City of Ocean City

Green Infrastructure Strategies

Executive Summary

At the regional scale, green infrastructure is a network of natural areas and open spaces that provide multiple benefits for people and wildlife, such as regional parks and nature preserves, river corridors and greenways, and wetlands (Benedict and McMahon 2006). At the neighborhood and site scales, the U.S. Environmental Protection Agency (EPA) refers to green infrastructure as stormwater management practices that mimic natural processes by absorbing water, such as green streets, green roofs, rain gardens, and pervious pavement. Trees are a type of green infrastructure that spans these scales, from regional woodlands to the urban forest to street and other tree plantings.

Green infrastructure plays an important role in preparation for and recovery from natural disasters. Climate change scenarios project that precipitation and temperature extremes, storm frequency and intensity, and sea-level rise will accelerate in the coming century. By incorporating green infrastructure into post-disaster recovery, communities can become more resilient to future disasters.

Introduction

As communities continue to recover from Superstorm Sandy, strong efforts are being made to implement several resiliency practices to help handle the effects of similar future events. Green infrastructure is one of these key practices whose use should be maximized to promote sound stormwater management and reduce the impacts of future storm events.

Green Infrastructure refers to methods of stormwater management that reduce wet weather/stormwater volume, flow, or changes the characteristics of the flow into combined or separate sanitary or storm sewers, or surface waters, by allowing the stormwater to infiltrate, to be treated by vegetation or by soils; or to be stored for reuse. Green Infrastructure (GI) practices include, but are not limited to, pervious paving, bioretention basins, vegetated swales, and cisterns. The use of green infrastructure encourages the idea that stormwater is a resource that can be reused, instead of being treated as a nuisance that needs to be removed as quickly as possible.

Many states and local governments have adopted green infrastructure (GI) policies such as green streets or rainwater harvesting codes. Although no comprehensive catalogue of

these policies exists, a simple Google search turns up numerous compilations of case studies.

These case studies illustrate policy commitments to use green infrastructure in demonstration projects, street retrofits, and other local capital projects. In addition, since communities regulate the green treatment of stormwater (either requiring or at least allowing it) they often have policies for both stormwater fees and incentives. Finally, many policies address education and outreach.

Adopting a variety of green infrastructure policies may be an effective approach in communities where there is political support and general acceptance of the benefits of green infrastructure. By using green infrastructure, planners hope to encourage a greater percentage of stormwater to infiltrate into soils or be taken up by plants.

Green infrastructure planning is important because it:

1. Supports working lands (farms and forest) and the landscapes for tourism
2. Prioritizes limited financial resources wisely
3. Helps a community or region visualize its future
4. Provides more information to decision makers to improve outcomes
5. May help with compliance with regulatory review and requirements
6. Provides predictability and a level playing field for both developers and conservationists
7. Supports ecosystem services that provide benefits to communities without additional financial investment
8. Makes communities more disaster resistant by using the landscape to protect communities from flooding and focusing development in appropriate areas
9. Supports biodiversity and facilitates ecotourism
10. Supports a high quality of life, attracting businesses and retirees.

The City of Ocean City has implemented green infrastructure strategies in demonstration projects, and continues to explore additional opportunities to utilize these strategies where appropriate. This report provides an evaluation of green infrastructure policies and strategies that may be most effective for Ocean City.

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Key Points

1. Green infrastructure reduces damage from storm surge and flooding and plays a role in other types of disasters.
2. Resilience to natural disasters is one of a broad array of benefits provided by green infrastructure.
3. Particularly in urban contexts, green infrastructure must be combined with gray infrastructure to effectively reduce damage from natural disasters.
4. Green infrastructure resources can suffer severe damage from disasters, which in the absence of preplanning can be exacerbated in short-term recovery response.

For the purposes of the [Hurricane Sandy] Rebuilding Strategy[1], green infrastructure is defined as the integration of natural systems and processes, or engineered systems that mimic natural systems and processes, into investments in resilient infrastructure. Green infrastructure takes advantage of the services and natural defenses provided by land and water systems such as wetlands, natural areas, vegetated sand dunes, and forests, while contributing to the health and quality of America's communities.

KEY POINT #1: Green infrastructure reduces damage from storm surge and flooding and plays a role in other types of disasters.

Damage from flooding in inland areas, and from storm surge and flooding in coastal environments, is significantly reduced when natural wetland, riparian, and floodplain areas and the ecosystem services they provide are protected. Buildings, roads, and other supporting infrastructure are particularly vulnerable to storm damage when constructed in these areas, and loss of natural functions such as flood storage capacity can increase damage to development on adjacent, less sensitive lands. Thus a particularly effective use of green infrastructure to reduce damage from natural disasters is to conserve environmentally sensitive areas through strategies such as acquisition of land or easements, natural resource protection ordinances, and other regulatory controls and incentives.

In many urban areas, natural resources such as streams, floodplains, and wetlands have been replaced by development and natural hydrological processes have been disrupted by fill and impervious surfaces. The conventional stormwater management approach in such areas has been to collect the high volumes of runoff generated during storms and convey them via pipes to nearby waterways. This approach can exacerbate flooding

[1] Hurricane Sandy Rebuilding Task Force 2013

from major storms and degrade water quality, for example from combined sewer overflow (CSO) in older cities with connected storm and sanitary sewer systems. Green infrastructure is an alternative approach that retains stormwater near where it is generated through infiltration (rain gardens, stormwater planters, pervious surfaces, etc.) and evapotranspiration from trees and other vegetation. While green stormwater infrastructure is most commonly used at the site scale to manage runoff from smaller storms, when deployed at a watershed scale it can reduce flooding from larger disasters such as the benchmark 100-year storm (Medina, Monfilis, and Baccala 2011).

Green infrastructure — and how it is managed — plays a role in other types of natural disasters. For example, intense urban heat waves such as those experienced by Chicago (approximately 700 fatalities in 1995) and Europe (more than 70,000 fatalities during the summer of 2003) will likely become more common in the future as a result of climate change and the global trend of increasing urbanization. Green infrastructure such as trees, parks, and green roofs can ameliorate the so-called urban heat island effect.

KEY POINT #2: Resilience to natural disasters is one of multiple benefits provided by green infrastructure.

Green infrastructure can mitigate the direct effects of natural disasters through services such as reducing stormwater runoff, buffering against storm surge in coastal environments, and reducing surface temperatures during heat waves, while also providing a broad array of other community benefits. Often framed in terms of the triple bottom line of environmental, economic, and social return on investment, these additional benefits include:

Environmental

- Improved air and water quality
- Natural habitat preservation
- Climate change mitigation (from reduced fossil fuel emissions, reduced energy consumption, and carbon sequestration)

Economic

- Creation of job and business opportunities
- Increased tourism, retail sales, and other economic activity
- Increased property values
- Reduced energy, health care, and gray infrastructure costs

- Provision of locally produced resources (food, fiber, and water)

Social

- Promotion of healthy lifestyles through walking,
- Improved public health outcomes (e.g., by connecting people to nature)
- Increased environmental justice, equity, and access for underserved populations
- Enhanced community identity through public art, culture, and places for people to gather

While many of the above benefits do not directly relate to post-disaster recovery, they can contribute to increased community resilience and, in doing so, reduce vulnerability to natural disasters. A park designed to accommodate flooding during storms while providing benefits such as recreation, social interaction, and increased commerce is an example of using green infrastructure to leverage multiple benefits beyond mitigating the direct impacts of a disaster.

KEY POINT #3: Particularly in urban contexts, green infrastructure must be combined with gray infrastructure to effectively reduce damage from natural disasters.

According to a recent study by the Natural Capital Project and the Nature Conservancy, 16 percent of the U.S. coastline, inhabited by 1.3 million people and representing $300 billion in residential property value, is located in high-hazard areas (Arkema et al. 2013). Sixty-seven percent of these areas are protected by natural green infrastructure (intact reefs, sand dunes, marshes, and other coastal vegetation), and the number of people and total property value exposed to hazards would double if this habitat were lost. These findings underscore the effectiveness of preserving and restoring natural habitat areas, as well as mimicking the services provided by such areas through "naturebased" approaches (e.g., artificial oyster reefs and living shorelines), to increase resilience to natural disasters. However, in many populated areas at risk from flooding, natural ecosystems have been extensively altered or replaced by development. Moreover, barrier beaches, dunes, riverine floodplains and the like are dynamic systems that move in response to natural processes such as erosion and sea-level rise, with implications for adjacent developed properties. Green infrastructure can reduce damage but may be insufficient to protect against catastrophic events such as the storm surge experienced during Hurricane Sandy.

Traditional structural protection measures (often referred to as gray infrastructure) include, among others, seawalls, bulkheads, breakwaters, and jetties to protect against erosion and storm surge in coastal areas. Such measures can be effectively deployed to protect urban and other areas with extensive investment in buildings and infrastructure. Considerations regarding the use of gray infrastructure include cost relative to benefits provided (it is typically more expensive than green infrastructure), unintended consequences caused by interruption to natural processes, and the possibility of inadequate protection or even failure during catastrophic events (e.g., levee failure in New Orleans during Hurricane Katrina). Examples of unintended consequences include barriers that displace flooding from one area to another or groins (coastal erosion structures typically constructed perpendicular to the shoreline to trap sand) that cause beach erosion along the "downdrift" shoreline.

Integrated approaches to planning for future disasters combine green and gray infrastructure strategies. For example, a study of Howard Beach, a neighborhood in Queens that was flooded by Hurricane Sandy, concluded that a combination of natural and structural defenses would provide the most cost-effective protection against future storms (Nature Conservancy 2013). These "hybrid" strategies include restored marsh, mussel beds, rock groins, removable flood walls, and flood gates. At a larger scale, *A Stronger, More Resilient New York*[2] combines nature-based (e.g., beach, dune, and marsh restoration) and structural (e.g., floodwalls and storm surge barriers) measures to protect against the effects of climate change.

Louisiana's Coastal Protection Master Plan[3] proposes a combination of restoration, nonstructural, and targeted structural measures to provide increased flood protection for all communities. The plan proposes nine project types, ranging from marsh creation, barrier island restoration, and oyster barrier reefs to bank stabilization and structural protection (levees, flood walls, and pumps).

KEY POINT #4: Green infrastructure resources can suffer severe damage from disasters, which in the absence of preplanning can be exacerbated in short-term recovery response.

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[2] New York, City of. 2013. *A Stronger, More Resilient New York*. Available at http://www.nyc.gov/html/sirr/html/report/report.shtml.

[3] Louisiana, State of. 2012. *Louisiana's Comprehensive Master Plan for A Sustainable Coast*. Coastal Protection Master Plan available at http://coastal.la.gov/a-common-vision/2012-coastal-master-plan.

Dunes, marshes, and wetlands are adapted to withstand storm damage if natural processes such as overwash (the landward transport of beach sediments across a dune system) are retained. Other types of coastal vegetation can sustain significant damage from saltwater flooding, storm surge, and high winds.

While the effects of a severe storm can be devastating, the long-term recovery phase provides the opportunity to "regrow" forms of green infrastructure that provide enhanced community benefits while being more resilient to future disasters.

Green Infrastructure Practices

Water Resource Projects

At the municipal scale, gray infrastructure for water resources and stormwater management has been largely focused on replacing natural systems for dealing with flood events. The man-made engineering approach is frequently expensive, adversely affects the environment, and has at times failed to correct the problem of flooding. Increasingly, municipal sewer districts and flood control authorities are using green infrastructure planning to identify undeveloped lands that could provide significant flood prevention benefits if acquired and conserved.

Responding to Climate Change

For this century the central challenge to the conservation community and planners is how to address the impacts of climate change. Many conservation models and planning efforts are snapshots in time, using existing information on the presence or absence of species or habitat types. Global climate change will force green infrastructure methods and models to become dynamic, taking into account both current environmental conditions as well as forecasting what the landscape could look like in 70 to 100 years.

Watershed Planning

Traditional, or gray infrastructure, generally focuses on collecting rainwater and sending it downstream to ultimately be discharged into a waterway. Green infrastructure (GI), on the other hand, mimics natural processes utilizing soils and vegetation to manage rainwater where it falls.

GI can be applied on different scales. For instance, on a regional scale, GI can focus on an interconnected network of waterways, wetlands and forested areas. In this way, municipalities can incorporate stormwater management goals into their open space plans and greenways plan. Information on the Garden State Greenways program is available at http://www.gardenstategreenways.org/.

Municipalities can also incorporate GI on a neighborhood scale. Tree plantings and downspout disconnection can be utilized in areas where there is an existing flooding problem. GI can also be used in downtown areas, green street planning can help promote walkability while at the same time managing stormwater. Schools and community groups can also incorporate GI strategies such tree planting and community gardens the neighborhood scale. These practices can go a long way to creating a neighborhood.

GI can also be applied on a site-specific scale. Business owners can retrofit parking lots with pervious pavement and larger bioretention systems that can be placed in the islands. Some businesses may be able to collect rainwater in a cistern for non-potable uses. Many school campuses are large enough to incorporate rain gardens and tree plantings, as well as installing pervious pavement on parking lots and basketball/tennis courts. Homeowners can also incorporate GI into their existing landscape. GI strategies, like rain gardens and rain barrels, are easily implemented into yards.

Low Impact Development (also known as non-structural strategies) is the concept of designing a site to reduce the impacts. Design techniques include:

- preserving stream buffer areas
- minimizing the number of trees cut down during construction
- minimizing the areas on site where heavy equipment is used
- using the soils and vegetation that are beneficial on site, and
- using GI practices that treat stormwater runoff through soil and vegetation

Green Infrastructure Design

Green infrastructure practices to be incorporated into site design should be selected based on an evaluation of individual site characteristics and needs. Informational fact sheets on common GI practices, including rain gardens/bioretention basins, grass swales, constructed gravel wetlands, and rain barrels are generally considered as part of development design, but most GI practices can also be used as a retrofit option once a site has already been developed depending on the site conditions. Finally, despite the name, "green" infrastructure doesn't have to be vegetated; GI can include designs incorporating pervious pavement and sand filters that use the soils to reduce runoff and treat pollutants, and rain barrels and cisterns that store rainwater for later reuse.

GI manages stormwater in two ways: by reducing the volume of runoff and by treating runoff. GI strategies reduce runoff volume by allowing rainfall to infiltrate into the soil where it can be used by plants or where it can recharge aquifers and stream base flow. Another way to reduce volume is to capture the rainfall in man-made structures like rain barrels or cisterns where it is stored until it can be reused; however, the use of this stored water is limited to non-potable uses, such as irrigation.

RAIN GARDEN/BIORETENTION BASIN

Rain gardens are landscaped, shallow depressions that capture rainwater and allow it to percolate slowly into the ground. Large rain gardens are called bioretention basins.

In practice, stormwater flows into the rain garden or basin where it is temporarily stored. The plants in the rain garden take up some of this rainwater, and the rest infiltrates the soil. Rain gardens are generally planted with more deeply rooted grasses and flowers than a traditional lawn, so water is able to drain more deeply into the soil, maximizing infiltration and groundwater recharge. Also, because runoff is collected in the rain garden instead of flowing directly into a storm drain, it has a chance to interact with the plants and soil, where pollutants can be broken down and filtered.

Rain gardens are best placed between two impervious surfaces, like between a downspout draining a roof and a sidewalk, so it can slow down and intercept runoff. Because infiltration of rainwater into the soil is one of the major purposes of rain gardens, it is important to make sure the soil in your rain garden is sandy enough. If it is not, it is important to add coarse sand to the soil to increase the amount of water that can be penetrated into the soil. Finally, it is best to choose native plants; native plants are accustomed to New Jersey's climate, so they are less likely to need fertilizer to thrive.

GREEN ROOFS

Green roofs are roofing surfaces that are partly or completely covered with vegetation. Green roofs provide stormwater management by slowing down rainfall and by allowing a portion of the precipitation to be returned to the atmosphere through evapotranspiration.

Precipitation that falls on the green roof is either taken up by the plants, which return it to the atmosphere, or slowly drain through to the planting media into the storage bed and drainage system below. Some of the water that passes through the planting or growing media remains in the soil. The portion that makes it to the storage slowly drains off the roof through a structure. Green roofs have been shown to hold a significant amount of the rainfall that reaches their surface in the summer, but the

amount of rainfall which can be taken up by the plants are reduced in the winter. Green roofs decrease stress on storm sewer systems by retaining and delaying the release of stormwater. Non-stormwater related benefits of green roofs include insulation and shading of the building, mitigation of the "urban heat island" effect - a phenomenon that causes cities to be a few degrees warmer than surrounding areas, and reduced air pollution and greenhouse gas emissions.

The major components of a green roof are a waterproof membrane, root barrier, drainage system, planting media and vegetation. An extensive green roof is lightweight, includes shallow-rooted drought-resistant plants, typically Sedum species, and requires minimal maintenance. An intensive green roof has a thicker layer of growing medium, so it can contain a variety of vegetation, including grasses, ornamentals, flowers and small trees. This type of green roof requires a greater weight bearing capacity and more frequent maintenance. Extensive roofs are the more typical for stormwater management purposes.

Prior to implementation, rooftops must be evaluated for suitability in terms of roof load and accessibility for maintenance in advance of installation. Other factors to take into account are the height and the pitch of the roof, as well as construction and maintenance budgets. The best time to install a green roof is either during building construction or when a roof requires replacement.

PERVIOUS PAVEMENT

Pervious pavement systems are paved surfaces that allow rainwater to infiltrate into underlying soils. There are three types of pervious pavement systems: pervious concrete, porous asphalt and interlocking concrete pavers.

Rain that falls on these systems enters an underground storage bed through either pores in the paved surface, as in porous asphalt or pervious concrete, or through gaps between pavers, as in interlocking concrete pavers. Water is held temporarily in the storage area while it slowly percolates into the soil beneath the pervious paving system. Because rainwater is able to flow through this type of pavement, the runoff is treated for pollutants as it passes through the soils; from there it is available to replenish groundwater. In addition, the soils below pervious pavement tend to be wetter than soils underneath traditional pavement. The water in the soil traps heat, so pervious pavement does not freeze as quickly as standard pavement; this can reduce the amount of salt needed for de-icing in the winter.

Because pervious pavement relies on the underlying soils to treat pollutants and to recharge groundwater, these soils must be sandy enough to allow the rainwater to flow

through it. Also, because these types of systems ultimately do flow into the groundwater, they should not be used where chemicals that could contaminate groundwater supplies are present.

RAIN BARREL

Rain barrels are generally 55-gallon barrels that are placed under a gutter's downspout, which are used to collect rainwater from roofs.

In practice, rainwater that falls on a roof flows into gutters, and then enters the rain barrel through the downspout where it is stored for later use. Approximately 500 gallons of that rainwater can come off of an 800-square-foot roof in a one-inch rain storm, so every gallon of that rainwater that can be captured in rain barrels is a gallon of rainwater that does not flow into a storm drain or a stream. This can make a difference in the long-term maintenance of storm sewer systems; it can also make a difference in the amount of runoff that enters nearby streams. In addition, because water captured in rain barrels can be used to irrigate gardens and lawns, it can add up to significant savings on water bills.

A number of pollutants can be deposited on roofs through air deposition, bird droppings and chemicals used to treat roof tiles; therefore, it is important to never consume water collected in rain barrels or use it to wash anything that will later be consumed. Water collected in rain barrels is perfect, however, for water gardens and lawns and for rinsing garden tools. Finally, because mosquitoes need standing water to breed, it is important to always keep your rain barrel covered.

Green Streets

Green streets are beneficial for new road construction and retrofits. They can provide substantial economic benefits when used in transportation applications. Coordinating green infrastructure installation with broader transportation improvements can significantly reduce the marginal cost of stormwater management by including it within larger infrastructure improvements. Also, and not unimportantly, right-of-way installations allow for easy public maintenance. A large municipal concern regarding green infrastructure use is maintenance; using roads and right-of-ways as locations for green infrastructure not only addresses a significant pollutant source, but also alleviates access and maintenance concerns by using public space.

Green streets can incorporate a wide variety of design elements including street trees, permeable pavements, bioretention, and swales. Although the design and appearance of green streets will vary, the functional goals are the same: provide source control of stormwater, limit its transport and pollutant conveyance to the collection system,

restore predevelopment hydrology to the extent possible, and provide environmentally enhanced roads. Successful application of green techniques will encourage soil and vegetation contact and infiltration and retention of stormwater.

Prototypes and Pilots

Many communities have implemented prototypes so that they can prove the benefits of a particular green infrastructure method before allowing, requiring, or funding it throughout a community. Green infrastructure demonstration projects in Ocean City have provided valuable insight into the benefits, challenges and potential future uses of GI in the City. The primary impetus behind the projects completed to date is to reduce flooding by increasing the infiltration of stormwater from rain events.

Complete Streets. Complete Streets are those designed to balance the needs of pedestrians, bicyclists, motorists, transit vehicles, emergency responders, and goods movement. The specific design depends on the context of the location, but safety is always a priority. New Jersey is a national leader in Complete Streets policies, with the most policies of any state. The New Jersey Department of Transportation was among the first to adopt an internal Complete Streets policy. Today, 121 municipalities and seven counties have policies.

Recognizing the value of complete streets, Ocean City adopted a resolution endorsing complete streets policies in October 2011. The City also received the State of New Jersey's "Complete Streets Excellence Award," and was commended "for instituting an all-encompassing program to provide a "safe, multi-modal transportation system that is accessible to all."

Ocean City was one of only six entities in the State to receive the Complete Streets Excellence Award. The community's emphasis on safe street polices is especially important to a tourist destination that experiences huge influxes of vacationers many of whom need extra attention when it comes to street safety.

In conjunction with complete streets considerations, street design and infrastructure improvements in Ocean City incorporate features to increase the infiltration of storm water. Impervious surfaces are reduced where possible, and permeable landscaped areas are provided where appropriate.

Bioretention Curb Extensions and Sidewalk Planters. Bioretention is a versatile green street strategy. Bioretention features can be tree boxes taking runoff from the street, indistinguishable from conventional tree boxes. Bioretention features can also be

attractive attention grabbing planter boxes or curb extensions. Many natural processes occur within bioretention cells: infiltration and storage reduces runoff volumes and attenuates peak flows; biological and chemical reactions occur in the mulch, soil matrix, and root zone; and stormwater is filtered through vegetation and soil.

Ocean City constructed a bioretention curb extension at the intersection of North Street and West Avenue. This bioretention area takes runoff from the street and the sidewalk through curb cuts and has demonstrated the practical application of this GI and enhanced the appearance of this intersection. This practice may be used in other areas subject to an evaluation of the impact on parking, grade elevation and right-of-way width.

Rainwater Harvesting. Rainwater harvesting systems come in all shapes and sizes. Cisterns and rain barrels capture rainwater, mainly from rooftops. The water can then be used for watering gardens, washing vehicles, or for other non-potable uses.

These systems are good for harvesting rainwater in the spring, summer, and fall but must be winterized during the colder months. Cisterns are winterized, and then their water source is redirected from the cistern back to the original discharge area.

The Ocean City Environmental Commission conducted a Rain Barrel Workshop Wednesday, June 28, 2017 to acquaint the public with the potential benefits and use of rain barrels to reduce stormwater flows.

Permeable Paving. Ocean City has utilized permeable paving in City-owned parking lots and road construction. Factors limiting the use of permeable paving include street grade and right-of-way width, on-street parking, traffic volumes, soil conditions and depth to groundwater. Projects utilizing permeable paving are helping the City build experience and a market for this green streets technology.

Stormwater Management Planning

Managing stormwater with green infrastructure has become a high priority in MS4 (municipal separate storm sewer system) communities. The EPA has determined that MS4 systems can be regulated under the Clean Water Act. EPA's Stormwater Phase II Final Rule is "intended to further reduce adverse impacts to water quality and aquatic

habitat by instituting the use of controls on the unregulated sources of stormwater discharges that have the greatest likelihood of causing continued environmental degradation."[4] Due to these Phase II regulations, NJDEP issued MS4 permits to all 565 municipalities in New Jersey. These permits require municipalities to develop, implement, and enforce a stormwater program that "shall be designed to reduce the discharge of pollutants from the municipality's small MS4 to the maximum extent practicable to protect water quality."[5] While these MS4 permits do not specifically require that green infrastructure be used to manage stormwater from uncontrolled sources, green infrastructure would be a cost effective way to reduce stormwater runoff and pollutants entering local waterways.

Even though the regulatory requirements do not specifically require municipalities to retrofit existing development with green infrastructure, there has been a strong need for municipalities to become more resilient to the changing climate. While recent hurricanes, superstorms, and nor'easters have severely impacted many New Jersey residents, localized flooding causes a more regular disruption in the lives of New Jersey residents. By retrofitting existing development with green infrastructure, these localized flooding events can be reduced or eliminated.

Ocean City's Master Plan contains the following goal pertaining to stormwater management:

"To encourage the efficient management of stormwater runoff through the development of appropriate guidelines which will prevent future drainage problems and provide environmentally sound land use planning and to reduce water pollution and tidewater infiltration through capital improvements."

The City's Stormwater Management Plan includes the following goals:

1. Reduce flood damage, including damage to life and property;
2. Minimize, to the extent practical, any increase in stormwater runoff from any new development;
3. Reduce soil erosion from any development or construction project;
4. Assure the adequacy of existing and proposed culverts and bridges, and other in-stream structures;

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[4] United States Environmental Protection Agency (USEPA). 2005. Stormwater Phase II Final Rule, An Overview. EPA833-F-00-001. http:// www3.epa.gov/npdes/pubs/fact1-0.pdf

[5] New Jersey Department of Environmental Protection (NJDEP). 2005. Tier A Municipal Stormwater General Permit (NJ0141852) Major Modification. http://www.nj.gov/dep/dwq/pdf/final_tier_a_permit.pdf

5. Maintain groundwater recharge;
6. Prevent, to the greatest extent feasible, an increase in nonpoint pollution;
7. Maintain the integrity of stream channels for their biological functions, as well as for drainage;
8. Minimize pollutants in stormwater runoff from new and existing development to restore, enhance, and maintain the chemical, physical, and biological integrity of the waters of the state, to protect public health, to safeguard fish and aquatic life and scenic and ecological values, and to enhance the domestic, municipal, recreational, industrial, and other uses of water; and
9. Protect public safety through the proper design and operation of stormwater basins.

To achieve these goals, the SWMP outlines specific stormwater design and performance standards for new development. Additionally, the plan proposes stormwater management controls to address impacts from existing development. Preventative and corrective maintenance strategies are included in the plan to ensure long-term effectiveness of stormwater management facilities. The plan also outlines safety standards for stormwater infrastructure to be implemented to protect public safety.

Conclusion

As with other environmental trends that became conventional, there are still numerous challenges to advancing the state of the art in green infrastructure and to increasing its usage.

The potential of green infrastructure to reduce damage from natural disasters has risen to the forefront in recent years in the aftermath of catastrophic events such as Hurricanes Katrina and Sandy. Preservation and restoration of marsh, dune, floodplains, and other natural systems; creation of living shorelines, oyster reefs, and other nature-based solutions; and integration of green resources (trees, green streets, green roofs, etc.) into the urban environment can increase community resilience while providing multiple environmental, economic, and social benefits. Planning for post-disaster recovery should use green infrastructure in combination with appropriate structural protection measures to reduce potential risks; specify how short-term recovery will address trees and other green resources; and set the framework for incorporating green infrastructure into long-term recovery. The result will be healthier communities that are more resilient to future disasters.

Ocean City has implemented a number of green infrastructure strategies that have demonstrated their suitability for a barrier island community. The City will continue to explore and evaluate the use of green infrastructure strategies discussed in this report and implement them where feasible. Subsequent to further review, the City may conclude that amendment to the Complete Streets program to include green streets may be appropriate.

The "Green Streets" and "Green Alleys" programs from Portland, Oregon and Chicago respectively may be considered to provide guidance for advancing green infrastructure in Ocean City. Portland's green streets program demonstrates how common road and right-of-way elements (e.g., traffic calming curb extensions, tree boxes) can be modified and optimized to provide stormwater management in addition to other benefits. Where Portland used vegetation, Chicago's Green Alley Program similarly demonstrates that hardscape elements can be an integral part of a greening program. By incorporating permeable pavements that simulate natural infiltration, Chicago enhances the necessary transportation function of alleys while enhancing infrastructure and environmental management.

The City may consider additional review and evaluation of green roofs to mitigate stormwater runoff and the "urban heat island" effect. Amendments to the land development and zoning code including the development of design standard may be required.

The City will also continue to advocate for green infrastructure on private property including reduction of impervious surfaces, and rain harvesting via rain barrels and rain gardens.

Additional guidance regarding green streets is available from a number of sources including the Green Streets Manual which subject to appropriate revisions may be adopted by the City to assist in advancing future green infrastructure projects.

Resources

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- Green Infrastructure Guidance Manual for New Jersey, http://water.rutgers.edu/Green_Infrastructure_Guidance_Manual/2016-08-10_REV1_Manual.compressed.pdf