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Shoreline Evolution Update: 1937/38-2009 End Point Rate Calculations Counties of Accomack, Gloucester, and York Cities of Newport News, Norfolk, and Poquoson

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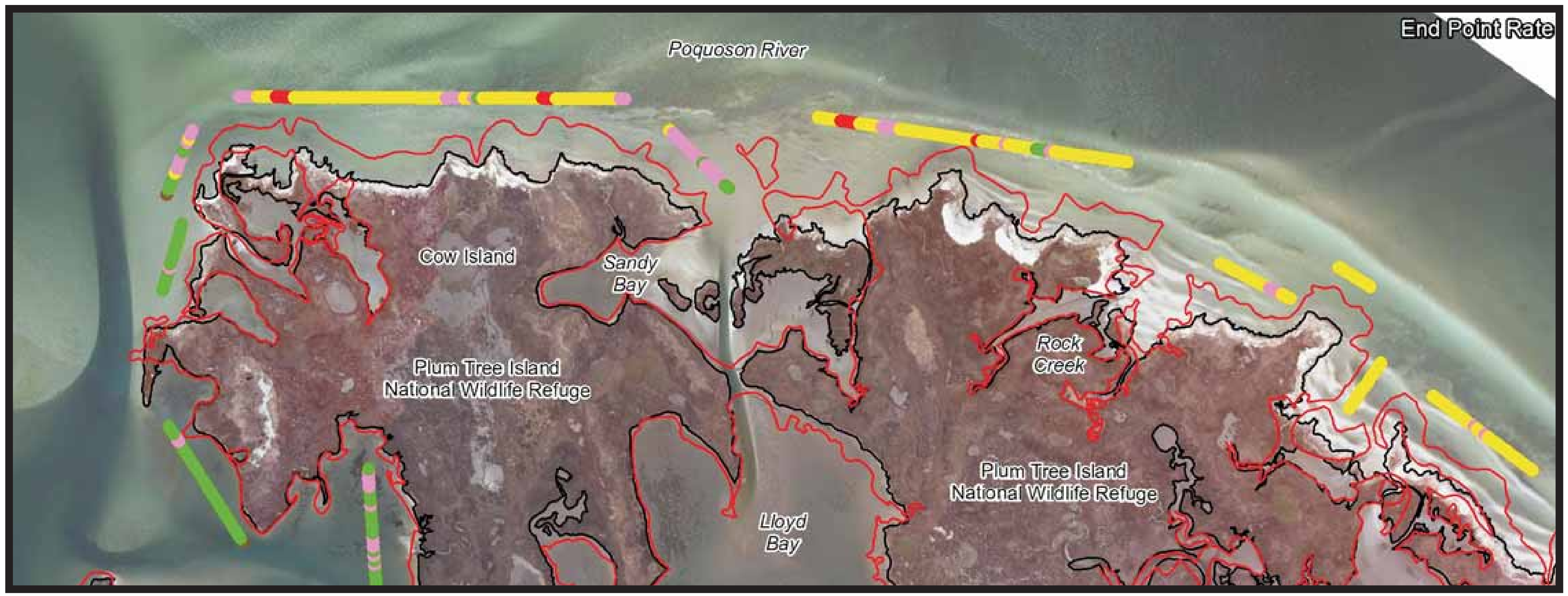

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Method Summary Report

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1 Introduction

Through time, Chesapeake Bay's shoreline has evolved, and determining the rates and patterns of shore change provides the basis to know how a particular coast has changed through time and how it might proceed in the future. Along Chesapeake Bay's estuarine shores, winds, waves, tides and currents shape and modify coastlines by eroding, transporting and depositing sediments.

The purpose of this report is to document how the shore zone of six Virginia localities, Accomack, Gloucester, York, Newport News, Norfolk, and Poquoson, have evolved since 1937/38 (Figure 1). Aerial imagery was taken for most of the Bay region beginning then and can be used to assess the geomorphic nature of shore change. Aerial photos show how the coast has changed, how beaches, dunes, bars, and spits have grown or decayed, how barriers have breached, how inlets have changed course, and how one shore type has displaced another or has not changed at all. Shore change is a natural process but, quite often, the impacts of man, through shore hardening or inlet stabilization, come to dominate a given shore reach. In addition to documenting historical shorelines, the change in shore positions along the rivers and larger creeks will be quantified in this report. The shorelines of very irregular coasts, small creeks around inlets, and other complicated areas will be shown but not quantified.

2 Methods

2.1 Shoreline Digitizing

The shorelines were digitized in ArcMap with the 2009 Virginia Base Mapping Program (VBMP) photo mosaics in the background. Along Norfolk and Virginia Beach's sandy, Bay-front and ocean-front shoreline, approximate high tide was digitized. High water limit of runup can be difficult to determine on river and creek shorelines due to narrow or non-existent beaches against upland banks or vegetated cover. In all other localities, the morphologic toe of the beach or edge of marsh was used to approximate low tide. In areas where the shoreline was not clearly identifiable on the aerial photography, the location was estimated based on the experience of the digitizer. The displayed shorelines are in shapefile format. A combined total of almost 1,400 miles of shoreline was digitized in these six localities (Table 1). The length of the 2009 shoreline may not accurately represent the actual length of a locality's shoreline. All tidal shoreline was digitized,

Table 1. Length of digitized shoreline in 1937/1938 and 2009. 1937/38 has less aerial mosaic coverage.

	1937/38	2009
Accomack	376	457
Gloucester	326	415
York	140	225
Newport News	73	87
Norfolk	23	22
Poquoson	110	150
Total	1048	1356

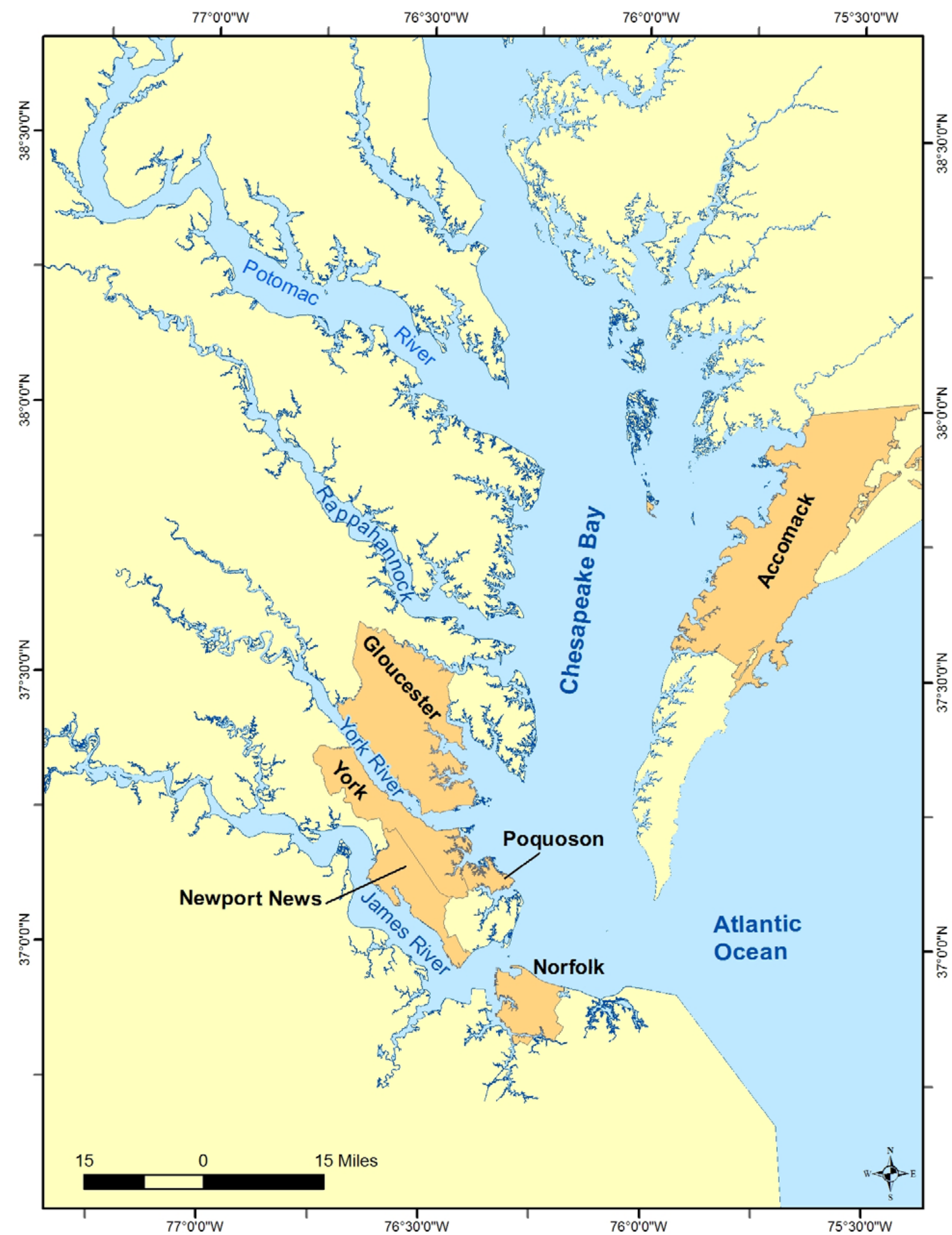

Figure 1. Locations of the six Virginia localities digitized for this project.

but small creeks were not digitized to their complete end. This is because the digitizing occurred to determine shoreline change (as opposed to determining total shore length). The difficulty in rectifying and digitizing these areas in the historical images could lead to increased errors. Therefore, they are not included in the shoreline change analysis.

2.2 Rate of Change Analysis

The Digital Shoreline Analysis System (DSAS) was used to determine the rate of change for the County's shoreline (Himmelstoss, 2009). All DSAS input data must be managed within a geodatabase, which includes all the baselines created for the localities and the digitized shorelines for 1937/38 and 2009. Baselines were digitized about 200 feet, more or less, depending on features and space, seaward of the 1937/38 shoreline and encompassed most of the locality's main shorelines but generally did not include the smaller creeks. It also did not include areas that have unique shoreline morphology such as creek mouths and spits. DSAS generated transects perpendicular to the baseline about 33 ft apart which were manually checked for accuracy of rate calculation.

The End Point Rate (EPR) is calculated by determining the distance between the oldest and most recent shoreline in the data and dividing it by the number of years between them. This method provides an accurate net rate of change over the long term and is relatively easy to apply to most shorelines since it only requires two dates. This method does not use intervening shorelines so it may not account for changes in accretion or erosion rates that may occur through time. However, Milligan *et al.* (2010a, 2010b, 2010c, 2010d) found that in several localities within the bay, EPR is a reliable indicator of shore change even when intermediate dates exist. Some localities did not have an existing 1937/38 digitized shoreline in some of the smaller creeks and rivers and therefore no EPR could be calculated. EPR rates are shown on plates in Appendices A (Accomack), B (Gloucester), C (Newport News), D (Norfolk), E (Poquoson), and F (York).

Using methodology reported in Morton *et al.* (2004) and National Spatial Data Infrastructure (1998), estimates of error in orthorectification, control source, DEM and digitizing were combined to provide an estimate of total maximum shoreline position error. The 1937/38 data sets that were orthorectified have an estimated total maximum shoreline position error of 20.0 ft, while the total maximum shoreline error 2009 is 10.2 ft. 2009 Virginia Base Mapping Program's orthophotography were developed in accordance with the National Standard for Spatial Data Accuracy (NSSDA).

The calculated maximum annualized error for these shoreline dates are $\pm$0.3 ft/yr. The smaller rivers and creeks are more prone to error due to their lack of good control points for photo rectification, narrower shore features, tree and ground cover and overall smaller rates of change. These areas are digitized but due to the higher potential for error, rates of change analysis are not calculated. Some of the areas that show very low accretion can be due to errors within the method described above.

3 Results

The calculated end points rates of change summary for each locality is shown in Table 2. There is a large difference between the amount of digitized shoreline and the amount of shoreline analyzed for EPR. A great deal of shoreline in each locality exists in small creeks and in areas of irregular morphology. These areas did not receive EPR calculations, as noted earlier, because the difficulty in creating baselines in these areas or the lack of shoreline change.

In almost all localities, the 2009 shoreline is longer than the 1937/38 shoreline. This results from several factors. The shoreline is much more clear than the historical photos and can be digitized in greater detail. Because the focus of previous projects for which the 1937/38 shoreline was created focused on higher energy shorelines, the smaller creeks and rivers were not included in the analysis. The only exception is the City of Norfolk. Sections of its 1937 shoreline was in a natural state that had a more complex morphology than 2009's straightened and bulkheaded shoreline.

Of the shoreline analyzed, most are undergoing very low erosion (0 to -1 ft/yr) or low erosion (-1 to -2 ft/yr). The exception to this trend was Norfolk. The installation of structures along the Chesapeake Bay shoreline has created a slight bayward location of the shoreline. Areas of high and very high accretion in almost all cases were man-influenced. Accomack and Poquoson, which have a great deal of high-energy, non-protected shoreline, have the most high erosion (-5 ft/yr to -10 ft/yr) and very high erosion (>-10 ft/yr).

4 Summary

Digitizing the 2009 shoreline from VBMP's images provided detailed information with which to calculate the EPR along sections of shoreline in Accomack, Gloucester, Newport News, Norfolk, Poquoson, and York. The 1937/38 shoreline existed from previous projects and was not updated for this report. However, all digitized shorelines are updated when inaccuracies are found. As such, the shorelines may not exactly match previous reports. By completing these localities, Shoreline Studies Program, VIMS has calculated 1937/38-2009 EPR of change for 20 localities along the Virginia-portion of Chesapeake Bay and it's tributaries.

5 References

Himmelstoss, E.A., 2009. "DSAS 4.0 Installation Instructions and User Guide" in: Thieler, E.R., Himmelstoss, E.A., Zichichi, J.L., and Ergul, Ayhan. 2009 Digital Shoreline Analysis System (DSAS) version 4.0 — An ArcGIS extension for calculating shoreline change: U.S. Geological Survey Open-File Report 2008-1278.

Milligan, D. A., K.P. O'Brien, C. Wilcox, C. S. Hardaway, JR, 2010a. Shoreline Evolution: City of Newport News, Virginia James River and Hampton Roads Shorelines**.** Virginia Institute of Marine Science. College of William & Mary, Gloucester Point, VA. http://web.vims.edu/physical/research/shoreline/docs/dune_evolution/NewportNews/1NewportNews_Shore_Evolve.pdf

Milligan, D. A., K.P. O'Brien, C. Wilcox, C. S. Hardaway, JR, 2010b. Shoreline Evolution: City of Poquoson, Virginia, Poquoson River, Chesapeake Bay, and Back River Shorelines. Virginia Institute of Marine Science. College of William & Mary, Gloucester Point, VA. http://web.vims.edu/physical/research/shoreline/docs/dune_evolution/Poquoson/1Poquoson_Shore_Evolve.pdf

Milligan, D. A., K.P. O'Brien, C. Wilcox, C. S. Hardaway, JR, 2010c. Gloucester County, Virginia York River, Mobjack Bay, and Piankatank River Shorelines. Virginia Institute of Marine Science. College of William & Mary, Gloucester Point, VA. http://web.vims.edu/physical/research/shoreline/docs/dune_evolution/Gloucester/1Gloucester_Shore_Evolve.pdf

Milligan, D. A., K.P. O'Brien, C. Wilcox, C. S. Hardaway, JR, 2010d. Shoreline Evolution: York County, Virginia York River, Chesapeake Bay and Poquoson River Shorelines. Virginia Institute of Marine Science. College of William & Mary, Gloucester Point, VA. http://web.vims.edu/physical/research/shoreline/docs/dune_evolution/York/1York_Shore_Evolve.pdf

Morton, R.A., T.L. Miller, and L.J. Moore, 2004. National Assessment of Shoreline Change: Part 1 Historical Shoreline Change and Associated Coastal Land Loss along the U.S. Gulf of Mexico. U.S. Department of the Interior, U.S. Geological Survey Open-File Report 2004-1043, 45 p.

National Spatial Data Infrastructure, 1998. Geospatial Positional Accuracy Standards, Part 3: National Standard for Spatial Data Accuracy. Subcommittee for Base Cartographic Data. Federal Geographic Data Committee. Reston, VA.

Table 2. Length of shorelines in each end point rate category by locality. Note: the 1937 digitized shoreline for Norfolk only included it's Chesapeake Bay and Willoughby Bay shorelines. It did not include the Elizabeth River and it's tributaries.

	Accomack		
Category	#transects	Feet	Miles
Very High Erosion	235	7755	1
High Erosion	562	18546	4
Medium Erosion	2145	70785	13
Low Erosion	4165	137445	26
Very Low Erosion	6483	213939	41
Very Low Accretion	175	5775	1
Low Accretion	55	1815	0
Medium Accretion	49	1617	0
High Accretion	1	33	0
Very High Accretion	0	0	0
Total EPR (1938-2009) miles			87

	Newport News		
Category	#transects	Feet	Miles
Very High Erosion	0	0	0
High Erosion	17	561	0
Medium Erosion	372	12276	2
Low Erosion	750	24750	5
Very Low Erosion	1730	57090	11
Very Low Accretion	833	27489	5
Low Accretion	121	3993	1
Medium Accretion	140	4620	1
High Accretion	129	4257	1
Very High Accretion	174	5742	1
Total EPR (1937-2009) miles			27

	Gloucester		
Category	#transects	Feet	Miles
Very High Erosion	0	0	0
High Erosion	26	858	0
Medium Erosion	1082	35706	7
Low Erosion	2338	77154	15
Very Low Erosion	7078	233574	44
Very Low Accretion	1187	39171	7
Low Accretion	59	1947	0
Medium Accretion	11	363	0
High Accretion	0	0	0
Very High Accretion	0	0	0
Total EPR (1937-2009) miles			74

	Norfolk*		
Category	#transects	Feet	Miles
Very High Erosion	0	0	0
High Erosion	5	165	0
Medium Erosion	23	759	0
Low Erosion	40	1320	0
Very Low Erosion	467	15411	3
Very Low Accretion	574	18942	4
Low Accretion	304	10032	2
Medium Accretion	161	5313	1
High Accretion	7	231	0
Very High Accretion	102	3366	1
Total EPR (1937-2009) miles			11

	York		
Category	#transects	Feet	Miles
Very High Erosion	0	0	0
High Erosion	36	1188	0
Medium Erosion	503	16599	3
Low Erosion	859	28347	5
Very Low Erosion	4388	144804	27
Very Low Accretion	411	13563	3
Low Accretion	58	1914	0
Medium Accretion	17	561	0
High Accretion	0	0	0
Very High Accretion	0	0	0
Total EPR (1937-2009) miles			39

	Poquoson		
Category	#transects	Feet	Miles
Very High Erosion	18	594	0
High Erosion	42	1386	0
Medium Erosion	329	10857	2
Low Erosion	544	17952	3
Very Low Erosion	1394	46002	9
Very Low Accretion	189	6237	1
Low Accretion	52	1716	0
Medium Accretion	23	759	0
High Accretion	0	0	0
Very High Accretion	0	0	0
Total EPR (1937-2009) miles			16

Very High Accretion: >+10 ft/yr; High Accretion: +10 to +5 ft/yr; Medium Accretion: +5 to +2 ft/yr; Low Accretion: +2 to +1 ft/yr; Very Low Accretion: +1 to 0 ft/yr; Very Low Erosion: 0 to -1 ft/yr; Low Erosion: -1 to -2 ft/yr; Medium Erosion: -2 to -5 ft/yr; High Erosion: -5 to -10 ft/yr; Very High Erosion: <-10 ft/yr;