City of Suffolk, Virginia
Shoreline Inventory Report
Methods and Guidelines

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City of Suffolk - Shoreline Inventory Report

Supported by the Virginia Institute of Marine Science, Center for Coastal Resources Management, Comprehensive Coastal Inventory Program

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Chapter 1. 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 that 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 locality by locality basis with additional resources provided by the National Oceanic and Atmospheric Administration's Office of Coastal Zone Management (Hobbs et al., 1975).

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 desktop reference.

The Comprehensive Coastal Inventory Program (CCI) is committed to developing a revised series of Shoreline Situation Reports that address the management questions of today and take advantage of new technology. New techniques integrate a combination of Geographic Information Systems (GIS), Global Positioning System (GPS) and remote sensing technology. Reports are now distributed electronically unless resources become available for hardcopy distribution. The digital GIS shape files, along with all reports, tables, and maps are available on the web at http://ccrm.vims.edu/gis_data_maps/shoreline_inventories/index.html by clicking on City of Suffolk.

1.2 Description of the Locality

City of Suffolk is located in the southeastern Virginia within the metropolitan area of Hampton Roads. It is bounded by the James River in the north. It is bordered on the northwest by Isle of Wight County, on the west by Southampton County, on the south by the State of North Carolina, on the east by the City of Chesapeake, on the northeast by the City of Portsmouth, and on the north by the James River. According to the U.S. Census Bureau, City of Suffolk has a total area of 429 miles^2 (400 miles^2 is upland and 29 miles^2 is water).

The City presents with gentle slopes downward west to east with the higher ground closest to the Isle of Wight County boarder. Suffolk has elevations ranging from nearly 85 feet to 25 feet and lower near main rivers.

The City of Suffolk is changing and adapting to new opportunities. Areas of rural landscape are being transformed into high technology centers. However, more than 75% of the City remains predominately agricultural.

Comprehensive planning is vital for the City. The 2018 Comprehensive Plan, adopted in 1998, has been the City's primary planning document. To continue with the success begun with the 2018 Comprehensive Plan, the City of Suffolk has established a policy to periodically review, update and adjust the adopted comprehensive plan. The updated 2026 Comprehensive Plan is the result of such a review. Protecting the environment is one of the most important goals of the Plan. The City of Suffolk has an abundance of unaltered natural areas such as the wetlands of the Great Dismal Swamp and the tidal wetlands along the banks of the Nansemond River, Chuckatuck, Bennetts Creeks and James River. For that reason, the comprehensive planning process tries to develop policies to protect and preserve the City's natural resources while balancing the needs of continued development (City of Suffolk, 2006).

1.3 Purpose and Goals

This shoreline inventory is developed as a resource for assessing conditions along the tidal shoreline in the City of Suffolk. These data provide important baseline information to support shoreline management and improve the decision making capacity of local and state governing boards. These data are also required to run shoreline management models which will comprise the Comprehensive Coastal Resource Management Plan for the City and define shoreline best management practices (BMPs) for the City's tidal shoreline.

Field work was accomplished in phases for the City's tidal shoreline. The City of Suffolk was surveyed in the field in 2013. Detailed field surveys were conducted along the James River, Nansemond River, Brewers Creek, Chuckatuck Creek, Bennett Creek, Knotts Creek, Streeter Creek and Hoffler Creek. Some of the upper reaches of these tributaries as well as the section of

the Backwater River were accomplished using 2012 oblique Pictometry imagery available through Bing Maps, and 2011(where available) and 2009 high resolution imagery from the Virginia Base Mapping Program (VBMP). Remote sensing techniques are applied throughout the field study sites when water depths prevent access by boat. Conditions are reported for three zones: the riparian upland immediately adjacent to the shoreline, the bank as the interface between the upland and the shoreline, and the shoreline itself; with attention to shoreline structures and hardening.

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. Chapter 4 gives instructional details about the website where the data can be found.

1.5 Acknowledgments

This project was funded in part by the Virginia Coastal Zone Management Program at the Department of Environmental Quality through Grant # NA12NOS4190168 of the U.S. Department of Commerce, National Oceanic and Atmospheric Administration, under the Coastal Zone Management Act of 1972, as amended.

This work was completed entirely with staff support and management from the VIMS Center for Coastal Resources Management'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 the VIMS Vessel Center for field support.

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 GPS registered videography 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 (Berman and Hershner, 1999).

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

2.2 Three Tiered Shoreline Assessment

The data inventory developed for the Shoreline Inventory 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 on the upland seaward to the shoreline. This assessment approach was developed to use observations that could be made from a moving boat. To that end, the survey is a collection of descriptive measurements that characterize conditions. A GPS registered videography was used to collect data on conditions observed from a boat. No other field measurements are performed.

The three shorezone regions addressed in the study are: 1) the immediate riparian zone, evaluated for land use, tree fringe and canopy overhang; 2) the bank, evaluated for height, stability, cover, and natural protection; and 3) the shoreline, describing the presence of shoreline structures for shore protection as well as recreational access. Each tier is described in detail below.

2.2a) Riparian Land Use: Land use adjacent to the bank is classified into one of fourteen classes (Table 1). The classification provides a simple assessment of land use, which provides insight to land management practices that may be anticipated. GPS registered videography is used to measure the linear extent along shore where the practice is observed. The width of this zone is not measured. Riparian forest is considered the primary land use if the buffer width equals or exceeds 30 feet.

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, and pasture land
Agriculture	includes cropland
Residential	includes single or multi-family dwellings
Commercial	small and moderate business operations, recreational facilities
Industrial	includes large industry and manufacturing operations
Military	includes all observable military installations
Marsh Island	island primarily composed of marsh and surrounded by water
Extensive Marsh	a large marsh where the length and depth or width are roughly comparable
Bare	lot cleared to bare soil
Timbered	clear-cuts
Paved	areas where roads or parking areas are adjacent to the shore
Unknown	land use undetectable from the vessel

Note: occurrence of tree fringe with/without canopy is noted along non-forest dominated shoreline

This width is calculated from digital imagery as part of the quality control in data processing. If the width is less than 30 feet some other primary land use is designated. The presence of tree fringe is noted along land uses other than forest use. Tree canopy overhang is also noted were possible.

2.2b) Bank Condition: The bank extends off the fastland, and serves as the seaward edge of the upland. It is a source of sediment and nutrient fluxes from the fastland, and bears many of the upland soil characteristics that 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 infrastructure 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 and characteristics, vegetative cover, and the presence of buffers channelward of the bank to absorb energy impact to the bank itself. The bank assessment in this inventory addresses: bank height, bank cover, bank stability, and the presence of natural buffers (beach, marsh) at the bank toe (Table 2).

Bank height is reported as a range in feet. Height is estimated visually in the field from the vessel or remotely from the videography. In some cases LIDAR data may be used to

Table 2. Tier 2 - Bank Conditions and Natural Buffers

Bank Attribute	**Range**	**Description**
bank height	0-5 ft	from toe of the bank to the top of the bank
	5-10 ft	from toe of the bank to the top of the bank
	10-30ft	from toe of the bank to the top of the bank
	> 30 ft	from toe of the bank to the top of the bank
bank stability	stable	minimal erosion on bank face
	transitional	bank shows signs of instability
	unstable	includes slumping, scarps, exposed roots
	undercut	erosion at the base of the bank
bank cover	bare	<25% vegetated/structural cover
	partial	25-75% vegetated/structural cover
	total	>75% vegetated/structural cover
marsh buffer	no	no marsh vegetation along the bank toe
	yes	fringe, extensive, embayed, or marsh island
beach buffer	no	no sand beach present
	yes	sand beach present
Phragmites australis	no	no Phragmites australis present on site
	yes	Phragmites australis present on site

determine bank height particularly in areas being addressed using remotely sensed data sources. All attributes assessed for the bank are qualitative. Bank cover is an assessment of the percent of cover on the bank face, and includes vegetative and structural cover, in this case. Therefore, if the entire bank has been covered with a revetment the bank will be classified as “total” cover. Bank stability characterizes the condition of the bank face. Banks that have exposed root systems, down vegetation, or exhibit slumping of material qualify as “unstable”. A transitional bank has some evidence of erosion but is largely still stable. Undercutting happens at the toe of the bank and can occur on banks that are classified as stable, unstable or transitional.

At the base of the bank, marsh vegetation, sand beach or Phragmites australis may be present. Marshes and beaches offer protection to the bank and enhance water quality. Marshes were delineated from high resolution imagery (2009 VBMP) as part of a separate activity. Their locations were verified in the field and for some marshes the vegetation communities, including the presence of Phragmites australis were assessed to understand the distribution of marsh types within the major tributaries. Beaches were noted as part of the Shoreline Inventory survey.

Table 3. Tier 3 - Shoreline Features

Feature	Feature Type	Comments
Erosion Control Structures		
riprap	L	
bulkhead	L	
dilapidated bulkhead	L	structure no longer performing its function
breakwaters	L	first and last of a series is surveyed alongshore
groinfield	L	first and last of a series is surveyed alongshore
jetty	P	
unconventional	L	constructed of nontraditional but permitted material
debris	L	constructed of unauthorized material (e.g tires)
marsh toe revetment	L	rock placed at the toe of the marsh
seawall	L	solid structure that performs like a bulkhead
Recreational Structures		
pier	P	includes private and public
dilapidated pier	P	appears unsafe
wharf	L	includes private and public
boat ramp	P	distinguishes private vs. public landings
boat house	P	all covered structures, assumes a pier
marina	L	includes infrastructure such as piers, bulkheads, wharfs; number of slips are estimated

L= line features; P= point features

Sediment composition and bank slope cannot be surveyed from a boat, and are not included.

2.2c) Shoreline Features: Structures added to the shoreline by property owners are recorded as a combination of points or lines. These features include defense structures, such as riprap, constructed to protect the shoreline from erosion; offense structures such as groins, designed to accumulate sand in transport; and recreational structures, built to enhance public or private use of the water (Table 3). The location of these features along the shore is surveyed with the GPS registered video camera. Structures such as docks and boat ramps are delineated as point features. Structures such as revetments and bulkheads are delineated as line features. Table 3 summarizes the features surveyed. Linear features are denoted with an “L” and point features are denoted with a “P.” The glossary describes these features, and their function along a shoreline.

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 one data surveyor. The boat operator navigates the boat to follow the shoreline geometry.

The shoreline was surveyed in 2013 using Red Hen® video system. This system interfaces a standard video camera (e.g. Sony ACC-HDV7) with an external GPS and uses specialized hardware (VMS300) to convert the GPS data into an audio signal which is transmitted to the video through the microphone input connector on the camera. As the video is recorded, GPS data are transmitted once per second to the video camera. Each GPS location is linked with a time code on the video. Therefore, the survey is a set of geographically referenced videos of the shoreline referenced to the position of the boat as it moves alongshore.

As indicated earlier, tidal marshes were delineated from the 2009 VBMP imagery using onscreen digitizing techniques at a scale of 1:1,000. They are coded based on a classification applied in the first City of Suffolk Tidal Marsh Inventory (Moore and Dewing, 1991). In several areas, field inspections verified marsh boundary and community types.

2.4 Data Processing

A baseline digital shoreline was derived from the VBMP imagery from 2009 and 2011 (where available) using ESRI's ArcGIS® v.10.0 GIS software.

Data collection was conducted using the Red Hen videography system; a multi-dimensional data collection package that interfaces GPS with a video camera in the field and provides an integrated software platform to allow the video image to be processed within ESRI's ArcGIS.

Two different software packages from Red Hen Systems are used to process the field data: PixPoint and GeoVideo for GIS. The PixPoint software package is used to generate a point shapefile containing points representing locations of geo-referenced still photos taken during the survey. GeoVideo software package is an ArcGIS extension. It is a desktop mapping application that brings geo-referenced video directly into the ArcGIS environment. This software enables users to digitally map videos using GPS coordinates. After the videos are downloaded into the

computer, the GeoVideo software is used to generate a point shapefile which is geotagged to the video survey. This shapefile references the boat track of the survey and the video linked to it.

GIS personnel use the shoreline developed from the VBMP imagery as the base shoreline to code for the attributes observed in the video survey. VBMP imagery is used in the background for reference during the data processing. Each section of the digital shoreline is coded using ArcGIS 9.3. A random site selection process is employed to conduct QA/QC on the final product. The final products are: Suffolk_lubc (depicting land use and bank condition) Suffok_sstru (depicting linear structures), and Suffolk_astru (depicting point structures).

The City of Suffolk Shoreline Inventory is delivered to the end user through a website; http://ccrm.vims.edu/gis_data_maps/shoreline_inventories/index.html (Figure 1.), by clicking on City of Suffolk in the map or list of localities. The format for this inventory includes a map viewing tool rather than individual maps as in previous inventories. The map viewer allows users to interact with the datasets within a familiar "google" type map service that was developed in a Flex/Flash framework. Here they can view data of their choice and customize map products for printing themselves. Access to the GIS data, summary tables, and report is also available through this website.

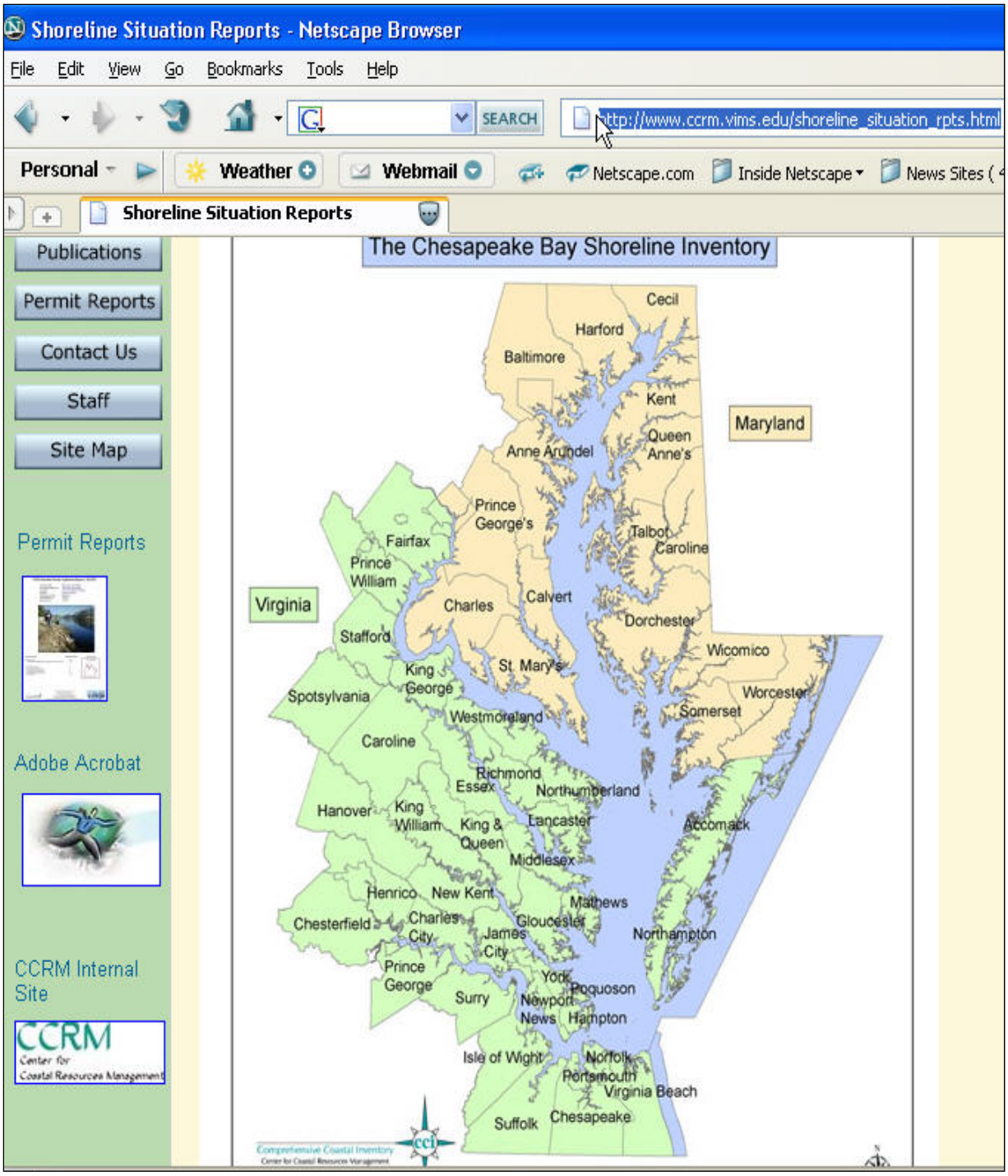

Figure 1. Shoreline Inventory Website

Summary tables quantify conditions observed on the basis of river systems (Figure 2). The total miles surveyed in the field and using remote sensing techniques is reported in Table 4.

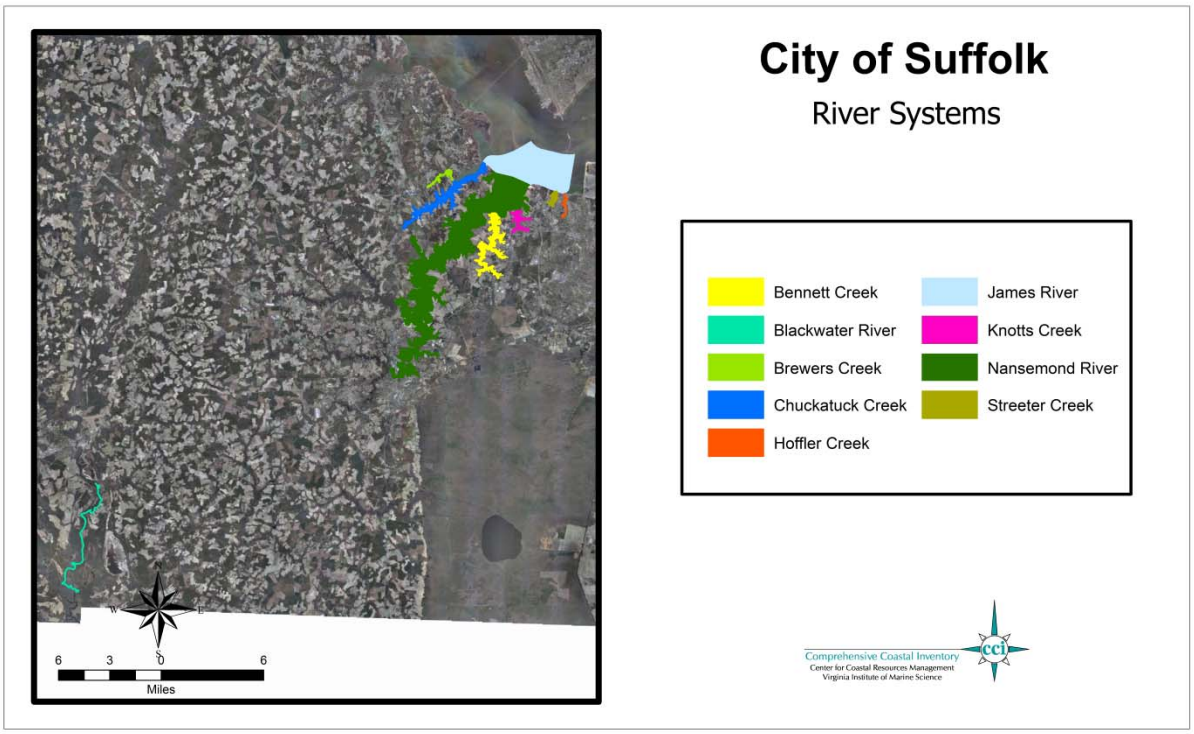

Figure 2. River Systems in the City of Suffolk

In the City of Suffolk, nearly 123.6 miles of shoreline were surveyed in the field. Just over 135 miles of shoreline were surveyed remotely. Remotely sensed areas comprised the Blackwater River and some upper reaches of the other tributaries (Figure 3). All these areas are noted in Table 4 along with either survey dates and/or the image year class used for remote coding.

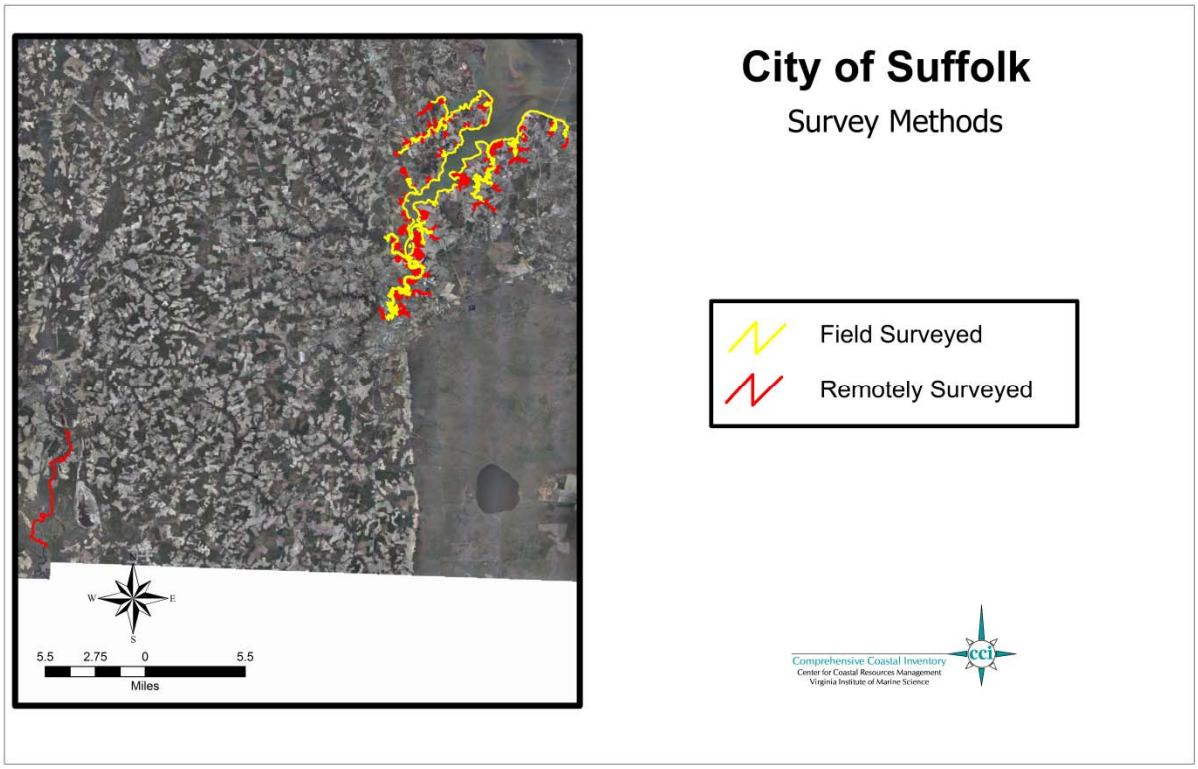

Figure 3. Survey Methodology in City of Suffolk

Tables 5, 6, 7 and 8 quantify features and conditions mapped along the rivers using frequency analysis techniques in ArcInfo. The values quantify features by river systems (Figure 2). For linear features, values are reported in actual miles surveyed. Point features are enumerated. Polygon features are reported in acres surveyed. These tables are downloadable as pdf files from the website. They are not included in this document.

Chapter 3. Applications for Management

There is a number of different management applications for which the Shoreline Inventory Reports support. This section discusses several high profile issues within the Commonwealth or Chesapeake Bay watershed. The inventories are data reports, and the data provided are intended for interpretation and integration into other programs. This chapter offers some examples for how data from the Shoreline Inventory can be analyzed to support current state management programs.

3.2 Shoreline Management

The first uses for Shoreline Inventory 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 that have persisted. At the same time, the value of waterfront property has escalated, and the exigency to protect shorelines as an economic resource using stabilization practices has also increased. 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 with respect to current states and future sea level rise scenarios, and determining future uses of the shore with regards to ecosystem services, economic development, and climate change impacts. The Shoreline Inventories provide data for such assessments. These data are currently being used to determine best strategies to counter erosion based on existing condition. Shoreline Inventories are the backbone for the development of Comprehensive Coastal Resource Management Guidance, the Shoreline Management Model and Shoreline Management Plans that integrate data and scientific rationale to strategize best management practices on a reach-by-reach basis.

For example, land use, to some extent, directs the type of management practices one can expect to find along the shoreline. The land use data illustrates current land use at the time of survey that may be an indicator of shoreline management practices existing or expected in the future. Residential and commercial areas are frequently altered to counter act shoreline erosion problems or to enhance private access to the waterway. In contrast forested or agricultural uses are frequently unmanaged even if chronic erosion problems exist. Small forest tracks nestled

among residential lots have a high probability for development in the future. These areas are also target areas then for shoreline modifications if development does occur. If these banks happen to be low-lying then there are risks associated with flooding and erosion due to storms and sea level rise. The bank height data can help you determine this level of risk from the map viewer. Areas primed for development can be assessed in advance to determine the need for shoreline stabilization, and the type of stabilization that should be recommended.

Stability at the shore is characterized by the conditions at the bank, in particular. The bank is characterized by its height, the amount of cover on the bank face, the state of erosion, and the presence or absence of natural buffers at the bank toe. Upland adjacent to high, stable banks with a natural buffer at the base is less prone to flooding or erosion problems resulting from storm activity. Upland adjacent to a bank of lesser height (< 5feet) is at greater risk of flooding, but if the bank is stable with marsh or beach present, erosion may not be a significant 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 by selecting these attribute features in the map viewer and assess their distribution. Note that banks without natural buffers yet classified as low erosion are often structurally controlled with riprap or bulkheads. The user can visually check for this by looking at the location of shoreline structures along in conjunction with these stable areas.

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. In the near future, the Comprehensive Coastal Resource Management Portal (CCRMP) (http://ccrm.vims.edu/ccrmp/index.html) and the guidance contained therein will provide the shoreline best management practices directly. Currently, with the data here one can assess various conditions and attributes through the viewer as a means to evaluate planned projects that present themselves for review.

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 may be indicative that structures have controlled an erosion problem; however, a pre-existing erosion problem cannot be verified. 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 may have secured the erosion problem at the bank, they have also deflated the supply of sediment available to nourish a healthy beach. The structure may actually be enhancing erosion at the base of the structure by causing scour from wave reflection. The deepening of the nearshore can adversely affect the benthic community. This is a typical shore response, and has lead many coastal managers to deny applications requesting the construction of bulkheads.

In the development of a shoreline management plan, all these possibilities are taken into account. Shoreline managers are encouraged to use the three-tiered shoreline assessment approaches together when developing management strategies or making regulatory decisions. Each assessment provides important information independent of the others, but collectively the assessments become a more valuable management tool. The Center for Coastal Resources Management (CCRM) is using these data to run the Shoreline Management Model that delivers best management practices to counter shoreline erosion. This product may already be available for your locality. Check the CCRMP website (http://ccrm.vims.edu/ccrmp/index.html) or http://ccrm.vims.edu/ for news and updates.

3.3 Stream Restoration for Non-Point Source Management

The identification of potential problem areas for non-point source pollution is a focal point of water quality improvement efforts throughout the Commonwealth. This is a challenge for any large landscape. Fortunately, we are relatively well informed about the landscape characteristics that contribute to the problem. This shoreline inventory provides a data source where many of these landscape characteristics can be identified. The three tiered approach provides a collection of data which, when combined, can allow for an assessment of potential non-point source pollution problem areas in a waterway. Managers can effectively target river reaches for restoration sites. Below, methods for combining these data to identify problem sites are described.

Residential land and agricultural lands have the highest potential for nutrient runoff due to fertilizer applications. Agricultural lands are also prone to high sediment loads since the adjacent banks are seldom restored when erosion problems persist. Residential areas contribute

to non-point source problems through leaking septic systems as well. Intensely developed areas which may include commercial and industrial sites have a high percentage of impervious surface which concentrates upland runoff into waterways.

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 low profile, 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.

To identify areas with the highest potential for non-point source pollution combine these land uses with "high" bank erosion conditions, bare bank cover, 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 associated with sediment load is reduced. If the following characteristics are delineated: low bank erosion, marsh buffer, riprap or bulkhead; the potential for non-point source pollution from any land use class can be lowered.

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, construction of living shorelines, and bank re-vegetation programs. Installation of BMPs is costly. There are cost share programs that 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 shoreline inventory can assist with targeting efforts for designating AOCs. AOCs can be areas where riparian buffers are fragmented, and could be restored. Information reported on riparian land use can be used to identify forest areas, breaks in forest coverage and the type of land use occurring where fragmentation has happened. 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 “agriculture” or “grass” land.

An examination of conditions pertaining to the bank also contributes to targeting areas of concern with respect to sediment load sources to the watershed. Look for areas where 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 that might be most appropriate. Marsh planting may be difficult to establish at the toe of a bank with high exposure to wave conditions. Look for other marsh fringe in the vicinity as an indicator that marshes can successfully grow. A riparian forest may include a tree canopy with overhang that could be trimmed to increase sunlight to promote marsh growth. Check for existing shoreline erosion structures in place. We can combine this information to assess where significant problems exist and what types of solutions will mediate the problems.

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 combined data for 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.

As water quality programs move into implementation phases the importance of shoreline erosion in the lower tidal tributaries will become evident. Erosion from shorelines has been associated with high sediment loads in receiving waters (Hardaway et al., 1992), and the potential for increased nutrient loads coming off eroding fastland is a concern (Ibison et al., 1990). The contribution to the suspended load from shoreline erosion is not quantified. Water quality modelers are challenged by gathering appropriate data for model inputs.

Waterways with extensive footage of eroding shorelines represent areas that should be flagged as hot spots for sediment input. The volume of sediment entering a system is generally estimated by multiplying the computed shoreline recession rate by the bank height along some distance alongshore. Estimated bank height is mapped along all surveyed shorelines. Banks designated as “eroding” and in excess of 30 feet would be target areas for high sediment loads. If these areas coincide with uplands in agricultural use, nutrient enrichment through sediment erosion is also a concern. Table 6 quantifies the linear extent of high, eroding banks on a river system basis. Using the GIS data site-specific calculations can be made.

3.5 Summary

These represent only a handful of uses for the Shoreline Inventory data. Users are encouraged to consider merging these data with other local or regional datasets. Now that most agencies and localities have access to some GIS capabilities, the uses for the data are even greater. The opportunity to update these datasets independently is not only possible, but probable. Historically, the development of the Chesapeake Bay Shoreline Inventory has evolved as new issues emerge for coastal managers, and technology improves. We expect to see this evolution and product enhancement continue into the future.

Chapter 4. The Shoreline Inventory for the City of Suffolk

Shoreline condition is described for City of Suffolk along primary and secondary shoreline. Characteristics are described for all navigable tidal waterways contiguous to these shorelines. A total of 259.62 miles of shoreline are described. Just over 135 miles of this shoreline were surveyed remotely; due primarily to limited boat access. Figure 3 illustrates which areas were field surveyed and which areas were surveyed using remote sensing techniques.

Shoreline Inventory Reports are only available electronically. From this website: http://ccrm.vims.edu/gis_data_maps/shoreline_inventories/index.html users can access the interactive Shoreline Inventory map viewer, electronic tables and report, GIS data, and metadata. The website is organized to encourage users to navigate through a series of informational pages before downloading the data. A map of the Chesapeake Bay region depicting counties and cities is shown on the main homepage for the Shoreline Inventory website (Figure 1). Scroll over the County/City name to link to the completed inventory. There is a list of completed inventories by state below the map. Click on "City of Suffolk" to access the information available.

From City of Suffolk Shoreline Inventory homepage, the user can read a project summary and disclaimer explaining data use limitations. There are five self-explanatory links on the page: map viewer, tables, report, GIS data, and historical report. The link to the map viewer will take you to the interactive Shoreline Inventory map viewer where data layers can be turned on and off in the side bar and displayed in the viewing window (Figure 4.). The map viewer can be opened using any internet browser. As the map viewer is opened, a Welcome dialog box is launched that provides some useful information about the tool.

The Viewer has two panels: "Map Window", where the map is displayed and "Map Contents and Legend", where data that can be selected and viewed in the map window are listed. A tool bar is located along the top of the "Map Window" which gives users some controls for navigation and analysis (Figure 4.).

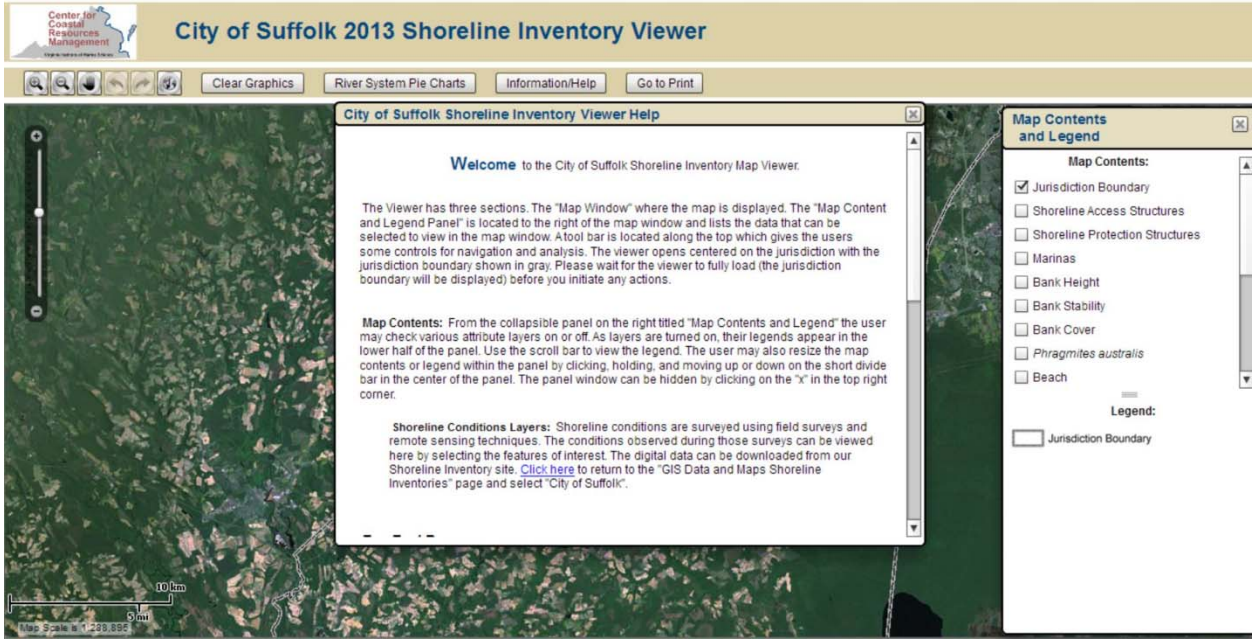

Figure 4. Opening page for the City of Suffolk Shoreline Inventory Viewer

From the "Map Contents and Legend" the user may check various attribute layers on or off. The user must use the scroll bar on the far right to see the complete list of attributes available. When layers are turned on, the corresponding legend appears in the lower half of the panel, and the data are displayed in the "Map Window" (Figure 5).

Figure 5. Map Viewer illustrates Shoreline Access and Protection Structures.

In Figure 5 Shoreline Access Structures, and Shoreline Protection structures have been selected along with the boundary. Shoreline Access structures are point features that includes piers and boat ramps. The actual footprint of these structures is not measured; only their location. Shoreline Protection Structures are line features and are mapped and illustrated in the viewer to show where they occur along the shoreline. Figure 6 illustrates riparian land use.

Figure 6. Distribution of land use in the riparian zone is displayed for this region of the City.

The user can use the zoom and pan tools from the top toolbar or the slide bar on the left side of the map window to change their map extent. If the map resolution is exceeded the window will become illegible. Detailed information can be obtained about the data by selecting the “Information/Help” tab at the top of the map viewer. From here the inventory glossary and metadata records can be easily accessed. In Figure 7 the selection for metadata has been made and 5 possible records can be retrieved.

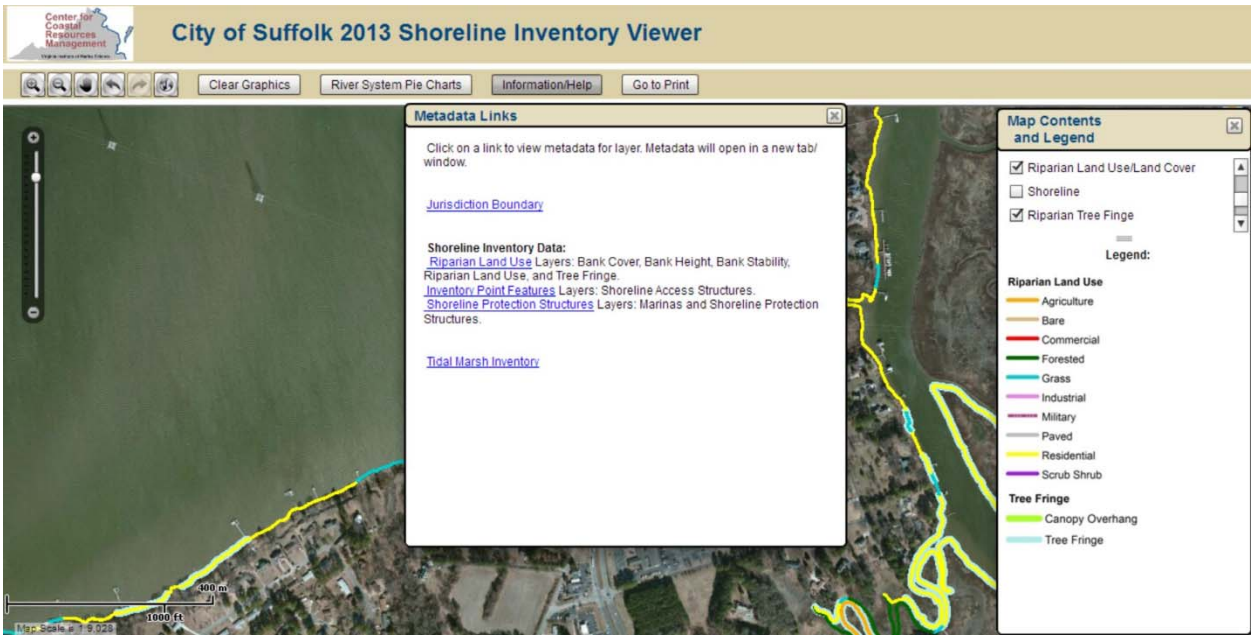

Figure 7. Link to Metadata records has been selected from the top Information tab in the toolbar.

The top toolbar also includes tabs to access some important status information for the locality. By clicking on the “River System Pie Charts” button, users can obtain a statistical summary distribution of the riparian land use and amount of hardened shoreline for a specific water body which is selected from the drop down menu in the upper left (Figure 8). More detailed results in table format can be found by clicking the City of Suffolk Summary PDF button also in the window. The summary statistics are reported by river systems (Figure 2).

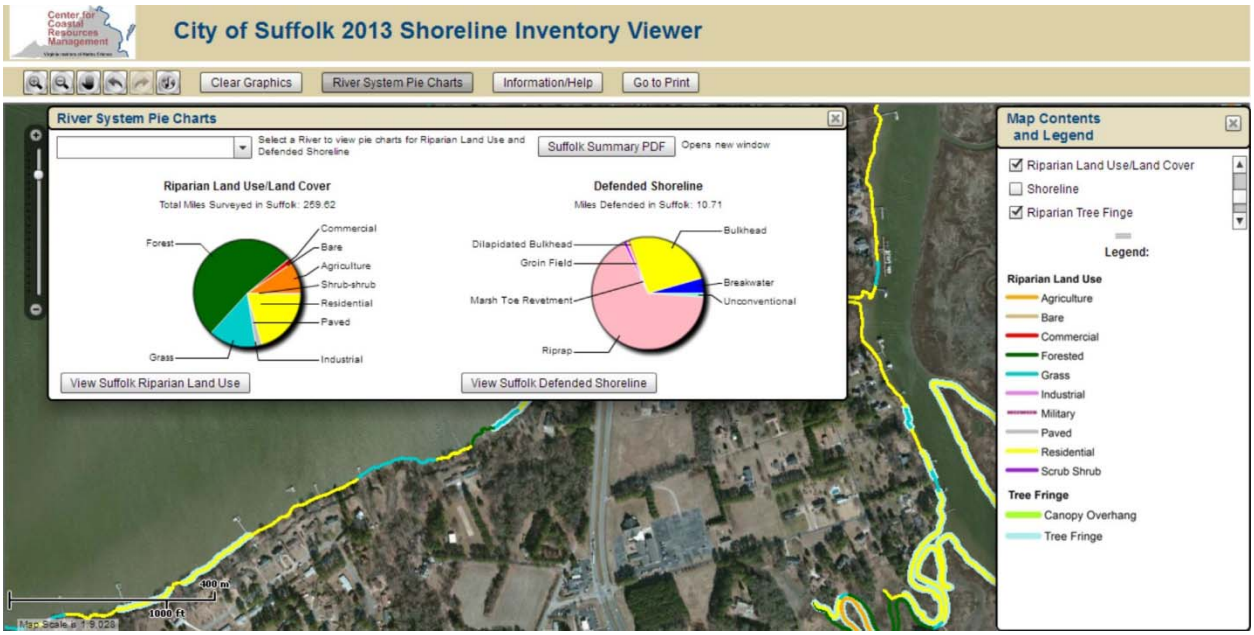

Figure 8. Pie charts display land use and shoreline hardening statistics for each tributary.

Finally, users have the option to personalize their own maps (i.e. map extent, data displayed, map title, etc) and print them by clicking "Go to Print" button. The map legend and the charts display below the map. The page is set up for printing to 8.5 x 11 portrait style. Figure 9 is an example of a customized map generated for the mouth of Nansemond River. Here the tidal marsh communities are displayed, and the community type is reported in the legend below the illustration. Also illustrated are the summary pie charts showing land use and shoreline hardening along the entire tributary.

Resource Guides

The City of Suffolk Shoreline Inventory is one of several products generated to assist with shoreline management within the community and beyond. The inventory is part of the larger Comprehensive Coastal Resource Management Plan (CCRMP) initiative which includes all Tidewater localities and provides specific guidance for managing tidal shoreline in your locality. Release of the CCRMP for City of Suffolk is anticipated by January, 2014 and will be accessible through this site: http://ccrm.vims.edu/ccrmp/index.html.

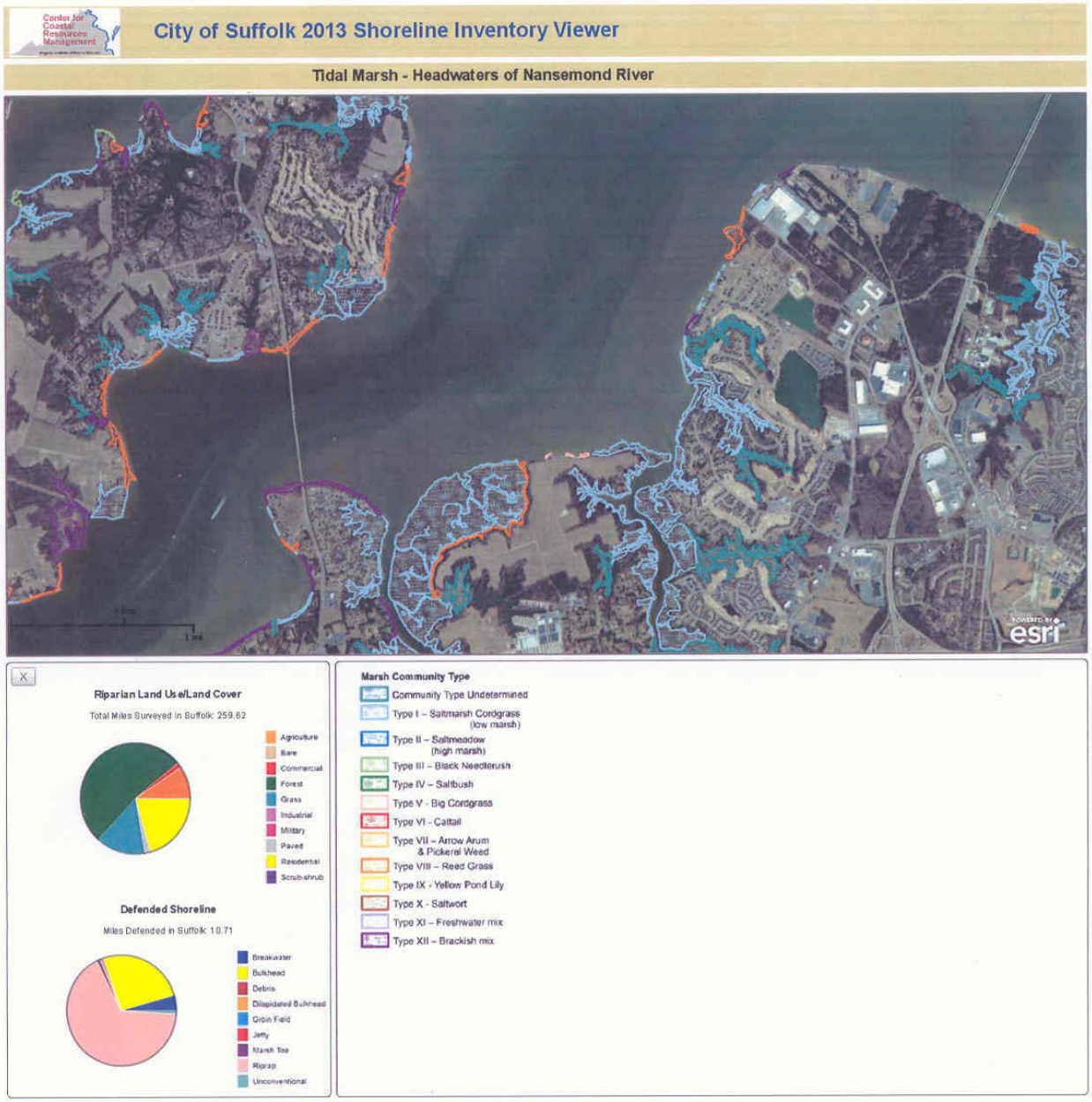

Figure 9. Customized print window for the mouth of Nansemond River.

Glossary of Shoreline Features Defined

Agricultural - Land use defined as agricultural includes farm tracts that are cultivated and crop producing. This designation is not applicable for pastureland.

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

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

Boathouse - 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 that offer only overhead protection. Since nearly all boathouses have adjoining piers, piers are not surveyed separately, but are assumed. Boathouses 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. Private and public ramps are denoted where possible. Private ramps are illustrated as purple squares. Orange squares represent public ramps. The location of these ramps was determined from static 6 second GPS observations.

Breakwaters - Breakwaters are structures that 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 that 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 that may accumulate behind the structures can be. In this survey, individual breakwaters are not mapped. The first and last breakwater in the series is surveyed as a six-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.

For a variety of environmental reasons, bulkheads are not a desirable alternative for shoreline protection. Nevertheless they are still very common along residential and commercially developed shoreline. From aerial photography, long stretches of bulkheaded shoreline may be observed as an unnaturally straight or angular coast. In this inventory, bulkheads are mapped using kinematic GPS techniques. The data are displayed as linear features on the maps.

Commercial - Commercial zones include small commercial operations as well as parks or campgrounds. 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.

Extensive Marsh – A large marsh where the length and depth or width are roughly comparable; most extensive marshes are drained by many tidal channels and creeks which have little freshwater input.

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 - Grasslands include large unmanaged fields, managed grasslands adjacent to large estates, agriculture tracts reserved for pasture, and grazing.

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. We assume those in between are evenly spaced. On the map composition, the groin field is designated as a linear feature extending along the shore.

Industrial - Industrial operations are larger commercial businesses.

Marina - Marinas are denoted as line features in this survey. They are a collection of docks and wharfs that 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. However, if a boat ramp is present it will be surveyed separately and coded as private. 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 will denote the use of the land at the site as residential for a community facility, rather than commercial. The survey estimates the number of slips within the marina and classifies marinas as those with less than 50 slips and those with more than 50 slips.

Marshes - Marshes can be extensive, embayed or fringe marshes. Extensive marshes generally occupy significant acreage. Embayed marshes are similar to pocket or headwater marshes and are often fill and surround headwater areas. Fringe marshes are narrow strips of marsh vegetation that extend along the shoreline. In all cases, vegetation must be relatively well established, although not necessarily healthy.

Marsh Island – Land mass surrounded by water primarily composed by vegetated wetland (marsh).

Marsh toe revetment – A marsh toe revetment is a low profile revetment, typically constructed of stone, placed along the eroding edge of an existing tidal marsh. The structure may include tidal openings to allow for the easy exchange of free swimming organisms during tidal cycles.

Miscellaneous - Miscellaneous features represent segments along the shore where unconventional material or debris has been placed dumped to protect a section of shore. Miscellaneous can include tires, bricks, broken concrete rubble, and railroad ties as examples.

Paved - Paved areas represent roads which run along the shore and generally are located at the top of the banks. Paved also includes parking areas such as parking at boat landing, or commercial facilities.

Phragmites australis - a non-native, invasive wetland plant known to thrive in areas that have

experienced disturbance. The plant is prolific and is known to out complete native species. Various types of eradication methods have been used to stop the growth of this plant.

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. 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 marsh toe protection. This inventory does not distinguish among the various types of revetments.

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 are usually dominated by shrubs and bushy plants.

Tree Canopy - When the forest cover or the tree fringe (see below) appears to overhang the bank a canopy is formed that provides shading and sometimes cooling of the bank and shallow nearshore.

Tree Fringe - When the dominant riparian land use is not forested but a line of trees is maintained along the bank edge, the land use is noted to include a tree fringe.

Wharf – Typically describes a shore parallel structure where boats are tied. While often associated with large public or commercial facilities, in this inventory the term “wharf” is also used to describe smaller scale structures that can be found parallel to the shore to accommodate docking facilities for adjacent private properties in a neighborhood.

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