CITY OF ROSEMOUNT:

STORMWATER MANAGEMENT PLAN

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On behalf of

The City of Rosemount

With support from

The Resilient Communities Project

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This project was supported by the Resilient Communities Project (RCP), a program at the University of Minnesota that convenes the wide-ranging expertise of U of M faculty and students to address strategic local projects that advance community resilience and sustainability. RCP is a program of the Center for Urban and Regional Affairs (CURA).

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Project Purpose

The purpose of this report is to shed light on best management practices for managing stormwater in the City of Rosemount, Minnesota. The City of Rosemount is situated 15 miles south of the Twin Cities. With a population of roughly 22,000, the citizens live in a mixed residential community consisting of single family homes, townhomes, condominiums and affordable housing all situated around its commercial center. Rosemount currently uses the traditional curb and gutter system to manage their stormwater. For large rain events, they rely solely on infiltration through retention ponding. As they are physically expanding, larger rain events are becoming more common, and the city is looking for alternative methods to accommodate their increasing volumes of stormwater.

Overpriced, traditional techniques have been looked at by the city as a possibility; such as outlet piping of excess stormwater to the Mississippi River. This was quickly ruled out as an option by the city because of the amount of investment needed in this type of infrastructure. Other techniques examined by the city are small scale systems such as rain gardens and they were ruled to be less attractive to the City of Rosemount for two reasons:

1. Community-based projects tend to be implemented and maintained on an individual level. In this way they are not always maintained to the standard that the city may require. Additionally, logistics begin to have an effect as to payment methods, tax-credits, insurance issues, and maintenance issues.
2. The City of Rosemount would rather pay for larger-scale projects focused in specific areas rather than hundreds of small projects scattered across the city. This again has implications of maintenance costs and logistics.

Research

Research topics for the report focused on BMP's that rely on infiltration and catchment of stormwater. Systems looked at in the report are pervious paving, green roofs, large scale rain gardens, bioswales, water quality channels, retention and detention ponds, and constructed wetlands. These systems were examined because of their relevance to the City of Rosemount. All these systems are effective infiltration treatments for stormwater and directly relate to new development that is starting to occur within the city.

Recommendations

As part of the findings, the report recommends that the City of Rosemount implement at least one of each system looked at in the research section. These systems include pervious paving, green roofs, large scale rain gardens, bioswales, water quality channels, retention and detention ponds, and constructed wetlands. The research shows that having at least one of each system helps to drastically reduce stormwater runoff and increase its management. Within the recommendations section of the report, maps and graphics are used to highlight areas that would be ideal for these new systems to be implemented. These maps were created using GIS information technology and Google Earth imaging software. With the implementation of these stormwater systems, the City of Rosemount will be able to manage its ever growing volume of stormwater for many years to come.

Stormwater management is quickly becoming a hot issue in today's urban planning and design fields. With climate change creating heavier, more frequent storm events, and as urban development continues, more and more stormwater runoff is produced. In areas such as Minnesota, which are rich with lakes and rivers connecting to larger systems such as The Mississippi River, increased runoff means increased flooding and standing water following large storm events. While development has been demonized recently, not all development has adverse effects. Over the past two decades, there has been an increased demand for stormwater best management practices (BMPs) to be incorporated into many large, multi-use development projects in order to mitigate the effects of urban runoff. Construction of large, impervious, developments can nearly double the volume of predevelopment runoff. Some of the trending BMPs being used to combat these higher volumes of runoff include; storm water ponds, divergence channels, rain gardens, and infiltration basins, among many more. Implementing stormwater BMPs would help to mitigate flooding caused by increased runoff and help in maintaining water quality that makes the World a more desirable place to inhabit.

Traditional stormwater management uses a curb and gutter system to shuttle water to the nearest river or stream. These practices have been in place for nearly 4000 years and have been documented as far back as the Ancient Greek city of Phaistos. These systems have prevailed primarily because of their effectiveness. They are seen in the daily landscape; outside homes, offices, restaurants, everywhere frequented by the average person. Depending on the size of the pipes used to convey the water, thousands of gallons can be moved in a matter of minutes. With the ability to quickly and effectively move large amounts of water, curb and gutter systems keep streets from flooding even in the largest of rainfall events. While this may be the most effective way to remove stormwater from a site, this method has many negative impacts to the environment.

Many curb and gutter systems do not provide a method of treating stormwater before it flows into local streams, rivers, and lakes. Thus, receiving waters are often met with harmful chemicals and debris. Many local communities and activist groups are working furiously to shut down these systems or attempting to require monitoring of discharged water.

Awareness for the necessity of clean water has risen exponentially in recent years. In the case of the Mississippi River, this creates pollution which not only impacts Minnesota, but also runs down the length of the Mississippi River and discharges into the Gulf of Mexico where it contributes to the large hypoxic zone. Besides being destructive to the environment, the amount of infrastructure needed for curb and gutter systems is vast and requires valuable resources and heavy maintenance schedules. The average cost of a traditional curb and gutter system is between $11,000-$15,000 per 500 linear feet. This doesn't even include additional factors such as widening of streets and adding additional utilities. In addition, these conveyance systems run along roadways and require routine maintenance and upkeep, contributing to inconveniences like traffic congestion caused by construction.

MODERN DAY BEST MANAGEMENT PRACTICES

There are a multitude of local stormwater BMPs which work well in controlling excessive runoff volumes, maintaining better water quality and providing a significant cost savings to a city compared to traditional curb and gutter systems. Many of these practices have already been implemented around the Twin Cities to manage stormwater. Some methods already implemented include; permeable pavement, rain gardens, bioswales and others. Each of these techniques utilizes infiltration rates of the local soils to help filter water through the ground as fast as possible. The main difference between these systems and traditional systems is that these systems allow water to infiltrate through the ground where it falls, rather than being conveyed off the site to be managed elsewhere. By allowing the water to infiltrate, pollutants are removed and utilized by native vegetation before they are able to contaminate local surface water or groundwater systems. Because these types of systems require less infrastructure, ultimately they are much less expensive to install and maintain. Depending on the system, prices can range from a couple hundred dollars to a few thousand.

While these systems do not convey stormwater off site as quickly as curb and gutter systems, they are still effective at managing stormwater runoff. However, many of these BMPs are reliant on infiltration rates of local soils, meaning that some areas will drain faster than others. Appropriate technologies need to be installed accordingly to accommodate for maximum stormwater management.

Modern best management practices such as rain gardens, bioswales and permeable pavement are able to handle standard frequent rainfall events and provide more benefits to the environment, while adding aesthetic quality to the landscape as opposed to traditional curb and gutter systems. During large rainfall events, additional multi-use temporary flooding structures may be a useful way to ensure there is no flood damage within local roadways, parks and private lots.

The City of Rosemount is situated 15 miles south of the Twin Cities. Established in 1856, it has since developed to include approximately 35 square miles of industry, agriculture and residences. The population of roughly 22,000 people live in a mixed-residential community consisting of single family homes, townhomes, condominiums and affordable housing, all situated around its commercial center. Rosemount is a strong business community which plans to expand through the industrial and commercial lands which have been reserved for future development. Currently, the northeastern third of the City is occupied by industries such as Flint Hills Resources, SKB, Spectro Alloys and Hawkins Chemical. The western third of the city hosts businesses such as Greif Brothers, the regional home base for the National Guard and an 80 acre business park. The community has preserved 302 acres of land over 23 parks for the residents to enjoy as well as an additional 270 acres of the Spring Lake Regional Park Preserve. Additionally, future development plans of the City provide ample opportunity to implement modern stormwater best management practices.

Rosemount currently uses the traditional curb and gutter system to manage their typical stormwater. For large rain events, they rely solely on infiltration through retention ponding. As they are physically expanding and larger rain events are becoming more frequent, the City of Rosemount is looking for alternative methods to accommodate current and future stormwater conditions.

There are four classes which describe a soils ability to infiltrate. The classes range from Group A to Group D, where Group A has the highest infiltration rates and D the lowest.

Rosemount is situated on a class of Group A and B soils; which are composed of loam and sand and infiltrate well. There are pockets of Group C and D soils consisting of clays which do not infiltrate well, however those areas can be managed with temporary surface storage if necessary. Given the predominate types of soil classes, Rosemount is situated on land which could accommodate a number of infiltration best management practices, as well as surface retention practices to manage their stormwater.

In talking with planners and engineers from the City of Rosemount, a number of concerns regarding stormwater BMP's have been addressed. The city would like to avoid certain scenarios or situations outlined below:

Small-Scale Projects

The City of Rosemount has been fairly adamant that larger-scale stormwater projects are preferred compared to small-scale, community-based projects for two reasons:

1) Community-based projects tend to be implemented and maintained on an individual level. In this way they are not always maintained to the standard that the city may require. Additionally, logistics begin to have an effect as to payment methods, tax-credits, insurance issues, and maintenance issues.
2) The City of Rosemount would rather pay for larger-scale projects focused in specific areas rather than hundreds of small projects scattered across the city limits. This again has implications of maintenance costs and logistics.

Outlet Pipe

As stated before, the City of Rosemount relies fully on soil infiltration for large storm events. There is no outlet for the city as a whole. The city has looked into running a pipe through the city to discharge flow into the Mississippi River, however the cost of construction and implementation were prohibitively high. Additionally, the potential land area lost for development as a result of the outlet pipe, has significant financial costs for the city. Additionally, this option isn't desirable because of previous discussion about the implications that large conveyance pipes have to water quality.

Land Allocation

The City would also like to use land in the most efficient way possible. Best management practices that use the smallest amount of land are most desirable, or, if large amounts of land were allocated, systems which were multifunctional could be implemented. The main reason for this is that the City wants to keep as much land available as possible for future development.

NOTE: It should be noted that some of the BMPs outlined in this document do not align directly with the wishes of the City. All feasible practices are presented in order to provide the City with all possible methods for stormwater management in the event that desires in the community evolve. Specific reasoning for each best management practice is provided to address concerns of the City.

BEST MANAGEMENT PRACTICES

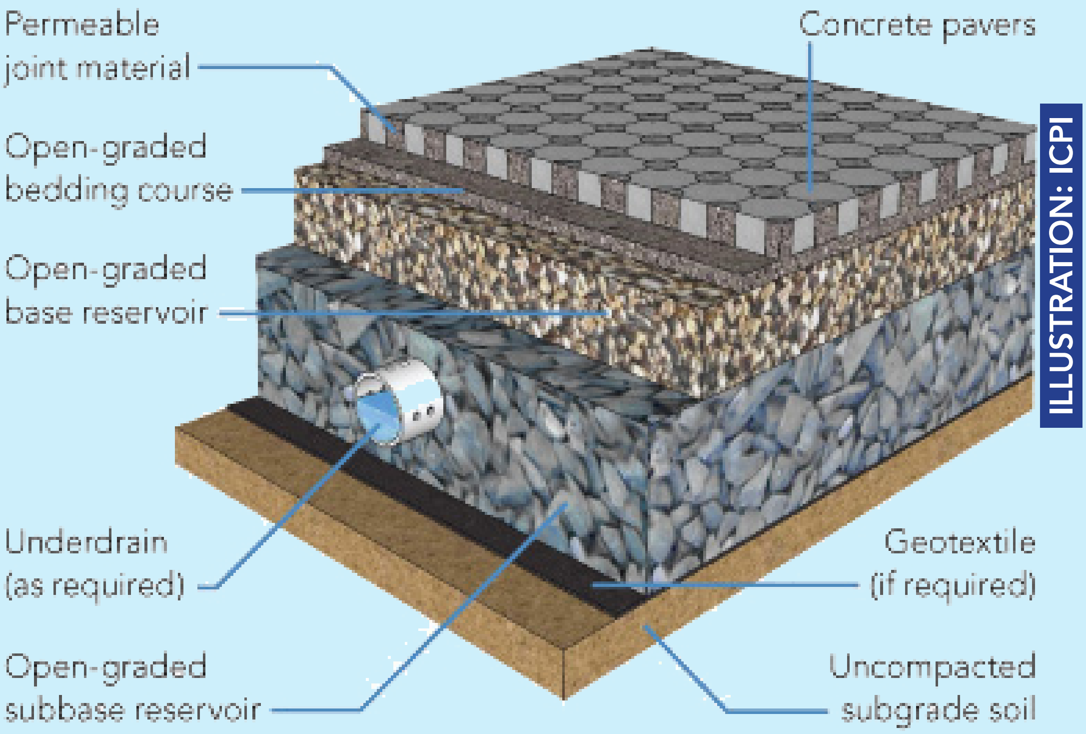
SMALL SCALE BMP'S

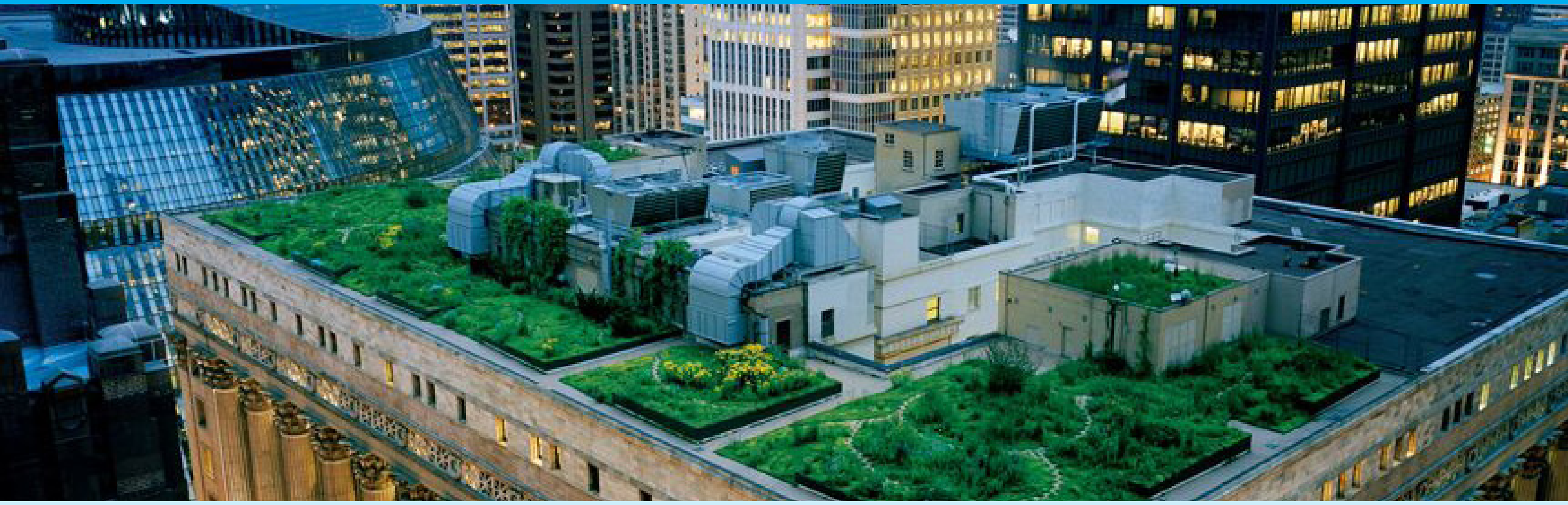
Permeable pavement is a type of pavement that allows water to drain through, typically into a stone filled reservoir that slowly infiltrates into the soil below. There are a number of variations of permeable pavement. Some options can be poured like traditional concrete and are grey in color. Other options include concrete paver blocks that are either permeable themselves or have gaps in between them that allow water to filter through. Regardless of the style of pavement use, this technology can hold a tremendous amount of rainwater. The amount of runoff most pavements can filter correlates to the volume of the rock layer in the subgrade and the infiltration rates of the soil below. Permeable pavements have been proved to have comparable strengths compared to standard concrete, however require additional maintenance not require from typical pavement. For the water to pass through the pavement pores, the pores need to be free of any small debris. The pores allow small particles of dirt and sand to pass through and can after time can cause clogging. When this happens, vacuuming is necessary to evacuate the pores and restore the pavement to optimal draining capacity. Under optimal conditions where small debris is not near the pavement, this maintenance may only need to be done once a year or every other year.

Permeable pavement is a growing trend in the landscape architecture field because of its environmental benefits and ability to function like traditional pavement, granting it a dual purpose. There have been a number of projects throughout Minneapolis which have implemented porous pavement to contain runoff generated from new development. One of these projects was Silverwood Park in the Three Rivers Park District in Northeast Minneapolis. Silverwood Park was formerly a Salvation Army Camp which had operated for nearly 100 years. Silverwood Park previously featured tennis courts, picnic areas, parking lots, and a significant amount of buried debris. In total there were 19 buildings on the 125 acre site.

In 2009, Silverwood Park was renovated including many ecological BMP's to serve as environmental education tools as well as to manage stormwater runoff into the often polluted Silver Lake. The goals of the project were to achieve Pre-European settlement runoff volumes and rates. This was accomplished through mixing natural solutions with engineered solutions. Sixty eight acres of upland vegetation and 3 acres of wetland vegetation were planted. These types of vegetation

specifically help to increase infiltration of stormwater. Additionally, half an acre of permeable pavement was installed around the new visitor center which drained into a 5,500 gallon cistern. A reinforced turf parking lots with strips of permeable pavement for cars to part on also allowed infiltration of stormwater. It is important to be mindful that a majority of a sites runoff comes directly from parking lots so permeable pavement is a great solution to mitigate this. Surface rain gardens were also installed to handle any additional storm water flow that could not be absorbed by the pavement in large storm events. The combination of these management solutions allowed efficiency to be balanced with aesthetics.



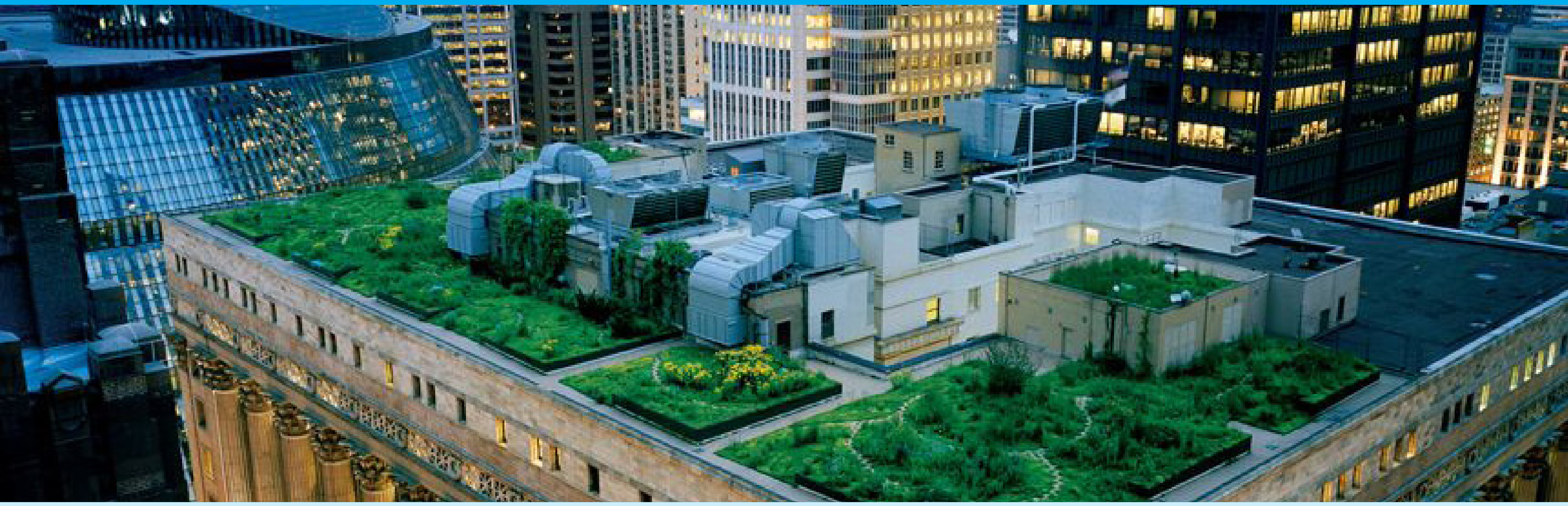


A green roof is a structurally build roofing system that utilizes engineered planting medium and native planting vegetation to absorb rainwater that falls on the roof. Green roofs work to utilize stormwater before it can reach the ground and enter a traditional curb and gutter system. Green roofs are commonly found on the roofs of large civic buildings that have limited to no pitch angle. Roofs with pitch angles can still support green roofs, however the stormwater is more likely to runoff the roof before the plants can absorb it because of the angle.

Because of their simplicity, green roofs can range in size anywhere between a small residential garage to the size of the Target Center in Minneapolis or City Hall in Chicago. The can operate in both metropolitan areas and suburban landscapes. Typical vegetation used in the planting of green roofs are sedums, alliums, delosperma, Russian Sage and several types of grass species. When selecting vegetation, it is important to keep climate factors in mind. Plants need to be well adapted to full sun since there is rarely shad on building-tops to shield them from the sun. Additionally, since the main purpose of green roof plantings is to reduce water runoff, no irrigation is necessary. The plants must not only be able to survive temporary submergence during rain events but also drought within the summer, even in Minnesota. If a plant dies off from drought, the green roof loses its ability to collect stormwater and creates costs of replacing the plants.

In 2001, City Hall in Chicago completed what is now the largest extensive green roof in the City of Chicago. The green roof has an area of approximately 20,300 square feet and is home to over 10,000 plants and 150 different types of shrubs. Chicago has seen the green roof absorb up to 75% of a one inch rainfall event before it creates any stormwater runoff. While this may not seem significant, 90% of all rainfalls in Minnesota are under one inch. Green roofs can be scaled to any size. On the roofs of large commercial and industrial developments, this could create a huge impact for stormwater runoff.

Blue roof structures are fairly similar to green roof structure with the exception of gravel trays replacing the soil and planting medium. The objective of a blue roof is to hold water until the sun evaporates access water in the trays. Blue roofs are cheaper and require less maintenance over green roofs, but fall short of aesthetically pleasing or providing habitat to insects and other flora/fauna.



PLANT LIST:

Green Roofs:

There are 3 different types of green roofs:

Extensive -- These types of green roofs contain a planting medium between 2"-6" and usually contain low plant diversity. These are also the cheapest of all the green roof systems.

Typical plant types within extensive green roofs include SUCCULENT PLANTS from the genus:

- Sedums
- Sempervivums

Semi Intensive -- These types of green roofs contain 6"-12" of soil medium and usually contain some plant diversity.

Typical planting types within semi intensive systems include GRASSES from the genus:

- Androgopon
- Festuca
- Carex

Intensive -- These systems contain +12" of soil medium and are costly to build. The benefit of these systems is the high amount of plant diversity due to the depth of soil medium.

Typically, ALPINE plant species are used in these situations for the larger trees due to their ability to grow on higher ground & in variable wind conditions

Rainwater harvesting is a technique that dates back thousands of years and is excellent way to decrease runoff volume of storm events. Indians have been using rain harvesting systems since 3000 BC. Ruins of these ancient systems can be seen on the island of Malta as well as in Israel. In the modern world, rainwater harvesting can help conserve water which can save the precious resource during droughts and help reduce water utility costs. Capturing rainwater at the source not only reduces the amount of stormwater runoff that needs to be managed, but also reduces pollution by preventing runoff flowing over contaminated pavements.

Rainwater harvesting systems can include both small personal rain barrels for use at home up to large-scale cistern systems used on commercial or public property. Rain barrel systems channel water from rooftops, into collection tanks at the end of gutter downspouts and are typically 50 to 100 gallons in size. Typically water from these systems is used for watering gardens. Larger-scale harvesting systems on the other hand can capture anywhere between 1000-100,000 gallons. These systems can occur above or below ground, and can require additional planning due to complexity, and often include components such as electronic pumps and filters. Like smaller systems, water from these systems is used for irrigation but can also be used for non-potable purposes such as toilet flushing or evaporative cooling.

One example of large-scale rainwater harvesting operates in the city of St. Anthony, Minnesota. St. Anthony is the home of a water reuse facility which collects storm water runoff and water treatment backwash (a waste product from water treatment) in a 500,000 gallon underground tank. Water channeled into the tank from 17 acres of roads, parking lots, and public facilities is used to irrigate about 20 acres of parks and greenspace. Using rainwater in this manner has had multiple benefits:

-Prevented the city from using 5 million gallons of municipally treated water
-Reduced stormwater and backwash discharge by up to 95%
-Helped contain nutrient runoff, rerouting it to be taken up by grasses and trees in the irrigation process

In addition to all these benefits, the city of St. Anthony estimates it saves $12,000 a year in water use costs.

A small-scale example of rainwater harvesting can be seen in the case of

Shepherd Creek Project of 2007 in Cincinnati, Ohio. Shepherd Creek is a 1.8 square kilometer watershed that drains into the Ohio River. A combination of best management practices were used to reduce stormwater runoff and to increase storage capacity, one of which utilized rain barrels distributed across watershed private properties. Property owners were invited to attend a reverse auction of rain barrels and rain gardens. In this reverse auction, property owners bid on barrels and gardens which would be installed for free or for compensation paid to the owner. The auction resulted in the installation of 100 barrels and 50 gardens, more than half of which were $0 bids. This strategy not only engaged property owners in the storm water reduction process, but also reduced runoff within the watershed by up to 28%.

Rain gardens and bioswales are methods of stormwater management which work by diverting runoff from impervious surfaces to depressions in the ground where they can be infiltrated into the soil and flow into the groundwater supply. As urban development expands, infiltrating on-site reduces the potential for regional flooding as well as provides an opportunity for runoff to be treated and stored by the soil. While the term rain garden and bioswales are often used interchangeably, they have slight differences. Rain gardens are typically smaller systems that use existing soils, and native flood and drought resistant plants to infiltrate runoff flows. Bioswales are usually larger systems which are engineered to hold a designated volume of runoff and sometimes use more porous soils or aggregates beneath the surface to hold more runoff before it infiltrates into the soil. Both rain gardens and bioswales can be used in residential and mixed use developments and can be used as new installations or retrofit into existing footprints.

The volume of runoff which can be infiltrated by rain gardens and bioswales is not insignificant. Rain gardens have an impervious drainage area to treatment facility are ratio of approximately 5:1 for 5 and 10 year events. Similarly, bioswales have ratios of between 5:1 and 15:1. This means that rain gardens have the potential for treating runoff from impervious areas up to five times larger than the area of the rain garden. Bioswales can treat between five and 15 times their surface area. Even in clay soils, they can have a peak flow reduction of up to 80% which is still a significant amount of flow infiltrated. Rain gardens and swales, when correctly installed, are designed to have a 24 hour drawdown of ponded water with complete drainage between 48 and 72 hours. This would negate any standing water.

While rain gardens typically use existing soils without doing many alterations, bioswales generally require a bit of excavation and alternative materials in exchange for their increased capacity. Swales are generally composed of approximately a meter of filter media consisting of sand, peat moss, double shredded mulch or similar materials in combination. Under the filter media is usually a gravel reservoir of clean uniformly graded stones approximately 50mm in diameter or a formal underdrain structure. Pre-treatment of the bioswales included introducing pea gravel trenches, forebays, stone splash pads, filter strips, and mulch.

Key design features to develop the rain gardens and bioswales are to select plants tolerant to salts, periodic flooding and drought, and snow storage. These plants are similar to those that can be used in green roofs. Native plants which have minimal maintenance requirements are ideal for mitigating maintenance costs.

A secondary benefit of rain gardens and bioswales is that they are able to remove select pollutants before they infiltrate into groundwater supply. Case studies conducted across Canada have monitored runoff quality after it has run through the rain garden or bioswale. The studies showed that rain gardens and bioswales specifically have a significant percentage reduction of effluent total suspended solids, metals, oils and greases and nutrients, however chlorides were not removed and have the potential to travel to groundwater. To avoid this, it would be useful to reduce ice usage around these infiltration technologies or to divert runoff to it early to reduce the need for deicing. Special gates can also be installed to divert chloride-high runoff for alternative management.

Rain gardens and bioswales have the potential to be long lasting nstallations. Some installations have been functioning for more than two decades with minimal maintenance and continued pollutant removal. Additionally, these local infiltration technologies can serve as an educational tool for the public to convey the importance of on-site stormwater management.

PLANT LIST:

Aquatic Plants: grown in less than 12" of water, soil is always saturated

Botanical Name:	Common Name:	Bloom Time:
Carex comosa	bottlebrush sedge	May-June
Carex crinita	fringed sedge	May-June
Carex lacustris	lake sedge	May-June
Carex stricta	tussock sedge	May-June
Eleocharis palustris	spike rush	August
Iris versicolor	blue flag iris	June-July
Juncus effusus	soft rush	July-Aug
Sagittaria latifolia	common arrowhead	July-Aug
Scirpus acutus	hardstem bulrush	June-July
Scirpus validus	softstem bulrush	July-Aug

Non-Aquatic Plants: Wildflowers or Forbs

Agastache foeniculum	fragrant hyssop	June-Oct
Allium stellatum	prairie wild onion	July-Aug
Anaphalis margaritacea	pearly everlasting	July-Sept
Anemone canadensis	Canada anemone	May-July
Arisaema triphyllum	jack-in-the-pulpit	April-June
Asclepias incarnata	swamp milkweed	June-Aug
Asclepias tuberosa	butterfly flower	June-Sept
Aster novae-angliae	New England aster	Aug-Oct
Boltonia asteroides	boltonia	Aug-Sept
Dalea purpurea	purple prairie clover	June-July
Echinacea angustifolia	purple coneflower	July-Aug
Eupatorium maculatum	Joe-Pye weed	July-Sept
Gentiana andrewsii	bottle gentian	Aug-Oct
Geum triflorum	prairie smoke	April-June

NOTE: A a general note, using a variety of plants in tight groups of 3's 5's or 7's will allow the rain garden to look and function to its full extent. Bloom times should also be considered to achieve a year-round aesthetically pleasing effect. Consult with a landscape architect, designer, or horticulturist should any questions or concerns arise.

PLANT LIST:

Non-Aquatic Plants: Wildflowers or Forbs (cont.)

Botanical Name:	Common Name:	Bloom Time:
Helianthus maximiliani	Maximilian sunflower	Aug-Oct
Liatris pychnostachya	prairie blazing star	July-Sept
Lobelia cardinalis	cardinal flower	July-Oct
Lobelia siphilitica	great blue lobelia	July-Oct
Monarda fistulosa	wild bergamot	July-Aug
Rudbeckia hirta	black-eyed Susan	June-Oct
Rudbeckia laciniata	wild goldenglow	July-Aug
Thalictrum dasycarpum	tall meadow rue	June
Uvularia grandiflora	large-flowered bellwort	May
Verbena hastata	blue vervain	June-Sept
Zizia aurea	golden Alexander	May-July

Graminoides (grasses and grass-like plants)

Acorus calumus	sweet flag	July-Aug
Andropogon gerardii	big bluestem	July-Sept
Bouteloua curtipendula	side oats grama	July-Sept
Bouteloua gracilis	blue grama	July-Sept
Bromus kalmii	Kalm's brome	June-July
Calamagrostis canadensis	bluejoint grass	July-Sept
Carex bebbii	Bebb's sedge	May-June
Carex comosa	bottlebrush sedge	May-June
Carex lacustris	lake sedge	May-June
Carex pensylvanica	Pennsylvania sedge	May
Carex scoparia	pointed broom sedge	May-June
Carex sprengelii	Sprengel's sedge	June-July
Carex stricta	tussock sedge	May-June
Carex vulpinoidea	fox sedge	May-June
Eleocharis palustris	spike rush	Aug

NOTE: A a general note, using a variety of plants in tight groups of 3's 5's or 7's will allow the rain garden to look and function to its full extent. Bloom times should also be considered to achieve a year-round aesthetically pleasing effect. Consult with a landscape architect, designer, or horticulturist should any questions or concerns arise.

PLANT LIST:

Graminoides (grasses and grass-like plants) (cont.)

Botanical Name:	Common Name:	Bloom Time:
Elymus hystrix	bottlebrush grass	June-July
Glyceria canadensis	rattlesnake manna grass	July-Aug
Glyceria grandis	tall manna grass	July-Aug
Hierochloe odorata	sweet grass	May-June
Juncus effusus	soft rush	July-Aug
Juncus tenuis	path rush	July-Aug
Koeleria macrantha	June grass	June-July
Panicum virgatum	switchgrass	June-Oct
Schizachyrium scoparium	little bluestem	July-Sept
Scirpus atrovirens	green bulrush	June-July
Scirpus cyperinus	wool grass	June-July

Shrubs and Small Trees

Amelanchier laevis	serviceberry	April-May
Aronia melanocarpa	black chokeberry	May-June
Cornus alternifolia	pagoda dogwood	May-July
Cornus racemosa	gray dogwood	May-July
Cornus sericea (stolonifera)	red-osier dogwood	May-July
Corylus americana	American hazel	March-April
Diervilla lonicera	bush honeysuckle	June-July
Prunus virginiana	chokecherry	May
Sambucus pubens	red berried elderberry	May
Symphoricarpos albus	snowberry	May-July
Viburnum atropurpurea	downy arrowwood	May-June
Viburnum lentago	nannyberry	May-June
Viburnum trilobum	highbush cranberry	June

NOTE: A a general note, using a variety of plants in tight groups of 3's 5's or 7's will allow the rain garden to look and function to its full extent. Bloom times should also be considered to achieve a year-round aesthetically pleasing effect. Consult with a landscape architect, designer, or horticulturist should any questions or concerns arise.

LARGE SCALE BMP'S

Wetlands are land areas that are saturated with water, either permanently or seasonally, such that it takes on the characteristics of a distinct ecosystem. Wetlands are a critical component for managing stormwater and groundwater within the state of Minnesota. They are natural sponges that serve as filters and barriers to larger watershed systems. Additionally, they provide much social value by creating an environment for recreating. Canoeing, kayaking, hunting, fishing, and exploring are just a handful of recreational activities that wetlands may provide. They also can be a source of income in regards to fisheries and spatial amenities coveted by developers.

The state of Minnesota's Department of Natural Resources (DNR) identifies six different categories of wetlands: bogs, marshes, shallow open water, swamps, basins, and wet meadows. These six groups give way to sub-categories that go into further depth to the distinct characteristics of soil, hydrology, vegetation, and site location.

Historically, the value of wetlands was thought to be little, and developers would commonly fill them in to accommodate urban development projects, and by 1990 the state of Minnesota had lost over 52% of its naturally occurring wetlands. However, with the introduction of the Minnesota's Wetland Conservation Act of 1991, the deconstruction of wetlands is now highly regulated and requires developers to construct greater wetland areas in a 2:1 ratio based on what they fill. Additionally, rare wetland types such as calcareous fens are protected under state law and are unable to be filled or altered for any reason.

There are significant environmental benefits to both natural and constructed wetlands. Wetland vegetation can reduce erosion along lakes and stream banks by decreasing the effects of wave action. Wetlands can slow stormwater runoff, reducing the likelihood of flooding neighboring areas. They serve as a source of groundwater recharge and discharge by allowing water to percolate at a slow rate into the aquifer. Contrarily, wetlands may also discharge groundwater supplies during drought periods. This helps to reduce the effects of short-term drought on lakes and rivers. Wetlands act as natural sponges and filters. They trap water, sediments, nutrients and pollutants in their soils allowing clean water to flow into larger water-body systems. Finally, wetlands serve as habitat to wildlife and rare species of both flora and fauna. Roughly 43% of threatened flora and fauna species within the U.S. rely on wetlands to survive. Additionally, many species of

fish use wetlands as a source for food, habitat, and for spawning cycles.

Retaining the highest amount of naturally occurring wetlands is ideal; however, urban development will continue to give-way to engineered wetland construction. These engineered ecosystems remain highly valuable in filtering and storing stormwater, while also creating habitat for hundreds of flora and fauna species. Constructed wetlands will also typically connect to a larger stormwater management system and may be placed in locations to create aesthetically pleasing landscapes within the urban environment. In addition to the six traditional types of wetlands, new research has been experimenting with the concept of 'floating wetlands.' These are systems that sit on constructed trays in larger stormwater ponds to help absorb nutrients and pollutants, and manage sediment deposits.

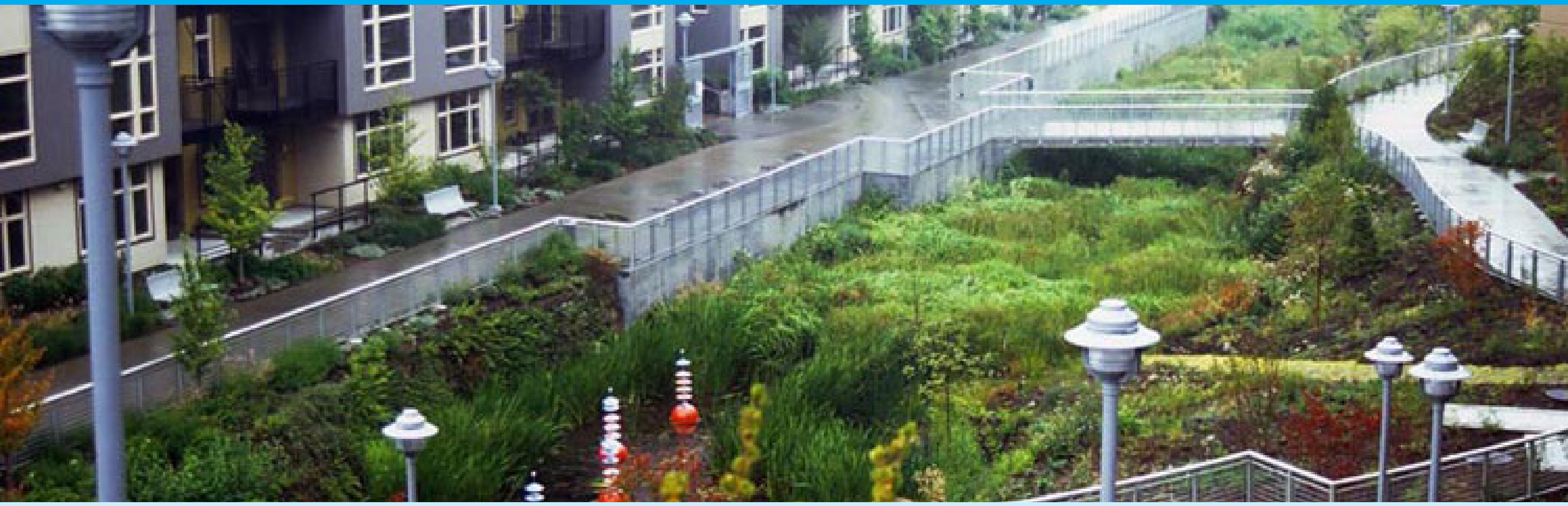
PLANT LIST:

River Banks & Wetlands

Botanical Name:	Common Name:	Bloom Time:
Andropogon gerardii	big bluestem	Aug-Sept
Aquilegia canadensis	wild columbine	June-July
Aster cordifolius	heart-leaved/blue wood aster	Aug-Sept
Aster ericoides	heath aster	Aug-Sept
Aster novae-angliae	New England aster	Sept-Oct
Bouteloua curtipendula	sideoats grama	July-Sept
Chelone glabra	white turtlehead	Aug
Cornus sericea	red osier dogwood	year round
Eupatorium maculatum	Joe-Pye weed	July-Aug
Eupatorium perfoliatum	boneset	July-Aug
Geranium maculatum	wild geranium	May-June
Iris cristata	dwarf crested iris	May
Liatris punctata	dotted blazing star	Sept-Oct
Lobelia cardinalis	cardinal flower	Aug-Sept
Lobelia siphilitica	great blue lobelia	Aug-Sept
Mimulus moschatus	monkey flower	July
Phlox divaricata	woodland phlox	May-June
Rudbeckia laciniata	greenheaded coneflower	Aug-Sept
Schizachyrium scoparium	little bluestem	Aug-Sept
Vernonia fasciculate	ironweed	July-Aug
Viola canadensis	Canada violet	June-Aug

Note: ***Majority of aquatic plants in rain garden/water quality channel plant list will work in constructed wetland settings***

NOTE: A a general note, using a variety of plants in tight groups of 3's 5's or 7's will allow the rain garden to look and function to its full extent. Bloom times should also be considered to achieve a year-round aesthetically pleasing effect. Consult with a landscape architect, designer, or horticulturist should any questions or concerns arise.



A water quality channel is essentially a larger version of a bioswale designed to be aesthetically pleasing, provide recreational opportunities, and establish habitat and filtration qualities within an urban settings. More importantly, water quality channels are designed to be the first line of defense before harmful pollutants and sediments enter into larger water-bodies and naturally occurring systems.

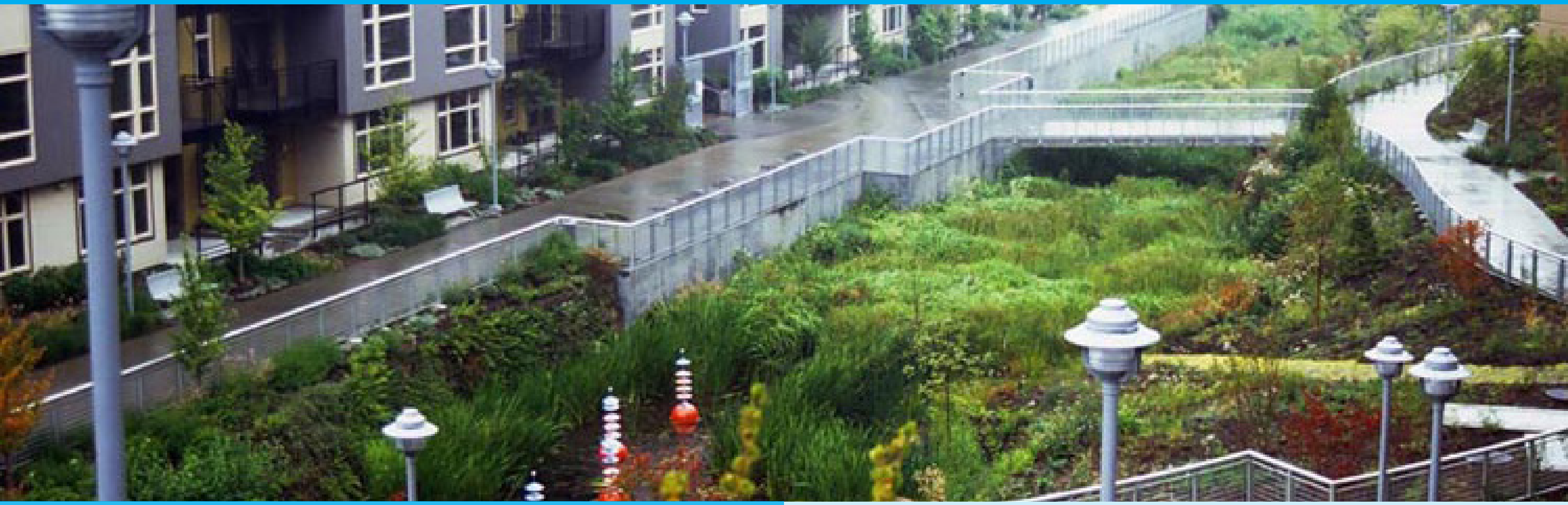
Typically, water quality channels contain at least three key design elements: wet bioswale areas to channelize water, sediment pools to allow for suspended solids to settle and nutrient uptake by vegetation, and a base flow channel to allow for constant running water within the channel, even throughout drought conditions. These channel systems, if designed correctly, can remove up to 80% of total suspended solids from stormwater runoff. While these BMP devices accommodate the majority of stormwater runoff, given their context and design parameters; typically, a bypass pipe reroutes additional water into an existing city sewer systems or other BMP's during large storm events.

Water quality channels also have the ability to serve multiple purposes. Water quality channels, since they are aesthetically pleasing, can become destinations in addition to managing stormwater runoff. A large swath of vegetation and water running through the middle of a major commercial & residential development project increases its value by not only being aesthetically pleasing but also accommodates runoff from the development, provides recreational uses, and helps to establish urban tree canopy and habitat.

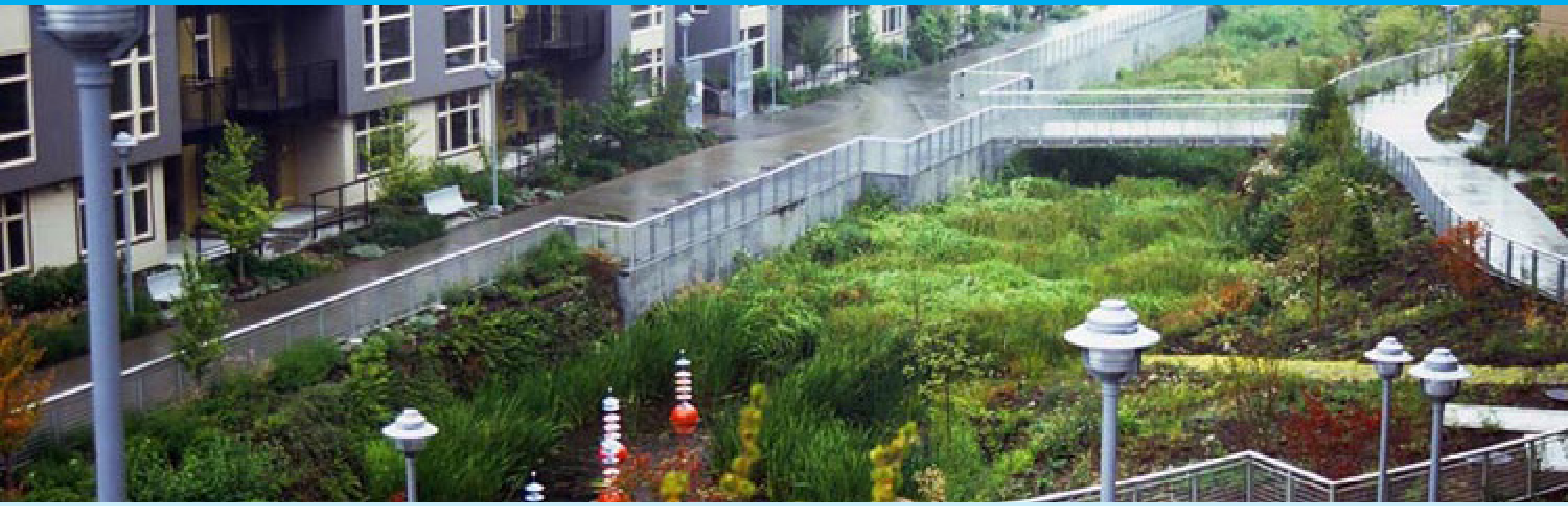
Additionally, these BMP systems, have the ability of being scaled appropriately. In urban settings, typically the price of land is high. Certain BMP practices require a lot of land to have positive effects such as wetlands. However, a water quality channel can be designed to fit into a relatively small, linear area and still provide a high amount of beneficial functions. This quality alone will be useful as populations being to rise and urban land becomes increasingly expensive and valued.

An example of a successful installation of a water quality channel can be seen in the Thornton Creek Water Quality Channel in Seattle, Washington. "The Thornton Creek Water Quality Channel is a step towards improving the balance between urbanization and environmental sustainability. The Facility is located in the Northgate neighborhood, near the headwaters of

WATER QUALITY CHANNELS



Thornton Creek's South Fork. The Facility is designed to remove pollutants from stormwater by slowing urban runoff before these flows enter the creek. The Facility, in conjunction with improvements to surrounding roadways, Northgate Mall, Northgate Library and the Northgate Community Center, is part of a larger strategy to revitalize the Northgate Urban Center."



PLANT LIST:

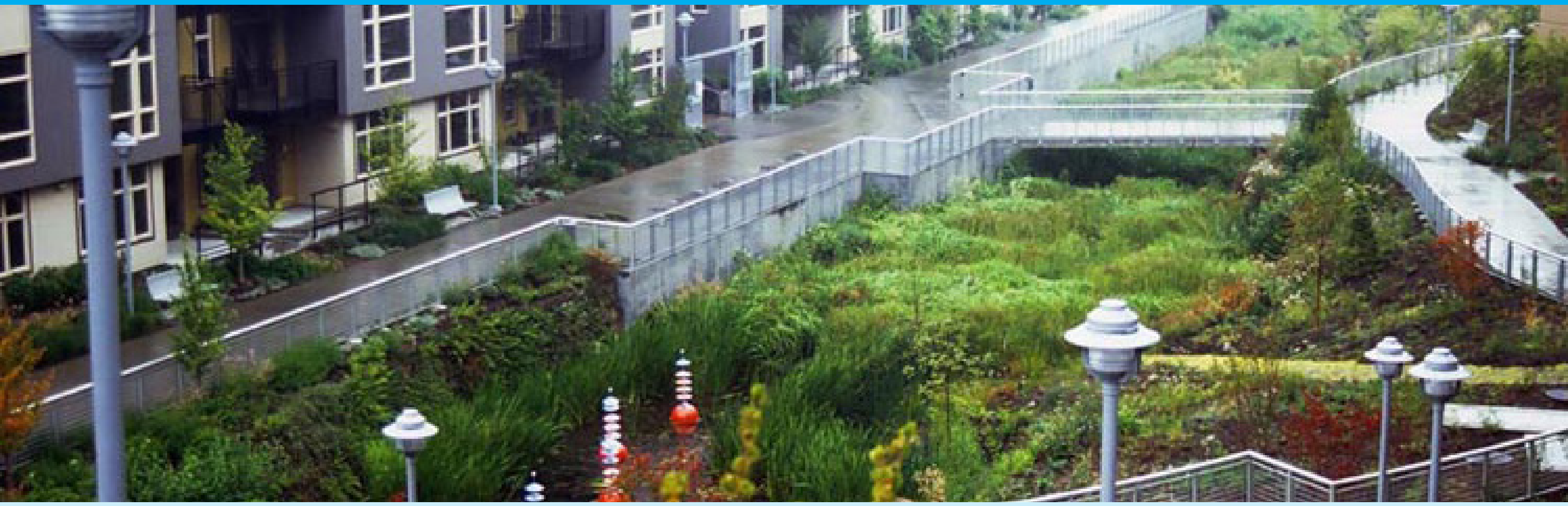
Aquatic Plants: grown in less than 12" of water, soil is always saturated

Botanical Name:	Common Name:	Bloom Time:
Carex comosa	bottlebrush sedge	May-June
Carex crinita	fringed sedge	May-June
Carex lacustris	lake sedge	May-June
Carex stricta	tussock sedge	May-June
Eleocharis palustris	spike rush	August
Iris versicolor	blue flag iris	June-July
Juncus effusus	soft rush	July-Aug
Sagittaria latifolia	common arrowhead	July-Aug
Scirpus acutus	hardstem bulrush	June-July
Scirpus validus	softstem bulrush	July-Aug

Non-Aquatic Plants: Wildflowers or Forbs

Agastache foeniculum	fragrant hyssop	June-Oct
Allium stellatum	prairie wild onion	July-Aug
Anaphalis margaritacea	pearly everlasting	July-Sept
Anemone canadensis	Canada anemone	May-July
Arisaema triphyllum	jack-in-the-pulpit	April-June
Asclepias incarnata	swamp milkweed	June-Aug
Asclepias tuberosa	butterfly flower	June-Sept
Aster novae-angliae	New England aster	Aug-Oct
Boltonia asteroides	boltonia	Aug-Sept
Dalea purpurea	purple prairie clover	June-July
Echinacea angustifolia	purple coneflower	July-Aug
Eupatorium maculatum	Joe-Pye weed	July-Sept
Gentiana andrewsii	bottle gentian	Aug-Oct
Geum triflorum	prairie smoke	April-June

NOTE: A a general note, using a variety of plants in tight groups of 3's 5's or 7's will allow the water wuality channel to look and function to its full extent. Bloom times should also be considered to achieve a year-round aesthetically pleasing effect. Consult with a landscape architect, designer, or horticulturist should any questions or concerns arise.



PLANT LIST:

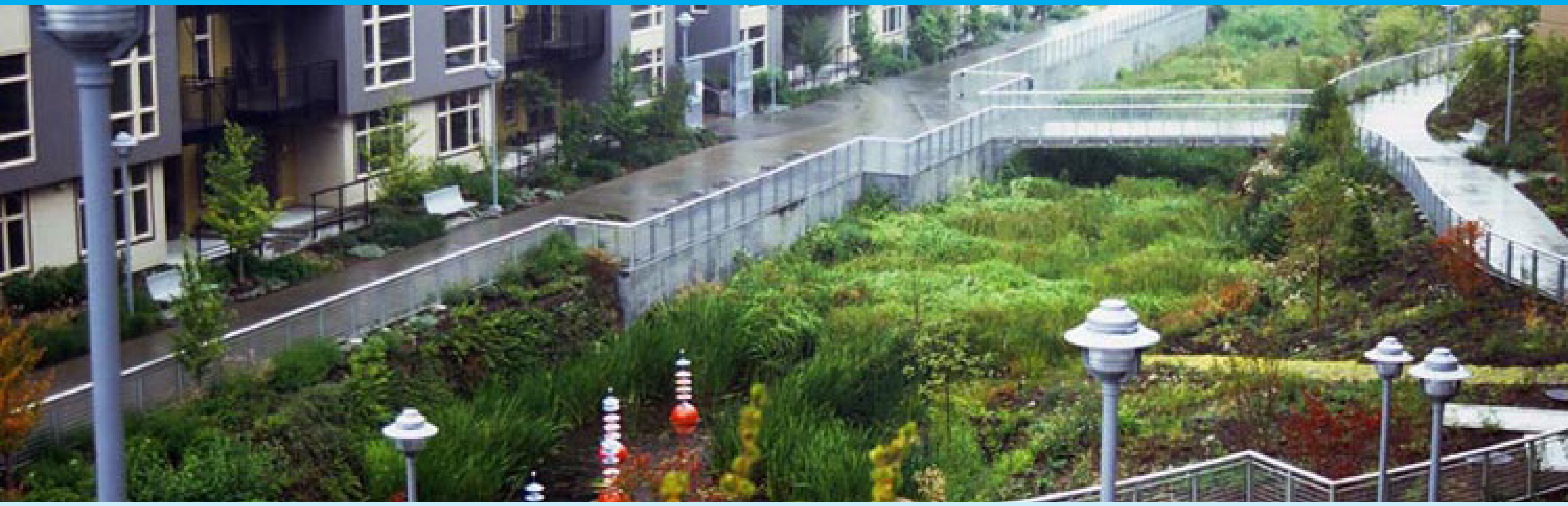
Non-Aquatic Plants: Wildflowers or Forbs (cont.)

Botanical Name:	Common Name:	Bloom Time:
Helianthus maximiliani	Maximilian sunflower	Aug-Oct
Liatris pychnostachya	prairie blazing star	July-Sept
Lobelia cardinalis	cardinal flower	July-Oct
Lobelia siphilitica	great blue lobelia	July-Oct
Monarda fistulosa	wild bergamot	July-Aug
Rudbeckia hirta	black-eyed Susan	June-Oct
Rudbeckia laciniata	wild goldenglow	July-Aug
Thalictrum dasycarpum	tall meadow rue	June
Uvularia grandiflora	large-flowered bellwort	May
Verbena hastata	blue vervain	June-Sept
Zizia aurea	golden Alexander	May-July

Graminoides (grasses and grass-like plants)

Acorus calumus	sweet flag	July-Aug
Andropogon gerardii	big bluestem	July-Sept
Bouteloua curtipendula	side oats grama	July-Sept
Bouteloua gracilis	blue grama	July-Sept
Bromus kalmii	Kalm's brome	June-July
Calamagrostis canadensis	bluejoint grass	July-Sept
Carex bebbii	Bebb's sedge	May-June
Carex comosa	bottlebrush sedge	May-June
Carex lacustris	lake sedge	May-June
Carex pensylvanica	Pennsylvania sedge	May
Carex scoparia	pointed broom sedge	May-June
Carex sprengelii	Sprengel's sedge	June-July
Carex stricta	tussock sedge	May-June
Carex vulpinoidea	fox sedge	May-June
Eleocharis palustris	spike rush	Aug

NOTE: A a general note, using a variety of plants in tight groups of 3's 5's or 7's will allow the water wuality channel to look and function to its full extent. Bloom times should also be considered to achieve a year-round aesthetically pleasing effect. Consult with a landscape architect, designer, or horticulturist should any questions or concerns arise.



PLANT LIST:

Graminoides (grasses and grass-like plants) (cont.)

Botanical Name:	Common Name:	Bloom Time:
Elymus hystrix	bottlebrush grass	June-July
Glyceria canadensis	rattlesnake manna grass	July-Aug
Glyceria grandis	tall manna grass	July-Aug
Hierochloe odorata	sweet grass	May-June
Juncus effusus	soft rush	July-Aug
Juncus tenuis	path rush	July-Aug
Koeleria macrantha	June grass	June-July
Panicum virgatum	switchgrass	June-Oct
Schizachyrium scoparium	little bluestem	July-Sept
Scirpus atrovirens	green bulrush	June-July
Scirpus cyperinus	wool grass	June-July

Shrubs and Small Trees

Amelanchier laevis	serviceberry	April-May
Aronia melanocarpa	black chokeberry	May-June
Cornus alternifolia	pagoda dogwood	May-July
Cornus racemosa	gray dogwood	May-July
Cornus sericea (stolonifera)	red-osier dogwood	May-July
Corylus americana	American hazel	March-April
Diervilla lonicera	bush honeysuckle	June-July
Prunus virginiana	chokecherry	May
Sambucus pubens	red berried elderberry	May
Symphoricarpos albus	snowberry	May-July
Viburnum atropurpurea	downy arrowwood	May-June
Viburnum lentago	nannyberry	May-June
Viburnum trilobum	highbush cranberry	June

NOTE: A a general note, using a variety of plants in tight groups of 3's 5's or 7's will allow the water wuality channel to look and function to its full extent. Bloom times should also be considered to achieve a year-round aesthetically pleasing effect. Consult with a landscape architect, designer, or horticulturist should any questions or concerns arise.

Wet detention or retention ponds are a best management practice employing an unlined basin with a permanent pond which serves to reduce both runoff and pollution. During a storm event, water is directed toward the pond where it can collect. The pond allows for sediment and pollutants suspended in the water to settle. Additionally, nutrients are taken up by aquatic vegetation which are typically planted in and around the pond. The clean water is then flushed out by the next storm event and the cycle continues.

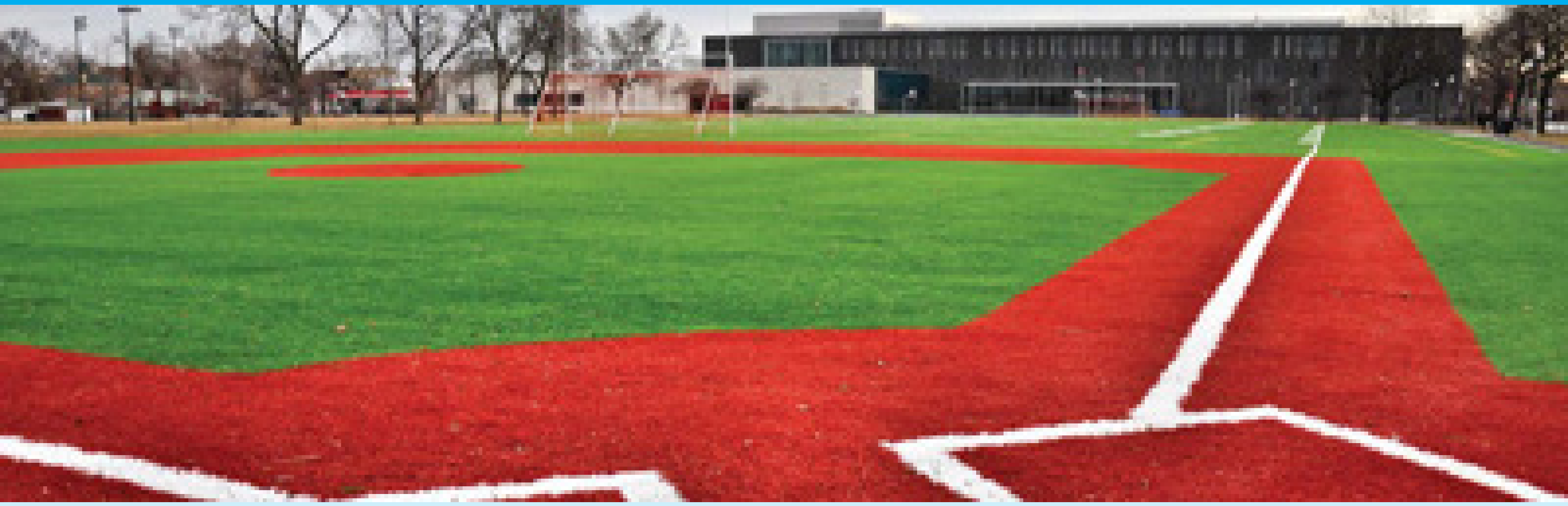
Dry detention is a method similar to wet detention utilizing a basin to attract and slow runoff during storm events. However, dry detention only temporarily holds water and is designed to empty typically with a 48 hour period. Dry detention typically requires at least 10 acres of land to be effective and unlike wet detention dry detention is not as effective for pollution control. Typically, dry basins are used to control storm water events in areas prone to flooding.

A study published in 2011 out of Selangor, Malaysia at Kota Damansara measures quantitative effectiveness of dry detention. The dry detention pond lies at the end of the Tambul River, a 3.5km stream. The detention area is 6.55 hectares with 428 hectares of catchment drain. The catchment area was composed of approximately 50% buildings and developed land with the other half being pervious forests or open fields. Results showed a water flow attenuation of 40m3/s and a decrease to peak time by 40 minutes in the 50 year event. In a 100 year event dry detention performance resulted in a flow attenuation of 42m3/s and a decrease in peak time by 45 minutes.

Another study from 1994 out of Tampa Bay, Florida measures wet retention pond effectiveness. The site has 6.5 acre retention basin with a catchment area consisting of 30 percent buildings and paved surface with the rest being grassed area. Results from this study show an attenuation rate of 1.3ft3/s (61% reduction) in 1993 and a rate of attenuation of 2.4ft3/s (86% reduction) in 1994. Average time to peak flow was extended by 3 hours (67% increase) in 1993 and 3.5 hours (75% increase) in 1994.

Some considerations when designing wet retention ponds include climate, available land, sediment loads, and retention times. In cold climates the issue of snow melt and freezing arises. Snow melt in the spring produces a large influx of water and pollution. To alleviate this problem wet ponds sediments.

can be fitted with valves which allow for drainage during cold months. This allows for accommodation of spring melt influx but will also require a higher initial investment cost. Wet retention also requires a considerable amount of land, typically 25 acres minimum, to allow for water pooling and a permanent pond. For the most efficient pollutant removal, retention times must be considered as different pond configurations and water levels dictate settling times for



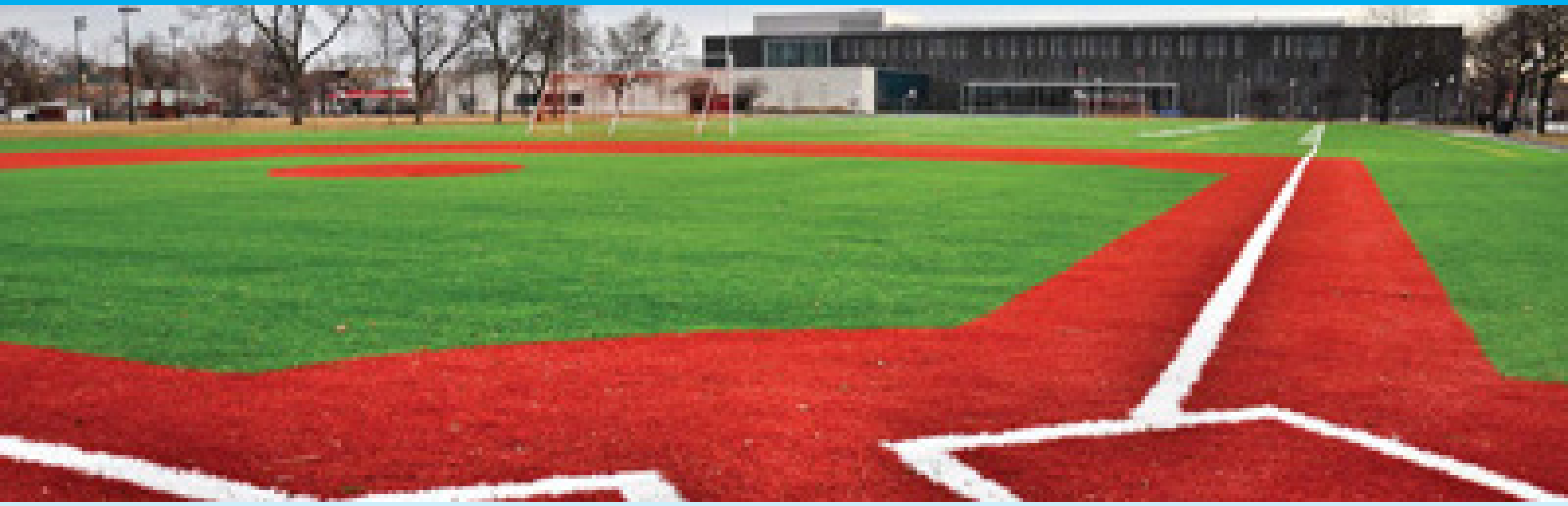
Multi-purpose detention areas are facilities designed primarily to hold a large quantity of stormwater runoff. Many times these facilities are not intended to provide any water quality treatment. These practices are often used in urbanized areas where structures can be flooded temporarily to reduce the volume of runoff entering drainage systems. The most common examples of multi-purpose detention areas are specialized parking lots, rooftops, sports fields and recessed plazas. To effectively work, grading and drainage must be installed so that the detention area can return to its original use after a storm event. It is also advised that the detention areas be built in series with some form of a water quality control structure to manage pollutants before discharging to any receiving waters.

Multi-use detention areas are flexible in that they can be located either upstream or downstream of other structural stormwater management systems, depending on the needs of the installation. Typically multi-use detention areas are designed to temporarily store all of a 50 year rain event or aid in managing a 100 year storm event. Because these drainage areas hold large volumes of water, they need to be designed so that the release of their volume or overflow of storms greater than their capacities do not have any safety risks, property damage, or take away from the primary purpose of the structure.

Parking lot detention is used in areas where large portions of a parking lot can be utilized without disrupting normal pedestrian or vehicle traffic. In these applications, ponding can be made either by areas with raised curbs or through depressed areas of pavement. The generally accepted depth for these structures is 6 inches for a 10 year storm, 9 inches for a 50 year storm and 12 for a 100 year storm. The parking lot should also have a slope of greater than 0.5% towards the outlet to provide for drainage following the storm event. One important factor is to keep fire lanes and other emergency equipment free from ponding.

Rooftop storage can be used if the roof structure can hold the weight of the ponded water and if the roof is adequately waterproof for a life span of up to 30 years. A secondary outlet needs to be installed in the event that the primary outlet is clogged. The minimum pitch for ponding on a roof is 0.25 inches per foot.

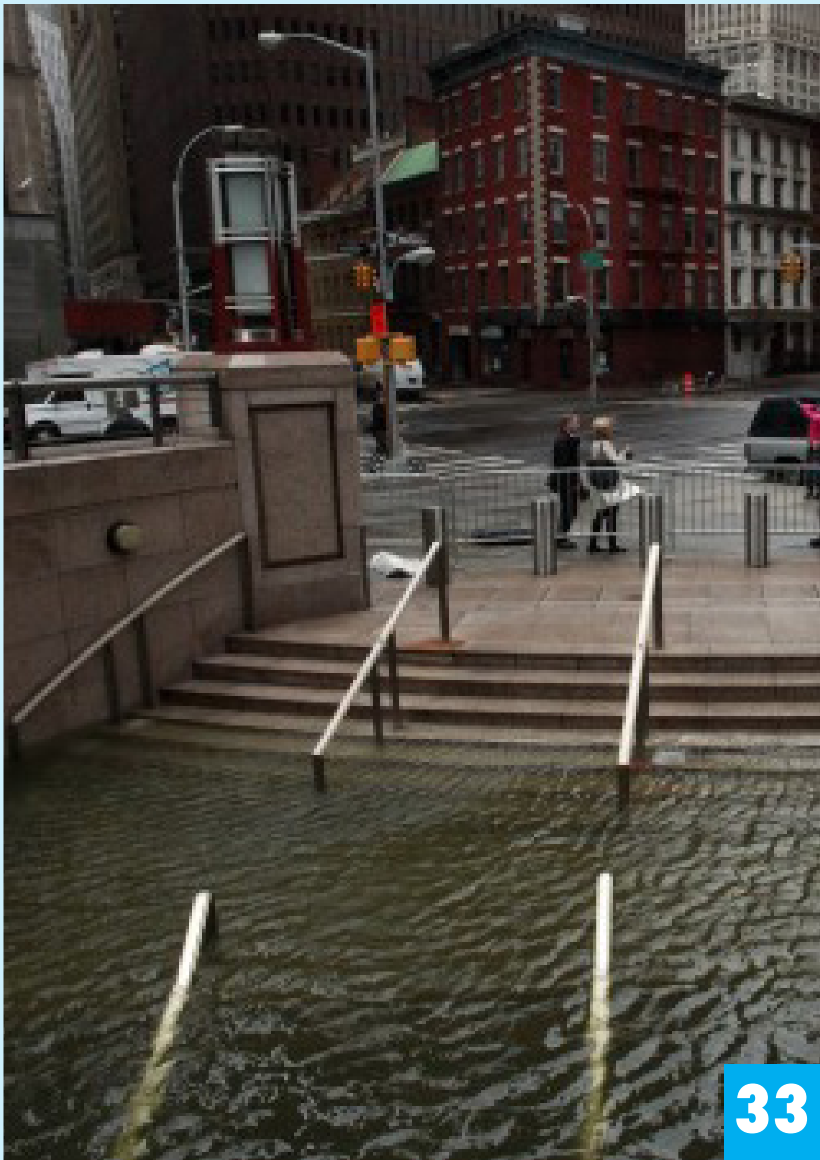
Sports fields can also be used for stormwater detention. Municipalities have converted football, soccer and baseball fields to retention basins by



constructing berms around the facilities. The outflow is controlled through and overflow weir or other adequate structure. Additionally, proper grading must be met so that the field drains completely. One of the main complaints of this alternative is that following storm events, the field is often too wet or muddy to use, defeating the original purpose. Golf courses are another area which has a large area of land to be used for detention.

Recessed public plazas can be used for stormwater detention but should be designed to flood no more than once or twice a year and be accessible for public use at all other times.

While detention on sports fields can be installed retroactively, the other forms of detention would need to be build or significantly altered from common uses in order to apply these technologies to most municipal applications. Many of these detention areas do not have the capability to provide stormwater quality improvement, however, in the case of sports fields, if the infiltration rate of the native soil is such that infiltration in an acceptable timespan is likely, it can provide for some water quality benefits before infiltrating into groundwater. If groundwater recharge is anticipated, measures should be taken to ensure that not only chlorides are minimized but also to ensure that the infiltration capacity allows for the primary use to be maintained after stormwater events.



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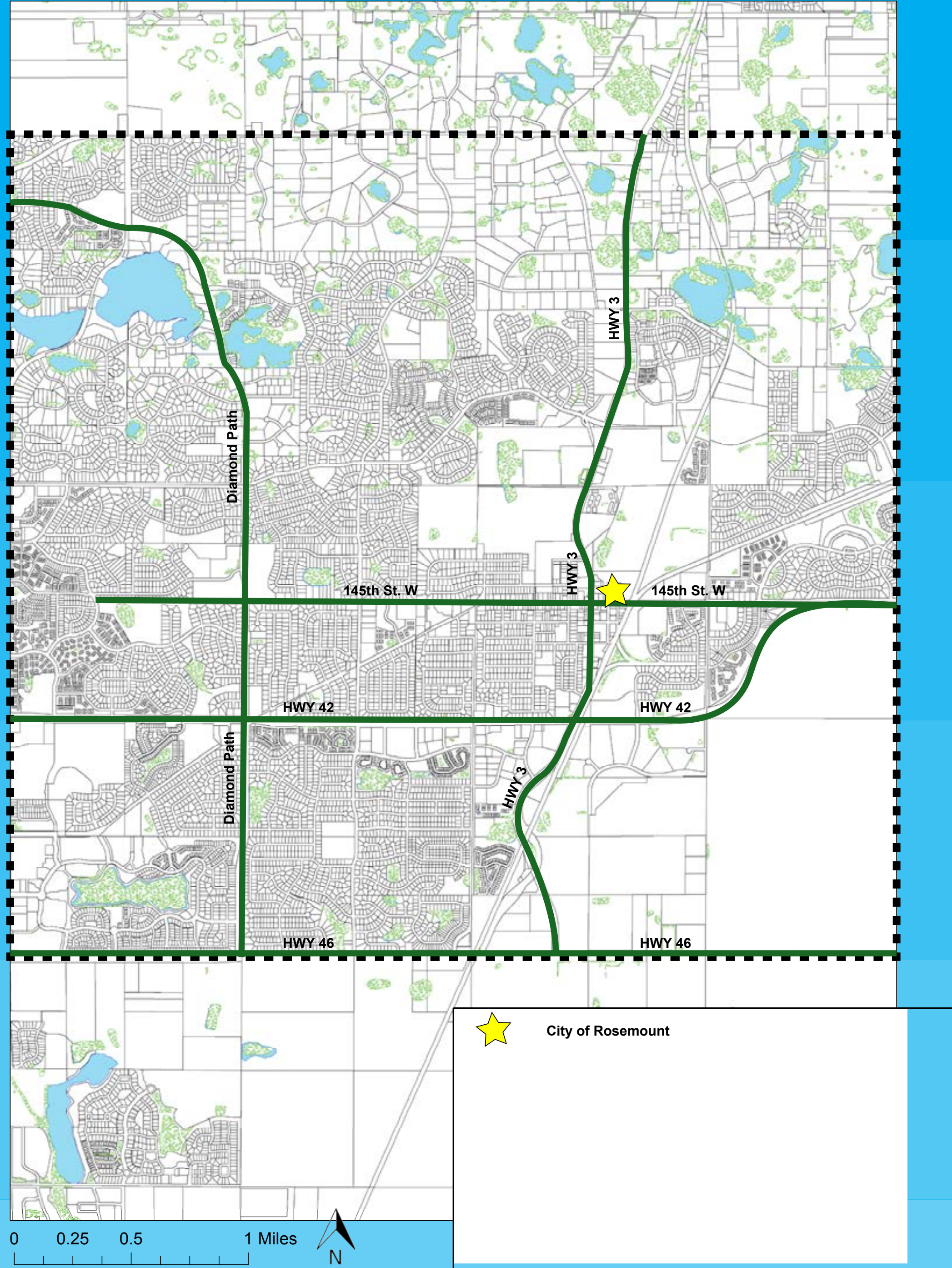
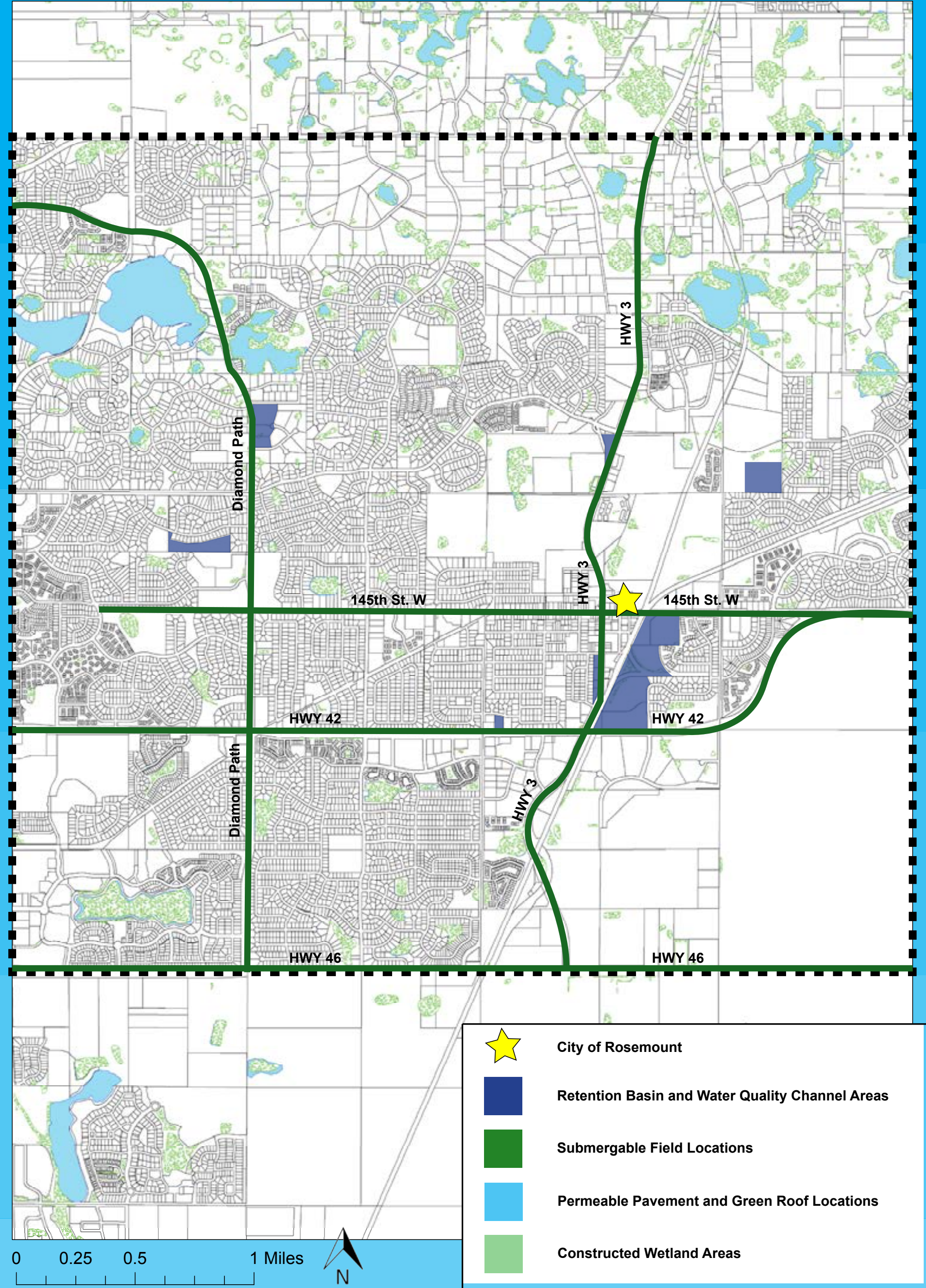
WHAT'S BEST FOR ROSEMOUNT



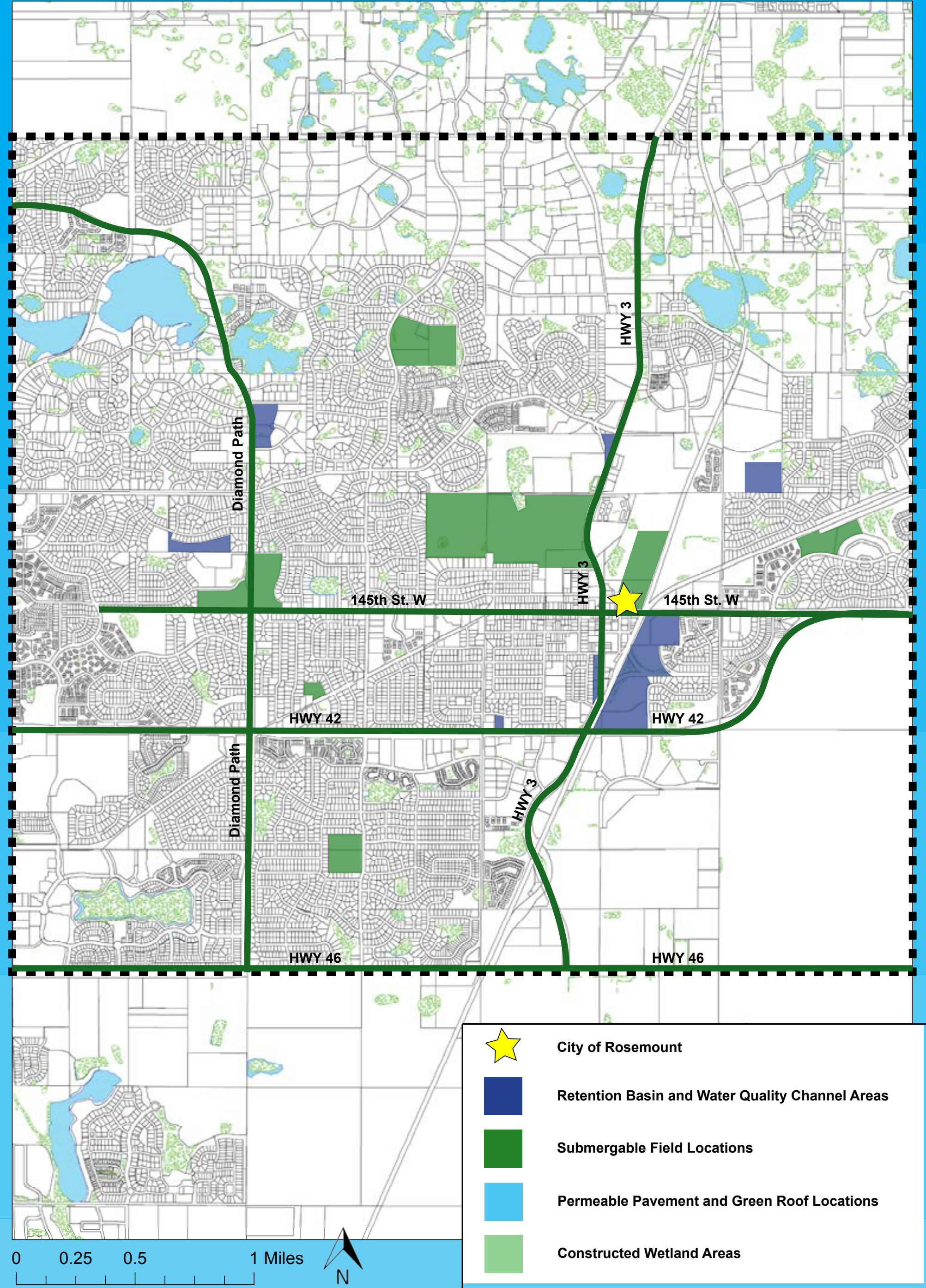
CITY OF ROSEMOUNT

Through the research on the above described best management practices; the ideal techniques for the City of Rosemount are a combination of the above. With the current infiltration rates that Rosemount has, all of the BMP's listed will be sufficient in treating and managing stormwater both in summer and winter. In the below sections, areas of importance will be called out identifying the best type of practice for the area. Areas of importance that will be evaluated are open, undeveloped swaths of land; existing athletic fields that may be transformed and current "wet" areas defined by GIS mapping technologies.



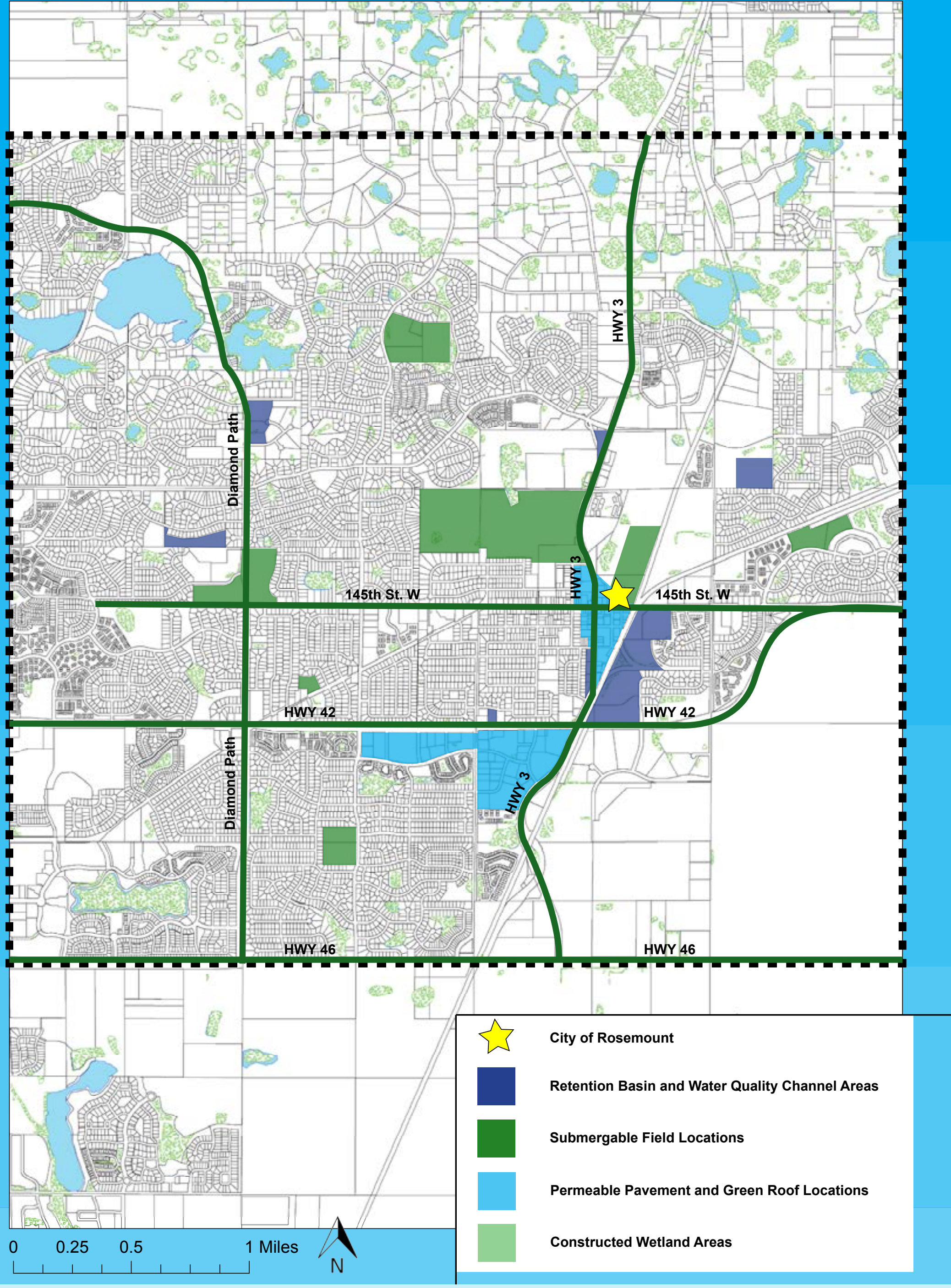
BIORETENTION AREAS

The map showing bioretention and water quality channel hot spots shows where in the City of Rosemount would be ideal areas for these systems. These areas were chosen through a combination of GIS information and Google Earth imaging software. By using the information gathered, areas were selected that would collect the most rainwater and provide setbacks from residential areas. While these two systems are effective in managing rainwater runoff, they do have a few drawbacks. One of the drawbacks is that they can take up large footprints within the landscape. This can be a problem in some developing areas because the land could otherwise be used towards a tax generating purpose. Another drawback of these systems is that they are not the prettiest during their dormant stage. During early spring and summer most of these systems appear to be dead because of the dormancy they go into during the winter months. While not a majority of residents think this, some find this time period unattractive and devaluing of their property.



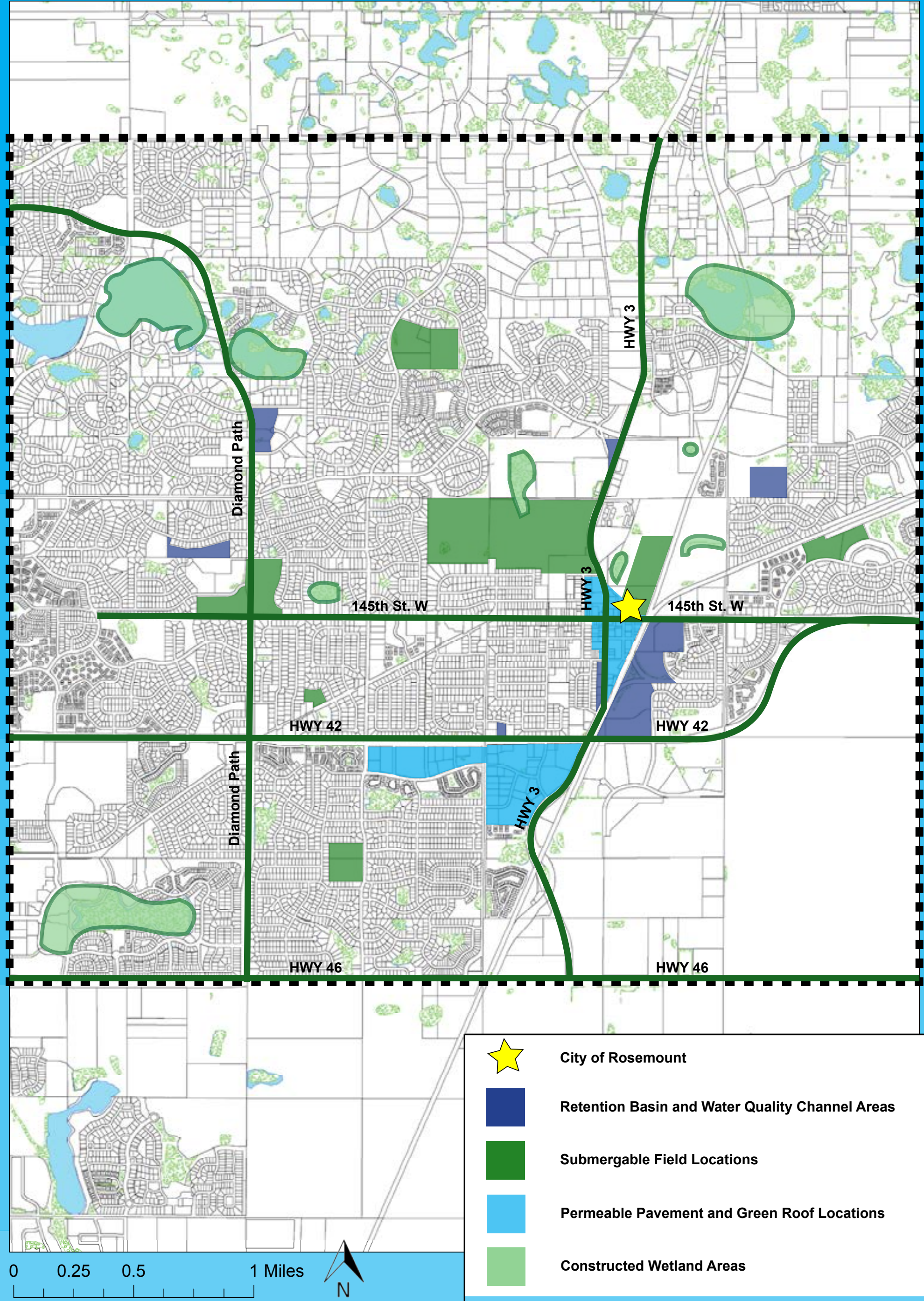
MULTI-USE FIELDS

Similar to the bioretention area map, the athletic field map identifies locations of existing parks and ball fields that would be candidates to be transformed into the submersible fields. These areas were identified through the use of Google Earth imaging software. These systems have been shown to be effective in managing rainwater. Some positives with submersible athletic field systems are that they utilize space that normally is not used during storm events. This area of land can be significant in smaller cities where park space takes up a larger percent of overall land use. As with any system there are a few drawbacks to these types of rain management techniques. During larger storm events the fields may remain underwater longer than wanted preventing the continuation of sporting events. Another and frequent drawback with this type of system is that it can get muddy and dirty after drying out. This is due to the stormwater that is held within the athletic field. The water typically has some sort of erosion sediment or mud that settles out as the water infiltrates. This is not only unattractive in terms of looks but also because of sporting participants getting unnecessarily dirty.



PERMEABLE PAVEMENT

Permeable pavement and green roof selection is a bit harder than plugging information into GIS programs. While green roofs and permeable pavements of any size are effective, the larger the systems; the better they are. Within the City of Rosemount there are only a few areas that would significantly benefit from the installation of these systems. Identified on the map are areas of high commercial development that have large square footages of parking lot and large roof areas. Through the research, retrofitting many of these large parking lots and roofs would help infiltrate much of the rainwater generated from these currently impervious surfaces. By doing this conversion, Rosemount would remove thousands of gallons from their current stormwater system. Once again, these systems come with some drawbacks. One is price. For these systems to be utilized it requires a change in basic infrastructure. For permeable pavement the correct base layers need to be laid down to get proper infiltration. For green roof installation many current buildings would need to be reinforced to take the load of having a waterlogged soil medium on the roof. This is particularly important when you start factoring in additional snow loads during the winter months. While these systems have high upfront costs, they have long life spans and are very effective at managing rainwater at the source rather than off site.



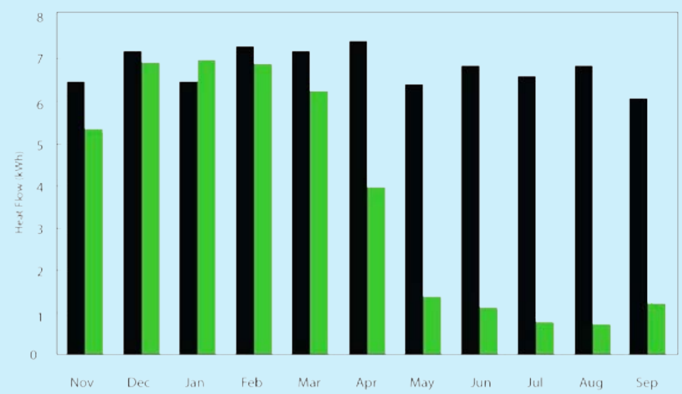
CONSTRUCTED WETLANDS

The last of the recommended systems for Rosemount to consider are those of constructed wetlands. Constructed wetlands function like natural wetlands while providing habitat for small mammals and birds. Areas for these wetlands are identified on the map. These areas were chosen using GIS information of "wet" areas, or in other terms, low points within the community that typically hold water. Other areas examined for constructed wetlands include areas around lakes. These areas are the ideal scenario locations because they already are somewhat of a wetland and would help to protect the water bodies from direct runoff of stormwater. Drawbacks of these systems include large footprints and high initial costs. While these systems appear to be "self sustaining", they are only to an extent. These types of wetlands require lots of engineering for them to work properly. Water levels are typically controlled to make sure flooding isn't an issue, while species selection is heavily monitored to prevent invasive species from overtaking the wetland.

Alternative stormwater management practices can have a number of financial benefits compared with traditional curb and gutter systems. In general, managing stormwater closer to the source reduces the likelihood of flooding along the conveyance system and reduces the potential costs associated with flooding events. Certain best management technologies previously mentioned have specific associated savings. Porous pavement systems have the potential to reduce deicing costs because they pull water off the surface of the pavement before it can pool and freeze. This not only decreases the cost of salt to be used, but also decreases manpower costs associated with application. Green roofs have associated energy savings for the buildings on which they are installed. They insulate the buildings from the summer heat and winter cold better than traditional roofing. Rainwater harvesting, as mentioned previously, has the potential to reduce consumptive use of treated water thus reducing the volume of water needed to be treated and also reducing costs for the users.

A study conducted by the EPA showed that alternative methods of stormwater management had significant cost savings to a city. The study examined 17 development projects which used methods other than traditional curb and gutter systems to manage their stormwater such as the best management practices outlined in this report. The actual costs of the BMPs were compared to estimated costs for the project using traditional stormwater management. The study found that stormwater BMPs can have cost savings through reduced grading, landscaping, paving and infrastructure costs such as curbing, pipes, and catch basins. Alternative best management practices can also eliminate or reduce the size of stormwater structures, which can provide more open space or buildable lots. Overall, capital costs were lower than traditional methods with costs savings ranging from 15 to 80% for comparable performance.

United States Environmental Protection Agency Graph

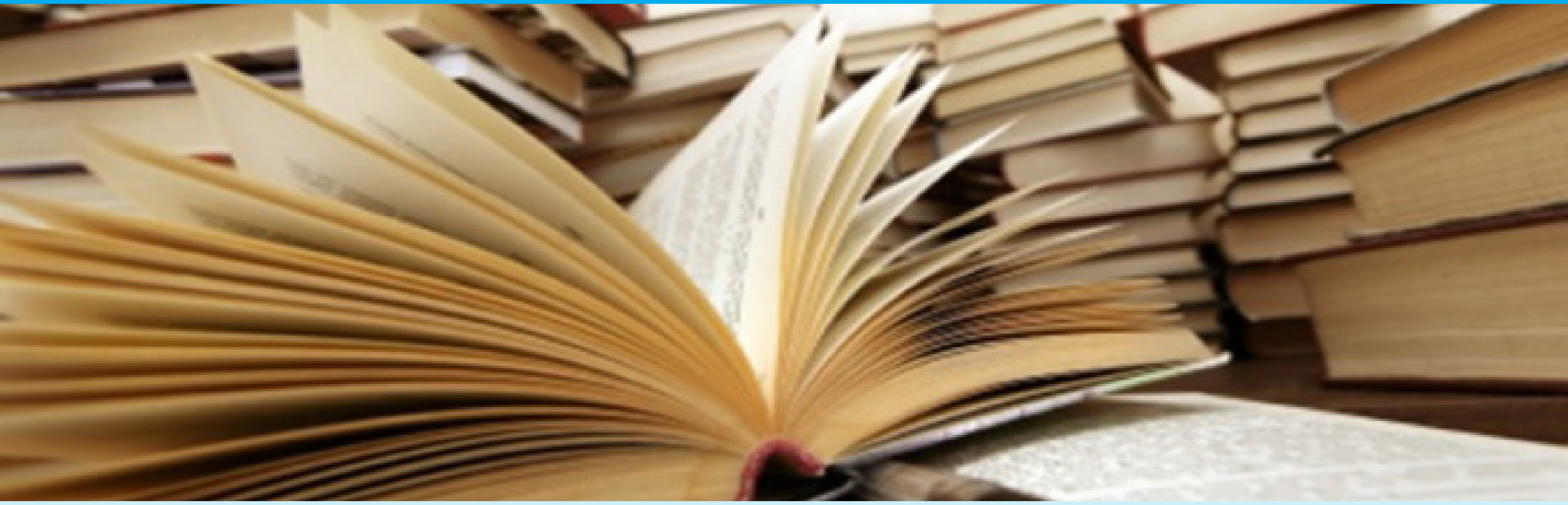


Community involvement will play a large role in successfully implementing stormwater quality BMPs. Education and outreach programs will aid in the planning, design, construction, and maintenance processes. Outreach events, which include the community in the planning process are integral to gaining approval for these projects. Some suggestions for events would be a Community Design or Youth Design Workshop Day or a City Planner/ Developer/Stakeholder Design Workshop. These would allow parties to provide input and also voice concerns they have regarding alternative stormwater practices.

Educational efforts are another key facet to the successful implementation of these projects and can be made independently or can be combined with city events, which have already been planned. City events such as planning commission meetings, city council meetings, and parks & recreation meetings are a way to present the ideas to important stakeholders and gain support for alternative BMPs for stormwater management.

Existing events such as Friday Night Live, the Community Tennis Block Party, and farmers market are events in which the public can have the opportunity to learn about stormwater management and explore some of the new technologies. Promoting alternative green stormwater management in a pamphlet provided at City Hall and on the City of Rosemount's website would be an easy way for the public to learn about the BMPs on their own time and also to potentially attract new residents or companies to the area. Additionally, depending on the location of implementation of some of these technologies, they can allow school groups an opportunity to learn about water management and environmental issues.

Community involvement in regards to stormwater BMPs is mostly about educational efforts to the residents and businesses that will be affected once implementation has begun. It is important to let these people know the cost, benefits, drawbacks, and potential outcomes of all the proposed best management practices. Furthermore, it is imperative to get the community involved in the design and planning process. This will allow for a sense of community pride and effort when these systems are implemented. Additionally, the city may get some creative ideas from the community.



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