

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

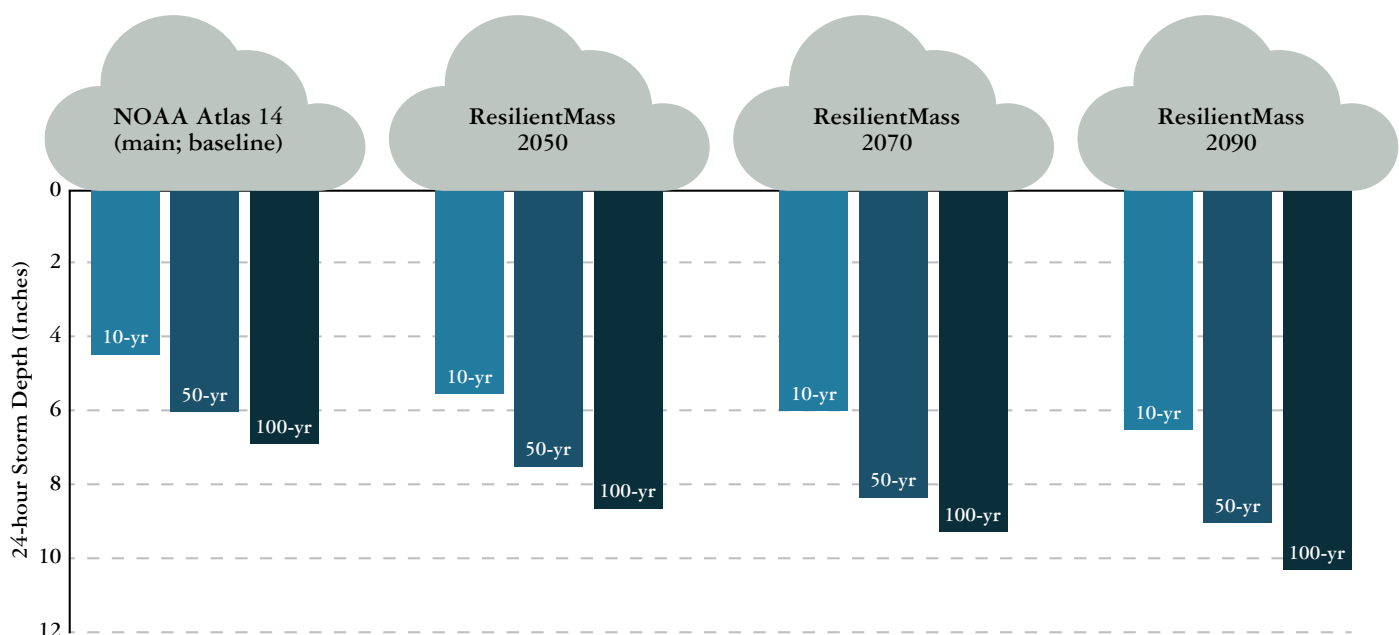
- Includes best management practices for managing stormwater to meet both state and federal water quality regulations. These regulations prioritize water quality metrics to improve the health of ecosystems; they do not contain specific requirements to handle increases in volume of runoff. As climate 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.





Mt. Tom State Reservation Universal Access Trail Redesign A Nature-Based Solution Case Study



Project Background

In collaboration with a multidisciplinary team, DCR is leading a comprehensive project at Mt. Tom State Reservation in Holyoke to reduce precipitation-based flooding and erosion of a universal access (UA) trail to support accessible recreation. Stormwater issues stem from natural runoff from the mountain, which trail projects have redirected into two discharge areas.

Historically, stormwater has been managed at the site through gray infrastructure such as catch basins and culverts. These methods require frequent maintenance and often fail to prevent flooding along the UA trail, causing extended closures and reduced public access. Implementing NBS such as vegetated step pools and leveraging existing wetlands could decrease maintenance requirements and mitigate flooding.

Project at a Glance:

- **Location:** Mt. Tom State Reservation, Holyoke, MA
- **Project manager:** Ale Echandi
- **Collaborators:** DCR (Trails & Greenways Section, Office of Climate Resilience, Stormwater & Environmental Section, Park Operations), EEA's Office of Climate Science, Holyoke Conservation Commission, Massachusetts Division of Fisheries and Wildlife's Natural Heritage and Endangered Species Program
- **Contracted services:** KZLA, Woodard and Curran, Oxbow Associates
- **Challenge:** Stormwater flooding causes frequent and extended closures of access path and erosion of UA trails
- **Impact of climate change:** More frequent and higher intensity storms will cause increased flooding and trail erosion
- **Climate change considerations:** The project incorporated data from the [ResilientMass Climate Hub's](#) Projected Precipitation Frequency Tables to inform a climate-resilient design.
- **Implemented NBS:** Vegetated step pools for floodplain restoration, which will leverage existing wetlands and create an open vegetated channel.



Image 1. Existing conditions after a rain event. Flooding and sediment build-up impact trail accessibility.



Image 2. Existing conditions after a rain event showing significant sediment build-up.



Image 3. Step pools along the graded slope leading to the flooding-prone area will alleviate erosion and sediment transport.



Image 4. Existing wetland is disconnected from the lake. The project will reconnect it to the lake via an open channel under the trail.



Project Status: Planning and Design



Project Design Approach

- **Climate projections.** The site's existing stormwater infrastructure was built to handle a present-day 25-year storm event. Frequent flooding and erosion of the UA trail show this system is undersized. The new design incorporates climate resilience by using future rainfall projections to ensure long-term effectiveness. NBS designs were evaluated for 10-, 25-, and 50-year, 24-hour storm events in 2030, 2050, and 2090 using [ResilientMass Projected Precipitation Frequency Tables](#) for future conditions against National Oceanic and Atmospheric Administration Atlas 14 estimates for current design storms based on historical rainfall data. The analysis showed that the 25-year storm for 2050 is comparable to a present-day 50-year storm, which underscores the need for climate-ready designs. This project design approach reflects a shift toward forward-looking, sustainable NBS that improve infrastructure, provide ecological benefits, and improve the visitor experience.
- **Selection of NBS.** NBS were selected for this site because they address flooding and erosion challenges while offering benefits over traditional gray infrastructure, including longer lifespans, reduced maintenance needs once established, and adaptability to changing conditions. After reviewing various design options, DCR selected a design providing flood reduction through the projected 50-year storm for 2090. The design builds on the existing vegetated wetlands, which functions as a natural stormwater retention basin, and incorporates an open vegetated channel and bridge to improve stormwater flow and protect the UA trail from washouts. The project team also added step pools to slow down stormwater on steep slopes, reducing erosion and sediment transport.

NBS Benefits & Co-Benefits

The Mt. Tom NBS project achieves the following environmental and social benefits.

Environmental

	Stormwater retention
	Improved water quality
	Increased wildlife habitat
	Reduced erosion

Social

	Recreation
	Education
	Aesthetics

Overcoming Project Challenges

- **Collaboration and climate education.** Planning for future storms means designing for larger events today, which requires clear guidance to contractors and careful balancing of cost, maintenance, and the level of design effectiveness under varying storm magnitudes. The DCR project manager worked with the DCR Climate Resilience team and EEA. Together, they educated the contractors on the commonwealth's climate projections.
- **Long term maintenance considerations.** From the start, the project team prioritized low-maintenance concepts to minimize future upkeep. This approach makes it easier for staff with limited experience or capacity to maintain the NBS successfully.



Siting Considerations

- During trail reconstruction, a broken catch basin and blocked culvert were found to be causing flooding, erosion, and sediment buildup. Because a new bridge limits access for large equipment, the project team had to find alternative ways to manage stormwater.
- The woodland trail's natural setting and the site's topography made it a good fit for NBS. Existing wetlands serve as a natural stormwater retention basin, and the project team considered expanding these wetlands as a solution to flooding. However, further study showed that expansion alone wouldn't handle the projected increased precipitation volumes for this site.
- The concept design was further informed from studying the site's hydrology, as well as how water flows across the three sub-basins. Creating an open channel under the trail allows stormwater to flow freely from the wetland to the lake, reducing flooding and erosion. Adding step pools along the graded slope slows down water, helping it soak into the ground and reducing erosion and sediment buildup on the trail.

Regulatory and Policy Considerations

- Project designs require review and approval by the Holyoke Conservation Commission. The project team plans to include the Conservation Commission on the permitting review team. Required permits may include a Notice of Intent to the Conservation Commission and the Massachusetts Department of Environmental Protection, a Massachusetts Endangered Species Act filing, and an archaeological consultation with a possible Project Notification Form to the Massachusetts Historical Commission.

Operations and Maintenance Considerations

- The open vegetated channel and step pools incorporated into the design offer a low-maintenance and resilient approach for state agencies with fluctuating staff and budget projections.

Lessons Learned and Transferable Tips

- **Establish clear communication with consultants from the outset.** Invest time in developing a well-written Request for Proposal that clearly defines project specifications and outcomes, such as maximizing the use of NBS and incorporating climate change projections to ensure NBS are appropriately sized.
- **Involve an interdisciplinary review team early in the process.** Involving individuals in the Project Management team with different perspectives and expertise—in this case, stormwater, climate, and operations—supports holistic evaluation of design options against project goals. It also streamlines decision-making and saves time by aligning design choices from the start.

Additional Resources

- [Vascular Plants of MA: A County Checklist](#) provides guidance on native plants.
- [Massachusetts Native Plant Palette](#) provides a visual assortment of appropriate plants for NBS designs.

