Vermont
Green Streets Guide

A Resource For Planning And Building Green Infrastructure Within Our Communities

First Edition • June 2018

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STOWE, VERMONT: The beautiful character of many Vermont towns.

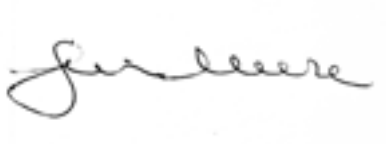
Special Statement

Over 250 towns, villages, and cities in Vermont are connected by shared natural landscapes. From forested hills and rolling farm fields to winding rivers and intricate wetlands, Vermonters value the diversity in our backyards and the plants, animals, rivers and lakes that bring us outside. Yet our communities are also linked by roads – interstates, paved connectors, rural backroads, and private lanes. Both practical and abundant, roads divide as much as they connect. They break natural ecological processes that shape our region and, particularly in urban areas, replace the plants that we value in our everyday lives.

Stormwater, or water stemming from overland flow from a rain event or melting snow, carries with it sediment and nutrients picked up along its path. In nature, stormwater is intercepted by vegetation and filtered by the soil before it recharges streams, lakes, and groundwater. Some rain or snowfall evaporates from the tree canopy or ground, reducing stormwater volume. However, we interrupt this hydrologic cycle when we construct impervious surfaces like streets, sidewalks, and buildings. Our conventional approach to managing rainfall and snow melt is to "capture and convey," or to channel stormwater on or under our streets into a common discharge point. These networks of streets and parking lots are often overlooked as contributors to large environmental problems such as urban air pollution and water pollution from stormwater runoff.

Vermonters know that our waterbodies are at risk. Cyanobacteria blooms in Lake Champlain, nutrient overload in Lake Memphramagog, and elevated nitrogen levels in the Connecticut River now force us to examine all aspects of our built environment that have led to a decline in watershed health across our state. Wetter winters and larger and more frequent storm events are pushing the limits of our constructed stormwater networks. With smarter design and increased knowledge of natural systems, we can now engineer and build urban infrastructure that positively impacts the water cycle and, in turn, safeguards and restores the health of our waterways.

'Green' needs to be at the heart of street design in Vermont for the vitality of both our environmental health and local economies. The sustainability of our waters requires that we change the way we approach street design, that we implement practices that protect and maintain the quality of our waters and contribute to the livability of our urban centers. Green Streets create opportunities for municipalities to manage stormwater in a more holistic manner, increasing mobility and a sense of community in our urban environments while reducing pollutant loading in our waterbodies. The Vermont Green Streets Guide provides direction on planning, design, and maintenance of common urban road and parking lot conditions throughout the state, moving us towards a more sustainable and connected urban environment.



"With smarter design and increased knowledge of natural systems, we can now engineer and build urban infrastructure that postively impacts the water cycle and, in turn, safeguards and restores the health of our waterways."

Julie Moore

Secretary, Vermont Agency of Natural Resources

Acknowledgements

VERMONT URBAN & COMMUNITY FORESTRY PROGRAM
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in partnership with University of Vermont Extension

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Additional Information:

Statement of Non-Discrimination:

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WHAT'S IN THIS GUIDE?

This Guide is intended as a springboard for action; as such, it can be read in its entirety or in sections as needed. It describes a linear process of Green Street design and build, from envisioning, to planning, to design, to maintenance, and to monitoring.

The Guide includes:

- Planning considerations to advance Green Street design along streets and in parking lots.
- Guidelines for selecting the appropriate application for the right site.
- Implementation and maintenance strategies that make Green Street design more achievable.
- Examples of Green Streets throughout the state, highlighting their successes and challenges.

Technical guidance in terms of specifications and detail drawings not included in this Guide.

Rural roads are also not covered. Refer to the *Vermont Better Roads Program* for further information on stormwater management, erosion mitigation, and best management practices for rural road safety and ecological protection.

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SECTION 1

Introduction to the Vermont Green Streets Guide

KEVIN ROBERT PERRY

PORTLAND, OREGON: NE Siskiyou Street, Portland's first green street project.

Conventional street design dominates large expanses of our urban landscapes, providing corridors for vehicle movement and above- and below-ground space for utilities. Green Street design, a new take on urban street design, takes a complete view of the street, seeing stormwater as a resource, universal mobility as a priority, and local plants as co-engineers of a complex built environment. It reimagines a singular street design that efficiently prioritizies multiple uses and recognizes the unique value of shared spaces.

Green Street design involves more than the addition of a little shrubbery; it considers local ecology and addresses environmental stressors caused by street design, traffic, and human activity. It shapes sustainable communities where streets are both safe and comfortable for all users. And it boosts the economy by drawing people to downtowns and village greens enhanced by beautiful streetscapes and defined by a sense of place.

1.1 ABOUT GREEN STREETS

A Green Street framework relies on its three pillars: **Green Stormwater Infrastructure**, **Mobility**, and **Placemaking**.

- **Green Stormwater Infrastructure** is part of a "treatment train" approach to stormwater mitigation. Rather than relying entirely on rapid conveyance of runoff in underground pipe systems directly to waterways, Green Stormwater Infrastructure intercepts, holds, slows down, and treats stormwater as close to its source as possible. By bringing parts of natural hydrologic systems into streets, Green Street designs can replicate natural mechanisms that reduce or slow down the flow of stormwater and allow it to be cleaned by plants and soil.

- **Mobility** considers street design for people of all ages and physical abilities. It includes safe access for pedestrians, bicyclists, motorists, and public transit riders. It provides amenities such as benches and shade trees that are essential for non-motorized users and encourages walking or biking, particularly for those with varying physical capabilities.

Introduction to the Vermont Green Streets Guide

- **Placemaking** is an approach to planning, design, and public space management that creates beautiful and vibrant places by focusing on a community's assets. It emphasizes human health, economic vitality, and quality of life.

By combining **Green Stormwater Infrastructure, Mobility,** and **Placemaking** principles, towns can build upon a context- and user-sensitive approach to conventional street and parking lot design that directly connects protection of environmental resources with transportation and community.

1.2 WHAT IS THE VERMONT GREEN STREETS GUIDE?

This Vermont Green Streets Guide is a resource for community leaders, community planners, and policymakers wishing to advocate for and implement Green Streets throughout Vermont. It serves as a step-by-step document for communities to identify why Green Streets are relevant, where and how they can be implemented, and who will implement and maintain them.

The Guide is also a tool to help community leaders evaluate the role of their streets and parking lots in the environmental, economic, and social networks of their communities. It offers a framework for intentional design that incorporates natural systems into the urbanized contexts of streets and parking lots under local or state jurisdiction. It is intended for new developments, retrofits, redevelopments, and anywhere Green Streets opportunities exist within and adjacent to the public right-of-way or parking lots.

1.3 WHY DO WE NEED GREEN STREETS IN VERMONT?

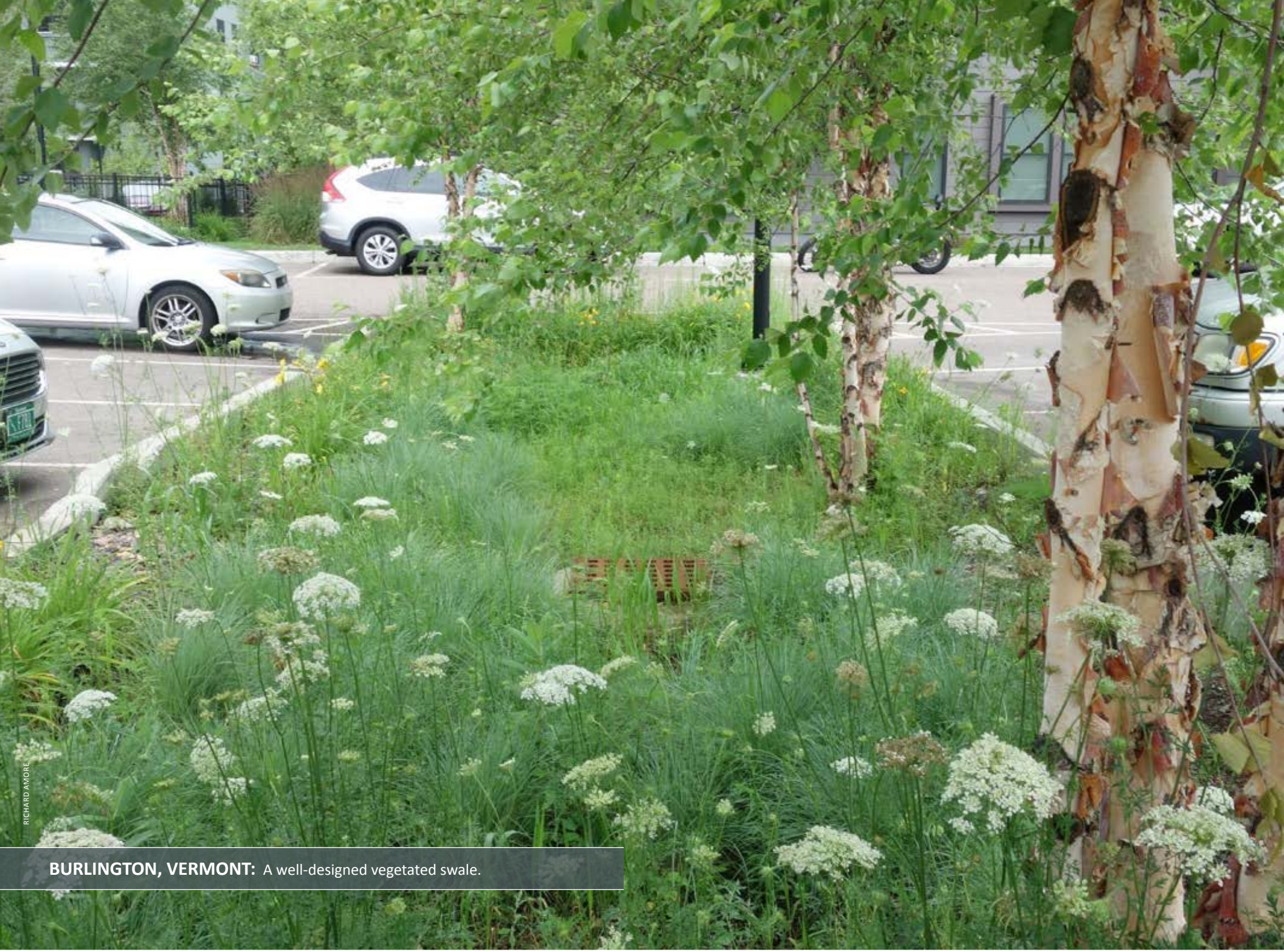
Water quality is faltering in Vermont and urban stormwater is part of the problem. Growing expanses of pavement in urban and exurban settings are adding to the stormwater pressures already created by dense development.

Investing in and maintaining vibrant and green streets in downtown and village centers attracts visitors and improves quality of life for residents. Vermonters are learning how Green Stormwater Infrastructure can help to meet multiple goals such as: absorbing runoff to effectively treat urban pollutants before they reach local waterways while creating wildlife habitat in what would otherwise be unwelcoming urban corridors. By incorporating Green Streets into the planning and design of municipal infrastructure, streets can now serve as connectors for people in cars, on foot, or on bikes. They can also provide areas for environmental mitigation, improve the safety and aesthetics of the built environment, strengthen public and community health, and build upon the natural aesthetic treasured in the state.

In Vermont, this Guide is not a stand-alone resource to facilitate a shift to Green Streets. Additional resources include:

- **Vermont Guide to Stormwater Management for Homeowners and Small Businesses**
- **Vermont Green Infrastructure Toolkit**
- **Vermont Stormwater Management Manual**
- **Vermont Rain Garden Manual**
- **Vermont Tree Selection Guide**
- **Landscape Guide for Vermont Roadways & Transportation Facilities**
- **Complete Streets: A Guide for Vermont Communities**
- **Design Toolkit for Designated Downtowns and Village Centers**

These and many more resources are available on the Vermont Urban & Community Forestry's website at vtcommunityforestry.org/green_streets.



RICHARD AMORE

BURLINGTON, VERMONT: A well-designed vegetated swale.

Section 2

The Benefits of Green Streets

SECTION 2

The Benefits of Green Streets

SOPHIE SAUVÉ

SOUTH BURLINGTON, VERMONT: This rain garden adjacent to a parking lot helps keep the library from flooding.

Green streets provide multiple environmental, social, and economic benefits to communities, businesses, families, and individuals. Approaching the implementation of a Green Street from a landscape perspective means that stormwater management is part of a dynamic and complex system full of opportunities to meet environmental goals, enhance mobility, and build community and place.

2.1 MEETING ENVIRONMENTAL GOALS

Incorporating natural systems into Green Streets improves ecosystem health and supports current State and local priorities and policies for stormwater management. Green Streets boost a variety of environmental benefits that can assist communities as they strive to protect air and water quality, increase species habitat, mitigate and adapt to a changing climate, and build community resilience.

Improving Water Quality

In a natural, undeveloped landscape, rain and snowmelt trickles into the ground to moisten the soil and recharge groundwater that feeds lakes, rivers, and streams. In an urban environment, compacted soil and impervious surfaces reroute precipitation over streets and into underground pipes. This collected stormwater runoff is laden with sediment and pollutants and channeled straight into nearby rivers and lakes. To make matters worse, some municipalities (6% of towns and 66% of cities) in Vermont direct stormwater into sewer systems that also pipe sanitary sewage. When these combined systems reach capacity, both sewerage and stormwater flow directly into waterbodies, pollutants and all.

Green Streets improve the quality of stormwater runoff by:

- utilizing engineered combinations of vegetation and soil media to remove pollutants and reduce sediment in stormwater before discharge to natural waterways, and
- reducing the velocity of stormwater via a decentralized set of practices to slow the rate of flow into a conventional storm sewer system and/or into the aquatic environment.

The Benefits of Green Streets

Green Street design reduces the quantity of water destined for sewer systems by:

- minimizing impervious surface area in urban areas, increasing infiltration;
- intercepting rainfall with the addition of tree canopies and other layers of vegetation.
- minimizing impact on existing vegetation and natural hydrologic conditions, and:
- using permeable treatments where feasible.

Improving Air Quality

Densely developed areas concentrate traffic, creating air quality problems and public health concerns, particularly in valleys where air pollutant dispersion is restricted. Green Streets incorporate vegetation in the form of trees, shrubs, and perennials into the streetscape to sequester carbon and improve air quality by removing airborne particulate matter.

Reducing Urban Heat Islands

Impervious surfaces in downtowns and village centers contribute to the 'heat island' effect where ambient air temperatures remain higher in urbanized areas than in surrounding rural areas. This is due to a difference in the evaporative cooling influence of vegetation coverage versus impervious surfaces. Green Streets reduce the urban heat island effect by replacing paved surfaces with carefully selected vegetation that provides shade, absorbs solar radiation, and increases evaporative cooling.

Creating Wildlife Habitat and Species Diversity

Streets and parking lots devoid of vegetation degrade both wildlife habitat and the human experience in nature. Wildlife that live in or near developed areas require habitat structure, connectivity, or stepping stones of vegetation to maintain population health. Green Streets create habitat in downtowns, villages, and neighborhoods, and provide stepping stones of vegetation that maintain regional biodiversity at all scales.

KEVIN ROBERT PERRY

▲ *Green Streets captures runoff and pollutants and treats it prior to entering a nearby creek, stream, river, or lake. (Montpelier, VT)*

RICHARD AMORE

▲ *On dry days, Green Streets provide shade and cooling of surfaces helping reduce the urban heat island effect. (Burlington, VT)*

The Benefits of Green Streets

WIKIMEDIA COMMONS

BURLINGTON, VERMONT: Historic Church Street is vibrant with pedestrians.

2.2 ENHANCING MOBILITY

Green Streets consider the network, security, and ease with which multimodal users of all ages and ability can move through our downtowns, village centers, and neighborhoods to access goods and services.

Human Health

Spacing, alignment, and character of urban streets can support active transportation by designing options for all tiers of users including the very young, the elderly, and the disabled. Accessibility, transportation options and streets with greenery entice people to get out and enjoy outdoor spaces, and to linger longer. Incorporating street-side amenities such as benches, appropriate lighting, and attractive vegetation shifts the purpose of streets from merely corridors to vibrant destinations. Ultimately, this increased time in outdoor spaces contributes to improved human health and longevity. Studies on nature's influence on human health indicate lower stress levels, greater reported levels of happiness, and longer lives, ultimately leading to lower healthcare costs.

Safety

Green Streets that are also multimodal and structurally complex reinforce lower vehicle speeds, increasing safety for all users. Buffers separating pedestrians and cyclists from vehicles reduce incidents of collisions. Protected bike lanes increase the number and types of cyclists willing to use the streets. Additionally, more people on the street means that more eyes are on the space, adding security through communal surveillance.

2.3 BUILDING COMMUNITY AND MAKING PLACES

Green Streets support statewide planning goals and policies that maintain the historic settlement pattern of Vermont, one of compact cities, towns, and villages separated by rural land. Moreover, well-designed streets create places people are more inclined to visit – fulfilling the cultural value of Vermont's downtown spaces as community focal points. They can help facilitate community interactions, reinforce

The Benefits of Green Streets

the history and culture of a place, support economic development, and encourage public investment that will serve multiple benefits. Combined with a backdrop of green infrastructure and trees, streets can thrive, surrounding businesses can prosper, and stormwater can be efficiently managed.

Community Connections and Engagement

While streets are primarily used for getting from one place to another, they are also created as spaces for people to gather, rest, and talk. Deliberate gestures that contribute to placemaking allow for spontaneity to occur, especially on highly walkable main streets. Unplanned encounters and socializing take place when well-designed sidewalk space is wide enough for people to stop and meet and includes amenities, such as benches, at street intersections and mid-block locations. By creating places where people will linger, several environmental design principles are activated, in turn increasing a commitment to place through investment in street beautification and fostering environmental stewardship through visible connections to the natural environment.

Financial Savings

More frequent and intense rainfall events are stressing existing conventional stormwater systems to the point of requiring costly expansions or repair. Green Streets designs can effectively reduce the quantity of stormwater and slow its flow, dropping demand or even the need for capital investments in gray stormwater infrastructure. Further, green stormwater designs are associated with higher pollutant removal capacities than conventional infrastructure and at a lower cost.

Economic Vitality

Green Streets signal investment in a community that cares about its streets and in turn, both its residents and visitors. Public investment in Green Streets and related amenities spurs private investment by developers and increases public-private partnerships benefiting downtowns and village centers. Walkability and bikeability often correlate with economic vitality, as street-level businesses benefit from more pedestrian and bike traffic. These factors contribute to rising property values, improving tax revenues, and encouraging further public and private investments.

MONTPELIER, VERMONT: A parklet along State Street.

BURLINGTON, VERMONT: College Street redesigned as a Green Street

Section 3

Planning for Green Streets

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Planning for Green Streets

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HUNTINGTON, VERMONT: A Town Meeting with public engagement.

Planning plays a significant role in whether or not communities create well-designed streets that attract residents, businesses, and visitors. Green Streets offer opportunities for communities to address water quality goals while creating public spaces that deliver social and economic value, as well as protecting resources and reconnecting natural ecological processes. To successfully launch a Green Streets initiative, communities should follow a thoughtful planning process to determine goals, encourage engagement, assess conditions, and identify opportunities.

3.1 EXPRESS A VISION AND DEVELOP GOALS

At the outset of developing a Green Streets plan or program, craft a clear vision that expresses why a Green Streets plan is important in your community. There are no shortage of opportunities to introduce Green Street design into the built environment, whether as retrofits or in new development. But Green Streets design principles also recognize that there is no 'one size fits all' approach to identifying the type of improvements that can foster multimodal travel, establish a sense of place, and mitigate stormwater.

To inspire the community, begin by showing the multiple benefits of Green Streets demonstrated through local case studies. Paint a picture of what the project area will be like when work is complete. Outline realistic and quantifiable goals that manage both the project expectations throughout the process and evaluate the project once it is complete. Remember that the project outcomes should align with the identified vision and goals.

3.2 ENGAGE COMMUNITY AND STAKEHOLDERS

Ultimately, a local Green Streets initiative should reflect the vision and goals developed through a community-driven process that engages the public and requires the involvement of key stakeholders. The community engagement process should be coordinated with local, regional, and state partners, local business leaders, and community members to build community buy-in and support for the infrastructure projects. These projects should engage the public and stakeholders from the start and can include multiple innovative outreach activities such as charrettes, surveys, local events, pop-up events, interactive mapping, and demonstration projects.

Key stakeholders will vary based on the project's vision and context. Potential stakeholders to consider include:

- **Public Works or VT Agency of Transportation (VTrans)** – Municipal public works departments or town highway departments need to be involved when anything is being proposed within the municipal public right-of-way. If the project involves work in a state highway right-of-way, then the VTrans District Maintenance staff should be contacted. Public works officials and District staff will be aware of existing infrastructure within the project area - such as above and below ground utilities, and the potential impacts of the project work. Maintenance staff will also know whether they have the capacity, skills and budget to maintain changes within travel lanes, sidewalks and public parking areas.

- **Business Community** – The local business community, chamber of commerce, and individual property owners need to be involved to allow opportunities for input and to address any concerns. In downtowns, Green Street investments should not compete with business storefronts. Storefront façades welcome customers, provide for display of merchandise, and denote that a commercial district exists.

- **Public Safety** – Any change in the width of travel lanes or medians may require changes in practices for emergency service providers. Consult these providers, including the police and fire departments, during the planning and design processes.

- **Adjacent Landowners** – Projects in the public right-of-way will affect neighboring land. Green Street design teams should consider and value input from adjacent landowners and address their concerns before the design of a project.

- **Local Boards** – Involve the town Selectboard and Planning Commission, and staff representatives of the local government responsible for the development of municipal policy and its implementation and associated funding. Additionally, local Conservation Commissions, Natural Resource Boards, and Tree Committees are excellent groups that encourage community participation around the protection of water resources and tree care. The town-appointed tree warden can provide valuable information on the suitability and maintenance of green infrastructure practices that involve trees.

- **State/Regional Planners and Agency Staff** – Any proposal or plan that might have an environmental impact or be proposed on or adjacent to state-owned property or a state highway must involve state officials. For example, a project may require a state stormwater permit or other state permit review. Many village Main Streets are on state highways and rights-of-ways and will need early coordination with VTrans staff. In addition, staff at the Agency of Natural Resources can offer valuable input and information about stormwater management, wildlife habitat, tree selection, and invasive species. Likewise, at the regional level, the Regional Planning Commission staff can provide input and technical assistance regarding water quality, applicable regulations, or financial resources.

- **Community at Large** – Given that local residents often bear the cost of infrastructure improvements and long-term maintenance, gather their input and listen carefully to their concerns.

3.3 CONSULT LOCAL, REGIONAL, AND STATE PLANS

Town Plans and Capital Budgets

Town or municipal plans are a basis for decision-making and community investment in local infrastructure including the transportation systems, land use decisions, and natural resource protection. They play a significant role in the ability of communities to continue maintaining infrastructure, attract residents and businesses, or support community goals by including policy documents that inform funding opportunities. The municipal plan and capital budget serves as a long-term guide, a basis for community programs and taxpayer investment, a basis for municipal regulatory action, a source of information about the community, and a source for community standards in regulatory proceedings at the state and regional levels.

SECTION 3

Planning for Green Streets

RICHARD AMORE

ST. ALBANS, VERMONT: A tour of Main Street stormwater improvements.

While much of Vermont is rural in nature, careful analysis of local policies and issues that relate to villages, downtowns, and neighborhoods can provide meaningful insight into community priorities. It is not unusual for a community to identify enhancement of streetscaping through green space and improved pedestrian access within the village as a goal in a town plan. During plan updates, identify opportunities to include goals that support the vision of Green Streets. Communities also use regulations to implement green infrastructure investments through zoning, subdivision regulations, and low impact development management standards. See *Vermont's Green Infrastructure Toolkit* for model language.

Downtown and Village Center Master Plans

Master plans present a community-driven vision of the built environment for a downtown/village center/neighborhood/street. Master plans engage the community in a process to evaluate ways to enhance their community through improved connectivity, rehabilitation of buildings, or redevelopment of sites, and the introduction or improvement of streets, parks, and open space. Frequently, these plans are illustrative in nature and offer detailed Green Street strategies for improvements to both the public realm and for private sector development. Master plans are action-oriented and lay out a strategic implementation plan for both short-term and long-term public and private (Green Streets) investments in the downtown, village center, or neighborhood.

Regional Plans

Vermont's 11 Regional Planning Commissions develop comprehensive plans that include an analysis of the regional transportation system, future regional land uses, infrastructure, and facilities. Regional Plans may have specific information regarding transportation improvement projects or areas in need of specific stormwater-related improvements. Additionally, many Regional Plans include policies supportive of Complete Streets concepts that are relevant to Green Streets implementation.

Regional Plans are required to address a number of natural resource issues in each region, including water quality, flood resiliency, and forests. Examine these plans for indicators of areas with significant water quality and quantity problems or for any basin-wide planning initiatives. Regional Planning Commissions are a valuable resource and are able to provide data, mapping, and guidance with regard to regional transportation infrastructure, flood resiliency, and water quality protection.

See *Vermont Association of Planning and Development Agencies* for a list of Vermont's Regional Planning Commissions.

Watershed, Stormwater, and River Plans

Municipalities engage in various planning efforts focused on assessing and protecting water resources that should be consulted.

River Corridor Plans written by the *Vermont Department of Environmental Conservation (DEC)* focus on the current conditions in the streams, brooks, and rivers and associated goals for preservation, protection, and restoration. They also include goals for management and the effect of land uses within the corridor.

Stormwater Master Plans are developed for dozens of *Vermont towns*. These documents provide details regarding areas of concern, optimal locations for stormwater management, a ranked list of projects based on cost and pollutant reduction potential, and often include partial designs on promising projects.

Tactical Basin Plans, also written by *Vermont DEC*, guide all work in a watershed, integrating priority items from complementary plans, including River Corridor Plans, Stormwater Master Plans, Backroads Inventories, and Agricultural Environmental Assessments.

Project Definition or Scoping Studies

Project definition studies, also called scoping studies, are often undertaken when a transportation need is first identified but before a preferred alternative is defined, selected, or funding is identified. If a municipality intends on using state and federal transportation funds to implement a project, it is highly recommended they undertake a project definition study. The Vermont Agency of Transportation (VTrans) funds a wide variety of projects to maintain and improve Vermont's transportation infrastructure, ranging from simple and low-cost projects to those that are more complex and costly. The VTrans Project Definition guidebook addresses how project definition may be applied in different situations, rather than prescribing a 'one-size-fits-all' approach to every project. The guidebook also provides room for flexibility to apply innovative methods and adapt to changing needs.

The project definition process includes the following steps:

- Developing the project purpose and need;
- Identifying the project context; identifying alternatives;
- Developing evaluation criteria and process;
- Selecting a preferred alternative and providing a rationale for its selection; and
- Involving stakeholders in the process. For details of the process see the *VTrans Project Definition Process Guidebook*.

VERMONT PLANNING RESOURCES:

Agency of Commerce and Community Development
accd.vermont.gov/community-development

Vermont's Green Infrastructure Toolkit
vpic.info/GreenInfrastructureToolkit.html

Vermont Association of Planning and Development Agencies
vapda.org

Vermont Department of Environmental Conservation (DEC)
dec.vermont.gov/

VTrans Project Definition Process Guidebook
vtrans.vermont.gov/sites/aot/files/highway/documents/publications/ProjectDefinitionProcessGuidebook2017.pdf

Tactical Basin Planning
dec.vermont.gov/watershed/map/basin-planning

Stormwater Maps and Stormwater Master Plans
dec.vermont.gov/watershed/cwi/manage/idde

Planning for Green Streets

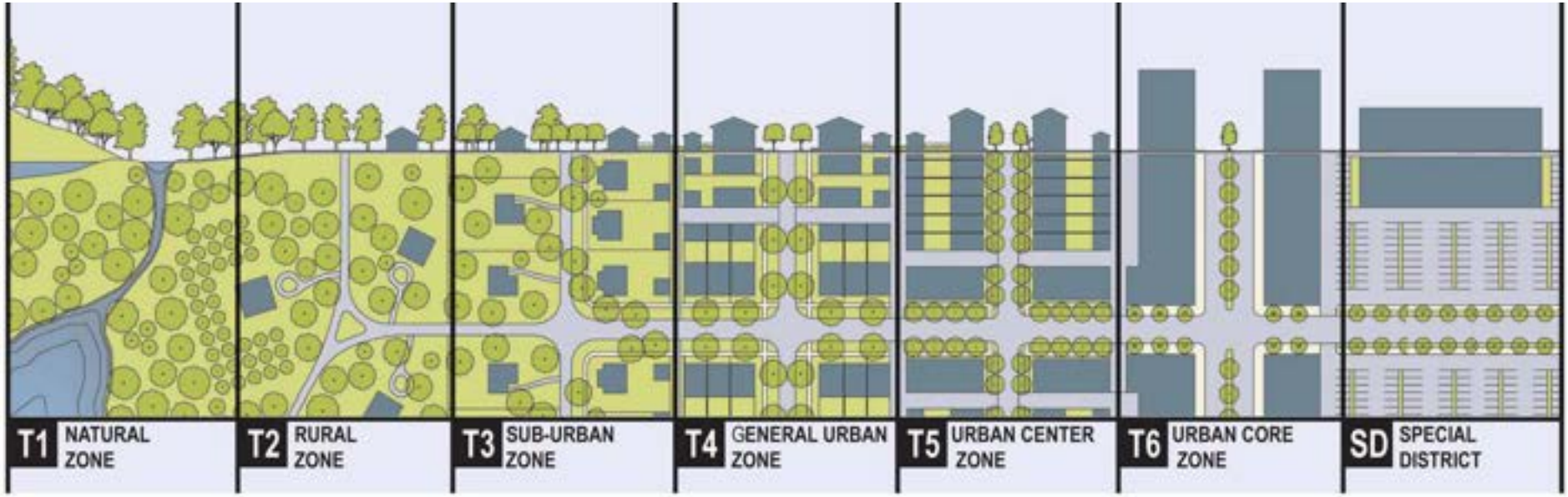
3.4 UNDERSTAND THE LOCAL CONTEXT

One of the key principles of Green Streets is understanding the local context. Green Streets recognizes that there is no 'one-size-fits-all' approach to identifying the type of improvements that can foster multimodal travel, establish a sense of place, or mitigate stormwater. For example, sidewalks work well in urban centers, but in very rural areas a wide shoulder might be more appropriate. Vermonters value the diversity and contrast between the working and natural landscapes and vibrant downtowns and village centers. The urban-to-rural transect is an illustration of this range of contexts, and can be a useful tool in planning and design.

Determine Street Type

The typology and function of a street should be considered when evaluating its Green Street potential. Any Green Streets infrastructure proposed in the right-of-way must consider effects on existing streets and users. Consider the following elements:

- **What type of street is it?** While adding vegetated swales or curb extensions to a side street may be the appropriate tool to use in areas where traffic calming is warranted, reducing travel lanes and providing landscaped medians might be better suited on an arterial road.
- **What is the street's jurisdiction?** In general, the numbered routes are state-controlled, but there are numerous exceptions. Major routes through downtowns or villages often shift to local control within the village boundaries – called Class I Town Highways. If the state owns and maintains the street, early and frequent coordination with VTrans and the District Office is essential.
- **What is the role of the street in the transportation network?** Determining the volume and mix of traffic is essential. Is there heavy through-traffic, or is it a low volume side street? Is it a Main Street or major freight route? What are existing bicycle and pedestrian patterns? A road that receives a significant amount of truck traffic may need to allow for wider turning



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RURAL TO URBAN DEVELOPMENT TRANSECT

vehicles and would benefit from more road-to-sidewalk buffer than a quiet neighborhood street. The level of traffic congestion is also necessary to understand, as there may be opportunities to reduce or change the number of lanes to better suit current travel patterns, freeing up paved area in the process.

- **What are the road's needs to maintain public safety?** Depending on the type of street, maintenance needs will vary. If the street is a main artery for emergency services, it's expected to be plowed quickly during winter storm events and this may necessitate larger equipment that could conflict with Green Street elements. Safe access of public safety vehicles also needs to be considered.

Determine Maintenance Capacity

The incorporation of Green Streets principles into the urban environment inevitably triggers a need to understand the local context, not only in terms of the location or type of system, but also the available capacity to maintain infrastructure over the long-term. A Green Street will inevitably fail if there is confusion over who is responsible for maintaining the infrastructure. Local knowledge and maintenance expertise involved early in the planning process are essential to the success of Green Streets projects.

3.5 IDENTIFY GREEN STREET AND PARKING LOT OPPORTUNITIES

There is no shortage of opportunities for introducing Green Streets into the built environment. The key is having the vision to identify these opportunities in both retrofit conditions and new development/redevelopment. One of the greatest opportunities in implementing Green Street projects is to look at the current built environment and to capitalize on inefficient use of space.

Identify Inefficiently Designed Streets and Parking Lots

One of the first questions a designer or builder should ask themselves about their project is: Has the impervious area from streets, parking lots, and/or buildings been minimized? From a design perspective, there are several practical strategies to reduce these areas. However, what makes sense from a design perspective may conflict with current policy. Design and policy must work together to achieve site-specific Green Streets goals. A carefully thought out site plan will often yield the space for green infrastructure that fits seamlessly with the other site uses. This holds true for new streets, parking lots, and buildings, but is especially evident when designing street and parking lot retrofit projects.

Efficient Design of Streets

Many streets are wider than necessary. Consider narrowing travel lanes down to the Vermont State Standards width of 10-11 feet (or less depending on neighborhood context) for urban and village principal arterials only or allowing more options for narrow street widths based on variable venues. Narrowing streets reduces impervious area and new development infrastructure costs, and contributes to traffic calming in pedestrian-oriented areas. The saved space also makes room for decentralized Green Stormwater Infrastructure techniques. Consider these questions when evaluating street width:

- **Can a travel lane on multi-lane streets be eliminated?** Many four-lane arterial streets can be placed on a "road diet" to allow for two travel lanes and a center turn lane.
- **Can the size or number of on-street parking spaces be reduced in favor of increased landscape area along a street?**
- **Are there existing zones marked "no parking" that can be consolidated into landscaped space designed to capture stormwater?**
- **Are there road shoulders next to travel lanes that could be converted into landscape areas?**

Exploring a "yes" answer to these questions can often yield landscape space for Green Stormwater Infrastructure, as well as create space for bike lanes, wider sidewalks, and a more balanced and vibrant streetscape.

Planning for Green Streets

GREEN STREET OPPORTUNITIES

▲ *Plaza spaces can utilize selective green spaces and pervious paving to manage stormwater.*

▲ *Arterial roads with existing landscape strips can be redesigned to capture runoff.*

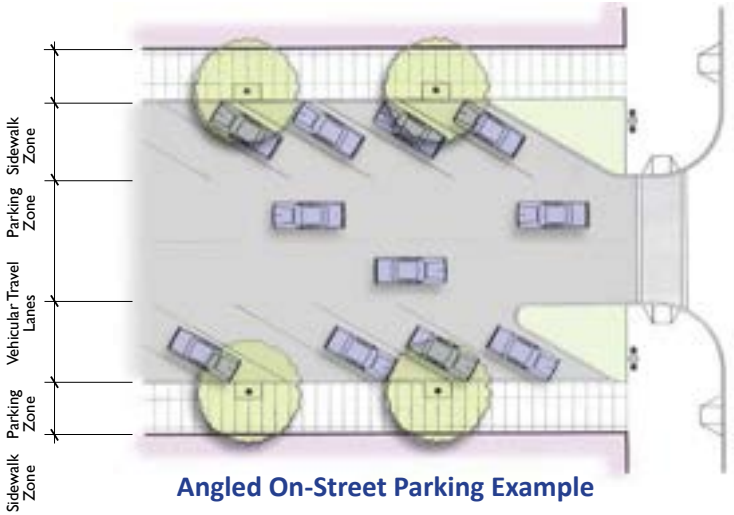
▲ *Angled parking spaces in town centers often have under-utilized space that can be transformed into green space*

▲ *Streets with on-street parking can utilize either pervious paving and/or stormwater planters to manage runoff.*

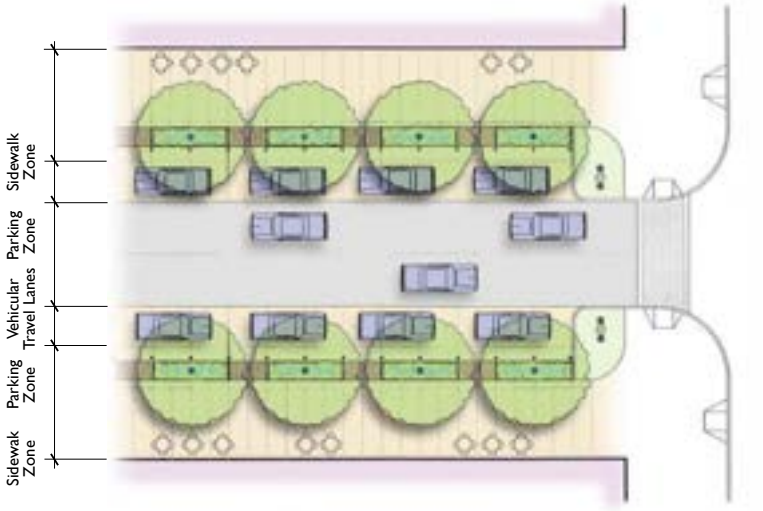
▲ *Red zones designated as no parking can also be transformed into green space used to capture runoff.*

▲ *Residential landscape strips and parking zones that are not heavily used can be retrofitted with larger rain gardens for stormwater management.*

ON-STREET PARKING OPPORTUNITIES



Angled On-Street Parking Example



Parallel On-Street Parking Example

The illustrations above compare the existing condition of using 30 degree angled on-street parking with that of a redesigned condition using parallel parking. By switching from an angled to parallel parking configuration, considerable space can be made available for wider sidewalks, more landscaping, and stormwater management with only minimal loss of on-street parking.

KEVIN ROBERT PERRY

▲ *Angled parking configurations, such as this example along Main Street in downtown Burlington, consumes vast amount of space and can often create a bleak pedestrian/retail environment.*

KEVIN ROBERT PERRY

▲ *This downtown main street has opted for increased landscaping, wider sidewalks, and fewer parallel parking spaces to help activate the retail scene.*

SECTION 3

Planning for Green Streets

SOPHIE SAUVÉ

MONTPELIER, VERMONT: A parking lot swale in autumn.

Efficient Design of Parking Lots

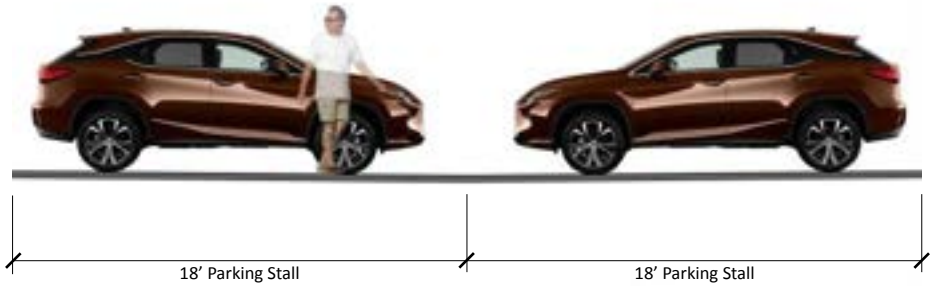
There are an estimated 800 million parking spaces in the United States. Many of those spots exist in expansive paved lots with uninterrupted impervious cover. Green infrastructure can be incorporated to moderate summer temperatures, improve safety, enhance aesthetics, and provide valuable stormwater treatment services. Parking lot retrofits can be accommodated with some simple adjustments:

- **Remove or adjust parking minimums in your town bylaws.** This will reduce the size and number of excessively large lots, freeing up more space for green and multifunctional elements.
- **Specify a 15-foot parking stall length and a 22-foot driving aisle in your town's municipal code.** These dimensions are adequate for modern vehicles but smaller than conventional standards.
- **Incentivize the use of pervious parking surfaces**. Particularly to address the needs of large event spaces and malls where maximum use is rare but necessary.

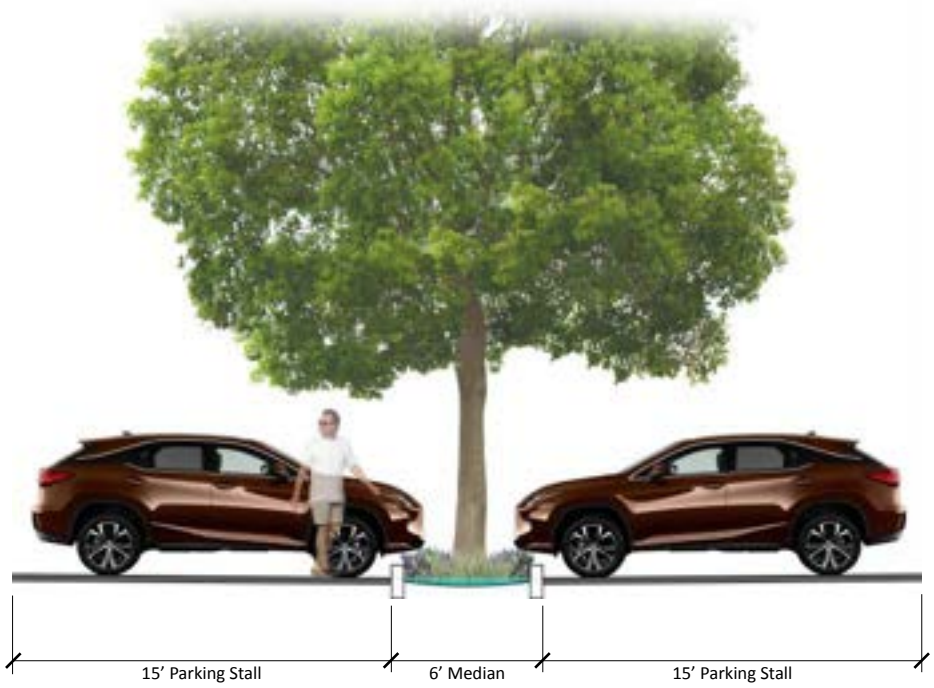
Balancing Green and Gray

Once a street or parking lot has been designed to be as spatially efficient as possible, the savings of space converted into green infrastructure may still not be enough to manage the desired amount of stormwater runoff. In these cases, decisions will need to be made to balance green and gray infrastructures. Adding green infrastructure can often conflict with the need for on-street or storefront parking, sidewalk space, emergency vehicle access, or maintenance needs. The best Green Street and parking lot designs should provide a balance. Given that many town streets are designed primarily for vehicular travel and on-street parking, with little or no green space, and parking lots are often oversized, some level of compromise will be necessary to design a truly balanced condition. Some parking loss might be acceptable or even desirable if the overall street or parking lot condition has a stronger aesthetic appeal due to increased landscape area and enhanced pedestrian spaces, or increased stormwater management potential. Studies have shown that greening of business districts increases community pride and positive perception of an area, drawing customers to the businesses.

PARKING LOT OPPORTUNITIES



▲ *This typical cross section illustrates a conventional parking lot condition with 18 feet long parking stalls.*



▲ *This cross section shows how a 15 feet parking stall can help create room for landscaping used for stormwater management. Note that the parked cars in both scenarios are placed in the same place and fit within reduced length the parking stalls.*

▲ *This parking lot in Middlebury shows how over-sized parking stalls create more impervious area and wasted space.*

▲ *This parking lot at Middlebury College is efficiently designed to mazimize the amount of landscape and trees on the site.*

Planning for Green Streets

PARKING LOT OPPORTUNITIES

▲ *Parking stalls that are not heavily utilized can be converted into landscaped areas designed to capture runoff*

▲ *Existing lawn areas can be transformed into rain gardens that capture and treat runoff prior to entering the storm drain system.*

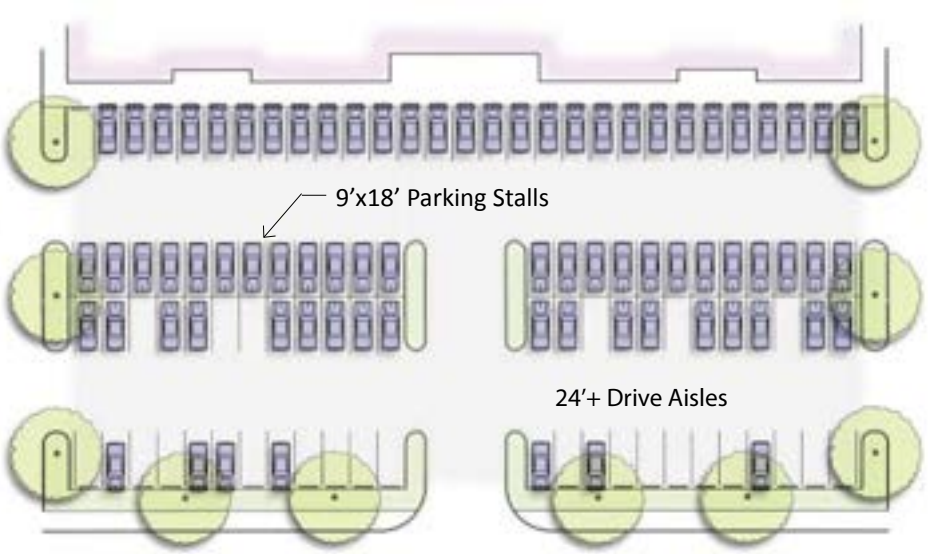
▲ *Overly long parking stalls can be shortened to allow for landscaped space at the front of vehicles to capture runoff.*

▲ *Some parking lot layouts are quite inefficient with excessive asphalt areas supporting only a few parking spaces. They can be redesigned to yield more landscaped space.*

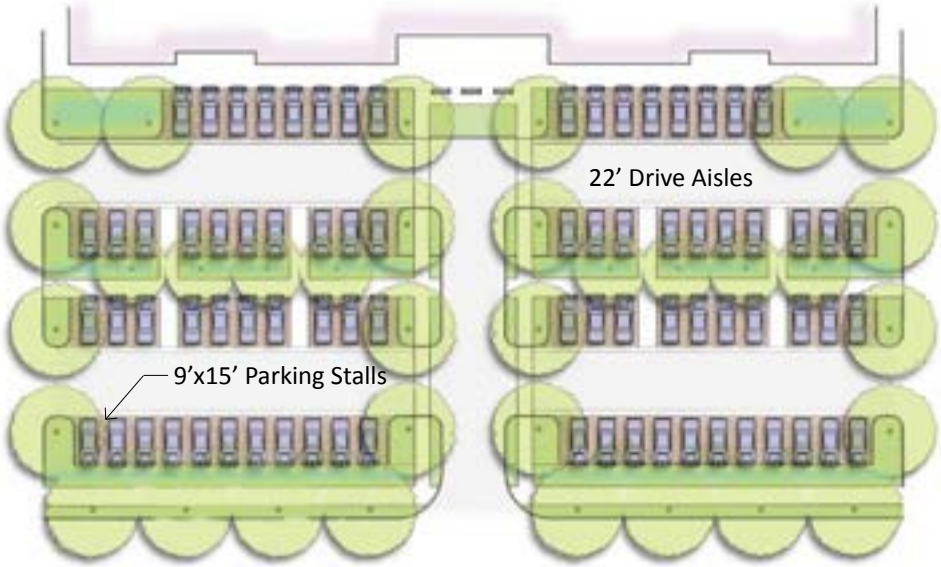
▲ *Existing parking lots often are completely paved with no landscaping and poor pedestrian circulation.*

▲ *Even well-used parking lots sometimes have existing landscaped space that can be redesigned to capture runoff.*

PARKING LOT OPPORTUNITIES



Oversized Parking Lot Dimensions



Efficient Parking Lot Dimensions

KEVIN ROBERT PERRY

▲ *This parking lot in Vermont has little interior landscaping and has oversized parking isles.*

LES VICTOIRES DU PAYSAGE

▲ *This parking lot example in France significantly increases pervious surfaces and landscaping within the parking lot, provides for safe pedestrian circulation, and manages runoff on site.*

Planning for Green Streets

3.6 MULTIPLE SHADES OF GREEN

Green Streets vary according to the site and do not all fit into one definition. For the purposes of this guide, they include streets and parking lots designed with a landscape or paving system that slows, captures, filters, and infiltrates stormwater runoff while supporting mobility and providing comfort and security for all users. The degree to which a project takes the Green Streets approach can vary based on goals, available resources, and space constraints.

We can think of green streets as having various levels of sustainability ranging from simple Level 1 designs to the most complex Level 5 designs. The boldest Green Street designs intertwine stormwater management with the tenants of livability and placemaking. They are primarily related to streets, not parking lots. New and redevelopment projects offer more opportunities to achieve a higher level of site integration. Other projects - especially retrofits - might only be able to achieve minimal green design due to site constraints or existing policy restrictions. Regardless of challenges, the most important consideration is to always strive to reach the highest level of green design possible.

KEVIN ROBERT PERRY

LEVEL 1

LEVEL 1 is simply an increase in the amount of vegetation along a street and reducing the area of impervious surfaces.

KEVIN ROBERT PERRY

LEVEL 2

LEVEL 2 design features a street or parking lot with substantial landscape areas and a system of broad canopy trees to capture rainfall. There may be no dedicated stormwater treatment measures, but on days with minimal rainfall, most stormwater may be captured within the tree canopy, soil, and landscaping.

KEVIN ROBERT PERRY

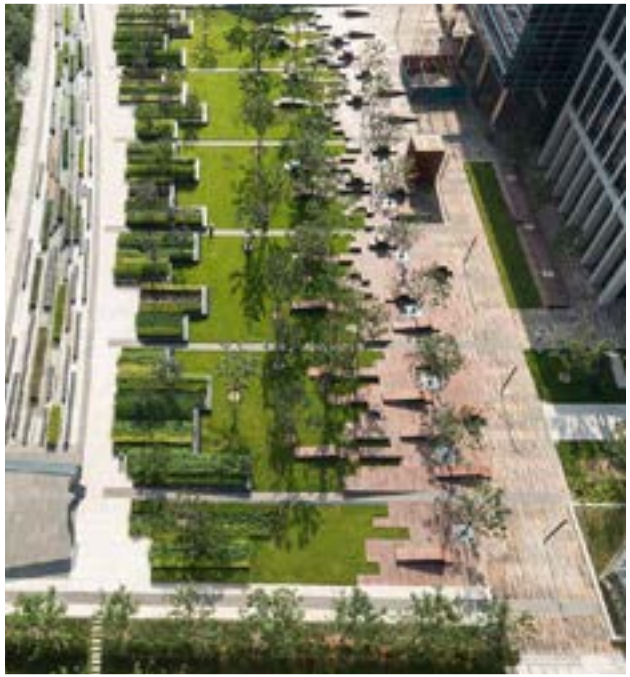
LEVEL 3

LEVEL 3 design represents the most common perception of a Green Street or Green Parking Lot in which some type of stormwater treatment measure (e.g., vegetated swale, planter, rain garden, etc.) actively captures and manages surface runoff at its source.

KEVIN ROBERT PERRY

LEVEL 4

LEVEL 4 design not only encompasses the attributes of Levels 1, 2, and 3, but also provides a direct emphasis on alternative transportation options, such as walking, biking, or use of buses or trains.



MARTHA SCHWARTZ

LEVEL 5

LEVEL 5 design is the most effective level of Green Street design, and is the most challenging to achieve. This comprehensive approach allows stormwater to be managed within the entire street envelope and begins to blur the line between public and private space. Stormwater from private driveways and buildings can be managed within the public right-of-way, and stormwater from the street is filtered in available landscape spaces on private property.

Planning for Green Streets

ANDREW HILLMAN

LANCASTER, NEW YORK: Pervious Pavement and no-curb landscape median.

3.7 KEEP IT SIMPLE

Just as Green Streets can be multiple shades of green, they can also have multiple levels of complexity. Identify those projects that are simple and low-cost, then rank them as high-priority. Too often, very complex green infrastructure projects are built first, leaving small "low-tech" projects with little funding capital to implement. Simple, low-cost Green Street projects might include modification of underutilized spaces that already receive stormwater. Examples include conversion of an on-street parking zone with an existing drain inlet into a stormwater curb extension or the addition of street trees to an existing lawn strip along a residential neighborhood street. These solutions rely on simple regrading or replanting, minimal hardscape improvements, and little or no alteration of the existing stormwater system.

3.8 A PLAN OF ACTION

Identifying your vision, goals, and objectives, and understanding how these relate to the local context is essential to developing a plan of action. Equally as important is identifying the barriers to implementation including physical and environmental constraints, skepticism, land ownership, maintenance considerations, and funding. Transforming a street into a Green Street or parking lot, or a community to fully embracing Green Street principles does not need to be an all-or-nothing all-at-once approach, but can include several short, medium, and long-term actions that ultimately move to the (re)design of streets and parking lots. The plan should be realistic, with phasing based on feasibility and funding.

Planning for Green Streets

BURLINGTON, VERMONT: A vegetated swale between a bike path and parking lot.

BURLINGTON, VERMONT: A wetland adjacent to a bike path.

Section 4

Green Street Design Principles

SECTION 4

Green Street Design Principles

KIMBERLY JENSEN

MORRISTOWN, VERMONT: A bioretention area in a school parking lot median.

Aligning street and parking lot use and long-term Green Street objectives can help communities make the most of their streets and time projects for when opportunities arise.

4.1 LANDSCAPE APPROACH

Low Impact Development (LID) is a design approach that recognizes the value of natural landscape features that support the infiltration, evapotranspiration or use of stormwater to protect water quality and associated aquatic habitats. LID principles indicate that key site characteristics should be preserved for optimal environmental outcomes. Before beginning to design a Green Street, take an LID approach and evaluate your site for successful ecological or community features that can be preserved or enhanced. These features might include something as expansive as a continuous wetland system but could also come in the form of matures trees. For example, in areas without curbs, examine all pros and cons of adding curbs that may channelize stormwater flow. Adjacent landscape areas may already be directing or filtering stormwater. Consider how these features can be integrated into the design rather than eliminated in lieu of something entirely new.

4.2 STORMWATER MANAGEMENT PRINCIPLES

A landscape approach to stormwater management entails bringing together built and natural elements valuing water as a limited and precious resource, rather than as waste or a problem. It also recognizes that each site is unique, both in constraints and opportunities and applicable design solutions must reflect the context. Simultaneously, public safety is holistically addressed by catalyzing on more livable spaces and sustainable environments. By aiming to reduce the amount of impervious cover and seeing every surface as an opportunity to capture water, an integrated design can emerge which is not only effective, but pleasant to experience.

Green Streets strive to meet three general goals when addressing water treatment: 1) **water quality goals**; 2) **flow reductions goals**; and 3) **volume reduction goals**. Achieving all three goal categories is ideal but seldom possible based on site and capacity restraints.

Green Street Design Principles

WATER QUALITY GOAL

KEVIN ROBERT PERRY

WATER QUALITY GOALS include ensuring that runoff that enters waterbodies is free of pollutants. Filtration through assemblages of plants and soil media can physically trap suspended sediments, chemically bind nutrients and metals, and biologically transform pollutants. This goal may be especially relevant from a compliance standpoint for communities with an impaired waterbody.

FLOW-REDUCTION GOAL

KEVIN ROBERT PERRY

FLOW REDUCTION GOALS recognize the negative impact that stormwater runoff velocity can have on waterbodies – regardless of the quality of the runoff water. Common strategies to achieve this goal include facilities that detain stormwater for slow release over several hours following a rain event. Stormwater detention ponds are a commonly-used practice to meet this goal but they require large areas of land. Integrating functional design elements such as rain gardens, pervious paving, and green roofs in a decentralized system addresses flow reduction within a developed area. Naturalized surfaces can help slow the flow by mimicking the natural hydrological cycle. Achieving this goal may be especially beneficial to a community with a steep topography that contributes to accelerated velocity of flow.

VOLUME-REDUCTION GOAL

KEVIN ROBERT PERRY

VOLUME REDUCTION GOALS are focused on the management of the overall volume of water that enters waterbodies as surface runoff. Retention systems that hold water for longer-term storage or infiltrate runoff into the ground reduce the overall volume of surface flow. Plants also play an important role in volume reduction by intercepting rainfall, taking up water from the soil and causing evapotranspiration as well as providing conduits for infiltration adjacent to root systems. Aiming for volume reduction may be especially beneficial for large catchment areas where the amount of runoff can be particularly damaging to receiving waters.

Green Street Design Principles

WARD JOYCE

MONTPELIER, VERMONT: The Main Street Pocket Park.

4.3 STREETSCAPE PRINCIPLES

Placemaking

Placemaking is an essential element in the success of Green Streets, yet it is often overshadowed by the importance of stormwater management. While streets are primarily used for getting from one place to another, they are also meant for people to walk, gather, rest, and interact. Placemaking is a way to make the village or downtown a better place to live and work by transforming streets into vibrant community places. Well-designed streets and wide sidewalks can allow for unplanned human encounters through amenities such as benches at street intersections and mid-block locations. Existing parking spaces and private frontages can be transformed into "parklets" (as shown in the example on this page) that can foster a greater sense of place. Combined with a backdrop of green infrastructure and trees, streets can thrive, surrounding businesses can prosper, and stormwater can be managed.

Walkability

Providing adequate pedestrian circulation along streets and in parking lots should always be a priority and should not be compromised when considering stormwater systems. Many Green Streets can offer solutions for better pedestrian circulation by providing more buffer against vehicular traffic, reducing pedestrian crossing distances, or improving sight angles at intersections. Many conflicts arise when trying to integrate stormwater systems with the need for on-street parking. However, there are ways that stormwater systems can be integrated into differing street conditions while still maintaining on-street parking and adequate pedestrian circulation.

Creating Safe Access

When on-street parking is designed next to a stormwater system, it is critical to consider where people will walk when they leave their cars. People need adequate room and a place to step when they exit their vehicle that does not interfere with the stormwater system. This area should be a minimum of 3 feet wide adjacent to the street curb. Pedestrians also need to have sufficient access from the sidewalk to the parking zone. This can be provided by installing frequent walkways or bridges across stormwater systems.

Green Street Design Principles

People also need to safely detect where there is a change in grade adjacent to walkways. Where there is a vertical grade change of more than 6 inches immediately adjacent to a sidewalk zone, every effort should be made to visually and physically denote this through installation of a raised curb edge, a low-profile railing, or detectable warning. These design elements give people, especially the visually-impaired, a means to safely navigate around any grade changes.

Bikeability

Bicycling, whether for commuting to and from work or for recreation, requires safe and connected streets. Design elements should address the range of both existing and potential bicycle users. For low-volume and low-speed residential streets, use sharrows (painted symbols) on the road to signal a shared use between bikes and vehicles. On busier streets separate, painted bike lanes and signage are often warranted. In high use corridors and areas with on-street parking, bicyclists and vehicles may need to be completely separated from each other on the street through use of landscaped buffer areas. These landscaped buffers are well-suited for green infrastructure facilities that can also capture stormwater.

Transit Facilities

Along streets with higher traffic volumes, transit stops and pedestrian amenities should also be included and be connected to walking and biking systems. Green infrastructure systems such as stormwater planters, pervious paving, and green roofs covering bus shelters can provide stormwater benefits as well as opportunities for education about stormwater.

Outreach and Education

Active pedestrian use also provides educational opportunities to showcase the differences between conventional streetscapes and the functional landscapes of Green Street design. Sometimes, this can be accomplished through educational signage. In other instances, this may require low fences, rails, or exposed curbs to alert users of the presence and value of green infrastructure. Investment in outreach often gives users of the site a greater sense of responsibility to keep the site clean, care for the plants, and respect the overall space.

KEVIN ROBERT PERRY

▲ *This Green Street project utilizes a series of stormwater planters while maintaining on-street parking and adequate space for pedestrian circulation.*

KEVIN ROBERT PERRY

▲ *This bold Green Street project separates bike, pedestrian, and vehicular movements with vegetated swales and stormwater planters.*

Green Street Design Principles

KEVIN ROBERT PERRY

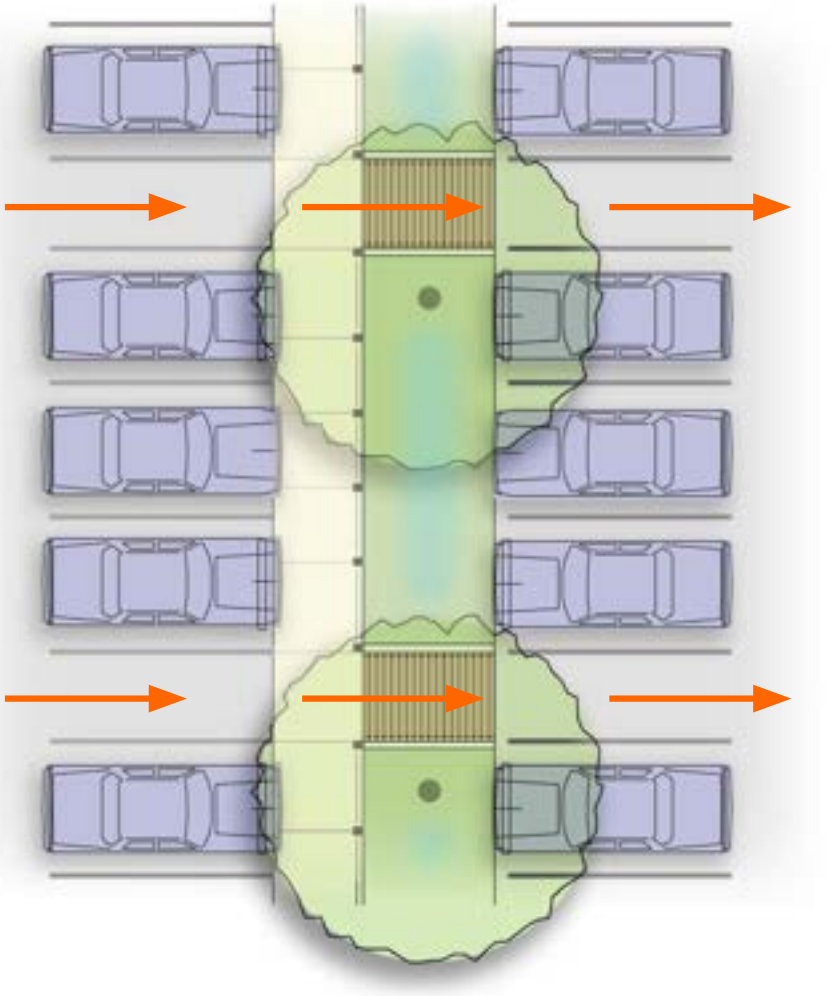
BRISBANE, CALIFORNIA: A pedestrian bridge crossing a rain garden.

Walkability In Parking Lots

Pedestrian circulation is an important design consideration when using stormwater systems in parking lots. It is essential to identify the primary pedestrian destination(s) in relation to the parking lot. For stormwater management, it is best to align stormwater systems perpendicular to the sheet flow of water to maximize the capture potential. Sometimes this optimum alignment conflicts with the desired pedestrian flow to and from a destination. It is important to design a parking lot that provides bridges/pathways over the stormwater systems and/or walkways for people to safely walk alongside and to prevent people from cutting through the landscaped areas. Inadequate provisions for pedestrian circulation may result in trampled plants, compacted soil, and increased erosion in the stormwater system.

Many well-intended landscape projects are negatively impacted by wayward foot traffic and trampling. Providing ample space for pedestrian circulation within or around green infrastructure ensures basic safety for both people and plants. Consider natural human movement patterns in a downtown street scape or parking lot. Provide clearly delineated and convenient walking spaces to avoid vegetation damage.

WALKABILITY IN PARKING LOTS



Perpendicular Pedestrian Flow

Pedestrian circulation is perpendicular to a stormwater facility alignment

KEVIN ROBERT PERRY

▲ *To protect plants from being trampled, multiple pedestrian crossings were placed through a rain garden at this middle school project.*

KEVIN ROBERT PERRY

▲ *Another method for protecting plant material from foot traffic but also provide space for stormwater management is to introduce raised boardwalks over the landscape.*

RICHARD AMORE

ST. ALBANS, VERMONT: A Downtown Main Street pedestrian crossing.

Section 5

Design Considerations: Physical & Environmental

SECTION 5

Design Considerations: Physical & Environmental

KEVIN ROBERT PERRY

BURLINGTON, VERMONT: Driveway curb cuts and narrow storefront sidewalks.

5.1 DRIVEWAY LOCATIONS

Like any street, Green Streets must accommodate access to residential and commercial driveways. However, closely spaced driveways limit opportunities to implement Green Street design elements by breaking up linear green road buffers. They also pose increased risk for pedestrians and cyclists. Consider an access management plan that consolidates closely spaced driveways and incorporates adequate areas for vehicles to safely enter and exit without damaging adjacent stormwater landscaping.

5.2 UTILITIES

Above- and below-ground utility conflicts are among the most commonly perceived physical constraints to implementing Green Streets projects. Utilities and stormwater systems can coexist with the right site conditions and stakeholder support. Understanding and communicating different approaches to dealing with potential utility constraints is critical as they range in cost and complexity.
Work with the local utility companies during the design process to identify existing utility needs and concerns. Where overhead utilities are present, carefully consider and plan for the mature height of selected shade trees to avoid conflicts. Be aware of minimum required setback distances for maintenance of above- and below-ground utility infrastructure early in a Green Streets effort. Work to avoid potential conflicts associated with infiltrated stormwater increasing subsurface saturation by prioritizing alternatives - such as lined filtration units - where there is concern. Pervious pavers and low-expenditure landscape stormwater systems may reduce the cost of underground utility access for repairs as they are easier to remove and replace than traditional hardscapes.

5.3 EXISTING TREES

Existing healthy trees are an extremely important element of Green Street design. Construction of Green Stormwater Infrastructure adjacent to existing trees should preserve the integrity of the soil and roots within the tree's critical root zone. At a minimum, this is the area under the tree's canopy. Although many tree species will benefit from the increased availability of water, some species may not respond well to a sudden influx of stormwater at the root zone. Green Street designers should consult with a qualified arborist when planning new Green Stormwater Infrastructure adjacent to existing trees.

5.4 COMMERCIAL STOREFRONTS

Although many businesses will welcome improvements to adjacent streetscape, some storeowners may be concerned that new landscaping will obscure the visibility of their storefront, compete for valuable sidewalk space for signage or pedestrians, or inhibit their ability to provide ADA access to their store. Additionally, new stormwater management approaches may be perceived as potential causes of ponding or damage to existing built infrastructure. As a general rule, stormwater infiltration should not occur any closer than 10 feet from a building foundation. Any infrastructure placed within 10 feet of a building foundation should not promote water migration underground. Lined filtration practices with underdrains or container landscaping will capture rainwater without diverting it toward building foundations and can safely and effectively be employed in space-constrained downtown locations.

5.5 TOO MUCH STORMWATER

Large parking lots and broadly paved downtown areas generate a large volume of stormwater runoff. Addressing the volume issue with green features requires a decentralized treatment approach where multiple small practices installed evenly throughout a landscape manage the water volume incrementally. The combined impact is superior to large individual practices (such as detention ponds) that are less effective at mimicking natural hydrologic conditions.

KEVIN ROBERT PERRY

▲ *Commercial storefronts often have highly-impacted furnishing zones.*

KEVIN ROBERT PERRY

▲ *Many downtown streets are the low points for all drainage and receive significant amounts of runoff.*

Design Considerations: Physical & Environmental

RICHARD AMORE

BRATTLEBORO, VERMONT: A parking lot rain garden.

5.6 TOPOGRAPHY AND SLOPE

Steep slopes can present design challenges and opportunities. In Vermont, steep slopes can express the character of a town. Where a village center is sited on a gradient, the flow of stormwater should be expected to be more rapid and efforts to infiltrate must consider a terraced approach to allow sufficient time for water to move into the soil profile. Slope stabilization is critical for improved water quality and public safety as instability can lead to erosion and slumping. Vegetative cover at multiple levels – from canopy to ground cover – is a highly effective method for ensuring stable green spaces on slopes. Care should be taken when directing stormwater runoff to a steeply sloping vegetated area to account for expected velocity and volume in high flow events to avoid potential damage.

Where adjacent private properties contribute flow to a public right-of-way (via long sloped driveways, for instance), working directly with several landowners to incrementally address runoff from each property may be most efficient. Recognizing features, such as slope, as unique assets of place rather than design hindrances can make unique solutions more likely.

5.7 SOILS

The structure and composition of soil affects vegetation success, types of structures that can be installed, and the capacity of water to penetrate the ground. Urban soils can be challenged by human influences such as compaction, salt addition, industrial pollution, and hydrologic alterations from development.

All rooted vegetation receives nutrients, water, and stability from the soil. No matter the species, successful plant growth requires access to sufficient soil volume with the necessary amount and ratios of those necessities. Vegetation types vary in their specific requirements regarding space, water saturation tolerance, and chloride sensitivity. When selecting species, their needs should be considered in relation to the site's soil characteristics. Where soil amendments are required for plant establishment, restraint should be used in the addition of excess nutrients as they can leach from the landscape (particularly if the vegetated area is used as a focused stormwater practice) and negatively impact water quality.

Design Considerations: Physical & Environmental

In locations where soils are contaminated with pollutants, are excessively wet, or exhibit slow infiltration rates, green infrastructure selection should reflect the challenges. For instance, while infiltration is not appropriate in saturated soils, subsurface filtration in an under-drained bioretention practice may be a suitable alternative. Soil conditions within a Green Stormwater Infrastructural practice will influence the water quality of its effluent. As a result, constituents of native soils and engineered media should be determined to not leach any undesirable elements into the water that passes through.

Soil Hydrologic Group

Soils are classified by hydrologic group based on how readily they infiltrate water. Soil hydrologic groups A or B denote high infiltration rates and low runoff potential. These soils are mostly deep sands and gravels and are ideal sites for infiltration practices and can accommodate large volumes of water over short periods of time as a result of their physical characteristics. Soil groups C or D are characterized by slower rates of infiltration due to finer soil texture (chiefly silt and clay) and an impediment to downward water movement, often from either a high groundwater table or a subsurface clay pan restricting flow. While not ideal for infiltration practices, C and D soils can be effective sites of filtration practices (such as gravel wetlands or lined bioretention). Planting trees, shrubs, and other plant material with extensive root systems can help loosen tight soils, provide more infiltration capacity and capillary storage space, and allow for greater evapotranspiration of water. Green Street designs in group C and D soils can also incorporate additional draining components such as underdrains to account for the limited infiltration capacity of the native material.

Be Aware of Hazardous Materials

Know the history and prior uses of a site before determining the safety of a stormwater infiltration practice. Consult municipal records and prior deeds and if contamination is suspected, test soils for any hazardous materials.
Per the Vermont Stormwater Manual (Manual), areas with concentrations of hydrocarbons, trace metals, and other contaminants above those found in typical stormwater runoff are referred to as 'Stormwater Hotspots'. Hotspots include areas where there is a potential risk for spills, leaks, or discharges, such as petroleum

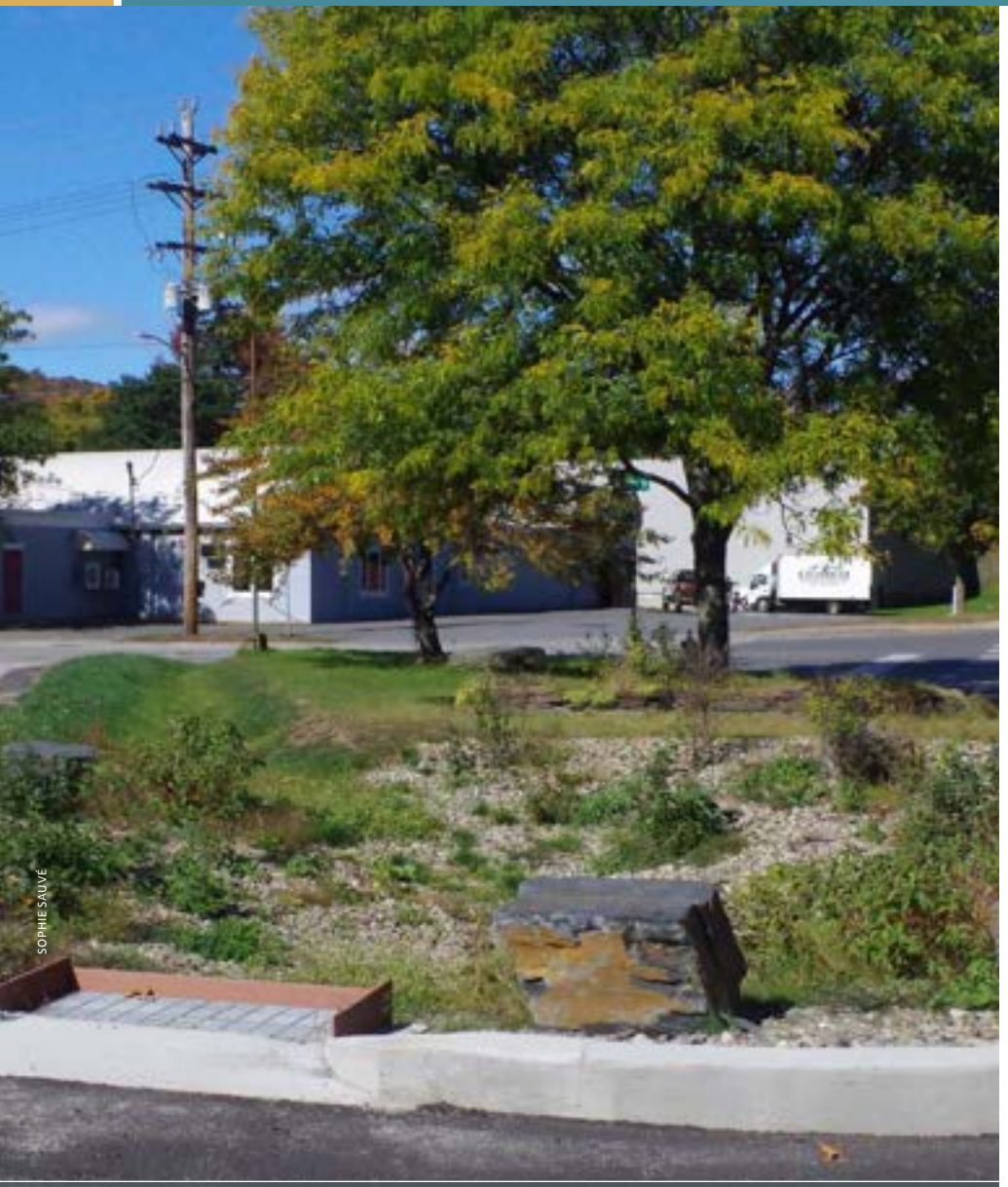
KEVIN ROBERT PERRY

▲ *Despite native soils with high clay content and low infiltration rates, this green street project with a shallow graded landscape filters pollutants while retaining only 2-3" of runoff. This allows runoff to infiltrate or evaporate within a reasonable amount of time.*

KEVIN ROBERT PERRY

▲ *Conversely, this green parking lot project has excellent free-draining soils and is designed to retain the maximum amount of stormwater runoff. Stormwater is infiltrated within a span of a couple of hours.*

Design Considerations: Physical & Environmental



NORTHFIELD, VERMONT: A rain garden in a private parking lot.

distribution centers, hazardous material loading and storage facilities, and many other industrial sites. Due to the threat of pollution migration, and to prevent groundwater contamination, stormwater that encounters hotpots should not be treated with stormwater infiltration practices. Please consult the Manual for more information.

VT Agency of Natural Resources hosts a geographical tool, *Natural Resources Atlas,* that can help identify hotspots if it's located adjacent to a dry cleaner, or has a land use restriction associated with the property as well as the other sources you've provided. From the Atlas, open the waste management layer and select the following categories: *landfills*, *land use restrictions*, *hazardous site*, *hazardous waste generators*, *brownfield*, *salvage yard*, *AST*, *UST*, *dry cleaner*, and *urban soil background area*.

Increasing Soil Volume to Support Vegetation

One of the most important factors to consider in a Green Street design with vegetation is available soil volume. Trees planted in sidewalk cutouts along streets typically have very limited soil volume, leading to stunted growth, sidewalks heaving due to constricted root growth, and shortened lifespan. A tree's ability to grow and thrive is largely dependent on available rooting space. Trees need at least 1 to 2 cubic feet of soil volume for every square foot of crown area projection. For columnar or fastigiate trees, which have a narrower overall crown area, the diameter at breast height or DBH should be used to estimate the soil volume needed for a specified tree.

5.8 WINTER CLIMATE CONSTRAINTS

Vermont's winters can limit certain Green Streets applications, but clear knowledge of thresholds and careful planning can safeguard success.

- **Identify the soil's frost depth and install below it**; for most of Vermont the depth of frost protection is five feet. Similar to designing footings for retaining walls or stairs in our winter climate, footings and any inlet and outlet pipes in stormwater basins need to reach below frost depth. If not properly located below frost levels, they can freeze and cause water

Design Considerations: Physical & Environmental

to bypass the practice untreated, or can crack and cause maintenance problems. Additionally, any low-flow orifice can become clogged with ice, potentially causing flooding.

- **Verify plant hardiness zones and avoid planting salt-intolerant species directly adjacent to roads**. Note that salt can damage vegetation and soil structure, creating less permeable soils and further reducing the effectiveness of any practices located near the road. In vegetated infiltration practices adjacent to road surfaces, select road deicing practices less likely to cause damage. Discuss the reduction of salt use and alternative approaches to deicing in combination with a Green Street is essential.

- **Carefully consider the limitations of permeable pavement.** The use of sand on permeable pavement can eventually clog the pavement and the subbase below, rendering the system impermeable. Limiting the use of permeable pavement to areas with low traffic volumes, that only use salt for de-icing, have good drainage and enough storage capacity underneath, is essential, but not impossible.

- **Understand restrictions of road and sidewalk removal equipment**. Adding medians or stormwater bump-outs may require a different approach to snow plowing and in some cases, require different snow plowing equipment. Municipal Public Works staff need training to anticipate changes on roads with traffic bump-outs, especially during winter months, to avoid damage to new curbing and to avoid storing snow in Green Stormwater Infrastructure areas. Trees along the streets may also require special protection during the winter to protect from mechanical damage from the plow or other snow removing equipment. Permanent or temporary guards can be installed.

- **Plan for street sweeping soon after the snow melt in the spring.** Street sweeping will help to reduce the volume of sediment that gets carried to conventional systems. Street sweeping can also be undertaken after intense storm events to prevent additional runoff from erosive material.

WARREN SPINNER

▲ *These street trees are installed with structural soil to increase soil volume and allow for greater root expansion. (Winooski)*

KEVIN ROBERT PERRY

▲ *Winter conditions require the use of snow removal equipment even on sidewalks. Green street design should help accomodate maintenance equipment as much as possible.*

SOPHIE SAUVÉ

BURLINGTON, VERMONT: New pervious pavers at Champlain College.

Section 6

Green Stormwater Management Tools

SECTION 6

Green Stormwater Management Tools

ANDREW HILLMAN

QUEENS, NEW YORK: A simple and colorful stormwater planter along a sidewalk.

Section 3.5 of this guide illustrates ways to design sites to maximize spatial efficiency and create room for potential stormwater practices. Combining site design philosophy and the full toolbox of stormwater management strategies that are most applicable to conditions in Vermont, optimizes the potential for stormwater management in urban conditions.

Green stormwater tools can be classified based on their dominant functional mechanism: **1. Conveyance and Treatment**, **2. Infiltration/Filtration,** and **3. Evapotranspiration**. Understanding the function of stormwater tools can help to prioritize the most appropriate options for your site conditions.

CONVEYANCE AND TREATMENT

Conventional conveyance structures primarily perform the function of moving stormwater from one place to another. The green versions of this functional group differ from conventional conveyance systems because vegetated structures also provide some filtration through plant structure, infiltration as water from the surface moves through the soil profile, and evapotranspiration as plants take up water in the channel. Open vegetated conveyance structures provide more water quality benefit - in terms of quantity and quality - than closed piped systems which solely provide water movement conduits without treatment. In downtown areas where space is limited, treatment at the source of stormwater is not always possible. The following conveyance tools can be applied where water needs to be moved from one location to another before treatment or discharge. Many green practices rely on a combination of mechanisms; here, they are categorized based on dominant functional type.

INFILTRATION / FILTRATION

Infiltration is the action of water moving vertically through soil media and into groundwater. This removes pollutants from the water and eliminates excess surface runoff by providing a conduit for water to enter subsurface channels. Filtration is a similar mechanism initially, but results in a surface discharge of cleaner water rather than its infiltration underground. Infiltration practices are best suited in well-drained soils where stormwater can readily move into the ground. They are most appropriate in areas where there are no hazardous materials either in the soil media or being transported in stormwater runoff. Filtration practices are

more flexible in their appropriate application because they do not function by the movement of water throughout a soil profile and therefore do not require highly infiltrative soils or extreme caution to protect groundwater quality.

EVAPOTRANSPIRATION

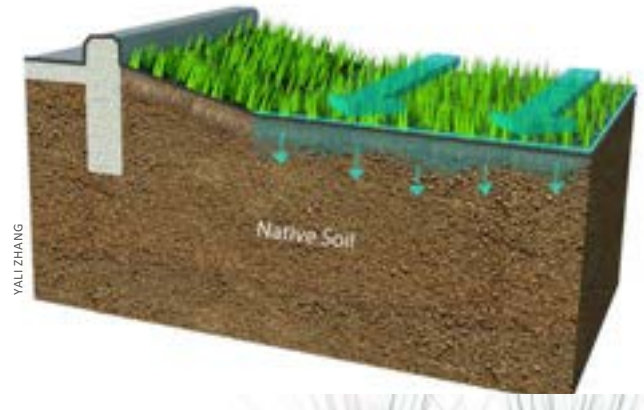
Evapotranspiration refers to the actions of evaporation (the change of water from a liquid to gaseous phase) and transpiration (water movement from a plant's roots through its vascular system). Plants move water into the atmosphere from the ground by taking up more than is required for biological processes. The excess is evaporated from aerial plant parts and returned to gaseous form. This is a critical part of the natural hydrologic cycle that is most often lacking in our downtown centers. By providing space for vegetation - most notably, large trees - to grow and thrive, evapotranspiration can be maximized.

6.1 THE STORMWATER MANAGEMENT TOOLS

Green Stormwater Management Tools showcase ways that stormwater can be actively managed. This section details design parameters and examples for street and parking lot applications for the most common tools for Green Street application.

Each Tool description includes:

- How it works and common applications;
- Environmental, transportation, and community benefits;
- Constraints; and
- Typical unit cost range



CONVEYANCE/ TREATMENT FACILITIES

FILTRATION FACILITIES

INFILTRATION FACILITIES

Green Stormwater Management Tools

SOPHIE SAUVÉ

HINESBURG, VERMONT: A vegetated swale along a residential street.

6.2 VEGETATED SWALES

Vegetated swales are long, narrow landscaped depressions with slight longitudinal slopes. They are primarily used to convey stormwater runoff on the land's surface while also providing water quality treatment. As water flows through a vegetated swale, it is slowed by the interaction with plants and soil, allowing sediments to settle out. Pollutants are entrapped by vegetation or broken down by microbial action, rendering the water cleaner. Some water is taken up by plants, and some infiltrates through well-drained soil. The remaining water that continues to flow downstream travels more slowly than it would through pipes in a conventional stormwater conveyance system. Vegetated swales are designed to be shallow (12 inches or less), with gently sloping sides (no more than 3:1), to transport runoff only a few inches deep in the bottom of the channel. They can be planted in with any type of vegetation, from mown grass to a diverse palate of groundcovers, grasses, sedges, rushes, shrubs, and trees. Generally, ground cover should be full and thick and maintained at a height of at least 4 inches for best water quality results.

Opportunities for Streets and Parking Lots

Swales are excellent choices for new residential and commercial development and can be retrofitted along arterial streets and within parking lots where space allows. Parking lots and certain streets that have a long, continuous space to support a functioning landscape system are excellent candidate sites for vegetated swales. The longer a vegetated swale is in relation to the volume of water it carries, the greater the time for slowing and filtering of stormwater runoff. Existing streets often have a wide right-of-way space that is underutilized. Consider removing existing buried storm sewer pipes and replacing with vegetated swales to achieve a similar conveyance purpose with greater water quality benefit.

There are many creative ways to include swales in parking lots. Oversized parking stalls can be shortened to yield a few extra feet for swale installation at the perimeter of the lot. Existing landscaping can readily be integrated into a vegetated swale design with no functional or aesthetic loss.

Green Stormwater Management Tools

STORMWATER FUNCTION

- ✓ Conveyance & Treatment
- ✓ Infiltration/Filtration
- ✓ Evapotranspiration

NICOLE LIMESAND

EXAMPLE VEGETATED SWALE

ACTIVE TRANSPORTATION

Supports Pedestrians	●●●●●
Supports Bikes	●●●●○
Calms Traffic	●●●●○

Can act as buffers between sidewalks, bike lanes, and vehicle travel lanes, contributing to the safety and walkability of a street.

URBAN ECOLOGY

Manages Stormwater	●●●●○
Enhances Habitat	●●●○○
Cools Air Temperature	●●●○○

Excellent method for cleaning water prior to entering a downstream waterbody and are superior to pipe and gutter systems for this reason.

NEIGHBORHOOD ENHANCEMENT

Placemaking	●●●○○
Usable Public Space	●●○○○

COSTS TO IMPLEMENT/MAINTAIN

Cost Effective	●●●●●
Ease of Maintenance	●●●○○

Costs: $8-25/square foot depending on retrofit conditions or new construction.

CONSTRAINTS

Swales require long, continuous spaces which may be challenging to find in retrofit conditions without some creativity.

Swales designed to be too deep or with steep sides more closely resemble ditches and do not achieve the functional or aesthetic goals of a swale. Attention in the design and construction oversight of a project can help avoid this common pitfall.

In steeper topography conditions, swales will need frequent check dams in place to slow the movement of water.

Green Stormwater Management Tools

KEVIN ROBERT PERRY

SAN MATEO, CALIFORNIA: A narrow green gutter along a residential street.

6.3 GREEN GUTTERS

Green gutters are very narrow, landscaped systems along street frontages that capture and slow stormwater flow. Typically, less than 3 feet wide, green gutters resemble planters as they are confined by vertical curbs and have a flat-bottom profile. Unlike typical planters, however, green gutters are designed to be flush with street surface, are very shallow and perform little or no water retention. While infiltration of stormwater is a possibility, the primary purpose of using green gutters is to filter out pollutants and slow the flow of water using only a narrow strip of landscaping – like a swale but possible in highly space-constrained areas where the sloping sides of a swale are not feasible.

Opportunities for Streets and Parking Lots

Green gutters introduce green space along streets that lack landscaping, provide a landscape buffer between vehicular traffic and pedestrians, and create desirable and safe street conditions for people.

Green gutters are useful along wide streetscapes. In many cases, simply narrowing the travel lanes along a residential or commercial street can yield enough space for green gutter installation. Similarly, for small parking lots, shortening parking stall lengths can provide space at the front of parked cars for a narrow green gutter application around the perimeter of the lot.

Green Stormwater Management Tools

STORMWATER FUNCTION

- ✓ Conveyance & Treatment
- ✓ Infiltration/Filtration
- ✓ Evapotranspiration

NICOLE LIMESAND

EXAMPLE GREEN GUTTER

ACTIVE TRANSPORTATION

Supports Pedestrians	●●●●○
Supports Bikes	●●●○○
Calms Traffic	●●●○○

Can act as buffers between sidewalks, bike lanes, and vehicle travel lanes, contributing to the safety and walkability of a street.

URBAN ECOLOGY

Manages Stormwater	●●●○○
Enhances Habitat	●●●○○
Cools Air Temperature	●●●○○

Excellent method for cleaning water prior to entering a downstream waterbody and are superior to pipe and gutter systems for this reason.

NEIGHBORHOOD ENHANCEMENT

Placemaking	●●●○○
Usable Public Space	●○○○○

COSTS TO IMPLEMENT/MAINTAIN

Cost Effective	●●●●○
Ease of Maintenance	●●●○○

Costs: $8-25/square foot depending on retrofit conditions or new construction.

CONSTRAINTS

Require a long, continuous space to effectively slow and filter pollutants.

With heavy snow accumulation, it may be difficult for both drivers and snowplow operators to see the width of the green gutter. Adequate markings or grating at the road surface is necessary to overcome this constraint.

In steeper topography conditions, green gutters will need frequent check dams in place to slow the movement of water.

Green Stormwater Management Tools

FRIENDS OF THE MAD RIVER

WAITSFIELD, VERMONT: A rain garden within a parking lot island.

6.4 RAIN GARDENS (BIORETENTION)

Rain gardens (also known as bioretention) are shallow vegetated depressions in the landscape. They can be any size or shape, and are often molded to fit leftover spaces in parking lots, along street frontages, and in spaces where streets intersect at odd angles. In retrofit conditions, rain gardens can add significant vegetation to spaces that would otherwise be covered by asphalt. Like stormwater planters, they are typically designed to be flat-bottomed without any longitudinal slope to maximize storage potential for stormwater.

Rain gardens retain stormwater, attenuating peak flows and reducing overall stormwater volume. They can also allow for infiltration, depending on the capacity of the native soil. Although rain gardens can share certain characteristics with swales, their primary function is to maximize stormwater storage and infiltration, not conveyance to another location. As a result, they are located where they can collect and treat stormwater from adjacent impervious surfaces.

Their versatility in size and shape make rain gardens a flexible option for application in space-constrained downtown areas. In well-drained soils, rain gardens can maximize infiltration. However, where infiltration capacity is limited, rain gardens can also be designed as flow-through filtration systems with an underdrain to facilitate drainage in high flow events. Simple rain garden designs that do not use extensive hardscape or pipe infrastructure can be very cost effective to install.

Opportunities for Streets and Parking Lots

Rain gardens can be retrofitted in a variety of street applications. Large areas of unused or inefficiently used spaces are prevalent throughout town centers, industrial areas, and residential neighborhoods. These leftover landscape and asphalt spaces are prime candidates for rain gardens to increase stormwater storage and infiltration as well as green space.

Rain gardens are effective in large parking lots (i.e., shopping malls, big box stores) because they can be designed to manage large amounts of stormwater runoff when sized appropriately. For retrofits, several parking stalls can be converted into one large rain garden to capture sheet flow from parking areas.

Green Stormwater Management Tools

STORMWATER FUNCTION

- ✓ Conveyance & Treatment
- ✓ Infiltration/Filtration
- ✓ Evapotranspiration

NICOLE LIMESAND

EXAMPLE RAIN GARDEN

ACTIVE TRANSPORTATION

Supports Pedestrians	●●●●●
Supports Bikes	●●●●○
Calms Traffic	●●○○○

Allow for separation between sidewalks and vehicular travel lanes creating a safer and more walkable environment.

URBAN ECOLOGY

Manages Stormwater	●●●●●
Enhances Habitat	●●●●●
Cools Air Temperature	●●●●●

Provide additional stormwater storage and flow reduction as well as pollutant filtration which helps prevent damage to downstream waterbodies.

NEIGHBORHOOD ENHANCEMENT

Placemaking	●●●●○
Usable Public Space	●●●●○

COSTS TO IMPLEMENT/MAINTAIN

Cost Effective	●●●○○
Ease of Maintenance	●●○○○

Costs: $8-50/square foot depending on retrofit conditions or new construction and if the rain garden has landscaped side slopes or vertical planter walls.

CONSTRAINTS

Require maintenance similar to perennial gardens which may be outside the regular scope of municipal public works staff. Identifying a suitable maintenance plan and appropriate town staff to manage is critical for success.

Rain gardens collecting large amounts of road runoff are prone to clogging without pretreatment. Space for settling particles (either in a catch basin sump or a forebay structure) is critical to avoid excess sediment build-up in the garden itself.

Green Stormwater Management Tools

BECKY THARP

BURLINGTON, VERMONT: A simple green street retrofit along Decatur Street.

6.5 STORMWATER CURB EXTENSIONS

Stormwater curb extensions (or curb bump-outs) are landscaped areas that extend into the street and capture stormwater runoff. Conventional curb extensions (a.k.a. bulb outs, chokers, chicanes) are commonly used to increase pedestrian safety and help calm traffic. A stormwater curb extension shares these same elements, adding the benefit of stormwater management by allowing water to flow into the space for treatment though soil media and vegetation. This landscape space can be designed with the physical characteristics of vegetated swales, planters, or rain gardens depending on the available space and specific site conditions.

Stormwater curb extensions are particularly advantageous in retrofit situations because they can be added to existing streets with minimal disturbance and added benefit to meet other municipal goals of safety and traffic calming. Where existing curb extensions are already in place, adding stormwater treatment benefits within the same space is possible by removing curb sections to allow water to flow through and modifying ground cover to allow water retention and infiltration.

Stormwater curb extensions can be used in any type of street, from low-density residential routes to highly urbanized commercial streetscapes. Curb extensions are excellent to use in steep slope conditions because they can act as a backstop for upstream flow.

Opportunities for Streets

Existing residential streets offer some of the best opportunities for conversion of a portion of the street's parking zone into stormwater curb extensions. In Vermont, many low-density residential streets have unused on-street parking zones that could capture stormwater with no negative impact to residents. Stormwater curb extensions in low-density residential areas can often be installed with minimal impact to existing infrastructure. In some cases, the curb extensions can be designed so that the existing street curb and stormwater inlets remain intact.

In areas where on-street parking is fully utilized, smaller stormwater curb extensions, spaced more frequently, can be used to minimize parking losses. In many urban examples, there are streets striped with "no parking" zones that could be converted into stormwater curb extensions without any loss of parking. Additionally, parking is generally not allowed within 20 feet of an intersection. These areas may be good candidates for stormwater curb extensions.

Green Stormwater Management Tools

STORMWATER FUNCTION

- ✓ Conveyance & Treatment
- ✓ Infiltration/Filtration
- ✓ Evapotranspiration

NICOLE LIMESAND

EXAMPLE STORMWATER CURB EXTENSION

ACTIVE TRANSPORTATION

Supports Pedestrians	●●●●●
Supports Bikes	●●●○○
Calms Traffic	●●●●○

Can narrow intersection crossing distances, slow traffic, and create a safer and more walkable environment.

URBAN ECOLOGY

Manages Stormwater	●●●●○
Enhances Habitat	●●●●○
Cools Air Temperature	●●●●○

Provide additional stormwater storage and flow reduction as well as pollutant filtration which helps prevent damage to downstream waterbodies.

NEIGHBORHOOD ENHANCEMENT

Placemaking	●●●●○
Usable Public Space	●●●○○

COSTS TO IMPLEMENT/MAINTAIN

Cost Effective	●●●●○
Ease of Maintenance	●●●●○

Costs: $25-50/square foot depending on retrofit conditions or new construction and if the stormwater curb extensions has landscaped side slopes or vertical planter walls.

CONSTRAINTS

Sometimes requires the removal of on-street parking.

Can conflict with bike travel if adequate space is not allowed between edges of curb extension and a street's travel lane.

Can conflict with snow removal equipment maneuverability.

Green Stormwater Management Tools

KEVIN ROBERT PERRY

BURLINGTON, VERMONT: Concrete pervious pavers in a parking lot.

6.6 PERVIOUS PAVING

Pervious paving systems allow rain water to pass through their surface and soak into the underlying ground, reducing areas of imperviousness on a site and providing huge inlet areas to facilitate infiltration. There are generally three types of pervious paving options: concrete, asphalt, and pavers. Consider use patterns of a site to determine application of one over another.

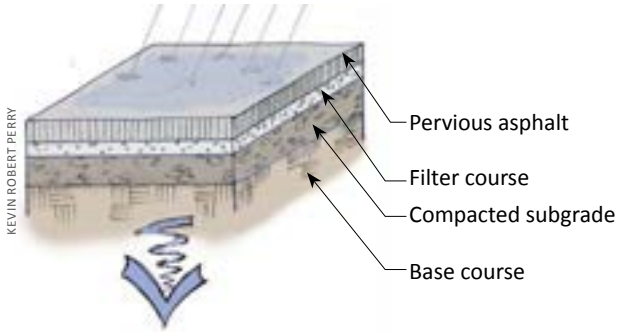
Pervious concrete in its current mix formation has been determined to be ill suited for cold climate application on driving surfaces due to Vermont's multiple freeze thaw cycles and the deleterious effects of road salt application that cannot be eliminated from driving or parking surfaces as a result of vehicle tire tracking. On walkways porous concrete can be effective if they are managed without salt or sand addition.

Pervious asphalt is effective in Vermont's cold conditions and several installations in the state have performed well over multiple years. The mix looks very similar to conventional asphalt but has larger aggregate pieces and cures with pore spaces to allow water movement through the material. Regular inspections and maintenance of pervious asphalt surfaces is required for the long-term viability of the paving system. For preventative maintenance, vacuum cleaning on a yearly basis, preferrably in late fall, is imperative to limit the amount of sediment clogging the pore spaces and to retain permeability, for areas that do not receive significant sediment, debris, leaf litter year-round.

Permeable pavers come in a variety of materials and shapes. All use a sand and gravel mix between the pavers to provide permeability – the pavers themselves lack pore spaces. Reinforced grass and gravel grid systems also allow rainwater to soak into open pore spaces in the soil while providing a rigid driving surface for travel and vehicle parking.

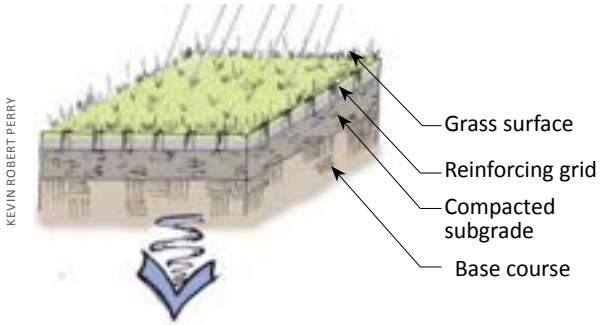
Pervious paving is primarily used on parking lots and roadways with low-traffic speeds and volumes, but there are successful examples of pervious asphalt employed on high-traffic streets throughout the United States. Pervious paving should not be used in situations with known soil contamination or high groundwater tables as the stormwater entering the subsurface could migrate pollutants. Generally, soil infiltration rates that exceed or meet the accepted standard of 0.5"/hour are suitable for pervious paving systems. However, several limitations for pervious pavement in a northern climate are discussed in Section 6.3 under Winter Climate Constraints.

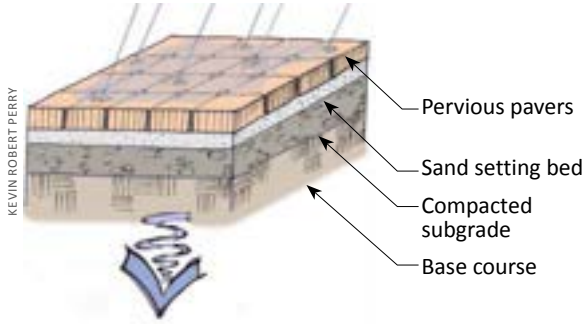
Green Stormwater Management Tools



Pervious Asphalt

The difference between pervious asphalt production and standard asphalt production is the omission of fine particles in the added aggregate. This results in small holes within the paving that allows water to drain through the surface. When installing pervious asphalt, the subgrade must be properly prepared, and the surface material must be poured following temperature, humidity, and curing protocols specific to the material. As with conventional paving, if pervious asphalt is not properly installed, it is prone to failure. Seek an experienced contractor for installation of pervious hardscape material. Periodic inspections are imperative; at least once or twice a year to determine whether any changes in the maintenance schedule is required. Vacuuming is especially encouraged in late fall (after the leaf drop) and before winter to remove any clogged materials prior to freezing temperatures. In addition to visual inspections, performing an infiltration assessment will gauge the need for more frequent vacuuming.





Pervious Pavers

Permeable pavers include a surface layer of interlocking bricks made of either fired clay or concrete. The space in between the pavers is filled with stone aggregate that allows water to move through and into the bedding surface which consists of gravel material with pore space sufficient to hold water as it slowly percolates into the native soil. This system is widely applicable to both small and large paving projects and is easily repaired because small sections can be removed and replaced. Permeable pavers offer flexibility in color, style, joint configuration, and paving pattern. It is important to note that permeable pavers (as with any brickwork) along pedestrian walkways must be ADA-compliant and not create tripping hazards. When installing permeable pavers, care should be taken to assure that the base and subgrade are properly constructed to minimize the potential for differential settling. Regular vacuuming and cleaning of the paver joints aggregate will help prevent clogging and extend the longevity of the system.

Reinforced Grass Paving

In areas needed for intermittent load-bearing use (such as overflow parking), grass paving or other paving/ planting hybrids, can be used to provide structural support while allowing plant growth and stormwater infiltration. These systems may be appropriate in areas of low use and where soil, drainage, sunlight, and other conditions are conducive to plant growth. Salt application should be avoided on grass paving sites as excess chloride is toxic to plant life.

ACTIVE TRANSPORTATION

Supports Pedestrians	●●●●○
Supports Bikes	●●○○○
Calms Traffic	●●○○○

Can reduce local flooding and icy conditions by allowing water to infiltrate rather than collect on the pavement surface.

URBAN ECOLOGY

Manages Stormwater	●●●●○
Enhances Habitat	○○○○○
Cools Air Temperature	●●○○○

Reduces the size of other stormwater treatment measures and provides additional perviousness within the urban context.

NEIGHBORHOOD ENHANCEMENT

Placemaking	●●●●○
Usable Public Space	●●●●○

COSTS TO IMPLEMENT/MAINTAIN

Cost Effective	●●●○○
Ease of Maintenance	●●●○○

Costs: $15-30/square foot depending on the type of pervious paving material and the amount of gravel subbase needed.

CONSTRAINTS

Requires well-drained native soil or underground gravel storage layers.

Needs special maintenance (that may include new equipment purchases) to keep pavement from clogging over time.

Has limited infiltration effectiveness on street slopes over 5%.

Green Stormwater Management Tools

KEVIN ROBERT PERRY

PORTLAND, OREGON: Stormwater planters along SW 12th Avenue.

6.7 STORMWATER PLANTERS

Stormwater planters are narrow, flat-bottomed, often rectangular, landscape areas used to treat stormwater runoff. They are a popular choice for urban environments. Their most distinguishing features are the vertical side walls that create greater storage volume in less space than a swale.

Stormwater planters are easily incorporated into retrofit conditions and in places where space is limited as they are highly versatile in shape and size. They can be built to fit between driveways, utilities, trees, and other existing site elements and can be planted with a simple palate of sedges or rushes, or with a mixture of trees and shrubs. Because planters have no side slopes and are contained by vertical curbs, it is best to use plants that will grow at least as tall as the planter's walls to help soften the edges. Planters can be used in both relatively flat conditions and in steep conditions if they are appropriately terraced. Because they tend to have small footprints, they are best used to control small volumes of water and should not be installed where heavy runoff flows are likely.

Opportunities for Streets and Parking Lots

Stormwater planters are good candidates for main streets due to flexibility with siting and shape and a small footprint. They can fit between driveway curb cuts, utilities, trees, and street furnishings commonly found along urban streets. Planters can be a very good choice for streets that require on-street parking, but thoughtful design must accommodate pedestrian circulation.

Planters can also be an effective design tool for parking lot applications. Parking lot planters can be designed to take the place of a few parking spots or they can fit in the long, narrow space between the front ends of parking stalls. Due to their tidy architectural appearance, stormwater planters are excellent choices to flank the front access doors to a commercial or retail location.

◂ *This stormwater planter along a residential street captures and conveys runoff slowly on the ground surface.*

Green Stormwater Management Tools

STORMWATER FUNCTION

- ✓ Conveyance & Treatment
- ✓ Infiltration/Filtration
- ✓ Evapotranspiration

*Image courtesy of the 2014 Philadelphia Green Streets Design Manual

EXAMPLE STORMWATER PLANTER

ACTIVE TRANSPORTATION

Supports Pedestrians	●●●●○
Supports Bikes	●●●○○
Calms Traffic	●●●○○

Can provide separation between sidewalks and vehicular travel lanes, which help provide a safer and more walkable environment.

URBAN ECOLOGY

Manages Stormwater	●●●●○
Enhances Habitat	●●●○○
Cools Air Temperature	●●●●○

Stormwater planters provide filtration and treatment of road and parking lot runoff, improving the quality of water flowing to downstream waterbodies.

NEIGHBORHOOD ENHANCEMENT

Placemaking	●●●○○
Usable Public Space	●●●○○

COSTS TO IMPLEMENT/MAINTAIN

Cost Effective	●●●○○
Ease of Maintenance	●●●●○

$35-50/square foot depending retrofit conditions or new construction.

CONSTRAINTS

Planters are generally more expensive than swales due to the increased hardscape infrastructure.

Are contextually appropriate in urban settings rather than in residential or rural communities where stormwater planters may appear overbuilt or out-of-place.

Green Stormwater Management Tools

MATTALLTRADES.BLOGSPOT.COM

BURLINGTON, VERMONT: Church Street trees during autumn.

6.8 URBAN STREET TREES

Soils in downtown areas are often compacted by transportation surfaces and are lacking the physical and chemical characteristics needed by vegetation. Street trees are conventionally planted in small rigid cubes - tree pits filled with soil. The size of tree pits is often insufficient for large tree growth and results in reduced life span and stunted canopy size of street trees. Because large healthy trees provide a number of environmental and social benefits, ensuring they can thrive in downtown areas is a critical component of Green Streets. Several innovative approaches to provide adequate soil quality and rooting space have emerged in recent years. Suspended pavements and structural soils give support to pavement while allowing roots to move through an extensive and loose soil profile. Suspended pavement systems utilize an underground scaffolding to support the weight of infrastructure without compacting soils. Engineered structural soils combine stone, soil, and a binding agent to hold the soil to the stones. This provides a similar service to suspended pavements without a rigid scaffolding. Structural soil supports pavement while allowing tree roots to move through pore spaces. Engineered soil does not appear to be susceptible to frost heaves in decade-long applications in Vermont and neighboring New York.

Where there is interest in preserving existing trees in urban areas, suspended pavement, structural cells, and engineered soils can be used to create a 'bridge' between a vegetative strip along a road and a green space. The 'bridge' entails removing paving and compacted subbases in between the tree pit and the green space and replacing the subbase with structural soil and then repaving. Practices that allow for full maturation of a tree will see larger benefits over the long-term than trees that are planted in areas that limit their growth. Designing sidewalks for the anticipated use will benefit street trees by increasing the potential rooting space underneath the surface. If given room to grow, trees can be a stand-alone stormwater system.

◀ *These urban trees provide not only shade but also habitat in this dense area of town. Trees can also spatially "narrow" a street, encouraging motorists to slow down and perceive a gateway into a more urban area.*

Green Stormwater Management Tools

STORMWATER FUNCTION

- ✓ Conveyance & Treatment
- ✓ Infiltration/Filtration
- ✓ Evapotranspiration

*Image courtesy of the 2014 Philadelphia Green Streets Design Manual

EXAMPLE URBAN STREET TREE

ACTIVE TRANSPORTATION

Supports Pedestrians	●●●●○
Supports Bikes	●●●○○
Calms Traffic	●●●○○

Can provide a visual trigger to reduce traffic speeds in downtown areas, making a safer and more walkable environment.

URBAN ECOLOGY

Manages Stormwater	●●●●○
Enhances Habitat	●●●○○
Cools Air Temperature	●●●●○

Provide shade, stormwater benefits through interception on leaves and evapotranspiration, and habitat for native species.

NEIGHBORHOOD ENHANCEMENT

Placemaking	●●●○○
Usable Public Space	●●●○○

COSTS TO IMPLEMENT/MAINTAIN

Cost Effective	●●●○○
Ease of Maintenance	●●●●○

$150-600/tree depending on size and species of tree. Total cost of tree depends on caliper and whether structural soil or suspended soils are utilized. It is common for structural soil to be used more now in urban environments, with a line item for the tree and a separate volume for structural soil.

CONSTRAINTS

Require regular, skilled maintenance to ensure long term growth and health.

Contributes leaf fall to street surfaces, increasing need for regular street sweeping efforts.

Species selection is limited by above-ground infrastructure and utilities – making larger varieties ill-suited where overhead power lines may conflict.

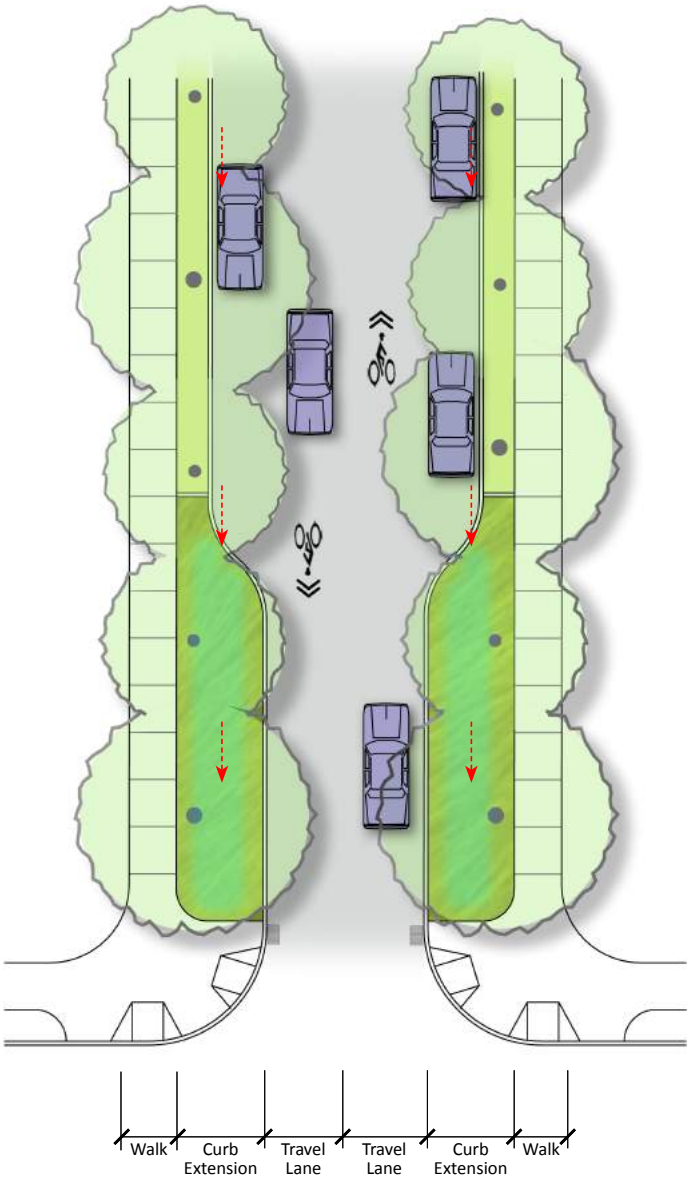
RICHARD AMORE

ST. ALBANS, VERMONT: Vermont's first Main Street with stormwater planters.

Section 7

Green Street and Parking Lot Examples

Green Street and Parking Lot Examples



7.1 RESIDENTIAL STORMWATER CURB EXTENSIONS AT INTERSECTIONS

This residential street example illustrates how stormwater curb extensions can be easily retrofitted alongside the existing curb line. Runoff from the street can simply enter these landscape areas and overflow into the existing drain inlets. Because this street has a lot of unused on-street parking, installing curb extensions does not adversely impact existing parking. With the new stormwater curb extensions and street trees in place, the narrower street provides a more aesthetically pleasing and potentially safer traffic environment.

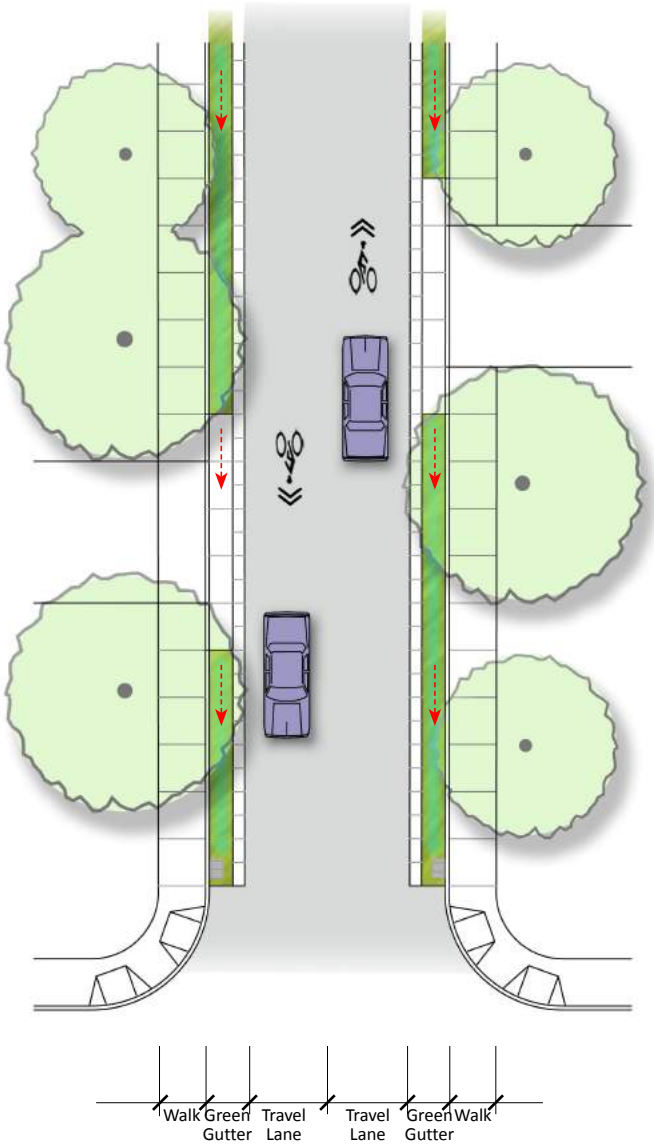
URBAN RAIN DESIGN

▲ *EXISTING: A typical low-density residential street in Vermont.*

RAYMOND PAPA/URBAN RAIN DESIGN

▲ *RETROFIT OPPORTUNITY: The same residential street retrofitted with stormwater curb extensions, as well as additional street trees. In this example, the curb extension is only within the street leaving the existing curb in place.*

Green Street and Parking Lot Examples



7.2 RESIDENTIAL GREEN GUTTERS

Residential streets that have a wide right-of-way and do not need on-street parking are good candidates for retrofitting with a green gutter system. A green gutter is a narrow stormwater planter that can be placed alongside streets. The example below shows that removing a few of feet of asphalt on one side of this street provides enough space for a green gutter system without impeding two-way travel along the street.

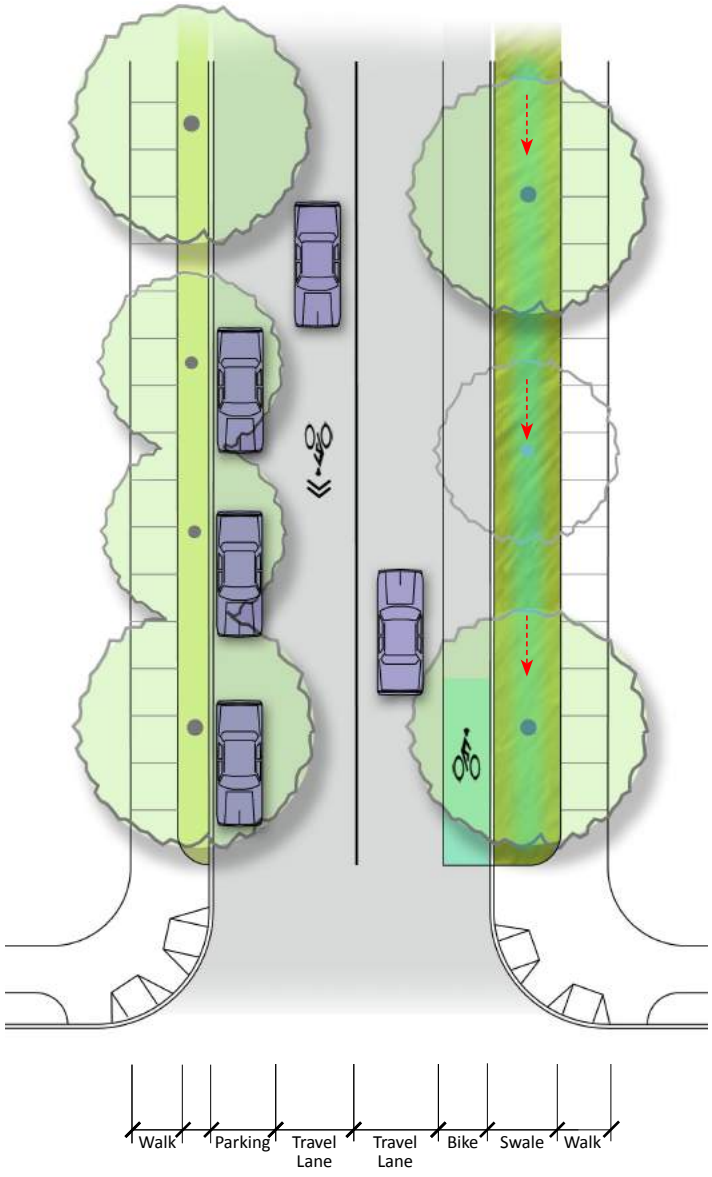
URBAN RAIN DESIGN

▲ *EXISTING: A typical low-density residential street in Vermont.*

RAYMOND PAPA/URBAN RAIN DESIGN

▲ *RETROFIT OPPORTUNITY: The same residential street retrofitted with a green gutter. In this example, the green gutter is only within the street leaving the existing curb in place and replaces the failing asphalt area.*

Green Street and Parking Lot Examples



7.3 RESIDENTIAL VEGETATED SWALES

Many residential streets in Vermont are overly wide and have large impervious areas. Green Streets reduce impervious area and help green the character of the street by introducing vegetated swales along the street curb lines. Runoff from the street enters these landscaped areas and overflows into the existing drain inlets. If a street is particularly wide, introducing bike lanes in conjunction with stormwater systems helps provide enhanced mobility for all users.

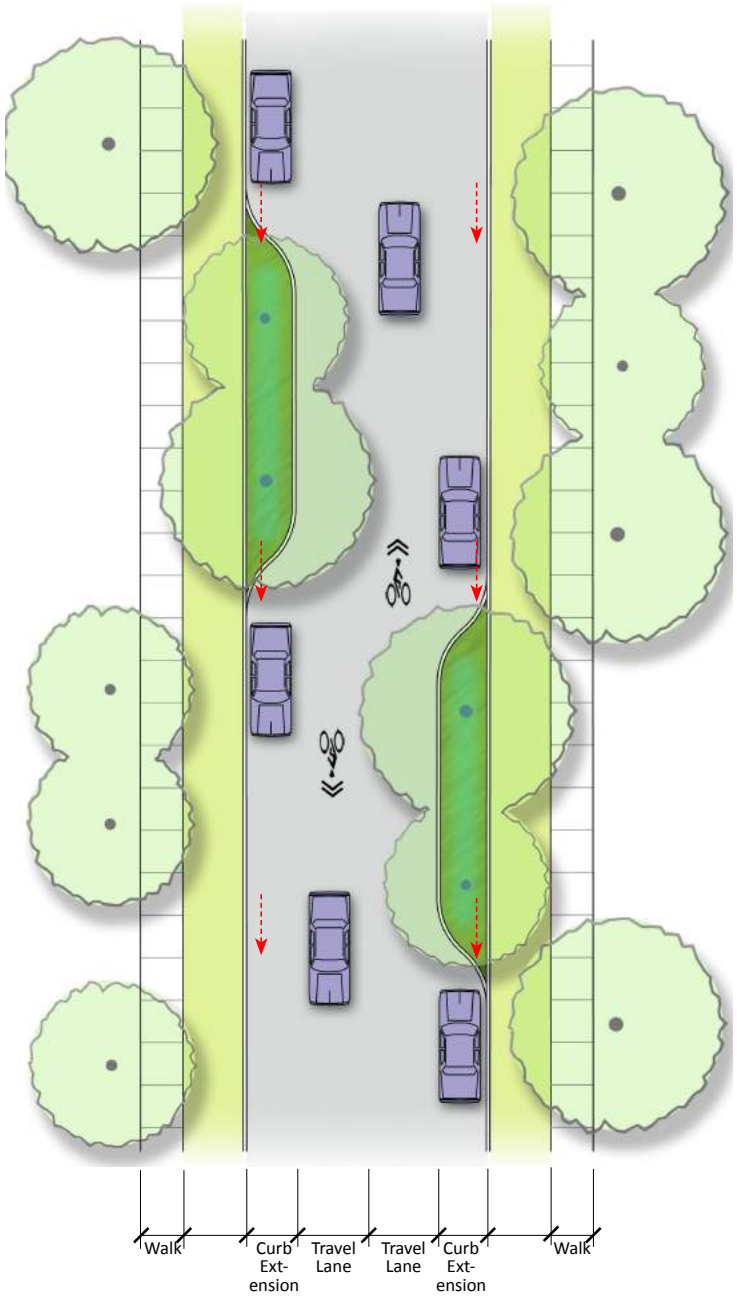
URBAN RAIN DESIGN

▲ *EXISTING: A typical low-density residential street in Vermont.*

RAYMOND PAPA/URBAN RAIN DESIGN

▲ *RETROFIT OPPORTUNITY: The same residential street retrofitted with a vegetated swale, optional bike lane, as well as additional street trees. In this example, the vegetated swale helps separate the sidewalk zone from vehicular traffic.*

Green Street and Parking Lot Examples



7.4 MID-BLOCK STORMWATER CURB EXTENSIONS

Stormwater curb extensions are not limited to intersection conditions, but can also be located along a street's mid-block. Mid-block curb extensions can be designed in many shapes and either in a symmetrical or staggered pattern to create a traffic calming feature. The illustration below shows mid-block curb extensions used on both sides of the street in a staggered pattern.

SOPHIE SAUVÉ

▲ *EXISTING: A typical low-density residential street in Vermont.*

RAYMOND PAPA/URBAN RAIN DESIGN

▲ *RETROFIT OPPORTUNITY: The same residential street retrofitted with staggered mid-block stormwater curb extensions. Take note that the staggered condition helps create a traffic calming feature.*

Green Street and Parking Lot Examples

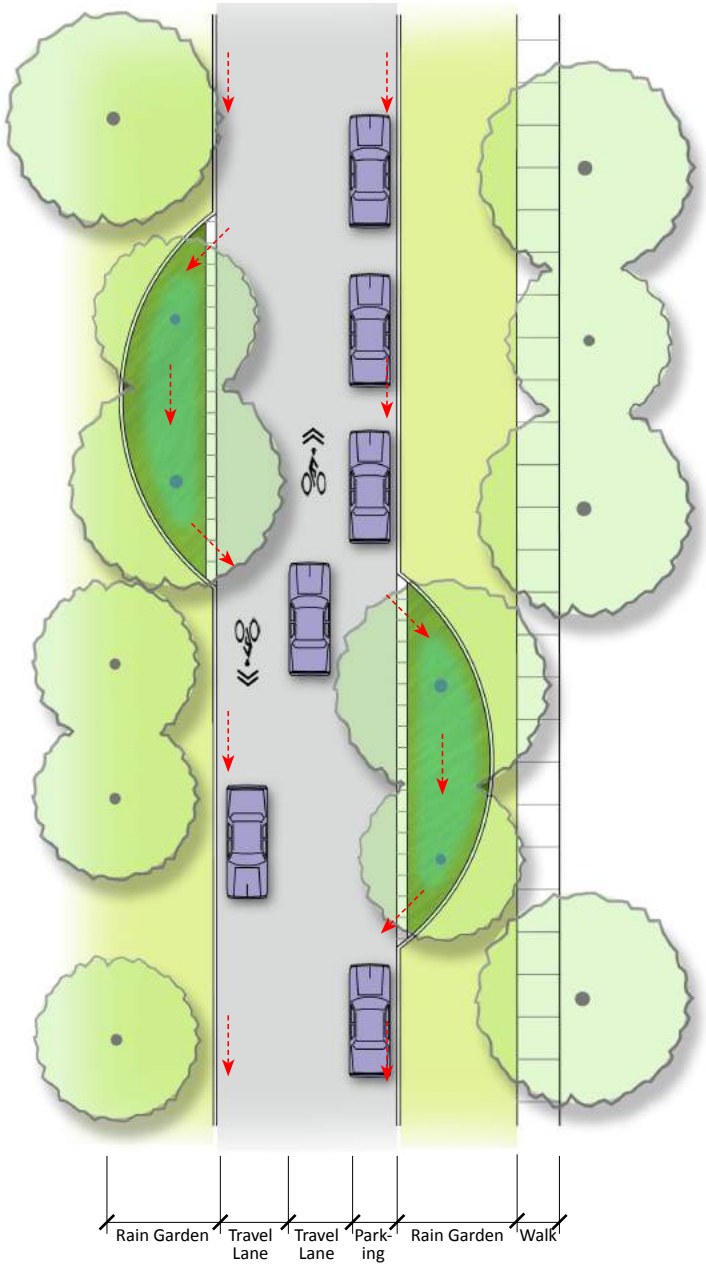
7.5 ODD ANGLED INTERSECTION RAIN GARDENS

Many residential streets in Vermont have intersections with acute angles and do not conform to the standard city grid pattern. This can sometimes result in an inefficient layout with open swaths of impervious asphalt area and difficult crossings for pedestrians. Depending on how much right-of-way is available, these street intersections can be realigned to increase spatial efficiency and create opportunities for stormwater facilities and enhanced pedestrian crossings. The illustration below shows how a 4-point intersection with odd angles can be realigned with new rain gardens and pedestrian crossings.

▲ *EXISTING: A typical low-density residential street intersection with odd angles in Middlebury, Vermont.*

▲ *RETROFIT OPPORTUNITY: The same residential streets in Middlebury retrofitted with multiple rain gardens once the intersection is realigned.*

Green Street and Parking Lot Examples



7.6 RESIDENTIAL STREET-SIDE RAIN GARDENS

In residential neighborhoods, where there is a considerable amount of landscape space between the street edge and the sidewalk zone (or if there is no sidewalk), larger rain gardens can be installed to accept runoff. These rain gardens can conform to any shape and can receive runoff from the street and/or the residential lot. The example shown below is a rain garden that captures runoff from both the street and surrounding residential lots.

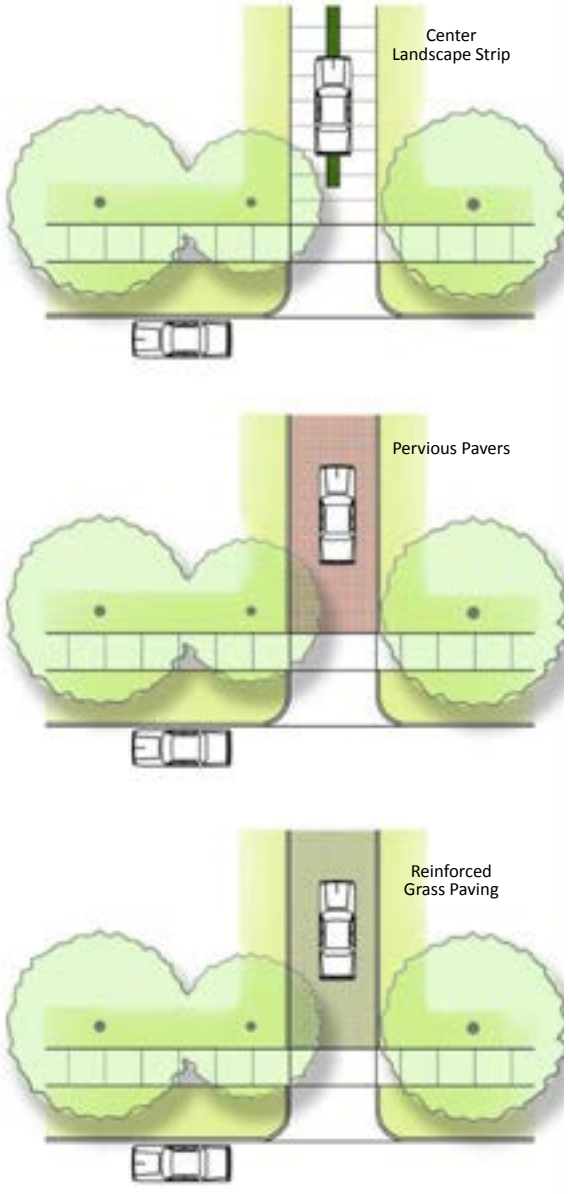

URBAN RAIN DESIGN

▲ *EXISTING: A typical low-density residential street in Vermont.*


RAYMOND PAPA/URBAN RAIN DESIGN

▲ *RETROFIT OPPORTUNITY: The same residential street retrofitted with a rain garden. Take note that esign incorporated an existing catch basin as part of the design.*

Green Street and Parking Lot Examples



7.7 RESIDENTIAL DRIVEWAY OPTIONS

Many residential driveways in Vermont are long and continuous areas of asphalt or impermeable gravel that contribute stormwater runoff to the site. The following residential driveway examples illustrate how existing concrete or gravel driveways can be retrofitted with pervious interlocking concrete pavers, driveway grass strips, or reinforced grass paving systems.


URBAN RAIN DESIGN

▲ *EXAMPLE: A typical low-density residential driveway using pervious concrete.*


URBAN RAIN DESIGN

▲ *EXAMPLE: A typical low-density residential driveway with minimal paving and a center landscape strip.*

Green Street and Parking Lot Examples

IMPLEMENTED RESIDENTIAL GREEN STREET EXAMPLES

▲ A pair of stormwater curb extensions along a residential street captures runoff and also preserves existing mature street trees.

▲ A green gutter along a neighborhood street combined with a pervious concrete sidewalk.

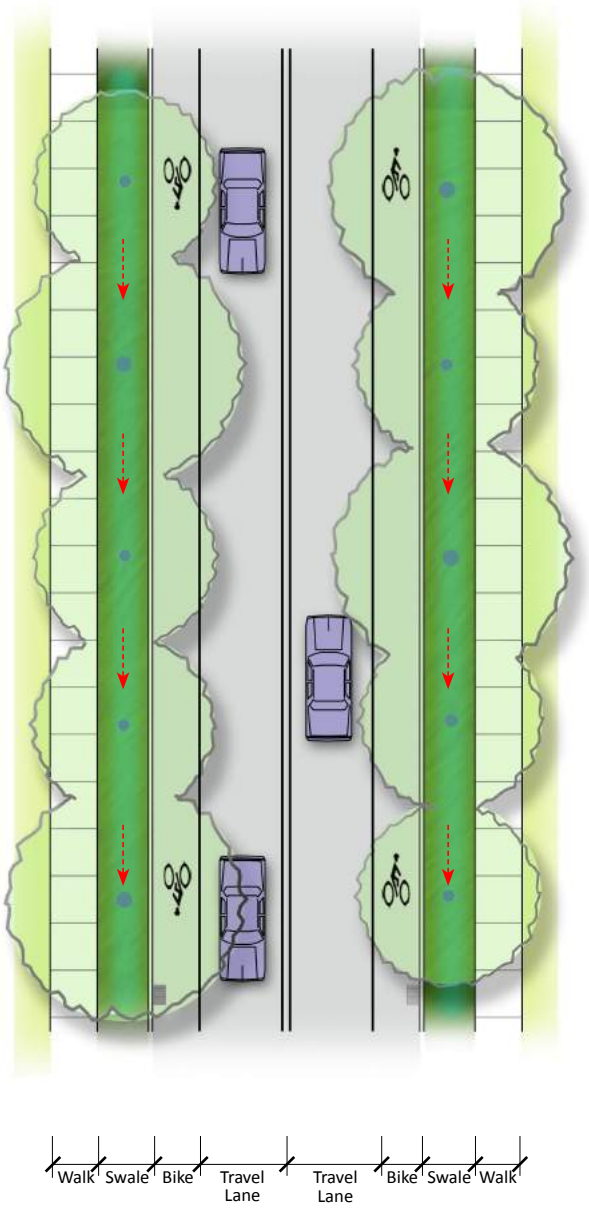
▲ A narrow residential street with a “curbless” street profile and a series of inter-connected vegetated swales.

▲ A “front yard” rain garden accepts runoff from both the street and residential lot.

▲ A long continuous stormwater swale on one side of the street in a new residential development.

▲ A pervious interlocking concrete paver application on a shared residential driveway.

Green Street and Parking Lot Examples



7.8 ARTERIAL VEGETATED SWALES

This example shows how a lawn strip along an arterial street can be easily retrofitted with a vegetated swale capturing runoff before it enters a drain inlet. Retrofitting under-used landscape space is often a very cost-effective way to create a green street. Where the native soils have moderate to high infiltration rates, simply re-grading the soil, installing new landscaping, and constructing a series of curb cuts allows water to enter and exit the new vegetated swale. These types of simple retrofit opportunities should be prioritized.

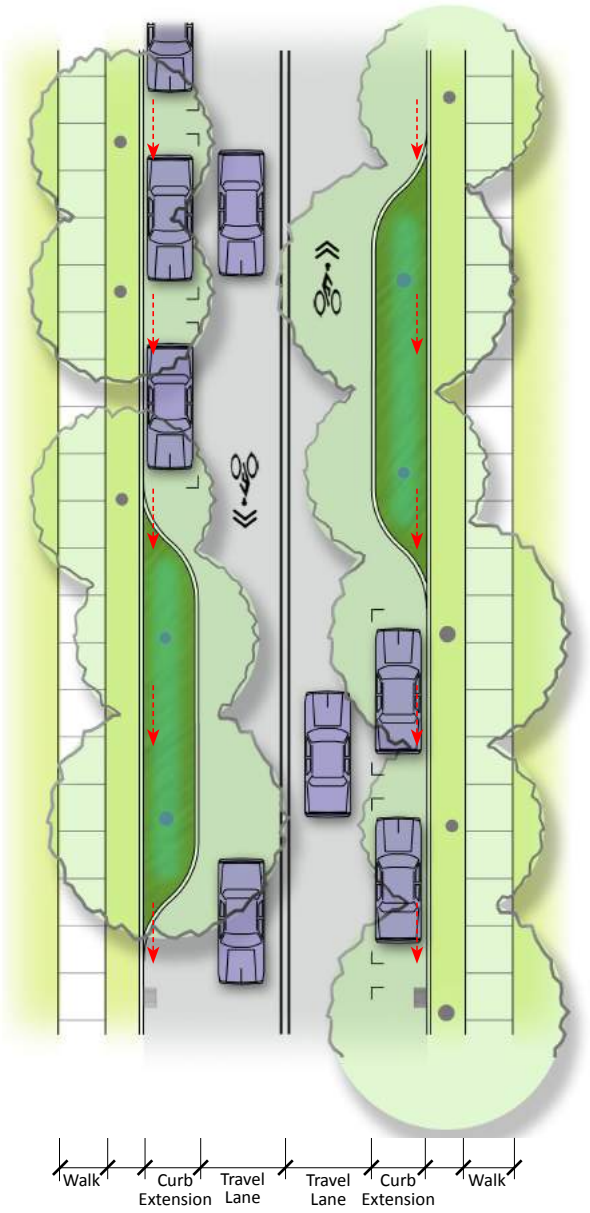
URBAN RAIN DESIGN

▲ *EXISTING: A typical arterial street with an existing lawn strip in Vermont. (Burlington)*

RAYMOND PAPA/URBAN RAIN DESIGN

▲ *RETROFIT OPPORTUNITY: The same arterial street retrofitted with a vegetated swale, as well as additional street trees. In this example, the vegetated swale only is within the existing landscape strip leaving the existing curb in place.*

Green Street and Parking Lot Examples



7.9 ARTERIAL STORMWATER CURB EXTENSIONS

Along select arterial streets, converting some on-street parking into stormwater curb extensions provides room for green space and street trees. Smaller curb extensions could be placed close together, or, conversely, larger curb extensions could be spaced further apart. This newly introduced landscape area next to the sidewalk can help buffer the pedestrian zone from high-speed traffic, as well as treat stormwater runoff.

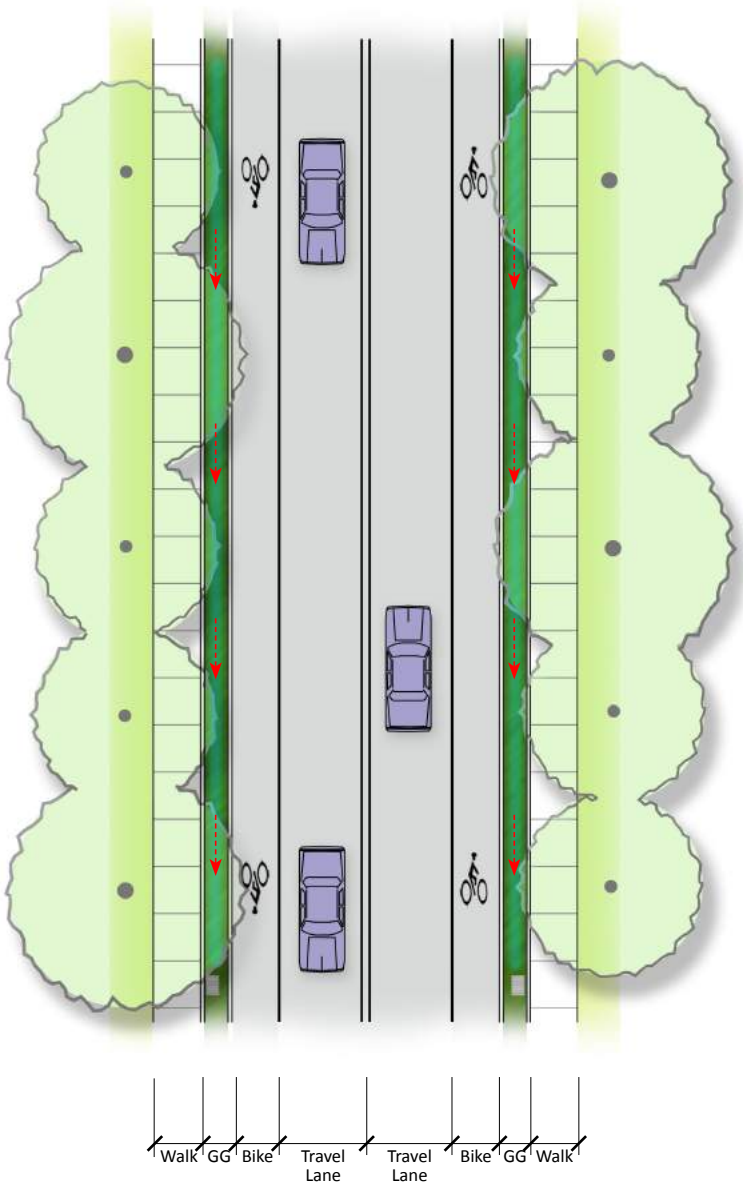
URBAN RAIN DESIGN

▲ *EXISTING: A typical arterial street with on-street parking in Vermont.*

RAYMOND PAPA/URBAN RAIN DESIGN

▲ *RETROFIT OPPORTUNITY: The same arterial street retrofitted with a stormwater curb extension.*

Green Street and Parking Lot Examples



7.10 ARTERIAL GREEN GUTTERS

This existing lawn strip is only approximately 5 feet wide. While too narrow for a stormwater swale, it can accommodate a narrower green gutter system. The example shown below replaces the existing lawn strip with a shallow green gutter. The green gutter also helps provide a buffer between the high-speed traffic of the arterial and pedestrians using the sidewalk.

SOPHIE SAUVÉ

▲ *EXISTING: A typical arterial street with a narrow grass strip in Vermont. (Williamstown)*

RAYMOND PAPA/URBAN RAIN DESIGN

▲ *RETROFIT OPPORTUNITY: The same arterial street retrofitted with a green gutter system, as well as additional street trees.*

Green Street and Parking Lot Examples

IMPLEMENTED ARTERIAL GREEN STREET EXAMPLES

▲ This arterial street utilizes a vegetated swale for managing street runoff and a pervious concrete sidewalk.

▲ A green gutter along an arterial street helps separate vehicular traffic from pedestrians.

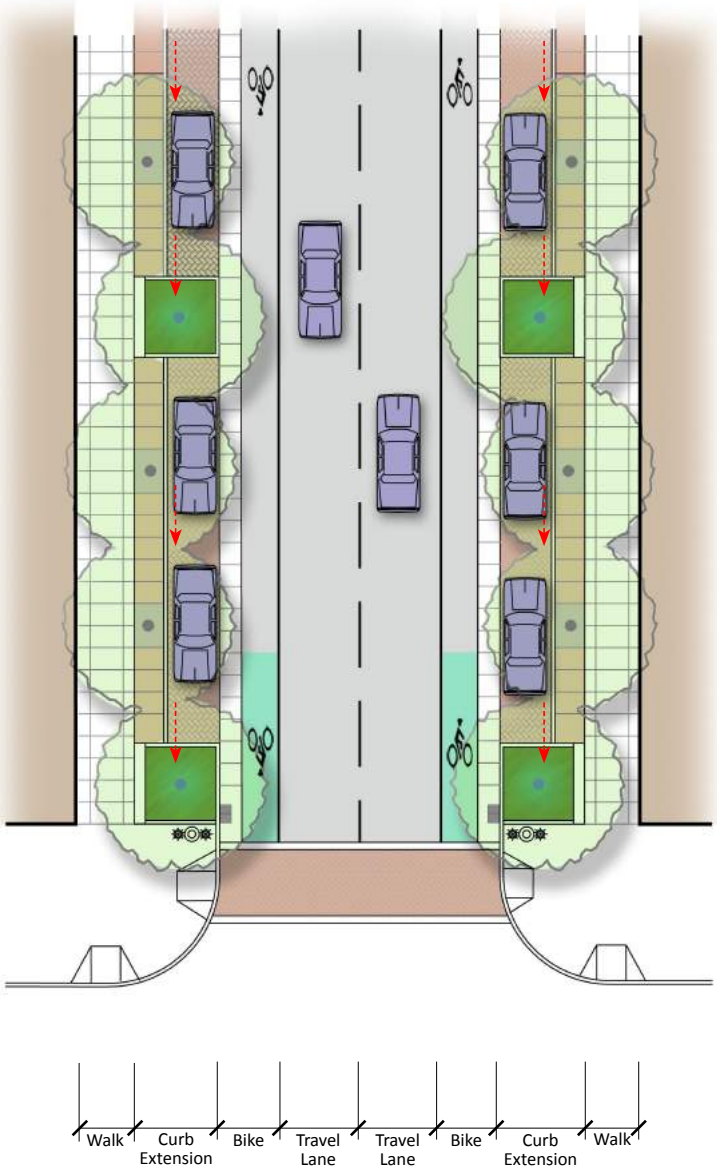
▲ Stormwater curb extensions along this arterial street also help shorten pedestrian crossing distances.

▲ This rain garden along an arterial street boldly greens the street.

▲ Stormwater planters provide buffers for a multi-use path.

▲ An arterial street with stormwater curb extensions and pervious paving parking zone.

Green Street and Parking Lot Examples

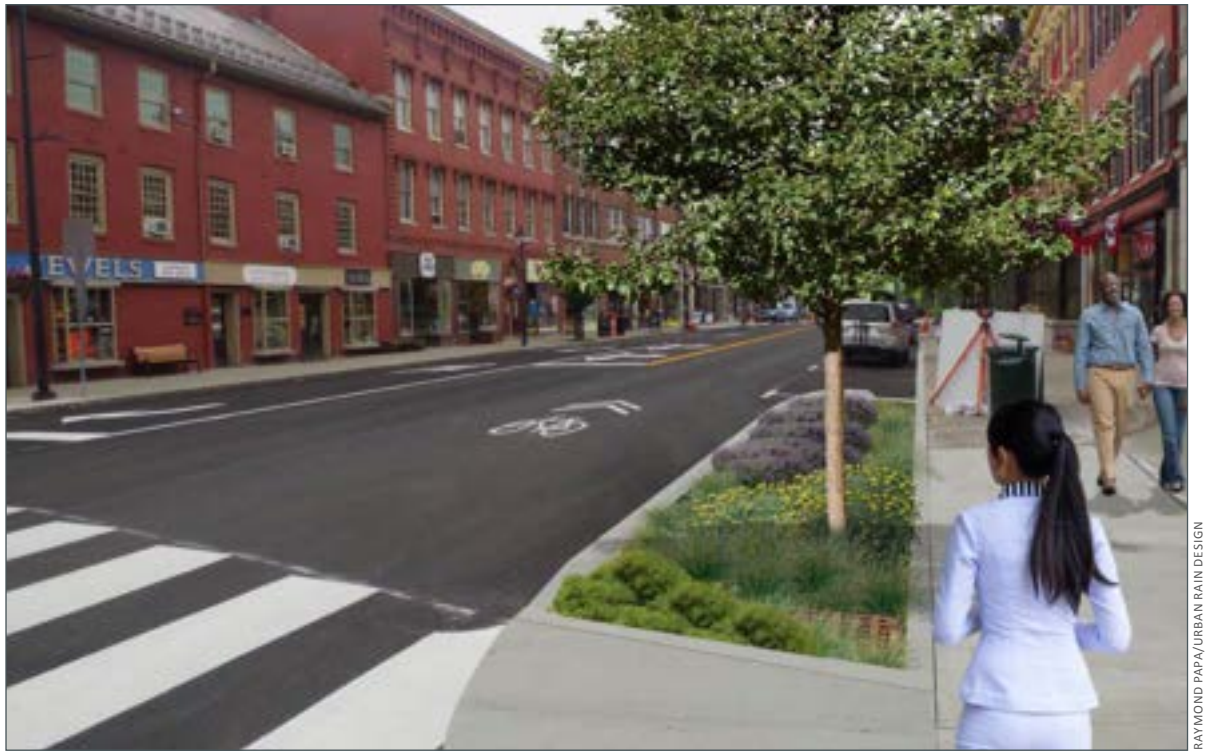


7.11 COMMERCIAL STORMWATER CURB EXTENSIONS WITH PARALLEL PARKING

Downtown main streets at midblock and at intersections can benefit from additional green space in the form of curb extensions. Also known as bump outs, curb extensions can soften the look of the street, provide space for stormwater management, provide refuge for pedestrian crossings, or create opportunities for outdoor seating. The example below illustrates how a curb extension captures a portion of the existing parking zone with a stormwater curb extension to manage street runoff.

SOPHIE SAUVÉ

▲ *EXISTING: A typical downtown main street parking zone in Vermont.*



RAYMOND PAPA/URBAN RAIN DESIGN

▲ *RETROFIT OPPORTUNITY: The same downtown main street retrofitted with a stormwater curb extension.*

7.12 COMMERCIAL STORMWATER CURB EXTENSIONS WITH ANGLED PARKING

Angled parking along downtown main streets is very common in Vermont. Although parallel parking is a more efficient use of space, there are some green street options available for an area with angled parking. One potential green street scenario is to consolidate one or more parking spaces into a stormwater curb extension. Converting angled parking spaces into curb extensions adds more landscaping to the street, which also has the potential to enhance the aesthetics of storefront businesses.

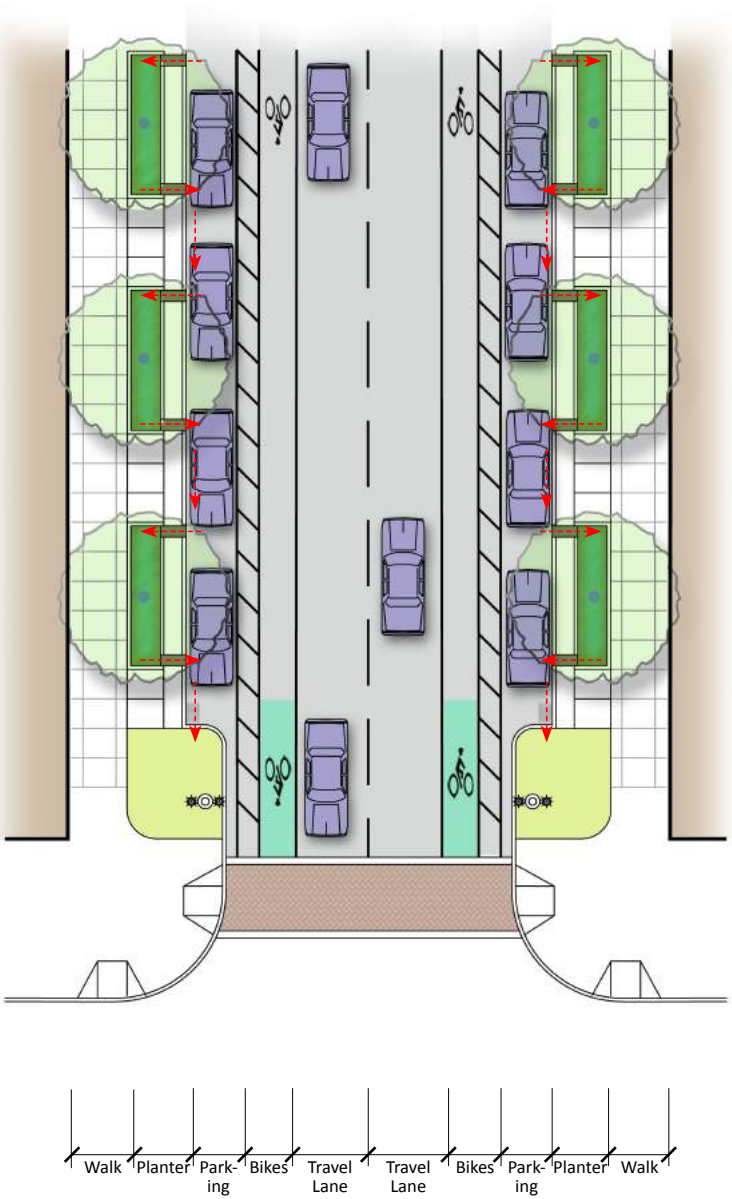
URBAN RAIN DESIGN

▲ *EXISTING: A typical downtown main street with angled parking in Vermont.*

RAYMOND PAPA/URBAN RAIN DESIGN

▲ *RETROFIT OPPORTUNITY: The same downtown main street retrofitted with stormwater curb extension. In this example, the stormwater curb extension also uses space that is already striped as "no parking".*

Green Street and Parking Lot Examples



7.13 COMMERCIAL STORMWATER PLANTERS WITH ON-STREET PARKING

Where space allows, stormwater planters can be added to the furnishing zone - the portion of the sidewalk used for street trees, landscaping, transit stops, street lights, and site furnishings - while retaining on-street parking. Pedestrian circulation can be accommodated by creating walkways in between the planters and a pedestrian egress zone adjacent to on-street parking. The retrofit opportunity illustrated below shows how a flow-through or infiltration planter can be inserted between the sidewalk and parking zone of the street. In more urban downtown areas, using planters is advantageous because they allow for stormwater treatment in limited spaces.

URBAN RAIN DESIGN

▲ *EXISTING: A typical commercial main street with on-street parking in Vermont.*

RAYMOND PAPA/URBAN RAIN DESIGN

▲ *RETROFIT OPPORTUNITY: The same downtown main street retrofitted with a series of stormwater planters.*

Green Street and Parking Lot Examples

7.14 COMMERCIAL STORMWATER PLANTERS WITHOUT ON-STREET PARKING

On some downtown main streets there is parking only on one side of the street, leaving the opportunity to create stormwater planters between the street and the sidewalk zone without the need of a parking egress zone. The example below shows an existing downtown main street with a large stormwater planter replacing a lawn area.

URBAN RAIN DESIGN

▲ *EXISTING: A typical downtown main street with no on-street parking in Vermont.*

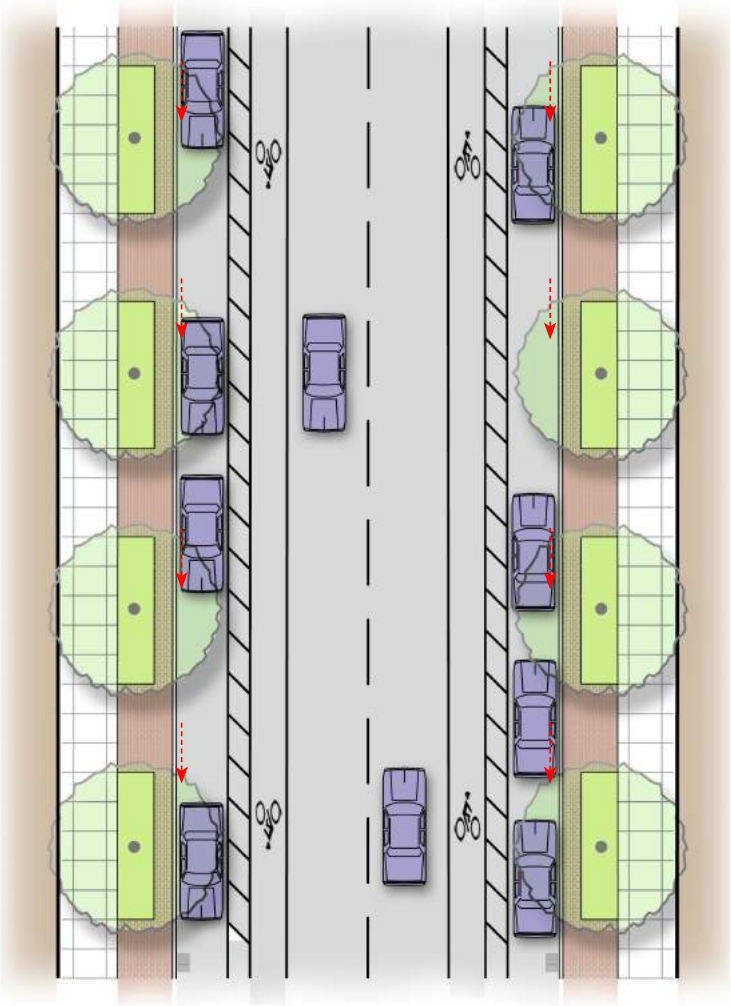
RAYMOND PAPA/URBAN RAIN DESIGN

▲ *RETROFIT OPPORTUNITY: The same downtown main street retrofitted with a linear stormwater planter and pervious paving furnishing zone.*

Green Street and Parking Lot Examples

7.15 COMMERCIAL PERVIOUS PAVING IN FURNISHING ZONE

Some downtown main streets experience heavy amounts of pedestrian traffic and may not have sufficient space to introduce stormwater curb extensions or stormwater planters. However, pervious paving can be used in the furnishing zone of the street (between the sidewalk and street) that can manage sidewalk runoff only and provide a stable and aesthetic street condition. The example below retrofits a worn downtown grass parking zone into a pervious paving condition.



URBAN RAIN DESIGN

▲ *EXISTING: A typical downtown street with a trampled grass furnishing zone in Vermont.*

RAYMOND PAPA/URBAN RAIN DESIGN

▲ *RETROFIT OPPORTUNITY: The same downtown main street retrofitted with pervious paving in the furnishing zone.*

Green Street and Parking Lot Examples

IMPLEMENTED COMMERCIAL GREEN STREET EXAMPLES

▲ A series of stormwater planters allows for on-street parking and pedestrian circulation around the stormwater facilities.

▲ A green gutter along a downtown plaza with metal grates for pedestrian crossing.

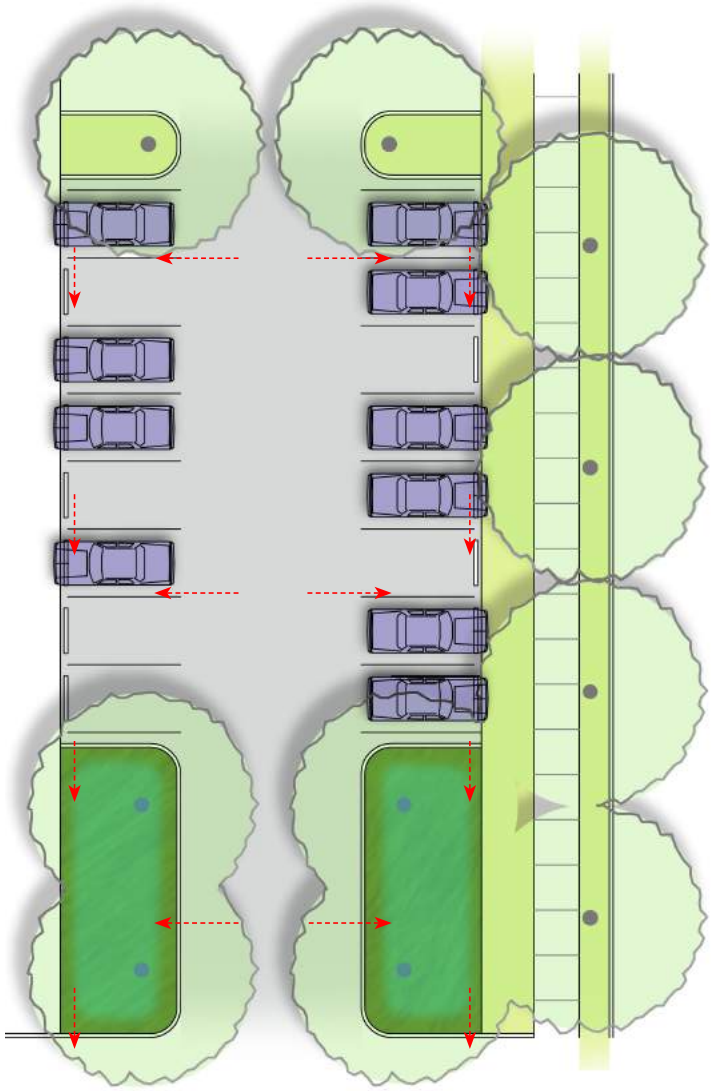
▲ Angled parking can accommodate stormwater curb extensions.

▲ Pervious pavers in the parking zone of this commercial street captures sidewalk and parking runoff.

▲ A downtown plaza is designed with a rain garden and pervious pavers.

▲ An urban tree well accepts street stormwater runoff.

Green Street and Parking Lot Examples



7.16 PARKING LOT STORMWATER PLANTERS IN LANDSCAPE ISLANDS

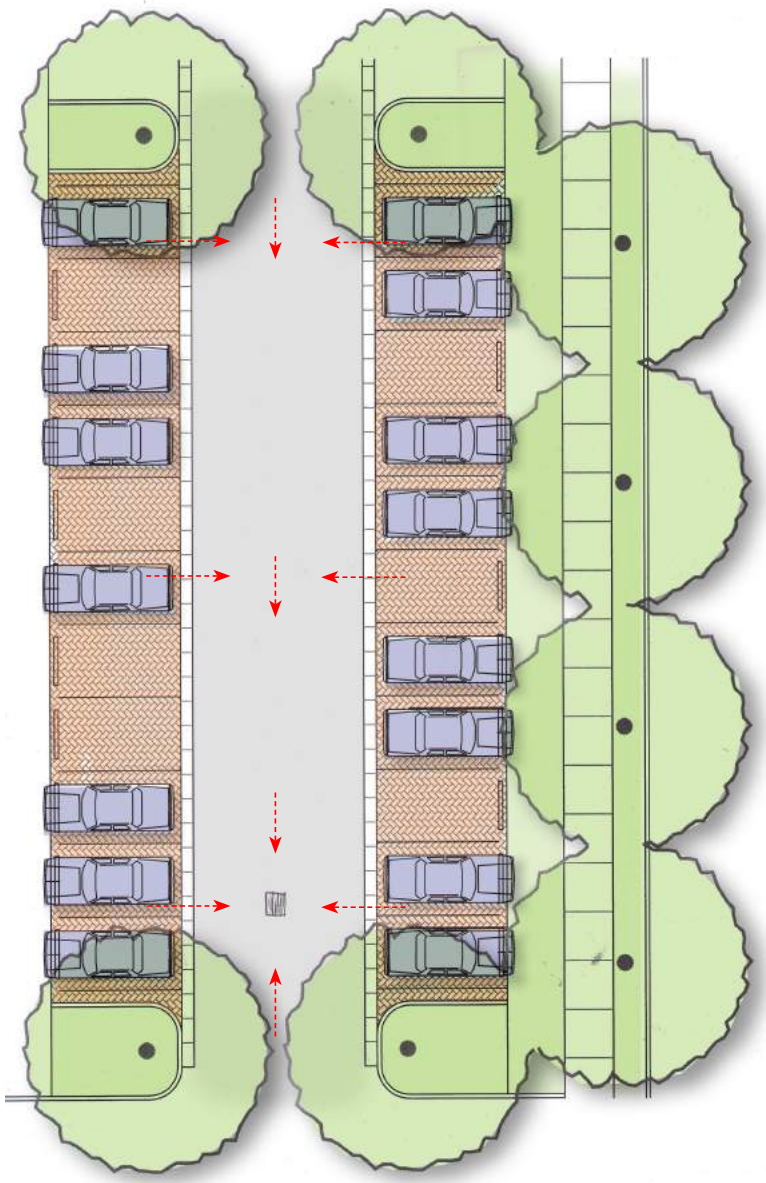
This example shows a parking lot with stormwater planters replacing empty parking stalls. This is one of the simplest parking lot retrofit actions to implement. The best approach is to convert the parking stalls immediately adjacent to a drain inlet. Depending upon the size and parking demand of a parking lot, a series of parking stalls may be consolidated into stormwater planters.

URBAN RAIN DESIGN

▲ *EXISTING: A typical parking lot with empty parking lots in Vermont.*

RAYMOND PAPA/URBAN RAIN DESIGN

▲ *RETROFIT OPPORTUNITY: The same parking lot in Middlebury, VT retrofitted with a stormwater planter replacing two parking stalls near the existing drain inlet.*



7.17 PARKING LOT PERVIOUS PAVING IN PARKING STALLS

This example shows a parking lot where stormwater drains into the center of the parking drive aisles (internally drained) as opposed to sheet flow to the periphery of the site. This is a common condition especially with small-scale parking lots. Without redesigning the drainage system, the best and most practical option is to install pervious paving. The illustrated example below employs pervious paving within the parking stalls and allows any excess stormwater runoff to drain into the existing storm inlet.

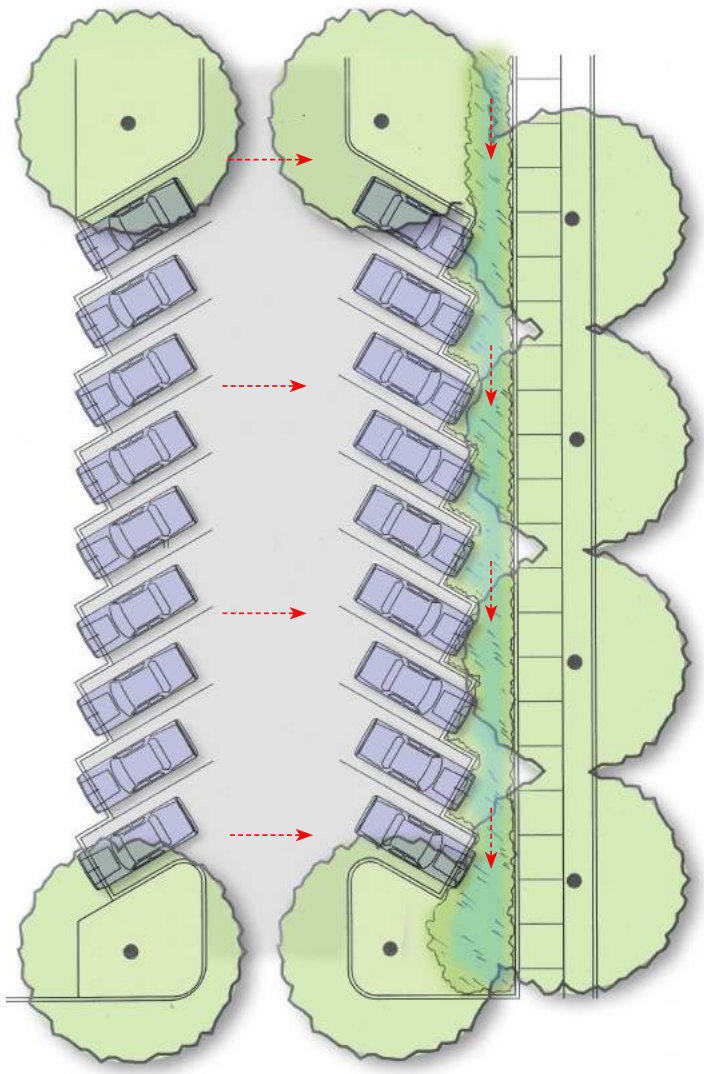
URBAN RAIN DESIGN

▲ *EXISTING: A typical small-scale parking lot in Vermont.*

RAYMOND PAPA/URBAN RAIN DESIGN

▲ *RETROFIT OPPORTUNITY: The same parking lot retrofitted with pervious interlocking concrete pavers within the parking stalls.*

Green Street and Parking Lot Example



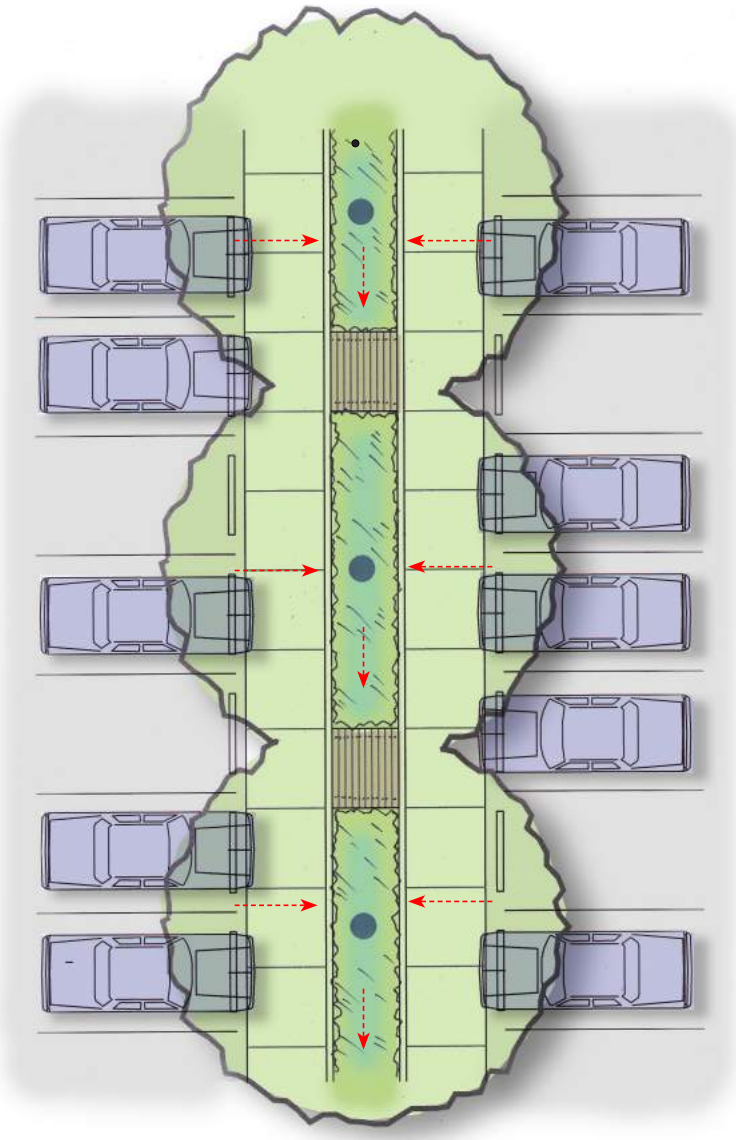
7.18 PARKING LOT PERIMETER VEGETATED SWALE

Frequently, parking lots drain surface runoff towards the perimeter of the site for capture by drain inlets. In this example, there is already a grassed drainage swale at the perimeter parking edge. However, the rim of the overflow inlet is low and allows no retention of stormwater, the short roots of lawn provide little uptake benefit, and there is lack of plant diversity. The illustration below shows a more functional vegetated swale condition.

URBAN RAIN DESIGN

▲ *EXISTING: A typical parking lot with existing perimeter space in Vermont.*

▲ *RETROFIT OPPORTUNITY: The same parking lot perimeter space retrofitted with a vegetated swale. Notice the amount of plant diversity compared to just a mowed lawn space.*



7.19 PARKING LOT CENTER MEDIAN VEGETATED SWALE

The example below shows the length of the parking stalls shortened to provide space for a vegetated swale or planter. Introducing more landscaping and trees within large urban parking lots also keeps asphalt surfaces cooler and helps reduce the urban heat island effect. Depending on the primary pedestrian traffic flow, additional space may be needed to assure that people can safely cross the landscape area without damaging plant material.

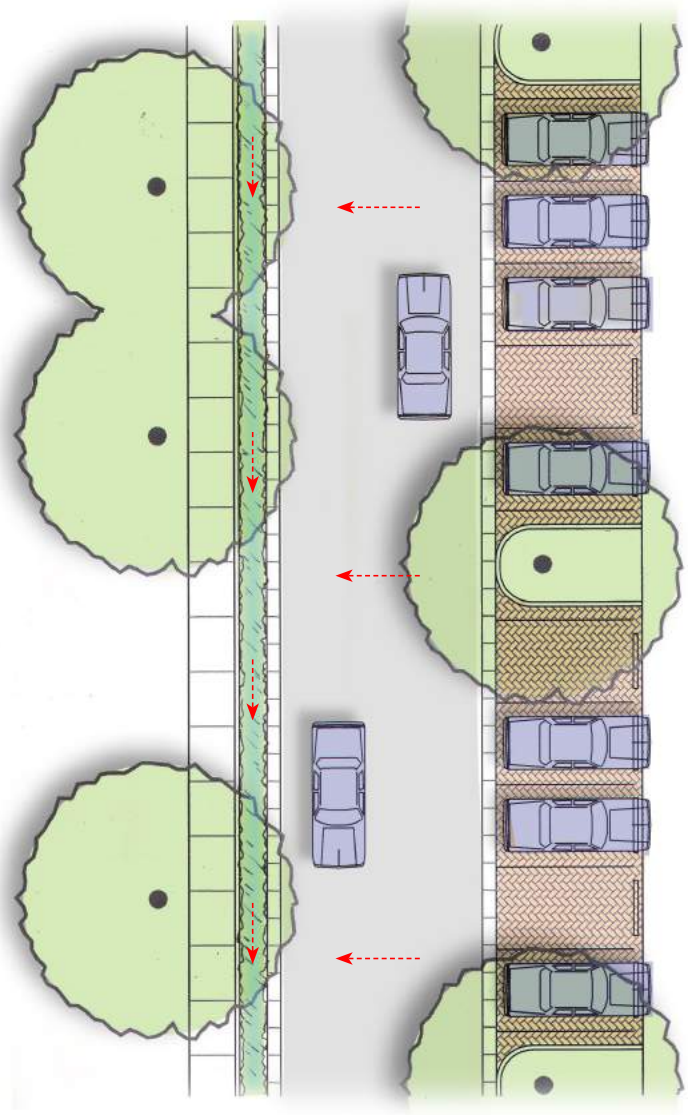
URBAN RAIN DESIGN

▲ *EXISTING: A typical parking lot center median in Vermont.*

RAYMOND PAPA/URBAN RAIN DESIGN

▲ *RETROFIT OPPORTUNITY: The same parking lot retrofitted with a vegetated swale median placed between parking stalls. Specific design considerations should be taken to manage pedestrian flow through these landscape areas.*

Green Street and Parking Lot Examples



7.20 PARKING LOT GREEN GUTTER

In many situations, if drainage is flowing towards a space, a few feet of linear space can be taken up in a parking lot for conversion to a green gutter system. Many parking areas are loaded on one side of a drive aisle or there may be a few of feet at the front of parking stalls that can provide enough room for a green gutter. Often drive aisles are oversized and can be reduced in width to accommodate a green gutter. To further enhance stormwater management on-site, pervious paving and a green gutter system can be combined as shown in the illustrated graphic to the left.

URBAN RAIN DESIGN

▲ *EXISTING: A typical oversized parking lot stall in Vermont.*

RAYMOND PAPA/URBAN RAIN DESIGN

▲ *RETROFIT OPPORTUNITY: The same parking lot scenario replacing the first couple of feet of asphalt with a green gutter system.*

7.21 DESIGN STRATEGY MATRIX

STREET/PARKING LOT TYPE	VEGETATED SWALE	STORMWATER PLANTER	RAIN GARDEN	CORNER CURB EXTENSIONS	MIDBLOCK CURB EXTNS.	GREEN GUTTERS	PERVIOUS PAVING*	STREET TREES
High-Volume Pedestrian Street	●	○	○	○	○	●	○	○
Civic/Ceremonial Street	●	○	○	○	○	●	○	○
Walkable Commercial Corridor	◐	○	○	○	○	◐	○	○
Auto-Oriented Commercial/ Industrial Street	○	○	○	○	○	◐	○	○
City Neighborhood Street	○	●	○	○	○	●	○	○
Low-Density Residential Street	○	◐	○	○	○	○	○	○
Local Street	○	◐	○	○	○	○	○	○
Parking Lots	○	○	○	◐	◐	○	○	○

○ Recommended
◐ Possible, but requires design considerations
● Not Recommended

*NOTE: for installation along state routes, coordinate with VTrans early in the process.

KEVIN ROBERT PERRY

PORTLAND, OREGON: A public plaza with a rain garden and pervious paving.

Section 8

Plant Selection Considerations

SECTION 8

Plant Selection Considerations

SOPHIE SAUVÉ

SOUTH BURLINGTON, VERMONT: Plants within a vegetated swale system.

In a Green Street, plant selection depends upon the type of system, the purpose and function of the planting, site conditions above and below ground, and the maintenance that will be required. Prioritizing objectives at the inception of designing a Green Street will help direct end results in terms of what type of plants should be used, the media (soil) requirements, and a maintenance schedule. When identifying a design consultant, be sure to prioritize experience with these factors of green design.

8.1 KEY PLANT SELECTION FACTORS

Factors to be kept in mind when selecting plants.

- **Function:** In addition to the water quality benefits, what other functions do you want the vegetation to provide, i.e. shading, color and/or visual barrier? Plants vary in the services and benefits they contribute to the landscape. To achieve desired results, choose plants based on function.

- **Site Conditions:** Understanding the site's limitations and potential is necessary for successful plantings and involves analyzing above and below ground conditions. Below ground considerations include understanding the soil texture, structure, drainage, and chemical properties. Inadequate soil volume or soil compaction will limit plant growth. Trees and other vegetation benefit from being planted in a continuous soil system; connecting systems underground benefits health and growth. Medium to large trees require 500 – 1000 cubic feet of soil to grow to maturity. Above ground considerations include exposure, as plants differ in their adaptions to temperature and ability to withstand cold, and available overhead space to accommodate crown development. Planting plans should consider mature size, height and spread in relationship to potential conflicts such as sidewalks, parking, utilities, lights, viewsheds, and line of sight.

- **Maintenance:** Understanding long-term maintenance needs is critical to facilitate the to select of the right plants. Regardless of plant selection, all plantings will require maintenance, especially in the early years of establishment. Deciduous leaf drop and other vegetative changes that create litter, such as fruit and seeds, can become a safety hazard or a clogging risk for drainage systems. Care should be taken near permeable pavements

Plant Selection Considerations

to avoid obstruction of the surface from leaf litter. If not already in effect, municipalities should consider adoption of regular street sweeping to collect leaf litter along roads before it enters conventional storm drainage systems.

- **Tolerances:** Placement of vegetation along roads where salt or other de-icing compounds are used throughout the winter months is a concern. It is highly advisable that any vegetation located adjacent to roads be tolerant of both salt applications and air pollution emitted from vehicular traffic. Where road salt application is excessively high, to support any native species consider changes to the deicing policy in order to balance public safety and environmental and community benefits.

- **Characteristics:** Plants characteristics may be desirable only in certain situations. For example, plants that attract pollinators are ecologically beneficial and add colorful insect life to vegetation. But bees may not be ideal guests at a public park or school. Similar considerations should be given to plants that are known to be poisonous or have thorns.

- **Native**: It is preferable to use native when possible, however, options may be limited to meet desired function(s), conditions, and aesthetics. At all times, invasive plants should be avoided.

- **Diversity:** Diversity of plant species is encouraged, as it contributes habitat for more species and increases resistance to future pests and diseases. When considering diversity, look beyond the project and consider the broader landscape context. To create healthy and resilient landscapes, species, spatial, and age diversity needs to be considered.

- **Quantity:** To improve the success of vegetation in stormwater installations, specifying a higher density of plants is recommended. This provides an immediate 'look' of a system and reduces the potential for weeds to grow among the plants. However, this does not go for woody plants, particularly trees. The quantity selected and density of planting should be based on the desired outcome at mature size.

Several Guides for selecting plants are available in Vermont, including:

- Vermont Tree Selection Guide, Vermont Urban & Community Forestry Program

- Vermont's Landscape Plants for Vermont, University of Vermont Extension

- The Vermont Rain Garden Manual, Winooski Conservation District, UVM Extension, and Lake Champlain Sea Grant.

Cross referencing these resources, as well as observing successful applications of difference species from existing projects throughout Vermont or nearby States is recommended. These resources are available at the Vermont Urban & Community Forestry's website: VTcommunityforestry.org/greenstreets

KEVIN ROBERT PERRY

▲ *High-density planting installed within green street projects provides maximum pollutant treatment, supresses weed growth, and looks great.*

Plant Selection Considerations

INDIANAPOLIS, INDIANA: The Indianapolis Cultural Trail green street plantings.

8.2 AESTHETICS

Green Street projects should all be designed as community amenities. Hence, the decision on what plant material should be installed within a Green Street or parking lot project is an important one. One primary consideration in choosing plants for a particular stormwater project is how the project will ultimately look.

The overall look of a Green Street project can vary considerably. Plantings can have a relatively formal and manicured appearance, or they can have a more "natural" look. Regardless, the choice of plant material should fit with the surrounding landscape context i.e. residential, urban.

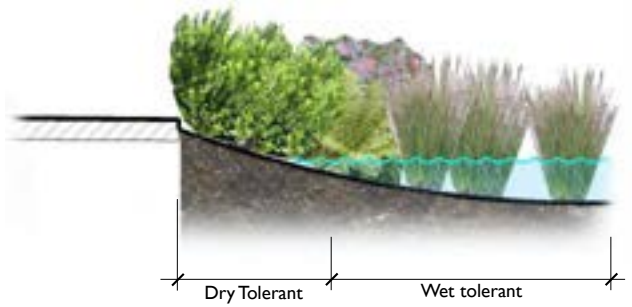
The overall diversity of plant material within a Green Street project can also affect aesthetics. A highly diverse planting palette with differing textures, colors, and growing heights can be very desirable. This is especially true for larger stormwater facilities and those that incorporate side slopes in the design. For those stormwater facilities that are smaller and more linear, such as stormwater planters, a single-species planting may be more appropriate. Regardless of the chosen palette, it is important to design and install the plant material at an appropriate density. Too often, stormwater facilities are installed with too few plants, so few, in fact, that one can't really call the project a "Green Street." A well-designed stormwater facility should have no bare ground showing after a two-year plant establishment period.

Except for trees, choose lower-growing plant material that do not exceed three feet in height. Low-growing plants tend to be more aesthetically and functionally preferable for Green Street applications. In addition, low-growing plant varieties help to reduce ongoing maintenance by eliminating the need for plant trimming.

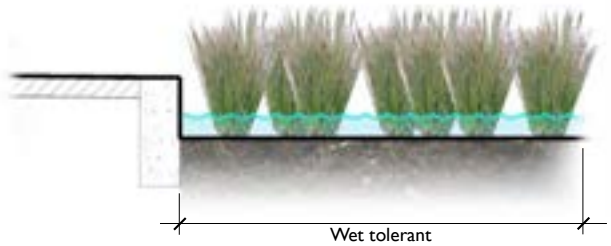
The last aesthetic consideration is how much of the plant material should be designed as evergreen versus deciduous. It is recommended that at least 70% of the plant palette, excluding trees, be evergreen. This helps to ensure that Green Street projects have year-round plant structure. Having a predominantly evergreen green street also helps slow water runoff due to the persistence of leaves.

8.3 PLANTING ZONES FOR STORMWATER

Green Street projects may have different planting zones based on the type of stormwater facility used. Stormwater facilities that are designed with a side slope condition (e.g. ,vegetated swales) have two planting zones: dry and wet. Shrubs, groundcovers, and perennials that thrive in drier conditions should be placed on the upper portions of the side slopes while wet tolerant plants, such as sedges and rushes, are best suited for the low, flat bottom zone of the stormwater facility. Stormwater facilities that have only a flat-bottom condition with no side slope (e.g., stormwater planters) have only one planting zone that should only be planted with wet-tolerant plant material. The illustrations below show the typical planting conditions based on stormwater facility type. It should be noted plants chosen for wet zone conditions should also have some level of drought tolerance in order to minimize, or potentially eliminate, the need for supplemental irrigation during dry periods.



Typical Side Slope and Flat-Bottom Planting Condition



Typical Flat-Bottom Planting Condition

KEVIN ROBERT PERRY

▲ *This street rain garden has two planting zones with dry-tolerant plants placed on the side slopes and wet-tolerant plants placed at the lowest elevations..*

KEVIN ROBERT PERRY

▲ *These street stormwater planters have no side slope condition and have only one planting zone featuring wet-tolerant plant material.*

KEVIN ROBERT PERRY

MONTPELIER, VERMONT: An educational sign for a parking lot swale.

Section 9

Implementing Green Streets

SECTION 9

Implementing Green Streets and Parking Lots

ANDREW HILLMAN

LANCASTER, NEW YORK: Green infrastructure outreach workshop.

A Green Streets approach requires a change in the way a community has historically viewed and evaluated its streets, from mostly single-purpose (moving people in vehicles) to a holistic approach that includes multimodal transportation, placemaking, and sustainability. Communities that want Green Streets need to build local support and capacity to ensure that project ideas can become reality.

9.1 BUILDING AWARENESS AND SUPPORT

To create a new vision for a street, community members need to build awareness, support, and buy-in. Demonstrating and communicating the values of Green Streets to public officials, municipal staff, and the community at large creates early buy-in and support. It also informs future opportunities to implement Green Streets or develop supportive policy. Examine what specific communities have used in the past and employ the most successful avenues for community engagement. Strategies may include:

- Outreach and Communication: Outreach is important for public awareness and building support. Presentations in the community, articles in the local paper or social media, and displays at town meeting are all strategies that can be employed to introduce and promote Green Streets.
- Pilot Projects: Low-cost, quick-build demonstration projects can help a community experience Green Street elements, build awareness, garner support, and test practices. They can also add value to programming by demonstrating effectiveness and reliability.
- Educational signage that signals to passers-by the unique and multifunctional aspects of existing green features and can help community members embrace change that increases green elements in street design.
- Public Installations: Beyond a pilot project, the installation of green streets facilities in public spaces offers municipalities several benefits, including first-hand experience with design, construction and maintenance of green streets before requiring it of others. Public installations not only help the public develop familiarity with Green Streets, but empowers municipalities to answer questions from private landowners who may have questions to make their practice own successful.

Talking about and demonstrating the values of Green Streets to public officials, municipal staff and the community at large creates buy-in early and when an opportunity arises; whether it is built infrastructure or a policy adjustment, the seed has been planted.

9.2 DEVELOPING LOCAL LEADERSHIP AND PARTNERSHIPS

Growing local capacity is at the heart of any community revitalization program. Sharing successful examples of Green Streets and making resources accessible to community members can help grow local interest and support in planning, constructing, and maintaining Green Streets.

Support for potential volunteers is also key to redevelopment initiatives. They are the people who will see the project to fruition and provide maintenance once a project is installed. Vermont communities are rich with individuals and groups who value the natural environment, such as SOUL Tree Stewards, members of a tree board, garden club, conservation commissions, or UVM Extension Master Gardeners.

Building partnerships between public and private entities is essential. Such partnerships can inform changes in regulations that help support Green Street principles or even fund green infrastructure in new development.

Key partnerships in a municipality may also include those between public works department staff, road foremen, local arborists, tree boards, tree wardens, bicycle and pedestrian committees, and community business associations. Fostering relationships between these entities and other volunteer-led organizations, such as watershed groups, can create a project vision with multiple benefits and long-term viability.

Identifying Project Leaders

Developing a successful Green Streets plan or program requires coordination between local, regional, and state organizations. Identify local leaders currently managing infrastructure or environmental projects and enlist help from town staff, local boards, non-profits or regional watershed groups, regional planning commissions, or state-wide non-profits.

State Partners

The State offers resources and technical assistance to support local development and implementation of Green Streets. State agencies that have resources and technical expertise in Green Streets includes the Department of Environmental Conservation, the Department of Forests, Parks and Recreation, the Vermont Agency of Transportation (VTrans), and the Agency of Commerce and Community Development.

The key resource for identifying state projects and best practices in green stormwater infrastructure is the state's Green Infrastructure (GI) Coordinator, a position jointly funded by the Department of Environmental Conservation and the University of Vermont's Lake Champlain Sea Grant Program. The GI Coordinator convenes a statewide group, the Green Infrastructure Roundtable, composed of individuals from municipalities, watershed organizations, state agencies, and the university community. GI Roundtable furthers green infrastructure goals throughout Vermont by sharing information on best practices, future funding opportunities, and education opportunities for green infrastructure.

Regional Planning Commissions

Regional Planning Commissions (RPCs) help local communities in their municipal planning efforts, including transportation planning and project development. RPCs help ensure that Green Streets policies and projects are identified and developed in local municipal and transportation plans. They also work closely with VTrans through the Transportation Planning Initiative and can help communities develop and implement future transportation-related infrastructure projects that include elements of Green Streets. RPCs also play a vital role in connecting local municipalities to state entities and funding sources.

State-Wide Non-Profits

The Vermont League of Cities and Towns, Watersheds United Vermont (WUV), and the Vermont Housing and Conservation Board (VHCB) are state-wide non-profits

Implementing Green Streets and Parking Lots

ANDREW HILLMAN

LANCASTER, NEW YORK: Green infrastructure outreach workshop.

that can provide insight, technical expertise, and leadership on implementation of Green Streets. The Vermont Natural Resource Council (VNCR), a leader in protecting our natural resources and building sustainable communities, is another great resource for providing education and developing local capacity.

Watershed Groups and Conservation Districts

Given the impact of conventional stormwater management systems on local water resources, watershed groups and Conservation Districts are particularly interested in the stormwater management capacity of Green Streets. These groups often advocate for Green Streets principles, apply for funding, and oversee the implementation process of stormwater-related projects in local communities.

9.3 DEVELOPING A LOCAL STRATEGY

Although communities may be receptive to creating Green Streets, there may be reluctance to initiate a Green Streets project without local leadership and community support. Establishing goals and identifying hurdles for implementing Green Streets, then identify what strategies and activities will help move communities towards project implementation. The table below explains what each potential strategy entails.

Providing a variety of opportunities for the public to get to know Green Streets in a community can increase willingness to change. Every town has at least one green feature to begin a conversation about Green Streets.

9.4 INFLUENCING LOCAL AND STATE POLICY AND REGULATION

Green Streets and parking lots can be achieved when policies align with community support. There are opportunities to influence regulations or local plans every few years during updates of municipal plans or local bylaws. The development of local policies and actions help lay the groundwork for future Green Streets installations and programs.

- Municipal Plan – Include specific language that recognizes the importance of Green Streets, their benefits to the community in new developments and redevelopment. The Plan should include policies and action items that could result in changes to land use regulations (zoning & subdivision),

POLICY, PROGRAM, AND PROJECT EXAMPLES

	DEFINITION	EXAMPLE
POLICY	A plan or course of action set by a government, business, or municipal board or committee intended to influence and determine decisions, actions, and other matters.	Develop a local Green Streets resolution and policy to promote and incorporate Green Streets principles in public and private development.
PROGRAM	A group of related projects managed in a coordinated way to obtain benefits not available from managing the projects individually. A program may also include elements of on-going, operational work.	Public "Build-Your-Own" Rain garden training program.
PROJECT	Temporary undertaking with a defined start and end point and specific objectives to create a unique installation or service that, when attained, signifies completion.	New bioretention retrofit project at a city parking lot.

changes to municipal infrastructure investments and public works policies, and new approaches to conservation. In addition, any barriers to the implementation of Green Streets techniques that exist in current land use regulations should be identified. Potential changes to these regulations and funding strategies to implement Green Streets should be evaluated and discussed.

- Zoning and Unified Development Regulations – Many local bylaws need updating to prevent new development from harming the natural features that help absorb stormwater. Municipalities can adopt Green Stormwater Infrastructure requirements in new construction. While the State of Vermont regulates stormwater runoff for development projects that disturb over one acre of earth or create one acre of impervious surfaces, the stormwater from many developments of less than one acre can cumulatively cause flooding and negatively impact water quality. Zoning regulations should require specific site design review and explicitly allow for bioretention areas, rain gardens, and filter strips. Parking requirements should be focused on reducing impervious surfaces through methods such as parking maximums (vs. the typical minimum required parking) or shared parking. Municipalities can fill the gap by regulating the stormwater impacts of smaller development projects through zoning and subdivision regulations.

- Subdivision regulations are a tool that communities can use to address the early stages of development planning as it relates to Green Streets. During the development of subdivisions, communities could require applicants to maximize design and functionality of stormwater management practices using Green Streets techniques relating to the design of internal roads, lot layout, parking, open space, public spaces and land to be conserved.

- Public Works Specifications - Green Streets practices impact a number of different municipal programs including street design and maintenance, underground utilities such as sewer, water and power, public space planning, management, and budgeting. As a result, there needs to be a unified approach to developing a Green Streets project. All municipal departments should be kept aware of potential projects, and municipal policy should require collaboration and synchronization, particularly when cost savings from Green Streets improvements can be realized when completed in coordination other projects. For example, Green Streets project may be included during a sewer or water line replacement that already impacts a street.

- Local Tree ordinances - Municipalities should consider integrating Green Streets into standalone ordinances or other municipal policies such as tree ordinances, which define the procedures for tree plantings and protection. These practices could be coordinated with a Green Streets approach, such as requiring a tree box filter when a new tree is installed by the municipality under certain circumstances.

- Local Energy Planning - Similarly, municipal energy planning and policy can encourage Green Streets practices as a way to reduce the need for cooling during the summer. For communities developing Enhanced Energy Plans, support for Green Streets should be included as one component of how the municipality will demonstrate "leadership by example" with respect to reducing energy use throughout the community.

9.5 PROGRAMMING

Identify opportunities in municipal planning and policy to initiate Green Streets

Implementing Green Streets and Parking Lots

project in a coordinated and systematic approach. While individual Green Streets gestures improve water quality and make our streetscapes and parking lots more enjoyable places, connecting elements in a coordinated program enhances the benefits and maximizes impact. Determining programming goals, whether that is the capture of stormwater runoff or the amount of urban tree canopy, will help narrow the program, maximize impact, and prioritize projects. Programming helps communities align projects that meet multiple goals in a focused, cost-effective, and impactful manner.

9.6 PROJECT

The development and identification of a project typically goes through a four step process:

1. **Planning and Feasibility, or Project Scoping and Identification**
2. **Design, Engineering and Permitting**
3. **Construction**
4. **Maintenance and Monitoring**

The first stage, planning and scoping, requires identification of the size and location of the project area. The scoping of the project will help the municipality explore what is feasible, given the financial, environmental, community, and infrastructure opportunities and constraints. Additional projects can be added over time, as momentum builds, to meet the overall programming and goals of the community. Within the project area, identify priority zones for investment to enable a project to be flexible to match funding opportunities.

Once a project has been identified, technical experts can then propose concepts and involve the public in the selection of alternatives. Selected concepts are then developed into construction documents and can go out to bid. Projects that receive public funding are required to go through a competitive bidding process.

After a bid has been accepted, construction begins. However, like all infrastructure projects, the end of construction is not the end of a project – it is the beginning of long-term maintenance and monitoring. Green Streets must have a detailed maintenance schedule in place to ensure it long-term success and viability.

9.7 FUNDING

Like any new project, securing the funding for Green Streets and parking lots can be intimidating. But it's necessary to make a Green Street design become a reality. Many projects require intentional and thoughtful combinations of local matching funds and grant programs. Below are some ways to plan for the funding of a Green Street project.

Capital Improvement Planning

One of the best tools available to meet your community vision and objectives is *capital planning*, a process that outlines the use of limited funds to achieve needed improvements in public facilities and infrastructure such as Green Streets. Not all improvements can be funded immediately, and some may be more critical than others to meeting your planning goals. The capital budget and program helps municipalities select, schedule, and finance their public facility improvements. The plan sets forth the capital projects to be funded each year for a period of five or more years and identifies the anticipated source of funding for each project. The long-term capital program informs the annual capital budget, and projects listed on the capital program are likely to be implemented because funding is allocated to make it a reality. While capital planning may seem purely an accounting exercise for municipalities to manage public facilities, it is a powerful implementation tool when used to fund priority projects that move the community closer to the vision in the plan.

Local Funding Sources

Vermont towns, villages, and cities can encourage good design through incentives at the local level. These incentives cover a wide array of potential services and funds and can be scaled to suit the budget and size of the community. Among the most frequently used local tools are:

Downtown Improvement Districts (DID) – DIDs are special assessments made on downtowns where the additional tax revenues are dedicated to improvements within that district. Green infrastructure improvements could be supported through a DID.

Local Option Tax – Local option tax is a way for municipalities in Vermont to raise additional revenue to support (green stormwater) infrastructure improvements.

Bonding - Bond issues by the town may provide important opportunities to leverage other funds, such as required match amounts for federal or state grant programs. Regional bonds may be needed for larger scale projects.

Private Donors and Fundraising - Funds can be provided by private donors or through special fund-raising efforts that can supplement or substitute for local funds. A Conservation Commission can be an excellent representative to encourage donations related to the implementation of Green Infrastructure.

Funding Opportunities

Funding opportunities are always changing and evolving, and staying abreast of current grants is challenging. To assist in locating viable funding options, below is a list of grant resource hubs that could be applied for to implement a Green Streets initiative or project.

- The *Agency of Commerce and Community Development* offers a comprehensive directory of grants and assistance in matching projects with funding.
- The Department of Environmental Conservation's *Clean Water Initiative* Program offers a list of current and prior water quality grants and the ability to sign up for grant notifications.
- The *Agency of Transportation's Municipal Assistance Bureau* provides both technical and financial assistance in the planning and implementation of projects.
- The *Vermont Urban & Community Forestry Program* offers grants to support projects that grow tree canopy.
- The *Lake Champlain Basin Program* offers a variety of grants and links to other funding opportunities.
- The *Environmental Protection Agency* hosts a site that list the federal grant programs that support green infrastructure.

Philanthropic foundations are strong in Vermont and worth investigating. Some of the top giving foundations for projects aligning with Green Streets principles include the *Vermont Community Foundation*, the *Lintilhac Foundation*, and the *New England Grassroots Environmental Fund*.

These resources are available on Vermont Urban & Community Forestry's website, *vtcommunityforestry.org*.

The Vermont League of Cities and Towns developed a model *Low Impact Development Bylaw Template* to help reduce the impacts of conventional development practices on water quality. While the model is aimed at stormwater management, it is a stepping stone in providing the content that may be envisioned in advancing Green Streets at the local level.

SOPHIE SAUVÉ

SOUTH BURLINGTON, VERMONT: Students help install one of many rain gardens throughout their school grounds and parking lot.

Section 10

Maintaining Green Streets

SECTION
10

Maintaining Green Streets

GARDENBLOGSPOT.COM

Like all infrastructure, green street practices require a detailed maintenance regime. Integrating the who, what, when, and how of maintenance into design concepts will ensure that the final project reflects local capacity and resources. Matching practice selection with site-specific resource conditions will improve the likelihood of appropriate regular maintenance and project success. A detailed maintenance plan describes these elements and should accompany any Green Streets design. Maintenance plans typically include:

- **WHO:** Identification of the responsible parties to manage maintenance tasks.
- **WHAT:** A protocol of tasks (such as weeding and sediment removal) and any determination of functionality (such as an infiltration test)
- **WHEN:** Timing of regular maintenance.
- **HOW:** Design details with photographs to identify plant species and necessary tools to perform maintenance tasks.
- **WHY:** Without a maintenance plan, a green street will appear neglected. Overgrown plant may become an eyesore and deter from the objective of a green street.

Long-term funding should be considered if equipment purchase is necessary or the municipality elects to hire skilled workers to fulfill the maintenance requirements. For projects in a state highway right-of-way, a signed maintenance agreement between the host municipality and VTrans is required to ensure continued compliance with stormwater laws. Maintenance agreements are also required when the site is permitted by the state.

10.1 PLANNING: BEFORE AND DURING CONSTRUCTION

Before any construction occurs, proper measures for protecting existing vegetation should be established. Details specific to tree root zone protection should be noted in any project that includes disturbance of developed land. To meet state regulations, erosion and sediment controls (ESC) are expected to be installed before the start of any construction project. It is essential that municipalities and state agencies regularly inspect ESC throughout the construction process to prevent undue harm of waterways during the construction of a project. The timing of

when a stormwater facility comes 'on line' is also vital during the completion of a project. Some facilities, like rain gardens, are required to remain 'off line' until all construction is complete and, in many cases, until vegetation is established. Careful oversight of these steps will enable the life of a project to start on positive footing.

10.2 WHO

The decentralization of green stormwater infrastructure was partially motivated by the feasibility of maintenance on a smaller scale. Rather than requiring heavy equipment for the maintenance of centralized systems, such as detention ponds, green streets options can be maintained with shovels, rakes and pruners.

Early in a Green Streets design process, planners and designers should seek to be in close contact with municipal staff to best understand the human resources available for long-term maintenance. If the new infrastructure will require duties that depart from current practices, staff training needs should be identified and planned for prior to project completion.

Green Streets maintenance is commonly completed by one of three options: solely by a municipality as part of their public infrastructure upkeep tasks, through a private–public partnership where an organization works with the municipality to take over the work or pays for an outside group to do it, or through a publicly-funded contract to a professional maintenance crew. The City of Portland, Oregon has developed a stewardship program for volunteers to help maintain Green Streets. While they have staff that oversee maintenance of the infrastructure, they provide a clear list of tasks that stewards can undertake and when. The City also provides details on the schedule and content of tasks that will be undertaken by staff or a contractor. Green Streets maintenance success is also influenced by educating surrounding residents and businesses so that they are connected to and aware of the living system in their neighborhood. For example, maintenance staff can leave door hangers for Green Street neighbors with a description of the work performed and contact information for reporting maintenance needs between regular visits.

10.3 WHAT

Maintenance interventions differ by practice type. Note that most practices fall into more than one category, and as a result will need attention that addresses multiple functions. A maintenance plan specific to the infrastructure on your site will ensure clarity for those administering the inspection and upkeep tasks. Green Street's practice maintenance can be categorized based on several factors:

Presence and type of vegetation

Practices that utilize vegetation will necessitate regular care of the vegetation. Tasks range from regular mowing in grass swales, weed removal in bioretention cells, and pruning of trees. In all cases, vegetation requires special care, including watering, during establishment.

Pretreatment

Pretreatment allows settling of particles out of stormwater before it is routed to a vegetated practice. Catch basin sumps and forebay cells are common pretreatment mechanisms. Because they function as settling basins, practices that utilize pretreatment should have sediment regularly removed. Depending on the practice and design, this is commonly achieved either by hand with a flat shovel or with a vacuum truck.

Mechanism of treatment

Both infiltration and filtration practices require consistent ability for water to move through the media (known as hydraulic conductivity). In these practices, removal of sediment build-up that can clog the media is necessary, usually every year. This can vary depending on the characteristics of the watershed. In bioretention cells, this type of maintenance includes scraping of the top layer of soil and mulch and replacement with fresh material.

Presence of hard infrastructure

Practices with hard infrastructure (such as underdrains or concrete inlet structures) require assessment of the integrity of the built elements. Underdrains may become clogged and require backflushing through maintenance ports at the surface of the practice. This may require pressurized hose equipment. Practices such as planter boxes or green gutters that rely on intact hard surfaces should be inspected for cracking or damage that may inhibit function.

10.4 WHEN

Maintenance should begin immediately following installation. For vegetated

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KEVIN ROBERT PERRY

systems, this is especially true as newly-planted vegetation requires irrigation and protection from weeds while root systems establish. This initial maintenance could be included in the contractor's warranty period. In these cases, it is advisable to have a retainer in place to ensure that maintenance is performed by the contractor as specified in the contract.

Infiltration and filtration practices can become clogged with sediment, rendering them useless, if not protected during construction. Requiring a post-construction infiltration test by the contractor to verify the practice integrity can incentivize extra care of the site by project managers.

10.5 HOW

Some inspection and maintenance activities are routine, like weeding and mowing. Others require special knowledge and tools, like infiltration testing or catch basin vacuuming. How an activity is completed can be flexible based on local needs. For instance, if a town does not own or regularly contract the use of a vactor truck, a shallow forebay structure can be specified to allow sediment removal with a flat shovel instead. Similarly, if a town or property owner lacks the capacity or will to maintain complex flowering perennial plantings, a simple plant palette of clumping grasses or shrubs can reduce maintenance burden without impacting practice functioning. The "how" of maintenance should carefully consider the capacity of the ultimate caretaker so design can reflect an agreed upon method for care.

10.6 WHY

Without designing with maintenance in mind, green streets and especially, green infrastructure will not perform as expected over the long-term. There are several maintenance factors to consider before project implementation, especially in our unique Vermont-climate which consists of several freeze-thaw cycles.

10.7 MAINTENANCE ACTIVITIES SPECIFIC TO VERMONT

Vermont's weather means including winterization as part of a maintenance plan. Draining, cleaning, and sealing any subsurface systems above the frost line, removing standing water with an approved vacuum cleaning device, and waste disposal are a few things to consider. Some traffic bump-out stormwater systems may require installation of vertical posts to delineate the border for snow plowing. Avoid the storage of snow piles containing sand on or near any green infrastructure practice. Communication with plowing contractors and clear delineation of practice area will be necessary to ensure compliance.

10.8 MAINTENANCE ACTIVITY SCHEDULE

	Green Street Care and Maintenance Activity	2-3 Year Establishment Period		Long-Term Stewardship Phase
		Frequency	Time of Year	
VEGETATION	**Water vegetation**	Weekly during first 2-3 months after installation and when rainfall is less than one inch per week; 25 gallons bi-monthly via slow release device	May – September	After first three years: weekly during droughts (more than two weeks without rain).
	Spot weeding	Inspection in the spring and the fall at minimum and maintain as needed	April-October	
	Remove and replace mulch layer (and upper layer of soil if clogged)	Annually or as needed	May-June	Annually or as needed
	Prune trees and shrubs as needed to keep inlets and outlets clear		February-April	As needed
	Add planting to maintain desired vegetation density, if applicable		September/October	As needed
	Street sweep for leaves	As needed	September/October	
HARDSCAPE & TRASH	**Clear stormwater curb openings of leaves, trash, debris.**	Following storm events; quarterly inspections	May- November	Quarterly Inspections at minimum to maintain function
	Remove trash	Quarterly inspection at minimum and maintain as needed	May-October	Quarterly Inspections at minimum to maintain function
	Remove sediment in pretreatment cells and inflow points	Quarterly inspection at minimum and maintain as needed	May-October	Quarterly inspection at minimum and maintain as needed
	Clear top of overflow drain	Quarterly inspection at minimum and maintain as needed	May-October	Quarterly inspection at minimum and maintain as needed
	Structural repairs	Quarterly inspection at minimum and maintain as needed	May-September	Quarterly inspection at minimum and maintain as needed
	Vacuum clean out of inlet/storm lines	Annually or as needed		Annually or as needed
	Winter protection of systems	Quarterly inspection at minimum and maintain as needed	Install Fall/ Remove Spring	Annually

SOPHIE SAUVÉ

MIDDLESEX, VERMONT: An interactive and educational vegetative swale.

Section 11

Case Studies

Case Studies

SOPHIE SAUVÉ

PROJECT LEAD: Dan Currier, Central Vermont Regional Planning Commission (CVRPC)
PARTNERS: Northfield, Friends of the Winooski River
DESIGNED BY: Watershed Consulting Associates, LLC

11.1 NORTHFIELD: CENTRAL STREET BIORETENTION

PROBLEM DEFINITION: Located adjacent to Depot Square in downtown Northfield, Central Street is on a steep grade, making it susceptible to fast erosive flow during storm events. Catch basins in this part of town are linked to the combined storm sewer system that discharges to the wastewater treatment plant. Large volumes of water during storm events can overwhelm the capacity of the treatment plant, causing discharge of untreated sewage to the Dog River. Reducing the volume of water that reaches the storm sewer can reduce the regularity of these overflow events and protect water quality.

PROJECT BACKGROUND: The VT Department of Environmental Conservation (VT DEC) manages a mapping program that identifies a town's existing stormwater infrastructure and sources of runoff, and then prioritizes project locations based on feasibility, cost, and pollutant reduction potential. This site was identified in 2011 during a mapping exercise in the Village as a priority location for intervention to protect the Dog River. The Central Street Bioretention is one of three stormwater practices installed in this area with funding the Vermont Department of Environmental Conservation's Ecosystem Restoration Program (ERP) –now the Clean Water Initiative.

TECHNICAL INFORMATION: Central Street Bioretention is a terraced series of filtration planters with a timber frame and check dams to reduce water velocity on the steeply sloped site. The terraced chambers allow water to filter into the amended soil and into ground water – reducing the volume of stormwater that enters the catch basins at the roadway. A standpipe in the lowermost chamber allows rare large events to safely discharge to the storm sewer without risk of flooding infrastructure.

BENEFITS: Outfalls disconnected stormwater runoff from Central Street and eliminated combined sewer overflow events by reducing loading to the system. The two basins (also one adjacent to Legion Hall Parking Lot) receive water from 14 acres, seven of which are impervious surfaces. The partnership with the municipality, who maintain the facility and worked with the CVRPC to build it quickly, was crucial to the success of this project.

LESSONS LEARNED: When seeking to design and install innovative infrastructure, hiring qualified contractors and receiving accurate quotes for work can be a challenge. Ensuring experienced project management and construction oversight can help reduce these challenges.

11.2 HINESBURG: SILVER STREET RAIN GARDEN

PROBLEM DEFINITION: The LaPlatte River has been identified as stressed due to stormwater runoff influencing flow and nutrient loading to the waterbody. In a 2010 stormwater mapping study, the intersection of Route 116 and Silver Street in Hinesburg was noted as a site generating a large runoff volume from extensive impervious cover and limited infiltration or retention in the drainage area. The LaPlatte River is less than 800 feet from the roadway junction – making management of stormwater critical for waterway health.

PROJECT BACKGROUND: The Hinesburg Community School parcel is adjacent to the well-travelled intersection of Route 116 and Silver Street, making this location ideal for treatment, visibility, and public access. Over the past decade several Vermont Agency of Transportation (VTrans) projects were constructed in this drainage area, including a new bridge over the LaPlatte and intersection realignment and sidewalk extension. None of these projects were required to address stormwater. With leadership from the Lewis Creek Association, the rain garden project was prioritized for implementation and funded by the VT Department of Environmental Conservation Ecosystem Restoration Program (ERP).

TECHNICAL INFORMATION: The Silver Street Rain Garden consists of two-tiered vegetated chambers with a forebay at the outfall of 3 large stormwater pipes to settle out particles and slow water velocity. The garden was designed to filter runoff before it reaches the LaPlatte River – providing reduced storm flow and improved water quality. Native plant species including iris, marsh marigold, aster, and turtle head were selected for suitability in rain garden soil conditions, visual interest, and pollinator benefits. Pollutant removal modelling of the project indicates a reduction of 87% of suspended solids and 34% total phosphorus from the drainage area.

BENEFITS: Stormwater captured in the rain garden is filtered and infiltrates into the soil rather than flowing directly into the LaPlatte untreated. The garden's proximity to the Hinesburg Community School allows educational benefits for the children, including regular visits to observe wildlife and vegetation growth. The diversity of native plants creates habitat for multiple wildlife from insects, amphibians and birds and provides visual interest at different times of year. What was once a monoculture of mowed lawn on a steep slope now a highlights the important ecological functions that can be incorporated into a village environment that includes multiple modes of transportation.

LESSONS LEARNED: As a retrofit project, it was challenging to work within the existing site constraints. Recognition by VTrans of stormwater impacts to the LaPlatte during the design and engineering phases of the multiple projects would have allowed time and cost savings for construction of the rain garden. The existing small colony of cattails was not expected to dominate the planted area. The aesthetic features of the diverse plantings are now overwhelmed by the cattails but the diversity of native plant species still provides ecological benefits. A strong maintenance plan with dedicated funding and staff is important to ensure long term project success. Cattails are establishing in the garden which was not part of the design. A strong maintenance plan with dedicated funding and staff is important to ensure long term project success.

PROJECT LEAD: Lewis Creek Association, Andrea Morgante, Board Member
PARTNERS: Town of Hinesburg, Mike Anthony, Road Foreman
DESIGNED BY: Milone & MacBroom In., Brian Cote Project Engineer

Case Studies

PROJECT LEAD: Paul Simon (formerly of White & Burke)
PARTNERS: Malone Properties, property owners
DESIGNED BY: White & Burke, SE Group, DeWolf Engineering

11.3 SOUTH BURLINGTON: TRADER JOE'S: PARKING LOT RAIN GARDEN

PROBLEM DEFINITION: In 2013, the Development Review Board and City Council of South Burlington were debating the adoption of a Form Based Code for their City-Center District. While regulations at the time were in flux during a period of Interim Zoning, the prospective tenant and owner sought to meet both current and future regulations, leading them to address stormwater on site.

PROJECT BACKGROUND: Garden Street, the Street leading to Trader Joe's / Pier 1 in South Burlington is expected to be extended and become one of the main entry points to the cities planned City-Center. Ahead of the city-wide standard that would set a threshold of half acre of disturbance/ development to trigger stormwater management requirements (lower than the state's one acre), the use of Low Impact Development (LID) techniques for typical rainfalls were sought. Stormwater was part of the permitting process, including the maintenance agreement and bioswale management, therefore, if not well cared for, it becomes a zoning violation.

TECHNICAL INFORMATION: Green Stormwater Infrastructure includes a bioswale within the parking median central to the development, in addition to landscaping around the building and in the parking islands. The bioswale includes sloped vegetation and numerous plantings capable of withstanding periodic saturated soil conditions working to trap pollutants and silt particles from the parking lot.

BENEFITS: The bioswale was designed as an attractive site feature and is maintained by the property owner. Educational signage is also included on-site to educate the importance of a bioswale and highlight the benefits of the project.

LESSONS LEARNED: Looking ahead at future regulations can help ease the permitting process.

11.4 ST. ALBANS: PERMEABLE PAVEMENT, SILVA CELLS, AND STORMWATER PLANTERS

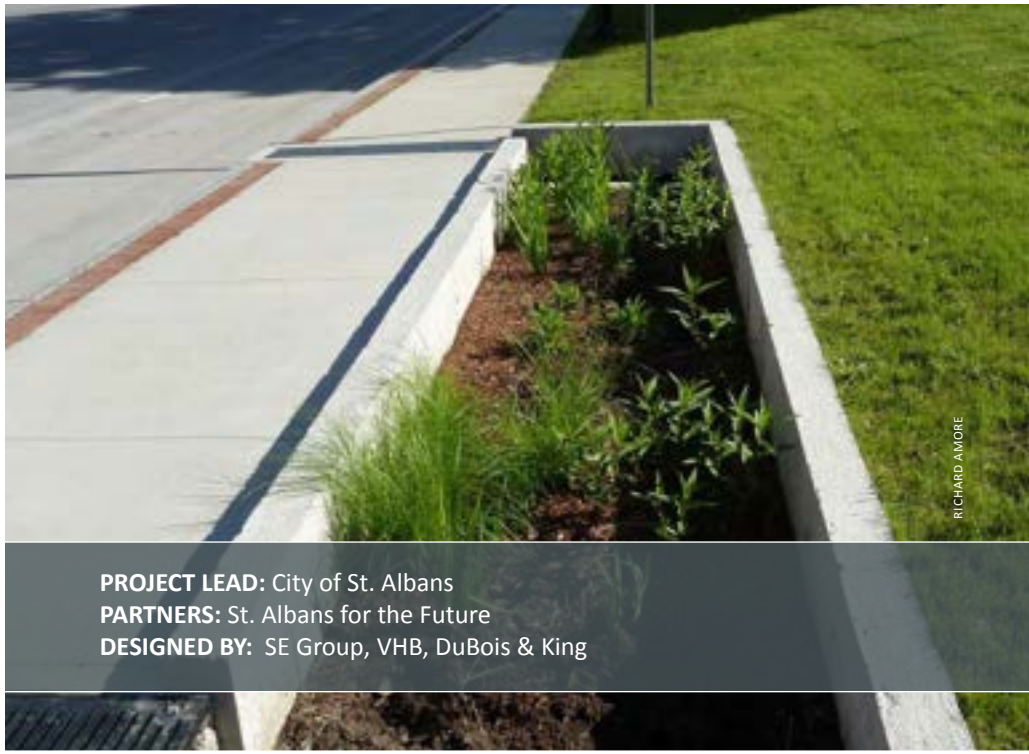
PROBLEM DEFINITION: Downtown St. Albans is an historic town center with a rich tradition as a center of commerce in the northern part of the state. Aging infrastructure, parking patterns that impede multi-modal transportation and narrow sidewalks were impacting the City's ability to attract new businesses, provide access to new and existing visitors, and serve as an attractive and safe place for community gatherings. To the west of the downtown square, St. Albans Bay is impacted by excess phosphorus runoff, causing algae blooms that impede use of the natural resource.

PROJECT BACKGROUND: As the first in a series of projects, the Main Street Streetscape project was not the only public infrastructure project that was finished to revitalize the Downtown, but it was the one that started the ripple effect. Green features were integrated at several points in the planning and design. Pervious concrete replaced asphalt paving along pedestrian walkways in Taylor Park. Installation of that feature took place over multiple project and funding rounds from 2009-2011. In 2013, the larger revitalization effort was underway and included stormwater planters installed along Main Street adjacent to the park and street trees with Silva Cell technology on the merchant side of the road. Concurrently, sidewalks were widened to accommodate pedestrians and outdoor seating and parking patterns were updated to allow safe crossing with bump outs and improved access for multiple transportation modes.

TECHNICAL INFORMATION: Pervious concrete in Taylor Park reduced impermeable surfaces in the downtown and provides a publicly accessible example of its installation. Stormwater planters along the roadway filter and infiltrate runoff prior to discharge into the City storm sewer. The result is a reduction in volume and an improvement of water quality reaching waterways. Silva Cells® provide structural support for the expanded sidewalk while giving tree roots access to substantial soil volume to increase healthy growth.

BENEFITS: The public investment in downtown St. Albans has resulted in new development including a new 84-room Hampton Inn Hotel and expansion of existing businesses to provide outdoor dining on the extended sidewalk area. Downtown storefront vacancies decreased by 75% and all upper story spaces along Main Street are either inhabited or planned for renovation. The prominence of the green features in the downtown core invites conversation and learning from locals and visitors on unfamiliar techniques for managing stormwater that incorporates an historic village character.

LESSONS LEARNED: The selected stormwater features require more maintenance than the City can regularly provide with its limited staff. Considering local capacity for ongoing maintenance is critical for functioning and beautiful Green Streets features. Many of the trees required replacing in the first couple of years. As with any landscaping effort, including a replacement insurance provision with the contractor ensures that vegetation failure within the first year of planting will be replaced at no cost to the City. Permeable concrete in its currently available mixture, has been found unsuitable for Vermont's harsh conditions of freeze-thaw cycles and common use of deicing salts. The walkways in the park are showing signs of premature wear as a result. Careful selection of materials for the specific conditions of a site can reduce the chance of failure. Alternatives to pervious concrete are readily available in the marketplace.



PROJECT LEAD: City of St. Albans
PARTNERS: St. Albans for the Future
DESIGNED BY: SE Group, VHB, DuBois & King

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