ASSESMENT OF ALTERNATIVE BEACHFILL PLACEMENT ON SURFING RESOURCES

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In February 2009, a 700,000 cy, $9 million beach nourishment project was completed in Long Branch, New Jersey. The beach fill was constructed using an innovative feeder beach design, rather than a standard linear fill template. The feeder beach design was adopted to address the concerns of local surfing groups by initially burying fewer structures, and by potentially creating additional surfing opportunities through enhanced bar formation during the equilibration process. Nine months of monitoring results show that roughly 84% of the placed material can be accounted for within the project area and on the downdrift beaches. The immediate impact of the fill on the local surfing conditions was negative within the project area as steep slopes, violent plunging breakers, and narrow surfzones limited the use of the feeder beach area; however traditional surf spots to the north and south were unaffected by the nourishment due to the concentrated nature of its placement. More recently, as the post-nourishment slopes have begun to equilibrate, surfing conditions have improved markedly within the project area, while the up drift and down drift beaches remain relatively unaffected.

Keywords: beach nourishment; surfing; morphology

BACKGROUND

In February 2009, a 700,000 cy, $9 million beach nourishment project was completed in Long Branch, New Jersey as a part of the New York District of the US Army Corps of Engineers (USACE), Sandy Hook to Barnegat Inlet, Beach Erosion Control Project. Since the project's completion, the Center for Maritime Systems (CMS) at Stevens Institute of Technology has been monitoring the equilibration of the nourishment project and its impact on the local surfing conditions. The beach fill was constructed using an innovative feeder beach design, rather than a standard linear fill template, in an attempt to address the concerns of local surfing groups. The feeder beach was designed with several purposes in mind. First and foremost the protection provided by the feeder beach needed to be commensurate with that provided by a standard linear fill. Second, by concentrating the fill over a shorter length of beach, fewer structures would be buried, and the recreational opportunities associated with them (surfing/fishing) could be preserved. Finally, it was hoped that during the fill equilibration process, additional surfing opportunities would be created through enhanced bar formation.

In May 2008, a monitoring plan (Miller and Herrington 2008) was designed in coordination with the New Jersey Department of Environmental Protection (NJDEP) and the NY District of the USACE with the following primary objectives:

1. To determine if the feeder beach material stays within the active beach profile system, and provides protection benefits for the Long Branch community,
2. To determine if surfable waves were generated adjacent to the feeder beach immediately after construction, and how long the feeder beach provides surfable waves,
3. To determine if surfing downdrift of the feeder beach is affected by the potential creation of sandbars along the downdrift groins.

Project Description

Construction on the project began in November 2008 and continued through February 2009. An aerial view of the project during construction is given in Figure 1. The modified design template consisted of a trapezoidal center section with berm extending approximately 500 feet from the seawall, flanked by a traditional linear fill extending 300 feet from the seawall. The toe of the fill within the feeder section was designed to extend approximately 900 feet from the seawall and to tie in with the existing grade at a depth of approximately 29 feet. Due to complications encountered with placing the material in water depths greater than 25 feet, the feeder beach was actually constructed 300 feet shorter (at the toe) than the design template.

Data Collection

The original monitoring plan (Miller and Herrington 2008) called for a total of 54 profiles spaced at 125 intervals to be surveyed with frequencies ranging from one week during the first month, to biweekly during the second month, to monthly thereafter. As the project evolved it became necessary to add profile lines to the north and eliminate a few from the south, resulting in a final monitoring region containing a total of 64 profile lines along a 1.75 mi long stretch of shoreline. All of the data was collected with the Stevens Dynamic Underwater Coastal Kinematic Surveying (DUCKS) System

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(Miller, *et al*. (2009a). The majority of the profiles remain spaced 125 ft; however the spacing between some of the added profiles ranges up to 400 ft. Surveys were conducted weekly during the first two months of monitoring, biweekly during the third month, and approximately monthly thereafter through the first year. Each profile extends from the landward-most accessible point on the dry beach (typically adjacent to the seawall or dune) out to an offshore depth of approximately 30 feet NGVD (National Geodetic Vertical Datum of 1929). Land based measurements of the dry beach are collected during periods of mid to low tide, with the offshore data collected during periods of mid to high tide. This ensures the highest likelihood of achieving an overlap between the two surveys. A site plan showing the profile lines, the project baseline, and the original feeder beach design is shown in Figure 2.

Figure 1. Construction of the feeder feature.

Directional wave data was also collected as a part of the project monitoring. An ADV was deployed offshore of the project area in 32 feet of water to collect north-south and east-west wave orbital velocities, as well as pressure. Data collection is performed hourly in 10 minute bursts at a frequency of 2 Hz. The unit is deployed in a self contained mode which requires retrieval every couple of months for routine maintenance and data download. Analysis of the data follows the Field Wave Gaging Program, Wave Data Analysis Standard prepared for the US Army Corps of Engineers (Earle, *et al*. 1995).

MORPHOLOGY

A variety of tools were used to track the morphological and volumetric changes within the project area and on the adjacent beaches. The morphologic evolution has been dominated at various times by a discreet set of processes. Initially, spreading from the feeder region to both the north and south was the dominant process. To the north, a large outfall pipe initially impeded the transport. Once the downdrift groin cell filled to capacity however; transport resumed and sediment began filling the downdrift beaches. During this spreading phase beach slopes within the feeder region remained unnaturally steep and close to their placed angle of repose. With the onset of the winter storm season, the profiles gradually began to flatten out and approach a more natural equilibrium condition. The combination of the fill spreading and the slopes flattening caused several of the buried structures to be exposed. The most recent surveys suggest the exposed structures are beginning to re-exert their influence over the local morphology.

Figure 2. Profile lines and groin cell numbering system.

Profile Evolution

Profile 25 located in the center of the feeder region, is shown in Figure 3. Initially slopes within this region remained stable and close to the placed slope (~1:15). Beginning in June 2009 (Postfill 13), the slopes finally began to flatten; however the natural slope equilibration was significantly influenced by summer beach maintenance activities which included smoothing the nearly vertical scarp at the run-up limit. The most recent surveys (Postfill Surveys 18 and 21), reflect the impact of the winter storm season. In contrast to the gradual, uniform slope modifications experienced during earlier periods, these two surveys exhibit prototypical winter/storm profile response with material being removed from the subaerial beach and deposited in a bar. The bar is particularly pronounced in Postfill Survey 21. As of December 2009, the MHW shoreline (+3' contour) had retreated approximately 345 ft from its post construction (Postfill Survey 1) position.

Moving north along the project site in the direction of the predominant littoral drift, many of the features of Profile 25 are preserved although the impact of the initial fill is lessened outside of the feeder region. Profile 15 which is shown in Figure 4 exemplifies the types of changes observed along Profile Lines 10-17. Profiles in this region experience significant gains in volume both along the upper beach face and at depths between 10 and 20 ft below NGVD29. In both cases, the material comes from the neighboring feeder beach region. The sediment influx along the beach face is somewhat typical of beach nourishment evolution; however the deposition of material in deeper water is less common. A detailed analysis has not be performed, however the current hypothesis is that the combination of an extremely steep beach face combined with the extra sharp initial shoreline gradient associated with the feeder feature resulted in sediment moving alongshore and sliding into the trough or pocket measured during the initial Postfill Survey.

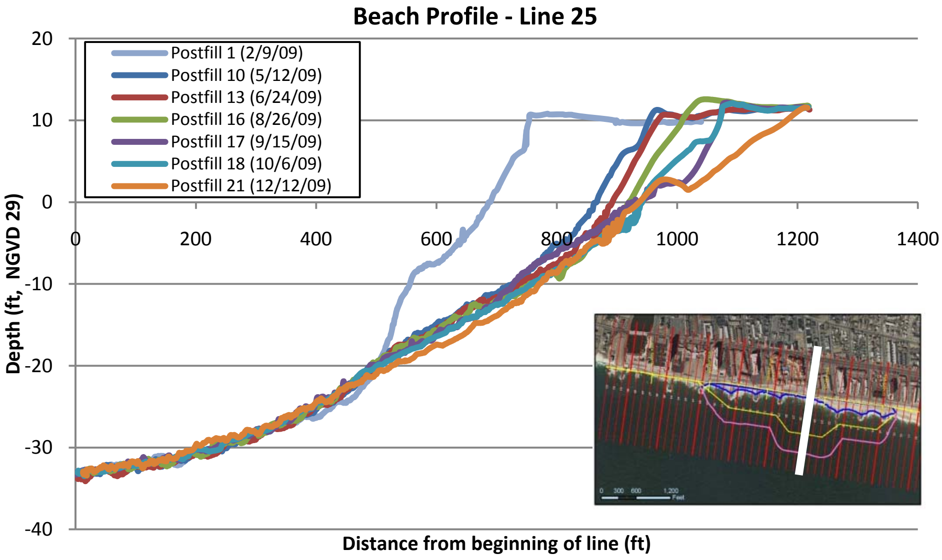


Figure 3. Beach profile along Profile 25 (center of feeder feature)

Further to the north some interesting behavior is observed at Profiles 5 and 6 associated with a 78" diameter outfall pipe that initially acts as an oversized groin, effectively limiting transport to the north. As the beaches updrift of the pipe built up in response to the impoundment of the fill material moving north, the pipe was eventually bypassed. For comparison, Profile 6 located just updrift of the pipe is shown in Figure 5, and Profile 5 located just downdrift of the barrier is shown in Figure 6. The broad flat-crested berm exhibited by Profile 6 is reflective of the dominant northward littoral drift which has caused the downdrift beach to accrete both vertically and horizontally. The maximum beach width achieved during Postfill Surveys 10 and 18 occurs when the updrift beach builds out to the tip of the outfall pipe and significant bypassing occurs. In general the downdrift profile is less stable as the beach width and elevation is regulated by the amount of bypassing that occurs. Even during transport reversals associated with storms, the amount of sediment within the system is insufficient to build the downdrift beach out to the tip of the pipe.

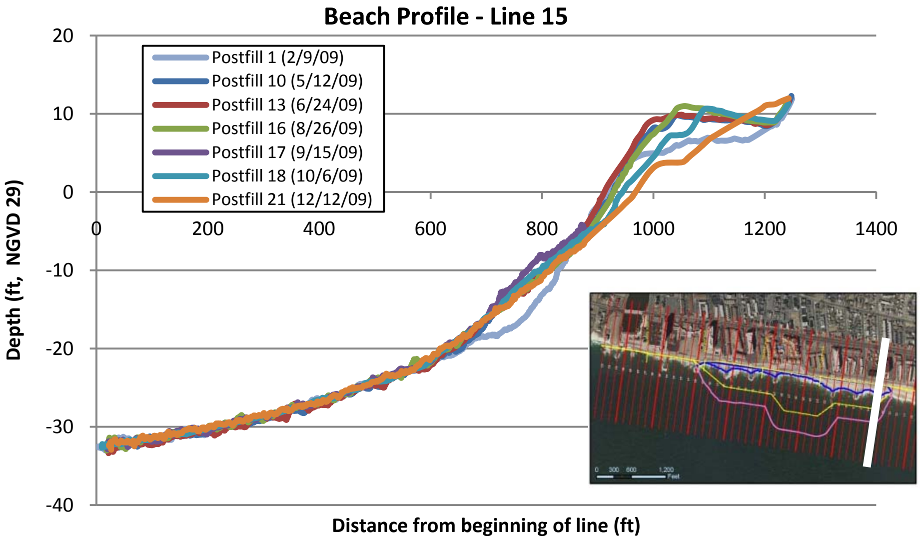


Figure 4. Beach profile along Profile 15 (within fill template, downdrift of feeder beach)

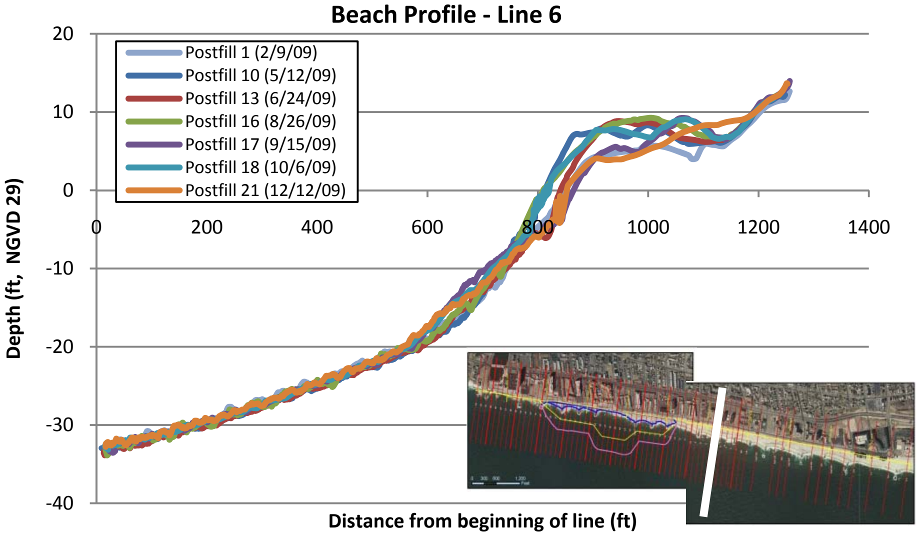


Figure 5. Beach profile along Profile 6 (downdrift of fill area, updrift of outfall pipe)

Further downdrift, the impact of the fill is being felt as well, although to a lesser extent. Profile 108 (shown in Figure 7) is the northernmost profile collected throughout the monitoring period and as such represents the limit for comparisons/calculations of elevation and or volume change. Only minor differences exist between the first two surveys shown on the plot (1 and 10). Beginning with Postfill 13 however, the beach berm begins to build in elevation. The reason for the delayed response is attributed to the large outfall pipe between Profiles 5 and 6, a smaller outfall near Profile 105, and the series of notched and unnotched groins between Profiles 6 and 108. Initially much of the sediment was deposited near the shoreline on the subaerial beach; however most recently, winter storms have reworked the profile into a typical winter/storm configuration complete with a subaqueous nearshore bar.

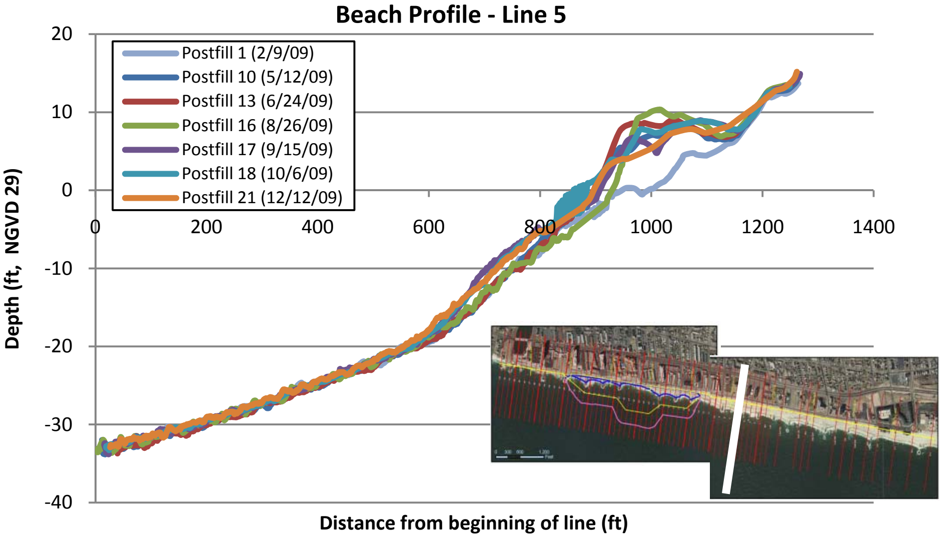


Figure 6. Beach profile along Profile 5 (downdrift of fill area, downdrift of outfall pipe)

Beach Slope Changes

One of the more interesting and most significant facets of the profile changes that have occurred relates to the nearshore beach slope. To illustrate the extent to which the beach nourishment project altered the nearshore slope, a comparison was made between the measurements collected along Profile 25, historical data collected nearby by the Coastal Research Center (CRC) at The Richard Stockton College of New Jersey and two sets of Equilibrium Beach Profiles (EBP) (Dean, 1977). Figure 8

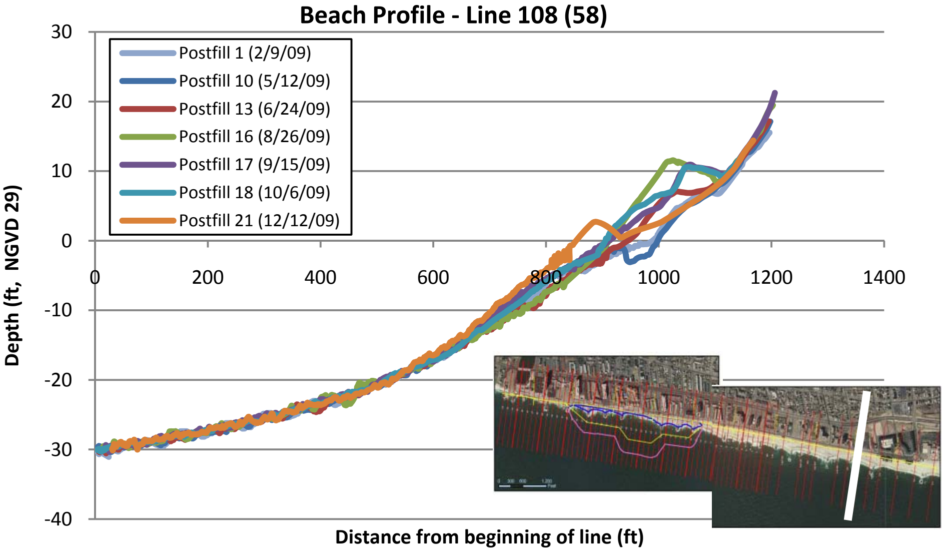


Figure 7. Beach profile along Profile 108 (58) (downdrift of fill area)

shows the comparison. Previous calculations (Mahon, *et al* 2009) have indicated that the offshore slopes of the CRC profiles (~1:25) approximately match those associated with the equilibrium beach profiles (EBP). By comparison, both of the measured post-construction profiles are dramatically steeper.

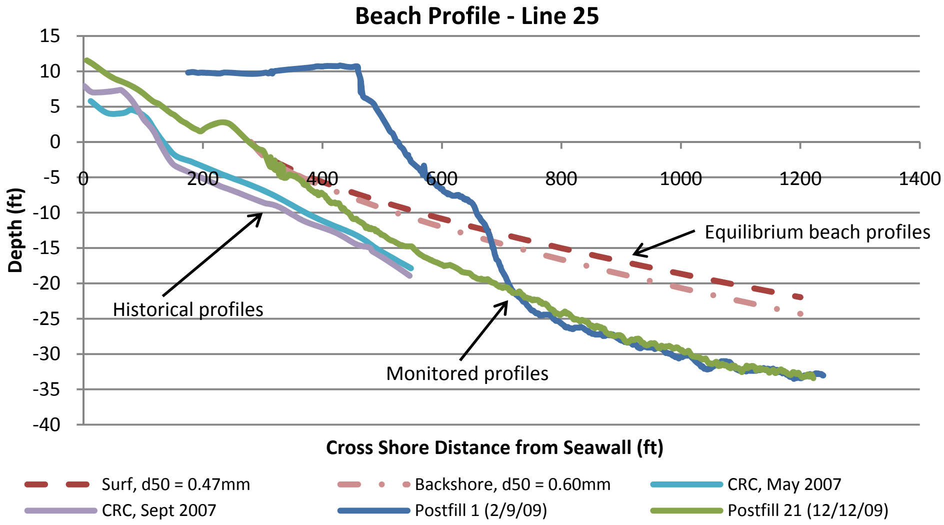


Figure 8. Comparison of the initial and most recent observed profile at line 25, with historically measured, and equilibrium beach profiles.

Table 1 summarizes the changes in beach slope at several profile locations through time. Slopes were calculated by fitting a linear regression line through the measured data. Most slopes are in the 1 on 16 to 1 on 20 range throughout the monitoring period; however nearly three months after the project's completion, surf zone slopes within the project area remained uncharacteristically close to their placed value. Generally, profiles within the fill area and to the south have flattened, while profiles to the north have steepened slightly. The sediments collected within the fill placement area are coarser than sediments collected updrift and downdrift of the fill area. As the fill equilibrated and fill material moved downdrift in the direction of longshore transport, the coarser fill material was deposited within the downdrift groin cells, steepening the offshore slopes within these areas.

Table 1. Beach slope changes at select locations.

Profile	Postfill 1 (2/9/09)	Postfill 10 (5/12/09)	Postfill 13 (6/24/09)	Postfill 16 (8/26/09)	Postfill 17 (9/15/09)	Postfill 18 (10/6/09)	Postfill 21 (12/12/09)
113	-	22.5	19.8	18.8	25.1	25.4	24.6
110	-	32.2	25.6	27.7	35.1	32.2	23.0
105	21.3	16.4	17.6	16.2	19.6	16.4	17.8
5	20.2	15.5	15.0	20.7	21.6	18.2	18.1
15	8.9	14.9	13.2	14.1	19.3	17.6	16.3
25	15.2	16.8	19.4	21.6	21.2	20.8	18.5
35	12.6	18.0	13.4	22.0	38.2	24.6	18.8
43	26.5	22.4	17.2	22.0	22.9	26.0	23.4

Note: Slopes are shown as 1V:H

Elevation Change

Elevation difference plots were generated to emphasize the changes that have occurred between surveys and since the completion of the project. To create the plots, the interpolated surfaces from two surveys are subtracted from one another, resulting in a map of elevation difference. The resulting plots clearly identify areas where the beach has exhibited a significant gain or loss in elevation, and by extension volume. Only changes greater than 1 ft are identified, with warmer colors used to represent accretion and cooler colors used to signify erosion. Each plot is constrained to the region covered by the smaller of the two surveys used to create it. For example if one of the two surveys is a complete survey, but the other is only a bathymetric survey, elevation differences can only be calculated over the bathymetric region where the two surveys overlap.

The most significant changes during the monitoring period take place within the feeder feature and around the large outfall pipe. A close-up of the feeder beach region is shown in Figure 9, where the six panels shown represent the periods with the most significant changes. Special attention is given to surveys surrounding the two major storm events of the monitoring period, Hurricane Bill and the Ida, or “Friday the 13th”, Nor’easter. Plots created by subtracting two surveys spanning the events are denoted as “impacts”, while plots created by subtracting a post event survey from the next sequential survey are designated as “recovery” plots. As discussed below, in some cases the terminology turns out to be an oxymoron as the actual changes observed during the recovery phase range from minimal accretion to further erosion.

The most common feature amongst the six panels in Figure 9 is a general lowering of the back beach region. Typically this occurs in association with a build-up of the nearshore, resulting in a flattening of the nearshore slope. Unfortunately the elevation plot illustrating the impact of Hurricane Bill is missing the offshore component. As a result, it is impossible to know whether the material removed from the beach during the storm was transported offshore to a bar, or along the beach. The “recovery” from Bill was marked by a significant infilling of the nearshore slope; however at the same time the back beach continued to erode. The exception is the region in the vicinity of the notched groin, where erosion is the predominant trend. The plot in the lower left shows pockets of accretion; however the most apparent feature is the erosional area overlapping, and all but negating, the accretion experienced during the previous survey period. Interestingly, the changes experienced between Postfill Surveys 18 and 19 are very similar to those experienced during Hurricane Bill, but of a lesser magnitude. The final survey of the period which reflects the impacts of Ida is marked by erosion of both the back beach as well as the area just offshore of the exposed groins. Separating these two areas however, is a region of deposition that was most likely formed during the height of the storm when material from the back beach was deposited at or near the original pre-storm shoreline.

Significant changes during the monitoring period were also observed adjacent to the large outfall pipe shown in Figure 10. The outfall extends approximately 475 feet from the base of the seawall and, as suggested earlier, plays a significant role in regulating sediment transport and influencing local morphology. The anti-symmetric patterns of erosion and accretion expected at a littoral barrier are present during the majority of the surveys, however due to the significant bypassing that occurs the patterns are somewhat muted. In the upper left panel, the development of bars connecting the tips of adjacent groins is illustrated. Such a phenomenon is relatively common in New Jersey with some of the bars being ephemeral and others permanent. The plots in the upper center and upper left panels illustrate the transient nature of this particular shoreface bar system. In the upper center panel, the

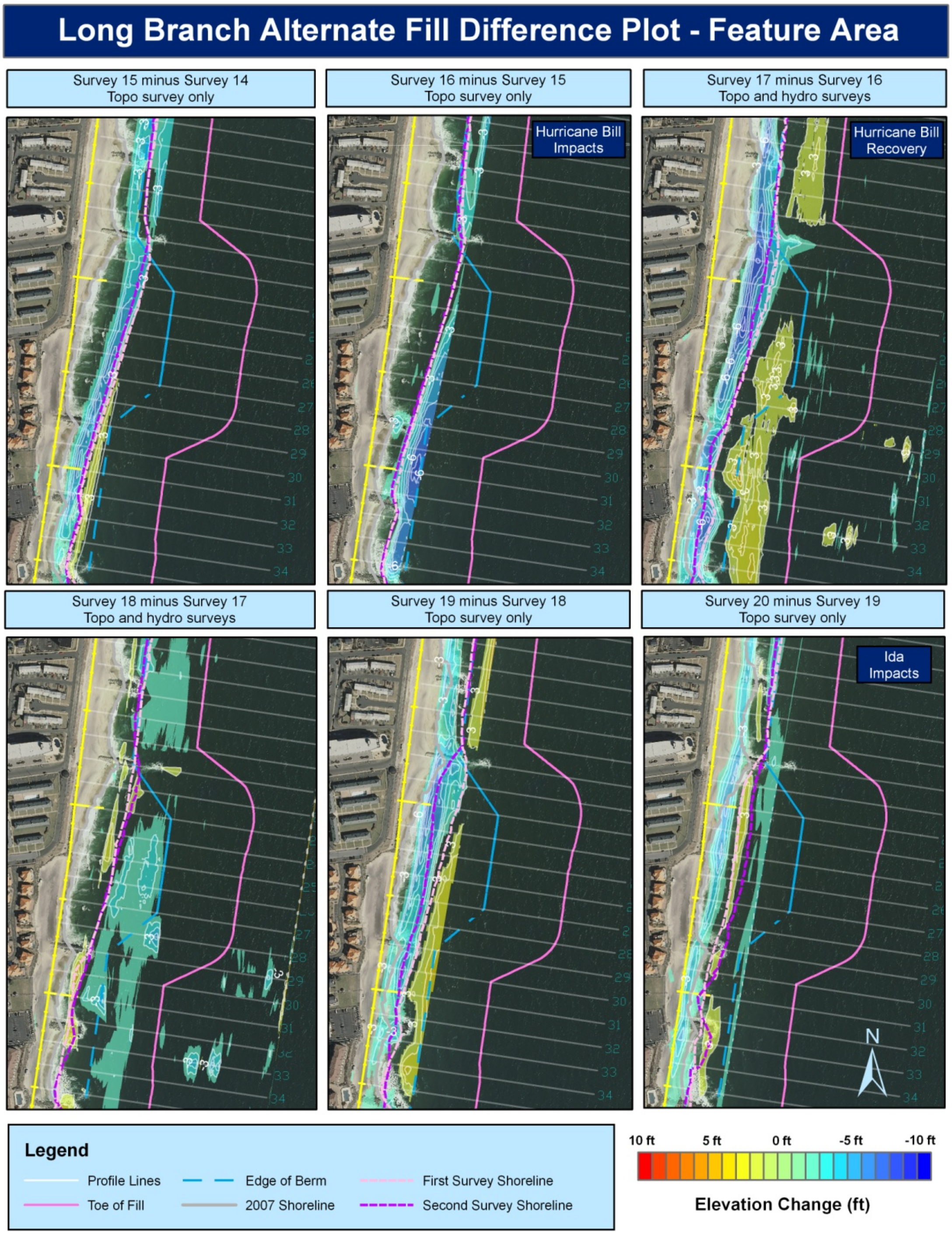


Figure 9. Difference plots within feeder beach region

southern shoreface erodes and the northern bar remains stable, while in the upper left panel the northern bar migrates onshore. The onshore migration of the bar is consistent with the wave climate during Bill which consisted of large long period swell. The subsequent Bill "recovery" plot is shown in the lower left panel and is marked by significant erosion south of the outfall. To the north of the pipe, the beach experiences significant erosion near the shoreline, but also some accretion in deeper water. Based upon the pattern of sedimentation, these changes are most likely due to an early winter storm, during which the dominant direction of transport temporarily reverses causing a buildup on what is normally the downdrift side (north) side of the pipe and erosion on what is normally the updrift side. A similar sedimentation pattern is exhibited in the lower center plot suggesting the temporary sediment transport reversal persisted through Postfill Survey 19. The final plot in the lower right illustrates the impacts of Ida which were remarkably longshore uniform. The beaches to the north and south of the outfall pipe experienced erosion both near the shoreline, and along the bar. Unfortunately the hydrodynamic data collected during Postfill Survey 19 were incomplete; therefore it is unclear whether the eroded material moved offshore or alongshore during the storm.

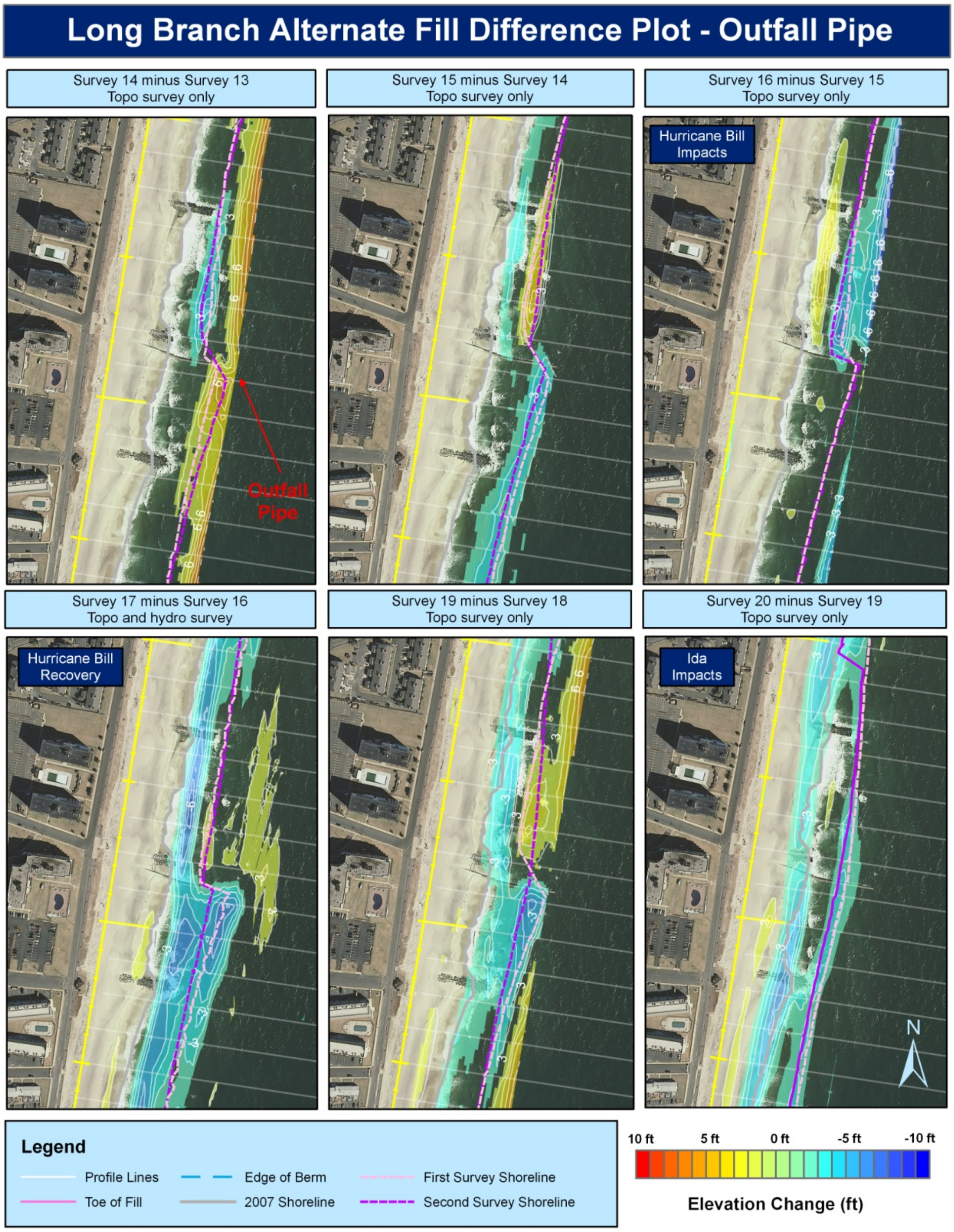


Figure 10. Difference plots around outfall pipe

The dramatic changes that have occurred during the project are emphasized in Figure 11. Most dramatic are the changes associated with the spreading of the feeder feature. In the center of the feature, elevation changes between March and December of 2009 have exceeded 12 ft. The rest of the monitoring area however, has experienced increases in elevation of up to 9 ft, with the majority of the material moving to the north. Although most of the back beach areas have experienced some positive elevation change, the most dramatic impacts are focused near the original shoreline, within the area typically occupied by the surf and swash zones. Although the northernmost profiles are not shown in Figure 14 (the first postfill survey only extended as far north as Profile 108), the majority of those have experienced accretion as well.

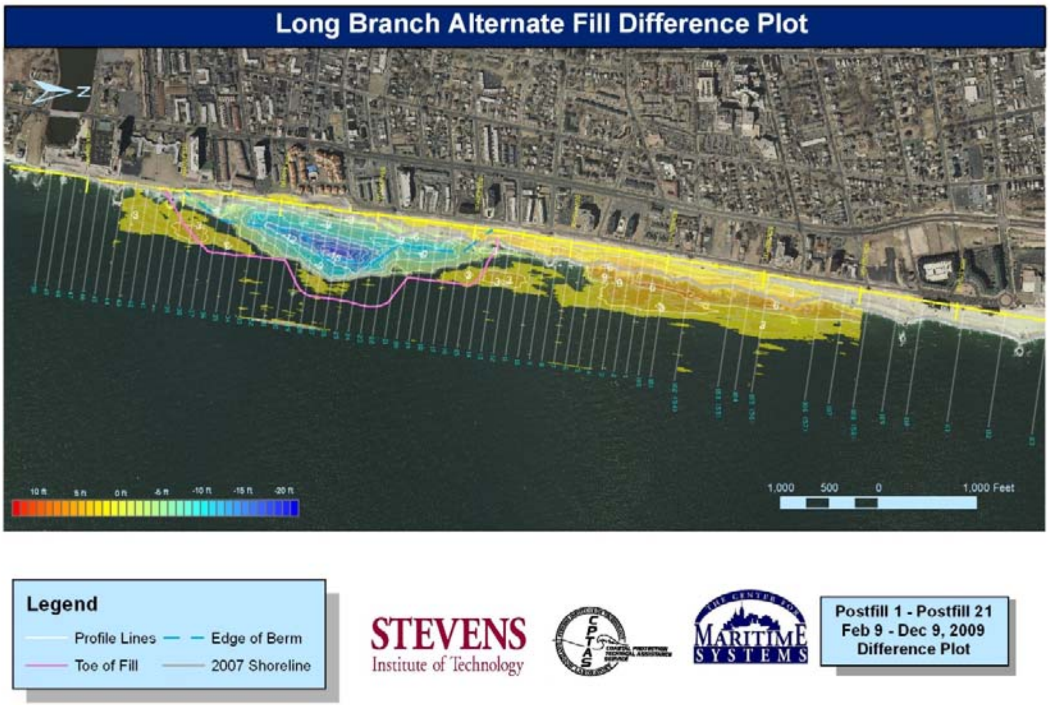


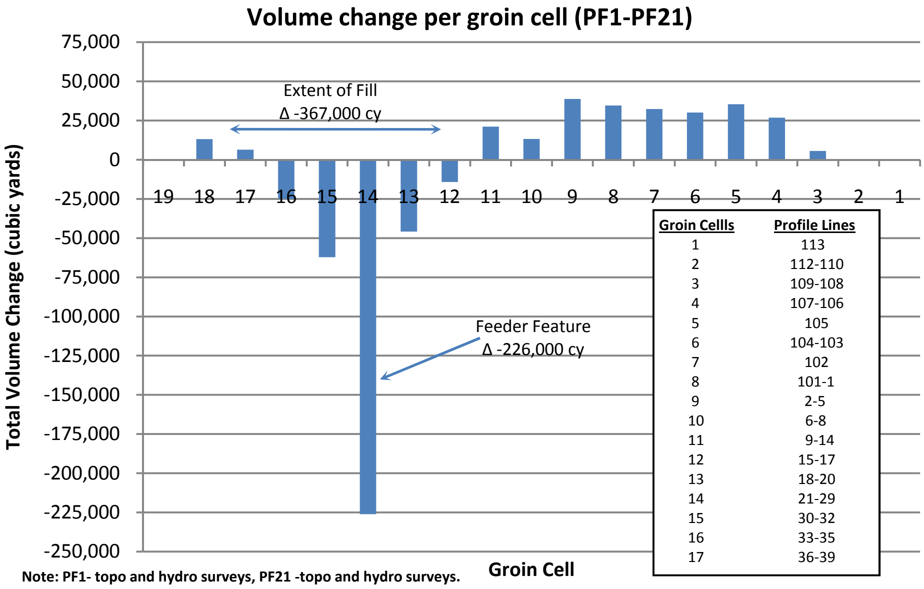
Figure 11. Elevation difference plot illustrating the cumulative changes between Postfill Surveys 1 (Feb. 2009) and 21 (Dec. 2009)

Volumetric Changes

The incremental and cumulative volumetric changes were calculated for each survey and for each groin cell, utilizing a tool within the Quick Terrain Modeler software package. The tool works by integrating the difference plot created by subtracting two surveys over a common area. Two types of volume change plots were generated. The first shows the volume changes by groin cell between two specific surveys, while the second shows the cumulative volumetric change for an individual groin cell since the project's completion.

Table 2 summarizes the volumetric changes that have occurred since the project's completion. As expected, the cells within the original nourishment area including the feeder feature have lost the most material. During the first three months, the feeder feature alone (Profiles 20 through 30; groin cell 14) lost just over 135,000 cy of material, while nearly 225,000 cy were lost from the entire nourished region (Profiles 13 through 40, groin cells 12 through 17). During the same time period, an increase of approximately 150,000 cy of material was found on the beaches to the north (Profiles 1through 12 and 100 through 108, groin cells 3 through 11) and south (Profiles 40 through 44, groin cell 18), resulting in a net loss of approximately 75,000 cy (~ 10% of the placed volume) from the monitoring area. Over the period covered by Monitoring Report 2, an additional 91,000 cy of material have been lost from the feeder feature, and an additional 106,000 cy have been lost from the entire fill, bringing the total losses within the feeder feature and fill areas to 226,000 cy and 367,000 cy (~52% of the placed volume), respectively. During this same time period, an additional 100,000 cy were deposited on the beaches to the north and south, bringing the total volumetric increase on the adjacent beaches to 250,000 cy. Overall a total of 115,000 cy of material (~16% of the placed volume) has been lost from the monitoring region between Profiles 1 and 44 and 100 through 108 (groin cells 3 through 18) between February 9 and December 12, 2009. Figure 12 summarizes the cumulative volumetric change on a groin cell by groin cell basis. Small but consistent increases in volume observed in groin cells 1 and 2 suggest that at least a portion of this unaccounted for material has moved north out of the monitored region, but likely remains within the bounds of the City of Long Branch.

Table 2. Volume Change Within Project Area					
	Volume Change (cy)				
Area	**Postfill 1-10**	**Postfill 1-13**	**Postfill 1-16**	**Postfill 1-18**	**Postfill 1-21**
Feeder Beach	-135,105	-161,987	-168,528	-192,599	-226,111
Original Fill Template	-223,897	-259,386	-294,259	-324,681	-366,796
Downdrift (south)	4,500	2,364	1,388	3,094	13,210
Updrift (north)	146,809	168,745	256,218	242,406	238,125



Groin Cellls	Profile Lines
1	113
2	112-110
3	109-108
4	107-106
5	105
6	104-103
7	102
8	101-1
9	2-5
10	6-8
11	9-14
12	15-17
13	18-20
14	21-29
15	30-32
16	33-35
17	36-39

Note: PF1- topo and hydro surveys, PF21 -topo and hydro surveys.

Figure 12. Volume change per groin cell (PF1 – PF21)

Volume changes in three specific groin cells are shown below in Figure 13 through Figure 15. Figure 13 shows the volume change in groin cell 14, which is the feeder beach region. Note that the color of the bar is reflective of the type of comparison being made, i.e. full survey, topographic only, or bathymetric only. The graph is somewhat skewed by the fact that the x-axis is categorical rather than

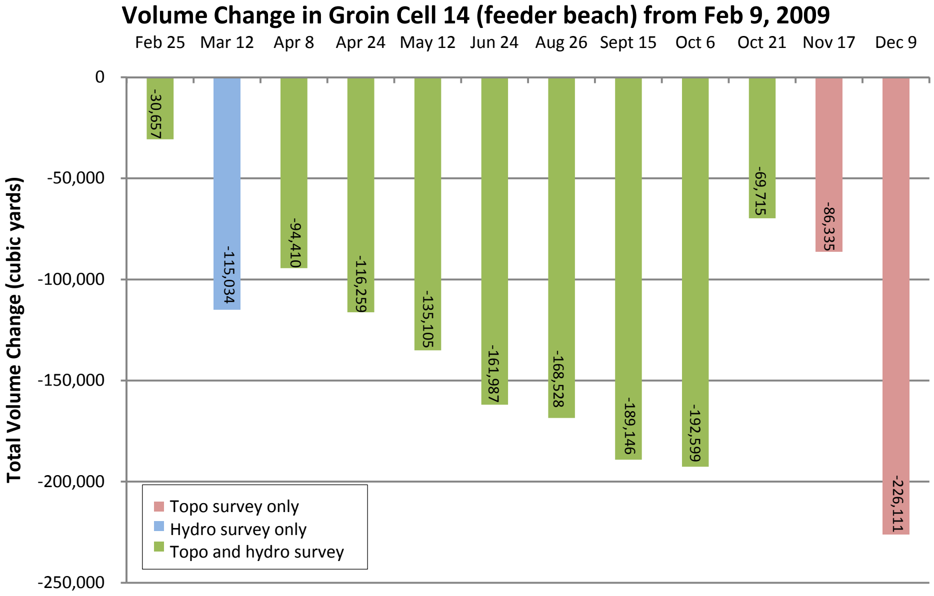


Figure 13. Volume change in groin cell 14 (feeder beach)

quantitative, such that each bar takes up the same amount of space even though the last six bars represent a time period twice as long as the first six. Considering this, it’s obvious that the rate of volume change has slowed considerably

Groin cell 12, shown in Figure 14 is interesting in that its represents a sort of fixed nodal point where volumetric changes have been consistently negligible throughout the monitoring period. Looking at the physical characteristic of this cell, it represents one of the smallest in the study, and is located near the northern limit of the fill. Each of the updrift cells between the center of the feature and Groin Cell 12 experience consistent erosion, while downdrift they all experience accretion. This suggests that the amount of material leaving cell 12 after the placement of the initial nourishment is balanced by the amount entering as the feeder feature spreads out. The most recent surveys suggest cell 12 may be entering an erosional phase. This is potentially related to the fact that as the feeder feature has spread the rate of sediment supply into cell 12 at the southern end has been reduced.

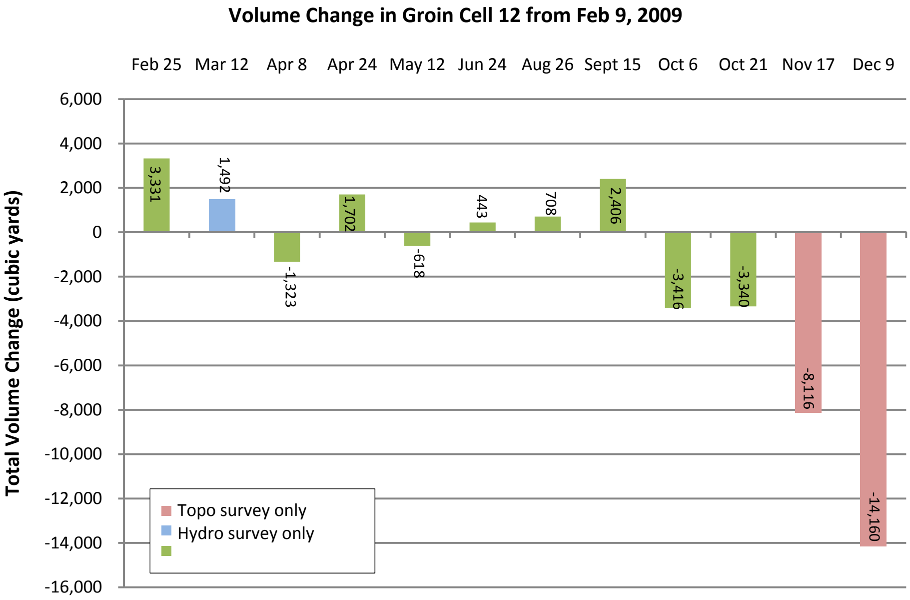


Figure 14. Volume change in groin cell 12 (northern extent of fill)

The changes in Groin Cell 5 (downdrift of the fill placement area) are shown in Figure 15. As with each of the groin cells downdrift (north) of the project site, significant accretion is observed. Cell 5 is located immediately downdrift of a small outfall pipe/groin combination which impacts the local

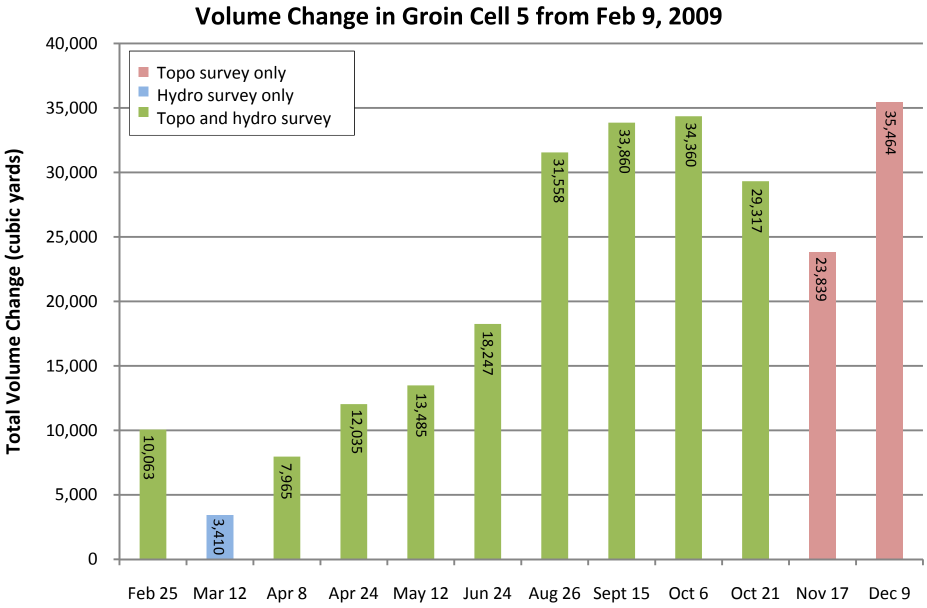


Figure 15. Volume change in groin cell 5 (downdrift)

morphology although not to the same extent as the large pipe discussed previously. The sharp increase in volume observed between the June 24 and August 26 survey is potentially related to the updrift cell filling to such a capacity that bypassing of the pipe/groin system is enhanced. Subsequent surveys indicate that minimal changes have been observed within the cell subsequent to the abrupt jump.

Table 3 contains net sediment transport rates calculated by dividing the volumetric changes in Table 2 by the number of days between surveys. As expected, the initial sediment transport rates calculated based on the amount of material leaving the fill area, are extremely high compared to historically published rates which range from 319,000 – 493,000 cy/year (New York District of the US Army Corps of Engineers 1984). As the fill has equilibrated however, the rates have begun to approach those published previously. It should be noted that the rates in Table 6 should be considered preliminary in that they are only based on nine months of data and while the rates are converging somewhat, significant variability remains.

Table 3. Sediment Transport Rates Within Project Area

	Sediment Transport Rate (cy/yr)				
Area	**Postfill 1-10**	**Postfill 1-13**	**Postfill 1-16**	**Postfill 1-18**	**Postfill 1-21**
Feeder Beach	-536,381	-390,268	-406,027	-294,337	-272,565
Original Fill Template	-888,896	-624,928	-708,946	-496,192	-442,153
Downdrift (south)	17,867	5,695	3,345	4,729	15,924
Updrift (north)	582,847	406,551	617,296	370,456	287,047

IMPACTS TO SURFING

The analysis of the project objectives related to surfability is ongoing. A synopsis is presented below. The time series of significant wave height, wavelength and period through December 2009 is shown below in Figure 16. Also noted on Figure 16 are the dates corresponding to the Postfill surveys.

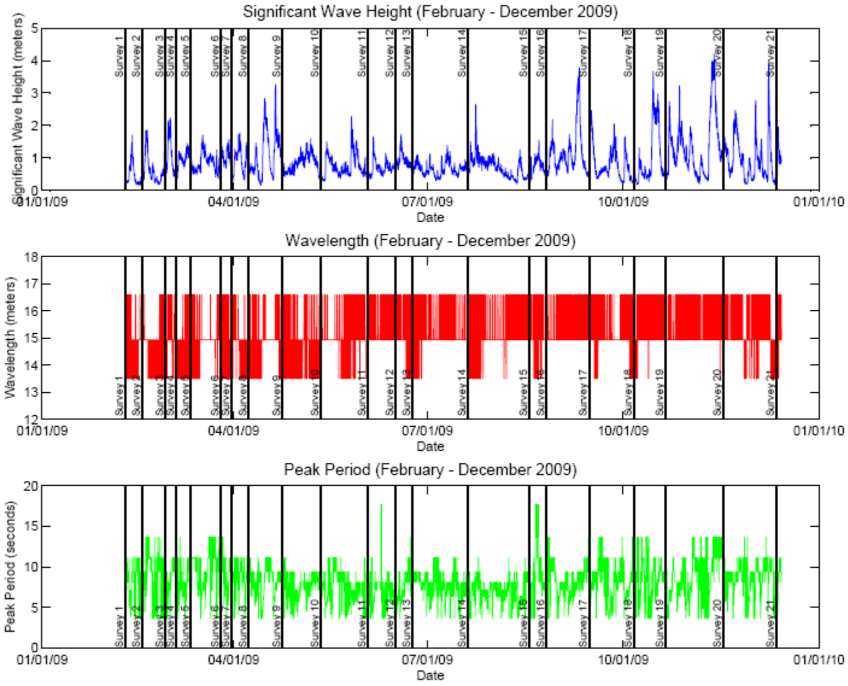


Figure 16. Time series of wave data

Breaker Type

One of the objectives of the feeder beach design was to enhance the surfability of waves in the surf zone through the creation of offshore sandbars during the equilibrium process. There are many parameters related to a wave's surfability. For example, the wave peel angle, defined as the angle between the wave crest and the breaker line (Walker 1974), is one of the most important surf parameters. Advanced surfers prefer peel angles between 30 and 40 degrees, while beginners prefer peel angles between 60 and 90 degrees (Benedet, et al. 2007). Other surfability parameters include the breaker location, wave celerity, surfer velocity and current velocity.

In order to document the evolution of wave breaking during the monitoring period, the breaker type was calculated for every 5th profile line, based on the wave heights and periods calculated from the ADV data, and the beach slopes determined from the bathymetric surveys. The surf similarity parameter, $\xi = \tan\beta/(H_b/L_o)^{1/2}$ was calculated based on the offshore beach slope, $\tan\beta$, the breaking wave height, H_b, and the deepwater wavelength, L_o. These values were compared with values of $\xi < 0.4$, $0.4 < \xi < 2.0$, and $\xi > 2.0$, found by Battjes (1974) to correspond to spilling, plunging, and surging breakers, respectively. In terms of surfability, plunging breakers are preferred by most surfers, due to their curling front faces which create "hollow" or "tubing" waves (Benedet, et al. 2007). Table 4 gives the percentage of measured waves falling into the "plunging" category according to the calculated surf similarity parameter. Generally, the percentage of plunging waves increases to the north and south of the feeder beach, and decreases slightly in the feeder beach region.

Surfzone Width

While breaker type plays an important role in determining whether a given wave is desirable from a surfing stand point, surfzone width is also critical. If a plunging breaker breaks too close to the shoreline the wave closes out, and is not surfable; however, if a plunging breaker breaks a significant distance offshore, the potential exists for a longer, more enjoyable ride. To estimate the surfzone width a simple approach was used where depth limited breaking ($H_b/h_b = 0.78$) was assumed. The nearshore slopes were then used to estimate the offshore extent of the surfzone. Table 5 summarizes the surf zone widths calculated along several profile lines. The surfzone widths along all the lines have increased as the fill equilibrated, yet generally remain relatively short for surfing purposes. Short surfzone widths do not provide a length of surf ride long enough for the wave to be considered surfable. The surfzone widths to the north of the fill remain larger than those within the feeder beach region, which is a reason why the area to the north of the fill continues to be a popular surfing spot.

Table 4. Percent of Plunging Breakers

		Profile Line				
Survey	**Date**	**110**	**1**	**10**	**25**	**43**
Postfill 1	2/9/2009	-	78%	92%	92%	58%
Postfill 3	2/25/2009	-	75%	93%	88%	55%
Postfill 8	4/8/2009	55%	99%	95%	99%	74%
Postfill 9	4/24/2009	18%	96%	98%	98%	73%
Postfill 10	5/12/2009	51%	98%	95%	94%	61%
Postfill 13	6/24/2009	46%	68%	65%	96%	77%
Postfill 16	8/26/2009	12%	97%	90%	76%	68%
Postfill 17	9/15/2009	37%	86%	96%	79%	57%
Postfill 18	10/6/2009	66%	89%	94%	81%	64%
Postfill 21	12/12/2009	72%	93%	95%	88%	70%

Table 5. Surfzone Width (in feet)

		Profile Line				
Survey	**Date**	**110**	**1**	**10**	**25**	**43**
Postfill 1	2/9/2009		46.7	30.3	30.3	74.2
Postfill 3	2/25/2009		65.0	35.0	32.8	87.6
Postfill 8	4/8/2009	94.4	46.4	38.5	48.0	78.1
Postfill 9	4/24/2009	111.1	57.9	34.8	53.1	77.2
Postfill 10	5/12/2009	72.8	32.4	28.3	39.1	63.6
Postfill 13	6/24/2009	79.5	17.5	17.1	32.9	61.1
Postfill 16	8/26/2009	143.3	60.6	68.4	80.0	85.4

Postfill 17	9/15/2009	106.4	51.6	39.1	59.2	80.5
Postfill 18	10/6/2009	69.3	48.3	44.7	54.3	71.1
Postfill 21	12/12/2009	80.8	56.4	52.2	63.4	82.9

RESULTS AND CONCLUSIONS

Monitoring Report 1 (Miller, *et al.* 2009b) described the results of the first ten Postfill Surveys and covered the period from February 9, 2009 until May 12, 2009. During this period, the feeder beach at the center of the project eroded rapidly, losing 135,000 cy and up to 15 feet in elevation. The entire fill region lost 224,000 cy of material. The majority of this material moved to the north in the direction of the net littoral drift, resulting in a gain of 147,000 cy of material, within the downdrift profiles. This suggested that the majority of the fill material remained within the active littoral system and on the beaches of the City of Long Branch, although not within the original project bounds. It should be noted that these volume calculations represent an updated version of those presented in Monitoring Report 1, based upon a recalibration of the sound velocity measurements performed between monitoring reports. The surfing analysis showed a high percentage of plunging breakers within the monitoring area. However, small surfzone widths (and hence short surf rides) within the fill area prevent surfers from surfing within the area. Larger surfzone widths are seen to the north of the fill area, which could be a reason why surfers appear to prefer this area.

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