NEW JERSEY STORMWATER RETROFIT BEST MANAGEMENT PRACTICES GUIDE

NEW JERSEY FUTURE

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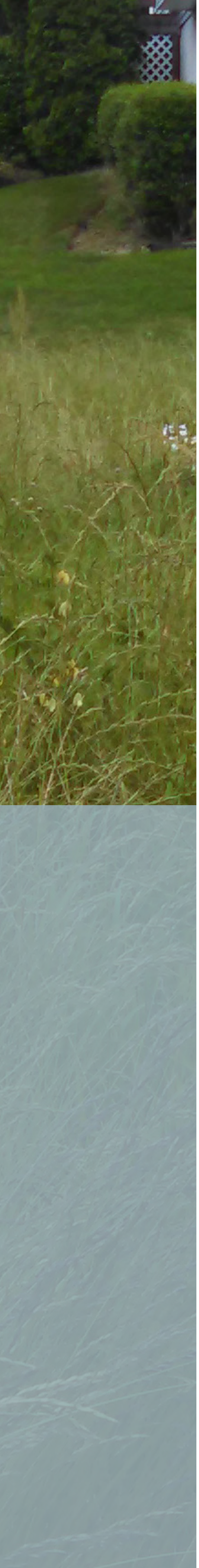

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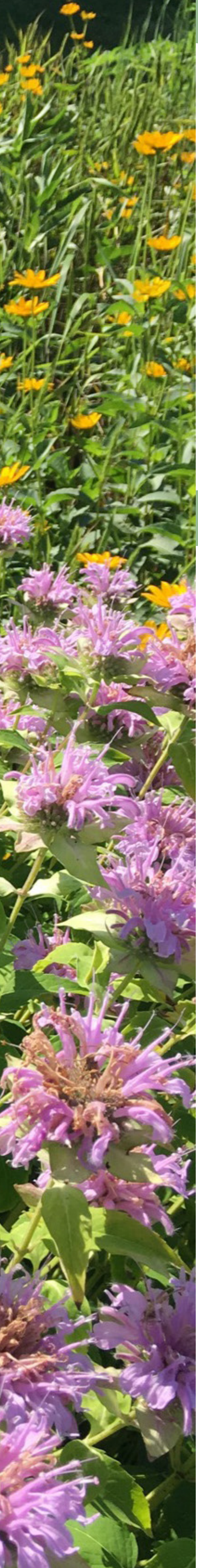
- Want to improve aesthetics?



PURPOSE

The New Jersey Stormwater Retrofit BMP Guide aims to provide best practices for retrofitting stormwater infrastructure for local and county government, nonprofit organizations, developers, and property owners

1.1 What's the Purpose of Stormwater Management?

The practice of stormwater management has emerged and evolved as the impacts of altering the hydrology of our watersheds from development and urbanization are realized. The natural hydrologic cycle is highly dependent on the vegetation, land cover, and topography of an area. Specifically, the processes of infiltration (the absorption of water into the soil and groundwater table) and evapotranspiration (the evaporation and uptake of water from vegetation) are reduced by replacing natural instances of wetlands, meadows, forests, etc. with large areas of impervious surfaces. The result is that runoff (water that flows over land to watercourses) is disproportionately increased as the other natural functions are decreased, which can lead to problems with pollution of our waterways, increased flooding, and reduction of groundwater.

In order to mimic natural hydrologic functions, delay the discharge of stormwater runoff, and reduce nutrient and sediment runoff, artificial stormwater management measures are implemented alongside development to mitigate its impacts. However, as our understanding of the effects of urbanization has evolved, it has become increasingly necessary to design stormwater management systems that not only mitigate for the impacts of current development or redevelopment, but improve upon designs of the past and plan for the changing landscape of the future by designing climate-resilient infrastructure.

Historically, stormwater management measures, often seen in the form of detention basins in residential developments, shopping centers, and corporate complexes, have been designed to control peak flow (i.e., the maximum flow of water during a storm event) and do not necessarily provide a water quality improvement benefit. Many Best Management Practices (BMPs) were installed prior to the New Jersey Department of Environmental Protection's (NJDEP) 2004 Stormwater Management Rule, so they are outdated and were not designed to manage current and future storm events.

NJ Stormwater BMP Manual (Chapter 8) defines a stormwater retrofit as:

"...expanding, modifying, or otherwise upgrading existing stormwater management measures. As such, retrofitting stormwater management measures can reduce some of the adverse groundwater recharge and stormwater quantity and quality impacts caused by existing land developments. In many instances, existing stormwater management measures can be dramatically improved, and downstream waterbodies protected, through effective retrofitting."

1.2 What is a Stormwater Retrofit?

A stormwater retrofit aims to modify the existing drainage system to further improve stormwater control and treatment practices. This can include improving or enhancing the function of older, poorly designed, or poorly maintained stormwater management systems. Retrofits can reduce runoff volume, filter out pollutants, increase groundwater recharge, and help mimic pre-development hydrology.

Thinking about the system as a whole is critical when implementing retrofits, and in some cases, thinking outside of the box for what defines a retrofit (e.g., a floodplain reconnection or stream restoration) may be the best option for the community and environment. The ideal stormwater retrofit will control peak rate (i.e., runoff volume) and treat water quality, among other benefits.

1.3 How Can This Guide Help Your Community?

The purpose of this guide is to provide local and county government, nonprofit organizations, developers, and property owners in the state of New Jersey with the tools to identify opportunities to retrofit existing stormwater BMPs and opportunities to install new stormwater BMPs in built-out environments. It is intended to provide context and fill in gaps in current guidance for the planning, prioritization, and design of BMP retrofits.

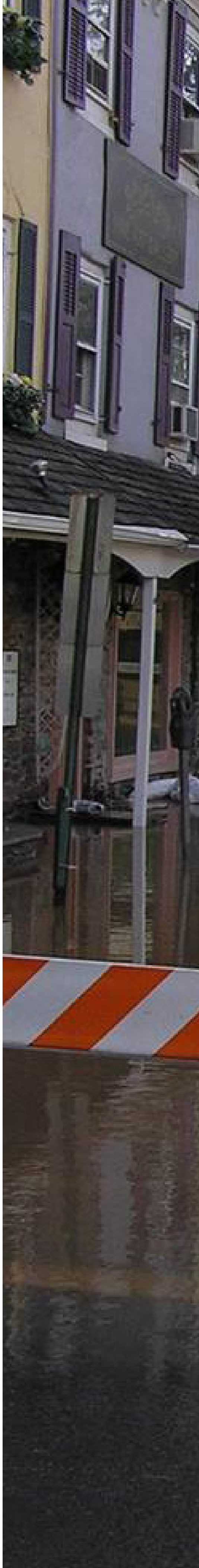
The hope is that this guide will be useful for MS4 Tier A permit compliance, help with project identification and design, and foster public-private partnerships for the purpose of improving stormwater management and water quality.

It is within the mission of New Jersey Future to promote sensible and equitable growth, redevelopment, and infrastructure investments to foster healthy, strong, resilient communities. New Jersey Future has made a commitment to addressing our state's preparedness for future storms and rising to the challenge presented by climate change. This guide is intended to supplement existing resources provided by the State of New Jersey as well as New Jersey Future's Mainstreaming Green Infrastructure Program's **New Jersey Green Infrastructure Municipal Toolkit** and **New Jersey Developers Green Infrastructure Guide**.


NO
OUTLET

BACKGROUND

A review of stormwater management and regulations in New Jersey



2.1 The Evolution of Stormwater Regulation in New Jersey

The standards, techniques, and philosophies governing stormwater management in New Jersey have evolved progressively over time. Prior to the introduction of the first iteration of the Stormwater Management Rule (N.J.A.C. 7:8) in 1983, the practice of stormwater management generally involved diverting runoff from developed areas through use of conveyance systems (e.g., storm drainage and swales) directly into nearby watercourses. Following implementation of the Stormwater Management Rule, peak flow control governed. With little consideration for water quality or groundwater recharge, the standard practice of the time encouraged the widespread use of typical dry detention basins, many of which still exist today.

The second iteration of the **New Jersey Stormwater Management Rule** was issued on February 2, 2004. This specified the applicability of the rule to any "major development," which is generally defined as development which will disturb one acre or more of land or increase impervious surface coverage by one-quarter acre or more. This iteration of the rule also introduced the standard practices of groundwater recharge, stormwater runoff quality control, and stormwater runoff quantity control.

Under the Stormwater Management Rule (N.J.A.C. 7:8), municipalities are required to adopt a Municipal Stormwater Control Ordinance that reflects the most recent amendments to the Rule. To assist municipalities in adopting stormwater ordinances, New Jersey Future developed an **Enhanced Model Stormwater Ordinance**. While it is based on NJDEP's Model Stormwater Control Ordinance, it includes modifications beyond the minimum to provide for improved water quality, more widespread implementation of green infrastructure, and greater protection of water resources.

The Green Infrastructure Rule, which was adopted in March of 2021, implemented standards for the required use of green infrastructure stormwater management measures which, "...manage stormwater close to its source." Green infrastructure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CLOSED

is not just a means of classifying BMPs, but rather an approach to engineering design that emphasizes the use of natural processes. Green infrastructure approaches often decrease the volume of stormwater runoff and provide nutrient and sediment reduction through processes similar to undeveloped land (e.g., infiltration, evapotranspiration, vegetative filtration, and nutrient uptake).

All major developments that are required to meet groundwater recharge, stormwater runoff quantity, and stormwater runoff quality standards must use green infrastructure stormwater BMPs that:

- Treat stormwater runoff through infiltration into the subsoil;
- Treat stormwater runoff through filtration by vegetation or soil; or
- Store stormwater runoff for reuse.

Green infrastructure has other added benefits such as reducing the heat island effect, reducing energy use, removing air pollutants, beautifying public spaces, providing ecological/habitat value, and increasing property value. Examples include bioswales, rain gardens, green roofs, floodplain reconnection, etc.

In 2020, New Jersey embarked on a targeted regulatory reform effort to modernize environmental laws to protect against climate threats deemed New Jersey Protecting Against Climate Threats (NJ PACT). It aims to help reduce greenhouse gas (GHG) and other climate pollutant emissions, while making our natural and built environments more resilient to the impacts of climate change that are now unavoidable.

In July 2023, the Inland Flood Protection (IFP) Rule was adopted. It establishes design elevations that are reflective of New Jersey's changing climate and more frequent and intense rainfall, replacing standards based on outdated data and past conditions.

Under the two primary components of the rule:

- The elevation of habitable first floors will be two feet higher than currently indicated on NJDEP state flood maps and three feet higher than indicated on FEMA maps.
- Applicants for certain permits will use NJDEP's New Jersey-specific projected precipitation data based on the latest climate science when calculating peak flow rates of streams and rivers for permits under the Flood Hazard Area Control Act Rules (N.J.A.C. 7:13), as well as when proposed development triggers compliance with the Stormwater Management Rule (N.J.A.C. 7:8).

Collectively, notable goals of the Green Infrastructure and IFB amendments include:

- Maintaining groundwater recharge
- Pollutant removal (sediment)
- Ensuring new development does not increase flooding
- Climate resilience

2.2 Municipal Separate Storm Sewer System (MS4) Permit

NJDEP is responsible for the issuance of permits under the New Jersey Pollutant Discharge Elimination System (NJPDES) to satisfy the requirements of the federal National Pollutant Discharge Elimination System (NPDES). The NJPDES rules (N.J.A.C. 7:14A-25) govern the discharge of stormwater from MS4. There are NJPDES general permits that authorize discharge from Tier A municipalities, public complexes, and highway agencies. NJDEP updates the MS4 permit every five years, which allows for opportunities to include provisions to improve the water quality of New Jersey's rivers, streams, lakes, and groundwater [21,22].

NJDEP issued the updated Tier A Municipal Separate Storm Sewer System (MS4) Permit, effective on January 1, 2023. This represents a major change from previous MS4 permits with the addition of a Watershed Improvement Plan requirement aimed at identifying water quality projects that will help local waterways meet water quality standards and reduce flooding. This three-phased requirement includes [23]:

- The mapping of all stormwater infrastructure, including green infrastructure;
- Outlining water quality improvement projects; and
- A final plan that summarizes proposed projects, implementation schedules, and expected costs.

NJDEP offers opportunities for grants and loans to assist Tier A municipalities to upgrade their MS4 programs in order to comply with updated permit requirements. Stormwater retrofits are a vital component to allow municipalities to address MS4 permit requirements.

Check out New Jersey Future's "**Understanding the New MS4 Permit: A Primer for New Jersey Municipalities**."

2.3 Clean Stormwater & Flood Reduction Act

The Clean Stormwater and Flood Reduction Act (P.L.2019, c. 42 (C.40A:26B-1 *et al.*)), signed into law on March 18, 2019, amends existing statutes to allow municipalities, counties, sewerage authorities, municipal and county utility authorities, and county improvement authorities to, by resolution or ordinance, establish a stormwater utility. A stormwater utility is a dedicated and equitable funding source for stormwater management and can be used for acquiring, constructing, improving, maintaining, and operating stormwater management systems in the county, municipality, or service area consistent with state and federal laws, rules, and regulations.

For municipalities in New Jersey, without a dedicated funding source, management costs for stormwater are included in local government processes (e.g., general budget, sewer fees, property taxes) or via one-time grant funding for specific projects. This system has led to an under-investment in managing stormwater, lending itself to a strategy of deferred maintenance to focus on higher-profile needs (e.g., schools, etc.). A stormwater utility would help a municipality dedicate funds to proactively plan for and implement stormwater retrofits and BMPs, update their infrastructure, and comply with MS4 Permit requirements.

Check out the New Jersey Stormwater Utility Resource Center for more information.

2.4 Regional Protection Acts

In addition to compliance with the Stormwater Management Rule, there are three regional protection acts which govern development in areas of high sensitivity and/or ecological value in the state, including the Highlands Region (Highlands) (N.J.A.C. 7:38), the Delaware and Raritan Canal Zone (DRCC) (N.J.A.C. 7:45), and the Pinelands Region (Pinelands) (N.J.A.C. 7:50). Each of these regions is protected under a respective act, which are facilitated by independent state agencies that oversee the authorization of land development projects and advocate for conservation and stewardship of resources within their respective regions. The regulations adopted by each of the regional protection acts are unique to the specific goals of the region. However, each must conform to the requirements of N.J.A.C. 7:8 at minimum, with additional provisions, definitions, and requirements which may make compliance with the standards more restrictive. Specifically, projects under the jurisdiction of the DRCC or Highlands that ultimately disturb more than 1 acre of land or increase impervious surface by 0.25 acres require permit approval. Projects under the jurisdiction of Pinelands that grade, clear, or disturb more than 5,000 square feet require permit approval.

Similarly, municipalities throughout New Jersey are required to adopt local stormwater management ordinances that must meet or be more stringent than the requirements of N.J.A.C. 7:8, depending on local permit requirements, management plans, and/or community needs, to name a few.

2.5 Soil Conservation Districts

There are 14 soil conservation districts (SCDs) in New Jersey, which were formed under the New Jersey Soil Erosion and Sediment Control Act (N.J.S.A. 4:24-39) and tasked to govern certain aspects of new development. SCDs generally follow county boundaries, with some districts being responsible for more than one county. These authorities are locally controlled and play a strong role in the protection of New Jersey's natural resources. Often, SCDs are valuable partners in stormwater management, both leading and supporting local projects. They have provided letters of support and in-kind match for many grant-funded stormwater management and green infrastructure projects.

SCDs are also charged with enforcing the design standards found in the Soil Erosion and Sediment Control Standards. A project must comply with these regulations if the project disturbs more than 5,000 square feet of land. This is typically considered a minor permit that will pertain mostly to control measures of sediment and erosion control.

2.6 The Shift in Land Use

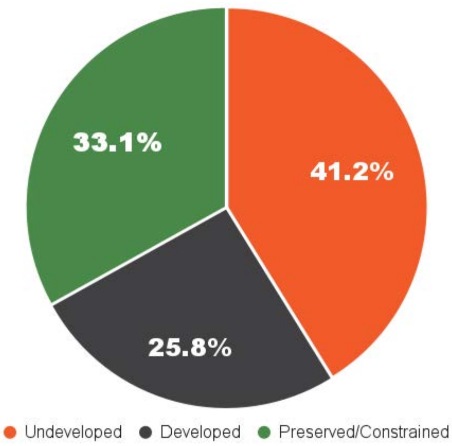
New Jersey is a high-density state, the most developed state in the country by land area, and is expected to be the first state to reach build-out (i.e., where all land is either protected or developed). This presents unique challenges when designing stormwater management infrastructure to address concerns of flooding, water quality, and groundwater recharge. NJDEP's Land Use and Land Cover data reveal development trends over the last several decades (right).

These figures exhibit that a vast majority of development in the state of New Jersey occurred before the implementation of the 2004 Stormwater Management Rule, indicating that stormwater management measures designed and constructed during this time period are not likely to satisfy the more robust requirements for groundwater recharge and water quality implemented in 2004, nor would they meet the definition of green infrastructure or have considerations for climate resilience. The 2015 Land Use and Land Cover data also provides another piece of information: there is significantly less undeveloped land area available to construct new stormwater management infrastructure. Coupled, these points provide justification for the need to rehabilitate and retrofit the existing available infrastructure in order to:

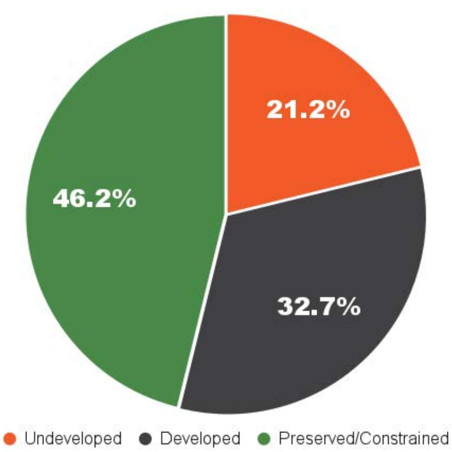
- Improve upon outdated design practices;
- Utilize impaired lands that are no longer serving their intended purpose; and
- Preserve and protect lands, habitats, resources, etc.

Land Use Changes in New Jersey

Prior to 1986



2007



2015

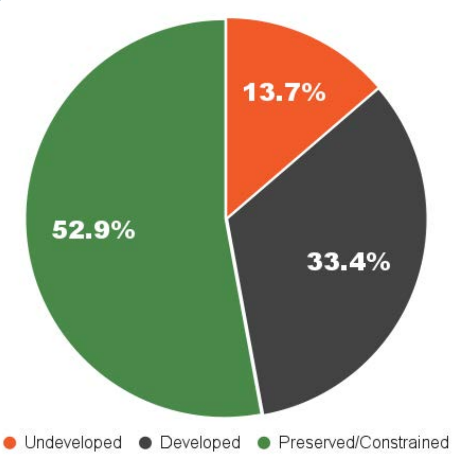


Diagram information adapted from NJFuture.org

03

SITE EVALUATION & RETROFIT SELECTION

A holistic approach to selecting the right retrofit for your community

The selection of potential retrofit sites, types of BMPs, and prioritization of retrofits is often an iterative process that can vary from municipality to municipality based on several variables, including:

- NJPDES/MS4 permit compliance
- Combined Sewer Overflow (CSO) compliance
- Cost to design and construct
- Cost to inspect and maintain
- Identified needs, problem areas, and/or sensitive receptors
- Waterways with an impairment status
- Availability of funding or grants
- Community buy-in
- Contributing drainage area and impervious cover percentage
- Physical constraints
- Legal constraints (e.g., land ownership)

When determining a strategy to implement stormwater retrofits, it may be tempting to target known sources of flooding or pollution, but these problems are rarely isolated. While individual sites can certainly contribute more towards the problem than others, applying retrofit methods on a site-by-site basis without consideration for the watershed as a whole can be short-sighted. In fact, it has been found that the net effect on waterways downstream of multiple sites that exclusively provide peak flow control (i.e., no water quality or volume treatment) is either a negligible peak flow reduction or a potential increase in peak flow rates [4]. This happens because hydrology is a function of time, and historically, the goal of stormwater management measures was simply to detain runoff and slowly release it back into the watershed. However, the convergence of the delayed runoff from all of these sites can result in a secondary peak in the receiving waterway or otherwise influence the primary peak, depending on watershed conditions. As such, it is recommended to collaborate with both government, nonprofit, and private organizations to develop watershed-wide goals and implement a Watershed Restoration and Protection Plan (WRPP), also known as a Watershed-based Plan (WBP) or Watershed Improvement Plan (WIP).


NATURALIZED
STORMWATER BASIN
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3.1 Holistic Watershed Planning

Watershed-based planning is a nationally recognized strategy used to address nonpoint source pollution by a holistic evaluation of the contributing watershed to first assess contributing causes of pollution and then prioritizing methods of restoration or protection to address the problems. The plans must follow USEPA's framework called Nine Minimum Elements of Watershed-based Plans, which include nine components of the watershed planning process that USEPA believes are the most critical to preparing effective watershed plans [23]:

a. Identify causes and sources of pollution.
b. Estimate pollutant loading into the watershed and the expected load reductions.
c. Describe management measures that will achieve load reductions and targeted critical areas.
d. Estimate amounts of technical and financial assistance and the relevant authorities needed to implement the plan.
e. Develop an information/education component.
f. Develop a project schedule.
g. Describe the interim, measurable milestones.
h. Identify indicators to measure progress.
i. Develop a monitoring component.

These nine elements were developed many years ago, and with increased rainfall, storm surge, and sea level rise happening in real time due to climate change, we recommend including a tenth element of "Planning for Climate Change Impacts" into the WRPP project ranking process. This will help prioritize not only the reduction of nutrient, sediment, and bacterial pathogens, but incorporate more storage and infiltration (when feasible) to minimize flooding.

WRPPs are eligible for [NJDEP grants under Section 319(h)](#) to facilitate the planning process and implement the priority projects identified in the plan, and ultimately, meet the total maximum daily load (TMDL) goals established by NJDEP [14]. As per USEPA's definition, a TMDL is the calculation of the maximum amount of a pollutant allowed to enter a waterbody so that the waterbody will meet and continue to meet water quality standards for that particular pollutant. A TMDL determines a pollutant reduction target and allocates load reductions necessary to the source(s) of the pollutant [25].

These watershed plans include stormwater BMPs, retrofits, and green infrastructure solutions (e.g., rain gardens, permeable pavement, detention basins, bioswales, rainwater harvesting, green streets, etc.), and nature-based strategies that reduce polluted runoff from entering waterways and make communities more resilient to future flooding and storm hazards.

Stormwater and flooding do not follow municipal boundaries, so regional and watershed level planning are important approaches to improving water quality and reducing flooding, thus the importance of a holistic, integrative, and long-term watershed-based planning process that is cost effective and improves environmental health cannot be overstated.

Compliance with MS4 Tier A Permit requirements requires the creation of a Watershed Improvement Plan (MS4 WIP), which is limited to individual municipality boundaries. While there is overlap between a WRPP and the MS4 WIP, these approaches are separate and satisfy different ends. Thus, planners, engineers, community advocates, and members are all needed to work together to assist municipalities in managing stormwater, define the Level of Service needed, and meet state-level requirements. It is important that watershed improvement planning is equitable, inclusive, and fairly distributes the environmental, social, and economic benefits.

When municipalities think about how to begin implementing stormwater management retrofits to satisfy their MS4 WIPs (see Section 2.2), there are an innumerable amount of considerations that must be thought through to ensure that the retrofits fairly benefit the environment, communities, and the economy.

3.2 Getting Started: Stormwater Retrofit Applicability

The following checklist and matrix are intended to be a tool to simplify the process of prioritization in order to inform conversations with stakeholders, communities, and professional planners and engineers such that they can identify and define the goals, feasibility, and equitability of the retrofit implementations.

Identify goals or concerns:

- Dealing with a flooding problem?
- Concerned about pollutant loading?
- Evidence of streambank erosion?
- Want to create a wildlife habitat?
- Concerned about water quality/fish health?
- Dealing with nuisance species?
- Want to improve aesthetics?

Evaluation of sites:

- What existing infrastructure is available?
- What space is available to develop new BMPs?
- What type of BMP are you willing to maintain?
- What type of BMP will neighbors accept?
- What existing drainage pathways and stormwater systems can be evaluated?
- Is there a concentration of impervious surface?
- What are the contributors to erosion?
- Does the site experience flooding (general or localized)? If so, where?
- Is there an established TMDL?
- Is the habitat fragmented?
- What types of retrofits are feasible based on potential site constraints and needed functionality?
- Do you have ownership of the site or the ability to obtain property, construction and maintenance access?
- Are there any visible constraints?

Prioritization ranking of potential sites

- What is the estimated cost (design, permitting, construction)?
- Is there an opportunity to count progress towards other program requirements or benefits (MS4, TMDL, stormwater utility credits)?
- What is the size of the existing BMP/drainage area treated?
- Will a retrofit make maintenance easier/less expensive?
- Is there an equitable allocation of resources?
- Do you have stakeholder buy-in?
- Do you have a responsible party and funding identified for long-term maintenance?

Note: This section is intended to provide readers with considerations to develop appropriate plans based on their needs and priorities and is not a comprehensive or inclusive tool to be used in place of professional planning or engineering.

Table 1: Applicability Matrix

Retrofit Option	Peak Flow Control	Water Quality	Groundwater Recharge	Habitat Restoration	Cost
Detention Basin Naturalization		X	X	X	$
Bioretention Basin	X	X	X	X	$$$
Infiltration Basin	X	X	X		$$$
Subsurface Gravel Wetland		X			$$$
Wet Pond Retrofit		X		X	$$
Constructed Wetlands	X	X		X	$$$
Porous Pavement	X	X	X		$$
Removal of Impervious Cover	X	X	X		$
Downspout Retrofits	X	X	X		$
Inlet/Traffic Island Bioretention		X	X		$$
Inlet MTD		X			$$
Grass Swales		X			$
Streambank Stabilization		X		X	$$
Floodplain Reconnection	X	X	X	X	$$

04

BMP RETROFIT GUIDANCE

Explore stormwater retrofit options, techniques, and strategies that can be implemented in your community

This section discusses potential retrofit options and strategies that can be implemented based on existing site conditions, available infrastructure, physical constraints, costs, and specific retrofit design goals. Prioritization of these goals, along with other factors informing retrofit strategies, is further discussed in Section 3 of this guide. While many of the retrofit opportunities discussed herein are examined individually, it is important for project executors to understand that several implementations or strategies can and should be considered concurrently whenever possible.

Any retrofit techniques discussed herein may be subject to municipal, county, and/or state approval if the project triggers permit submissions to any of these authorities. Please refer to Section 2 for discussion of the various regulations throughout New Jersey that may be applicable to retrofit projects. Please note that these regulations are primarily intended for large land development projects and are typically triggered when a project involves a significant amount of land disturbance or an increase in impervious surface for a site. Most retrofit projects are relatively small and are not likely to increase impervious surface coverage. As such, many recommended retrofit strategies may only require approval from the local SCD, which requires a permit when as little as 5,000 square feet is disturbed.

It is essential to thoroughly understand local and state regulations to determine whether a retrofit is exempt. Some projects may necessitate support from a licensed professional engineer or regulatory expert to confirm exemption from these regulations.

Strategies which promote infiltration of water into the subsoil are the preferred retrofit alternatives, in accordance with the definition of green infrastructure. Encouraging filtration and infiltration can provide both water quality and water quantity benefits to the system and receiving watercourses by removing various pollutants through filtration through soil media and root system uptake as well as providing volume control, particularly for regular rainfall events.

4.1 Detention Basin Retrofit Opportunities

Prior to the adoption of the Green Infrastructure Rule (2021) and the Inland Flood Protection Rule (2023), the Stormwater Management Rule (N.J.A.C. 7:8) permitted the use of large, turf grass dry detention basins as the sole means of treating runoff from land development projects. Detention basins are engineered structures designed to temporarily detain runoff from flood events, releasing water slowly over a maximum of 72 hours to reduce peak flow rates and delay the peak time of the flood hydrograph. These basins were primarily intended for flood control during large storm events, with limited consideration for water quality or groundwater recharge objectives.

Consequently, stormwater infrastructure constructed during this period has been associated with various performance and maintenance issues over time, including:

- **Erosive stream downcutting.** Detention basins were designed primarily for control of runoff from storm events and often did not consider the effects of smaller, more frequent storm events. Exacerbated by widespread use of concrete low-flow channels to encourage fully emptying the basins, the single point discharge of runoff from highly impervious developments causes many streambank erosion concerns in receiving watercourses [2].
- **Increased pollutant discharge.** Detention basins in particular provide the lowest reduction rates for Total Suspended Solids (TSS) as compared to other traditional BMPs [1], as well as often offering no additional means for chemical or biological pollutant removal. In addition, the mowed turf landscape invites nuisance species such as White-tailed deer and Canada goose. These species, especially Canada goose, can introduce additional nutrients and bacteria sources into the watershed [5].
- **Disruption of the infiltration process.** Detention basins are often found to have excessively compacted soils, which offer little to no infiltration capacity. Compacted soil may be caused by construction practices or ongoing maintenance operations needed in the bottom of the facility. As a result, detention facilities allow nearly all of the increased runoff volume from the accompanying imperviousness to be released to receiving watercourses.
- **Watershed-scale flooding impacts.** Because the primary function of detention basins was the reduction of the peak flow rate at the site level and the limited infiltration potential cited above, there is ultimately no runoff volume control. Peak flow control without volume control can lead to a net-zero improvement or even worsened flooding conditions on the watershed level due to converging peaking times [4].

There are a wide range of retrofit options available for standard dry detention basins. Following this section is a list with descriptions of each option, arranged from the simplest to the most complex. Some of the simpler methods can be combined. The descriptions will outline the methods for implementing each retrofit and the specific problems the retrofit aims to address. Regardless of the simplicity of the proposed retrofit, it is recommended to involve a licensed professional engineer or landscape architect in the design and implementation process.

Retrofit Option: Detention Basin Naturalization

Detention basin naturalization is as straightforward as its name suggests. Detention basins are typically found in developed suburban and urban environments and are usually covered with turf grass, much like most open spaces in these areas. Naturalizing detention basins involves changing their vegetation to better match the local natural surroundings.

The simplest approach is to alter the maintenance practices for the basin. Basins are typically mowed regularly to keep the grass short. To naturalize them, maintenance mowing should be reduced from once every week or two to perhaps once every few months. Furthermore, the mowing

height should be adjusted. Turf grass is typically kept at a maximum height of a few inches, while meadows feature much taller vegetation. Reducing how often the area is mowed will allow for the turf grass to grow longer and for a greater diversity of species to develop in the detention basin. Naturalizing the basin will increase infiltration due to deeper root structures, enhance pollutant removal from stormwater runoff, and create more habitat for local wildlife.

Many existing detention basins have concrete low-flow channels, which connect inlet pipes directly to the basin's outlet. The channels facilitate the maintenance of turf grass vegetation and the required frequent mowing schedule by moving water through the basin quickly and preventing any standing water in the basin from small storms and immediately following larger storms. By design, these channels bypass the natural filtration/pollutant removal that occurs when stormwater flows through vegetation.

Removing the low-flow concrete channel can be a critical step in the naturalization process. Once the concrete channel is removed, the area should be re-graded to prevent concentrated flow in the path of the former low-flow channel and promote a more shallow and dispersed flow through native vegetation. This provides water quality while maximizing contact with soil and encouraging infiltration into the soil. Whenever possible, the path should be elongated and allowed to meander to allow the stormwater runoff to be treated by the vegetation. If the existing detention basin is not expected to provide any substantial infiltration, perhaps due to low hydraulic conductivity soils or a shallow groundwater table, the removal of the low-flow channels and regrading of the basin bottom should maintain a positive slope to the outlet structure to prevent any unintended ponding. It is advisable to consult with a licensed professional engineer

The Water Quality Design Storm (WQDS) as defined by NJDEP is 1.25 inches of rainfall in two hours. A typical/standard design storm in NJ is a 24-hour event. This rainfall event is used to compute water quality reductions pursuant to N.J.A.C. 7:8-5.5 to quantity pollutant removal rates, specifically total suspended solids (TSS). Stormwater management measures must be designed to remove 80% of the anticipated post-construction TSS loading when a major development results in an increase of one-quarter acre or more of regulated motor vehicle surface.

if your retrofit project will entail the removal of low flow channels.

While allowing the turf grass in the basin to grow taller and resemble a meadow is a more natural approach, it's important to note that turf grass is not a native vegetation choice and preference should be given to the introduction of native species to the basin whenever possible. However, minimizing soil disturbance while seeding native species to prevent excessive erosion can be a delicate process. To achieve this, the bottom and side slopes of the basin should be tilled or scarified.

The USDA defines scarifying as follows:

> *"Scarifying involves the tilling or ripping of the soil across the slope using farming or construction equipment. The purpose of this treatment is to loosen and mix the soil profile to create a better seedbed, improve infiltration, and, where present, reduce any hydrophobic characteristics that may have developed as a result of the fire. It can be done in many ways, depending on the size of the project."*

Once the basin side slopes and bottom have been scarified, they should be seeded with native meadow seed mixes that are appropriate for each site. As mentioned earlier, New Jersey Department of Agriculture has developed Soil Erosion and Sediment Control Standards, including recommended seed mixes for various conditions such as meadow seed mixes. The standards also provide protocol to stabilize the sacrificed soil after it is reseeded. USDA NRCS' "New Jersey Vegetative Plantings Technical Reference: Establishment and Maintenance Guide" is also a great resource for planting and seed mix recommendations.

Removing low flow channels, widespread tilling, or scarifying soil can greatly increase the potential for erosion prior to vegetation establishment in a detention basins undergoing a retrofit or naturalization process. A detention basin retrofit plan must also address erosion control during the construction process to ensure that adequate measures are provided to minimize erosion prior to full vegetation establishment. One potential alternative approach which avoids the widespread disturbance associated with soil amendments and tilling/scarification is the use of a no-till seed drill to plant the native seed mix.

It is always advisable to consult with a licensed landscape architect before finalizing seed mixes for specific basins. Removing the low-flow concrete channel, scarifying the soil, and introducing native vegetation will increase infiltration and groundwater recharge, enhance pollutant removal from runoff, and create habitat for local insects and wildlife.

The ideal location for naturalized vegetation is the basin bottom, where runoff, even from smaller more frequent storms, will temporarily pond and be in contact with vegetation and soil. However, this vegetation is less effective on basin side slopes. Specifically, vegetation on any berms that permanently or temporarily impound water should be mowed routinely to improve access and visibility for inspection and deter burrowing animals which may compromise earthen structures. Similarly, a mowed perimeter around all inlet and outlet structures should be maintained to facilitate inspection and maintenance.

Retrofit Option: Detention Basin Expansion

Detention basins were originally designed to address flooding issues, with less emphasis on water quality and groundwater recharge. However, current regulations require stormwater basins to detain and infiltrate all the runoff from the NJDEP Water Quality Storm. Typically, the stormwater runoff from this storm passes through the detention basin with minimal detention. A detention basin can undergo retrofitting to capture and infiltrate more stormwater runoff by expanding its size, which may involve increasing both the area and depth if feasible, and modifying the outlet control structure, if necessary. Expanding the size of the detention basin and altering the outlet control structure is permissible as long as these changes do not negatively impact the basin's performance, particularly by increasing flooding in any areas. This is a technical undertaking that requires the expertise of a licensed professional engineer to develop construction documents demonstrating the proposed changes and their lack of adverse effects.

When implementing these modifications, it is crucial to assess the soil and groundwater conditions of the basin. The basin should be capable of completely draining any retained water within 72 hours. If the basin does not exhibit sufficient soil and groundwater conditions that would support draining in a 72-hour period, efforts can be made to enhance it, as discussed in the section below. Expanding the detention basin has the potential to increase groundwater recharge, enhance water quality, and offer slight improvements in flood control.

Retrofit Option: Improving Infiltration

A common issue with many detention basins is the presence of standing water due to poor soil conditions and/or the presence of a shallow groundwater table. Typically, extended periods of ponding in detention basins can be attributed to three main factors: highly compacted soil, naturally occurring low permeability soils like clay, or the presence of a shallow groundwater table. Enhancing infiltration in a stormwater basin is an effective method to promote groundwater recharge, improve stormwater quality, and eliminate nuisance standing water.

An example of localized shoreline erosion in a retention basin.

The initial step in improving infiltration through a detention basin involves identifying the root cause of the low infiltration rate. It is essential to investigate whether a high water table is the culprit. The USDA Web Soil Survey offers comprehensive information for 95% of all counties in the United States. This can be used to obtain general information about groundwater depth based on the soil types in the region. However, it is recommended to collect field data as the USDA Web Soil Survey is not prepared at a site specific level. A geotechnical engineer can conduct a brief investigation to determine the water table's depth. If the water table is very close to the basin's surface, then there may be limited options for improving infiltration. Other retrofits, such as converting it into a constructed wetland, may be more appropriate.

If the groundwater level is not close to the surface of the basin, several methods can be employed to enhance the infiltration rate. These methods may include scarification of the soil, soil replacement, and/or drilling with limited soil replacement. It is advisable to consult with a geotechnical engineer to determine the most suitable approach for improving infiltration on a site-by-site basis.

Quantifying the Benefit of the Detention Basin Retrofit

When selecting a type detention basin retrofit, a main consideration may be to help meet a regulatory need such as for MS4 Permit or TMDL compliance or a stormwater utility credit program. For example, as part of the MS4 Permit process, each municipality is required to

An example of a standard detension basin.

develop a Watershed Improvement Plan to address nonpoint source pollution within their respective boundaries. This process mirrors the one used to tackle impairments caused by point and nonpoint source pollution in streams and lakes across New Jersey. Regional approaches to these plans are encouraged by NJDEP.

To address and mitigate pollutant loads, projects in these plans may be listed as a priority for implementation ranging from structural BMPs (e.g., rain gardens) to non-structural BMPs (e.g., ordinances limiting fertilizer use within the municipality). In order to justify a retrofit for a water quality improvement credit, the benefit must be quantified (i.e., rate of pollutant load reduction). This may be done by providing scientifically-justifiable data from a published study, proper collection of data pre- and post-construction to quantify results, and/or using a rate established via an accepted guidance manual. The same methods may be applied if the goal of the project is to address concerns related to habitat loss, groundwater recharge, and flood mitigation. Keep in mind that quantifying the project's benefit also may be required if it is a grant-funded project. Quantifying benefits is also a great way to share the overall success of the project with your community. The New Jersey Stormwater BMP Manual also provides accepted pollutant removal rates for a variety of standard BMPs which can be used to quantify the impact.

NJDEP Design Standards for BMPs

Detention basins could be retrofitted into a bioretention basin, infiltration basin, sand filter, or subsurface gravel wetland. The New Jersey Stormwater BMP Manual provides comprehensive design standards for each of the BMPs. To demonstrate compliance with these design standards, the expertise of a licensed professional engineer must be employed. It's worth noting that the design standards are more complex and detailed than the other retrofit modifications described previously. Meeting these standards may entail a more intricate and costly process, even though the simpler recommendations mentioned previously can achieve similar results concerning groundwater recharge, stormwater quality improvement, and flood control compared to BMPs designed according to the New Jersey Stormwater BMP Manual.

4.2 Wet Pond Retrofit Opportunities

Similar to dry detention basins, wet ponds (i.e., retention basins) designed under previous regulations were primarily intended for flood control. They maintain a permanent pool of water between storm events that allows for more effective settlement of sediment from incoming stormwater runoff. Despite this, most existing wet ponds designed under previous regulations would not meet the definition of green infrastructure. As a result, these facilities present an opportunity for retrofit in order to enhance water quality and/or the basin's hydrologic function, while also addressing some common concerns. Some of the common maintenance and performance concerns related to wet ponds are outlined below:

- **Encourages nuisance species.** Similar to detention basins, wet ponds often attract nuisance species such as Canada goose. The permanent pool and adjacent turf grass lawn areas provide ideal habitat for Canada goose. The shallow stagnant water and lack of vegetation may also provide habitat for mosquitoes.
- **Excessive nutrient loads.** With little to no upstream treatment or pretreatment of stormwater or vegetated buffers, runoff from urban, suburban, and agricultural sources can easily carry the nutrients necessary for algae and harmful algal blooms (HABs) in wet ponds [10]. Excessive nutrient loading in stormwater basins can carry effects downstream to receiving watercourses, which can lead to water quality degradation and eutrophication that may cause ecosystem imbalances and HABs [12].
- **Localized shoreline erosion.** The typical steep perimeter side slopes with shallow-rooted turf grass vegetation coupled with the intended rapid fluctuation of water levels creates an ideal condition for shoreline erosion. The often slow but steady shoreline erosion poses aesthetic, structural, and water quality concerns by creating a source for additional sediment loading to the system.
- **Erosive stream downcutting.** Similar to many BMPs, the point discharge of runoff from highly impervious developments and wet pond outfalls can cause streambank erosion concerns in receiving watercourses [2].

The techniques to retrofit wet ponds can vary based on site- or watershed-specific goals, scope, and site constraints. Some retrofit options for wet ponds are outlined on the next pages.

An example of shoreline erosion before (left) and after (right) the bank was vegetated with native flora.

Retrofit Option: Vegetated Shoreline

To address concerns with nuisance species, pollutant loading, and shoreline erosion, implementation of vegetated shorelines should be considered when retrofitting wet ponds. Similar to detention basin naturalization, upgrading a wet pond to include a vegetated shoreline can be as simple as altering maintenance frequencies to allow for plant species to volunteer around the perimeter of an existing wet pond. Alternatively, a vegetated buffer or shoreline vegetation can be designed specifically to armor a shoreline that is showing evidence of being undermined by implementing physical erosion control practices in addition to plantings.

Wet ponds are often an attractive feature to Canada goose in a suburban and urban landscape because they provide habitat for nesting, brooding, molting, and feeding as well as serve as a deterrent from predators by creating escape onto open waters [20]. Canada goose feed on the turf grass immediately adjacent to open water and uninterrupted visibility provided by the mowed open lawn provides them with good visibility for potential predators. The nearly constant browsing of turf grass by geese provides a significant source of nutrients and bacteria influx for the wet pond; a unique pollutant source that is only present as a result of the BMP itself.

Vegetated buffers and shoreline vegetation create a physical barrier that reduces access between the open water and the open turf grass. They also create a less attractive habitat for nesting by providing separation from water, and potentially offer habitat for predators of eggs and goslings [19]. Canada goose is considered a nuisance species not only due to their aggression during the brooding period and noise, but can also exacerbate other environmental concerns for wet ponds:

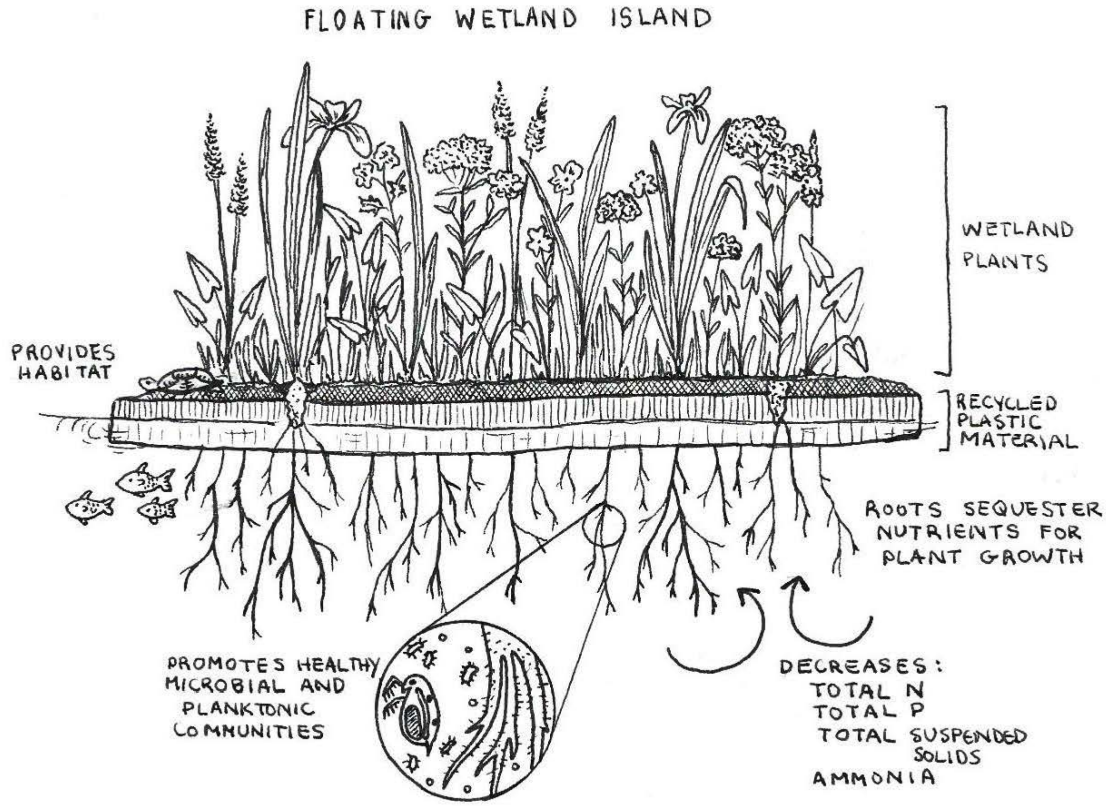
- Excessive fecal matter produced by goose populations can result in higher pollutant loadings in stormwater systems, including nutrients leading to algal growth and bacteria.
- Exacerbated shoreline erosion can occur due to soil disturbance at common access points to the open water and reduced vegetative protection as a result of excessive grazing of turf grass along the shores.

Vegetated shorelines can provide improvements to both of these ends by introducing plant species that have deeper root structures than standard turf grasses and are more effective at filtering out excessive pollutants as well as securing pond edges to combat erosive forces from both surface runoff and water surface fluctuations. In many instances, simply adding native vegetation to wet pond perimeters may be sufficient, however if shoreline erosion has been unaddressed for extended periods of time, minor regrading may be necessary to restore a stable shoreline. In some cases, coir logs or other material may be necessary.

Eroded shorelines have the potential to expose existing pond liners, which are essential to maintain the wet pond's permanent pool. As with any BMP retrofit, care must be taken during design to ensure that neither an existing problem nor the potential solution negatively impact the hydraulics of the stormwater management system.

Like detention basin naturalization, consideration must be given to the tolerance for non-native and/or invasive species to determine the method in which shoreline vegetation will be implemented. Altering mowing frequencies is likely to result in the volunteering of both desirable and undesirable vegetation, both of which can be effective to deter goose populations and minimize shoreline erosion. This approach is a simple, cost-effective method of improving an existing condition.

However, in order to achieve both the aesthetic and ecological benefits offered by native vegetation, existing turf must be removed in order to introduce seeds or plugs of the desired species, and subsequently maintained throughout the establishment period (typically two to three growing seasons) to remove weeds and other undesirable plants while the native vegetation becomes established. Removal of turf grass can occur either chemically through herbicide application or through various physical approaches; a landscape professional is recommended to determine the appropriate course of action prior to beginning any work and all local ordinances must be followed.



This illustration, sketched by Ivy Babson of Princeton Hydro, conveys the functionality of a floating wetland island.

Retrofit Option: Floating Wetland Islands

Floating wetland islands (FWIs) are a low-cost and effective retrofit option. They are designed to mimic natural wetland functionalities in order to enhance water quality by assimilating and removing excess nutrients; provide valuable ecological habitat for a variety of beneficial species; help mitigate wave and wind erosion impacts; provide an aesthetic element; and add significant biodiversity enhancement within open freshwater environments. FWIs are a particularly appealing solution for addressing concerns of excessive nutrient loadings that lead to algal growth and HABs in existing wet ponds as they are incredibly diverse in their application and have both low principal and maintenance costs.

Typically, FWIs consist of a constructed floating mat, usually composed of woven, recycled plastic material, with vegetation planted directly into the material. The islands are then launched into the pond and anchored in place and, once established, require very little maintenance. Because they are inclusive systems, FWIs can be installed with little to no disturbance to existing soils and may not require any permitting to implement. As every site is different, it is important to check with your local and state agencies prior to installation.

An example of a floating wetland island.

Retrofit Option: Basin Expansion and Outlet Modification

Expanding existing wet ponds can provide additional flood storage, encourage longer residence times through the system in order to allow for settling of sediment, and create opportunities to grade in benches for the planting of aquatic species for added water quality benefits. Outlet modifications can be as simple as implementing hooded outlets or reverse slope pipes in order to reduce effluent temperatures resulting from heat sink in permanent pools, or as complicated as installing a new outlet configuration to provide extended detention within the system. Similar to basin expansion and outlet modification for detention basins, this retrofit will require the expertise of a licensed professional engineer to appropriately analyze, model, and detail the hydraulic impacts the associated work will have on the original engineered design and assess applicability with any local or state regulations.

Retrofit Option: Pretreatment

Pretreatment is way to capture runoff immediately upgradient of a stormwater control in order to reduce flow rates and trap sediment, pollutants, bacteria, and debris at the source. This helps to improve removal efficiency and water quality as well as reduce maintenance requirements.

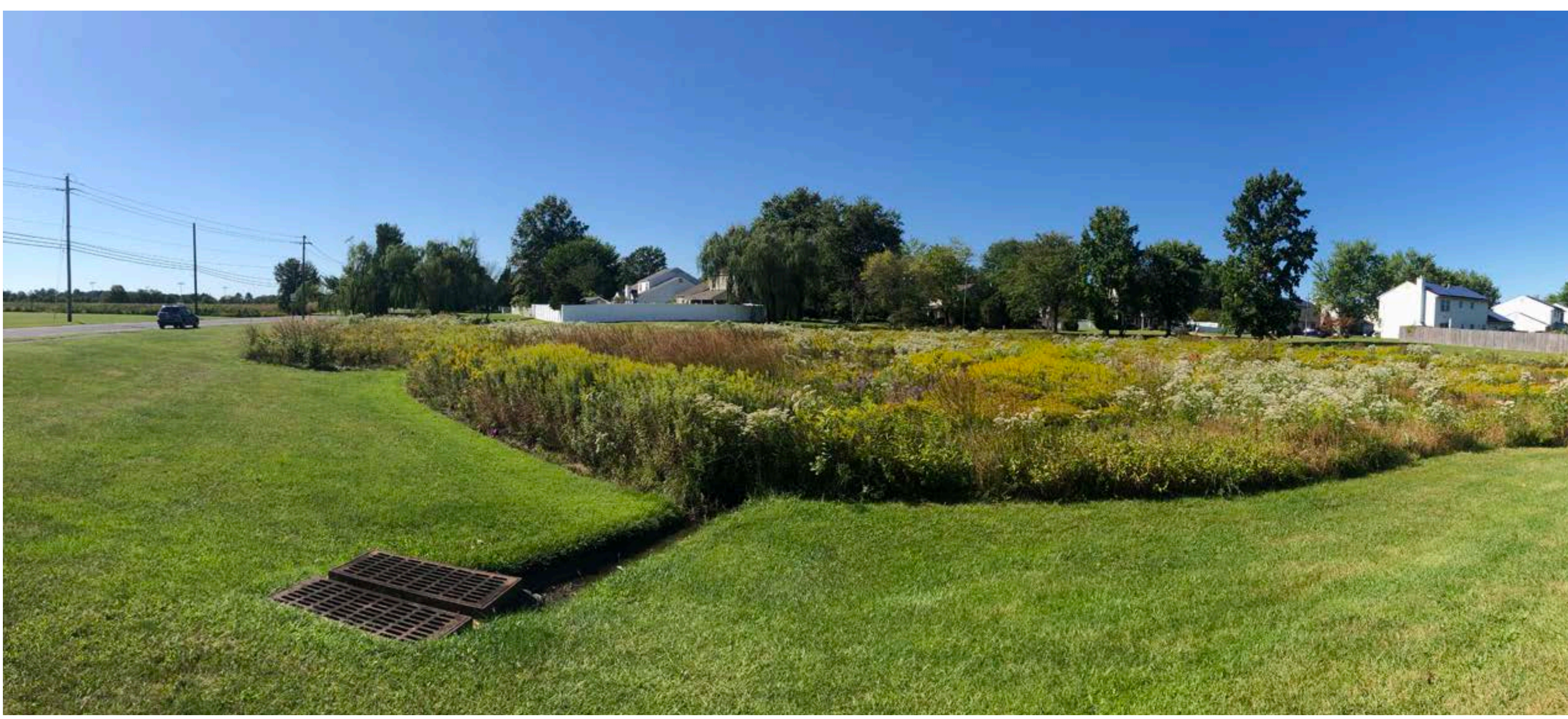
If a comprehensive constructed retrofit of a wet pond is not possible due to cost, access, environmental concerns, and/or limitations imposed by NJDEP regulations, providing pretreatment to the system may be an effective method to achieve certain goals of the retrofit. Pretreatment may consist of a forebay or a structural BMP designed and sized appropriately for the contributing drainage area. While providing pretreatment to an existing wet pond may not completely resolve existing problems, certain implementations may assist in areas where site conditions contribute to excessive sedimentation or nutrient loads that ultimately disrupt the basin’s functionality and exacerbate the maintenance burden. This retrofit is also applicable to detention basins.

Retrofit Option: NJDEP Standard BMPs

As discussed in the previous section, some stormwater retrofits may be implemented concurrently to site redevelopment efforts or other construction that may trigger the requirements for compliance with N.J.A.C. 7:8, including the Green Infrastructure and Inland Flood Protection Rule standards. Dependent upon site conditions and applicable requirements, as determined by a licensed professional engineer, existing wet ponds could potentially be retrofitted to meet the standards of the following BMPs as defined in the New Jersey Stormwater BMP Manual:

- Green Infrastructure Wet Ponds
- Standard Constructed Wetlands
- Subsurface Gravel Wetlands

NJDEP provides comprehensive design standards for each of the BMPs listed above. It is worth noting that the design standards are more complex and detailed than the other retrofit modifications described earlier. Meeting these standards may entail a more intricate and costly process, even though the simpler recommendations mentioned earlier can achieve similar results concerning stormwater quality improvement and flood control compared to what is expected from NJDEP standard BMPs.



4.3 Natural Green Infrastructure

New Jersey's green infrastructure BMPs are designed to mimic the natural processes provided by our natural green infrastructure. It is through understanding the valuable services that our natural green infrastructure contributes to water quality maintenance that provided the impetus to seek ways to replicate these natural functions in engineered BMPs. However, it is directly related to the services that our natural green infrastructure provides to integrate natural areas into watershed-based management strategies.

USEPA identifies larger-scale natural green infrastructure opportunities to include preserving or restoring floodplains, open space, wetlands, and forests [24]. Although the preservation of natural areas should be embraced as important elements of watershed-based stormwater management plans, it is also important to acknowledge that many of New Jersey's natural systems may be degraded due to anthropogenic changes such as those related to impervious cover. It is related to these changes that natural areas no longer function as well as they once did.

One of the key destructive attributes of stormwater associated with developed watersheds is related to excess volume. The increased volume of runoff typically leads to channel instability in the form of downcutting and widening and as a result increased sediment loads. Frequently, most of the total suspended solid (TSS) load of a stream in a developed watershed is due to instream erosion. In addition, as a result of these human-induced stream impacts, many streams have little interaction with their floodplains and thus compromise floodplain functions.

However, this is where ecological restoration can be utilized to enhance the ecological value and functions of our natural green infrastructure. The enhancement of our natural green infrastructure can provide significant benefits, including increased flood storage and water quality improvements. This idea is supported in the Stormwater Management Rule (N.J.A.C.7:8-3.7.3) for selecting stormwater management measures:

> **Stormwater management measures that enhance, protect, and/or preserve land or water areas possessing characteristics or features that provide for flood control, maintenance or improvement of water quality, or conservation of natural resources (for example, land use controls, local and regional open space plans and taxes, buffer zones, redirecting, recharging or minimizing stormwater discharges, pretreatment and/or end-of-pipe treatment).**

In fact, this type of stormwater retrofit will result in land use changes (e.g., reforestation of impervious areas, restoration of degraded habitat, reconnection of streams to their floodplains, and/or creation of wetlands) that can provide the most nutrient and sediment reduction. Various ecological restoration techniques associated with stream and wetland restoration projects typically focus on the enhancement of natural functions and services including water quality improvement, flood resilience, and ecological habitat benefits. These types of projects are directly related to the enhancement of our natural green infrastructure compared to other types of artificial stormwater management systems. Ecological restoration approaches also serve as a means to increase the extent of New Jersey's natural green infrastructure.

The following section describes some of the ecological restoration approaches that would serve to enhance the functions of our natural green infrastructure.

Retrofit Option: Stream Restoration and Streambank Stabilization

Ecological restoration practices may include streambank stabilization and stream restoration. Although ecological restoration approaches may be perceived as fundamentally different than more engineered BMPs, they can be highly effective - if not more effective - with regard to reducing nutrient and sediment loading. According to the Maryland Department of the Environment [29]:

Typical stream restoration techniques aim to stabilize streambeds and banks to prevent erosion and sediment export, promote floodplain reconnection, enhance surface/groundwater interaction, promote nutrient cycling and denitrification, enhance sediment trapping in floodplains, and improve habitat conditions for in-stream aquatic life.

Because of many benefits of stream restoration, the USEPA Chesapeake Bay Program Partnership and the State of Maryland allow and encourage local jurisdictions, watershed organizations, and other stakeholders to use stream restoration projects to meet MS4 permit requirements and TMDL goals. These restoration-focused objectives are equally relevant to New Jersey's streams and watersheds and should be considered as a retrofit option.

Retrofit Option: Floodplain Reconnection

Unlike other retrofit alternatives, floodplain reconnection or creation has the capability to provide a naturalistic solution to existing flooding and enhance flood resilience. This practice may be achieved by reconnecting streams to their floodplains by elevating the invert of a degraded stream channel or lowering the adjacent floodplain through excavation. The restoration of floodplains through reconnection or creation efforts serves to increase flood storage, provides natural floodplain habitat for plants and animals, and fosters sedimentation (*See Case Studies #6 and #7.*).


NO
MOWING
BEYOND
THIS POINT

4.4 New BMPs

In addition to retrofits on both municipal and private sites, opportunities within public rights-of-way should be considered by municipal, county, and state agencies wherever possible. Roadway networks in New Jersey are large and variable, with a long history of ever-changing standards that have led to New Jersey having more miles of highway per square mile than any other state in the U.S. [13]. Excessive impervious coverage generates numerous problems at the site- and watershed-level, including excessive runoff by limiting infiltration and groundwater recharge and contributing to poor water quality in receiving watercourses. Roadway development in particular is a large contributor to concerns of water quantity and flooding due to the widespread use of closed storm drain systems. These systems are effective means of quickly draining roadways, but result in large networks of connected impervious surfaces and often consolidate flows from large overland areas to singular points of discharge. Roadways, parking lots, and other motor vehicle surfaces are also a primary source for nonpoint source pollutants in stormwater runoff, including heavy metals and hydrocarbons.

To install new BMPs in heavily built-out environments, executors must be aware of the conditions which will trigger the need for compliance with N.J.A.C. 7:8, particularly when retrofits alter the hydraulics of a stormwater conveyance system. The Stormwater Management Rule is applicable to all projects which meet the definition of a "major development," which is any development that results in:

- the disturbance of 1 acre or more of land;
- the creation of 0.25 acres or more of *regulated impervious surface*;
- the creation of 0.25 acres or more of *regulated motor vehicle surface*; or
- the creation of a combined total of 0.25 acres of regulated impervious surface and regulated motor vehicle surface.

A "regulated impervious surface" includes:

- a net increase of impervious surface;
- the total area of impervious surface collected by a new stormwater conveyance system;
- the total area of impervious surface proposed to be newly collected by an existing stormwater conveyance system; and/or
- the total area of impervious surface collected by an existing stormwater conveyance system where the capacity of that conveyance system is increased.

A "regulated motor vehicle surface" includes:

- a net increase in motor vehicle surface; and/or
- the total area of motor vehicle surface that is currently receiving water quality treatment where the water quality treatment system will be modified or removed.

Retrofit measures in heavily built-out environments must focus on impervious disconnection, infiltration and media filtration, and removal of impervious cover. Often targeting the existing inlets of mostly impervious surfaces, the following retrofit options are not suitable alternatives to specifically address flood control, and in fact are often bypassed using upstream diversion methods during large storm events. However, these retrofits are effective in treatment of the Water Quality Design Storm (WQDS) management and facilitate enhancements to water quality and groundwater recharge, where applicable.

When implemented properly, urbanized stormwater retrofits can provide benefits beyond those associated with stormwater management. Those seeking more tangible quality-of-life improvements for their communities may consider reallocating existing developed land to BMPs as part of comprehensive planning efforts for enhancing livability in urban settings. For example, the City of Portland, Oregon has cited some of the following goals of their Green Street Program [15]:

- Improve pedestrian and bicycle safety
- Improve air quality and reduce air temperatures
- Increase urban green space
- Increase opportunities for industry professionals

An example of a traffic island feature.

Retrofit Option: Traffic Island or Bump-Out Bioretention

Traffic island or bump-out bioretention facilities are small stormwater management systems that feature a soil bed planted with vegetation, which operate by treating stormwater close to its source (i.e., treating stormwater runoff by infiltration into the subsoil and treating runoff through filtration by vegetation or soil). They are diverse in their application as they can be implemented in small, opportunistic areas that would otherwise be left as impervious, such as existing islands along roadways or existing parking buffers in parking lots. They may be designed with an underdrain where soil conditions would preclude infiltration, or they can be designed to infiltrate into the subsoil. These facilities are effective at treating a wide range of pollutants including suspended solids, nutrients, metals, hydrocarbons, and bacteria through use of native plantings introduced in soil beds consisting of an engineered planting media.

Although discussed largely in the context of roadway retrofits, private or commercial entities may also consider use of small-scale bioretention on redevelopment sites within parking lots or drive aisles to achieve similar goals.

Retrofit Option: Manufactured Treatment Devices

Similar to small-scale bioretention facilities, manufactured treatment devices (MTDs) are small and widely applicable in a range of highly impervious settings to provide water quality treatment of the WQDS. MTDs are proprietary installations that are often sized and designed by the manufacturer. Though a diverse category, many MTDs treat stormwater runoff through hydrodynamic sedimentation and filtration, and may consist of above grade installations (e.g., tree boxes, planter boxes, shrubs, etc.) or below grade installations (e.g., subsurface infiltration vaults). Other MTD implementations may include stormwater snouts, which attach to the intake of an effluent storm sewer pipe in an inlet box and allow for both the settlement of suspended solids and the separation of floatable debris from runoff to prevent migration of the pollutants through the system.

Additionally, MTDs can be a lower-cost option that are not design-intensive due to their prescribed design applications. Because of this, MTDs are often used in series and as pretreatment for other BMPs due to their versatile application and added water quality benefits. NJDEP has a list of approved MTDs, however, projects can use MTDs that aren't on their list if they aren't required to meet specific removals per the rules.

An example of a manufactured treatment device during installation.

Retrofit Option: Pervious Pavement

Pervious pavement may be considered as a retrofit option where functionality of an otherwise impervious surface, such as a parking stall or roadway shoulder, is pertinent to a design but additional infrastructure may be required if the project is large enough to trigger water quality and/or groundwater recharge requirements. The systems can consist of porous surface course, interlocking paver units that allow for runoff to filter vertically through the pavement into the subsoil, or an underdrain. In addition to serving the functionality of both stormwater management treatment and driveable/walkable area, pervious pavement can also reduce loads on storm sewer systems, allowing for smaller pipes, fewer inlets, and reduced ponding.

Pervious pavement is subject to very specific loading ratios and the design is governed by the hydraulic conductivity of the underlying soil and depth to seasonal high groundwater table (SHWT), as with all infiltrating BMPs. Consideration must also be given to the maintenance and operations costs associated with pervious pavement installations as regular vacuum street sweeping is vital to their continued operation.

An example of pervious pavement in Camden, NJ.

A rain garden being maintained by Samuel T. Busansky School's Environmental Club in Pemberton, NJ. Photo courtesy of Pinelands Preservation Alliance.

4.5 Downspouts

Traditional treatment at roof downspouts is nearly nonexistent, with most conditions ranging from standard at-grade splash blocks to subsurface drainage connecting to roadway storm drain systems. As a result, there are abundant opportunities to retrofit roof downspouts to provide treatment for the millions of acres of impervious area associated with roofs — particularly residential — and introduce impervious disconnection, filtration and infiltration, and/or beneficial reuse at smaller scales.

It is important to note that some installations may be subject to municipal approval and/or require a professionally engineered design; executors must be aware of their local ordinances and take appropriate steps to ensure stormwater management installations are in compliance and that any work will not exacerbate flooding conditions beyond their property. Proximity to both natural and artificial subsurface features, including soil conditions and basements or utilities must be carefully considered and analyzed. Any excavation to occur on one's property must be in compliance with New Jersey One-Call (N.J.A.C. 14:2) ([redacted], call 811 before you dig) to ensure the protection of all existing underground infrastructure and utilities.



Examples of rain gardens in NJ. Photos 2 and 3 are courtesy of Pinelands Preservation Alliance.

Retrofit Option: Rain Gardens

Rain gardens can offer impervious disconnect, filtration, and infiltration to improve water quality at downspouts at an accessible scale to homeowners, schools, nonprofits, or other private entities. Rain gardens are often installed opportunistically upstream of areas which experience ponding and offer an aesthetic and functional solution to small-scale residential flooding. Resources available include the **Rutgers University Rain Garden Manual of New Jersey** and **Princeton Hydro's How to Build a Rain Garden in 10 Steps**.

Retrofit Option: Dry Wells

Dry wells are subsurface storage chambers or vaults used to temporarily store roof runoff and allow for infiltration of water into the subsoil. Overflow from roof downspouts is typically provided prior to connection to dry wells to divert runoff from large storm events.

Retrofit Option: Vegetated Swales

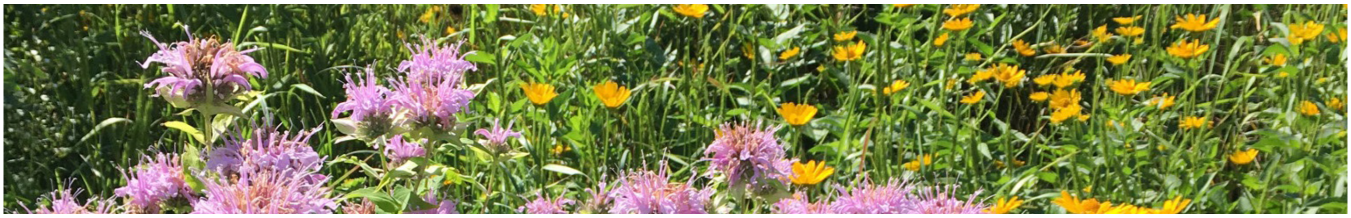
Vegetated swales are constructed channels that convey runoff from points of concentrated flow, such as roof downspouts or outfalls, to provide impervious disconnection and facilitate pollutant removal. The use of native flora is best suited for vegetated swales as it also provides wildlife habitat.

Retrofit Option: Cisterns/Rain Barrels

Cisterns are storage tanks that are used to capture, collect, and reuse runoff from an impervious area, most likely a roof. Cisterns come in many shapes and sizes from rain barrels to larger plastic, steel, or concrete tanks. The design of cisterns can vary in scale and can be located above or below the soil surface depending on the site's needs. A rain barrel is a great option for a residential property. Water collected can be used at a later use to water lawns, gardens, and/or indoor plants.

4.6 Nonstructural Stormwater Strategies

In addition to some of the retrofit approaches discussed previously, including disconnecting impervious cover, other nonstructural strategies may be introduced in the context of a retrofit. Particularly when used in conjunction with other structural BMP retrofits, the use of nonstructural LID techniques can provide a significant benefit to the overall stormwater management system by potentially reducing the size or number of structural BMPs required to satisfy the goals of the retrofit [2].



LID Technique: Minimizing Turf Grass Lawns

One such strategy may be converting standard turfed lawn to meadow or wooded condition. This provides an array of benefits both ecologically and hydrologically. By promoting biodiversity in a relatively simple setting, meadow conversions can provide habitat for a variety of beneficial native birds, mammals, and insects, including pollinators. Meadow conditions are also beneficial hydrologically by naturally reducing a site's curve number (i.e., the numerical indication of the catchment's ability to generate runoff), as well as increasing its time of concentration (i.e., the period of time required for storm runoff to flow from the most remote part of a drainage basin to the outlet), both of which yield a lower volume and rate of runoff generated by a site.

This technique may be considered in a variety of circumstances and does not need to be "all-or-nothing." Portions of existing turf lawns can be converted to meadows depending on the use of the space and the needs of the responsible party, such as:

- by a homeowner along a fence line for added privacy;
- by an HOA in designated open space areas in between mowed walking paths;
- by a municipality along roadways that are burdensome to maintain; or
- by a commercial operator on portions of sites that are otherwise unused.

LID Technique: Removing Impervious Cover

As discussed throughout this guide, excessive impervious cover has detrimental effects on stormwater runoff quantity and quality by its disruption to the hydrologic cycle. This disruption impacts infiltration and groundwater recharge capability, increases runoff rates/volume, yields converging peak times throughout the watershed, and introduces sediment, nutrients, bacteria, and other pollutants into the watershed. These impacts each degrade the health of receiving watercourses which in turn, can harm and degrade entire ecosystems, in addition to having severe impacts on human health and safety.

Excessive impervious cover, which no longer serves a purpose, creates a maintenance burden, and/or poses safety or aesthetic concerns, can be eliminated. Doing so reduces the percentage of land dedicated to impervious cover and provides opportunity for impervious surface disconnection. This technique can be implemented on a site-level or watershed-level based on need and opportunity, and may be considered:

- by a homeowner to remove a defunct walkway and install garden beds;
- by a municipality to strategically reduce excessively wide shoulders along a roadway corridor; or
- by a commercial operator to remove unneeded parking spaces.

INSPECTION & MAINTENANCE

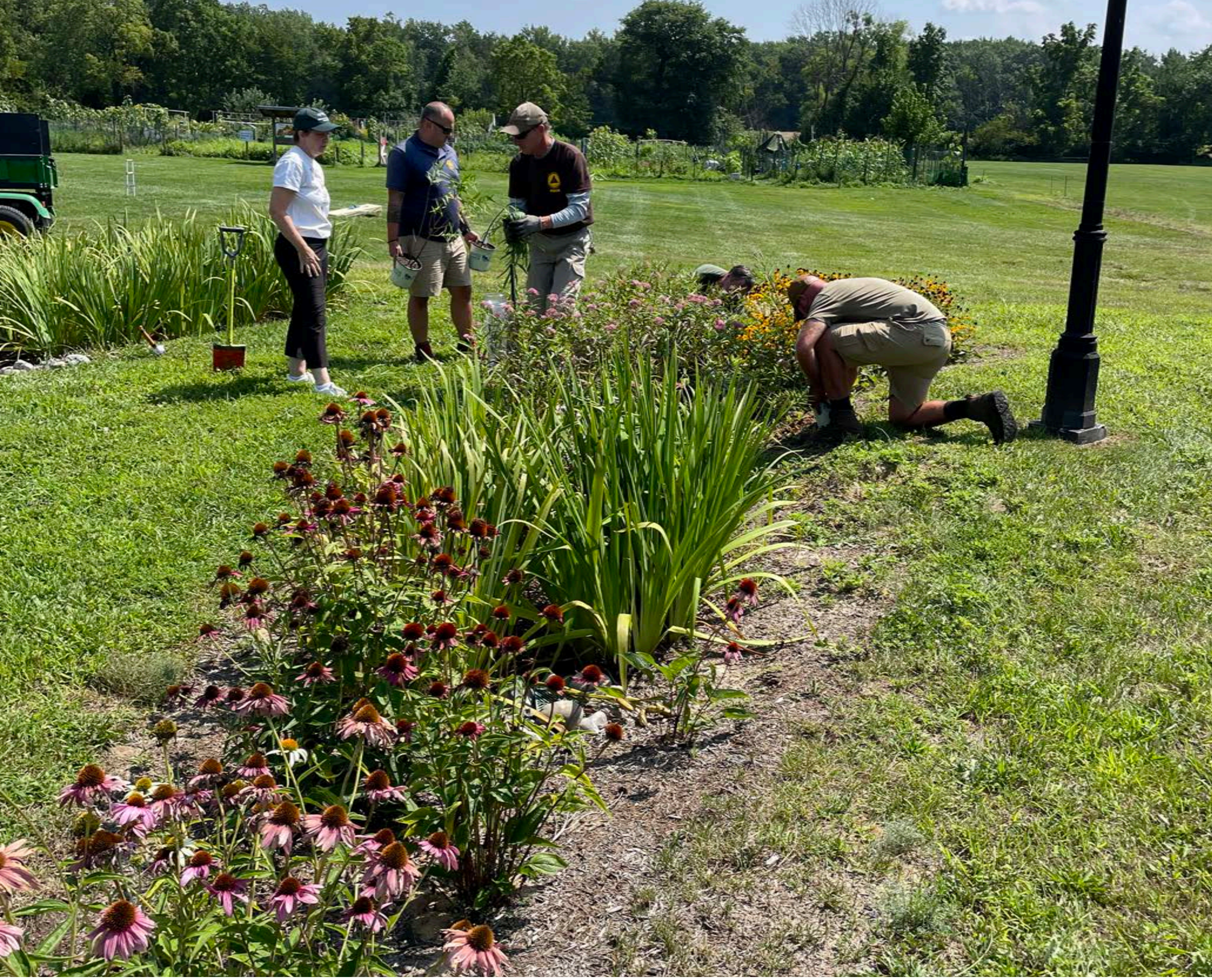
Post-construction, it is important to plan for regular inspection and/or maintenance of your stormwater retrofit feature

When designing stormwater retrofits, one of the largest considerations for post-construction operation and maintenance efforts revolve around vegetation. Though the benefits of introducing naturalized vegetation into retrofits have been discussed throughout this guide, BMPs are still artificial, constructed systems that are engineered to serve particular hydrologic and hydraulic functions that can be impeded by improper maintenance of vegetation. The discussion in this section is only intended to provide the executor of BMP retrofits a general idea of some common considerations pertaining to the operation and maintenance of their infrastructure. Specific inspection and maintenance tasks and frequencies shall be detailed in the maintenance plan that is required of all BMPs designed in accordance with the New Jersey BMP Manual.

Basins naturalized by way of reducing mowing frequencies may be more susceptible to the growth of invasive species. If a goal of the retrofit is to provide habitat and resources for local wildlife or pollinators, tolerance of invasives may be more stringent than if vegetative uptake or other hydrologic benefits are a goal of the retrofit. Invasive species may provide similar benefits hydrologically, but cannot substitute native species for ecological benefit. Therefore, they must be monitored and maintained to the extent such that their existence within a stormwater management system is contained if it is not practical to fully remove the invasives from the system.

Retrofits which intentionally introduce native vegetation may focus on cultivating a diverse array of plant life to mimic natural conditions, which could include herbaceous grasses and perennials and/or woody shrubs and trees. Whether woody vegetation is appropriate to introduce into a BMP retrofit is largely a maintenance consideration due to the means and methods required to maintain it and/or its ability to outcompete herbaceous understory vegetation. Because plant selection for nutrient removal in the context of stormwater management systems is not a widely studied metric, the water quality benefit of woody vegetation versus herbaceous vegetation does not dictate use in BMPs. According to a 2016 study, woody vegetation has been found to uptake high levels of nitrogen and phosphorus per specimen and per cost, whereas herbaceous vegetation has been found to uptake high levels of nitrogen and phosphorus per area [18].

Regardless of the type of BMP, access to the facility must always be appropriately maintained to facilitate inspection and both regular and emergency operation and maintenance activities. Regular maintenance operations will vary depending on the type of BMP and individual regimens specified in the maintenance plan. For example, BMPs with subsurface features such



Rain Garden Maintenance at Blue Barn in Evesham, NJ, August 2023. Photo courtesy of Pinelands Preservation Alliance.

as underdrains must be routinely inspected and flushed as necessary to ensure the network is free of debris and is functioning as designed. Additionally, any BMP with critical infrastructure, particularly outlet structures or berms than either permanently or temporarily impound water, must have vegetation regularly mowed or cleared around those structures to facilitate hydraulic performance and allow for necessary inspections.

Operation and maintenance efforts must also consider regular removal of trash and debris, particularly in highly urbanized areas where litter accumulates quickly due to high population densities and impervious surfaces, which facilitates the spread of trash by way of surface runoff. As a result, trash and debris have the tendency to accumulate where runoff accumulates: stormwater facilities. Inlets to many different BMPs or outlet structures feature trash racks or debris screens to prevent clogging within the internal works and allow functionality during rain events, but still require intermittent cleaning to ensure adverse effects from excessive accumulation of debris that may disrupt inflow to the system. The demand on publicly funded forces to regularly remove trash from stormwater infrastructure with various chambers, openings, or other complex engineered systems should be considered during planning processes.

CASE STUDIES

Explore a variety of stormwater retrofit options that have been designed and implemented throughout New Jersey

On the following pages, a variety of stormwater retrofits that have been implemented around New Jersey are showcased. Several of these examples have more than one type of retrofit built within the project area, including both traditional and non-traditional types of retrofits.

1. Franklin Township Stormwater Basin Retrofits - Franklin, NJ
2. Metedeconk River Watershed Green Infrastructure Projects - Lakewood, NJ
3. DRBC Headquarters Stormwater Retrofit Demonstration Park - Trenton, NJ
4. Manalapan Brook Watershed Protection and Management Plan Implementation Projects - Various locations in Middlesex County, NJ
5. Deal Lake Watershed Protection Plan Implementation Projects - Asbury Park and Ocean Township NJ
6. Lion Gate Park and Urban Wetland Floodplain Creation - Bloomfield, NJ
7. Tremley Point Flood Mitigation Projects - Linden, NJ

An example of detention basin naturalization installation with Tabernacle Elementary School at Prickett's Mill Park in Tabernacle NJ in April 2023. Photo courtesy of Pinelands Preservation Alliance.

Case study photos courtesy of New Jersey Water Supply Authority.

01 FRANKLIN TOWNSHIP STORMWATER BASIN RETROFITS

New Jersey Water Supply Authority (NJWSA) worked together with NJDEP to re-imagine existing stormwater systems in Franklin Township. With TSS reduction as the primary driver, the projects focused on retrofitting existing stormwater detention basins. It aimed to improve the water quality performance of existing detention basins while also providing ancillary hydrologic and ecological benefits. Project objectives were accomplished by removal of low-flow concrete channels, replacement of existing turf grass with native meadow vegetation, and providing infiltration within the basins through soil improvements and re-contouring the basin bottoms. A total of five standard dry detention basins were ultimately retrofitted, each with a unique and creative design approach which transformed the traditional standard detention basin into a multi-functional and ecologically thriving system. Project implementation required stakeholder coordination with adjacent property owners. Long-term operation and maintenance shifted from routine mowing throughout the growing season to a recommendation of a single annual mowing in late winter/early spring.

KEY PROJECT INFO

Lead | NJ Water Supply Authority

Owner | Franklin Township

Location | Franklin Township, NJ

Designer | Princeton Hydro

Funder | NJDEP Watershed Restoration 319(h) Grant and Delaware Raritan Canal Commission

Year Completed | 2020 + 2021

The designs utilized a variety of techniques to improve TSS removal, all of which focused on extending the retention time of runoff in the basin with a focus on smaller, more frequent storms. This was accomplished through the creation of meandering flow paths within the basins and the creation of bioretention pockets and small berms within the basin bottom to slow and better distribute the runoff across the entire basin bottom area. The focus of these efforts was to maximize the runoff contact with native meadow vegetation, providing increased opportunity for both direct water quality treatment and infiltration. Together, these techniques increased both the functionality and aesthetic quality of the basins. The retrofit detention basins now also provide desirable wildlife habitat and local ecological uplift.

02

METEDECONK RIVER WATERSHED GREEN INFRASTRUCTURE PROJECTS

To improve the water quality and overall health of the Schoolhouse Branch and the North Branch of the Metedeconk River, several retrofit green infrastructure projects were implemented and linked throughout Ocean County Park. The Metedeconk River is a major tributary of Barnegat Bay. The BMPs were not retrofits of existing traditional stormwater system, but instead were retrofit improvements within an existing park. These newly constructed retrofit BMPs are working in unison to decrease nonpoint source pollutant loading to the Metedeconk River while also providing aesthetic improvements and increased ecological diversity within the park.

These improvements included the installation of two Manufactured Treatment Devices (MTDs) consisting of curb-side tree planters, a vegetated bioretention swale, two living shorelines along the banks of Duck Pond, and the installation of two floating wetland islands within Duck Pond. These BMPs not only directly benefit the water quality of the Metedeconk River, but also provide benefit for the greater Barnegat Bay.

KEY PROJECT INFO

Lead | American Littoral Society

Owner | Ocean County

Location | 659 Ocean Ave, Lakewood, NJ

Designer | Princeton Hydro

Funder | Federal Watershed Restoration 319(h) Grant

Year Completed | 2019

A curb-side tree box is a specialized BMP that utilizes vegetation and high performance bioinfiltration media to reduce the stormwater pollutant load. Parking lots and other urbanized areas can benefit tremendously from their compact size and performance value.

03 DRBC HEADQUARTERS STORMWATER RETROFIT DEMONSTRATION PARK

The Delaware River Basin Commission (DRBC) Headquarters was designed and constructed prior to the adoption of stormwater regulations, as such the property lacked adequate stormwater control measures. A facility stormwater master plan and retrofit was designed to be high-visibility demonstration for the headquarters which is routinely visited by people attending meetings from the four-state region under the authority of the DRBC. The comprehensive stormwater management master plan involved the installation of a bioretention island, an extended detention basin and rain garden, and an infiltration basin. The project also incorporated techniques to reduce impervious surfaces where feasible.

The first phase of the retrofit implementation featured a vegetated basin in front of the existing building to provide water quantity control and water quality treatment through sedimentation and native vegetation uptake. An array of native plants were planted to create a colorful four-season landscape. Following construction, Eastern Box Turtle as well as butterflies and other pollinators quickly took up residence in the completed basin. The vegetated basin now provides aesthetic and wildlife value, creating an educational and interactive element at the headquarter facility, which serves as a demonstration for visitors to the headquarters.

KEY PROJECT INFO

Lead | Delaware River Basin Commission

Owner | Delaware River Basin Commission

Location | 25 Cosey Road, West Trenton, NJ

Designer | Princeton Hydro

Funder | Delaware River Basin Commission

Year Completed | 2007

The vegetated basin now provides additional aesthetic and wildlife value, creating an interactive element within the headquarters from which visitors can observe.

04 MANALAPAN BROOK WATERSHED PROTECTION AND MANAGEMENT PLAN IMPLEMENTATION PROJECTS

A comprehensive Watershed Protection and Restoration Plan was developed for the Manalapan Brook Watershed, a 43-square mile watershed that spans 10 municipalities in Middlesex and Monmouth Counties, New Jersey. In order to attain the TMDL target for total suspended solids (TSS) and total phosphorus (TP) established by NJDEP, the plan prioritizes retrofit watershed BMPs and restoration projects for implementation.

To date, many of the identified projects, including a rain garden retrofit, stormwater detention basin retrofits, and shoreline and streambank stabilizations, have been implemented. Two of the dry detention basin retrofit projects are highlighted here.

KEY PROJECT INFO

Lead | South Jersey RC&D / New Jersey Water Supply Authority

Owner | Middlesex County

Location| Manalapan Brook Watershed

Designer | Princeton Hydro

Funder | NJDEP Watershed Restoration 319(h) Grant

Year Completed | 2011 (Plan), 2021 (Retrofits)

Dry Detention Basin Retrofits

A standard dry detention basin with turf grass vegetation and concrete low-flow channels was retrofitted to improve the water quality performance of the basin while also encouraging infiltration. The construction of this specific basin retrofit included the removal of all of the concrete low flow channels, the creation of pretreatment forebays and stone filter berms at both inlets, the overall elongation of the flow path, a complete re-planting of the basin with native meadow vegetation, and the creation of a large, designated infiltration area within the basin.

A second standard dry detention basin retrofit was completed. This basin also contained turf grass and concrete low-flow channels. The design approach for this retrofit also included the removal of a large section of the concrete low flow channels, the creation of pretreatment forebays and stone filter berms at both inlets, the elongation of the flow path, the modification of the outlet structure, and a complete re-planting of the basin which included native meadow vegetation.

05 DEAL LAKE WATERSHED PROTECTION PLAN IMPLEMENTATION PROJECTS

Encompassing 155 acres with over 27 miles of shoreline, Deal Lake is the largest of New Jersey's coastal lakes. The lake's 4,400-acre watershed is highly developed and modern stormwater management with respect to water quality and runoff volume management is largely lacking. Since 1980 the Deal Lake Commission has served as the State-appointed steward of the lake. With NJDEP 319(h) funding, the Deal Lake Commission has implemented several projects aimed at decreasing pollutant loading and increasing stormwater infiltration using a variety of BMPs along the Deal Lake shoreline.

Although the project involved a number of various retrofits, three retrofit projects are highlighted here.

KEY PROJECT INFO

Lead | Deal Lake Commission

Owner | Various

Location | Asbury Park & Ocean Township, NJ

Designer | Princeton Hydro

Funder | NJDEP Watershed Restoration 319(h) Grant

Year Completed | 2013

Colonial Terrace Golf Course Bioretention BMPs

A series of bioretention basins were retrofitted into the existing golf course. The retrofit systems were constructed in areas of the course where there were previously identified drainage issues. The design of the bioretention BMPs had to accommodate for a relatively shallow depth to groundwater table. As such, the systems incorporated a relatively shallow treatment zone and featured an upturned underdrain system to encourage infiltration to the greatest extent possible.

Asbury Park Boat Launch Shoreline Stabilization

Coir fiber logs were used to stabilize an approximately 250-foot segment of highly eroded shoreline. Invasive species were treated with herbicide and the shoreline was planted with native vegetation. A bioretention rain garden was also constructed to control stormwater runoff from the boat launch parking area.

Asbury Park Comstock Street MTD

This project involved the installation of a retrofit Manufactured Treatment Device (MTD) within a built environment. Post-installation field testing and STEPL modeling confirmed that the MTD significantly decreased the pollutant loading from one of the lake's major stormwater outfalls.

06 LION GATE PARK AND URBAN WETLAND FLOODPLAIN CREATION

Effective stormwater retrofits don't just apply to standard dry detention basins. In this case, an opportunity for a retrofit floodplain connection was key in increasing flood storage capacity for urban stormwater runoff in Bloomfield, New Jersey. Along the Third River and Spring Brook, two freshwater tributaries of the Passaic River, a highly disturbed and flood-prone former industrial site was transformed into a thriving public park allowing for both passive and active recreational activities. By removing four acres of upland historic fill in this densely developed area and retrofitting it into 4.2 acres of a functioning floodplain wetland, the project restored valuable ecological functions and greatly enhanced wetland and riparian zone habitat.

The Third River, like many urban streams, tends to be the victim of excessive runoff volume and is subjected to erosion and chronic, uncontrolled flooding. The vast majority of development in the watershed predated modern stormwater requirements and therefore lacks any significant stormwater control. This retrofit green infrastructure project not only re-established the natural floodplain wetland and native riparian plant communities, but also created public space for recreational activity. This project demonstrates that even in an urban environment retrofits can be completed which restore natural floodplain and stormwater functions.

The Third River, like many urban streams, tends to be the victim of excessive volume and is subjected to erosion and chronic, uncontrolled flooding.

This green infrastructure and retrofit project not only re-established the natural floodplain wetland and native riparian plant communities, but created public space for recreational activity.

KEY PROJECT INFO

Lead | Bloomfield Township, NY/NJ Baykeeper, Bloomfield Third River Association

Owner | Bloomfield Township

Location | Lion Gate Drive, Bloomfield Township, NJ

Designer | Princeton Hydro, PPD Design; gk+a Architects

Funder | NJ Freshwater Wetlands Mitigation Council & NJDEP Office of Natural Resource Restoration

Year Completed | 2020

This project won the 2022 New Jersey Future Smart Growth Award.

07 TREMLEY POINT FLOOD MITIGATION PROJECTS

The highly urbanized, low-lying Tremley Point neighborhood in the City of Linden suffers severe flooding from intense rainfall and storm surge. Post-Hurricane Sandy, NJDEP's Blue Acres Program led an effort to acquire 24 homes in Tremley Point that were especially impacted. In 2014, Rutgers University secured a $2.7 million grant to implement a series of green infrastructure projects throughout the region. Six rain gardens, a series of rain barrels, and two porous parking lots were installed throughout Tremley Point.

One of the highlights of the project was an innovative floodplain enhancement project involving the restoration of coastal plant communities and floodplain wetlands. The design included the creation of a floodplain bench, overall site re-grading, mechanical soil improvements and amendment, planting of 770 native trees and plants, and installation of a gravel walking path. This project is the first restoration project ever to be performed on NJDEP Blue Acres-acquired property.

KEY PROJECT INFO

Lead | Rutgers University

Owner | City of Linden

Location | 350 Madison Street, Linden, NJ

Designer | Princeton Hydro + Rutgers University

Funder | National Fish & Wildlife Foundation, NJ Corporate Wetlands Restoration Partnership, and Phillips 66

Year Completed | 2020

The restored area now provides natural buffering to storm surge and enhances floodplain functions to capture, infiltrate, store, and slow excess stormwater runoff which serves to reduce the risk of future flood damage in the area.

07 CONCLUSION

Stormwater retrofits are an ideal way to provide water quality improvement and stormwater management in the built environment. Whether they entail modifications to existing stormwater management structures or the incorporation of new BMPs in a developed area, retrofits can offer a cost-effective solution to address water quality and localized flooding concerns.

Each site offers its own unique set of constraints, which often include existing infrastructure, utilities, as well as soil and groundwater conditions. However, each application also provides its own set of opportunities. As has been outlined in this guide, stormwater retrofits are flexible in nature and can be designed to fit the unique constraints and opportunities of sites ranging from low-density residential areas to dense commercial spaces.

Whether you are starting from scratch or looking to move to the next level for stormwater management, smart planning is a must. If you are interested in implementing a stormwater retrofit in your local community, it is advisable to speak with your municipal or county government agency, a local university, soil conservation district, and/or local watershed association. Representatives from these organizations can guide you forward in identifying the best solution for your neighborhood.

To browse potential funding sources for green infrastructure retrofit projects, check out the **New Jersey Municipal Green Infrastructure Toolkit's Funding page** for a list of grant and low-interest loan opportunities.

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