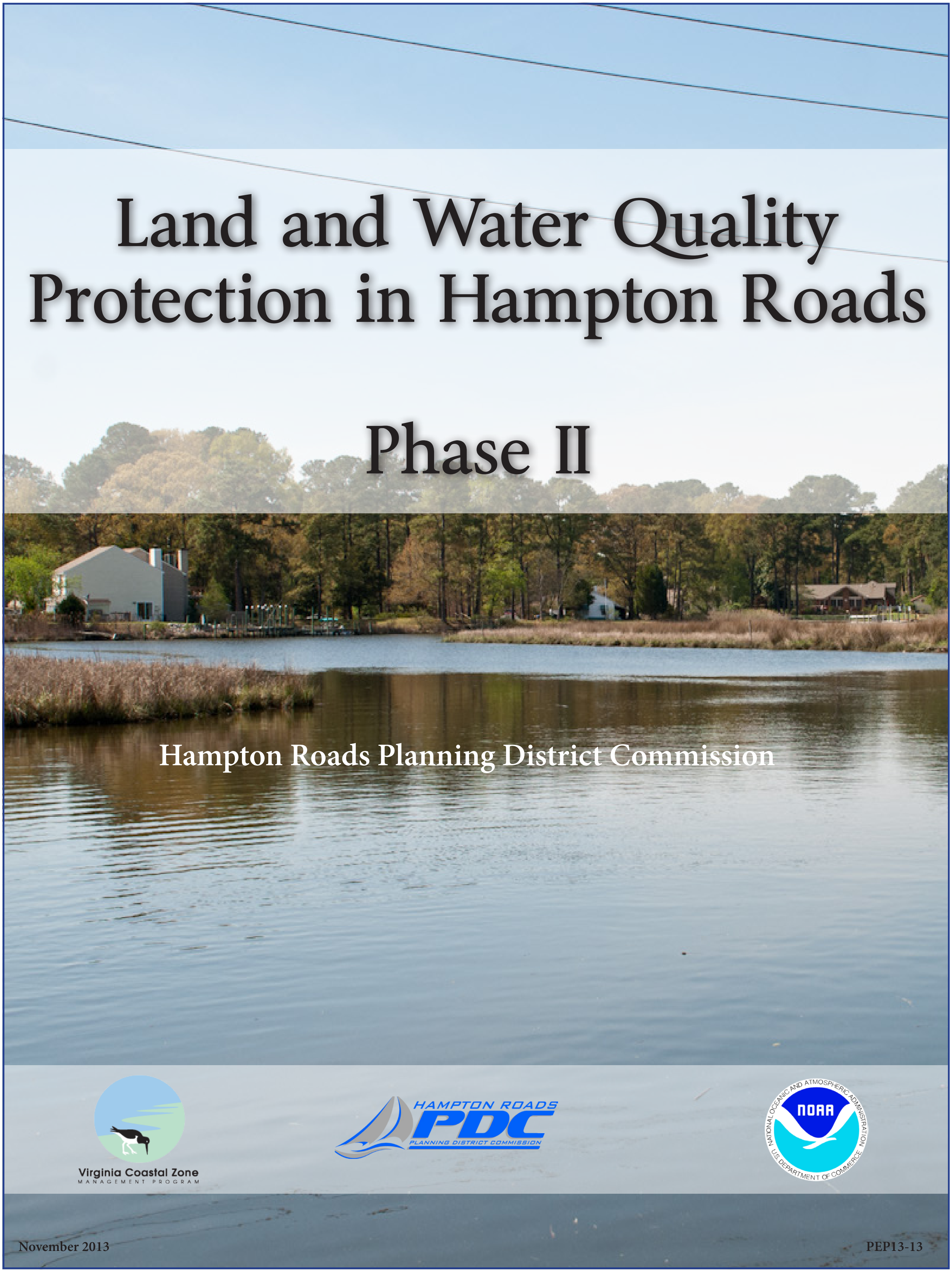

Land and Water Quality Protection in Hampton Roads

Phase II

Hampton Roads Planning District Commission

Virginia Coastal Zone Management Program
Hampton Roads PDC Planning District Commission
National Oceanic and Atmospheric Administration, U.S. Department of Commerce

November 2013
PEP13-13

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LAND AND WATER QUALITY PROTECTION IN HAMPTON ROADS
PHASE II

This report was funded, in part, by the Virginia Coastal Zone Management Program at the Virginia Department of Environmental Quality through Grant # NA11NOS4190122 of the U.S Department of Commerce, National Oceanic and Atmospheric Administration, under the Coastal Zone Management Act of 1972, as amended.

The views expressed herein are those of the authors and do not necessarily reflect the views of the U.S Department of Commerce, NOAA or any of its subagencies.

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Prepared by the staff of the Hampton Roads Planning District Commission

NOVEMBER 2013

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Land and Water Quality Protection in Hampton Roads Phase II

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ABSTRACT
This report provides a summary of the second year of the Hampton Roads Planning District Commission's work under a Section 309 Grant from the Virginia Coastal Zone Management Program. The goal of this work is to develop implementable policies, which will assist local governments in addressing the requirements of the new Virginia Stormwater Management Regulations and the Chesapeake Bay Total Maximum Daily Load. The report contains three major sections. The first section provides guidance to local governments that document recommended stormwater best management practices for coastal areas. The second section describes a review of two Hampton Roads localities, Norfolk and Suffolk, to identify potential opportunities for ordinance or policy changes, and includes some potential changes to consider. The third section demonstrates the use of geographic information systems (GIS) to inform the site design process.

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INTRODUCTION

In October 2012, the Hampton Roads Planning District Commission (HRPDC) was awarded a grant under Section 309 of the Coastal Zone Management Act, as amended, from the Virginia Coastal Zone Management Program to continue efforts to assist local governments in Hampton Roads in implementing required and recommended land development and environmental protection practices in response to the Chesapeake Bay Total Maximum Daily Load (TMDL) and revised Virginia Stormwater Management Regulations. This project was included as part of the Land and Water Quality Protection section of Virginia's Section 309 Cumulative and Second Impacts Strategies for 2011-2016 and is part of a five-year planned program. This specific grant project builds upon work done in the previous year, which assessed the potential impacts of these new requirements on local governments and identified some tools currently available to help develop effective responses.

This project consists of three parts, each of which is described in a section of the following report. The first part provides a series of specific findings and recommendations related to stormwater best management practices (BMPs) and land development practices, including how they are treated by the stormwater spreadsheet now mandated by the Virginia Department of Environmental Quality. This section describes the relative benefits of various common stormwater management BMPs and assesses if and how they should be discounted when used in the coastal plain. The first section also describes the potential for using site design to reduce nutrient loads.

The second section describes an assessment of local codes and ordinances for two cities in Hampton Roads, Norfolk (representing urban, developed communities) and Suffolk (representing growing, suburban or transitional communities). The local development regulations for both cities were analyzed using a tool identified during the previous grant year, the Center for Watershed Protection's Code and Ordinance Worksheet. This section also includes several specific recommendations that were developed based on ordinance assessments and discussions with locality staff.

The third section demonstrates the use of a geographic information systems (GIS) approach to model potential development impacts on stormwater runoff in order to inform the site design process. Two case study sites are used: a redevelopment site in Norfolk and a reimagining of an existing subdivision in Suffolk as a cluster development. This approach combines a typical GIS analytical approach with the

Virginia Runoff Reduction Method spreadsheet to calculate the impacts of various development scenarios on specific sites.

This report is intended to guide discussions between HRPDC staff and locality staff from the Cities of Norfolk and Suffolk in deciding which policy changes to pursue and what specific changes to make during 2013 and 2014.

SECTION 1: COASTAL PLAIN STORMWATER BMP GUIDE

Virginia has developed statewide stormwater standards to protect water quality that will be implemented by local governments beginning July 1, 2014. Developers will need to employ a mix of site design, runoff reduction, and pollutant control practices in order to comply with the water quality and quantity criteria in the regulations. The physiographic characteristics of the coastal plain can make it challenging to meet the criteria in a cost effective way. The purpose of this document is to highlight the practices that are well suited for the coastal plain and summarize the design modifications that may be necessary. The Virginia Stormwater Handbook is the official guidance document for compliance with the Virginia Stormwater Management Law and Virginia Stormwater Management Permit (VSMP) Regulations. Design specifications for the BMPs that can be utilized to meet the standard are located on the BMP Clearinghouse website[1] and reflect the most recent research on BMP sizing, design and performance.

SUMMARY OF VIRGINIA STORMWATER MANAGEMENT PERMIT (VSMP) REGULATIONS

The revisions to the Virginia Stormwater Management Regulations (SWM) became effective on September 13, 2011 after a significant stakeholder process that began in 2004 with legislation that transferred stormwater regulatory programs for construction activity and municipal permits from the Department of Environmental Quality (DEQ) to the Department of Conservation and Recreation (DCR) and required DCR to issue regulations to establish statewide post construction stormwater criteria to protect water quality. Starting on July 1, 2014, all development subject to permitting under the Virginia Stormwater Management Program (and sites greater than 2,500 square feet in Chesapeake Bay Preservation Act (CBPA) areas) must meet the new water quality and quantity criteria for post construction stormwater runoff. Local governments will be responsible for reviewing site plans for compliance with these post construction criteria. These regulations are also an important part of the state's efforts to protect and restore the Chesapeake Bay.

Virginia's revised water quality criteria of 0.41 pounds of phosphorus per acre per year will be implemented beginning on July 1, 2014. The criteria was developed to be protective of local water

[1] http://vwrrc.vt.edu/swc/

quality and to achieve no net increase in nutrients for new development. The new criterion was calculated using the Runoff Reduction Method rather than the Simple Method and translates to a land cover condition of 10% impervious cover, 30% turf, and 60% forest.

The Runoff Reduction Method for Virginia is focused on site compliance to meet site-based load limits. This means that the proposed Virginia stormwater regulations are aimed at limiting the total load leaving a new development site. This is a departure from water quality computations of the past, in which the analysis focused on comparing the post-development condition to the pre-development, or an average land cover condition.

The central component of the Runoff Reduction method is treatment volume (Tv). The runoff reduction method incorporates recent research that shows that some BMPs are quite effective at reducing the volume of runoff that reaches surface waters. By applying site design, structural, and nonstructural practices, the designer can reduce the treatment volume by reducing the overall volume of runoff leaving a site. Virginia developed a compliance spreadsheet to help designers and plan reviewers quickly evaluate the implementation of BMPs on a given site and verify compliance with the State stormwater requirements. Appendix B of the *Technical Memorandum for the Runoff Reduction Method* describes this research in greater detail and explains the basis for the runoff reduction rates of each BMP. The report, *Land and Water Quality Protection in Hampton Roads, Phase I* [2], explains the new stormwater regulations and the runoff reduction method in greater detail.

OBSTACLES TO MANAGING STORMWATER IN THE COASTAL PLAIN

Traditional stormwater practices were developed for the Piedmont physiographic region and often require adaptations to properly function in the coastal plain. Implementation of these stormwater practices in the coastal plain is constrained by the flat terrain, high water table, and low permeable soils. These characteristics make stormwater management more complex and limit the BMPs that can be implemented to control the quality and quantity of runoff in the coastal plain. This report aims to inform developers about the challenging conditions in the coastal plain, environmental site design techniques, important factors to consider during BMP selection, and design modifications to make

[2] http://hrpdcva.gov/uploads/docs/HRPDCAgendas/2013/March/Website/03212013-PDC-E8G.pdf

certain BMPs feasible in the coastal plain. With careful BMP selection, design, and implementation, development in Hampton Roads can occur without flooding, groundwater contamination, and water quality degradation caused by improper stormwater management.

FLAT TERRAIN

The flat terrain (zero to 3 percent slopes) of the coastal plain creates several site design challenges Flat terrain increases surface water/groundwater interactions and reduces the hydraulic head available to treat the quantity of stormwater produced during the intense rainstorms that are common throughout the region. Many of the stormwater practices discussed in the Structural BMP Implementation section of this report require minimum slopes in order to ensure that runoff will flow to the device and that if an underdrain is present, it will function properly.

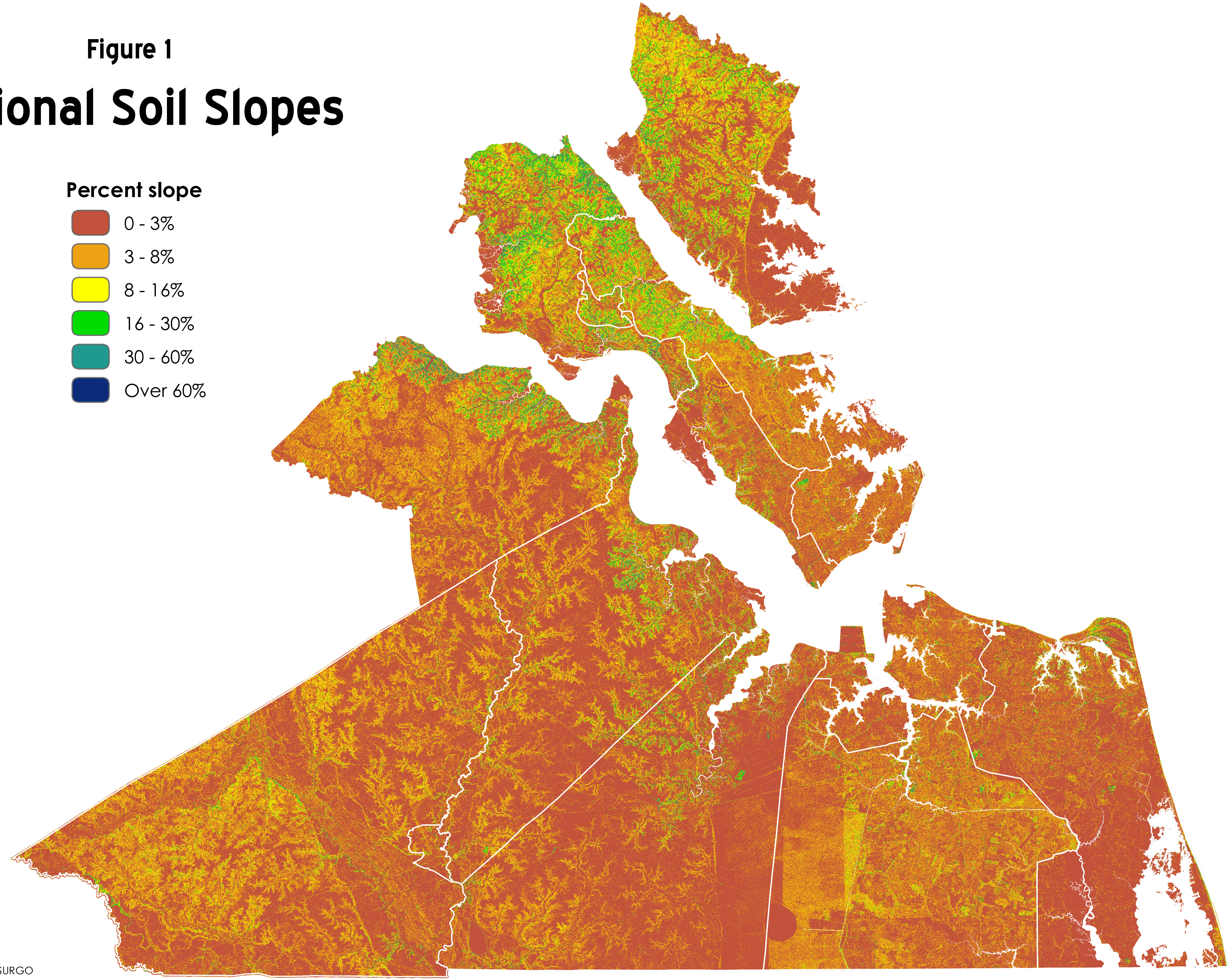
Figure 1 illustrates the range of slopes throughout Hampton Roads. Most of the land is classified as flat with 63 percent of the area having a slope less than 3 percent. Twenty five percent of the land area is classified as undulating with slopes between 3 and 8 percent.

Slopes were calculated by applying the ArcGIS slope function to the Seamless Regional Digital Elevation Model documented in Appendix B of *Hampton Roads Coastal Resources Technical Assistance Program Fiscal Year 2011-2012* [3]. The slope function in ArcGIS calculates a single representative value for each cell using its eight neighboring cells. The result is the maximum rate of change between the cell and its neighbors. For this exercise, slope was calculated as a percentage using ten-foot square cells.

[3] http://hrpdcva.gov/uploads/docs/HRPDCAgendas/2013/April/04182013-PDC-E9K.pdf

Figure 1

Regional Soil Slopes



Data Source: USDA SSURGO

HAMPTON ROADS PDC PLANNING DISTRICT COMMISSION

POORLY DRAINED SOILS

Soil regulates the processes of surface runoff, infiltration and percolation, and is a major controlling factor in evapotranspiration through the capacity of the soil to store and release water. The characteristics of soils on site should be carefully considered during the development of a stormwater management strategy because runoff volumes and flow rates can be reduced through infiltration and storage in the pore space of the soil substrata and pollutants can be removed from the water column via sorption to soil particles.

The ability of surface soil layers to infiltrate and their capacity to store stormwater are important design parameters that are represented by the hydraulic conductivity and the storage capacity of the soil type. A Regional map of NRCS hydrologic soil groups is provided as Figure 2. This map should only serve as a general guide because soils can be highly heterogeneous. A site specific soils investigation should be conducted to fully evaluate the feasibility of infiltration at a site.

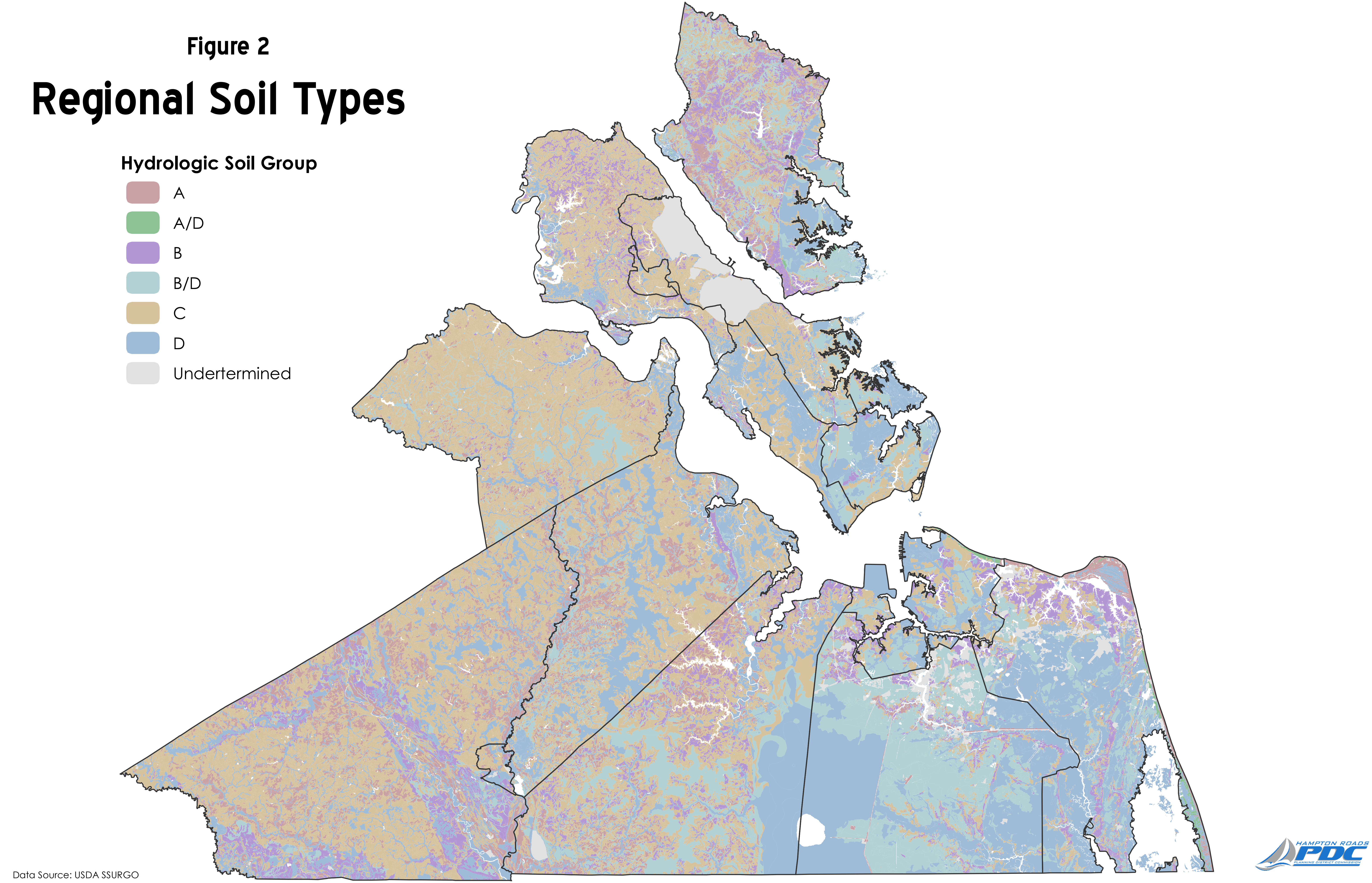
Hydrologic soil groups are based on estimates of runoff potential. Soils are assigned to one of following four groups according to the rate of water infiltration when the soils are not protected by vegetation, are thoroughly wet, and receive precipitation from long-duration storms:

- **Group A** soils have a high infiltration rate and low runoff potential. These consist mainly of deep, well drained to excessively drained sands or gravelly sands.
- **Group B** soils have a moderate infiltration rate. These consist primarily of moderately deep or deep, moderately well drained or well drained soils that have moderately fine texture to moderately coarse texture.
- **Group C** soils have a slow infiltration rate. These consist chiefly of soils having a layer that impedes the downward movement of water or soils of moderately fine texture or fine texture.
- **Group D** soils have a very slow infiltration rate and high runoff potential when thoroughly wet. These consist chiefly of clays that have a high shrink-swell potential, soils that have a high water table, soils that have a claypan or clay layer at or near the surface, and soils that are shallow over nearly impervious material. Only soils that in their natural condition are in group D are assigned to dual classes. The first letter is for drained areas and the second is for undrained areas.

Seventy percent of the soils in Hampton Roads are of hydrologic class C and D, and the majority of the C soils are found in the western half of the Region. Unfortunately, these soils have limited ability to infiltrate stormwater and make large scale infiltration BMPs infeasible. However, small scale infiltration can still be effective at reducing runoff volumes even when native soils have low permeability. The following modifications can be implemented to prevent the BMP from remaining saturated with water: local soils may be amended; alternative outlets, such as underdrains, can be installed; and a gravel layer beneath the underdrain can be added to provide subsurface pore storage.

Figure 2

Regional Soil Types



HIGH WATER TABLE

Groundwater is an important element in the hydrologic cycle. During long periods of dry weather, groundwater is the source of baseflow in rivers, canals, and stormwater drainage systems especially in shallow groundwater regions like Hampton Roads. The depth to groundwater is an important factor to consider when selecting and designing a stormwater BMP. Throughout the coastal plain, the water table is within a few feet of the surface (Figure 3). The proximity of the groundwater table to the surface increases the potential for groundwater contamination from stormwater infiltration and diminishes the performance and feasibility of many stormwater BMPs.

The distance between the bottom of the stormwater control practice and the groundwater table, depth and direction of groundwater flow, seasonal groundwater variation, regional geology, and the slope of the water table are important factors to consider when evaluating a site's potential for stormwater infiltration. The soil infiltration properties, groundwater use, and groundwater flow characteristics must all be considered to ensure that the water quality of the groundwater resource is not negatively impacted.

Figure 3 illustrates that 40 percent of the Hampton Roads area has a separation of less than 1 foot between the land surface and the seasonal high groundwater table and 60 percent of land is within 2 feet. Depth to seasonal high groundwater table was calculated using data from the Soil Survey Geographic (SSURGO) Database and assuming that groundwater levels would be highest between January and April. Site specific data should be acquired prior to BMP selection and design.

POLLUTANTS OF CONCERN

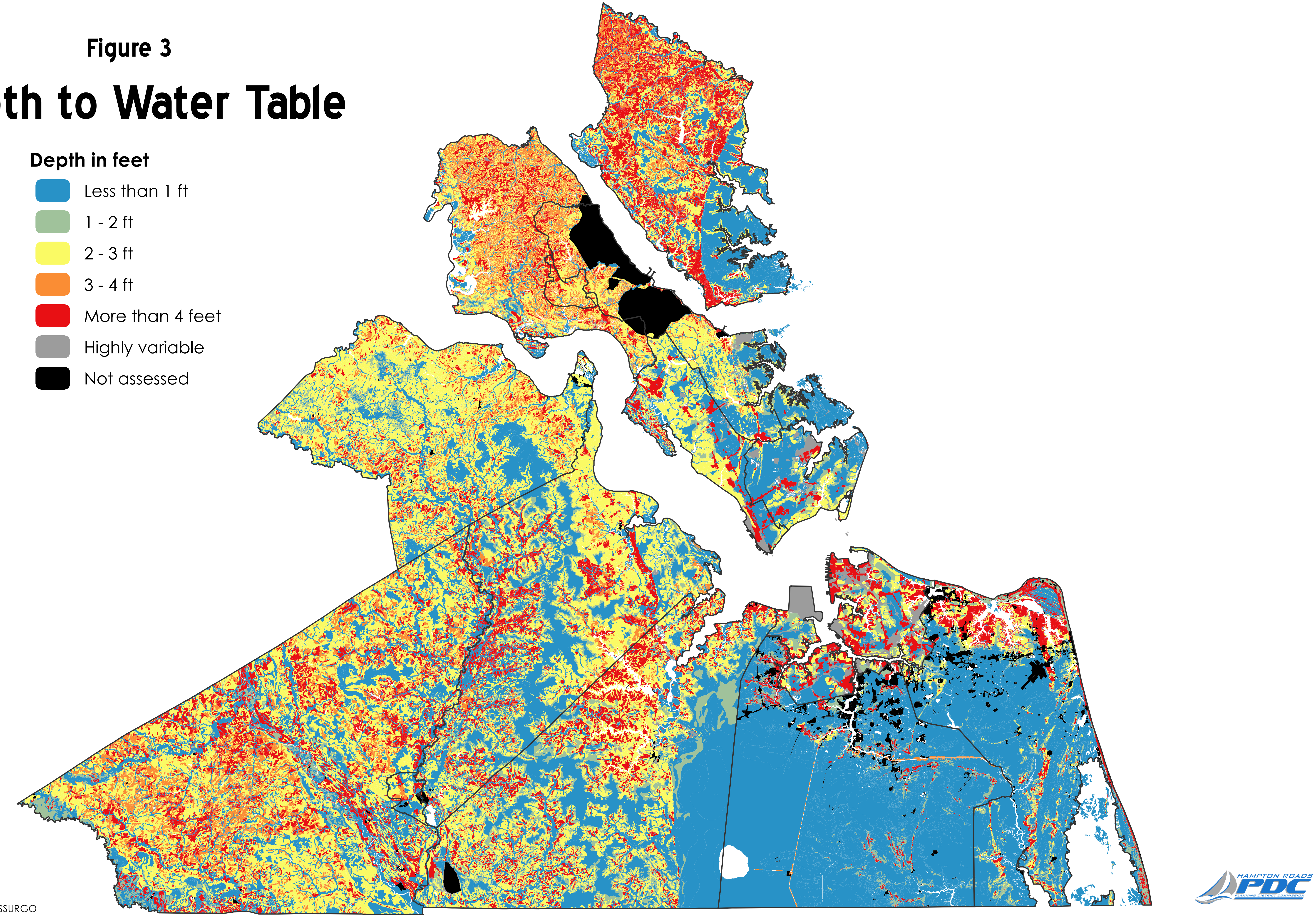
Virginia's stormwater regulations are tied to phosphorus control which is frequently the limiting nutrient for fresh water. However, the most common impairment of local water quality in Hampton Roads is bacteria. In addition, coastal plain localities also need to reduce nitrogen and sediment loads in order to comply with the Chesapeake Bay TMDL. In order to protect water quality in the coastal plain and meet TMDL requirements, the ability of a BMP to control pollutants other than phosphorus should be considered when deciding which stormwater practices should be implemented to meet the stormwater regulations. The capacity of each BMP to remove bacteria and nitrogen is presented in the

Structural BMP Implementation section of this report, but the following considerations and modifications can reduce bacteria and nitrogen concentrations in runoff:

- Maintain setbacks from septic drainfields and connect household waste discharges to the local sanitary sewer system when feasible.
- Use dry or wet swales rather than grass channels.
- Minimize site runoff by utilizing infiltration and filtration practices.
- Avoid using turf around ponds and wetlands. Consider planting taller native vegetation to make shoreline access more difficult for geese and waterfowl.
- Use vegetated filter strips at the edge of riparian buffer areas.
- Use shallow wetlands and benches to create natural micro-predators for bacteria.
- Enhance sand filter media with a layer of organic matter.
- Create high light conditions to promote UV in areas of standing water.
- Design treatment systems to prevent re-suspension of bottom sediments.

Figure 3

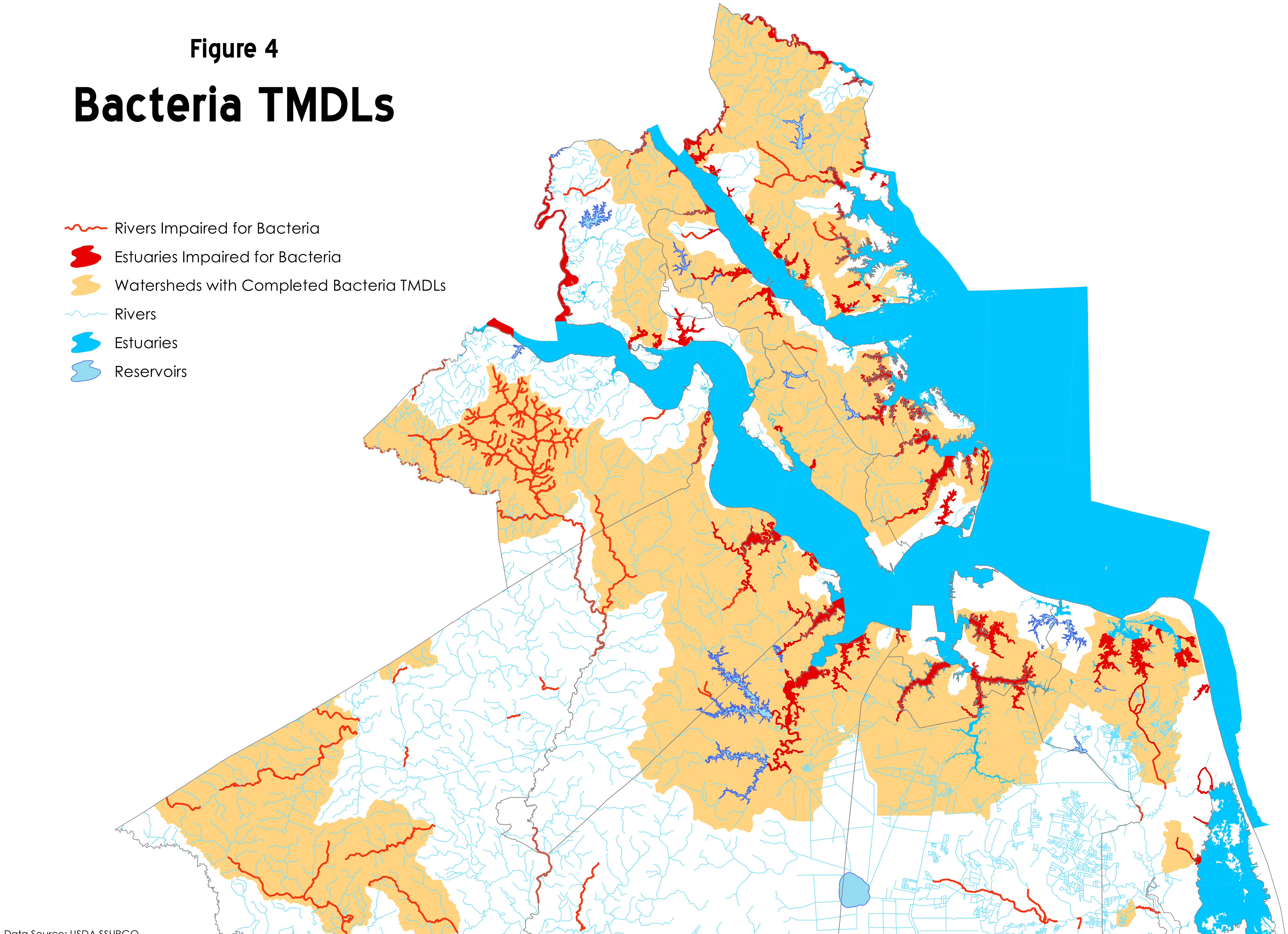
Depth to Water Table



Data Source: USDA SSURGO

Figure 4

Bacteria TMDLs



IMPLEMENTING THE RUNOFF REDUCTION METHOD IN THE COASTAL PLAIN

To limit the cost and space expended for structural stormwater controls, developers should plan to minimize the runoff generated by the development. The runoff reduction method encourages the developer to utilize environmental site design techniques to minimize the stormwater runoff and pollutant load leaving the site prior to the implementation of structural BMPs. After implementing environmental site design as much as feasible on site, structural BMPs are installed to close the gap to meet the regulations.

REVIEW OF THE RUNOFF REDUCTION METHOD

In order to understand how site design influences runoff and pollutant loads, it is important to understand the mechanics of how pollutant loads are calculated using the runoff reduction method. Examining the pollutant load equation in Figure 5, it is evident that the only variable the developer can control is the treatment volume (T_v). A detailed look at the treatment volume equation in Figure 6 reveals how utilizing environmental site design practices can result in lower pollutant loads. Pollutant loads are driven by the hydrologic soil groups present on site and the relative amounts of impervious cover, forest, and turf areas in the post development condition. The runoff coefficients for each of these land uses are displayed in Table 1.

Developers can reduce the treatment volume by maximizing forest and open space which has the lowest runoff coefficient and minimizing impervious area which has the highest runoff coefficient. If the developer can reduce the treatment volume, then less structural BMPs will need to be built to meet the regulations. The design examples at the end of this section illustrate how each environmental site design practice affects these variables and subsequently the post development load reduction requirements.

Figure 5: Runoff Reduction Pollutant Load Equation

$$\text{Pollutant Load (lb/yr)} = R \times Pj \times (Tv|P) \times C \times 2.72$$

R = Annual precipitation (inches)

Pj = Fraction of runoff producing rainfall events = 0.9

Tv = Post development treatment volume

C = Pollutant concentration (mg/l)

P = Depth of rainfall for "water quality" event (equals 1 inch in Virginia)

2.72 = Unit conversion factor

Figure 6: Treatment Volume Equation

$$\text{Treatment Volume (Tv)} = \frac{P \times (RvI \times \%I + RvT \times \%T + RvF \times \%F) \times SA}{12}$$

- P = Depth of rainfall for "water quality" event (equals 1 inch in Virginia)
- RvI = runoff coefficient for impervious cover[1]
- RvT = runoff coefficient for turf cover or disturbed soils[1]
- RvF = runoff coefficient for forest cover[1]
- % I = percent of site in impervious cover (fraction)
- %T = percent of site in turf cover (fraction)
- %F = percent of site in forest cover (fraction)
- SA = total site area (acres)

[1] Rv values from Figure 4

Table 1: Land Use Runoff Coefficients

	A soils	B Soils	C Soils	D Soils
Forest/Open Space (RvF)	0.02	0.03	0.04	0.05
Managed Turf (RvT)	0.15	0.20	0.22	0.25
Impervious Cover (RvI)	0.95	0.95	0.95	0.95

Table 2: Land Cover Definitions for the Runoff Reduction Method[1]

Land Cover	Description
Impervious Cover	Paved surfaces including roadways, driveways, rooftops, parking lots, decks, and sidewalks. Other surfaces used for vehicular access or storage that are compacted with little vegetative cover including gravel or dirt roads, driveways, or parking lots may also be considered impervious. Also includes the surface area of wet ponds and BMPs that replace an otherwise impervious surface (green roof, pervious parking). These BMPs are still assigned Runoff Reduction and/or Pollutant Removal rates within the spreadsheet, so their "values" for stormwater management are still credited.
Managed Turf	Grassed soil that was disturbed and compacted during development, so that it no longer functions in its natural hydrological state. Includes areas that will be mowed and maintained following development including: residential yards, septic fields, utility and roadway rights-of-way, and grassy areas of commercial, industrial, and institutional properties.
Forest and Open Space	Land that will remain undisturbed during development or will be restored to a hydrologically functional state following development including: • Wetlands • Surface area of stormwater BMPs that have vegetative cover, and that do not replace an otherwise impervious surface (bioretention, dry swale, grass channel, stormwater wetland, and infiltration). • Portions of residential lots that will **not** be cleared or graded. • Roadway rights-of-way that will be used as filter strips, grass channels, or stormwater treatment areas post construction if soil is restored or engineered soil mix is utilized according to the design specifications. • Community open space or utility rights of way that will be left in a natural vegetated state. Areas cannot be mowed routinely, but they can be bush hogged up to four times per year.

[1] Virginia Runoff Reduction Method Compliance Spreadsheet User's Guide & Documentation (April, 2012 Version 2.5)

ENVIRONMENTAL SITE DESIGN

Environmental site design (ESD) focuses on using natural systems and processes to achieve stormwater management objectives. This type of site planning prior to layout of a development is the most effective approach for meeting the stormwater regulations and reducing adverse water quality impacts. This approach can also be used to enhance the beneficial functions of natural resources on site. A site design that preserves existing wetlands, promotes the critical functions of floodplains, integrates the riparian buffer, and leaves permeable soils undisturbed is a cost effective strategy that can help satisfy stormwater requirements. The prevalence of wetlands, high groundwater table, and low permeable soils makes environmental site design cost effective and ecologically important in the coastal plain.

Many of these non-structural practices can also reduce the cost of stormwater infrastructure relative to conventionally designed developments. The Hampton Roads Planning District Commission developed a 'Low Impact Development Checklist for Hampton Roads' that includes the twelve steps of environmental site design exhibited in Table 3. Following this checklist will assist the developer in minimizing the pollutant load that must be treated by structural BMPs. This section highlights several of these practices and illustrates how the runoff reduction method credits their implementation.

Table 3: 12 Steps of Environmental Site Design

	Practices	**Yes**	**No**	**N/A**
1	Conduct environmental mapping of site prior to layout.			
2	Conserve natural areas (forest, wetlands, steep slopes, and floodplains).			
3	Preserve stream, wetland, and shoreline buffers.			
4	Minimize disturbance of permeable soils.			
5	Maintain natural flow paths across site.			
6	Layout buildings to reduce clearing and grading of site.			
7	Grade site to promote sheet flow from impervious areas to pervious areas.			
8	Reduce impervious area.			
	Use minimum required width for roadways.			
	Utilize pervious pavements for parking and pedestrian areas.			
9	Maximize disconnection of impervious cover.			
10	Identify potential hotspot generating areas for stormwater treatment.			
11	Integrate erosion and sediment control practices and post construction stormwater management practices into a comprehensive site plan.			
12	Use tree planting to convert turf areas into forest.			

CONSERVE NATURAL AREAS (FOREST, WETLANDS, STEEP SLOPES, AND FLOODPLAINS)

When planning a site for development, it is important to minimize disturbance of areas containing dense vegetation or well-established trees and to avoid sensitive areas, such as wetlands, streams, and floodplains. Soils with undisturbed vegetation have a much higher capacity to store and infiltrate runoff than disturbed soils. Vegetative cover can also provide additional volume storage of rainfall by retaining water on the surfaces of leaves, branches, and trunks of trees during and after storm events. These functions are represented in the treatment volume equation in Figure 6 by the lower runoff coefficients for forest and open space (Table 1). Reestablishment of a mature vegetative community can take decades. By preserving natural areas on site, developers can reduce the runoff and pollutants leaving the site thereby reducing the cost of installing structural stormwater controls.

MINIMIZE DISTURBANCE OF PERMEABLE SOILS

As discussed in the previous section, soil type plays a key role in determining the quality and quantity of runoff generated by a particular site. Healthy soils effectively cycle nutrients; store carbon as organic matter; minimize runoff and maximize water holding capacity; absorb excess nutrients, sediments and pollutants; and provide a healthy rooting environment and habitat to a wide range of organisms. Preserving soil horizons also saves money by reducing the need for soil restoration and surface drainage improvements.

Infiltration of stormwater into the soil reduces both the volume and peak discharge of runoff and provides for water quality treatment and groundwater recharge. Permeable soils (hydrologic soil group A and B) maximize infiltration of runoff into the subsoil. This process is reflected in the treatment volume equation Figure 6 by the use of lower runoff coefficients for permeable soils. The rarity of permeable soils in the coastal plain makes their preservation on site even more important. Undisturbed soils can also be utilized as a stormwater control practice when sheet flow from impervious surface is directed to the preserved areas.

In order to preserve permeable soils, a soil survey of the site should be conducted. General soil types should be delineated on concept site plans to guide site layout and the placement of buildings and impervious surfaces. Areas of the site with permeable soils should be preserved for use as stormwater runoff infiltration zones. Buildings and impervious surfaces should be located in areas with less permeable soils.

REDUCE IMPERVIOUS AREA

One of the principal causes of hydrologic and water quality impacts due to development is the creation of impervious surfaces that do not allow rainfall to infiltrate into the soil. Increased impervious cover results in increased stormwater runoff and increased pollutant loadings. This impact is evidenced in the treatment volume equation (Figure 6). The runoff coefficient for impervious areas is twenty times greater than the runoff coefficient for forest even for the least permeable soils.

Reducing the area of total impervious surface on a site will directly reduce the volume of stormwater runoff and associated pollutants. It can also reduce the size and cost of necessary infrastructure for stormwater drainage, conveyance, and control and treatment. Impervious cover can be minimized through identification of the smallest possible land area that requires roofing and pavement as opposed to landscaping. Practices that reduce impervious cover include:

- Reduce Roadway Lengths and Widths
- Reduce Building Footprints
- Reduce the Parking Footprint
- Reduce Setbacks and Frontages
- Use Fewer or Alternative Cul-de-Sacs
- Create Parking Lot Stormwater Islands

REDUCE CLEARING AND GRADING OF SITE

Clearing and grading of a site should be limited to the minimum amount needed for the development, road access, and the necessary infrastructure. Mass grading should be avoided because removal of forest or other vegetation will increase runoff volumes and erosion during and following construction. Minimal disturbance methods that limit the amount of clearing and grading and focus on the preservation of vegetation, permeable soils, and natural drainage patterns reduce the hydrologic impacts of development.

Soil compaction caused by the movement of construction equipment can reduce soil infiltration rates by 70-99 percent (DEQ 2013). Soil compaction also severely limits the establishment of healthy root systems of plants that may be used to revegetate the area following construction. The use of clearly defined protection areas will help to preserve the existing capacity of the site to store, treat and infiltrate stormwater runoff. The preservation of these soils will also reduce on site flooding following construction.

The runoff reduction method credits reductions in clearing and grading through the calculation of the stormwater treatment volume. The runoff coefficient for disturbed areas (managed turf) is 5 times greater than the runoff coefficient for undisturbed areas (forest/open space). The example below illustrates this benefit. By limiting grading, sites can also reduce costs for construction machinery and transport of imported soils.

GRADE SITE TO PROMOTE SHEET FLOW FROM IMPERVIOUS AREAS TO PERVIOUS AREAS

With proper design, undisturbed natural areas, such as forested conservation areas and riparian buffers can be used to receive runoff from upslope areas of the development site. If natural areas are delineated in the initial stages of site planning and left undisturbed during development, then sheet flow can be directed towards the areas to infiltrate runoff, reduce runoff velocity, and remove pollutants. For example, sidewalks, driveways, and rooftops can be designed to drain evenly onto adjacent undisturbed vegetated areas.

Virginia’s stormwater regulations credit this practice through the implementation of two stormwater control practices: rooftop disconnection and sheetflow to filter strip or open space. These are low cost runoff reduction method BMPs that work well in the coastal plain, but require the presence of undisturbed areas. **If the entire development project is cleared and graded, then higher cost BMPs will need to be implemented to treat the runoff from the impervious areas.**

Operational & Management Conditions for Land Cover in Forest & Open Space Category

- Areas must be shown outside the limits of disturbance (LOD) on approved E&S plans **and** demarcated in the field prior to construction beginning.
- Roadway rights-of-way are assumed to be disturbed during construction, and must follow the most recent design specifications for soil restoration or site reforestation.
- If the area will be used as a filter strip, grass channel, bioretention, then the BMP specifications for soil media must be followed.
- All areas considered forest/open space for stormwater purposes must have documentation that prescribes that the area will remain in a natural, vegetated state.
- Appropriate documentation includes:
    - subdivision covenants and restrictions,
    - deeded operation and maintenance agreements and plans,
    - parcel of common ownership with maintenance plan
    - third-party protective easement, within public right-of-way or
    - easement with maintenance plan

• Activities permitted within the area include forest management, control of invasive species, replanting and revegetating, passive recreation, limited bush hogging to maintain desired vegetative community.

ENVIRONMENTAL SITE DESIGN EXAMPLES

Table 4 demonstrates the benefit of applying environmental site design practices on a 10 acre forested site with a mix of C and D soils. A developer of this site could reduce his stormwater management costs by 68% if he reduced impervious areas, minimized disturbance of permeable soils, and conserved natural areas. Costs could be reduced further if sheet flow to open space was utilized. Each design example is illustrated in Figures 7-12. The hatched areas represent C soils and the circles represent trees. The number of developable lots was kept constant, but the footprint of the structural BMP was not accounted for.

Load reduction requirements were calculated using the runoff reduction method compliance spreadsheet based on the proportion of site remaining in forest, turf, and impervious cover following development. The runoff reduction compliance spreadsheet was utilized to calculate the area of impervious cover and turf that would have to be treated by the selected BMP in order to comply with the stormwater regulations.

Treatment was applied first to all impervious areas, then turf areas as necessary. Level 2 designs were used if compliance could not be met by treating all areas with the level 1 practice design. Costs were calculated by multiplying the BMP construction from King and Hagan 2011 by the number of acres treated by the selected BMP. Level 2 designs were assumed to be 50% more expensive than the level 1 design. Treating four acres of turf was assumed to be the equivalent of treating one acre of impervious area.

Table 4: Benefits of Environmental Site Design Practices

Environmental Site Design Practice	Soil Type	Forest Acres	Turf Acres	Impervious Cover Acres	Remaining Phosphorus Load Reduction Requirement	Cost to treat remaining Phosphorus Load with Bioretention	Cost to treat remaining Phosphorus Load with Constructed Wetland
Predevelopment Condition	C soils	5			NA	NA	NA
	D soils	5					
Traditional Development	C soils		3.5	1.5	6.15 lbs	$237,900	$148,800
	D soils		3.5	1.5			
Conserve Natural areas	C soils	2.5	1	1.5	4 lbs	$167,100	$96,400
	D soils	2.5	1	1.5			
Minimize Disturbance of permeable soils	C soils		5		6.05 lbs	$232,700	$147,300
	D soils		2	3			
Reduce impervious area	C soils		4	1	4.52 lbs	$189,500	$109,684
	D soils		4	1			
All of the above	C soils	5			1.94 lbs	$82,300	$47,000
	D soils	1	2	2			
All of the above plus grade site to promote sheet flow to open space*	C soils	5			1.94 lbs	NA	NA
	D soils	1	2	2			

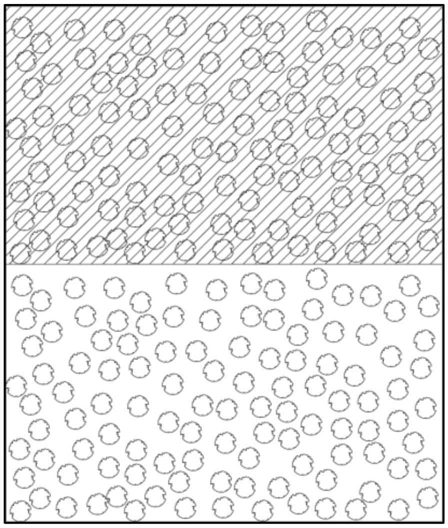


Figure 7: Predevelopment Condition*

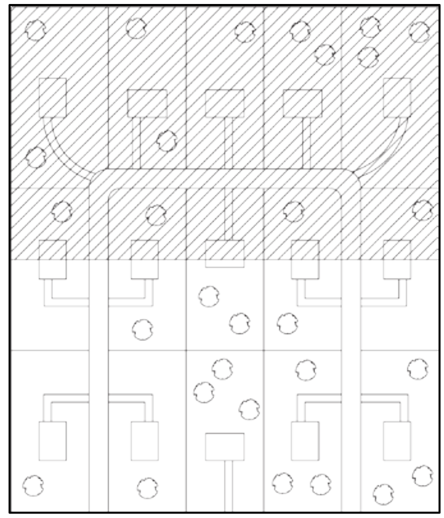


Figure 8: Conventional Development

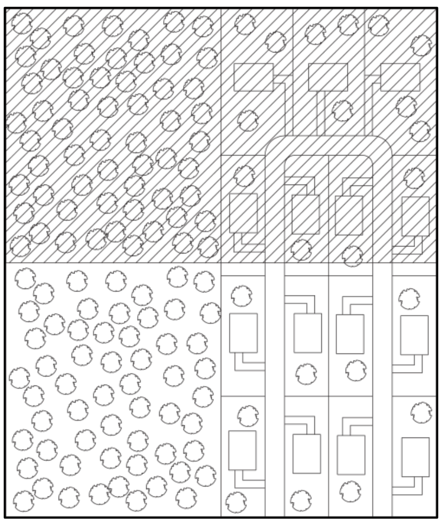


Figure 9: Conserve Natural Areas

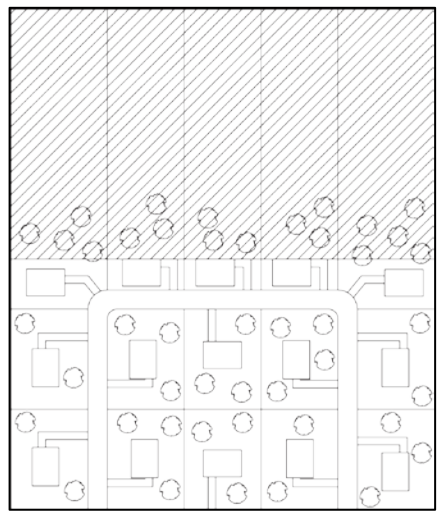


Figure 10: Minimize Disturbance of Permeable Soils

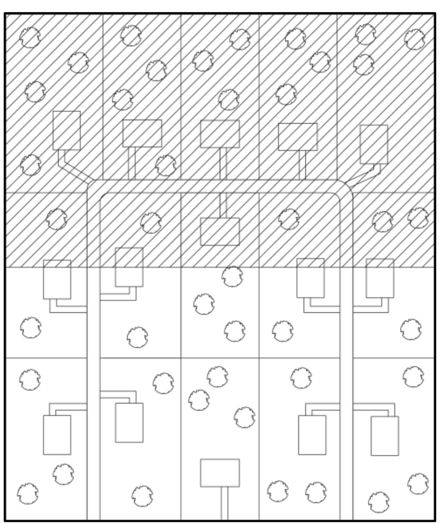


Figure 11: Reduce Impervious Areas

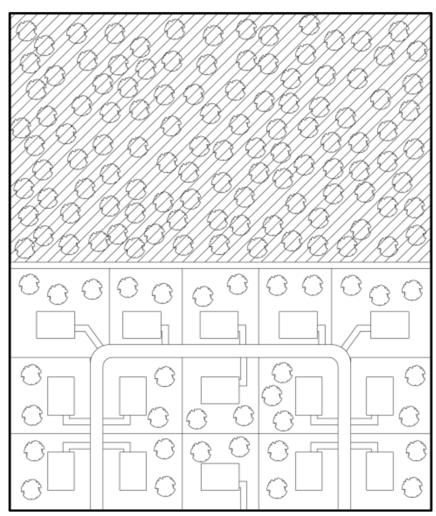


Figure 12: All of the Site Design Practices

*The hatched areas represent C soils and the circles represent trees.

STRUCTURAL BMPS IN THE COASTAL PLAIN

The structural BMPs that can be installed to close the gap to meet the regulations are grouped into two categories: runoff reduction practices and pollutant removal practices. Runoff reduction practices reduce the volume of runoff they receive as well as removing pollutants from the runoff. Pollutant control practices retain runoff and remove nutrients and sediment, but do not reduce the volume of runoff leaving the site.

Appendix 6-C of the Virginia Stormwater Management Handbook discusses special considerations for stormwater management in coastal settings and classifies structural BMPs as preferred, accepted, or restricted for use in the coastal plain as illustrated in Table 5. This document addresses the BMPs in each of these categories and explains their strengths and weaknesses in the coastal plain and identifies the modifications necessary to accommodate physiographic conditions. The recommendations in this document are consistent with Virginia’s Stormwater Handbook and BMP specifications. Localities may choose to deviate from these recommendations due to local conditions or long term maintenance concerns. Developers should check each locality’s public facilities manual for specific guidance.

Preferred practices are widely feasible at development sites in the coastal plain (with some design adaptations) and have a high rate of runoff volume reduction and/or the capability to remove pollutants of concern in the coastal plain (nitrogen and bacteria). Accepted stormwater control measures may work at many coastal plain sites, but they either require major design adaptations or have a low-to-moderate capability to reduce the coastal pollutants of concern. Restricted practices have limited feasibility in the coastal plain and/or poor removal capability for the pollutants of concern and are not recommended as the primary stormwater control at coastal plain development sites.

Table 5: BMP Suitability in the Coastal Plain

Practice	Preferred	Accepted	Restricted	Phosphorus Removal Efficiency (%)
Rooftop Disconnection	X			25
Sheet flow to open space	X			50-75
Rainwater Harvesting	X			Up to 90
Permeable Pavement	X			59-81
Bioretention	X			55-90
Dry Swales	X			52-76
Wet Swales	X			20-40
Constructed Wetlands	X			50-75
Small Scale Infiltration	X			63-93
Soil Amendments		X		
Vegetated Roofs		X		45-60
Filtering Practices		X		60-65
Wet Ponds		X		45-65
Grass Channels			X	23
Extended Detention Ponds			X	31
Large Scale Infiltration			X	63-93

RUNOFF REDUCTION BMPS

Runoff Reduction is the total annual runoff volume reduced through canopy interception, soil infiltration, evaporation, transpiration, rainfall harvesting, engineered infiltration, or extended filtration. BMPs that achieve at least a 25 percent reduction of the annual runoff volume are classified as Runoff Reduction BMPs.

Table 6: Suitability of Runoff Reduction Practices in the Coastal Plain

Practice	Coastal Plain Suitability	Level 1 Efficiency (%)		Level 2 Efficiency (%)		Relative Bacteria Removal Efficiency	Level 2 Available in Hampton Roads
		P	N	P	N		
Rooftop Disconnection	Preferred	25	25	50	50	None	A&B soils/CA[1]
Sheet flow to open space	Preferred	50	50	75	75	Low	A&B soils
Rainwater Harvesting	Preferred	40	40	40	40	None	NA
Bioretention[2]	Preferred	55	64	90	92	Medium	Limited
Permeable Pavement[2]	Preferred	59	59	81	81	No Data	Limited
Dry Swales[2]	Preferred	52	55	76	74	Low	Limited
Small Scale Infiltration[2]	Accepted	63	57	93	92	Medium	Limited
Soil Amendments	Accepted	50	50	NA	NA	None	NA
Vegetated Roofs	Accepted	45	45	60	60	None	Yes
Grass Channels[2]	Restricted	24	28	40	44	Negative	A&B soils/CA[1]
Large Scale Infiltration	Restricted	63	57	93	92	Medium	Limited

[1]Compost amended soils
[2] These practices provide both runoff reduction and pollutant removal resulting in greater total efficiency.

PREFERRED RUNOFF REDUCTION PRACTICES

Practices are preferred if they are widely feasible at development sites in the coastal plain (with some design adaptations) and have a high rate of runoff volume reduction and/or the capability to remove pollutants of concern (nitrogen and bacteria).

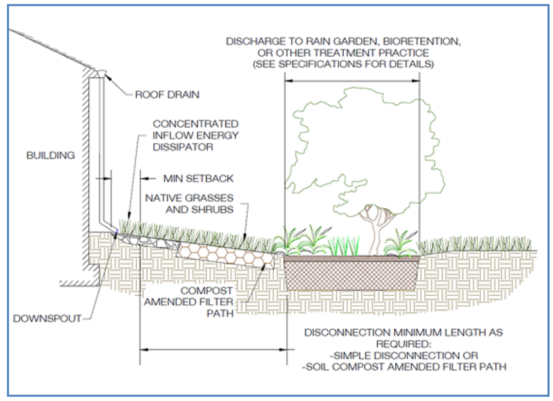


Figure 13: Rooftop Disconnection*

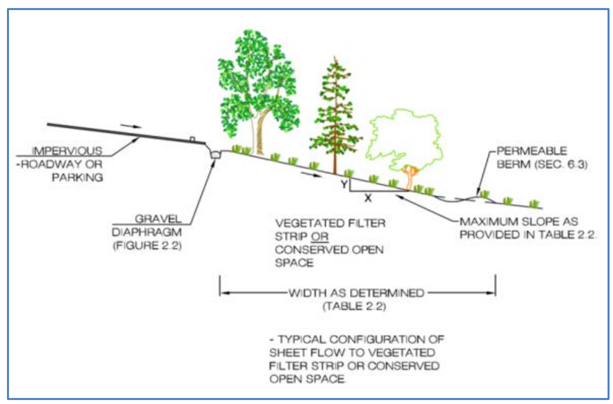


Figure 14: Sheetflow to Openspace*

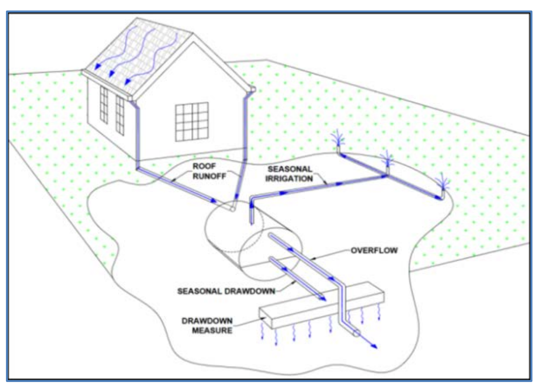


Figure 15: Rainwater Harvesting*

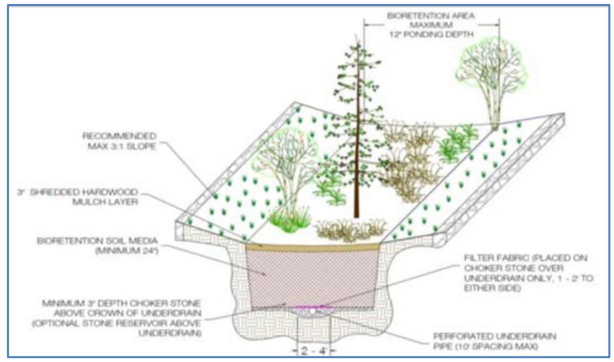


Figure 16: Bioretention*

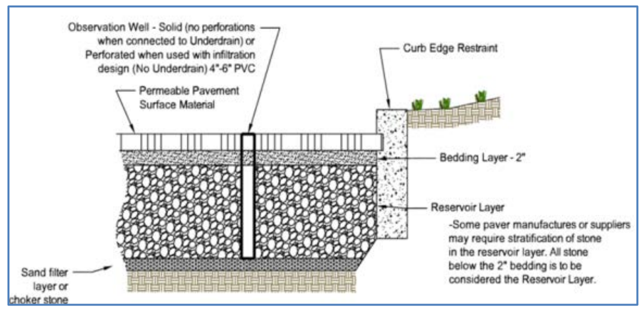


Figure 17: Permeable Pavement*

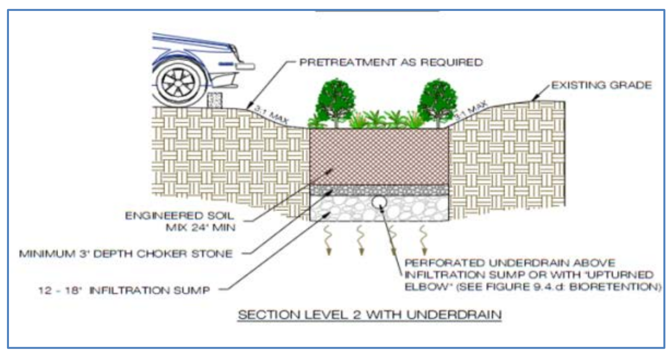


Figure 18: Dry Swale*

***Photos and drawings from Virginia Stormwater BMP Specifications.**

SIMPLE ROOFTOP DISCONNECTION (VA STORMWATER DESIGN SPECIFICATION #1)

Rooftop disconnection involves managing runoff from impervious areas by intercepting, infiltrating, filtering, treating, or reusing it as it moves towards the drainage point.

With proper design and maintenance, simple rooftop disconnection can provide relatively high runoff reduction. Additional nutrient reduction is not provided unless runoff is directed to an alternate practice that provides concentration based pollutant removal. The runoff reduction achieved by rooftop disconnections can also help achieve the channel protection and flood control volume requirements. Designers can use the Virginia Runoff Reduction Method (VRRM) compliance spreadsheet to calculate a curve number adjustment for each design storm for the contributing drainage area, based on the degree of runoff reduction achieved.

Rooftop disconnection is recommended for all residential lots with areas of less than 6,000 square feet that meet the design criteria for groundwater separation

Design Limitations	Coastal Plain Modifications
Minimum slope of corridor in first 10 feet = 1%*	Add compost amended soils to achieve level 2 removal efficiencies.
Vertical separation from water table = 2 feet	

*Building code requirements may be more stringent.

Runoff can simply be directed to pervious areas (simple disconnection) or it can be directed to an adjacent alternate runoff reduction practice in order to enhance runoff reduction rates or pollutant removal. Alternate practices and their associated design specifications include:

- Soil compost-amended filter path (VA Design Specification #4)
- Micro-infiltration practice (VA Design Specification #8)
- Rain gardens or micro-bioretention (VA Design Specification #9)
- Rainwater harvesting (VA Design Specification #6)
- Urban bioretention facility (VA Design Specification #9, Appendix A)
- Sheet Flow to a Vegetated Filter Strip or Conserved Open Space for larger scale/commercial projects (VA Design Specification #2).

SHEETFLOW TO VEGETATED FILTER STRIP OR CONSERVED OPEN SPACE (VA STORMWATER DESIGN SPECIFICATION #2)

Runoff can be directed from impervious and managed turf areas to adjacent vegetated areas in order to reduce runoff velocities and sediment and nutrient concentrations. Conserved Open Space and designed vegetated filter strips treat runoff through settling and filtering. For both practices, stormwater must enter as sheet flow. Flow tends to concentrate after 75 feet of flow length from impervious surfaces, and 150 feet from pervious surfaces. If the inflow is concentrated, then an engineered level spreader must be designed in accordance with the design criteria to convert the runoff to sheet flow. When sheet flow is not feasible, a vegetated swale should be used instead of a vegetated filter strip.

Conserved open space can be utilitized for stormwater treatment when developed areas are hydrologically connected to a protected stream or wetland buffer, floodplain, forest conservation area, or other protected lands. Runoff must be received as sheet flow, and any energy dissipaters or flow spreading devices should be located outside of the protected area. The following criteria must also be met in order to apply this practice:

- No major disturbance can occur within the conserved open space during or after construction.
- Limits of clearing and grading must be clearly delineated on all construction drawings and protected by signage and erosion control measures.
- Conserved area cannot contain any jurisdictional wetlands that are sensitive to increased inputs of stormwater runoff.
- A long term vegetation management plan must be prepared to maintain the conserved open space in a natural condition.
- Conserved area must be protected by a perpetual easement

If undisturbed open space is not available on site, then vegetated filter strips can be utilized. Filter strips are best suited to treat runoff from small segments of impervious cover (usually less than 5,000 sq. ft.) adjacent to road shoulders, small parking lots and rooftops. Vegetated filter strips may also be used as pretreatment for another stormwater practice such as a dry swale, bioretention, or infiltration areas. Filter strips are subject to the following constraints:

- Soil compaction or disturbance should be minimized. If this is unavoidable, the area can be restored by tilling or otherwise re-establishing the soil permeability.
- The proposed vegetated filter strip shall be shown on the erosion and sediment control plan.
- A vegetation management plan should be developed to maintain the vegetation density of the filter strip.
- The vegetated filter strip should be identified and protected in a perpetual easement, deed restriction, or other accepted mechanism that assigns the responsible party to ensure that no future development, disturbance or clearing may occur within the area, except as stipulated in the vegetation maintenance plan.

Design Limitations	Coastal Plain Modifications
Vertical separation from water table = 1.5 feet	Add compost amended soils to achieve higher removal efficiencies.

RAINWATER HARVESTING (VA STORMWATER DESIGN SPECIFICATION #6)

Rainwater harvesting systems intercept, store, and release rainfall for future use. Rooftop runoff is collected and conveyed into an above- or below-ground storage tank where it can be used for non-potable water uses including flushing of toilets and urinals, landscape irrigation, exterior washing, and fire suppression systems. The design and implementation of a rainwater harvesting system must be coordinated with the end user of the building or structure, and the designer must quantify and balance the water supply and demand for the project. Using the design specification and the accompanying Virginia Cistern Design (VCD) spreadsheet, the designer can ensure that the system meets the intended use and configuration of the proposed development.

The annual runoff volume reduction and pollutant removal performance credit of rainwater harvesting systems are a function of the cistern tank size, configuration, and water demand or use. The annual volume reduction credit is therefore user defined in the Virginia Runoff Reduction Method (VRRM) compliance spreadsheet. The designer can calculate the annual water demand based on a single or multiple uses that may be constant on a monthly basis, such as toilet/urinal flushing and laundry, or that vary seasonally, such as landscape irrigation, cooling towers, vehicle washing, etc. A use that is seasonal can be supplemented with a secondary runoff reduction drawdown in order to establish an annual demand.

The capture and use of rainwater can significantly reduce stormwater runoff volumes and associated pollutant loads. Cisterns can also have additional environmental and economic benefits because they provide reliable and renewable source of water.

Design Limitations	Coastal Plain Modifications
Above-ground rainwater harvesting systems perform best in the coastal plain since they are not constrained by the flat terrain and high water table.	Tanks can be combined with automated irrigation, front yard bioretention, or other secondary practices to maximize runoff volume reduction.

PERMEABLE PAVEMENT (VA STORMWATER DESIGN SPECIFICATION #7)

Permeable pavements are alternative surfaces that permit stormwater runoff to into an underlying stone reservoir, where it is temporarily stored or infiltrated. Available surfaces include pervious concrete, porous asphalt, permeable grid pavers, and interlocking concrete pavers. All permeable pavements consist of a permeable surface pavement layer, an underlying stone aggregate reservoir layer, and a filter layer or fabric on the bottom. Permeable pavement can be used at commercial, institutional, and residential sites in place of impervious surfaces. Permeable pavement reduces the effective impervious cover of a development site by providing a high degree of runoff volume reduction and nutrient removal.

Permeable pavement can be designed to treat stormwater that falls on the pavement surface area as well as runoff from small areas adjacent to impervious surfaces. Careful sediment control is needed for to avoid clogging of the down-gradient permeable pavement. The contributing drainage area should be limited to paved surfaces in order to avoid sediment wash-on. If pervious areas are conveyed to permeable pavement, then sediment source controls and pre-treatment must be provided. If designed properly, the pre-treatment practice may also qualify for a runoff reduction credit.

Properly designed and installed permeable pavement systems can work effectively in the coastal plain as long as underlying soils are moderately permeable. In low-infiltration soils, some or all of the filtered runoff can be collected in an underdrain and delivered to the storm drain system. If infiltration rates in the soils are greater than .5 inches per hour, then the permeable pavement system can be designed without an underdrain to increase the effectiveness of the practice. Underdrains should be utilized if this practice is applied at a stormwater hotspot facility or an area that provides groundwater recharge to a shallow aquifer used as a water supply.

Design Limitations	Coastal Plain Modifications
Vertical separation from bottom of system to water table = 2 feet	Avoid using permeable pavement if the site is near sandy soils to minimize clogging.
Maintain a minimum slope of 0.5% for underdrains to ensure proper drainage.	

BIORETENTION (VA STORMWATER DESIGN SPECIFICATION #9)

Bioretention removes pollutants through runoff reduction, filtration, biological uptake, and microbial activity. Bioretention facilities can become attractive landscaping features if properly installed in the coastal plain. Surface runoff is directed into a shallow landscaped depression that incorporates many of the pollutant removal mechanisms that operate in a forest ecosystem. The primary component of a bioretention practice is a filter bed, a mixture of sand, soil, and organic material, which is topped with a surface mulch layer. During storms, runoff temporarily ponds 6 to 12 inches above the mulch layer, and then rapidly filters through the bed. Bioretention can be applied in the coastal plain at three scales:

Rain Gardens are micro-bioretention practices designed to treat runoff from individual rooftops, driveways or other on-lot features in single-family detached residential development. Inflow is typically sheet flow, or can be concentrated flow with energy dissipation, when located at downspouts. The maximum contributing drainage area is half an acre with up to 25 percent impervious cover.

Bioretention Basins/Filters treat parking lots rooftops and are usually constructed in commercial or institutional areas. Inflow can be either sheetflow or concentrated flow. Bioretention basins can be constructed in residential areas, but they should be located in a common area or within drainage easements and treat a combination of roadway and lot runoff. Each bioretention basin can serve areas up to 2.5 acres with 50 percent impervious coverage.

Urban Bioretention includes structures such as expanded tree pits, curb extensions, and foundation planters located in dense urban areas such as city streetscapes. Facilities function similar to regular bioretention practices except they are adapted to fit into containers. Urban bioretention is not intended for large commercial areas, nor should it be used to treat small sub-areas of a large drainage area such as a parking lot. It is intended to be incorporated into small fragmented drainage areas such as shopping or pedestrian plazas within a larger urban development. Urban bioretention features hard edges, often with vertical concrete sides, rather than the gentle earthen slopes of regular bioretention. These practices may be open-bottomed, to allow some infiltration of runoff into the sub-grade, but they generally are served by an underdrain. The detailed design specifications for urban biorention are contained in Appendix A of VA Stormwater Design Specification #9.

Design Limitations	Coastal Plain Modifications
Maintain a minimum underdrain slope of .5%. and tie into a ditch or conveyance system.	Utilize linear approach of multiple storage cells to conserve hydraulic head.
Minimum depth of filter bed is 18 inches for Level 1 and 24 inches for Level 2.	Underdrains should be connected to the stormwater drainage system.
Obtain media from an approved vendor to ensure nutrient content of the soil and compost is within acceptable limits.	Depth to groundwater can be reduced to 1 foot if a large diameter (6 inches) underdrain is utilized.
Avoid using on-site soils in the coastal plain, unless soil tests show low nutrient concentrations.	Limit surface ponding to 6 to 9 inches.
Select plant species that reflect coastal plain plant communities and are wet-footed and salt-tolerant.	Designers can utilize a turf cover rather than mulch for shallower facilities, but they should follow the design specifications and pollutant removal values for dry swales.

In the coastal plain, most bioretention facilities will require an underdrain that collects the filtered runoff and returns it to the storm drain system. The underdrain consists of a perforated pipe in a gravel layer installed along the bottom of the filter bed. A bioretention facility with an underdrain system is commonly referred to as a bioretention filter. If a site contains soils with an infiltration rate greater than half an inch per hour and has a low groundwater table and a low risk of groundwater contamination, then a bioretention basin can be designed without an underdrain. If soil conditions require an underdrain, bioretention areas can still qualify for the Level 2 design if they contain a stone storage layer beneath the invert of the underdrain. Bioretention should not be applied on marginal sites. Other stormwater practices, such as dry or wet swales, ditch wetland restoration, and smaller linear wetlands, are preferred alternatives in the coastal plain.

DRY SWALES (VA STORMWATER DESIGN SPECIFICATION #9)

The dry swale is a soil filter system that temporarily stores and then filters runoff. Dry swales are essentially bioretention cells that are shallower, configured as linear channels, and covered with a material other than mulch and ornamental plants such as turf. Dry swales utilize a pre-mixed soil media filter below the channel that is the same as that used for bioretention. In most applications, the runoff treated by the soil media flows into an underdrain, which conveys treated runoff back to the conveyance system. Swales can be planted with turf grass, tall meadow grasses, decorative herbaceous cover, or trees. The primary pollutant removal mechanisms operating in swales are settling, filtering infiltration and plant uptake.

Design Limitations	Coastal Plain Modifications
Maintain a minimum underdrain slope of .5%.	Utilize multiple storage cells to conserve hydraulic head.
Minimum depth of filter bed is 18 inches for Level 1 and 24 inches for Level 2.	Depth to groundwater can be reduced to 1 foot if a large diameter (6 inches) underdrain is utilized.
	Native plants should be used if the surface is landscaped.

Dry Swales should not be applied to marginal sites where the groundwater table is less than 30 inches below the swale invert. Wet swales or linear wetlands work better on sites with a high groundwater table.

ACCEPTED RUNOFF REDUCTION PRACTICES

Accepted stormwater BMPs may work at many coastal plain sites, but they either require major design adaptations or have a low-to-moderate capability to reduce nitrogen and bacteria.

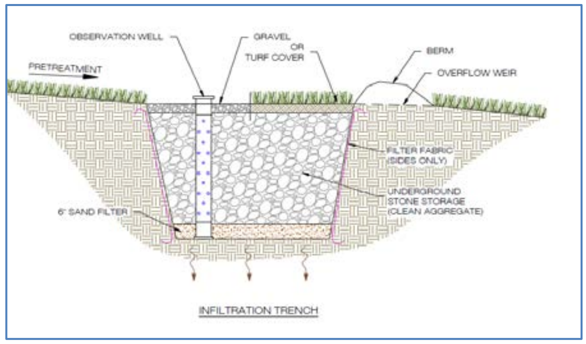


Figure 19: Small Scale Infiltration*

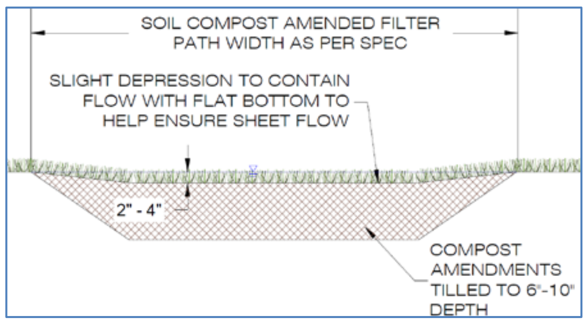


Figure 20: Soil Amendments*

(Photo Credit: Geosynthetics)

Figure 21: Vegetated Roofs

***Photos and drawings from Virginia's Stormater BMP Design Specifications.**

SOIL AMENDMENTS (VA STORMWATER DESIGN SPECIFICATION #4)

Compost amendments are cost effective practice to boost the runoff reduction capability of grass vegetated filter strips, grass channels and rooftop disconnections on C and D soils. In order to avoid saturation of the entire soil depth, designers should ensure a minimum separation of 2 feet from the water table.

VEGETATED ROOFS (VA STORMWATER DESIGN SPECIFICATION #5)

Vegetated roofs are an acceptable runoff reduction practice for the coastal plain, but they have a limited water quality treatment function. Designers should choose plant materials that can tolerate drought and salt spray.

SMALL SCALE INFILTRATION (VA STORMWATER DESIGN SPECIFICATION #8)

Micro and small-scale infiltration practices are suitable in the coastal plain particularly if a single practice is not used to infiltrate the entire treatment volume. Secondary practices should be utilized to achieve the remaining runoff reduction. If soils are extremely permeable and infilitration rates are more than 4 inches per hour, then shallow bioretention is preferred. If soils are impermeable with infiltration rates less than 0.5 inches/hour, then designers should use bioretention with underdrains as an alternative.

Design Limitations	Coastal Plain Modifications
Vertical separation from water table = 2 feet	Keep the depth of infiltration to less than 24 inches and maximize the surface area of the infiltration practice.

RESTRICTED RUNOFF REDUCTION PRACTICES

Restricted practices are not recommended as the primary stormwater control at coastal plain sites because they have limited feasibility in the coastal plain and/or poor removal capability for nitrogen and bacteria.

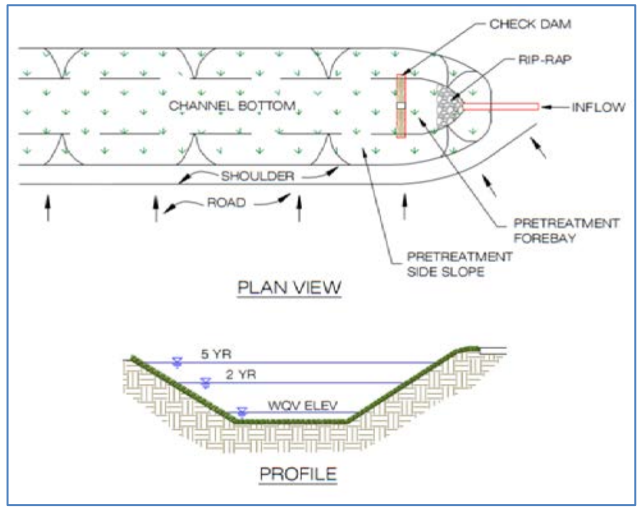


Figure 22: Grass Channels*

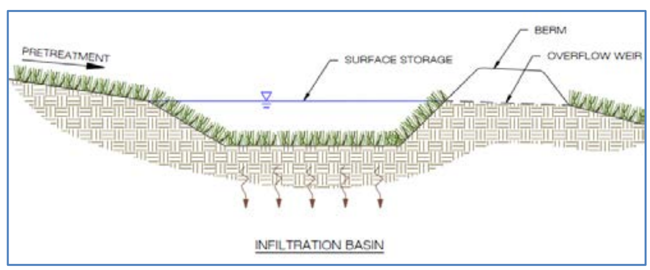


Figure 23: Large Scale Infiltration*

***Photos and Drawings from Virginia's Stormwater BMP Design Specifications.**

LARGE SCALE INFILTRATION (VA STORMWATER DESIGN SPECIFICATION #8)

Large scale Infiltration is defined as serving a contributing drainage area of 20,000 to 100,000 square feet of impervious cover. It has limited applicability in the coastal plain but can work at sites where soils have an infiltration rate between 0.5 to 4.0 inches per hour. If soils are extremely permeable (more than 4 inches per hour), a shallow bioretention or filtering practice should treat runoff before reaching the infiltration practice. Infiltration should not be used if the site is a designated stormwater hotspot.

GRASS CHANNELS (VA STORMWATER DESIGN SPECIFICATION #3)

Although grass channels can work well in the flat terrain and low hydraulic head conditions of many coastal plain sites, they have very poor nutrient and bacteria removal rates. Grass channels should not be used as a primary BMP on a coastal plain site. The grass channel may have off-line cells and should be connected to a ditch or other stormwater drainage system. A dry or wet swale is a preferred option to a grass Channel, unless the soils are highly permeable (A soils).

Design Limitations	Coastal Plain Modifications
A minimum slope of 0.5% must be maintained to ensure positive drainage.	The minimum depth to the seasonally high water table may be reduced to 18 inches.

POLLUTANT REMOVAL PRACTICES

Pollutant Removal is the change in event mean concentration (EMC) as runoff flows into and out of a BMP. Pollutant removal processes include settling, filtering, adsorption, and biological uptake. EMC is the average concentration of a pollutant in runoff calculated from monitored storm events.

Table 7: Suitability of Pollutant Removal Practices in the Coastal Plain

Practice	Coastal Plain Suitability	Level 1 Efficiency (%)		Level 2 Efficiency (%)		Relative Bacteria Removal Efficiency	Level 2 Available in Hampton Roads
		P	N	P	N		
Wet Swales	Preferred	20	25	40	35	None	Yes
Constructed Wetlands	Preferred	50	25	75	55	High	Yes
Filtering Practices	Accepted	60	30	65	45	Low	Limited
Wet Ponds	Accepted	45	30	65	40	High	Yes
Extended Detention Ponds	Restricted	15	10	31	24	Medium	Limited

PREFERRED POLLUTANT REMOVAL PRACTICES

Practices are preferred if they are widely feasible at development sites in the coastal plain (with some design adaptations) and have a high rate of runoff volume reduction and/or the capability to remove pollutants of concern (nitrogen and bacteria).

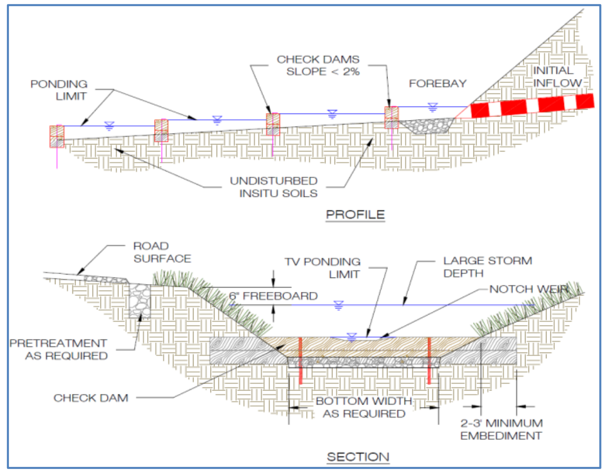


Figure 24: Wet Swales*

(Photo Credit: US EPA)

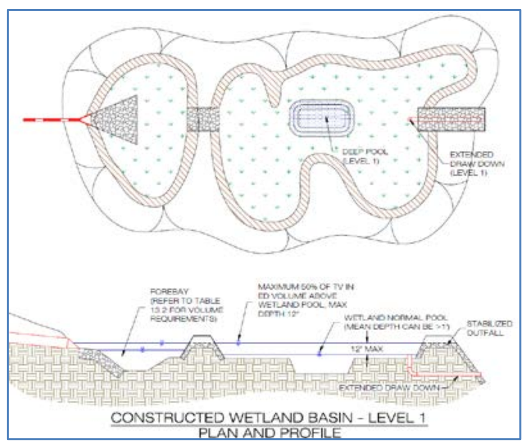


Figure 25: Constructed Wetlands*

*** Photos and Drawings from Virginia's Stormwater BMP Design Specifications.**

WET SWALES (VIRGINIA STORMWATER DESIGN SPECIFICATION #11)

A wet swale is essentially a linear wetland consisting of a series of on-line or off-line storage cells. Wet swales are well suited for implementation in the coastal plain because their design relies on flat terrain and a high water table. If there is a significant drop in elevation from the channel to the outfall, then the regenerative conveyance system also described within design specification #11 can be utilized.

Wet swales are not recommended in residential areas due to concerns about mosquito breeding. Several design characteristics should be considered to maximize function:

- Design cells so underlying soils are saturated but do not contain standing water between storm events.
- Plant with native wet-footed species, such as sedges or wet meadows.
- Incorporate sand or compost into the surface soils to promote a better growing environment.

Wet swales are so well suited to coastal plain conditions that they are one of the few practices where additional pollutant removal can be maximized by implementing level 2 design criteria. The table below outlines the design features and nutrient removal rates of the two design levels.

Level 1 Design (TP:20 TN:25)	**Level 2 Design (TP:40 TN:35)**
Swale slopes less than 2%	Swale slopes less than 1%
On-line design	Off-line swale cells
Minimal planting; volunteer vegetation	Wetland planting within swale cells
Turf cover in buffer	Trees, shrubs, or ground cover within swale cells and buffer

CONSTRUCTED WETLANDS (VIRGINIA STORMWATER DESIGN SPECIFICATION #13)

Constructed or stormwater wetlands are shallow basins (6-18 inches deep) that provide water quality treatment with a dense and diverse wetland cover. Runoff from each new storm displaces runoff from previous storms, and the long residence time allows multiple pollutant removal processes to operate. The wetland environment provides an ideal environment for gravitational settling, biological uptake, and microbial activity. Constructed wetlands can also help to meet channel protection requirements by utilizing detention storage above the permanent pool to reduce peak flows from the 1-year design storm using the energy balance method described in the Virginia Stormwater Management Program, but this limits the phosphorus removal efficiency to level 1 removal rates.

Constructed Wetlands are an ideal stormwater control measure for the flat terrain, low hydraulic head, and high water table conditions common at coastal plain development sites. They are also effective at reducing bacteria concentrations. Shallow, linear and multiple-cell wetland configurations are preferred. Deeper basin configurations, such as the pond/wetland system and the extended detention wetland have limited application in the coastal plain.

Enhanced design elements (level 2) can be implemented in the coastal plain to maximize nutrient reduction. These design features are described fully in Virginia Stormwater Design Specification #13. In general, additional nutrient reductions can be achieved if the design includes multiple cells, diverse topography, a shallow wetland depth, a larger surface area to drainage area ratio, and a longer flow path.

Design Limitations	Coastal Plain Modifications
Plant with native vegetation that can tolerate periodic inundation.	Incorporate sand or compost into the surface soils to promote a better growing environment.
The volume below the seasonally high water table is acceptable for the Treatment Volume, as long as the other design requirements are met.	The use of flashboard risers is recommended to control or adjust water elevations in wetlands constructed on flat terrain.
	It is acceptable to excavate up to 6 inches below the seasonally high water table to for wetland planting zones, and up to 3 feet below the water table for micropools, forebays and other deep pool features.

ACCEPTED POLLUTANT REMOVAL PRACTICES

Accepted stormwater BMPs may work at many coastal plain sites, but they either require major design adaptations or have a low-to-moderate capability to reduce nitrogen and bacteria.

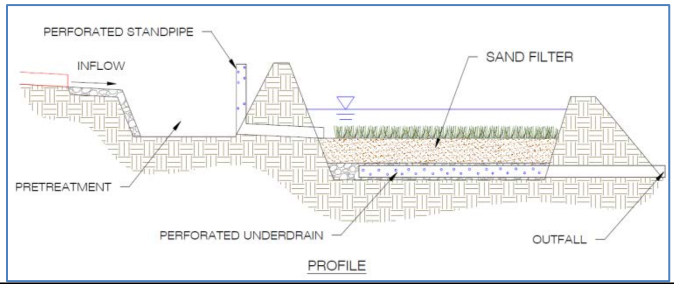


Figure 26: Filtering Practices*

(Photo credit: Longwood University)

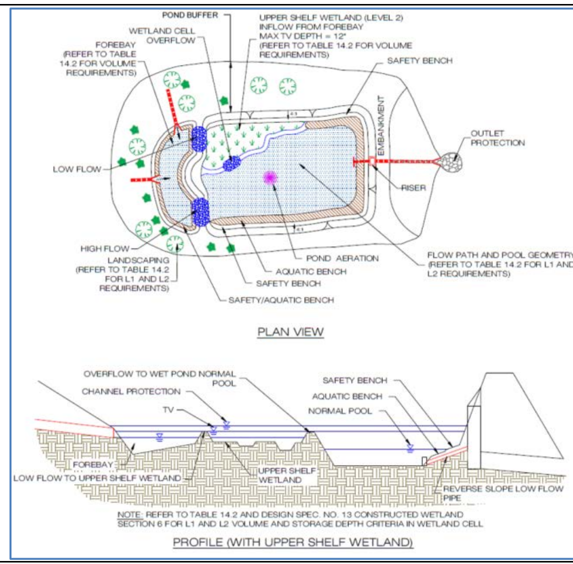


Figure 27: Wet Ponds*

*** Photos and Drawings from Virginia's Stormwater BMP Design Specifications.**

FILTERING PRACTICES (VIRGINIA STORMWATER DESIGN SPECIFICATION NO. 12)

Stormwater filters capture, temporarily store, and treat stormwater runoff by passing it through an engineered filter media, collecting the filtered water in an underdrain, and then returning it back to the storm drainage system. Stormwater filters are useful for treating runoff from small, highly impervious sites. The filter consists of a settling chamber and a second filter bed chamber composed of sand or other filter media. Stormwater filters are a versatile option because they consume very little surface land and have few site restrictions. In the coastal plain, the perimeter sand filter and the non-structural sand filter have the least hydraulic head requirements and can work effectively at many small sites.

Design Limitations	Coastal Plain Modifications
A minimum slope of 0.5% for the underdrain must be maintained to ensure positive drainage, and the drain must be connected to a ditch or stormwater drainage system.	The minimum depth to the seasonally high water table may be reduced to 12 inches if the filter is equipped with a large diameter (6 inches) underdrain.
The combined depth of the underdrain and sand filter bed may be reduced to 18 inches.	Designers may wish to maximize the length of the stormwater filter or provide treatment in multiple connected cells.
	The depth to the seasonally high groundwater can be further reduced if the filter is self-contained to prevent untreated stormwater from entering the groundwater. A geotechnical or structural engineer must verify sufficient support and anchoring to counteract any uplift from hydrostatic pressure.

WET PONDS (VA STORMWATER DESIGN SPECIFICATION #14)

Wet ponds are an acceptable stormwater practice for use in the coastal plain, but constructed wetlands are a preferred especially where the water table is less than four feet below the land surface. A wet pond provides no volume reduction credit and should be the final element in the pollutant removal sequence on a site. Generally, a wet pond should only be installed if there is remaining pollutant removal or channel protection volume to manage after all other upland runoff reduction options have been considered. Wet ponds do help to meet channel protection requirements by utilizing detention storage above the permanent pool and extended detention storage volumes to reduce peak flows.

Wet ponds consist of a permanent pool of water that provides an environment for settling, biological uptake, and microbial activity that removes sediment and associated nutrients. When sized properly, wet ponds have a residence time that ranges from many days to several weeks which allows numerous pollutant removal mechanisms to operate. Wet ponds can be designed to improve performance and meet the Level 2 performance goal by constructing multiple cells or including extended detention of a portion of the treatment volume above the permanent pool.

The flat terrain, low hydraulic head, and high water table of many sites constrains the application of wet ponds in the coastal plain. Excavating ponds below the water table displaces the treatment volume with groundwater and creates dugout ponds with reduced mixing and treatment efficiency that creates nuisance conditions.

Design Limitations	Coastal Plain Modifications
Small (pocket) ponds must meet the minimum design geometry requirements for all ponds.	Reduced removal rates due to groundwater influence are reflected in the BMP summary table above.
Multiple cells, benches, and adequate flow paths are essential to achieving optimal nutrient removal rates.	Pond landscaping and aeration features can improve pollutant removal functions.
Wet ponds could produce and or export harmful algal blooms if they interact with brackish groundwater or surface waters.	

In instances where a wet pond is proposed as an aesthetic amenity, the design parameters presented in design specification #14 represent good engineering design necessary to maintain a healthy pond. The treatment volume requirements for water quality and detention requirements for channel protection may be more economically met through the upstream runoff reduction practices; however, the basic wet pond features related to aesthetics (pool volume and geometry) and safety (aquatic and safety benches, side slopes, maintenance, etc.) remain as important neighborhood or site design features.

RESTRICTED POLLUTANT REMOVAL PRACTICES

Restricted practices are not recommended as the primary stormwater control at coastal plain sites because they have limited feasibility in the coastal plain and/or poor removal capability for nitrogen and bacteria.

EXTENDED DETENTION PONDS (VIRGINIA STORMWATER DESIGN SPECIFICATION # 15)

The application of extended detention (ED) ponds in the coastal plain is constrained by the lack of sufficient hydraulic head and the high groundwater table common at many sites. Excavating ED ponds below the water table creates unacceptable conditions within the basin, so the water volume below the seasonally high water table is not included in the treatment volume. In general, shallow constructed wetlands are a preferred alternative to ED ponds in the coastal plain.

(Photo Credit: US EPA)

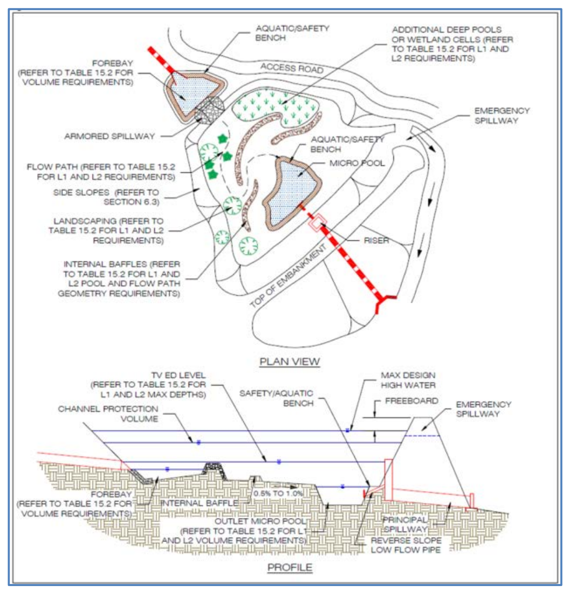


Figure 28: Extended Detention

*** Photos and Drawings from Virginia's Stormwater BMP Design Specifications.**

CONCLUSIONS

While the new stormwater regulations require developers to achieve greater nutrient removal from stormwater runoff, they also acknowledge the runoff reduction potential of select BMPs and allow for greater flexibility in BMP design than the current criteria. The new criteria can be difficult to meet in the coastal plain environment where low permeable soils and high groundwater tables are pervasive. However, with careful site planning, thoughtful BMP selection, and slight design modifications, many of the stormwater treatment practices included in Virginia's stormwater design specifications can perform well in the coastal plain.

Perhaps the most cost effective practice is the implementation of environmental site design principles. By reducing impervious area, preserving natural areas, and reducing clearing and grading, developers can reduce their pollutant removal requirement even before structural BMPs are implemented. The following section of this report addresses the potential barriers to implementing these practices and contains recommendations to local governments on codes and ordinance revisions to remove these barriers.

REFERENCES

Virginia Department of Environmental Quality (DEQ). Virginia Stormwater Management Handbook. http://www.deq.virginia.gov/Programs/Water/LawsRegulationsGuidance/Guidance/StormwaterManagementGuidance.aspx. October 2013.

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SECTION 2: ASSESSMENT OF LOCAL ORDINANCES AND RECOMMENDED CHANGES

The Chesapeake Bay Total Maximum Daily Load (TMDL) and new Virginia Stormwater Management Regulations pose challenges for both municipal governments and individual developers. As described in the Phase I report from March 2013, these two regulatory developments will require local governments to enact new ordinances and policies or change existing ones. Local governments are responsible for reducing nutrient and sediment loads from current levels, which will be accomplished through a combination of public and private retrofits and construction of best management practices (BMPs). A significant consequence of Virginia's statewide Watershed Implementation Plan (WIP) for the Chesapeake Bay TMDL is that new developments that do not exceed the state's stormwater management standards will not count toward local governments' load reduction mandates. However, redevelopment projects, which are required to reduce nutrient loads by a certain percentage based on the size of the project (20% if an acre or larger, 10% if less), will contribute toward those TMDL targets. Thus, local governments have an incentive under the Chesapeake Bay TMDL to encourage and foster redevelopment projects.

The TMDL and new regulations will also increase the requirements for managing stormwater runoff on both new development projects and redevelopment projects. The new stormwater regulations are more stringent than before, which means developers will have to do more mitigation to offset the impacts of their projects. As a result, developers now have an incentive to reduce or minimize the amount of excess or unnecessary impervious cover. However, many local codes and ordinances require developers to put in place impervious surfaces in the form of parking lots, driveways, setbacks, sidewalks, and streets. In addition, other local policies may preclude the use of some BMPs, making it more difficult for developers to meet load reduction requirements.

This section builds on the first year of work by utilizing one of the evaluation tools, the Center for Watershed Protection's (CWP) Code and Ordinance Worksheet. The CWP Code and Ordinance Worksheet is designed to compare a locality's codes and ordinances to standards that either directly or indirectly help promote water quality. This worksheet was identified as the more useful tool to assess a locality's ordinances and identify specific changes to regulations that would reduce impervious cover mandates. Through the use of this tool and a series of discussions with the staff from two pilot localities, the Cities of Norfolk and Suffolk, several potential policy and ordinance changes have been identified for further development and consideration by the localities. These recommendations are described later in this section.

A MULTIPLE BENEFITS APPROACH

In addition to the Chesapeake Bay TMDL and stormwater regulations, local governments are also facing many other regulatory, fiscal, and environmental challenges. Budgets are stretched thin, resulting in fewer resources available to develop and implement new programs. Aging infrastructure is requiring more and more maintenance to keep it operational. Coastal cities are dealing with flooding and the threat of sea level rise. A multiple benefits approach, which would seek to identify and enact policies that would simultaneously address two or more local government issues, would be preferable to an approach that solely targets water quality improvements. Such an approach would, given the context of the Chesapeake Bay TMDL and stormwater regulations, first identify potential solutions or policy changes to those issues and then consider them against the objectives of other local government issues or concerns. For example, a local government identifying areas to encourage and focus redevelopment (to gain credit for load reductions) may want to avoid areas prone to flooding or that could be vulnerable to sea level rise. Another example might be a local government reducing street width requirements in residential neighborhoods to reduce impervious area and to promote slower automobile traffic and thus pedestrian safety. There are many opportunities to align local government and citizen efforts from different departments and organizations. Based on discussions with the pilot localities' staffs, pursuing a multiple benefits approach would be both useful and highly preferable to an approach that did not account for other issues and challenges. As a result, the policy recommendations discussed later in this chapter will include discussion of how they can be tailored to meet multiple goals.

REVIEW OF LOCAL CODES

During the first year of this project, HRPDC staff identified two tools that could be used to assess local ordinances: the EPA Water Quality Scorecard and the CWP Code and Ordinance Worksheet. The CWP tool was judged to be and the most relevant tool for this exercise, since it focused exclusively on codes and ordinances. The Water Quality Scorecard also considered comprehensive plans and other similar documents. HRPDC staff used to the worksheet to review local documents from both cities, including zoning ordinances, city codes, and public facilities manuals for both Norfolk and Suffolk, as well as several state documents. The common state documents used in the review for both cities were the Virginia Stormwater Design Specifications and VDOT's Road Design Manual and Secondary Street Acceptance Requirements. Overall, the reviews identified some areas in which the cities seemed to be doing well and others where there was room for improvement. These findings were included in discussions between HRPDC and locality staff in considering which potential code changes to pursue.

The CWP Code and Ordinance Worksheet is designed to compare a locality's codes and ordinances to standards that either directly or indirectly help promote water quality. Key documents to review include several local ordinances (zoning, subdivision, floodplain management, stormwater management, etc.) and design manuals or specifications. The worksheet includes twenty-two sections, ranging in length from one question to five. The sections cover many topics related to water quality, including impervious cover (street and right-of-way dimensions, parking regulations, sidewalks, driveways), site planning regulations (open space design), stormwater management (allowed practices, specifications), and development regulations (buffer requirements, preservation of existing vegetation). There are a total of one hundred points available on the worksheet. Scoring a 90 or above indicates a very high level of dedication to protecting water resources and environmental quality, while scoring below a 60 indicates minimal water quality protection is being accomplished through existing ordinances or policies. Given that the focus of this project is specifically look at policies that reduce impervious cover requirements, remove impediments to the use of vegetated stormwater BMPs, or promote redevelopment, emphasis was placed on those questions that addressed those focus areas as opposed to the worksheet as a whole. Of the 66 questions and 100 total points on the worksheet, 43 questions and 66 points were most relevant to this project. The relevant questions covered issues such as street dimensions, cul-de-sacs, parking, open space design, setbacks, sidewalks, and driveways. These questions were relevant because they pertain directly to minimum impervious surface requirements or limit the ability of developers to address stormwater runoff. Non-relevant questions, for this study, covered stream buffer requirements, open space management, and tree conservation, which, while good for protecting water quality; these questions did not address impervious cover minimums or prevent developers from pursuing specific water quality protection strategies. The following sections compare the minimum for road widths, parking, setbacks, and other development requirements for Norfolk and Suffolk to the standards contained in the CWP Code and Ordinance Worksheet. The comparison focuses on these specific parts of the worksheet because these aspects directly affect the amount of impervious cover included in a development project.

NORFOLK

In the case of Norfolk, HRPDC staff reviewed the City's Code of Ordinances, including the zoning ordinance, and Norfolk's City Design Standards. The review identified opportunities to modify city requirements for street dimensions, parking, setbacks, and sidewalks. Norfolk scored 32.5 points out of the 100 available for the entire worksheet; of the 66 points available for study-relevant policies, Norfolk scored 15.5.

The CWP Worksheet awards three points for allowing a minimum pavement width of 18 to 22 feet in low traffic, low density residential areas. Currently Norfolk's Code of Ordinance's specifies a minimum street width of 50 feet for local residential streets, which would imply a minimum pavement width of 39'.[4] The most recent VDOT Secondary Street Acceptance Requirements[5] specify a minimum curb-to-curb distance of 29' for roads with parking on both sides (24' for roads with no parking or only on one side) with projected average traffic volume of up to 2,000 vehicles; up to 4,000 vehicles requires a minimum width of 36' for roads with parking on both sides (26' for roads with no parking and 31' for roads with parking on one side). The minimum street width allowed under VDOT's Road Design Manual for urban local streets would be 20' for a two-lane roadway.

The CWP Worksheet also awards points for having low minimum (or no minimum) parking requirements. The recommended minimum parking ratio for an office building is 3.0 spaces per 1,000 ft^2; Norfolk's ordinance calls for 4.0 spaces per 1,000 ft^2. The suggested minimum for shopping centers is 4.5 spaces per 1,000 ft^2. In this case, Norfolk applies a different standard to larger shopping centers (5 spaces per 1,000 ft^2 if greater than 55,000 square feet gross floor area) than to smaller shopping centers (4.0 spaces per 1,000 ft^2 if less than 55,000 square feet gross floor area). The worksheet also

[4] Norfolk Code of Ordinances Sec. 42.5-7 (a): "All other local streets shall not be less than fifty (50) feet wide." Sidewalks are required on both sides of streets and have a minimum width of 5'. Curbs are required to be 6" wide according to Norfolk's Public Works Design Standards Manual.
[5] VDOT Road Design Manual Volume 1

awards two points for setting maximum or median parking requirements instead of minimums. Providing a model shared parking arrangement, allowed by Norfolk's code, also earns a point, as does reducing parking requirements near transit locations. While the City's standard for minimum parking stall width exceeds the worksheet's recommendation (8' in Norfolk versus the 9' recommendation), the City's minimum stall length exceeds the regulation by one foot (19' versus 18'). Points are also available for mandating compact car spaces in large parking lots and incentivizing parking garages.[6]

Site planning and sidewalk requirements are another area where Norfolk's code appears to miss out on several points.[7] The worksheet awards points for meeting setback standards, as determined based on a one-half acre residential lot. The closest equivalent in Norfolk's zoning ordinance is the One-Family District (R-1), with a 25,000 sf minimum lot area. One point is given for having a front setback of twenty feet or less; Norfolk's requirement is twenty-five feet. Norfolk meets the recommended standard for rear setbacks (twenty-five feet), but does not for side setbacks (ten feet versus eight feet). Norfolk's minimum frontage requirement of one hundred feet also exceeds the recommended eighty feet. Norfolk's mandatory sidewalk requirements exceed the recommended amounts for minimum width (five feet versus four feet).[8] Norfolk also appears to require sidewalks on both sides of residential streets; the recommendation is to require sidewalks on only one side of the street if at all (Table 8).

In some respects, the CWP Worksheet is not an ideal tool for a city that is nearly completely built out, as Norfolk is. For example, open space design and management requires a certain amount of usable open space to be undeveloped, which is not widely available in a city like Norfolk. The focus on open space (the worksheet offers a total of 18 points related to open space design and management) lessens the utility of this tool for urban communities, which is one reason this assessment focused on those specific components directly related to impervious cover instead of the total score.

SUFFOLK

[6] Norfolk's parking regulations are found in Sections 15-5.1 and 15-5.2 of the Zoning Ordinance.
[7] Norfolk's setback and frontage requirements are found in Chapter 4 of the Zoning Ordinance.
[8] Norfolk City Design Standards

For Suffolk, HRPDC staff reviewed the Suffolk Code of Ordinances, the Suffolk Unified Development Ordinance, and the city's Public Facilities Manual. The review identified opportunities to modify city requirements for street dimensions, parking regulations, setbacks, and driveways. As with Norfolk, Suffolk's minimum pavement width for a low-traffic, low-density residential street exceeds the recommended amount, though in this case by only six feet (28' to 22'). The 28' is also in line with VDOT's road design regulations. Suffolk also meets the recommended standards for street length (the City discourages non-efficient street layouts), right-of-way width, and cul-de-sacs.[9]

[9] Suffolk Unified Development Ordinance Section 31-612

	CWP Recommendation	Norfolk Standard	Standard Met?
Minimum Street Width for Low Traffic Residential Areas	18 to 22 feet	39’	No
Parking for Office Buildings	3.0 spaces per 1,000 ft^2	4.0 spaces per 1,000 ft^2	No
Parking for Shopping Centers	4.5 spaces per 1,000 ft^2	5.0 spaces per 1,000 ft^2 if greater than 55,000 ft^2 gross floor area; 4.0 spaces per 1,000 ft^2 if less	Partially
Minimum Parking Stall Width	8’	9’	No
Minimum Parking Stall Length	18’	19’	No
Minimum Front Setback	20’	25’	No
Minimum Rear Setback	25’	25’	Yes
Minimum Side Setback	8’	10’	No
Minimum Frontage	80’	100’	No
Minimum Sidewalk Width	4’	5’	No

Table 8: Norfolk Development Standards Compared with CWP Recommended Standards

Suffolk’s minimum parking standard for office buildings is 4 spaces per 1,000 ft^2 gross floor area, but its minimum standard for shopping centers is only 1 space per 1,000 ft^2 gross floor area. Suffolk also includes maximum parking amounts in addition to minimums (for example, the maximum amount of parking for office buildings is 8 spaces per 1,000 ft^2).[10] While Suffolk allows and incentivizes shared parking, there does not appear to be a model agreement in the code or on the City’s website. Suffolk does not require compact car parking or appear to mention it in code at all. The minimum parking stall width in Suffolk is 9’, while the minimum stall length is 18’; both exceed the CWP recommended minimums (Table 9).

[10] Suffolk Unified Development Ordinance Section 31-606

While Suffolk gets more credit for its sidewalk regulations than Norfolk, due to a smaller minimum width (4', though 5' is "desirable") and no universal requirement to have sidewalks on both sides of a street, the city's setback requirements are greater than those recommended by the worksheet. Suffolk's minimum required front and back setbacks for a Residential Low Density lot (30,000 square foot minimum lot area) both exceed the recommended values, 35' compared to 20' and 30' compared to 25'. The city's minimum required side setback is also larger than the recommended value (15' compared to 8').[11] Suffolk's driveway regulations also appear to contradict water quality goals. Though the minimum required width meets the recommendation of 9', the ordinance appears to forbid such impervious cover reducing techniques as pervious driveway materials, the use of "two track" layouts, and shared residential driveways.[12]

Suffolk scored very highly on the checklist for its open space/cluster ordinance and for its transfer of development rights ordinance. These ordinances allow for considerable flexibility in meeting regulatory demands and market preferences for development projects. However, these programs are somewhat limited in how they can be applied.[13]

	CWP Recommendation	Suffolk Standard	Standard Met?
Minimum Street Width for Low Traffic Residential Areas	18 to 22 feet	28'	No
Parking for Office Buildings	3.0 spaces per 1,000 ft^2	4.0 spaces per 1,000 ft^2 gross floor area	No
Parking for Shopping Centers	4.5 spaces per 1,000 ft^2	1.0 space per 1,000 ft^2 gross floor area	Yes
Minimum Parking Stall Width	8'	9'	No
Minimum Parking Stall Length	18'	19'	No

[11] Suffolk Unified Development Ordinance Section 31-407
[12] Suffolk Unified Development Ordinance Section 31-605
[13] Suffolk's Cluster Ordinance is located in Section 31-411 of the Unified Development Ordinance. Suffolk's Transfer of Development Rights ordinance is located in Section 31-409 of the Unified Development Ordinance.

Minimum Front Setback	20’	35’	No
Minimum Rear Setback	25’	30’	No
Minimum Side Setback	8’	15’	No
Minimum Frontage	100’	80’	Yes
Minimum Sidewalk Width	4’	4’	Yes

Table 9: Suffolk Development Standards Compared with CWP Recommended Standards

RESULTS

Based on these code and ordinance reviews, it appears the minimum requirements for residential development in both Norfolk and Suffolk, in terms of setbacks, driveways, parking, sidewalks, and street layouts, contribute significantly to the amount of impervious cover that is included on these lots. This is true for all types of typical by-right residential development, regardless of density. Comparing the minimum requirements for setbacks, street frontage, sidewalk width, and road width shows that just these requirements can contribute between 0.03 and 0.06 acres of impervious cover, without even including a house or any other structures or walkways (Table 10). The largest contributor is the minimum street pavement requirement, which is a function of minimum street frontage and minimum road pavement width requirements. Reducing or eliminating some of these requirements can help property developers achieve stormwater treatment requirements. Reducing or eliminating requirements for streets, sidewalks, setbacks, and other sources of impervious cover can potentially help improve water quality, promote redevelopment, or both. Specifically, it appears that both cities could revise their street standards, parking regulations, and minimum setback requirements to reduce the amount of impervious cover developers are required to incorporate into their designs. This should reduce the costs of development from stormwater treatment.

MEETINGS WITH LOCALITIES

As part of this project, HRPDC worked with locality staff from Norfolk and Suffolk to identify potential recommendations to consider, options that would probably not be considered feasible, and what other efforts each locality was already engaged in that were relevant to this project. HRPDC staff met in person with staff from each city on three occasions. The first meeting consisted of a full briefing to each group on what had been conducted in the first year and what would be included in the work plan for the second year. Shorter briefings were included in the later meetings to make sure everyone in attendance understood the project's goals and deliverables. In general, locality staff members who attended these meetings were from each city's Public Works Department, but other departments, including planning, parks, zoning, and environmental services were also represented. For the most part, the later meetings focused on status updates from HRPDC staff and giving each locality a chance to provide input or direction to the project. Each meeting also typically included an update from each locality concerning ordinance changes in process and the status of their stormwater program overhauls.

Zoning Classification	City	Minimum Lot Size (sf)	Minimum Front Setback (feet)	Minimum Driveway Width (feet)	Minimum Street Frontage (feet)	Minimum Sidewalk Width (feet)	Minimum Road Pavement Width (feet)	Total Minimum Impervious Cover (sf)	Total Minimum Impervious Cover (acres)
Residential Low Density (RL)	Suffolk	30,000	35	9	100	0	28	1,715	0.04
One-Family R-1	Norfolk	25,000	25	10	100	5	39	2,700	0.06
Residential Low-Medium Density (RLM)	Suffolk	15,000	30	9	100	0	36	2,070	0.05
One-Family R-3	Norfolk	15,000	25	10	100	5	39	2,700	0.06
Residential Medium Density (RM)	Suffolk	10,000	25	9	80	4	30	1,745	0.04
One-Family R-5	Norfolk	10,000	25	10	100	5	39	2,700	0.06
Residential Compact (RC)	Suffolk	6,000	20	9	60	4	30	1,320	0.03
One-Family R-7	Norfolk	6,000	25	10	60	5	39	1,720	0.04
Residential Urban (RU)	Suffolk	4,000	20	9	50	4	36	1,280	0.03
One-Family R-9	Norfolk	4,000	25	10	40	5	39	1,230	0.03

Table 10: Minimum Impervious Cover in Residential Developments in Norfolk and Suffolk

NORFOLK

HRPDC staff met with staff from the City of Norfolk on three occasions: February 19, April 12, and June 26, 2013. The focus of these meetings early on leaned toward engaging multiple departments beyond public works and planning to develop a more holistic and comprehensive approach to any potential ordinance changes in response to the Chesapeake Bay TMDL and new stormwater management regulations. Engaging multiple departments also helped develop a multiple benefits mindset for this project. Issues identified for this multiple benefits focus included flood mitigation, beautification, sea level rise vulnerability, and water quality. City staff also highlighted the need to develop strategies for private actors and homeowners in addition to the city, and to engage with the public and decision makers to build support for any proposed changes. Examples of quality developments or successful best management practices could be used to educate and build support. Another issue that was identified during the discussions was the importance of departmental policies, training, and education in the successful implementation of any ordinance changes; for example, educating maintenance personnel on native vegetation that should not be mowed.

In addition to the general strategy discussion, Norfolk staff provided specific recommendations of best management practices, policies, and potential sites for GIS modeling for HPRDC staff to investigate as part of this project. Some of these were already being considered by Norfolk staff, while others were the result of the discussion. Specific policy ideas included: looking at the existing weed nuisance ordinance and modifying it or a related ordinance to allow for larger native or buffer plants in certain areas; revising parking standards, such as establishing maximums and lowering minimums (currently under consideration by Norfolk staff); revising landscaping standards to provide more guidance to developers and tie together landscaping with stormwater management requirements; and redevelopment incentives such as the city's transit oriented development (TOD) ordinance and a potential transfer of development rights program. Specific BMP categories discussed included restoration BMPs, retrofits, living shorelines, buffers, and aquatic benches. City staff highlighted their desire for low maintenance designs, since maintaining BMPs, especially those on private land, can be challenging.

Developing some sort of process to add consistency to private property BMP maintenance and inspections was also discussed. Norfolk staff also expressed interest in a regional BMP manual that could be tailored for each locality to use. The ability to track and get credit for both private and public BMPs was also identified as an important consideration. Norfolk staff also identified several potential locations to be used for modeling demonstrations, including the St. Paul's district, East Beach, Pickett Farms, the Harris Teeter site at Ward's Corner, and a redevelopment site at the intersection of East Princess Anne Road and Ingleside.

SUFFOLK

HRPDC staff met with staff from the City of Suffolk on three occasions: February 15, May 2, and June 27, 2013. Discussions with the City of Suffolk were generally limited to the Planning and Public Works Departments. Early discussions focused on identifying and moving forward with strategies that were legally available to localities. For example, the stormwater regulations do not allow local governments to prohibit any state-approved BMPs, but local governments can encourage the use of some over others. The City is in the middle of a comprehensive plan update, though it is not a full-scale rewrite. This presents an opportunity to incorporate the recommendations or lessons learned from this project into that update. Suffolk staff mentioned several specific issues that should be kept in mind throughout the process. In general, the city updates its ordinance as needed in an incremental manner. However, the city would prefer not to force best practices through ordinance changes, but would prefer to enable and encourage those practices through education and examples. Another issue is that Suffolk already has some policies incorporated into the Unified Development Ordinance, including by-right cluster development and a transfer of development rights program, but they are not being used much if at all. The lesson here is that having an ordinance is only the first step; it has to be understood, supported, and promoted to be successfully implemented.

As with Norfolk, Suffolk staff provided several ideas for BMPs, policies, and sites to be looked into further. BMPs that were mentioned or discussed during this series of meetings included buffers for streams (including non-Chesapeake Bay watershed streams) and drinking water reservoirs, living shorelines, buffer restoration projects, and green streets. Policies that were recommended for consideration included promoting redevelopment in the City's two growth areas (Harborview and Downtown Suffolk), improving and encouraging the use of the existing TDR and cluster ordinances, potentially developing an acquisition program for flood-prone properties, and developing maintenance permits for BMPs located on single family home properties. Suffolk staff also provided several recommendations for sites to model; these included Bennetts Creek, Four Farms, Pitch Kettle, Governor's Point, and Graystone Reserve. These areas could be modeled under the old stormwater regulations and the new ones; city staff was also interested in seeing how a cluster development approach would have altered the projects' environmental impacts.

PRELIMINARY RECOMMENDED POLICIES

Based on the code and ordinance reviews described above and the discussions held with Norfolk and Suffolk city staffs, HRPDC staff has developed the following recommended policies to be investigated further. These recommendations should be considered preliminary. During the upcoming year HRPDC staff will work with Norfolk and Suffolk to refine some or all of these recommendations so that they can be formally considered for adoption at some point.

REDUCING IMPERVIOUS COVER

As discussed above, there are many city requirements that force developers to put some minimum amount of non-building related impervious cover on a plot of land. Some of these requirements are direct (sidewalks, parking, driveways) while others are indirect (setbacks). Norfolk and Suffolk should consider lowering the minimum requirements for each of these site planning requirements.

1) Parking regulations should be amended to require less parking overall and to reduce the stormwater impacts from large surface lots. This can be done in several ways:[14]
    a. Reduce or eliminate minimum parking requirements. This can be done city-wide or in more urbanized areas.

[14] Lowering or eliminating minimum parking requirements would not necessarily lower the number of parking spaces constructed, but would allow developers the flexibility to decide how many spaces are necessary. Downtown or commercial areas are excellent opportunities for removing parking minimums.

b. Express parking requirements as maximums instead of minimums. This can be combined with reduced minimums to lower developer requirements while also capping the total amount of area devoted to surface parking.
c. Allow for compact car spaces to be used for a significant percentage of total parking requirements (this would reduce the overall amount of impervious cover due to parking).
d. Allow for the use of permeable pavements for surface parking.
e. Allow and encourage for landscaping within parking areas to serve as stormwater management features.
f. Calculate parking requirements based on district or area needs instead of specific parcel or development uses.
    i. Consider waiving parking requirements if there is already sufficient parking available in the immediate area.
g. Encourage shared parking arrangements in urban or mixed use areas. Localities should publish model arrangements/agreements on their websites and discuss the option with developers during the project review and site planning process.

2) Cities should consider reducing the minimum dimensions specified for sidewalks and driveways.
    a. Minimum sidewalk widths should be reduced to 4'. Suffolk currently requires a minimum of 4', but encourages 5'.
    b. Permeable surface materials should be allowed and encouraged for both sidewalks and driveways.
    c. Minimum driveway widths should be reduced to 8'.

3) Cities should consider lowering their minimum road width standards to those established in VDOT's Road Design Manual and Secondary Street Acceptance Requirements. City road standards should be diversified to reflect different types of neighborhoods and projected traffic volumes.

4) Cities should consider lowering their minimum setback requirements (front, back, and side) and road frontage requirements. Setbacks increase the amount of impervious cover on a site by making driveways and walkways longer. Road frontage requirements increase the length of roadway needed in a development. Specific changes should be tailored to each zoning classification.

LOCATING DEVELOPMENT TO REDUCE WATER QUALITY IMPACTS

Choosing where to develop, whether on a small site or within a large watershed, can significantly affect the development's impacts on local water quality. At the site level, certain areas, such as riparian buffers or some soil types, such as A or B soils, provide ecosystem services, including treatment and retention of stormwater. These areas should be avoided in general and preserved if possible. At larger scales, some areas may be important to protect due to agricultural or cultural value. Two development strategies that can be used to preserve these valuable ecosystem functions are clustering and transfers of development rights. Both of these strategies are also useful for achieving multiple goals, such as floodplain management and agricultural and cultural preservation, in addition to improving water quality.

Clustering, cluster development, or conservation development all refer to development practices that preserve open space by intensifying the amount of development that occurs on a portion of a lot or subdivision. Instead of subdividing an entire property into individual lots, ecologically or agriculturally significant areas are identified and set aside, and the development that would have occurred there is transferred to another part of the property. Local ordinances that allow for clustering are enabled by the Code of Virginia.[15] In addition to allowing for by-right development, based on a property's underlying zoning classification, to be shifted and concentrated, state code also allows localities to incentivize certain types of cluster development through the use of density bonuses. Clustering is most applicable in areas where new development, as opposed to redevelopment, is occurring. Suffolk currently has a cluster

[15] Code of Virginia § 15.2-2286-1

ordinance in its city code, while Norfolk does not.[16] In order to qualify, a proposed development must protect between 35% and 50% of the property's gross acreage as open space.

Based on discussions with Suffolk city staff, the principal incentive for developers to use cluster zoning is that it allows for the maximum possible yield, in terms of home sites, on a property. Under conventional zoning, the default open space requirement (which ranges from 3% to 10%) and infrastructure requirements (including sidewalks and streets) would take up a small but significant amount of space. This, combined with minimum lot sizes would result in a site plan with less than the number of units allowed based on maximum density. Clustering, which has no minimum lot size, would allow a developer to build the maximum number of units the underlying zoning classification allows. Clustering could also allow for maximizing development yield when site conditions, such as riparian buffers or other critical areas, would normally prevent it. Depending on the site conditions, this can be a significant incentive. The stormwater management benefits of clustering, as described in Section 1 of this report, can provide an additional incentive. To encourage clustering, Suffolk could consider developing a guide for developers summarizing the benefits of clustering and how it should be accomplished. Suffolk could also consider providing a small density bonus, such as 5% or a single extra dwelling unit, to developers to further encourage cluster development. Norfolk could consider adopting a cluster ordinance that could be used in redevelopment projects. Since most of Norfolk is already developed, a cluster ordinance could be used to incentivize redevelopment projects in ecologically sensitive areas (that could then be returned to native vegetation) or areas vulnerable to flooding.

Transfer of development rights, or TDR, is another tool that localities can use to incentivize the preservation of critical areas, such as floodplains or farmlands, while allowing for profitable development by landowners. Localities are allowed by state law to establish ordinances that establish transfer of development rights programs within their jurisdictions.[17] A transfer of development rights program is in some ways a larger scale version of clustering. Areas where

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[16] Suffolk's cluster ordinance is contained in the city's Unified Development Ordinance, Sec. 31-411.
[17] Code of Virginia § 15.2-2316.2

development is not preferable are identified as sending areas, while those where more development would be beneficial are identified as receiving areas. By-right development that would be allowed by the underlying density of a sending area is transferred to a more suitable area, such as a village or town center, and the agricultural land or ecologically important area is conserved and protected against development in perpetuity. Suffolk already has a TDR ordinance in place, while Norfolk does not.[18] Suffolk's ordinance was developed to protect both agricultural lands and other critical areas (defined elsewhere in the Unified Development Ordinance as areas in Chesapeake Bay Resource Protection Areas, the Flood Plain District, or the Wetlands District; also included are non-tidal wetlands and permanently inundated areas[19]). The focus is on agricultural preservation; the ordinance allows for 100% of the developments rights to be transferred from agricultural lands, while only 50% of the development rights can be transferred from critical areas.

TDR programs are typically used to protect and preserve agricultural areas from development due to a desire to protect those areas as important parts of the local economy or as important parts of the local culture and history. However, the enabling legislation allows for much broader programs that can be used by local governments to address many issues, including agricultural preservation and conservation, but also, for example, floodplain management and climate change adaptation.[20] One method for expanding the scope of Suffolk's existing ordinance would be to add additional areas, such as those vulnerable to sea level rise, to the list of critical areas eligible to the program. Suffolk could also consider increasing the percentage of developed allowed to transfer from critical areas or even offer a density bonus for transfers from some areas where the city does not want development to occur. For a developed city like Norfolk, a TDR program could be established to try to remove existing development from sensitive or threatened areas. For example, Norfolk could identify floodplains or Chesapeake Bay Resource Protection Areas as sending areas, establish receiving areas in less threatened parts of the city, and provide a density bonus for removing existing development. Such a

[18] Suffolk's TDR ordinance is contained in the city's Unified Development Ordinance, Sec. 31-409, Incentive Zoning.
[19] See Appendix A – Definitions of the Suffolk Unified Development Ordinance
[20] The enabling legislation states that the goal of these ordinances is "to conserve and promote the public health, safety, and general welfare…"

strategy could reduce the city's vulnerability to flooding, provide a financial incentive to developers and current residents, and return developed areas to a natural state (which would count as a stormwater BMP for credit under the Chesapeake Bay TMDL). In general, a density bonus provision could be used to encourage redevelopment projects, which would also contribute toward local load reduction requirements.

NATIVE VEGETATION AND VEGETATED BMPS

Most municipal weed ordinances define weeds as non-trees that exceed a certain number of inches in height and are not cultivated at least once a year. Norfolk's current definition is twelve inches[21], while Suffolk's is fifteen inches.[22] The Virginia Coastal Zone Management Program and other organizations have encouraged the use of native plants on private and public property, and many vegetated BMPs require the use of plants that are not intended to be trimmed. Both cities should consider exempting certain areas, such as Chesapeake Bay Resource Protection Areas, and BMPs from these maintenance requirements. Area-based exemptions should apply by right, while BMPs should be regularly inspected to make sure they are functioning properly not endangering health, safety, and welfare.

Another possible approach to promoting or allowing native vegetation while still controlling weeds is to identify specific species in the local weed ordinance that are determined to be weeds and thus subject to eradication or control. This is an approach recommended by Wild Ones, a native plants and landscapes advocacy organization.[23] Further investigation as to what authority local governments have in Virginia to determine weed species would be need to implement this approach.[24] Once an ordinance or ordinance amendment has been adopted, education of city or county maintenance personnel, residents, and elected officials would be critical to actually allowing native vegetation to grow.

[21] Norfolk Code of Ordinances Section 27-9
[22] Suffolk Code of Ordinances Section 34-106
[23] http://www.wildones.org/
[24] Code of Virginia Section 15.2-1115 allows for municipal corporations to "compel the abatement or removal of all nuisances, including but not limited to the removal of weeds from private and public property…"

POTENTIAL ISSUES TO BE RESOLVED

Through discussions with both the pilot localities' staffs and with the Hampton Roads Regional Environmental Committee, several potential roadblocks were identified that could impede the adoption or implementation of the policy or ordinance changes discussed in this report. Several of these could potentially be resolved through coordinated education efforts that would dispel negative misconceptions and outline the potential benefits of these changes. Other issues appear to be the result of conflicting interests which would need to be resolved through coordination between the parties or departments in conflict.

Most of the proposals described above would benefit from and require the educating of decision makers about the proposed changes and potential benefits. Some would also benefit from educating the general population or various segments. For example, changing local weed ordinances to allow for native plant growth would require educating residents about what is allowed and where. The Virginia Coastal Zone Management Program (VCZMP) has been working on programs to promote the planting of native vegetation throughout Tidewater by educating residents, retailers, and wholesalers about native plants. The Hampton Roads Planning District Commission will be working on a VCZMP-funded effort to develop strategies to promote native vegetation in Hampton Roads. Local governments could work with HRPDC to identify potential issues that could be resolved through education. In addition to the proposed changes to weed ordinances, the recommendations related to both cluster development and TDR programs would both be aided by efforts to educate developers, since both are voluntary programs. Local governing and appointed boards would also need to be educated about any proposed changes to ordinances or policies.

In some cases, greater coordination between city departments may be needed to move forward on some of the above recommendations. Particularly concerning standards for roadway dimensions, other departments, including public work, transportation, and fire and public safety, will need to be consulted to assess whether or not narrower roadways or alternative surface materials are feasible, given interests beyond stormwater management. Public works, zoning, economic development, and planning departments should also coordinate to implement policies such as clustering or TDR, as well as the proposed changes to site planning regulations. Outside parties, such as builders' associations and neighborhood groups, could also be included in the discussion. Local governments should establish interdepartmental working groups to address any potential issues early on in the process of considering and adopting these recommendations.

FUTURE STEPS

The work described in this section has included the assessment of the zoning codes and other regulations for two cities in Hampton Roads, Norfolk and Suffolk, to identify opportunities for potential changes to those regulations that could assist local governments in meeting the requirements of Virginia's stormwater management regulations and the Chesapeake Bay TMDL. Several specific recommendations have been identified, and HRPDC staff will be working with the staffs from both cities to identify which potential changes should be pursued for consideration and adoption. This process will include refining the recommendations described to create specific language for inclusion in local ordinances, plans, and policies.

SECTION 3: MODELING OF DEVELOPMENT IMPACTS ON WATER QUALITY

The first year of grant work for this task focused on selecting a methodology for modeling impacts of development on water quality in Hampton Roads localities. Modeling various development scenarios can assist the localities in reaching the nutrient reduction goals required by the Chesapeake Bay TMDL and the new Virginia stormwater management regulations by reducing expected runoff through planning and design upfront.

The method selected was the combination of CommunityViz, a third-party extension to Esri's ArcGIS software, and the Virginia Runoff Reduction Method (VRRM) spreadsheet. CommunityViz can be customized with the formulas from the VRRM and integrated into a GIS environment to calculate stormwater runoff interactively in different scenarios. The test scenario in the previous study looked at how a locality could model a change to an ordinance, such as tree canopy requirements, and view the impact on stormwater runoff. This test scenario used hypothetical land use based on the current tree canopy and impervious surface ratios for the City of Suffolk.

For the current grant year project, Norfolk and Suffolk each selected a sample site to apply this methodology to a real-world scenario.

REDEVELOPMENT SCENARIO – CITY OF NORFOLK

The City of Norfolk is primarily urban and nearly built out so the Virginia Runoff Reduction Method spreadsheet for redevelopment was used in this example case. The sample site chosen by Norfolk staff represents a typical redevelopment scenario. This test case modeled an actual proposed redevelopment project. The three scenarios modeled were the current conditions, proposed redevelopment site plan, and an alternative to the proposed redevelopment site plan. The results were also compared against the existing stormwater regulations (10% reduction per site) and the new regulations which will be in effect in 2014 (20% reduction per site over 1 acre). The CommunityViz project in ArcGIS was set up in the same way as was described in Section 3 and Appendix A in the final report of the first year of this grant project.

STUDY AREA

The location chosen as the study area is located at 3350 E. Princess Anne Rd, Norfolk, VA which is a light industrial parcel. The size of the lot is approximately 7.9 acres.

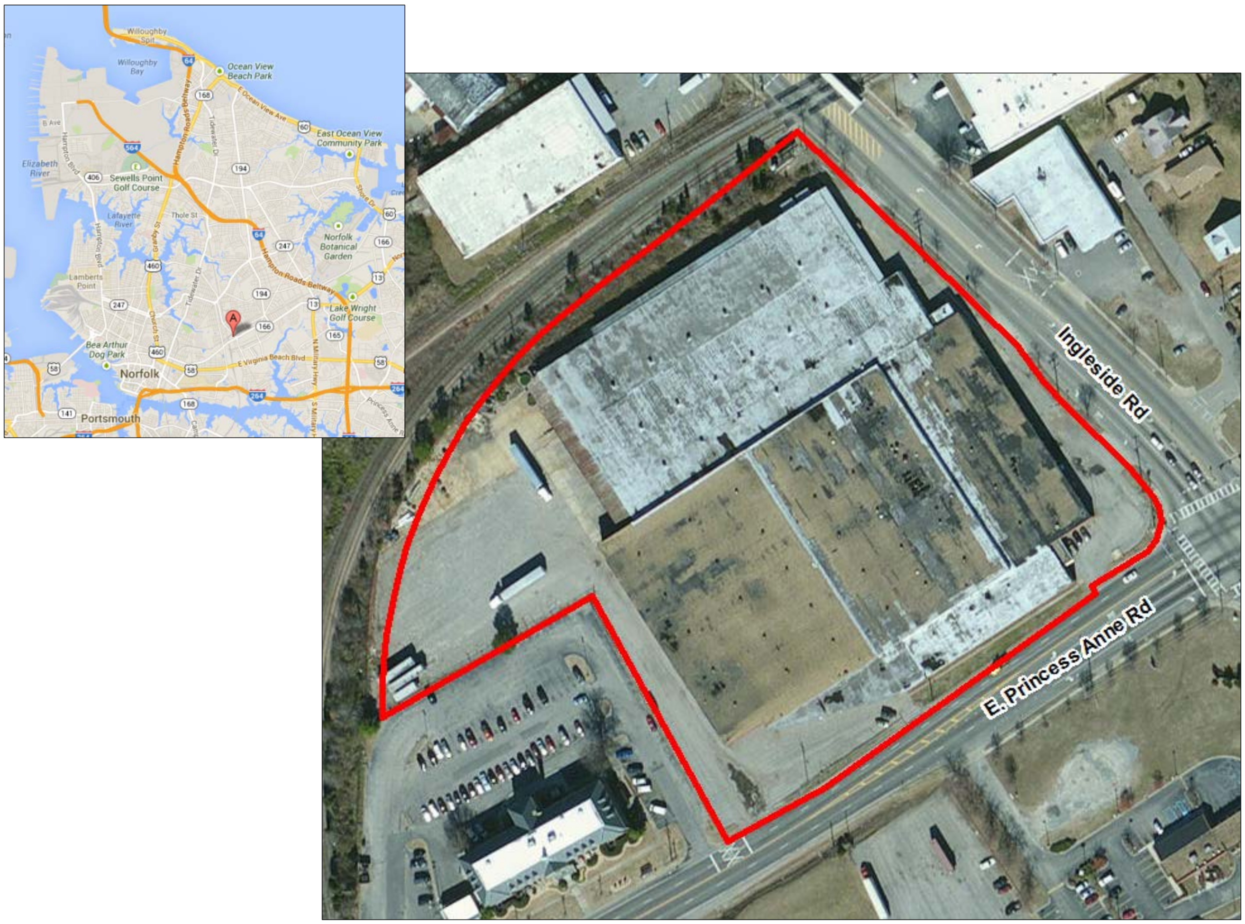

Figure 29: Location and aerial view of Norfolk study area

SCENARIOS

The selected study area has a redevelopment proposal and land use change application currently in process in Norfolk. The proposal seeks to replace the current site with a new big box retail store and a gas station/convenience store. The proposed new land use is commercial.

Because an actual proposed development was modeled, the land use percentages were calculated based on what is actually on the ground using aerial imagery, the site plan, and staff knowledge. Additionally, the soil type was the same for the entire parcel (soil type D) so no extra calculations were needed to account for different soil types.

The first scenario modeled reflected the conditions as they exist currently. The first Pre-Development 1 scenario reflects the proposed changes, which includes new commercial buildings and parking lots. The site plan was digitized in ArcGIS to determine the proposed land cover ratios. The site plan includes a "residual area" (see Figure 30) but it was unclear with the information provided if this area would become managed turf or remain impervious so both options were modeled. Table 11 describes the three scenarios that were tested and compares the different land cover percentages.

Scenario	Land Use	Land Cover	Notes
Pre-Development	Light Industrial	94% impervious 6% managed turf	Existing conditions on the site
Post-Development 1	Commercial	83% impervious 17% turf	Proposed redevelopment with "residual area" remaining impervious
Post-Development 2	Commercial	71% impervious 29% turf	Proposed redevelopment with "residual area" converted to managed turf

Table 11: Chart comparing CommunityViz model scenarios

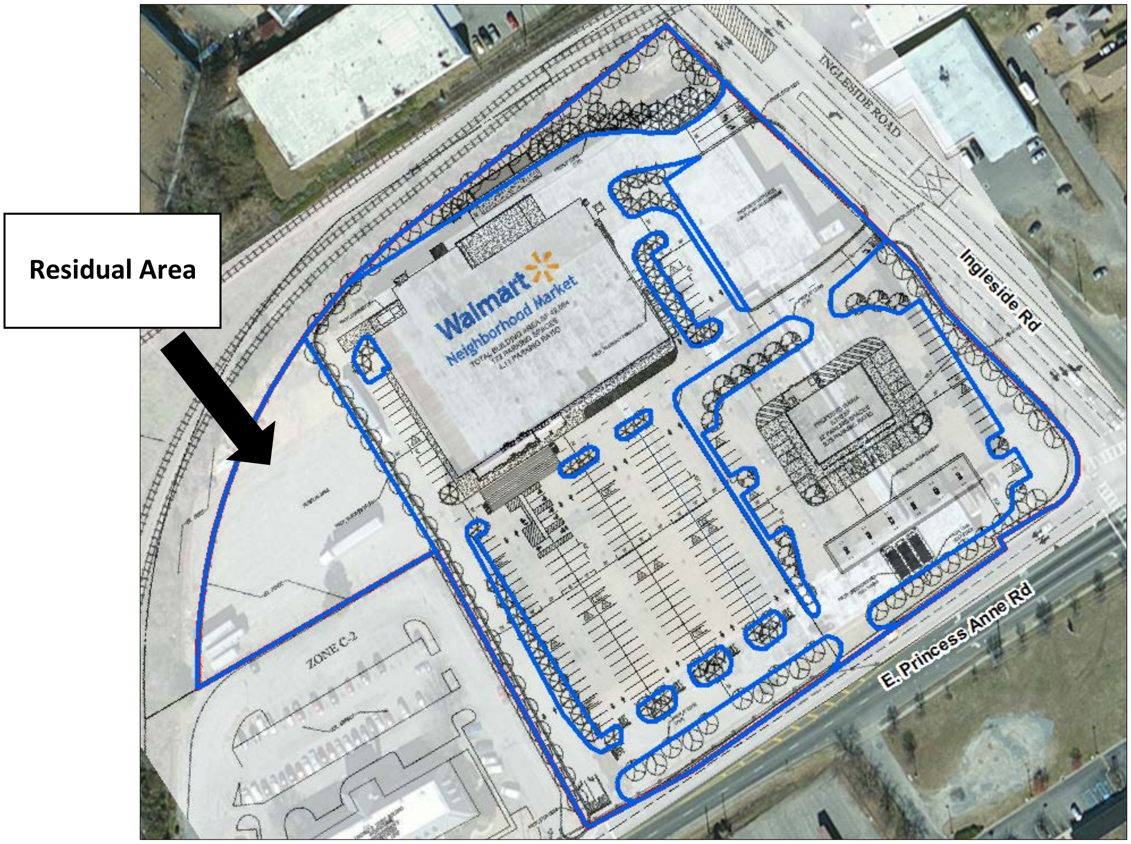

Figure 30: Proposed redevelopment site plan

RESULTS

The table below (Table 12) summarizes the results for total Phosphorus (P) load, total treatment volume, and required P reductions for this study area. As expected, the less impervious cover on the site, the lower the nutrient loads and the amount of stormwater treatment required.

Although the proposed redevelopment will be built under the current regulations due to the timing of the project, as a demonstration, the resulting stormwater runoff for each of the three scenarios was calculated for both the existing stormwater regulations (which require a 10% reduction from pre-development P load) and also for the new regulations which will go into effect in 2014. The new regulations will require a 20% reduction from pre-development P load if the site is over 1 acre in size.

The Post-Development 1 scenario shows that the site will be very close or right at the required P reduction amount for current regulations if the residual area remains impervious. If the residual area is converted to turf as in Post-Development 2, then the site would exceed the required P reduction requirement by 1.38 lbs/yr. If modeled under the new requirements, then neither of the scenarios would meet the regulations and would require an additional treatment for either 1.97 lbs/yr or 0.35 lbs/yr of P load (Table 12).

		Pre-Development Scenario	Post-Development 1 Scenario	Post-Development 2 Scenario
	Total Treatment Volume (cubic feet)	25,734	23,530	21,125
	Total P Load (lbs/yr)	17.3	15.82	14.2
Current Regulations (10% reduction)	P Reduction Target Goal (lbs/yr)	**15.57**	**15.57**	**15.57**
	Remaining P Reduction Required (lbs/yr)	n/a	0.24	Exceeds by 1.38
New Regulations (20% reduction)	P Reduction Target Goal (new) – 20% reduction (lbs/yr)	**13.84**	**13.84**	**13.84**
	Remaining P Reduction Required (new) – 20% reduction (lbs/yr)	n/a	1.97	0.35

Table 12: Results from the three CommunityViz model scenarios

NEW DEVELOPMENT SCENARIO – CITY OF SUFFOLK

As a still-growing suburban community with a large amount of undeveloped land, the City of Suffolk is an ideal locality to study stormwater runoff for new development. Suffolk was interested in comparing the stormwater runoff between traditional style large lot subdivisions and cluster style subdivisions. Although Suffolk has an existing open space/cluster ordinance, it has not been utilized very much. An existing traditional subdivision was chosen for this scenario. HRPDC staff redesigned the subdivision as a hypothetical cluster subdivision, with smaller lots closer together and larger areas of continuous open space. The VRRM formulas were integrated into CommunityViz for both design styles in order to compare the results.

STUDY AREA

The Quaker Neck subdivision is located off Bob White Lane and along Bennett's Creek. It is approximately 89 acres in size.

Figure 31: Location and aerial view of Suffolk study area

Existing Subdivision

The current land cover was determined by digitizing areas of forest, turf, and impervious cover from 2011 Virginia Base Mapping Project (VBMP) aerial imagery of the site. The study area was primarily an agricultural field before being developed so a majority of the area is now managed turf. There is a forested buffer and some wetlands along Bennett's Creek as well. Included in the impervious cover were the existing homes, driveways, and streets. HRPDC staff modeled the site as if all the planned homes had been built so 30 additional homes were added to the existing 19 homes (for a total of 49 parcels) in the impervious cover GIS data. The parcels that extend into the creek were clipped to the shoreline to simplify the analysis. The average size of the parcels in the current design is about 1.5 acres.

The new development scenario required processing the soil data in GIS in order to determine the acres of each soil group by each category of land cover. Most of the area within the subdivision is soil type C; however there were a few locations with type D near the creek (Figure 4). The soils data were processed using the same methods as described in the final report for the first year of this work on this project.

Cluster Subdivision

A hypothetical cluster subdivision was designed by HRPDC staff in order to compare the runoff with the existing design (Figure 33). The cluster design has the same number of developable parcels as the existing site but the parcels are smaller (about .5 acres on average) and more compact. The pre-existing land cover used to design the cluster subdivision was obtained from historical VBMP imagery from 2002, before the site was developed. The pre-development forested area was kept intact as much as possible in the design. There were also three large community open space parcels located along the northern edge of the site. The rest of the model was set up and run in the same manner as the existing subdivision. A comparison between the land cover ratios of the two scenarios is in Table 13.

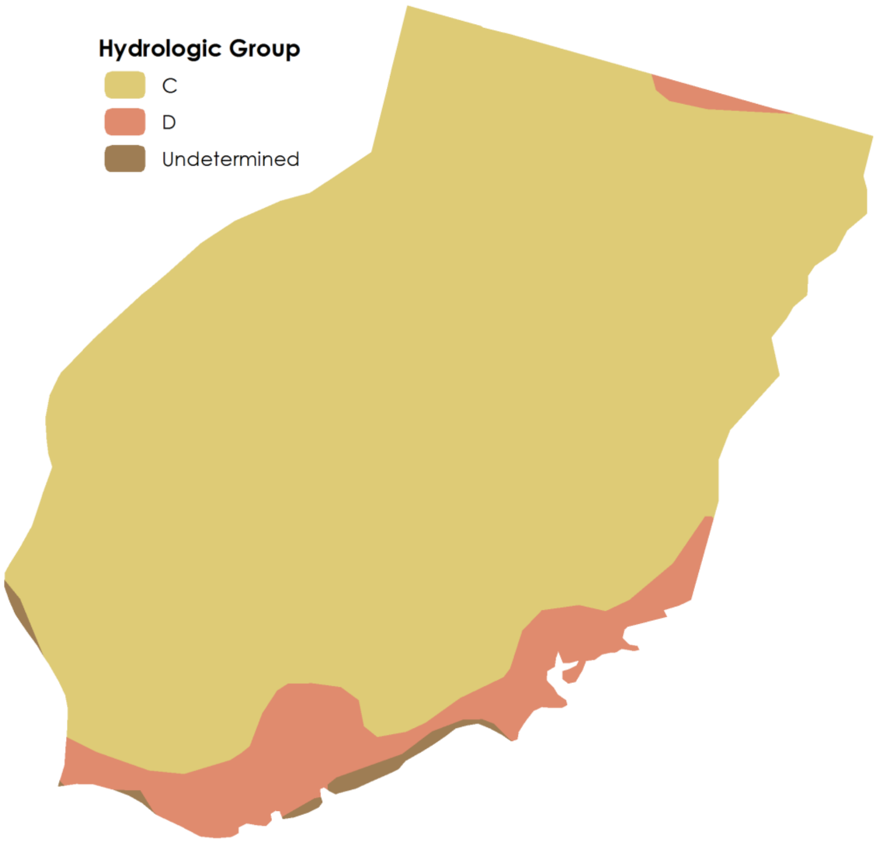

Figure 32: Map of soil hydrologic groups in Quaker Neck

Scenario	Forest	Turf	Impervious
Conventional Subdivision	28.8%	56%	15.2%
Cluster Subdivision	49.9%	39%	11.1%

Table 13: Comparison of land cover ratios between scenarios

Figure 33: Comparison of subdivision designs

RESULTS

The results of this modeling exercise shows that the hypothetical cluster subdivision does reduce the amount of P load by about 25%. The required P reduction for the entire site was reduced by nearly 60%. This is due to the decrease in turf and impervious areas as well as the increase in forested areas in the cluster design. The total P load can be compared using individual parcels (Figure 34) or at the site level (Table 14). This analysis is based on the new stormwater regulations for new development which will require a reduction of 0.41 lbs/ac/yr for new development; as such neither design of this subdivision would meet the requirements if built after 2014 when the regulations go into effect.

If the conventional design was implemented under the new regulations, then it would require a BMP to remove 25.63 lbs/yr of Phosphorus, which falls short of the 36.53 lbs/yr goal. If the cluster design was implemented, then a BMP would need to be constructed to remove only 10.36 lbs/yr of Phosphorus.

The cost of constructing a BMP depends on the volume of treated stormwater and the amount of Phosphorus that will be removed. Ultimately, a BMP constructed in the cluster design would be less expensive because it will be removing less Phosphorus and take up less acreage in the subdivision.

Scenario	Total Treatment Volume (cubic feet)	Total P Load (lbs/yr)	P Load Target Goal (lbs/yr)	P Reduction Required (New Regulations) (lbs/yr)
Conventional Design	90,509	62.16	**36.53**	25.63
Cluster Design	68,449	47.01	**36.53**	10.36

Table 14: Comparison of CommunityViz model results

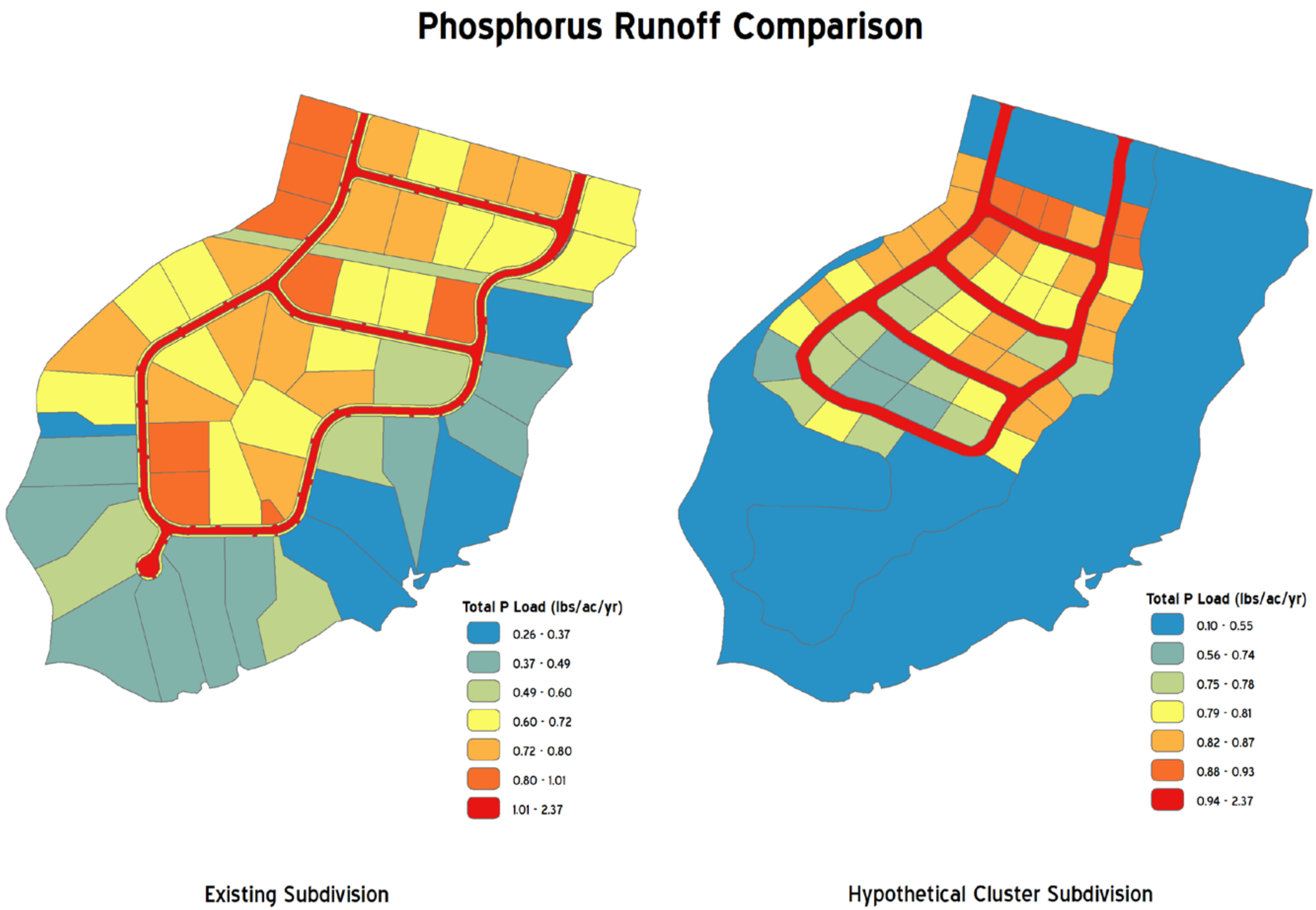

Figure 34: Phosphorus Runoff Comparison Maps

DISCUSSION

After working with both redevelopment scenarios and new development scenarios, several lessons can be taken from these exercises. First, it may not be as practical to use CommunityViz when looking at a single, small redevelopment site, particularly if there is only one soil type. In this case, time may be more wisely spent using the VRRM spreadsheet directly instead of digitizing/importing a site plan into GIS and setting up the formulas.

When looking at scenarios that involve multiple sites or a single large site with multiple soil types, the CommunityViz method has the advantage in efficiency. A GIS can do the heavy lifting when it comes to processing the soil data and applying the VRRM to the entire study area.

One disadvantage of using GIS for a large study area is that high resolution land cover data is needed, unless one is modeling a hypothetical case, as was done in the first year of this project. It is not generally practical to digitize actual land cover for a large area so this data should be obtained if possible in the form of an impervious features layer and tree canopy layer.

Overall, this exercise has demonstrated that taking the time to model stormwater runoff during the planning phase of development can provide insight into the proposed design's stormwater impact and perhaps save money on construction costs by reducing the size of BMPs or retrofits that must be added to the site.

FUTURE STEPS

There is a lot of potential work that could be done in the future with the CommunityViz methodology. One area HRPDC staff may explore in the future is incorporating runoff reduction practices found in the VRRM spreadsheet into CommunityViz. If this could be accomplished, then a local planner could thoroughly evaluate a specific site or area all within the ArcGIS environment by including the credits in process as well.

It would also be worthy to investigate the possibility of creating an online tool, like the InForest application[25] which could replicate the ArcGIS/CommunityViz methodology but make it easier to use and more accessible. Working with ArcGIS/CommunityViz requires a steep learning curve so simplifying the tool and making it more accessible would be a valuable service for developers and local government staff. The cost and level of effort is unknown to develop a tool like this but it is worth exploring.

[25] http://inforest.frec.vt.edu