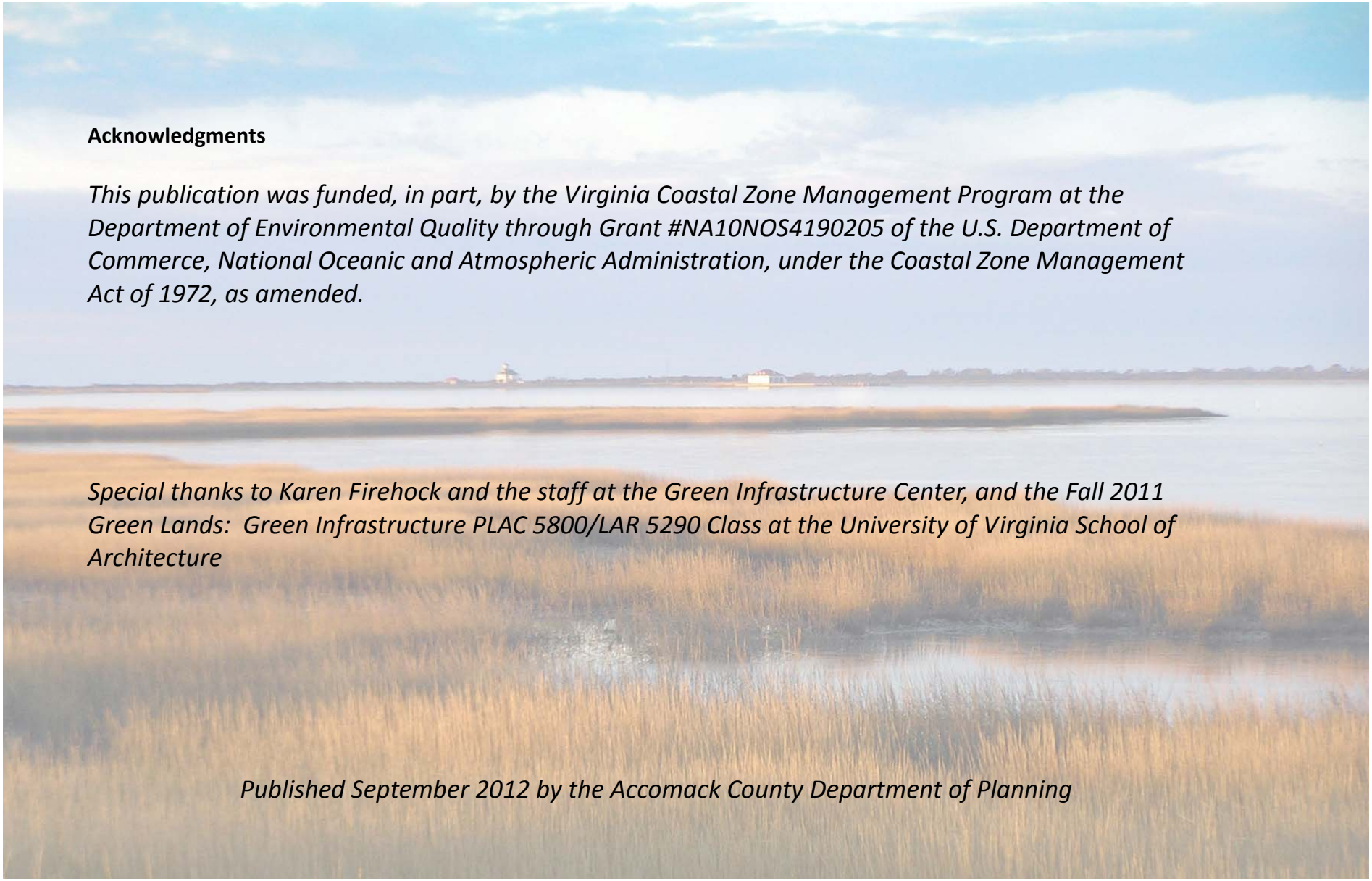
BLUE AND GREEN INFRASTUCTURE IN ACCOMACK COUNTY



Acknowledgments

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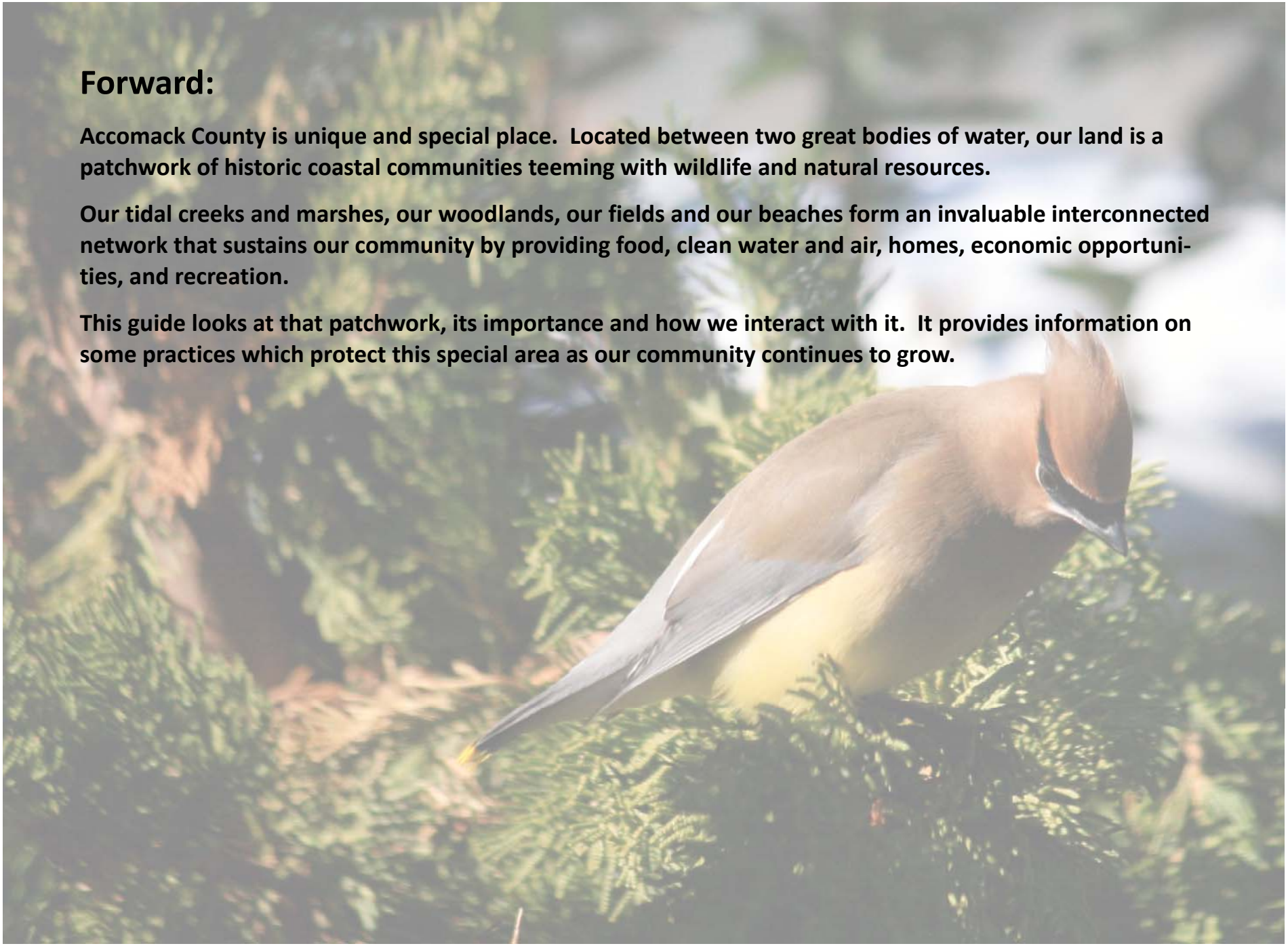
Virginia Coastal Zone MANAGEMENT PROGRAM

NOAA

Green Infrastructure Center

COUNTY OF ACCOMACK VIRGINIA



Forward:

Accomack County is unique and special place. Located between two great bodies of water, our land is a patchwork of historic coastal communities teeming with wildlife and natural resources.

Our tidal creeks and marshes, our woodlands, our fields and our beaches form an invaluable interconnected network that sustains our community by providing food, clean water and air, homes, economic opportunities, and recreation.

This guide looks at that patchwork, its importance and how we interact with it. It provides information on some practices which protect this special area as our community continues to grow.

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What is Blue and Green Infrastructure?

When we think of infrastructure, we think of the man-made structures and items that allow us to move around goods and services and work. These can be our roads and bridges, our airports and railroads, water and sewer lines. Other assets that exist as part of our infrastructure include landfills, schools, police, fire and rescue services; all items that we need in a complex society in order to sustain and grow. Since these items are focused on the built environment, this type of infrastructure is also commonly referred to as grey infrastructure.

Green Infrastructure has a wide range of definitions. Most definitions focus that green infrastructure is based on a combination of the landscape, of biodiversity, or as nature-based alternatives to gray infrastructure.

Green infrastructure takes the approach that certain lands have value that are made even greater when part of a network as defined by The Conservation Fund:

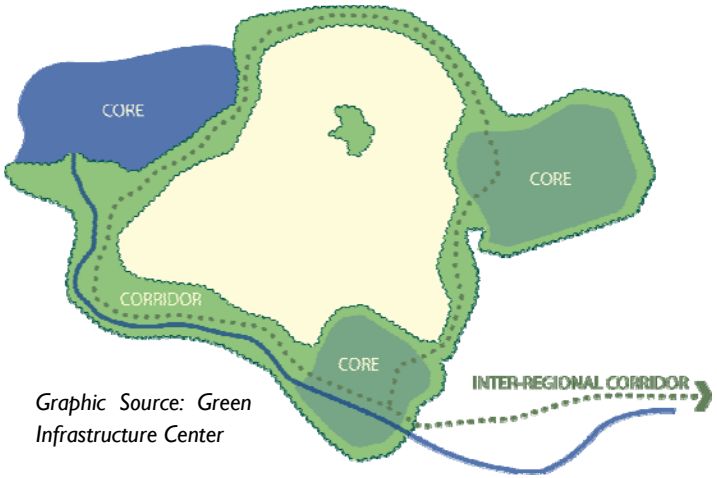
> *Strategically planned and managed networks of natural lands, working landscapes, and other open spaces that conserve ecosystem values and functions and provide associated benefits to human populations.*

The foundation of a green infrastructure network consists of the woodlands, wetlands, creeks, and pastures that work together to maintain and sustain ecological functions. It also includes agricultural working lands, trails and other recreational features, and cultural and historic sites. These areas form a connection of natural systems and ecological processes that provide critical functions such as rich soils for farming, habitat for wildlife, drinking water storage and filtration, and clean air.

While the more common term is "Green Infrastructure," we've used the terms "Blue and Green" or "Blue/Green" infrastructure interchangeably to highlight the importance of bays and oceans, tidal creeks and marshes on our local network.

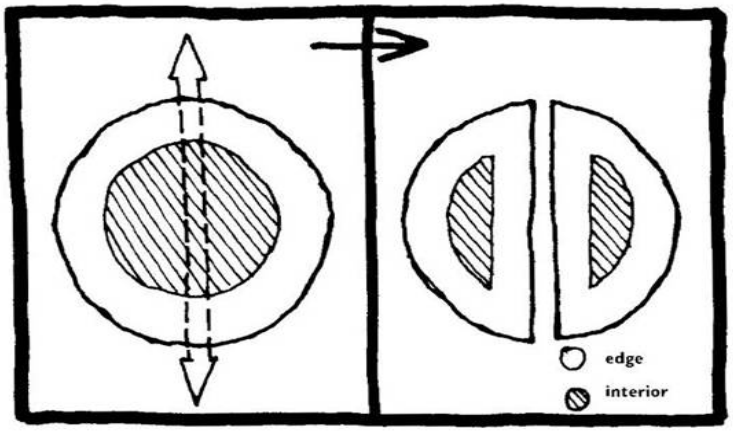
Accomack's green infrastructure links to and supports historic and cultural resources which provide opportunities for hunting, hiking, horseback riding, and bird watching. The County's blue infrastructure supports the rich fisheries economy, tourism, and aquatic recreation opportunities.

On a grand, macro scale, blue and green infrastructure planning connects intact larger natural habitats such as wetlands and forests (also known as ***hubs*** or ***cores***) through a network of ***corridors*** such as a steam corridor to allow people, wildlife, and plants to move across the landscape between cores. The system manages stormwater, reduces flooding, and improves water quality naturally instead of relying on man-made features to perform the same function at a much greater cost.



Graphic Source: Green Infrastructure Center

Cores need to be at least 100 acres in order for interior species to thrive. When a core is removed or a corridor is disrupted such as through roads and development, connectivity is lost resulting in fragmentation of the natural system. A connected landscape benefits natural systems by keeping habitats connected so that animals, plants, seeds, and pollinators can reach areas needed to survive and propagate. Disconnected habitats can weaken a species. If population numbers drop in one area and the species is isolated from other areas, the species can lose genetic diversity and face extinction in that area. A connected landscape provides a more resilient ecosystem and is also important for human recreational activities.



Graphic Credit: Dramstad, Wenche E., et al. Landscape Ecology Principles in Landscape Architecture and Land Use Planning. Washington D.C., Island Press, 1996.

Delmarva Fox Squirrel. Image Source: Chincoteague National Wildlife Refuge

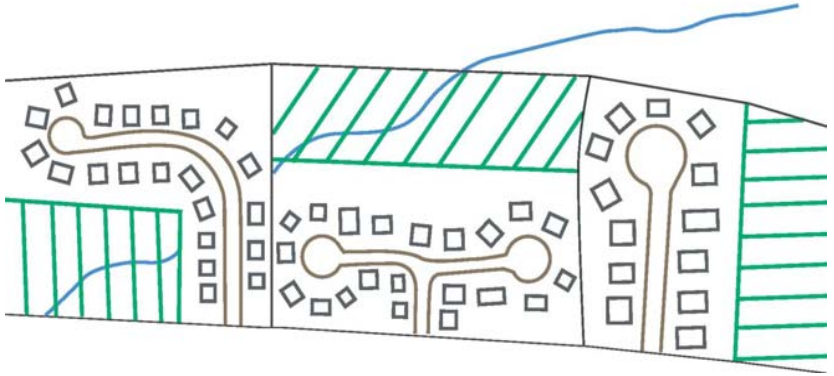
Blue and Green Infrastructure and Development

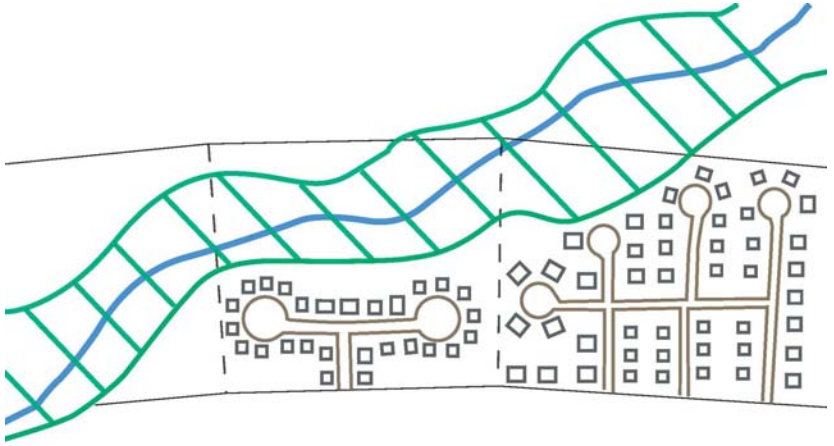
The rate at which Accomack has been developing land is faster than our population growth. The period from 2000 until 2010 saw a period when the County's population remained relatively flat while there was an huge increase in new homes and residential lots. Part of this is a result of national trends where land development is outpacing population growth due to sprawl but another part of this is due to the attractions provided by our proximity to the Atlantic Ocean and the Chesapeake Bay as well as the natural environment provided by our blue and green infrastructure.

As of 2012, one-third of all developed property in Accomack County was owned by people who resided outside of Accomack. As development continues both for current residents as well as the second home market and tourism, it is important to maintain the connection to the natural environment for the economic opportunities it provides by attracting people to the areas as well as for the natural functions it provides for the community.

Economic growth provides jobs and opportunities for Accomack County, its people, and businesses. However some aspects of growth negatively impact the natural system and its processes. The blue and green infrastructure can become further fragmented as development increases if improperly handled.

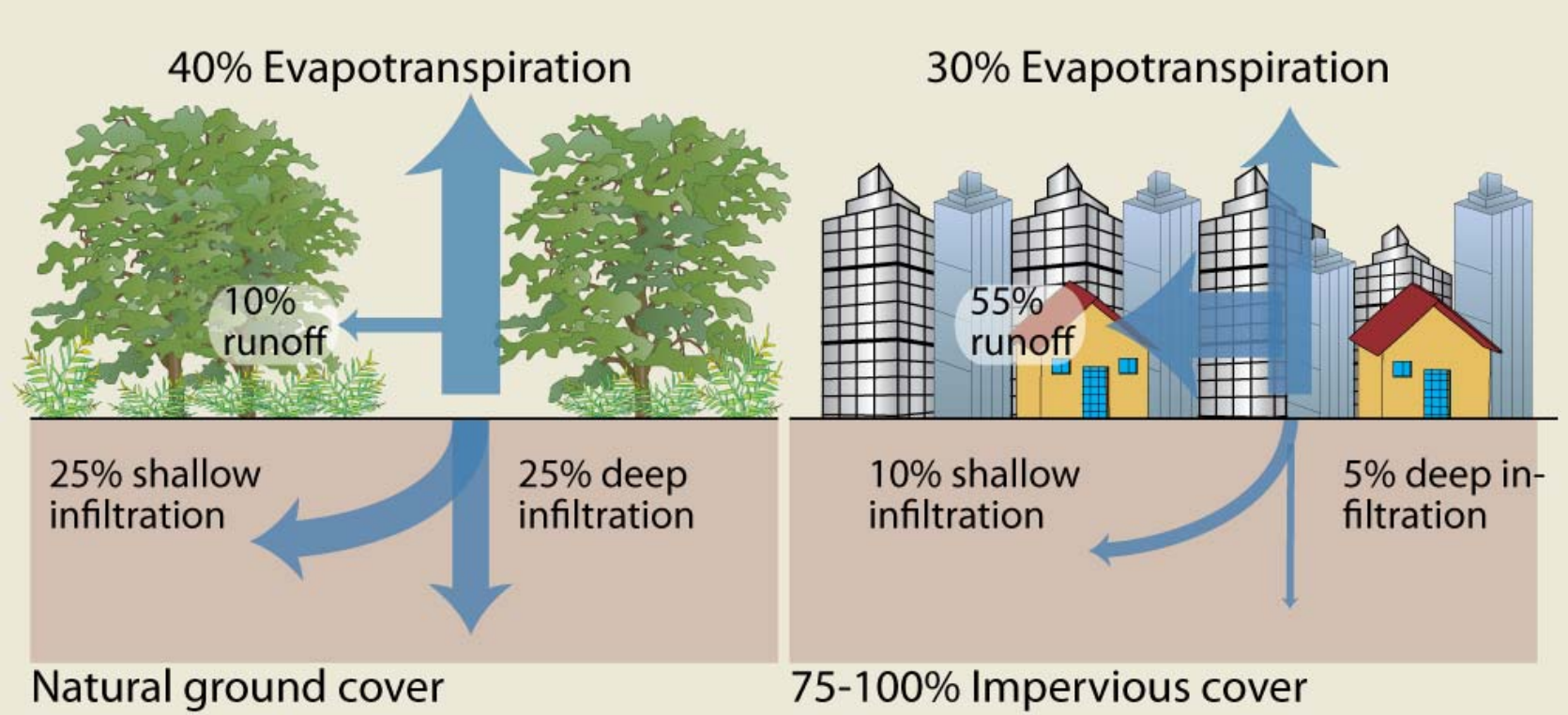
Increased development also means increased impervious surfaces as our landscape is covered with roads, buildings, and parking lots. As the surface is increasingly hardened, the ability of the surface to absorb rainfall is lessened.





Above and Below: Examples how development can either fragment or maintain blue/green infrastructure. Graphic Source: Green Infrastructure Center

Increased runoff from development poses several challenges. As a flat, coastal community with little in the way of fresh surface water, Accomack relies solely on groundwater for its drinking water supply. Increased runoff means that less water is available to recharge the aquifer.

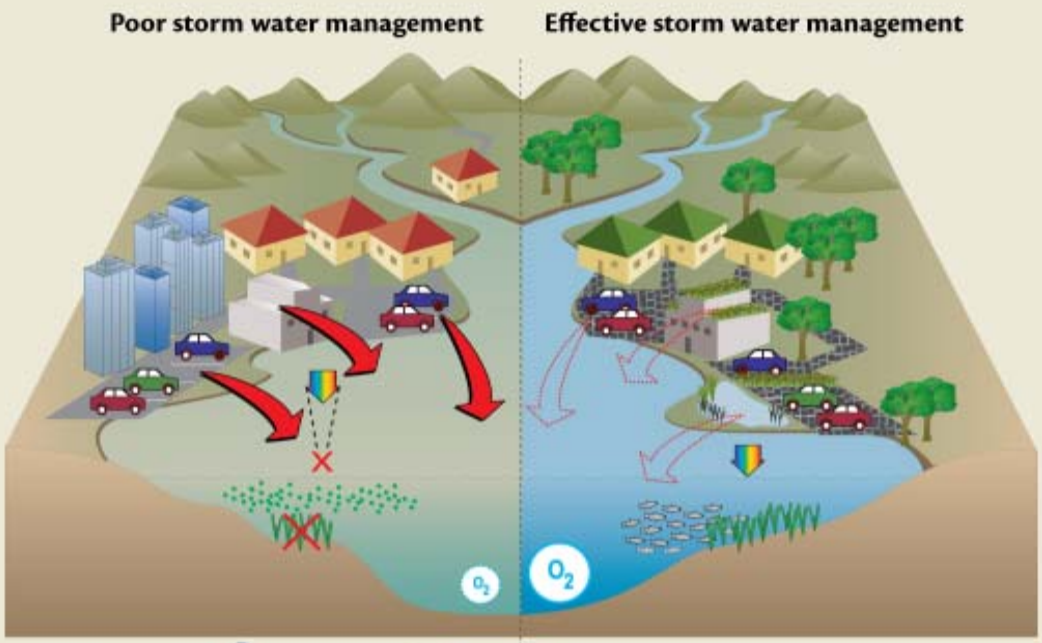


Conceptual diagram illustrating a natural verses impervious water filtration system.

Even in the absence of impervious surfaces, our brackish creeks and marshes would receive some runoff after a storm. But with increased impervious surfaces these natural systems receive increased volumes of freshwater runoff with an increased frequency, changing the salinity of the near shore creeks and marshes and causing spikes in freshwater inundation. These events can cause stress to the local habitat and reduce its ability to adapt to wildly changing water conditions as a result of runoff.

There are additional impacts that need to be mitigated with increased runoff. Runoff entering streams is coming off of a site at a faster rate than would be over vegetated areas.

The water coming off has increased volume, velocity, and is lasting for a longer period which can lead to increased flooding. Increased volumes and velocity can lead to stream bank erosion. Finally, runoff from development can carry higher levels of sediments, fertilizers, pesticides, and other items harmful to aquatic live. With increased development comes an increased need to mitigate the impacts of development.



Urban development , urban sprawl , roads and parking lots , and buildings without green roofs all increase impervious surfaces on the landscape. Impervious surfaces cause stormwater runoff and nutrients to enter waterways in large, pulsed amounts . This influx of nutrients can result in an increased incidence of algal blooms , decreased light availability , low dissolved oxygen levels , and loss of submerged aquatic vegetation .

The use of pervious pavers on roads and parking lots , rain gardens , stormwater retention ponds , and green roofs minimize impervious surfaces on the landscape. Minimizing impervious surfaces allows stormwater runoff and nutrients to enter waterways in small, diffuse amounts . This allows natural levels of light availability , dissolved oxygen O_2 , submerged aquatic vegetation , and other aquatic organisms to proliferate.

Additional Resources:

- **United States Environmental Protection Agency, Green Infrastructure** http://water.epa.gov/infrastructure/greeninfrastructure/index.cfm
- **Environmental Protection Agency, Why Green Infrastructure? http://water.epa.gov/infrastructure/greeninfrastructure/gi_why.cfm#WaterQuality**
- **Virginia Coastal Zone Management Program Blue Green Infrastructure Mapping and Planning Efforts.** http://www.deq.state.va.us/Programs/CoastalZoneManagement/CZMIssuesInitiatives/BlueGreenInfrastructure.aspx
- **Virginia Department of Conservation and Recreation Video on Green Infrastructure.** http://www.youtube.com/watch?v=fb7HLYPwJ4I
- **Accomack County Blue & Green Infrastructure.** http://www.co.accomack.va.us/Planning/BlueGreen%20Infrastructure/BlueGreenInfrastructure.html
- **Green Infrastructure Center gicinc.org**
- **Maryland's Green Infrastructure**. http://www.dnr.state.md.us/greenways/gi/gi.html

Clustering Options

One method to preserve blue/green infrastructure in Accomack County is to utilize the clustering options of the Accomack County Zoning Ordinance in the Agricultural, Rural Residential, and Village Residential Districts.

Clustering allows the grouping homes on smaller lots in a development than would ordinarily be allowed instead of spreading units evenly across the parcel on large lots. By clustering, large areas are kept intact and it reduces the opportunity to further fragment the landscape.

Clustering can also mean more money to the developer. The land developer can potentially sell more lots using the cluster option as the Zoning Ordinance provides a bonus for clustering. The developer can maximize income by providing additional lots for development.

The developer can also save on expenses using the clustering option. By having development concentrated in one area and reducing impervious surfaces that increase the amount of stormwater runoff, costs for gray infrastructure can be lessened significantly. The property owner can maintain the benefits of preserving blue/green infrastructure by having the development clustered outside of sensitive areas. In Accomack County the cluster option is not mandatory.

The following pages show are some sample scenarios using the clustering option on a 50 acre parcel in the Agricultural, Rural Residential, and Village Residential Districts. In each case the total number of lots, the area used and the area maintained as open space are shown.

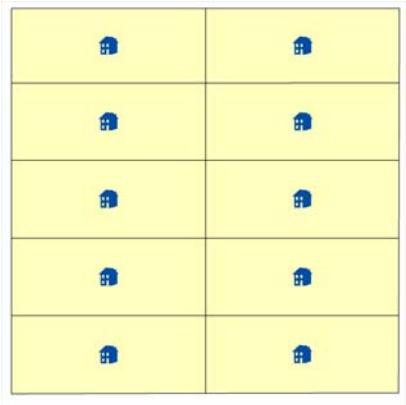
Note: The examples provided are for illustrative purposes and does not take into account land area needed for other items such as roads and stormwater management or for the presence of sensitive environmental features on the site which may impact lot placement. The applicable sections of the Accomack County Zoning Ordinance and the Accomack County Subdivision Ordinance should be consulting prior to submitting an application for development.

Additional Resources:

- **Accomack County Zoning Ordinance, Agricultural District Clustering Provisions**. http://library.municode.com/HTML/13191/level3/CO_CH106ZO_ARTIIIAGDIA.html#CO_CH106ZO_ARTIIIAGDIA_S106-55ARDERE
- **Accomack County Zoning Ordinance, Rural Residential District Clustering Provisions**. http://library.municode.com/HTML/13191/level3/CO_CH106ZO_ARTXXRUREDIRR.html#CO_CH106ZO_ARTXXRUREDIRR_S106-505ARDERE
- **Accomack County Zoning Ordinance, Village Residential District Clustering Provisions.** http://library.municode.com/HTML/13191/level3/CO_CH106ZO_ARTXXIVIREDIVR.html#CO_CH106ZO_ARTXXIVIREDIVR_S106-535ARDERE
- **National Association of Home Builders: Mixed Use and Compact Development Introduction.** http://www.nahb.org/generic.aspx?sectionID=628&genericContentID=16945
- **Code of Virginia Section on Clustering Provisions.** http://lis.virginia.gov/cgi-bin/legp604.exe?000+coh+15.2-2286.1+500018

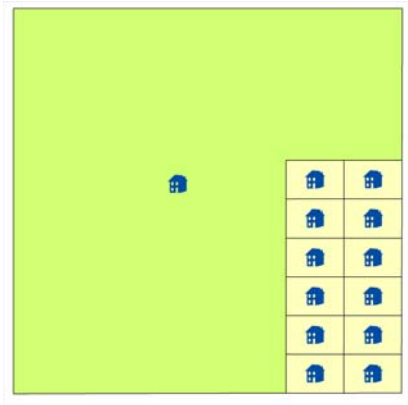
Agricultural District—50 Acres

Without the clustering option, the minimum lot size in the Agricultural Zoning District is 5 acres. There is no maximum lot size.. Theoretically a 50 acres parcel could potentially be divided into 10 parcels with no open space maintained.



No Cluster Option	
Min /Max Lot Size Conventional	5 Acres/None
Min/Max Lot Size Cluster	N/A
Total Conventional Lots Allowed	10
Total Cluster Lots Allowed	None
Open Space Maintained/Preserved	**N/A**
Conservation Lot	N/A

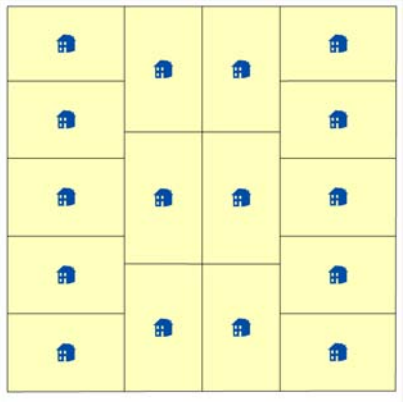
If the property is developed using the cluster option the property owner is able to cluster 12 lots on just over 8 acres, maintaining up to 83% of the 50 acres as open space.



Cluster Option	
Min /Max Lot Size Conventional	5 Acres/None
Min/Max Lot Size Cluster	30,000 sq. ft./3 Acres
Total Conventional Lots Allowed	1
Total Cluster Lots Allowed	12
Open Space Maintained/Preserved	**Up to 83%**
Conservation Lot	N/A

Rural Residential District —50 Acres

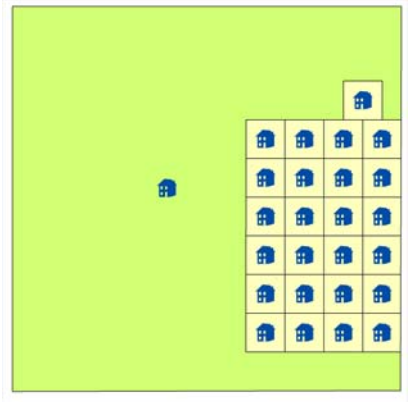
Without the clustering option, the minimum lot size in the Agricultural Zoning District is 3 acres. There is no maximum lot size.. Theoretically a 50 acres parcel could potentially be divided into 16 parcels with no open space maintained.



No Cluster Option

Min /Max Lot Size Conventional	3 Acres/None
Min/Max Lot Size Cluster	N/A
Total Conventional Lots Allowed	16
Total Cluster Lots Allowed	None
Open Space Maintained/Preserved	**N/A**
Conservation Lot	N/A

If the property is developed using the cluster option the property owner is able to cluster 12 lots on just over 8 acres, maintaining up to 83% of the 50 acres as open space.

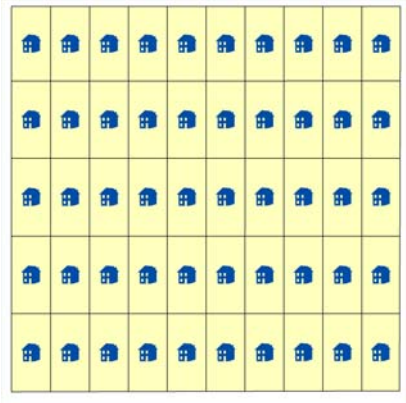


Cluster Option

Min /Max Lot Size Conventional	3 Acres/None
Min/Max Lot Size Cluster	20,000 sq. ft./2 Acres
Total Conventional Lots Allowed	N/A
Total Cluster Lots Allowed	25
Open Space Maintained/Preserved	**60% Minimum**
Conservation Lot	Required

Village Residential District —50 Acres

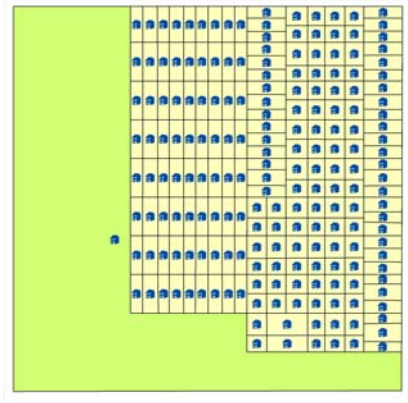
Without the clustering option, the minimum lot size in the Agricultural Zoning District is 3 acres. There is no maximum lot size.. Theoretically a 50 acres parcel could potentially be divided into 16 parcels with no open space maintained.



No Cluster Option

Min /Max Lot Size Conventional	1 Acre/None
Min/Max Lot Size Cluster	N/A
Total Conventional Lots Allowed	50
Total Cluster Lots Allowed	None
Open Space Maintained/Preserved	**N/A**
Conservation Lot	N/A

If the property is developed using the cluster option the property owner is able to cluster 12 lots on just over 8 acres, maintaining up to 83% of the 50 acres as open space. Cluster lots would be served by water and wastewater utilities.

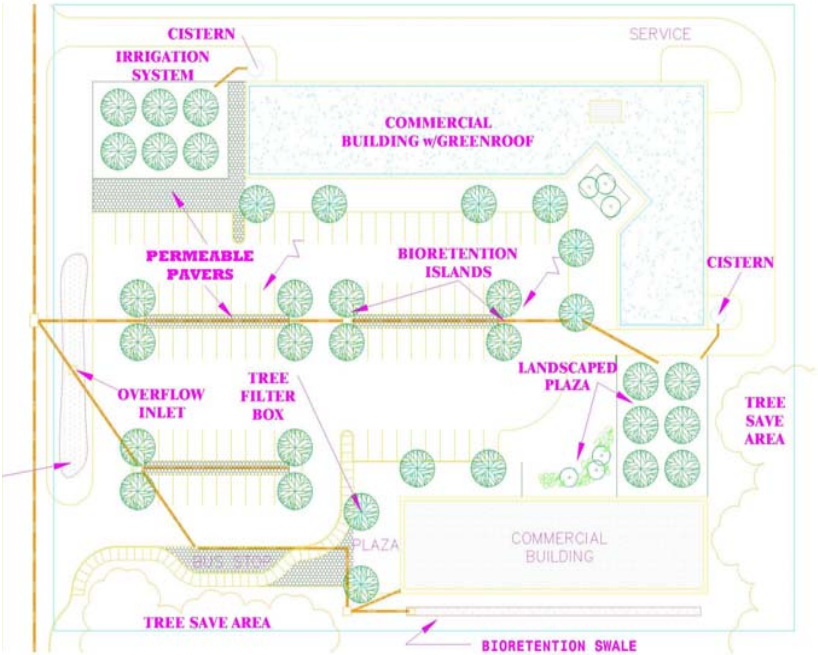


Cluster Option

Min /Max Lot Size Conventional	N/A
Min/Max Lot Size Cluster	6,000 sq ft/30,000 sq ft
Total Conventional Lots Allowed	None
Total Cluster Lots Allowed	200
Open Space Maintained/Preserved	**40% Minimum**
Conservation Lot	Required

Low Impact Development concepts offer another vehicle to protect blue/green infrastructure and on a micro level are often seen as components of blue/green infrastructure.

Low impact development (LID) is an approach to stormwater management that aims to handle it as much as possible as the way it was handled prior to development. That is to utilize techniques to infiltrate, filter, store, and evaporate water at the site rather than to simply convey it offsite via a stormwater drainage system. In essence, it treats the water on a site as a resource and opportunity rather than a by-product to be disposed of as quickly as reasonable.



Graphic Source: Low Impact Development Center

LID looks at the entire site, both hardened areas and soft as an opportunity to manage the hydrologic process on site by retaining, storing, and changing the timing of, or filtering runoff. Some of the most common techniques of LID include:

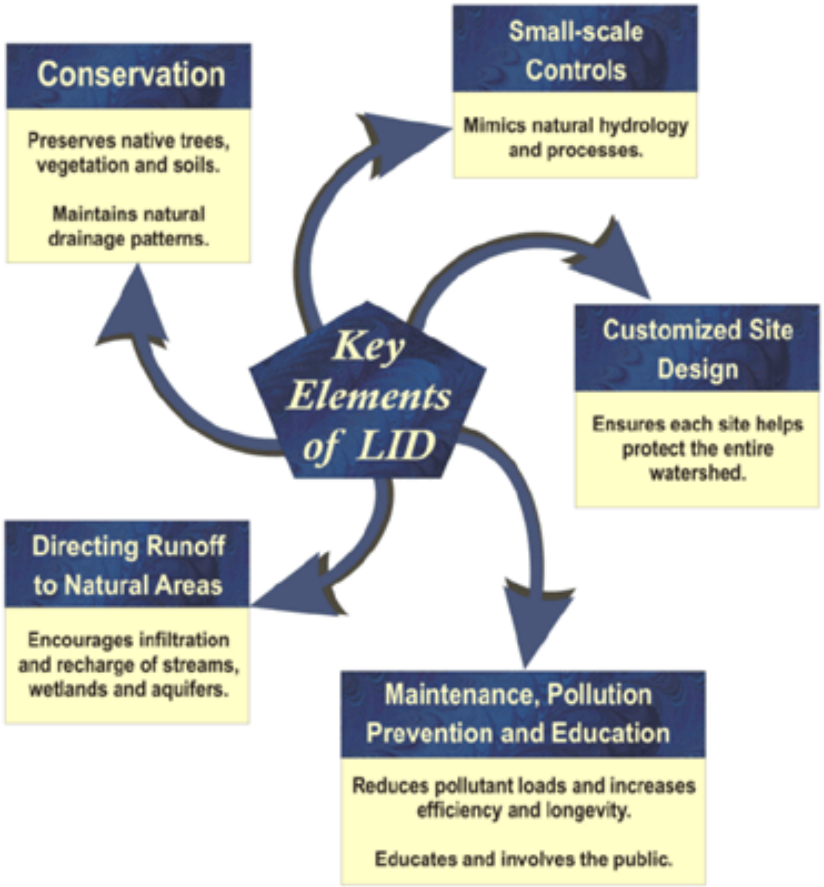
- Reducing imperviousness by using permeable paving or landscaping to break up large expanses of impervious surfaces.
- Directing runoff into or across vegetated areas to help filter runoff and encourage groundwater recharge.
- Preserving vegetated areas near parking areas, buildings, and other impervious expanses in order to slow runoff, filter out pollutants, and facilitate infiltration.
- Remove curbs and gutters parking areas and parking islands to allow storm water sheet flow into vegetated areas.
- Install green roofs.
- Use devices such as bioretention cells, vegetated swales, infiltration trenches, and dry wells to increase storage volume and facilitate infiltration.
- Grade to encourage sheet flow and lengthen flow paths to increase the runoff travel time in order to modify the peak flow rate.
- Disconnect impervious areas from the storm drain network and maintain natural drainage divides to keep flow paths dispersed.
- Disconnect roof downspouts and direct storm water into vegetated areas or into water collection devices.
- Install cisterns or sub-surface retention facilities to capture rainwater for use in irrigation and non-potable uses.

- Use native plants (or adaptable species) to establish an adaptable and low maintenance landscape that requires less irrigation and are appropriate for the climatic conditions.
- Use naturally occurring bio-chemical processes in plants located in tree box filters, swales, and planter boxes.
- Divert water away and disconnect from the storm drain or CSO using correctional drainage techniques.

Principles of LID are achieved through both structural and nonstructural practices. LID offers many benefits over traditional stormwater management such as increased groundwater recharge, less runoff, less pollution, less erosion and less damage to our coastal waters.

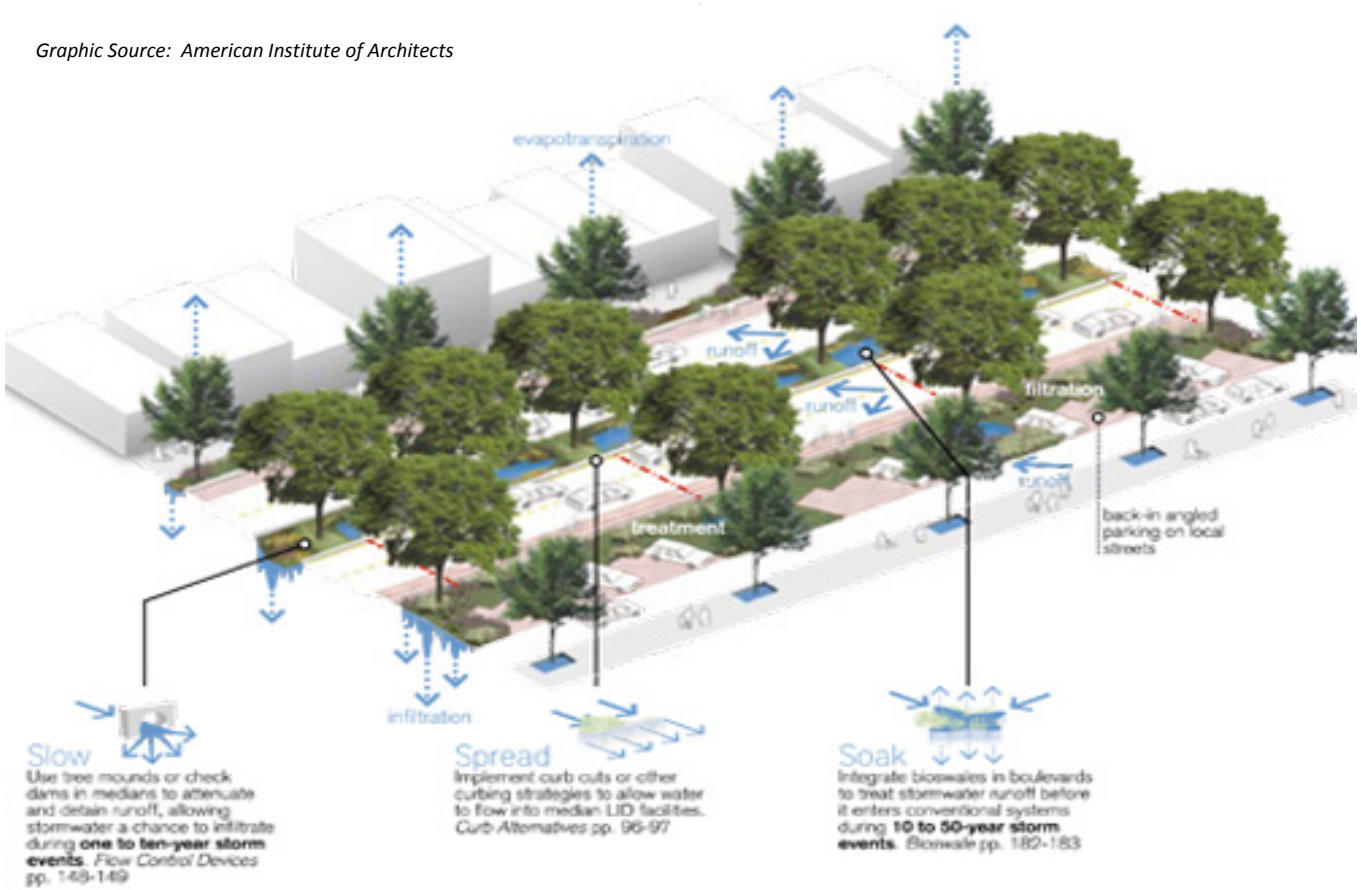
By incorporating nonstructural components into the design, LID can be a cost=effective method of handling and treating water over structural stormwater management componentsA 2007 EPA cost comparison 17 projects of conventional development costs versus using LID principles found that while one LID project did have higher costs, capital costs were reduced by 15% - 80% on the remaining sites and environmental performance was improved.

There are some important caveats to keep in mind when attempting to implement elements of low impact development on a site. First, each element must be tailored to the unique circumstances on each site. For example, many applications require quick drainage and do not work in areas with wet soils or a high water table. Also, while current Virginia regulations allow many uses of low impact development to meet criteria for reducing pollutants under stormwater regulations, they have not been incorporated within the erosion and sediment control regulations for accommodating the amount of stormwater runoff. Although some of these practices do not reduce the volume of stormwater required to be handled on site, they can provide many other benefits.



Graphic Source: National Institute of Building Sciences

Graphic Source: American Institute of Architects



On the following pages are some additional information about selected low impact development practices, both structural and nonstructural. The list is by no means comprehensive.

Information is also provided on pollutant removal efficiencies of various stormwater and low impact development practices

Based on a 1 inch rainfall event. Higher pollutant removal efficiencies may be achieved by utilizing multiple practices.

Many of these low approaches require professional design, installation, and possibly maintenance as well as approval by the Accomack County Department of Planning for compliance with Stormwater and Erosion and Sediment Control Ordinances.

Reported Pollutant Removal Efficiencies of Certain LID Practices

PMP	TSS	Total P	Total N	Zinc	Lead	BOD	Bacteria
Bioretention	-	81	43	99	99	-	-
Dry Well	80-100	40-60	40-60	80-100	80-100	60-80	60-80
Infiltration Trench	80-100	40-60	40-60	80-100	80-100	60-80	60-80
Filter/Buffer Strip	20-100	0-60	0-60	20-100	20-100	0-80	-
Vegetated Swale	30-65	10-25	0-15	20-50	20-50	-	Neg.
Infiltration Swale	90	65	50	80-90	80-90	-	-
Wet Swale	80	20	40	40-70	40-70	-	-
Rain Barrel	NA	NA	NA	NA	NA	NA	NA
Cistern	NA	NA	NA	NA	NA	NA	NA

Hydrologic Functions of Certain LID Practices

	PMP						
Hydrologic Functions	Bio Ret	Dry Well	Filter/ Buffer	Swale Grass	Rain Barrel	Cistern	Infilt. Trench
Interception	H	N	H	M	N	N	N
Depression Storage	H	N	H	H	N	N	M
Infiltration	H	H	M	M	N	N	H
G.W. Recharge	H	H	M	M	N	N	H
Runoff Volume	H	H	M	M	L	M	H
Peak Discharge	M	L	L	M	M	M	M
Runoff Frequency	H	M	M	M	M	M	M
Water Quality	H	H	H	H	L	L	H
Base Flow	M	H	H	M	M	N	L
Stream Quality	H	H	H	M	N	L	H

H = High M = Moderate L = Low N = None

Tables Source: Low-Impact Development Design Strategies: An Integrated Design Approach, Prince George's County Maryland Department of Environmental Resources

Additional Resources:

- **United States Environmental Protection Agency, Low Impact Development (LID) .** http://water.epa.gov/polwaste/green/index.cfm
- **Urban Design Tools Low Impact Development.** **http://www.lid-stormwater.net/**
- **Low Impact Development Center.** **http://www.lowimpactdevelopment.org/publications.htm**
- **Prince George County, Maryland, Low-Impact Development Design Strategies: An Integrated Design Approach.** http://www.lowimpactdevelopment.org/pubs/LID_National_Manual.pdf
- **Low Impact Development: A Guidebook for North Carolina.** http://www.ces.ncsu.edu/depts/agecon/WECO/lid/documents/NC_LID_Guidebook.pdf

Bioretention (Rain Garden) - Bioretention is a shallow densely vegetated depression that captures rainwater from impervious surfaces and allows stormwater to infiltrate through the soil media. As the water infiltrates, it provides onsite pollutant removal of the stormwater. Some of the incoming runoff is temporarily held by the bioretention area and exits the system by way of evaporation, plant uptake or infiltration

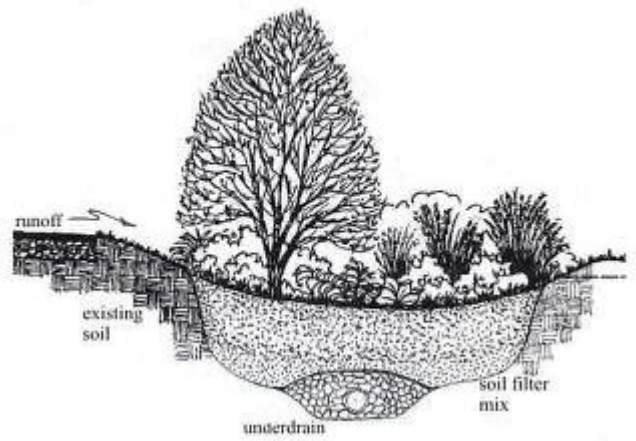
In Virginia, there are seven major components to bioretention areas including a grass buffer strip, additional plantings. ponding area, surface mulch and planting soil, optional sand bed, organic layer, plant material, and infiltration chambers.

Some bioretention facilities also incorporate underground drainage to convey excess water away from the area after being filtered through the soil medium.

Bioretention has been found to be highly effective at treating the stormwater by removing sediments, phosphorus, nitrogen, coliform and heavy metals. It can also be used to slow runoff reduce the peak runoff rate.

Common uses for bioretention have been to treat runoff from parking lost and commercial rooftops and one benefit is that they can be broken up to fit smaller areas such as between rows of parking as well as traffic islands.

Bioretention cells serve smaller areas than a stormwater management pond and, unlike a stormwater pond, it is designed to be shallower, generally holding no more than 5 –6 inches of water in the cell after a rain event. It alternates between slight ponding after a storm event with water filtering into the ground and uptake through plants and evapotranspiration within in a day.



Graphic Source: Virginia Stormwater Management

Since it is not permanently wet a bioretention cell can accommodate vegetation which aids in filtering pollutants as well as provides habitat for birds and butterflies.

Smaller, less complex systems serving primarily residential runoff fro m areas as residential rooftops or driveways are more commonly known as rain gardens and provide similar functions. Inflow is generally from sheet flow although concentrated flow withy energy dissipation can be found in downspouts. It is a practice individual homeowners can implement. Rain gardens can be planted with native plants that are ornamental and in many cases, the environmental functions provided is not apparent to others.

Since bioretention promotes quick groundwater recharge, it is not appropriate for areas with a high water table without underground drainage to a stormwater pond or receiving channel.

Rain garden filtering runoff from nearby street. Image Source: City of Lincoln, NE.

Additional Resources:

- **Virginia Department of Conservation and Recreation, Bioretention Design Specification.** http://vwrrc.vt.edu/swc/april_22_2010_update/DCR_BMP_Spec_No_9_BIORETENTION_FinalDraft_v1-8_04132010.htm
- **United States Environmental Protection Agency, Bioretention (Rain Gardens).** http://cfpub.epa.gov/npdes/stormwater/menuofbmps/index.cfm?action=factsheet_results&view=specific&bmp=72
- **Chesapeake Stormwater Network, Bioretention.** http://chesapeakestormwater.net/training-library/stormwater-bmps/bioretention/
- **Urban Design Tools, Bioretention. http://chesapeakestormwater.net/training-library/stormwater-bmps/bioretention/**
- **Rain Garden Templates.** http://www.lowimpactdevelopment.org/raingarden_design/templates.htm
- **Chesapeake Bay Foundation, Build Your Own Rain Garden.** http://www.cbf.org/document.doc?id=31

Permeable Pavement—Permeable pavement is one of any number of terms (others include porous asphalt, open cell paving, pervious concrete, etc.) that allows water to infiltrate beneath paved services and a underlying stone reservoir rather than running off into a storm drain. It provides pollutant removal as it filters through the underlying reservoir and filter and is slowly released into the surrounding soil.

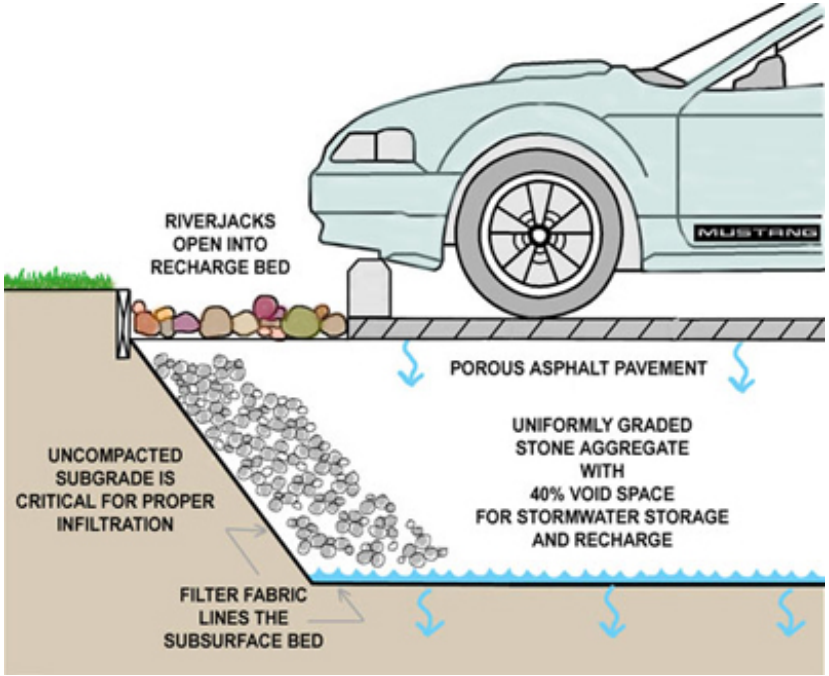
This practice is best suited to relatively flat areas of sidewalks, patios, parking or low traffic roadways. In Accomack County the water table should be at least 4 feet below the bottom of the stone reservoir. It is not appropriate for high traffic or heavy load areas.

This type of practice can be more expensive to install than traditional roadways and some parking areas but the increased costs may be offset by eliminating the need or capacity for curb and gutters, storm water inlets and conveyance systems, and smaller stormwater detention ponds.

Most of these practices require professional design and installation. Proper maintenance is also needed to prevent the surface from becoming clogged with sediments and reducing the permeability of the surface. Also, issues do arise with respect to using chemicals or plows for snow removal.

Above: Example of water passing through permeable pavement. Image Source: Clean Rivers Campaign

Below: Sample design of permeable pavement system. Graphic Source: University of Maryland



Above: Example of rainfall simultaneously on standard pavement (background) and pervious concrete (foreground). Image Source: Environmental Protection Agency

Below: Examples of pervious pavers (left) and open celled pavers (right). Image Source: New York State Environmental Facilities Corporation

Another type of practice which falls into this category are pervious pavers and open celled pavers.. These are generally precast concrete or brick. Although they are used on commercial sites, they are attractive LID feature for landowners as they are easier to install, come in a variety of colors and shapes and can be used for driveways, walkways, and patios.

Pervious pavers are laid over a drainage base and permeable joint material. Water will seep between the joints into the ground. Open celled pavers are concrete or plastic grids installed over a bed of drainage material and soil. Grass is able to grow through the voids in the pavers or they may ve filled with gravel or sand.

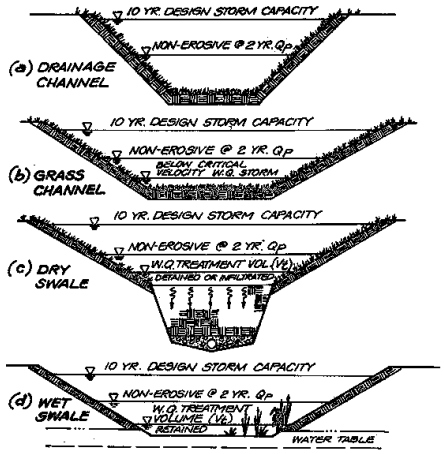
Additional Resources:

- **Virginia Department of Conservation and Recreation, Permeable Pavement Design Specification.** http://vwrrc.vt.edu/swc/april_22_2010_update/DCR_BMP_Spec_No_7_PERMEABLE_PAVEMENT_Final_Draft_v1-7_03082010.htm
- **Perviouspavement.org.** http://perviouspavement.org/
- **Vermont Department of Environmental Conservation, Pervious Pavement.** http://www.vtwaterquality.org/stormwater/htm/sw_PerviousPavement.htm
- **North Carolina State University, Permeable Pavement: Research Update and Design Implications.** http://www.bae.ncsu.edu/stormwater/PublicationFiles/PermPave2008.pdf

Swales – Swales come in various forms and names performing a variety of functions. In general, a swale is a long, broad, and vegetated shallow channel which reduces the peak flow of runoff, reduces the velocity of flow and promotes the infiltration of water and removal of sediment and pollutants. They are commonly located near roadways and parking lots

Grassed swales are incorporated into sites where there are lesser amounts of impervious surfaces and pollutants coming off of a are not as high and the underlying soils already provide relatively quick infiltration. Rock check dams are incorporated into the design in order to promote ponding behind them which results in greater infiltration and less stormwater runoff.

A **dry swale, water quality swale,** or **bioswale** incorporates concepts of bioretention into the design of the swale with underlying drainage and soil mediums to promote infiltration and pollutant removal. Compared to grassed swales, this practice is appropriate to larger impervious areas and sites where higher pollutant removal is necessary.



Various types of swales. Graphic Source: Environmental Protection Agency

Left: Grassed Swale
Image Source: Delaware Department of Transportation

Right: Dry Swale
Image Source: New York Department of Environmental Conservation

Additional Resources:

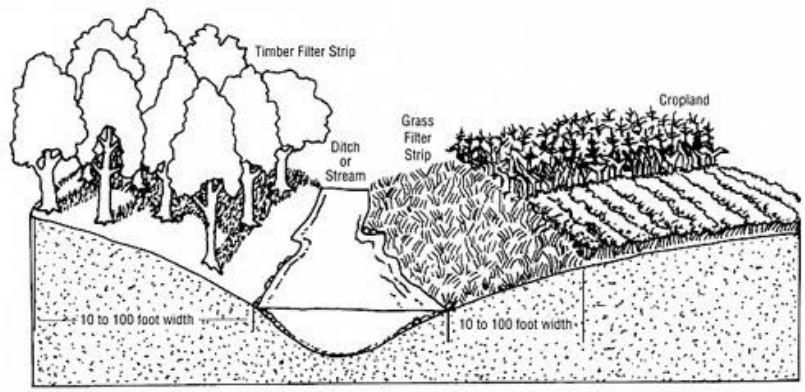
- **Virginia Department of Conservation and Recreation Design Specification, Grassed Channels.**
  http://vwrrc.vt.edu/swc/NonPBMPSpecsMarch11/DCR%20BMP%20Spec%20No%203_GRASS%20CHANNELS_Final%20Draft_v1-9_03012011.pdf

- **Virginia Department of Conservation and Recreation Design Specification, Dry Swale.**
  http://www.cwp.org/cbstp/Resources/d2s5a-dcr-bmp-dryswale.pdf

- **United States Environmental Protection Agency, Grassed Swales.**
  http://cfpub.epa.gov/npdes/stormwater/menuofbmps/index.cfm?action=factsheet_results&view=specific&bmp=75

Vegetated Filter Strips are used to treat sheet flow coming off a site. The vegetated strip slow the rate of runoff, allow pollutants and especially sediments to be filtered out and provide for some infiltration of stormwater.

Filter strips are also commonly used to address agricultural runoff and on the Eastern Shore they are used as a tool to help mitigate runoff from plasticulture.



Vegetated Filter Strip Used in Agricultural Setting.
Image Source: University of Florida

In addition to being used as an agricultural practice, vegetated strips can be effective when used as a tool of Low Impact Development by treating sheet flow coming off impervious surfaces such as parking lots or roadways. Concentrated flow must be converted to sheet flow prior to entering a filter strip.

In Accomack, filter strips generally are broad and relatively flat . A level spreader on the down slope side of a filter strip can provide an opportunity for slight ponding and additional infiltration.

Above: Flow from parking area passes through filter strip prior to entering dry swale. Image Source: Virginia Department of Conservation and Recreation

By themselves, vegetated buffer strips can only treat low intensity rainfall events. The real value of buffer strips are as a best management practice when located upstream of other practices that have higher pollutant removals. An example would be a buffer strip to accommodate sheet flow prior to water entering a bioretention facility or into a stormwater management pond. By providing sediment and other pollutant removal as well as some infiltration prior to runoff entering a bioretention site, swale, or a stormwater pond, a filter

strip can reduce the amount of maintenance required on these other more complex installations and increase both their functionality and their lifespan. With respect to agricultural filter strips, they are often combined with practices such as contour plowing, conservation tillage, and nutrient management.

Areas that have runoff that typically contains higher concentrations of pollutants compared to most other types of stormwater runoff (such as runoff from a gas station) are not good candidates for filter strips and bioretention as it provides a greater potential for groundwater contamination.

Additional Resources:

- **Virginia Department of Conservation and Recreation. Virginia DCR Stormwater Design Specification – Sheet Flow to a Vegetated Filter Strip or Conserved Open Space.**
  http://vwrrc.vt.edu/swc/NonPBMPSpecsMarch11/DCR%20BMP%20Spec%20No%202_SHEET%20FLOW_Final%20Draft_v1-9_03012011.pdf

- **Virginia Department of Conservation and Recreation. Virginia Erosion and Sediment Control Handbook, Vegetated Filter Strip.**
  http://dcr.cache.vi.virginia.gov/stormwater_management/documents/Chapter_3-14.pdf

- **United States Environmental Protection Agency, Vegetated Filter Strip.**
  http://cfpub.epa.gov/npdes/stormwater/menuofbmps/index.cfm?action=factsheet_results&view=specific&bmp=76

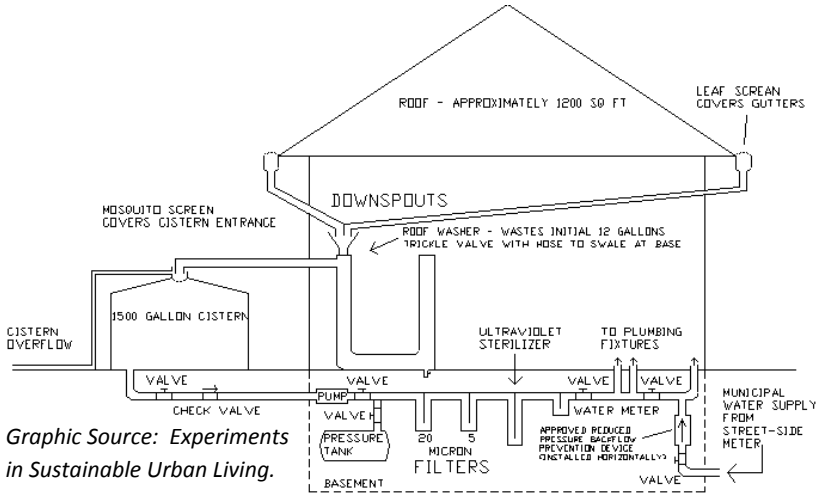
Cisterns/Rain Barrels

Cisterns and rain barrels collect rainwater for later use. Unlike relatively recent practices such as bioretention, they are not new technology. These practices are low cost devices that reduce runoff volume and can delay and reduce peak runoff rates. They provide a source of water for gardens and landscaping and can provide a source of water when it is needed rather than when it is collected from impervious surfaces.

Cisterns store rainwater in much larger volumes in tanks or underground storage. Sometimes rainwater collected in cisterns is also used for irrigation, water for livestock, toilet flushing, or groundwater recharge.

Rain barrels are commonly used in residential locations and are a low cost tool. Collection barrels are placed outside a building at roof downspouts to store rooftop runoff for later reuse in lawn and garden watering. Although they can be larger, most rain barrels commonly used to collect water from residential downspouts are generally less than 100 gallons each. Since cisterns and rain barrels are sources of standing water, care must be taken to ensure they do not become breeding grounds for mosquitoes.

Image Source: Live Green Lancaster



Graphic Source: Experiments in Sustainable Urban Living.

Additional Resources:

- **Virginia Department of Conservation and Recreation. Virginia DCR Stormwater Design Specification – Rainwater Harvesting.** http://vwrrc.vt.edu/swc/april_22_2010_update/DCR_BMP_Spec_No_6_RAINWATER_HARVESTING_Final_Draft_v1-8_04132010.htm

- **Virginia Department of Health. Rainwater Harvesting & Use Guidelines.** http://www.vdh.state.va.us/EnvironmentalHealth/ONSITE/gmp/documents/2011/pdf/GMP_154.pdf

- **Chesapeake Stormwater Network, Rainwater Harvesting.** http://chesapeakestormwater.net/training-library/stormwater-bmps/rainwater-harvesting/

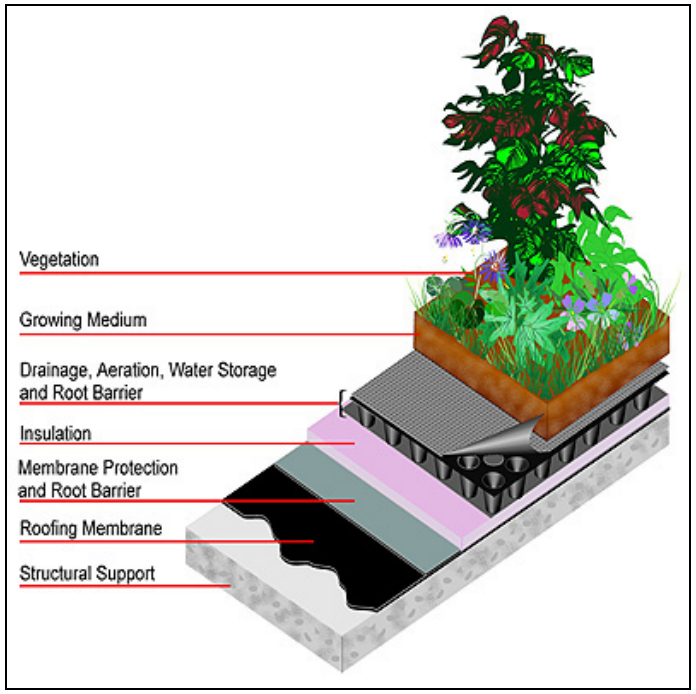
- **Urban Design Tools for Low Impact Development, Rain Barrels and Cisterns.** http://www.lid-stormwater.net/raincist_specs.htm

- **Live Strong, Ways to Keep Mosquitoes from Rain Barrels.** http://www.livestrong.com/article/272199-ways-to-keep-mosquitoes-from-rain-

Green Roofs – Green roofs are those that have been partially or fully covered in vegetation on top of the man-made roofing structure. The vegetation and soil are placed over a waterproofing membrane and other items such as root barriers, irrigation systems, and drainage systems may be incorporated as part of the green roof system.

Green roofs can be either ***intensive*** or ***extensive***. Extensive green roofs have a shallow growing medium, generally 2—6 inches. Intensive green roofs consist of deep growing medium greater than 6 inches that can support a full range of vegetation from groundcovers to large trees. It is intended to be self sustaining with little to no maintenance and requires less reinforcement of existing roofing when installed. The roof deck layer is the foundation of the roof and the type of roof will determine strength, load bearing capacity, and longevity of the system. Increasingly, roofs are being constructed with portable modular trays which may or may not be preplanted.

Green roofs can provide many environmental and economic benefits. Depending on rain intensity and soil depth, anywhere from 15 to 90% of runoff can be absorbed by the area it covers. This considerably reduces both the runoff and the potential pollutants from traditional building surfaces. Building energy costs can be reduced as the natural insulation property now provided by the roof leads to structures that are cooler in the summer and warmer during the winter and energy consumption is reduced. The evaporation of water held by the soil also adds in reducing roof surface temperatures.



Above: Layers of a typical green roof. Image Source: City of Toronto, CA.

Below: Extensive Green Roof, Image Source: University of Connecticut

In addition to being properly designed by a structural professional, green roofs should also incorporate a planting plan created by a landscape architect, botanist, or other profession with experience in green roofs. Plant species should be chosen based on sunlight conditions, ability to sow, water needs, plant hardiness zone and spreading rate. For a shallow green roof, the primary plants are low growing succulents such as *Sedum, Delosperma, Talinum, Semperivum* or *Hieracium*. Roofs can take at least one full growing season to become fully established.

Above: Green roofs are not limited to flat roofs as shown in this example. Image Source University of Minnesota.

Green roofs also insulate a building against external sound. Depending on the type of vegetation, it can provide habitat and food for birds and butterflies. A green roof also protects the existing roofing, reducing the number of roofing replacements required as well as waste from reroofing.

Top/Middle/Bottom: Example of an existing building in Toronto being retrofitted for a green roof with a combination of both intensive and extensive plantings with preplanted modular components. Image Source: Josephine Chan, ESRI Canada

Additional Resources:

- **Virginia Department of Conservation and Recreation, Vegetated Roof Design Specification.** http://vwrrc.vt.edu/swc/NonPBMPSpecsMarch11/VASWMBMPSpec5VEGETATEDROOF.html
- **United States Environmental Protection Agency, Green Roofs.** http://www.epa.gov/hiri/mitigation/greenroofs.htm
- **Chesapeake Stormwater Network, Bioretention.** http://chesapeakestormwater.net/training-library/stormwater-bmps/bioretention/
- **Virginia Tech News:** ***Green roof design may help control urban runoff*****.** http://www.vtnews.vt.edu/articles/2012/07/070312-caus-greenroof.html

Native Landscaping – Native landscaping involves the use of trees, shrubs, and groundcover that have developed or occurred naturally in an area. They are a hardy source for plantings as they have already adapted to local growing conditions and the local area will support this type of vegetation. Native plants resist local pests and disease.

Traditional gardens and landscaping have higher costs and impacts compared to native landscaping. According to the Environmental Protection Agency, a one-acre lawn costs $400 to $700 annually to maintain. The amount of air pollution from one hour of mowing with a gas mower is equal to that from driving 20 miles in a vehicle. Homeowners use pesticides at a rate of 10 times per acre over the amount used by farming. Beneficial species are inadvertent targets of pesticides. Improperly disposed pesticides have been found in detectable limits in 5% to 10% of wells. Nitrogen and phosphorus from fertilizers are the main pollutants in the Chesapeake Bay and a high amount of nitrogen from fertilizer makes its way into surface and groundwater.

With established native plantings and landscaping, maintenance costs are reduced as less money, if any, is needed since they do not need fertilizers, herbicides, pesticides, or watering. Native landscapes do not need to be mowed as would a conventional lawn which saves time and reduces harm from runoff of herbicides and pesticides. Native plants attract a diverse variety of wildlife such as birds, butterflies and other animals, which supports biodiversity in a community.

Native plantings and landscapes are a process of selecting the right plant for the right place. It requires selecting plants that thrive in the conditions while avoiding invasive plant species. Using a diversity of plants will provide more interest from season to season and more wildlife habitat. Dense layered plantings provide better water retention, greater air quality benefits and increase cooling. Perennials or annuals that have high rates of reseeding are best.

Plant ES Natives
They're Shore Beautiful!

The Plant ES Natives campaign was initiated by the Virginia Coastal Zone Management Program and participating partners through its Virginia Seaside Heritage Program. The campaign published a guide entitled *Native Plants of Accomack and Northampton* which highlights the benefits of using native plants locally. The guide provides information on native plants including grasses, shrubs, trees, vines, forbs, and ferns as well as local demonstration sites and information on plant care and conditions.

As part of the campaign banners have been distributed to participating local garden centers which identify them as native plant providers and campaign partners. Native plants have been tagged with unique tags also highlighting the program. The guide is available from project partners, local garden centers as well as online. Local plant suppliers are also on the site.

Several demonstration sites to fit a variety of sites have been created in Accomack and Northampton Counties. In Accomack County there is a Shady ES Native Plant Demonstration along the Chincoteague Island Nature Trail along Hallie Whealton Smith Drive, a Healing Garden ES Native Plant Demonstration at the Onley Rural Health Center on Badger Lane and another demonstration site is planned for Seaside Park in Wachapreague. In Northampton County there is a Living Shoreline ES Native in Oyster near the boat ramp for kayaks and canoes, a Maritime Forest ES Native Plant Demonstration at the UVA Anheuser Busch Coastal Research Center in Oyster, a Shoreline ES Native Plant Demonstration at the observation platform in Willis Wharf, a butterfly Native Plant Demonstration at the Northampton Free Library on Seaside Road in Nassawadox, and a Pollinator native Plant Demonstration at the Eastern Shore of Virginia National Wildlife Refuge.

Above and Below: From the Healing Garden ES Native Plant Demonstration, Onley Rural Health Center.

Additional Resources:

- **Virginia Coastal Zone Management Program: Native Plants of Accomack and Northampton.**
  http://www.deq.virginia.gov/Portals/0/DEQ/CoastalZoneManagement/esnativeplantguide_000.pdf

- **Virginia Department of Conservation & Recreation, Natural Heritage—Native Plants for Conservation, Restoration, and Landscaping (site includes brochures for Coastal Plain Native Plants and Riparian Native Plants)**
  http://www.dcr.virginia.gov/natural_heritage/nativeplants.shtml

- **U.S. Fish & Wildlife Service: Native Plants for Wildlife Habitat and Conservation Landscaping/Chesapeake Bay Watershed.**
  http://www.nativeplantcenter.net/guides/chesapeakenatives.pdf

- **Lady Bird Johnson Wildflower Center, Virginia Recommended.**
  http://www.wildflower.org/collections/collection.php?collection=VA

Tree Preservation and Planting - Trees and forests improve stream quality and watershed health primarily by decreasing the amount of stormwater runoff and pollutant. Trees and forests reduce stormwater runoff by capturing and storing rainfall in the canopy and releasing water into the atmosphere through evapotranspiration. In addition, tree roots and leaf litter create soil conditions that promote the infiltration of rainwater into the soil. This helps to replenish our groundwater supply.

The presence of trees also helps to slow down and temporarily store runoff, which further promotes infiltration, and decreases flooding and erosion downstream. Trees and forests reduce pollutants by taking up nutrients and other pollutants from soils and water through their roots, and by transforming pollutants into less harmful substances. In addition to these stormwater benefits, trees provide a host of other benefits such as improved air quality, reduced air temperatures in summer, reduced heating and cooling costs, noise and wind screening, increased property values, habitat for wildlife, and recreation and aesthetic value.

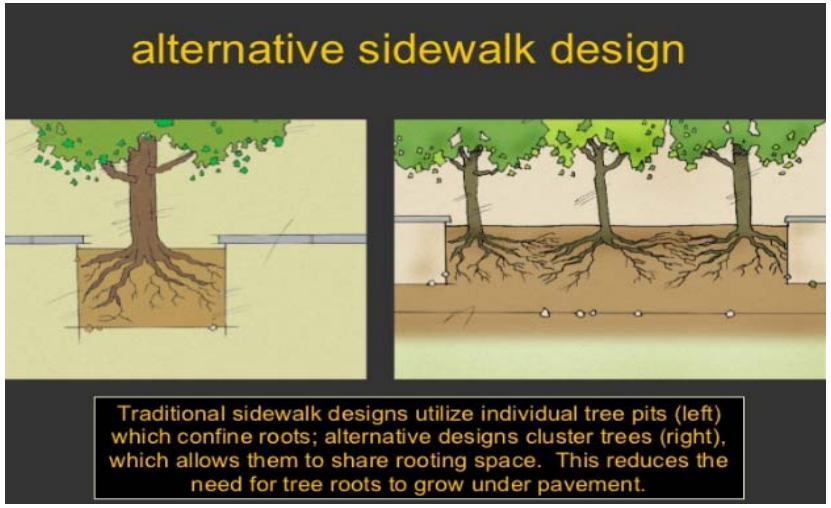
Established trees on a site when possible are normally preferable to planting new trees. The uptake of water is greater leading to reduced runoff, and the extensive roos system of established trees stabilize the soil and hold it in place. As less area is disturbed, costs for excavation and grading are reduced.

The *Virginia Erosion and Sediment Control Handbook* contains information on protecting trees during construction. Primary considerations are keeping the preserved trees protected from the trunk past the drip line of the tree. Construction activities such as fill and excavation, compacting the roots by driving heaving equipment over the root zone, and trenching through the root zone can be harmful to the tree. These activities could possibly destroy the benefits that preserving trees during construction were planned to provide.

Improper (Above) and Proper (Below) Tree Preservation During Construction. Image Sources: National Tree Preservation and Elkhart County Soil and Water Conservation District.

There are additional financial benefits of trees on sites. According to the U.S.D.A. Forest Service, just 20% shad on a street improves pavement conditions to increase time between required repaving. This amounts to a 60% savings in resurfacing costs over 30 years.

Along streets, tree boxes are mini bioretention filters can provide expanded space under sidewalks that with proper growing mediums would provide additional pollutant removal and infiltration.



Graphic Source: USDA Forest Service

Additional Resources:

- **Virginia Department of Conservation and Recreation. Erosion and Sediment Control Handbook, Tree Preservation and Protection.** http://dcr.cache.vi.virginia.gov/stormwater_management/documents/Chapter%203%20-%203.38.pdf
- **Virginia Tech, Stormwater Management: Using Trees and Structural Soils to Improve Water Quality.** http://urbanforestry.frec.vt.edu/stormwater/
- **Trees Virginia, Planning for Tree Preservation.** http://www.treesvirginia.org/joomla/treecare/Planning%20for%20Tree%20Preservation.pdf

Conservation Easements – A conservation easement protects property from certain development activities. The landowner achieves this by voluntarily placing a legally binding restriction on their deed restricting or limiting future development rights. The landowner maintains ownership of the property while the development rights are sold or donated to a government entity or a qualified conservation organization.

Typically a conservation easement allows a property to continue its current use in farming, forestry, or as open space but restricts development rights. These restrictions run with the land and are binding on future landowners. Other property rights not addressed under the easement such as hunting, maintaining a residence, etc, remain as they existed prior to the easement.

Conservation easements can be beneficial to preserving blue/green infrastructure as they preserve open space, keep the landscape and animal habitat from becoming further fragmented, protecting sensitive lands and provide mitigation opportunities to reconnect blue/green infrastructure hubs and corridors that have become fragmented. While not necessarily a tool of low impact development, it does provide an opportunity for someone who is not developing their property to potentially positively impact our blue/green infrastructure.

A conservation easement is a binding agreement with legal and tax implications for the property owner. Decisions to place property in an easement should be done in consultation with a combination of the following: attorney, accountant, and/or a qualified conservation easement appraiser.

As of 2012, there were just over 200 parcels in Accomack County with recorded conservation easements. This amounts to about 24 square miles or between 6% and 6.5% of privately owned land in Accomack. In order for a conservation easement to be valid and enforceable, the property and conditions must conform with the Accomack County Comprehensive Plan at the time the easement is granted. For example a conservation easement on property shown as appropriate for residential or commercial development on the Future Land Use Map could be in conflict with the Comprehensive Plan.

Additional Resources:

- **Virginia Department of Conservation and Recreation Office of Land Conservation.** http://www.dcr.virginia.gov/land_conservation/index.shtml
- **Virginia Department of Forestry Forest Legacy Program.** http://www.dof.virginia.gov/mgt/index-flp.htm
- **Virginia Outdoors Foundation.** http://www.virginiaoutdoorsfoundation.org/
- **Virginia Eastern Shore Land Trust.** http://www.veslt.org/
- **Code of Virginia Sections on Conservation Easements §10-1-1009 through 16.** http://leg1.state.va.us/cgi-bin/legp504.exe?000+cod+10.1-1009

Appendices

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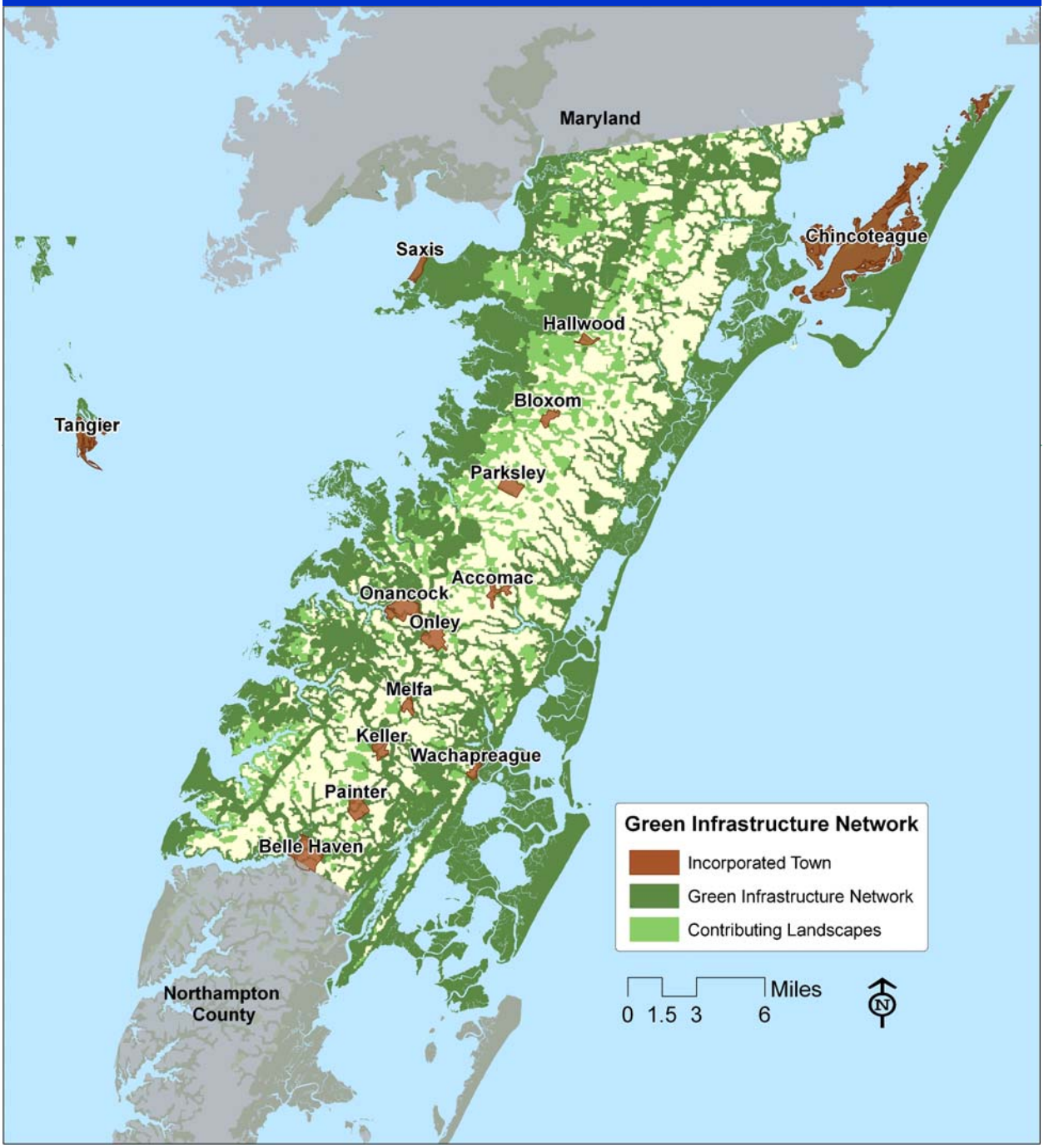
Accomack County

Blue and Green Infrastructure



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The following chart, prepared by the Center for Neighborhood Technology and American Rivers provides a quick reference on some different types of low impact development practices and the resulting benefits each may provide. *Source: [The Value of Green Infrastructure: A Guide to Recognizing Its Economic, Environmental and Social Benefits.] Center for Neighborhood Technology, 2010.*

Benefit	Reduces Stormwater Runoff				Increases Available Water Supply	Increases Groundwater Recharge	Reduces Salt Use	Reduces Energy Use	Improves Air Quality	Reduces Atmospheric CO_2	Reduces Urban Heat Island	Improves Community Livability					Improves Habitat	Cultivates Public Education Opportunities
	Reduces Water Treatment Needs	Improves Water Quality	Reduces Grey Infrastructure Needs	Reduces Flooding								Improves Aesthetics	Increases Recreational Opportunity	Reduces Noise Pollution	Improves Community Cohesion	Urban Agriculture		
Practice										CO_2								
Green Roofs	●	●	●	●	○	○	○	●	●	●	●	●	◒	●	◒	◒	●	●
Tree Planting	●	●	●	●	○	◒	○	●	●	●	●	●	●	●	●	◒	●	●
Bioretention & Infiltration	●	●	●	●	◒	◒	○	○	●	●	●	●	●	◒	◒	○	●	●
Permeable Pavement	●	●	●	●	○	◒	●	◒	●	●	●	○	○	●	○	○	○	●
Water Harvesting	●	●	●	●	●	◒	○	◒	◒	◒	○	○	○	○	○	○	○	●

● Yes ◒ Maybe ○ No

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COUNTY OF ACCOMACK
VIRGINIA