Middlesex County
Shoreline Situation Report

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CHAPTER I - Introduction

1.1 Background

In the 1970s, the Virginia Institute of Marine Science (VIMS) received a grant through the National Science Foundation's Research Applied to National Needs Program to develop a series of reports which would describe the condition of tidal shorelines in the Commonwealth of Virginia. These reports became known as the Shoreline Situation Reports. They were published on a county by county basis with additional resources provided by the National Oceanic and Atmospheric Administration's Office of Coastal Zone Management (Hobbs et.al., 1979).

The Shoreline Situation Reports quickly became a common desktop reference for nearly all shoreline managers, regulators, and planners within the Tidewater region. They provided useful information to address the common management questions and dilemmas of the time. Despite their age, these reports remain a desk top reference.

The Comprehensive Coastal Inventory Program is committed to developing a revised series of Shoreline Situation Reports which address the management questions of today. The series reports shoreline conditions on a county by county basis. Reports are distributed in hardcopy. CCI is exploring techniques for serving the publications online. Those interested should check the CCI web site periodically at www.vims.edu/ccrm/publications.html. The digital GIS coverages developed for the report are available on the web at www.vims.edu/ccrm/gis/gisdata.html.

1.2 Description of the Locality

Middlesex County includes 130.7 square miles of land area, and another 52.4 square miles of major surface water area (Figure 1). The county marks the northern limit of the Middle Peninsula, and occupies the mainland peninsula between the Piankatank and the Rappahannock Rivers. Middlesex County borders Essex County at the northwest terminus of the locality, King and Queen County at the western limit, and Gloucester and Mathews Counties to the south across the Piankatank River. The centerline of the Rappahannock River separates Middlesex County from Lancaster County on the north shore.

The two major river systems in the locality are the Piankatank River along the south shore and the Rappahannock River on the north shore. The drainage area of both rivers extends well beyond the county limits. This is particularly true of the Rappahannock River basin. There are many small creeks and tributaries which enter the larger rivers at various places. Conditions within these smaller waterways are recorded if they can be navigated by boat.

Tidal shoreline protection is afforded through regulations established by the Clean Water Act, and the Chesapeake Bay Preservation Act. Their 1994 Comprehensive Plan indicates that water quality in Middlesex will be preserved in accordance with rules and regulations established by the Chesapeake Bay Preservation Act. No further details were provided (Middlesex County Planning Commission, 1994).

1.3 Purpose and Goals

This shoreline inventory has been developed as a tool for assessing conditions along the tidal shoreline in Middlesex County. Recent conditions are reported for three zones within the immediate riparian river area: riparian land use, bank and buffers, and the shoreline. A series of maps and tabular data are published to illustrate and quantify results of an extensive shoreline survey. On the Piankatank River, the survey extends from Stingray Point along the north shore to the Dragon Swamp. This includes Jackson Creek, Broad Creek and Wilton Creek. On the south shore of the Rappahannock River the survey extends from Stingray Point to the county border at the Robert O. Norris Jr. Bridge (Route 3). All major creeks have been surveyed on the Rappahannock including Parrots, Weeks, Lagrange, Urbanna, Whiting, Meachim, Bush Park, and Hunton (Figure 1).

1.4 Report Organization

This report is divided into several sections. Chapter 2 describes methods used to develop this inventory, along with conditions and attributes considered in the survey. Chapter 3 identifies potential applications for the data, with a focus on current management issues. From existing literature and the current survey, Chapter 4 reports the general state of the county's shoreline, and integrates a series of maps which illustrate current conditions.

1.5 Acknowledgments

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This work was completed entirely with staff support and management from the Virginia Institute of Marine Science's Comprehensive Coastal Inventory Program (CCI). A host of individuals are acknowledged. In addition to those listed as preparers, the project directors would like to thank Dave Weiss of CCI, former graduate student Mike Campana, the VIMS Vessel Center, and the VIMS Publication Center for their support.

Middlesex Shoreline

CHAPTER 2 - The Shoreline Assessment: Approach and Considerations

2.1 Introduction

The Comprehensive Coastal Inventory Program (CCI) has developed a set of protocols for describing shoreline conditions along Virginia's tidal shoreline. The assessment approach uses state of the art Global Positioning Systems (GPS), and Geographic Information Systems (GIS) to collect, analyze, and display shoreline conditions. These protocols and techniques have been developed over several years, incorporating suggestions and data needs conveyed by state agency and local government professionals.

Three separate activities embody the development of a Shoreline Situation Report: data collection, data processing and analysis, and map generation. Data collection follows a three tiered shoreline assessment approach described below.

2.2 Three Tiered Shoreline Assessment

The data inventory developed for the Shoreline Situation Report is based on a three-tiered shoreline assessment approach. This assessment characterizes conditions in the shorezone, which extends from a narrow portion of the riparian zone seaward to the shoreline. This assessment approach was developed to use observations which could be made from a moving boat. To that end, the survey is a collection of descriptive measurements which characterize conditions. GPS units log location of conditions observed from a boat. No other field measurements are performed. Some minor assessments may be performed using remote sensing techniques and digital high altitude imagery if data could not be gathered in the field at some critical sites. These locations are indicated in tables.

The three tiered shoreline assessment approach divides the shorezone into three regions: 1) the immediate riparian zone, evaluated for land use; 2) the bank, evaluated for height, stability and natural protection; and 3) the shoreline, describing the presence of shoreline structures for shore protection and recreational purposes. Each tier is described in detail below.

2.2a) Riparian Land Use: Land use adjacent to the bank is classified into one of eight categories (Table 1). The categories provide a simple assessment of land use, and give rise to land management practices which could be anticipated. GPS is used to measure the linear extent along shore where the practice is observed. The width of this zone is not measured. Riparian forest buffers are considered the primary land use if the buffer width equals or exceeds 30 feet. This width is calculated from digital imagery as part of the quality control in data processing.

2.2b) Bank Condition: The bank extends off the fastland, and serves as an interface between the upland and the shore. It is a source of sediment and nutrient fluxes from the fastland, and bears many of the upland soil characteristics which determine water quality in receiving waters. Bank stability is important for several reasons. The bank protects the upland from wave energy during storm activity. The faster the bank erodes, the sooner the upland will be at risk. Bank erosion can contribute high sediment loads to the receiving waters. Stability of the bank depends on several factors: height, slope, sediment composition, vegetative cover, and the presence of buffers to absorb energy impact to the bank itself.

A GPS operator observes shoreline conditions from a shoal draft boat.

Table 1. Tier One - Riparian Land Use Classes

Forest	stands greater than 18 feet / width greater than 30 feet
Scrub-shrub	stands less than 18 feet
Grass	includes grass fields, pasture land, and crop land
Residential	includes single or multi family dwellings
Commercial	includes industrial, small business, recreational facilities
Bare	lot cleared to bare soil
Timbered	clear-cuts
Unknown	land use undetectable from the vessel

The bank assessment in this inventory addresses three major bank characteristics: bank height, bank stability, and the presence of stable or unstable natural buffers at the bank toe (Table 2). Conditions are recorded continuously using GPS as the boat moves along the shoreline. The GPS log reflects any changes in conditions observed.

Bank height is described as a range, measured from the toe of the bank to the top. Bank stability characterizes the condition of the bank face. Banks which are undercut, have exposed root systems, down vegetation, or exhibit slumping of material qualify as a "high erosion". At the toe of the bank, natural marsh vegetation and/or beach material may be present. These features offer protection to the bank and enhance water quality. Their presence is noted in the field, and a general assessment (low erosion/high erosion) describes whether they are experiencing any erosion.

Table 2. Tier 2 - Bank Conditions

Bank Attribute	Range	Description
bank height	0-5 ft	from the toe to the edge of the fastland
	5-10 ft	from the toe to the edge of the fastland
	> 10 ft	from the toe to the edge of the fastland
bank stability	low erosion	minimal erosion on bank face or toe
	high erosion	includes slumping, scarps, exposed roots
marsh buffer	no	no marsh vegetation along the bank toe
	yes	fringe or pocket marsh present at bank toe
marsh stability (if present)	low erosion	no obvious signs of erosion
	high erosion	marsh edge is eroding or vegetation loss
beach buffer	no	no sand beach present
	yes	sand beach present
beach stability (if present)	low erosion	accreting beach
	high erosion	eroding beach or non emergent at low tide

Sediment composition and bank slope cannot be surveyed from a boat, and are not included. Bank cover was added as a feature to be surveyed subsequent to data collection for this inventory. Other Shoreline Situation Reports will include bank cover as a descriptive attribute.

2.2c) Shoreline Features: Features added to the shoreline by property owners are recorded as a combination of points or lines. These features include defense structures, which are constructed to protect shorelines from erosion; offense structures, designed to accumulate sand in longshore transport; and recreational structures, built to enhance recreational use of the water. The location of these features along the shore are surveyed with a GPS unit. Linear features are surveyed without stopping the boat. Structures such as docks, and boat ramps are point features, and a static ten-second GPS observation is collected at the site. Table 3 summarizes shoreline features surveyed. Linear features are denoted with an "L" and point features are denoted by a "P." The glossary describes these features, and their functional utility along a shore.

Table 3. Tier 3 - Shoreline Features

Feature	Feature Type	Comments
Control Structures		
riprap	L	
bulkhead	L	
breakwaters	L	first and last of a series is surveyed
groinfield	L	first and last of a series is surveyed
jetty	P	
miscellaneous	L	can include tires, rubble, tubes, etc
.		
Recreational Structures		
pier/wharf	P	includes private and public
boat ramp	P	includes private and public
boat house	P	all covered structures, assumes a pier
marina	L	includes piers, bulkheads, wharfs

2.3 Data Collection/Survey Techniques

Data collection is performed in the field, from a small, shoal draft vessel, navigating at slow speeds parallel to the shoreline. To the extent possible, surveys take place on a rising tide, allowing the boat to be as close to shore as possible. The field crew consists of a boat operator, and two data surveyors. The boat operator navigates the boat to follow the shoreline geometry. One surveyor collects information pertinent to land use and bank condition. The second surveyor logs information relevant to shoreline structures.

Data is logged using the handheld Trimble GeoExplorer GPS unit. GeoExplorers are accurate to within 4 inches of true position with extended observations, and differential correction. Both static and kinematic data collection is performed. Kinematic data collection is a collection technique where data is collected continuously along a pathway (in this case along the shoreline). GPS units are programmed to collect information at a rate sufficient to compute a position anywhere along the course. The shoreline data is collected at a rate of one observation every five seconds. Land use, bank condition, and linear shoreline structures are collected using this technique.

Static surveys are used to pin-point fixed locations which occur at very short intervals. The boat actually stops to collect these data, and the boat operator must hold the boat against tidal current, and surface wind waves. Static surveys log 10 GPS observations at a rate of one observation per second at the fixed station. The GPS receiver uses an averaging technique to compute one position based on the10 static observations. Static surveys are used to position point features like piers, boat ramps, and boat houses.

Trimble Explorer GPS receivers include a function that allows a user to pre-program the complete set of features they are surveying in a "data dictionary". The data dictionary prepared for this Shoreline Situation Report includes all features described in section 2.2. As features are observed in the field, surveyors use scroll down menus to continuously tag each geographic coordinate pair with a suite of characteristics which describe the shoreland's land use, bank condition, and shoreline features present. The survey, therefore, is a complete suite of geographically referenced shoreline data.

2.4 Data Processing

Data processing occurs in two parts. Part one processes the raw GPS field data, and converts the data to GIS coverages (section 2.4a). Part two corrects the GIS coverages to reflect true shoreline geometry (section 2.4b).

2.4a.) GPS Processing: Differential correction improves the accuracy of GPS data by including other "known" locations to refine geographic position. Any GPS base station within 124 miles of the field site can serve as one additional location. The VIMS' base station was used for most of the data processing in Middlesex. Data from base stations maintained by the United States Coast Guard at Cape Henry, or the VA Department of Transportation in Richmond were also available. Both of these stations are no longer active.

A hand-held Trimble Geo-Explorer logs field data observed from the boat.

Differential correction is the first step to processing GPS data. Trimble's Pathfinder Office GPS software is used. The software processes time synchronized GPS signals from field data and the selected base station. Differential correction improves the position of the GPS field data based on the known location of the base station, the satellites, and the satellite geometry. When Selective Availability was turned off in late Spring, 2000, the need to post process data has nearly been eliminated for the level of accuracy being sought in this project

Although the Trimble Geo-Explorers are capable of decimeter accuracy (~ 4 inches), the short occupation of sites in the field reduces the accuracy to 5 meters (~16 feet). In many cases the accuracy achieved is better, but the overall limits established by the CCI program are set at 5 meters. This means that features are registered to within 5 meters (~16 feet) (or better) of their true position on the earth's surface. In this case, positioning refers to the boat position during data collection.

An editing function is used to clean the GPS data. Cleaning corrects for breaks in the data which occur when satellite lock is lost during data collection. Editing also eliminates erroneous data collected when the boat circles off track, and the GPS unit is not switched to "pause" mode.

The final step in GPS processing converts the files to three separate ArcInfo GIS coverages. The three coverages are: a land use and bank condition coverage, a shoreline structure coverage (lines only), and a shoreline structure coverage (points only).

2.4b.) GIS Processing: GIS processing uses ESRI's ArcInfo® GIS software, and ERDAS' Imagine ® software. Several data sets are integrated to develop the final inventory products. First, the shoreline situation data are derived from the GPS field data, and the three coverages discussed above. These attributes are summarized in Tables 1, 2, and 3. Second, the basemap coverage is derived from a digitized record of the high water shoreline illustrated on 7.5 minute USGS topographic maps for the study area. Since it is available for the entire Tidewater area, this shoreline has been selected as the baseline shoreline for development of all Shoreline Situation Reports. The digital coverage was developed by the CCI program in the early 1990s using most recent topographic maps available. These maps range from the late 1960s to the early 1980s. As USGS updates these maps, revisions to the digital basemap series can be made. Finally, the third data set integrated is digital color infra-red imagery known as Digital Ortho Quarter Quadrangles (DOQQs). These products are circulated by the USGS. DOQQs are fully rectified digital imagery representing one quarter of a USGS 7.5 minute quadrangle. They were released in 1997, and use imagery flown in 1994. The imagery are used as background during data processing and maps production. They are an important quality control tool for verifying the location of certain landscape attributes, and provide users with additional information about the coastal landscape.

GIS processing includes two separate parts. Part one checks the relative accuracy of the shoreline coverage. Since this coverage was developed from topographic maps dating back to the 1960s, significant changes in the shoreline orientation may have occurred. While this process does not attempt to recompute a shoreline position relative to a vertical tidal datum, it adjusts the horizontal geographic position to reflect the present shoreline geometry. Using ERDAS' Imagine software, the 1994 DOQQ imagery is displayed onscreen behind the digitized USGS shoreline coverage. The operator looks for areas where the digitized shoreline departs greatly from the land water interface depicted in the background image. The digitized shoreline coverage is then corrected using Imagine's onscreen digitizing techniques to align more closely with the land water interface displayed. This revised shoreline coverage is used in all subsequent inventory steps and products.

Step two corrects the coverages generated from the GPS field data to the shoreline record. These coverages, having been processed through GPS software, are geographically coincident with the path of the boat, from where observations are made. They are, therefore, located somewhere in the waterway. Step two transfers these data back to the corrected shoreline record so the data more precisely reflects the location being described along the shore.

The majority of data processing takes place in step two, which uses all three data sets simultaneously. The corrected shoreline record, and the processed GPS field data are displayed at the same time onscreen as ArcInfo coverages. The imagery is used in the background for reference. The corrected shoreline is the base coverage. The remaining processing re-codes the base shoreline coverage for the shoreline attributes mapped along the boat track. Each time the boat track data (i.e GPS data) indicates a change in attribute type or condition, the digital shoreline arc is split, and coded appropriately for the attributes using ArcInfo techniques.

This step endures a rigorous sequence of checks to insure the positional translation is as accurate as possible. Each field coverage; land use, bank condition, and shoreline condition, is processed separately. The final products are three new coded shoreline coverages. Each coverage has been checked twice onscreen by different GIS personnel. A final review is done on hardcopy printouts.

2.4c.) Maps and Tables: Large format, color maps are generated to illustrate the attributes surveyed along the shore. A three-part map series has been designed to illustrate the three tiers individually. Plate A describes the riparian land use as color coded bars along the shore. A legend keys the color to the type of land use.

Plate B depicts the condition of the bank and any natural buffers present. A combination of color and pattern symbology gives rise to a vast amount of bank and natural buffer information. Erosional conditions are illustrated in red for both bank and buffer. Stable or low erosion conditions are illustrated in green. Bank height varies with the thickness of the line; where the thickest lines designate the highest banks (> 10 feet). Natural buffers, when present, are described by small circles parallel to the shore. Open circles just seaward of the line indicate a natural fringe marsh along the base of the bank. Solid circles indicate a sand beach buffer at the base of the bank. It is possible to have both. The length of the symbology along the shore reflects the length alongshore that the features persist. The symbology changes as conditions change.

Plate C combines recreational and shoreline protection structures in a composition called Shoreline Features. Linear features, described previously, are mapped using color coded bar symbols which follow the orientation of the shoreline. Point features use a combination of colors and symbols to plot the positions on the map.

DOQQ imagery are used as a backdrop, upon which all shoreline data are superimposed. The imagery was collected in 1994. The color infra red image is used as a backdrop to Plate A. A gray-scale version of this same image is used for Plates B and C.

For publication purposes the county is divided into a series of plates set at a scale of 1:12,000. The number of plates is determined by the geographic size and shape of the locality. An index is provided in Chapter 4 which illustrates the orientation of plates to each other. The county was divided into twenty-two plates (plate 1a, 1b, 1c, etc.), for a total of 66 map compositions.

Tables 4 and 5 quantify features mapped in the locality. These are generated using frequency analysis techniques in ArcInfo. Table 4 bases its calculations on river reaches which were delineated in the 1970s by VIMS' coastal geologists to represent short, process similar stretches of shoreline. They provide a unit of measure for comparative purposes over time (Byrne and Anderson, 1983). The reach boundaries are illustrated in Figure 2. Table 4, quantifies present conditions (1999) on a reach by reach basis. There are 100 reaches in Middlesex County (reaches 43-72 along the Piankatank River; reaches 73-144 along the Rappahannock River). Table 4 reports the linear attribute data as a percent of the total reach length, and point data as the number of features per reach. Total miles surveyed for Tables 4 and 5 differ because the 1999 survey extends beyond the historic river reach boundaries, and includes more shoreline miles. The amount of shoreline characterized within the older river reach boundaries is illustrated in Figure 2.

Tables 5 also quantifies features mapped along the rivers using frequency analysis techniques in ArcInfo. The values quantify features on a plate by plate basis. For linear features, values are reported in actual miles surveyed. The number of point features surveyed are also listed on a plate by plate basis. The total miles of shoreline surveyed for each plate is reported. A total of 188.07 miles of shoreline were surveyed in Middlesex. Since there is plate overlap, this number can not be reached by adding the total shoreline miles for each plate. The last row of Table 5 does, however, report the total shoreline miles surveyed for the county, and the total amount of each feature surveyed along the measured shoreline.

Eroding bluff along McKans Bay on the Rappahannock River..

Chapter 3. Applications for Management

3.1 Introduction

There are a number of different management applications for which the Shoreline Situation Reports (SSRs) support. This section discusses four of them which are currently high profile issues within the Commonwealth or Chesapeake Bay watershed. The SSRs are data reports, and do not necessarily provide interpretation beyond the characteristics of the nearshore landscape. However, the ability to interpret and integrate these data into other programs is key to gleaming the full benefits of the product. This chapter offers some examples for how data within the SSRs can be integrated and synthesized to support current state management programs.

3.2 Shoreline Management

The first uses for SSRs were to prepare decision makers to bring about well informed decisions regarding shoreline management. This need continues today, and perhaps with more urgency. In many areas, undisturbed shoreline miles are almost nonexistent. Development continues to encroach on remaining pristine reaches, and threatens the natural ecosystems which have prevailed. At the same time, the value of waterfront property has escalated, and the exigency to protect shorelines through stabilization has increased. Generally speaking, this has been an accepted management practice. However, protection of tidal shorelines does not occur without incidence.

Management decisions must consider the current state of the shoreline, and understand what actions and processes have occurred to bring the shoreline to its current state. This includes evaluating existing management practices, assessing shore stability in an area, and determining future uses of the shore. The SSRs provide data to perform these evaluations.

Plate A defines the land use adjacent to the shoreline. To the extent that land use directs the type of management practices found, these maps can predict shoreline strategies which may be expected in the future. Residential areas are prone to shoreline alterations. Commercial areas may require structures along the shore for their daily operations. Others frequently seek structural alternatives to address shoreline stability problems. Forested riparian zones, and large tracts of grass or agricultural areas are frequently unmanaged even if chronic erosion problems exist.

Stability at the shore is described in Plate B. The bank is characterized by its height, its state of erosion, and the presence or absence of natural buffers at the bank toe. Upland adjacent to high, stable banks with a stable natural buffer at the base are less prone to flooding or erosion problems resulting from storm activity. Upland adjacent to banks of lesser height (< 5feet) are at greater risk of flooding, but if banks are stable with marshes or beaches present, erosion may not be as significant a concern. Survey data reveals a strong correlation between banks of high erosion, and the absence of natural buffers. Conversely, the association between stable banks and the presence of marsh or beach is also well established. This suggests that natural buffers such as beaches and fringe marshes play an important role in bank protection. This is illustrated on the maps. Banks without natural buffers, yet classified as low erosion, are often structurally controlled with rip rap or bulkheads.

Plate C delineates structures installed along the shoreline. These include erosion control structures, and structures to enhance recreational use of the waterway. This map is particularly useful for evaluating requests from property owners seeking structural methods for controlling shoreline erosion problems. Shoreline managers can evaluate the current situation of the surrounding shore including: impacts of earlier structural decisions, proximity to structures on neighboring parcels, and the vicinity to undisturbed lots. Alternative methods such as vegetative control may be evaluated by assessing the energy or fetch environment from the images. Use this plate in combination with Plate B to evaluate the condition of the bank proposed for protection.

A close examination of shore conditions may suggest whether certain structural choices have been effective. Success of groin field and breakwater systems is confirmed when sediment accretion is observed. Low erosion conditions surveyed along segments with bulkheads and riprap indicate structures have controlled the erosion problem. The width of the shorezone, estimated from the background image, also speaks to the success of structures as a method of controlling erosion. A very narrow shorezone implies that as bulkheads or riprap have secured the erosion problem at the bank, they have also deflated the supply of sediment available to nourish a healthy beach. This is a typical shore response, and remains an unresolved management problem.

Shoreline managers are encouraged to use all three plates together when developing management strategies or making regulatory decisions. Each plate provides important information independent of the others, but collectively the plates become a more valuable management tool.

3.3 Non-Point Source Targeting

The identification of potential problem areas for non-point source pollution is a focal point of water quality improvement efforts throughout the Commonwealth. The three tiered approach provides a collection of data which, when combined, can allow for an assessment of potential non-point source pollution problems in a waterway.

Grass land, which includes cultivated and pasture lands, has the highest potential for nutrient runoff. These areas are also prone to high sediment loads since the adjacent banks are seldom restored when erosion problems persist. Residential, bare, and commercial land uses also have the potential to contribute to the non-point source pollution problem due to the types of practices which prevail, and large impervious surface areas.

The highest potential for non-point source pollution combines these land uses with "high" bank erosion conditions and no marsh buffer protection. The potential for non-point source pollution moderates as the condition of the bank changes from "high" bank erosion to "low" bank erosion, or with the presence or absence of stable marsh vegetation to function as a nutrient sink for runoff. Where defense structures occur in conjunction with "low" bank erosion, the structures are effectively controlling erosion at this time, and the potential for non-point source pollution is reduced. If the following characteristics are delineated: low bank erosion, stable marsh buffer, riprap or bulkhead; the potential for non-point source pollution from any land use class can be lowered.

At the other end of the spectrum, forested and scrub-shrub sites do not contribute significant amounts of non-point source pollution to the receiving waterway. Forest buffers, in particular, are noted for their ability to uptake nutrients running off the upland. Forested areas with stable or defended banks, a stable fringe marsh, and a beach would have the lowest potential as a source of non-point pollution. Scrub-shrub with similar bank and buffer characteristics would also be very low.

A quick search for potential non-point source sites would begin on Plate A. Identify the "grass" areas. Locate these areas on Plate B, and find those which have eroding banks (in red) without any marsh protection. The hot spots are these sites where the banks are highest (thick red line), so the potential sediment volume introduced to the water is greatest. Finally check plate C to determine if any artificial stabilization to protect the bank has occurred. If these areas are without stabilizing structures, they indicate the hottest spots for the introduction of non-point source pollution.

3.4 Designating Areas of Concern (AOC) for Best Management Practice (BMP) Sites

Sediment load and nutrient management programs at the shore are largely based on installation of Best Management Practices (BMPs). Among other things, these practices include fencing to remove livestock from the water, installing erosion control structures, and bank re-vegetation programs. Installation of BMPs is costly. Cost share programs provide relief for property owners, but funds are scarce in comparison to the capacious number of waterway miles needing attention. Targeting Areas of Concern (AOC) can prioritize spending programs, and direct funds where most needed.

Data collected for the SSR can assist with targeting efforts for designating AOCs. AOCs can be areas where riparian buffers are fragmented, and could be restored. Use Plate A to identify forested upland. Breaks in the continuity of the riparian forest can be easily observed in the line segments, and background image. Land use between the breaks relates to potential opportunity for restoring the buffer where fragmentation has occurred. Agricultural tracts which breach forest buffers are more logical targets for restoration than developed residential or commercial stretches. Agricultural areas, therefore, offer the highest opportunity for conversion. Priority sites for riparian forest restoration should target forested tracts breached by “grass” land (green-yellow-green line pattern).

Plate B can be used to identify sites for BMPs. Look for where “red” (i.e. eroding) bank conditions persist. The thickness of the line tells something about the bank height. The fetch, or the distance of exposure across the water, can offer some insight into the type of BMP which might be most appropriate. Re-vegetation may be difficult to establish at the toe of a bank with high exposure to wave conditions. Plate C should be checked for existing shoreline erosion structures in place.

Tippett et.al.(2000) used similar stream side assessment data to target areas for bank and riparian corridor restoration. These data followed a comparable three tier approach and combine data regarding land use and bank stability to define specific reaches along the stream bank where AOCs have been noted. Protocols for determining AOCs are based on the data collected in the field.

3.5 Targeting for Total Maximum Daily Load (TMDL) Modeling

As the TMDL program in Virginia evolves, the importance of shoreline erosion in the lower tidal tributaries will become evident. Total maximum daily loads are defined as a threshold value for a pollutant, which when exceeded, impedes the quality of water for specific uses (e.g. swimming, fishing). Among the pollutants to be considered are: fecal coliform, pathogens, nitrogen, phosphorous, and sediment load.

State agencies will develop models to address each of these parameters. In upper watersheds, nutrient and fecal coliform parameters will be critical where high agricultural land use practices prevail. Sediment loads will eventually be considered throughout the watershed. In the lower watersheds, loads from shoreline erosion must be addressed for a complete sediment source budget. Erosion from shorelines has been associated with high sediment loads in receiving waters (Hardaway et.al., 1992), and the potential for increased nutrient loads (Ibison et.al., 1990). Virginia’s TMDL program is still developing. Impaired stream segments are being used to initially identify where model development should focus. For Virginia, this streamlining has done little to reduce the scope of this daunting task, since much of the lower major tributaries are considered impaired. Additional targeting will be necessary to prioritize model development.

Targeting to prioritize TMDL can be assisted by maps which delineate areas of high erosion, and potential high sediment loads. Plate B in this inventory delineates banks of high erosion. Waterways with extensive footage of eroding shorelines should be targeted. The volume of sediment entering a system is also a function of bank height. Actual volumes of sediment eroded can be estimated by using bank height, and the linear extent that the condition persists along the shore. Bank height is an attribute defined in Plate B by the width of the line. Eroding banks (in red) with heights in excess of 10 feet (thickest line) would be target areas for high sediment loads. Plate A can be used in combination with Plate B to determine the dominant land use practice, and assess whether nutrient enrichment through sediment erosion is also a concern. This would be the case along agriculturally dominated waterbodies. Tables 4 and 5 quantify the linear extent of high, eroding banks on a reach by reach, or plate by plate basis, respectively.

Middlesex shoreline construction.

Chapter 4. The Shoreline Situation

The shoreline situation is described for conditions in Middlesex County along the Piankatank River, the Rappahannock River, and the small portion of Chesapeake Bay shoreline forming Stingray Point. Characteristics are described for all navigable tidal waterways contiguous to these larger waterways.

Brief descriptions are provided on the basis of river segments, the boundaries of which are geographically determined. These descriptions summarize tabular data (Table 5) and notable features present. Four segments are defined. Segment 1 includes plates 1-3. Segment 2 includes plates 4-7. Segment 3, plates 8-14, and Segment 4 describes plates 15-22. An index preceding the map compositions illustrates the plate boundaries. Important documentation pertaining to each plate map follows the segment description.

Sandy shore along Punchbowl Point on the Rappahannock River.

Middlesex County Plate Descriptions

Segment 1 (Plates 1 – 3)

Description: Segment 1 along the Rappahannock River begins in McKans Bay at Punchbowl Point and continues to Stove Point and Weeks Creek. Mud Creek and Parrots Creek are included in this segment. Approximately 26.39 miles of shoreline were surveyed, of which 7.97 miles were surveyed remotely. Field observations took place in June,1999. Much of the shoreline in this segment is protected by marsh and beach. More than half the shoreline has marsh protection, while a third is fronted by beach. All of the marsh and beach was observed to be non-eroding. Extensive shoals bordering the Rappahannock River absorb wave energy which might otherwise impact the nearshore.

Land Use: The majority (>70%) of the shoreline in the segment is forested. Approximately 18.3% of the shoreline is residential. Most of this development occurs at Bayport, at the entrance to Parrots Creek, and near Smokey Point. Residential density has not changed substantially since 1975 in Segment 1 (Whitcomb et.al., 1975). Commercial land use and grass cover, combined, comprise less than a half of a mile of adjacent shore cover, while scrub-shrub can be found along 2.64 miles of shoreline.

Bank Condition: Banks along this segment range from less than 5 feet to greater than 10 feet in height. Three-fourths of the banks are less than 5 feet, while 17.5% are between 5 and 10 feet. Only 8.5% of the banks are greater than 10 feet. The majority of these banks are characterized as low erosion. Approximately 3.5 miles of shoreline banks are highly eroding. These areas are concentrated in the vicinity of Weeks Creek. Highly eroding banks greater than 10 feet in height are found along McKans Bay. Flood hazard potential is low, noncritical along this segment as all the residential districts are located above the 5-foot contour (Whitcomb et.al., 1975).

Shore Condition: Bulkheads can be found along 1.83 miles of shoreline, while riprap has been placed along 1.04 miles of shoreline. Groins are common along this segment, taking up 1.73 miles of shoreline in Segment 1. No jetties or breakwaters were found. There is one marina, in Parrots Creek, and a few ramps throughout the segment. The boat ramp in Parrots Creek is a public landing. Pier and boathouse density is relatively low, with only about 50 docks and less than 10 boathouses in Segment 1. High historical erosion rates of 2-6 feet per year are found along McKans Bay. Punchbowl Point is accreting at approximately 2 feet per year, as is Smokey Point at 0.7-1.9 feet per year. Moderate erosion rates are found along the mainstem of the Rappahannock River, while the tidal creeks in this segment typically have low erosion rates (Byrne and Anderson, 1983).

Groinfields and bulkheads along the sandy residential shore of McKans Bay.

Segment 2 (Plates 4 - 7)

Description: This segment begins at Weeks Point along the Rappahannock River and includes Lagrange, Robinson, and Urbanna Creeks. Approximately 45.12 miles of shoreline was surveyed out of a total of 51.74 miles of shoreline in Segment 2. Of the 45.12 miles surveyed, 6.26 miles were remotely surveyed using 1994 imagery. The field survey was conducted in June 1999. Almost ¾ of the shoreline is protected by pocket and fringing marshes. Beaches are not common in this segment, and the morphology of the coast is very typical of a tidal creek shoreline. Only 8.8% of the shoreline is fronted by beach. All marshes and beaches observed in the field were classified non-eroding.

Land Use: Similar to Segment 1, the majority of the shoreline in Segment 2 is forested. This land use comprises 60% of the shoreline. Thirty percent of the adjacent land use is residential. Much of the residential development in this segment can be found near Balls Point and Robinson Creek. Since 1975 residential development along the shore has increased from approximately 5 miles of coverage (Whitcomb et.al., 1975) to just less than 14 miles. Scrub-shrub dominates along 1.46 miles of shoreline. Grass and commercial land uses are equally minor in this segment.

Bank Condition: There is a wide range of bank heights in this segment. There are 14.5 miles of banks with heights less than 5 feet, and 0.48 miles of these are highly eroding. One mile of the 15.35 miles of banks with heights

Forested headwaters of Robinson Creek.

Urbanna Yachting Center on Urbanna Creek.

between 5-10 feet are highly eroding. Only 0.46 mile of the 15.28 miles of banks greater than 10 feet high are eroding. A large percent of these eroding banks are located along Weeks Creek and Weeks Point. The flood hazard potential for most of this segment is low and noncritical. The potential for flooding was designated as critical at the Urbanna Creek Jetty and Remlick Wharf (Whitcomb et.al., 1975).

Shore Condition: Shoreline defense structures include 3.75 miles of riprap and 2.54 miles of bulkheads. One jetty is constructed at the entrance to Urbanna Creek, and there is a series of groins at the entrance to Lagrange Creek. A few marinas are located in the three main tidal creeks. Pier density is much higher in this segment, with over 150 surveyed. There is a concentration of piers along Balls Point, Robinson Creek, and Urbanna Creek. Historical erosion rates are moderate, noncritical at Balls Point and low in Lagrange and Robinson Creeks. Severe erosion rates of 2-3.7 feet per year can be found along the Urbanna waterfront, but reduces to low erosion rates in Urbanna Creek (Byrne and Anderson, 1983).

Segment 3 (Plates 8 - 14)

Description: Segment 3 begins at Baileys Point on the Rappahannock River and extends through Broad Creek to Stingray Point. Approximately 63.87 miles were surveyed out of 70.26 total shoreline miles in this segment. Field observations were conducted in May and June of 1999 to survey 43.83 of the miles. The other 20.04 miles were remotely surveyed.

Shallow bathymetry restricted access to Whiting Creek, Bush Park Creek, Woods Creek, and Hunton Creek. As these represented a significant amount of shoreline in the segment, remote sensing techniques were applied to interpret land use, bank conditions, and shoreline structures. DOQQ imagery was used to determine adjacent land use, the presence of marshes or beach buffers, and piers. Since most of these shorelines are well protected, the condition of banks and buffers are assumed to be stable (low erosion). Bank height was estimated from topographic data. Shoreline defense structures are more difficult to determine from digital imagery at the available resolution. Therefore, these structures are only noted in these creeks if obvious.

Throughout the entire segment, the survey indicates one-third of the shoreline protected by marsh. This occurring mainly in the tidal creeks. Just over 5.2 miles of marsh is highly eroding. Beaches are found along the mainstem of the Rappahannock River. One-fourth of the shoreline in this segment has beaches, and only 2.76 miles of these beaches is highly eroding.

Land Use: Approximately 38.8% of the land is forested, while 44.2% of the land is residential. Residential density along this shoreline has nearly doubled since 1975. Whitcomb et.al (1975) reported 15 miles of residential developement. Today nearly 28 miles of shoreline is residentially used. Scrub-shrub comprises another 4.76 miles of shoreline. Grass and commercial land uses are found along 2.96 and 2.92 miles, respectively.

Bank Condition: Approximately 42.7% of the shoreline has banks less than 5 feet in height. High erosion exists along 2.62 miles of these low banks. Cliffs with bank heights greater than 10 feet are also common. Thirty-nine percent of the shoreline has banks this high, and 5.69 miles of these banks are highly eroding. Such areas occur along three tidal creeks (Meachim, Locklies,

Fringe marsh along the upper reaches of Jackson Creek.

and Mill Creeks). Banks between 5-10 feet high are found only along 13.66 miles of shoreline in Segment 3. Flood hazard potential for this segment is low and noncritical from Baileys Point to Greys Point, while the shoreline from Deltaville to Stingray Point has a moderate and critical flood hazard potential (Whitcomb et.al., 1975).

Shore Condition: This segment also has heavily armored shoreline. Bulkhead and riprap can be found along 6.87 miles and 8.15 miles of the shoreline, respectively. Over three miles of groins, particularly from Baileys Point to Burhans Wharf, have been constructed along the shoreline. Marinas stretch along 3.06 miles of shoreline in Segment 3. Pier density is high in this segment. More than one hundred found on Plate 11, and over 200 found in Sturgeon and Broad Creeks. Boathouses are abundant in Meachim, Locklies, and Mill Creeks. Historical erosion rate data reveal that the region from Baileys Point to Greys Point is eroding at 1-2 feet/year. Moderate, noncritical erosion rates of 1-3 feet/year are found from Greys Point to Bush Park Creek. Severe erosion, however, is occurring from Woods Creek to Stingray Point, (Byrne and Anderson, 1983).

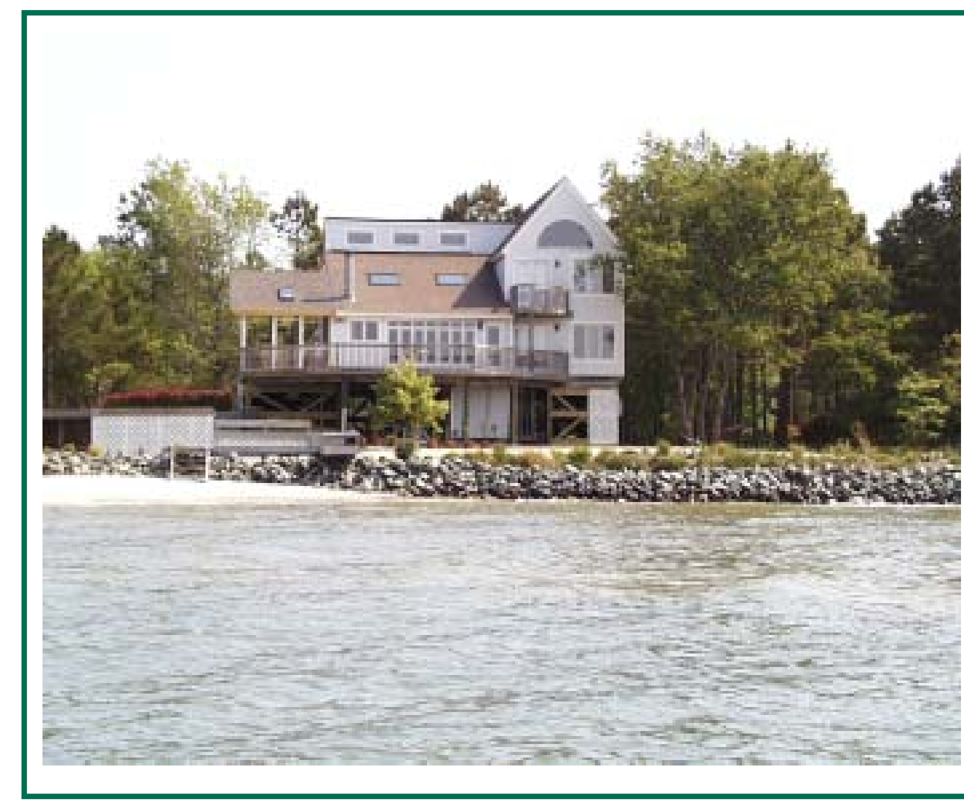
Segment 4 (Plates 15 – 22)

Description: The final segment of Middlesex County extends from Stingray Point into the headwaters of the Piankatank River. This includes approximately 68.2 surveyed miles of shoreline along a total of 71.67 miles of shoreline in the segment. Only 5.1 miles of the shoreline was remotely surveyed. Segment 4 is highly developed around Stingray Point, Stove Point, Wilton Creek, and Piankatank Shores. Pristine undeveloped areas can be found in the headwaters of the Piankatank River. The headwaters are characterized by extensive embayed marshes. Over thirty percent of the shoreline in Segment 4 is protected by marsh, most of which is classified as stable, "low erosion". Beaches are not very common in this segment (9% of shoreline).

Land Use: Dominant land use changes along the segment. From the mouth of the Piankatank River to Piankatank Shores, land use is primarily residential. Residential density has increased tremendously since 1975. Above Piankatank Shores, forested land cover begins to dominate at the shore, and continues to dominate to the headwaters. Overall, 36% of the shoreline in Segment 4 is forested. Scrub-shrub comprises 4.69 miles of shoreline, and commercial is found along 3.62 miles of this segment.

Bank Condition: Approximately half of the shoreline has banks less than 5 feet in height. Most of these banks are characterized as stable or low erosion. The remaining shoreline has bank heights between 5-10 feet high, and greater than 10 feet. High erosion occurs along the higher banks. Almost 2 miles of banks between 5-10 feet in height are highly eroding, while 2.47 miles of bank heights greater than 10 feet are highly eroding. Eroding banks are prevalent along Stingray Point, Jackson Creek, and in My Ladys Swamp. Flood hazard potential is low from the headwaters of the Piankatank River downstream to Fishing Point. Moderate, critical flood hazard potential exists from Fishing Point to Stove Point, becoming high and critical in Jackson Creek (Whitcomb et.al., 1975).

Shore Condition: Approximately 8.15 miles of riprap and 6.87 miles of bulkhead have been placed along the shorelines of this segment. There is a jetty at the entrance to Moore Creek and numerous marinas around Jackson Creek, Broad Creek, and Fishing Bay. Groins are common around Stingray Point as well as the East side of Stove Point neck. Pier density is very high in this segment. Over 300 docks can be found around Stingray Point, and more than 150 docks exist around Deltaville in Jackson Creek. Historical erosion rates reveal that Stingray Point is eroding at a rate of 6.1 feet/year. Moderate, noncritical erosion occurs at Horse Point, Glebe Neck and Wilton Point. These areas are eroding at rates of 1-2 feet/year. Fishing Point and Bland Point are both accreting at 0.7-1 feet/year, while Coach Point is accreting at a rate of 0.8 feet/year. The section from Wilton Point to Doctors Point is eroding at a rate of 1-1.3 feet/year and shoreline from Doctor Point to Coach Point is eroding at a rate of 0.7 feet/year (Byrne and Anderson, 1983).



Residential shoreline protection at the entrance to Jackson Creek.

Map Compositions

Middlesex County

Plate 1

Location:	Butylo to 1.5 miles east of Bayport
Major River:	Rappahannock
Reach(s):	73, 74
Total Shoreline Miles:	3.05
Shoreline Miles Surveyed:	3.05
Survey Date(s):	6/9/99
Plate Rotation:	0 degrees

Plate 2

Location:	1.5 miles east of Bayport around Punchbowl Point and through Parrots Creek
Major River:	Rappahannock
Reach(s):	75, 76, 77, 78, 79, 80, 81
Total Shoreline Miles:	11.96
Shoreline Miles Surveyed:	11.96
Survey Date(s):	6/9/99
Plate Rotation:	90 degrees W

Plate 3

Location:	1.3 miles northwest of Smoky Point through Weeks Creek
Major River:	Rappahannock
Reach(s):	82, 83, 84, 85, 86, 87
Total Shoreline Miles:	12.0
Shoreline Miles Surveyed:	12.0
Survey Date(s):	6/9/99
Plate Rotation:	90 degrees W

Plate 4

Location:	Weeks Creek around Goose Point and into Langrange Creek
Major River:	Rappahannock
Reach(s):	86, 87, 88, 89, 90, 91 (partial)
Total Shoreline Miles:	13.25
Shoreline Miles Surveyed:	10.53
Survey Date(s):	6/8/99
Plate Rotation:	90 degrees W

Plate 5

Location:	Lagrange Creek
Major River:	Rappahannock
Reach(s):	91 (partial)
Total Shoreline Miles:	11.71
Shoreline Miles Surveyed:	11.6
Survey Date(s):	6/8/99
Plate Rotation:	0 degrees

Plate 6

Location:	1.25 miles northwest of Balls Point to the mouth of Urbanna Creek
Major River:	Rappahannock
Reach(s):	90, 92, 93, 94, 95, 96, 97, 98, 99 (partial), 100
Total Shoreline Miles:	17.60
Shoreline Miles Surveyed:	16.79
Survey Date(s):	6/7/99 and 6/8/99
Plate Rotation:	52 degrees W

Pristine stretch of Urbanna Creek.

Plate 7

Location:	Urbanna Creek
Major River:	Rappahannock
Reach(s):	98, 99, 100
Total Shoreline Miles:	12.93
Shoreline Miles Surveyed:	9.72
Survey Date(s):	6/2/99 and 6/7/99
Plate Rotation:	0 degrees

Plate 8

Location:	Bailey Point to 1 mile west of Burhans Wharf
Major River:	Rappahannock
Reach(s):	101, 102, 103, 104, 105, 106 (partial)
Total Shoreline Miles:	7.8
Shoreline Miles Surveyed:	5.47
Survey Date(s):	6/2/99
Plate Rotation:	42 degrees W

Plate 9

Location:	1 mile west of Burhans Wharf through Whiting Creek
Major River:	Rappahannock
Reach(s):	106 (partial), 107 (partial)
Total Shoreline Miles:	9.26
Shoreline Miles Surveyed:	7.67
Survey Date(s):	6/2/99
Plate Rotation:	0 degrees

Plate 10

Location:	1 mile east of Whiting Creek through Meachim Creek
Major River:	Rappahannock
Reach(s):	107 (partial), 108, 110
Total Shoreline Miles:	13.37
Shoreline Miles Surveyed:	12.98
Survey Date(s):	6/1/98 and 6/2/98
Plate Rotation:	0 degrees

Plate 11

Location:	1.3 miles west of Grey Point through Mill Creek
Major River:	Rappahannock
Reach(s):	111, 112, 113, 114, 115, 116, 117, 118, 119, 120, 121, 123, 124, 125, 126, 127
Total Shoreline Miles:	15.2
Shoreline Miles Surveyed:	14.81
Survey Date(s):	6/1/99
Plate Rotation:	90 degrees W

Plate 12

Location:	0.6 miles southwest of Parrott Island to 1.1 miles southeast of Duck Pond
Major River:	Rappahannock
Reach(s):	128, 130, 131, 132 (partial)
Total Shoreline Miles:	4.09
Shoreline Miles Surveyed:	2.05
Survey Date(s):	5/26/99
Plate Rotation:	90 degrees W

Plate 13

Location:	1.1 miles northwest of Bush Park Creek to 0.75 miles northwest of Hunton Creek
Major River:	Rappahannock
Reach(s):	132 (partial), 133, 134, 135
Total Shoreline Miles:	9.23
Shoreline Miles Surveyed:	9.19
Survey Date(s):	5/26/99
Plate Rotation:	0 degrees

Plate 14

Location:	0.75 miles northwest of Hunton Creek through Broad Creek
Major River:	Rappahannock
Reach(s):	136, 137, 138, 139, 140, 141, 142
Total Shoreline Miles:	15.17
Shoreline Miles Surveyed:	15.17
Survey Date(s):	5/26/99
Plate Rotation:	0 degrees

Plate 15

Location:	Broad Creek around Stingray Point and through Jackson Creek
Major River:	Rappahannock, Piankatank
Reach(s):	139 (partial), 140, 141, 142, 143, 144; 43, 44, 45, 46
Total Shoreline Miles:	20.88
Shoreline Miles Surveyed:	20.88
Survey Date(s):	5/5/99 and 5/26/99
Plate Rotation:	0 degrees

Plate 16

Location:	Jackson Creek around Stove Point and through Fishing Bay
Major River:	Piankatank
Reach(s):	46, 47, 48, 49, 50, 51
Total Shoreline Miles:	11.63
Shoreline Miles Surveyed:	11.63
Survey Date(s):	9/2/98 and 5/5/99
Plate Rotation:	90 degrees W

Shoreline Protection at Stove Point.

Inlet at Cores Creek.

Plate 17

Location: Moore Creek through Healy Creek and around Horse Point

Major River: Piankatank

Reach(s): 52, 53, 54, 55, 55A, 56, 57, 58, 59, 60, 61 (partial)

Total Shoreline Miles: 12.27

Shoreline Miles Surveyed: 12.27

Survey Date(s): 9/2/98

Plate Rotation: 0 degrees

Plate 18

Location: Wilton through Wilton Creek and around Wilton Point

Major River: Piankatank

Reach(s): 61 (partial), 62, 63, 64, 65, 66 (partial)

Total Shoreline Miles: 10.48

Shoreline Miles Surveyed: 10.48

Survey Date(s): 9/3/98

Plate Rotation: 0 degrees

Plate 19

Location: 1.2 miles northwest of Wilton Point around Doctor Point to Fairfield Landing

Major River: Piankatank

Reach(s): 66 (partial), 68 (partial)

Total Shoreline Miles: 6.06

Shoreline Miles Surveyed: 5.43

Survey Date(s): 9/12/98

Plate Rotation: 0 degrees

Plate 20

Location: Fairfield Landing through My Ladys Swamp

Major River: Piankatank

Reach(s): 68 (partial), 69, 70, 71, 72

Total Shoreline Miles: 7.84

Shoreline Miles Surveyed: 7.79

Survey Date(s): 9/17/98

Plate Rotation: 0 degrees

Plate 21

Location: My Ladys Swamp into headwaters of river

Major River: Piankatank

Reach(s): none

Total Shoreline Miles: 7.15

Shoreline Miles Surveyed: 7.15

Survey Date(s): 9/17/98

Plate Rotation: 0 degrees

Plate 22

Location:	Headwaters of river into Dragon Swamp
Major River:	Piankatank
Reach(s):	none
Total Shoreline Miles:	5.8
Shoreline Miles Surveyed:	3.01
Survey Date(s):	9/17/98
Plate Rotation:	0 degrees

Upper reaches of Wilton Creek.

Glossary of Shoreline Features Defined

Bare - Land use defined as bare includes areas void of any vegetation or obvious land use. Bare areas include those which have been cleared for construction.

Beaches - Beaches are sandy shores which are subaerial during mean high water. These features can be thick and persistent, or very thin lenses of sand.

Boat house - A boathouse is considered any covered structure alongside a dock or pier built to cover a boat. They include true "houses" for boats with roof and siding, as well as awnings which offer only overhead protection. Since nearly all boat houses have adjoining piers, piers are not surveyed separately, but are assumed. Boat houses may be difficult to see in aerial photography. On the maps they are denoted with a blue triangle.

Boat Ramp - Boat ramps provide vessels access to the waterway. They are usually constructed of concrete, but wood and gravel ramps are also found. Point identification of boat ramps does not discriminate based on type, size, material, or quality of the launch. Access at these sites is not guaranteed, as many may be located on private property. The location of these ramps was determined from static ten second GPS observations. Ramps are illustrated as purple squares on the maps.

Breakwaters - Breakwaters are structures which sit parallel to the shore, and generally occur in a series along the shore. Their purpose is to attenuate and deflect incoming wave energy, protecting the fastland behind the structure. In doing so, a beach may naturally accrete behind the structures if sediment is available. A beach nourishment program is frequently part of the construction plan.

The position of the breakwater offshore, the number of breakwaters in a series, and their length depends on the size of the beach which must be maintained for shoreline protection. Most breakwater systems sit with the top at or near MHW and are partially exposed during low water. Breakwaters can be composed of a variety of materials. Large rock breakwaters, or breakwaters constructed of gabion baskets filled with smaller stone are popular today. Breakwaters are not easily observed from aerial imagery. However, the symmetrical cuspate sand bodies which may accumulate behind the structures can be. In this survey, individual breakwaters are not mapped. The first and last breakwater in the series are surveyed as a ten-second static GPS observation. The system is delineated on the maps as a line paralleling the linear extent of the breakwater series along the shore.

Bulkhead - Bulkheads are traditionally treated wood or steel "walls" constructed to offer protection from wave attack. More recently, plastics are being used in the construction. Bulkheads are vertical structures built slightly seaward of the problem area and backfilled with suitable fill material. They function like a retaining wall, as they are designed to retain upland soil, and prevent erosion of the bank from impinging waves. The recent proliferation of vertical concrete cylinders, stacked side by side along an eroding stretch of shore offer similar level of protection as bulkheads, and include some of the same considerations for placement and success. These structures are also included in the bulkhead inventory.

Bulkheads are found in all types of environments, but they perform best in low to moderate energy conditions. Under high energy situations, the erosive power of reflective waves off bulkheads can scour material from the base, and cause eventual failure of the structure.

Bulkheads are common along residential and commercially developed shores. From aerial photography, long stretches of bulkheaded shoreline may be observed as an unnaturally straight or angular coast. In this inventory, they are mapped using kinematic GPS techniques. The data are displayed as linear features on the maps.

Commercial - Commercial zones include small commercial operations and larger industrial facilities. These operations are not necessarily water dependent businesses.

Dock/Pier - In this survey, a dock or pier is a structure, generally constructed of wood, which is built perpendicular or parallel to the shore. These are typical on private property, particularly residential areas. They provide access to the water, usually for recreational purposes. Docks and piers are mapped as point features on the shore. Pier length is not surveyed. In the map compositions, docks are denoted by a small green dot. Depending on resolution, docks can be observed in aerial imagery, and may be seen in the maps if the structure was built prior to 1994, when the photography was taken.

Forest Land Use - Forest cover includes deciduous, evergreen, and mixed forest stands greater than 18 feet high. The riparian zone is classified as forested if the tree stand extends at least 33 feet inland of the seaward limit of the riparian zone.

Grass - Grass lands include large unmanaged fields, managed grasslands adjacent to large estates, agriculture tracts reserved for pasture, and cultivated fields.

Groinfield - Groins are low profile structures that sit perpendicular to the shore. They are generally positioned at, or slightly above, the mean low water line. They can be constructed of rock, timber, or concrete. They are frequently set in a series known as a groinfield, which may extend along a stretch of shoreline for some distance.

The purpose of a groin is to trap sediment moving along shore in the littoral current. Sediment is deposited on the updrift side of the structure and can, when sufficient sediment is available in the system, accrete a small beach area. Some fields are nourished immediately after construction with suitable beach fill material. This approach does not deplete the longshore sediment supply, and offers immediate protection to the fastland behind the system.

For groins to be effective there needs to be a regular supply of sediment in the littoral system. In sediment starved areas, groin fields will not be particularly effective. In addition they can accelerate erosion on the downdrift side of the groin. The design of "low profile" groins was intended to allow some sediment to pass over the structure during intermediate and high tide stages, reducing the risk of down drift erosion.

From aerial imagery, most groins cannot be observed. However, effective groin fields appear as asymmetrical cusps where sediment has accumulated on the updrift side of the groin. The direction of net sediment drift is also evident.

This inventory does not delineate individual groins. In the field, the first and last groin of a series is surveyed. Others between them are assumed to be evenly spaced. On the map composition, the groin field is designated as a linear feature extending along the shore.

Marina - Marinas are denoted as line features in this survey. They are a collection of docks and wharfs which can extend along an appreciable length of shore. Frequently they are associated with extensive bulkheading. Structures associated with a marina are not identified individually. This means any docks, wharfs, and bulkheads would not be delineated separately. Marinas are generally commercial operations. Community docks offering slips and launches for community residents are becoming more popular. They are usually smaller in scale than a commercial operation. To distinguish these facilities from commercial marinas, the riparian land use map (Plate A) will denote the use of the land at the site as residential for a community facility, rather than commercial.

Marshes - Marshes can be extensive embayed marshes, or narrow, fragmented fringe marshes. The vegetation must be relatively well established, although not necessarily healthy.

Miscellaneous - Miscellaneous point features represent short isolated segments along the shore where material has been dumped to protect a section of shore undergoing chronic erosion. Longer sections of shore are illustrated as line features. They can include tires, bricks, broken concrete rubble, and railroad ties as examples.

Residential - Residential zones include rural and suburban size plots, as well as multi-family dwellings.

Riprap - Generally composed of large rock to withstand wave energy, riprap revetments are constructed along shores to protect eroding fastland. Revetments today are preferred to bulkhead construction. They reduce wave reflection which causes scouring at the base of the structure, and are known to provide some habitat for aquatic and terrestrial species. Most revetments are constructed with a fine mesh filter cloth placed between the ground and the rock. The filter cloth permits water to permeate through, but prevents sediment behind the cloth from being removed, and causing the rock to settle. Revetments can be massive structures, extending along extensive stretches of shore, and up graded banks. When a bulkhead fails, riprap is often placed at the base for protection, rather than a bulkhead replacement. Riprap is also used to protect the edge of an eroding marsh. This use is known as toe protection. This inventory does not distinguish among the various types of revetments.

Riprap revetments are popular along residential waterfront as a mechanism for stabilizing banks. Along commercial or industrial waterfront development such as marinas, bulkheads are still more common since they provide a facility along which a vessel can dock securely.

Riprap is mapped as a linear feature using kinematic GPS data collection techniques. The maps illustrate riprap as a linear feature along the shore.

Scrub-shrub - Scrub-shrub zones include trees less than 18 feet high, and is usually dominated by shrubs and bushy plants.

Abandoned vessel along the Piankatank River.

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Upper reaches of Wilton Creek.