Appendix A: Final Report, Singleton Swash Current Velocities and Discharge Rates, January 2008

SINGLETON SWASH
CURRENT VELOCITIES AND DISCHARGE RATES
JANUARY 2008
FINAL REPORT

SUBMITTED TO:
US ARMY CORPS OF ENGINEERS
CHARLESTON DISTRICT

Final Report for USACE Charleston District
MONITORING CURRENT VELOCITIES WITHIN SINGLETON SWASH

1.0 OBJECTIVE:

The purpose of the study was to measure velocities and water levels within the swash channel of Singleton swash in order to estimate the discharge rates. Specifically, the purpose of this project was to: (1) measure the along-channel and cross-sectional depths of the swash channel at several specified locations (2) measure the variation of current speeds across the creek (3) measure velocity profiles and water levels in the center of the swash channel for approximately one month and (4) estimate the discharge rates of the swash channels.

2.0 METHODOLOGY

2.1 Cross-sectional study of the swash creek

Elevation and position data were collected at specified locations along and across the swash channel to measure the bathymetry of the channel and adjacent beach. Real-Time Kinematic (RTK) GPS position and elevation data were collected along the swash channel and across the ten specified transects as shown in Figure 1. The RTK-GPS was used because of its high accuracy within the vertical plane. The data was collected in International feet and referenced to NAVD 88.

Current velocities and depth measurements were collected at 3 foot intervals across the channel where the ADCP was deployed. Coastal Carolina University's electromagnetic current meter was used with a 100 foot tape to accurately measure the currents within each 3 foot increment. These data were used to measure the spatial variation of flow and depth across the channel to better estimate discharge rates.

2.2 Current and Water Level Measurements

This task involved a deployment of the Corps of Engineer's 1200kHz Acoustic Doppler Current Profiler (ADCP) within the swash channel from January 7th – January 26th, 2008. Prior to the deployment, pre-deployment field tests were conducted within the swash tidal creek to determine the best sampling mode for the deployment over the range of conditions encountered within the swash. Although the location created a challenging deployment environment, CCU was successful at determining an appropriate sampling set-up in Mode 11 (Pulse-coherent mode) where bin sizes can be reduced to 5 cm (Table 1).

Table 1. Sampling set-up for 1200kHz ADCP at Singleton swash

Blanking Distance	0.15 m (15 cm)
Bin Size	0.05 m (5 cm)
Sampling Frequency	1 Hz, every 5 minutes, 60 profiles per ensemble
Deployment Date	01/07/08 for 26 days
Mode	11 (Pulse Coherent Mode)

The ADCP was deployed in an aluminum frame with dimensions of approximately 0.5 m x 0.5 m x 0.5m. The ADCP was attached to the frame with titanium bolts and two 50 lb weights were used to keep the frame in place during the deployment. Additionally, because of the depth limitation within the creek, the ADCP was partially buried within the sediment in order optimize the vertical measurement of the water column and minimally disrupt the flow. The ADCP collected current profiles from approximately 40 cm above the channel bed to the free surface. Current profiles and water level (pressure) data were collected throughout the water column in 5 cm bins for 60 seconds every 5 minutes.

In order to calculate a time series of discharge rates, an individual bin at approximately 50 cm above the channel bed (bin 2) was chosen to provide a representation of the current throughout the water column. Because the current velocity was fairly consistent throughout the water column in the creek, assuming a constant vertical velocity profile should have provided a good estimate of the discharge rates.

Discharge rates into and out of the swash were calculated within 17 cross-section increments across the channel. A Matlab program was written to calculate the discharge rate every 5 minutes throughout the deployment for each of the 3 ft increments across the channel. This was done by estimating the current velocities within each increment across the creek using a ratio of the measured ADCP currents and the measured across-channel currents measured with the current meter. Cross-sectional flow velocities were estimated by multiplying the calculated ratio for each of the 17 sections by the measured ADCP velocity for each 5 minute ensemble throughout the deployment. Once each across-channel velocity was determined, they were multiplied by the increment width (91.44 cm) and depth. The depth of the water column in each segment was calculated by subtracting the difference in elevation of the channel bed within each increment and the depth of the channel at the ADCP from the total water column height recorded by the ADCP.

3.0 RESULTS

3.1.1 GPS survey data

The GPS coordinates were then imported into GIS and overlaid onto an aerial photo of the swash area to show the exact locations where the GPS survey data was collected (Figure 1). A depth scale was implemented in GIS to visually indicate deeper and shallower areas around the study sites.

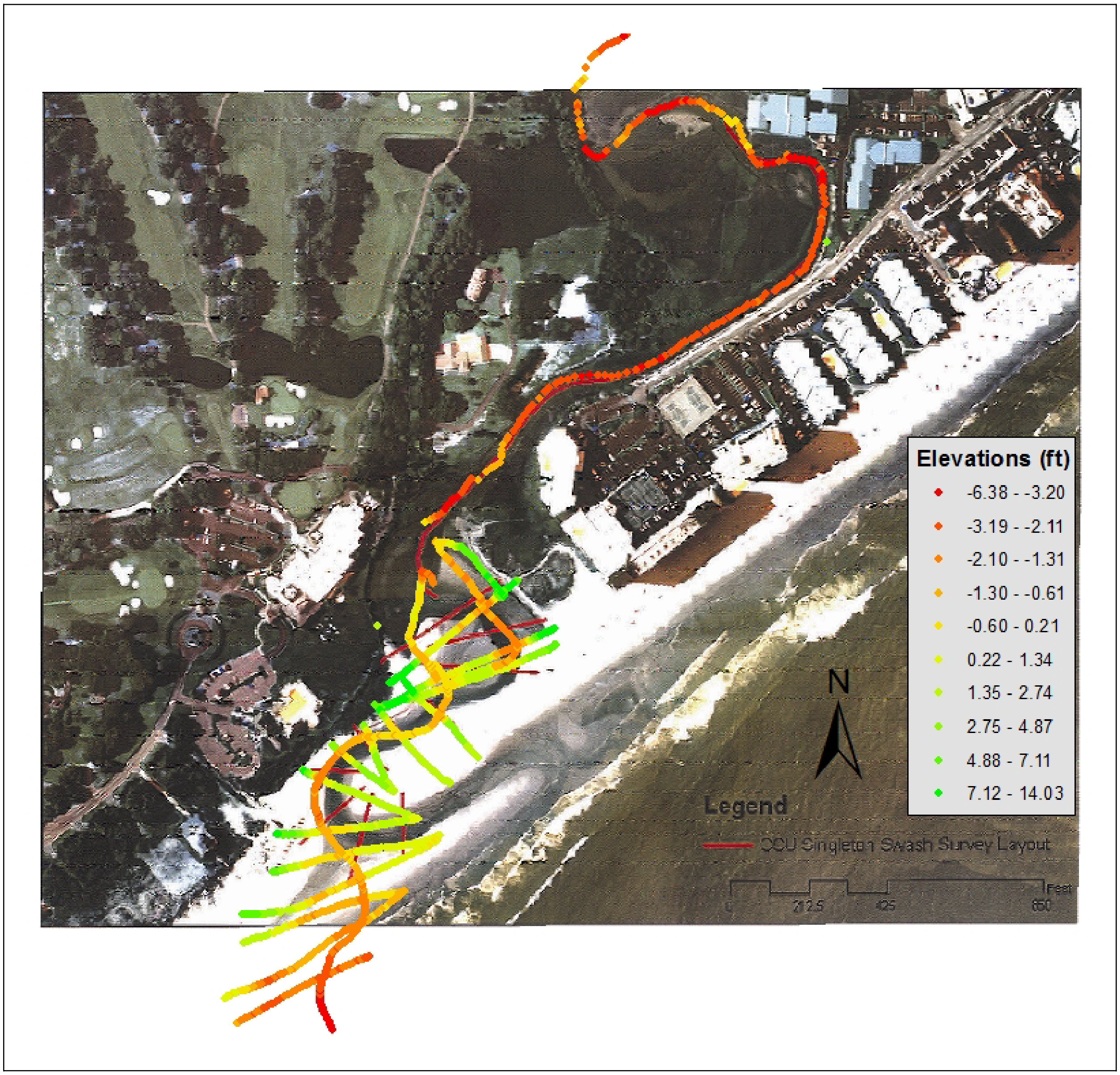


Figure 1. GIS interpretation of the survey data overlaid onto an aerial photo of the study site. Shallow depths appear in yellow, while the deeper channel can be seen as the darker red.

3.1.2 Current velocities and cross-section depths

A handheld electromagnetic current meter was used to measure the spatially varying currents across the tidal creek while cross-sectional depth measurements were also recorded. Figure 3 provides a depth cross-section of the channel where the ADCP was deployed, as well as the spatial variation of the across-channel flow in the creek channel. The flow velocity was greatest in the center of the channel, although this was not where the channel depth was the greatest. The ADCP was placed approximately 12 feet from the steep-sloping northern bank of the channel; however, the change in the flow across the creek was taken into account when the discharge rates were calculated.

The channel bed was composed of a very fine grained and organic-rich sediment resembling a sandy-silt. The channel slope was shallow on the southern side of the channel , whereas on the northern side of the channel there was a steep bank and natural levee at the elevation of the salt marsh canopy (Figure 2). At low tide, the bank was approximately 1m above the elevation of the surface water in the creek.

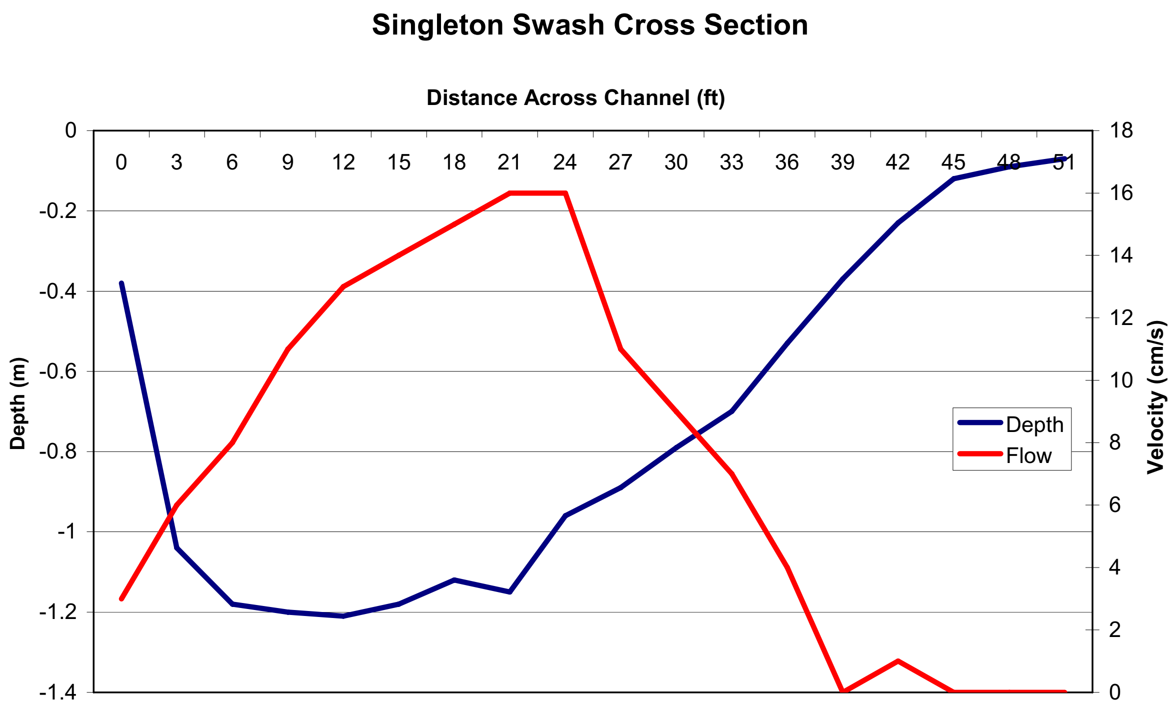


Figure 2. Current magnitude and depth across the creek channel where the ADCP was deployed. The zero distance across the channel is the north side of the channel.

3.2 ADCP Current Velocities within the swash channel

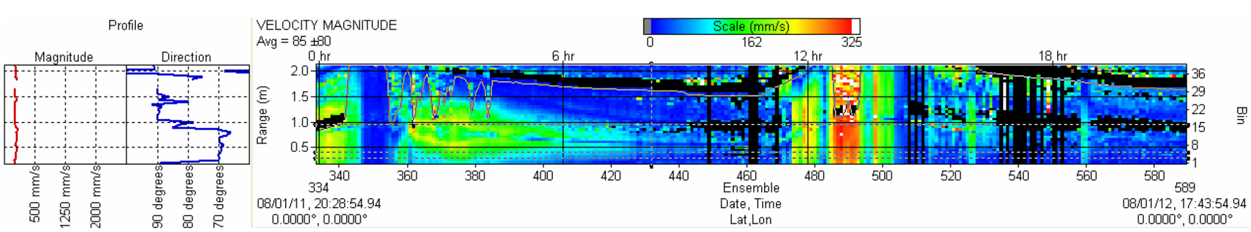
The ADCP was deployed from January 7th through January 26th, 2008. Current velocity profiles throughout the water column of the tidal creek were collected and internally recorded every 5 minutes. The location for the deployment (Figure 3) was chosen because of the relatively deeper channel depth and accessibility.

Continuous current velocity profiles, temperature, and pressure were measured simultaneously every 5 minutes throughout the deployment. A subset of the data is shown in Figure 4, where magnitude and direction profiles are shown for one burst, along with a subset of the current velocities throughout a tidal cycle on the right. The contour plot of current magnitude is a good representation of the quality of data that was collected during the deployment.

Figure 3. Singleton Swash tidal creek and location of the ADCP.

Quality data was measured during a majority of the deployment during times of flooding and ebbing tides. However, the ADCP was unable to measure the current velocities during the lowest part of the tide due to the very shallow depth and the fine sediment that settled onto the transducer faces at slack tide when currents were close to zero (Wren, per obs.). This should not be viewed as a problem due to the fact that the flows at this time were minimal and would not significantly change the discharge calculations.

Figure 4. Snapshot of raw ADCP current data in the viewing software WinADCP.



The ADCP current data also indicate that the tidal cycle was asymmetrical at the site (Figure 5). Flooding of the swash occurred very rapidly, whereas the ebbing tide was longer. This is most likely due to the bathymetric control from the swash channel closer to the beach. The offshore tidal elevation must inundate the higher elevations closer to the beach, which can be seen in the survey data as shallower creek depths, before flowing into the swash channel where the ADCP was located.

Another interesting feature that can be seen in the raw ADCP data is the surface tracking from the ADCP within the channel. A comparison of the pressure data and the current velocity data revealed that the surface tracking feature of the ADCP was detecting the surface, which can be seen as the first high return in the echo intensity data (Figure 5). However, due to the shallow water environment, the ADCP also indicates a second high return in the echo intensity where the acoustic signal is bouncing off of the channel bed. This appears to create a "mirror image" of the velocity data within the contour plots. Any error that may have been associated with this second detection of the "surface" was alleviated by only using the velocity measurements below the first detection of the surface. Caution should be exercised when interpreting the ADCP data from the raw data plots in order to make sure the velocities above the first surface detection are omitted.

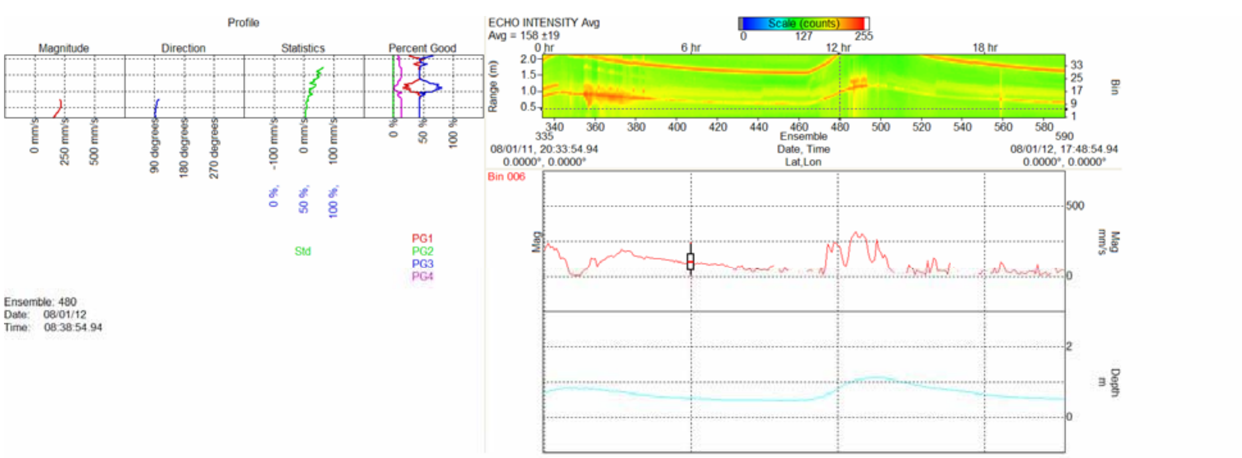


Figure 5. Snapshot of raw ADCP echo intensity data in the viewing software WinADCP. The first high return in the contour plot is the actual surface of the water column.

The raw data was subsequently exported into Matlab for analysis. Time series data of the measured and adjusted creek depth, measured water temperature, and current magnitude and direction throughout the deployment are shown below (Figure 6). The depth measurements below include an offset that was measured from the pressure transducer down to the channel bed so that the entire water column depth is represented. The data is compiled of three deployments in which the changes in the offsets for each deployment were taken into consideration.

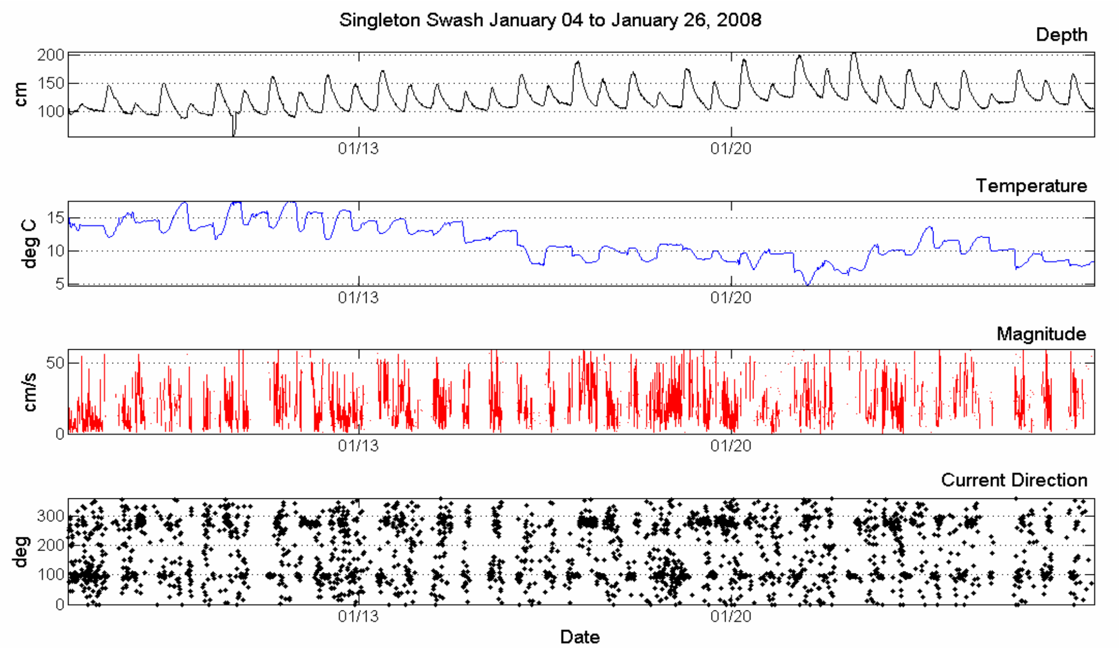


Figure 6. Singleton swash water level, measured temperature, current magnitude, and current direction in the channel for the entire deployment period.

Current speeds ranged from approximately 0-60 cm/s. Largest velocities occurred during the flooding and ebbing of the tide, and had a very short duration. The current direction plot shows two distinct bands which indicate the flooding and ebbing cycles of each tidal cycle. The current directions and east-west orientation of the channel can be seen in Figure 7, which is a compass plot illustrating the magnitude and direction of the current velocities over the duration of the deployment. .

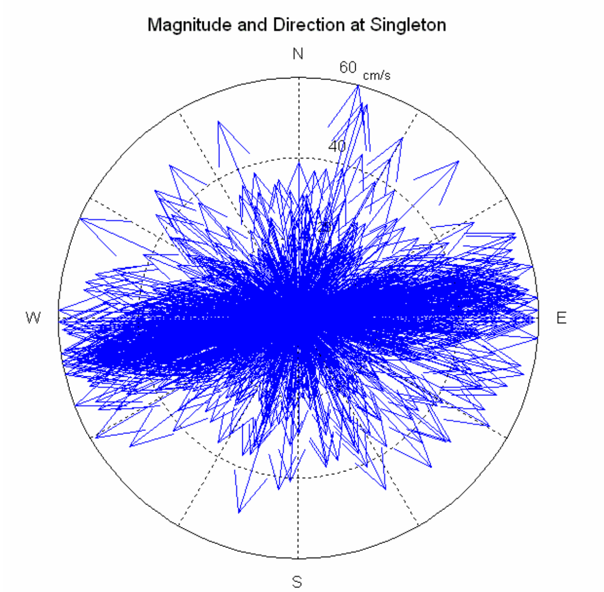


Figure 7. Compass plot of the current velocities from the ADCP approximately 50 cm above the creek bed throughout the entire deployment. The creek orientation was approximately east – west and the dominant current direction was in the along-channel direction.

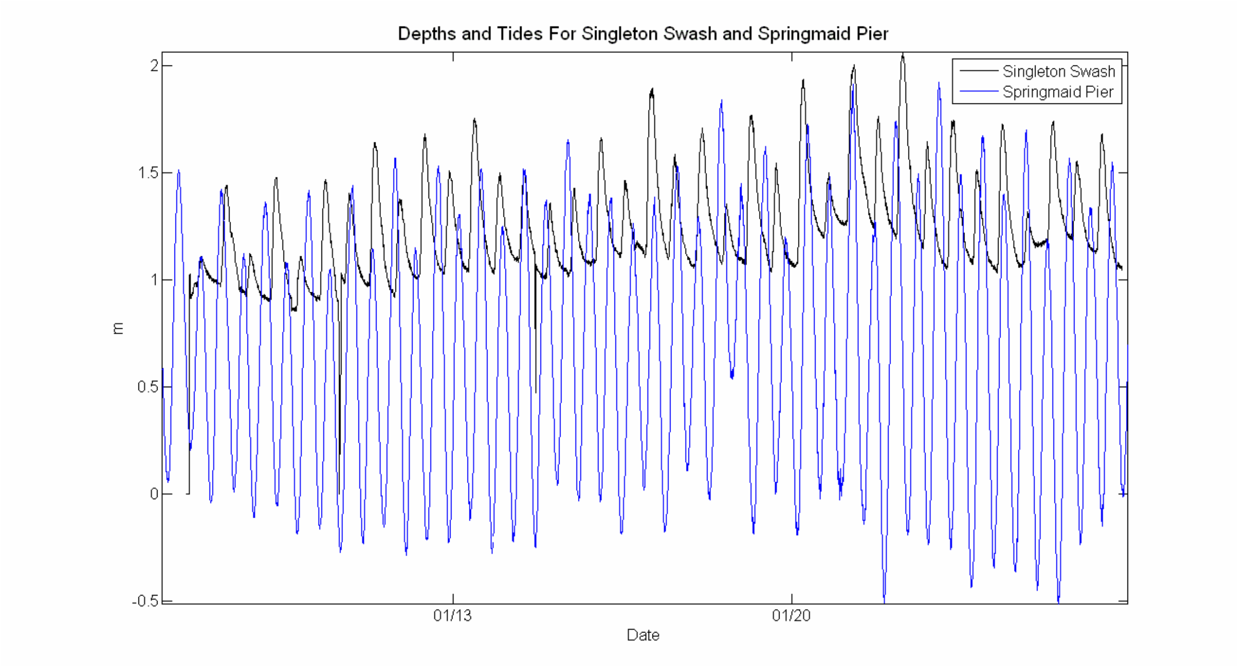


Figure 8. A comparison of the water level data from Singleton swash and Springmaid Pier.

Water column depths within the creek at the location of the ADCP ranged from about 1 - 2 m. An interesting feature of the depth plot is that there is a strong mixed tidal signal with no strong signal between spring and neap tides. A comparison was made between the coastal water level data measured at Springmaid Pier in Myrtle Beach and the Singleton swash tidal data (Figure 8). The below figure shows the two data sets and indicates that there was some diurnal inequality in the coastal tidal signal during a majority of this deployment, although not as pronounced as that of the swash creek.

3.3 Discharge Calculations

Discharge rates were calculated for every 5 minute ensemble using the depth and velocity data from the ADCP as described in the methods in section 2.0. The discharge rates in the creek ranged from approximately 0.45 m3/s to -0.5 m3/s, and it appears that the flooding discharge rates where slightly smaller than the ebbing discharge rates.

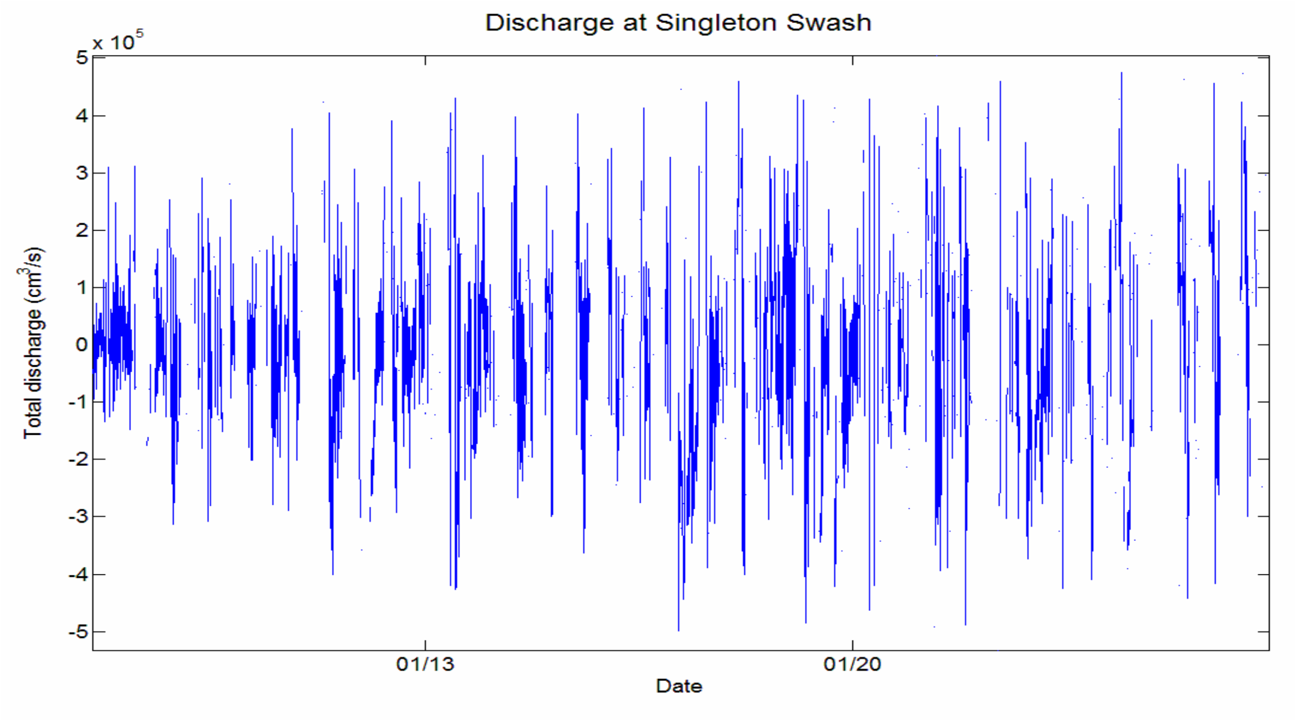


Figure 9. Discharge calculations for Singleton swash throughout the deployment period.

4.0 Conclusions

This study provided estimated discharge rates over the course of a month and shows the variability of water depth, velocity, and discharge rate over a three week duration at Singleton swash. The measurements here are form a winter deployment, and variation may also occur on a seasonal or annual basis. Not only is it evident that the tide affects the amount of water flowing into and out of the swash system, but the surrounding bathymetry also exerts control over the swash velocities and discharge rates.

Appendix B: Final Report, White Point Swash Current Velocities and Discharge Rates, October-November 2007

WHITE POINT SWASH
CURRENT VELOCITIES AND DISCHARGE RATES
OCTOBER – NOVEMBER 2007
FINAL REPORT

SUBMITTED TO:
US ARMY CORPS OF ENGINEERS
CHARLESTON DISTRICT

Final Report for USACE Charleston District
MONITORING CURRENT VELOCITIES WITHIN WHITE POINT SWASH

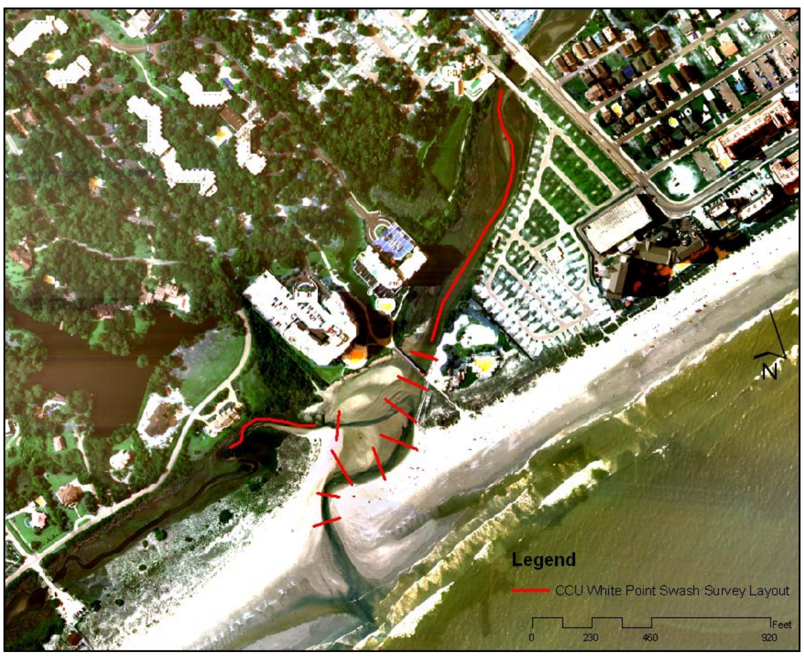
1.0 OBJECTIVE:

The purpose of the study was to measure velocities and water levels within the swash channel of White Point swash in order to estimate the discharge rates. Specifically, the purpose of this project was to: (1) measure the along-channel and cross-sectional depths of the swash channel at several specified locations (2) measure the variation of current speeds across the creek during one ebb and one flood tide (3) measure velocity profiles and water levels in the center of the swash channel for approximately one month and (4) estimate the discharge rates of the swash channels.

2.0 METHODOLOGY

2.1 Cross-sectional study of the swash creek

Elevation and position data were collected at specified locations along and across the tidal creek and swash channel to measure the bathymetry of the channel and adjacent beach. Real-Time Kinematic (RTK) GPS position and elevation data were collected along the two swash channels and across the ten specified transects as shown in Figure 1. The RTK-GPS was used because of its high accuracy within the vertical plane. The data was collected in International feet and referenced to NAVD 88.



Simultaneous current velocities and depth measurements were also collected at 3 foot m intervals across the channel where the ADCP was deployed. Coastal Carolina University's Sontek/YSI Flowtracker was used with a 100 foot tape to accurately measure the currents within each 3 foot increment. These data were used to measure the spatial variation of flow and depth across the channel to better estimate discharge rates.

2.2 Current and Water Level Measurements

This task involved a deployment of the Corps of Engineer's 1200kHz Acoustic Doppler Current Profiler (ADCP) within the swash channel from October 18th – November 18, 2007. Prior to the deployment, pre-deployment field tests were conducted within the swash tidal creek to determine the best sampling mode for the deployment over the range of conditions encountered within the swash. Although the location created a challenging deployment environment, CCU was successful at determining an appropriate sampling set-up in Mode 11 (Pulse-coherent mode) where bin sizes can be reduced to 5 cm (Table 1).

Table 1. Sampling set-up for 1200kHz ADCP at White Point swash

Blanking Distance	0.15 m (15 cm)
Bin Size	0.05 m (5 cm)
Sampling Frequency	1 Hz, every 5 minutes, 60 profiles per ensemble
Deployment Date	10/18/07 12:54 pm for 31 days
Mode	11 (Pulse Coherent Mode)

The ADCP was deployed in an aluminum frame with dimensions of approximately 0.5 m x 0.5 m x 0.5m. The ADCP was attached to the frame with titanium bolts and two 50 lb weights were used to keep the frame in place during the deployment. Additionally, because of the depth limitation within the creek, the ADCP was partially buried within the sediment in order optimize the vertical measurement of the water column and minimally disrupt the flow. The ADCP was deployed within the deepest location of the channel cross-section and the first bin was located approximately 30 cm above the channel bed. Current profiles and water level (pressure) data were collected throughout the water column in 5 cm bins for 60 seconds every 5 minutes.

In order to calculate a time series of discharge rates, an individual bin at 50 cm above the channel bed (bin 4) was chosen to provide a representation of the current throughout the water column. Because the current velocity was consistent throughout the water column, assuming a constant vertical velocity profile should have provided a good estimate of the discharge rates.

Discharge rates into and out of the swash were calculated within 26 cross-section increments across the channel. A Matlab program was written to calculate the discharge rate every 5 minutes throughout the deployment for each of the 3 ft increments across the channel. This was done by estimating the current velocities within each increment across the creek using a ratio of the measured ADCP currents and the measured across-channel currents measured with the Flow Tracker. Cross-sectional flow velocities were estimated by multiplying the calculated ratio for each of the 26 sections by the measured ADCP velocity for each 5 minute ensemble throughout the deployment. Once each across-channel velocity was determined, they were multiplied by the increment width (91.44 cm) and depth. The depth of the water column in each segment was calculated by subtracting the difference in elevation of the channel bed within each increment and the depth of the channel at the ADCP from the total water column height given by the ADCP.

3.0 RESULTS

3.1.1 GPS survey data

The GPS coordinates were then imported into GIS and overlaid onto an aerial photo of the swash to show the exact locations where the GPS survey data was collected (Figure 2). A depth scale was implemented in GIS to visually indicate deeper and shallower areas around the study sites. Additionally, the individual transects were plotted in Excel for visualization purposes and to quickly discern the maximum depths in the channel (Appendix 1).

Figure 2. GIS interpretation of the survey data overlaid onto an aerial photo of the study site. Shallow depths appear in yellow, while the deeper channel can be seen as the darker red.

3.1.2 Current velocities and cross-section depths

A handheld Acoustic Doppler Velocimeter was used to measure the spatially varying currents across the tidal creek while cross-sectional depth measurements were recorded. Figure 3 provides a bottom contour of the channel, as well as the spatial variation of the flow across the creek channel. The flow velocity was the greatest where the depth in the channel was the deepest, which was closest to a 8 foot revetment wall that can be seen on the left side of Figure 3. The shallow area was comprised of sand ripples, except between approximately 20 - 25 m from the seawall, where flows began to interact with the spartina which decreased current velocities. Within the deepest part of the channel the bed was smooth and bedforms were absent, which would indicate that sediments are being transported via suspension in this region.

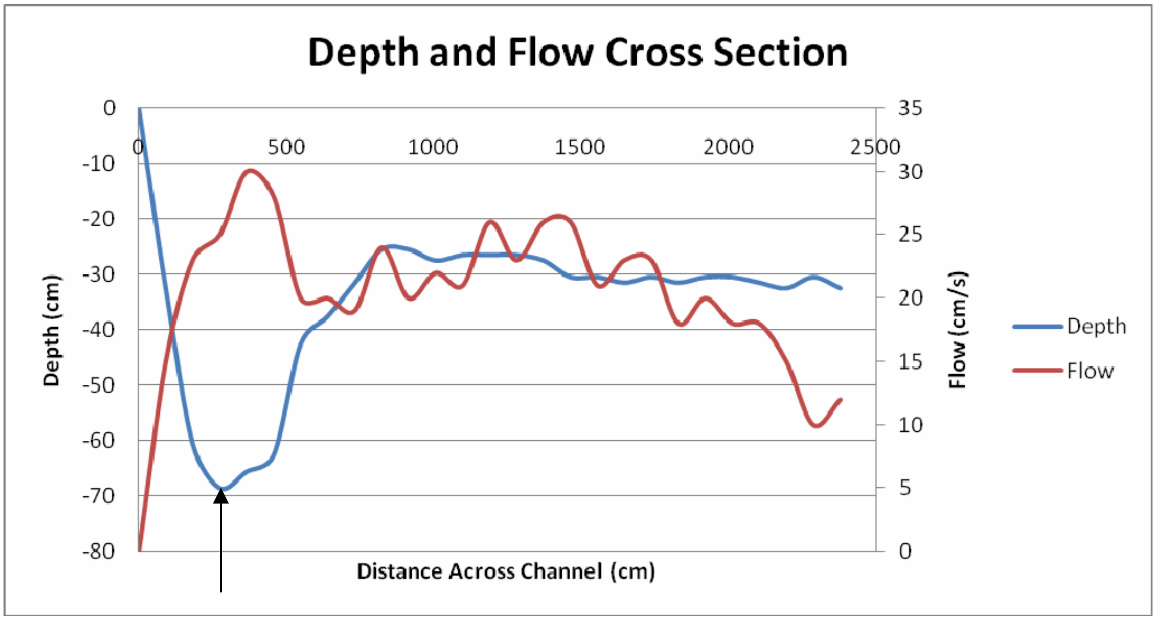


Figure 3. Current magnitude and depth across the creek channel where the ADCP was deployed. The arrow indicates the location of the ADCP within the cross section.

3.2 ADCP Current Velocities within the swash channel

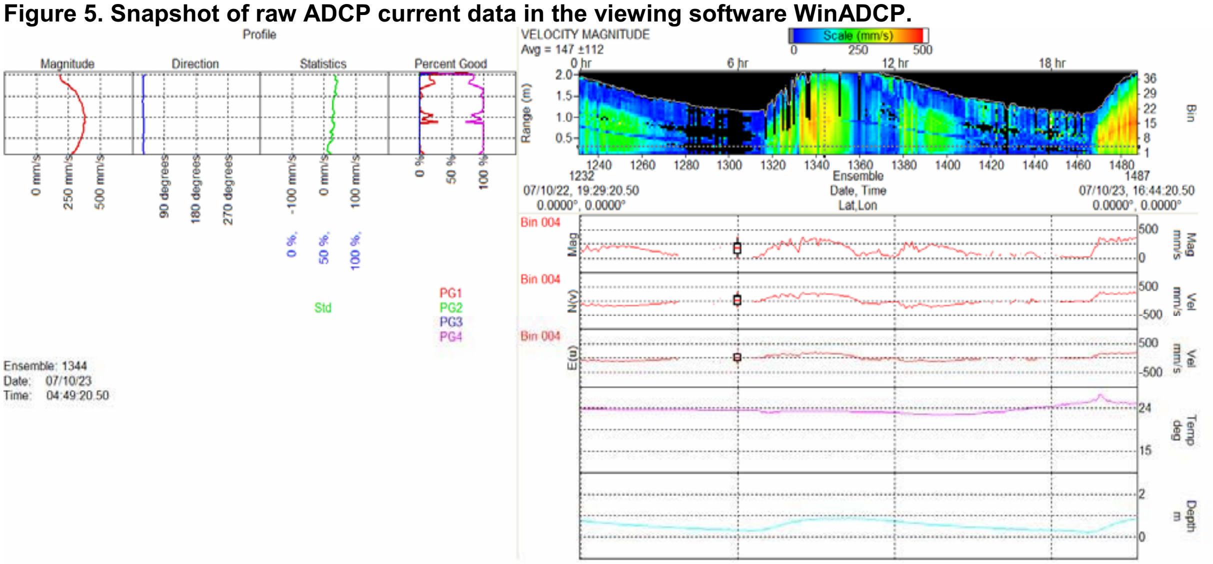
The ADCP was deployed on October 18th through November 18th, 2007. Current velocity profiles throughout the water column of the tidal creek were collected and internally recorded every 5 minutes. The location for the deployment (Figure 4) was chosen because of the relatively deeper channel depth and accessibility.

Continuous current velocity profiles, temperature, and pressure were measured simultaneously every 5 minutes throughout the 31 day deployment. A subset of the data is shown in Figure 5, where magnitude and direction profiles are shown for one burst on October 23rd, along with a subset of the current velocities throughout a tidal cycle on the right. The contour plot of current magnitude is a good representation of the quality of data that was collected during the deployment.

Figure 4. White Point Swash tidal creek and location of the ADCP.

Quality data was measured during a majority of the deployment during times of flooding and ebbing tides. However, the ADCP was unable to measure the current velocities during the lowest part of the tide due to the very shallow depth and the fine sediment that settled onto the transducer faces at slack tide when currents were close to zero (Wren, per obs.). This should not be viewed as a problem due to the fact that the flows at this time were minimal and would not significantly change the discharge calculations.

Figure 5. Snapshot of raw ADCP current data in the viewing software WinADCP.



The ADCP current data also indicate that the tidal cycle was asymmetrical at the site (Figure 5). Flooding of the swash occurred very rapidly, whereas the ebb tide was elongated beyond the approximate 6 hour semi-diurnal period. This is most likely due to the bathymetric control from the swash channel closer to the beach. The offshore tidal elevation must inundate the higher elevations closer to the beach, which can be seen in the survey data as shallower creek depths, before flowing into the swash channel where the ADCP was located.

Another interesting feature that can be seen in the raw ADCP data is the surface tracking from the ADCP within the channel. A comparison of the pressure data and the current velocity data revealed that the surface tracking feature of the ADCP was detecting the surface, which can be seen as the first high return in the echo intensity data (Figure 6). However, due to the shallow water environment, the ADCP also indicates a second high return in the echo intensity where the acoustic signal is bouncing off of the channel bed. This appears to create a "mirror image" of the velocity data within the contour plots. Any error that may have been associated with this second detection of the "surface" was alleviated by only using the velocity measurements below the first detection of the surface. Caution should be exercised when interpreting the ADCP data from the raw data plots in order to make sure the velocities above the first surface detection are omitted.

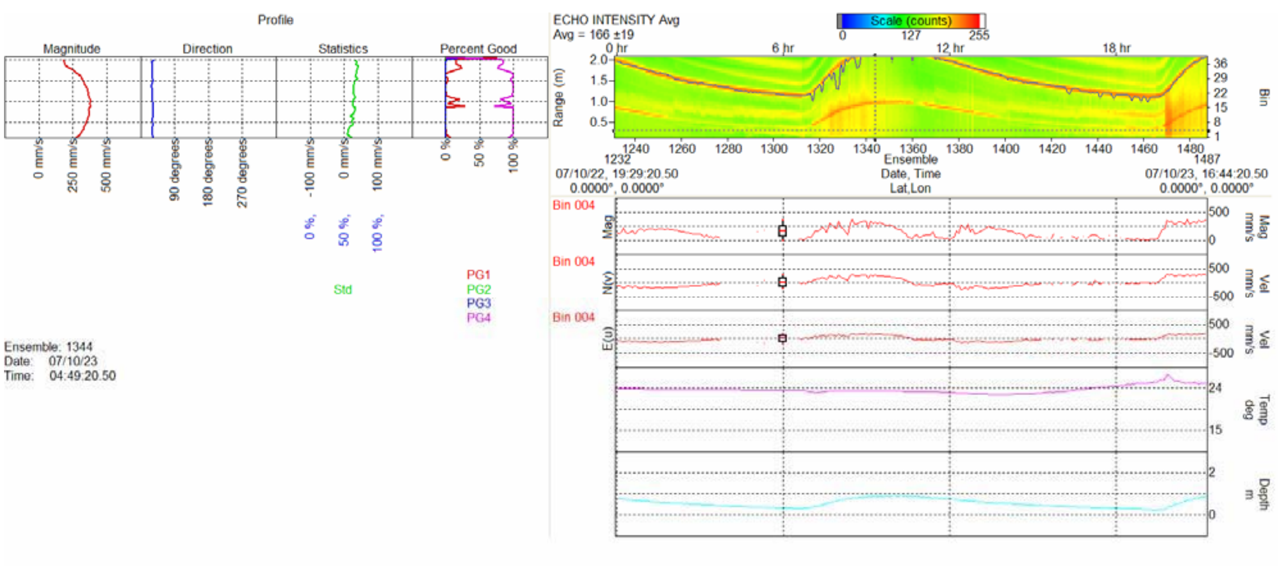


Figure 6. Snapshot of raw ADCP echo intensity data in the viewing software WinADCP. The first high return in the contour plot is the actual surface of the water column.

The raw data was subsequently exported into Matlab for analysis. Time series data of the ADCP depth, along-channel flow, current direction, and calculated discharge rates throughout the deployment are shown below (Figure 7). The depth measurements below include an offset that was measured from the pressure transducer down to the channel bed so that the entire water column depth is represented.

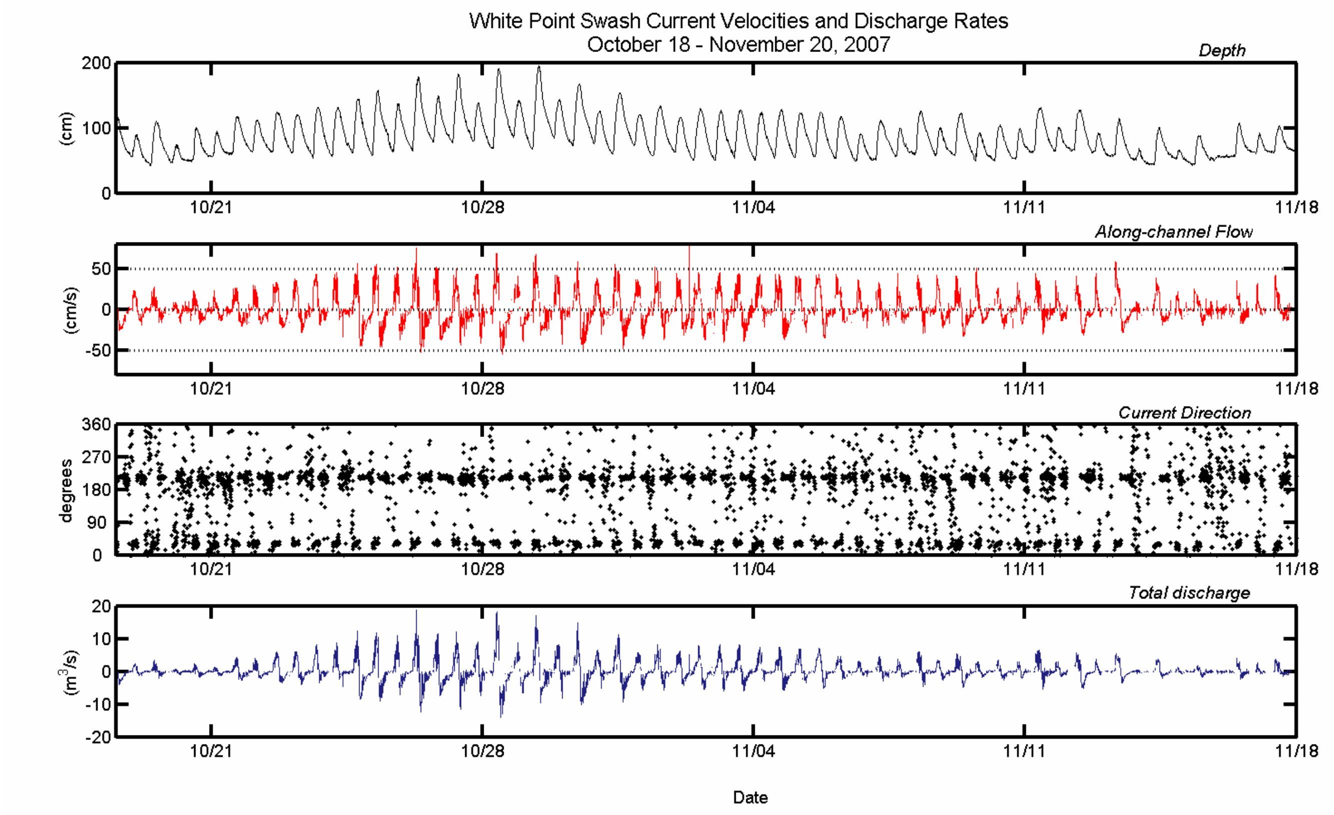


Figure 7. White Point Swash water level, along-channel currents, current direction, and discharge rates across the channel for the entire deployment period.

Water column depths within the creek at the location of the ADCP ranged form less than 50 cm to 2 meters during the spring high tides. An interesting feature of the depth plot includes the strong mixed tidal signal during the spring tide. As the tide moves into the neap cycle, a consistent semidiurnal tidal signal can be seen.

The along-channel velocity was calculated from the east and north components of the velocity using the compass heading of 33.7 degrees east of north, where positive values indicate a flooding tide and negative values indicate an ebbing tide. Velocities ranged from approximately -50 – 65 cm/s. Largest velocities occurred when the tidal range was approximately 1.5 m during the spring tidal cycle the last week of October. The current direction plot shows two distinct bands which indicate the flooding and ebbing cycles of each tidal cycle. The current directions of the flooding and ebbing cycles can be seen more clearly in Figure 8, which is a compass plot illustrating the magnitude and direction of the current velocities over the duration of the deployment. These data also show that velocities reached higher magnitudes during flood tides.

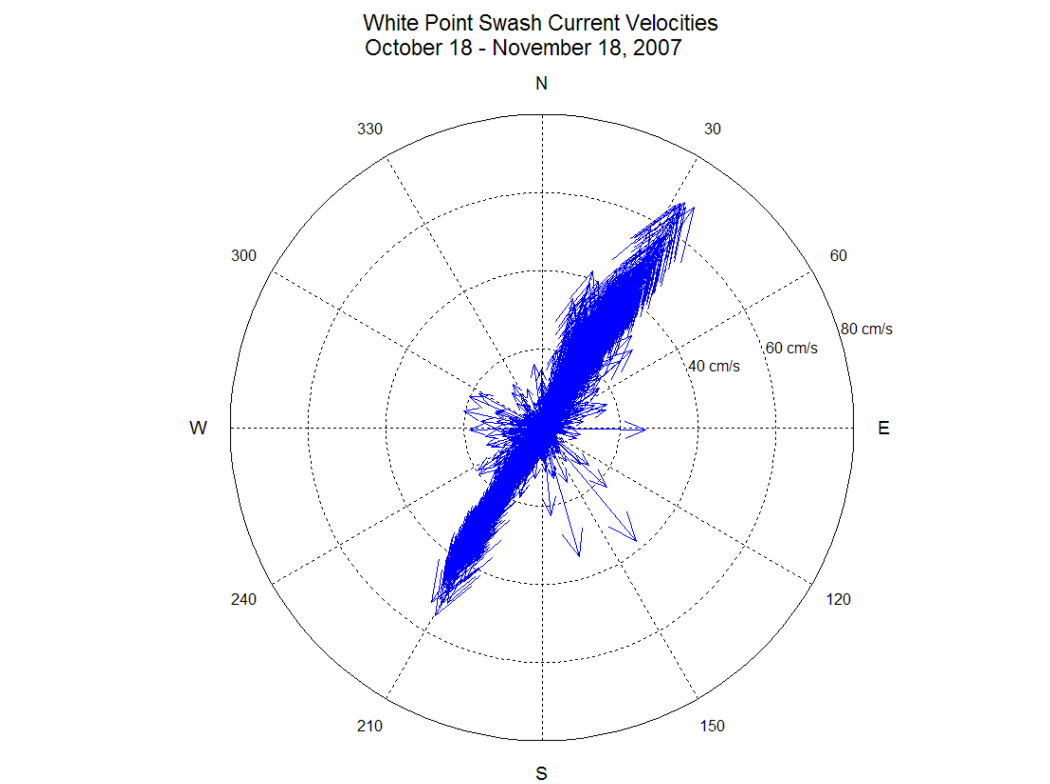


Figure 8. Compass plot of the current velocities from the ADCP approximately 50 cm above the creek bed throughout the entire deployment. The creek orientation was approximately 33 degrees east of north. Dominant current direction was in the along-channel direction, and strongest currents were observed during the flooding tide.

3.3 Discharge Calculations

Discharge rates were calculated for every 5 minute ensemble using the depth and velocity data from the ADCP as described in the methods in section 2.0. Discharge rates ranged from +18 $m^3 s^{-1}$ to -14 $m^3 s^{-1}$. The largest discharge occurred during the last week of October, and was most likely due to the combination of the large spring tide and a rain event that occurred during this time. The rain event occurred from October 25th through October 27th, and within this time period 2.2 inches of rain was reported at the Myrtle Beach International airport (NWS Wilmington District).

A comparison of the discharge rates was conducted between the ADCP calculated rates using the methods in section 2 and the rates using the measured currents from the Flow Tracker (Table 2). The percent error was 5.38% which implies that the calculated discharge rates are rather precise using our methods to estimate the flow velocities across the creek, given that the ADCP only measures flow at one location within the cross-section.

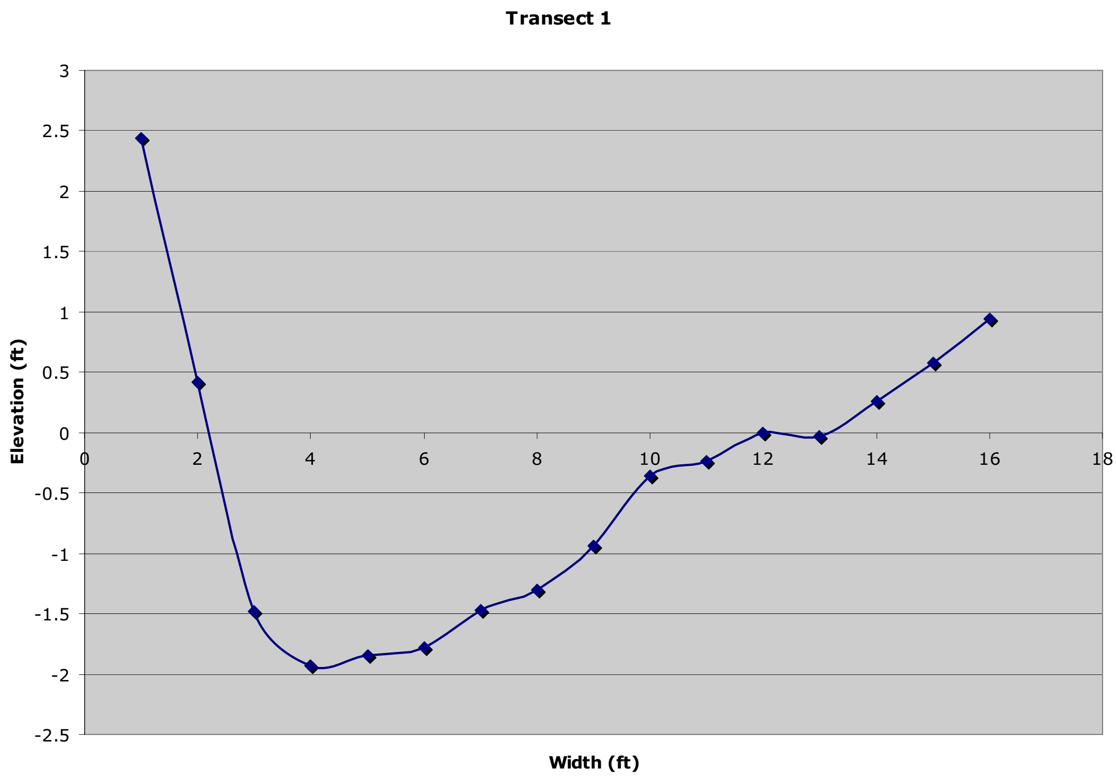
Table 2: The discharge rate from the handheld current meter compared to the discharge rate from the ADCP.

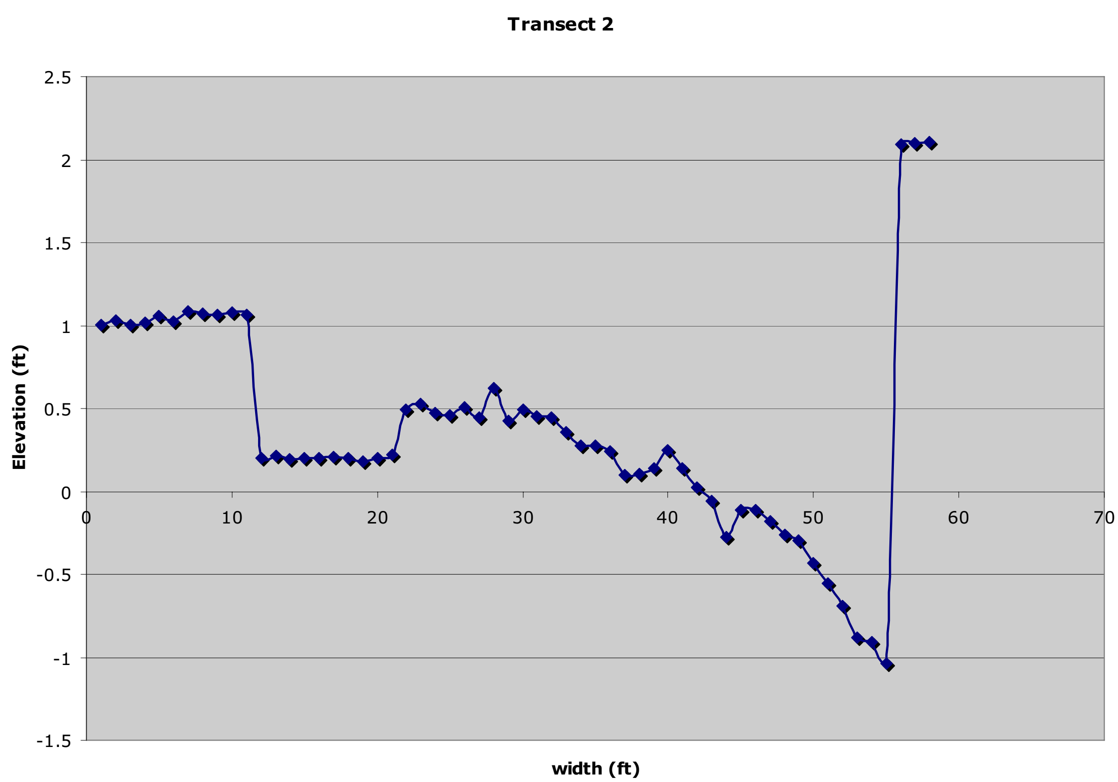
Measured Discharge (cm^3/s)	APCP Discharge (cm^3/s)	Percent Error
1837651.39	1738838.35	5.38

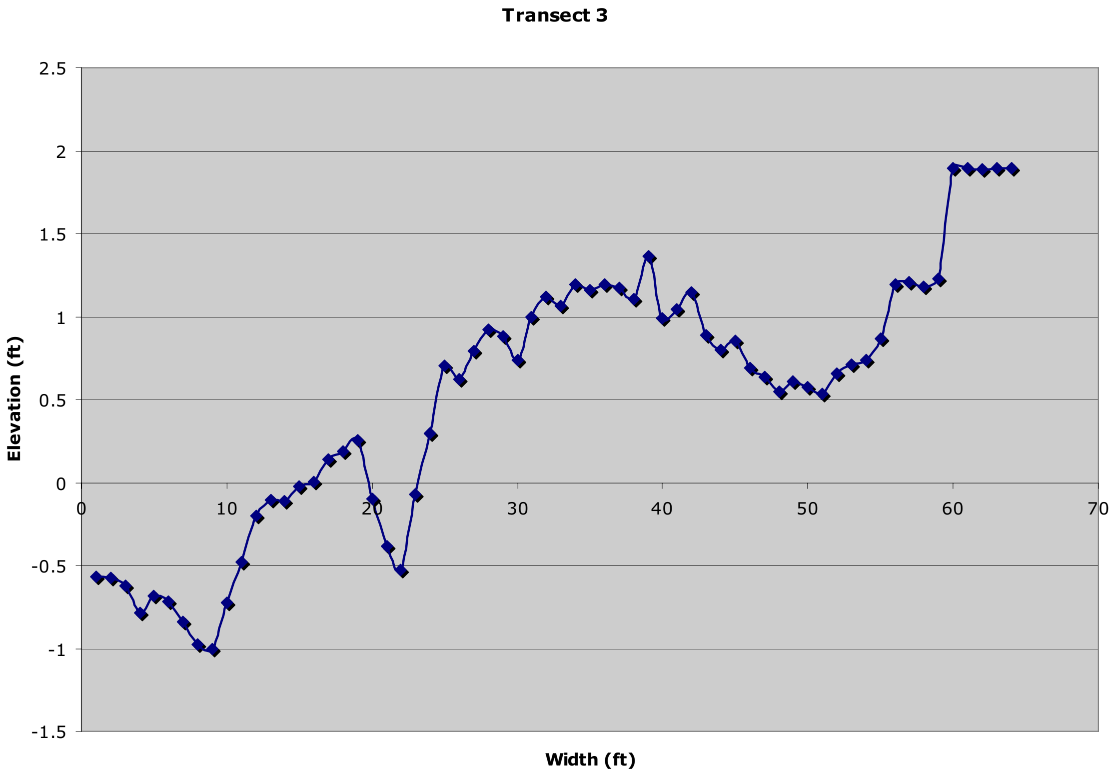
4.0 Conclusions

White Point Swash is one of many swash systems in the Grand Strand region. This study provided estimated discharge rates over the course of a month and shows the variability of water depth, velocity, and discharge rate due to the neap-spring cycle. Variation may also occur on an annual basis. The discharge rates that were calculated during the late October spring tide represent some of the highest discharge rates for this swash system, as this was one of the highest spring tides of the year. Additionally, this is when a rain event occurred in which water levels increased even more due to local runoff. Not only is it evident that the tide affects the amount of water flowing into and out of the swash system, but the surrounding bathymetry also exerts control over the swash velocities and discharge rates. Bathymetric controls are most likely the cause of the mixed tidal signal that was observed during both spring tides.

Appendix 1
Cross-section transect plots



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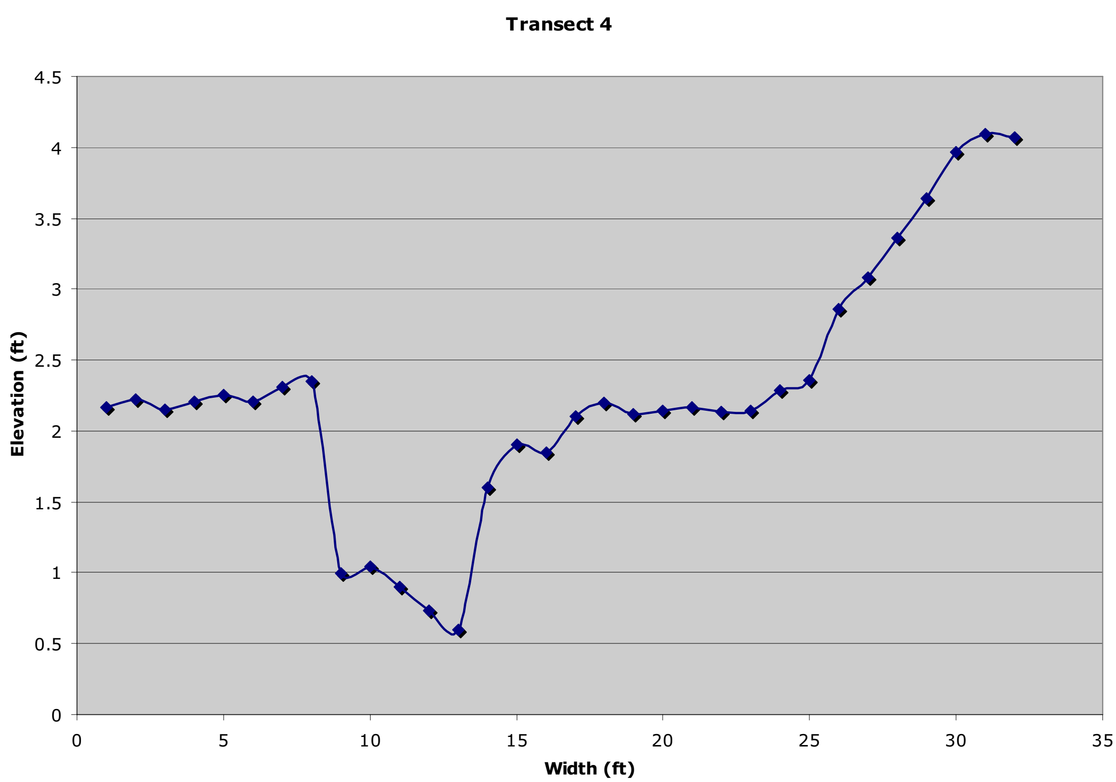
30
40
50
60
70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Width (ft)
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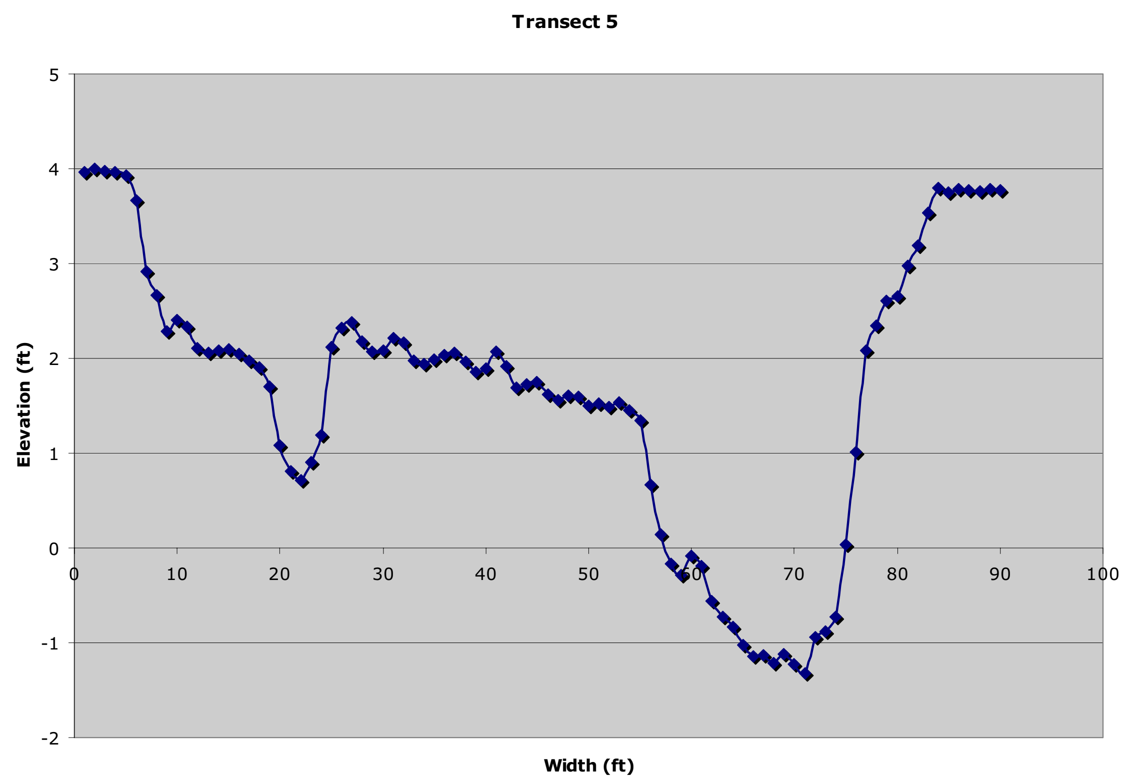
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Elevation (ft)
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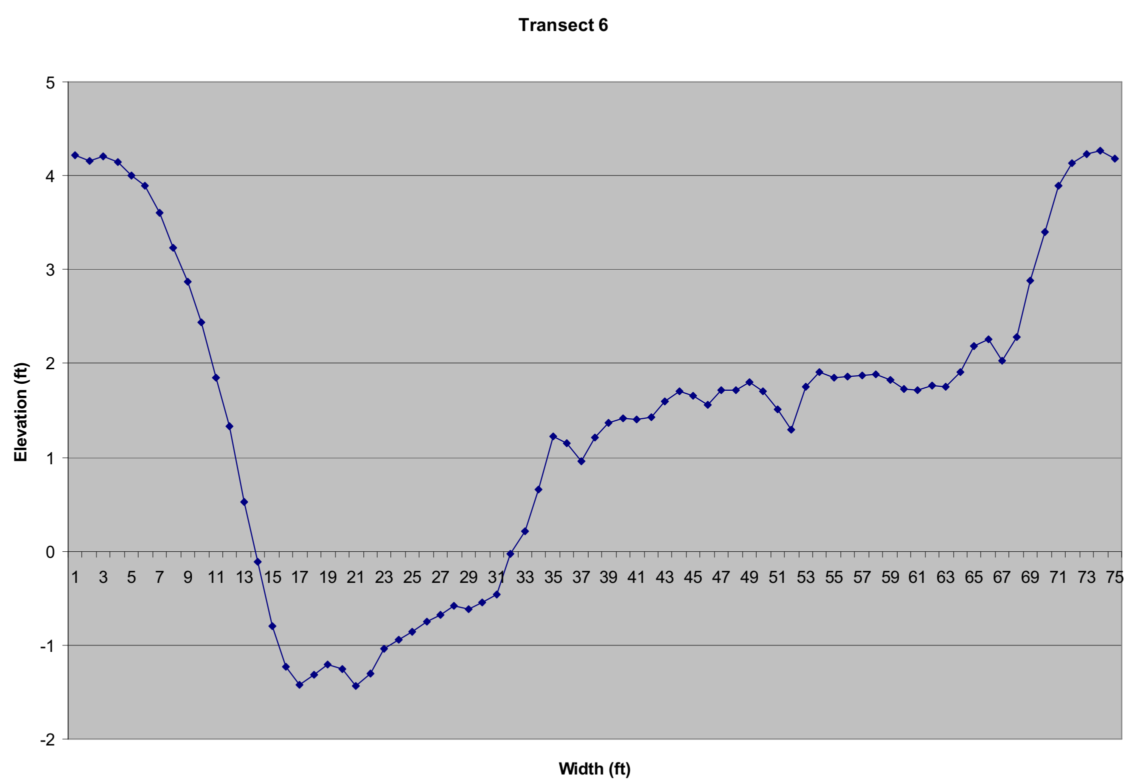
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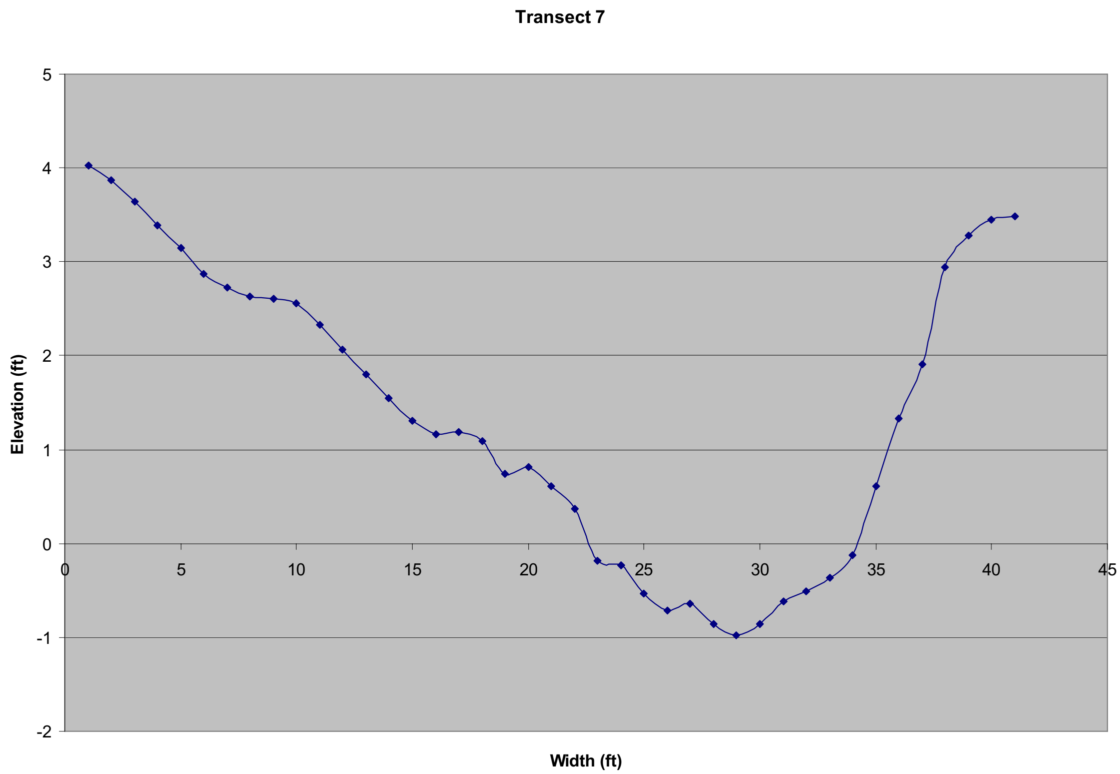
Elevation (ft)
Width (ft)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-2
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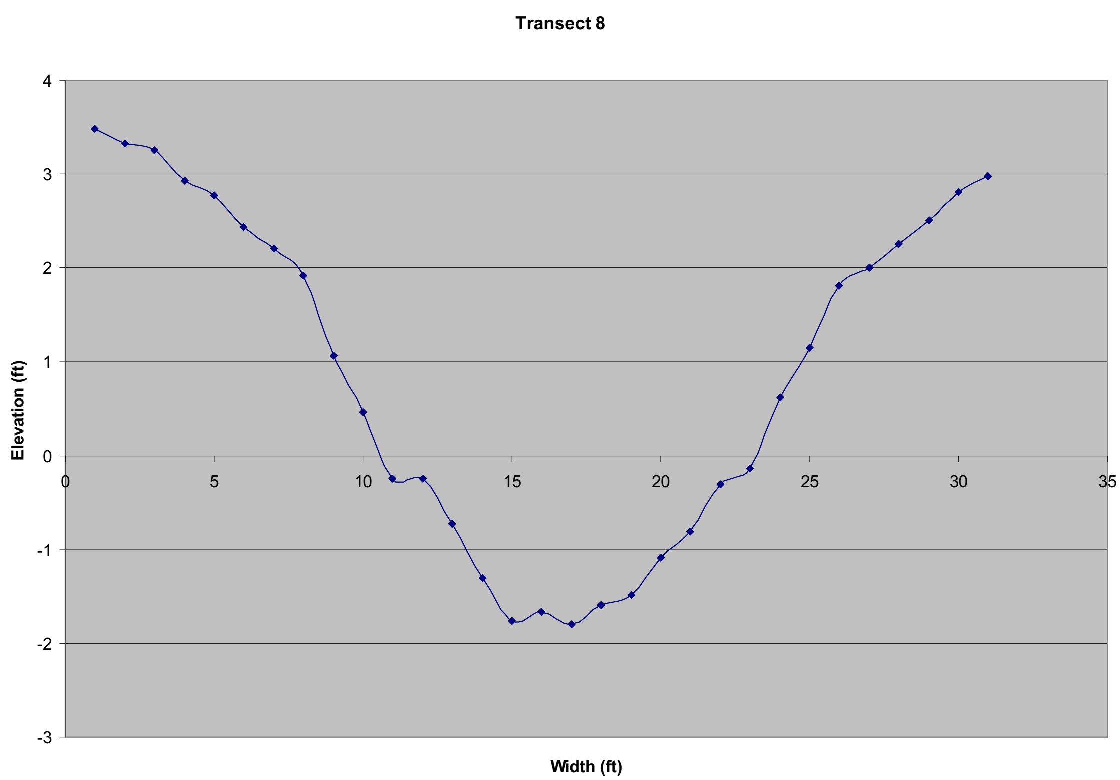
30
35
40
45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Width (ft)
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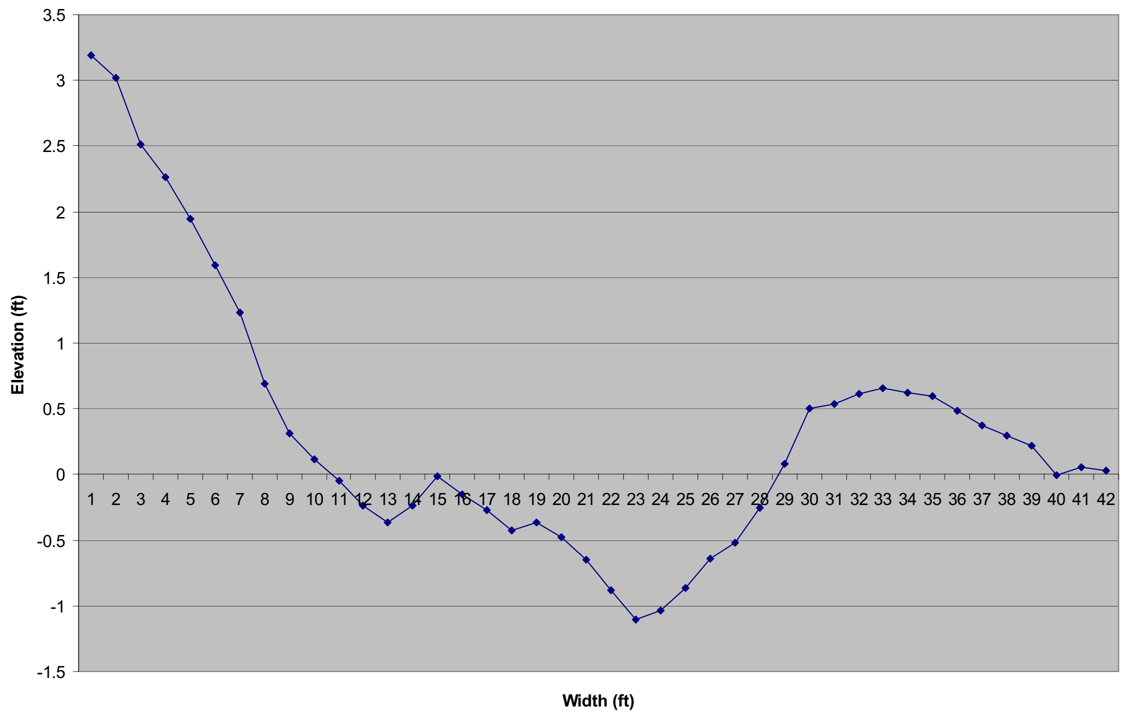
Transect 9



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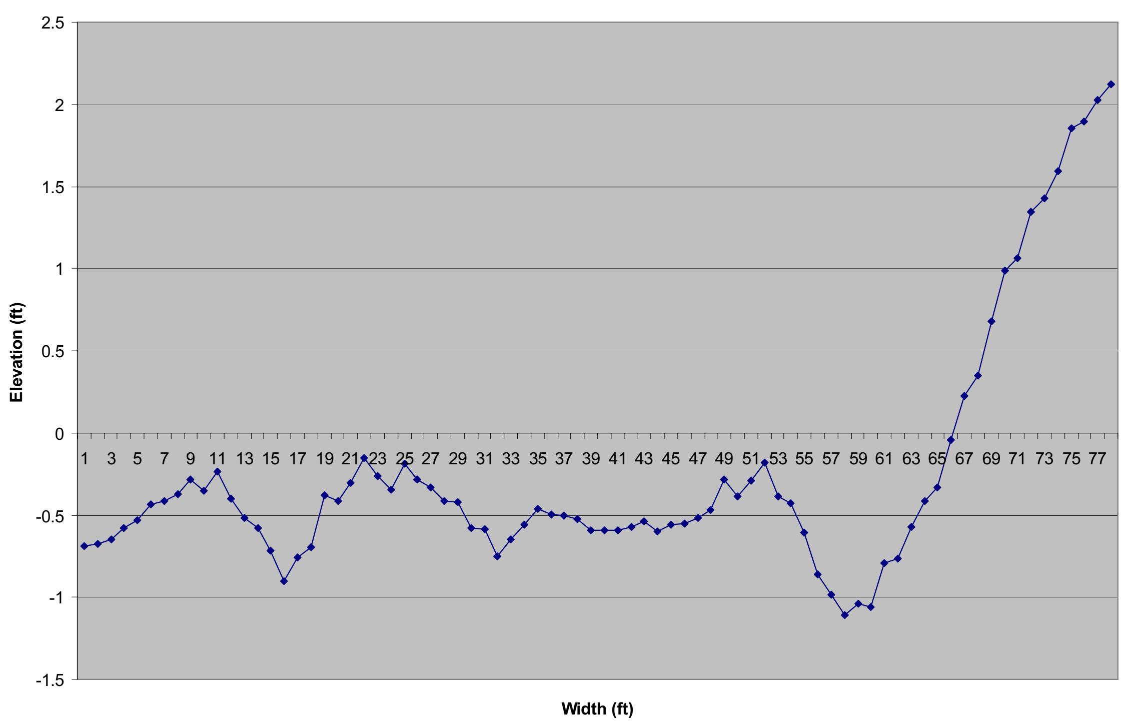

Appendix C: FPMS Special Study, Assessment of Shoreline Change and Impacts on Singleton Swash Channel, May 2009.

Assessment of Shoreline Change and Impacts on Singleton Swash Channel

FPMS Special Study

Horry County, South Carolina

May 2009

2001 Aerial photograph of Singleton Swash

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1. Project Description

Singleton Swash is located in the Arcadian Shores area of Horry County between the northern termination of North Ocean Boulevard and the southern termination of Shore Drive. Singleton Swash also serves as the outfall of a 2.62 square mile drainage area with a mix of residential, commercial, and golf course land use. The position of the swash channel mouth has been very dynamic within the past eight (8) years, creating a maintenance problem for the county. Un-stabilized inlets (without jetties) are often very dynamic as littoral drift and tidal exchange reshape and realign the inlet channel. A common feature in these cases is the spit: a beach and dune system attached to the coast at one end and unbound at the other, which grows in the direction of net longshore sediment transport. In the Myrtle Beach area, as with most of South Carolina, the direction of net longshore sediment transport is from north to south. When spits form and redirect an inlet channel, natural processes would allow the spit to continue to grow until the inlet is hydraulically inefficient. Eventually a new inlet channel would cut through the spit near the original inlet location and the remainder of the spit would then be incorporated into the downdrift beach. Assuming the magnitude and direction of net sediment transport remain somewhat constant, the cycle of spit formation, new cut and spit incorporation will continue.

It can be assumed that the long-term net longshore sediment transport direction will remain constant in this area and that suitable quantities of sediment from beach nourishment activities will be available north of Singleton Swash for the spit formation cycle to continue. However, the risk to real property in the vicinity of Singleton Swash prohibits allowing the spit to evolve naturally. Horry County has been managing the migration of the Swash channel by mechanically relocating the channel when the clubhouse of the Dunes Course and houses along the beachfront are threatened. Horry County has been forced to relocate the channel nine times since 1999, at a total cost of approximately $370,000.

The purpose of this report is to provide the results of a study of the evolution of Singleton Swash and the surrounding shorelines. This study focused on quantifying and qualifying the migration of the swash and swash channel over time and gaining a better understanding of the potential causes of migration and their relative magnitude of influence. The resources used to accomplish these goals included temporally varying spatial data and computer software capable of analyzing the difference between the sets of available data.

Background

The primary purpose of this report is to provide the results of a study of the changes to Singleton Swash; however, White Point Swash is also included in the study to serve as a control subject with which to contrast Singleton Swash. The maintenance of Singleton Swash by Horry County makes isolating a natural channel evolution signal difficult. White Point Swash is less than 4 miles (6200 meters) northeast of Singleton Swash and is similar enough in physical characteristics and impacts to serve as a control subject (limited channel maintenance). For example, the planform area of the intertidal swash channel and bay of Singleton Swash is 33 acres (0.13 km^2) versus 38 acres (0.15 km^2) for White Point Swash. This measure of area is one important parameter for comparing the tidal flow in (flood) and out (ebb) of inlets/swashes. In addition, the two inlets are physically close enough together to have been impacted by the same ocean and weather conditions (i.e., hurricanes, tropical storms, tides, waves, etc.). Figure 1-1 below provides the location of each swash and their relative positions to each other.

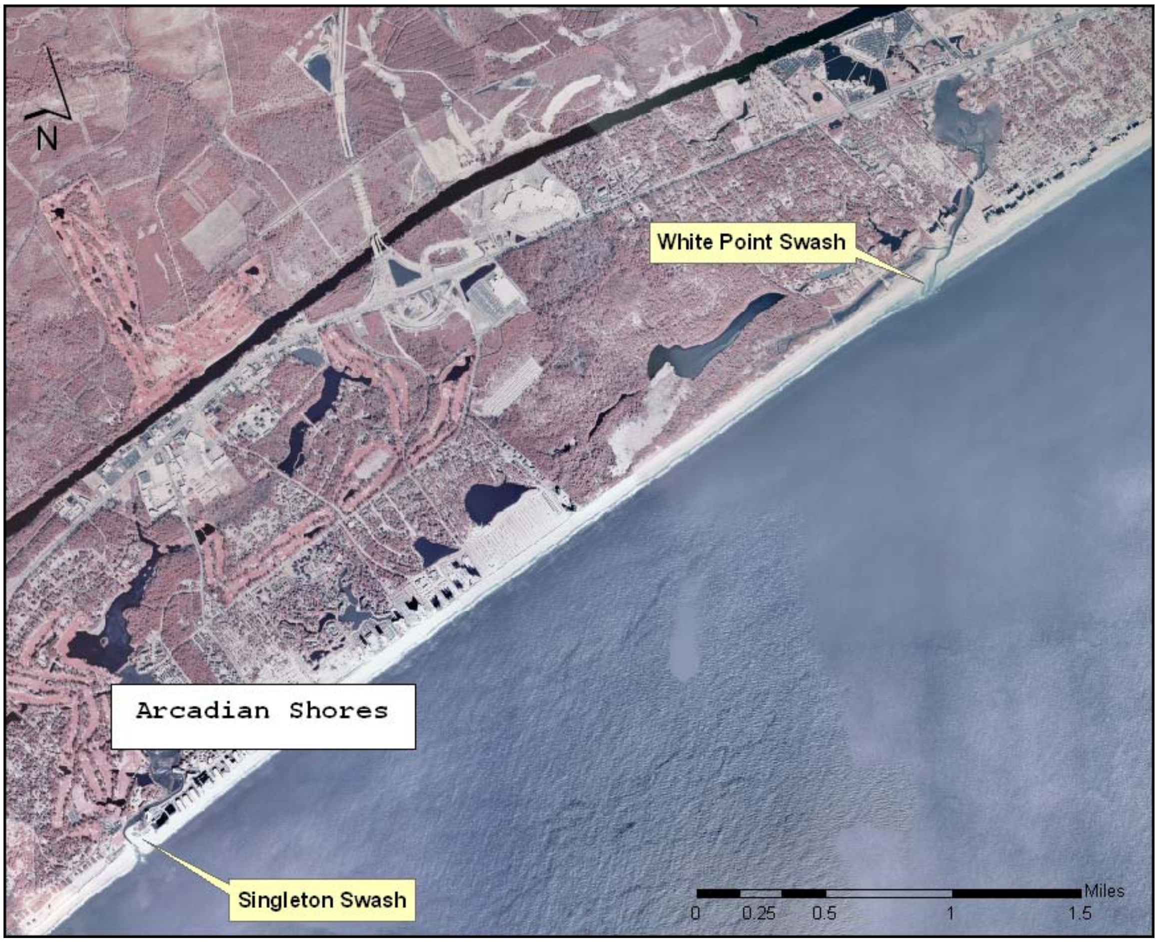

Figure 1-1: Location Map.

Other similarities exist between the swash channels. Both channels have had and will continue to have beach nourishment construction immediately updrift of their northern banks. As can be seen in the figures below, Singleton Swash is immediately south (downdrift) of the Arcadian Shores beach nourishment project (Figure 1-2) and White Point Swash is immediately south of the North Myrtle Beach (Reach 1) portion of the Myrtle Beach Shore Protection Project (Figure 1-3).

Figure 1-2: Singleton Swash location map with OCRM Monument locations.

As previously mentioned, Singleton Swash has been periodically maintained by Horry County in order to protect at-risk structures in the vicinity of the Dunes Course. Entries labeled "Swash channel relocated" in the timeline below (Figure 1-4) indicate maintenance by Horry County. The timeline also lists the hurricanes and tropical storms that have influenced the area from 1995 through 2006. Though no data exists concerning storm-induced sediment transport for these events, it is logical to assume that the storms significantly influenced the amount and direction of sediment moving along the shore and towards Singleton Swash. For example, it is reasonable to conclude that Hurricanes Dennis (Aug.), Floyd (Sept.), and Irene (Oct.) influenced the need for channel maintenance in October of 1999.

Figure 1-3: White Point Swash location map with OCRM Monument locations.

Because of the similarities between Singleton and White Point swashes and the fact that maintenance of White Point Swash has been very limited when compared to that of Singleton Swash, White Point Swash represented the control condition in this analysis. One potentially important difference between Singleton and White Point is the distance between each of the swash channels and its adjacent beach nourishment projects. The transition zone of the Arcadian Shores beach nourishment project extended to the banks of the Singleton Swash channel, while the full nourishment template was approximately 150 meters (490 feet) northeast of the channel. In contrast, the transition zone of the North Myrtle Beach nourishment project terminated slightly northeast of the White Point Swash channel and the full nourishment template was approximately 530 meters (1740 feet) northeast of the channel. Therefore, Singleton Swash is potentially impacted immediately by the additional sand supply in the littoral drift as the nourishment project loses fill volume while attempting to reach a new equilibrium condition. In theory, the potential impact to White Point Swash from the adjacent beach nourishment project would be more gradual.

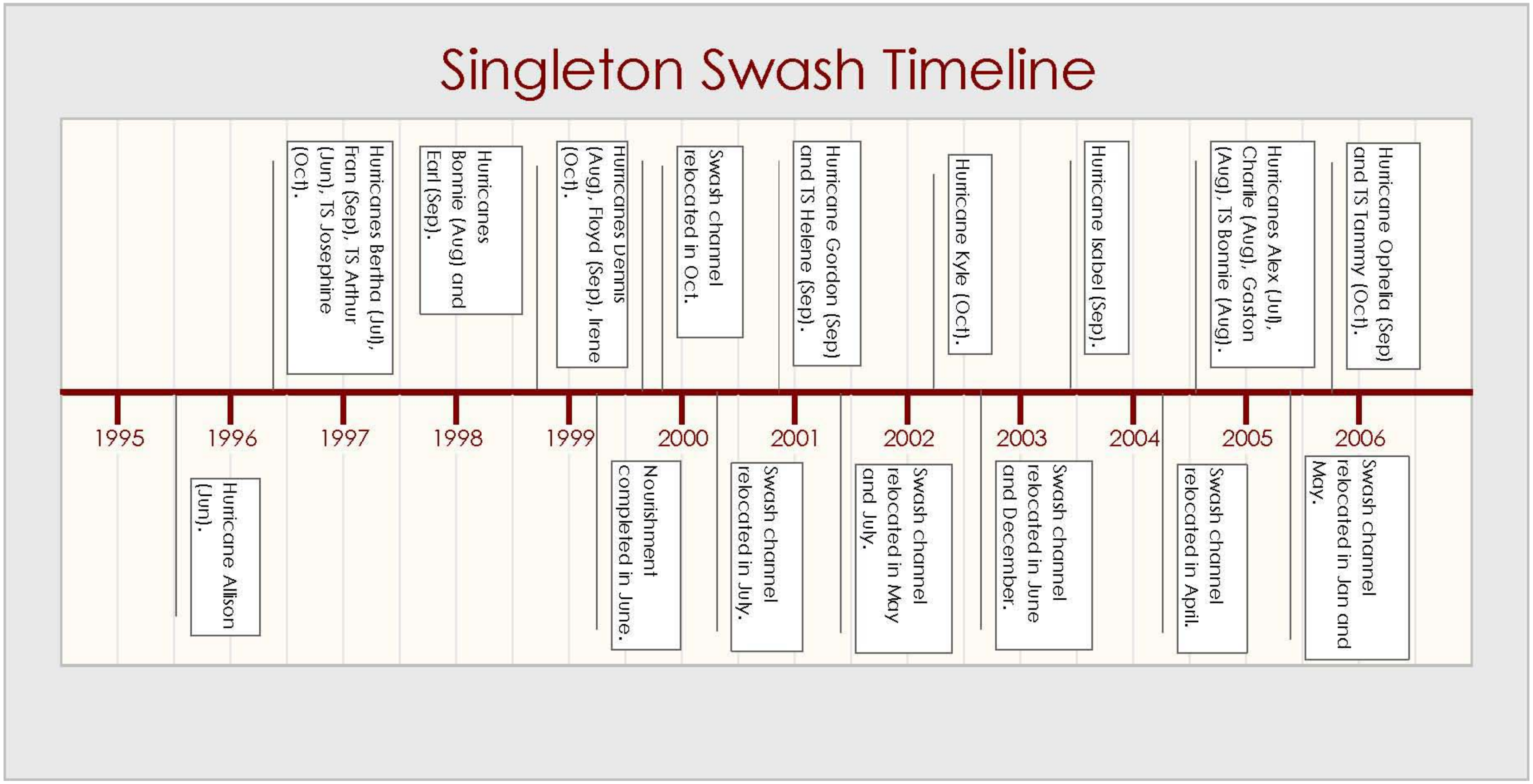

Figure 1-4: Timeline of events at Singleton Swash.

This study makes use of beach profiles, topographic surveys and georeferenced aerial photography to analyze changes to the swashes and the surrounding shorelines. The available beach profile data was collected annually through the Beach Erosion Research Monitoring (BERM) program. The BERM program is a cooperative effort involving the South Carolina Office of Ocean and Coastal Resource Management (OCRM), the US Geological Survey (USGS), and Coastal Carolina University. The topographic survey data was collected annually from 1996 to 2000 and in 2005 by LIDAR (Light Detection And Ranging) equipment and is used to analyze changes to both swash channels and their surrounding banks. LIDAR data is collected using a pulsed laser ranging system mounted onboard an aircraft to measure ground elevation and coastal topography. The system records the elapsed time between emission of the laser beam and return of the reflected laser signal. The time difference can then be converted to a distance and finally an elevation relative to the appropriate vertical datum. Due to the turbidity of the water in South Carolina, this technique is only able to collect topographic data to the approximate low water line. Aerial photography was available from a variety of sources, with the SC Department of Natural Resources data collection providing the majority of the aerial images.

2. Beach Profile Analysis

As previously mentioned, this report makes use of beach profile data to aid in understanding the changes that have taken place on the updrift (north) and downdrift (south) beaches adjacent to each of the swashes in this study. SC OCRM has collected beach profiles on an annual basis along the entire coast of South Carolina since 1988, more than 20 years. The beach profiles are obtained at constant and fixed locations (benchmarks) from year to year. This consistency in beach profile collection locations allows for a more accurate analysis of the changes to a particular section of beach over time. Figures 1-2 and 1-3 show the benchmark locations adjacent to Singleton Swash and White Point Swash respectively. The purpose of this portion of the analysis is to attempt to track the movement of sand from north to south, through and around the swashes over time. Because the beach nourishment projects in the vicinity of each swash have been the major sources of sand contributed to the littoral system, special attention will be paid to the influence they have had both north and south of each swash.

Several OCRM benchmark locations were selected both north and south of each swash. Benchmarks 5515, 5513, and 5510 were selected to represent the beach north of Singleton Swash, while 5505 and 5500 were selected for the beach south of Singleton. Benchmarks 5700 and 5650 were selected to represent the beach north of White Point Swash, while 5590 and 5580 were selected for the beach south of White Point.

The Corps' Regional Morphology Analysis Package (RMAP) software was used to determine the volume of material (sand) within each beach profile. The total set of available beach profiles for each OCRM benchmark location were grouped together (i.e., all the profiles measured at OCRM 5515) and volumes were computed beginning at a common landward point and extending seaward to the -5-foot (NAVD88) contour. The calculated volumes represented a unit volume, or volume per linear foot (cubic yard per