Section 5

Design Considerations: Physical & Environmental

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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.*

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

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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.

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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

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▲ *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.*

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▲ *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.*

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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

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.