

8-31-2014

Project Report: Green Infrastructure for Sustainable Coastal Communities

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Recommended Citation

Houle, James J.; LaBranche, Julie; Gruber, James; Roseen, Robert M.; Watts, Alison; Ballesterio, Thomas P.; Bourdeau, Dan; Gorham, James; Keeley, Chris; Miller, Steve; Puls, Timothy A.; Stacy, Paul; and Tsiamis, Christos, "Project Report: Green Infrastructure for Sustainable Coastal Communities" (2014). *UNH Stormwater Center*. 63.

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PROJECT REPORT

Green Infrastructure for Sustainable Coastal Communities



A PROJECT FUNDED BY THE NATIONAL ESTUARINE RESEARCH RESERVE SYSTEM SCIENCE COLLABORATIVE TO A PROJECT TEAM LED BY THE UNIVERSITY OF NEW HAMPSHIRE STORMWATER CENTER AND THE GREAT BAY NATIONAL ESTUARINE RESEARCH RESERVE IN SUPPORT OF GREEN INFRASTRUCTURE IMPLEMENTATION WITH LOCAL MUNICIPAL, NON-PROFIT AND PRIVATE SECTOR PARTNERS.

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PROJECT INTRODUCTION

Among the many qualities that attract people to live in southern New Hampshire is the beauty of its beaches, wetlands, fields, and forests. Yet as the population grows, there has been a rise in the impervious surfaces that allow polluted stormwater runoff to flow into rivers, lakes, and coastal waters. This has led to a decline in the natural infrastructure that preserves water quality and protects property from storms and floods. At the same time, a shifting climate is bringing more frequent and intense storms to the area. Excessive rain, combined with increasing impervious surfaces is generating more runoff—often more than existing stormwater infrastructure can handle.

Regional research conducted by the University of New Hampshire Stormwater Center (UNHSC) supports the idea that green stormwater infrastructure techniques that capture runoff close to its source and weave natural processes into the built environment could address these challenges.



Green Stormwater Infrastructure (GSI) could include:

- Structural treatments such as rain gardens and pervious pavements
- Regulations that require improved stormwater treatment performance
- Incentives to encourage property owners to protect water quality

However, stakeholders are often hesitant to use these techniques if the technical concepts are unfamiliar or the cost of implementation and maintenance is uncertain.

The goal of this project was to build municipal capacity in coastal watershed communities for Green Infrastructure by engaging local and regional stakeholders in a planning and implementation process that was supported by technical resources and current relevant information. A collaborative process was used to build trust and to promote the legitimacy and relevance of the project for the intended users, and, as a result, build community resilience and improve capacity for managing water resources and related ecosystem services.

PLANNED APPROACH

The project team – which included the UNH Stormwater Center, Great Bay National Estuarine Research Reserve, Southeast Watershed Alliance, Rockingham County Planning Commission, Geosyntec Consultants, and Antioch University – used the principles of public participation with the goal of creating regional dialogue with stakeholders, building mutual trust, and linking relevant scientific research to local knowledge.

Stakeholders for this project included municipal staff and decision-makers from 42 towns in the New Hampshire coastal watershed, the New Hampshire Coastal Adaptation Workgroup, and the Seacoast Stormwater Coalition and NH Department of Environmental Services (NHDES). The team formed an Advisory Board with representatives from these groups to ensure that stakeholders could be effectively engaged throughout the project, and that their feedback would be used to inform its course.

The project team began by working with the Advisory Board to identify mentor communities where they could install high-visibility green stormwater infrastructure projects to demonstrate the science and effectiveness of these practices. The team planned to install and monitor these installations to assess their performance in reducing stormwater and chemicals that contribute to water pollution.

The ultimate goal of the team was to combine data from this analysis and demonstration site monitoring with input from stakeholders to develop a framework of resources for promoting and implementing green stormwater infrastructure solutions in a network of towns throughout the region.

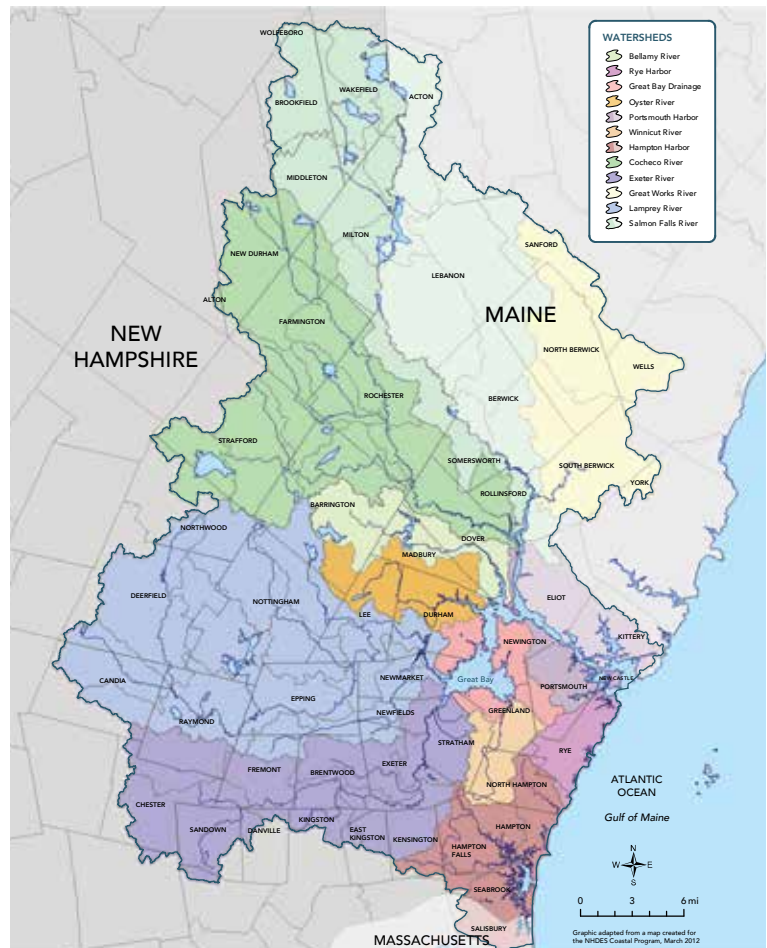


Figure 1: The New Hampshire coastal watersheds and watershed communities.

COLLABORATIVE PROJECT METHODS

Research priorities and science communication and evaluation for this project were developed through a collaborative approach that provided structured opportunities for the engagement of intended users and other stakeholders in the coastal watershed. The objective of the collaborative research and implementation approach was to fully integrate end user perspectives into the problem definition, solutions, and methods for integration of GI practices.



Throughout the project period, the project team held a schedule of regular meetings and conference calls. An Advisory Board (AB) was developed and served in a collaborative leadership role with the Project Team. The AB provided a key link between collaborative project activities and local communities and other stakeholders.

Identifying Issues, Targeting Implementation

As a result of the participation and input of the Advisory Board, it became evident that there was a need for change in the approach the project team used in addressing issues, and a more focused approach to implementation efforts. The team began working in three to five municipalities within the coastal watershed, as opposed to more broadly in eight to twelve communities as the proposal originally recommended. The focus turned to target communities that were motivated and prepared.

However, there arose some division over the communities that should be targeted for implementation. On the one hand, it was agreed that many communities are poised to explore innovative water resource management strategies, as there are emergent permits and new water quality thresholds advancing. In early majority communities, Green Infrastructure implementation and improved water resource management are seen as imminent, and a focus on these early adopters served as a

The Advisory Board provided a key link between collaborative project activities and local communities and other stakeholders.



positive way to increase awareness and bring more communities into the project. On the other hand, the smaller un-permitted municipalities should not be overlooked; they should have the opportunity to take advantage of program benefits. Some feared that there might be a rush to work with those communities ready to move forward, while the communities not as well staffed might not be considered.

The Advisory Board challenged the project team to develop and apply a two-phase approach to selecting implementation communities. Phase I would work with “low hanging fruit” communities with proven success and commitment. Phase II would provide opportunities to communities who might be inspired by the potential successes of early adopters and would pick up ideas from projects that other communities have already completed.

From this input a clear and simple set of procedures, selection criteria and an implementation time frame were prepared for the application and selection of implementation communities. This approach was not one that was included in the original proposal, but was a modification that was directed by the Advisory Board and seemed to address some of the concerns.

Direction from the Advisory Board led to the initiation of an application process to select Phase I and Phase II implementation communities. Three projects were selected for Phase I and an additional three communities for Phase II (see project summary section for specifics).

The application process took on a very different procedural approach and led to a fundamentally different and significantly more beneficial result than originally anticipated. Asking the communities to bring their specific needs and propose their own solutions to the project resulted in increased sense of ownership in the process and a commitment to involvement. This level of engagement was a refreshing change from the often tedious and thorny process of convincing people of the merits of an idea or a particular concept. In addition, the community’s high level of involvement and ownership of the project brought local enthusiasm to complete and replicate that idea as well.

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Measuring Productivity, Defining Success

The concept of appropriate and productive projects obviously involves different meanings and outcomes depending on who is interpreting results. In many cases science-based research supports the implementation of total maximum daily loads (TMDLs) for impaired watersheds. These involve models that distribute the proportion of allowable pollution to a water body and call for mandated reductions of that pollutant of concern. Scientists have become adept at modeling the benefits of best management practices (BMPs) to reduce pollution; however, the test of any plan to control pollutants such as nitrogen or phosphorus will be measured in the water body. For impaired waters that do not have TMDLs prepared, there is no real plan to manage pollution reductions. Many municipalities rely on standard practices and approaches until there are mandates that direct them to do otherwise. The differences in these approaches are stark and highlight areas of opportunities that this project has investigated.

In many cases, projects forwarded by scientists and researchers are interpreted as “demonstrations” and do not often have the full support of the municipalities and staff where they are implemented. Alternatively, some standard approaches to municipal repairs and maintenance – particularly with respect to drainage and stormwater management – lack appropriate control of runoff volumes and the pollutants that threaten receiving waters. It is hard to deny that municipalities have a great deal of power to move beyond demonstration to full implementation and that grants alone will not move the needle toward watershed wide restoration. With more direction from municipalities and other owners of closed urban drainage systems there is potential to do more to manage non-point source pollution (NPS) long-term.

From the research perspective, it may be beneficial to rethink our overall approaches to watershed management and work more directly with municipalities to improve approaches. Our experience with LID and GI stormwater management approaches has been that as a programmatic strategy, they are flexible and can accommodate many different demands from being nearly invisible and underground to being highly visible aesthetic enhancements to the landscape. This means building trust within communities and developing more coordinated working relationships a major component of what this project aimed to investigate.

From the research perspective, it may be beneficial to rethink our overall approaches to watershed management and work more directly with municipalities to improve approaches.



The Complete Community Approach

One of the most successful outcome of the project's work with the Advisory Board was the development of the "complete community approach."

It started when the project team was challenged with answering this rather simple question from one of the members of the AB: "What would it look like if a community were to successfully incorporate a GI approach into their water resource management efforts?" The complete community approach was developed by the project team and the AB as the best and most current answer.

The following measures were developed as a comprehensive complete community approach to the introduction and implementation of green infrastructure practices:

- Adopt ordinances and regulations for new development that mandate the use of stormwater filtration to clean runoff, and infiltration practices to reduce runoff.
- Require improved stormwater controls for reducing runoff for redevelopment projects or other significant construction, and for site improvements such as repaving or building renovations.
- Apply conservation strategies such as protecting naturally vegetated areas near water bodies and wetlands, and limiting the size or percentage of allowable impervious cover in high value natural resource areas.
- Reduce existing impervious cover through targeted site improvements and stormwater management changes in high impact locations (i.e. locations that contribute high amounts of polluted runoff).
- Make a long-term commitment to fund and maintain stormwater controls along with an accounting mechanism to track long-term benefits of strategies. Consider innovative funding mechanisms such as impacts fees, exaction fees and stormwater utilities.
- Provide opportunities for outreach by sharing plans and progress with citizens and business owners through community newsletters, cable access, and on-site signs that explain what steps are being taken to protect waterways or improve stormwater management.

The complete community approach is the best answer to this question:

How does better stormwater management become part of the DNA of municipal management efforts?

The complete community approach is the best answer to one of the core questions as to how does better stormwater management become part of the DNA of municipal management efforts. Municipalities implementing measures of a complete community approach have a leg up on important issues looking into the future. So far there are only a handful of communities that are comprehensively pursuing a complete community approach and this is one of the barriers to more wide-spread implementation.

The approach is ultimately more than a few bullet points on paper – it is a municipal perspective that takes advantage of opportunities where possible to improve the effectiveness of municipal infrastructure wherever and whenever possible.

Barriers to Implementation

In 2013, a working session was held with local decision makers to identify the existing barriers to the implementation of green infrastructure projects in New Hampshire. Participants included municipal staff, volunteer board members, and elected and appointed officials. In addition to identifying local barriers, participants also developed specific strategies and approaches to address them. What follows is an overview of the results of this working session.



Green Infrastructure approaches represent a change to traditional approaches to drainage and often barriers block their adoption. These barriers can occur throughout the planning and development process and typically fall into four main categories:

1. Technical and Physical
2. Legal and Regulatory
3. Financial
4. Community and Institutional

Many of the barriers in these categories are due to unfamiliarity with green infrastructure; however, there are strategies to overcome these.

TECHNICAL AND PHYSICAL BARRIERS

At the local level, these include limited or no maintenance of existing infrastructure, unfamiliarity with green infrastructure, little or no trust in the science and technology behind it, and a lack of understanding how green infrastructure is relevant to local stormwater issues.

Some of the specific technical and physical barriers include:

- Practice is new, not widely understood, and unproven
- Limited ability of local DPWs to maintain existing infrastructure
- Existing maintenance and capital improvement priorities

Many of the technical and physical barriers at the local level are the result of limited outreach and education, limited resources, competing interests, and a lack of confidence in a new way of managing drainage.

A peer group of municipal officials generated a list of solutions for local governments and municipalities to overcome these barriers, including:

- Develop training programs for staff
- Increase training opportunities for staff
- Improve documentation of maintenance activities

Green Infrastructure approaches represent a change to traditional approaches to drainage and often barriers block their adoption.

LEGAL AND REGULATORY BARRIERS

Legal and regulatory barriers at the local level include resistance to new rules and regulations, perceived adverse impacts to property owners, and difficulty in understanding the importance of water quality issues.

Some of the specific legal and regulatory barriers include:

- overly prescriptive, inflexible, and conflicting rules,
- complications associated with property rights, and
- lack of a clear regulatory framework.

The acceptance and implementation of green infrastructure projects is dependent on the leadership, knowledge, and support by local officials.

To overcome the legal and regulatory barriers, local governments and municipalities need to:

- Ensure and maintain local control rather than rely on state and federal agencies to mandate standards
- Ensure that property rights are not adversely impacted
- Make available cost benefit analyses showing the cost effectiveness of green infrastructure and its positive impacts on the local economy



FINANCIAL BARRIERS

Currently, most local governments and municipalities are experiencing a time of fiscal constraint where limited resources and funds are available for infrastructure projects. Therefore, in order to implement green infrastructure projects local governments and municipalities must find innovative ways to fund these projects. Even without current fiscal constraints, a number of financial barriers remain.

Some financial barriers include:

- Perception that the community cannot afford green infrastructure investments
- Low priority for green infrastructure projects compared to other infrastructure projects
- Perception that green infrastructure may be an unfunded mandate from state and federal governments.

Green infrastructure can be less costly over its operational life span and has the ability to meet multiple development and stormwater management objectives. Therefore, it can be an efficient and cost effective alternative compared to conventional stormwater infrastructure.

In order to overcome perceived financial barriers:

- Local governments are encouraged to share with the public the multiple benefits and avoided costs associated with green infrastructure
- Local officials need to consider providing incentives that encourage the use of green infrastructure over conventional infrastructure

The acceptance and implementation of green infrastructure projects is dependent on the leadership, knowledge, and support by local officials.

COMMUNITY AND INSTITUTIONAL BARRIERS

Community and institutional barriers at the local level are a considerable constraint to green infrastructure projects. The characteristics and values of a community significantly influence the acceptance of green infrastructure and may represent critical barriers to its implementation. These barriers include public knowledge and perception, landowner preferences, development plans, resistance to change, and a lack of political commitment and leadership.

Barriers in this category include:

- Insufficient and inaccessible information about green infrastructure and its benefits for political leaders, administrators, agency staff, developers, builders, landscapers, and others, including the public
- Lack of integration of green infrastructure in local rules and regulations
- Lack of understanding concerning the interconnectedness of our water resources
- Resistance by developers to integrate and use green infrastructure

Overcoming these barriers will require local governments to:

- Generate public understanding and potential support
- Conduct education and outreach
- Ensure broad stakeholder participation.

This can be most easily achieved if local government leaders gain a better understanding about opportunities, funding, benefits, and avoided costs associated with green infrastructure.

Conclusion

To date, few communities have actually achieved all facets of the complete community approach (see Strategic Implementation and Effectiveness). While the vast majority of gaps exist with long-term commitments to fund and maintain stormwater controls, there is a high variability with respect to the new development and redevelopment regulations and their overall enforcement. Many updates to municipal regulatory standards have been done through the planning board through the site plan and subdivision review process. A few others have been passed as an amendment or addition to the zoning ordinances. While these changes are beneficial and represent significant progress, there are still educational and enforcement gaps with respect to enforcement.

If communities can make a long-term commitment to implement, fund and maintain stormwater controls, significant progress could be made toward protecting water resources through the economic development and redevelopment process. (See *Fact Sheet: Pollution Prevention Modeling in Appendix A.*)

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PROJECT OUTCOMES

EXETER, NEW HAMPSHIRE: Improving the Brickyard Pond Residential Watershed

THE PROBLEM

Brickyard Pond, once a community gathering place and natural playground, has deteriorated steadily over the years. As excess fertilizer, soil, oils, salt, and other components of stormwater pollution flow through stormdrains from a neighboring community and enter the pond, a food smorgasbord is created for unwanted plants and algae. The plants and algae grow in excess, reducing the overall water quality and degrading the habitat for fish.

THE SOLUTION

Neighbors in the Marshall Farms community expressed their concerns. Working with the town and with GISCC, they learned what small changes they could make on their property to work toward improving the pond's condition. Their focus was on making these changes using three Green Infrastructure tools: lawn care, rain barrels and rain gardens.

The town of Exeter and residents living near Brickyard Pond participated in an education program that was followed by implementation of several residential stormwater treatment

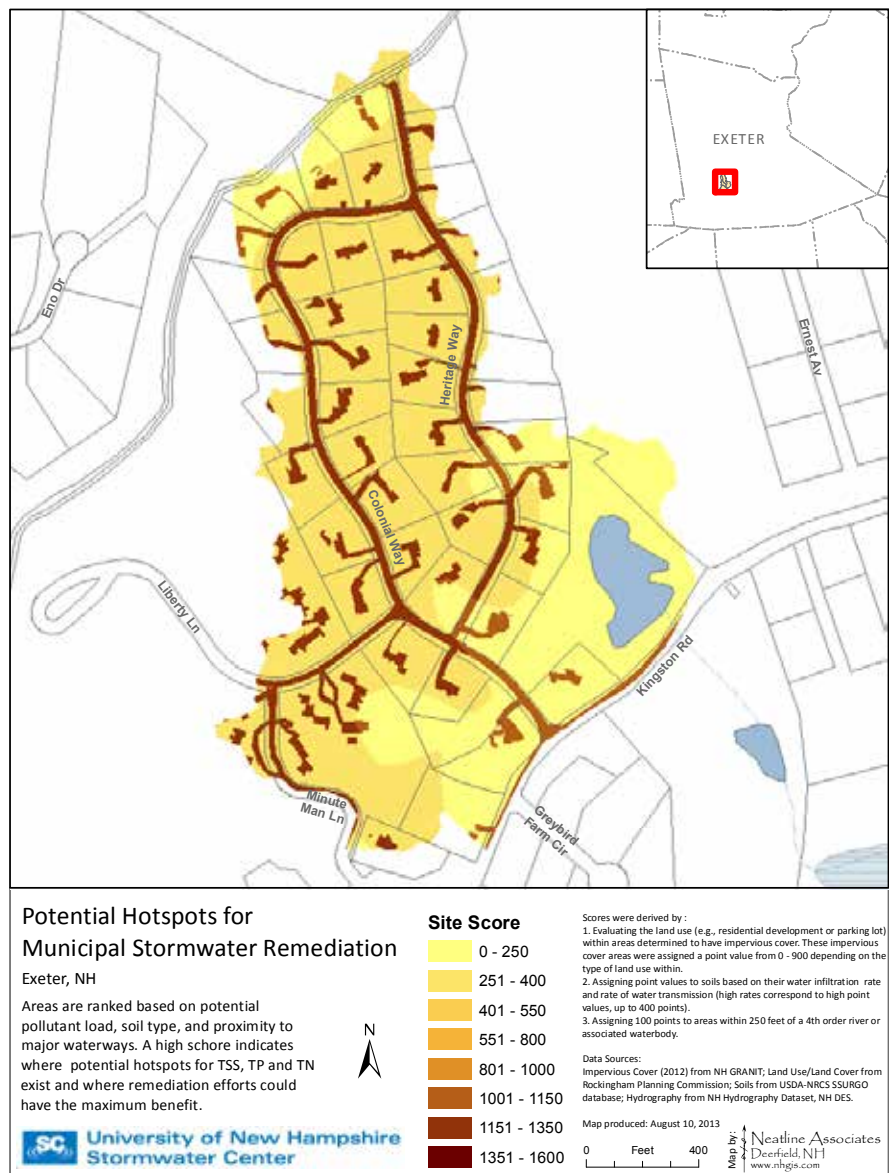


Figure 2: Hotspot mapping for the Brickyard Pond Watershed identifying areas that represent opportunities for pollutant load reductions through targeted GI retrofits.

systems. The project combined education with water treatment and monitoring and engaged a wide range of stakeholders. In the initial stages of this program, seven rain barrels and two rain gardens were installed and, most importantly, a relationship was established between residents and the town to resolve issues with stormwater and the health of Brickyard Pond.

Lawn Care

In a neighborhood workshop, residents learned about the importance of letting soil conditions, not past habits, dictate what their lawns need for fertilizer. By committing to the Happy Lawns-Blue Waters campaign, residents agreed to opt for slow release, phosphorus-free fertilizers unless soil tests indicate otherwise. In addition, they committed to cleaning up after their pets, reducing yet another source of excess nutrients. When mowing lawns, they would cut to three inches or higher to encourage stronger grass root growth and leave the cut grass on the lawn to take advantage of the free fertilizer provided as clippings decompose.

Rain Barrels

Residents were offered the opportunity to purchase SkyJuice rain barrels at a discounted rate. The result is not only a free water source for the residents, but a reduction in the amount of stormwater that leaves the property

RAIN GARDENS

Two neighborhood rain gardens were installed in this community. They were designed by Ironwood Design Group LLC with donations and assistance from Rye Beach Landscaping and Churchill's Gardens. Residents were invited to participate in construction to gain hands-on experience. They then applied their newly acquired skills to construct a rain garden on their own property.

RESULTS

The experience of working with the expertise of the technical team helped build trust among town staff and residents. The project made staff feel more comfortable with public outreach/education regarding the impact of stormwater on water quality. As a result staff are now more likely to share information on the Commissions facebook page, the town website or in public at meetings. In addition two educational workdays were hosted at two other locations throughout town.

The GI program is a great model of how, with the support of a team to build a strong foundation of experience, I am both more confident and more likely to continue to implement projects that work toward improving water quality."

*—Kristen Murphy
Natural Resource Planner, Town of Exeter*





BRENTWOOD, NEW HAMPSHIRE: Brentwood Goes Green

In November of 2013, the Town of Brentwood received funding to assist with projects that would apply green infrastructure and low impact development methods on municipally owned lands, and would include an outreach and education campaign. To identify these projects, the GISCC project team agreed to complete the following tasks:

1. Evaluate municipal sites including the town shed, town office, library and school.
2. Develop a stormwater management plan for each site that incorporated LID projects.
3. Make presentations of stormwater management plans to town boards (Select Board, Highway Department, Planning Board and Conservation Commission) to educate and improve understanding and benefits of LID. Representatives from these town boards would then meet and pick two to three projects to implement.
5. Implement improvement projects on town-owned lands by September 2014.
6. Conduct follow-up meetings with town boards after completion.

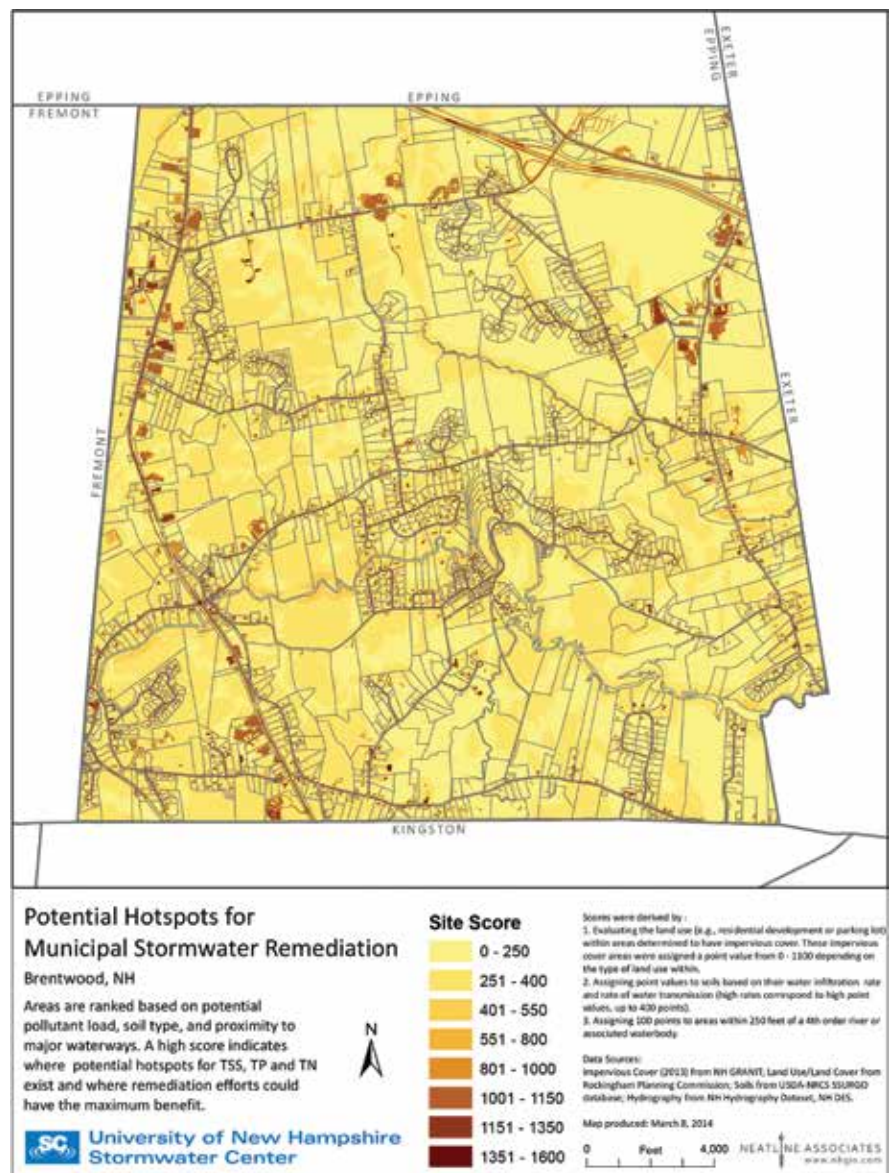


Figure 3: Hotspot mapping for the town of Brentwood identifying areas that represent opportunities for pollutant load reductions through targeted GI retrofits.

This hands-on approach, including implementation of direct improvements and education in the understanding of LID, has led to increased awareness of LID strategies and how to incorporate them into development and redevelopment activities in the town.

The management plans will provide an invaluable resource and roadmap for the town for future implementation of LID strategies at municipal sites, which will lead to continued improvement in the water quality in the Exeter River.

OVERVIEW

The Brentwood project included optimization modeling of updated, watershed-wide impervious area data used to target pollution hotspots based on land use, zoning, soils, proximity to a water body, and other common GIS data layers.

Stormwater-derived loadings were modeled and classified to identify municipally owned hotspot locations for installation of cost-effective stormwater solutions that maximize pollutant load reductions.

Attribute tables generated by the modeling effort were then used to sort and filter results based on specific town official interests. Municipally owned lands were ranked by final modeling point total and then in descending order according to total parcel acreage. Final points indicate the pollutant potential of any parcel area with higher numbers indicating larger pollution threats. Secondary sorting by parcel size indicated opportunities where more could be done, as larger parcels with higher potential for pollution indicate larger benefits from retrofit activities; this is a quick screening method to further investigate potential implementation sites.

A project installation site was chosen from a list of municipally owned lands with a high potential to reduce pollutant loads and with high visibility and outreach/educational opportunity. The selected property was the town-owned Mary E. Bartlett Library. The property consists of a 3.4-acre parcel with 0.71 acres of impervious cover.

As a result of this project, 90% of the Mary E. Bartlett Library impervious cover has been disconnected via treatment through green infrastructure practices. Two GI stormwater control measures have been installed that treat 0.64 acres of drainage area and annually reduce 413 lbs of TSS, 1.6 lbs of phosphorus and 9.1 lbs of nitrogen on an annual basis.

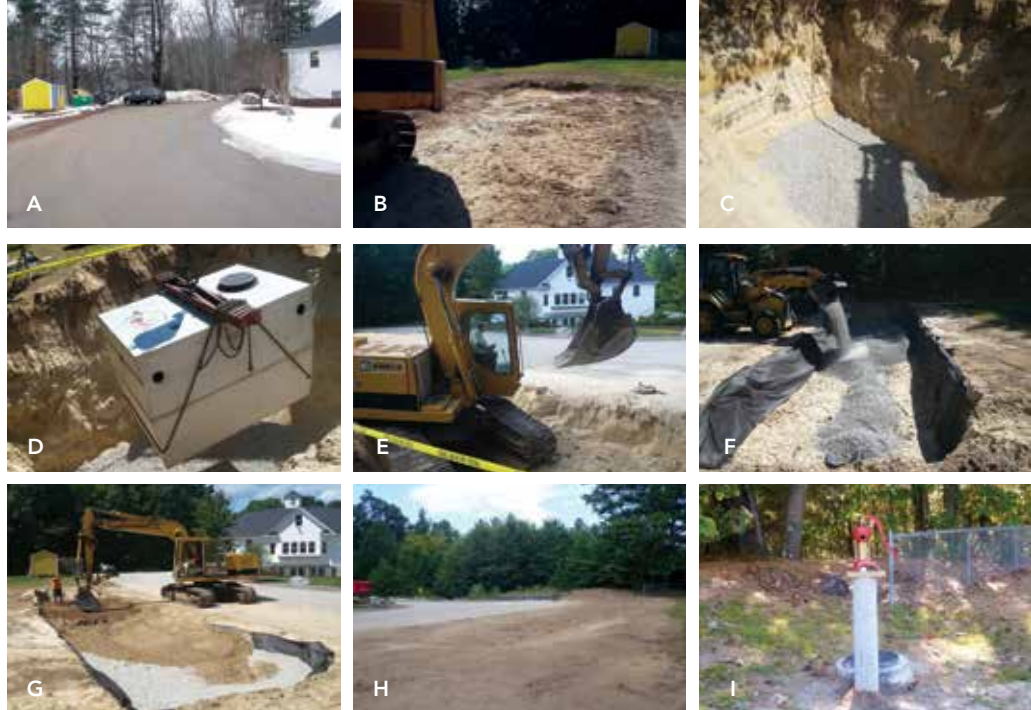


Figure 4: The Brentwood project area. A. Western perimeter drive and parking area; B: re-graded site; C: excavated hole for cistern; D: installed cistern; E: excavated bioretention area; F: placed stone; G: backfilled with BSM; H: finished grade; I: installed cistern pump.

2014 BMPS	ANNUAL LOAD 'L' #/YEAR	EFFLUENT LOAD 'Le' #/YEAR	ANNUAL PL REMOVED #/YEAR
TSS #/year	456	42	413
TP #/year	1.95	0.35	1.61
TN #/year	17.6	8.5	9.1

Table 1: Summary of annual pollutant load reductions estimated for the retrofits at the Library.

As a result of this project, 90% of the Mary E. Bartlett Library impervious cover has been disconnected via treatment through green infrastructure practices.



The historic Rochester City Hall & Opera House.

ROCHESTER, NEW HAMPSHIRE: Incorporating Updates to Stormwater Management in the City Ordinance and Land Use Regulations

IDENTIFIED NEED

The City of Rochester's Planning and Community Development Department recognized that their current approach to stormwater management needed major revisions and updating. Many of the best management practices referenced in documents including site plan and subdivision regulations and city ordinances were outdated and no longer the best options for management of stormwater runoff.

The city's stormwater regulations were created at different times and had many inconsistencies and outdated references. Conventional stormwater management had resulted in many of the problems Rochester has experienced, including flooding that has stressed the existing public drainage systems and degraded wetlands, rivers, and aquifers. All of these impacts represent economic and health costs to the city's population.

As one of the fastest developing communities in the New Hampshire Seacoast, it was important that the documents be revised so that the city can take advantage of low impact development and green infrastructure stormwater best management practices moving forward.

ROCHESTER'S COMMITMENT TO GREEN INFRASTRUCTURE

The goal of this project was to improve the quality of life of Rochester's citizens and visitors, protect natural resources and reduce municipal costs by:

- Updating the stormwater regulations so the City can consistently require the implementation of the current best management practices using low impact development and green infrastructure
- Establishing recommendations for developing a database to track and account for best management practices, maintenance, impervious cover, and other elements of future permit reporting requirements.

REGULATION UPDATE PROCESS

The city staff, their technical consultant, and a subcommittee of the city's planning board review used the following process:

- Review stormwater components of the existing city documents, including the Site Plan Regulations, Subdivision Regulations, Public Works Design Standards, and Chapter 50 of the City Ordinance
- Collect and review other available information, including the 2012 Southeast Watershed Alliance Stormwater Standards
- Provide recommendations for regulation updates to improve consistency, clarify the review process, and include revisions to best management practices requiring the usage of low impact development and green infrastructure for stormwater management
- Facilitate public outreach efforts
- Specific Outcomes Proposed in the Revised Stormwater Ordinance
- Low Impact Development (LID) site planning and design strategies will be required to the maximum extent practicable
- Unique regulatory standards will be created for projects that meet the definition of "redevelopment project" thus fostering responsible redevelopment while reducing regulatory burden
- Offsite mitigation will now be permissible when onsite mitigation is impractical
- The 50-year, 24-hour storm event will be required to be modeled, in addition to the 2-year, 10-year, and 25-year events, 24 hour events.
- Specific water quality standards will become part of the minimum design standards
- Stormwater systems will not be allowed in sensitive areas
- Stormwater standards will now be in a single regulatory location (Chapter 50 of the General Ordinance)



When Rochester saw the opportunity to update its stormwater rules, adopting Green Infrastructure techniques was a no-brainer. Soon, thanks to Green Infrastructure stormwater standards, Rochester will begin to see developments creating gardens, shallow ponds that drain quickly, and other vegetated areas instead of ponds and pipes. This will really be a win-win for all parties: the City will have cleaner and less stormwater to pay for and treat; developers will reap economic benefits in the means of less maintenance and greater flexibility to retrofit a built site, and residents/visitors will enjoy more attractive and welcoming developments. Green Infrastructure design should simply be called "good design".

*—Seth Creighton,
Staff Planner with
the City of Rochester*

CONCLUSION

The City of Rochester has been able to use funds and technical assistance provided through this project to simplify and advance stormwater management regulations in the city and include development and redevelopment requirements. This is an important step toward more effective stormwater management in the city.



PORTSMOUTH, NEW HAMPSHIRE: The Peirce Island Municipal Snow Dump

THE PROBLEM

The Peirce Island snow dump site in Portsmouth, NH covers approximately 0.54 acres and serves as the dumping location for snow removed from the urban core of the city.

This is a known high load contribution site or pollution “hot spot” and is a frozen monument to the brew of salt, trash, nutrients, oil and sediment that are deposited on urban city streets. Snow plowing activities collect, convey and concentrate these pollutants into a single large location.

THE PROJECT

The Peirce Island Snow Dump Project was developed to address this issue. The project’s objectives:

1. Research a Low Impact Development/ Green Infrastructure (LID/GI) solution to mitigate water quality impacts associated with snow removal
2. Quantify the pollutant load and future reductions associated with LID/GI implementation.
3. Recommend a design for a LID/GI system for this location.

UNHSC staff developed a sampling plan over the course of the 2013-2014 and 2014-2015 winter seasons to quantify the pollutant load potential from snow dump facilities. A series of grab samples were collected from December 2013 through April 2014 and January through April 2015 from the snow dump site. Grab samples were taken from snow that was recently delivered to the snow dump facility (i.e. new snow) and of the snow that had been stored for an extended period of time (i.e. old snow).

During each sample event the snow pile was measured to provide an estimation of the total volume of snow. The density of the snow pile was calculated using the snow



This high load contribution site is a frozen monument to the brew of salt, trash, nutrients, oil and sediment that are deposited on urban streets.



to water equivalency ratio (SWE), which is a percentage of the volume of water contained within the snow pile. This SWE ratio was then multiplied by the measured snow volume to generate the volume of water (gallons) tracked over two winter seasons (Figure 5).

To quantify this pollutant removal potential, an assessment of the annual pile volume, the total pollutant mass delivered to the snow dump area, the exported pollutant mass, and the pollutant removal potential by a properly designed GI system were quantified and modeled. The results of this assessment are shown in Table 2 and Figure 6.

In addition to standard practices associated with snow dump activities, it was proposed that an appropriately sized bioretention system could be installed to manage the exported mass from rain and melt events.

CONCLUSIONS

This study demonstrated that standard snow dump facilities by themselves remove a large mass of pollutants from the urban core. The process of collecting, trucking, and dumping snow into a dedicated location dramatically reduces pollutants otherwise exported to receiving waters by up to 87%. This practice itself should be considered a best management practice (BMP) for urban stormwater pollution.

These pollutant removal potentials can be increased even further, by up to 98%, through the design and installation of appropriately sized GI systems. (The lone exception is with respect to chloride loads, which may be an issue if discharging to freshwater areas.)

As a result of this project, a bioretention system has been designed for this location in Portsmouth. The total cost estimates for the materials and installation of the facility are between \$13,500 and \$17,400, and the City has committed to installing the system within the next two to three years.

PROJECT TOTALS	TSS	Zn	Cu	TN	TP	Cl
% RE Snow Dump Only	85%	80%	81%	81%	82%	24%
% RE Snow Dump w/ BMP	98%	97%	98%	92%	92%	24%
% Export Rate	15%	20%	19%	19%	18%	76%

% RE = Percent Removal Efficiency; BMP = Best Management Practice (Bioretention System in this example)

Table 2: Pollutant removal potential through standard operating snow removal practices and the addition of a properly sized bioretention system for managing runoff.

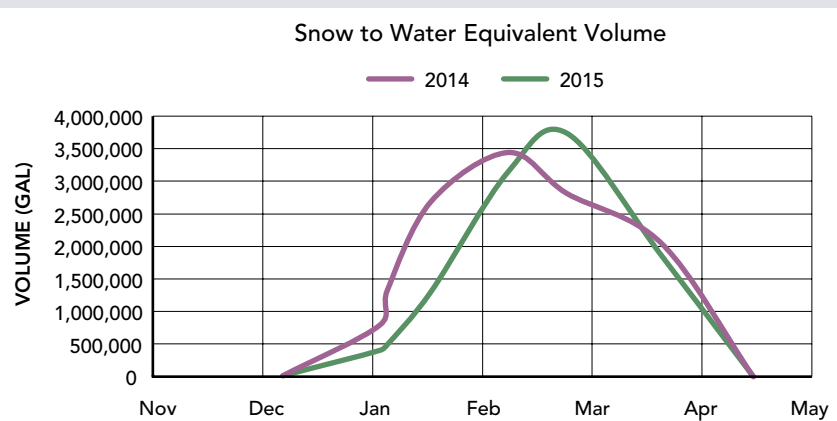


Figure 5: Snow Water Equivalent (SWE) in gallons during the winter sampling season 2014-2015.

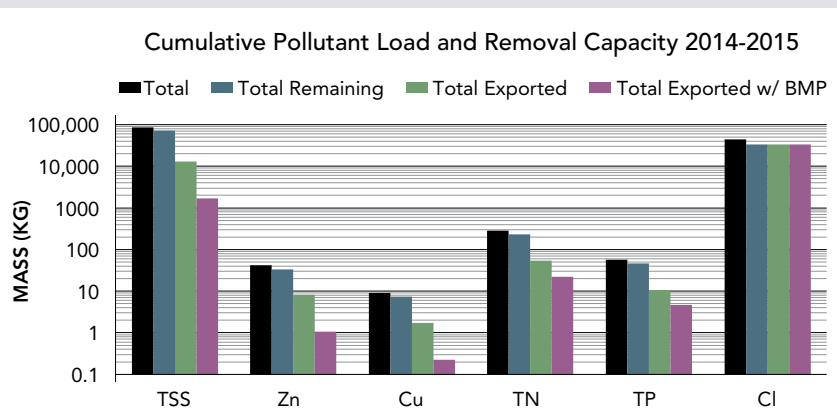


Figure 6: Snow dump pollutant load assessment comparing pollutant load deposited onsite (total), pollutant mass retained onsite (total remaining), pollutant load generally exported to the environment (total exported) and additional load reduction when export is through an innovative bioretention system (total export w/BMP).



DURHAM, NEW HAMPSHIRE: Design and Construction of a Stormwater Retrofit

The goal of this public infrastructure repair and improvement project was to disconnect the stormwater runoff generated from the neighborhood and reduce non-point source pollution on the Oyster River. The UNH Stormwater Center assisted by developing design plans and provided building oversight for the project. The Town of Durham and their selected contractors finalized the construction in the spring of 2015.



DURHAM'S COMMITMENT TO GREEN INFRASTRUCTURE

- 2010 Incorporated stormwater regulations with low impact development incentives in site plan review and subdivision regulations
- 2011 Partnered with the UNH Stormwater Center to retrofit a custom designed state-of-the-art nitrogen treatment bioretention structure in a busy downtown parking lot
- 2012 Town partnered with the Oyster River High School to design and construct a 1,000-square-foot rain garden to disconnect and treat stormwater runoff from 10,000 square feet of the school's main parking lot
- 2013 Adopted a new water ordinance, which includes protection of all the town's water resources from discharges of polluted stormwater runoff and illicit discharges

IDENTIFIED NEED

The Town of Durham's Department of Public Works recognized that a stormwater outfall in a residential neighborhood had fallen into serious disrepair and was discharging directly into the Oyster River. The existing drainage structure and outlet pipe were under capacity and severely degraded. The site contained a highly eroded trench that had undermined a 20' section of corrugated metal pipe that, according to the UNH Stormwater Center, was responsible for releasing approximately 30 dump truck loads of fine sediment per year into the river. The undercutting from the existing pipe resulted in massive erosion, slope instability, and water quality issues. Due to these factors, staff from the Durham Public Works Department submitted a grant application to evaluate the contributing drainage area and existing stormwater management infrastructure, design an engineered green solution, and install a control measure.

SPECIFIC RESULTS OF THIS PROJECT

- Stabilization of 50 feet of heavily eroded and entrenched gully discharging directly to the Oyster River
- Installation of a subsurface gravel wetland system at the outfall to slow flow and provide water quality treatment from 6 acres of untreated residential/and uses
- Employ a regenerative stormwater conveyance approach that will use the existing eroded gully as the excavation for the treatment area and will result in less than 750 square feet of temporary disturbance associated with an access for construction; no additional impervious area is proposed
- Overall improvement to the aesthetics of the site, which in its former condition had become a dumping ground for nutrient laden lawn and leaf debris from local yards



“This subsurface gravel wetland installation created an eventual win-win-win, where we reduced dissolved nutrient contributions from yard waste, prevented localized soil erosion, and improved water quality control of a 10-acre residential area discharging directly to the Oyster River.”

*—Jamie Houle
Program Manager,
UNH Stormwater Center*

OUTREACH AND ASSESSMENT METHODS AND RESULTS

The Green Infrastructure for New Hampshire Coastal Watershed proposal defined its Collaborative Science element as:

1. Developing a collaboration between municipalities and the research community to understand the benefits of GI for creating resilient systems and cost effective policies
2. Increasing willingness to implement innovative stormwater management through building trust between the selected community representatives and the project team, ensuring the relevance of these methods to community priorities
3. Delivering needed and relevant technical support.

The Collaborative Science Team applied multiple methods to guide the project, engage stakeholders, build capacity for implementation, and obtain feedback on the effectiveness of these methods. These methods included:

- Collaboration between Regional Planning Commissions
- Formation of an Advisory Board
- Scoring criteria for implementation grant applications
- Creation of outreach materials (website, fact sheet series, case studies and presentations)
- Delivery of watershed-based workshops
- Delivery of a final site implementation tour and Advisory Board meeting
- Project Team, Advisory Board and stakeholder surveys

Advisory Board

An Advisory Board was developed to serve in a collaborative leadership role with the Project Team. Invitations to AB participants went out to the 42 municipalities and seven Rivers Advisory Committees (Salmon Falls/Piscataqua, Cocheco, Isinglass, Oyster/Bellamy, Lamprey, Exeter/Squamscott, and Winnicut) governing watershed wide decisions in the region. A final body participated in over eight meetings at key times throughout the project period; it was comprised of 17 members representing diverse interests across the coastal watershed, including 12 municipalities, one non-governmental organization, one regional planning commission, two watershed groups, and one New Hampshire state agency.



The AB served as a key link between project activities and local communities and other collaborative stakeholders. The role of the Advisory Board was to ensure:

- Each phase of the project was responsive to the concerns and priorities of local governments
- All discussions included a diverse and thorough representation of local community members
- Priority issues relating to stormwater management, water quality and water resource management were identified
- Opportunities for community-community mentoring and peer-to-peer learning were implemented
- An ongoing evaluation process of project goals and objectives would take place

Watershed-Based Workshops

Focused Sub-watershed Methods Workshops were also held in each of the four coastal sub-watershed areas where river advisory committees or watershed associations existed. Workshops were held to introduce GI concepts in more detail and get watershed specific feedback on requested tools and information. AB membership was critical to the development and implementation of the workshop series for the project.

LAMPREY RIVER WATERSHED

The Lamprey River Watershed Green Infrastructure Workshop was held on May 13, 2014 with presentations about water quality and water resource management, the SWA model stormwater standards, and a case study from the Town of Newfields about their adoption of the SWA Model Standards.

HAMPTON-SEABROOK ESTUARY

The Hampton-Seabrook Estuary Green Infrastructure Workshop was held on May 14 and 17, 2014 with presentations about site design and installation of rain gardens. In addition, volunteers from Hampton and Hampton Falls installed a rain garden at the front entrance of the Lane Memorial Library in Hampton.

EXETER-SQUAMSCOTT RIVERS WATERSHED

The Exeter-Squamscott Rivers Watershed Green Infrastructure Workshop was held on May 27, 2014 with presentations about the functions and benefits of green infrastructure, strategies for complying with federal and state stormwater permits, and municipal implementation.

WINNICUT RIVER WATERSHED

The Winnicut River Watershed Green Infrastructure Workshop was held on November 13, 2014 with presentations about the functions and benefits of green infrastructure, strategies for complying with federal and state stormwater permits, and municipal implementation.

WORKSHOP SURVEY RESULTS

Participants of the workshop series (N=21) completed a survey to assess the effectiveness of their workshop. Results indicate that the majority of participants found the scientific and technical information “useful and relevant.” Overall, they expressed that their understanding and awareness of green infrastructure as a stormwater management tool “somewhat” increased as a result of the evening workshop. Participants reported the most useful aspects of the workshops were:

- Specific examples of where and how green infrastructure was implemented successfully
- Networking with stormwater professionals and municipal representatives
- Adaptation/use of the Southeast Watershed Alliance model stormwater standards



Rain garden installation at the Lane Memorial Library in Hampton, NH.

Participants of the workshop series completed a survey to assess the effectiveness of their workshop. Results indicate that the majority of participants found the scientific and technical information “useful and relevant.”

Outreach Materials

WEBSITE

The Green Infrastructure for NH Coastal Watershed Communities website (www.unh.edu/unhsc/green-infrastructure-sustainable-coastal-communities) serves as the primary information hub for the project. The site contains links to sources for information on stormwater, non-point source pollution and low impact development, in addition to archived project materials and the outreach materials listed below.

FACT SHEETS (See Appendix A)

Project team members, student interns and a professional designer contributed to production of the GI Fact Sheet Series, which includes:

- A Community Approach to Green Infrastructure
- The Legal Basis in New Hampshire: Adopting Stormwater Zoning Ordinances and Land Use Regulations
- The Up Side of Implementing Green Infrastructure and Low Impact Development Practices
- Overcoming Barrier to Green Infrastructure
- Using Green Infrastructure and Low Impact Development to Address Impacts of Climate Change
- Minimizing Environmental Impacts Through Stormwater Ordinance and Site Plan Regulation



CASE STUDIES (See Appendix B)

Implementation case studies were prepared for five projects:

1. Brentwood, NH: Town Owned Lands Improvement Project
2. Durham, NH: Oyster River Road and Garden Lane GI System Project
3. Exeter, NH: Brickyard Pond Community Project
4. Rochester, NH: Stormwater Management Standards Update
5. Portsmouth, NH: Pierce Island Snow Dump Project

Each case study documents project goals, outcomes, partners, installation and benefits to the community.



POWERPOINT PRESENTATIONS

Powerpoint presentations were created for the customized watershed-based workshop series and presentations by various project team members at conferences and professional meetings about the Green Infrastructure for NH Coastal Watershed Communities project.

Survey Results

An end of project survey was conducted following the Site Implementation Tour and Wrap-up Discussion held on June 4, 2015. In addition, prior information was solicited from Advisory Board members at the end of their final meeting in spring. Ten individuals completed the end of project survey that excluded project leadership team members. These individuals, through their self identified primary or secondary affiliations, represented all target groups of the project (Figure 7).

Although the sample (N=10) was small, there was an excellent diversity of participants that were well informed and involved in the project. The results indicate that the participants believe that all seven goals were somewhat or fully achieved. The successful outcomes of the pilot sites and the effectiveness of resources and support provided by the Project Team were rated as the highest. The results to other survey questions clearly indicate that as a result of this project, trust of scientific information by the participants was significantly increased (Figure 8).

Results indicate that the overall project and specific project outcomes were managed effectively. It is clear that stakeholders had fair and equitable representation and that their input had dramatic and lasting impact on how the project was managed. Results associated with the institutionalization of GI strategies in future shift toward the less decisive. This shift is troubling in that these long term changes in the culture of GI implementation were primary objectives in the project.

- The survey was designed to solicit feedback on the following key questions:
1. How successful or useful were the outcomes (including the pilot site demonstration projects)?
 2. How effective were resources and support provided?
 3. How equitable and fair was stakeholder representation and the overall project process?
 4. Was a shared vision developed?
 5. Were mechanisms for collaboration between stakeholder groups established that will continue after the project?
 6. Is there willingness among local officials and other stakeholders to participate in future collaborative climate change adaptation planning projects?
 7. Are there tangible next steps being pursued on additional green infrastructure implementation?

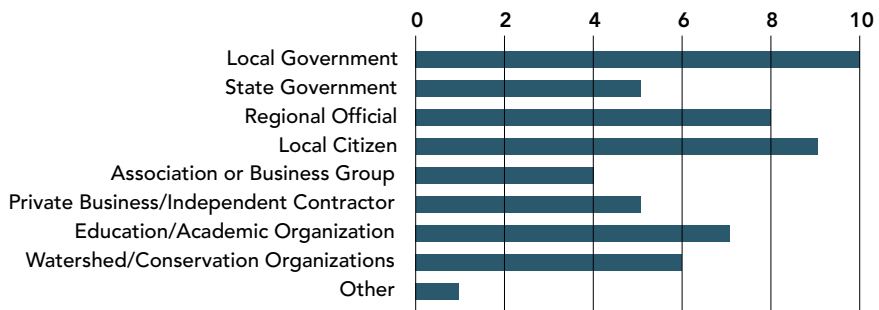


Figure 7. Affiliation of final survey respondents.

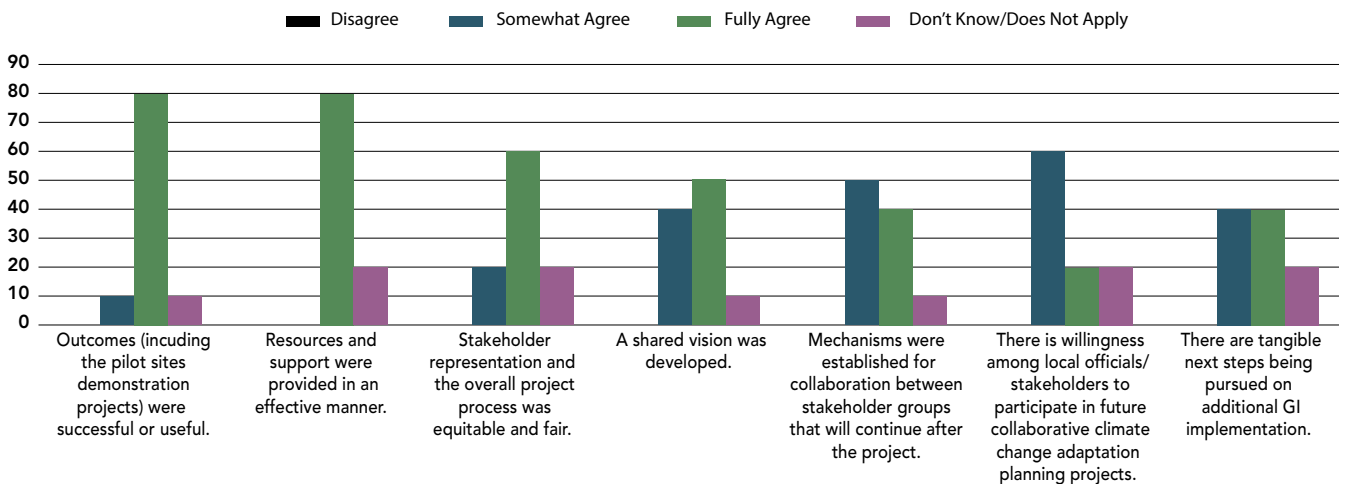


Figure 8. End-of-project survey results with respect to the project's seven key goals.

STRATEGIC IMPLEMENTATION AND EFFECTIVENESS

Rapid Assessment Methods for Audience Segmentation to Enhance Diffusion of Innovative Water Resource Management Strategies

Just because scientific research develops innovative solutions to current problems doesn't mean that they get used by populations that need them. Diffusion theories consider the readiness and willingness of populations to adopt new solutions.

Diffusion of innovation theory assumes that in response to any disruptive technological advancement, potential end-users self-aggregate into one of five distinct categories of adopters.

Watershed Municipality Rankings

LONG-TERM EXTENSION STRATEGIES

The transfer of GI implementation concepts is more difficult than it might appear. In the past, GI implementation concepts have been developed independently, followed by a search for willing municipal partners. The UNH Stormwater Center has a long and successful track record of implementation in this manner, yet there has been no true success where, as a result, GI has been adopted as a management directive.

As researchers, we tend to focus heavily on the technology and less on the social context in which the innovations are applied. However, the stages of adoption can be used to develop a contextual road map to direct outreach and communication campaigns that specifically target and market to end user needs. Some communities are going to be ready to move forward, whereas others will follow later. In this respect, adopter categories could be viewed generically to identify how ready communities are to receive a given message. This is a slight but powerful shift in strategy and invests trust in the fact that adoption of GI strategies are going to be largely directed by interpersonal communication between peers as opposed to those directed by academic or planning professionals (see Figure 9).

The persuasive power of outreach campaigns built around simple presentation of scientific evidence of an innovation's effectiveness is likely limited. More influence is exerted by peer-to-peer communication pathways. The implication is that change agents wishing to move

ADOPTER CHARACTERISTICS

Innovators (2.5%):

The visionaries and champions. You know who they are because they attend all your workshops.

Early Adopters (13.5%):

A critical target audience, early adopters are not looking to be persuaded. Instead, they are looking to see whether the product is flexible and workable.

Early Majority (34%):

Typical pragmatists, early majorities are always harder to convince, more sensitive to economics and costs, and tend to be more risk averse

Late Majority (34%):

Late majorities are risk averse and generally do not like change. They are also almost entirely influenced by their peers as opposed to anything scientific.

Laggards (16%):

Holdouts averse to change; they seek contrary science to support their opposition.

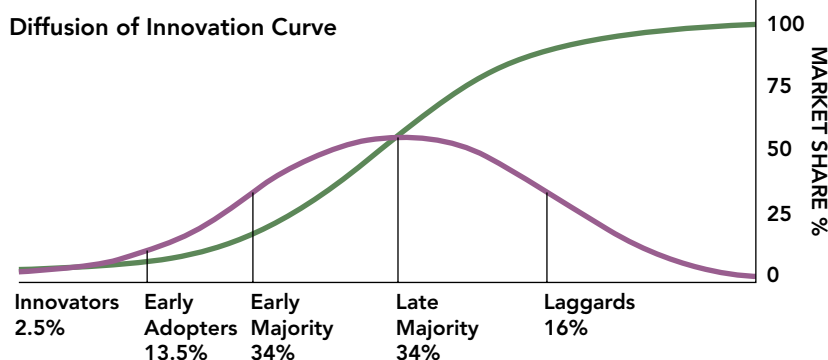
innovations forward within different communities should strategically focus efforts on working with municipalities that are ready and able to act (early majorities). Once established, these early majorities that hold status within peer networks will drive change forward.

In this project, there was much discussion about how best to develop projects and choose the communities with whom to work. The result was the innovative plan that municipalities would bring their project ideas to the team instead of the other way around. The project team then worked with the community to refine and advance implementation efforts. This meant that the project team provided technical assistance – and more importantly funding – to address issues of local concern. This resulted in a tremendous opportunity to really collaborate with practitioners in the field. A positive bi-product of this approach was that due to the community investment in the project, much of the motivation to complete it – and promote new GI concepts – was transferred from the project team to the community partners.

However, this approach was not without its difficulties. In some cases communities wanted to work with partners outside the project team with whom they had a history of success and a level of trust. This raised the cost of some implementation efforts, as well as opening the project to different designs and approaches that were not always consistent with the latest science. In other cases, communities worked very hard to maintain control of the implementation process and preserve their right to come up with potentially different solutions than experts on the project team might have advocated.

These detours within the initial approach were viewed by the project team as learning opportunities. These are the human dimensions that represent the next phase of implementation barriers. New barriers present themselves when a technology, in this case GI, progresses from demonstration project to mainstream. The use of diffusion of innovation theory can help identify partners that are in an economic position to advance innovations, trust the science and can accept the inherent risks that comes with any change in approach.

Diffusion of Innovation Curve



Diffusion Model in Marketing

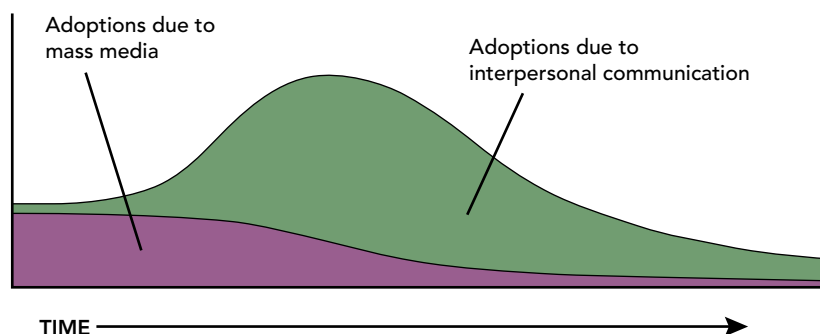


Figure 9: Diffusion Theory at a Glance. Top: The diffusion of innovation curve. Successive adoption trends (shown in purple), alongside cumulative market share (green). Bottom: Diffusion model in marketing (adapted from Mahajan, et al.) representing the impact of peer to peer communication in the DoI process.

The persuasive power of outreach campaigns built around simple presentation of scientific evidence of an innovation's effectiveness is likely limited. More influence is exerted by peer-to-peer communication pathways.

RESULTS AND DISCUSSION

The goal of this project was to build capacity in coastal communities to integrate and implement green infrastructure for improved stormwater management.

Urbanization radically alters hydrology, with impacts from very local to regional scales. Green Infrastructure techniques use natural processes to restore hydrologic function and provide multiple companion benefits such as energy savings, increased green space and improved ecosystems.

Although science can clearly demonstrate the benefits and cost savings associated with Green Infrastructure, many community decision makers continue to be reluctant to incorporate these methods into standard planning practices. In spite of the wealth of evidence, communities are very slow to codify and adopt the practices, commonly waiting for regulatory or legal directives to force them down the path.

Barriers to implementation include misconceptions of performance, reliability and cost. For Green Infrastructure to be effective, implementation must become a standard practice, rather than something new. This requires input from local officials implementing these practices on a daily basis and moving GI from an innovation to the mainstream. The methods and concepts related to GI implementation must be integrated into the planning DNA of municipal operations. Fundamentally, successful GI implementation comes down to changing behavior, perceptions, and priorities, and fostering trust in the science.

The overarching goal of this project was to facilitate this process. In the end we learned more about the long process of behavior change than we accomplished getting GI implementation into the mainstream.

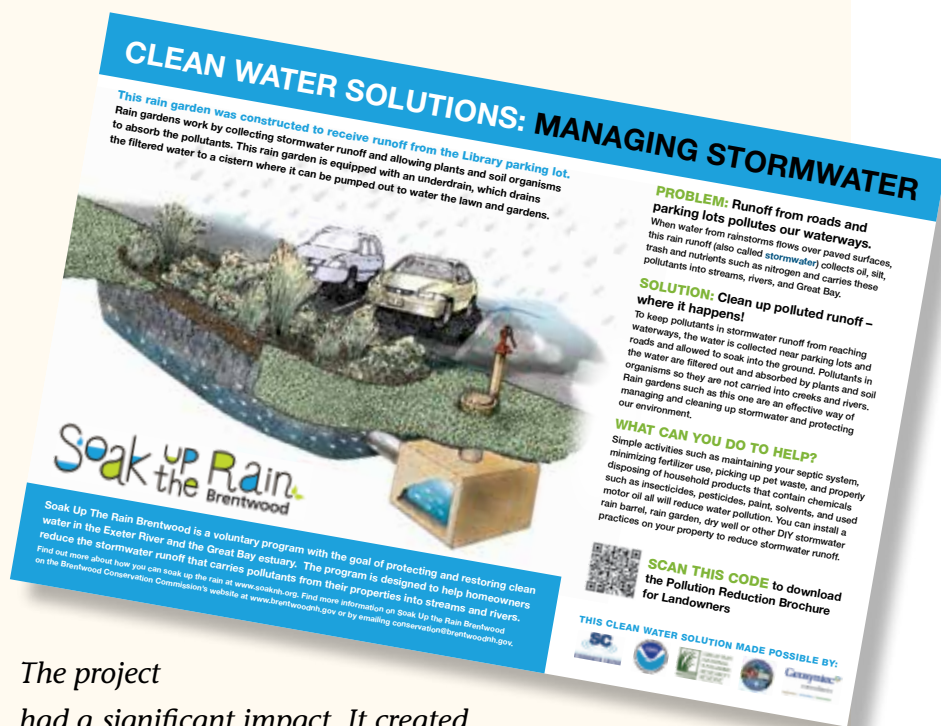


However, the outcomes and lessons learned have been quite valuable. Stormwater management is a young science – it's only in the last ten years that stormwater has become a familiar term, along with the growing awareness of its associated issues. This far exceeds the natural tenure of many of the public officials that must directly confront municipal management issues. Stormwater management in general is an innovative experiment and there is a wide range in its methods of implementation across the country.

Our project begins to illustrate the fact that we all struggle with very similar hurdles with respect to implementation. In essence this project was aimed at turning the page on stormwater management as simply a pilot or demonstration project and exploring the territory of what it might take to push advanced strategies into the forefront of the day-to-day management decisions. Ultimately this project was a venture into uncharted territory, a complicated and multidimensional progression toward a linear goal where there's been a lot of learning and more questions than answers.

This is all part of a long-term commitment to more resilient communities. Resilience takes time. We are used to planning for what is right in front of us, but not what may be five or ten years in the future. In the wake of extreme weather events and increased

pollution from impervious surfaces that have been causing many problems over the past several years, we can at least respond that we are planning for the future when asked the question: Are we prepared for the next storm?



The project had a significant impact. It created a real awareness of the water quality issues facing Great Bay throughout the community including the Selectboard, Planning Board and residents. The installation at the Mary E. Bartlett Library will be a permanent reminder and the interpretive sign will be something residents see as they visit the library. The knowledge and impact from this project lead to the strong support for the follow-on project to do installations at three other town facilities. The Pollutant Load map was very enlightening and we need to incorporate that into the planning process. I know that the Planning Board is now much more aware of issues and have already seen them incorporate the discussion of LID systems into a review for a variance. Overall, it was a fantastic project that will have a lasting impact on the community and is helping Brentwood be proactive in doing its share towards improving water quality in Great Bay.”

—Rob Wofchuck

Chair of Conservation Commission, Brentwood, NH

PROJECT REPORT

Green Infrastructure for Sustainable Coastal Communities

APPENDIX A: FACT SHEETS



A PROJECT FUNDED BY THE NATIONAL ESTUARINE RESEARCH RESERVE SYSTEM SCIENCE COLLABORATIVE TO A PROJECT TEAM LED BY THE UNIVERSITY OF NEW HAMPSHIRE STORMWATER CENTER AND THE GREAT BAY NATIONAL ESTUARINE RESEARCH RESERVE IN SUPPORT OF GREEN INFRASTRUCTURE IMPLEMENTATION WITH LOCAL MUNICIPAL, NON-PROFIT AND PRIVATE SECTOR PARTNERS.



Using Green Infrastructure and Low Impact Development to Address Impacts of Climate Change



Advantages of Incorporating Climate Change Projections into the Design of Stormwater Management (SWM) Systems

Stormwater infrastructure designs are based traditionally on rainfall, land use and sea level data modeled after historical trends and conditions.

Infrastructure decisions and investments should consider future conditions in order to remain functional and able to respond to more frequent severe weather events. These decisions should promote design and management capacities that will improve community resilience—the ability of natural systems and physical structures to recover quickly from changes in environmental conditions by accommodating future temperature, rainfall and drought projections and the effects of land development.

IMPROVING DESIGN AND PERFORMANCE OF SWM SYSTEMS

Climate change is expected to affect traditional stormwater management system design calculations by:

- increasing rainfall intensity and frequency;
- raising moisture levels in soils; and
- increasing the average amount of water contained in storage ponds.

New or retrofitted SWM systems need to account for the anticipated intensity of future rainfall events, which could affect system design, lifecycle, performance, and timing of upgrades.

Traditional stormwater models may need to be updated to get a better picture of SWM system performance under future climate conditions. These components may include: changes in mean temperature; changes in mean rainfall (which affects soil moisture saturation); increases in total rainfall for storm events; and increases in wind.



ENHANCING THE RESILIENCY OF SWM SYSTEMS

Poorly managed stormwater runoff can lead to:

- higher mobility and transport of pollutants into surface and ground water;
- increased erosion potential, causing loss of property, aquatic habitat and organism passage, and damage to infrastructure; and
- increases in nutrients, leading to algae blooms, reduced dissolved oxygen levels, and the possible loss of sensitive aquatic species.

Climate projections can be incorporated into measures to improve water supplies, sanitation services, drainage systems, building codes, and flood-proofing of infrastructure.

PROTECTING HUMAN HEALTH

Direct health and safety impacts may include injury and disease from flooding, and contamination of drinking water. Standing water caused by floods and higher temperatures dramatically increase the risk of diseases transmitted by food, air, water, insects, and ticks. Resource-intensive disaster response and recovery efforts will be constrained by diminishing local, state and federal budgets.

REDUCING COSTS BY REDUCING IMPACTS

NH's most densely-populated and developed areas occur along or in river floodplains, making riverine flooding the most common and costly disaster event in NH. Continued damage to infrastructure represents a serious drain on the economy. Better predictions of changing climate may lessen the need to repair and replace stormwater infrastructure. Expanding protection for and use of natural stormwater management assets, like wetlands and forests, will further reduce these costs.

Local officials can use climate projections to estimate long-term operation, maintenance, and investments in stormwater conveyance and drainage networks that can withstand changing conditions.



HELPING COMMUNITY LEADERS MAKE DECISIONS UNDER CONDITIONS OF UNCERTAINTY

It is challenging to pinpoint exactly when and where climate impacts will occur, but there is sufficient evidence that climate adaptation can no longer be responsibly postponed until all uncertainty is eliminated. Proactive and cost-effective methods can be identified to address lingering uncertainty and provide local leaders with support for implementing infrastructure adaptation programs.

Municipalities can begin directing funds toward protecting infrastructure prior to flooding impacts by incorporating climate projections into their planning decisions. Assessing community risks and identifying specific assets that might be vulnerable will help local officials prepare a range of appropriate responses prior to impact.

Applying climate projections in stormwater planning ensures that the future safety of communities is considered. Climate data can be used to identify areas that can sustain future economic development and population growth.

PROTECTING WATER QUALITY AND QUANTITY

Increased rainfall predicted for the northeast U.S. will alter the region's hydrology, which is deemed to be a primary cause of water quality degradation. Communities may need to reassess the capacity of their reservoirs to withstand longer periods of drought. This can impact drinking water supplies and agricultural networks to support specific crops due to decreased water tables.

Benefits of Using Green Infrastructure and Low Impact Development to Adapt to Climate Change

Compared with conventional SWM systems, Green Infrastructure (GI) and Low Impact Development (LID) are easily adapted to most sites and environmentally friendly.

These approaches can:

- add water storage to the built landscape,
- provide open space allowing stormwater to naturally infiltrate soils,
- contribute to social and ecological resiliency,
- reduce the amount of polluted runoff reaching surface and ground waters,
- use to retrofit existing development,
- help maintain natural stream channel functions and habitat.

GI and LID minimize impervious surfaces and use natural landscape features to create functional and appealing drainage features that allow rain water and snow melt to soak into the ground.

Broad use of LID across a watershed can:

- reduce the urban heat island effect (by shading and minimizing impervious surfaces),
- address impacts from climate change by allowing plants to capture carbon dioxide,
- reduce energy use by installing green roofs and trees, and avoided water treatment,
- reduce air pollution by avoiding power plant emissions and reducing ground-level ozone,
- combat drought by increasing groundwater recharge.



This project is funded by the
**National Estuarine Research Reserve
Science Collaborative**
and the
**National Oceanic and Atmospheric
Administration (NOAA)**



The Legal Basis in New Hampshire: Adopting Stormwater Zoning Ordinances and Land Development Regulations

FEDERAL LAW

CLEAN WATER ACT

The Clean Water Act (CWA) originated as the Federal Water Pollution Control Act of 1972 in response to unchecked dumping of pollution into the nation's surface waters. At that time, about $\frac{2}{3}$ of U.S. waters had been declared unsafe for fishing and swimming. The CWA provides the basic structure for:

- 1) regulating discharges of pollution into the waters of the United States, and
- 2) regulating quality standards for the nation's surface waters. Its objective is "to restore and maintain the chemical, physical, and biological integrity of the nation's waters."

The U.S. Environmental Protection Agency (EPA) administers the CWA and enforces its provisions. The EPA is authorized to implement water pollution control programs, like setting water quality standards for all surface waters (streams, lakes and coastal waters).

NATIONAL POLLUTANT DISCHARGE ELIMINATION SYSTEM (NPDES)

The CWA made it illegal to discharge any pollutant from a point source into navigable waters without an NPDES permit. The NPDES Storm Water Program addresses non-agricultural sources of stormwater discharges. The program's permitting mechanism requires dischargers to implement control measures that prevent pollution from being washed into surface waters by stormwater runoff. Control measures, like stormwater management programs, must use best management practices. The NPDES gives permitting authorities guidance on meeting stormwater pollution control goals as cost-effectively as possible. The CWA also requires NPDES permits to be consistent with applicable state water quality standards.

NPDES AND EPA

Through the Phase 1 and Phase 2 NPDES programs EPA sets water quality standards for point source and wastewater discharge permits. EPA administers NH's NPDES permit program and permits for stormwater and sewer overflow discharges. Individual homes that are connected to a municipal system, use a septic system, or do not produce surface discharge do not need an NPDES permit. Industrial, municipal, and other facilities must obtain permits if their discharges go directly to surface waters.

NPDES STORMWATER PERMIT TYPES

The NPDES permit regulations cover 3 main classes of stormwater and wastewater discharges.

Municipal Separate Storm Sewer Systems (MS4s) Permits

EPA administers its Stormwater Program in two phases. Generally, under Phase I of the program, EPA issues NPDES permits for:

- A) "medium MS4s" and "large MS4s"
- B) certain construction activities; and
- C) multiple categories of industrial activity.

Phase II extends coverage of the program nationwide to:

- 1) automatically include "small MS4s" in urbanized areas; and
- 2) include on a case-by-case basis small MS4s outside of EPA-designated urbanized areas.

MS4 permits are generally required for small, medium and large MS4s in urbanized areas. Any MS4 permit may include additional EPA requirements for pollution control. MS4 permits may be issued for a specific storm sewer system or an entire jurisdiction. MS4 permits prohibit non-stormwater discharges into storm sewers and require implementation of pollution reduction controls to the "maximum extent practicable" (MEP) using best management practices (BMPs).

The lack of a precise definition of MEP allows small MS4s flexibility in tailoring their programs to their actual needs.

The MEP standard requires small MS4s to satisfy the following six "minimum control measures":

- 1) Public Education and Outreach
- 2) Public Participation
- 3) Illicit Discharge Detection and Elimination (IDDE) Program
- 4) Construction Site Runoff Controls
- 5) Post-Construction Runoff Controls
- 6) Good House Keeping and Pollution Prevention for Municipal Operations

Construction Activities Permits

All construction activities 1 acre or larger must obtain a permit, and those less than 1 acre must obtain a permit if they are part of a larger common development plan or sale that totals at least 1 acre. Small construction activities (less than 5 acres) may qualify for a waiver. In NH, where EPA is the permitting authority, operators must meet EPA's Construction General Permit requirements.

Industrial Activities Permits

Industrial facilities (as defined by the facility's Standard Industrial Classification code) that discharge to an MS4 or to waters of the U.S. must obtain a permit. Operators (excepting construction) may qualify for a waiver by certifying to a condition of "no exposure" if their industrial materials and operations are not exposed to stormwater. NH operators must meet the requirements of EPA's Multi-Sector General Permit.

OTHER FEDERAL LAWS THAT MAY AFFECT NPDES PERMITS

Four federal acts apply to the EPA's issuance of an NPDES permit to an MS4: the Endangered Species Act, the National Historic Preservation Act, the Magnuson-Stevens Fishery Conservation and Management Act, and the Coastal Zone Management Act.

STATE LAW

Although many larger sites are subject to NH's Alteration of Terrain permit requirements and the EPA's stormwater management requirements under the CWA, local zoning ordinances and land development regulations provide municipalities the authority to act independently to address local problems and issues relating to water quality impacts and water resource management on a case-by-case basis. Often federal and state regulations apply to only the largest development projects and lack the oversight and enforcement for which municipalities are ultimately responsible.

NH statutes provide the authority and legal mechanisms for municipalities to enforce standards for land use, the environment, and protection of life and property.

GENERAL AUTHORITY AND ADMINISTRATION

RSA 149-I:1-25 Sewers, RSA 432:3 State Plan, RSA 483-B:8 Municipal Authority, RSA 485-A:13 Water Discharge Permits, RSA 674:20 Districts, RSA 674:21-a Development Restriction Enforceable

REGULATORY/PLANNING

RSA 483:10 Rivers Corridor Management Plans, RSA 485-A:17 Terrain Alteration, RSA 674:2 Master Plan Purpose and Description, RSA 674:3 Master Plan Preparation, RSA 674:17 Purposes of Zoning Ordinances, RSA 674:44 Site Plan Review Regulations, RSA 674:36 Subdivision Regulations, RSA 674:16 Grant of Power

ENVIRONMENTAL

RSA 483-B:9 Minimum Shoreland Protection Standards, RSA 674:21 Innovative Land Use Controls, RSA 674:55 Wetlands, RSA 674:57 FEMA Flood Insurance Rate Maps (and 44 C.F.R. 67.5), RSA 674:56(I) Flood Hazards: Fluvial Erosion Hazard Zoning, RSA 674:56(I) Flood Hazards: Floodplain Zoning

MUNICIPAL LAW

Vermont Law School Study: New Floodplain Maps for a Coastal New Hampshire Watershed and Questions of Legal Authority, Measures and Consequences

The Vermont Law School Study assessed the level of legal risk communities may face if they choose to adopt regulations and policies based on new floodplain maps that utilize projected future conditions. The study concluded that the level of risk of being successfully sued is very low, as long as the typical procedures and precautions are taken. The study may be found at <http://100yearfloods.org/resources>.

The following sections outline the questions addressed by the Vermont Law School Study pertaining to the legal basis for adopting municipal zoning ordinances and land development regulations.

MUNICIPAL LIABILITY

What is the potential liability of a governmental entity that fails to take steps to reduce the vulnerability of its landowners and other citizens to flooding risks and storm damage as revealed by UNH's research efforts and mapping information?

Answer: Municipalities are very unlikely to be held liable for actions related to adopting new floodplain maps.

Recommendations: At a minimum, always abide by the "reasonable person" standard – i.e., what a reasonable person would do under same circumstances. There is no need to take action related to municipal liability for failing to adopt floodplain maps. Acknowledge the unpredictability of future flood hazards in plans while emphasizing importance of taking action to protect the public despite uncertainty. Give the public meaningful opportunities to participate in the planning process.

LEGAL AUTHORITY

Do New Hampshire communities have the legal authority under state planning and zoning enabling legislation, or other state legislation, to design and implement regulatory controls based on current and predicted environmental conditions, specifically projected flooding levels?

Answer: Whether towns have the requisite enabling authority depends on the type of regulation being imposed; municipalities must clearly identify the enabling statute that allows the enactment of the ordinance or regulation.

Recommendations: Clearly identify the enabling statute(s) authorizing the ordinance/regulation. Check the language of the statute to make sure specific authorizations are not being exceeded. Show that your decision is reasonable by drawing from supporting data and documentation from trusted sources, like academic, state and federal reports and studies. When enacting new ordinances related to or referencing new floodplain maps, use the previous list of potential enabling statutes as a resource.

USE OF PROJECTED DATA AND MAPS AS EVIDENCE

What legal standard of scientific and technical reliability must planners and other officials meet in order to support regulatory measures that are based on current and projected future – as opposed to past – environmental conditions?

Answer: Scientific evidence is generally not needed to justify the enactment of ordinances or regulations.

Recommendations: To ensure the use of future climate conditions and related floodplain maps stands up in court, clearly identify and define in the ordinance the reason you are adopting or referencing the maps. Only use maps generated from reliable science. **Note:** Projected future conditions may include land conversion and impervious surface cover using a buildout analysis,

or projected changes in environmental parameters such as precipitation or sea level rise.

TAKINGS

What is the potential regulatory takings exposure of New Hampshire communities if they impose regulatory controls that are designed at least in part to address anticipated future environmental conditions?

Answer: Though most takings are determined on a case-by-case basis, it is unlikely that a municipality could be successfully sued on the basis of a taking suit for imposing regulatory controls intended to reduce the risk of harm from future flooding events. Courts are much more likely to hold that a "harm preventing" (versus "benefit-conferring") regulation does not constitute a compensable taking.

Recommendations: Enact regulations in a way that preserves some economically viable use of the land, such as for agricultural and recreational activities. Indicate that the purpose of the regulation is to promote hazard mitigation to protect the public health, safety and welfare, and make this clear in the master plan. Include a variance option to deal with requests on a case-by-case basis. Be sure that the potential harm of flooding to the community outweighs the regulatory restrictions. Use the principle of No Adverse Impact (NAI) as a standard when creating floodplain regulations (or to prevent harm to a body of water held in public trust). NAI is the principle that the action of one property owner may not adversely impact the flooding risk for other property owners. Stay consistent with the existing regulatory scheme to the extent possible; when the regulation aims to correct an unforeseen problem, existing landowners will have a much stronger argument for a taking.

REFERENCES

Vermont Law School Land Use Clinic. *New Floodplain Maps for a Coastal New Hampshire Watershed and Questions of Legal Authority, Measures and Consequences*. South Royalton, VT: National Sea Grant Law Center Grants Program, University of Mississippi, June 2012.

Southeast Watershed Alliance. *Model Stormwater Standards for Coastal Watershed Communities*. Exeter, NH: University of New Hampshire Stormwater Center and Rockingham Planning Commission, December 2012 draft.



This project is funded by the
**National Estuarine Research Reserve
Science Collaborative
and the
National Oceanic and Atmospheric
Administration (NOAA)**



Overcoming Barriers to Green Infrastructure

Green infrastructure is an approach to water resource management that incorporates vegetation, soils, and natural processes into the built environment to manage stormwater, mitigate the impacts of climate change, and maintain healthy and sustainable communities.

Green infrastructure's ability to capture, absorb, and filter stormwater before it flows into groundwater or surface waters has provided economic, social, and environmental benefits to numerous communities. Nonetheless, the approach is still relatively new and many still have questions.

As the benefits of green infrastructure have become more widely known, barriers still often block the adoption of green infrastructure approaches. These barriers can occur throughout the planning and development process, and can take many forms.

The barriers to green infrastructure typically fall into four main categories:

1. Technical and Physical Barriers
2. Legal and Regulatory Barriers
3. Financial Barriers
4. Community and Institutional Barriers

Many of the barriers in these categories are due to unfamiliarity with green infrastructure; however, there are strategies to overcome these barriers.

BARRIERS IN NH AND STRATEGIES USED TO OVERCOME THEM

In 2013, a working session was held with local decision makers to identify the existing barriers to the implementation of green infrastructure projects in New Hampshire. Participants included municipal staff, volunteer board members, and elected and appointed officials. In addition to identifying local barriers, participants also developed specific strategies and approaches to address them. What follows is an overview of the results of this working session.

Technical and Physical Barriers

Technical and physical barriers to green infrastructure at the local level include limited or no maintenance of existing infrastructure, unfamiliarity with green infrastructure, little or no trust in the science and technology behind it, and a lack of understanding how green infrastructure is relevant to local stormwater issues.



Some of the specific technical and physical barriers include:

- The practice is new, not widely understood, and unproven,
- The limited ability of local DPWs to maintain existing infrastructure
- Existing maintenance and capital improvement priorities.

Many of the technical and physical barriers at the local level are the result of limited outreach and education, limited resources, competing interests, and a lack of confidence in local government.

To overcome these barriers, local governments and municipalities need to:

- Develop training programs for staff
- Increase training opportunities for staff
- Improve documentation of maintenance activities.



Legal and Regulatory Barriers

Legal and regulatory barriers at the local level include resistance to new rules and regulations, perceived adverse impacts to property owners, and an inability to understand its importance.

Some of the specific legal and regulatory barriers include:

- overly prescriptive, inflexible, and conflicting rules,
- complications associated with property rights, and
- lack of a clear regulatory framework.

The acceptance and implementation of green infrastructure projects is dependent on the leadership, knowledge, and support by local officials.

To overcome the legal and regulatory barriers, local governments and municipalities need to:

- ensure and maintain local control rather than allow state and federal agencies to mandate standards,
- ensure that property rights are not adversely impacted, and
- make available cost benefit analyses showing the cost effectiveness of green infrastructure and its positive impacts on the local economy.

Financial Barriers

Currently, most local governments and municipalities are experiencing a time of fiscal constraint where limited resources and funds are available for infrastructure projects. Therefore, in order to implement green infrastructure projects local governments and municipalities must find innovative ways to fund these projects. Even without current fiscal constraints, a number of financial barriers remain.

Some financial barriers include:

- a perception that the community cannot afford green infrastructure investments,
- a low priority for green infrastructure projects compared to other infrastructure projects, and
- the perception that green infrastructure may be an unfunded mandate from state and federal governments.

Green infrastructure can be less costly over its operational life span and has the ability to meet multiple development and stormwater management objectives. Therefore, it can be an efficient and cost effective alternative compared to conventional stormwater infrastructure.

In order to overcome perceived financial barriers:

- local governments are encouraged to share with the public the multiple benefits and avoided costs associated with green infrastructure
- local officials need to consider providing incentives that encourage the use of green infrastructure over conventional infrastructure.

Community and Institutional Barriers

Community and institutional barriers at the local level are a considerable constraint to green infrastructure projects. The characteristics and values of a community significantly influence a community's acceptance of green infrastructure and may represent critical barriers to its implementation. These barriers include public knowledge and perception, landowner preferences, development plans, resistance to change, and a lack of political commitment and leadership.

Barriers in this category include:

- insufficient and inaccessible information about green infrastructure and its benefits for political leaders, administrators, agency staff, developers, builders, landscapers, and others, including the public,
- a lack of integration of green infrastructure in local rules and regulations,
- a lack of understanding concerning the interconnectedness of our water resources, and
- resistance by developers to integrate and use green infrastructure.

Overcoming these barriers will require local governments to:

- generate public understanding and potential support,
- conduct education and outreach, and
- ensure broad stakeholder participation.

This can be most easily achieved if local government leaders gain a better understanding about opportunities, funding, benefits, and avoided costs associated with green infrastructure.

For more information about Green Infrastructure for NH Coastal Watershed Communities and the Green Infrastructure approach, please visit the following resources:



STORMWATER FOR COASTAL COMMUNITIES
southeastwatershedalliance.org/wordpress

UNH STORMWATER CENTER
www.unh.edu/unhsc

WATER: POLLUTION PREVENTION AND CONTROL
water.epa.gov/polwaste

HOW CAN I OVERCOME BARRIERS TO GREEN INFRASTRUCTURE?
water.epa.gov/infrastructure/greeninfrastructure/gi_barrier.cfm

NERRS SCIENCE COLLABORATIVE
www.nerrs.noaa.gov/ScienceCollaborative.aspx





Minimizing Environmental Impacts Through Stormwater Ordinance and Site Plan Regulation

Environmental and Financial Benefits of Adopting Local Stormwater Regulations to Reduce Pollutant Loads Associated with Future Development

The Seacoast Region and the larger Great Bay watershed represents one of the fastest developing regions in the state. Stormwater runoff from impervious surfaces has been shown to be one of the leading causes for declining water quality and increased flooding in our region's water resources. The Great Bay Estuary, a critical ecological and economic resource in the NH Coastal Region is listed as impaired due to declining water quality conditions resulting from increased pollutant loads largely contributed from non-point sources. As future development continues to unfold, pollutant loads from development activity are only going to increase.

In 2012, the Southeast Watershed Alliance (SWA) commissioned the UNH Stormwater Center and the Rockingham Planning Commission to develop model stormwater standards that communities could adopt in zoning or land development regulations to help minimize the environmental impacts of increased stormwater runoff from new and redevelopment activity.

SWA MODEL STORMWATER STANDARDS

Core Elements:

- Promote LID Planning and "Green Infrastructure"
- Enable groundwater recharge and volume control
- Address existing impervious cover through redevelopment requirements
- Require operations and maintenance

PILOT TEST CASE

Using the Oyster River watershed as a pilot test case, this study evaluated the financial and ecological benefits of adopting the enhanced model stormwater standards to reduce future pollutant loads resulting from expansion of impervious area in the watershed over the next 30 years. The standards would apply to new development and redevelopment projects subject to site plan and/or subdivision review by the Planning Board. This includes most, if not all, commercial or mixed use development projects and residential multi-family or subdivision projects.

FUTURE COMMERCIAL IC AREA

One of the most important aspects of the model regulation is the adoption of the actual trigger threshold which would require a new development or redevelopment to comply with the regulatory standards. Often this decision is made by comparing the state program trigger (100,000 sf of disturbance) to the proposed town standard. The model advocates adoption of a 5,000 sf trigger condition. This aspect of the regulation has a substantial effect on the future water quality and pollutant load reduction potential and should be carefully considered.

For context the statistical analysis of existing impervious cover (IC) for commercial parcels in Durham is shown in [Table 1](#).

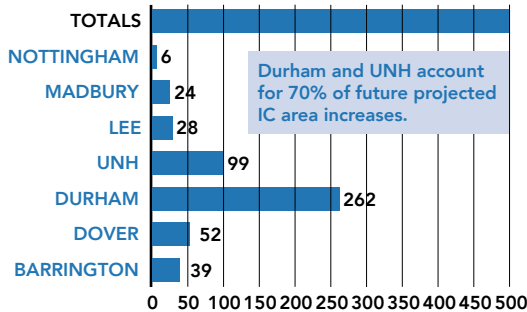
TABLE 1: Statistics for existing commercial developments in Durham that would be subject to regulation.

TRIGGER THRESHOLD	PERCENT REGULATED
5,000 sf	80%
10,000 sf	60%
20,000 sf	50%
40,000 sf	30%

PROJECTED FUTURE IC AREA BY 2040

Another important component of the study was the watershed-based approach as opposed to simply analyzing changes in a particular town or city. Since most towns contribute to multiple watersheds – as is the case with Barrington, Dover and Nottingham – only a portion of the land area of those municipalities contributes to the overall watershed load. In the Oyster River watershed, another 500 acres of IC area is estimated to be added over the next 30 years due to future residential and commercial development activity ([Figure 1](#)).

FIGURE 1: Projected increase in IC Area (acres).



This represents a 40 percent increase over existing conditions. With no local stormwater regulations in place, by 2040 this new IC area would increase the average annual Total Suspended Sediment (TSS) load by approximately 217,700 pounds (~109 tons), as well as add 1,060 pounds of Total Phosphorus (TP), and 9,950 pounds of Total Nitrogen (TN). With enhanced stormwater treatment in place as a result of local stormwater standards, the predicted average annual pollutant loads would be approximately 40 to 70 percent lower, eliminating 147,150 pounds (~74 tons) of TSS, 450 pounds of TP and 4,900 pounds of TN that would otherwise be discharged to the Oyster River and the Great Bay Estuary. For nitrogen alone, more than half of the predicted future annual load attributed to new IC area could be reduced by providing enhanced stormwater treatment. (Figure 2).

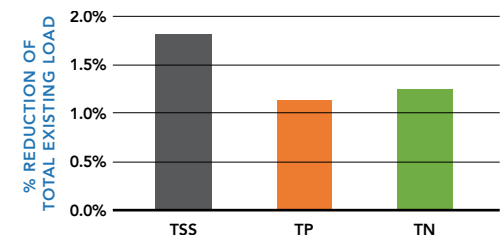
POTENTIAL REDUCTION CREDITS

An important outcome of this study is that the adoption of more stringent redevelopment requirements, which are relatively easy and inexpensive to

implement, can be highly effective in reducing future pollutant loads not only from future development but from existing untreated commercial land uses as well. In essence these model standards can leverage the economic investment of developers in redevelopment projects to improve water quality conditions in the Great Bay and meet future state and federal permit requirements. Over the course of a five-year permit term, this study found that a 1.8% decrease in TSS, 1.1% decrease in TP and a 1.3% decrease in TN from baseline pollutant loads could be credited to a municipality that updated their stormwater standards. (Figure 3).

In addition, early adoption of these model standards could result in substantial cost savings through future cost avoidance in not having to construct numerous stormwater BMP retrofits to meet future regulations. The overall cost to retrofit this IC area would be approximately \$14 million, using an average retrofit cost of \$30,000 per acre. These estimated future costs do not include the cost of inflation nor the added potential cost of lost or diminished ecological services and/

FIGURE 3: Pollutant load reduction credit per permit term (5 years)



or recreational uses as a result of decreased water quality conditions. A breakdown of the estimated cost avoidance for each town within the Oyster River watershed is shown in Figure 4.

FIGURE 4: Cost Avoidance

TOWN	FUTURE IC TREATED	FUTURE COSTS \$30K PER ACRE
Barrington	29	\$861,000
Dover	43	\$1,300,000
Durham	231	\$6,944,000
UNH	102	\$3,048,000
Lee	32	\$967,000
Madbury	15	\$446,000
Nottingham	3	\$89,000
TOTAL	455	\$13,655,000

COST AVOIDANCE FOR GREAT BAY WATERSHED

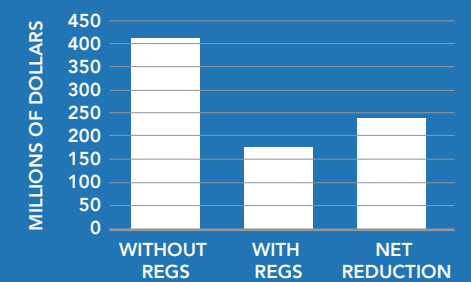
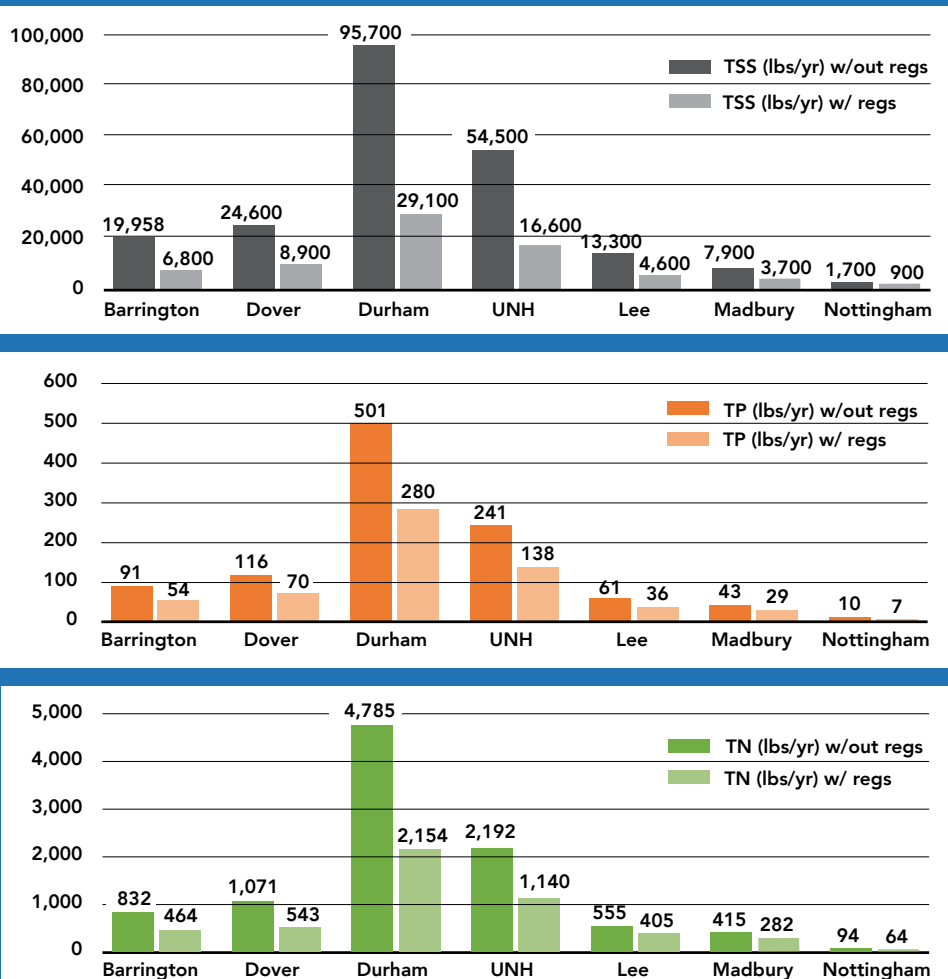


FIGURE 2: Estimated Effect on Future TSS, TP and TN Loads (lbs/yr) Due to Stormwater Regulations



ECONOMIC IMPACT – COST AVOIDANCE

If the potential savings in deferred costs or cost avoidance gained through early adoption of stormwater regulations and enhanced treatment were extended beyond the Oyster River watershed to include the entire Great Bay watershed, the potential future cost savings could be in the hundreds of millions of dollars.



This research project was conducted by the UNH Stormwater Center in cooperation with VHB and the SRPC. Support for the SWA Model Stormwater Standards was provided by the NH Coastal Program and was completed by UNHSC and RPC.

The Up Side of Implementing Green Infrastructure and Low Impact Development Practices

PROVEN PRACTICES



POROUS PAVEMENT
STRATHAM, NH

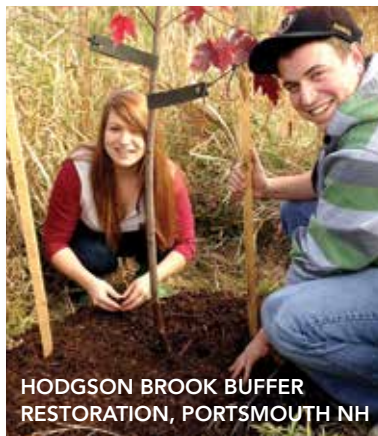


BIORETENTION SYSTEM
DURHAM, NH

Low impact development (LID) and green infrastructure (GI) are approaches to stormwater management that can improve water and air quality, enhance recreational opportunities, improve quality-of-life, protect ecosystem function, save energy, reduce the urban heat island effect, and alleviate the effects of climate change. These goals are advanced by LID and GI in ways that traditional “grey” infrastructure cannot match.

WHAT IS LOW IMPACT DEVELOPMENT?

Low impact development practices manage runoff in ways that reduce the impact of built areas and promote the natural movement of water within soils, ecosystems or a watershed. Applied on a broad scale, LID can maintain or restore a watershed’s hydrologic and ecological functions. LID employs principles such as preserving and restoring natural landscape features and minimizing impervious surfaces to create functional and appealing site drainage systems that treat stormwater as a resource rather than a waste product.

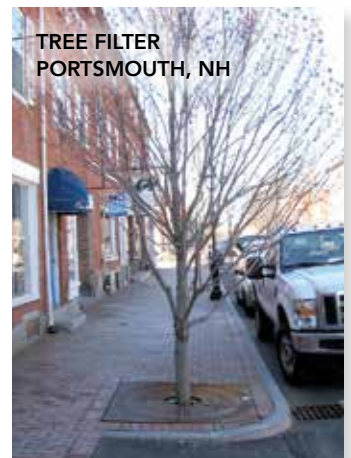


**HODGSON BROOK BUFFER
RESTORATION, PORTSMOUTH NH**

Green infrastructure practices (also a low impact development tool) serve to manage runoff as an integrated part of the developed landscape by capturing runoff close to its source and weaving natural processes into the built environment. Practices use vegetation and soils to absorb and infiltrate excess runoff and remove pollutants. Implementing stormwater standards for development and protecting existing natural areas and land in river corridors are also part of the green infrastructure approach.

WHAT IS GREEN INFRASTRUCTURE?

Green infrastructure practices (also a low impact development tool)



TREE FILTER
PORTSMOUTH, NH

Benefits for Communities

URBAN HEAT ISLAND EFFECT REDUCTION

The urban heat island (UHI) effect occurs when built-up urban areas become warmer than nearby areas due to the amount of “hard surfaces” such as buildings, roads and parking lots. The UHI effect is of particular concern in summer, when higher surface air temperatures and solar radiation heat exposed surfaces. UHI can increase electricity demand, air pollution, and heat-related mortality and illness. **LID and GI can mitigate the UHI effect through added shade and evapotranspiration in urban areas.**

ENERGY CONSERVATION AND CLIMATE CHANGE OFFSETS

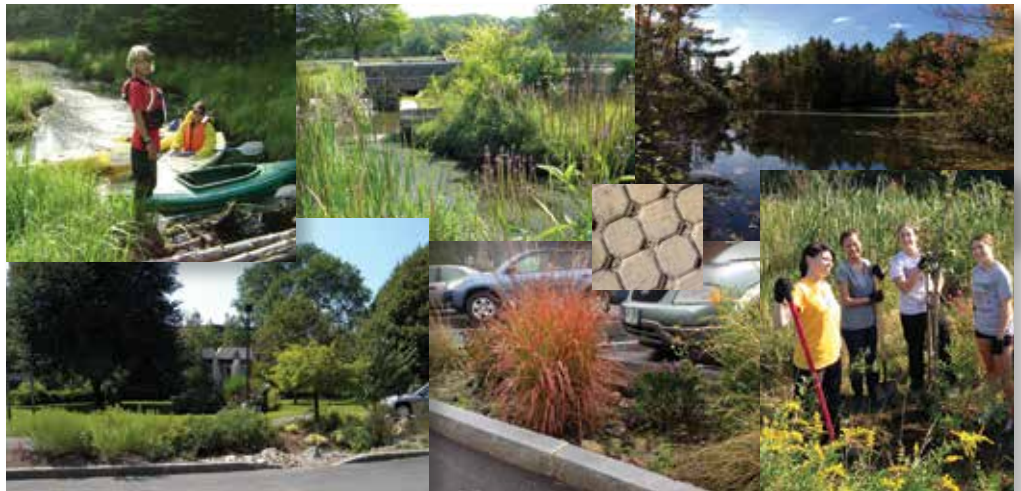
Green infrastructure can be adapted to address site-specific conditions to meet the anticipated challenges of climate change. Properly placed trees and natural vegetation can provide shade in summer and reduce wind speeds in winter, reducing the energy needed for heating and cooling. **Trees and vegetation help to offset carbon dioxide emissions by removing pollutants from and cooling the air.** Unlike some traditional grey infrastructure, GI installations do not need electricity to operate, so they do not produce greenhouse gas emissions.

IMPROVED AIR QUALITY

LID and GI improve air quality by incorporating vegetated areas that absorb pollutants, like ozone and nitrogen dioxide, intercept airborne particles, like dust, smoke, and pollen, and decrease carbon dioxide levels and increase oxygen levels. LID and GI help ponds, swamps and other water bodies from becoming toxic by limiting inflows of nutrients that cause massive algal blooms, the decay of which can create strong odors and rob the waters of life-sustaining dissolved oxygen.

ENHANCED PROPERTY VALUES, RECREATION AND QUALITY OF LIFE

GI and LID enhance neighborhood livability, in turn elevating property values, by beautifying yards and streets, increasing privacy, reducing noise pollution, providing urban agriculture opportunities, and creating or expanding attractive outdoor spaces. **Healthy environments can promote community development and foster stronger community connections** (via community tree planting programs, recreational activities, and social gatherings)



that can reduce community costs for emergency response, crime, transportation, and water supply restoration. Properties in LID neighborhoods have been shown to sell faster and for higher amounts than those in competing areas not using LID, in part due to proximity to open space and high-quality waterways. The significant improvements in water quality yielded by GI and LID can increase market value by 15% for properties bordering the water body. Similarly, LID has been shown to generate higher rents and lower vacancy and turnover rates. Therefore, **protecting water quality helps boost tax revenues by enhancing local real estate values.**

PROTECTED ECOSYSTEMS

GI and LID protect wildlife and habitats by enabling the ecosystem to perform its natural functions, like water restoration, nutrient recycling, and the capture and storage of carbon dioxide from the atmosphere. **GI's enhancement of native vegetation along streams keeps stream ecosystems healthy.** The natural areas near streams, or “riparian buffers,” provide a number of ecological and water quality benefits by: filtering sediments and pollutants out of runoff before reaching streams; slowing runoff to allow it to soak into and be filtered by the soil; reducing erosion and stabilizing stream channels; allowing plants to absorb flood waters; providing shade that keeps stream water cool in summer so that it can hold more oxygen for use by fish and other aquatic species; and providing food and habitat for a number of land and water species. On a smaller scale, street trees and green roofs can provide nesting, migratory, and feeding habitat for a variety of birds, butterflies, bees, and other pollinating insects.

OPERATION AND MAINTENANCE BENEFITS

Natural systems are lower-maintenance, compared with conventional systems. **LID uses small, cost-effective landscape features throughout developed areas to slow runoff, delay peak flows, increase evaporation, remove sediment, and remove pollutants.** This maximizes water quality treatment and reduces the dangerous and damaging erosional forces of fast-moving waters. Protecting water quality through GI and LID practices is usually less expensive than cleaning contaminated water. LID's decentralized approach reduces municipalities' stormwater management costs by letting private landowners handle rain as it falls on their properties. This extends the useful life of central and underground infrastructure while reducing chemical, energy, and maintenance costs at treatment plants.



This project is funded by the **NERRs Science Collaborative** to a project team led by the **University of New Hampshire Stormwater Center** and the **Great Bay National Estuarine Research Reserve.**

It supports Green Infrastructure implementation with local municipal, non-profit and private sector partners.

For more information please visit southeastwatershedalliance.org/green-infrastructure



A Community Approach to Green Infrastructure for New Hampshire's Coastal Watershed



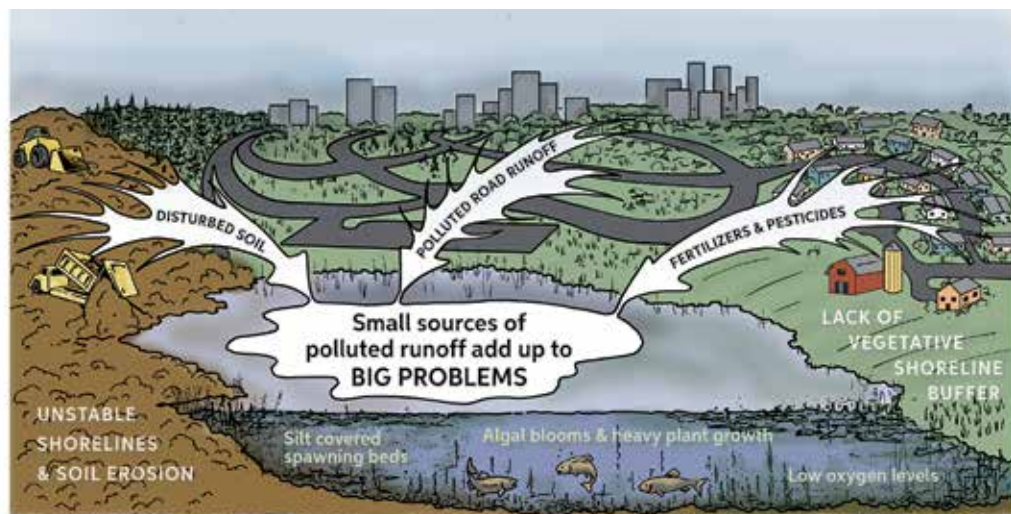
SNOW MELT/
RUNOFF



STORMWATER
RUNOFF

In natural landscapes like forests, wetlands, or fields, rainwater falling to the earth tends to quickly absorb into the ground and underlying soils. But when landscapes are developed – adding hard surfaces (called *impervious cover*) such as roads, sidewalks, buildings, and parking lots – rainwater is prevented from filtering into the ground and instead flows across these hard surfaces.

This unabsorbed water, called stormwater runoff, collects pollutants and carries them into waterways, causing substantial water quality problems.



Research and monitoring clearly shows that in rapidly developing areas, greater amounts of impervious cover result in stormwater runoff that causes higher levels of water pollution. This can lead to significant financial costs to local communities. Green infrastructure can provide effective solutions to this problem by reducing stormwater runoff and filtering harmful pollutants from stormwater runoff.

The Green Infrastructure project advocates a “complete community approach” for mitigating the negative effects associated with increasing impervious cover and stormwater runoff, thus minimizing impacts to water quality and protecting ecosystems and water resources.

Building Green Infrastructure Through a Complete Community Approach

The following measures outline a comprehensive strategy towards achieving the complete community approach:

- Adopt ordinances and regulations for new development that mandate the use of stormwater filtration to clean runoff, and infiltration practices to reduce runoff.
- Require improved stormwater controls for reducing runoff for redevelopment projects or other significant construction, and for site improvements such as repaving or building renovations.
- Apply conservation strategies such as protecting naturally vegetated areas near water bodies and wetlands, and limiting the size or percentage of allowable impervious cover in high value natural resource areas.
- Reduce existing impervious cover through targeted site improvements and stormwater management changes in high impact locations (i.e. locations that contribute high amounts of polluted runoff).
- Make a long-term commitment to fund and maintain stormwater controls along with an accounting mechanism to track long-term benefits of strategies. Consider innovative funding mechanisms such as impacts fees, exaction fees and stormwater utilities.



BIORETENTION SYSTEM



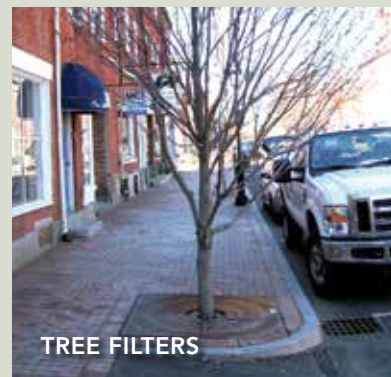
POROUS PAVEMENT



RAIN GARDEN SIGNAGE

- Provide opportunities for outreach by sharing plans and progress with citizens and business owners through community newsletters, cable access, and on-site signs that explain what steps are being taken to protect waterways or improve stormwater management.

FILTRATION SYSTEMS



TREE FILTERS



BIORETENTION SYSTEM



BIORETENTION SYSTEM



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PROJECT REPORT

Green Infrastructure for Sustainable Coastal Communities

APPENDIX B: CASE STUDIES



A PROJECT FUNDED BY THE NATIONAL ESTUARINE RESEARCH RESERVE SYSTEM SCIENCE COLLABORATIVE TO A PROJECT TEAM LED BY THE UNIVERSITY OF NEW HAMPSHIRE STORMWATER CENTER AND THE GREAT BAY NATIONAL ESTUARINE RESEARCH RESERVE IN SUPPORT OF GREEN INFRASTRUCTURE IMPLEMENTATION WITH LOCAL MUNICIPAL, NON-PROFIT AND PRIVATE SECTOR PARTNERS.



Background

In November of 2013, the Green Infrastructure for Sustainable Coastal Communities (GISCC) provided funding to the Town of Brentwood to assist with projects that apply green infrastructure (GI) and low impact development (LID) methods on municipally-owned lands, and would include various components, including an outreach and education campaign.

To identify these projects, the GISCC project team agreed to complete the following tasks:

1. Evaluate municipal sites including the town shed, town office, library and school.
2. Develop a stormwater management plan for each site that incorporates LID projects.
3. Make presentations to town boards of these stormwater management plans to educate and improve understanding and benefits of LID (the Selectboard, Highway Department, Planning Board and Conservation Commission).
 - Representatives from these town boards would then meet and pick two to three projects to implement.
5. Implement improvement projects on town-owned lands by September 2014.
6. Conduct follow-up meetings with town boards after completion.

This hands-on approach, including implementation of direct improvements and education in the understanding of LID, has led to increased awareness of LID strategies and how to incorporate them into development and redevelopment activities in the town.

The management plans will provide an invaluable resource and roadmap for the town for future implementation of LID strategies at municipal sites, which will lead to continued improvement in the water quality in the Exeter River.

Project Results and Future Considerations

The project included optimization modeling of updated, watershed-wide impervious area data used to target pollution hotspots based on land use, zoning, soils, proximity to a water body, and other common GIS data layers.

Stormwater-derived loadings were modeled and classified to identify municipally-owned hotspot locations for installation of cost-effective stormwater solutions that maximize pollutant load reductions.

Attribute tables generated by the modeling effort were then used to sort and filter results based on specific town official interests. Municipally owned lands were ranked by final modeling point total and then in descending order according to total parcel acreage. Final points indicate the pollutant potential of any parcel area with higher numbers indicating

LAND COVER	ACRES
Impervious	10,256
Pervious	607
Total	10,863
% IMPERVIOUS COVER	5.6%



Impervious and pervious land cover statistics for the town of Brentwood.

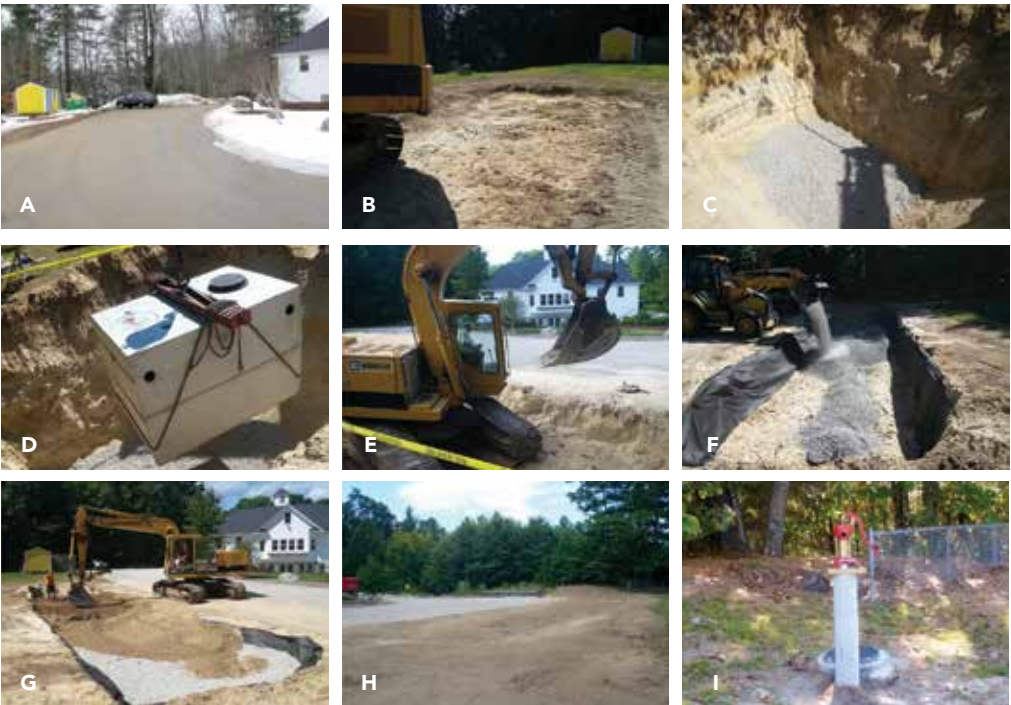
larger pollution threats. Secondary sorting by parcel size indicates opportunities where more can be done, as larger parcels with higher potential for pollution indicate larger benefits from retrofit activities. This is a quick screening method to further investigate potential implementation sites.

RANK	LANDUSE DE	HSG	FINAL POINT	PARCEL ADDRESS	LOCATION	FINAL ACRES	NOTES
1	Government	A	1200	22 Dalton Rd	Brentwood Library	0.71	Managed through GISCC
2	Educational	B	1100	355 Middle Rd	Swasey School	3.02	Partially Managed Proposed
3	Government	B	1100	1 Dalton Rd	Town Hall	0.81	No Management Proposed
4	Government	C	1000	207 Middle Rd	Brentwood Highway Shed	0.76	No Management Proposed
TOTAL						5.30	

Project Conditions

The selected property was the town-owned Mary E. Bartlett Library. The property consists of a 3.4-acre parcel with 0.71 acres of impervious cover.

As a result of this project, 90% of the Mary E. Bartlett Library impervious cover has been disconnected via treatment through green infrastructure practices. Two GI stormwater control measures have been installed that treat 0.64 acres of drainage area and annually reduce 413 lbs of TSS, 1.6 lbs of phosphorus and 9.1 lbs of nitrogen on an annual basis.



A. Western perimeter drive and parking area; B: re-graded site; C: excavated hole for cistern; D: installed cistern; E: excavated bioretention area; F: placed stone; G: backfilled with BSM; H: finished grade; I: installed cistern pump.

2014 BMPS	ANNUAL LOAD 'L _i ' #/YEAR	EFFLUENT LOAD 'L _e ' #/YEAR	ANNUAL PL REMOVED #/YEAR
TSS #/year	456	42	413
TP #/year	1.95	0.35	1.61
TN #/year	17.6	8.5	9.1

Summary of annual pollutant load reductions estimated for the retrofits at the Library.

The Impervious Cover Model and Future Permit Compliance

Numerous watershed studies throughout the country have correlated the percentage of IC to the overall health of a watershed and its ability to meet designated uses. According to studies, it is reasonable to rely on the surrogate measure of percent IC to represent the combination of pollutants that can contribute to aquatic life impacts. Without a total maximum daily load assessment for a watershed, a general target related to the ICM is 10% Effective Impervious Cover (EIC). That is, if IC in a watershed can be disconnected through treatment through an appropriately sized BMP, it can be removed from the EIC.

This approach can serve as a surrogate for water quality criteria in the absence of any other governing regulatory limits.

The analyses performed in this project constitute major elements of any required WQRP and include the following elements:

- 1. Preliminary source assessment with respect to potential stormwater sources
- 2. Implementation of programs leading to the disconnection of DCIA
- 3. Structural BMP retrofits

While additional analyses and comprehensive assessment of illicit discharge detection and elimination (IDDE) programs and revision of good housekeeping and pollution practices (such as catch basin cleaning frequency and leaf litter collection programs) may be required, the analyses and action items embodied in this report represent a major contribution to any future WQRP or SWMP permit submission.



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A Commitment to Green Infrastructure

What is Green Infrastructure?

Green Infrastructure is a programmatic use of Low Impact Development [LID] and other management measures to control drainage and pollution in a watershed or municipal setting.

LID techniques mimic natural processes to capture and treat stormwater close to its source and enhance overall environmental quality.

As a general principal, green infrastructure engineered systems use soils and vegetation to infiltrate and/or treat runoff.

STRUCTURAL EXAMPLES:

- bioretention systems and rain gardens,
- permeable pavements,
- tree filters and stormwater planters, and
- vegetated roofs.

NON-STRUCTURAL ELEMENTS:

- incorporating best practices into site design,
- regulations requiring better infrastructure performance, and
- incentives or education that encourages property owners to protect water quality.

Durham, New Hampshire

THE GREEN INFRASTRUCTURE PROJECT

Researchers from the University of New Hampshire and Geosyntec, as well as staff from the Southeast Watershed Alliance, Strafford Regional Planning Commission, Rockingham Planning Commission, Antioch University, and the Great Bay National Estuarine Research Reserve, partnered to deliver customized technical assistance and educational resources focused on stormwater management in the coastal watershed. One of the primary goals of this project was to communicate with municipalities on the values of green infrastructure in order to assist them in deciding where, when, and to what extent green infrastructure practices should become part of future planning, development, and redevelopment efforts.

BECOMING AN IMPLEMENTATION COMMUNITY

The Green Infrastructure Project advocates that municipalities take a Complete Community Approach to mitigate the negative effects associated with increasing impervious cover and stormwater runoff, thus minimizing impacts to water quality and protecting ecosystems and water resources.

A Complete Community Approach uses green infrastructure throughout all aspects of community planning. This approach includes: ordinances and regulations, stormwater controls, conservation strategies, reduced impervious cover, long-term commitments to fund and maintain stormwater controls, and opportunities for outreach.

DURHAM'S COMMITMENT TO GREEN INFRASTRUCTURE

2010 Incorporated stormwater regulations with low impact development incentives in site plan review and subdivision regulations

2011 Partnered with the UNH Stormwater Center to retrofit a custom designed state-of-the-art nitrogen treatment bioretention structure in a busy downtown parking lot

2012 Partnered with the Oyster River High School to design and construct a 1,000 square foot rain garden to collect and treat stormwater runoff from 10,000 square feet of the school's main parking lot

2013 Adopted a new water ordinance, which includes protection of all the town's water resources from discharges of polluted stormwater runoff and illicit discharges



Bioretention Retrofit,
UNH Campus, Durham, NH

LOCAL PLANNING: TOWN OF DURHAM

Design and Construction of a Stormwater Retrofit at the Intersection of Oyster River Road and Garden Lane

The goal of this public infrastructure repair and improvement project was to disconnect the stormwater runoff generated from the neighborhood and reduce non-point source pollution on the Oyster River.

IDENTIFIED NEED

The Town of Durham's Department of Public Works recognized that a stormwater outfall in a residential neighborhood had fallen into serious disrepair and was discharging directly into the Oyster River. The existing drainage structure and outlet pipe were under capacity and severely degraded. The site contained a highly eroded trench that had undermined a 20' section of corrugated metal pipe (see picture, middle left), which according to the UNH Stormwater Center, was responsible for releasing approximately 30 dump truck loads of fine sediment per year into the river. The undercutting from the existing pipe resulted in massive erosion, slope instability, and water quality issues. Due to these factors, staff from the Durham Public Works Department submitted a grant application to evaluate the contributing drainage area and existing stormwater management infrastructure, design an engineered green solution, and install a control measure.

SPECIFIC RESULTS OF THIS PROJECT



BEFORE

"This subsurface gravel wetland installation created an eventual win-win-win, where we reduced dissolved nutrient contributions from yard waste, prevented localized soil erosion, and improved water quality control of a 10-acre residential area discharging directly to the Oyster River."

—Jamie Houle, Program Manager,
UNH Stormwater Center



AFTER

- Stabilization of 50 feet of heavily eroded and entrenched gully discharging directly to the Oyster River
- Installation of a subsurface gravel wetland system at the outfall to slow flow and provide water quality treatment from 6 acres of untreated residential/and uses
- Employ a regenerative stormwater conveyance approach that will use the existing eroded gully as the excavation for the treatment area and will result in less than 750 square feet of temporary disturbance associated with an access for construction; no additional impervious area is proposed
- Overall improvement to the aesthetics of the site, which in its former condition had become a dumping ground for nutrient laden lawn and leaf debris from local yards

The UNH Stormwater Center assisted by developing design plans and provided building oversight for the project. The town of Durham and their selected contractors finalized the construction in the spring of 2015.



The Value of Green Infrastructure

Investing in Green Infrastructure can provide municipalities with a range of long-term economic, environmental, and social benefits including:

- The potential to reduce municipal costs for stormwater management by decreasing a reliance on costly grey infrastructure
- Reducing stress to aging municipal grey infrastructure and minimizing the need for capacity increases (i.e., gutters, storm sewers)
- Improving water quality in our streams, rivers, ponds, and estuaries
- Increasing groundwater aquifer recharge to support drinking water and stream baseflow
- Minimizing flooding and building resiliency to extreme storm events
- Increasing the usage of green spaces for water management and improving community aesthetics
- Cultivating public education opportunities by connecting people more directly with natural resources



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The Green Infrastructure Project

provides resources and technical support for communities to improve stormwater management. We support pilot projects and provide workshops, fact sheets and other resources to help communities protect water resources.

Improving the Brickyard Pond Residential Watershed

What Is Green Infrastructure?

Green infrastructure is the utilization of natural processes to help control rain runoff.

This can include **constructed systems** such as **raingardens** or **buffers** along streams that treat runoff by filtering the water.

There are also **non-structural strategies** such as **incentives** or **education** to encourage homeowners to protect water quality, and **regulations** that require better stormwater control for new construction.

A **complete community approach** uses green infrastructure throughout all aspects of community planning.

Exeter, New Hampshire



THE PROBLEM

Brickyard Pond, once a community gathering place and natural playground, has deteriorated steadily over the years. As excess fertilizer, soil, oils, salt, and other components of stormwater pollution flow through stormdrains from a neighboring community and enter the pond, a food smorgasbord is created for unwanted plants and algae. The plants and algae grow in excess, reducing the overall water quality and degrading the habitat for fish.

THE SOLUTION

Neighbors in the Marshall Farms community expressed their concerns. Working with the town and with support from a Green Infrastructure grant, they learned what small changes they could make on their property to work toward improving the pond's condition. Their focus was on making these changes using three Green Infrastructure tools: **Lawn Care**, **Rain Barrels** and **Rain Gardens**.



Improving the Brickyard Pond Residential Watershed Exeter, New Hampshire

The town of Exeter and residents living near Brickyard Pond participated in an education program that was followed by implementation of several residential stormwater treatment systems. The project combined education with water treatment and monitoring and engaged a wide range of stakeholders. In the initial stages of this program, seven rain barrels and rain gardens were installed and, most importantly, a relationship was established between residents and the town to resolve issues with stormwater and the health of Brickyard Pond.

Why Do We Care About Stormwater And How Does Green Infrastructure Help?

Stormwater is **rain runoff** that flows across parking lots, roads or other hard surfaces. The runoff contributes to **flooding** and can carry **pollutants** including road salt and nitrogen into our rivers, lakes and the Great Bay.

Existing stormwater management systems designed to control runoff and protect life and property are not always able to handle the large **storm events** that New Hampshire has experienced over the last several years. Better water resource management will reduce infrastructure costs and help to alleviate flooding.

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LAWN CARE

In a neighborhood workshop, residents learned about the importance of letting soil conditions, not past habits, dictate what their lawns need for fertilizer. By committing to the Happy Lawns-Blue Waters campaign, residents agreed to opt for slow release, phosphorus-free fertilizers unless soil tests indicate otherwise. In addition, they committed to cleaning up after their pets, reducing yet another source of excess nutrients. When mowing lawns, they would cut to three inches or higher to encourage stronger grass root growth and leave the cut grass on the lawn to take advantage of the free fertilizer provided as clippings decompose.



RAIN BARRELS

Residents were offered the opportunity to purchase SkyJuice rain barrels at a discounted rate. Rain barrels capture clean water from rooftops through gutter downspouts and store it for use whenever houseplants, gardens, or flowerbeds need watering. The result is not only a free water source for the residents, but a reduction in the amount of stormwater that

leaves the property. So how much water can you save? A half-inch rainfall falling on a 1,000 square foot roof will provide 300 gallons of water.

RAIN GARDENS

A rain garden in its simplest form is a depression in your yard that uses soil, mulch, and plants to capture, absorb, and treat stormwater. This helps reduce the amount of stormwater coming from your property and to recharge groundwater.

Two neighborhood rain gardens were installed in this community. They were designed by Ironwood Design Group LLC with donations and assistance from Rye Beach Landscaping and Churchill's Gardens. Residents were invited to participate in construction to gain hands-on experience. They then applied their newly acquired skills to construct a rain garden on their own property.



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The Peirce Island Municipal Snow Dump Project

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THE PROBLEM

The Peirce Island snow dump site in Portsmouth, NH covers approximately 0.54 acres and serves as the dumping location for snow removed from the urban core of the city.

This is a known high load contribution site or pollution "hot spot" and is a frozen monument to the brew of salt, trash, nutrients, oil and sediment that are deposited on urban city streets. Snow plowing activities collect, convey and concentrate these pollutants into a single large location.

THE PROJECT

The Peirce Island Snow Dump Project was developed to address this issue. The project's objectives:

1. Research a Low Impact Development/ Green Infrastructure (LID/GI) solution to mitigate water quality impacts associated with snow removal
2. Quantify the pollutant load and future reductions associated with LID/GI implementation.
3. Recommend a design for a LID/GI system for this location.

UNHSC staff developed a sampling plan over the course of the 2013-2014 and 2014-2015 winter seasons to quantify the pollutant load potential from snow dump facilities. A series of grab samples



were collected from December 2013 through April 2014 and January through April 2015 from the snow dump site. Grab samples were taken from snow that was recently delivered to the snow dump facility (i.e. new snow) and of the snow that had been stored for an extended period of time (i.e. old snow).

During each sample event the snow pile was measured to provide an estimation of the total volume of snow. The density of the snow pile was calculated using

the snow to water equivalency ratio (SWE), which is a percentage of the volume of water contained within the snow pile. This SWE ratio was then multiplied by the measured snow volume to generate the volume of water (gallons) tracked over two winter seasons (Figure 1).

To quantify this pollutant removal potential, an assessment of the annual pile volume, the total pollutant mass delivered to the snow dump area,

the exported pollutant mass, and the pollutant removal potential by a properly designed GI system were quantified and modeled. The results of this assessment are shown in Table 1 and Figure 2.

In addition to standard practices associated with snow dump activities, it was proposed that an appropriately sized bioretention system could be installed to manage the exported mass from rain and melt events.

CONCLUSIONS

This study demonstrated that standard snow dump facilities by themselves remove a large mass of pollutants from the urban core. The process of collecting, trucking, and dumping snow into a dedicated location dramatically reduces pollutants otherwise exported to receiving waters by up to 87%. This practice itself should be considered a best management practice (BMP) for urban stormwater pollution.

These pollutant removal potentials can be increased even further, by up to 98%, through the design and installation of appropriately sized GI systems. (The lone exception is with respect to chloride loads, which may be an issue if discharging to freshwater areas.)

As a result of this project, a bioretention system has been designed for this location in Portsmouth. The total cost estimates for the materials and installation of the facility are between \$13,500 - \$17,400, and the City has committed to installing the system within the next two to three years.

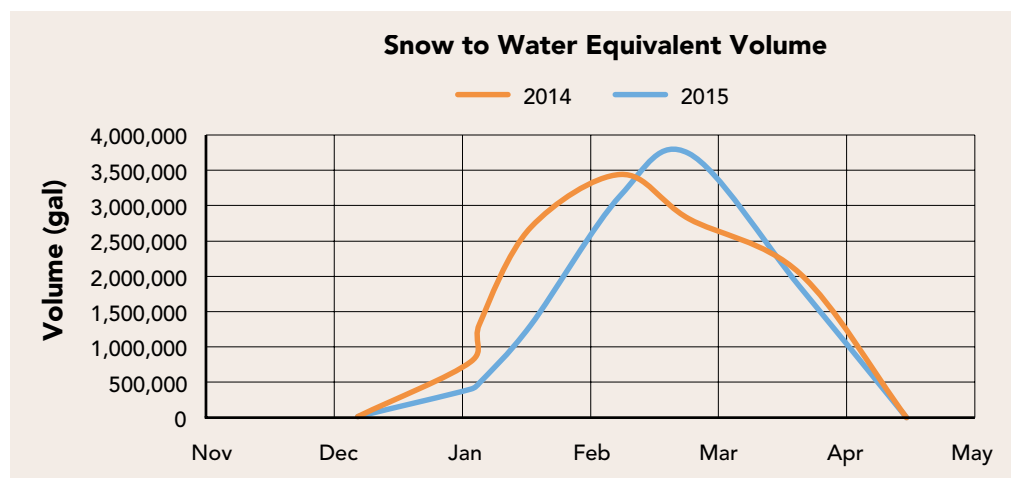


Figure 1: Snow Water Equivalent (SWE) in gallons during the winter sampling season 2014-2015.

Project Totals	TSS	Zn	Cu	TN	TP	Cl
% RE Snow Dump Only	85%	80%	81%	81%	82%	24%
% RE Snow Dump w/ BMP	98%	97%	98%	92%	92%	24%
% Export Rate	15%	20%	19%	19%	18%	76%

*%RE = Percent Removal Efficiency; BMP = Best Management Practice (Bioretention System in this example)

Table 1: Pollutant removal potential through standard operating snow removal practices and through the addition of a properly sized bioretention system for managing runoff.

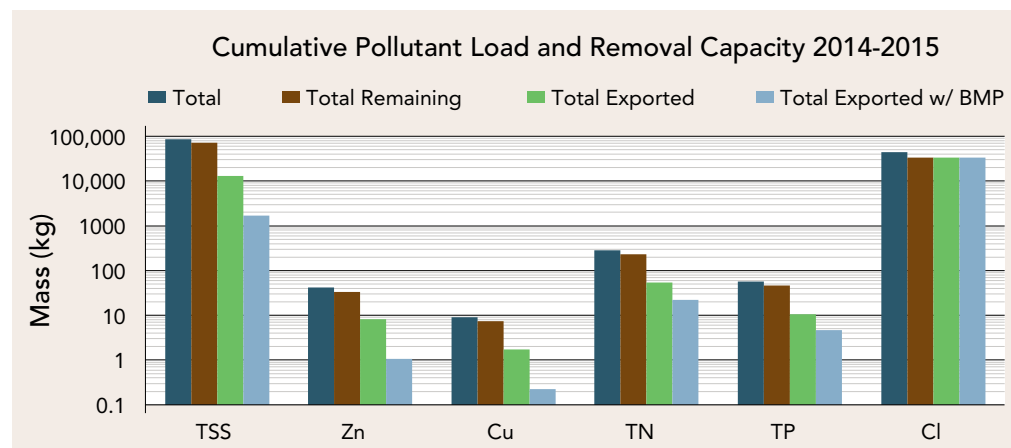


Figure 2: Snow dump pollutant load assessment comparing pollutant load deposited onsite (total), pollutant mass retained onsite (total remaining), pollutant load generally exported to the environment (total exported) and additional load reduction when export is through an innovative bioretention system (total export w/BMP).



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Green Infrastructure is Good Design

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ROCHESTER'S COMMITMENT TO GREEN INFRASTRUCTURE

The goal of this project was to improve the quality of life of Rochester's citizens and visitors, protect natural resources and reduce municipal costs by:

- Updating the stormwater regulations so the City can consistently require the implementation of the current best management practices using low impact development and green infrastructure
- Establishing recommendations for developing a database to track and account for best management practices, maintenance, impervious cover, and other elements of future permit reporting requirements.

LOCAL PLANNING: CITY OF ROCHESTER

Incorporating Updates to Stormwater Management in the City Ordinance and Land use Regulations

IDENTIFIED NEED

The City of Rochester's Planning and Community Development Department recognized that their current approach to stormwater management needed major revisions and updating. Many of the best management practices referenced in documents including Site Plan Regulations, Subdivision Regulations, and Chapter 50 of the City Ordinance were outdated

Green Infrastructure design is good design.

"Thanks to Green Infrastructure stormwater standards, Rochester will begin to see developments creating gardens, shallow ponds that drain quickly, and other vegetated areas instead of ponds and pipes. This will really be a win-win for all parties: The City will have cleaner and less stormwater to pay for and treat; developers will reap economic benefits in the means of less maintenance and greater flexibility to retrofit a built site, and residents/visitors will enjoy more attractive and welcoming developments. Green Infrastructure design should simply be called good design."

—Seth Creighton, Staff Planner,
City of Rochester

and no longer the best options for management of stormwater runoff.

The City's stormwater regulations were created at different times and have many inconsistencies and outdated references. Conventional stormwater management had resulted in many of the problems the City has experienced, which include: flooding, stressing the existing public drainage systems, and degrading wetlands, rivers, and aquifers. All of the impacts represent economic and health cost to the City's population.

As one of the fastest developing communities in the NH Seacoast, it is important that the documents be revised so that the City can take advantage of low impact development and green infrastructure stormwater best management practices moving forward.

REGULATION UPDATE PROCESS

The city staff, their technical consultant, and a subcommittee of the city's planning board review used the following process:

- Review of stormwater components of the existing city documents including the Site Plan Regulations, Subdivision Regulations, Public Works Design Standards, and Chapter 50 of the City Ordinance
- Collection and review of other available information including the 2012 Southeast Watershed Alliance Stormwater Standards
- Provide recommendations for regulation updates to improve consistency, clarify the review process, and include revisions to best management practices requiring the usage of low impact development and green infrastructure for stormwater management
- Facilitate public outreach efforts

SPECIFIC OUTCOMES PROPOSED IN THE REVISED STORMWATER ORDINANCE

- Low Impact Development (LID) site planning and design strategies will be required to the maximum extent practicable
- Unique regulatory standards will be created for projects that meet the definition of "redevelopment project" thus fostering responsible redevelopment while reducing regulatory burden
- Offsite mitigation will now be permissible when onsite mitigation is impractical
- The 50-year, 24-hour storm event will be required to be modeled, in addition to the 2-year, 10-year, and 25-year events, 24 hour events.
- Specific water quality standards will become part of the minimum design standards
- Stormwater systems will not be allowed in sensitive areas
- Stormwater standards will now be in a single regulatory location (Chapter 50 of the General Ordinance)



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