LID

Low Impact Development Manual

and stormwater reference manual

TOWN OF NAGS HEAD

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Working Together for a Healthy Coast

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Acknowledgements

In 2013, the Town of Nags Head began work with the N.C. Coastal Federation to develop a Low Impact Development manual as a reference document for local citizens and developers as part of Town efforts to improve stormwater management and as a technical resource for application of Town Stormwater regulations. This project is based on the LID manual for the coastal towns of Columbia, Cedar Point and Cape Carteret. The Town of Columbia worked in direct partnership with the N.C. Coastal Federation to complete an LID manual. The Town of Cedar Point worked in partnership with the Town of Cape Carteret, the N.C. Coastal Federation, engineering consultants WithersRavenel, N.C. Division of Water Quality and the LID Technical Review Team to complete the Cedar Point/Cape Carteret manual. We would like to thank these three communities and their partners for sharing their work and providing a model for us to follow.

In 2019, the Town of Nags Head initiated an update of the Low Impact Development Manual with assistance from the N.C. Coastal Federation to reflect modifications to the Town's residential stormwater management ordinance.

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Chapter 1

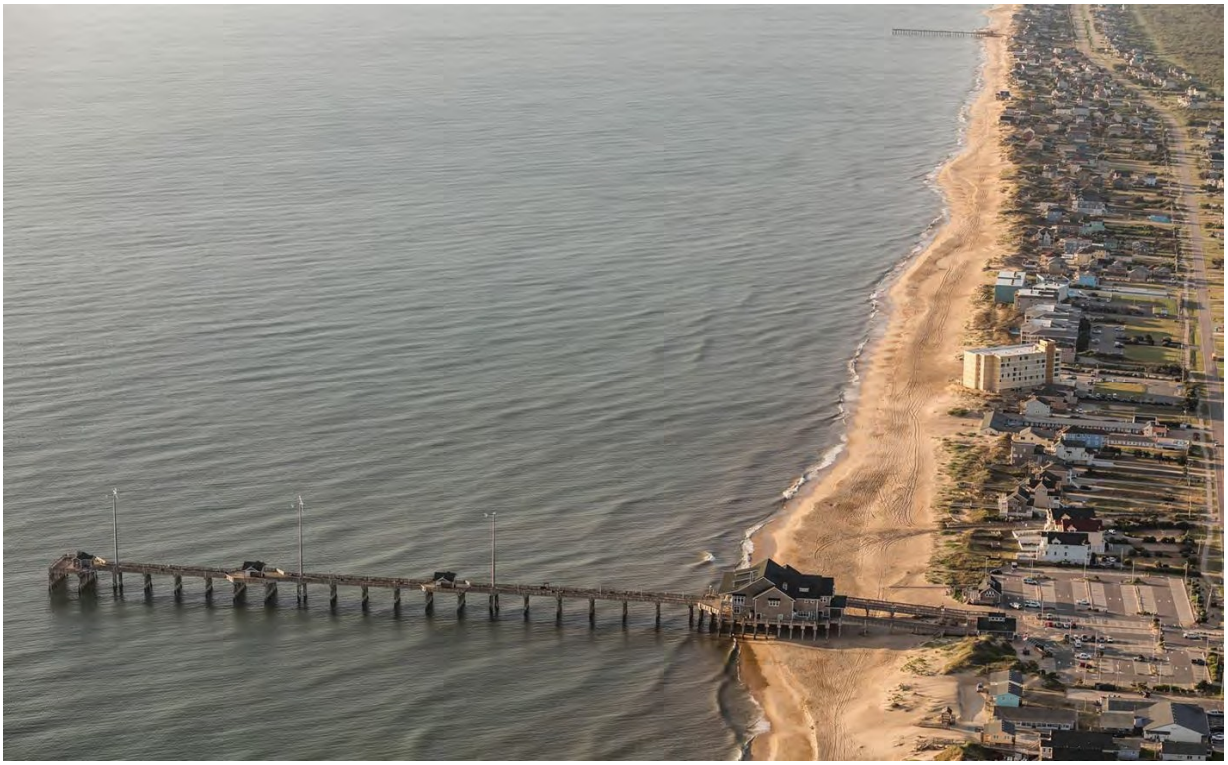
Introduction

The Town of Nags Head is a unique resort community that takes pride in its clean water, low density of development and vast open spaces. Residents and visitors alike rely on the Town's abundant water resources to live, work and play. Nags Head's economic prosperity is dependent on the availability and health of its water resources.

Due to the various ways we use our water, it is essential for us to protect our water resources. To achieve this goal, actively managing stormwater runoff is essential. An effective approach to managing stormwater runoff is through Low Impact Development (LID).

Town of Nags Head Facts

- Nags Head has 11 miles of oceanfront coastline and an equivalent amount of estuarine shoreline.
- Approximately 90% of the properties are developed.
- Approximately 50% of the developed properties were developed prior to 1980.
- About 55 miles of drainage infrastructure within the Town boundaries.
- Approximately 80% of the developed properties are served by on-site wastewater.



A view of the Nags Head oceanfront shoreline near Jennette's Pier (Photo credit: Great Lakes Dredge and Dock Company, LLC)

Background

The Town of Nags Head is located on Bodie Island, east of Roanoke Island in Dare County, North Carolina. The 6.7 square mile township is bounded by the Roanoke Island to the west, Atlantic Ocean to the east, Town of Kill Devil Hills to the north, and Cape Hatteras Seashore to the south. Incorporated in 1961, the Town of Nags Head has developed into a popular vacation destination. Over the last 40 years development within Nags Head has accelerated creating an increased burden on the Town's resources. As development occurs, the additional impervious surfaces create more stormwater runoff and less availability for infiltration into the surrounding sandy soils. The increase in stormwater runoff can contribute to roadway and property flooding as well as the degradation of the water quality of the surrounding waterbodies.

The existing stormwater drainage system for the Town relies heavily on (5) ocean outfalls maintained by the North Carolina Department of Transportation (NCDOT). The outfalls were originally constructed to provide drainage for ocean overwash events when the storm surge from the ocean overtops the dunes. As development has occurred, additional stormwater drainage systems were connected to the outfall. In most instances the outfall pipes were not designed to convey flows from the drainage systems that are currently connected to the outfalls.

The existing outfall system operation primarily serves as a mechanism to provide flood relief for roadways. However, providing flood relief by draining runoff towards surrounding waterbodies can degrade the water quality of the receiving waters as pollutants from impervious surfaces are conveyed through the stormwater outfalls.

Preserving water quality is critical to the Town of Nags Head as we strive to be good stewards of the environment in our mission "to provide for the health, safety and welfare of the citizens, property owners and visitors to the Town." In order to protect this vital resource, stormwater management strategies can be employed to reduce the volume of untreated stormwater discharging to receiving waters. Low Impact Development is a specific management strategy that can be applied to mitigate both flood related impacts and water quality treatment.

Figure 1.1 Town of Nags Head Map

Purpose

This manual is intended to provide a broad application of Low Impact Development techniques to new, existing and redevelopment sites. The level and types of applications will vary from site to site. It is intended to provide property owners, builders, developers and the general public with guidance on integrating LID at various scales. Stakeholders can use this manual as technical guidance to design, construct and maintain specific LID measures.

This manual can also be used as a reference for those who seek compliance with the provisions of the Town of Nags Head Unified Development Ordinance, Chapter 11, Environmental Regulations, Part 1 Stormwater, Fill and Runoff Management. To proactively manage stormwater and protect water quality, it will take the support of all stakeholders involved to successfully, communicate, coordinate and educate to implementing LID into the community.

Application of Manual

This document provides technical guidance on the application of LID practices as an acceptable approach to meet state and local stormwater management objectives. The information contained within the manual is intended as a starting point to provide guidance in the application of LID practices.

For new development and redevelopment projects requiring permits, this manual should be used in conjunction with applicable current local, state and federal laws, rules, codes, ordinances and standards.

Existing property owners and community members play a vital role in protecting the health and welfare of coastal water quality. This manual provides simple solutions that can be implemented on a lot by lot basis. Town staff can advise and assist property owners on smaller scale residential projects.

A view of the Nags Head oceanfront (Photo courtesy of Town of Nags Head)

Chapter 2

Stormwater Management

Clean water resources are essential to the economic vitality of Nags Head. Proper stormwater management is an essential component of water quality protection. Low impact development is the cornerstone of stormwater management and a mechanism to protecting our water resources.

Hydrologic Cycle

A key component to protecting water resources is to keep the water cycle in balance. The movement of rainfall from the atmosphere to the land and then back to the atmosphere is a naturally continuous process to humans and virtually all other forms of life. The balanced water cycle of precipitation, evapotranspiration, infiltration and groundwater recharge sustains Nags Heads vast but fragile water resources.

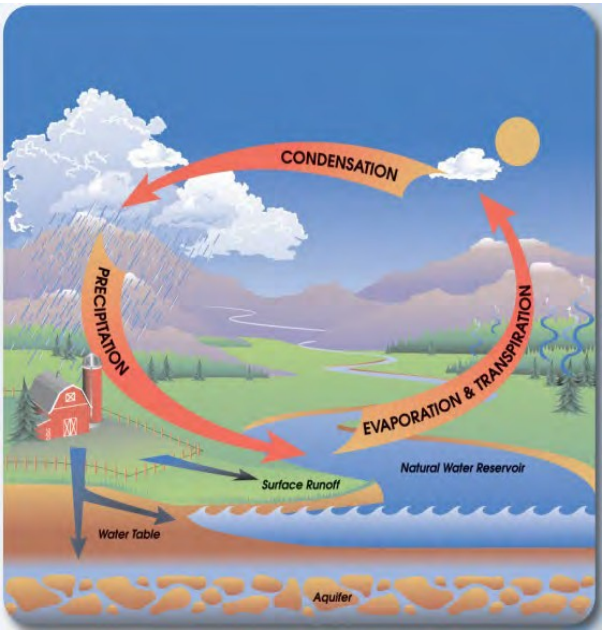


Figure 2.1 Water Cycle Graphics courtesy of the NC Wildlife Resources Commission

In the Town of Nags Head, most of the annual rainfall infiltrates, (soaks into), the underlying sandy soils. Infiltration is the result of precipitation percolating downward through the soil until it reaches the water table. The water table moves laterally and downgradient, through the influence of gravity, ultimately intersecting with channels, wetlands and surface waters.

Over half of the annual rainfall returns to the atmosphere through evapotranspiration. Surface vegetation, especially trees, transpire water to the atmosphere. Evapotranspiration rates for vegetation vary by season, with peak evapotranspiration rates occurring during the spring and summer growing season.

Land development and construction activities change the land surface and impacts the water cycle. Altering one component of the water cycle results in changes in other elements of the cycle. Impervious surfaces, such as roads, buildings and parking lots, prevent rainfall from infiltrating into the soil and significantly increases the amount of rainfall that runs off. Research shows that soil compaction resulting from land development activities produces a greater amount of runoff than pre-development conditions. When natural vegetation is removed, the amount of evapotranspiration decreases. As impervious areas increase, runoff increases and can result in the decrease of groundwater recharge.

Impacts of Development

Stormwater runoff is precipitation which sheds off improved or unimproved surfaces that is released into channels, wetlands, estuaries and surface waters. Problems related to stormwater runoff are most evident in developed areas. A change in the water cycle can have a dramatic effect on our

water resources. The impact is based on both the quantity and quality of stormwater runoff reaching our sounds and oceans.

When rain reaches the ground, it typically infiltrates into the soil until the point where the soil can become completely saturated. The infiltration process naturally filters the water before it settles into aquifers or makes its way as groundwater flow to estuaries, the sound, or the ocean. The sandy soils of the Outer Banks generally absorb rainfall efficiently into the ground. However, some periods of rainfall may exceed the ground's ability to collect and filter the water. Precipitation onto saturated ground can result in surfacing groundwater and localized flooding.

Development activities that result in the removal of trees and other vegetation can effectively reduce natural and passive stormwater measures such as evapotranspiration, (plant uptake). This can result in less absorption of precipitation into the ground, or used by plants, thereby increasing the potential for stormwater to concentrate and collect pollutants with discharges to the bodies of water that we depend on for food, income, and recreation.

Residential and commercial development can alter natural drainage patterns and increase impervious surfaces such as parking lots, driveways, or rooftops that do not absorb water. As precipitation falls and flows from an impervious surface, the runoff collects chemicals, oil, antifreeze and refuse from parking lots, or fertilizers, pesticides, and sediment from lawns and gardens. Runoff can also pick up loose soil or scour the ground, producing erosion. Sediment and silt carried by stormwater can impede drainage flow resulting in reduced system effectiveness.

Impervious surfaces are warmed by the sun. Runoff from warmed surfaces increase the temperature of water entering our estuaries,

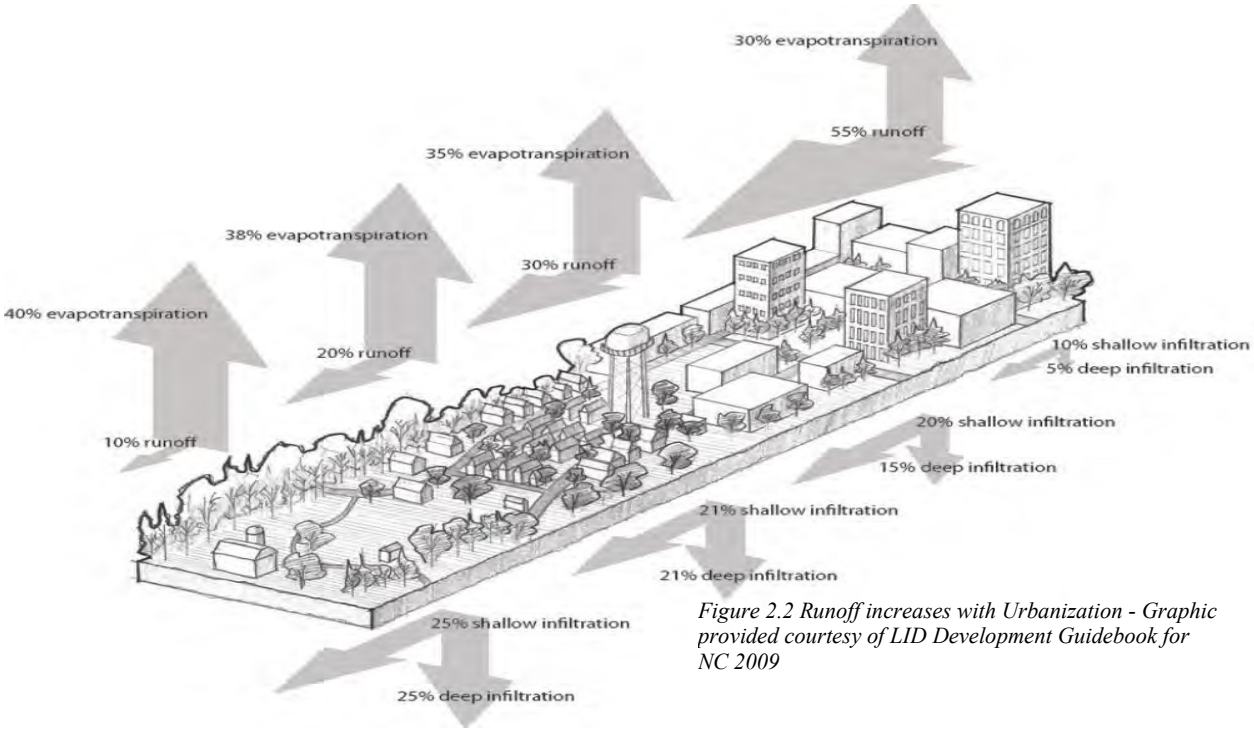


Figure 2.2 Runoff increases with Urbanization - Graphic provided courtesy of LID Development Guidebook for NC 2009

sounds and ocean. Erosive flows and increased water temperature will negatively impact the diversity of aquatic habitat.

Stormwater runoff can negatively impact water resources in many ways leading to diminished economic and recreational opportunities.

Low Impact Development

The term low impact development (LID) refers to systems and practices that are implemented in such a manner that the post-development hydrologic response mimics the predevelopment response (quantity, character and constituents). From a stormwater management perspective, LID is the application of techniques to emulate the natural water cycle. The basic principle is modeled after nature and manage rainfall runoff close to its source.

Low impact development techniques are based on the premise that stormwater is a resource and not to be quickly transported and disposed of. Instead conveyance/ management/ treatment in large costly end-of-pipe facilities, LID addresses stormwater through small, cost-effective and integrated landscape features that can be implemented at various scales.

With the change in land surface from construction and land development activities, not only does the peak runoff rate increase, but the total volume of runoff can dramatically increase. LID focuses on both peak rates and total volumes of runoff.

LID application techniques are designed to attenuate peak rates of runoff for larger storms and prevent runoff volume increases for more frequent smaller storms. Thus, natural flow patterns are kept in balance, minimizing the adverse impacts associated with stormwater runoff.

This manual focuses on Low Impact Development (LID) approaches to managing stormwater. LID uses techniques to capture and store stormwater as close to the source as possible to promote infiltration and treatment, thereby reducing runoff and the amount of pollution that runoff can convey. LID practices include site planning that provides small, decentralized management practices and approaches that are versatile and site specific.

LID Practices

Strive to replicate all components of the hydrologic cycle by:

- Minimizing total runoff volume
- Controlling peak runoff rate
- Maximizing infiltration and groundwater recharge
- Maximizing evapotranspiration
- Protecting water quality

For new development, an LID approach identifies natural features and strategically places buildings, driveways and parking areas advantageously to allow for a stormwater management system that works with existing natural features and drainages.

In redevelopment, LID includes forming an inventory of built and natural areas that can incorporate strategies and technologies to handle existing conditions and maximize infiltration in existing open space.

LID Principles

1. Focus on Prevention
   - Protect wetlands, floodplains and coastal habitats
   - Maintain slopes and flow paths
   - Minimize grading and tree clearing

2. Work with the Landscape
   - Identify environmentally sensitive areas
   - Outline a plan to protect those areas
   - Use hydrologic features of the site

3. Keep it Simple
   - Use low-cost approaches to decentralize run-off
   - Micromanage stormwater close to where it falls
   - Direct runoff from impervious surfaces to landscaped areas and other small scaled techniques for infiltration

4. Practice multi-tasking
   - Use landscaping for a variety of purposes. Landscapes can capture and treat pollutants and provide curb appeal
   - Distribute management practices on a site so that they work together to reduce runoff and associated impacts

5. Maintain and Sustain
   - Maintain LID features so that they remain effective and provide long-term success

Vegetated swale – Photo provided by the Town of Nags Head

Rainwater Harvesting – Photo provided by Town of Nags Head

Rain Garden – Photo provided by Town of Nags Head

Stormwater Control Measures (SCM)

Stormwater Control Measures (SCMs) are structural measures that are used to capture, control and treat stormwater runoff. Stormwater Control Measures and Best Management Practices (BMPs) are essentially interchangeable terms that describe techniques to manage stormwater.

An individual SCM or combination of SCMs can effectively treat and reduce pollutants contained within stormwater runoff. SCMs provide an effective and practicable means to meet water quality standards or goals by reducing the volume of stormwater runoff and concentration of pollutants contained therein when implemented as designed and appropriately maintained.

SCMs are physical structures that are designed to remove pollutants from stormwater runoff while simultaneously improving water quality, reducing flooding, erosion, and promoting groundwater recharge. An SCM can be designated either primary or secondary based on its level of Total Suspended Solid (TSS) removal. Primary or secondary SCMs can cooperate with each other to achieve more effective on-site stormwater management.

There is no single SCM that is suitable for every site, and one SCM might not provide the necessary measures to fully manage stormwater runoff in compliance with goals and regulations. Plus, unique land features or differences in development impact the effect of certain SCMs for proper stormwater management. There are different SCMs that are better suited for different aspects of stormwater management. The use of multiple SCMs and integration with the natural surroundings is highly recommended to meet stormwater management goals.

Grassed Swale – Photo provided by Town of Nags Head

Concrete Grid Pavers – Photo provided by Town of Nags Head

Infiltration Basin – Photo provided by Town of Nags Head

Chapter 3

Non-Structural Practices

Site Fingerprinting

A core concept of LID is managing stormwater runoff at the source by integrating site design and planning to preserve natural systems, protect open spaces, retain existing vegetation and maintain hydrologic functions. Site Fingerprinting is a practice that uses site design as a stormwater management tool by reducing land disturbance, preserving soil structure, and utilizing suitable natural areas (rather than expensive structural practices for runoff management). Rather than grading land to fit a desired development type, the type of development is dictated by the existing conditions of the site, resulting in a developed site which uses the land to maintain and protect the natural balance of the surrounding ecosystem.

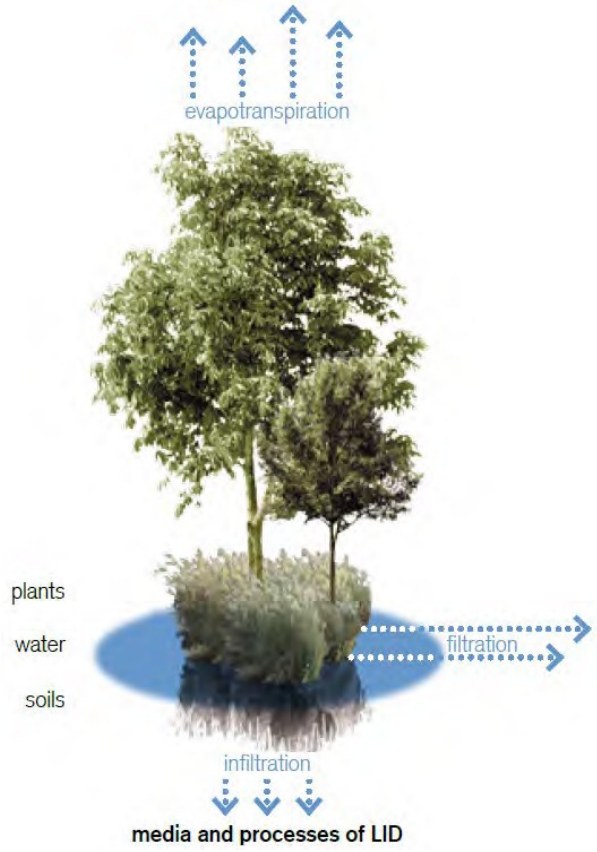
Site fingerprinting utilizes nonstructural Best Management Practices (BMP's) which take broader planning and design approaches that are less structural in nature. Examples of non-structural BMP's are:

Non-Structural BMP's

- **Cluster** development
- **Minimize** soil compaction
- **Minimize** disturbed areas
- Protect natural drainage pathways
- **Protect** riparian buffers
- **Protect** environmentally sensitive areas
- **Reduce** Impervious surfaces
- **Disconnect** stormwater connections

By fitting the development to the land, it is often easier to preserve existing vegetation, giving a more established look to new developments. Incorporating Site Fingerprinting into the site development planning process includes many benefits which include:

- Reduced land clearing costs,
- Reduced costs for total infrastructure,
- Reduced costs for stormwater management,
- Reduced runoff volumes discharged into our waterways, and
- Enhanced community and individual lot aesthetics.



Graphic courtesy of UACDC Low Impact Design a design manual for urban areas

Re-Routing Downspouts

A downspout or roof drainpipe is a vertical pipe that conveys rainfall runoff from roof gutter collection system. Typically, downspouts are directed to driveways or to a storm sewer system which conveys flow to either the Atlantic Ocean or the Roanoke Sound. By disconnecting your downspout and redirecting runoff to a landscaped area or lawn, you can create opportunities for infiltration reducing impacts to our vital water resources. Alternatively, roof runoff can also be directing into a rain barrel or a cistern. It is a simple and effective way to reduce stormwater runoff.

Additional benefits of downspout re-routing include:

- Reduced runoff volume and water quality impacts on downstream resource areas,
- Directs water to landscaped areas saving on the cost of irrigation,
- Can be combined with other SCM's to create an effective stormwater management plan, and
- It's cost effective.

Helpful Hints

Receiving Area length should be a minimum of half of the roof length that is directed to it.

Receiving Area width should be at least half of the overall length.

Avoid diverting runoff onto neighboring properties or onto your septic system or drainfield area**.**

Use pop-up emitters to disperse runoff onto landscaped areas.

Helpful Hints (continued)

Link downspouts to rain barrels or cisterns for rainwater harvesting.

Direct downspouts to areas where water can infiltrate into the ground such as lawns, and landscaped areas.

Receiving Area should be lower than the elevation around building foundation and graded at least 5 ft. from the dwelling.

Avoid adding downspout connections across a walkway, patio or driveway to avoid creating a tripping hazard**.**

Homeowners show how to add a diverter to redirect drainage from downspouts away from sidewalks and driveways towards lawns, natural areas, or rain gardens - photo courtesy of N.C. Coastal Federation

Living Shorelines

A Living Shoreline is a natural solution for shoreline erosion and protection. It also provides retrofits for common practices, such as bulkheads, which are temporary measures to combat shoreline erosion. A living shoreline system implements native marsh plants and sometimes oyster or rock sills to create a more natural and productive shore. It also provides a stabilization method for erosion with the changing tides and storms while simultaneously enhancing and preserving natural ecosystems. There are stormwater control measures that can benefit from living shorelines like backyard wetlands. A living shoreline is a secondary technique for a SCM. The protection of shorelines from erosion allows the native marsh vegetation and soils to reduce pollutant loads, help improve water quality though plant uptake and infiltration, and water filtration where oyster sills are in place.

Living Shoreline at the North Carolina Coastal Federation's office in Wanchese, NC, Photo courtesy of N.C. Coastal Federation

Several different techniques can be employed for the construction of a living shoreline This includes

- Hybrid techniques: Combination of structural and non-structural practices. (Example: Rock sills and edging, oyster sills)
- Non-structural techniques: implements native features of the land and vegetation. (Example: Planting native vegetation to marshlands, edging)

Helpful Hints

Wave Energy is a primary factor in determining living shoreline placement and type of technique, (i.e. hybrid or non-structural) to be employed.

Excessive wave energy may impede growth and development of newly planted vegetation.

Consider the type of technique to be employed how (i.e. hybrid or non-structural) and how it will be adapted to the existing landscape.

Use native vegetation when possible, to maintain natural habitat and features.

There are many benefits to utilizing living shorelines that include:

- Reduced erosion and wave energy
- Maintained natural marsh
- Protected coastal habitat
- Filtered and improved water quality
- Buffered shore for changing water levels

If considering a living shoreline please contact the N.C. Division of Coastal Management representative for permit guidance. The N.C. Coastal Federation or a licensed design professional can be an additional resource for design assistance.

Backyard Wetlands

Backyard wetlands are depressed wet areas that are planted with native wetland plants. They are well suited for areas that are usually wet for several days following a rain event. Backyard wetlands are designed to capture and treat stormwater similar to a rain garden but in locations with high-water tables and soggy soils. They are meant to mimic natural wetlands by using physical, chemical, and biological processes to treat stormwater. The temporarily stored stormwater will support emergent and riparian vegetation.

Constructed stormwater wetland in Manteo, NC, Photo courtesy of N.C. Coastal Federation

A man-made backyard wetland can provide the same benefit of natural wetlands providing an ideal, natural matrix that aids in pollutant removal and nutrient reduction. A wetland will temporarily store, filter, and clean runoff water from your roof, lawn, and other impervious surfaces reducing runoff peak flows, reducing velocities to adjacent natural wetlands, streams and surface waters.

Helpful Hints

Locate the backyard wetland away from high traffic areas and where it is not likely to attract unattended children.

Choose areas of your lawn that include naturally occurring wet spots for siting of the wetland**.**

Review existing state and local regulations for horizontal setbacks and to determine appropriateness of backyard wetlands**.**

Consider tributary drainage area being conveyed to backyard wetlands.

Ponding depth of the wetland should be no greater than 9 inches in depth.

Use native plants and vegetation that are suitable for saturated soil conditions. Utilize a diverse range of native plants to mimic a natural habitat. Transplanting of nursery stock obtained from a local aquatic plant nursery may yield the best results. Refer to *Common Wetland Plants of North Carolina or Seacoast Plants of the Carolinas* for reference.

Optimal planting period is between April to mid-June.

Maintain a stable groundcover adjacent to the wetland area to reduce sediment loads.

Aside from the water quantity and quality benefits, backyard wetlands can provide for an enhanced landscape feature and habitat for birds & butterflies.

If considering a backyard wetland please contact the N.C. Coastal Federation, Town of Nags Head or a licensed design professional for assistance.

Chapter 4

Non-residential Stormwater Management

Stormwater Management for Commercial, Mixed Use, and all Non-Single Family or Non-Duplex Residential development, including Multi-Family development is regulated by Article 11.4, Environmental Regulations of the Town of Nags Head Unified Development Ordinance. This section shall serve as a supplement to these set of regulations to provide technical guidance and specifically to describe design methods to calculate the level of control to meet the regulations set forth in Article 11.4.

Non-residential stormwater management differs from single-family residential individual lot development in that stormwater management plans and supporting technical documents shall be prepared by a qualified and registered design professional knowledgeable within the field of work for the performance of the design, construction, operation and function of the stormwater facilities. Development and redevelopment of property with commercial uses, mixed land uses or residential uses other than single-family or duplex residential uses require the submission of a stormwater management plan with the exception of the following:

- Is consistent with the zoning regulations of the UDO related to redevelopment & nonconformities;
- Does not result in the net gain of built upon area;
- Does not include the importation of any fill material;
- A stormwater retrofit for an existing property for flood mitigation limiting the import of fill to 12 inches or less.

All other development or redevelopment that results in a net gain in built-upon area requires the submission of a stormwater plan demonstrating that the stormwater runoff generated from the project's built-upon area shall be directed into an approved stormwater management system designed to accommodate the volume of runoff generated by a 4.3-inch design storm event.

The manual is intended to provide guidance in the selection of appropriate structural control measures (SCM's), design criteria to meet applicable stormwater regulations. However, this manual does not cover every situation or potential solutions. The design professional is responsible for exercising professional judgement when selecting, siting and designing SCM's to meet applicable local and state regulations. Additional guidance can be found at North Carolina Department of Environmental Quality Stormwater Design Manual, (NCDEQ 2017).

Designers should review state stormwater requirements for applicability. If greater than 10,000 sf of built upon area or greater than 1.0 ac. of land disturbance activities are proposed, state regulatory requirements may apply. For those cases where the developer is required to submit stormwater management applications to meet both local and state requirements, copies of the NCDEQ state approved plans in conjunction with fully executed operation and maintenance agreements shall be provided to the Town.

In general, if any part of this manual differs from any other ordinance, rule, regulation or provision of law, whichever provision that imposes the higher protective standard shall control.

Stormwater Management Calculations

Stormwater programs in North Carolina require high density development projects to treat to a design storm depth in a SCM. To size the SCM, the designer shall calculate the volume of runoff that will drain to it. Stormwater rules do not reference any specific calculation methods. This chapter provides technical guidance for stormwater calculation methods that are typically used at both the state and local levels.

Rational Method for Peak Flow

$$Q_p = C*I*A$$

Q_P= Peak Flow for design storm (cfs)
C = Composite runoff coefficient
I = Rainfall intensity for design storm (in/hr)
A = Drainage Area (ac.)

The peak flow is often calculated using the Rational Method. The composite runoff coefficient, C, reflects the runoff potential for the area. The range of runoff coefficients typically varies between 0.35 to 0.95, with the higher values representing the greater runoff potential. The composite runoff coefficient is the weighted average of all the land uses in the drainage area. Table 1 presents values of runoff coefficients for various surfaces.

Table 1: Rational Runoff Coefficients by Land Use (ASCE 1975,Viessman, et.al.1996, Malcom 1999)

Surface Description	Runoff Coefficient (C)
Unimproved Areas	0.35
Asphalt	0.95
Concrete	0.95
Brick	0.85
Roofs, inclined	1.00
Roofs, flat	0.90
Lawns, sandy soil, flat (<2%)	0.10
Lawns, sandy soil, avg. (2-7%)	0.15
Lawns, sandy soil, steep (>7%)	0.20
Lawns, heavy soil, flat (<2%)	0.15
Lawns, heavy soil, avg. (2-7%)	0.20
Lawns, heavy soil, steep (>7%)	0.30
Wooded Areas	0.15
Pervious Pavement	0.67
SCM urface Area	1.0

The rainfall intensity for stormwater management plans prepared to meet the Town of Nags Head requirements is 2.15 in/hr. The storm duration is 2 hrs. It should be noted that the Rational Method is the most applicable to drainage areas that are 20 acres or less.

Steps for using the Rational Method for Peak Flow:

Step 1: Delineate the tributary drainage area (**A**) that will be directed to the SCM, calculated in (ac.).

Step 2: Define the individual land use surface areas located within the boundaries of the tributary drainage area noted in **Step 1**.

Individual land use surface type descriptions are located in **Table 1.**

Step 3: Multiply the individual land use surface areas from **Step 2** by the associative land use runoff coefficient (unitless) shown in **Table 1.**

Step 4: Add the calculated values from **Step 3** and divide by the tributary drainage area (**A**) from **Step 1** to obtain the composite runoff coefficient (**C**).

Step 5: To obtain **Q** (cfs), multiply **C** (from **Step 4**), by **I** (2.15 in/hr), by A (from **Step 1**).

Step 6: To obtain the minimum required storage volume **Rv,** multiply **Q** (cfs) by the duration of the storm event. The Nags Head storm duration is 2 hrs or 7200 seconds.

Simple Method for Runoff Volume (Schueler 1987)

$$R_v = 0.05 + 0.9*I_A$$

Rv= Runoff coefficient (unitless)
I_A = Impervious fraction (unitless)

$$D_v = 3630*R_d*R_v*A$$

D_V = Design Volume (cu ft)
Rd = Design storm depth (in.)
A = Drainage area (ac)

An alternate and more simplified method for computing stormwater runoff is the Simple Method (Schueler 1987). The required information is as follows: (1) tributary area A (sf) that drains to a SCM, (2) the percentage of drainage area that is impervious (%), (3) the desired depth of rainfall targeted for capture. The Simple Method calculation process is as follows:

Step 1: Calculate the proposed imperviousness **I_A** of the proposed site development plan, (as a percentage or fraction)

Step 2: Multiply the impervious fraction **I_A** by 0.9 and add to 0.05 to calculate the runoff coefficient **R_V** (unitless).

Step 3: The design storm depth **R_d** for Nags Head is 4.3 in..

Step 4: Multiply the tributary drainage area **A** by the runoff coefficient **R_V** calculated in **Step 2** by the design storm depth 4.3 in. in **Step 3** by 3630 to obtain the design volume **D_V** (cu ft).

Step 5: The SCM volume shall be based on **D_V** or the minimum volume of runoff to be controlled.

Discrete NRCS Curve Number for Runoff Depth

$$S = 1000/CN - 10$$

S= Maximum retention after rainfall begins (in)

CN = Curve number (unitless)

$$Q = \frac{(P-0.2S)^2}{(P+0.8S)}$$

Q = Runoff depth (in)

P = Rainfall depth (in.)

The steps for using the Discrete NRCS Curve Number are as follows:

Step 1: Divide the tributary drainage area into land uses and assign the appropriate curve number **CN**, to each one (see Table 4). The **CN** characterizes the amount of runoff generated by a drainage area based on its USGS Hydrologic Soil Group (HSG) and ground cover.

Step 2: Refer to **Table 3** to obtain the CN curve number by HSG and associative land use cover.

Step 3: Multiply the individual land use areas from **Step 1** by the assigned land use **CN** by HSG described in **Step 2**.

Step 4: Add the calculated values from **Step 3** and divide by the total tributary drainage area **A** from **Step 1** to obtain the composite curve number **CN**.

Step 5: Calculate the maximum retention after rainfall begins **S** (in) by dividing curve number **CN**-10 into 1000

Step 6: The rainfall depth **P** for Nags Head is 4.3 in.

Step 7: Compute the runoff depth **Q** by inputting the results of **Step 5 S** maximum retention after rainfall begins and **Step 6 P** into the Runoff Depth equation.

Step 8: Find the runoff volume by multiplying **Q** runoff depth from Step 7 times the tributary area **A** (sf) and dividing by 12.

Table 2: Hydrologic Soil Groups

Soil Group	Description
A	Low runoff potential and high infiltration rates even when thoroughly wetted. Consist chiefly of deep, well to excessively drained sand or gravel and have a high rate of water transmission (greater than 0.30 in.hr). The textures of the sand are typically sand, loamy sand or sandy loam.
B	Moderate infiltration rates when thoroughly wetted and consist chiefly of moderately deep, well drained soils with moderately fine to moderately coarse texture. These soils have a moderate rate of water transmission (0.15-0.30 in/hr). The textures of these soils are typically silt loam or loam.
C	Low infiltration rates when thoroughly wetted and consist chiefly of soils with a layer that impedes downward of water and soils with moderately fine to fine texture. These soils have a low rate of water transmission (0.05-0.10 in/hr). The soil texture is typically sandy clay loam.
D	High runoff potential and low infiltration rates when thoroughly wetted and consist chiefly of clay soils with a high swelling potential, soils with a permanent high water table, soils with a clay layer at or near the surface and shallow soils over nearly impervious material. These soils have a very low rate of water transmission (0.0-0.05 in/hr). The textures of these soils are typically clay loam, silty clay loam, sandy clay, silty clay, or clay.

Additional information related to Hydrologic Soil Group can be referenced from the Soil Survey of Dare County, North Carolina, USDA SCS, March 1992

Table 3: Urban areas runoff curve numbers for SCS method by HSG

Cover Description	Curve Number by HSG			
	A	B	C	D
Fully developed urban areas				
Open space (lawns, parks, golf courses, etc.)				
Poor condition (<50% grass cover)	68	79	86	89
Fair condition (50%-75% grass cover)	49	69	79	84
Good condition (>75% grass cover)	39	61	74	80
Impervious Areas:				
Paved parking lots, roofs, driveways, etc.	98	98	98	98
Streets and roadways:				
Paved; curbs and storm sewers	98	98	98	98
Paved; open ditches	83	89	98	98
Gravel	76	85	89	91
Dirt	72	82	85	88
Developing urban areas				
Newly graded areas	77	86	91	94
Pasture (<50% ground cover or heavily grazed)	68	79	86	89

Pasture (50%-75% ground cover, moderately grazed)	49	69	79	84
Pasture (>75% ground cover, lightly grazed)	39	61	74	80
Meadow- continuous grass, protected from grazing, mowed for hay	30	58	71	78
Brush (,50% ground cover)	48	67	77	83
Brush (50% to 75% ground cover)	35	56	70	77
Brush (>75% ground cover)	30	48	65	73
Woods (forest litter, small trees and heavy grazing or regular burning)	45	66	77	83
Woods (some forest litter covering soil w/ moderate grazing but not burned, some	36	60	73	79
Woods (litter and brush cover the soil, no grazing)	30	55	70	77

Methodologies for Peak Runoff Rates

Many methodologies have been developed to estimate peak runoff rates and total runoff volume from land surfaces under many conditions. This Chapter describes methods that are most widely used in the State of North Carolina. This is not a complete list of procedures nor is it intended to discourage using alternative methods as they become available.

Additional Design Considerations

There are numerous factors that the designer should consider when undertaking a stormwater management plan in the coastal environment. These design factors should include, but are not limited to: pre-development conditions, topography, seasonal high water table and soil wetness conditions, site layout, impervious coverage, vegetative surface cover, environmental setbacks, grading, stormwater overflow, etc. Most of these items area covered within Article 11-Envirnmental Regulations -Part I Stormwater, Fill and Runoff Management. Several technical factors should be considered as part of the stormwater management planning process are not specifically noted in this Article of the Unified Development Ordinance. Additional guidance is provided below.

Storage capacity (interstitial storage) within existing soils and/or fill material shall not be counted towards the volume requirement for the stormwater management design. This is consistent with the standards for residential stormwater management plan development and with the NCDEQ Stormwater Design Manual. Interstitial storage calculations shall only be used to demonstrate excess storage above and beyond the local stormwater volume control requirement.

Site development proposals that include "piping in" of existing open drainage channels shall include design calculations that consider upstream tributary drainage areas for appropriate sizing of storm drainage infrastructure. All drainage facilities shall be encompassed within drainage easements to permit for maintenance activities.

Off-site flows into Town rights-of-ways or existing Town maintained drainageways shall provide supporting calculations demonstrating that post-development project outflows do not exceed pre-development project outflows OR a downstream analysis of existing facilities demonstrating that it can accommodate the proposed additional flows.

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Glossary

Annual plant - A plant that completes its entire life cycle in a single growing season.

Aquifer- A stratum of rock or soil that contains groundwater.

Base flow — Water flow in a stream or man-made channel between rainfall events. The source of the water flow is supplied by groundwater.

Best Management Practice (BMP) – Methods, measures or a practice or a combination of practices to prevent or reduce water pollution. Examples include treatment techniques, operating procedures, erosion control practices, fertilizer and animal waste management and runoff control.

Bioretention area — A water quality practice that utilizes landscaping and soils to treat stormwater bycollecting it in shallow depressions and then filtering it through aplanting soil media. (Also see rain garden.)

Buffer - An area of trees, shrubs and plants next to a waterbody that provides a permanent barrier against runoff from development, construction and other land uses. Buffers are designed to filter and protect the receiving waterbody from sediment and pollutants contained in storm water runoff. Buffers also function as habitat for migratory birds and aquatic and terrestrial wildlife.

Built Upon Area - means that portion of a development project that is covered by impervious materials or partially impervious surfaces and used to calculate stormwater runoff potential, including buildings; pavement and compacted gravel areas such as roads or parking lots, and paths and recreation facilities such as athletic courts and concrete pool decks. Built-upon area does not include the surface area of pools, wooden slatted decks, or un-compacted, washed gravel, or pervious or partially pervious paving material to the extent that the paving material absorbs water or allows water to infiltrate through the paving material. Built-upon area is distinct from "lot coverage" as defined herein.

Channel- means a natural or artificial watercourse with a definite bed and banks that conducts continuously or periodically flowing water.

Check dam - A small barrier built across the direction of water flow in a channel to retain excess water during heavy rains and toslow the speed of runoff traveling through the channel.

Deciduous plant - A plant that sheds or loses its foliage at the end of each growing season.

Detain (detention)- The temporary storage of stormwater prior to controlled release as runoff. (Contrast with retention.)

Disconnected impervious surfaces - Integration of treatment and management measures into developed areas to remove the links between hardscaped areas such as driveways, walkways, parking areas with the strategic placement of distributed lot-level controls that can be customized to more closely mimic a watershed's hydrology.

Ecosystem — An interactive system that includes the organisms of a natural community together with their abiotic, physical, chemical and geochemical environment.

Easement - A right, such as a right-of-way, afforded a person to make limited use of another's real property.

Estuary — Brackish-water area influenced by the tides where the mouth of the river meets the sea. Estuaries are breeding grounds for many species of fish and shellfish.

Evergreen plant - A plant that remains green and retains its foliage throughout the year.

Fecal coliform bacteria — Bacteria that are present in the intestines or feces of warm-blooded animals. The potential for contracting diseases from pathogens can be determined by testing for an "indicator" organism such as coliform bacteria. Testing of surface waters for coliform bacteria are often used as a measure of safe water quality levels.

Floodplain — Land areas adjacent to water courses, rivers or water bodies subject to recurring inundation.

Forebay — Stormwater design feature that uses a small basin to settle out incoming sediment delivered in runoff to a stormwater BMP.

Geographic information systems (GIS) — A computer system for capturing, storing, checking, integrating, manipulating, analyzing and displaying data related to positions on the Earth's surface. Typically, GIS is used for handling maps of one kind or another. These might be represented as several different layers where each layer holds data about a particular kind of feature (i.e. roads, waterbodies, etc.). Each feature is linked to a position on the graphical image of a map.

Groundwater - Water below the earth's surface, typically in aquifers, that supplies drinking wells and springs. Runoff can seep into the soil and recharge groundwater supplies.

Habitat - The specific area or environment where a plant or animal lives. A habitat must provide all of the basic requirements for life (food, water, shelter) and should be free of harmful contaminants and pollution.

Hydrologic Soil Group (HSG) - means a Natural Resource Conservation Service (NRCS) classification system in which soils are categorized into four groups of infiltration potential. The groups range from A soils, with high permeability and little runoff production, to D soils, which have low permeability and produce much more runoff.

Hydrology — Movement and distribution of groundwater and surface water in a system.

Impervious surface - Any hardened surface improvement that water cannot penetrate into (i.e. parking lots, streets, sidewalks, rooftops).

Infiltration – The process by which water drains or seeps into the soil matrix from the ground surface.

Infiltration Device - Any structure or measure designed to infiltrate retained water to the subsurface. These facilities may be above grade or below grade.

Land Use - The way land is used or developed, such as the types of buildings and activities permitted. Particular land uses are often associated with different types of pollution, such as erosion and sedimentation from construction activities.

Lot Coverage - means that portion of the lot area, expressed as a percentage, that is covered or occupied by impervious surfaces or structures. For the purposes of determining lot coverage, the following features shall be considered impervious: any principal or accessory use or structure located above the ground including decks; parking areas; vehicular use areas; roadways; access ways; and sidewalks or walkways that prevent the infiltration of rainwater. Lot coverage is utilized to determine zoning compliance and is distinct from the amount of built upon area used in stormwater management calculations.

Low impact development (LID) - Low impact development is an innovative stormwater management approach with a basic principle that is modeled after nature: manage rainfall at the source using uniformly distributed decentralized micro-scale controls. LID's goal is to mimic a site's predevelopment hydrology by using design techniques that infiltrate, filter, store, evaporate, transpire and detain runoff close to its source.

Mimic – Significantly equivalent in nature.

Mitigation - Actions taken to avoid, reduce, or compensate for the effects of human-induced environmental damage.

Native plant — A plant that naturally occurred in an area before disturbance by humans. Native plants are adapted to the weather, temperature and soil conditions of this region. Native plants require less (if any) fertilizers, pesticides or irrigation and tend to be disease and drought-tolerant.

Nonpoint source pollution (NPS) – Pollution that enters water bodies from a variety of sources. NPS pollution is caused by runoff from rainfall or snowmelt that moves over and through the ground, washing natural and human-made pollutants into surface waters and underground sources of drinking water Typical NPS pollutants are pet waste, lawn fertilizer, pesticides, car washing detergents, litter and sediment.

Nutrient — Substances such as nitrogen and phosphorous that are required by plants and animals for growth. In some circumstances, excessive nutrient additions to surface waters may result in excessive algal or plant growth and, subsequently, the accumulation and decay of increased organic matter.

Open Space - A vegetated, unoccupied, space open to the sky, without vertical structures or surfaces covered with pavements or other relatively impervious materials.

Outfall — Is a discharge point of stormwater system that exits the system and flows into a body of water. Outfalls include discharges from pipes, ditches, swales and other points of concentrated flows.

Pathogen - A disease-causing organism (viruses, bacteria, or fungi can be pathogenic organisms)

Perennial plant - A plant that grows and persists for more than one year. Perennial plants persist as vegetation from year to year or re-sprout from their rootstock annually.

Permeable - Soil or other material that allows the infiltration or passage of water or other liquids. This term is typically interchangeable with the term pervious.

Pervious paving – Is a stormwater control system that captures stormwater through voids in the pavement surface and filters water through an underlying aggregate reservoir. The reservoir can either infiltrate into the underlying soil subgrade or be designed to detain and release water to a stormwater conveyance system. Water-pervious materials such as a washed aggregate, concrete grid pavers, pervious concrete or pervious paving blocks for driveways, parking areas, walkways, and patios that minimize runoff from those areas, as well as increase infiltration.

Point source pollution - Pollution that can be traced to a single point, or output, such as a pipe.

Pollution - Any substance that exists in the environment that is undesirable or harmful for that environment.

Rain garden — A rain garden is a shallow depression planted with native plants, flowers or grass that captures and infiltrates rain before it becomes polluted runoff.

Receiving waters — Creeks, streams, rivers, lakes, estuaries and other bodies of water into which stormwater is discharged to.

Recharge – The downward movement of water through the soil matrix to below the limits of active evapotranspiration effects.

Retain (retention) – To facilitate full infiltration and/or evapotranspiration of stormwater, not allowing runoff.

River basin - Area encompassing all the land drained by streams and creeks flowing downhill into a major river. All water that falls within the basin flows into these streams and rivers.

Runoff -Water flowing across the land that does not infiltrate the soil, but drains into surface or groundwater, or when rainfall exceeds the infiltration capacity of the land.

Runoff volume - The volume of water that runs off the land development project from a prescribed storm event.

Sedimentation - Particles of soil, sand, silt, clay, or organic matter that are deposited onto the bottom of any surface water or are left behind when water leaves. Sedimentation often originates from land disturbance activities associated with construction sites or where bare land surfaces exist.

Storm drainage system – A network of structures, channels and underground pipes built to collect and transport runoff to streams, ponds, lakes, rivers and other water bodies. Storm drainage systems are completely separate from those that carry domestic and commercial wastewater (sanitary sewer system).

Stormwater Control Measures (SCMs) - "Stormwater Control Measure" or "SCM," also known as "Best Management Practice" or "BMP," means a permanent structural device that is designed, constructed, and maintained to remove pollutants from stormwater runoff by promoting settling or filtration; or to mimic the natural hydrologic cycle by promoting infiltration, evapotranspiration, post-filtration discharge, reuse of stormwater, or a combination thereof

Stormwater Management - The use of structural or nonstructural practices to

manage one or more components of hydrologic response (quantity, constituents, and character) from stormwater inputs**.**

Surface water — The water that rests on top of the earth in streams, lakes, rivers, oceans and reservoirs and is open to the atmosphere (i.e. rivers, lakes, creeks, streams, etc.).

Swales - Minor channels usually lined with grass used to transport runoff from less developed areas.

TMDL — Total maximum daily load is the calculation of the maximum amount of pollutants that a waterbody can receive and still meet water quality standards.

Tributary - A stream that flows into a larger stream or other body of water.

Water Cycle - The cycle in which water evaporates from surface waters, condenses into clouds, and falls again to the earth as rain or other forms of precipitation**.**

Water Quality — The biological, chemical and physical conditions of a waterbody; a measure of the ability of a waterbody to support designated uses.

Water Table – The depth at which the ground is saturated with water**.**

Watershed - Ecosystem consisting of three major components—stream channel, floodplain, and upland areas—that function together and drain to water bodies, including lakes, rivers, estuaries, wetlands, streams, and the surrounding landscape (groundwater recharge areas are also considered).

Wetland - Land whose soil is saturated with moisture either permanently or seasonally. They are generally distinguished from other water bodies or landforms based on saturated soil conditions for a period of time long enough season each year to support aquatic plants.

Web Resources

Rainwater Harvesting

NC Department of Environmental Quality *Stormwater Design Manual, Part C-7 Rainwater Harvesting* *https://deq.nc.gov/about/divisions/energy-mineral-land-resources/energy-mineral-land-permit-guidance/stormwater-bmp-manual*

North Carolina Coastal Federation, Smart Yards- Simple DIY Solutions: Rain Barrels, 2017 *https://www.nccoast.org/wp-content/uploads/2017/09/SmartYards_07-17.pdf*

Town of Nags Head Recommended Standard Details Manual- Rain Barrel- Detail 505 https://www.nagsheadnc.gov/938/Recommended-Standard-Details-Manual--Sto

Re-routing Downspouts

North Carolina Coastal Federation, Smart Yards- Simple DIY Solutions: Re-routing Downspouts, 2017 *https://www.nccoast.org/wp-content/uploads/2017/09/SmartYards_07-17.pdf*

NC Department of Environmental Quality *Stormwater Design Manual, Part C-10 Disconnect Impervious Surfaces* *https://deq.nc.gov/about/divisions/energy-mineral-land-resources/energy-mineral-land-permit-guidance/stormwater-bmp-manual*

North Carolina Cooperative Extension, Disconnect for Rainwater Dispersal, 2012 *https://wrri.ncsu.edu/docs/partnerships/bcwa/2.DISCONNECT.pdf*

Vegetated Swales

NC Department of Environmental Quality *Stormwater Design Manual, Part C-1 Infiltration Systems* *https://deq.nc.gov/about/divisions/energy-mineral-land-resources/energy-mineral-land-permit-guidance/stormwater-bmp-manual*

North Carolina Cooperative Extension, *Low Impact Development, A Guidebook for North Carolina, Swales* *http://www.onsiteconsortium.org/npsdeal/NC_LID_Guidebook.pdf*

North Carolina State University, NC State Extension, *Swale Terminology for Urban Stormwater Treatment, 2020,* *https://content.ces.ncsu.edu/swale-terminology-for-urban-stormwater-treatment*

Rain Gardens

North Carolina Cooperative Extension, Backyard Rain Garden,2014 https://forsyth.ces.ncsu.edu/wp-content/uploads/2016/03/RGmanual2015.pdf?fwd=no

North Carolina State Stormwater Engineering Group, *https://stormwater.bae.ncsu.edu/ search rain gardens.*

North Carolina Coastal Federation, Smart Yards- Simple DIY Solutions: Rain Gardens, 2017 https://www.nccoast.org/wp-content/uploads/2017/09/SmartYards_07-17.pdf

Contact your local nursery or Dare County Cooperative Extension for more assistance

Infiltration Trenches

NC Department of Environmental Quality *Stormwater Design Manual, Part C-1 Infiltration Systems https://deq.nc.gov/about/divisions/energy-mineral-land-resources/energy-mineral-land-permit-guidance/stormwater-bmp-manual*

North Carolina Cooperative Extension, Low Impact Development, A Guidebook for North Carolina, Infiltration Trench http://www.onsiteconsortium.org/npsdeal/NC_LID_Guidebook.pdf

Susdrain, *Component Infiltration trenches: https://www.susdrain.org/delivering-suds/using-suds/suds-components/infiltration/infiltration_trench.html*

Living Shorelines

North Carolina Coastal Federation, Smart Yards- Simple DIY Solutions: Living Shorelines, 2017 https://www.nccoast.org/wp-content/uploads/2017/09/SmartYards_07-17.pdf

North Carolina Coastal Federation, *Living Shorelines, https://www.nccoast.org/protect-the-coast/estuarine-shorelines/*

Living Shorelines Academy, *https://www.livingshorelinesacademy.org/index.php*

Virginia Institute of Marine Science (VIMS)-Living Shoreline Summit Presentations, 2006 https://www.vims.edu/cbnerr/coastal_training/recent_workshops/ls_summit.php

National Oceanic and Atmospheric Administration (NOAA) Living Shorelines Workgroup,2015, *https://www.habitatblueprint.noaa.gov/wp-content/uploads/2018/01/NOAA-Guidance-for-Considering-the-Use-of-Living-Shorelines_2015.pdf*

References

Currituck County *Stormwater Manual,* December 2017

Town of Nags Head *Stormwater Management Plan Volume II: Technical Report,* 2006

Southeast Michigan Council of Governments*, Low Impact Development Manual for Michigan, A Design Guide for Implementors and Reviewers,* 2008

North Carolina Cooperative Extension*, Low Impact Development A Guidebook for North Carolina,* 2009

North Carolina Department of Environmental Quality *Stormwater Design Manual,* 2017.

North Carolina State University*, Low Impact Development Fast Track Certification,* February 2011

Town of Nags Head *Recommended Standards Detail Manual,* 2019

Town of Cedar Point/Town of Cape Carteret *Low Impact Development (LID) Manual,* 2010

Georgia Department of Natural Resources, *Green Growth Guidelines*, 1st Edition, 2011

Urban Land Institute, *Environment and Development, Myth and Fact*, 2012

North Carolina Coastal Federation*, Low Impact Development: https://www.nccoast.org/protect-the-coast/restore/low-impact-development/*

Additional Resources

NC Water Resources Research Institute: https://wrri.ncsu.edu

NC Cooperative Extension: https://www.darenc.com/departments/planning/soil-and-water/rain-garden-information

Low Impact Development Center: http://www.lowimpactdevelopment.org/resources

North Carolina State University Stormwater Engineering Group*: https://stormwater.bae.ncsu.edu/*

FORMS

Residential Stormwater Checklist

Residential Stormwater Checklist

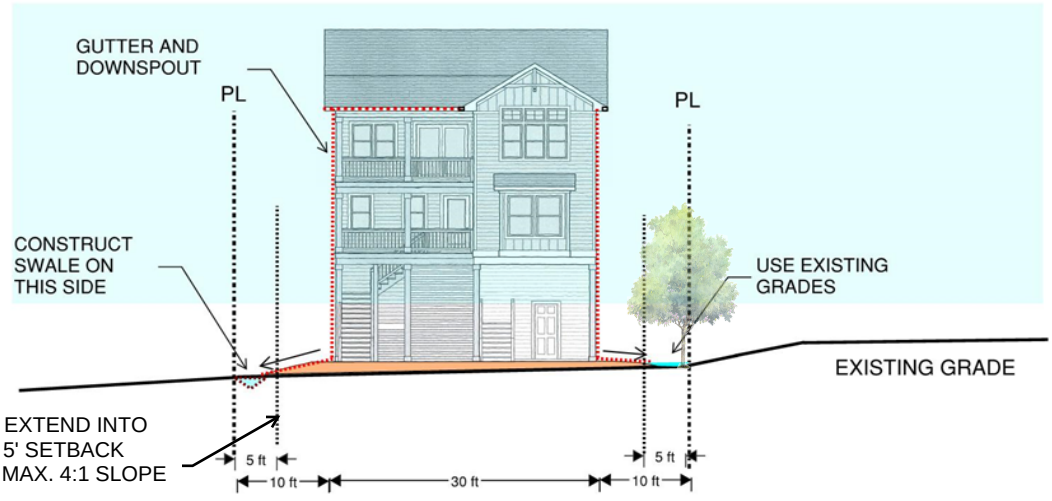
All new residential development on individual lots, and redevelopment of 500 square feet or more of new impervious area require a stormwater management plan. The stormwater plan shall be submitted as part of the application for a land disturbance or building permit. In addition to the information listed on the Minimum Required Survey Information which can be found in Appendix A, please identify the following information on your site plan/survey:

- ☐ **Direction of flow of stormwater runoff under existing conditions.**
- ☐ **Location of areas on site where stormwater collects or infiltrates into the ground.**
- ☐ **Approximate elevation of the seasonal high water table.**
- ☐ **Proposed vegetation to be preserved, or planted.**
- ☐ **Proposed stormwater improvements, and their size.**
- ☐ **Erosion and Sediment control measures.**

What are my options for creating a stormwater management plan?

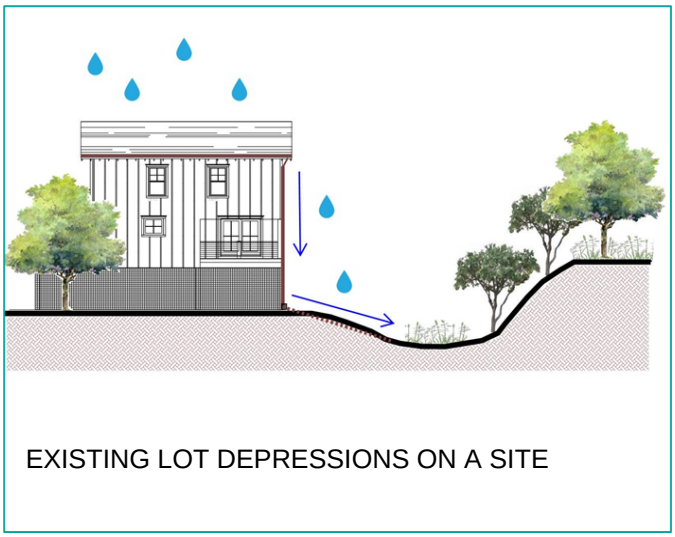
It depends on your site. You may be able to take advantage of existing mature vegetation, adjacent grades, and in some cases, stabilized open space areas not associated with a septic system. You may need to contruct a stormwater improvement.

For example:

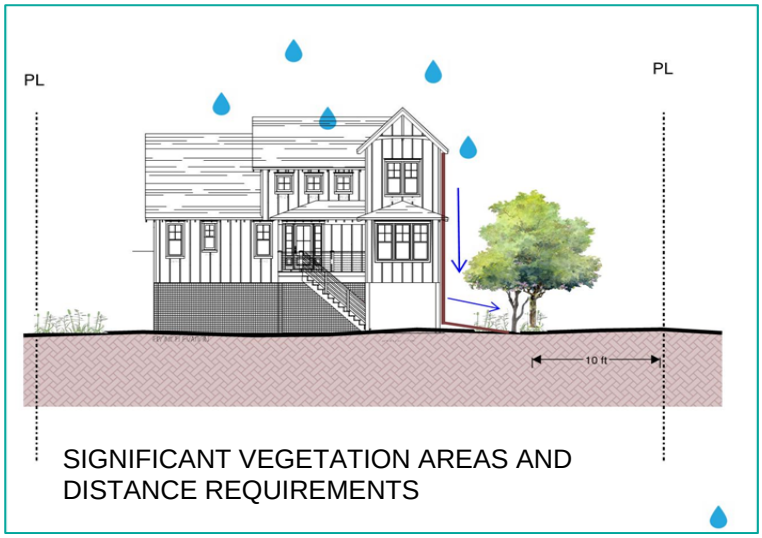


R-2 South Old Oregon Inlet Road
Example with New Ordinance
Approx 7" - 1.25' Fill for house pad

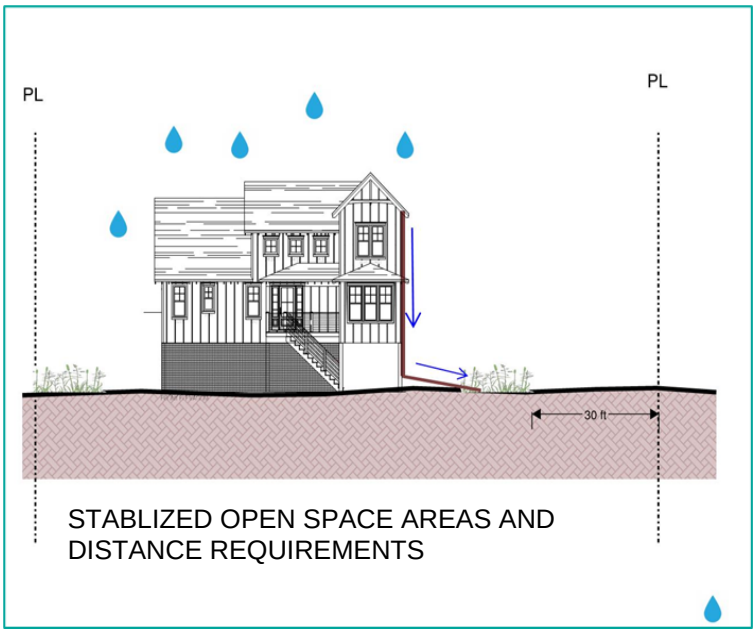
EXISITNG CONDITION EXAMPLES:



EXISTING LOT DEPRESSIONS ON A SITE



SIGNIFICANT VEGETATION AREAS AND DISTANCE REQUIREMENTS



STABLIZED OPEN SPACE AREAS AND DISTANCE REQUIREMENTS

FOR A COMPLETE LIST OF STORMWATER IMPROVEMENTS AND EXISTING CONDITION OPTIONS, SEE APPENDIX A OF THE TOWN OF NAGS HEAD'S LOW IMPACT DEVELOPMENT MANUAL

Who do I contact if I have questions?

For general permit questions, not necessarily related to stormwater, contact the planning department front desk at (252) 441-7016.

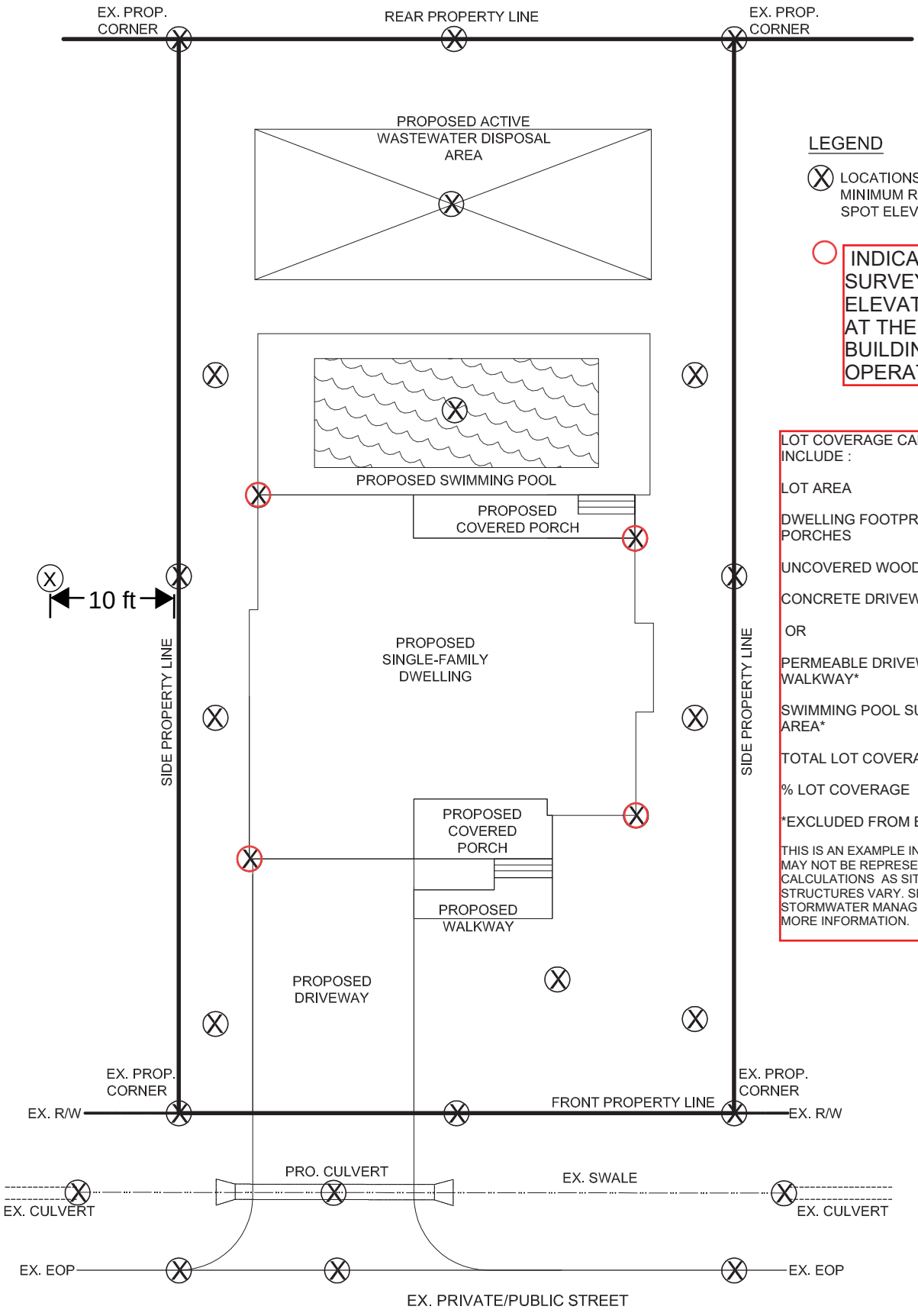
For specific questions related to residential stormwater management, contact

Kate Jones
Senior Environmental Planner
Email – kate.jones@nagheadnc.gov
(252) 449-4209

TOWN OF NAGS HEAD LOW IMPACT DEVELOPENT MANUAL - APPENDIX A

RESIDENTIAL STORMWATER IMPROVEMENTS

EXISTING SITE FEATURES (NON-STRUCTURAL)



LEGEND

⊗ LOCATIONS OF MINIMUM REQUIRED SPOT ELEVATIONS

○ INDICATES ADDITIONAL SURVEY SPOT ELEVATIONS REQUIRED AT THE COMPLETION OF BUILDING PAD FILL OPERATIONS.

LOT COVERAGE CALCULATIONS SHOULD INCLUDE :

LOT AREA

DWELLING FOOTPRINT W/ COVERED PORCHES

UNCOVERED WOOD DECKING*

CONCRETE DRIVEWAY, PATIO AND WALKWAY

OR

PERMEABLE DRIVEWAY, PATIO AND WALKWAY*

SWIMMING POOL SURFACE AREA*

TOTAL LOT COVERAGE

% LOT COVERAGE

*EXCLUDED FROM BUILT UPON AREA

THIS IS AN EXAMPLE INTENDED FOR GUIDANCE. IT MAY NOT BE REPRESENTATIVE OF ALL REQUIRED CALCULATIONS AS SITE LAYOUT , MATERIALS AND STRUCTURES VARY. SEE RESIDENTIAL STORMWATER MANAGEMENT APPLICATION FOR MORE INFORMATION.

MINIMUM REQUIRED SURVEY INFORMATION FOR RESIDENTIAL SITE DEVELOPMENT PLANS

SCALE: NONE

IN ACCORDANCE WITH TOWN CODE SECT. 34-8.C

NOTE:
THE INFORMATION DESCRIBED HEREON IS FOR REFERENCE PURPOSES ONLY. EXISTING SITE CONDITIONS MAY WARRANT A GREATER LEVEL OF DETAIL, I.E. TOPOGRAPHY, DITCHES, SURFACE IMPROVEMENTS, ETC. IT IS THE RESPONSIBILITY OF THE APPLICANT TO PROVIDE A SUFFICIENT LEVEL OF DETAIL IN ACCORDANCE WITH CHAPTER 34, STORMWATER, FILL AND RUNOFF MANAGEMENT.

THE TOWN OF 1961 NAGS HEAD N.C.

VEGETATED SWALE

A vegetated swale is a depression (about 6 to 12" inches deep) that collects storm water runoff from a roof, driveway or yard and allows it to infiltrate into the ground. Vegetated swales are typically planted with shrubs and perennials (natives are ideal), and can be colorful, landscaped areas in your yard.

MAINTENANCE

- Watering

During the establishment period of the first year, watering may be required on a more frequent basis. Once established, watering should not be necessary at all except in cases of extreme drought.

- Weeding

Weeding will be required during the first three years of establishment and will be less frequent after the three-year period.

- Remedial Measures

Annual maintenance is not different than traditional landscaping and includes removal of dead vegetation each spring, addition of mulch, periodic inspection of soil erosion and plant health.

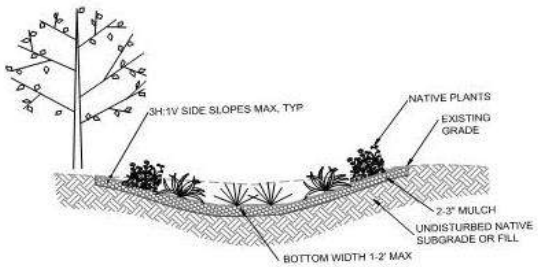
Topography: Vegetated swale are easiest to install in flat areas.

Soils: Well drained ; avoid placing swales in areas with existing standing water.

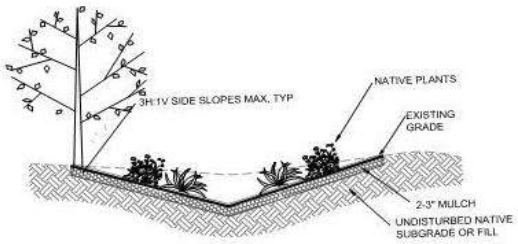
Setbacks: 5' from septic systems, 5-10' from buildings, decks and driveways. Can be placed adjacent to property line.

Vertical Separation: Recommended 12" from seasonal high water table.

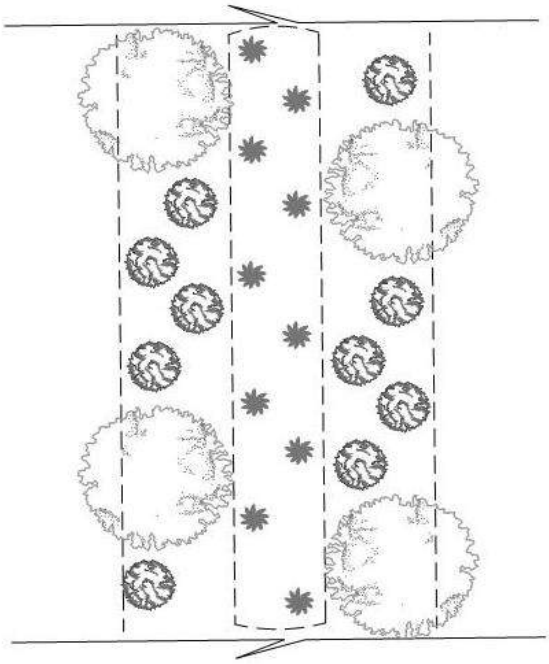
RESIDENTIAL STORMWATER MAGAGEMENT 252-449-4209

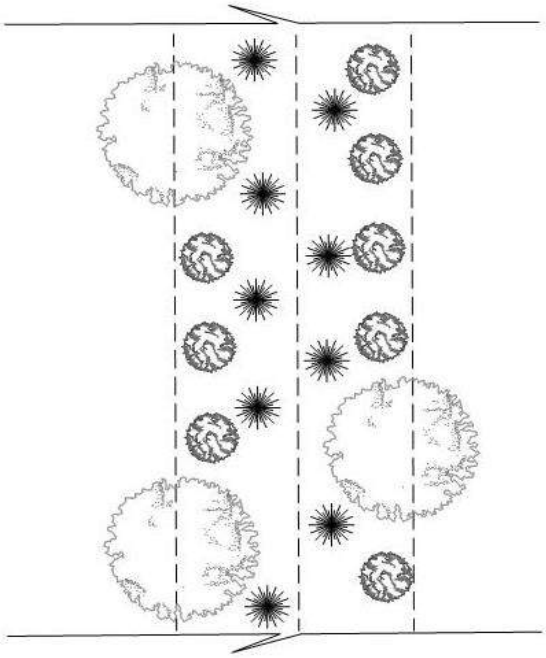


Trapezoidal



Triangular





Shrub

Tree

Grass

*Total # of plants varies with swale dimension. Trees are optional, but provide more water uptake. Please see the Plant List for more recommendation on types of plants.

RAIN GARDEN

A rain garden is a depression (about 6 inches to 1 foot deep) that collects storm water runoff from a roof, driveway or yard and allows it to infiltrate into the ground. Rain gardens are typically planted with shrubs and perennials (natives are ideal), and can be colorful, landscaped areas in your yard.

MAINTENANCE

- Watering

During the first year, watering may be required on a more frequent basis. Once established, watering should not be necessary at all except in cases of extreme drought.

- Weeding

Weeding will be required during the first three years of establishment and will be less frequent after the three-year period.

- Remedial Measures

Annual maintenance is not necessarily different than traditional landscaping and includes removal of dead vegetation each spring, addition of mulch, periodic inspection of soil erosion, plant health and removal of litter as needed.

Topography: Rain gardens are easiest to install in flat areas.

Soils: Well drained soils are best ; avoid placing rain gardens in areas with existing standing water.

Setbacks: 5' from septic systems, 5-10' ' from buildings, decks and driveways. Can be placed adjacent to property line.

Recommended minimum 12" from bottom of garden to seasonal high water table.

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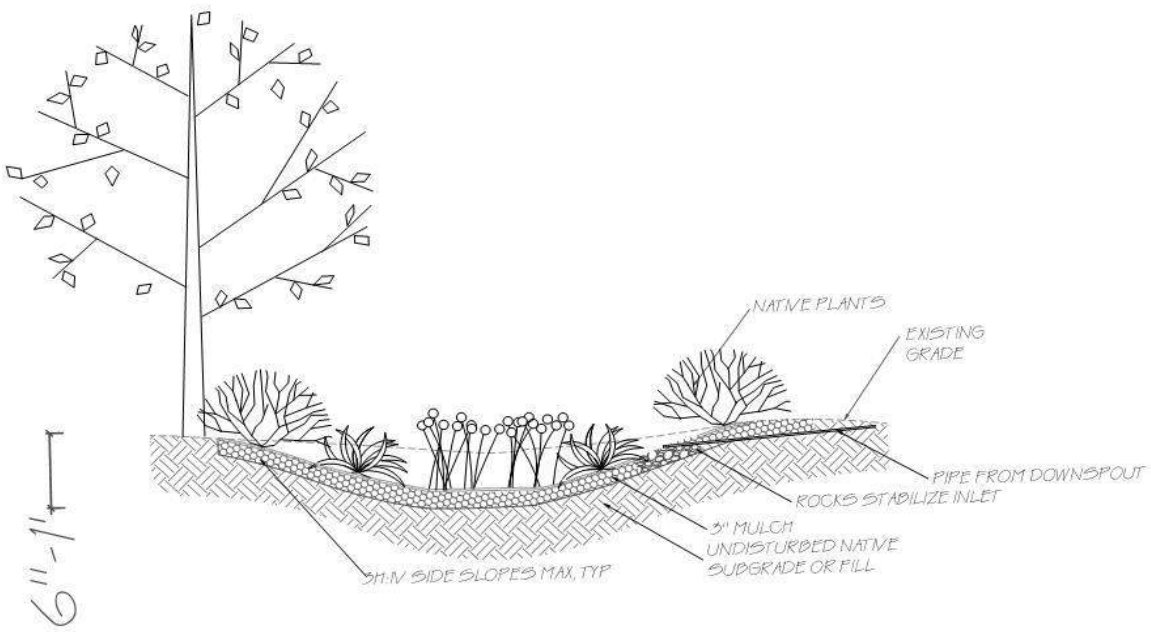

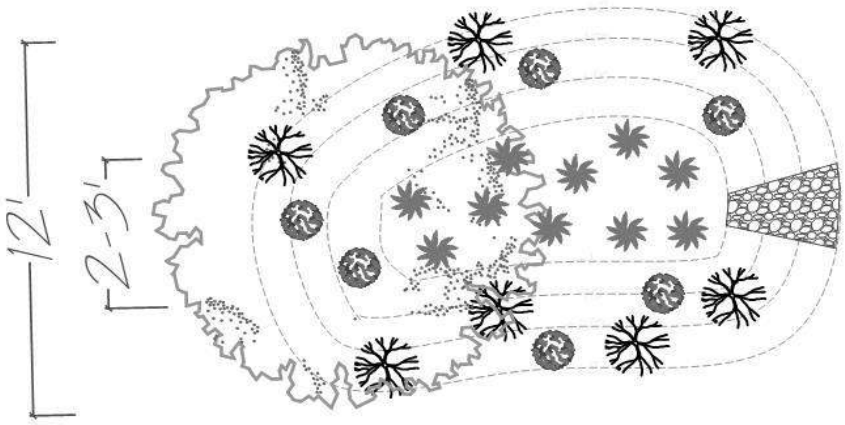

Flowering perennial

Tree

Grass

Shrub

*Total # of plants varies with rain garden dimension. Trees are optional, but provide more water uptake. Please see the Plant List for more recommendation on types of plants.

DRIP LINE INFILTRATION TRENCH

Dripline Infiltration trenches are excavated trenches located in the roof drip line area, filled with granular material. The voids between the aggregate materials provide the volume for temporary storage of runoff that gradually infiltrates into the surrounding soil.

MAINTENANCE

- **Clogging**

Remove debris and inspect for sediment buildup and structural damage. Ensure the trench is dewatering between storms.

- **Cleaning**

Remove sediment adjacent to or near trench. Repair any erosion in aggregate or grassed areas.

- **Remedial Measures**

If trench has not drained within 48 hours after storm, excavate around perimeter to expose clean soil (~2 inches). Replace and reline filter fabric (if using). Clean or replace aggregate.

Recommended maximum depth: 8”

Trench bottom should be level, but the surface may slope

Setback: 5’ from septic systems

Recommended minimum 12” from bottom of garden to seasonal high water table

Minimum depth 6”, Minimum width 1’ past roof drip line

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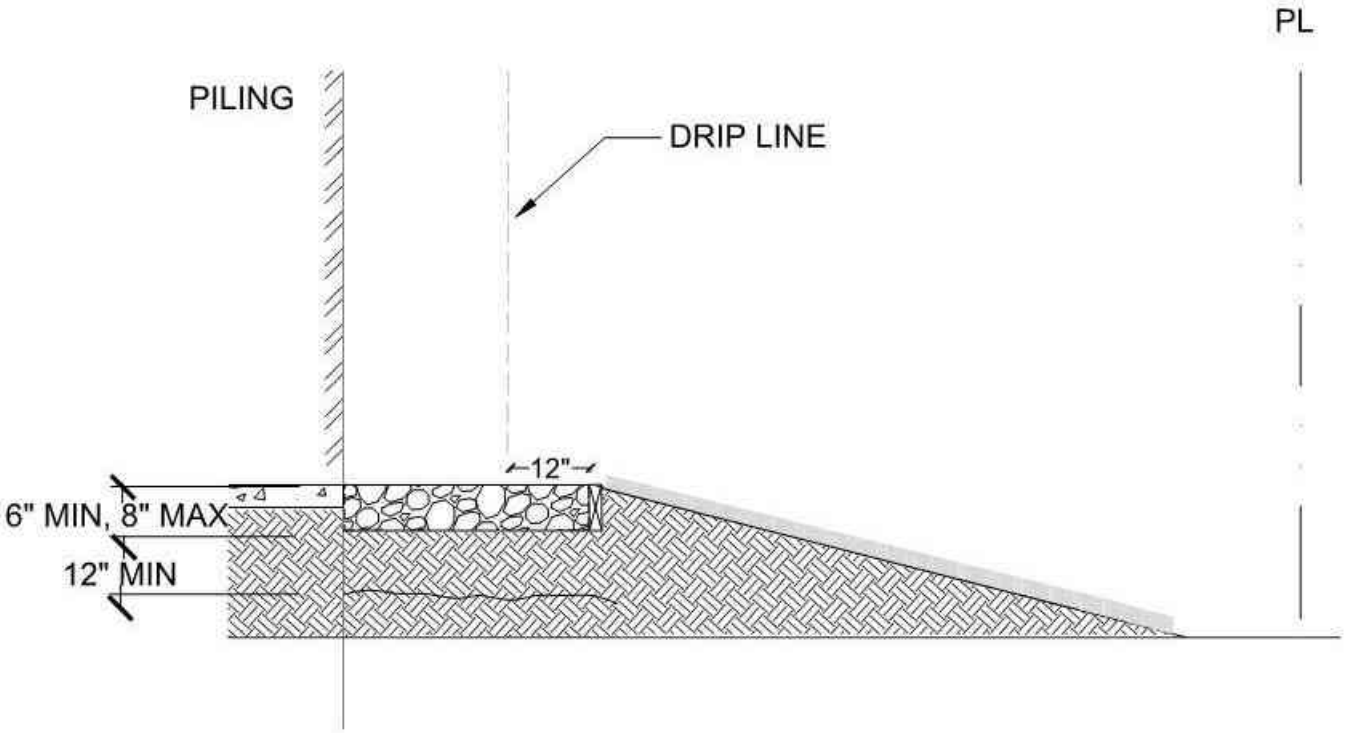
PL
PILING
DRIP LINE
12"
6" MIN, 8" MAX
12" MIN

INFILTRATION TRENCH/GRAVEL BED

Infiltration trenches, also called gravel beds, are excavated areas filled with clean granular material. The voids between the aggregate materials provide the volume for temporary storage of runoff that gradually infiltrates into the surrounding soil. A perforated pipe (french drain) may be added for additional volume storage, or to carry water to another location.

MAINTENANCE

- **Clogging**

Remove debris and inspect for sediment buildup and structural damage. Ensure the trench is dewatering between storms.

- **Cleaning**

Remove sediment adjacent to or near trench. Repair any erosion in aggregate or grassed areas.

- **Remedial Measures**

If trench has not drained within 48 hours after storm, drain via pumping. Excavate around perimeter to expose clean soil (~2 inches). Replace and reline filter fabric. Clean or replace aggregate.

Recommended maximum depth: 3'

Trench bottom should be level, but the surface may slope

Setbacks: 5' from septic systems

Recommended minimum 12" from bottom to seasonal high water table

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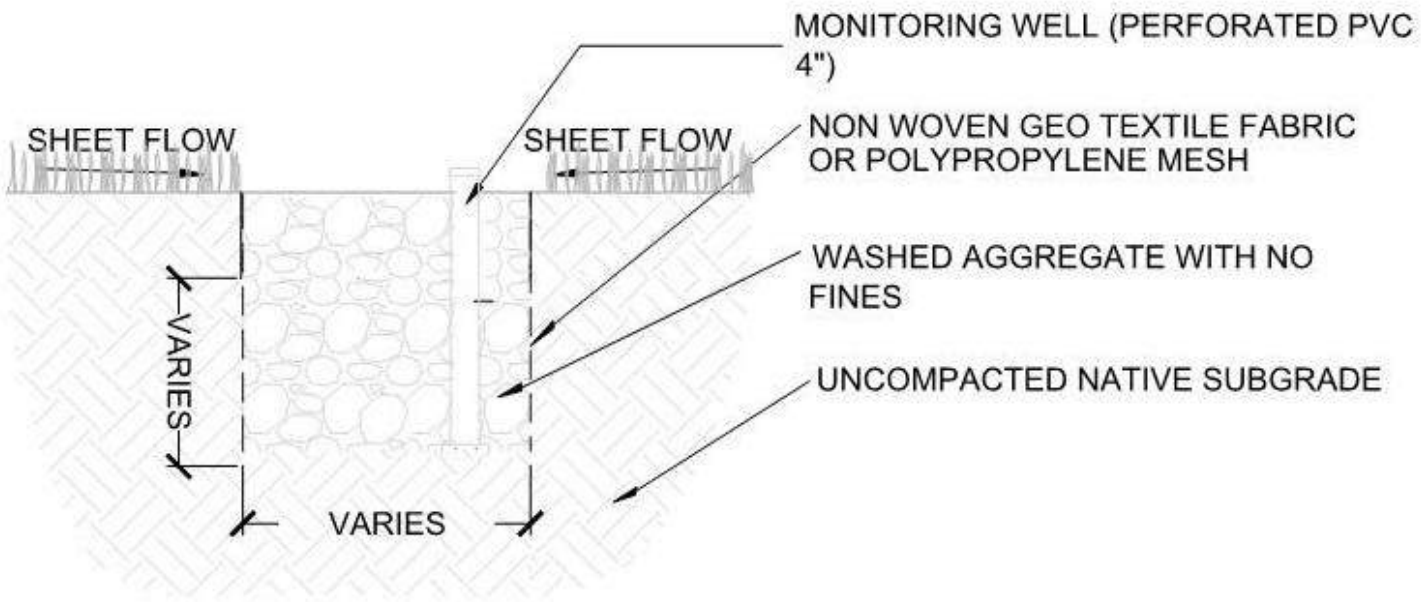
MONITORING WELL (PERFORATED PVC 4")
SHEET FLOW
SHEET FLOW
NON WOVEN GEO TEXTILE FABRIC OR POLYPROPYLENE MESH
WASHED AGGREGATE WITH NO FINES
UNCOMPACTED NATIVE SUBGRADE
VARIES
VARIES

CISTERN/RAIN BARREL

Rain barrels are containers used to collect a portion of the rainwater that flows from your rooftop and stores it for uses such as watering your lawn and garden.

MAINTENANCE

- Drain Rain Barrels after each significant rainfall from April to November. At a minimum, empty the rain barrel every two weeks.
- Clean the rain barrel periodically and inspect it for clogs and leaks. Remove leaves and other debris from the filter screen and ensure that it is not damaged and is securely fastened. IT is recommended to disinfect the rain barrel with bleach once a year. Unless designed for freezing temperatures, the rain barrel should be disconnected and drained for winter.
- If the Rain Barrel becomes cracked, or any of the materials become worn, replace as necessary to prevent leakages.

Barrels need to be installed on level surface

Rain barrels work where occupants intend to use the captured water

Multiple rain barrels can be connected together

Mosquito control is important and can be abated by using a screen or mosquito tablets

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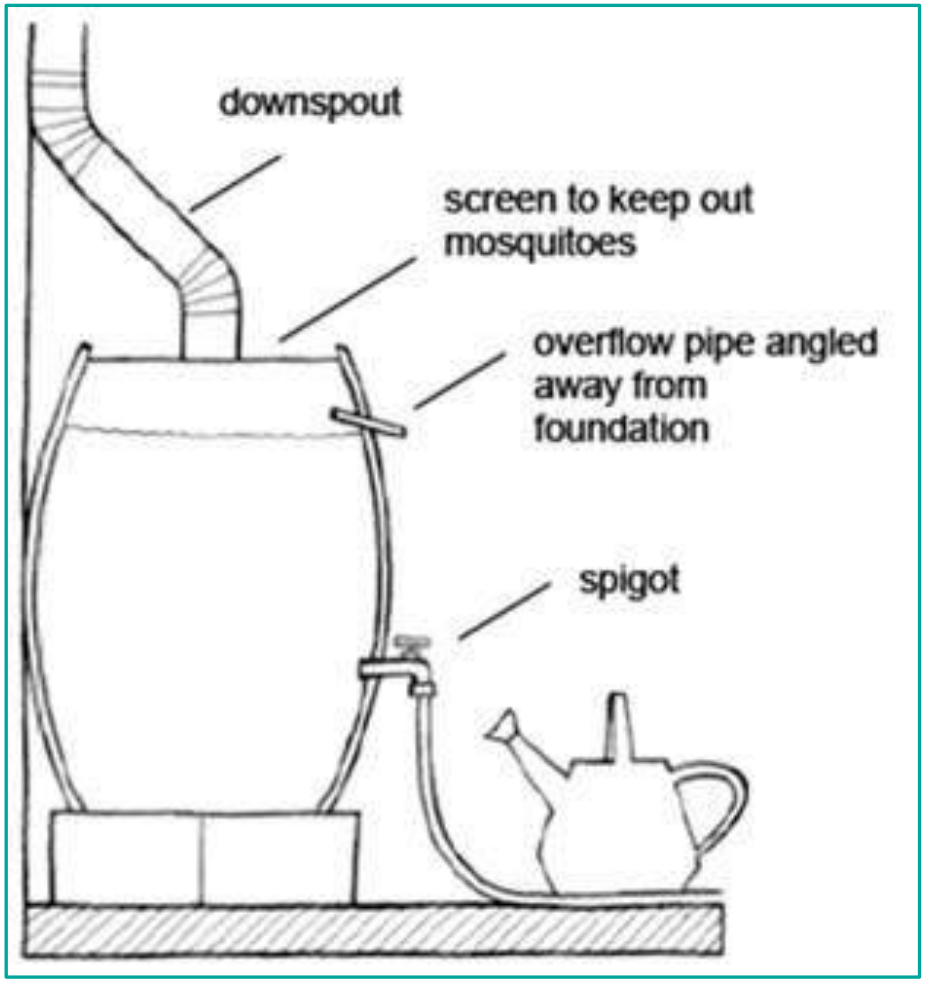
downspout
screen to keep out mosquitoes
overflow pipe angled away from foundation
spigot

PLANT LIST

DESCRIPTION

Plants used in stormwater control measures should be carefully considered depending on several factors: water requirements or tolerance, sun exposure, tolerance for drought, sandy soil adaptability, and salt tolerance.

- **Benefits**
  1. Additional water uptake through evapotranspiration.
  2. Filtering of environmental contaminants.
  3. Aesthetically pleasing additional to the landscape.
  4. Once established, minimal maintenance required weeding.
- **Design Considerations**
  1. Choose plants depending on the estimated amount of water they will receive.
  2. The use of native plants is suggested to reduce maintenance as they are better adapted to soils and environmental conditions.
  3. Choose a variety of plants instead of just one or two species.

Go Native! Ask local nurseries to stock native plants.

Keep existing native plants on your property whenever possible.

Use your smartphone camera to scan the QR code below for more native plant resources!

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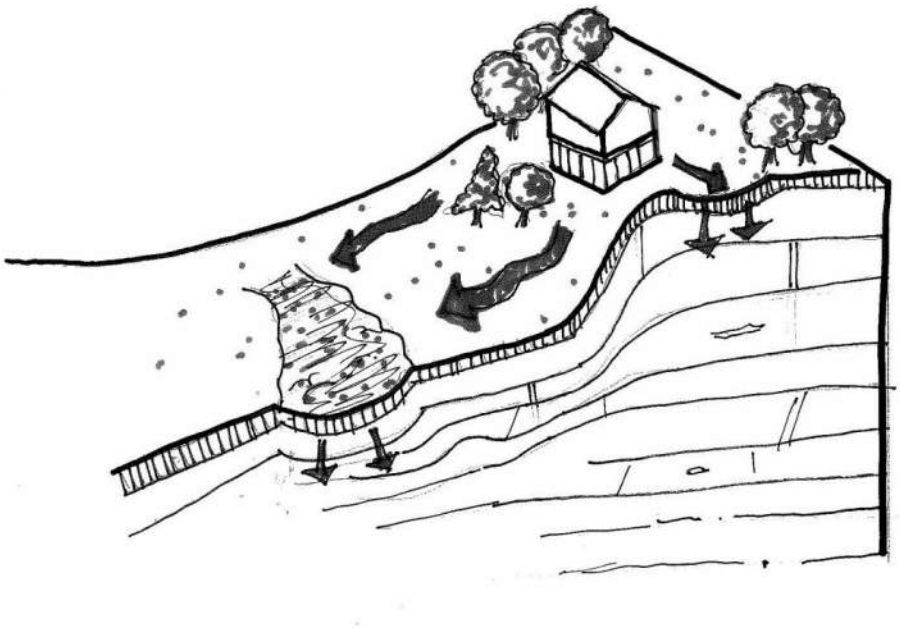
Plant	Type	Water	Sun	Height	BLOOM PERIOD										
					J	F	M	A	M	J	J	A	S	O	N
Swamp Magnolia	Tree			36-72’											
Persimmon	Tree			15-20’											
Cherry Laurel	Tree			12-36’											
Yaupon Holly *(Ilex vomitoria)*	Tree/Shrub			12-36’											
Inkberry *(Ilex glabra)*	Shrub			6-12’											
Sweet Pepperbush *(Clethra alnifolia)*	Shrub			3-6’											
Yucca *(Yucca filamentosa)*	Shrub			2-3’											
Blanket Flower *(Gaillardia pulchella)*	Flowering perennial			1-2’											
Coreopsis *(Coreopsis lanceolata)*	Flowering perennial			2-3’											
Milkweed (*Asclepias*)	Flowering perennial			1-3’											
Coneflower (Echinacea purpurea)	Flowering perennial			2-5’											
Muhly grass *(Muhlenbergia)*	Grass			3-4’											
Switchgrass *(Panicum Virgatum)*	Grass			2-3’											
Little blue stem (*Schizachyrium Scoparium)*	Grass			2-3’											
River oats *(Chasmanthium latifolium)*	Grass			3-4’											
Indian grass *(Sorghastrum Nutans)*	Grass			2-3’ 6’ w/bloom											

LOT DEPRESSIONS



Naturally occurring low areas on a site may be utilized for stormwater capture. These areas should receive water from impervious areas by way of a downspout pipe extension, swale, or other mechanism to transport water to the low area.

MAINTENANCE

- Keep any buried pipes and associated downspouts and gutters free of debris and flowing.
- Check gutters, downspouts and pipes for clogs or cracks and replace as needed.
- Make sure the area is not overflowing onto a neighbors property or the rights of way or road.
- Recommended to plant vegetation if none exists for additional water uptake.

Areas should be at least 5' away from structures.

May only be utilized where natural grades have resulted in a depression

Water should be contained on your property

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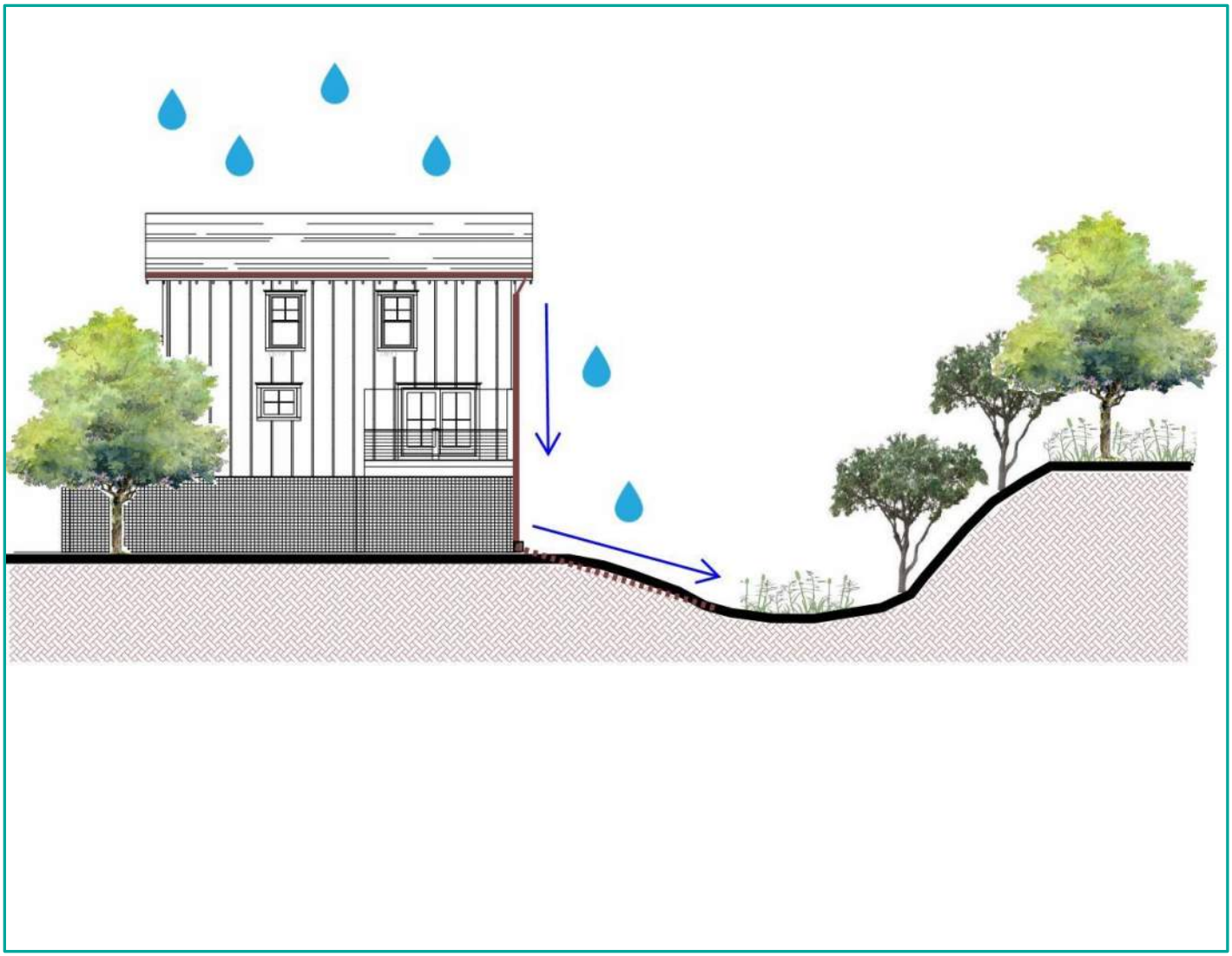
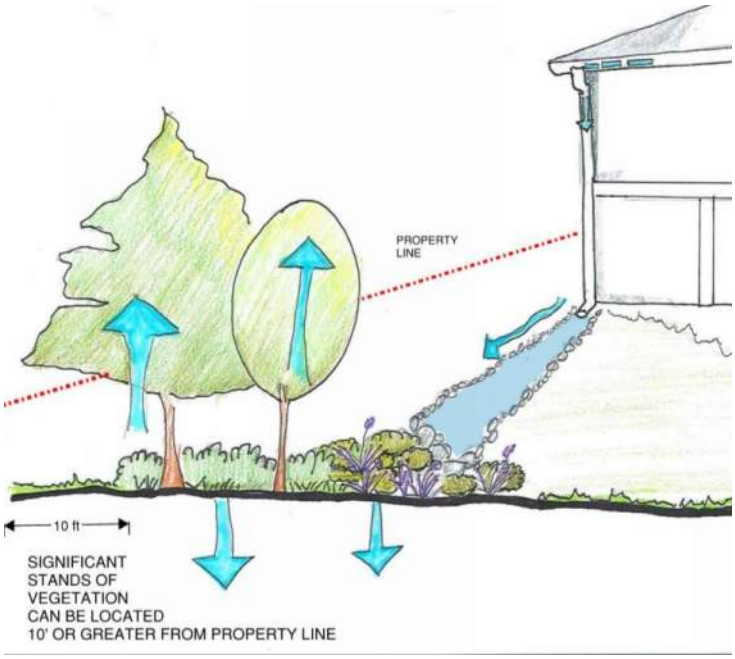


VEGETATED AREAS



Existing mature vegetation on a site may be utilized for stormwater capture and infiltration. These areas should receive water from impervious areas by way of a downspout pipe extension, swale, or other mechanism to transport water to the vegetation.

MAINTENANCE

- Keep any buried pipes and associated downspouts and gutters free of debris and flowing.
- Check gutters, downspouts and pipes for clogs or cracks and replace as needed.
- Make sure the area is not overflowing onto a neighbors property or the rights of way or road.
- Plant vegetation if none exists. That will soak up more water.

Areas should be at least 5' away from structures.

Vegetation should be mature

Water should be contained on your property

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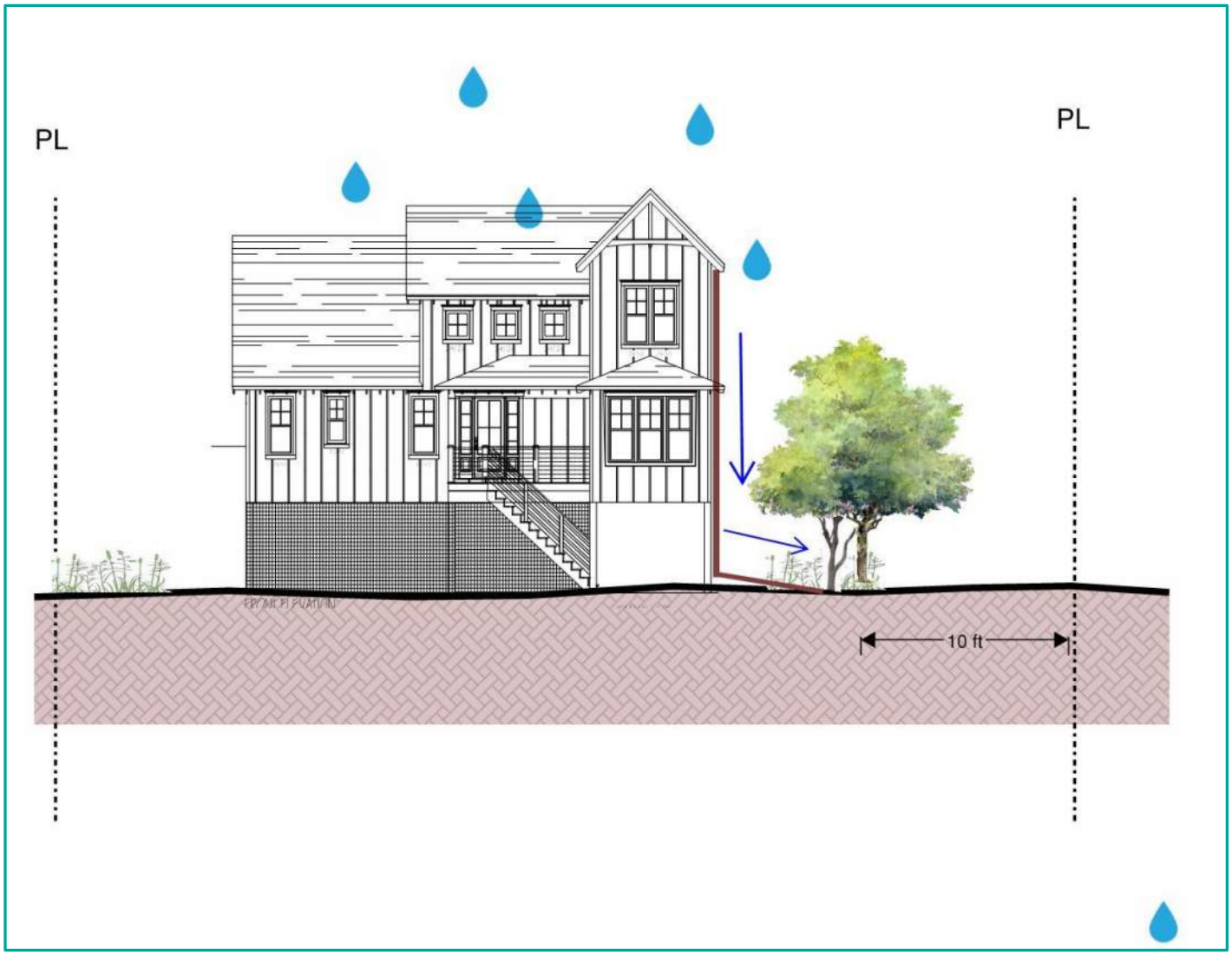
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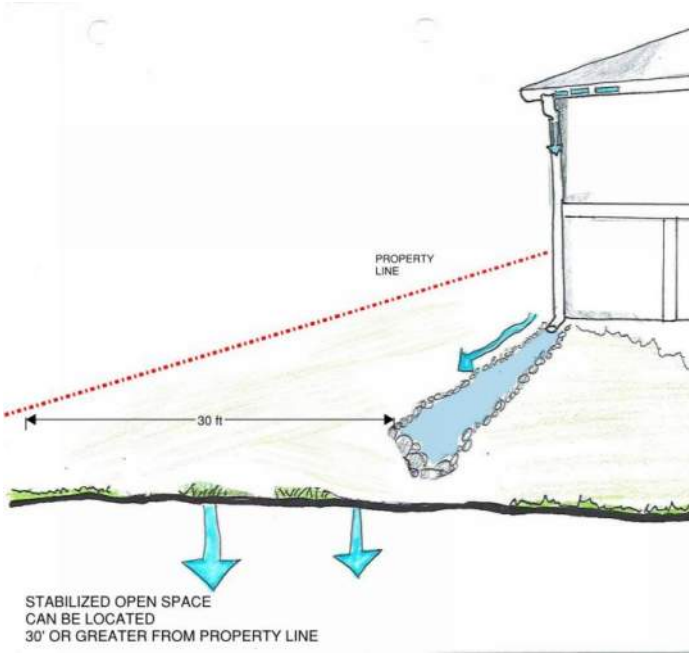
PL
10 ft

STABILIZED OPEN SPACE AREAS



Existing open space areas not associated with on site septic systems, may be utilized for stormwater capture and infiltration. These areas must be at least 30 feet from a property line, and should receive water from impervious areas by way of a downspout pipe extension, swale, or other mechanism to transport water to the area.

MAINTENANCE

- Keep any buried pipes and associated downspouts and gutters free of debris and flowing.
- Check gutters, downspouts and pipes for clogs or cracks and replace as needed.
- Make sure the area is not overflowing onto a neighbors property or the rights of way or road.

Areas should be at least 5' away from structures.

Open space areas must be stabilized, at a minimum with sod, grass or other ground cover.

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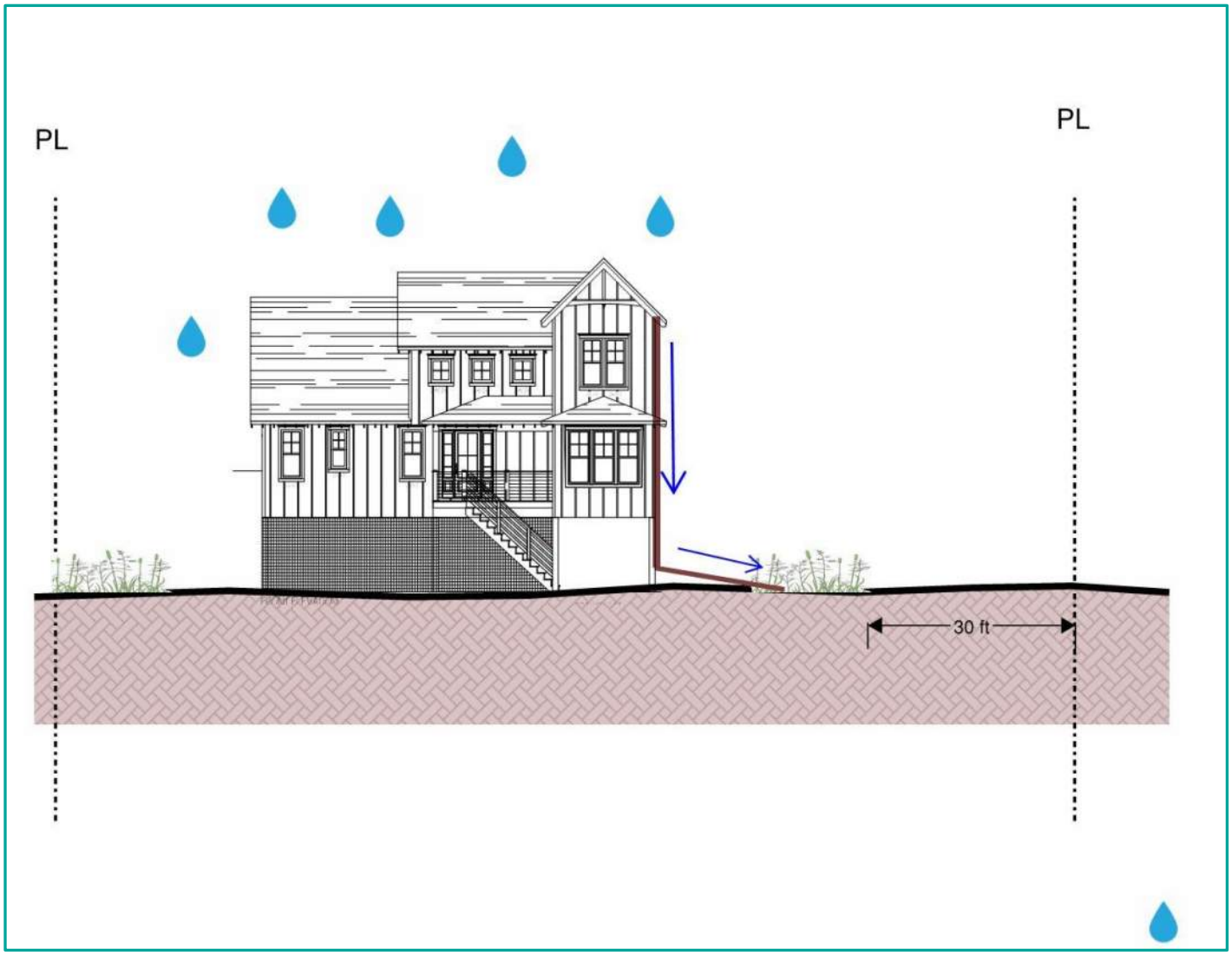
PL
PL
30 ft

WETLANDS

Existing wetlands should be kept as able to maintain infiltration patterns. These areas should receive water indirectly from impervious areas by way of a downspout pipe extension, swale, or other mechanism to transport water to the wetland. Make sure the water is discharged to a vegetated area or stormwater improvement before reaching the wetland.

MAINTENANCE

- Keep any buried pipes and associated downspouts and gutters free of debris and flowing.
- Check gutters, downspouts and pipes for clogs or cracks and replace as needed.
- Make sure the area is not overflowing onto a neighbors property or the rights of way or road.

Areas should be at least 5' away from structures.

May be utilized on lots where wetlands have been identified by ACOE

Water may sheet flow if the majority of wetlands outside built areas are retained.

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