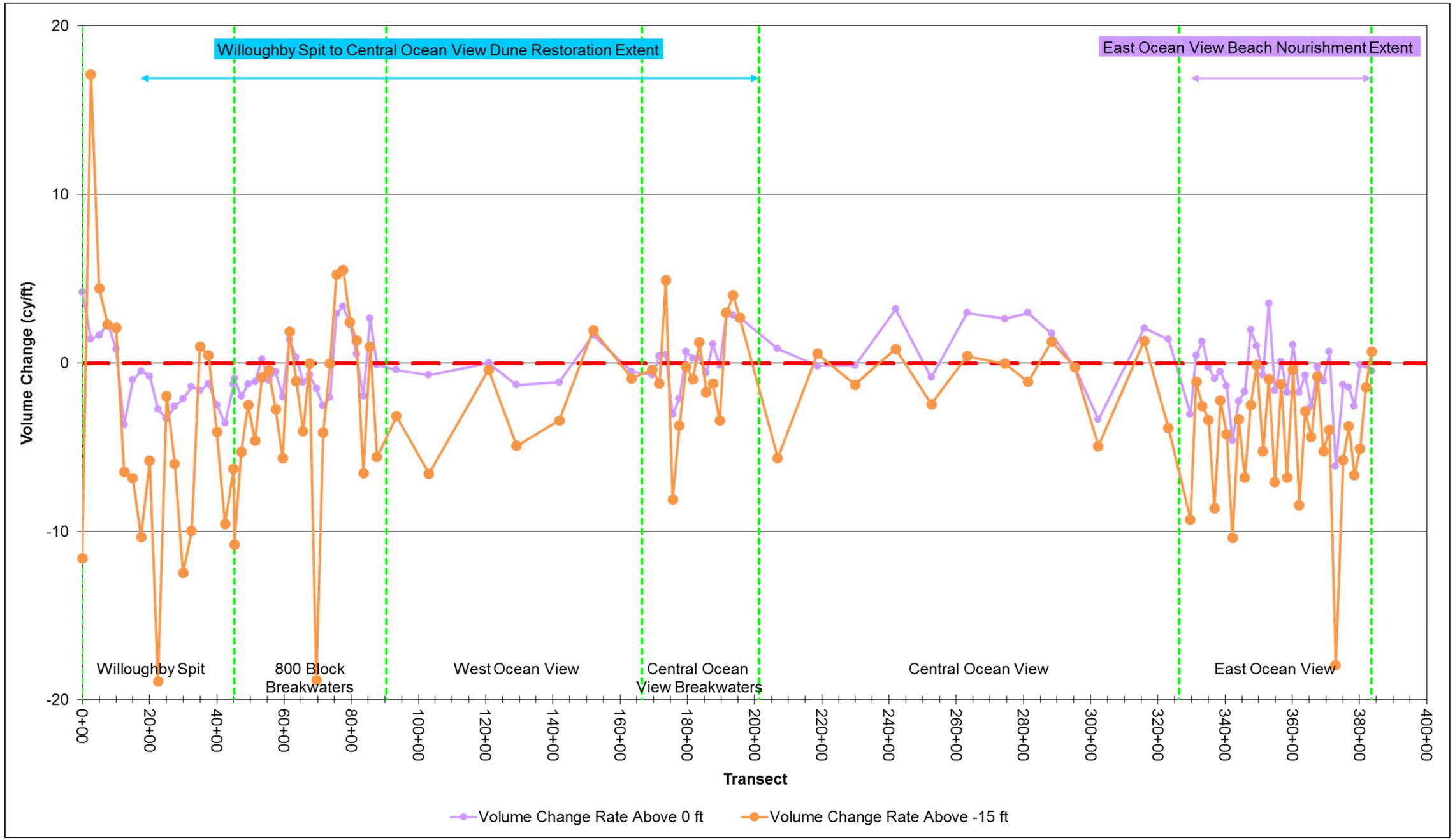

Figure 5-4: Volume Change Above 0 ft NAVD88 (cy/ft) and -15 ft NAVD88 for March 2012 to September 2012 (Note: Positive = Accretion, Negative = Erosion)

5.4. East Ocean View Beach Nourishment Project (2009)

An initial beach nourishment project took place along the East Ocean View shoreline in November 2003. Approximately 359,000 cy of material was placed on the beach between Sta 329+63 and Sta 383+58. More recently, the East Ocean View shoreline was renourished with approximately 196,000 cy of material in March 2009. The most recent periodic survey, taken in September 2012, was compared to the post-fill survey taken in March 2009. Table 5-9 presents the shoreline and volume change statistics comparing the two surveys.

Table 5-9: Overall Shoreline and Volume Change Statistics – East Ocean View Nourishment Project (March 2009 Post-Fill – September 2012 Comparison)

Region		Average Shoreline Change (ft)	Average Volume Change Above 0 ft NAVD88 (cy/ft)	Cumulative Volume Change Above 0 ft NAVD88 (cy)	Average Volume Change Above -15 ft NAVD88 (cy/ft)	Cumulative Volume Change Above -15 ft NAVD88 (cy)
East Ocean View (329+63 to 383+58)	Rate per Year	-1.21	-4.25	-22,105	-7.36	-38,205
	Total	-4.26	-14.98	-77,884	-25.93	-134,607

Results indicate that the East Ocean View shoreline has continued eroding with losses at MHW. Roughly 77,900 cy of material has been lost above 0 ft NAVD88, or approximately 70% of the 113,000 cy originally placed above 0 ft NAVD88. This loss of sediment is the result of the expected erosion due to design life of the nourishment project combined with storm activity. The East Ocean View Nourishment Project study prepared by M&N in June 2004 estimated the design life of the nourishment project to be on the order of 7 to 8 years with no major storm activity. In the instance of storm impacts along this reach of shoreline, the design life of the project was anticipated to be on the order of 4 to 5 years as long as some recovery does take place between these events. Impacts from storm events have reduced the anticipated project design life to be more in line with the 4 to 5 year range, and renourishment will likely be needed within the next 1 to 2 years.

Figure 5-5 shows areas of volume gain and volume loss between the post-fill survey and the September 2012 survey. As depicted in the figure, there has been erosion of the beach face and nearshore, which is to be expected since this shoreline is cut off from a sediment source by the jetty. Some of the sediment eroded from the beach face and nearshore appears to be caught offshore in the vicinity of the breakwaters. There has also been an increase in the dune area, which may partially be attributed to the annual dune planting project providing a mechanism for sand accumulation.

In addition, the September 2012 MHW shoreline was compared to the MHW shoreline from June 2003, before the first nourishment project in November 2003, as another way to measure the amount of protection being supplied by the March 2009 nourishment project. Areas where the current shoreline is within 20 feet of the June 2003 shoreline need to be targeted for nourishment. Figure 5-6 shows the MHW shoreline position difference between the June 2003 pre-fill and September 2012 shorelines. As can be seen, the 2009 nourishment project has provided ample protection along the East Ocean View shoreline. A portion of the shoreline that has eroded past the original pre-fill position occurs at Sta 331+43, immediately downdrift of the breakwaters constructed in 2009 and is

influenced by end effect erosion. It will be important to monitor this portion of shoreline as time and storms continue. Sediment from the middle region of the project has eroded as well and this section of shoreline is within 20 feet of the June 2003 shoreline. This may partially be attributed to recovery of the shoreline following Hurricane Irene as there were sediment gains further west in the project, in line with the direction of predominant littoral drift. It will be important to continue to monitor this area for planning purposes for future nourishment projects.

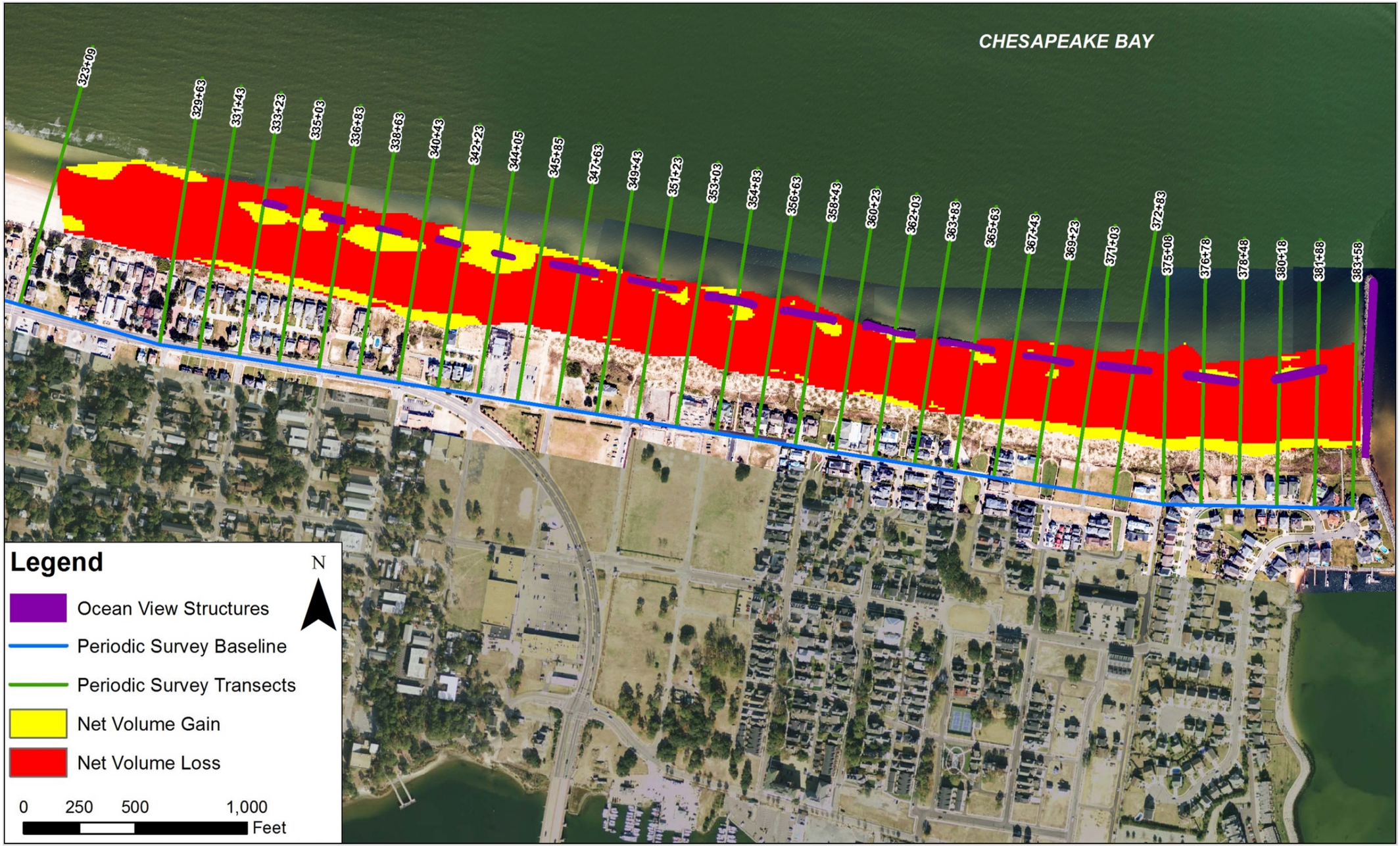

Figure 5-5: Net Volume Change Since the East Ocean View Nourishment Project (March 2009)

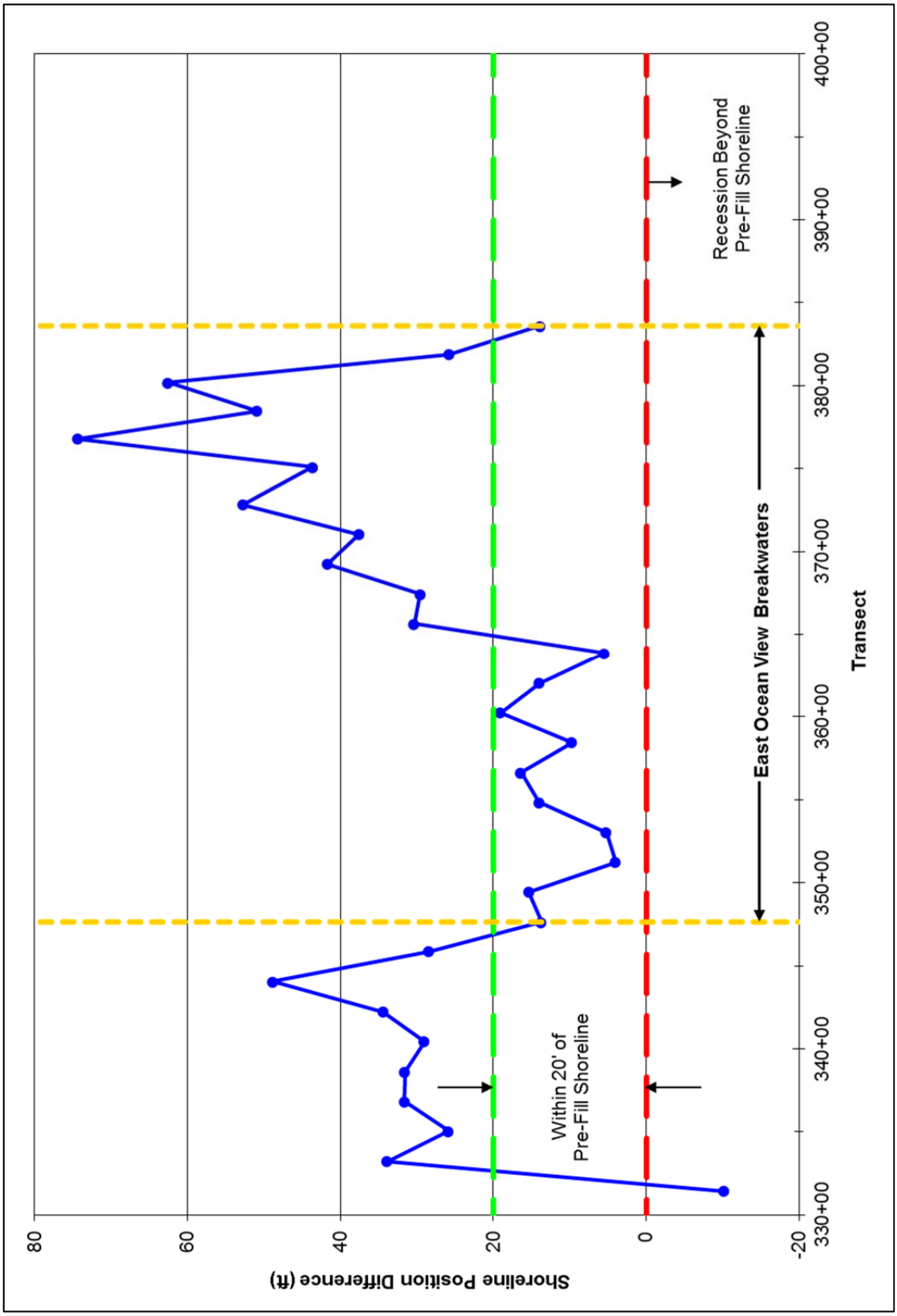

Figure 5-6: Shoreline Position Difference (ft) at MHW Between 2003 Pre-Fill and September 2012 Shorelines for East Ocean View

5.5. Central Ocean View Dune Restoration Project (2005)

The most recent periodic survey, taken in September 2012, was also compared to the post-fill survey taken in March 2005 after completion of the Willoughby Spit to Central Ocean View Dune Restoration project. A total of 504,300 cy of sand was placed from Sta 15+00 to Sta 195+63. Table 5-10 presents the shoreline and volume change statistics comparing the two surveys.

Table 5-10: Regional and Overall Shoreline and Volume Change Statistics for Central Ocean View Nourishment Project (March 2005 Post-Fill – September 2012 Comparison)

Region		Average Shoreline Change (ft)	Average Volume Change Above 0 ft NAVD88 (cy/ft)	Cumulative Volume Change Above 0 ft NAVD88 (cy)	Average Volume Change Above -15 ft NAVD88 (cy/ft)	Cumulative Volume Change Above -15 ft NAVD88 (cy)
Willoughby Spit (0+00 to 45+00)	Rate per Year	-0.56	-1.64	-4,959	-2.06	-6,181
	Total	-4.26	-12.34	-37,387	-15.50	-46,601
800 Block Breakwaters (45+25 to 87+62)	Rate per Year	-0.65	-1.16	-5,045	-1.91	-8,297
	Total	-4.93	-8.78	-38,040	-14.39	-62,557
West Ocean View (93+41 to 163+49)	Rate per Year	-0.57	-2.23	-17,340	-1.80	-13,341
	Total	-4.27	-16.83	-130,739	-13.59	-100,584
Central Ocean View Breakwaters (169+63 to 195+63)	Rate per Year	-0.31	-0.51	-1,498	0.57	2,192
	Total	-2.35	-3.83	-11,296	4.28	16,524
OVERALL	Weighted Average	Weighted Average	Total	Weighted Average	Total	Weighted Average
Rate per Year		-0.54	-1.56	-28,842	-1.43	-25,627
Total		-4.07	-11.73	-217,462	-10.80	-193,219

It is important to consider changes above the 0 ft contour since the project was primarily a dune restoration, placing the majority of sand above the intertidal zone. Table 5-10 shows that there has been significant loss of material in the dune system and subaerial beach above 0 ft NAVD88 since the project was completed. Roughly 217,500 cy of material has been lost above 0 ft NAVD88, or approximately 68% of the 320,700 cy originally placed above 0 ft NAVD88. As with the previous survey period, the influence of the dune restoration project that placed approximately 30,000 cy in this region between March and May 2010 is apparent in Figure 5-7 and supports the calculated statistics by showing gains in the region where the emergency dune restoration took place in 2010.

In addition, the September 2012 MHW shoreline was compared to the pre-fill MHW shoreline as another way to measure the amount of protection still being supplied by the January-March 2005 nourishment (dune restoration) project. The design life of the nourishment project was outlined in the M&N Willoughby Spit to Central Ocean View Dune Restoration Project Performance Analysis from October 2004. The study anticipated a project design life of 5 to 6 years with no major storm activity and 2 to 3 years at hot spot areas if there were impacts to this reach of shoreline from storms. The nourishment project is in its seventh year and has been impacted by several storms since its construction, e.g. October 2006 and November 2009 nor'easters and Hurricane Irene in August 2011.

Areas where the current shoreline is within 20 feet of the pre-fill shoreline need to be targeted for nourishment. Figure 5-8 shows the MHW shoreline position difference between the pre-fill and September 2012 shorelines. As can be seen, the September 2012 Willoughby Spit to Central Ocean View MHW shoreline comes within 20 feet of the pre-fill shoreline in many locations and has even receded past the pre-fill shoreline at several locations. Areas of concern include the shoreline to the west of the 800 Block breakwater field as well as portions of the breakwater field itself which exist westward of the tombolo formation from Sta 55+51 to Sta 45+25. The breakwaters are most likely inhibiting the transport of sand to the western portion of the field and shoreline beyond. Portions of the shoreline in the groin field of the Willoughby Spit region also appear to be retreating to the pre-fill shoreline position. The shoreline between the 800 Block breakwater field and the Central Ocean View breakwaters is also of concern as most transects either show recession beyond the pre-fill shoreline or shoreline positions within 20 feet of the pre-fill shoreline. The shoreline suffered significant impacts from the November 2009 nor'easter which were further exacerbated by Hurricane Irene in August 2011. While some natural recovery of the shoreline occurred from the storms, and the emergency dune restoration project in 2010 restored a portion of the dunes in certain areas, targeted nourishment projects should continue to be planned for these areas in the near future based on existing conditions.

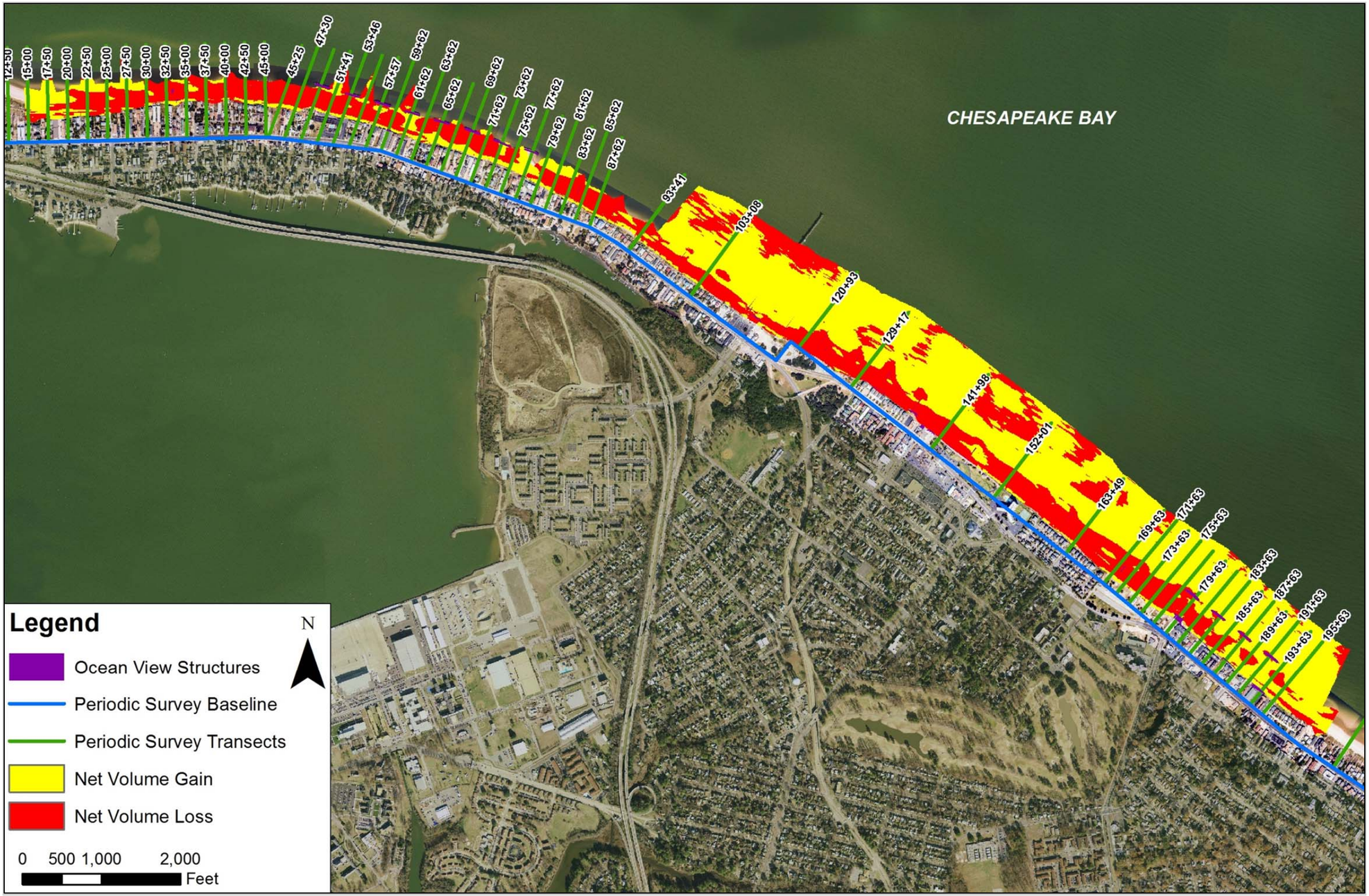

Figure 5-7: Net Volume Change Since the Willoughby Spit to Central Ocean View Dune Restoration Project (March 2005)

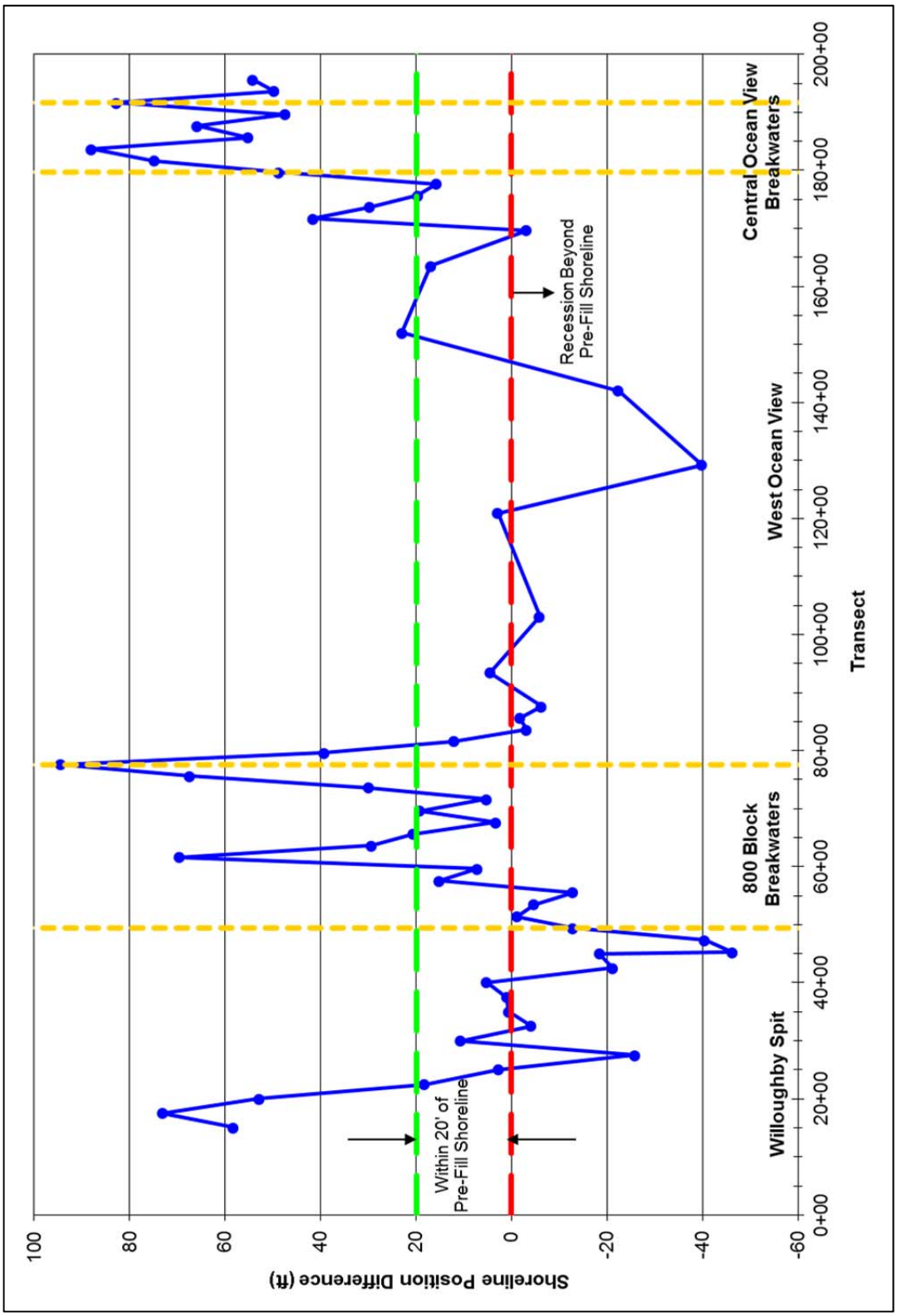

Figure 5-8: Shoreline Position Difference (ft) at MHW Between 2003 Pre-Fill and September 2012 Shorelines for Central Ocean View

6. Summary

Comprehensive periodic surveying of the entire Ocean View shoreline began with an initial survey in September 2005. The most recent survey was completed in September 2012. Subsequent surveys are planned to be conducted and evaluated every six months, in March/April and September/October. The beach and bathymetric surveys, performed by Geodynamics, utilized baseline and transect positions established in September 2005 which are used for all periodic surveys. For this periodic evaluation, the September 2012 survey was compared with both the March 2012 and October 2011 surveys. The surveys were used to compute shoreline change at MHW and volume change above 0 ft NAVD88 and above -15 ft NAVD88.

In addition, the most recent survey in September 2012 was compared to pre- and post-fill surveys taken after the East Ocean View beach nourishment and Willoughby Spit to Central Ocean View dune restoration projects in March 2009 and January-March 2005 respectively. This was done to quantify the amount of material loss since the projects were completed and condition of the shoreline with respect to pre-fill conditions.

Key statistics were computed for defined regions along Ocean View and the entire shoreline for the time period between both the October 2011 and September 2012 surveys and the March 2012 and September 2012 surveys.

Comparison	Parameter	Quantity
October 2011 vs. September 2012	Average Shoreline Change Rate at MHW (+0.98 ft NAVD88)	-1.98 ft/yr
	Cumulative Volume Change Rate Above 0 ft NAVD88	7,553 cy/yr
	Cumulative Volume Change Rate Above -15 ft NAVD88	-6,796 cy/yr
March 2012 vs. September 2012	Average Shoreline Change at MHW (+0.98 ft NAVD88)	-1.60 ft
	Cumulative Volume Change Above 0 ft NAVD88	-513 cy
	Cumulative Volume Change Above -15 ft NAVD88	-92,952 cy

The average shoreline change rate for the entire shoreline at MHW between the October 2011 and September 2012 surveys was -1.98 ft/yr. The cumulative volume change above 0 ft NAVD88 during this period was approximately 7,553 cy/yr. This indicates an overall volumetric gain in the dune, subaerial beach and subaqueous beach over the past year. The most recent period of comparison, from the March 2012 survey to the September 2012 survey depicts losses at the MHW line overall with the majority of the gains in sediment for the year occurring during the previous This can be attributed to recovery following Hurricane Irene in August 2011 and shifting sediments as the profile equilibrates.

Willoughby Spit

The Willoughby Spit region shoreline has returned to a more typical state following the impacts of Hurricane Irene in August 2011. The most significant gains over the year occurred adjacent to the terminal groin and while portions of this area showed losses during the most recent survey period, as sediment moved offshore out of the system, some recovery of the dune system occurred.

800 Block Breakwaters

A previous borrow area for a dune restoration project in 2010 was located landward of the easternmost breakwater and the removal of sediment allowed the tombolo that had formed at this breakwater to become detached. Hurricane Irene in August 2011 further decreased the salient formation. During the most recent period the tombolo has begun to form again and cut off sand to the downdrift areas. The relocation of this breakwater as part of the Willoughby Spit Shoreline Improvement Project is expected to permanently decrease the potential for formation of a tombolo at this location.

West Ocean View

The October 2011 to September 2012 survey comparison showed a slight decrease of the MHW, with overall losses to the system. Immediately updrift of the bulkhead and groin at the 200 Block of Ocean View the shoreline showed a loss of sediment which is characteristic of the effects of the armoring structures in the area. Also, updrift of the Central Ocean View breakwaters the shoreline showed losses which is indicative of the end effects caused by these structures. The patterns of sediment shift are related to the shoreline returning to equilibrium following Hurricane Irene in August 2011. The most recent period shows erosion more severe offshore at the west end of the region. This area is closest to the 800 Block Breakwaters and the changes with the tombolo detachment and attachment may have an effect on this section of shoreline.

Central Ocean View Breakwaters

The Central Ocean View Breakwaters region showed gains in the MHW shoreline position as well as gains in sediment volume above 0 ft NAVD88 and -15 ft NAVD88 over the year. The smaller volume increase above 0 feet NAVD88 in the most recent survey period, March 2012 to September 2012, indicate that the majority of the gains occurred during the winter season, which is likely due to recovery from Hurricane Irene in August 2011.

Central Ocean View

Typically a very stable region, Central Ocean View has experienced an increase at the MHW shoreline and volumetric gains in sediment above 0 ft NAVD88 and -15 ft NAVD88 over the past year. The majority of the volumetric gain occurred during the period from October 2011 to March 2012. This is likely due to sediment that was moved offshore during the hurricane being pushed back onshore during the post-storm recovery.

East Ocean View

As expected, due to sediment movement along the shoreline from east to west, there were continued volume losses to the beach in this this region between the October 2011 and September 2012 period. During the most recent period there were increased losses overall; however, the dune and subaerial beach showed gains as compared to the overall year. This is indicative of post-hurricane recovery with some sediment being moved onshore while the typical sediment losses due to sediment transport in the area were still experienced overall. The east end of the region, adjacent to the jetty, is more

erosive than most areas in the west of this region due to the lack of a sediment source and the littoral sediment movement in this region going from east to west. The profiles have a fairly steady pattern of accretion on the profiles landward of the breakwaters and erosion on the profiles between the breakwaters showing the influence of the breakwaters on decreasing the wave heights and retaining sediment along the shore.

In addition to regional assessments, comparison of the October survey was made against post-fill surveys from the East Ocean View beach nourishment and Willoughby Spit to Central Ocean View dune restoration which took place in March 2009 and January-March 2005 respectively.

Comparison	Average Shoreline Change	Average Volume Change Above 0 ft NAVD88	Cumulative Volume Change Above 0 ft NAVD88	Average Volume Change Above -15 ft NAVD88	Cumulative Volume Change Above -15 ft NAVD88
East Ocean View Nourishment vs. March 2012 Comparison	-71.38 ft	-14.32 cy/ft	-74,336 cy	-23.78 cy/ft	-122,669 cy
Central Ocean View Nourishment vs. March 2012 Comparison	-27.05 ft	-11.18 cy/ft	-208,904 cy	-8.86 cy/ft	-15,018 cy

The approximately 77,900 cy volumetric loss above 0 ft NAVD88 from the East Ocean View project is approximately 70% of the original amount placed in this dune and subaerial beach area while the approximately 217,500 cy loss above 0 ft NAVD88 in the Central Ocean View project area is approximately 68% of the original amount placed above 0 ft NAVD88. Due to storm impacts and background erosion that has occurred, as anticipated, over the projects' design life, there are areas in both of these shoreline regions that should be targeted for nourishment. The two design projects underway for the Willoughby Spit region and the West Ocean View region will help alleviate the concerns with these hot spots and provide additional protection in vulnerable areas; however, there are still other areas that may require nourishment to provide adequate storm protection. The East Ocean View project may also require a renourishment in the next 2 to 3 years.

As another measure of the protection being supplied by the East Ocean View and Central Ocean View nourishment projects, the projects' pre-fill and September 2012 MHW shoreline positions were compared. Areas where the current shoreline has receded beyond or eroded within 20 ft of the pre-fill shoreline may need to be targeted for immediate nourishment. Results of this analysis indicated that the East Ocean View nourishment project has provided ample shoreline protection for the majority of the shoreline with only slight end effects immediately east of the most recently constructed breakwaters; however, the November 2009 Nor'easter and Hurricane Irene have impacted the design life and renourishment of this area may be required in the next 2 to 3 years. The Willoughby Spit to Central Ocean View shoreline continues to have various problem spots. A portion of the shoreline in the Willoughby Spit groin field, the shoreline to the west of the 800 Block breakwaters, portions of the 800 Block region to the west of the easternmost breakwaters, and the shoreline between the 800 Block breakwaters and Central Ocean View breakwaters has eroded to within 20 ft of the pre-fill shoreline and even receded beyond the pre-fill shoreline in some locations. This project had an anticipated design life of 5 to 6 years with no storm activity with hot spot areas anticipated to require nourishment after 2 to 3 years if storm activity impacted this region. The project is at the end of the anticipated design life and has been impacted by storm activity. While the

emergency dune restoration project in 2010 restored a portion of the dunes in certain areas, there are still concerns about the hot spots in the area. Once construction is completed, the Willoughby Spit Shoreline Improvement Project and the West Ocean View Shoreline Improvement Project will help alleviate the concerns with these hot spots and provide additional protection in vulnerable areas.

This is the fifteenth periodic survey report completed to date, and fourteenth evaluation of a consistent survey period utilizing beach and bathymetric surveys. As noted, there are inevitable margins of error associated with the survey data that may reduce the accuracy of volumetric change analyses. Therefore, it is essential to thoroughly review the beach and bathymetric profiles using various analytical techniques and general engineering judgment to assure that results are not falsely interpreted. Comparison of seasonal surveys (i.e. October 2011 to September 2012) eliminates seasonal variation of profiles in volumetric change analyses. Consecutive survey comparisons are useful to assess the direct impact of extreme events which may occur during the six month period between surveys. Future periodic survey evaluations will continue to improve on analysis techniques so that the rich survey data sets are best utilized.