Green Infrastructure Application Best Management Practices

A Guideline for Stormwater Management

Downtown Geneva Historic District

FINGER LAKES INSTITUTE

HOBART AND WILLIAM SMITH COLLEGES

Acknowledgements

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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)

FINGER LAKES INSTITUTE

HOBART AND WILLIAM SMITH COLLEGES

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.

Geneva was originally where the Seneca Native American village of Kanadasaga settled. The village was destroyed and abandoned in 1779 and resettled by Europeans around 1793. The village of Geneva was officially established in 1806 and separated from the surrounding town of Geneva. The village then became the city of Geneva in 1871. Geneva was a hub for industry, experiencing a peak era between 1830 and 1875. Canal systems were built connecting the lakes and villages and were the dominant form of transportation for a while. The downtown area of the city of Geneva is currently under consideration and in the process to become an officially recognized historic area.

Green infrastructure practices recommended for Downtown Geneva are:

1. Rain Gardens

2. Rain barrels
3. Tree Planting & Pits
4. Stormwater planters
5. Cisterns
6. Green roofs
7. Storm Drain Marking

Downtown Geneva was built over a natural freshwater wetland that used to act as a natural barrier between lake and land, helping prevent floods and filtering out pollutants from the water. Today, property owners along Linden Street experience flooding in their basements during storm events, as the entire downtown is located downhill from the rest of Geneva, and a stream once flowed through the area. Implementing the above mentioned green infrastructure techniques will help return some green into an urban environment, as well as help mitigate stormwater and run-off issues, like the wetland used to.

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

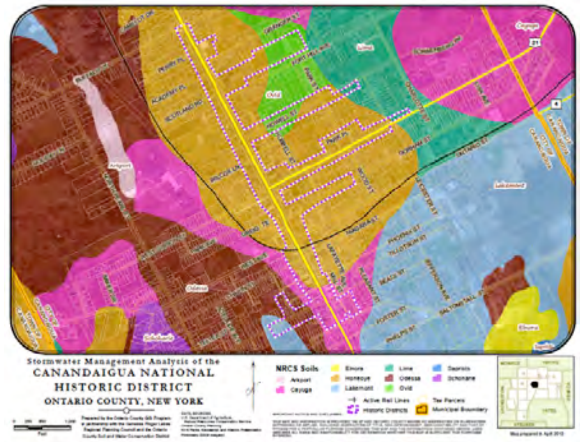
For more information about this funding opportunity, please see:

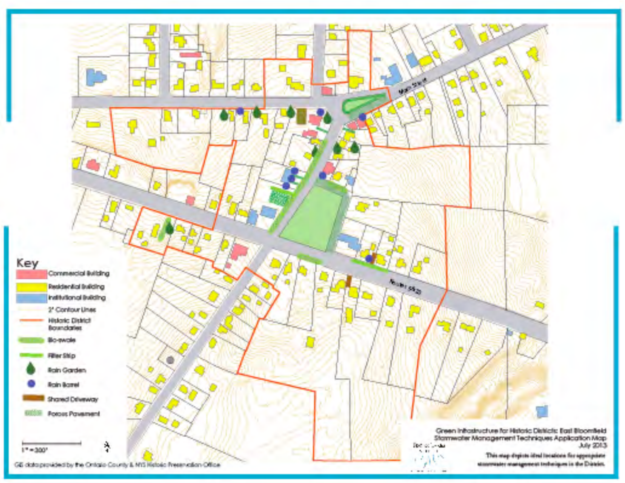
http://regionalcouncils.ny.gov/sites/default/files/documents/2013/resources_available_2013.pdf.

Soil Map

The soil map 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.

This map was 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.





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.

Historic District Boundary

Soil Classification:
Oa - Odessa Silt Loam 0-6A % Slopes
(imperfectly - poorly drained)

La - Lakemont Silty Clay Loam 0-2 % Slopes
(poorly drained)

GENEVA
UNIQUELY URBAN

GIS data provided by Ontario County & NYS Historic Preservation Office

Green Infrastructure for Historic Districts: Downtown Geneva
Stormwater Management Techniques Application Map
July 2013

Finger Lakes Institute

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

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: Rain water 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

Figure 4: Rain Garden

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

Figure 5: Rain Garden

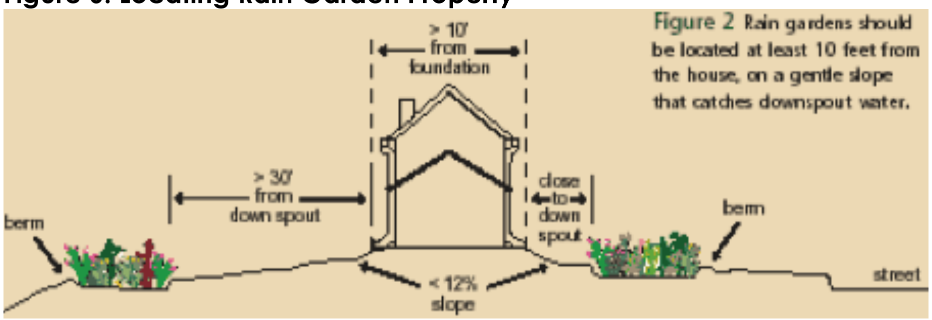
Source: http://mtwatercourse.org/media/photos/LIDRainBarrel01.jpg

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)

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



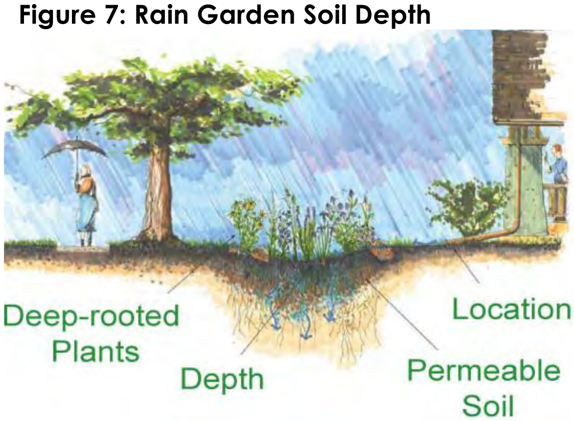
Source: (http://www.lakesuperiorstreams.org/stormwater/toolkit/raingarden.html)

Zoning & Historic Districts

The city of Geneva does not have any regulations specifically pertaining to the usage of rain gardens, however poisonous and noxious plants are prohibited from being planted.
Chapter 350, article X Historic Zoning also outlines recommendations and procedures concerning the alteration of exterior appearances of any historic structure.

Soil

Figure 7: Rain Garden Soil Depth



Source: http://www.thecoves.ca/projects/pollution-solutions

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 water within 24 hours after rainfall.

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 bioretentionmixture 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.

Downtown Geneva is comprised of Lakemont soils. The Lakemont series consists of deep, poorly drained and very poorly drained soils of lake plains. They are nearly level soils formed in very slowly permeable reddish colored clayey lacustrine sediments. Slope ranges from 0 to 3 percent. Permeability is moderately slow in the surface and very slow in the subsoil sand substratum. The potential for surface runoff is negligible to very high.
Areas that have been drained are used mainly for growing hay or pasture, and some corn and small grains. Some undrained areas are pastured, but most are idle or in woods. Because Lakemont is such a poorly draining soil, a rain garden allow stormwater run-off be more readily absorbed into the underlying soil. However, care must be taken to introduce the proper soil mixture to the garden (as described above) to maximize the rain garden's absorption potential.

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, Lakemont soil has high clay content, and will likely need to be mixed to properly host 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).

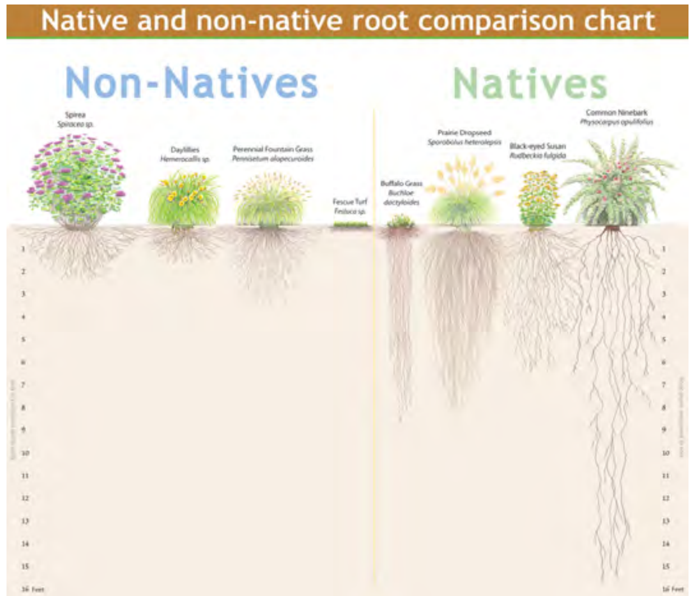
Another way to determine the slope of land where the garden is being built for the depth of the rain garden is by the rule of thumb:

- 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.

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 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.

In regions with heavy clay soil such as Downtown Geneva, deep rooted native plants break-up the soil better than typical varieties of lawn grass, thus improving clay soil's permeability. However, busting through layers of clay takes time, so expect rain gardens in Downtown Geneva to take several years to fully develop. 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.

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

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.

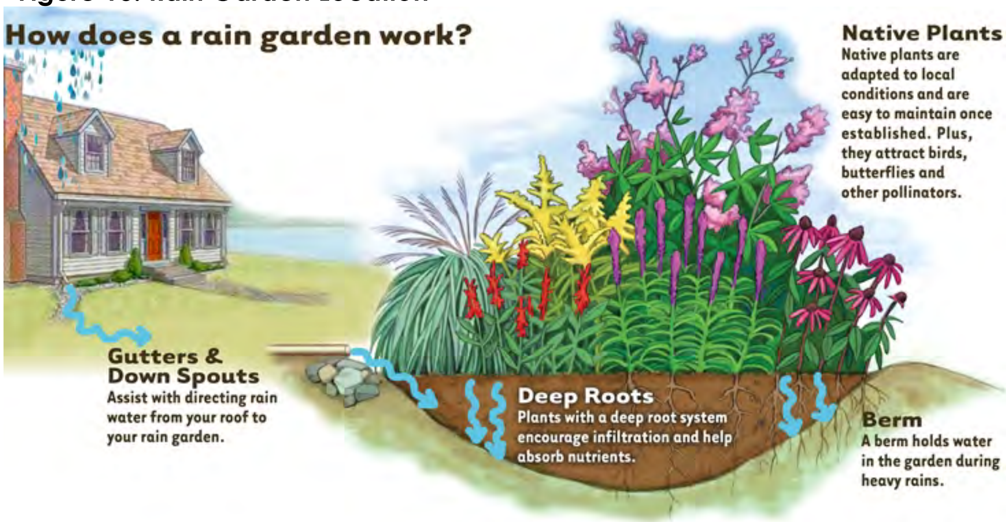
Site Prep Design

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 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.

Figure 12: Displaced rain water runoff

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

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.

Figure 13: Water Filtration

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

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.

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

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

Figure 14: Rain Garden

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

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.

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.

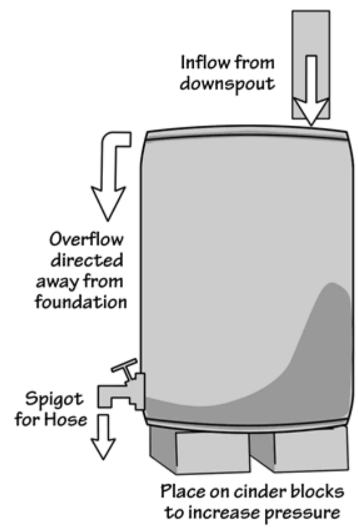
Rain Barrels

A rain barrel is a water tank used to collect and store rain water 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.

Introduction

In recorded history, the use of rainwater collection can be traced as far back as ancient times some 3,000 years ago (850 BC). In the days of the Roman Empire, atriums fed rainwater collection cisterns were commonplace 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.

Figure 1: Rain Barrel Parts



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

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 a typical rain 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 rain water 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.

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.

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

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

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

The city of Geneva does not have any regulations specifically pertaining to the use or placement of rain barrels, however, it is important that they are stabilized and on sturdy ground or surfaces to prevent spillage and/or harm. Chapter 350, article X Historic Zoning outlines procedures necessary concerning any alteration to a historic structure, so it is recommended to overview that section first.

For historic districts, maintaining the integrity of the built environment is of utmost importance. There are many rain barrel designs, which 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 helps 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 your plants do not take them up.

Pests

Mosquitos can quickly become a problem because larvae thrive in stagnant water. This can be prevented by ensuring you have a sealed watertight 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

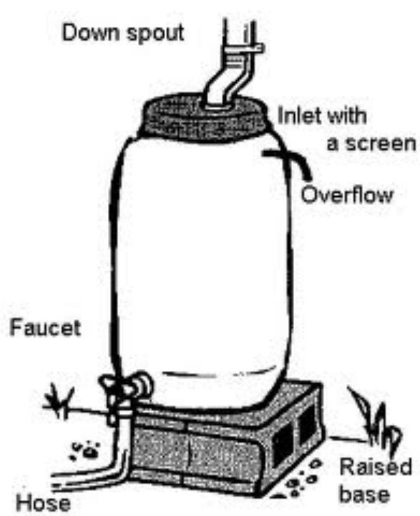
If present, a rain barrel's continuous discharge outlet should be placed so that the tank does not empty completely, ensuring water availability at all times, while also providing at least some storage capacity for every storm. A diverter at the cistern inlet can redirect the "first flush" of runoff, 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 trashcans 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. Constructing his or her own barrel, which can be done with basic supplies for as low as $20, can reduce costs to a homeowner still further.

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

Tree Plantings & Pits

Tree planting usually refers to concentrated groupings of trees planted in landscaped areas while tree pits, also called tree boxes, generally refer to individually planted trees in contained areas such as sidewalk cut-outs or curbed islands. Tree planting can be used for landscaping, stormwater management practice areas, conservation areas and erosion and sediment control. Conserving existing trees or planting new trees at new or redevelopment sites can reduce stormwater run-off, promote evapotranspiration, increase nutrient uptake, provide shading and thermal reductions, and encourage wildlife habitat.

Introduction

Common characteristics of many historic districts are wide-tree-lined streets. Figures 1 and 2 are old photos of Wilber Street in Canandaigua, and South Main Street in Geneva from the early 1900's.

Figure 1: Street Trees in Canandaigua

Source: Ontario County Historic Museum

Figure 2: Street Trees in Geneva

Source: Geneva Historic Society

Tree plots and planting trees are not only aesthetically pleasing, they also raise property values, and lend to a historic neighborhood feel. Streets and walkways are vastly improved by an increased number of trees also because the leaves, branches and trunks of street trees can capture up to 30% of a typical rainfall event through absorption and evaporation. Tree root systems can absorb up to another 30%, resulting in reduced stormwater runoff and potential flooding. This also results in less man-made drainage infrastructure. Furthermore, leaves absorb many pollutants, like CO^2, and provide shading which can lower temperatures up to 15 degrees Fahrenheit, reduce traffic noise levels, and help prevent ground level ozone-which often contributes to smog and other harmful pollution that caused respiratory problems in many elderly people and children.

Application in a Historic District

In the past, many downtowns such as Canandaigua featured wide, tree-lined streets. These trees provided shading for pedestrians, introduced greenery into urban areas and of course, mitigated stormwater run-off. As downtowns developed, street trees were often removed to allow motorists easy views of the storefronts or removed due to maintenance concerns. Today, street trees and tree pits are experiencing a revival. Tree pits built with materials like wrought-iron fencing or low brick walls are especially compatible with historic districts, and enhance the historic feel. For example, downtown Canandaigua is currently undergoing a major renovation of its sidewalks and adding tree pits with the specific intention of introducing green infrastructure. Trees and tree pits are a welcome addition to any historic district, and do not infringe on the historic integrity of the area, but rather contribute to it.

Benefits

The benefits of tree plots and general planting of trees include, but are not limited to:

- Increased property value
- Increase in aesthetics
- Reduced stormwater run-off and velocity of water moving over impervious surface
- Decrease in air, water, and soil pollution through aided and addition filtration methods
- Provide microhabitats
- Increase in shading provided
- Buffer traffic noise
- Reduce heat island effect

Figure 3: Street Trees

Source: http://actrees.org/news/trees-in-the-news/research/mature-trees-significantly-reduce-energy-use-in-urban-areas/

Recommended Application of the Practice

Conservation of existing trees is recommended where stands of existing trees are non-invasive, healthy and likely to continue to flourish in the proposed site conditions. Planting of new trees is recommended for areas that will remain or become pervious in the proposed condition and are large enough to sustain multiple trees. Planting of trees in tree pits is recommended in street rights-of-way or other small-scale pervious areas in highly impervious redevelopment sites that can support limited tree development.

Tree plots can also be used in more creative ways to help break up impervious structures in unconventional places, or areas that are typically hostile environments. A couple examples of this can be seen below in Figures 4 and 5.

Figure 4 shows tree plots in an open plaza, trees could be planted like this in parking lots --sloping the pavement towards the base of the trees. This would help drain stormwater, decrease run-off, and filter the water of pollutants; while providing shading and helping cool the temperature of the asphalt and surrounding area. Figure 5 shows how abandoned train cars can be repurposed by planting trees, a creative way to make otherwise barren sites more appealing to the eye.

Figure 4: A Creative Use of Street Trees

Source: "Trees as Green Infrastructure" By David Elkin.

Figure 5: An Unusual Vessel for Street Trees

Source: "Trees as Green Infrastructure" By David Elkin.

Site Specific Considerations

Environmental & Landscaping Elements

Before construction begins the following should be considered and standards met.

- Adequate space must be provided for each tree to grow.
- Trees should be selected for diversity and to promote native, non-invasive species.
- Soil quality and volume may be poor. Soil amendments and de-compaction may be required prior to planting. Heavy equipment traffic should be limited in the vicinity of both existing and proposed tree planting areas.

Figure 6: A Street Tree in an Urban Area

Source: http://erbology.com/2011/04/15/classy-upper-east-side-street-tree-pits/

Soil

In pursuit of soil volumes required to grow environmentally productive urban trees techniques can be used that rely on the inventive use of space and augmented construction methods. Space permitting, the easiest way to achieve target volumes is an open planting area (10 feet by 34 feet by 3 feet tree pit). Since this is usually not possible in heavily paved areas, augmented techniques using covered soil in combination with open soil can be used. These include the use of root paths (narrow trenches of un-compacted soil under pavement to connect the planting area to nearby volumes of soil), structural soils and suspended-pavement systems.

Professor Nina Bassuk and colleagues at Cornell University, solved the compaction problem by mixing angular one-inch crushed stone with planting soil, at a stone-to-soil ratio of 4:1. The stone pieces form a load bearing "rigid lattice" leaves space for un-compacted soil.

Suspended-pavement systems offer the best combination of structural strength and large volumes of quality soil. A suspended-pavement system consists of an underground post-and-beam structure and a deck with pavement on top. The structure supports the weight of the pavement and additional loading by pedestrians and vehicles, leaving the space for large volumes of un-compacted soil for root growth and storm-water treatment. This approach also protects pavement and curbs from the rogue roots of cornered trees.

Downtown Geneva is comprised of Lake Mont soils. The Lakemont series consists of deep, poorly drained and very poorly drained soils of lake plains. They are nearly level soils formed in very slowly permeable reddish colored clayey lacustrine sediments. Slope ranges from 0 to 3 percent. Permeability is moderately slow in the surface and very slow in the subsoil sand substratum. The potential for surface runoff is negligible to very high.
Some undrained areas contain American elm, black ash, red maple, and alder, thus these species would thrive in Downtown Geneva soils. However, if other tree species are planted, it is advised that the soil that the tree is planted in is mixed, as described above.

Zoning

Zoning codes for the city of Geneva state that it is prohibited to allow hedges, shrubs, or trees to encroach onto public sidewalks and lines of sight of public roadways. It also states that trees must be spaced according to the species size class (small trees must be spaced 15 ft., medium 25 ft., and large trees 35 ft.) and that tree lawns (the grassy area between the curb and sidewalk) must be at least 4 feet wide for small tree planting, and at least 6 feet wide for medium to large trees. Further regulations that may affect the planting of trees include:

- No street tree shall be planted within 35 feet of a street corner
- No street tree shall be planted within 10 feet of a fire plug or utility pole
- No street tree other than those species listed as small shall be planted under or within 10 horizontal feet of an overhead utility wire

It is asked that owners of any tree overhanging any street or right-of-way within the City of Geneva shall prune the branches so that such branches shall not severely obstruct the light from street lamps or obstruct the view of any intersection, and so that the lowest branches are at least 13 feet above the street surface and at least 8 feet above the sidewalk surface.

If for some reason a tree on your property is dead, or diseased, it is the owner's responsibility to remove any broken or decayed limbs, which are considered a menace to public safety. Because of this you may need to first consult with local officials to discuss waivers for alternative designs.

There are also specific procedures that must be adhered to concerning the alteration of the appearance of any historic structure, so it is recommended to review this which can be found in chapter 350, article X Historic Zoning.

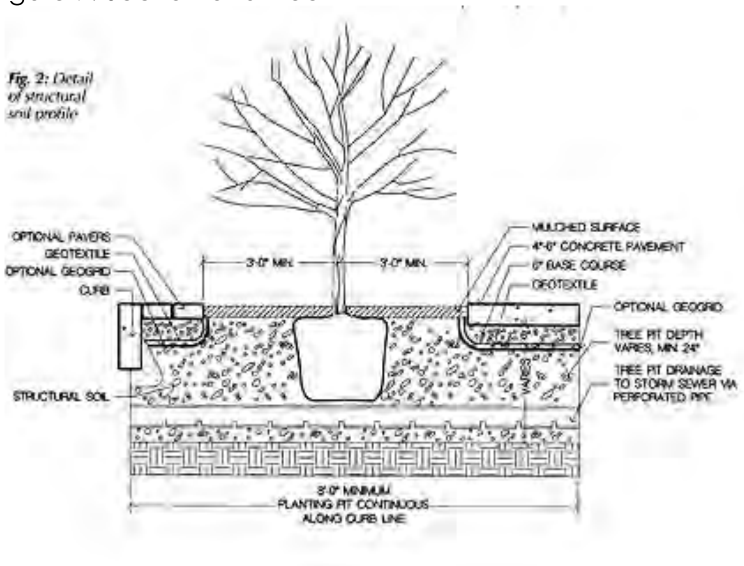
Sizing and Design Criteria

For tree planting, the area considered for runoff reduction is limited to the pervious area in which trees are planted. In an urban setting where trees are contained by impervious structures such as curbs and sidewalks, the area is calculated as follows: For up to a 16-foot diameter canopy of a mature tree, the area considered for reduction shall be the area of the tree canopy. For larger trees, the area credited is 100 square feet per tree. A typical planting detail specifies a 4-foot by 10-foot tree pit carved out of highly compacted soil and surrounded by pavement.

An alternative sizing for run-off reduction in urban settings may follow the bio-retention or stormwater planters design and sizing. In these cases, the sizing of the practice relies on the storage capacity of the soil in the cavity created for the root ball of the tree and ponding area. The infiltration rate for this type of planter must be a minimum of 2 inches per hour.

Retooling underground infrastructure to accommodate high quality, un-compacted soil enables the growth of large-canopy trees and the absorption of large volumes of stormwater.

Figure 7: Section of a Tree Pit



http://www.state.nj.us/dep/parksandforests/forest/community/tree_planting_specs.html

Required Elements

Conservation of existing native trees during the development process should be managed in a systematic manner using the following steps:

1. Inventory existing trees on-site.
2. Identify trees to be protected.
3. Design the development with conservation of these trees in mind.
4. Protect the trees and surrounding soils during construction by limiting clearing, grading and compaction.
5. Protect and maintain trees post construction.

Figure 7 is a cross section showing how a tree planter can be implemented.

New Trees

For planting of new trees, maximize the use of pervious areas on the site that are good locations for tree planting. For example: road rights-of-way, landscaped islands in cul-de-sacs or traffic circles, parking lots, and private lawns. These urban planting sites may have harsh soil and environmental conditions that must be addressed through appropriate species selection or proper site preparation prior to planting. However, as Figures 8 & 9 below show—it's more than possible to overcome these issues.

Figure 8: A Street Tree with Parking

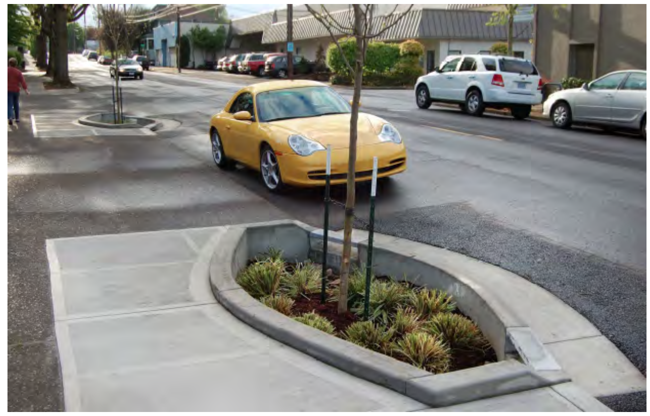
Source: "Trees as Green Infrastructure" By David Elkin.

Where the new trees will be planted:

- The tree species must be chosen from an approved list of local native species
- New trees planted must be planted within 10 feet of ground level, directly connected
- impervious areas.

- New deciduous trees must be at least 2-inch caliper and new evergreen trees must be at least 6 feet tall to be eligible for the reduction.
- A 100 square-foot directly connected impervious area reduction is permitted for each new tree. This credit may only be applied to the impervious area adjacent to the tree.
- Recommend minimum 1,000 cubic feet soil media available per tree.

Figure 9: Street Trees with Sidewalks



Source: "Trees as Green Infrastructure" By David Elkin.

For new trees, the average slope for the contributing area, including the area under the canopy must not be greater than 5%. The maximum slope can be increased where existing trees are being preserved. Slope specifications for filter strips and buffers should be followed as guidelines. The maximum reduction permitted, for both new and existing trees, is 25% of directly connected ground level impervious area.

Figure 10: New Trees in a Plaza

Source: "Trees as Green Infrastructure" By David Elkin.

Figure 11: Trees in Parking Lot

Source: "Trees as Green Infrastructure" By David Elkin.

Information about native trees, shrubs, and plant species as well as guides for transplanting, tips, and directions can be found on the Finger Lakes Native Plant Species website, and there are guides provided by Cornell online as well.

Some suggested trees that are native to the Finger Lakes region are listed below. They are characterized by having the ability to thrive in full to partial sun and shade, and moist to well-drained soil to periods of dry soil with hardiness levels that span 4-9, lower numbers are associated with more moist soils and higher numbers with dry soil.

Large Trees

Common Name: Katsura Tree, Scientific Name: Cercidiphyllum japonicum
Hardiness Zone: 5a, prefers full sun, tolerates partial shade, pH: < 8.2
Height: 40'-60' (can reach 100' in the wild), Width: quite variable, 25'-60', grows medium to fast

relatively pest free, resistant to Verticillium Wilt
Transplant Issues: easy to transplant B&B or < 2" caliper bare root, and is suggested for wide street tree lawns/pits and parks due to size and drought sensitivity

Common Name: Whitespire Sr. Gray Birch Scientific Name: Betula populifolia 'Whitespire Sr.'
Hardiness Zone: 4a (consistently moist-occasional periods of dry soil), full sun is preferred, pH: <7.5
Height: 40', Width: 25', grows medium (possibly fast)
Insect/Disease Factors: shows some resistance to bronze birch borer, reportedly leafhopper resistant there are no known management issues of significance, and are suggested for narrow or wide street tree lawns/pits (preferably wide lawns/pits for multi-stem form), parks

Figure 12: Sugar Maple

Source: Recommended Urban Trees: Site Assessment and Tree Selection for Stress Tolerance, Urban Horticulture Institute at Cornell University

Common Name: Sugar Maple, Scientific Name: Acer saccharum
Hardiness Zone: 4 (consistently moist, well drained soil-occasional periods of dry soil), full sun is preferred, pH: < 7.5
Height: 45'-50' typical, 60'-75' possible (can grow 100'+ in wild), Width: 35'-40' typical, 55'-70' possible, grows slow to medium
Transplant Issues: easy to transplant B&B or < 2" caliper bare root, has no significant management issues and is suggested for wide street tree/pits due to drought sensitivity, parks

Small Trees

Common Name: Trident Maple, Scientific Name: Acer buergerianum
Hardiness Zone: 6a (consistently moist, well drained soil, occasional periods of dry soil, prolonged periods of dry soil), prefers full sun, pH: < 7.5
Height: 20' - 25', Width: 20'-25', grows slow to medium, but typically slow
difficult to transplant B&B, may require pruning for low branching, is suggested for wide street tree lawns/pits, narrow tree lawns/pits with pruning, and parks. There are no insect or disease factors that are serious or limiting

Figure 13: Trident Maple

Source: Recommended Urban Trees: Site Assessment and Tree Selection for Stress Tolerance, Urban Horticulture Institute at Cornell University

Common Name: Goldenraintree, Scientific Name: Koelreuteria paniculata
Hardiness Zone: 5b (consistently moist, well drained-occasional dry periods-prolonged periods of dry soil), prefers full sun and tolerates heat well, pH: < 8.2
Height: 30' (can reach 40'), Width: 30', grows medium to fast
easy to transplant B&B or < 2" caliper bare root, has no significant management issues and is suggested for narrow or wide street tree lawns/pits, parks, suitable for CU-Structural Soil™, and is relatively pest free.

Common Name: Corneliancherry Dogwood, Scientific Name: Cornus mas
Hardiness Zone: 5a (4) (consistently moist, well drained soil, occasional periods of dry soil), prefers full sun and tolerates partial shade, pH: < 8.2
Growth Characteristics: Height: 20', Width: 20', grows slow to medium
easy to transplant B&B and < 2" caliper bare root, and is suggested for wide street tree lawns/pits, narrow street tree lawns/pits with pruning or single-leader form, parks, suitable for CU-Structural Soil™, and is relatively pest and disease resistant.

Some suggested flower plants and shrubs that are also native to the area and known to attract butterflies and birds include: Columbine, New England Aster, Spiked Gay-Feather, Cardinal Flower, and Purple Coneflower. Red Chokeberry and Summer Sweet Bush are also options.

By using other green infrastructure techniques such as permeable pavements, drainage slots, curb-cut inlets, and sheet flow stormwater can be allowed to infiltrate the soil in several ways.

Examples

An installation in downtown Minneapolis intercepts stormwater for 6.6 acres with 179 trees planted in Silva Cells. A Silva Cell is a modular suspended pavement system that uses soil volumes to support large tree growth and provide powerful on-site stormwater management through. Each Silva Cell is composed of a frame and a deck. Frames are 48" (1200 mm) long x 24" (600 mm) wide x 16" (400 mm) high, and each one holds 10 cubic feet (.28 cubic meters) of soil. They can be stacked one, two, or three high before they are topped with a deck to create a maximum containment area for lightly compacted loam soil. Silva Cells can be spread laterally as wide as necessary. Each unit is about 92% void space, making it easy to accommodate utilities. Suspended-pavement systems are not new, and one of the best case studies is in Charlotte, North Carolina, where, in 1985, 170 trees were planted using custom suspended pavement along a 10-block stretch in the downtown business district. A 2009 survey found that the trees (167 of the 170 survived) have thrived, reaching an average height of 44 feet and 16 inches.

Figure 14: Silva Cell

http://riles-files.blogspot.com/2012/09/silva-cells-infrastructure-concerns.html

Maintenance

During the first three years, mulching, watering and protection of young trees may be necessary and should be included in the inspection list. Inspections should be performed every three months and within one week of ice storms, within one week of high wind events that reach speeds of 20 mph until trees have reached maturity.

As a minimum, the following items should be included in the regular inspection list:

- Assess tree health
- Determine survival rate; replace any dead trees.
- Inspect tree for evidence of insect and disease damage; treat as necessary
- Inspect tree for damages or dead limbs; prune as necessary

Feasibility & Limitations

While tree planting can enhance stormwater management goals, it is not a "stand alone" treatment or management practice and should be used with other green infrastructure techniques. Overhead and underground utilities may also limit the types of trees that can be planted and their location. Trees sometimes do not survive through construction or in certain urban environments unless proper tree selection, landscape design, protection and maintenance are incorporated in the technique. Inadequate soil rooting volumes and compacted soils are the largest factors in tree decline, and can lead to cracked and lifted pavements, curbs and retaining walls.

Native vegetation may be perceived to harbor undesirable wildlife and insects. However, most people enjoy viewing wildlife, and native vegetation does not provide a food source for most vermin. Continued education is necessary to show that humans and wildlife can co-exist, even at the neighborhood level.

Cost

Depending on the scale and method of development for tree plots price can range quite a bit. If doing a home project, tree plots can be fairly economical with individual medium sized trees costing between $16.00-$20.00 for a sapling about 2-3 ft. tall at purchase. Below are some examples of larger, citywide projects.

Cost estimates based on the street tree plan for the Wilkinsburg Business District along Penn Avenue, PA:
Site Preparation, Materials, and Planting Costs per Tree:
Increasing or creating a new tree pit* $300.00
New tree* $250.00
Soil amendments (mulch, compost, etc.) $75.00
Accessory planting's $100.00
Stakes and guy materials $25.00
Maintenance and warrantees (2 year) $150.00
Total Estimated Cost $900.00
*Includes labor costs

Cost Estimates for Implementation of Plan
This includes the removal of approximately 50 existing trees, and the introduction of approximately 67 new trees.
Removal and Planting Estimates
Removal of approx. 50 existing trees $15,000.00
Planning of approx. 67 new trees $60,300.00
Total Estimated Cost $75,300.00

Another estimation based on the Tree-Eco plan in Georgia can be seen below:

Number of Plots: 200
Number of personnel per crew: 3
Cost per crew day: $800 ($100/hr. x 8 hours/day)
Number of plots per day: 3-4 (as few as one and as many as seven per day)
Total number of days for project with 200 plots: 50-67 days
Total cost based on 200 plots, 3 plots/day avg., and $800/day: $40,000 - $50,000

The Achilles heel of tree plots is the initial cost, adding as much as $10,000 per tree to install compared with conventional methods. A life cycle cost calculation goes a long way toward justifying this investment, and, in some cases, savings in up-front costs for traditional infrastructure can pay for it many times over. For instance, the City of Minneapolis chose a $1.5 million Silva Cell installation over a $7.5 million storm-sewer upgrade to meet the city's storm-water goals.

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.

Introduction

Historically, many more trees can be seen lining streets and parks. In Canandaigua and Geneva specifically there were freshwater wetlands that extended the lakes but these were drained and developed over. Stormwater planters can be an aesthetically pleasing way to help restore some natural integrity to more urban environments.

Application in a Historic District

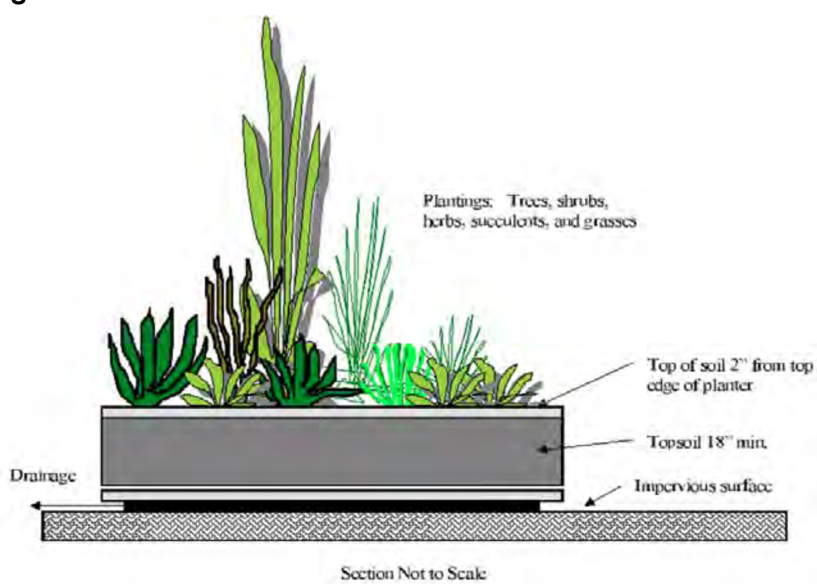
Stormwater planters are a very common application in urban, downtown areas as a way to introduce greenery and flowers and can be seen in Downtown Geneva, Canandaigua and Clifton Springs. There are many different ways to design stormwater planters, and a variety of materials to use. When incorporating 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.

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.

Benefits associated with contained planters include:

Figure 1: Stormwater Planter Section



Source: New York State Stormwater Management Design Manual

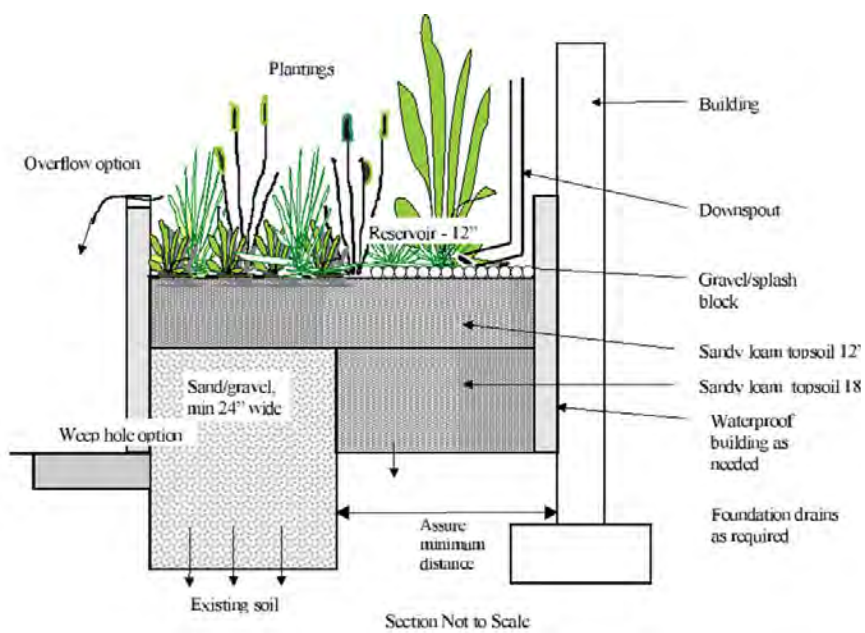
- Reduced impervious surface
- Decrease in stormwater run-off
- Visually appealing
- Versatile-can be placed on many types of impervious surfaces e.g. sidewalks, plazas, and rooftops

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

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.

Figure 2: Infiltration Planter Section



Source: New York State Stormwater Management Design Manual

Some benefits of infiltration planters are:

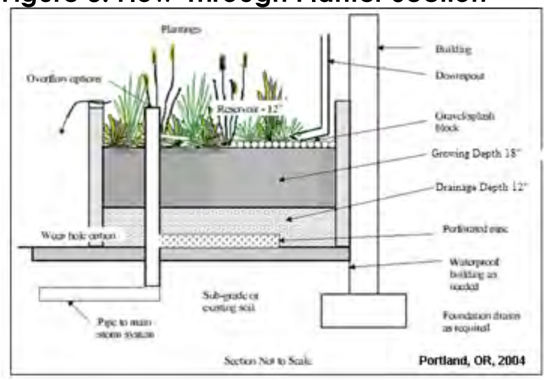
- Ideal for space-limited sites
- Reduce stormwater run-off flow rate, volume, and temperature
- Reduce pollutants entering into storm drains
- Recharge ground water
- Provide energy benefits when planted near building walls

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 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.

Figure 3: Flow-Through Planter Section



Source: New York State Stormwater Management Design Manual

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' incudes: columbine, New England aster, spiked gay-feather, and cardinal flower. And some suggested shrubs are red chokeberry, and summer sweet bush.

Figure 4: Example of Stormwater Planter

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

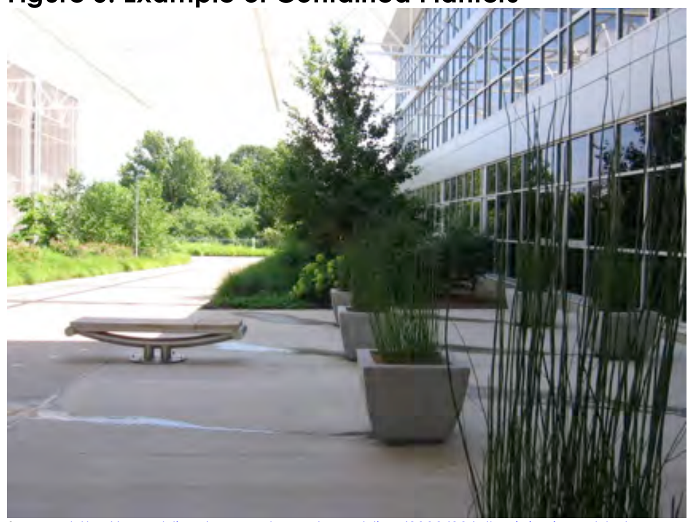
All three types of stormwater planters include three common elements: planter "box" material (e.g., wood or concrete); growing medium consisting of organic soil media; and vegetation. Infiltration and flow-through planters may also include splash rock, filter fabric, gravel drainage layer, and perforated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

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

The city of Geneva does not have any regulations specifically pertaining to stormwater planters of any type, however, if planting trees it is recommended to see the zoning regulations lined out in the Tree Plot section above. Chapter 350 article X Historic Zoning should also be visited regarding the change in appearance of any historic structure or district.

Generally, Downtown Geneva is an ideal location for stormwater planters because of the amount of impervious surface already in existence, and the limited ability to locate other stormwater management techniques, such as rain gardens, because of the lack of dedicated green space and unpaved surface.

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.

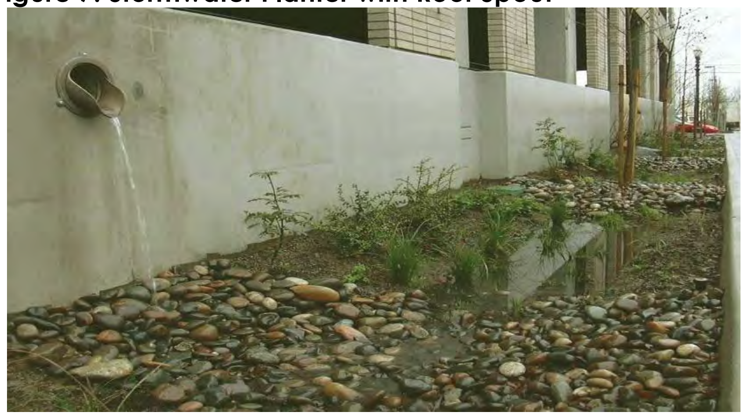
Materials suitable for planter wall construction include stone, concrete, brick, clay, plastic, wood, or other durable material.

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 x (df)/ [k x (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.

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.

Introduction

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.

Figure 1: A Small Cistern for Residential Usage

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

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 site.

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 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 4: Different Sizes of Cisterns

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

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.

Figure 5: Cistern Installation

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

Site Specific Considerations

Siting & Location

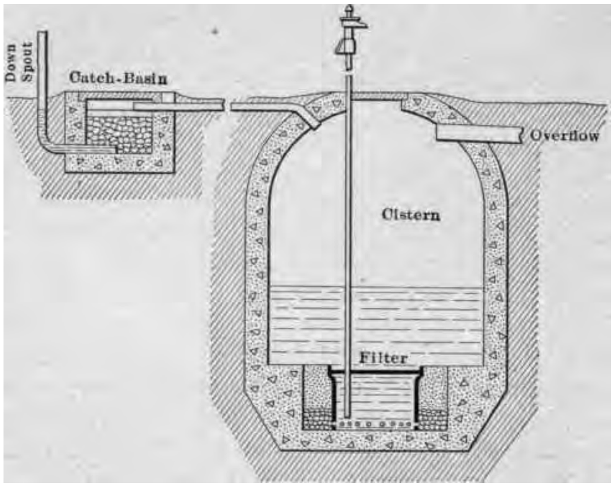
Cisterns may be used in most areas, residential, commercial, and industrial; due to their minimal site constraints relative to other stormwater management practices. They may be applied to manage rainwater in areas with almost every density from very dense urban to more rural residential areas. The necessary 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

The city of Geneva has no specified zoning regulations or recommendations concerning the use of cisterns. However, chapter 350 article X Historic Zoning outlines procedures and specifications about the alteration of any historic structure or the appearance of any exterior. Thus, it is recommended that underground cisterns be used in historic districts.

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 = (Capacity x 8.35 lb./gal + Cistern Weight)/Footprint Area

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 formulal (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°

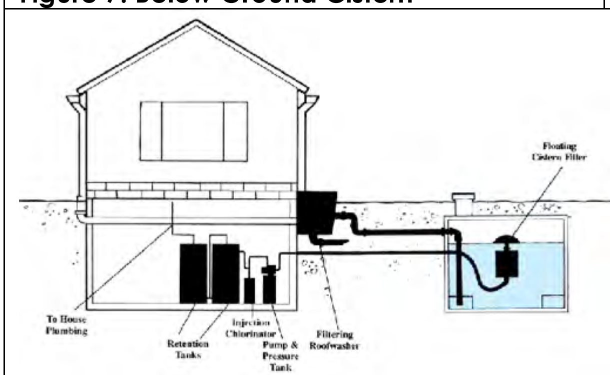
Mean	22°	24°	34°	45°	56°	65°	70°	68°	61°	50°	40°	28°
Avg. Precip.	1.8 in	1.8 in	2.1 in	2.9 in	3.0 in	3.7 in	3.0 in	3.1 in	3.3 in	2.9 in	3.1 in	2.5 in

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.

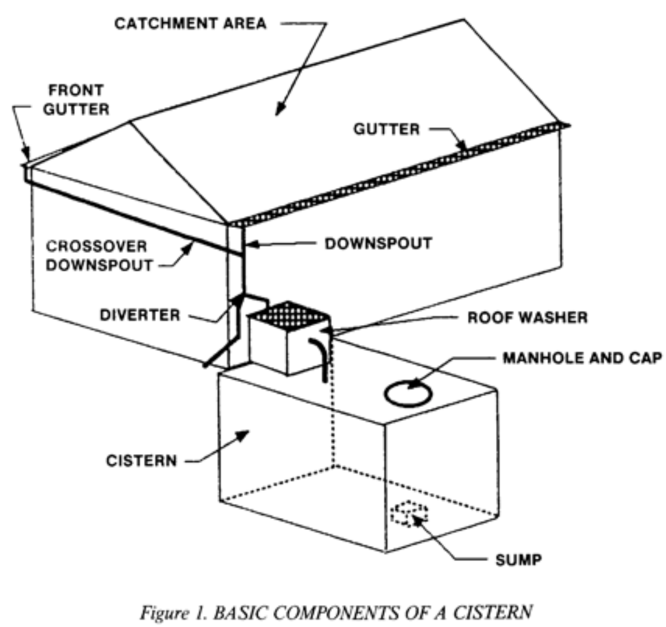
The excavation for below-ground cisterns should be large and deep enough to permit the laying of the foundation and walls. Underground tanks should be made from concrete to reduce problems of wall deterioration because of contact with the soil. Figure 6 shows the construction of a typical underground 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.

Figure 7: Below Ground Cistern



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

Figure 8: Below Ground 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 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 uses of cisterns are 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.

Green Roofs

Green Roofs, also known as eco roof, living roof or vegetated roof is one that is either partially or completely in vegetation on top of the human-made roof structure.

Introduction

A green roof is a roof of a building that is partially or completely covered with vegetation planted over a rooftop membrane. Green roofs, also known as eco-roofs, living roofs or vegetative roofs, use plants to improve the roofs appearance and environmental performance (See Figure 1). As green infrastructure, green roofs maximize the absorption of rainwater and reduce the runoff from urban impervious surfaces. Green roofs also improve air quality, provide insulation and lower urban air temperature.

Figure 1: Green Roofs

Source: http://www.oaa.on.ca/professional%20resources/sustainable%20design/case-study-details/preview/14

Some people often confuse green roofs and roof gardens. Although there are some similarities, green roofs and rood gardens have some major differences. Green roofs can cover the entire rooftop, which increased the environmental benefit. Unlike roof gardens, green roofs have several variations.

Application in a Historic District

Aesthetically, green roofs are a very low profile green infrastructure technique. The plantings common to green roofs, such as sedums, are unlikely to be viewable from the ground level, any more so than a regular roof. Sedum is a large genus of flowering plants usually used in place of grasses. Thus, it is unlikely that green roofs will have any negative impact on the character or integrity of a historic district. However, the benefits to the building owner in terms of energy savings and stormwater mitigation are likely to be great.

History and Aesthetic

Green roofs were originally inspired by roof gardens. The past green roof had featured many containerized plant species similar to a rain garden in the twentieth century. What is unique to modern green roofs is unlike roof gardens plants are installed directly into soil mixtures that sit atop of a waterproof barrier in the grass. The original modern green roof was developed in Germany in the 1960's and in the 1970's Stuttgart, Germany had created technologies and techniques to create a waterproof large flat roof that resulted into the current green roof system that is used today. Since then green roof green infrastructure technology has since spread to many different countries.

Site Specific Consideration

Types of Green Roofs

Green roofs have two main purposes: a visual aesthetic with a pleasant view and an environmental improvement. When installing a green roof there are three different types green roofs: extensive roofs, semi-intensive roofs and intensive roofs. (See Figure 2)

Figure 2: Types of Green Roofs

	Extensive Green Roof	Semi-Intensive Green Roof	Intensive Green Roof
Maintenance	Low	Periodically	High
Irrigation	No	Periodically	Regularly
Plant communities	Moss-Sedum-Herbs and Grasses	Grass-Herbs and Shrubs	Lawn or Perennials, Shrubs and Trees
System build-up height	60 - 200 mm	120 - 250 mm	150 - 400 mm on underground garages > 1000 mm
Weight	60 - 150 kg/m^2 13 -30 lb/sqft	120 - 200 kg/m^2 25 - 40 lb/sqft	180 - 500 kg/m^2 35 - 100 lb/sqft
Costs	Low	Middle	High
Use	Ecological protection layer	Designed Green Roof	Park like garden

Source: http://www.igra-world.com/types_of_green_roofs/

Figure 3: Extensive Roof

Source: http://www.igra-world.com/types_of_green_roofs/

Extensive Green Roof

Extensive green roofs are suited well to roofs with a light load holding the capacity and sites that are not meant to have a lot of weight. The concept is to design a rugged green roof that needs little maintenance or human intervention once it is established. Plants adapted to extreme climates often make good choices and may not require permanent irrigation systems. (See Figure 3) Some ideal plants that fit these conditions and are native to the Finger Lakes region are: cardinal flowers and columbine flower, for more options see the Native Plants section.

Overall, because of this type of green roof is lightweight, extensive systems will require the least amount of added structural support, which improves their cost-effectiveness when retrofitting an existing structure. (See Figure 4)

Extensive green roofs have been grown on roofs with slopes of 30° or more, which would equal a ratio of rise to run of 7:12 or greater. (In contrast, a low-sloped roof with a ratio of rise to run of 2:12 would have a slope of 9.5°.) The slope determines if the roof will need additional support to hold the growing medium and other parts of the vegetative layer in place. Steeper roofs may retain less stormwater than an equivalent, flatter roof.

Figure 4: Retrofitting Extensive Roof

Source: http://www.igra-world.com/types_of_green_roofs/

Semi-Intensive Green Roof

Semi-Intensive Green roofs are the middle ground between extensive and intensive green roofs. Semi-Intensive green roofs have a deeper roof level, which allows for more possibilities for deign and the kinds of vegetation that can be grown. Semi-Intensive allow for a heavier load that can sustain deeper soils and plant weight.
(See Figure 5 & 6)

Figure 5: Semi-Intensive Roof

Source: http://www.igraworld.com/types_of_green_roofs/

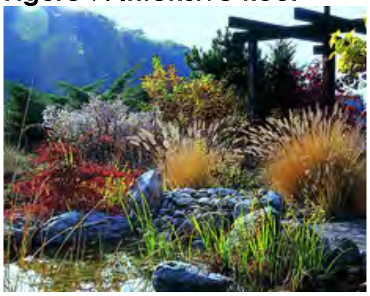
Figure 6: Semi-Intensive Roof

Source: http://www.igra-world.com/types_of_green_roofs/

Intensive Green Roof

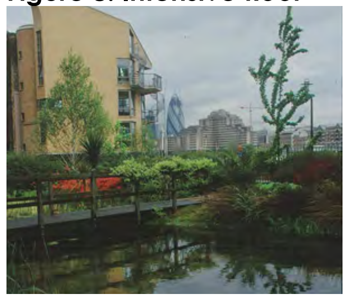
An intensive green roof is like a conventional garden, or park, with almost no limit on the type of available plants, including large trees and shrubs. Building owners or managers often install these roofs to save energy and provide a garden environment for the building occupants or the general public to enjoy. Compared to extensive green roofs, intensive green roofs are heavier and require a higher initial investment and more maintenance over the long term than extensive roofs. They generally require more structural support to accommodate the weight of the additional growing medium and public use. Intensive systems also need to employ irrigation for trees and vegetation, which can use rainwater captured from the roof or another source. (See Figure 7 & 8)

Figure 7: Intensive Roof



Source: http://www.igra-world.com/types_of_green_roofs/

Figure 8: Intensive Roof



Source: http://www.igra-world.com/types_of_green_roofs/

Location

Cities all over the world are facing similar environmental issues, one of them being Urban Heat Island Effect. This heating temperature affect are a result of materials such as concrete, stone and asphalt, which have a very high thermal absorptive in comparison soil and plants.

Green roofs can be installed in any location, rural or urban. (See Figure 9 &10) Green roofs can be installed on a wide range of buildings, including industrial, educational, and government facilities; offices; other commercial property; and residences. What must to be kept in mind is the weather conditions of each particular region, to pick the most
ideal plant types to go into the roof gardens that best suit the location. For the Finger Lakes region the weather is constantly fluxing. Therefore, it is important to plant a variety of plants that have different ideal growing conditions.

Figure 9: Slanted Green Roof

Source: http://en.wikipedia.org/wiki/Green_roof

Figure 10: Flat Green Roof

Source: http://en.wikipedia.org/wiki/Green_roof

Material

Depending on the type of roof you are trying to build your green roof on, the materials will vary (See Figure 11 & Figure 12).

Figure 11: Slanted Green Roof on Concrete Deck

Source: http://en.wikipedia.org/wiki/Green_roof

Figure 12: Slanted Green Roof on Steel Deck

Source: http://en.wikipedia.org/wiki/Green_roof

Native Plants

When choosing which plants to install in the green roof, it is ideal to choose plants that will survive in the weather conditions of the region. Therefore it is ideal to use native plant species. This is because those native plant species are the original crops and plants that thrive in the conditions of the area. Those native plants from the Finger Lakes region that will thrive on green roofs are grasses: Big Bluestems, Feather Reed Grass, Sedge and Switchgrass, Ferns: cinnamon fern and royal fern, Shrubs: summersweet, spice bush and inkberry, and Flowers: Bee balm, cardinal flower, Obedient plant, green-headed and blue flag iris.

How It Works

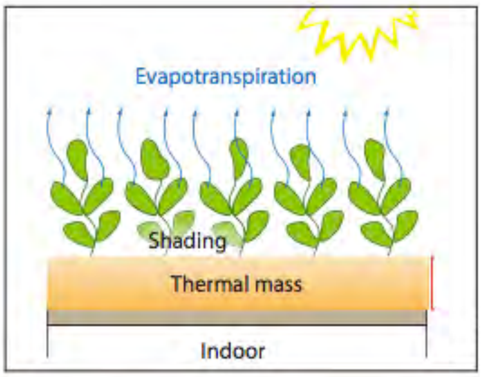
With regard to urban heat islands, green roofs work by shading roof surfaces and through evapotranspiration. Using green roofs throughout a city can help reduce surface urban heat islands and cool the air.

Shading

The plants of a green roof and specially engineered soil must have consciously blocked sunlight, so it does not reach the underlying roof membrane. Though trees and vines may not be common on green roofs, they indicate how other vegetation on green roofs shade surfaces below them.

"The amount of sunlight transmitted through the canopy of a tree will vary by species. In the summertime, generally only 10 to 30 percent of the sun's energy reaches the area below a tree, with the remainder being absorbed by leaves and used for photosynthesis and some being reflected back into the atmosphere. In winter, the range of sunlight transmit-ted through a tree is much wider—10 to 80 percent—because evergreen and deciduous trees have different wintertime foliage, with deciduous trees losing the leaves and allowing more sunlight through. Shading reduces surface temperatures below the plants."

Figure 13: Shading on a Green Roof



Source:
http://www.epa.gov/heatisland/resources/pdf/GreenRoofsCompendium.pdf

Evaporation

Plants absorb water through their roots and emit it through their leaves—this movement of water is called transpiration. Evaporation, the conversion of water from a liquid to a gas, also occurs from the surfaces of vegetation and the surrounding growing medium.. Evapotranspiration cools the air by using heat from the air to evaporate water. (See Figure 13)

Green roof temperatures depend on the roof's composition, moisture content of the growing medium, geographic location, solar exposure, and other site-specific factors. Through shading and evapotranspiration, most green roof surfaces stay cooler than conventional rooftops under summertime conditions. Numerous communities and research centers have compared surface temperatures between green and conventional roofs.

Site Prep Design

Installation Steps

1. Place a waterproof membrane on top of the roof, this is the base layer to the green roof.
2. Cover the rood with soil that is best suited for the weather condition of your area.
3. Then plant the roof with sedums and moss
4. Then water the roof thoroughly after then soils, sedums and moss are installed
5. Finally plant whatever grasses and plants you want on your roof.

Maintenance

Some cost can also be attributed to maintenance. Extensive green roofs have low maintenance requirements but they are generally not maintenance free. Maintenance of green roofs often includes fertilization to increase flowering and succulent plant cover. If aesthetics are not an issue, fertilization and maintenance are generally not needed. Extensive green roofs should only be fertilized with controlled-release fertilizers in order to avoid pollution of the stormwater. Conventional fertilizers should never be used on extensive vegetated roofs. It is also important to use a substrate that does not contain too many available nutrients.

Zoning

The city of Geneva does not have any specific regulations concerning green roofs. However, chapter 350 article X Historic Zoning should be reviewed before any plans are implemented. The section outlines procedures and applications that must be reviewed before any alteration to a historic building may happen.

Cost

A properly designed and installed green-roof system can cost 15 to 20 dollars per square foot as a total cost (with the average cost decreasing with a larger area), not including the roof's waterproof layers. Once a green roof is in full operation, the long term fiscal benefits will result, because it will be a natural temperature monitor of the building. The green roof should cut down on the amount of heat and air conditioning a building needs to maintain comfortable temperatures. Unlike conventional roofs, in the summer heat, green roofs can be 20-60 degrees cooler. The reduction in cost will be most evident in the monthly costs of electricity and natural gas use in a building. A living green roof will also extend the life of your roof by 20-40 years because it absorbs destructive UV rays. Green roofs also prevent extremely high temperatures from breaking down the waterproof membrane of roofs.

Figure 14: Green Roof

Source: http://charlestongreenroofs.com/what_are_green_roofs

Green roofs have diverse benefits for individuals and communities. They improve air quality, taking in pollutants and producing oxygen; they slow runoff of precipitation and are great water-harvesting tools. They also serve as "oases" for plants and wildlife migrating through degraded urban areas. The soils and plants that make up a green roof hold a substantial amount of water, which is a fantastic insulator from both heat and cold. In hot, dry climates like the desert southwest, this water also evaporates and cools the air above and around the green roof. If you have many or very large green roofs, they can actively cool down the ambient temperature of their surrounding urban area. Since so many cities suffer from overheating and the Urban Heat Island effect, green roofs have exciting potential (See Figure 14).

Benefits of installing a Green Roof

- Reduce stormwater run-off which, in turn, reduces the stress on urban sewer systems and decreases run-off related pollution of natural waterways
- Insulating qualities mean reduced energy costs for building owners
- Air quality improvement – lower rooftop temperatures mean less smog from the "urban heat island effect"
- Noise pollution reduction – studies show noise levels in a building can be reduced by as much as 40 decibels
- Extended life of the roof system due to moderated temperature swings that cause a roof system to expand and contract as well as protection from everyday wear and tear.

Storm Drain Marking

Storm drain marking is labeling a storm drain inlet with a pre-printed marker, title, sticker, or stencil that has a message to prevent pollution into storm drains. The message can read "Dump No Waste", or a similar written message that specifies the water body to which the storm drain inlet drains.

Introduction

When rainfall carries pollutants from a wide variety of sources into surface water or ground water, this creates nonpoint source pollution. Nonpoint source pollutants can be chemicals, such as pesticides and fertilizers. They can also be gasoline, motor oil, anti freeze and road salt (see Figure 1). The pollutants can also be natural, like soils, animal wastes, grass clippings and fallen leaves (see Figure 2). In urban areas, most nonpoint source pollutants get swept from rainfall flow, into drains and then into the waterways, leading to larger bodies of water.

Figure 1: Storm drain pollution

Source: hhttp://www.wilmingtonnc.gov/public_services/stormwater/report_stormwater_pollution

The polluted runoff flows through the storm sewer underground and is released untreated into local waterways. Many people do not know that storm drain inlets empty out directly into bodies of water. The lack of knowledge and care enables people to pollute. This contributes to the disconnect of action and outcome. Storm drain marking is a method used to maximize citizens' consciousness of what polluting storm drain results in for the environment.

Storm drain marking involves labeling storm drain inlets with plaques, tiles, and painted or pre-cast messages warning citizens not to dump pollutants into the drain. The messages are generally a simple phrase or graphic to remind those passing by that the storm drains connect to local water bodies and that dumping will pollute those waters (See Figure 3 & 4 & 5). Some storm drain markers specify which water body the inlet drains to or name a particular river, lake, or bay. For this area, we would use the Finger Lakes.

Figure 3: Storm drain marking

Source:
hhttp://www.ennisflint.com/Products/Preformed-Thermoplastic/PreMark/PreMark-Galleries/Two-Layer-Stencils-Gallery

Figure 4: Storm drain marking

Source:
http://www.clflwd.org/resources_news.php

Figure 5: Storm drain marking

Source:
http://www.watershedactivities.com/projects/summer/stormdrn.html

Storm Drain Marking provides a visible reminder of the consequences of improper waste disposal in storm drains. The focus is on storm drains because they are direct conduits that can carry pollution into area rivers and streams. Storm drain marking is one way to remind the public that storm sewers are for water and not trash.

Application in a Historic District

Storm drain markings are a relatively new technique designed to educate the public about where material that is dumped into storm drains, sewer grates and other gutters ends up – local water bodies. Because storm drain markings did not exist historically, there are no precedents to guide their incorporation into a historic district. But, like any signage in a historic district, they can be designed as such to be compatible with the overall aesthetic of the district. It is recommended that permanent sign type marking be used. These can be designed to even indicate that they are in a historic district, or can use serif fonts or historic color schemes so that they have a low visual profile. Because storm drain markings are so small and occur on the sidewalk or storm drain it is not anticipated that they would have a negative impact on the character of a historic district.

History and Aesthetics

Storm drain marking is a relatively modern green infrastructure technique. It was created and implemented in the late twentieth century. One of the first cities to undertake a storm drain-marking project successfully was in Austin, Texas in 1995. After experiencing an increased amount of storm drain pollution, the water protection department of Texas implemented this project.

The Finger Lakes does not have a history of storm drain marking projects historically, but has many storm drains in the historic districts, especially Geneva and Canandaigua, where there is a higher population.

Site Prep Design

Applicability

The entire community, in particular those areas that are more susceptible to where water or where trash, nutrients or biological oxygen demand has been a pollutant can participate in storm drain marking projects. And despite the condition of the body of water, these storm drain signs can raise awareness about storm drains and where it flows.

The drains should be carefully selected to send the message to the maximum number of citizens (for example, in areas of high pedestrian traffic) and to target drains leading to water bodies where illegal dumping has been identified as a source of pollution.

Implementation & Zoning

To successfully implement storm drain marking projects, it needs to be approved by local governmental regulations. This is because storm drains are public property and any unapproved art around it would be considered vandalism. The city of Geneva does not have any specific regulations pertaining to storm drain marking, but it cannot be implemented without permission first.

Figure 6: Paste Storm drain marking

Source: http://www.ccia-net.com/solid_waste/cleancommunities.aspx

If municipalities are the ones establishing storm drain markings, then there should be a prioritization of which storm drains are most passed by or have the potential to be dumped into. The drains should be carefully selected to send the message to the maximum number of citizens (for example, in areas of high pedestrian traffic) and to target drains leading to water-bodies where non-point source pollution has been identified.

Municipal crews or volunteers can paste or stencil messages on storm drains (See Figure 6 & Figure 7). Some municipalities may have their own workers to produce a message, to eliminate liability and safety concerns.

Figure 7: Stencil storm drain marking

Source: https://www.facebook.com/savebuzzardsbay?rf=171214736266070

On the other hand, volunteer groups could conduct marking projects in cooperation with a municipality. If this arrangement between municipalities and volunteers were to happen, usually volunteer groups provide the labor and the municipality provides supplies, safety equipment, and a map or directions to the drains to be marked. Using volunteers lowers costs and increases public awareness of stormwater pollutants and their path to water bodies. A municipality can establish a program to comprehensively address storm drain marking, actively recruit volunteer groups to help, or facilitate volunteer groups that take the initiative to undertake a marking project.

Organizers Role

Whoever initiates the storm drain marking project, the municipality or volunteer group should assign a person to be the leader of the project. The one responsible should coordinate volunteers and the process of the project. The best candidate for the project leader is someone who has background in public works or water quality department. Since this program is heavily dependent on the labor of volunteers, those who organize and coordinator the project should possess skills in recruiting, training, managing, and recognizing volunteers. Organizers and coordinators should provide the following:

- Marking kits containing all materials and tools needed to carry out a marking project,
- A map of the storm drains to be marked,
- Training for volunteers on safety procedures and on the technique for using stencils or affixing signs,
- Safety equipment (traffic cones, safety vests, masks or goggles for spray paint, and gloves if glue is used), and
- Incentives and rewards for volunteers (e.g. badges, T-shirts, certificates).

Another recommendation is for organizers to keep track of which storm drains are polluted, so that serious instances of dumping may be recorded and action taken. Participants in storm drain marking projects can also note storm drains that are clogged with debris. This way the city can organize future clean up efforts.

Organizers should organize and instruct volunteers on the signs of dumping and explain how to fill out data cards. In addition, volunteers should record the locations of all storm drains labeled during the project for the city to track. It would also be beneficial to get feedback from volunteers for organizers can improve future marking projects.

Organizers should utilize all advertisements opportunities as possible. This will not only make people more aware of the project, but it will potentially get more volunteers. Contact newspapers to provide advanced notice of a planned storm drain marking event. Public service announcements made before the event also will help to reinforce the message. Additionally, in targeted neighborhoods, volunteers can distribute door hangers that notify residents that storm drain marking is taking place, explain the purpose of the project, and offer tips on how citizens can reduce urban runoff.

Figure 8: Permanent Sign

Source: http://www.wilmingtonnc.gov/public_services/stormwater/education_outreach/storm_drain_marking

Since marking projects take place on city streets, volunteer safety is of utmost importance. The city might wish to designate lower-traffic residential areas as targets for volunteer marking and provide safety equipment and training. Most programs require that marking be done in teams, with at least one person designated to watch for traffic. Adult supervision is needed when volunteers are school children or members of youth groups. Most cities also require participating volunteers (or their parents, in the case of minors) to sign a waiver of liability. An attorney for the municipality should be consulted to determine what liability exists and how to handle this issue.

Types of Markings

With many different crafts and materials out there being produced. When implementing stormwater marking signs, the materials that are chosen are very important. Depending on the materials, it can determine how long the marking will last and the amount of maintenance that will be needed for it.

Permanent Signs

Figure 9: Permanent Sign

Source: http://www.almetek.com/sdmenvironmental.html

One option that can be used is permanent signs. This marking can be made form aluminum, ceramic, plastic, or other durable materials (See Figure 8 & Figure 9). These signs can be affixed with adhesive applied to the street or sidewalk surface. These markers last longer than stenciled messages and need only glue to affix them to storm drain inlets. It is important to use non-toxic, double stick adhesive pads. These are available from sign manufacturers as an alternative to glue, which may not be appropriate for use by children. When creating the sign it can be done by the municipality or volunteer, but it is best to localize it so people can recognize the place affected by the pollution. These permanent signs are beneficial because they can be neater and easier to read from a distance. However, tiles or plaques can be broken by pedestrian traffic if they are disturbed before the glue dries. If you choose to use tiles or plaques it would best to block off the affixed area to ensure the glue dried properly.

Figure 10: Stencil Sign

Source: http://www.clark.wa.gov/water-resources/education/stenciling.html

Stencils

Another type of marking is stencils and paint to label their storm drains. Communities can stencil directly onto the curb, street, or sidewalk. They can also paint a white background and then stencil over it. The most commonly used stencils are made of Mylar, a flexible plastic material that can be cleaned and reused many times. (See figure 10) However, stencils can also be made from cardboard, aluminum, or other material. Because painted stencils are not as durable as other types of markers, the message might need to be retouched or reapplied every few years.

Paint or ink can be sprayed on or applied by brush and roller. Spray paint is the quickest and probably the easiest to apply neatly (See Figure 11 & Figure 12). However, regions that do not meet federal air-quality standards should avoid using spray paints, since many contain air-polluting propellants. To prevent any materials from entering the storm drain, the use of "environmentally friendly" paints free of heavy metals and low in volatile organic compounds is recommended.

Figure 11: Spray Paint Marking

Source: ttp://www.estacadaeagle.com/EACTeamsUpWithPublicWorksToPromoteCleanWaterToTheClackamasRiver.html

Figure 12: Spray Paint Marking

Source: http://www.estacadaeagle.com/EACTeamsUpWithPublicWorksToPromoteCleanWaterToTheClackamasRiver.html

When using any of the storm drain marking techniques it is imperative to make sure that the materials: glue, paints, etc. is safely not going down sewers or the storm drains (See Figure 13).

Freehand Painting

There are many opportunities to bring outreach to the community through storm drain painting (See Figure 14).

Costs

Plastic stencils, which can last for 25 to 500 stenciling, depending on whether paint is sprayed or applied with a brush or roller, can be purchased for $10-$15.50 depending on the size, materials, quantity purchased, and manufacturer. Metal stencils, which last longer, can cost $100 or more.

Figure 13: Environmental Safety with markings

Source: http://blog.baybackpack.com/?m=201008

Storm drain markers vary in cost depending on materials, design requirements, and the quantity purchased. It is important to contact the manufacturer when pricing storm drain markers because custom sizes, shapes, and designs, such as those that specify a local water body, can increase the unit cost. For stock messages, however, ceramic tile markers cost approximately $7, whereas plastic markers of 4-inch diameter range in cost from $1 and $2.95, depending on material composition and quantity purchased. Glue for affixing the marker costs approximately $.025 per application.

Door hangers and other educational materials that complement the markers can also be purchased from some manufacturers, and often a "starter kit" is offered that includes a variety of materials to conduct a public outreach campaign.

Conclusions

Benefits

If a municipality chooses to initiate a storm drain marking program and solicit the help of volunteer organizations, they can advertise through a variety of channels. They can distribute pamphlets and brochures to area service organizations, place articles in local magazines, take

Figure 14: Hand painted design by LaSheria Bailey

Source: http://baltimorecommunitygroup.wordpress.com/901-arts/

out newspaper ads, place an environmental insert in the local newspaper, make presentations at community meetings, develop public service announcements for radio, and create a website with background and contact information as well as photographs and stories from past marking events.

Storm drain marking projects offer an excellent opportunity to educate the public about the link between storm drain systems, water quality, and their watershed. It increases public awareness of stormwater issues. Volunteer groups can provide additional benefits by picking up trash near the marked storm drains and by noting where maintenance is needed. Storm drain marking projects can become a community effort. Children or local artists can get involved. (See figure 14 & 15) It improves the aesthetic of the community and creates a connection between the citizens.

Limitations

A storm drain marking project is for the most part effective and inexpensive. The limitation comes with larger communities that have many storm drain inlets. The only limitation is getting enough volunteers to put in work to go through with the program. So volunteer coordinators need to be skilled at recruiting and organizing the efforts of volunteers to provide adequate coverage over large areas. Safety considerations might also limit marking programs in areas where traffic congestion is high. Other environmental considerations, such as the use of propellants in spray paint in areas that do not meet air quality standards, should be taken into account. Finally, stenciled messages will require repainting after years of weather and traffic, and tiles and permanent signs might need replacement if they are improperly installed or subject to heavy traffic or vandalism.

Figure 15: Community Efforts for Drain Marking Projects

Source: https://www.facebook.com/TAPPWater

Effectiveness

By raising public awareness of urban runoff, storm drain marking programs should discourage practices that generate stormwater pollutants. As with any public education project, however, it is difficult to precisely measure the effect that storm drain marking programs have on human behavior. Surveys of public recognition of the storm drain message, or surveys that capture changes in behavior, can indicate whether a storm drain marking program is effective. Some municipalities attempt to assess the effectiveness of storm drain marking programs by periodically examining water samples from targeted storm drain outfalls (places where storm drains empty into a water body). If the storm drains leading to a particular outfall have been labeled, and if the levels of pollutants from that outfall decline after the labels were put in place, one can assume the labeling has been effective.

Figure 17: Community Efforts for Drain Marking Projects

Source: http://ilove.springfieldmo.org/post/5219235280/storm-drain-murals-designed-to-educate-inspire