

King William 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 (CCI) 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/gis/gisdata.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

King William County includes 274.9 square miles of land area, and another 10.66 square miles of major surface water area (Figure 1). The county forms the mainland peninsula which divides the Mattaponi and Pamunkey Rivers at the confluence with the York River. The centerline of the Pamunkey River on the southwest shore is the border between King William and New Kent County. The centerline of the Mattaponi River on the northeast shore serves as the border between King William and King and Queen County. At the northwest terminus, King William borders Caroline County, and a small section of Hanover County. The two rivers, the Mattaponi and Pamunkey are the major river

systems within the county, and the drainage areas of both extend well beyond the county limits. A number of small creeks and tributaries feed the larger rivers.

King William is rural in character, with more than two-thirds of its land area covered with forest vegetation. Development is most prevalent along routes 30 and 360 in the upper portion of the county. Commercial expansion is noted in Central Garage, Aylett, and Manquin. Although not subject to policies established by the county, the town of West Point represents the most industrially developed area on the peninsula and is included as part of this inventory (PMA, 1997). In 1999, the population estimate for the county was reported to be 13,048 (UVA, 1999). Over the last 10 years, the growth rate seems to be nearly three time greater than estimates prior to 1990. Projected population for 2010 is 16,003 persons, as estimated by the Virginia Employment Commission State Data Center.

Tidal shoreline protection is afforded through regulations established by the Clean Water Act, and the Chesapeake Bay Preservation Act. King William County established Resource Protection Areas (RPAs) in accordance with the Chesapeake Bay Preservation Act (100 foot buffers landward of all streams, adjoining wetlands, and related sensitive areas). Resource Management Areas (RMAs) established by King William include all other land areas not designated as an RPA. The town of West Point is designated as an Intensely Developed Area (IDA), which are areas of concentrated development within an RPA. West Point is the only area within the county with this designation (PMA, 1997).

1.3 Purpose and Goals

This shoreline inventory has been developed as a tool for assessing conditions along the tidal shoreline in King William 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. The survey extends from the mouths of the Mattaponi and Pamunkey Rivers and continues up the Mattaponi to above Gravel Run near the Route 628 gaging station. On the Pamunkey, the survey extends upriver by Hanover town in Hanover County (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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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.

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.

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.



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

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.

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.

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

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

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

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 the 10 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 King William. 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 map 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. Step 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 re-compute 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 water-way. 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 thirty-one plates (plate 1a, 1b, 1c, etc.), for a total of 93 map compositions.

Tables 4 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 127.52 miles of shoreline were surveyed in King William. 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 4 does, however, report the total shoreline miles surveyed for the county and the total amount of each feature surveyed along the measured shoreline.



Cohoke Pond on the Pamunkey River, photo courtesy of Dwight Dyke.

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. Table 4 quantifies the linear extent of high, eroding banks on a plate by plate basis.

The town of West Point at the confluence of the Mattaponi and Pamunkey Rivers, photo courtesy of Dwight Dyke.



Chapter 4. The Shoreline Situation

The shoreline situation is described for conditions in King William County along the Mattaponi and Pamunkey Rivers. 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 4) and notable features present. Four segments are defined. Segment 1 includes plates 1-7. Segment 2 includes plates 8-14. Segment 3, plates 15-25, and Segment 4 describes plates 26-31. An index preceding the map compositions illustrates the plate boundaries. Important documentation pertaining to each plate map follows the segment description.



Flooded fresh marshes along the upper Mattaponi, photo courtesy of Dwight Dyke.

Segment 1 (Plates 1 – 7)

Description: Segment 1 begins at the headwaters of the Mattaponi River north of Aylett and continues down the river to Mantua Ferry. Along this meandering stretch of the Mattaponi, intertidal marsh islands form at the meanders. There are 36.93 mile of shoreline in this segment. Approximately 31.79 miles were surveyed in July and August, 1998. Marshes can be found along the shoreline, but they mainly exist below Aylett. Much of this segment is undeveloped.

Land Use: The majority (88.5%) of the shoreline in the segment is forested. Approximately 11.3% of the shoreline is residential, mostly below Aylett. A comparison with the 1975 Shoreline Situation Report (Hobbs et.al., 1975) suggests residential density has not changed substantially since this earlier assessment. Commercial and grass land uses are not found in this segment, while scrub-shrub comprises about 0.06 mile of shoreline.

Bank Condition: The bank here ranges from less than 5 feet to greater than 10 feet in height. Roughly half the bank heights surveyed are between 5-10 feet, while 42% are less than 5 feet. Only 8.5% of the banks are greater than 10 feet. Low erosion conditions persists along the majority of the bank face. Only 2.62 miles of bank are highly eroding. This is primarily undercutting at the bank toe from tidal scour. Development at risk to flooding is low along this segment as all of the residential development is above the 5-foot contour (Hobbs et. al., 1975).

Shore Condition: This segment contains very little armoring of the shoreline. Only 0.38 mile and 0.3 mile of bulkhead and riprap, respectively, is found along the shoreline. This is a very low energy environment with limited fetch and shallow



Pristine reaches of the tidal tributary, photo courtesy of Dwight Dyke.

water. The absence of defense structures is not surprising. Recreational structures can be found. There is a high density of piers and boat houses near Horse Landing, but few elsewhere along the segment. Three boat ramps were located.

Segment 2 (Plates 8 – 14)

Description: The lower Mattaponi River segment also is marked by marshy, meandering stretches with small fetches. Segment 2 begins at Scotland Landing and continues down to West Point where the Mattaponi River and Pamunkey River discharge into the York River. There is a total of 49.89 miles of shoreline in this segment. Approximately 26.32 miles of shoreline was surveyed here in July and August, 1998. The bulk of the unsurveyed miles of shoreline are shallow tidal creeks such as Brooks Creek and Madison Creek that dissect this

stretch of river. Approximately 86% of the shoreline in this segment is protected by fringe or embayed marshes.

Land Use: The majority of shoreline in Segment 2 is forested. This land use comprises 81.8% of the adjacent shoreland use. Just under fourteen percent of the land use is residential. Much of the residential development is concentrated near West Point. The geographic extent of Segment 2 has seen a slight increase in residential density from approximately 5% in 1975 (Hobbs et.al., 1975) to 14% in 1998. Scrub-shrub is found on 0.27 mile of shoreline, while grass and commercial land uses are also minor.

Bank Condition: Approximately 65% of the banks along this segment are less than 5 feet in height. These banks have been characterized as low erosion. Another 21% of the banks are 5-10 feet, including 0.18 mile of eroding shoreline. Banks greater than 10 feet in height comprise 13.2% of the shoreline. High erosion occurs along 2.69 miles of high banks primarily concentrated around Scotland Landing, the Mattaponi Indian Reservation, and the Mill Creek vicinity. Flood hazard potential for this segment reported in Hobbs et.al., (1975) is low/noncritical.



Wide fringe marshes are typical along the Mattaponi Indian Reservation, photo courtesy of James Blair.

Shore Condition: Short fetches and wide embayed marshes offer natural protection to much of this segment. Shoreline defense structures are generally unnecessary in most places. Only 0.33 mile each of bulkhead and riprap line the shore in this segment. No breakwaters, groins, or jetties are found. There are a number of recreational structures around West Point, Scotland Landing, and near Mill Creek. Most of these are private piers. There are three boat ramps near West Point. At least two of these are public landings.

Segment 3 (Plates 15 – 25)

Description: Segment 3 contains the lower reaches of the Pamunkey River from the entrance at West Point, upriver to Liberty Hall, above the Pamunkey Indian Reservation. Approximately 44.45 miles of shoreline was surveyed in August, 1998. A total of 106.1 miles of shoreline are calculated in King William along this segment. Despite the high number of unsurveyed shoreline miles, the bulk of the miles occurred in tidal creeks that dissect the numerous tidal marshes such as Lee Marsh and Sweet Hall Marsh. These tidal freshwater creeks included Williams Creek, Harrison Creek, and Jacks Creek. Over half of the shoreline has marshes, much of it embayed and relatively stable. This region of the Pamunkey River boasts some of the most pristine tidal freshwater marshes in the country. Unlike the Mattaponi, nearly 2.04 miles of sandy beach were observed during the survey. Most of these beaches are along the shore just north of Cohoke Marsh.

Land Use: Approximately 82% of the shoreline is forested, while only 7.9% is residential. Much of the residential development has occurred in West Point and on the Pamunkey Indian Reservation. Grass cover is minimal in this segment. Commercial and scrub-shrub comprise 1.65 miles and 2.10 miles of the shoreline, respectively. Very little change in residential density has taken place since 1975.

Bank Condition: More than half the shoreline in this segment is less than 5 feet in height. These banks are characterized as stable or low erosion. Another 31.2% of the shoreline has banks between 5-10 feet. These were all noted to be stable. Sixteen percent of the shore is



A fringe marsh offers protection to the forested bank, photo courtesy of Dwight Dyke.

backed by banks greater than 10 feet in height. Approximately 1.24 miles of shoreline with high banks has been characterized as highly eroding. These banks are mainly found near Romancoke. Flood hazard potential for this segment is low/noncritical except for some of the private residences in West Point.

Shore Condition: Armoring of the shoreline is not very common along this segment. There are 1.04 miles of riprap and 0.90 mile of bulkhead protecting the shoreline in Segment 3. Erosion is low as there is little exposure to high wave action, and significant fringe and embayed marshes to protect the fastland. Along West Point the shoreline (Plate 15) is pitted with private piers. The pier density is also relatively high near the Pamunkey Indian Reservation. Few boathouses and no marinas are found along this segment. While no data is available on historical erosion rates, it is known that considerable erosion occurs on the outside of the meanders within the Pamunkey River (Hobbs et.al., 1975).



Osprey utilize dead forest cover for perching, photo courtesy Dwight Dyke.

Segment 4 (Plates 26 – 31)

Description: The final segment of King William County covers the headwaters of the Pamunkey River. These shorelines are marked by narrow meanders and relatively little embayed marsh. While tidal influence extends far up into the Mattaponi River, the upper reaches of the Pamunkey River do not get the same tidal action. Thus, the intertidal marsh islands found in the upper reaches of the Mattaponi River are absent in this segment. Approximately 27.23 miles of shoreline out of a total of 46.98 miles was surveyed in August and September 1998. Unsurveyed shoreline was mainly concentrated in shallow tidal creeks such as Polkwest Creek and Broad Creek. In addition to a relative absence of embayed and fringing marsh, beaches are not found along these shorelines.

Land Use: Over 92% of the shoreline is forested land use in Segment 4. The section past the Rt. 360 bridge overpass is almost all forested. Only 1.5% of the shoreline is residential. Little change in residential density has occurred since 1975. Scrub-shrub land cover can be found on 0.10 mile of shoreline, while timbered land makes up 0.33 mile of shoreline. Approximately 1.16 miles of shoreline is grass.

Bank Condition: Approximately half (55.6%) of the shoreline has banks under 5 feet in height. Most of these banks have been characterized as stable or low erosion. Fourteen percent of the shoreline has bank heights between 5-10 feet, all of which are stable. This segment, however, has a higher percentage of banks over 10 feet in height. Thirty percent of the shoreline has such high banks and all are stable due to the absence of tidal influence. Flood hazard potential is low and noncritical in this segment (Hobbs et. al., 1975).

Shore Condition: This low energy environment is marked by a relative absence of shoreline erosion control structures such as riprap, bulkhead, groins, and breakwaters. Approximately 0.09 miles and 0.04 miles of shoreline have riprap and bulkhead, respectively. Due to the limited depths in this area, there are few piers and boathouses and no marinas. Only one ramp exists and it can be found near Jacks Creek at a private residence. No data on historical erosion rates exist for this segment of shoreline (SSR).



Fringe marshes and scrub shrub provide important bird habitat, photo courtesy of Dwight Dyke.

Map Compositions

King William County

Plate 1

Location:	Headwaters of river
Major River:	Mattaponi
Total Shoreline Miles:	6.48
Shoreline Miles Surveyed:	6.28
Survey Date(s):	8/6/98
Plate Rotation:	60 degrees W

Plate 2

Location:	Headwaters of river to 0.5 miles southeast of Chapel Creek
Major River:	Mattaponi
Total Shoreline Miles:	4.63
Shoreline Miles Surveyed:	3.98
Survey Date(s):	8/6/98
Plate Rotation:	90 degrees W

Plate 3

Location:	0.5 miles southeast of Chapel Creek to Cape Charlie
Major River:	Mattaponi
Total Shoreline Miles:	7.06
Shoreline Miles Surveyed:	6.51
Survey Date(s):	7/8/98 and 8/6/98
Plate Rotation:	90 degrees W

Plate 4

Location:	Cape Charlie to 0.3 miles west of Roanes Wharf
Major River:	Mattaponi
Total Shoreline Miles:	4.24
Shoreline Miles Surveyed:	3.48
Survey Date(s):	7/8/98 and 7/30/98
Plate Rotation:	25 degrees W

Plate 5

Location:	0.3 miles west of Roanes Wharf to Line Tree Bar
Major River:	Mattaponi
Total Shoreline Miles:	5.40
Shoreline Miles Surveyed:	4.35
Survey Date(s):	7/8/98
Plate Rotation:	50 degrees W

Plate 6

Location:	Line Tree Bar past Walkerton to 1.1 miles west of Horse Landing
Major River:	Mattaponi
Total Shoreline Miles:	4.24
Shoreline Miles Surveyed:	3.48
Survey Date(s):	7/8/98 and 7/30/98
Plate Rotation:	25 degrees W



Undercut banks are common along the forest shoreline, photo courtesy of Dwight Dyke.

Plate 7

Location:	1.1 miles west of Horse Landing to White Oak Landing
Major River:	Mattaponi
Total Shoreline Miles:	5.23
Shoreline Miles Surveyed:	3.63
Survey Date(s):	7/30/98
Plate Rotation:	25 degrees W

Plate 8

Location:	White Oak Landing to Sandy Point
Major River:	Mattaponi
Total Shoreline Miles:	3.41
Shoreline Miles Surveyed:	3.21
Survey Date(s):	7/30/98
Plate Rotation:	0 degrees

Plate 9

Location:	Sandy Point to Mattaponi Indian Reservation
Major River:	Mattaponi
Total Shoreline Miles:	7.24
Shoreline Miles Surveyed:	4.06
Survey Date(s):	7/30/98
Plate Rotation:	90 degrees W

Plate 10

Location:	Mattaponi Indian Reservation to 1.3 miles northwest of Gleason Marsh
Major River:	Mattaponi
Total Shoreline Miles:	3.01
Shoreline Miles Surveyed:	3.01
Survey Date(s):	7/30/98
Plate Rotation:	0 degrees

Plate 11

Location:	1.3 miles northwest of Gleason Marsh to Kentucky Farm
Major River:	Mattaponi
Total Shoreline Miles:	9.50
Shoreline Miles Surveyed:	3.81
Survey Date(s):	7/30/98
Plate Rotation:	90 degrees W

Plate 12

Location: Kentucky Farm to Chelsea Farm

Major River: Mattaponi

Total Shoreline Miles: 7.1

Shoreline Miles Surveyed: 4.18

Survey Date(s): 7/30/98 to 8/5/98

Plate Rotation: 30 degrees W

Plate 13

Location: Chelsea Farm to shore across from Muddy Point

Major River: Mattaponi

Total Shoreline Miles: 7.33

Shoreline Miles Surveyed: 4.81

Survey Date(s): 8/5/98

Plate Rotation: 50 degrees W

Plate 14

Location: Shore across from Muddy Point to Lord Delaware Bridge in West Point

Major River: Mattaponi

Total Shoreline Miles: 15.5

Shoreline Miles Surveyed: 6.23

Survey Date(s): 8/5/98

Plate Rotation: 70 degrees W

Plate 15

Location: Lord Delaware Bridge in West Point to Port Richmond

Major River: Mattaponi and Pamunkey

Total Shoreline Miles: 8.96

Shoreline Miles Surveyed: 7.18

Survey Date(s): 8/24/98

Plate Rotation: 74 degrees W

Plate 16

Location: Port Richmond to east side of Lee Marsh

Major River: Pamunkey

Total Shoreline Miles: 21.0

Shoreline Miles Surveyed: 2.56

Survey Date(s): 8/24/98

Plate Rotation: 45 degrees E



Mattaponi River, photo courtesy of James Blair.



A riparian forest buffer is preserved along this stretch of agricultural land, photo courtesy of Dwight Dyke.

Plate 17

Location:	Lee Marsh to 0.75 miles north of Lee Marsh
Major River:	Pamunkey
Total Shoreline Miles:	18.03
Shoreline Miles Surveyed:	4.88
Survey Date(s):	8/24/98
Plate Rotation:	90 degrees W

Plate 18

Location:	0.75 miles north of Lee Marsh to northeastern side of Sweet Hall Marsh
Major River:	Pamunkey
Total Shoreline Miles:	6.67
Shoreline Miles Surveyed:	4.35
Survey Date(s):	8/24/98
Plate Rotation:	0 degrees

Plate 19

Location:	Northeastern side of Sweet Hall Marsh to Sweet Hall Landing
Major River:	Pamunkey
Total Shoreline Miles:	14.63
Shoreline Miles Surveyed:	4.46
Survey Date(s):	8/24/98
Plate Rotation:	0 degrees

Plate 20

Location:	Sweet Hall Landing to 0.5 miles southeast of Brickhouse Landing
Major River:	Pamunkey
Total Shoreline Miles:	3.54
Shoreline Miles Surveyed:	2.86
Survey Date(s):	8/24/98
Plate Rotation:	0 degrees

Plate 21

Location:	Cohoke Marsh
Major River:	Pamunkey
Total Shoreline Miles:	9.4
Shoreline Miles Surveyed:	5.22
Survey Date(s):	8/24/98 and 8/31/98
Plate Rotation:	0 degrees

Plate 22

Location:	Riverview Landing to Johnson Landing
Major River:	Pamunkey
Total Shoreline Miles:	10.03
Shoreline Miles Surveyed:	3.06
Survey Date(s):	8/31/98
Plate Rotation:	90 degrees W

Plate 23

Location:	Johnson Landing to Pamunkey Indian Reservation
Major River:	Pamunkey
Total Shoreline Miles:	4.5
Shoreline Miles Surveyed:	3.87
Survey Date(s):	8/31/98
Plate Rotation:	45 degrees E

Plate 24

Location:	Pamunkey Indian Reservation to shore across from White House
Major River:	Pamunkey
Total Shoreline Miles:	17.64
Shoreline Miles Surveyed:	6.67
Survey Date(s):	8/31/98
Plate Rotation:	90 degrees W

Plate 25

Location:	Shore across from White House to Jacks Creek
Major River:	Pamunkey
Total Shoreline Miles:	11.35
Shoreline Miles Surveyed:	2.80
Survey Date(s):	8/31/98
Plate Rotation:	40 degrees W

Plate 26

Location:	Jacks Creek to 0.75 miles west Montague Landing
Major River:	Pamunkey
Total Shoreline Miles:	11.65
Shoreline Miles Surveyed:	3.81
Survey Date(s):	8/31/98 and 9/1/98
Plate Rotation:	40 degrees W

Plate 27

Location:	0.75 miles west of Montague Landing to Hogan Bar
Major River:	Pamunkey
Total Shoreline Miles:	8.2
Shoreline Miles Surveyed:	3.96
Survey Date(s):	9/1/98
Plate Rotation:	40 degrees W

Plate 28

Location:	Hogan Bar to Pampatike Landing
Major River:	Pamunkey
Total Shoreline Miles:	6.32
Shoreline Miles Surveyed:	3.68
Survey Date(s):	9/1/98
Plate Rotation:	40 degrees W

Plate 29

Location:	Pampatike Landing to 0.5 miles south of Rt. 360 bridge
Major River:	Pamunkey
Total Shoreline Miles:	8.46
Shoreline Miles Surveyed:	6.06
Survey Date(s):	9/1/98
Plate Rotation:	0 degrees

Plate 30

Location:	0.5 miles south of Rt. 360 bridge to 2.5 miles north of the bridge
Major River:	Pamunkey
Total Shoreline Miles:	5.09
Shoreline Miles Surveyed:	5.09
Survey Date(s):	9/1/98 and 9/17/98
Plate Rotation:	0 degrees

Plate 31

Location:	Headwaters of river
Major River:	Pamunkey
Total Shoreline Miles:	5.67
Shoreline Miles Surveyed:	4.58
Survey Date(s):	9/17/98
Plate Rotation:	90 degrees W



Forested cover dominates along the Mattaponi River, photo by Dwight Dyke.

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 cusped 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.

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Upper Limits of the Pamunkey River survey is largely forested land cover, photo courtesy of Dwight Dyke.