GREEN STREETS GUIDANCE DOCUMENT

CRWA

THE CAMBRIDGE DEPARTMENT OF PUBLIC WORKS

MassDEP

COVER: *Chestnut Street before-and-after visualization*

Addressing the challenge of stormwater runoff can be particularly difficult in a dense urban setting, like Cambridge, where pollutant loading is high, due to large amounts of impervious cover, and minimal space is available for siting treatment systems. Green Streets are a strategy for using public roadways and sidewalks to address stormwater runoff. Green Streets incorporate trees, plant-based stormwater treatment systems (known as green infrastructure), and alternative roadway designs to help slow car traffic, promote non-carbon based transportation (like walking and biking), beautify the neighborhood, and improve the quality of local rivers and streams.

Implementing Green Streets in Cambridge's dense network of streets, while challenging, presents many opportunities to achieve multiple City goals and represents a real win-win opportunity. Green Streets will help the City achieve its environmental goals for pollution reduction and climate mitigation and adaptation, while also improving quality of life. Streets are often collectively the largest amount of impervious cover that a community manages and cities across the state will need to address roadway runoff to meet stormwater permit requirements. Green Infrastructure differs from traditional stormwater infrastructure in that it requires space both underground and at street level, furthermore systems often include soil, plants and other features not found in traditional "grey" infrastructure; as a result planning, implementing and maintaining green infrastructure involves a broad cohort of City departments and residents.

RESIDENTIAL STREET DESIGNS

The City of Cambridge, in partnership with the Charles River Watershed Association (CRWA), developed conceptual green street designs for three public residential streets that can serve as models for residential streets citywide. The three streets are: Webster Avenue, in East Cambridge, Park Avenue, in Strawberry Hill, and Chestnut Street, in Cambridgeport.[1] Conceptual green street designs have been produced for each of the three streets including an evaluation of each design for water quality and quantity impacts, and benefits to the Charles River. These designs can serve as a model to help Cambridge systematically integrate green infrastructure into roadway projects, even those with very small or no design budgets. Across all three project streets, the following locations were identified as opportunity sites for green infrastructure implementation:

- Corners of street intersections
- Sites where underground stormwater drains converge
- Relative low points
- Brick or concrete plazas
- Stretches of sidewalk that lack street trees
- Existing sidewalk pinch points caused by the overgrowth of a mature tree out of its existing tree well
- Parking lanes for underground infiltration systems
- Open space including city parks, abandoned railroads, and private property

Based on underlying soil conditions, groundwater levels (GW), and whether or not streets were in a combined sewer (CS) area, stormwater treatment systems identified as preferred options on the three project streets included the following:

Project Street	Stormwater planter	Tree planter	Bump-out rain garden	Curb extension	Perforated pipe trench	Subsurface storage chamber
Webster Ave. (CS)	•	•	•	•	•	
Park Ave. (CS, High GW)	•	•	•	•		•
Chestnut St.	•	•	•	•	•	

CHARLES RIVER NUTRIENT TOTAL MAXIMUM DAILY LOAD (TMDL)

The Charles River currently receives roughly double the phosphorus pollution it should. Phosphorus is a nutrient that acts like a fertilizer in the river, allowing plants and algae to grow out of control, altering the natural balance of the riverine ecosystem. A total maximum daily load (TMDL) or pollution budget study conducted for the Charles River found that most of the phosphorus pollution is brought to the river in stormwater runoff (Figure 1). Phosphorus is found in detergents, fertilizers, deicers, naturally in soils, and is a by-product of burning fossil fuels. Due to the wide array of sources, where there is stormwater there is phosphorus and where there is a lot stormwater, such as in densely developed cities like Cambridge, there is a lot of phosphorus runoff!

The TMDL study calls for a 65% reduction in phosphorus in stormwater coming off of densely developed land. Green infrastructure systems, particularly infiltrating systems, are far more efficient at removing phosphorus when compared to traditional stormwater infrastructure.

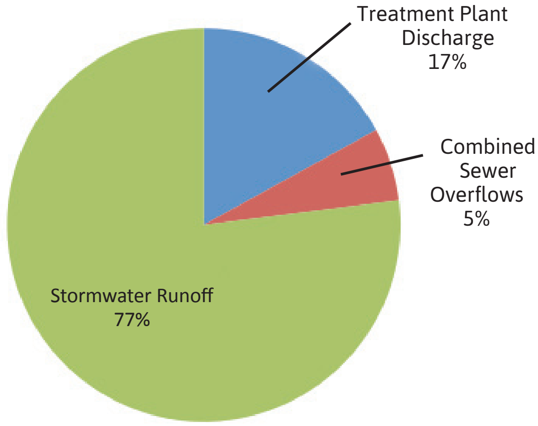
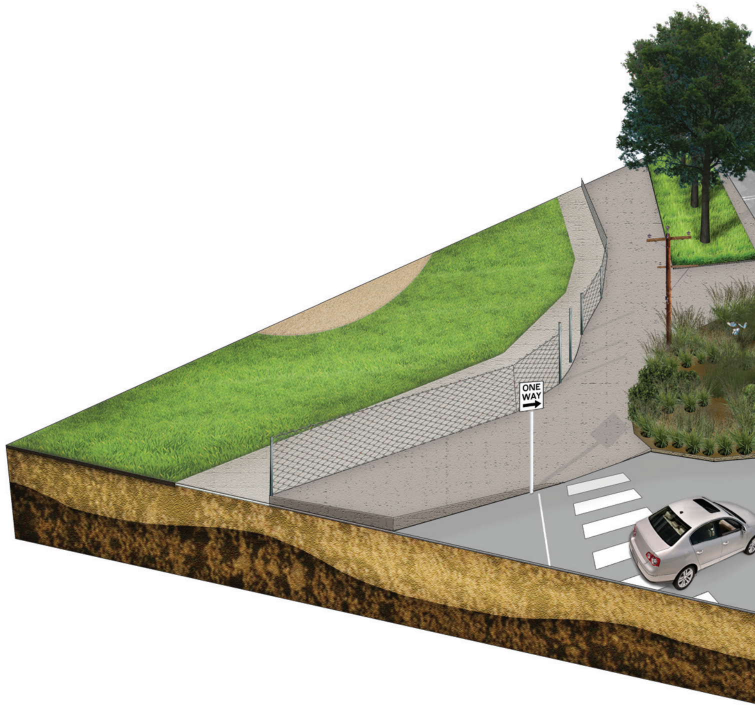
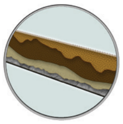


Figure 1: *Annual Phosphorous Load to the Charles River by Source Category (as determined by the Charles River Nutrient TDML)*

[1] In coming years the City will take up final design and ideally implementation for green infrastructure along these streets, all designs presented here are conceptual designs to help the City and residents think about way to implement GI in Cambridge.

DESIGN CONSIDERATIONS FOR CAMBRIDGE GREEN STREETS





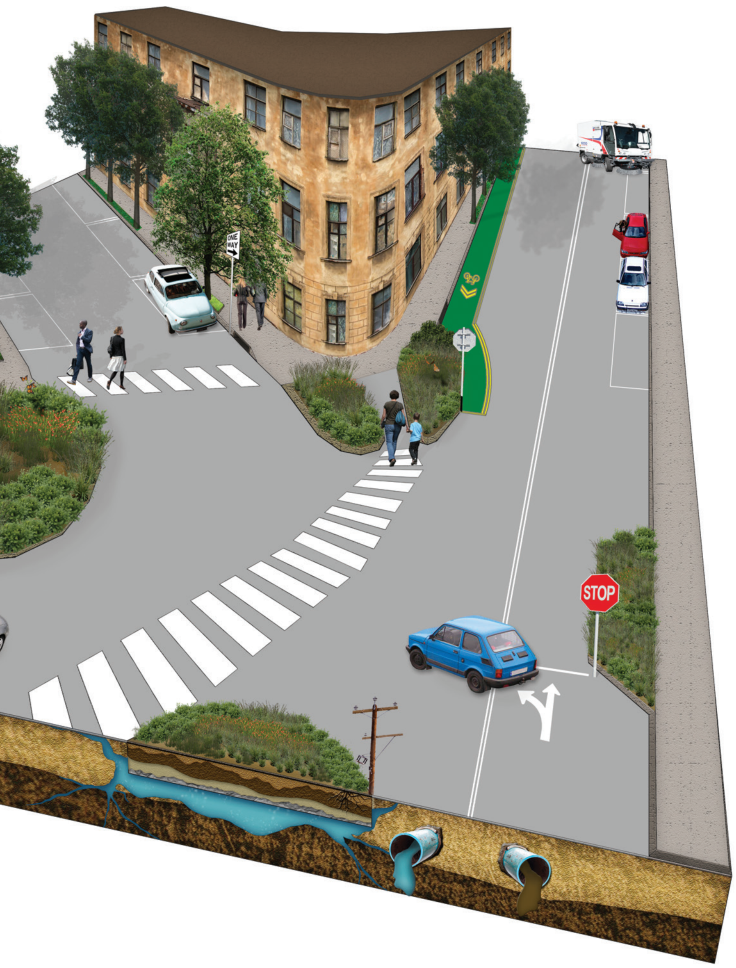
Soils: Soil conditions vary throughout the City. In areas with soils that drain water well (hydrologic soil groups A and B) and have low (deep) groundwater tables, prioritize green infrastructure systems that infiltrate water into the ground (i.e. infiltrating systems). These types of systems typically provide the most cost effective pollutant removal. In areas where either the groundwater table is high or the natural soils are constrictive to water flow, opt for lined filtration systems such as bioretention systems.

Sidewalks and pedestrians: Sidewalks can provide good opportunities to incorporate GI on dense or narrow streets. Sidewalks should maintain a minimum width of 5 ft. to ensure proper mobility for people with disabilities, people using strollers, wheelchairs or other mobility devices; where existing sidewalks are wider, however there may be opportunities to incorporate GI. A common situation found along Cambridge streets are mature trees which have outgrown their tree well. Based on space availability, sidewalks can be narrowed or extended into the parking lane (street-ward of the tree) to allow for a larger tree well or planted bed that could also incorporate GI. Stormwater planters placed along the street side of the parking lane should incorporate crossing paths approximately every 40’ to provide access to parking lanes and roadway. GI systems and healthy street trees can promote walking and other low-carbon forms of travel. Green streets can be used to connect neighborhoods to transit like the T or bus stops to make it easier or more attractive for individuals to access public transportation especially in hot weather.

Street trees: When possible, trees should be incorporated into or adjacent to new GI systems. Green Street designs should include recommendations for new street trees. Mature trees should be protected and restored. An analysis completed as part of the City’s climate planning initiative found that 5 mature trees over 150 feet (one tree every 30 feet) can provide a cooling effect up to 3.5 °F.

Street parking: Parking lanes can be an ideal spot for GI implementation. Consider “dead” spots, such as near intersections, cross walks or fire hydrants where cars would not park. Effective GI systems can also be implemented in the footprint of just one or two parking spaces. In sections of the City where parking demand is very high, eliminating parking spaces may not be an option. For these areas, consider underground infiltration that runs underneath the parking lane and is fed by existing catch basins.

Travel lanes: Look for opportunities to reduce the width of travel lanes or even eliminate a travel lane on larger streets as was done along Greenough Boulevard. This will provide space for GI systems and reduce traffic speeds to promote safe travel for everyone. Stormwater planters can be as narrow as 2 ft. and have an impact on local water quality. Low shrubs and grasses should be used near intersections so sight lines are not limited.

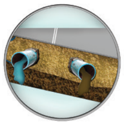


Open or under-utilized spaces: Green infrastructure can enhance existing small pocket parks or paved plaza areas that are currently under-utilized or unattractive. Some larger open spaces such as parks or vacant lots should be considered for redevelopment into stormwater parks. Stormwater parks function like a typical park during dry weather but during wet weather they store, filter or infiltrate stormwater runoff. Alternatively, storage or infiltration systems can be sited underneath parks.

Topography: Roadways with a lot of topographic changes can present a challenge. GI systems need to be sited at low points to allow the water to flow into them and ideally should be in the vicinity of existing stormwater infrastructure (such as a catch basin). Siting GI systems along a steep incline is possible but not preferred and will require design features that prevent the water from rushing down the system, eroding plants and soil.

Bicycles: Comprehensive planning has gone into identifying bicycle friendly streets and routes throughout the City. The City should seek every opportunity to implement GI in conjunction with bicycle improvements. GI can offer shade to bikers on a hot day or reduce overall urban heat island impact. When space constraints prevent above-ground GI, underground infiltration can be used under a bike lane. Very narrow GI systems can be used as a barrier between car traffic and dedicated bike lanes to separate bikes and cars.

Street sweeping and snow removal: GI system placement must accommodate street sweepers and snow plows that need to maneuver close to the curbside. Roadway bump outs may require winter weather visibility markings if vegetation is not visible. Plantings may need to be salt tolerant for areas where salt is used for snow removal.

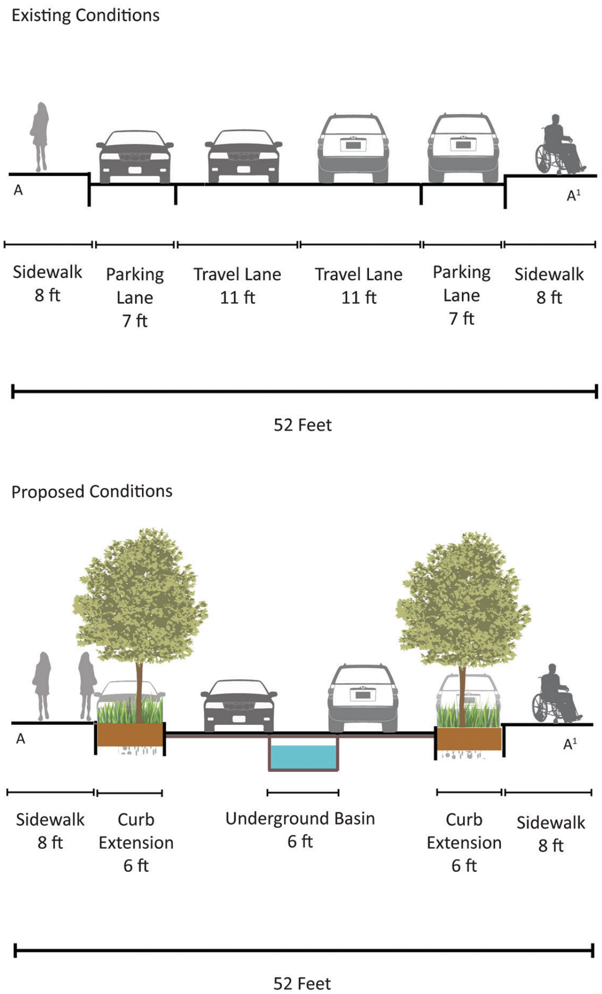


Existing utilities: The underground environment in cities can be nearly as dense and over prescribed as the above ground environment. Gas and communications lines are typically located right below a roadway surface along the curb. Water and wastewater pipes may run along the center of street with lateral lines extending to homes and businesses. Stormwater drains typically run along one side of the street.

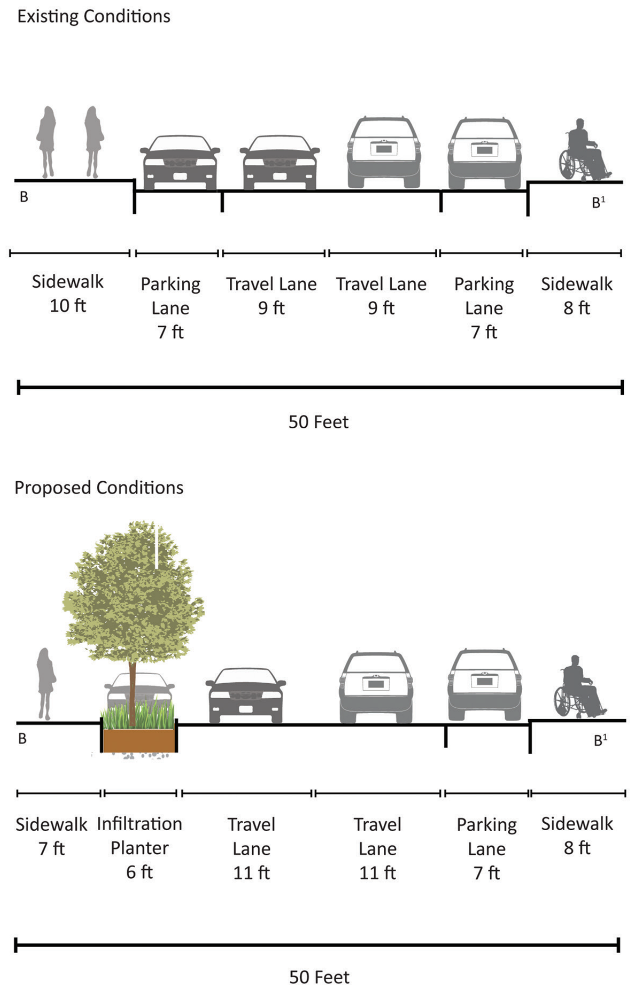
Combined sewer areas: In areas where stormwater drains to Cambridge's combined sewer system, GI systems that infiltrate runoff or maximize storage should be prioritized above flow through filtration systems.

Green infrastructure design and maintenance: Systems should be designed to include a pre-treatment forebay to collect trash and sediment that can be removed regularly. Systems that infiltrate stormwater runoff should be prioritized. Maintenance plans should be developed at the time of design with consideration for the City's equipment and human resources. Vacuum sweeping is a challenge for the City given their existing equipment and therefore underground infiltration may be preferred to porous pavement. Residents and businesses within the community should be drawn upon to assist with maintenance whenever possible.

Park Avenue Cross Section A–A[1]
At Elbow Intersection with Holworthy Place, Looking East



Webster Avenue Cross Section B–B[1]
Looking North



RESIDENT FEEDBACK

CRWA administered an online survey to Cambridge residents to solicit opinions on what makes a safe and pleasant street, what types of green infrastructure residents are interested in, as well as how willing residents would be to lose parking to green space and to help maintain a GI system. A total of 210 residents completed the survey.

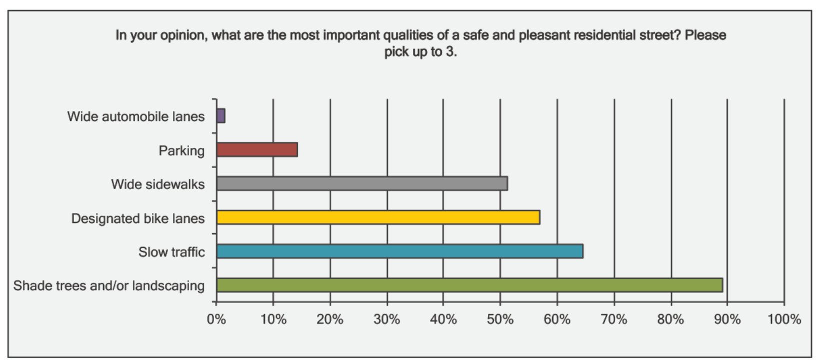


***Figure 3:** Resident Survey Results*

Eighty-nine percent of survey participants reported that one of the most important qualities of a safe and pleasant residential street is the presence of shade trees and/or landscaping (Figure 3). Slow traffic, designated bike lanes, and wide sidewalks were also valued by over 50% of survey participants. Resident respondents indicated they are concerned by traffic speed, as well as the level of difficultly involved when navigating the right-of-way as pedestrians and on a bicycle. Over thirty-percent of participants were concerned by the lack of trees/landscaping and the health of existing trees on their street. Only 8.5% of participants were concerned about a lack of parking. Many participants commented on the need for protected bike lanes and smoother pavement.

The main concerns expressed by survey participants included a lack of space in the right-of-way, maintenance needs, and accessibility for bicyclists as well as handicapped and elderly residents.

Overall survey results indicated that residents do value the benefits provided by green streets such as street traffic calming, shading by street trees, the opportunity for improved bike accessibility, and overall aesthetic value.

ENVIRONMENTAL IMPROVEMENTS

Conceptual green street designs for two specific residential streets Webster Ave. and Chestnut Street demonstrate that treating runoff from a 1" rain storm is possible on dense city streets and can result in >75% reduction in the amount of phosphorus (nutrient pollution) in runoff to the Charles River or Alewife Brook. Conceptual designs developed for Park Ave. and Webster Ave. in the City's combined sewer neighborhood also demonstrate numerous opportunities for reducing stormwater runoff to the combined system.

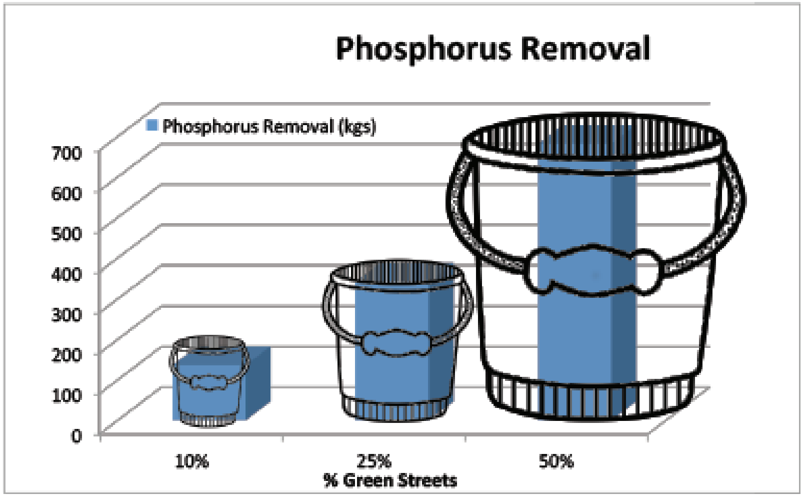


Figure 2: *Potential phosphorus removal through green street implementation*

CRWA determined the average phosphorus pollution reduction per linear foot of each of the project streets and applied the average to three hypothetical scenarios: conversion of 10%, 25% and 50% of the City's residential streets to green streets (Figure 2). The TMDL (see *Charles River Nutrient Total Maximum Daily Load*) requires a 62% reduction for phosphorus coming from stormwater in the Lower Charles River watershed which includes parts of Cambridge (Communities should check permits for specific load reduction requirements) . This is a total reduction of roughly 5,500 kg across the 40 square mile watershed of the Lower Charles River (approximately 2 square miles within Cambridge). If green streets become more common they can have a significant impact on phosphorus reductions. Employing phosphorus reduction techniques along city streets can go a long way toward helping the city meet pollution reduction requirements.

Finally, green infrastructure can help mitigate the impacts of urban heat island. Modeling work conducted under the City's climate planning process indicates that 5 mature trees over 150 feet (one tree every 30 feet) can provide a cooling effect up to 3.5°F. This is important for maintaining health and safety of both residents and those using Cambridge streets to bike, walk, run or travel in a warming climate.

FLOOD REDUCTION BENEFITS

In addition to improving water quality, green infrastructure can also reduce flooding by increasing storage and uptake of stormwater runoff. Green streets typically contain small scale green infrastructure installation, such as those designed to collect runoff from a 1" rain event or smaller (i.e. rain events that typically not associated with severe flooding impacts). As green streets are scaled up, however, multiple, small-scale installations can have an impact on stormwater flooding caused by even large rain events, such as those anticipated to occur more frequently in Cambridge as a result of a changing climate. Modeling results indicate that if the City were to change 50% of residential streets into green streets, certain residential neighborhoods could see a roughly 20% reduction in peak flow and flood volume from a rain event producing 6.4" in 24 hours. This storm is an anticipated 10-year storm event (10% chance of occurring any given year) under future climate conditions. Finally green streets may also reduce the impact of combined sewer overflows which occurring almost exclusively during large rain events and result in the discharge of wastewater and stormwater to local rivers.

Webster Ave.:* *Before-and-after visualization

Park Ave.: *Before-and-after visualization*

ABOUT CHARLES RIVER WATERSHED ASSOCIATION

One of the country's oldest watershed organizations, Charles River Watershed Association (CRWA) was formed in 1965 in response to public concern about the declining condition of the Charles River. CRWA initiatives and advocacy work over the last five decades have dramatically improved the quality of water in the watershed and fundamentally changed approaches to water resource management. Today CRWA is protecting, preserving and enhancing the entire Charles River watershed through science, advocacy and the law. Our strong science and engineering research and advocacy promote smart environmental policies. CRWA's work promotes resilient communities and a healthy river ecosystem.

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