Green Infrastructure Application Best Management Practices

A Guideline for Stormwater Management

Clifton Springs Sanitarium Historic District

FINGER LAKES INSTITUTE
HOBART AND WILLIAM SMITH COLLEGES

Acknowledgements

Support for this project was provided by Hobart & William Smith Colleges, the Isabel Foundation, and the Finger Lakes Institute. This project is a partnership with the Genesee/Finger Lakes Regional Planning Council (G/FLRPC) and the Ontario County Water Resources Council's 2013 Special Projects Fund.

Report Authors

Cari Varner – Director, Finger Lakes Institute – Community Design Center (FLI-CDC)
Margaret Markham WS'14 – Sustainable Community Development Assistant, FLI-CDC
Chelsea Encababian WS'14 – Sustainable Community Development Assistant, FLI-CDC

About the FLI-Community Design Center (FLI-CDC)

The Finger Lakes Institute, in partnership with Hobart & William Smith Colleges has created a community design center that strives to provide Finger Lakes communities with innovative, creative, and sustainable design solutions that improve the built environment and quality of life, while protecting the natural environment.

Communities throughout the Finger Lakes region share similar economic, environmental, and social characteristics mainly as a result of the natural assets and history of the region. The current and future state of communities relies on improving quality of life for all citizens, being good stewards of natural resources, and fostering the responsible growth of the built environment. To support these efforts, we offer comprehensive sustainable community development planning and design services to communities throughout the Finger Lakes region.

It is our mission to:

- Raise awareness of the benefits and potential of sustainable community development and design for small towns, villages, cities and other entities;
- Encourage preservation and protection of natural resources and the built environment;
- Facilitate regional planning and collaboration among communities, businesses, non-profits, higher education institutions, and other entities;
- Foster community resilience by providing an active resource center for holistic community planning and design and disseminating our expertise nationally.

About this Project

Genesee/Finger Lakes Regional Planning Council (G/FLRPC) has received partial funding through the Ontario County Water Resources Council's 2013 Special Projects Fund to work on a project entitled, Green Infrastructure for Historic Districts. G/FLRPC, in cooperation with the Ontario County Soil and Water Conservation District (OC SWCD), will identify sites suitable for green infrastructure practices and techniques in the seven National Register Historic Districts in Ontario County. These districts have been identified using New York State Department of Parks, Recreation and Historic Preservation data. Soil maps prepared by the Ontario County GIS Program will assist in these recommendations. Students from the Finger Lakes Institute – Community Design Center (FLI-CDC) will then create visual representations of the recommended green infrastructure practices and techniques.

Green infrastructure uses vegetation and soil to manage rainwater where it falls instead of using pipes to dispose of it in New York State waters. As a watershed develops, more impervious cover is created. Roads, buildings, parking, sidewalks, and driveways all increase runoff from rain events and snow melt. Stormwater runoff contains pollutants such as nutrients, pathogens, sediment, toxic contaminants, and oil and grease. Water quality problems generated by these pollutants have resulted with water bodies such as lakes and streams having impaired or stressed uses. Green infrastructure reduces stormwater discharges and lowers pollutant loads.

Green and sustainable design has become increasingly popular in both the preservation and new construction industries due to public interest in energy conservation, water efficiency, and source reduction and waste management. Preservation and green goals overlap, and reconciling their differences is possible—provided that both sides strive to be as creative and flexible as possible. Preservation of natural features; permeable paving materials for parking lots, walkways, and driveways; driveway reduction; vegetated swales; rain gardens; green roofs; stormwater planters; rain barrels and cisterns; native vegetation; and downspout disconnection or extensions have been identified as green infrastructure practices and techniques that could easily be incorporated into historic districts with some guidance.

The primary goal of Green Infrastructure for Historic Districts is to provide assistance to municipalities and residents who wish to incorporate the concepts and practices of green infrastructure into their structures while maintaining the historic integrity of the individual buildings and the overall character of their community.

Introduction

Due to its close proximately to multiple bodies of freshwater, the Finger Lakes region reaps the visual aesthetic and the environmental diversity benefits of the lake ecosystem. However, like many other water bodies, there are assorted threats to the health and vitality of the Finger Lakes. One of the main sources of pollution that contributes to the Finger Lakes is stormwater run-off. Stromwater is the water from rain and melted snow that runs off into nearby water bodies, instead of soaking into the ground. The runoff collects pollutions, such as chemicals, sediments, debris, and other pollutants that flow over impervious surfaces.

One of the ways to prevent the stormwater from reaching the water bodies is through green infrastructure. In the context of stormwater management, the term green infrastructure includes a wide array of practices at multiple scales to manage and treat stormwater, maintain and restore natural hydrology and ecological function by infiltration, evapotranspiration, capture and reuse of stormwater, and establishment of natural vegetative features. Unlike traditional grey infrastructure, green infrastructure is a practice that mimics the system of the natural environment to have a sustainable method of controlling pollution. Green infrastructure can be used to treat the polluted runoff to mitigate those pollutants from running into water bodies, like the Finger Lakes.

Green Infrastructure in Historic Districts

Ontario County is made up of many different towns and villages all with their own unique histories and cultures. Within the county, there are currently six National Historic Districts, soon to be seven as Downtown Geneva is in the process of applying for designation.

1. Farmington Quaker Crossroad Historic District
2. East Bloomfield Historic District
3. Canandaigua Historic District

4. South Main Street Historic District (Geneva)
5. Genesee Park Historic District (Geneva)
6. Clifton Springs Sanitarium Historic District
7. Downtown Geneva Historic District (TBD)

Historic research conducted as part of this project found that green infrastructure practices actually existed within each of these districts in the past, as it wasn't until 20th century industrialization that modern stormwater infrastructure practices were introduced and impervious paving became commonplace. Thus, it is hoped that by re-introducing green infrastructure into each of these historic districts, not only can their historic accuracy and integrity be improved, but protection of existing structures, regional water bodies and local habitats can be improved as well as decrease the need for traditional water management infrastructure practices.

A historic photograph of Geneva's South Main Street shoes permeable pavers, street trees and a bio-swale.

Methods

On May 8, 2013, Jayme Breschard Thomann, Senior Planner at the Genesee/Finger Lakes Regional Planning Council and P.J. Emerick, Sr. , District Manager for the Ontario County Soil and Water Conservation District visited each of the seven historic districts, evaluated soils and made recommendations about appropriate green infrastructure techniques for each district.

From those findings, for each district, the green infrastructure application guidelines were created. Recommendations are based off the research from the New York State Stormwater

Management Design Manual – Chapter 5. The research that was conducted also utilized historical background from the various Ontario County historical societies and online research.

EPA National Stormwater Calculator

The EPA's National Stormwater Calculator can also be used to help enhance planning and application of green infrastructure techniques. The calculator is a desktop application that estimates the annual amount of rainwater and frequency of runoff from a specific site anywhere in the United States. Estimates are based on local soil conditions, land cover, and historic rainfall records. It is designed to be used by anyone interested in reducing runoff from a property, including:

- site developers
- landscape architects
- urban planners
- homeowners

The Calculator accesses several national databases that provide soil, topography, rainfall, and evaporation information for the chosen site. The user supplies information about the site's land cover and selects the types of low impact development (LID) controls they would like to use, such as:

- Rain harvesting (cisterns, rain barrels)
- Rain gardens
- Green roofs
- Stormwater planters
- Porous pavement
- Infiltration basins (planters, swales, filter strips, rain gardens, porous pavement are all various forms of green infrastructure techniques that utilize an infiltration basin)

To better inform decisions, it is recommended that the user develop a range of results with various assumptions about model inputs such as percent of impervious surface, soil type, and sizing of green infrastructure.

Clean water is essential to keeping our families and the environment healthy. The Calculator helps protect and restore the environmental integrity of our waterways. The link to calculator can be found below.
http://www.epa.gov/nrmrl/wswrd/wq/models/swc/

About this Document

This document serves as a guide to the application of green infrastructure practices and techniques for each of the seven historic districts in Ontario County. Application details include descriptions of typical preferred locations of each practice, recommendations of the appropriate sizes and/or models of each practice, relevant products and costs, as well as any necessary site preparation and maintenance necessary.

Clifton Springs Sanitarium Historic District built their community due to the proximity of natural sulfur springs, which it is named for. Historically, it was a significant town because of the springs and its utilization as a health spa, focusing in on occupational therapy. This district has in its founding used infrastructure that resemble green infrastructure today. Gardening, permeable paving, and tree planting were vital in this town's natural stormwater management. Sulfer Creek, one of this historic districts natural water flow was channelized by concrete, which decreases flow and increases flood risk. Natural streams, like Sulfur creek historically formed as a buffer to mitigate stormwater runoff cleansing the water.

Green infrastructure practices recommended for Clifton Springs Sanitarium Historic District are:

1. Roof gardens
2. Stormwater planters
3. Rain barrels
4. Porous pavement
5. Stream daylighting
6. Cisterns
7. Roof garden

Clifton Springs Sanitarium Historic District being located to such a natural wonder, as a hot spring has a significant water body that encompasses both environmental significance and historic religious experiences. A main tourist attraction that contributes greatly to the historic features and economy is this environmental space. However, as development expands and flourishes, so do permeable surfaces and the potential for stormwater runoff pollution.

It is anticipated that this information will be utilized by property owners or municipal officials to incorporate the green infrastructure practices into each district, as appropriate.

Green Innovation Grant Program (GIGP)

A grant for various entities in New York State looking to incorporate green infrastructure exists, and could be applied for. The Green Innovation Grant Program (GIGP) provides grants on a competitive basis to projects that improve water quality and demonstrate green stormwater infrastructure in New York. GIGP is administered by NYS Environmental Facilities Corporation (EFC) through the Clean Water State Revolving Fund (CWSRF) and is funded through a grant from the US Environmental Protection Agency (EPA).

Projects selected for funding go beyond providing a greener solution, they maximize opportunities to leverage the multiple benefits of green infrastructure, which include restoring habitat, protecting against flooding, providing cleaner air, and spurring economic development and community revitalization. At a time when so much of our infrastructure is in need of replacement or repair and communities are struggling to meet competing needs, we need resilient and affordable solutions like green infrastructure that can meet many objectives at once.

EFC seeks highly visible demonstration projects which:

- Create and maintain green, wet-weather infrastructure
- Spur innovation in the field of stormwater management
- Build capacity locally and beyond, to construct and maintain green infrastructure
- Facilitate the transfer of new technologies and practices to other areas of the State

GIGP 5 applicants are strongly encouraged to work with their Regional Council to align their project with regional goals and priorities. EFC reserves the right to fund all, or a portion of, an eligible proposed project. Funding will be provided to selected projects to the extent that funds are available.

ELIGIBLE TYPES OF APPLICANTS:

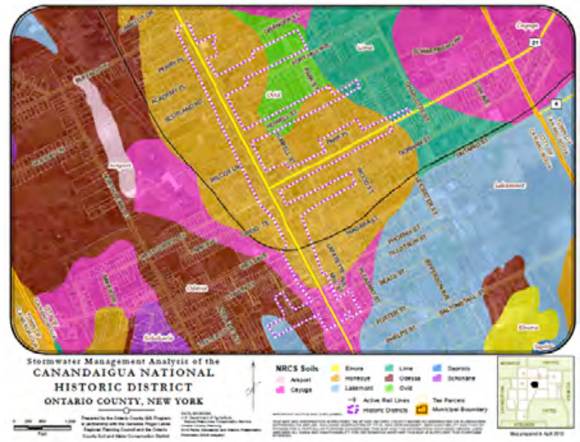
- Municipalities
- State Agencies
- Public Benefit Corporations
- Public Authorities
- Not-for-profit Corporations

- For-profit Corporations
- Individuals
- Firms
- Partnerships
- Associations
- Soil and Water Conservation Districts

For more information about this funding opportunity, please see:

http://regionalcouncils.ny.gov/sites/default/files/documents/2013/resources_available_2013.pdf.

Soil Maps

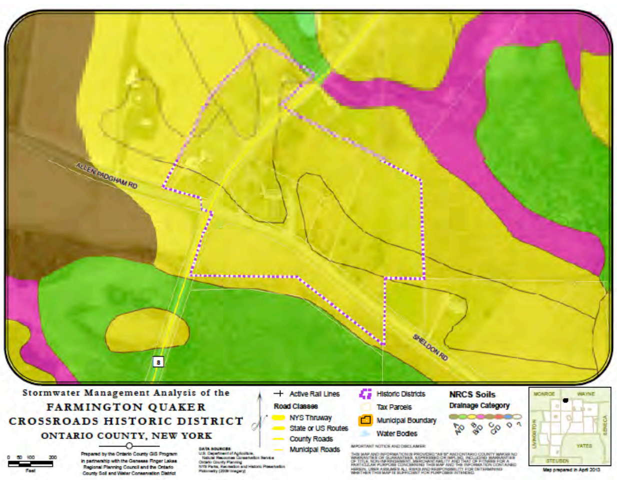


There are two types of soil maps provided within this report. The first illustrates the specific soil type present in the Historic Districts and the second shows its drainage classification. Data from these two maps was used in developing the following best management practices and if relevant, specific recommendations for dealing with the relevant soil type and drainage category for each Historic District are described for each stormwater management technique.

These maps were created by the Ontario County GIS Program in partnership with the Genesee/Finger Lakes Regional Planning Council and the Ontario County Soil and Water Conservation District.

Drainage Categories

The key provided on the Drainage Classification maps provides information about the drainage capabilities of the underlying soils in each Historic District. Definitions and descriptions of each drainage group are provided below.



Group A—Soils in this group have low runoff potential when thoroughly wet. Water is transmitted freely through the soil. Group A soils typically have less than 10 percent clay and more than 90 percent sand or gravel and have gravel or sand textures. Some soils having loamy sand, sandy loam, loam or silt loam textures may be placed in this group if they are well aggregated, of low bulk density, or contain greater than 35 percent rock fragments.

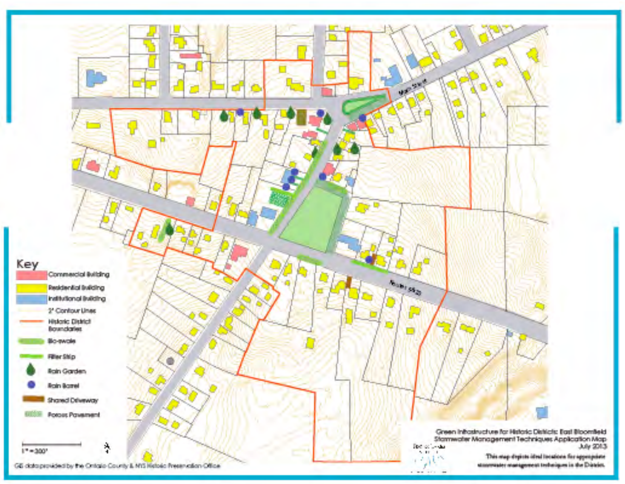
Group B—Soils in this group have moderately low runoff potential when thoroughly wet. Water transmission through the soil is unimpeded. Group B soils typically have between 10 percent and 20 percent clay and 50 percent to 90 percent sand and have loamy sand or sandy loam textures. Some soils having loam, silt loam, silt, or sandy clay loam textures may be placed in this group if they are well aggregated, of low bulk density, or contain greater than 35 percent rock fragments.

Group C—Soils in this group have moderately high runoff potential when thoroughly wet. Water transmission through the soil is somewhat restricted. Group C soils typically have between 20 percent and 40 percent clay and less than 50 percent sand and have loam, silt loam, sandy clay loam, clay loam, and silty clay loam textures. Some soils having clay, silty clay, or sandy clay textures may be placed in this group if they are well aggregated, of low bulk density, or contain greater than 35 percent rock fragments.

Group D—Soils in this group have high runoff potential when thoroughly wet. Water movement through the soil is restricted or very restricted. Group D soils typically have greater than 40 percent clay, less than 50 percent sand, and have clayey textures. In some areas, they also have high shrink-swell potential. All soils with a depth to a water impermeable layer less than 50 centimeters [20 inches] and all soils with a water table within 60 centimeters [24 inches] of the surface are in this group, although some may have a dual classification, as described in the next section, if they can be adequately drained.

Dual hydrologic soil groups—Certain wet soils are placed in group D based solely on the presence of a water table within 60 centimeters [24 inches] of the surface even though the saturated hydraulic conductivity may be favorable for water transmission. If these soils can be adequately drained, then they are assigned to dual hydrologic soil groups (A/D, B/D, and C/D) based on their saturated hydraulic conductivity and the water table depth when drained. The first letter applies to the drained condition and the second to the undrained condition. For the purpose of hydrologic soil group, adequately drained means that the seasonal high water table is kept at least 60 centimeters [24 inches] below the surface in a soil where it would be higher in a natural state.

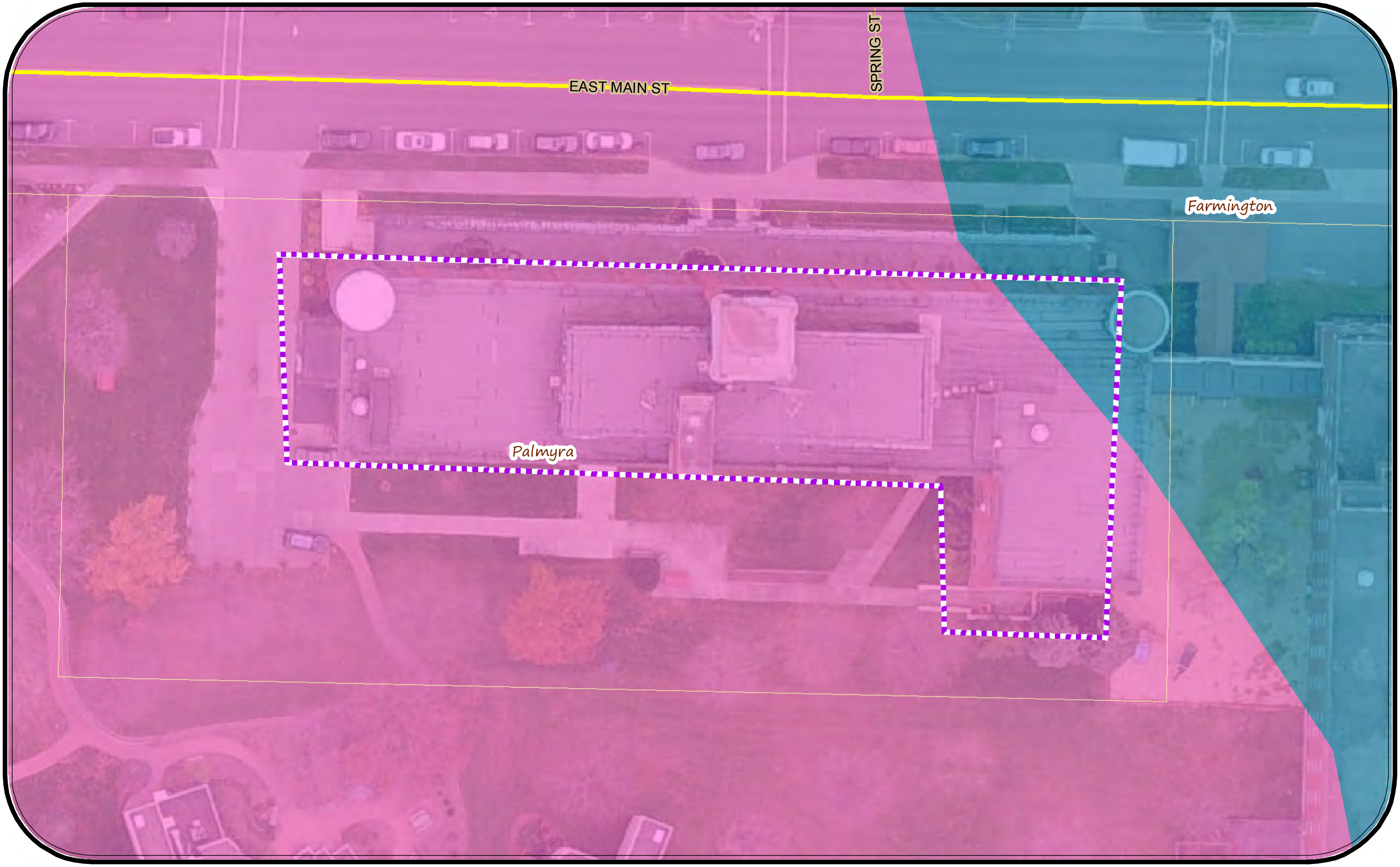
For more information about soil classification, see Part 630: Hydrology, Chapter 7 of the *National Engineering Handbook* by the United States Department of Agriculture.



Stormwater Management Techniques Map

Also included in the following pages is a map which details the ideal locations for the application of relevant stormwater management techniques for the Historic District. It is anticipated that these maps can be used by property owners and municipal officials to guide decisions regarding the location and need of green infrastructure techniques and methods within the Historic District. For further details regarding the installation of each technique, please see the following report.

These maps were created by the Finger Lakes Institute – Community Design Center using GIS data provided by Ontario County and the New York State Historic Preservation Office. Each Historic District was visited and appropriate places for green infrastructure were identified and recorded using physical observation and recommendations made by the Genesee/Finger Lakes Regional Planning Council. It should be noted that in most instances, all possible applications of the green infrastructure techniques were recorded, but each property owner should be careful to consider the specific needs and conditions of their property.



Stormwater Management Analysis of the

CLIFTON SPRINGS SANITARIUM HISTORIC DISTRICT

ONTARIO COUNTY, NEW YORK

0 10 20 40
Feet

Prepared by the Ontario County GIS Program in partnership with the Genesse Finger Lakes Regional Planning Council and the Ontario County Soil and Water Conservation District

DATA SOURCES:
U.S. Department of Agriculture,
Natural Resources Conservation Service
Ontario County Planning
NYS Parks, Recreation and Historic Preservation
Pictometry (2009 Imagery)

N

NRCS Soils

- Farmington
- Palmyra
- Historic Districts
- Tax Parcels
- Municipal Boundary
- Water Bodies

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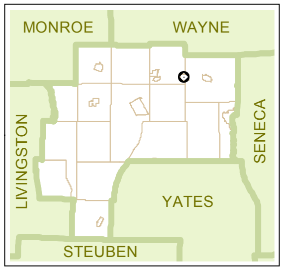

Map prepared in April 2013

Stormwater Management Analysis of the

CLIFTON SPRINGS SANITARIUM HISTORIC DISTRICT

ONTARIO COUNTY, NEW YORK

0 10 20 40

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Prepared by the Ontario County GIS Program in partnership with the Genesse Finger Lakes Regional Planning Council and the Ontario County Soil and Water Conservation District

DATA SOURCES:
U.S. Department of Agriculture,
Natural Resources Conservation Service
Ontario County Planning
NYS Parks, Recreation and Historic Preservation
Pictometry (2009 Imagery)

N

Active Rail Lines

Road Classes

NYS Thruway

State or US Routes

County Roads

Municipal Roads

Historic Districts

Tax Parcels

Municipal Boundary

Water Bodies

NRCS Soils

Drainage Category

A A/D B B/D C C/D D ?

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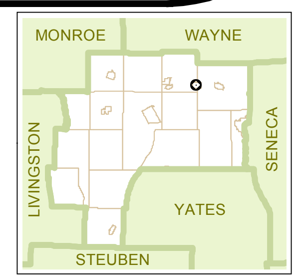
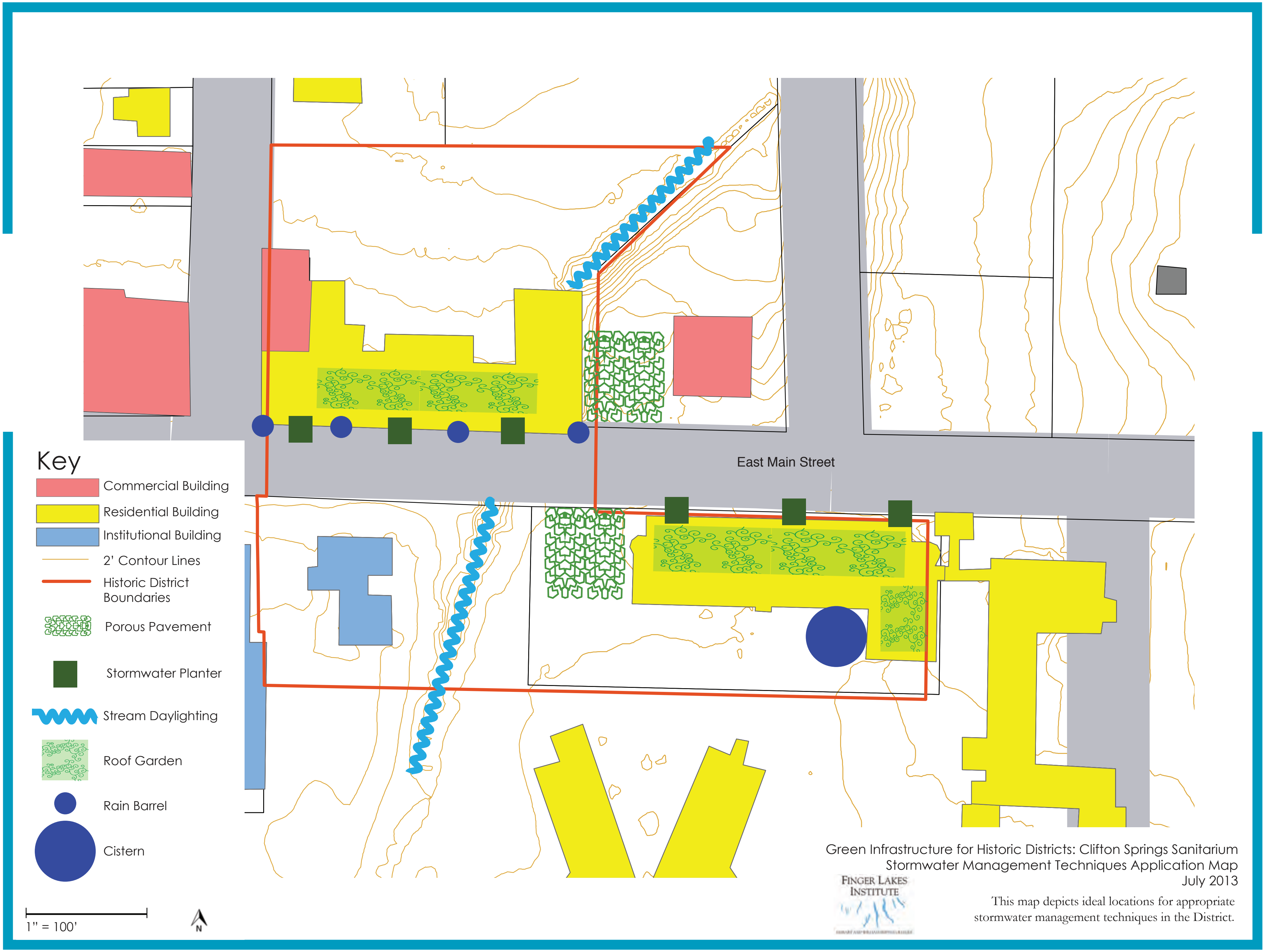


Map prepared in April 2013



Green Infrastructure for Historic Districts: Clifton Springs Sanitarium
Stormwater Management Techniques Application Map
July 2013

This map depicts ideal locations for appropriate stormwater management techniques in the District.

GIS data provided by Ontario County & NYS Historic Preservation Office

Rain Garden

A rain garden is a shallow depression in the landscape that is planted with deep-rooted native plants and grasses. It is a green infrastructure technique that allows rainwater and stormwater runoff from urban areas and impervious surfaces, such as roofs, driveways and sidewalks to be absorbed back into the ground and reduces the potential for runoff pollution.

Introduction

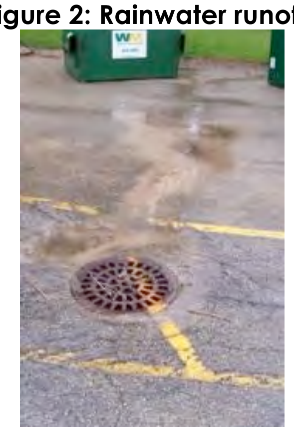
"A common problem for homeowners is what to do wet and soggy areas of their yard. Rain gardens help address both of these issues. A rain garden is a designated zone where water accumulates during storms and wet spells. Instead of grass, this area is planted with plants that are tolerant of standing water, and can also withstand the dry periods between storms." (See Figure 1)
(http://ferncreekdesign.org/raingarden.html)

Figure 1: Residential Rain Garden

Source: http://articles.washingtonpost.com/2011-07-20/lifestyle/35238427_1_rain-garden-rain-forests-storm-water

Redirected stormwater is often warmer than the groundwater normally feeding a stream, which has resulted in some negative outcomes. The increase of warmer water flowing into waterways, where normally ground water flows in, can upset in some aquatic ecosystems primarily through the reduction of dissolved oxygen. Stormwater runoff is also a source where pollutants washed off hard or compacted surfaces during rain events. These pollutants can derive from both human and natural causes. Some examples of pollutants that can be carried by stormwater runoff are fertilizers, pesticides, and bacteria from pet waste, eroded soil, road salt, grass clippings and litter.

Figure 2: Rainwater runoff



Source: http://www.uwgb.edu/facilities/stormwater/

The purpose of a rain garden is to improve water quality in nearby bodies of water. Rain gardens filter up to 99% of water pollutants through natural processes, making ground water safer and cleaner.

Rain gardens are a great technique to decrease the amount of stormwater that enters into sewer systems. Rain gardens are also a less costly alternative to traditional sewer treatment. Living in an ever-increasing urbanized society, the majority of land cover is made up of impervious surfaces. Some examples of impervious surfaces that contribute greatly to stormwater runoff are roofs, sidewalks, roads, and driveways. When it rains these surfaces cannot absorb the water, so the rainwater becomes run-off (See Figure 2). It is high-speed run-off and has high potential for infrastructure destruction. It can cause flooding, erode property and soils, and carry pollutants into streams, wetlands and lakes.

The purpose of rain gardens is to recall nature's natural filtration and retention process, while improving the visual aesthetics of the community. They also mitigate the potential for costly infrastructure, like pipes, drains and treatment facilities.

Application in a Historic District

To the outside observer, rain gardens look much like any other garden. For this reason, they have a minimal impact on a historic district, and with any well-maintained garden, can actually contribute beauty and interest to the area. Gardens in general and rain gardens were very common in Ontario County, as the glacial soils here are very rich. Rain gardens, like other gardens, are entirely compatible with the aesthetics and character of a historic district.

History and Aesthetics

The first rain gardens were in our native ecosystems. Before humans settled and began constructing the built environment with impervious surfaces, rain was filtered naturally through soil, roots, and plants in nature. Rain gardens were created as a result of trying to recreate the natural water filtration system. Stormwater specialists created the first conceived green infrastructure rain garden in Maryland in 1990. However, many conventional gardens were created not with stormwater runoff in mind, but worked as tool of filtration. In the Finger Lakes region, many of the historic districts before the twentieth century had gardens.

Site Specific Consideration

Location

Although rain gardens look like a typical flower garden, they are designed specifically to capture and absorb rainwater from impervious surfaces. Since they have a distinct purpose, they need to be strategically placed. When constructing rain gardens, their location is very important to optimize the potential absorption of stormwater runoff. Therefore it is necessary for homeowners to observe their property and base the rain garden location on the specific characteristic of rain flow to determine the best location.

Figure 3: Rain Garden

Source: http://ferncreekdesign.org/raingarden.html

When it rains, a rain garden can fill a few inches of water and it allows water to slowly filter into the ground and soil. Compared to a patch of lawn, a rain garden allows up to 30% more water to soak into the ground. To successfully optimize the runoff absorption of a rain garden, it should be located between a water source (roof down spout, a paved surface, or a hill in your lawn) and where the water usually runs to, examples are a storm drain or a gutter. (See Figure 3 & Figure 4& Figure 5)

Figure 4: Rain Garden

Source: http://www.mychamplain.net/raingardens

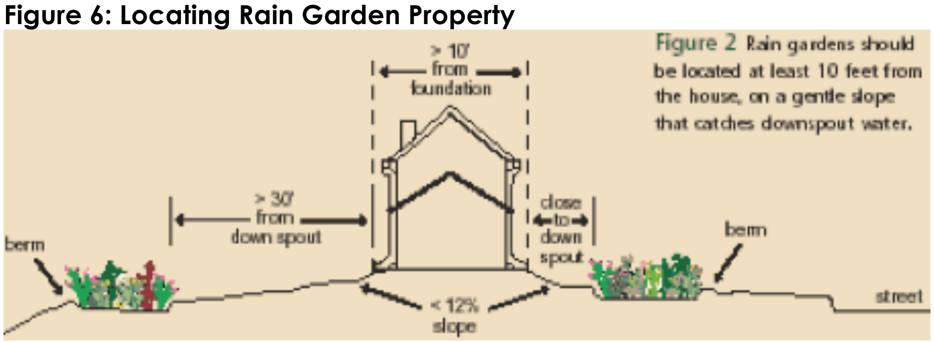
Figure 5: Rain Garden

Source: http://mtwatercourse.org/media/photos/LIDRainBarrel01.jpg

When locating where to place the rain garden on your property there are several different conditions that should be considered: (See Figure 6)

- Rain Gardens should be built at least 10 feet from a house or building.
- Think about the direction of flow from building downspouts/ sump pumps outlets, so that the rain garden is built on a low point in the lawn.
- Place the garden to take advantage of the natural drainage patterns that will direct garden overflow from the buildings.
- Locate the garden so it received full or partial sunlight.
- It should avoid areas over a septic system.

Figure 6: Locating Rain Garden Property



Source: (http://www.lakesuperiorstreams.org/stormwater/toolkit/raingarden.html)

Zoning & Historic Districts

In the hopes of enhancing both the rural historical setting and agricultural spaces, implementing green infrastructure is acceptable. In zoning codes, there is no code enforcing that any green infrastructure cannot be placed on residential lots. However, if green infrastructure techniques is desired to installed in historic districts of public spaces, then it asked that before placing it in, that it be brought to the Planning Board of the Village of Clifton Springs.

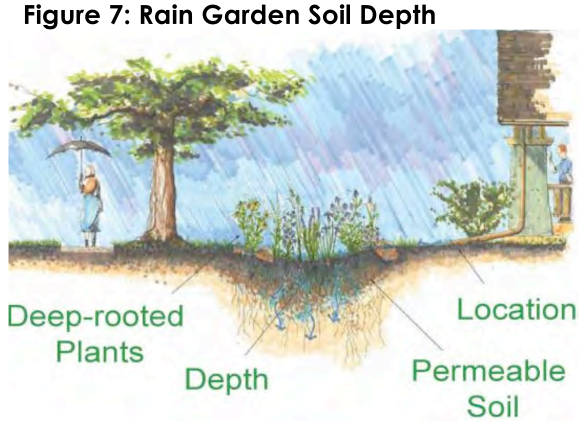
Installing editions on the exterior of owners structure is allowed as long as it represents a familiar visual aesthetic as the existing structure, identifies with historic personage and protects and improves the intention of the site. Therefor, it is anticipated that rain gardens will be allowed in the Clifton Springs Historic District.

Soil

Whenever it rains, water-flow from impervious surfaces is diverted into the garden, where there is maximum potential for water to infiltrate the ground and nourish the plants in the garden. The size and depth of the rain garden are based off of different environmental factor of the landscape.

Some of the dependent factors are soil type, slope and the size of the area that will be drained into the garden. Rain gardens must have good drainage location so it can soak in

Figure 7: Rain Garden Soil Depth



Source: http://www.thecoves.ca/projects/pollution-solutions water within 24 hours after rainfall.

The soils that are in the Clifton Springs Sanitarium Historic District consist dominantly of Palmyra soil. Palmyra soil consists of very deep soil that have the ability to drain easily, so there is a lesser chance of run off potential in this soil area. They are steep soils that are made up of stratified gravel and clay. This soil is best used for intensive growing of gardens and plants.

When an area's soils are not permeable enough to allow water to drain and filter properly, the soil should be replaced and an under-drain installed, which is a concealed drain with an opening that water can enter when it reaches drainage levels. The depth of the soils should be about 4 inches below the bottom of the plants roots. This bioretention mixture should typically contain 60% sand, 20% compost, and 20% topsoil. Bio-retention is the process that contaminants and sedimentation are removed from stormwater runoff through natural means. Existing soil must be removed and replaced. Do not combine the sandy soil (bio-retention) mixture with a surrounding, existing soil that does not have high sand content. Otherwise, the clay particles will settle in between the sand particles and form a concrete-like substance. Since most of the soils used in urbanized areas are reliant on chemical materials such as fertilizers it has a lowered rate of absorption, therefore it is necessary to test out the condition of your rain garden soil and if necessary, take the measures to build around the conditions of your soil. Preferred soil mixtures are discussed in the Cost & Products section below.

To test for the condition of your soil, take a handful of soil from your future garden site and squeeze firmly. If your soil holds shape, poke it slightly. If it gently crumbles then it is in proper condition for being a rain garden. If after poking it the soil remains in the same shape then the soil has too much clay. If the soil immediately falls apart then it is too sandy. As described above, Palmyra soil drains well, so it is not anticipated to need additional filler or manipulation to accept a rain garden.

Soil Depth

For rain gardens, it is most beneficial to have the soil deep enough so that it can accept large roots, which initially should be about 24 inches deep. Deep plant roots also create additional channels for stormwater to filter into the ground (See Figure 7). Microbial populations feed off plant root secretions and break down carbon (such as in mulch or desiccated plant roots) to aggregate soil particles. This increases infiltration rates.

Slope and Depth

When you have determined what type of soil you have you can determine the size of the garden. This is based on of the soil type and the area you are going to drain, and example of this is by using the size of your roof. To generally measure the size of your rain garden you can multiply the drainage area by the appropriate value according to the slope of your property. The rain gardens surface is dependent on the storage volume of runoff water. The storage volume requirements but should not exceed a loading ratio of 5:1 (drainage area to infiltration area, where drainage area is assumed to be 100% impervious; to the extent that the drainage area is not 100% impervious, the loading ratio may be modified).

Another way to determine the slope of land where the garden is being built for the depth of the rain garden is by the rule of thumb:

- Less than 4% slope: Dig garden 3-5 inches deep
- Between 5-7% slope: Dig garden 6-7 inches deep

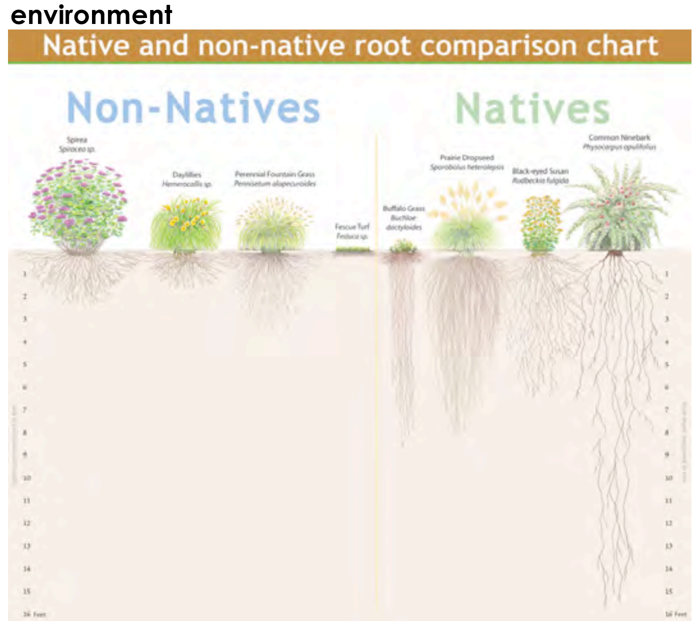
- Between 8-12% slope: Dig garden 8 inches deep

Native Plants

Unlike natural gardens, rain gardens are made with the purpose of reducing water runoff; therefore it is essential for rain gardens to be constructed with the environment in mind. The plants in the rain garden play an essential role in the functionality and performance of the garden. Therefore, builders need to be conscious of the plants that are placed into the rain gardens. Planters must be conscious of species of plants that are in the rain garden, so there are a variety of plants, be sure it is a native species to ensure durability and that the plant can survive in ranging weather conditions.

It is preferred when installing a rain garden that native plants should be used. Native plants are the plants that originated in the area, it is the vegetation that grow and thrive in the environment since it originated there and is best suited for the environmental conditions. This is because native plants are best adapted to soil and temperature conditions of your neighborhood, tolerable to both saturated and dry soil. Using native plants is ideal because they can have a greater survival rate when tolerating the soil conditions. The roots of the native plants are able to flourish with the native soil. (See Figure 8). Native plants also work as a positive contribution to urban habitats for native spices and insects.

Figure 8: Native Plants Thrive in their native environment



Source: http://water-festival.org/2013/635/where-water-falls-rain-gardens-as-a-clean-solution-to-spring-stormwater-pollution/

It is anticipated that in Clifton Springs, because of the well draining soil, that rain gardens will flourish. Often, simply adjusting the landscape so that downspouts and paved surfaces drain into existing gardens may be all that is needed because the soil has been well loosened and plants are well established. However, many plants do not tolerate saturated roots for long and often more water runs off one's roof than people realize. Often the required location and storage capacity of the garden area must be determined first. Rain garden plants are then selected to match the situation, not the other way around.

Some native plants that are in the Finger Lakes region as advised in the NYS Stormwater Management Design Manual in Chapter 5, can be seen in Figure 9.

Trees

Well-planned plantings require minimal maintenance to survive, and are compatible with adjacent land use. Trees under power lines, or that up-heave sidewalk when soils become moist, or whose roots seek out and clog drainage tiles can cause expensive damage.

Trees generally contribute most to the functionality of rain gardens when located close enough to tap moisture in the rain garden depression, yet do not excessively shade the garden. Also, the shading open surface waters can reduce excessive heating of habitat. Plants tolerate inundation by warm water for less time because heat drives out dissolved oxygen, thus a plant tolerant of early spring flooding may not survive summer inundation.

Figure 9: Finger Lakes Region Ideal Native Plants

Table 5.11 Suggested Rain Garden Plant List

Shrubs	Herbaceous Plants
Witch Hazel *Hamemelis virginiana*	Cinnamon Fern *Osmunda cinnamomea*
Winterberry *Ilex verticillata*	Cutleaf Coneflower *Rudbeckia laciniata*
Arrowwood *Viburnum dentatum*	Woolgrass *Scirpus cyperinus*
Brook-side Alder *Alnus serrulata*	New England Aster *Aster novae-angliae*
Red-Osier Dogwood *Cornus stolonifera*	Fox Sedge *Carex vulpinoidea*
Sweet Pepperbush *Clethra alnifolia*	Spotted Joe-Pye Weed *Eupatorium maculatum*
	Switch Grass *Panicum virgatum*
	Great Blue Lobelia *Lobelia siphatica*
	Wild Bergamot *Monarda fistulosa*
	Red Milkweed *Asclepias incarnate*
Adapted from NYSDM Bioretention Specifications, Bannerman, Brooklyn Botanic Garden.	

Source: http://www.dec.ny.gov/docs/water_pdf/swdm2010chptr5.pdf

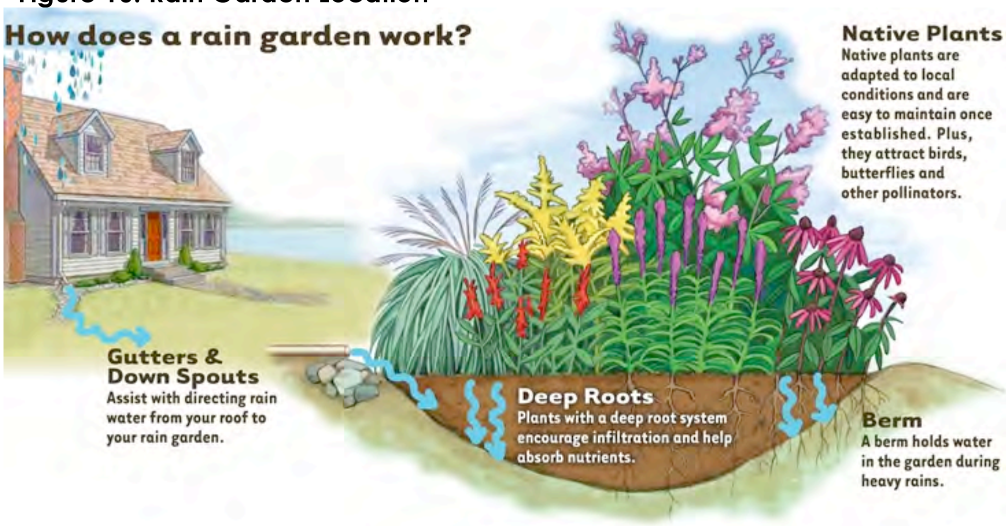
Site Prep Design

Installation and Maintenance

1. Choose Garden Location: Walk your property while it's raining and find out where the water runoff lies (See Figure 10).
2. Check for underground pipes: Make sure before you dig to make the rain garden to have a utility mark the location of underground lines.
3. Select the Plants: Choose native plants that bloom at different times of the season and have a variety of heights, shapes and textures. Variety is Key!
4. Start Digging: A rain garden is usually one to two feet deep with a flat bottom and angled sides. Most are between 100 and 300 square feet in size.

5. Add the soil that is best for the environmental conditions.
6. Plant, water, and tend: After building the rain garden the job is not done. You need to water your rain garden, especially when it's first planted and during dry weather. Rain gardens also need to be regularly weeded and mulched.

Figure 10: Rain Garden Location



Source: http://www.watershedcouncil.org/learn/rain-gardens/

Cost

One of the most important factors involved with the rain garden project is the budget. According to the Watershed Activities to Encourage Restoration website, the cost associated with installation of the rain garden is about $3-$4 per square foot, depending on the soil conditions and the type of plants used. Although the cost is a little more than a typical landscaping job, it is because of the increased number of plants that are being used. However, it is also this initial expensive investment that will pay off in the near future, both environmentally and homeowner costs. Below is a chart from the Chesapeake Bay Foundation and their materials budget (See Figure 11).

As far as choosing which kind of soils to place in for your rain garden, the ideal soil mix to use is 50-60% sand, 20-30% topsoil (no clay) and 20-30% compost. The reason sandy soil is the most ideal is because unlike regular gardens, sand and loamy soil drains better than clay soil that can be waterlogged or compacted soil, which is normally found on developed land and sand will not mix well with it. Sand and loamy soils drain water well. Unfortunately most of the Finger Lakes region is filled with soil with a high clay content so will be necessary to purchase soil that has a low clay level.

Figure 11: Example of Rain Garden Cost

Build Your Own Rain Garden
Sample Materials Budget

Material	Quantity	Price Each	Total Price	Source
2 x 12 #1 treated pine board	3	$15.00	$45.00	Hardware store
2 foot steel rebar	10	$ .96	$9.60	Hardware store
Stainless steel elbow brackets w/screws	2	$7.00	$14.00	Hardware store
40 lb. Bag topsoil	4	$3.00	$12.00	Donated by Nice Guy Landscaping Co.
20 lb. Bag sand	1	$5.00	$5.00	Donated by Nice Guy Landscaping
40 lb. Bag mulch	1	$3.00	$3.00	Donated by Nice Guy Landscaping
Straw bale	1	$5.00	$5.00	Donated by Sally's Dad
Screwdriver	1	$4.00	$4.00	Borrow from Janitor
Hammer	1	$12.00	$12.00	Borrow from Janitor
Shovels	3	$20.00	$60.00	Borrow from home
Rakes	2	$10.00	$20.00	Borrow from home
Total			**$189.60 + costs of plants and flowers**	

These prices are just estimates and will vary, depending on where you buy them. You may not need to **buy** everything on this list, and you may decide that you need items not included here. Your budget will also depend on the kinds of plants you decide to use, how many, and what size garden you design! And remember, if you are able to borrow materials, or have them donated, you can subtract them from the actual cost of the project. In other words, the total in this sample budget is $189.00, but the group only needs to raise $68.60 because many of the items have been donated or borrowed!

One more thing: don't forget to include the costs of your plants and flowers!

Source:
http://www.lowimpactdevelopment.org/raingarden_design/downloads/BaysaversRainGardenGuide.pdf

Conclusions

Environmental Benefits

There are many benefits of installing a rain garden. The first is the environmental benefits. Rain gardens improve water quality. Rain gardens filter contaminates from run-off, improving quality of water and recharging ground water.

Rain gardens also reduce stormwater pollution, by collecting and using rainwater that would otherwise be drained into the sewer system. Rain gardens divert this water and decrease the flow of pollution to sewers and instead flow to waste water treatment plants (See Figure 12).

Rain garden reduce sewer flooding and overflow. If adopted on a community or neighborhood scale, rain gardens can reduce combined sewer overflows and localized flooding. Most importantly, by creating a holding zone for water that would typically end up in the gutter, the total volume of runoff from a storm is reduced. Rain gardens ultimately protect rivers, streams and greater bodies of water, and in particular the Finger Lakes, which are treasured bodies of waters in this area. Polluted stormwater that enters rivers and creeks untreated can hurt both water quality and the wildlife that inhabit them. Excessive runoff can also erode banks and increase downstream flooding as well. Rain gardens can help minimize both.

This has an important positive benefit to rivers, streams, and lakes where high runoff volumes cause many devastating effects. Instead, water is able to slowly seep back into the ground and replenish the water table. In a related way, storm runoff also picks up phosphorous and nitrogen from lawn fertilizers and street debris, as well as pollutants like gas, oil, antifreeze, and other chemicals which can also cause major problems for the streams and lakes that it drains into.

When this water is allowed to slowly seep into the ground, most pollutants will become attached to the soil, and removed from the water (See Figure 13). As a benefit to the homeowner, rain gardens provide a solution to existing wet spots where water naturally accumulates, or a beautiful and environmentally-friendly garden to replace an area of lawn.

Figure 12: Displaced rainwater runoff

Source: http://www.watershedactivities.com/projects/fall/raingrdn.html

Benefits for Homeowners

Rain gardens reduce the potential for basement flooding. A rain garden gives runoff a beneficial, safe place to go, helping to keep it away from your home's foundation.

Rain gardens reduce garden maintenance. A rain garden essentially "waters itself," requiring little or no additional irrigation. In fact, rain gardens are more likely than other gardens to survive droughts. Periodic weeding, mulching and pruning are all the maintenance they need. Because you don't need to fertilize or spray them, they make your yard a healthier place for your children and pets as well.

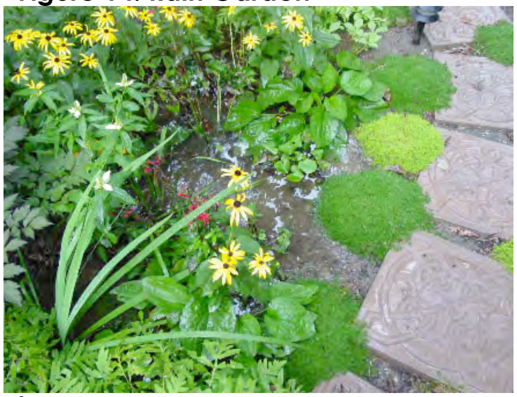
Figure 13: Water Filtration

Source: http://www.watershedactivities.com/projects/fall/raingrdn.html

Rain gardens enhance curb appeal. Because are more tolerant of the local climate, soil, and water conditions, native plants are recommended for rain gardens. These plants also provide interesting planting opportunities, and are an attractive and creative alternative to traditional lawn landscapes

Rain gardens increase garden enjoyment. Rain gardens are not only pleasing to look it, they are an ideal habitat for birds, butterflies, and other wildlife.

Figure 14: Rain Garden



Source:
http://www.watershedactivities.com/projects/fall/raingrdn.html

Rain gardens reduce mosquitoes. In a properly designed rain garden, water will soak into the ground within a day or two, long before mosquitoes have the opportunity to breed. They can also be designed to attract the kinds of insects that eliminate pest insects.

With just a little effort, a rain garden can be a beautiful, low-maintenance addition to your lawn. Its contribution to our region's water quality may seem small. But if we all do our part, the total impact can be environment-changing.

Stormwater planters

Stormwater planters are small landscaped stormwater treatment devices that can be placed above or below ground and can be designed as infiltration or filtering practices. Stormwater planters use soil infiltration and biogeochemical processes to decrease stormwater quantity and improve water quality, similar to rain gardens and green roofs. Three versions of stormwater planters include contained planters, infiltration planters, and flow-through planters.

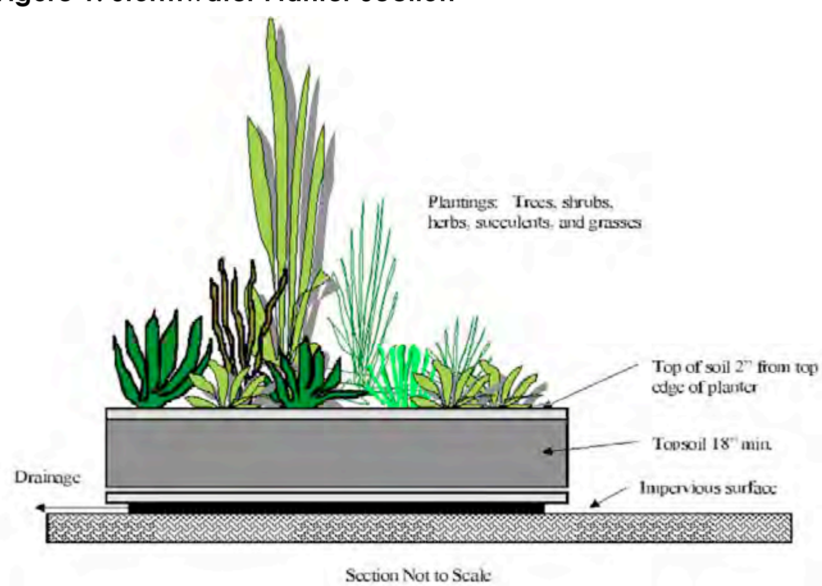
Application in a Historic District

Stormwater planters are a very common application in urban, downtown areas as a way to introduce greenery and flowers and can be seen in Downtown Geneva, Canandaigua and Clifton Springs. In Canandaigua and Geneva specifically there were freshwater wetlands that extended the lakes but these were drained and developed over. There are many different ways to design stormwater planters, and a variety of materials to use. When incorporating stormwater planters into a historic district, it is important to use historic details relevant to the district and containers such as natural or wire baskets, terra cotta pots, and brick planters. When the planters are selected with the aesthetics of the district in mind, they are likely to contribute the historic character of the area, as well as collect stormwater. Stormwater planters can be an aesthetically pleasing way to help restore some natural integrity to more urban environments.

Contained Planters

A contained planter is essentially a potted plant placed above an impervious surface (Figure 1). Rainwater infiltrates through the soil media (which can be mulch, soil, or gravel) within the container, and overflows when the void space or infiltration capacity of the container is exceeded. Contained planters do not receive stormwater run-off or treat it directly, however they do capture more rainwater, which decreases the amount of run-off from impervious surfaces during storm events.

Figure 1: Stormwater Planter Section



Source: New York State Stormwater Management Design Manual

Benefits associated with contained planters include:

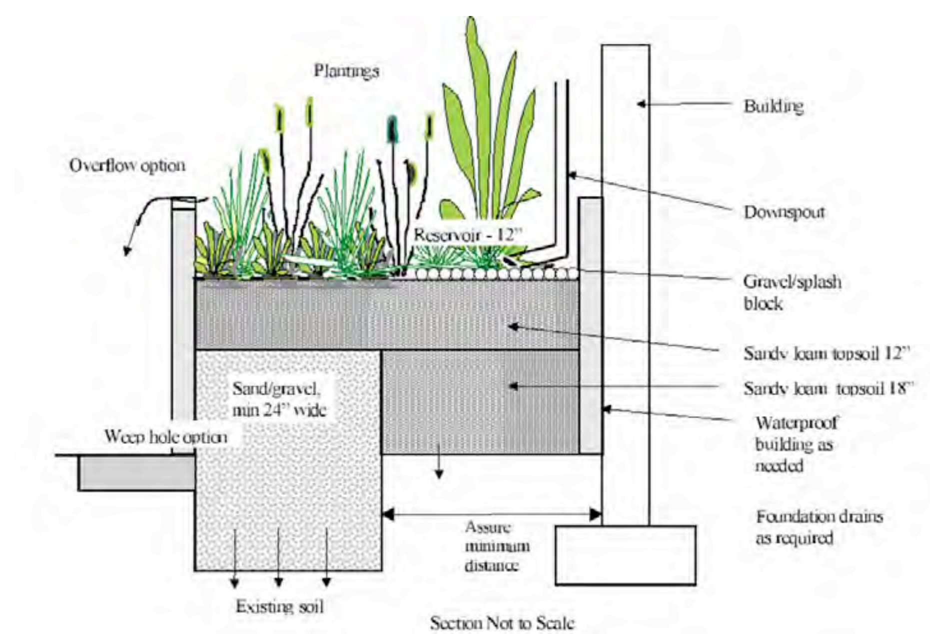
- Reduced impervious surface
- Decrease in stormwater run-off

- Visually appealing
- Versatile-can be placed on many types of impervious surfaces e.g. sidewalks, plazas, and rooftops

Contained planters can be planted with shrubs, flowers, bulbs, ground cover, herbs, and even small trees. Trees are especially recommended because they provide canopy cover for impervious surfaces that are not covered by the planter. Planting native species are beneficial and important to development because they are largely self-sustaining and do not require much extra maintenance like watering or pesticides.

Infiltration Planter

Figure 2: Infiltration Planter Section



Source: New York State Stormwater Management Design Manual

An infiltration planter (Figure 2) is a contained planter with a pervious, or open, bottom that allows stormwater to infiltrate through the soil within the planter and pass into the underlying soil. They usually contain a layer of gravel, soil, and vegetation. Stormwater run-off temporarily pools on top of the soil, then slowly infiltrates through the planter into the ground. These types of planters are not recommended for use if the soil does not drain well already.

Some benefits of infiltration planters are:

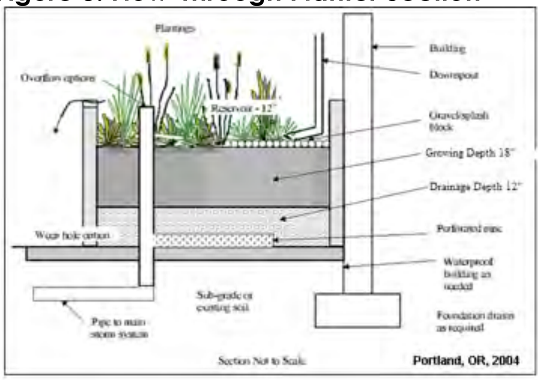
- Ideal for space-limited sites
- Reduce stormwater run-off flow rate, volume, and temperature
- Reduce pollutants entering into storm drains
- Recharge ground water
- Provide energy benefits when planted near building walls

Infiltration planters can contain the same types of plants a contained planter can.

Flow-Through Planters

A flow-through planter (Figure 3) is a contained planter with an under drain system that

Figure 3: Flow-Through Planter Section



Source: New York State Stormwater Management Design Manual

conducts filtered stormwater to the storm drain system or downstream waterway (Figure 3). Flow through planters do not infiltrate into the ground, and can be placed above or in the ground. They are filled with gravel, soil, and vegetation and are typically waterproofed. They are used to temporarily store stormwater run-off on top of the soil and then filter sediment and pollutants as the water slowly infiltrates down through the planter. Excess water collects in a perforated pipe at the bottom of the planter and drains to a destination point or conveyance system.

Benefits associated with flow-through planters include, but are not limited too:

- Ideal for constrained sites because they can be built directly next to buildings
- Useful on slopes that are too steep for other green infrastructure techniques
- Can be built and placed on poorly draining soils
- Used in contaminated areas
- Reduce stormwater flow rates, volume, and temperature
- Improve water quality
- Provide shading, and energy benefits when sited against building walls
- Aesthetically pleasing

Vegetation can include a variety of shrubs, small plants, and other plants that are appropriate seasonally. Summer irrigation and weeding may be required-this can be minimized though by planting native and well-adapted species. Some examples of native plants that could be used in any three of these stormwater planters include: columbine, New England aster, spiked gay-feather, and cardinal flower. And some suggested shrubs are red chokeberry, and summer sweet bush.

All three types of stormwater planters include three common elements: planter "box" material (e.g., wood or concrete); growing medium consisting of organic soil media; and vegetation. Infiltration and flow-through planters may also include splash rock, filter fabric, gravel drainage layer, and perforated pipe. All three types come in various different sizes and shapes, and can be made out of stone, concrete, brick, plastic, lumber, or wood.

Figure 4: Example of Stormwater Planter

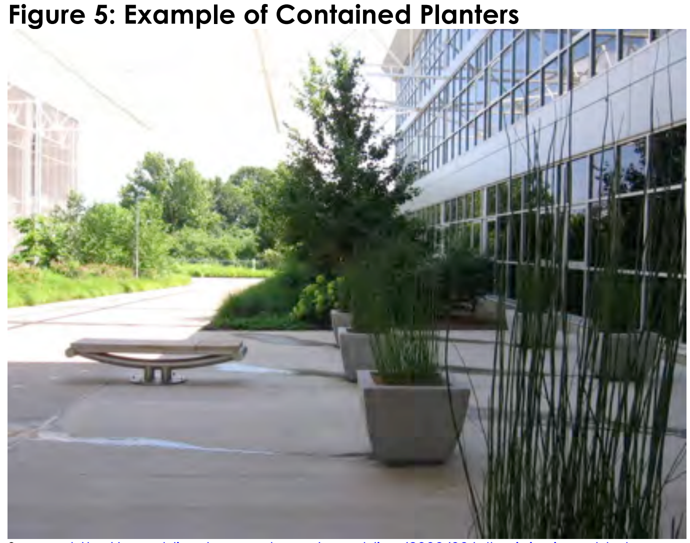
Source: http://www.portlandoregon.gov/bes/article/68716

In general, stormwater planters make filtration treatment of groundwater and soils possible. They also slow the velocity stormwater moves over impervious areas, as well as reduces the volume of stormwater. Planters also create an aesthetic landscape and provide microhabitats within urban environments.

Location

The versatility of stormwater planters makes them uniquely suited for urban redevelopment sites. Depending on the type, they can be placed adjacent to buildings, on terraces or rooftops. Building downspouts can be placed directly into infiltration or flow-through planters; whereas contained planters are designed to capture rainwater, essentially decreasing the site impervious area. The infiltration and adsorption properties of stormwater planters make them well suited to treat common pollutants found in rooftop runoff, such as nutrients, sediment and dust, and bacteria found in bird feces. Stormwater planters are most effective at treating small storm events because of their comparatively small individual treatment capacity.

Figure 5: Example of Contained Planters



Source: http://respublica.typepad.com/respublica/2008/08/alberici-rainwa.html

Currently, in Canandaigua bio-retention centers, rain gardens, and stormwater planters are being installed to help improve the appearance of the district whilst also helping mitigate stormwater. In many of the surrounding areas extensive gardens were a major characteristic of historic homes and properties, as well as wide tree-lined streets. Nowadays, telephone wires and underground pipes and systems can inhibit our ability to replant areas. Stormwater planters offer a compromise to this problem by providing specific designated areas and containers for plants and by using them as an economic agent to help clean our streets, air, and water and reduce pressures on stormwater sewers and drains during storms.

Site Specific Considerations

Required Elements

There are a number of siting, sizing, and material specification guidelines that should be considered during stormwater planter design. Specifically, vegetation selected for planters should be native species that are relatively self-sustaining and adapt well. Pesticides and fertilizers should be avoided whenever possible.

Siting

- Flow-through and infiltration stormwater planters should not receive drainage from impervious areas greater than 15,000 square feet.
- Infiltration planters should be located a minimum distance of ten feet from structures.
- To prevent erosion, splash rocks should be placed below downspouts or where

stormwater enters the planter.

Soil

- Soil specifications for the stormwater planter growing medium should allow an infiltration rate of 2 inches per hour, and 5 inches an hour for the drainage layer.
- Soil compaction must be no greater than 85% in the planter.
- The growing medium depth for all three stormwater planter types should be at least 18 inches.
- Growing media should be a uniform mixture of 70% sand (100% passing the 1-inch sieve and 5% passing the No. 200 sieve) and 30% topsoil with an average of 5% organic material, such as compost or peat, free of stones, roots and woody debris and animal waste.
- For infiltration and flow-through planters the drainage layer should have a minimum depth of 12 inches. Drainage layer should be clean sand with 100% passing the 1-inch sieve and 5% passing the No. 200 sieve.

Sizing

- Stormwater planters should be designed to pond water for less than 12 hours, with a maximum ponding depth of 12 inches.
- An overflow control should redirect high flows to the storm drain system or an alternative treatment facility.
- Generally, flow-though and infiltration planters should have a minimum width of 1.5 and 2.5 feet, respectively.

Zoning

In the hopes of enhancing both the rural historical setting and agricultural spaces, implementing green infrastructure is acceptable. In zoning codes, there is no code enforcing that any green infrastructure cannot be placed on residential lots. However, if green infrastructure techniques is desired to installed in historic districts of public spaces, then it asked that before placing it in, that it be brought to the Planning Board of the Village of Clifton Springs.

Historic Overlay

Installing editions on the exterior of owners structure is allowed as long as it represents a familiar visual aesthetic as the existing structure, identifies with historic personage and protects and improves the intention of the site.

Figure 6: Planters in a Public Plaza

Source: New York State Stormwater Management Design Manual

Site Preparation & Design of Infiltration Planters

The infiltration rate of the native soil should be a minimum of 2 inches per hour. A minimum infiltration depth of 3 feet should be provided between the bottom of the infiltration practice and any impermeable boundaries, such as the seasonal high groundwater level or rock. Infiltration planters should also be designed and constructed with no longitudinal or lateral slope.

Materials suitable for planter wall construction include stone, concrete, brick, clay, plastic, wood, or other durable material.

Treated wood may leach toxic chemicals and contaminate stormwater, and should not be used. Flow-through planter walls can be incorporated into a building foundation, with detailed specifications for planter waterproofing.

Sizing and Design Criteria

Stormwater planters should initially be sized to satisfy the WQv requirements for the impervious surface area draining to the practice. This does not apply to contained planters because they are designed to decrease impervious area, not receive additional runoff from adjacent surfaces. The basis for the sizing guidance is the same as that for bio-retention (see Chapter 6 of the New York Stormwater Management Design Manual) and relies on the principles of Darcy's Law, where water is passed through porous media with a given head, a given hydraulic conductivity, over a given timeframe. The equation for sizing an infiltration or flow-through stormwater planter based upon the contributing area is as follows:

Figure 7: Stormwater Planter with Roof Spout

Source: New York State Stormwater Management Design Manual

$$Af = WQv \times (df) / [k \times (hf + df)(tf)]$$

where:

- Af = the required surface area [square feet]
- WQv = water quality volume [cubic feet]
- df = depth of the soil medium [feet]
- k = the hydraulic conductivity [ft./day], usually set at 4 ft./day when soil is loosely placed in the planter, but can be varied depending on the properties of the soil media. Some other reported conductivity values are:
  - Sand: 3.5 ft./day
  - Peat: 2.0 ft./day
  - Leaf compost: 8.7 ft./day
  - Bioretention Soil: 0.5 ft./day
- Hf = average height of water above the planter bed [≤6 inches for a maximum ponding depth of 12 inches]
- tf = the design time to filter the treatment volume through the filter media [usually set at 3 to 4 hours]

Example

A simple example for sizing a stormwater planter using WQv is presented below. The ultimate size of a stormwater planter is a function of either the impervious area or the infiltration capacity of the media. Determine the required surface area of a stormwater planter that will be installed to treat stormwater run-off from an impervious area of 3,000 square feet, given the depth of the soil medium is 1.5 feet.

Step 1: calculate the WQv

$WQv = (P)\ (Rv)\ (A)\ /\ 12$

Where: P = 90% rainfall number =0.9 in

$Rv = 0.05 + 0.009\ (I) = 0.05 + 0.009(100) = 0.95$

I = percentage impervious area draining to planter = 100%

A = area draining to practice = 3,000 ft2

$WQv = (0.9)(0.95)(3000)/12$

WQv = 213.75 ft3

Step 2: Calculate required surface area:

$Af = WQv*(df)\ /\ [k*(hf + df)\ (tf)]$

where: WQv = 213.75 ft3

df = depth of soil medium = 1.5 ft.

k = hydraulic conductivity = 4 ft./day

hf = Average height of water above planter bed = 0.5 ft.

tf = filter time = 0.17 days

$Af = (213.75)(1.5)\ /\ [(4)(0.5+1.5)(0.17)]$

Af = 235.75 ft2

Therefore, a 240 square-foot stormwater planter with a soil medium depth of 1.5 feet will be needed to treat stormwater from a 3,000 square foot area. The calculated WQv of 213.75 ft3 is added to the Runoff Reduction Volume for the site (if the site soils are suitable for infiltration). If the planter is designed as a flow-through planter on C soils, then 96 ft3 (45% of the WQv for the area draining to the planter) is added to the Runoff Reduction Volume. 64 ft3 (30% of the WQv) is added towards the Runoff Reduction Volume for a flow through planter on D soils.

Maintenance

A regular and thorough inspection regime is vital to the proper and efficient function of stormwater planters. Debris and trash removal should be conducted on a weekly or monthly basis, depending on likelihood of accumulation. Following construction, planters should be inspected after each storm event greater than 0.5 inches, and at least twice in the first six months. Subsequently, inspections should be conducted seasonally and after storm events equal to or greater than the 1-year storm event. Routine maintenance activities include pruning and replacing dead or dying vegetation, plant thinning, and erosion repair. Since stormwater planters are not typically preceded by pre-treatment practices, the soil surface should be inspected for evidence of sediment build-up from the connected impervious surface and for surface ponding. Attention should be paid to additional seasonal maintenance needs as well as the first growing season.

Feasibility and Limitations

The primary limitation to the use of stormwater planters is their size. They are by definition small-scale stormwater treatment cells that are not well suited to treat runoff from large storm events, or large surface areas. They can, however, be used in series or to augment other stormwater management practices. Other limitations include:

- Stormwater planters are not designed to treat runoff from roadways or parking lots but are ideally suited for treating rooftop or courtyard/plaza runoff.
- Flow-through and infiltration stormwater planters should not receive drainage from impervious areas greater than 15,000 square feet.
- For all three types of stormwater planters, if the infiltration capacity of the soil is exceeded, the planter will overflow. Excess stormwater needs to be directed to a secondary treatment system or released untreated to the storm drain system.

Cost

Cost of installation is approximately $8/square foot, however, cost will vary depending on the size and material of the planter. Each planter is estimated to cost about $400-$500 per year for a 500 square foot planter. Maintenance costs will vary depending on the size and material of the planter as well, plus the types of plants utilized.

Conclusion

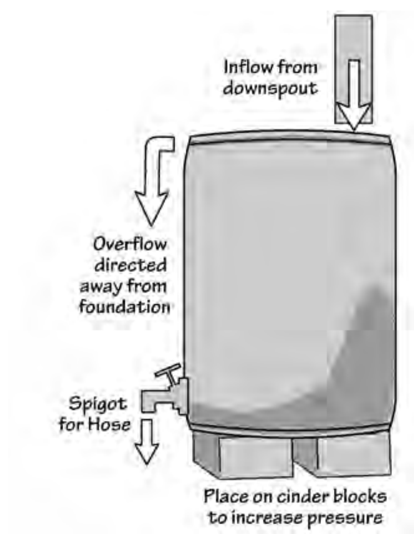
Stormwater planters offer a wide variety of ways to implement more nature into urban environments. Historically, trees and residencies were rich with vegetation and largely contributed to the aesthetics and visual appeal of these areas. This heavy vegetation also helped mitigate stormwater and prevent flooding during these times, which meant there was less of a need for man-made infrastructure and impervious surface. Installing planters in historic downtown areas will help improve the functionality of current water management systems and aesthetics, while also returning that historic small town feel to the area

Rain Barrels

A rain barrel is a water tank used to collect and store rainwater runoff, typically from rooftops via rain gutters. Barrels usually range from 50 to 80 gallons and have a spigot for filling watering cans and a connection for a soaker hose. Stormwater run-off can then be used later for lawn and landscaping irrigation or filtered and used for non-potable water activities and other uses that have a routine demand for water when in service.

In recorded history, the use of rainwater collection can be traced as far back as ancient times

Figure 1: Rain Barrel Parts



Source: http://www.lmvp.org/Waterline/2008number1/misc.html

some 3,000 years ago (850 BC). In the days of the Roman Empire, atrium fed rainwater collection cisterns were common place and to this day an important part of history. Although not documented photographically, it is known that many settlers in this region used rain barrels and catchment systems for washing clothes, bathing, cooking, and other uses. In today's modern world we have the ability to use a myriad of different catchment systems designed for specific collection and uses.

Today, typically, 55 gallon plastic barrels are used for water collection and storage, although their size may vary from a few gallons to hundreds. These types of containers are very economical and affordable as well as extremely durable and weather hardy and may be constructed of any water-retaining material. Rain barrels consist of:

- a watertight storage container
- secure cover
- a debris/mosquito screen
- a coarse inlet filter with clean-out valve
- an overflow pipe
- a drain for cleaning
- and an extraction system (tap or pump).

Figure 1 demonstrates how typical rains barrel functions. Additional features might include a water level indicator, a sediment trap or a connector pipe to an additional tank for extra storage volume. The storage containers are usually placed on riser blocks or a gravel pad to aid in gravity drainage of collected runoff and to prevent the accumulation of overflow water around the system.

A collection system can yield 623 gallons of water from 1 inch of rain on a 1,000 square foot roof. In arid climates, rain barrels are often used to store water during the rainy season for use during dryer periods. Harvesting rainwater through the use of rain barrels often reduces mains water and the amount of water that runs into storm drains which has economic and environmental benefits, and aids in self-sufficiency. Some of the most common uses of harvested rainwater include:

- watering gardens
- agriculture/irrigation
- flushing toilets and can be used for washing machines
- washing cars
- toping off, or filling pools
- drinking, especially when other water supplies are unavailable, expensive, or of poor quality, and that adequate care is taken that the water is not contaminated or the water is adequately filtered.

Application in a Historic District

Rain barrels were used throughout the region historically, and were a common technique to gather water for drinking and irrigation in the past. Almost every building has a gutter or downspout and thus rain barrels can be a ubiquitous technique in any historic district. There are a wide variety of types of rain barrels made from diverse materials available today. Care should be taken to select rain barrels, which are compatible with the aesthetics and character of a historic district. Natural materials such as wood, or incorporating plantings on the top of the barrel, and using landscaping can help obscure the barrel and allow it to blend in with it's surrounding environment. Additionally, barrels can be sited on the backs of buildings, or painted the same color of the adjacent building. Examples of the successful integration of rain barrels into a historic district can be seen throughout the South Main Historic District in Geneva.

Benefits

Rain barrels have various different economic and environmental benefits associated with them; the following passages explain the most prominent. Since the rainwater is usually collected from the roofs of houses, it picks up little contamination when it falls.

Therefore, it is important to keep your roof clean of debris and potential contaminants to maximize purity. The material your roof is made of is also important in how much contamination the water will carry. The chemicals and hard water from many of our municipal water systems can produce an imbalance in the soil of your garden. Chemical fertilizers, fungicides, pesticides, and drought can also disrupt the balance and harmony of the soil. This imbalance causes trees and plants to weaken and makes them more susceptible to disease.

Figure 2: Rain Barrel with Planter

Source: http://bungalowclub.org/newsletter/summer-2009/rain-gardens-and-rain-barrels/

Healthy Plants and Soil

Trees and plants have an efficient immune system that allows them to fend off diseases and other invaders as long as they have a healthy soil environment and aren't stressed by other factors such as drought. Trees and plants rely on fungus, bacteria, and nematodes to help them absorb the minerals and nutrients they need. When you look at your garden, visualize it as a vast interconnected community of trees, plants and tiny critters that live in the soil, all interacting and affecting each other. Thus, the type of water you use in your garden will affect the health of this intricate community. Tap water contains inorganic ions and fluoride compounds that accumulate in the soil over time and potentially harm plant roots and microorganisms in the soil. Rainwater does not contain the same additives found in tap water. It benefits plants in your garden by cleaning the soil of salt buildup, thereby promoting an environment conducive to root development.

The soils that are in the Clifton Springs Sanitarium Historic District consist dominantly of Palmyra soil. Palmyra soil consists of very deep soil that have the ability to drain easily, so there is a lesser chance of run off potential in this soil area. They are steep soils that are made up of stratified gravel and clay. This soil is best used for intensive growing of gardens and plants.

Money Saver

Rain barrels save homeowners money on their water bills. Garden and lawn irrigation accounts for 40% of residential water use during the summer, according to the U.S. Environmental Protection Agency. By using rain barrels, homeowners can save 1,300 gallons of water during the growing season. Connecting multiple barrels maximizes rain capture, which can provide a free water source for irrigation and ease reliance on the city's water supply.

Figure 3: Plastic Barrel

Source: http://www.cleanairgardening.com/rain-collection-barrel.html

Figure 4: Disguised Rain Barrel

Source: http://www.organicgardening.com/learn-and-grow/rain-barrels?page=0,5

Figure 5: Clay Barrel

Source: http://www.rainwatersolutions.com/pages/moby-faq

Reduction of Run-off

Rain barrels help reduce the flow of storm run-off. When it rains, run-off picks up soil, fertilizer, oil, pesticides and other contaminants from hard surfaces and landscapes. Storm run-off is not treated and flows directly into streams, lakes and other bodies of water nearby. Run-off fertilizers increase algae growth in lakes, and excess soil alters the habitat for fish. Bacteria can even make lakes and oceans dangerous for recreational activities. Rain barrels capture water that would have swept over a paved surface or lawn, thereby minimizing run-off pollutants

Types of Barrels

Rainwater tanks may be constructed from materials such as plastic (polyethylene), wood, concrete, galvanized steel, as well as fiberglass and stainless steel, which are rust and chemical-resistant. Tanks are usually installed above ground, and are usually opaque to prevent the exposure of stored water to sunlight, to decrease algal bloom. Rain barrels may be covered and have screen inlets to prevent insects, debris, animals and bird droppings from entering into the water.

Figure 6: Wood Rain Barrel on South Main Street, Geneva

Source: Photograph by Cari Varner, 2013.

There is a myriad of different types of rain barrels today, which Figures 3 - 5 demonstrate. The most common materials rain barrels are made out of are plastic, wood, galvanized metal, and ceramic clay or stone rain barrels. Wooden rain barrels are particularly complementary to historic areas, and have the ability to add to landscaping. Figure 6, is of a wooden rain barrel that can be seen in the historic district of Geneva, NY on South Main Street. Rain barrels that double as planters add some aesthetic value to your rain barrel and help it blend in as well, as seen in Figure 2. Many historic photos show elaborate vegetable and flower gardens in front of homes in Ontario County. Rain barrels help create a more historically accurate and aesthetically pleasing environment by encouraging more gardens, as seen, can even be planted themselves.

Climate

A full 55-gallon barrel represents a significant quantity of water. When filled, it weighs almost 500 lbs. If it's permitted to freeze, a number of unfortunate things might happen. For one, your drain spout might become plugged with ice and prevent drainage until the next thaw. The water contained in your hoses might freeze, splitting the hoses and releasing the barrel's overflow. In extreme cases, the barrel might split or crack from the pressure of the expanding ice. Below are a couple ways to help prevent this from happening this winter.

Taking Down the Barrel

Since, the Finger Lakes experience quite a bit of snow and cold weather, the most prudent course of action is to drain your barrel and store it for the winter. Open the bottom faucet and drain the barrel through a hose into your garden area, then drain and coil the hose. Do the same with the overflow, if it has a hose attached. Wash out the barrel with a gentle soap, and rinse it with vinegar and water. Store the barrel upside down in a sheltered location such as a shed or garage so it doesn't blow away during the winter.

Overwintering

If taking down the barrel is a nuisance, you might be able to safely overwinter your barrel while keeping it in use. You can do this by purchasing a dark-colored barrel or paint it a dark color to maximize solar warming. You should site the barrel on the south-facing side of your house, where it will receive the most sun, and when cold weather is in the forecast, insulate your barrel with an old blanket or with bags filled with dry autumn leaves. There are also now rain barrels made specifically to protect against freezing, for colder climates such as the Finger Lakes.

The links below provide helpful guides and reviews for different products and display the diversity that exists for rain barrel products.

http://www.organicgardening.com/learn-and-grow/rain-barrels?page=0,6
http://www.rainbarrelresource.com/

Site Design Criteria

Below is a DIY step by step guide to help walk you through the process of creating your own rain barrel and show you what you may need to expect and prepare for:

1. Start with a large, food-quality, plastic barrel and drill a hole in the cap of the barrel with a large, 3/4-inch drill bit. While plastic is preferred because it won't rust, any large, waterproof container will work well.
2. Drill a second hole nearby along the side of the container about 1 or 2 inches from the top.
3. Flip the barrel over and drill a third hole into the base.
4. Determine the number of pipe adaptors (male) and couplings (female) needed to span the distance from the hole at the barrel base to the outer edge of the barrel.
5. Wrap each threaded adaptor end of piping with plumber's tape for a watertight seal.
6. Screw the sections together, making sure they're secure and tight.
7. Attach a curved coupling to the hole on the barrel base and connect the additional adaptors to the curved section. Join a spigot to the end of the attached pipe section. This will allow you to control the release of the collected water.
8. The hole on the side of the barrel is for the spigot. Secure a small piece of PVC pipe through the hole to connect the spigot.
9. Join the spigot to the pipe.
10. Attach a garden hose to the spigot.
11. To make a water collection funnel, cut a piece of window screening a little bigger than the PVC coupling and secure it with a hose clamp.
12. Slide the pipe into the large hole in the barrel.
13. To attach the rain collector to your house, find a location that is level. Remember that when the rain collector is full, it can weigh more than 400 pounds, so it's important to place it in a level location to keep the barrel stable.
14. Place the rain barrel on stacked cinderblocks to raise it off the ground. This provides room underneath the barrel for the release spigot and a watering can to access the rainwater. Make sure the cinderblocks are stable.
15. About 1 or 2 inches above the barrel along the gutter, cut out and hinge an elbow section.
16. Fit the base of the section with a metal screen.
17. Place a pad on the metal screen to soften the sound of rain hitting the metal.
18. When the barrel is full, the downspout can be hinged closed to stop the flow of water to the barrel.
19. Because most rain barrels hold only 55 gallons of water, you can stretch the garden's water supply even further for those dry summer months by adding additional barrels. Just make sure to redirect the surplus water.
20. When you install your rain barrel, add an overflow pipe, so that excess water can escape. Make sure that the overflow pipe is pointed away from your home's foundation.
21. Always keep a lid on your rain barrel to prevent any curious children or animals from toppling in, as well as preventing any potential mosquito populations from exploding.
22. If you treat your roof for pests or wood, be sure to unhook your rain barrel for at least two weeks.

Zoning

In the hopes of enhancing both the rural historical setting and agricultural spaces, implementing green infrastructure is acceptable. In zoning codes, there is no code enforcing that any green infrastructure cannot be placed on residential lots. However, if green infrastructure techniques is desired to installed in historic districts of public spaces, then it asked that before placing it in, that it be brought to the Planning Board of the Village of Clifton Springs.

Historic Overlay

Installing editions on the exterior of owners structure is allowed as long as it represents a familiar visual aesthetic as the existing structure, identifies with historic personage and protects and improves the intention of the site.

For historic districts, maintaining the integrity of the built environment is of utmost importance. There are many rain barrel designs that can be utilized that minimize the visual impact, or are compatible with historic detailing. For example, rain barrels which are made of wooden materials (such as old wine barrels or similar), are obscured by vegetation, are painted to match the color of the house, are placed in the back of the house etc. are all recommended so that the historic feel is maintained.

Figure 7: A Typical Residential Roof

Source: http://www.rainbarrelresource.com

Site Preparation and Design

If you're wondering how many rain barrels you may want to purchase, or make, the following equation allows you to calculate an estimate of how much rainwater can be harvested from your roof.
First the catchment area must be determined, or the area of roof.
(L + gutters) x (W + gutters) = Catchment

It's important to know that for every single inch of rainfall on a 1,000 square foot roof, there are 623 gallons of rainwater that will be available.

Now to calculate the amount of rain you will be able to capture, use the following formula:
A = (catchment area of building)
R = (inches of rain)
G = (total amount of collected rainwater)

$$(A) \times (R) \times (600 \text{ gallons}) / 1000 = (G)$$

For example, the average monthly rainfall in the Finger Lakes region between April and October is approximately 3 inches. The cost of water in Geneva is currently $4.28/1,000 gallons. That means about 1,869 gallons of water will run off a 1,000 square foot roof during that 6 month period, which means if captured homeowners could save about $100 dollars on their water bill each year. Especially considering that water usage increases during peak summer months.
Table 1 below shows average monthly rainfall in Geneva, New York. The link below the table allows you to look up more rainfall averages for the Finger Lakes Region so you can calculate your own potential savings and figure out how big a rain barrel, or how many, you may want.

Table 1

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Avg. High	30°	31°	41°	54°	66°	75°	80°	78°	71°	58°	47°	35°
Avg. Low	14°	15°	24°	35°	45°	55°	60°	58°	51°	40°	32°	21°
Mean	22°	24°	34°	45°	56°	65°	70°	68°	61°	50°	40°	28°
Avg. Precip.	1.8 in	1.8 in	2.1 in	2.9 in	3.0 in	3.7 in	3.0 in	3.1 in	3.3 in	2.9 in	3.1 in	2.5 in

Contamination and Maintenance

If rainwater is used for drinking, it is often filtered first. Filtration may remove pathogens. While rainwater is pure it may become contaminated during collection or by collection of particulate matter in the air as it falls. While rainwater does not contain chlorine, contamination from airborne pollutants, which settles onto rooftops, may be a risk in urban or industrial areas. Many water suppliers and health authorities, such as the not advise using rainwater for drinking when there is an alternative mains water supply available. However, reports of illness associated with rainwater tanks are relatively infrequent, and public health studies have not identified a correlation. Rainwater is generally considered fit to drink if it smells, tastes and looks fine. However some pathogens, chemical contamination and sub-micrometer suspended metal may produce neither smell, taste and not be visible.

To keep a clean water supply, the rain barrels must be kept clean. It is recommended to inspect them regularly, keep them well-enclosed, and to occasionally empty them and clean them with an appropriate dilution of chlorine and to rinse them well. They can be cleaned by using a stiff brush to scrub all inside surfaces. A good disinfecting solution is 1/4 cup 5.25% liquid chlorine bleach in 10 gallons of water. Flush the barrel thoroughly with clean water to remove sediment after construction, cleaning or maintenance. Keeping gutters, gutter guards, downspouts, and roof washers free of foreign materials, clean, and uncluttered also help keep water clean and free of pollutants. If still worried about pollution-it is recommended to apply the water to the soil around plants, rather than directly on the plants themselves. By doing this you allow soil to perform it's role as a filter and help recharge your soil with compost, as well as tramps heavy metals so they are not taken up by your plants.

Pests

Mosquitos can quickly become a problem because larvae thrive in stagnant water. This can be prevented by ensuring you have a sealed water tight cover, or by adding a small amount of cooking oil to the surface. Cooking oil suffocates the larvae, but does not compromise sanitation. Bleach can also help prevent mosquitoes. Finally, by placing a screen a top of the downspout leaves and debris that washes down into the storage tank is minimized. If a screen is unsightly, exposed openings can also be screened with shrubs or other landscaped features.

Drainage & Irrigation

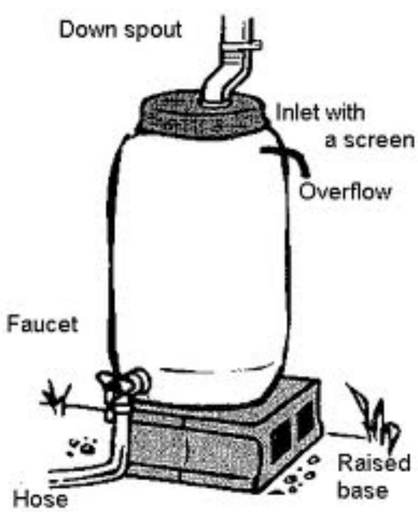
If present, a rain barrel's continuous discharge outlet should be placed so that the tank does not empty completely, ensuring water availability at all times, while also providing at least some storage capacity for every storm. A diverter at the cistern inlet can redirect the "first flush" of runoff, which is more likely to have particulates, leaves, and air-deposited contaminants washed off the roof. A first flush feature captures the first 5-10 gallons of water that comes off your roof and holds it separately from subsequent water that goes into the main storage tank. These first flush gallons contain the majority of dust, pollen, bird waste etc. that builds up between rains and can still be used on ornamentals or lawn away from vegetable gardens.

Keep your rain barrel reasonably clean. Rinse it thoroughly at the end of each growing season and as you have the opportunity throughout the summer. If you notice that its contents seem particularly mucky or smelly, drain the barrel, rinse it out, and start afresh with the next rainfall. In summary, maintenance includes checking roofs and rain gutters for vegetation and debris, maintaining screens around the tank, and occasionally dislodging (removing sediment by draining and cleaning the tank of algae and other contaminants).

Rain Barrels and Roofing

Certain paints and roofing materials may cause contamination. In particular, it is advised that lead-based paints never be used. Tar-based coatings are also not recommended, as they affect the taste of the water. Zinc can also be a source of contamination in some paints, as well as galvanized iron or zincalume roofs, particularly when new, should not collect water for potable use. Roofs painted with acrylic paints may have detergents and other chemicals dissolve in the runoff. Runoff from fibrous cement roofs should be discarded for an entire winter, due to leaching of lime. Chemically treated timbers and lead flashing should not be used in roof catchments. Likewise, rainwater should not be collected from parts of the roof incorporating flues from wood burners. Overflows or discharge pipes from roof-mounted appliances such as air-conditioners or hot-water systems should not have their discharge feed into a rainwater tank.

Figure 8: A Typical Rain Barrel



Source: http://www.stepbystep.com/how-to-build-a-rain-barrel-108267/

Considerations

Initial sizes typically range in capacity from around 100 to 25,000 gallons for larger commercial or residential uses. The most common rain barrels are usually plastic and hold about 55 gallons. Depending on predicted rainfall, and intended use, the consumer has the ability to choose from a diverse range of sizes. Some considerations before opting for bare minimum, or a more expensive larger barrel is the supply desired. The area of roof draining into the barrel, and intended use and typical consumption of water for certain activities such as washing a car, irrigation, garden use, watering a lawn, or topping off a pool are a few further considerations that should be made.

Concerning safety- Your rain barrel must be secured on a firm, level surface. A full 55-gallon rain barrel weighs over 400 lbs. and tipping is a risk if it's unsecured or on uneven ground. The barrel must be structurally sound and should be a food-grade container made to hold liquid. Containers such as trash cans are not designed to withstand the pressure of the water.

Cost

Rainwater tanks may have a high (perceived) initial cost. However, many homes use small scale rain barrels to harvest minute quantities of water for landscaping/gardening applications rather than as a potable water surrogate. These small rain barrels, bought new or can be recycled from food storage and transport barrels or, in some cases, whiskey and wine aging barrels, are often inexpensive. There are also many low cost designs that use locally available materials and village level technologies for applications in developing countries where there are limited alternatives for potable drinking water.

Although costs vary somewhat between manufacturers, in general, the cost of a single, rain barrel roof top water catchment system, minus the down spout and other accessories, averages about $120. Costs to a homeowner can be reduced still further by constructing his or her own barrel, which can be done with basic supplies for as low as $20.

While rain barrel installation costs are relatively easy to quantify, the costs savings, both to the individual and the local utility system are not as easy to measure. Nevertheless, it is reasonable to expect that widespread use of rain barrels or cisterns will decrease the hydraulic loads and hence the costs required for the construction and maintenance of off-site storm drain systems. The reduction in volume on the local water distribution system can extend the overall life of it.

Below, in Table 2, is a sample cost estimate for a single rain barrel, minus the downspout, in a residential area for use in small-scale irrigation and gardening purposes only. The estimate assumes that the homeowner, garden group, or volunteers provide the labor, including assembly of rain barrel if necessary. The disturbed area is considered to be minimal and small enough to avoid any permits and fees. The following are average costs for a typical, newly manufactured rain barrel plus optional accessories.

Table 2

ITEM	***COST***
Rain Barrel with sealed top	$120
Overflow Kit/Runoff pipe	$35
Rain Diverter	$18
Soaker Hose	$21
Linking Kit	$12
Spigot, if not supplied	$5
Additional Guttering	$5
TOTAL ESTIMATED COST:	**$216**

Conclusion

As stated before, in Geneva, water costs $4.28 per 1,000 gallons. The average person uses 50 gallons per day just for household utilities. In the U.S. approximately 7.8 billion gallons of the 26 billion gallons consumed daily are devoted to outdoor uses. In the summer this amount of water can exceed the amount used for all other purposes in the entire year. The typical suburban lawn consumed 10,000 gallons above and beyond rainwater each year. The EPA estimates that about 40% of total household water use in the peak summer months could be saved by using rain barrels to capture rainwater. This season in particular has exceeded average monthly rainfalls and harvesting even a fraction of that water can help save homeowners money, reduce stormwater run-off and flooding, help decrease demand and stress on local water systems, and reduce the amount of non-point source pollution that flows untreated into our precious waterways during storms.

For further tips and guides about cleaning, maintenance, and/or environmental impacts visit the link below, or see the attached link to the EPA guide about harvesting rainwater.
http://www.rainbarrelman.com/faq.htm
http://water.epa.gov/polwaste/nps/upload/rainharvesting.pdf

Porous Pavement

Porous, or permeable, pavement is material that allows stormwater to move through the surface and be absorbed rather than flow over the surface. Currently, most development uses impervious materials, such as asphalt and concrete. Rainwater cannot penetrate these materials and is directed into a storm drain off of impervious material, where it then continues to flow untreated into a waterway. Because of this during heavy rainfall sewer systems can also get overwhelmed and flood. Porous pavement is a development technique that can mutually reduce run-off and flooding, as well as minimize the spread of pollution.

Pervious pavement is widely available and can bear frequent traffic, as well as is universally accessible. Porous paving functions like a stormwater infiltration basin and allow the stormwater to infiltrate the soil over a large area, thus facilitating recharge of precious groundwater supplies locally.

Figure 1: Pebbled Path in Pulteney Park

Source: Geneva Historical Society.

Some examples of places that can utilize porous pavement include: roads, paths, lawns and lots that are subject to light vehicular traffic, such as car/parking lots, cycle-paths, service or emergency access lanes, road and airport shoulders, and residential sidewalks and driveways.

Historic photos from Ontario County show pebble and gravel sidewalks, dirt roads and driveways, and then later cobblestone and brick pathways before being paved over with impervious materials. Many home exteriors in Historic districts had descriptions of pathways with spaced out stones framed by grass, where water could easily run off the surface and be absorbed by it's surrounding environment. Figures 1 and 2 are pictures from Geneva, Figure 1 is a pebbled pathway in Pulteney Park, and Figure 2 shows a dirt road and sidewalk in downtown Geneva. The first porous pavement to be widely used however after the industrial revolution was pervious concrete. Pervious concrete was first used in the 1800s in Europe as pavement surfacing. Cost efficiency was the main motivator due to a decreased amount of cement. Then during WWII pervious cement became popular again due to a decrease in availability of cement. Below are some further porous pavement options.

Application in a Historic District

By implementing porous paving in a historic district, it is likely that this will improve the historic character and integrity of the district, as well as mitigate stormwater run-off. However, historic photographs and records should be consulted first, so that the porous pavement application is as accurate to past conditions of the site as possible. The Ontario County Historical Society and Museum has detailed records and photographs, which can be consulted.

Figure 2: Dirt Road & Sidewalk in Downtown Geneva

Source: Geneva Historical Society

Types of Porous Pavement

Concrete & Brick Pervious Pavers

Concrete and brick pervious pavers are commonly used materials that qualify as low impact development and allow the absorption of water. Concrete or brick pavers are manufactured in many sizes and shapes and are laid with a drainage base and permeable joint material, allowing water to slowly seep into the ground. Homeowners can use them for parking areas, patios, sidewalks, and pool decks. Driveways can be paved with these, however, snow removal equipment may catch edges.

Plastic Grids

Plastic Grids allow for a 100% porous system using structural grid systems for containing and stabilizing either gravel or turf. These grids come in a variety of shapes and sizes depending on use; from pathways to commercial parking lots. These systems can be used to meet LEED requirements as well. The ideal design for this type of grid system is a closed cell system, which prevents gravel/sand/turf from migrating laterally.

Figure 3: Loose Gravel

Source: http://www.englishgardenco.co.uk/driveways.html

Porous asphalt

Porous asphalt is conventional asphalt with large, single-sized aggregate particles that leave open voids and give the material porosity and permeability. Under the porous asphalt surface is a base course of further single-sized aggregate that acts as a reservoir where water can be allowed to evaporate and/or be absorbed by underlying soils. Porous asphalt surfaces, called *open-graded friction courses* (OGFC), are being used on highways to improve driving safety by removing water from the surface. OGFCs are not full-depth porous pavements, but a porous surface course usually 3/4 to 1.5 inches thick that allows for the lateral flow of water through the pavement, improving the friction characteristics of the road and reducing road spray.

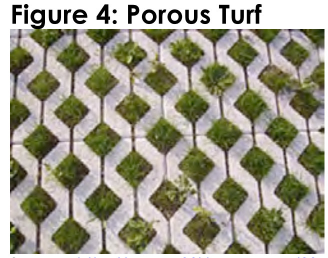
Loose Gravel

Loose gravel may be used or stone-chippings are another alternative. This form of porous paving should only be used in very low-speed, low-traffic settings like car-parks and drives.

Permeable Interlocking Concrete Pavements

Permeable interlocking concrete pavements are concrete (or stone) units with open, permeable spaces between the units. They give an architectural appearance, and can bear both light and heavy traffic, particularly interlocking concrete pavers, excepting high-volume or high-speed roads.

Figure 4: Porous Turf



Source: http://www.100khouse.com/2010/12/08/permeable-pavement-options-for-leed-projects/

Porous Turf

Porous turf, as seen in Figure 4, if properly constructed, can be used for occasional parking like that at churches and stadia. Plastic turf reinforcing grids can be used to support the increased load. Living turf transpires water, actively counteracting the "heat island" with what appears to be a green open lawn.

Figure 5: Permeable Clay Brick Pavements

Source: http://www.stixnstones.com/blog/bid/96524/Garden-Stone-Path-Ideas-and-Gallery

Permeable Clay Brick Pavements

Permeable clay brick pavements are fired clay brick units with open, permeable spaces between the units. Clay pavers provide a durable surface that allows stormwater runoff to permeate through the joints. These are ideal for incorporating porous pavement in historic districts.

Resin Bound Paving

Resin bound paving is a mixture of resin binder and aggregate. Enough resin is used to allow each particle to adhere to one another and to the base yet leave voids for water to permeate through. Resin bound paving provides a strong and durable surface that is suitable for pedestrian and vehicular traffic in applications such as pathways, driveways, car parks and access roads.

Elastomerically Bound Recycled Glass Porous Pavement

Elastomerically bound recycled glass porous pavement is made out of processed post consumer glass with a mixture of resins, pigments, and binding agents. The product trademarked as Filter Pave provides a permeable paving material that also reuses materials that would otherwise be disposed in landfills. Approximately 75 % of glass in the U.S. is disposed in landfills, so increasing the use of this form of porous pavement helps reuse material and reduce waste.

Benefits

Although some porous paving materials appear nearly indistinguishable from non-porous materials, their environmental effects are qualitatively different. Whether pervious concrete, porous asphalt, paving stones or concrete or plastic-based pavers, all these pervious materials allow stormwater to percolate and infiltrate the surface areas that currently do not utilize the soil below. The goal is to control stormwater at the source, reduce runoff and improve water quality by filtering pollutants in the substrata layers.

Figure 6: An Example of Porous Paving

Source: http://www.wycokck.org/InternetDept.aspx?id=23020&menu_id=1444&banner=15284

Benefits of permeable paving include:

- recharging ground water
- run-off reduction
- decrease in capacity restraints in stormwater networks
- effective pollutant treatment for solids, metals, nutrients, and hydrocarbons, as well as aesthetic improvement to otherwise hard urban surfaces.

Controlling Pollutants

Perhaps one of the most important benefits of porous pavement is the reduction of pollutants. Impervious pavement amplifies and spreads non-point source pollution. Non-point source pollution is caused by rainfall or snowmelt moving over the ground. As run-off moves it picks up human made pollutants and deposits them into streams, creeks, and lakes. Common examples of pollutants that fall into this category and spoil our waterways are: fertilizers, herbicides, insecticides, oil, and grease.

Porous pavement slows the velocity and momentum in which water moves over the surface, allowing sediment to drop out of the water, resulting in less erosion; and this means the water picks up less pollutants and allows the pollutants to filter into the ground. Studies have shown that porous pavements capture the heavy metals that fall on them, preventing them from washing downstream and accumulating inadvertently in the environment. In the void spaces, naturally occurring micro-organisms digest car oils, leaving little but carbon dioxide and water.

Examples

A study done in Rockville, MD reported high removal rates for zinc (99%), lead (98%), and chemical oxygen demand (82%). The University of New Hampshire Stormwater center found typical performance efficiencies for TSS, total zinc, and total phosphorous to exceed 95%, 97%, and 42% respectively. The EPA estimates that porous pavement has the ability to remove 65% of total phosphorous, 80-85% of nitrogen, and 82%-95% of suspended solids.

Site Specific Considerations

Soils

The soil should have a minimum infiltration rate of 0.5 inches per hour. Soil testing is required to maintain and ensure effective pollutant removal is taking place in the soils. The soils that are in the Clifton Springs Sanitarium Historic District consist dominantly of Palmyra soil. Palmyra soil consists of very deep soil that have the ability to drain easily, so there is a lesser chance of run off potential in this soil area. They are steep soils that are made up of stratified gravel and clay. This soil is best used for intensive growing of gardens and plants.

Siting

Permeable pavement cannot be used in areas where there are risks for foundation damage, basement flooding, interference with subsurface sewage disposal systems, or detrimental impacts to other underground structures. Permeable pavement, like any other stormwater infiltration practice, bears the possibility of groundwater contamination. Therefore, permeable paving infiltration systems should not be used to treat stormwater hot spots. Stormwater hot spots are areas where land uses or activities have the potential to generate highly contaminated run-off. Examples of this are commercial nurseries, auto recycling and repair facilities, fleet washing, fueling stations, high use commercial parking lots, and marinas.

Figure 7:

Source: http://homeklondike.com/2010/09/29/garden-path-design-ideas/

The recommended applications of permeable paving are for low-traffic roads, single-family residential driveways, overflow parking areas, sidewalks, plazas, tennis and or basketball courts, and courtyard areas, as well as backyard patios. Many opportunities exist in larger parking lots, schools, municipal facilities, and urban hardscapes as well. Permeable paving is easily applicable to redevelopment areas as well as new development. The recommended applications of porous pavement in Clifton Springs are all low-use parking lots and pathways.

As mentioned, porous pavement is recommended for mostly light traffic areas, however, given the variability of products available the range of accepted applications is expanding. Some concrete paver companies have developed products specifically for industrial applications.

Zoning

In the hopes of enhancing both the rural historical setting and agricultural spaces, implementing green infrastructure is acceptable. In zoning codes, there is no code enforcing that any green infrastructure cannot be placed on residential lots. However, if green infrastructure techniques is desired to installed in historic districts of public spaces, then it asked that before placing it in, that it be brought to the Planning Board of the Village of Clifton Springs.

Figure 8: A Terraced Application of Porous Pavement

Source: http://realestate.msn.com/garden-paths-12-easy-to-imitate-stone-walkways-1

Historic Overlay:

Installing editions on the exterior of owners structure is allowed as long as it represents a familiar visual aesthetic as the existing structure, identifies with historic personage and protects and improves the intention of the site. It is anticipated that porous pavement applications in Clifton Springs will comply with the above.

Slopes

Permeable paving can only be used on gentle slopes (<5%), ideal surfaces should be completely flat. For all permeable paving, base course is a reservoir layer of

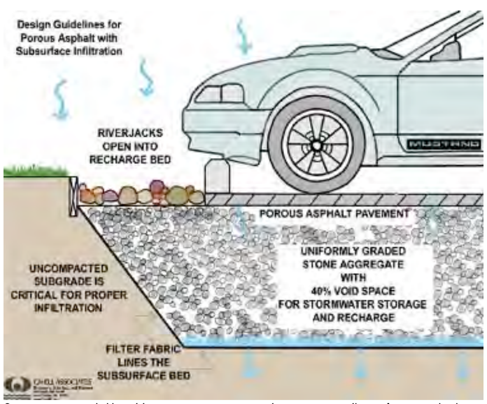
1"-2" crushed stone; depth to be determined by storage required and frost penetration.

The introduction of dirt or sand onto the paving surface, whether transported by runoff from elsewhere or carried by vehicles, will contribute to premature clogging and failure of the paving. Consequently, permeable paving should be constructed as one of the last items to be built on a development site and flat or very minimal slope. A terraced system may be used on slopes and perforated pipes can be used to help distribute run-off through the reservoir evenly. An example of a terraced system can be seen in Figure 8 above.

Drainage

Not all water will be absorbed by porous pavement, therefore drainage must be taken into consideration. Run-off should flow through and exit permeable pavements in a safe and non-erosive manner. Systems should be designed to ensure that the water surface evaluations for the 10- year 24-hour design storm do not rise into the pavement to prevent freeze/thaw damage. As a back up measure to help mitigate clogging, permeable paving practices can be designed with a perimeter trench to provide some overflow treatment.

Figure 9: Layers of Porous Paving



Source: http://www.mapc.org/resources/low-impact-dev-toolkit/permeable-paving

Climate

Concerns over the resistance to the freeze-thaw cycle have limited the use of pervious concrete in cold weather environments. The rate of freezing in most applications is dictated by the local climate. Avoiding saturation during the freeze cycle is the key to the longevity of the concrete. Having a well-prepared 8 to 24 inch (200 to 600 mm) sub-base and drainage will reduce the possibility of freeze-thaw damage. The use of salt or sand during the winter should be minimized. Road salt contains chlorides that could migrate through the porous pavement into groundwater. Snow plow blades could catch block edges and damage surfaces. Sand cannot be used for snow and ice control on pervious asphalt or concrete because it will plug the pores and reduce permeability.

These potential problems do not mean that porous pavement cannot be used here in the Finger Lakes though. Porous pavement designed to reduce frost heave and clogging has been used successfully in Norway. Furthermore, experience suggests that rapid drainage below porous surfaces increases the rate of snow melt above. So, salting and plowing may become less necessary and severe. Sidewalks, patios, and tennis courts are a few examples of places that are not greatly affected by snow and could still easily be paved with a form of porous pavement.

Figure 10: Layers of Porous Paving

Source: http://www.dot.ca.gov/hq/LandArch/ec/lid/lid-permeable-paving-new.htm

Site Preparation & Design
Construction Guidelines

When installing pervious pavement projects certain precautions should be taken.

Prior to installation areas for the porous pavement should be clearly marked in order to avoid compaction or disturbance of the soil. Weather conditions at the time of installation can affect the final product, as well. Extremely low or high temperatures should be avoided during construction. The pervious pavement and other infiltration practices should be installed towards the end of construction-to ensure securement and stability of upstream construction. It is recommended that filter fabric overlap a minimum of 16 inches and should be secured at least 4 feet outside of the bed to help drainage. The strip of fabric should remain in place until all bare soils contiguous to the beds are stabilized and vegetated.

More specifically, there are a few layers that should be incorporated into porous paving to ensure proper and efficient absorption and filtration. There should be a "choker course"—a single ½ inch layer of crushed granules and functions as a stabilizer for the open-graded asphalt surface for paving. A drainage layer is used to separate the underlying native soils from the filter layer with a 3 inch layer or gravel over a reservoir course. An underdrain is required to meet storage/release criteria and overflow piping is necessary to minimize the chance of clogging. It is recommended that a 4"-6" perforated PVC pipe with 3/8 inch perforations at 6 inches on center, solid connectors should be used. Each pipe should have a minimum 0.5% slope and be placed 20 feet apart. An observation well is also required-in order to observe any changes in groundwater levels that may occur over a period of time. Examples of these layers can be more clearly demonstrated in Figures 9 and 10.

Maintenance

If maintenance is not carried out on a regular basis, the porous pavements can begin to function more like impervious surfaces due to clogging. However, with more advanced paving systems the levels of maintenance needed can be greatly decreased. An example of this is plastic grid systems. Plastic grid systems are becoming more and more popular with local government maintenance personnel because they result in reduced gravel migration and increased weed suppression in public park settings.

Some permeable paving products are prone to damage from misuse, such as drivers who tear up patches of plastic & gravel grid systems by "joy riding" on remote parking lots at night. The damage is not difficult to repair but can look unsightly in the meantime. Grass pavers require supplemental watering in the first year to establish the vegetation, otherwise they may need to be re-seeded.

A maintenance checklist for permeable paving would include:

- Posting signs that identify porous pavement areas
- Keeping landscape areas well-maintained to help prevent soil transportation and erosion onto the pavement
- Regular cleaning with a vacuum sweeping machine, or high pressure hosing
- Regular monitoring to ensure the surface is draining properly after storms
- It should not be resealed or repaved with impermeable materials
- An annual inspection for deterioration is recommended

Basic quick fixes for each type are available and fairly easy to do. Potholes and cracks can be filled with patching mixes, as long as less than ~10% of the surface needs repairing. Spot clogging can be fixed by drilling 0.5 holes through the pavement every few feet. Displaced gavel in open celled pavers can be refilled as needed.

Feasibility & Limitations

Major limitations to this practice are suitability of the site grades, subsoils, drainage characteristics, and groundwater conditions. Proper site selection is an important criterion in reducing the failure rate of using porous paving. Ownership and maintenance also heavily influence the success of a permeable pavement. Soil should be permeable and able to support adequate infiltration. Sandy and silty soils are critical to successful application of permeable pavements. Chlorides can easily migrate into ground water, so heavily salted pavement is not ideal. The surface material must be able to tolerate undulations from frost movements, and be able to bear frost. Since the Finger Lakes experience a colder climate porous material may require more in-depth consideration.

Cost

Some estimates put the cost of permeable paving at two to three times that of conventional asphalt paving. Using permeable paving, however, can reduce the cost of providing larger or more stormwater BMPs on site, and these savings should be factored into any cost analysis. In addition, the off-site environmental impact costs of not reducing on-site stormwater volumes and pollution have historically been ignored or assigned to other groups (local government parks, public works and environmental restoration budgets, fisheries losses, etc.) The City of Olympia, Washington is studying the use of pervious concrete quite closely and finding that new stormwater regulations are making it a viable alternative to stormwater ponds. The table below shows cost estimates below for various different kinds of porous pavement options.

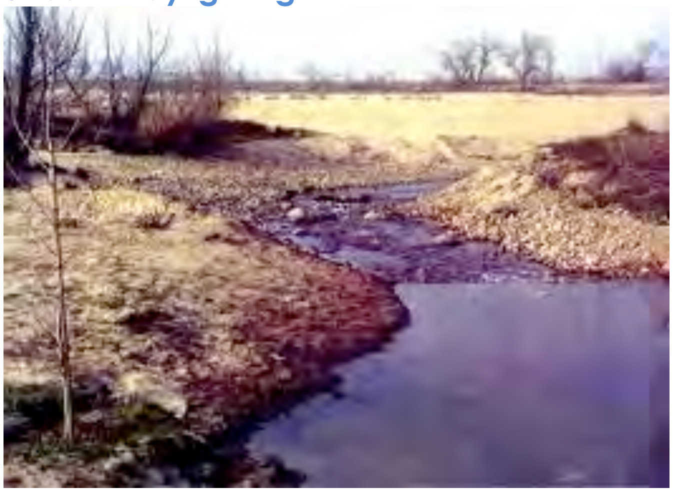
Table 3

	Paved Area (sq. ft.)	Quote ($) Highest	Quote ($) Lowest	Quote ($ sq. yd.) Highest	Quote ($ sq. yd.) Lowest
Hot Mix Asphalt	36,225	98,600	92,620	24.50	23.01
Porous Asphalt	5,328	28,650	18,352	48,40	31.00
Porous Pavers	5,328	67,960	61,755	114.80	104.32
Porous Concrete	7,988	63,200	53,919	71.21	60.75

Conclusion

The proper utilization of pervious paving is recognized by Best Management Practice by the U.S. Environmental Protection Agency (EPA) for providing first flush pollution control and stormwater management. As regulations further limit stormwater runoff, it is becoming more expensive for property owners to develop real estate, due to the size and expense of the necessary drainage systems. Pervious concrete reduces the runoff from paved areas, which reduces the need for separate stormwater retention ponds and allows the use of smaller capacity storm sewers. This allows property owners to develop a larger area of available property at a lower cost. Pervious concrete also naturally filters stormwater and can reduce pollutant loads entering into streams, ponds and rivers; protecting our ecosystems and unique glacially made region.

Stream Daylighting



Stream daylighting is the redirection of a stream into an aboveground channel. It is a green infrastructure technique used to restore streams to the natural environment and promote more permeable surfaces.

Introduction

Stream daylighting is the process of exposing the once concealed stream into an above ground surface. (See Figure 1 & Figure 2) It revitalizes the natural environment to the historic function of the streams. The enclosing of rivers and streams historically took place in urbanized areas with the purpose of maximizing the potential for development, such as Sulphur Creek in Clifton Springs. By building over these water sources, some creeks and streams dried up or remained under ground, forgotten about. This has changed the natural environment and the surrounding ecosystem. The goal of restoring the stream is to place it back into its natural state. Stream daylighting restores natural streams from artificial pipes and from underground tunnels, and allows them to return to the surface.

Figure 1: Before Stream Daylighting

Source: http://www.lafoundation.org/research/landscape-performance-series/case-studies/case-study/382/

Figure 2: After stream Daylighting

Source: http://www.lafoundation.org/research/landscape-performance-series/case-studies/case-study/382/

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Figure 3: Pipe

Source:
http://www.fs.fed.us/GRAIP/photos.shtml

Figure 4: Culvert

Source:
http://commons.wikipedia.org/wiki/File:Culvert_And_Stream

The intent of stream daylighting is to improve the riparian area for the stream that was at one point changed into a pipe, culvert or a drainage system (See Figures 3 & 4). This requires updating the in place stormwater infrastructure and altering the development that had established the water bodies to be displaced. Stream daylighting alters the development so that the once linear pipes that are heavily polluted with contaminated water can become a meandering stream. Stream daylighting can have dramatic aesthetic and water quality improvements.

Stream daylighting restores natural habitats, promotes infiltration, reduces pollutant load and alleviates runoff since it increases the storage size of the natural system. Some daylighting re-establishing can recreate wetlands, ponds or estuaries that once existed historically (See Figure 5).

Figure 5: Before and After of a Stream Daylighting Project

Source: http://stream.fs.fed.us/fishxing/case/WWeaver/imgs/indexSM.jpg

Application in a Historic District

With industrialization, many free flowing water bodies were channelized or placed in culverts to better direct the water to industrial uses and regulate its flow for energy production. This forever changed the water body, limited its use as a habitat for local flora and fauna, and increased the risk of flooding in the immediate area. Stream daylighting allows the stream or water body to be re-introduced to the surrounding area, which improves both visual appeal and strengthens the local ecosystem. Because a stream is a natural element, it is unlikely to have any kind of negative impact on the character of a historic district, and can help provide added space for native species.

History and Aesthetics

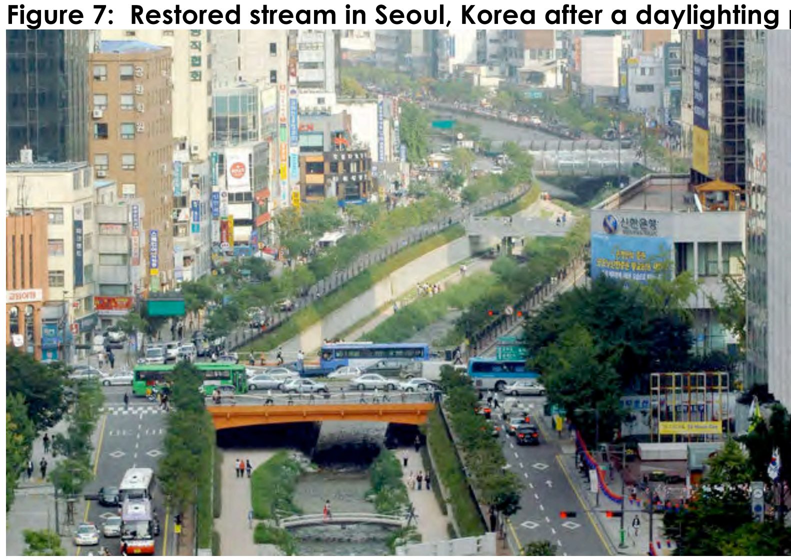
Stream daylighting is a relatively modern green infrastructure technique, since it is a radical restoration of natural environment from the urbanized development that was built in the twentieth century. One of the most recognized daylighting projects was the restoration of Strawberry Creek in Berkeley, California. Although the first re-exposing stream daylighting projects were done in the 1970's in Napa, California and Urbana, Illinois, Strawberry Creek is probably consider the most famous stream daylighting projects because it involved the community and had a wide range of support from citizens.

Figure 6: Sulphur Creek

Source (For photo on left): Joellen Mauch, 2013.

Although in the Finger Lakes regions there have not been any stream daylighting projects done, there are some areas in the historic districts that have underground water bodies that have been intentionally covered by development and infrastructure in the industrial age. One example is Castle Creek that was located in Downtown Geneva, that was built on top of it and ended up being redirected and ultimately dried up, resulting in the loss of a historic creek. Sulphur Creek, which travels through the Clifton Springs Sanitarium Historic District has been channelized, although it still runs above ground. There is an opportunity to return it to its original stream bed.

Figure 7: Restored stream in Seoul, Korea after a daylighting project



Source: http://www.businessweek.com/news/2012-06-19/cities-lead-effort-to-curb-climate-change-as-nations-lag

Site Specific Consideration

Location

Many people who live in urban spaces do not realize that their homes are most times located where there were once rivers and streams, as many early urban areas ran on water-powered mills. Stream daylighting can be done in any location, urban or suburban that has displaced water bodies from their natural placement (See Figure 7). Daylighting is typically done in areas that have higher infrastructure repair costs and typically have the highest problem with urban runoff, stormwater management, and water quality.

Urban areas seem to be in the most need for the revitalization of natural water spaces, both for bringing back a sense of nature to a very developed space and improvement of water quality and pollution runoff. A prime space for stream daylighting projects is streams within parks. It is a great opportunity to increase public community spaces (See Figure 8).

Figure 8: Restored stream in a park

Source: http://www.geoengineers.com/news/us-navy-hails-completed-beaver-creek-restoration-project

Soils

The soils that are in the Clifton Springs Sanitarium Historic District consist dominantly of Palmyra soil. Palmyra soil consists of very deep soil that have the ability to drain easily, so there is a lesser chance of run off potential in this soil area. They are steep soils that are made up of stratified gravel and clay. This soil is best used for intensive growing of gardens and plants.

Site Prep Design

Design Considerations

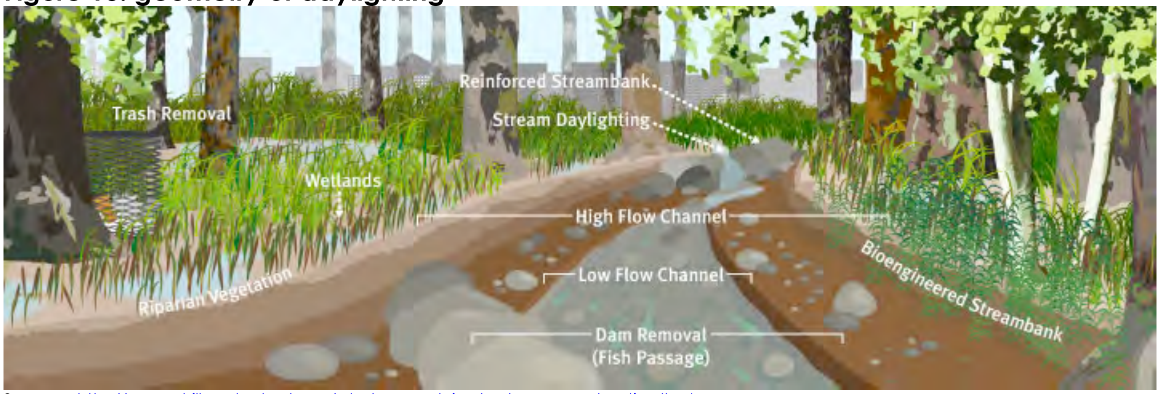
- Surface stream restorations may or may not require excavation and grading to correct channel alignments and geometries, but pulling up a culvert and creating a new channel where none exists usually involves a significant amount of earthmoving. It may be necessary to haul away the spoils. These operations add expense and may complicate permitting (See Figure 9).

Figure 9: Construction to get rid of a culvert

Source: http://www.geoengineers.com/news/us-navy-hails-completed-beaver-creek-restoration-project

- Existing surface waterways needing restoration may already have a buffer around them; daylighting projects are more likely to be squeezed for space. It is even more likely for there to be less available space in urban areas. The less space there is the less chance of creating natural channel geometry and a properly vegetated riparian corridor (See Figure 10).
- Additional hydraulic(water related) issues may occur. It may be necessary to build up hydraulic head to put a daylighted section of stream back into a pipe at its downstream end. Daylighting projects must be carefully engineered into the overall urban stormwater management system.
- Surface stream restorations are sometimes politically easier because the problems are apparent. With buried waterways, people may be unaware that a culvert carrying a historic stream is under their feet, or that the stream's absence means degraded water quality, lost habitat, and so on.

Figure 10: geometry of daylighting



Source: http://www.phillywatersheds.org/what_were_doing/waterways_restoration/tools

- Because people are not aware of the streams and there's "nothing" there now, daylighting projects may require extra community education and outreach to help people visualize the potential.

Key Constituents

Unger going a stream daylighting project will take a community effort. The first thing that should be done is gaining the support of your community citizens, municipalities that will neighbor the construction site and the community governmental office, because it will need to be approved by them.

As far as the construction of stream daylighting, it will require professionals to work on since it involves destroying development that most likely includes concrete and other hard surfaces. Since every site is unique, the construction steps will involve the construction company that will restore the water body.

Maintenance

After the restoration of the stream is completed there will be little need to maintenance. What will need to be maintained is annual inspections for pollution in the waterways. This can include community involvement.

Zoning

In the hopes of enhancing both the rural historical setting and agricultural spaces, implementing green infrastructure is acceptable. In zoning codes, there is no code enforcing that any green infrastructure cannot be placed on residential lots. However, if green infrastructure techniques is desired to installed in historic districts of public spaces, then it asked that before placing it in, that it be brought to the Planning Board of the Village of Clifton Springs. Obviously, for a project as extensive as removing the channelization of Sulphur Creek, significant town involvement, as well as coordination with the New York State Department of Environmental Conservation and any other relevant parties will be necessary.

Historic Overlay

Installing editions on the exterior of owners structure is allowed as long as it represents a familiar visual aesthetic as the existing structure, identifies with historic personage and protects and improves the intention of the site. Returning the Creek to its original bed would provide an opportunity to improve the historic integrity of the site and make this key water feature an even greater amenity for the historic district.

Cost

The cost of restoring a stream really depends on the situation. Projects in urban areas will cost more than areas in the suburbs. This is because urban areas have more of a dense architectural space, this usually results in little room to excavate and restore streams, because it would interfere with many other municipalities. Some of the cost components include excavation of the underground waterways, design work, construction, restoration and landscaping. According to the Rocky Mountain Institute, if everything is paid for at full market rates, then it is not common that the cost will be $1000 per linear foot or restored stream. However, it is possible for projects to be done at a lower cost, if purchases for materials are done locally or volunteer labor is used for some stages such as planting and landscaping of the daylighting construction process. Stream daylighting requires technical professional design expertise and heavy earth moving equipment.

Although the initial investment of stream daylighting may be great, in the long run the property values of surrounding areas will increase with this new amenity to the neighborhood.

Conclusion

With urbanization ever increasing, waterways were an afterthought, a means that slowed down construction and expansion. Now, however, people are placing a higher value on environmental spaces, like waterways. People are also discovering the many economic benefits to restoring streams. It increases vitality, property value, aesthetics and quality of water and habitats. By exposing water to sunlight, air, soil and vegetation water quality improves because it helps the process of removing pollutants (See Figure 11).

Figure 11: Finished stream daylighting project

Source: http://landscapeandurbanism.blogspot.com/2009/06/seeing-daylight.html

As the man made structure to hide the waterways deteriorate with time, like pipe failure, it is cheaper to follow through with stream daylighting than to place in a new pipe. Daylighting can also reduce flooding caused by under-capacity culverts, since an open stream typically has a wider cross-section and a greater channel depth than the pipe it replaces. This is important because many pipes historically were not sized adequately to carry the extra runoff that comes with upstream development.

Cisterns

Cisterns are large-scale rain barrels used in commercial and industrial settings. A cistern is a waterproof receptacle for holding liquids, usually water. Cisterns are often built to catch and store rainwater.

Cisterns are distinguished from wells by their waterproof linings. Modern cisterns range in capacity from a hundreds to thousands of gallons, effectively forming covered reservoirs. Cisterns are commonly used in areas where water is scarce, either because it is rare or because it has been depleted due to heavy use.

Figure 1: A Small Cistern for Residential Usage

Source: http://theinlet.wordpress.com/2011/01/25/cisterns-and-stormwater/

Early on, the water was used for many purposes including cooking, irrigation, and washing. Present day cisterns are often used for irrigation due to concerns over water quality. They can also be used for lawn and landscaping purposes, or filling swimming pools. Many greenhouses use cisterns to help meet their water needs. Some countries such as Bermuda and the U.S. Virgin Islands, have laws that require rainwater harvesting systems to be built alongside any new construction, and cisterns can be used in these cases. Other countries, such as Japan, Germany and Spain, also offer financial incentives or tax credit for installing cisterns.

Cisterns may also be used to store water for firefighting in areas where there is an inadequate water supply. In the UK "water butts" are used to water gardens; and fitting underground cisterns that these water butts feed into are now encouraged to collect water for flushing toilets, washing clothes, watering the garden, and washing cars. It is not uncommon for cisterns to be open in some way in order to catch rain or to include more elaborate rain-catching systems.

Application in a Historic District

Cisterns have been used to gather water for drinking and irrigation throughout the United States for many, many years. Modern applications of cisterns can still be seen on large commercial and industrial buildings. Cisterns are appropriate for a historic district if their visual impact is mitigated, either by burying the cistern underground, or by placing it in the back of buildings, out of sight.

Benefits

Some studies cite a percentage decrease in water consumed from the municipal water systems by as much as 50% for individuals who employ cisterns. Cisterns today can also be outfitted with filters or other water purification methods when the water is meant for consumption.

Figure 2: A Residential Cistern

Source: http://ucgroupthree.wordpress.com

Cisterns collect rainwater, which will provide a source of water that many people allow to go untapped. The vast majority of the world simply gets their water out of a well. The earth's drinkable water resource is limited, and growing even more so. Currently, we are taking water out of the ground for our own utility faster than it can naturally replenish itself. Therefore, capturing the water as it is released from the clouds is a great way to help natural water ways and the groundwater restore itself because there will be less heavy reliance on extracting water from these places.

Attaching a cistern to a water system also saves money, for both the individual and the municipal water supplier. By using rain harvested for free, this cuts down on the water needed from the supplier, who in turn experiences lower peak demand and less stress on water supplies. Furthermore, most cisterns are now outfitted with purification systems that clean the water and make it safe to drink. These systems use chlorine or ultraviolet light to sanitize the water, effectively killing any germs or bacteria that may live in the water. Finally, cisterns have the ability to reduce stormwater run-off volume through retention. This also reduces transportation of pollutants associated with atmospheric deposition on rooftops into receiving waters, especially heavy metals and other airborne pollutants. They can also be used as retrofits in urban redevelopment scenarios to reduce runoff volumes in areas where there is a high percentage of impervious cover, soils are compacted, groundwater levels are high, and/ or hot-spot conditions exist that preclude infiltration of runoff.

Figure 3: Industrial Sized Cisterns

Source: http://ecoartsofla.org/2012/07/20/957/

Types

Cisterns may be constructed out of any water-retaining material; their size varies from hundreds of gallons for residential uses to tens of thousands of gallons for commercial and/or industrial uses. The storage systems may be located either above or below ground and may be constructed of on-site material or pre-manufactured. Figures 1, 2, and 3 are examples of different types of cisterns. Figures 1 and 2 above show smaller, residential type cisterns attached to a downspout.

Figure 4: Different Sizes of Cisterns

Source:http://www.matherpumps.com/products/details/cistern_water_tanks_-_underground_burial/

Figure 3 Is an example of larger, more industrial sized cisterns.

The basic components of a cistern include:

- a watertight storage container
- secure cover
- a debris and mosquito screen
- a coarse inlet filter with clean-out valve
- an overflow pipe
- a manhole or access hatch
- a drain for cleaning
- an extraction system (tap or pump)
- Additional features might include a water
- level indicator, a sediment trap or a connector pipe to an additional tank for extra storage volume.

Figure 5: Cistern Installation

Source: http://www.electronichouse.com/slideshow/category/4875/770

The storage containers are usually placed on riser blocks or a gravel pad to aid in gravity drainage of collected runoff and to prevent the accumulation of overflow water around the system.

Figure 4 shows more cisterns that are available in different sizes, shapes, and designs.

Site Specific Considerations

Siting & Location

Cisterns may be used in most areas, residential, commercial, and industrial; due to their minimal site constraints relative to other stormwater management practices. They may be applied to manage rainwater in areas with almost every density from very dense urban to more rural residential areas. The necessary storage volumes of cisterns are directly proportional to their contributing rooftop drainage areas and the intended end use and demand for the collected rainwater.

Underground and surface cisterns should be located in areas that are sloped to drain surface water away from the cisterns and near existing downspouts. Cisterns are usually located near their catchments. Do not place underground or surface cisterns near sewage lines or other sources of contamination. The site should be in firm ground to avoid settling, which can cause cracking of cistern walls. Cisterns should be located as far from trees as possible because tree roots can crack cistern walls.

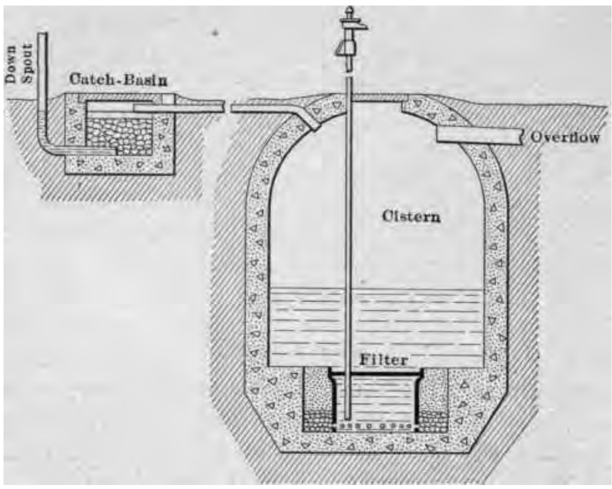
Zoning

In the hopes of enhancing both the rural historical setting and agricultural spaces, implementing green infrastructure is acceptable. In zoning codes, there is no code enforcing that any green infrastructure cannot be placed on residential lots. However, if green infrastructure techniques is desired to installed in historic districts of public spaces, then it asked that before placing it in, that it be brought to the Planning Board of the Village of Clifton Springs.

Historic Overlay

Installing editions on the exterior of owners structure is allowed as long as it represents a familiar visual aesthetic as the existing structure, identifies with historic personage and protects and improves the intention of the site. A cistern is recommended for the back of the Spa Apartments building, so that it would not be visible to pedestrians or visitors to the Historic District.

Figure 6: Section of Cistern as Installed



Source: http://chestofbooks.com/home-improvement/repairs/Mechanics-Household/Filters.html#.UcyOfL-H_dk

Climate

Climate is an important consideration and capture/reuse systems should be designed to account for the potential for freezing, especially in the Finger Lakes region. In our climate, cisterns should be designed for use throughout the year, and therefore will need to be protected from freezing. These systems may need to be located indoors or underground below the frost line if freezing conditions are expected. Cisterns placed on the ground require extra insulation on the exposed surfaces. Cisterns placed on rock will need the bottom surface to be insulated as well. For underground systems it may be cost-prohibitive to place the cistern below the freezing depth, so alternatively, insulation may be placed below the surface and above the underground cistern to prevent freezing. Other methods to prevent freezing include lining the intake pipe and cistern with heat tape and closing the overflow valve. Water levels in the cistern must be lowered at the beginning of winter to prevent possible winter ice damage and provide the needed storage in the cistern for capturing rooftop runoff from the spring snow melt. The year round use of rain barrels in cold climates is not recommended since these containers may burst due to ice formation and freezing temperatures. Downspout piping must be reconnected and directed to a grassy area away from the structure to prevent winter snowmelt from damaging building foundations.

Site Preparation

Elevated tanks can be fabricated from concrete, metal, or plastic. The weight of these tanks is considerable. One gallon of water weighs 8.3 pounds, and each cubic foot of water weighs 62.4 pounds. Concrete weighs about 150 pounds per cubic foot. Wind loads may also be a problem on exposed elevated tanks. Therefore, elevated tanks should be placed on structurally sound towers. The tower or structural support necessary can be calculated using the equation below:

Cistern Load = <u>(Capacity x 8.35 lb./gal + Cistern Weight)/Footprint Area</u>

Capacity: Cistern volume in gallons

Cistern Weight: Weight of the empty cistern in pounds. The weight of an empty plastic cistern can be approximated as 0.3 lb./gal if the specific weight is unknown.

Footprint Area: Area of the cistern that will be in contact with the ground in square feet.

Example

A 1,000-gallon plastic cistern has a diameter of 7.25 feet. Determine if additional structural support is required.

$$\textbf{Cistern Load} = \frac{(1{,}000 \text{ gal} \times 8.35 \text{ lb./gal}) + (1{,}000 \text{ gal} \times 0.3 \text{ lb./gal})}{\pi \times (7.25 \text{ ft.} \div 2).} = 210 \text{ lb./ft.}$$

The cistern load of 210 pounds per square foot is well below the soil load-bearing capacity of 2,000 pounds per square foot; therefore, the cistern does not need additional structural support.
When a cistern is elevated, the amount of pressure developed will depend upon the height of the water surface. About one pound of pressure is developed for each 2 1/2 feet the water surface is above the water outlet. To achieve a satisfactory rate of flow, a head of at least 20 feet of elevation is usually necessary. The outlet should be installed at least 6 inches above the bottom of the cistern to provide room for sediment storage. Friction causes pressure losses as water flows through a pipe. There is less loss in a large pipe than in a small pipe. It is best to use at least 1 1/4 inch pipe for main supply lines. Elevated tanks fabricated from plastics and fiberglass-reinforced plastic may have a shorter lifetime than metal or concrete tanks. If possible, tanks fabricated from synthetic materials should be located in shaded areas to reduce the damaging effects of ultraviolet radiation. Wooden cisterns are generally not satisfactory, particularly when they are used below ground, because they are difficult to keep sealed and allow pollution and ground water to enter through their cracks.

Underground cisterns offer some flexibility as to installation location because runoff can be piped underground to the cistern, and does not need to be placed near a downspout. In fact, piping runoff away from the house is preferred because installing an underground cistern immediately adjacent to a house may cause damage to the house foundation during

Site Preparation & Design

Sizing Criteria

The cistern sizing is based on the water demand for the intended use. The amount of water available for reuse is a function of the impervious area that drains to the device. The basic equation for sizing a system based on the contributing area is as follows:

Vol = WQv * 7.5 gals/ ft3

where:

Vol = Volume of system [gallons]
WQv = Water Quality Volume [ft3],
7.5 = Conversion factor [gallons per ft3]

Depending on the size of rooftops and the amount of contributing impervious area, increased runoff volume and peak discharge rates for commercial and industrial sites may require large capacity cisterns. Cisterns designed to capture small, frequent storm events must be actively or passively drained to provide sufficient storage in case of storm events. It is also recommended that cisterns be placed in areas where overflow run-off can be absorbed by a buffer area, like an open yard, grass swale, or rain garden.
Another example for sizing cisterns using the above mentioned formula (WQv) is presented in Table 1 below. As a rule of thumb, a 1,000 square feet of roof will generate 625 gallons of rain during a 1" storm event. At a minimum the water quality volume (WQv) must be stored in the cistern to earn runoff reduction credit, the amount of storage provided by the system determines the volume of water available for reuse.

Table 1

Table 1 Simple Cistern Sizing Example *Given a 3,000 square foot impervious surface area draining to a cistern, calculate the water quality volume and required storage volume within the system.*		
Step 1: Calculate water quality volume using the following equation:		
WQv =	(P)(Rv)(A) 12	
where:		
P = 90% rainfall number = 0.9 in		
Rv = 0.05+0.009 (I) = 0.05+0.009(100) = 0.95 I = the percentage of impervious area draining to site = 100%		
A = the Area Draining to Practice = 3,000 ft2		
WQv =	(0.9)(0.95)(3,000)12	WQv = 213.75 ft3
Step 2: Calculate storage volume using equation above: Vol = (WQv) (7.5 gals/ ft3)		
Vol = WQv x 7.5 gals/ ft3(1603 gal)		
Therefore, to treat the water quality volume for the area draining to the practice, a 1,650-gallon cistern is required. This equation must be utilized for the contributing drainage area to each downspout for the adequate sizing of a rain barrel or cistern. The calculated WQv is applied towards the Runoff Reduction Volume		

Table 2 represents the required catchment area in square feet depending on average rainfall. Table 3 shows the average monthly rainfall in Geneva, NY. This can be used as a guide to estimate how much rain a typical resident in the Finger Lakes region can expect.

Table 2

Water collected (gal)*	Amount of Rainfall (inches)						
	1.0	2.0	3.0	4.0	5.0	6.0	7.0
500	1200	600	400	300	250	200	200
1000	2400	1200	800	600	500	400	350
1500	3600	1800	1200	900	750	600	500
2000	4800	2400	1600	1200	1000	800	700
2500	6000	3000	2000	1500	1200	1000	850
3000	7200	3600	2400	1800	1450	1200	1000
*Loss of one-third assumed.							

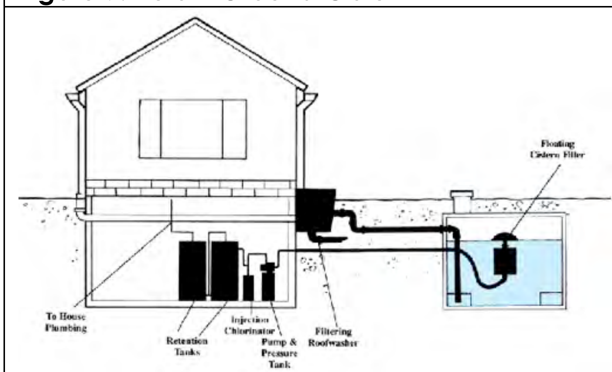
Table 3
Geneva Weather

US Geography / US Weather / New York Weather / Geneva												
	Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Avg. High	30°	31°	41°	54°	66°	75°	80°	78°	71°	58°	47°	35°
Avg. Low	14°	15°	24°	35°	45°	55°	60°	58°	51°	40°	32°	21°
Mean	22°	24°	34°	45°	56°	65°	70°	68°	61°	50°	40°	28°
Avg. Precip.	1.8 in	1.8 in	2.1 in	2.9 in	3.0 in	3.7 in	3.0 in	3.1 in	3.3 in	2.9 in	3.1 in	2.5 in

Because of the potential structural and safety concerns, it is important to comply with all underground cistern installation instructions and regulations. Below are a few beginning steps for determining whether an underground cistern is feasible.

Some further necessary components to proper installation include: a watertight cover with a lock to reduce risks of contamination or accidents. The opening should be large enough to provide easy access of a person into the cistern. An overflow pipe should also be provided. Inlets and outlets should be screened and valves should permit control of water flow. Positive ventilation must be provided when anyone is working in a cistern, due to the possibility of hazardous gases present or insufficient oxygen. A water sealant should also be applied to concrete tank surfaces.

Figure 7: Below Ground Cistern



Source: http://www.waterfiltrationcompany.com/watertreatment.htm

Figure 8: Below Ground Cistern

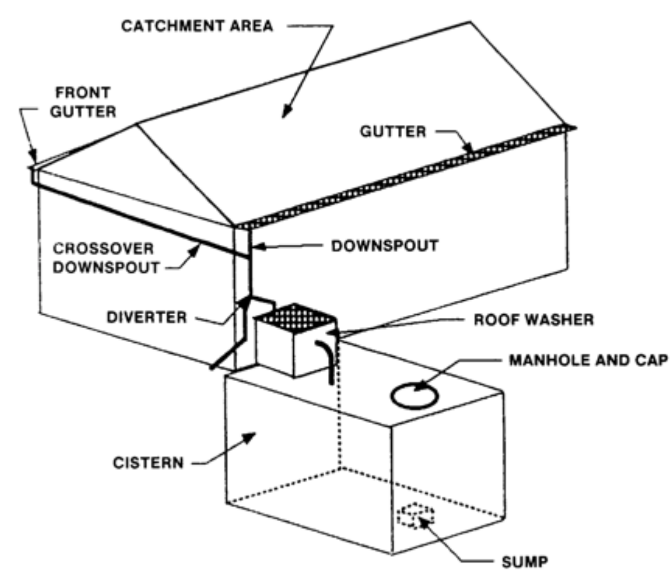


Figure 1. BASIC COMPONENTS OF A CISTERN

Source: http://www.bennydemus.tv/2012/10/10/big-bad-benny-demus-live-on-the-the-toni-and-griff-show-explaining-cistern-in-the-virgin-islands/

The excavation for below-ground cisterns should be large and deep enough to permit the laying of the foundation and walls. Underground tanks should be made from concrete to reduce problems of wall deterioration because of contact with the soil. Figure 6 shows the construction of a typical underground cistern. Cisterns located on the ground surface or below ground will require a pump to provide water pressure, as seen in Figures 7 and 8.

The walls of concrete cisterns should be four to six inches thick. A concrete mix of 5 gallons of water, 2 1/4 cubic feet of sand, and 3 cubic feet of gravel per sack of cement should be used. Use one inch diameter or smaller gravel. Make sure that the water is clean. Portland cement must be dry and free of lumps. Sand should be clean and well graded; that is, with particles of many sizes.

Maintenance

To keep a clean water supply, the cisterns must be kept clean. It is recommended to inspect them regularly, keep them well-enclosed, and to occasionally empty them and clean them with an appropriate dilution of chlorine and to rinse them well. They can be cleaned by using a stiff brush to scrub all inside surfaces. A good disinfecting solution is 1/4 cup 5.25% liquid chlorine bleach in 10 gallons of water. Flush the cistern thoroughly with clean water to remove sediment after construction, cleaning or maintenance. Do not interconnect cistern drains with waste or sewer lines to avoid backflow contamination. Keeping gutters, gutter guards, downspouts, and roof washers free of foreign materials, clean, and uncluttered also help keep water clean and free of pollutants. Mosquitos can quickly become a problem because larvae thrive in stagnant water. This can be prevented by ensuring you have a sealed water tight cover, or by adding a small amount of cooking oil to the surface. Cooking oil suffocates the larvae, but does not compromise sanitation. Bleach can also help prevent mosquitoes. Screens and pesticides are also recommended.

If present, a cistern's continuous discharge outlet should be placed so that the tank does not empty completely, ensuring water availability at all times, while also providing at least some storage capacity for every storm. A diverter at the cistern inlet can redirect the "first flush" of runoff, which is more likely to have particulates, leaves, and air-deposited contaminants washed off the roof. By placing a screen a top of the downspout leaves and debris that washes down into the storage tank is minimized. If a screen is unsightly, exposed openings can also be screened with shrubs or other landscaped features.

Considerations and Steps

Before beginning an underground cistern installation, contact your local utilities companies to locate any underground pipes or cables. Depending upon the specific underground cistern being installed, sand, pea gravel, or crushed stone backfill material may be required. Consulting the product literature should determine the required specifications for backfill material, excavation depths, and the depth of soil required over the cistern. In areas where the water table can rise above the bottom of the underground cistern, special consideration is required to ensure that the cistern is properly anchored against any potential buoyancy and is structurally suited to handle these additional forces. Finally, an underground tank must be properly vented to the atmosphere to prevent the buildup of pressure or vacuum within the tank. Vents are often incorporated into a tank or can be attached as a basic fitting.

Feasibility and Limitations

The biggest limitation to the installation and use of cisterns for the capture and reuse of stormwater is the need for active management/maintenance and initial capital cost. Generally, the ease and efficiency of municipal water supply systems and the low cost of potable water prevent people from implementing on-site rainwater collection and reuse systems. Specific limitations include: periodic maintenance and cleaning to ensure effective storage of stormwater while reducing the growth of algae and limiting the potential for mosquito breeding.

A supplementary water source may also be needed if captured water does not fulfill the intended water demand. Alternatively, if captured water is not used as anticipated or excessive rainfall occurs, the extra water collected must be managed to prevent overtopping and erosion of areas below the rain barrel or cistern.

Cost

The cost of rooftop runoff storage varies widely, from a homeowner-installed rain barrel to a commercially constructed underground cistern vault. Most rain barrels and cisterns do not retain enough stormwater to downsize the site's stormwater management system, but can provide cost savings because they reduce the demand for potable water for landscaping and irrigation. The cost-benefit ratio will depend on how much landscaping/irrigation water the property owner uses, and the unit cost of water from the local public water supply.

Cisterns are expensive due to the larger size and multiple "moving parts." Installation of buried cisterns can also be expensive. One system available in Massachusetts (SmartStorm) costs $3000 for an 800 gallon two-tank system complete with pump and drywell structure. A common cistern shared by multiple properties may result in considerable economies of scale because there is only one excavation, one tank or set of tanks, and one pump. Tables 4 and 5 below show different cost estimates.

Table 4

MATERIAL	COST, Small System	COST, Large system
galvanized steel	$225 for 200 gallons	$950 for 2000 gallons
Polyethylene	$160 for 165 gallons	$1100 for 1800 gallons
Fiberglass	$660 for 350 gallons	$10,000 for 10,000 gallons
ferro-cement	Price variable upon location	Price variable upon location
fiberglass/steel composite	$300 for 300 gallons	$10,000 for 5000 gallons
Aluminum	Cost prohibitive for water use	Cost prohibitive for water use

Above is a sample cost estimate for a pre-manufactured cistern, this does not include any additional costs associated with needed infrastructure such as gutters, downspouts, filter, inflow and outflow pipes and water treatment system. These represent average costs for typical, new, pre-manufactured cisterns with costs for minimum and maximum size given. Labor costs such as excavation, if required, and hook up to roof top catchment system are not included.

Below is a sample cost estimate for a single cistern assuming that the homeowner, garden group, or volunteers provide the labor, including hook up of cistern to roof top catchment system and construction and excavation if necessary. The disturbed area is considered to be minimal and small enough to avoid any permits and fees. The following are average costs for a typical, manually constructed cistern for residential use, made of reinforced-concrete at a size of 3000 gallons.

Table 5

ITEM	***COST***
Labor	provided by property owner
Lumber, to construct wall forms	$100
Concrete	$600
Rebar and mesh	$100
Latex based seal, to seal the inside of cistern	$50
Lid and hatches	$50
Miscellaneous items, i.e., crossover and overflow pipes, extraction system pipe	$100
TOTAL ESTIMATED COST:	**$1000**

In summary, the costs of cisterns is largely dependent on capacity, and whether the water will be used for irrigation or indoor residential use, and how. Most estimates site a cost of about $150-$300 for a small cistern that holds approximately 200 gallons. Cisterns that hold 500 gallons and more can cost anywhere between $500-$3,000. Installation costs can bring totals to between $2,000 and $20,000.

Conclusion

In summary, cisterns are an effective way to collect and store stormwater run-off for private or public uses such as landscaping or other outdoor chores. However, effective use of cisterns is heavily dependent on the owner's involvement. Stormwater volume/peak discharge rate benefits depend on the amount of storage available at the beginning of each storm. Improper or infrequent use of the collection system by the property owner, such as the cistern never being emptied between storm events to allow for subsequent capture of rooftop runoff may result in unintended discharges.

Greater effectiveness can be achieved by having more storage volume and by designing the system with a continuous discharge to an infiltration mechanism, so that there is always available volume for retention. Moreover, cisterns offer no primary pollutant removal benefits. However, rooftop runoff tends to have few sediments and dissolved minerals than municipal water and is ideal for lawns, vegetable gardens, car washing, etc. Most cisterns also come equipped with sanitation systems to help filter out any pollutants. It is important that cisterns are childproof, and sealed against mosquitoes. In cold climates, like ours, specific design or maintenance strategies will need to be considered to prevent freezing such as providing insulation or disconnecting the system during the winter months. Following these tips and instructions will ensure a properly constructed and managed cistern which can be a source of supplemental water, which can be especially useful when sources of water are either limited, or water prices increase.

In our beautiful region, an underground cistern is an economical and environmental way to help preserve the natural landscape without disturbing or obstructing the finger lake scenery, as well as keeping historical integrity in tact by moving away from our reliance on municipal works and incorporating water wise practices into our every day lives.

Roof Gardens

A roof garden is any kind of garden that is grown on the roof of a building. It hosts more intensive plants and flowers than a green roof, and is frequently occupiable. It is both an aesthetic and environmental infrastructure.

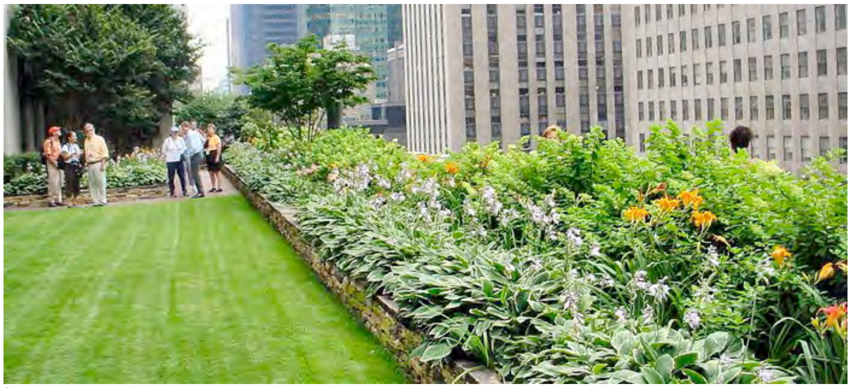
Introduction

A roof garden is any garden on the roof of a building (See Figure 1). It is a heavy weight vegetated roof system. It is used in place of a conventional permeable rooftop. Roof gardens normally consist of a waterproof membrane, drainage layer, a thick layer of soil (typically 12 inches or more), vegetation, and hardscaping to allow access to the garden (ex. Planters, stepping-stones, benches). Roof gardens have a decorative aesthetic benefit; it enhances the architecture, and could provide recreational opportunities. It also has many environmental advantages. Roof gardens and planting are a source of temperature control, may supply food, provide habitats for wildlife and acts as a stormwater controller.

Figure 1: Roof Garden

Source:
http://www.planetizen.com/node/20612

Since roof gardens can potentially support pedestrian traffic in urbanized areas (see Figure 2), it can be designed as an amenity for commercial use. Roof gardens differ from eco-roofs or green roofs because of the greater amount soil used, accessibility and the greater range of plants it can contain.



Source:
http://usahomeandgarden.com/garden/garden-rooftop/garden-rooftop.html

Roof gardens mitigate effects of heat islands caused by increased development. Heat island effect is a term that describes built up areas that have a hotter temperature than rural nearby areas.

It also is a tool used to mitigate overflow of water and polluted storm run off. With the increasing urbanized areas, rain gardens work as a tool to reduce the potential stormwater runoff. With the rain garden located on top of the building, it prevents the rainwater to run down and cause further pollution in storm drains.

Application in a Historic District

Roof gardens existed in the region, specifically in the Clifton Springs Sanitarium Historic District, and are adaptable to any building with a flat or slightly sloped roof and the structural integrity to support the additional load. Although many rooftop gardens are designed for a more modern, contemporary aesthetic, they can certainly be adapted to reflect the landscape design prevalent in the past. In addition, rooftop gardens are often difficult to see from the ground level due the building height. Thus, it is not anticipated that a rooftop garden would have any negative visual impact on the character or integrity of a historic district. Incorporating rooftop gardens into downtowns and other areas can provide visitors with another vantage point from which to view the architecture of the district, as well as reduce stormwater run-off and the heat island effect.

History and Aesthetics

Roof gardens are now seen as an innovative green infrastructure and visual appealing trend, however, roof gardens have been around for a long time. The earliest recorded roof garden was in ancient Babylon in 605 B.C. Roof gardens were present during the Renaissance, especially in Greece and Rome, who were famous for their ornate roof gardens. It spread to Western Society, especially to England and North America. One of the most famous roof gardens was created in 1938 in London, called The Kensington Roof Garden, with the purpose of creating visual beauty and working as a natural space for wildlife, where the garden houses ducks and birds because of the maximized water infiltration.

Roof Gardens were historically present, even in the Finger Lakes regions. One historic district in particular that was known for their roof gardens was the Canandaigua National Historic District, who had the Sonnenburg Gardens. Roof gardens also existed at the site of Clifton Springs Sanitarium, as Mr. Barton used the gardens as a therapeutic space for patients.

Site Specific Consideration

Location

The ideal location for roof gardens is on any rooftop that can hold a heavy load. As long as the rooftop can sustain the garden on its roof, it can be used for a flat or slanted roof. Any roof surface can be greened - even sloped or curved roofs can support a layer of sod or wildflowers (See Figure 3). However, the flatter the roof top the easier it will be to sustain a roof garden. As said in the Solutions for Change: Climate Alliance: "Switzerland has just passed a by law which states that new buildings must be designed to relocate the green space covered by the building's footprint to their roofs - even existing buildings -including historical buildings - must now green 20% of their rooftops. This has created an increased demand for research and material/product design, which will soon be available to North American markets."

When creating the roof garden, it is important to take into consideration the weather conditions of the area. Then as the installer can better choose the appropriate conditions for the garden to be in. With the average temperate in mind, the plant choice will also vary.

Roof gardens do not typically take up the entire roof space. This is because the gardens require heavier soil. The location on the roof that has the garden is important because you would like to maximize the sun exposure.

In the Finger Lakes region the weather varies greatly since we experience all four season. However, it is typical for the Finger Lakes region to experience a longer cold season than other locations. Therefore, when installing the roof garden, the ideal area to place the garden is either on the North or South side of the roof, in order to maximize the sun exposure.

Figure 3: Slanted Suburban Roof Garden

Source: http://www.sunshinelandscapespa.com/roof_gardens.html

Zoning

Clifton Springs has no specific zoning regulations, restrictions, or recommendations for roof top gardens but it is recommended to seek professional advice.

Site Prep Design

Issues to Address

Occupancy and the size of the garden as they relate to and impact on:

- Adjacent or superimposed occupancies
- Occupant load i.e. the number of people allowed to occupy the garden

Occupant load as it relates to an impacts on:

- Structural loading requirements
- Exiting requirement

Exiting Requirements:

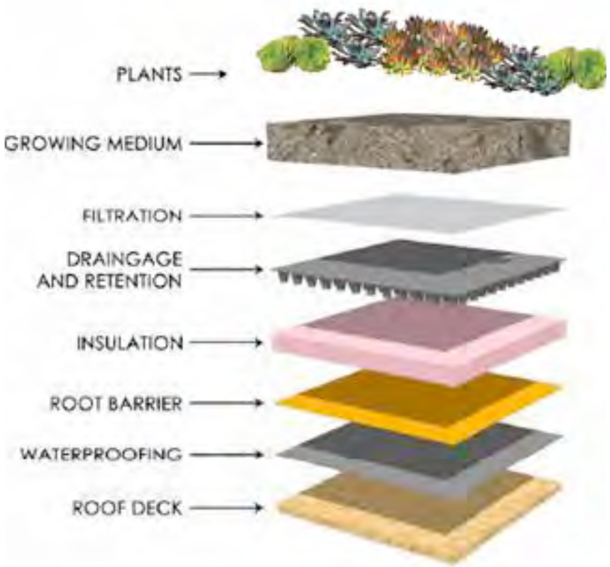
- Types of exits allowed and number of exits required

- Distance between exits and travel distance to exits
- Size of exits and areas defined as "access to exits"
- Fire separations between exits and the rest of the floor area
- Possible requirements for fire alarms, exit lights, emergency lighting

- Handicapped accessibility and Barrier Free Design

Client/User requirement:

Figure 4: Structure within a Roof Garden



Source: http://ayobikinrumah.wordpress.com/

Requirements for enclosures i.e. guards, railings, parapets, walls around rooftops, terraces, and balconies:

- Required heights
- The placement of elements such as planters adjacent to enclosures which may reduce their effective height
- Climability of enclosures
- Loading and structural stability of guards and railings

Specific requirements for structures/buildings on roofs, relating to:

- Effect on overall building height
- Fire rating of structural members
- Exiting

Other applicable issues might include:

- Possible modification of window washing anchors on the roof
- Possible upgrading of washroom and service requirements
- Possible upgrading of drainage and water-proofing requirements

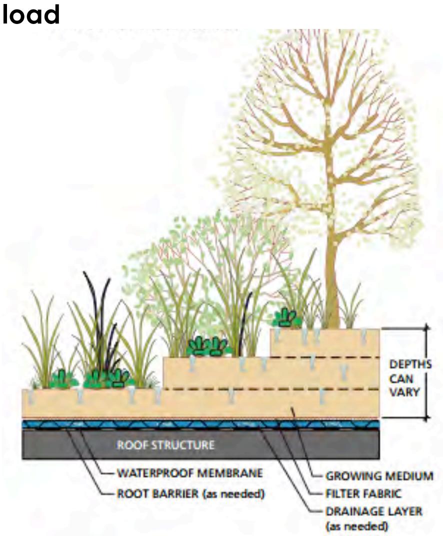
Structural Considerations

Remember there are two sides to this issue: there is the new loading exerted by the garden (the size and distribution of which can be altered by altering the layout of the garden) and there is the load carrying capacity of the structure (which can be enhanced by increasing the strength of existing load bearing members or by adding new ones)(See Figures 4 & 5). When designing a roof garden consult with a licensed engineer regarding the load carrying capacity of the building you are working with and ensure that the garden design and the structural capacity are compatible.

Additional Considerations

- Storage or areas for composting. Composting is a sustainable way to fertilize soil and not be wasteful.

Figure 5: Structural Roof Garden with a heavy load



Source: http://www.portlandoregon.gov/bes/article/127470

- Rainwater collection system, which can be on adjacent roof areas with storage on roof. There may be a possibility of flooding from a heavy rainfall. By installing rainwater collection systems, like a barrel, it can be used as another method to capture stormwater, and excess water can be used to water the roof garden during drier seasons or periods.

- Electricity for running power tools and equipment.

- Depending on how accessible you will want to make your roof garden it may be essential to think about general security and lock off to ensure limited access.

Figure 6: Finger Lakes Region Ideal Native Plants

Shrubs	Herbaceous Plants
Witch Hazel *Hamemelis virginiana*	Cinnamon Fern *Osmunda cinnamomea*
Winterberry *Ilex verticillata*	Cutleaf Coneflower *Rudbeckia laciniata*
Arrowwood *Viburnum dentatum*	Woolgrass *Scirpus cyperinus*
Brook-side Alder *Alnus serrulata*	New England Aster *Aster novae-angliae*
Red-Osier Dogwood *Cornus stolonifera*	Fox Sedge *Carex vulpinoidea*
Sweet Pepperbush *Clethra alnifolia*	Spotted Joe-Pye Weed *Eupatorium maculatum*
	Switch Grass *Panicum virgatum*
	Great Blue Lobelia *Lobelia siphatica*
	Wild Bergamot *Monarda fistulosa*
	Red Milkweed *Asclepias incarnate*
Adapted from NYSDM Bioretention Specifications, Bannerman, Brooklyn Botanic Garden.	

Source: http://www.dec.ny.gov/docs/water_pdf/swdm2010chptr5.pdf

Plants

It is essential to use a variety of Native Plants from the Finger Lakes Region. When planting different varieties of plants, you create a biodiversity that gives more nutrition to the soil. For the ideal plants to grow that are native to the Finger Lakes regions see Figure 6.

Site Prep in Detail

The first step is to evaluate your roof's load capacity. Load capacity is the amount of weight your roof structure can support. This includes everything: planter boxes, soil (when wet), possible water storage, weight of crops at maturity, equipment and such temporary loads as people and snow. Working with a structural engineer is helpful to reduce future problems.

Review your municipality's regulations. Architect or building designers can often assist you in interpreting building-code requirements for green roofs.

Consider sun and wind exposure. Edible plants require a minimum of six hours of sunshine. Study your patterns and hours of sunlight and note adjacent buildings that may create shadows. Wind is often stronger at rooftop heights than on ground level and can seriously damage plants. Structural windbreakers may need to be designed in conjunction with the building frame and they must be able to withstand wind loads.

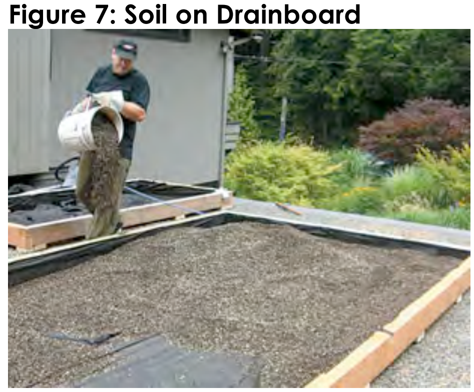
Step by Step Process

1. Prepare your roof structurally. Make sure that the construction of the gardens meets municipal building and safety requirements for a green roof. You should also check that your roof membrane can support walking and planters. This is to prevent the risk of leaks.

Figure 6: Planter for soil

Source: http://www.bcliving.ca/garden/design-a-green-roof-0

Figure 7: Soil on Drainboard



Source: http://www.bcliving.ca/garden/design-a-green-roof-0

2. Build planters to hold soil. Use a 2x4 firs on sleepers, allowing for 25 cm (10 in.) of soil. To enhance drainage it would be helpful to utilize gravel (See Figure 6).
3. Line your planters. To contain soil, use ½-in. drainboard appropriate for green-roof drainage. A drainboard adds a layer of insulation, that is designed for water retention (See Figure 7).
4. Add green-roof soil. Lightweight soil specific for rooftop gardens is placed in raised planters.
5. Then plant flowers, vegetables, herbs and fruit. Make sure to water the garden when necessary, which is at least 2 times a day. In drier seasons watering the garden should be more frequent, as opposed to the wet or colder season when watering once or twice would be adequate.

Maintenance

Similar to conventional rooftops, rooftop gardens need care to maintain its optimal capacity. Some of the maintenance that is required from the installer is that of any garden: irrigation, weeding and mulching. (See figure 8) This is most important in the beginning phases of establishing the roof garden.

Figure 8: Weeding and Mulching Roof Gardens

Source: http://israel21c.org/environment/turning-israeli-roofs-into-green-habitats/

The amount of irrigation and maintenance is also dependent on the plants that are in the garden. If the garden includes grasses or annual plants, it is necessary to cut and remove dry vegetation to prevent combustible material to accumulate. It is helpful to check drainage and vegetation regularly when maintaining a garden.

Cost

Unlike a conventional roof, to install roof gardens has a more expensive initial cost. Typically, expect to spend 25% to 30% more to install a rooftop garden than to install a traditional roof. This is because there are more materials that need to be purchased. Such as soils, plants, drainage materials, etc. Costs also depend on the type and amount of waterproofing and drainage material, depth of soil, amount of hardscaping and size and type of plant material.

In addition to the cost of the structural analysis and design assistance, your construction budget should include any needed structural or safety improvements, irrigation systems, garden materials, maintenance costs, transportation, and fees associated with any ongoing professional assistance and permits.

Container gardens can easily be adapted to fit your budget, depending on the type (wood, fiberglass, ceramic, terra cotta, concrete) and quantity you use. Rooftop garden systems, as a general rule of thumb, cost about 50% more than a conventional roof.

An extensive roof garden system is generally less costly than an intensive garden.

Either kind of rooftop garden system can increase the useful life of your roof by about 50% over a conventional roof because the roof garden system layers protect the "hard" roof from exposure to harsh weather conditions and possible flooding (See Figure 9).

Figure 9: Waterproofing Roof Garden

Source:
http://www.priorityzonedbn.co.za/2013/04/08/whats-happening-at-the-priority-zone-roof-garden/

Conclusions

Limitations

The membrane isn't protected from point-loading, shovels, shoe heels, and dropping equipment. However, a protective drainage layer between the soil and the membrane under planting beds, and raised surfacing treatment for non-planted areas should avoid damage, but it is more of an expense.

1. The roof drainage system gets clogged with sand, soil, or vegetation, and water is forced to sit on the roof for long periods of time, allowing it to either break down the membrane or work its way through the seams. To ensure that your roof drains have the proper covers, and that your planters are lined with a layer of filter cloth and gravel to keep the soil from draining out with the water often a layer of filter cloth or drainage mat is laid over the whole roof, just on top of the waterproofing, to avoid this problem.
2. Leachate from plants, fertilizers, and/or composters comes in contact with certain roofing membranes, leading to possible membrane breakdown.

3. A leak must be located and accessed after the garden is already in place - moveable planters/containers, modular walkways/surfacing treatment, and compartmentalized planting beds could solve this problem.

Advantages

1. Less chance of marauders (i.e., rabbits, raccoons, deer and bears) raiding the garden.
2. Freeing up valuable limited outdoor real estate by moving edible gardens to the unused roof.
3. Significantly fewer weeds than at garden grade.
4. Improve air quality and reduce CO2 emissions
5. Opportunities for rest and relaxation, particularly for occupants of the building below.
6. Delay stormwater runoff
7. Insulate buildings
8. Increase habitat for birds
9. Increase the value of buildings for owners and tenants alike
10. Create job opportunities in the field of research, design, construction, Landscaping/gardening, health, and food production

Environmental Impacts

Aside for rooftop gardens providing resistance to thermal radiation, rooftop gardens are also beneficial in reducing rain run off. A roof garden can delay run off; reduce the rate and volume of run off. "As cities grow, permeable substrates are replaced by impervious structures such as buildings and paved roads. Stormwater run-off and combined sewage overflow events are now major problems for many cities in North America. A key solution is to reduce peak flow by delaying (e.g., control flow drain on roofs) or retaining run-off (e.g., rain detention basins). Rooftop gardens can delay peak flow and retain the run-off for later use by the plants."

Plants have the ability to reduce the overall heat absorption of the building, which then reduces energy consumption. A study at the National Research Council of Canada showed the differences between roofs with gardens and roofs without gardens against temperature. The study shows temperature effects on different layers of each roof at different times of the day. Roof gardens are obviously very beneficial in reducing the effects of temperature against roofs without gardens. "If widely adopted, rooftop gardens could reduce the urban heat island, which would decrease smog episodes, problems associated with heat stress and further lower energy consumption."

Rooftop gardens are an excellent example of incorporating passive, eco-friendly technology into new or existing development. Rooftop gardens help mitigate the negative impacts of cities on the environment by: conserving energy and water, improving air and water quality, assisting in stormwater management, absorbing solar radiation, becoming a source of local food production, providing habitat restoration, and creating natural retreats. Rooftop gardens are most effective when constructed on the flat roof styles common to many city commercial, institutional, or industrial buildings. Depending on the load bearing capability, city buildings can either be retrofitted, or rooftop gardens can be incorporated into the original design. The basic components of a rooftop garden include: a waterproof membrane, a root barrier, a drainage system, filtering cloth, growing medium, and plants. Rooftop gardens can double the longevity of a roof when compared with traditional roofing materials, and some components in corporate recycled materials.