

Nature-Based Solutions

Nature-based solutions (NBS) are design strategies that conserve, create, and restore natural resources to address climate hazards and other environmental stressors. NBS are engineered and constructed to complement natural processes by using or mimicking natural systems like dunes, wetlands, reefs, and vegetated buffers. Also called **green infrastructure**, NBS can work on their own or in tandem with **gray infrastructure**, which includes humanmade engineering approaches like pipes, catch basins, and concrete channels, as well as larger engineered systems like dams and seawalls. Beyond their primary function, NBS provide co-benefits that support ecosystems and people.

For example, if a low-lying area in a park lawn is frequently waterlogged, engineers might install **gray infrastructure**—perhaps a catch basin and pipes to drain the lawn. However, the pipes concentrate the stormwater runoff to an outlet, which usually discharges into a nearby water body like a stream. The pipes can carry pollutants to the water body, and the velocity of the runoff during a storm can erode its banks. **An NBS design** might instead use a swale—a shallow, gently sloped channel planted with water-tolerant vegetation—to capture, slow, and filter stormwater on-site. A small engineered swale would make the lawn usable for visitors while providing added co-benefits, such as creating habitat and a food source for wildlife, filtering pollutants, and recharging groundwater. While NBS may require more regular monitoring and maintenance, they're often cheaper to install and maintain over time.

At scale, **DCR has the power of positive impact**. NBS can reduce the impacts of localized flooding, erosion, and other impacts of extreme storms and drought. With nearly 500,000 acres under its care, DCR has a unique opportunity to enhance ecosystem function by prioritizing NBS over gray infrastructure where appropriate. While some sites may require a greater reliance on gray infrastructure, DCR prioritizes NBS when they provide clear environmental and functional benefits. Ultimately, site-specific conditions guide whether NBS are the right fit to meet project objectives.

NBS Case Studies

DCR has developed a series of case studies to highlight:

- How NBS increase resilience to climate hazards and support **DCR's Climate Adaptation Goals** (as detailed in the sidebar).
- The decision-making process for evaluating and selecting NBS, including analyzing existing conditions as well as maintenance and regulatory requirements.
- Common NBS challenges and strategies to guide future projects.

DCR's Climate Adaptation Goals

DCR's Climate Adaptation Goals are a whole-agency approach to address the growing impacts of climate change. NBS support the **Design with Resilience in Mind** goal:

DCR will update existing design and management standards and coordinate new standards for resilience to climate impacts—incorporating NBS, low-impact development principles, and sustainable methods, equipment, and materials.



Tools for Resilient Designs

Commonwealth's ResilientMass Climate Hub

- Includes climate data for precipitation, sea level rise, and other hazards to effectively size infrastructure to address increasing risks. By using the Commonwealth's ResilientMass Climate Hub together with the DCR Stormwater Handbook, managers can more effectively size infrastructure to address increasing volumes of runoff.



DCR Stormwater Design Handbook

- Includes best management practices for managing stormwater to meet both state and federal water quality regulations. These regulations prioritize water quality metrics to improve the health of ecosystems; they do not contain specific requirements to handle increases in volume of runoff. As climate change increases the frequency and intensity of storms, projects must also be designed to handle larger volumes of runoff.

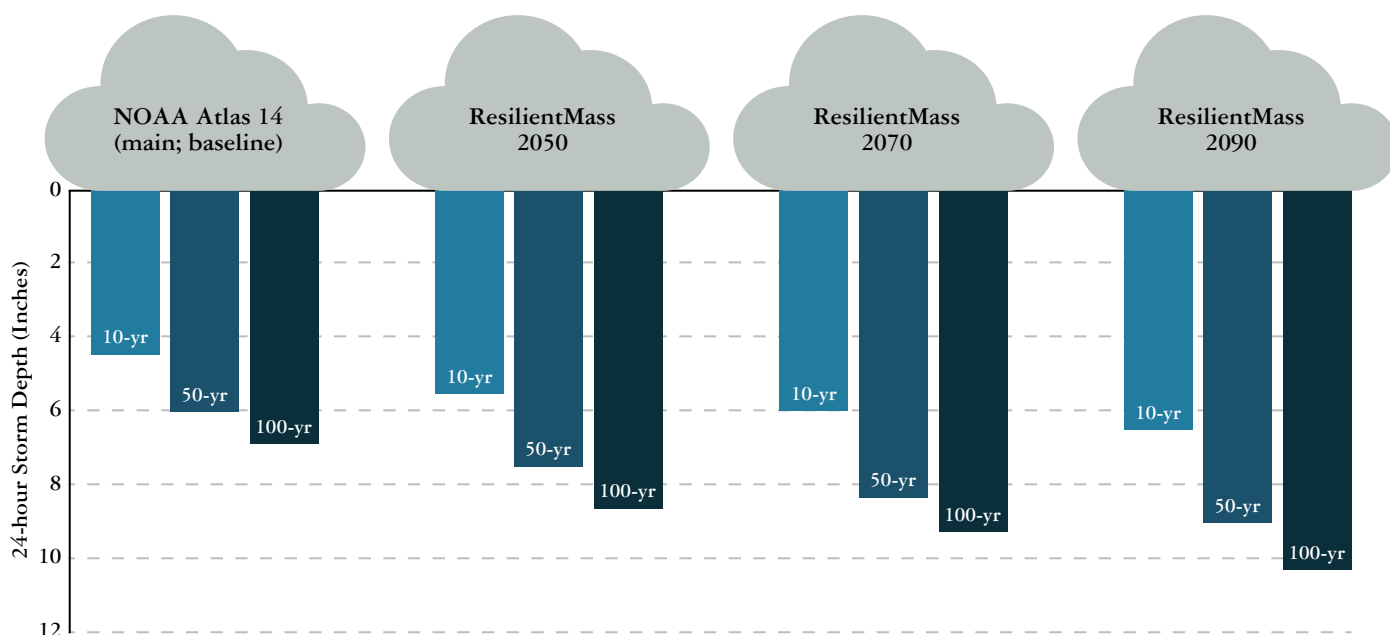
How to Ensure Resilient Designs

Project managers can work with DCR's Office of Climate Resilience and the Massachusetts Executive Office of Energy and Environmental Affairs' (EEA's) Office of Climate Science to understand available data sources and select those most suitable for their project.

The figure below provides a visual overview of three design storms from different sources and under different time periods for Erving State Forest. The volumes of rainfall experienced during heavy storms today are likely to be even higher in the future because of climate change. For instance, the figure shows that by 2050, the 50-year, 24-hour storm event is projected to be about 1.5 inches higher than the design value typically used for this storm today. Similarly, the 100-year, 24-hour storm event in 2050 is projected to be about 2 inches higher than the 24-hour storm with a 1% annual chance today.

Meaning, this storm will bring almost 30% more rainfall in 2050 than the same storm event today.

These projections highlight the importance of considering future climate conditions when planning NBS projects to maintain the projects' intended reliability for years to come.





Laurel Lake

A Nature-Based Solution Case Study



Project Background

A collaborative team across DCR offices evaluated opportunities to improve stormwater management at Laurel Lake, a site in Erving State Forest that includes hiking trails, a beach, a picnic pavilion, and a restroom. North of the beach, a large impervious parking lot and road sit atop a steep slope, causing stormwater to flow directly downhill and resulting in beach scour and erosion. Additionally, a stormwater outfall discharges untreated stormwater into the lake, posing a risk to water quality at one of the most pristine lakes in Massachusetts.

This project started as a retrofit stormwater maintenance project to address a localized water quality issue at an outfall on the beach. Maintenance projects entail replacing infrastructure in kind within the same footprint, as opposed to implementing a capital design project, which would allow for greater scope and new attributes. However, as site visits revealed broader runoff and erosion concerns from the adjacent parking lot, the project scope expanded to address increasing stormwater concerns at the beach and the parking lot. The team proposed a design that incorporated both gray infrastructure and NBS, with NBS features designed to account for more extreme precipitation events. Incorporating NBS provides environmental benefits, including increased wildlife habitat, and helps avoid problems often caused by gray infrastructure, like impacts to groundwater flow.



Image 1. View of Laurel Lake and beach from the southwest.

Project at a Glance:

- **Location:** Erving State Forest, Warwick, MA
- **Project manager:** Tom Valton
- **Collaborators:** DCR (Stormwater & Environmental Section, Office of Natural Resources, Lakes & Ponds Program, Field Construction Operations Section, ParkOperations), Warwick Conservation Commission
- **Contracted services:** AECOM, Western Earthwork
- **Challenge:** Stormwater runoff from parking lot was causing scouring and threatening the lake's water quality. Limited space was available to fit additional infrastructure
- **Impact of climate change:** Increasing frequency and intensity of storms will lead to increased beach scour and greater volumes of untreated runoff into Laurel Lake
- **Climate change considerations:** The project design included infiltration basins that were larger than what is typically required to enhance long-term stormwater infrastructure performance
- **Implemented NBS:** An infiltration basin and a series of bioswales with check dams at key locations around the parking lot





Image 2. Stormwater runoff from the large parking lot (Image 2A) flows rapidly down the steep slope towards the beach, causing beach scouring and erosion. The stairway connection between the parking lot and the beach shoreline (Image 2B) illustrates the sharp grade. Bioswales along the edge of the parking lot and road will help to alleviate these impacts.



Image 3. Frequent stormwater runoff from the parking lot causes beach scouring and erosion, and has led to vegetation growth in some areas of the beach (shown here).



Image 4. Bioswales will replace a vegetated area, pictured here, along the slope between the parking lot and the beach. This will help slow the flow of stormwater runoff and decrease beach scouring and erosion.



Image 5. Example bioswale installation. Included for illustrative purposes; not the project site.

NBS Spotlight: Bioswales

Bioswales (also referred to as bioretention areas or rain gardens) provide stormwater treatment by filtering runoff through vegetation and engineered soil media to infiltrate stormwater, allowing for groundwater recharge and reducing stormwater runoff.

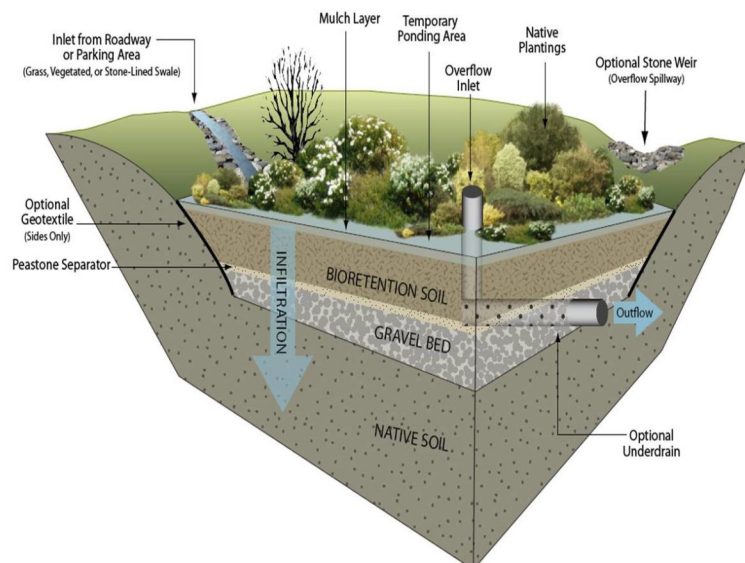


Image 6. Generic bioswale schematic used for illustration purposes only; not a depiction of the final design for this site. (Source: GeoSyntec Consultants)



Project Status: Permitting



Project Design Approach

- **Climate change considerations.** The NBS were sized for the 10-year, 24-hour storm in accordance with Massachusetts Stormwater Standards and regulations, using precipitation depths and rainfall distribution for Warwick. This project originally focused on maintaining a parking lot; however, stormwater runoff presented a greater challenge than what routine upgrades could address. In response, the project team proactively included redundant storage and overflow pathways to lend the design greater resilience until a more comprehensive capital improvement project could be undertaken. The team also considered the need to increase stormwater volume retention by using a larger and less frequent storm event (100-year, 24-hour storm) as a proxy for the future 10-year storm. This method allowed the team to evaluate NBS performance under more intense storm conditions and ensure discharge from the infiltration basin would not cause erosion in surrounding areas.
- **Selection of NBS.** NBS were initially explored to address water quality issues caused by an outfall discharging onto the beach. Further site evaluation revealed runoff from the parking lot would also need to be managed to protect Laurel Lake’s water quality. Because the park has existing gray infrastructure but limited space to add new infrastructure, adding NBS alongside current systems offers an effective way to enhance the site’s resiliency without disturbing the surrounding sensitive ecosystem. A combination of bioswales, check dams, infiltration basins, and natural swales will slow and filter runoff, reduce erosion, and improve water quality before it reaches the lake. This integrated approach complements existing gray infrastructure, removes the outfall, and supports DCR’s Design with Resilience in Mind goal by addressing stormwater at its source and protecting sensitive ecological areas.

NBS Benefits & Co-Benefits

The Laurel Lake project achieves the following environmental and social benefits.

Environmental

	Reduced stormwater flooding
	Improved water quality
	Reduced erosion
	Increased wildlife habitat

Social

	Recreation
	Education
	Aesthetics



Overcoming Project Challenges

- **Engagement with local conservation commission.** After reviewing the design plans, the Warwick Conservation Commission requested decreasing impacts to forested areas. In response, DCR modified the project by narrowing the roadway instead of removing trees and relocating proposed bioswales to avoid impacting the forested area. DCR's proactive adjustments and commitment to high environmental standards helped move the project forward.
- **Long-term maintenance considerations.** During the design phase, stormwater management practices were selected with consideration for the equipment available to DCR operations staff and their overall capacity, helping to ensure practical and consistent long-term care. DCR is also exploring developing clear, easy-to-follow maintenance guides to support routine NBS upkeep and improve coordination with stormwater staff when specialized maintenance is required.

Siting Considerations

- The site's large area, topography, and existing infrastructure allowed the project team to integrate multiple NBS throughout the project area—such as bioswales and infiltration basins—to slow runoff, promote infiltration, and prevent erosion.

Regulatory and Policy Considerations

- The project is subject to several regulatory and policy requirements, including the Massachusetts Wetlands Protection Act, which mandates the protection of wetlands and their buffer zones. The project also complies with the Massachusetts Department of Environmental Protection Stormwater Management Standards and has obtained necessary permits, such as the Order of Conditions issued by the Warwick Conservation Commission and the Project Notification Form required by the Massachusetts Historical Commission.

Operations and Maintenance Considerations

- During the planning phase, the project team carefully considered the maintenance equipment and capabilities available to DCR staff to ensure the designs would be practical and manageable.
- Routine maintenance checklists that empower staff unfamiliar with NBS to perform proactive tasks such as debris removal and preliminary inspections to identify clogged inlets or outlets will help maintain the NBS.

Lessons Learned and Transferable Tips

- **Effective collaboration.** Working together across DCR teams and with outside agencies is key to success. Local knowledge and institutional expertise help DCR design strong projects and navigate complex regulations.
- **Preventative maintenance.** By planning for maintenance early, DCR chose NBS that fit the site and matched the skills and capacity of operations staff. Selecting NBS that staff can maintain over time is essential.

Additional Resources

- [EPA's Bioretention Best Management Practices.](#)
- [Massachusetts Native Plant Palette](#) provides visual assortment of appropriate plants for NBS designs.
- [EPA's Types of Green Infrastructure](#) page provides information on various green infrastructure solutions, including images.

