White Paper

# Green Solutions for the City of Omaha

City of Omaha Department of Public Works

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## Background

The purposes of this White Paper is to define Green Solutions, also referred to as green infrastructure; and the role they may play in addressing Combined Sewer Overflows (CSOs), and to summarize those efforts currently underway by the City of Omaha. This paper will also lay out a strategy that will be followed to further incorporate these types of controls into the City's Long Term Control Plan (LTCP) and the Stormwater Program.

This White Paper is the outgrowth of two different drivers. The first is a desire voiced by citizens of Omaha to, where practical, incorporate into the City's Stormwater and CSO Program Management Program practices that improve the community and are environmental friendly. Second, subsequent to the City's efforts to develop a LTCP to address their combined sewer overflows (CSOs), EPA has launched an effort to look at Green Solutions and, as appropriate, encourage communities to include these in their wet weather plans. This emphasis by EPA was noted by Benjamin Grumbles, Assistant EPA Administrator, in a memo dated March 5, 2007. In addition, on April 19, 2007 EPA entered into Partnership with the National Association of Clean Water Agencies (NACWA), National Resource Defense Council (NRDC), the Low Impact Development Center (LID) and the Association of State and Interstate Water Pollution Control Administrators (ASIWPCA). The purpose of this partnership is to promote the benefits of using Green Solutions in protecting drinking water supplies and public health, mitigating overflows from combined and separate sewers and reducing stormwater pollution.

#### What are Green Solutions

For the purposes of this White Paper, "Green Solutions" refers to Green Infrastructure elements that can affect a combined sewer system and separate stormwater system. Per EPA, the term "Green Infrastructure" is used to represent a new approach to stormwater management that is cost-effective, sustainable, and environmentally friendly. The approach involves the use of natural systems, or engineered systems that attempt to mimic natural landscapes, to capture, cleanse and reduce stormwater runoff using plants, soils and microbes. On the regional scale, EPA suggests that Green Infrastructure consists of the interconnected network of open spaces and natural areas (such as forested areas, floodplains and wetlands) that improve water quality while providing recreational opportunities and wildlife habitat. These are strategies that can be implemented by the City. While on a local scale; Green Solutions consists of site-specific management practices (such as rain gardens, porous pavements, and green roofs) designed to maintain natural hydrologic functions by absorbing and infiltrating precipitation where it falls. Implementation of these types of systems cannot be directly implemented by the City but are efforts that private citizens and organizations can be encouraged to implement.

EPA states that Green Infrastructure can provide a number of environmental benefits. For example, when used as a wet weather management technique, Green Infrastructure can reduce reliance on traditional stormwater structures that are expensive to build, operate and

maintain. In addition, Green Solutions can also protect surface waters and drinking water supplies, mitigate the impact of urban heat islands, reduce energy demands, and protect highly valued natural habitats, forests, and agricultural lands. Many of the technologies that are considered Green Solutions are not new and are already being used in Omaha to control stormwater runoff quality.

#### **Green Technologies**

As stated previously there are "regional type" controls, those that can be implemented directly by the City, and "local or individual" controls, that need to be implemented by homeowners or private entities. For purposes of this document, regional controls will be referred to as "Public Green Solutions" and local or individual controls will be referred to as "Private Green Solutions." Table 1 outlines various technologies and their use as Private or Public Green Solutions. Detailed facts sheets on each of these can be found in Attachment 1. These fact sheets include pictures of the technologies and a discussion on where their uses are applicable.

TABLE 1
Summary of Green Technologies

Technology	Private	Public
Wet Ponds and Extended Dry Ponds		X
Wetlands		X
Bioretention (Bioswale)	X	X
Grass Swales	X	X
Filter Strips and Flow Spreaders		X
Sand Filters		X
Porous Pavement	X	X
Green Roofs	X	X
Rain Gardens	X	X
Rain Barrels	X	
Disconnection of Roof Drains	X	
Pollution Prevention	X	X
Public Education	X	Х

#### What Can Green Solutions Accomplish?

#### Peak Flow Reduction

#### Reduction in Downstream Flows

Green Solutions can help preserve and restore the hydrologic functions of watersheds. These practices are stormwater management approaches that manage rainfall at the source using a variety of structural and nonstructural controls. The main goal of green practices is to mimic a site's predevelopment hydrology by using design techniques that infiltrate, filter, store, evaporate, and detain runoff close to its source. Preservation of predevelopment hydrology can accomplish the following:

- Reduce imperviousness Changes in post development hydrology can be minimized by reducing impervious areas and preserving more trees and meadows to reduce the storage requirements to maintain the predevelopment runoff volume.
- Disconnection of impervious surfaces Additional environmental benefits can be achieved and the hydrologic impacts reduced by disconnecting impervious surfaces (such as rooftops) from the stormwater management systems as much as possible.
- Preservation and protection of environmentally sensitive site features Site features to be
  protected and preserved can include riparian areas, floodplains, stream buffers,
  wetlands, woodlands, conservation zones, and valuable trees.
- Maintaining predevelopment response of a watershed Maintaining the response of a
  watershed to a given storm event at predevelopment levels minimizes peak runoff rates.
  Green practices lengthen flow paths and reduce the length of the engineered runoff
  conveyance system.

Green practices are not intended to replace traditional stormwater management systems. Green practices specifically address the frequent or micro-storms that occur on a regular basis (weekly or monthly). Traditional stormwater management systems have been designed to function well under a single design condition such as the 10- and 100-year storms. Stormwater management systems designed for these larger flood control events may not perform adequately under other scenarios. A hybrid approach using green and traditional stormwater management practices may be needed in known flooding problem areas to reduce liability and provide for public safety.

#### Water Quality

#### Reduction in Pollutant Loadings

Green Solutions enhance the ability to protect surface and ground water quality and preserve the physical integrity of receiving streams. Several studies have been conducted to analyze the effectiveness of various green practices based on hydrology and pollutant removal capabilities. Generally, these practices are good for both pollutant removal and runoff volume reduction. Results from studies indicate that removal efficiencies were quite good for sediment, metals, nutrients, oil and grease, and some practices have potential to remove bacteria from runoff. However, it should be noted that removal data is limited and variable.

Using a Green Solutions approach in smaller drainage areas can potentially make it easier to identify and treat water quality problems at the source on a smaller scale, thus reducing the total pollutant loadings in stormwater runoff in a watershed. These practices enhance the watershed approach by going beyond reducing chemical contamination of water to find creative ways to enhance the overall health of a watershed.

#### **Improved Aesthetics**

Green practices are often more aesthetically pleasing than traditional, structural storm-water conveyance systems if implemented with planning and forethought. These controls can be integrated into multifunctional landscape features where runoff can be managed and controlled at the source. Native plants such as shrubs, grass, herbs, wildflowers, and other plants can be used, creating an aesthetically pleasing landscape.

## Other City's Experiences

#### Portland, Oregon

The Portland Bureau of Environmental Services (BES) provides wastewater treatment for 614,000 customers over 145.5 square miles of service area.

Portland's CSO program began in 1990 and implementation of their LTCP is anticipated in 2011. In 1993, the City began construction of baseline projects including sewer separations, sump installations, stream diversions and downspout disconnections. The City of Portland and State of Oregon signed the Amended Stipulation and Final Order to implement the CSO plan in 1994. In 2005, the City also adopted the Portland Watershed Management Plan to improve overall watershed health. The agreement with the State and City Watershed Management Plan now guide Portland's wastewater management practices.

Portland's CSO program combines conventional infrastructure solutions — tunnels, pipes and pump stations — and Green Solutions — downspout disconnections, "green streets" and landscaped infiltration basins. Conventional infrastructure solutions for the CSO program include:

- West Side Big Pipe (a 14' diameter tunnel, running 3 ½ miles)
- East Side Big Pipe (a 22' diameter tunnel, running 6 miles)
- Swan Island Pump Station
- Stream diversions
- Southwest Parallel Interceptor
- Pump station and wastewater treatment facility upgrades

It is anticipated that Portland's green and conventional infrastructure solutions will decrease CSOs by 94%. The total cost of the CSO Program is expected to be \$1.4 billion. Sewer fees will rise from \$45.25 per household in December 2006 to \$59.42 in December 2011.

#### **Green Solutions**

Portland incorporated Green Solutions into their CSO program to meet federal and state water quality mandates. Green roofs, landscape infiltration systems and flow-through system projects have been used as part of the CSO program to:

- Reduce peak flow and volume
- Determine size the East Side Big Pipe
- Prevent basement backups
- Address insufficient capacity

Since 2002, Portland has invested \$3 million to fund or partially fund more than 40 Green Solutions projects. These projects have not only raised public support of Green Solutions, they have also helped the City to refine their implementation practices. From these projects, Portland's BES has learned that in order to implement Green Solutions effectively they must:

- Carry out extensive field investigation and modeling in early design phases
- Increase coordination with other utilities and transportation systems to prevent potential conflicts
- Coordinate with Parks Department to maintain facilities for first two years

More effective implementation of Green Solutions led the City to address the CSO problem in the 1,460 acre Taggart D Basin with 500 + street swales and 100+ roof and parking lot facilities in conjunction with the East Side Big Pipe.

The BES recognizes that widespread implementation of green facilities in the Taggart D Basin and throughout Portland may create challenges. To proactively address these challenges, the BES works continually to improve:

- Design standards for public and private stormwater facilities
- Inspection of private stormwater facilities
- Maintenance practices of public facilities
- Coordination of interdepartmental projects
- Integration of green technologies into engineering pre-design

#### Philadelphia, Pennsylvania

The Philadelphia Water Department is the Nations oldest water utility and provides wastewater treatment for the City of Philadelphia (136 mi²) and approximately 270 mi² of the Philadelphia Metropolitan area. Water service is provided predominantly to the City proper, which has over 475,000 retail water accounts and approximately 1.4 million people.

The City's CSO program dates back to a 1976 facility plan that called for upgrading of the treatment facilities to secondary removal requirements and the expansion of the wet weather capacity to treat two-times the design flow at each of the three facilities. This plan also implemented real time control for eight CSO points, implemented system-wide monitoring and resulted in marked improvements to the quality of the Delaware River. The 1993 National Pollutant Discharge Elimination System (NPDES) Permit included requirements to develop a System Inventory in 1994, a System Hydraulic Characterization in 1995, Implementation of the EPA's Nine Minimum Controls in 1995, and development of a LTCP in 1997. This LTCP recommended that a 5-yr, \$50 million capital improvement program be undertaken in parallel with a comprehensive water quality assessment and watershed management planning process. This plan was approved by the Pennsylvania Department of Environmental Protection and incorporated by reference into the 1999 NPDES permit. The plan is being implemented and is expected to reduce annual CSO volume by 20%. At this time, watershed management plans have been completed for the

tributary watersheds and the City plans to undertake a revision of the LTCP in the next permit which has yet to be issued.

#### Clean Water – Green City Program

To implement the LTCP, the City established an Office of Watersheds (OOW) in 1999 to integrate 3 Separate Groups - CSO, SW, and Drinking Sourcewater Protection. A multi-disciplinary staff was hired to initiate and lead regional watershed partnerships, develop WQ baselines, and develop and implement watershed management plans. The chartering of the OOW developed a mission titled Clean Water - Green City. The resulting Green City Strategy included the following goals:

- Reconnect the City with its waterways
- Key in on environmental aesthetics
- Treat rainwater as an urban asset
- Encourage smart growth / smart urban renewal
- Empower the community, developers, architects
- Use best of science, technology and common sense
- Watershed Assessment and Management Plans
- Innovate and demonstrate

Key elements of the City's strategy are to incorporate the National Resource Defense Council (NRDC) Low Impact Development (LID) recommendations to the District of Columbia (DC) on their LTCP and appropriate elements of a green approach. This included:

- Revise codes and ordinances
- Lead by example use LID on City properties
- Educate development review agencies
- Prepare state of the art technical guidance document
- Promote high visibility LID projects
- Develop a large-scale "sewershed" LID application
- Create commercial incentives
- Foster coordination among City agencies
- Create an incentive program to encourage LID
- Protect existing open space
- Focus on redevelopment of existing areas not development of undeveloped areas

Based on the implementation of Green Solutions the City anticipates such controls will be effective in boosting CSO volume capture and will show progress to the regulators of the LTCP development. In addition it is believed that the program will:

- Increase in public awareness of interrelated water, watershed, flooding, water quality issues
- Political support for programs
- Recognition by PADEP / EPA of Philadelphia's innovative program
- Improved biologic health (DEP listing basis)

#### Louisville, Kentucky

The combined sewer system serving Louisville, KY is operated by the Louisville Metropolitan Sewerage District (MSD). The combined sewer area covers 24,000 acres,

serves approximately 324,000 people, and has 121 active CSO outfalls. During the period from 1985-2002 approximately \$1 billion has been spent on wastewater capital projects.

The CSO abatement efforts to date have included elements of green programs/solutions. The Louisville Green Programs have existed for a long time and have been primarily driven by regulatory compliance, increasing public support for infrastructure investments and to save money. Green programs and projects have been recognized as way to save money and gain public support. It is felt that the Green Projects save money and minimize impacts on neighborhoods over concrete and steel capital projects. In addition these projects can reduce maintenance for drainage infrastructure. Initial green program investments included the following projects and programs.

- Green corridors along streams preserved through ordinance changes
- 25 ft or more buffer required
- No floodplain development or stream relocation
- MSD projects sensitive to environment and restoration
- Aggressive erosion sediment control program implemented
- Early leader in stream restoration projects/bioengineering/wetlands protection

#### **Current Green Programs**

The Louisville Green programs have evolved to include a rain barrel program where homeowners can pick up a free barrel and attend periodic workshops on how to install it. Stormwater best management practice (BMP) demonstration projects have been undertaken throughout the City to demonstrate the effectiveness of stormwater controls in reducing runoff prior to entry into the combined sewer system. Porous pavement, rain gardens and community tree planting programs have been the primary BMPs that have been utilized to date. There is a continued emphasis on multi-objective environmental restoration in solving drainage and flooding problems in conjunction with resolving water quality impairments and the District uses a "Green before Grey" ethic in each project undertaking.

Louisville MSD is currently completing update of its long term CSO/Sanitary Sewer Overflow or stormwater plans and is using empowered public participation and a focus on green projects as core elements of the planning process. Risk-based approaches to defining in-stream water quality goals are being pursued so that the levels of use impairment resulting from a given control approach are well understood and stem from actual risk. Evaluations are being performed to develop an approach to scale up green programs so that their effectiveness as a part of the wet-weather control program can be demonstrated

### Kansas City, Missouri

Kansas City, Missouri has a current population of 440,000 and 180,000 estimated households. The City is served by both separate and combined sewer areas. The separate sanitary sewer areas include 159 square miles of land north of the Missouri River and 102 square miles of area south, which includes 1,690 miles of gravity sewer, 34 miles of force main, and 12 pumping stations. The combined sewer system is on average over 100 years old with the first part started in 1855. There are 56 square miles of area total with combined sewer, which includes the downtown area. This combined sewer area has approximately 200 diversion structures, which overflow about 6 billion gallons of sewage annually from storm events.

The Water Services Department of Kansas City has three divisions: the Overflow Control Program (OCP); the Stormwater Utility Division; and the Waterways Division that were combined in a comprehensive approach called the Wet Weather Solutions Program. The OCP is leading development of the City's LTCP, which will be submitted to the regulatory agencies in early 2008. The LTCP will recommend a capital improvements program for both combined sewer and separate sanitary sewer areas to reduce or eliminate overflows from the City's system. An integral part of the LTCP will be a Green Solutions approach to enhance the environmental benefits that are achieved.

#### **Green Solutions Program**

In 2003, a Wet Weather Community Panel was formed by the Mayor. As part of this panel, a Green Solutions Subcommittee was formed. This resulted in a Green Solutions Position Paper, which recommended a focus on source control and natural treatment systems to minimize stormwater impacts as part of the compliance with CSO controls. The City consequently has developed ordinances for stream setback controls, implemented a program to promote the construction of 10,000 rain gardens initiative, and is developing a multi-faceted approach to implement appropriate Green Solutions as part of the CSO program. This will likely include impervious pavement, bioretention facilities, stormwater detention and other relevant Green Solutions that are being evaluated. The City has also implemented an extensive public education program.

#### **Green Solutions for Omaha**

#### Master Plan Elements

The Concept Element of Omaha's Master Plan, adopted in 1993, included visionary objectives for sustaining the natural environment, preserving natural features and preventing environmental degradation. Since the late 1990's Omaha has been steadily and significantly enhancing the Land Use Element of its Master Plan to emphasize the importance of its environment. See <a href="http://www.ci.omaha.ne.us/planning">http://www.ci.omaha.ne.us/planning</a>

In 2004, Omaha adopted the Urban Design Element, which was developed under the broad based community initiative, Omaha by Design. This element outlined goals in three specific categories; Civic Omaha, Green Omaha, and Neighborhood Omaha. The Green Omaha category recognizes the preservation and enhancement of the city's natural setting and public park system. Upon its adoption, Omaha by Design outlined a 2005 program of work to prioritize the implementation the Urban Design Element's recommendations. Priority Green Omaha goals include a Green Streets Master Plan, expansion of the trail system, and a Papillion Creek Watershed Plan. In 2006, Omaha adopted the Stormwater Element, as more fully described below under Stormwater Program.

## Mayor Fahey's Commitment

In 2006, Mayor Fahey elected to join the Sierra Club and make Omaha one of the "Cool Cities" in America. The Cool Cities program is a coordinated, nation-wide movement to stop global warming. Four key steps are involved in being a Cool City. The first step is for the Mayor to sign the U.S. Mayor's Climate Protection Agreement, which sets the goal of reducing city wide global warming carbon dioxide pollution to 7 percent below 1990 levels by 2012. The second step is to conduct an inventory of the city's current global warming

emissions. The inventory identifies the City's major CO2 sources and a baseline to judge the city's progress toward its goal. The third step is to create a plan that implements initiatives to reduce emission and lower energy costs for the city. The fourth and final step is to implement the plan and monitor the results.

Omaha has made great progress to date by completing the first three steps. Three important strategy elements being implemented are: green vehicle fleets, energy efficiency, and renewable energy. Omaha Public Schools retrofitted with emission scrubbers 270 small buses that run on bio-diesel. Traffic lights are being converted to the more energy efficient LED traffic signals, and homeowners are being encouraged to convert incandescent bulbs to compact florescent lights. The mayor also has a tree planting program for residents of Omaha and is encouraging Omaha to be a bikeable community, as the number of bike lanes and trails expand throughout the city.

#### **Stormwater Program**

The City, as a member of the Papillion Creek Watershed Partnership, a consortium representing nine communities, two counties, and a natural resource district, developed six polices that addressed water quality and water quantity management issues. The policies were adopted to establish the new Stormwater Element of the City's Master Plan in the summer of 2006. The policies cover stormwater management financing, peak flow reduction, pollution control, landscape preservation, restoration and conservation, erosion and sediment control, and flood plain management. The first four policies either directly or indirectly promote Green Solutions.

The first and second policies, stormwater management financing and peak flow reduction, provide a regional approach and a dedicated and sustainable funding mechanism to construct capital projects that provides for improved water quality and peak flow reduction through the development of a Watershed Drainage Plan. A Conceptual Drainage Plan was developed shortly after the policies were drafted and the plan identified regional detention and retention sites. However, given the increasing level of interest in sustainable measures, the evolving plan is currently being refined to include Green Solutions for stormwater management and promote additional concept for "smart growth." Smart growth enables communities to pursue open space protection and development objectives through the clustering of development activity away from sensitive natural areas.

The third policy, pollution control, promotes Green Solutions to achieve water quality goals. Protecting surface and ground water from sedimentation, nutrient, and chemical contamination encourages the uses of best management practices (BMPs) to reduce pollution from contributing sources including, but not limited to, agricultural sources and combined sewer overflows. Green Solutions under this policy may include restricting fertilizer use, constructing water quality basins, and promoting no-till farming practices.

The fourth policy, landscape preservation, restoration, and conservation, encourages the use of conservation design practices low impact development to preserve natural features, benefit water quality and minimize the runoff associated with development.

#### Regulatory Requirements

The City's Stormwater Permit requires the City to develop a Stormwater Management Program that implements controls to reduce pollutants in municipal storm sewer discharges to the maximum extent practicable. In June 2006 City Council added Chapter 32,

Stormwater Management, to the Omaha Municipal Code. This ordinance requires the development of a Post Construction Stormwater Management Plan for all land developments and significant redevelopments have the potential to add pollutants to stormwater or to affect the flow rate or velocity of stormwater runoff after construction is completed. The Plan must include, at a minimum, BMPs selection and design, and schedules and procedures for BMP inspection and maintenance. BMPs recommended are detailed in the Omaha Regional Stormwater Design Manual (April 2006) and include a range of structural and non-structural solutions. Structural Green Solutions include detention and retention basins, constructed wetlands, grassy swales, filter strips and flow spreaders, sand filters, and turf paving. Non-structural Green Solutions include education, pollution prevention, minimizing directly connected impervious surfaces, and material use controls.

#### **Public Education Efforts**

The City formally initiated a stormwater public education and outreach program in the October 2003, when Omaha was issued its first National Pollutant Discharge Elimination System (NPDES, Phase I) Municipal Separate Storm Sewer System (MS4) permit. Over the last 4 years, stormwater public education efforts have been numerous and will continue to increase over time. A few of the most important efforts include the Watershed by Design Forum, the World O! Water Festival, Sediment and Erosion Control Seminars, and Green Solutions Workshops. Other education and outreach activities are coordinated in cooperation with Keep Omaha Beautiful who organizes storm drain marking activities, litter clean-up events, and stream clean-up events.

The Watershed by Design Forums were initiated in 2005 in response to awareness that proactive policies were needed throughout the watershed to address stormwater management and to build on the foundation set by Omaha by Design. The forum focused on three key elements of stormwater management: green, clean and safe. Policies were developed with input from workgroups that consisted of a broad base of local professionals include property managers, developers, attorneys, engineers, planners, and City and County staff. Work groups met beginning in the spring of 2005 and continued until the winter of 2006. The Policies were formally presented to the public in two meetings held on March 2 and July 20, 2006. The policies were presented to the City's planning board in March of 2006 and were later adopted by the Council into the City's Master Plan.

In the fall of 2007, the City will co-host the third annual World O! Water Festival for families in the greater metropolitan area. The festival is designed to educate families about stormwater and to provide a wealth of information from numerous organizations and agencies all involved in stormwater management. Green Solutions activities include information on constructing rain gardens and a demonstration of how to build a rain barrel.

In the winter of 2006, the City hosted the fourth annual Sediment and Erosion Control Seminar. The seminar is designed to educate builders, developers, engineers, and construction operators about the construction site regulations and requirements, the webbased reporting system, and post construction regulations and requirements.

Recently, Omaha and Douglas County have teamed together to work on a number of Green Solutions educational workshops and demonstration projects. The first workshop, offered in March 2007, covered a range of LID techniques used in site design and site evaluation. Topics covered included preserving natural drainage ways, cluster design, disconnecting

impervious surfaces, computer modeling, and case studies. The second workshop will be offered in October and will cover green roof design, construction, and maintenance as well as green roof policy development.

#### Stormwater Financing

Unlike the system that exists for sanitary sewage management, funding for both capital construction and ongoing operation and maintenance (O&M) of stormwater infrastructure has been a challenge for Omaha. Under the statutes of the State of Nebraska, Omaha currently lacks authority to establish a utility fee based on contributions to its storm sewer system. With a few exceptions, Green Solutions projects must compete with other basic City services (Police, Fire, Library, Parks) for general revenues.

With the support of the prevailing Administrations and City Councils for the last five years, Omaha has lobbied the Unicameral for enabling legislation that would provide Omaha with the option of establishing dedicated stormwater user fees. Stiff opposition to this legislation has come from groups including commercial property owners, non-profit organizations and many other special interests.

In 2006 a Stormwater Management Plan Program was established by the Nebraska Unicameral and grant funding was provided for a 2 year period to help Omaha and other NPDES communities meet the unfunded mandates of the Clean Water Act. However, only \$2.5 million annually has been appropriated for this fund, while state-wide needs have been estimated at over \$24 million. This estimate does not include Omaha's needs for flood control or the CSO program. Also, the grant funds cannot be used for O&M, so huge funding needs remain unresolved. Omaha's plans for using the limited grant funds currently available are summarized in Attachment 2.

#### **CSO Program**

Per EPA, combined sewer systems are sewers that are designed to collect rainwater runoff, domestic sewage, and industrial wastewater in the same pipe. Most of the time, combined sewer systems convey all sewage to a wastewater treatment plant, where it is treated to acceptable levels and then discharged to a waterbody.

During periods of heavy rainfall or snowmelt, however, the combined wastewater and stormwater volume in a combined sewer system can exceed the capacity of the sewer system or treatment plant. For this reason, and to prevent backups into basements, combined sewer systems are designed to overflow occasionally and discharge excess wastewater directly to nearby streams, rivers, or other waterbodies. The City currently has 29 such regulated overflow points that discharge into the Missouri River and various tributaries of Papillion Creek. The discharges from the CSOs impact these receiving streams. Both the Missouri River and Papillion Creek Wastewater Treatment Plants receive combined flows. In order to address the water quality impacts from CSOs, EPA published on April 19, 1994 its CSO Control Policy. This policy lays out the process to be followed by cities such as Omaha and regulatory agencies such as the Nebraska Department of Environmental Quality (NDEQ) in dealing with these discharges. In conformance with this policy, NDEQ has issued a permit to the City that requires the development of a CSO LTCP. The plan is under development and will detail the efforts to be undertaken to reduce or eliminate the water quality impacts of the discharges on the streams. The preliminary plan is due to NDEQ by October 1, 2007 with the final plan due by 2009. The plan submitted to

the NDEQ must result in elimination of the impact of the CSOs on the receiving stream and must be completely implemented by October 1, 2024. In order to meet the October 2007 deadline, the City has developed a preliminary plan to address the water quality impacts of the CSOs. Failure to submit such a plan will likely result in enforcement action and penalties from the state and EPA.

The plan currently being developed by the City is based on structural controls, with little reliance on Green Solutions. This is in part the result of NDEQ not requiring nor suggesting the inclusion of Green Solutions into the LTCP. Because of the uncertainty associated with the actual reductions in volume that can be obtained from some of these technologies, regulatory agencies, such as NDEQ, are reluctant to allow communities to reduce the size of their controls in anticipation of volume reductions obtained via Green Solutions. Until the City has tested more Green Solutions and measured its effectiveness, it will be difficult to evaluate any possible reductions or changes to the design of the LTCP.

As the result of the two step process: preliminary plan in 2007 and final in 2009, there is time to evaluate Green Solutions and as appropriate incorporate it into the Plan submitted in 2009. This will allow the City to evaluate what Public Green Solutions can be incorporated within the City and estimate its impacts to the volume and quality of the CSOs. It will also allow the City to develop and begin implementation of programs to encourage private landowners to incorporate Green Solutions. The plan for doing so is described later in this document.

#### **Current Green Controls**

From the onset of the City's sewer separation program, the City (where feasible) has been incorporating Green Solutions to manage water quantity and more recently water quality. The City currently maintains 5 wet retention ponds and 4 dry basins that were constructed in association with sewer separation projects. Eight other ponds, located in City parks, were constructed as park amenities, but also provide for stormwater storage.

In January of 2007, the NDEQ distributed grant funds to a number of NPDES Phase I and Phase II stormwater communities in Nebraska to be used to implement their Stormwater Management Plan. Omaha and Douglas County elected to pool their grant funds to design and construct demonstration projects that evaluate the effectiveness of a BMP's ability to yield water quality benefits. Demonstration projects include sustainable measures such as green roofs, bioswales, water quality basins, stormwater reuse, and rain gardens. Each demonstration project will have an educational benefit and will be accessible for the public to observe. Additionally, data will be collected to evaluate the water quality benefits, energy savings (where applicable) and flow attenuation.

Projects identified to date are listed below:

Green Roof Projects: Douglas County Health Center

Saddlebrook Joint Use Facility (City of Omaha & Omaha

Public Schools)

Wetland projects: Pawnee Wetland on Lake Cunningham

Rain Gardens/Bioswales: Under the Sink Regional Waste Collection Facility

Douglas County Health Center Saddlebrook Joint Use Facility

#### Structural Controls

As stated previously, the City has been implementing Green Solutions structural controls for many years both inside and outside the combined sewer service area. Some of these controls remove stormwater from the combined area while others detain the stormwater, thus reducing peak flows into combined sewers, and allowing flows to slowly drain to the sewers. Table 2 is a list of the current public stormwater structural controls that are in place. The flow reductions from these facilities have already been accounted for in the evaluation of the CSO controls.

In addition to a reduction in the volume of stormwater entering the system, these controls also remove pollutants. Therefore the stormwater entering the combined system is of better quality which can result in a reduction in pollutant loadings from the CSO points into the City's streams.

TABLE 2
Existing City Stormwater Structural Controls in the Combined Sewer Area

Facility Name	Туре
Storz Expressway (NE)	Extended Dry Detention Basins
Adams Park Lagoon	Retention (Wet) Ponds
Lake James Park	Extended Dry Detention Basins
Fontenelle Park Lagoon	Retention (Wet) Ponds
Storz Expressway (SE)	Retention (Wet) Ponds
13 <sup>th</sup> and Fowler	Retention (Wet) Ponds
Carter Lake	Retention (Wet) Ponds
19 <sup>th</sup> and Carter Blvd	Retention (Wet) Ponds
Nicholas Street	Stormwater Outfall with bar screen
14 <sup>th</sup> & Ida Street	Extended Dry Detention Basins

# **Future City Plans**

As stated previously, on October 1, 2007 the City will submit a Substantively Complete LTCP, which will spell out the CSO controls that are planned to address the impact that the CSOs have on the streams within the City. As part of this Plan, the City will commit to evaluate, and incorporate where feasible, Green Solutions into the LTCP during the two-year refinement period. Incorporation of these types of projects into the LTCP is not anticipated to have a significant impact on the structural solutions proposed. However, in addition to incorporation of Green Solutions, the City plans to develop a Sustainability Plan for the implementation of the LTCP for their CSOs.

The following should be a considered a starting point for the City's Green Solutions Plan. As part of the refinement period, the Plan will be further defined through the incorporation of public input.

#### Incorporation of Green Solutions into the LTCP

The City's Plan for incorporation of Green Solutions involves four main components. These are:

- Identification, evaluation and, where appropriate, incorporation into the LTCP refinement process Public Green Solutions
- Identification, evaluation and, if appropriate, implementation of demonstration projects aimed at more Private Green Solutions practices such as LID
- Development and implementation of a public education program to inform the public of what they can do to reduce the pollutants entering the streams within the City
- Monitoring Program to show improvements

Each of these components is discussed more fully below. The City will be working over the next two years on the implementation of these four concepts.

# Identification, Evaluation and, Where Appropriate, Incorporation into the LTCP Refinement Process Public Green Solutions

The City will be requesting that their Basin Consultants review their basins to evaluate possible locations for Public Green Solutions. This will include identification of possible sites for such structures, an evaluation of the impact of the structures on the overall CSO flows, development of cost estimates, and a review of other nonmonetary benefits of the structures such as community uses of open space. Based on the results of this analysis a determination will be made of the merits of incorporation of the proposed controls in the final LTCP.

# Identification, Evaluation and, if Appropriate, Implementation of Demonstration Projects Aimed at Incorporation of Private Green Solutions Practices Such as LID on Residential, Commercial or Industrial Properties

In addition to the identification and evaluation of Public Green Solutions into the LTCP, the City will focus efforts on encouraging developers, homeowners, and businesses to include Private Green Solutions, notably LID technologies on their property. As stated previously, the City has or is planning on implementing some of these technologies at various City sites. In addition, the City will request their Basin Consultants to evaluate their basins for possible locations where demonstration projects for these technologies could be implemented and the cost of such projects. This could include stormwater planters, bioretention basins, porous pavement, etc. These demonstration projects would allow the City to not only determine how well they work and evaluate operation and maintenance requirements but encourage others to implement such technologies. Funding of these demonstration projects will be based on their cost and the benefit of the project.

# Development and Implementation of a Public Education Program to Inform the Public of What They Can Do to Reduce the Pollutants Entering the Streams within the City

The final portion of the City's Green Solutions Plan under the LTCP, is to focus on public education. The City plans to expand its current public participation program to include more education. An important element of the City's program will be to educate the public

throughout the City, not just in the combined sewer area, of what they can do to improve the water quality of the streams within the City's boundaries. This will include actions that reduce the amount of pollutants that enter these streams as well as actions that reduce the amount of stormwater that comes off private property. This education program will build on the current efforts under the City's Stormwater Program. An example educational topic would include how residents may construct a rain barrel or rain garden on their property.

#### Monitoring Program to Show Improvements

An important part of the implementation of Green Solutions is to collect data that can be used to measure the benefit of these Solutions on water quality in the streams. Such a monitoring program needs to reflect the ability of individual public or private Green Solutions elements to improve water quality and reduce flows into the combined system.

As part of the LTCP implementation, the City will be implementing an ongoing monitoring program to measure the improvement in the streams. Also, it is anticipated that an important element of any demonstration projects implemented will be data collection on the performance of the control. This could include water quality sampling or a qualitative analysis.

#### Sustainability Plan

In conjunction with the implementation of a Green Solutions Plan, the City will be developing a Sustainability Plan. The purpose of the plan is to ensure that as the LTCP is implemented, practices are in place that address environmental concerns, economic factors, and community issues. It is anticipated that an important part of development will be to obtain public input on the elements of such a plan. The City will be providing more information regarding this Plan as it is developed.

## Bibliography

City of Omaha. 1996. Omaha Regional Stormwater Design Manual. Omaha, Nebraska.

U.S. Environmental Protection Agency (EPA) and National Association of Clean Water Agencies (NACWA) Natural Resources Defense Council (NRDC) Low Impact Development Center (LID), Association of State and Interstate Water Pollution Control Administrators (ASIWPCA), "Green Infrastructure Statement of Intent," dated April 19, 2007

USEPA, Office of Water, Memorandum from Benjamin H Grumbles, Assistant Administrator to EPA Regional Administrators titled, "Using Green Infrastructure to Protect Water Quality in Stormwater, CSO, Nonpoint Source and other Water Programs," dated March 5, 2007.

USEPA, Office of Water, http://www.epa.gov/waterinfrastructure/

(References for Fact Sheets are included with each sheet.)

# Attachment No 1 – Fact Sheets for Green Solutions Technologies

As stated in this White Paper, there are public type controls, those that can be implemented directly by the City, and local controls, that that need to be implemented by homeowners or private entities. The following fact sheets summarize the technologies and include a discussion on where there uses are applicable.

# Wet Ponds and Extended Dry Ponds

#### Description

Wet ponds (commonly known as stormwater ponds, retention ponds, wet extended detention ponds) are constructed basins that have a permanent pool of water throughout the year (or at least throughout the wet season). Also, another common version of the stormwater pond is the extended detention ponds (commonly known as dry ponds, detention ponds, extended detention basins) are basins whose outlets are designed to detain the stormwater runoff from a storm for some minimum duration (e.g., 12-24 hrs) which allow sediment particles and associated pollutants to settle out. Unlike wet ponds, dry extended detention ponds do not have a permanent pool.

Both the wet and extended dry ponds treat incoming stormwater runoff by settling and algal uptake. The primary removal mechanism is settling while stormwater runoff resides in the pool. Nutrient uptake also occurs through biological activity in the pond. Wet ponds are among the most cost-effective and widely used stormwater treatment practices. While there are several different versions of the wet pond design, the most common modification is the extended detention wet pond, where storage is provided above the permanent pool in order to detain stormwater runoff to provide greater settling. Dry extended detention ponds are often designed with small pools at the inlet and outlet of the pond, and can also be used to provide flood control by including additional detention storage above the extended detention level.

Figure 1 shows a wet detention pond installed at the EPA Research Triangle

Park campus to accommodate large volumes of runoff and retain runoff to remove pollutants (photo courtesy of EPA). A typical extended dry pond is shown in Figure 2 (photo courtesy of California Stormwater Quality Association, California Stormwater BMP Handbook). This pond was designed with an outlet structure to completely drain stormwater from the pond in a short period of time.



FIGURE 1



FIGURE 2

#### BMP Applicability

Wet ponds can be applied in most regions of the United States, with the exception of arid climates. In arid regions, it is difficult to justify the supplemental water needed to maintain a permanent pool because of the scarcity of water. Other modifications and design variations are needed in semi-arid and cold climates, and karst (i.e.,

limestone) topography. Dry extended detention ponds are among the most widely applicable stormwater treatment practice. While they may not always be applicable in highly urban watersheds, they have few other restrictions. Wet and extended dry ponds are recommended BMPs in the Omaha Regional Stormwater Design Manual. These BMPs can be incorporated in the development planning of watersheds in Omaha to provide water quantity and quality management.

Wet and extended dry ponds are applicable to the following areas:

- *Ultra Urban Areas* densely developed urban areas where enough land are may be available for the pond.
- Stormwater Hotspots -areas where land use or activities generate highly contaminated runoff, with concentrations of pollutants in excess of those typically found in stormwater. Wet or dry extended ponds can be used in hotspots areas if separation from groundwater is provided.
- Stormwater Retrofit Wet and dry extended ponds are commonly used for stormwater retrofits to improve water quality, protect downstream channels, and reduce flooding.

#### Key Benefits

Wet and dry extended detention systems can provide key stormwater benefits as well as other environmental advantages. These major benefits include:

- Reduce how fast runoff enters our natural waterways. This protects areas downstream from flooding and erosion.
- Trap pollutants in runoff such as nutrients, metals, and sediments.
   Specifically, wet ponds are the most effective stormwater treatment practices at removing stormwater pollutants.
- Naturally filtering stormwater before it reaches the downstream creek can be a cost-effective stormwater treatment option.
- Can be used towards creating green areas and natural habitat. Wet ponds can provide wildlife habitat for a variety of birds and animals.
- Can provide education value to teach people about how ponds work to improve water quality and how we affect our watersheds every day.

#### References

For more information about wet and extended dry pond technology see the following key references:

City of Omaha. 1996. Omaha Regional Stormwater Design Manual. Omaha, Nebraska.

Federal Highway Administration. 1996. Evaluation and Management of Highway Runoff Quality. Washington, DC.

Prince George's County Department of Environmental Resources. 1997. Low Impact Development. Laurel, MD.

Urban Drainage and Flood Control District. 2007. Urban Storm Drainage Criteria Manual - Volume 3. Denver,

Winer, R. 2000. National Pollutant Removal Database for Stormwater Treatment Practices: 2<sup>nd</sup> Edition. Center for Watershed Protection. Ellicott City, MD.

#### Wetlands

#### Description

Stormwater wetlands are structural practices that incorporate wetland plans in a shallow pool. Wetlands are a transition zone between the land and the water. As stormwater runoff flows through the wetland, pollutant removal is achieved by settling and biological uptake within the wetland. Stormwater wetlands are fundamentally different from natural wetland systems. Stormwater wetlands are designed specifically for the purpose of treating stormwater runoff, and typically have less biodiversity than natural wetlands both in terms of plant and animal life. Artificial wetlands offer natural aesthetic qualities, wildlife habitat, erosion control, and pollutant removal. There are several design variations of the stormwater wetland, each design differing in the relative amounts of shallow and deep water, and dry storage above the wetland.

Figures 1 and 2 show two artificial wetland facilities (photos courtesy of Wisconsin Department of Natural Resources and the Virginia Department of Conservation and Recreation).



FIGURE 1



FIGURE 2

#### BMP Applicability

Stormwater wetlands can be applied in most regions of the United States, with the exception of arid climates. In arid, and even semi-arid climates, it is difficult to design any stormwater practice that has a permanent pool. Because wetlands are relatively shallow, water losses due to evaporation can be high which can be critical for wetland plants.

Additionally, wetlands could be used in stormwater hotspot areas, but need significant separation from groundwater for this purpose. When retrofitting an entire watershed, stormwater wetlands have the advantage of providing educational and habitat value. One disadvantage is the difficulty storing large amounts of runoff without consuming a large amount of land.

Stormwater wetlands are recommended BMPs in the Omaha Regional Stormwater Design Manual. These BMPs can be incorporated in the development planning of watersheds in Omaha to provide water quantity and quality management.

#### Key Benefits

Wetlands can provide key stormwater benefits as well as other environmental advantages. These major benefits include:

- Can be incorporated into green spaces.
- Provide Stormwater peak flow, volume control, and groundwater recharge.
- Provide water quality control through multiple pollutant removal mechanisms such as filtration, adsorption to soil particles, and biological uptake by plants.

- Can be used towards creating green areas and natural habitat.
- Adaptable to many development sites and can be combined with other BMPs.
- May reduce the infrastructure costs required to collect and convey the runoff off-site, by disposing a significant volume of annual rainfall on-site.

#### References

For more information about wetland technology see the following key references:

City of Omaha. 1996. Omaha Regional Stormwater Design Manual. Omaha, Nebraska.

EPA. 2000. Guiding Principles for Constructed Wetlands: Providing for Water Quality and Wildlife Habitat. EPA 843-B-00-003. Available online at www.epa.gov/owow/wetlands/

Federal Highway Administration. 1996. Evaluation and Management of Highway Runoff Quality. Washington, DC.

Urban Drainage and Flood Control District. 2007. Urban Storm Drainage Criteria Manual - Volume 3. Denver, CO.

Winer, R. 2000. National Pollutant Removal Database for Stormwater Treatment Practices: 2<sup>nd</sup> Edition. Center for Watershed Protection. Ellicott City, MD.

#### **Bioretention**

#### Description

Bioretention areas are landscaping features adapted to treat stormwater runoff on the development site. They are commonly located in parking lot islands or within small pockets in residential land uses. Surface runoff is directed into shallow, landscaped depressions. These depressions are designed to incorporate many of the pollutant removal mechanisms that operate in forested ecosystems. During storms, runoff ponds above the mulch and soil in the system. Runoff from larger storms is generally diverted past the facility to the storm drain system. The remaining runoff filters through the mulch and prepared soil mix. Typically, the filtered runoff is collected in a perforated underdrain and returned to the storm drain system.

Figures 1 and 2 show two facilities installed in a mall parking lot in Greenbelt, MD (photos courtesy of University of Maryland Department of Civil and Environmental Engineering). These bioretention areas are set up along the length of the parking areas and receive runoff from the parking area through curb cuts. A manhole grate is set as an overflow for water exceeding the ponding depth.



FIGURE 1



FIGURE 2

#### BMP Applicability

Bioretention systems are applicable almost everywhere in the United States. In arid or cold climates, however, some minor design modifications may be needed. Bioretention areas are applicable to the following areas:

- *Ultra Urban Areas* densely developed urban areas in which little pervious surface exists.
- Stormwater Hotspots -areas where land use or activities generate highly contaminated runoff, with concentrations of pollutants in excess of those typically found in stormwater.
- Stormwater Retrofit areas where a stormwater management practice (usually structural) is put into place after development has occurred, to improve water quality, protect downstream channels, reduce flooding, or meet other objectives.

#### Key Benefits

Bioretention systems can provide key stormwater benefits as well as other environmental advantages. These major benefits include:

- Can be incorporated into green spaces, streetscapes, median strips, and parking islands.
- Provide Stormwater peak flow and volume control.
- Provide water quality control through multiple pollutant removal mechanisms such as filtration, adsorption to soil particles, and biological uptake by plants.
- Can be used towards creating green areas and natural habitat.
- May reduce the infrastructure costs required to collect and convey the runoff off-site, by disposing a significant volume of annual rainfall on-site.

- Land area requirement and cost can be minimized if the local jurisdiction considers bioretention area as part of the required vegetated open space set-aside or if installed trees count against local landscaping and tree coverage requirements.
- Maintenance is similar to conventional landscaping.

#### References

For more information about bioretention system technology see the following key references:

Davis, A.P., Shokouhian, M., Sharma, H., and Minani, C. 1998. Optimization of Bioretention Design for Water Quality and Hydrologic Characteristics.

Federal Highway Administration. 1996. Evaluation and Management of Highway Runoff Quality. Washington, DC.

Prince George's County. 1993. Design Manual for Use of Bioretention in Stormwater Management. Department of Environmental Resources, Prince George's County, Landover, MD.

Prince George's County Department of Environmental Resources. 1997. Low Impact Development. Laurel, MD

Prince George's County Department of Environmental Resources. 1997. Bioretention Monitoring: Preliminary Data Analysis. Landover, MD

#### **Grass Swales**

#### Description

Grass swales are vegetated channels that are designed to treat and convey stormwater runoff. As stormwater runoff flows through the channels, it is treated through filtering by the vegetation in the channel and filtering through the underlying soils. Grassed swales can be designed as wet or dry systems. Wet grassed swales maintain a volume of water in the bottom of the trench and it is designed to emulate a natural wetland. Water quality improvement is achieved by the settling out of particulates in the water, and by the biological and chemical action of the water. Dry grassed swales are designed so that runoff infiltrates through the bottom of the swale in the ground below.

Figure 1 shows a large capacity grass swale and channel designed for both conveyance and water quality objectives (photo courtesy of University of Alabama Department of Civil and Environmental Engineering).



FIGURE 1

Figure 2 shows a grassed swale with check dams installed to reduce channel erosion by slowing down the velocity of channel flow (photo courtesy of Alabama Soil and Water Conservation Committee).



FIGURE 2

#### BMP Applicability

Grassed swales can be applied in most development situations with few restrictions. Swales are well suited to treat roadway runoff because of their linear nature. Grass swales can be applied in most regions of the country. In arid and semi-arid climates, however, the value of swales needs to be balanced against water needs to irrigate them. One common retrofit opportunity is to use grassed swales to replace existing drainage ditches. It may be possible to incorporate features such as check dams in the drainage ditch to enhance pollutant removal or infiltration.

Additionally, grassed swales are not well suited in ultra urban areas because runoff is typically conveyed in underground storm drain pipes. Stormwater runoff from pollutant hotspot areas, like gas stations, should not be directed toward grassed channels due to the potential threat to groundwater quality.

Grassed swales are recommended BMPs in the Omaha Regional Stormwater Design Manual. These BMPs can be incorporated in the development planning of watersheds in Omaha to provide water quantity and quality management.

Key Benefits

Grassed swales can provide key stormwater benefits as well as other environmental advantages. These major benefits include:

- Can help to control peak discharges by reducing runoff velocity and lengthen flow paths.
- Infiltration through the natural substrate helps to reduce total stormwater runoff volume.
- Provide effective pretreatment for downstream BMPs by trapping, filtering and infiltrating particulates and associated pollutants.
- Accent the landscape and may help satisfy landscaping and greenspace requirements.

- Roadside swales effectively keep stormwater flows away from street surfaces.
- Construction may cost less than conventional curb and gutter systems.
- Provide water quality control through multiple pollutant removal mechanisms such as filtration, adsorption to soil particles, and biological uptake by plants.
- Can be used towards creating green areas and natural habitat.

#### References

For more information about grassed swales see the following key references:

City of Omaha. 1996. Omaha Regional Stormwater Design Manual. Omaha, Nebraska.

Center for Watershed Protection. 1996. Design of Stormwater Filtering Systems. Prepared for the Chesapeake Research Consortium, Solomons, MD and US EPA Region V, Chicago, IL

Federal Highway Administration. 1996. Evaluation and Management of Highway Runoff Quality. Washington, DC.

Prince George's County Department of Environmental Resources. 1997. Low Impact Development. Laurel, MD.

Urban Drainage and Flood Control District. 2007. Urban Storm Drainage Criteria Manual - Volume 3. Denver, CO.

Winer, R. 2000. National Pollutant Removal Database for Stormwater Treatment Practices: 2<sup>nd</sup> Edition. Center for Watershed Protection. Ellicott City, MD.

# Filter Strips and Flow Spreaders

#### Description

Filter strips are evenly sloped vegetated areas adjacent to impervious areas that treat stormwater filtering it through vegetation (usually grass or wooded growth). They are intended to reduce impacts of sheet flow and velocity of stormwater and help improve water quality. Filter strips are sometimes referred to as vegetated filter strips, grassed filter strips or buffer strips. They have the potential to remove sediments and other pollutants and provide good pretreatment of stormwater that will be routed to another BMP such as a bioretention area.

Flow spreaders are commonly used in conjunction with filter strips to dissipate energy and reduce the velocity of the stormwater from the pavement areas before it enters the filter strip. Typically, pea gravel or a concrete level spreader are used at the top of the filter strip to improve sheet flow and capture sediment.

Depending on the use of the level spreader, other elements may include a high flow bypass system, a forebay, and a filter strip.

Figures 1 shows a filter strip adjacent to a school (photo courtesy of Lower Columbia Estuary Partnership). The concrete berms act as level spreader devices, slowing and spreading out the water. A variety of trees, shrubs and grasses were used.

In Figure 2 an established filter strip along with a concrete level spreader is being used as a pretreatment for parking lot runoff directed to an infiltration basin (photo courtesy of California Stormwater Quality Association).



FIGURE 1



FIGURE 2

#### BMP Applicability

Filter strips are applicable in most regions of the country, but are restricted in some watersheds where land is not available to install them. Additionally, the cost of irrigating grass in arid areas can outweigh water quality benefits. Filter strips are best suited to treat runoff from roads and highways, roof downspouts, very small parking lots, pretreatment associated with another stormwater treatment BMP such as a swale or as part of a buffer zone to protect streams.

Additionally, filter strips should not accept runoff from pollutant hotspot areas, like gas stations, since the infiltrated stormwater may be a potential threat to groundwater quality. Filter strips may be not a good retrofit option because they require a large area of land.

Filter strips and flow spreaders are recommended BMPs in the Omaha

Regional Stormwater Design Manual. These BMPs can be incorporated in the development planning of watersheds in Omaha to provide water quantity and quality management.

#### **Key Benefits**

Filter strip and flow spreader systems can provide key stormwater benefits as well as other environmental advantages. These major benefits include:

 Partial removal of sediments and associated contaminants from stormwater runoff.

- Increased infiltration of stormwater runoff and some deposition of soluble contaminants.
- Relatively inexpensive and simple to design and build.
- Require a relatively low maintenance effort.
- Add a visually appealing green effect to parking lots.

#### References

For more information about filter strip and flow spreader systems see the following key references:

Atlanta Regional Commission. 2001. Georgia Stormwater Managmeent Manual.

City of Omaha. 1996. Omaha Regional Stormwater Design Manual. Omaha, Nebraska.

Federal Highway Administration. 1996. Evaluation and Management of Highway Runoff Quality. Washington, DC.

Prince George's County Department of Environmental Resources. 1997. Low Impact Development. Laurel, MD.

Urban Drainage and Flood Control District. 2007. Urban Storm Drainage Criteria Manual - Volume 3. Denver, CO.

Winer, R. 2000. National Pollutant Removal Database for Stormwater Treatment Practices: 2<sup>nd</sup> Edition. Center for Watershed Protection. Ellicott City, MD.

Yu., S., S. Barnes and V. Gerde. 1993. Testing of Best Management Practices for Controlling Highway Runoff. Virginia Transportation Research Council. FHWA/VA 93-R16.

#### **Green Roofs**

#### Description

Green roofs or vegetated roof covers (also referred to as living roofs, nature roofs and eco-roofs) are a thin layer of living plants growing on top of a roof. These roof systems store rainwater in a lightweight engineered soil medium, where the water is taken up by plants and transpired into the air. As a result, much less water runs off the roof, as compared to conventional rooftops.

There are two distinct types of green roofs: extensive green roofs require less than 6" of soil medium and support mostly herbaceous plants. These roof meadows generally have no public access and require little maintenance. In contrast, intensive green roofs include shrubs and small trees planted in more than six inches of growing medium. These green roof systems are often designed as accessible building amenities.

Figures 1 shows a lush roof garden surrounding a tower building. Roof gardens like this one minimize stormwater runoff as well as decreasing the ambient temperature in the surrounding urban area (photo courtesy of Lower Columbia Estuary Partnership). Figure 2 shows the installation of another green roof at the US EPA Denver headquarters.



FIGURE 1

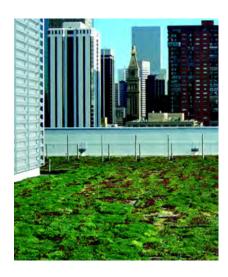


FIGURE 2

#### BMP Applicability

Green roofs are appropriate for commercial, industrial, and residential structures, especially those with a wide roof area. They can be incorporated into new construction or added to existing buildings during renovation or re-roofing. Most green roofs are built on flat or low-angle rooftops, but some have been installed on pitched roofs, with special design features to prevent slumping and ensure plant survival.

Green roofs are appropriate anywhere it is desirable to reduce the overall amount of stormwater runoff. They are an excellent technique to use in dense urban areas, in areas where infiltration is difficult due to tight soils or shallow bedrock, or on sites where infiltration is undesirable due to existing soil contamination. Because green roofs return rainwater to the atmosphere, they should not be used in situations where groundwater recharge is a priority, such as in stressed basins with chronic low-flow conditions. In these circumstances, roof runoff should be infiltrated whenever feasible.

#### Key Benefits

Filter strip systems can provide key stormwater benefits as well as other environmental advantages. These major benefits include:

- Reduce stormwater runoff so there is less water directed into storm drains.
- Reduce the need for energy to heat house in winter and cool in summer. The vegetation layer and trapped air help insulate buildings when the soils are dry to slightly moist. Additionally, the plants natural evapotranspiration process results in cooling of roof surfaces in summer. Heat loss due to the slowing of winter winds by friction created by the plant surface can reduce heat loss significantly.
- Green roofs absorb heat and lower ambient temperature near a building with a green roof, thus aiding in the reduction temperatures.
- Green roofs installed correctly can extend the life of a conventional roof by protecting the conventional

- roof surface from ultra violet light, large temperature fluctuations and normal wear and tear associated with exposed surface roofs.
- Green roofs can incorporate food gardens that can additionally stress organic methods. Careful plant selections can favor habitat creation utilizing appropriate threatened native species or as a food supply for birds and favorable insects
- Green roofs provide pleasant sights, smells and sounds that promote favorable social interaction and are beneficial to quality of life in urban areas.
- Plant photosynthesis reduces the negative impact of carbon dioxide and produces oxygen. Plants also help filter out airborne pollutants thus aiding in air quality improvements.
- Green roofs can be good sound insulators reducing the impact of noise to areas below the roof.

#### References

For more information about green roof technology see the following key references:

EPA website provides information on green roofs. http://www.epa.gov/hiri/strategies/greenroofs.html

Green Roofs for Healthy Cities is a non-profit industry association working to develop standards for green roofs in North America. They also provide training and design courses. http://www.greenroofs.org

www.greenroofs.com is the Green Roof Industry Resource Portal; the site include extensive directories of suppliers and contractors.

Researchers at North Carolina State University are studying the benefits, costs, and construction of green roofs. The results of their research can be found at http://www.bae.ncsu.edu/greenroofs/

The Center for Green Roof Research at Penn State University operates a test facility for green roofs. http://hortweb.cas.psu.edu/research/greenroofcenter/

Greening Gotham is an organization working to promote green roofs in NYC. They are developing a Green Roof Toolkit. http://www.greeninggotham.org/home.php

Roofscapes, Inc. is a leading North American Green Roof Provider. http://www.roofmeadow.com/

#### **Porous Pavement**

#### Description

Porous pavement is designed to allow percolation or infiltration of stormwater through the surface into the soil below where the water is naturally filtered and pollutants are removed. In contrast, normal pavement is an impervious surface that sheds rainfall and associated surface pollutants forcing the water to run off paved surfaces directly into nearby storm drains and then into streams and lakes. Porous pavement reduces stormwater runoff volumes and minimizes the pollutants introduced into stormwater runoff from parking areas.

All permeable paving systems consist of a durable, load bearing, pervious surface overlying a crushed stone base that stores rainwater before it infiltrates into the underlying soil. Permeable paving techniques include porous asphalt, pervious concrete, paving stones, and manufactured "grass pavers" made of concrete or plastic. Permeable paving may be used for walkways, patios, plazas, driveways, parking stalls, and overflow parking areas.

Figures 1 and 2 permeable pavers are used throughout the small parking lot to filter stormwater runoff (photos courtesy of Lower Columbia Estuary Partnership). Small gravel is used to increase permeability between the pavers. A small swale was also included in the parking lot's design. Figure 3 shows a parking lot where pourable porous concrete was used. This site is located at the Lancaster County Extension office at 27th and F Streets in Lincoln, Nebraska.



FIGURE 1



FIGURE 2



FIGURE 3

#### BMP Applicability

Porous paving is appropriate for pedestrian-only areas for very low-volume, low-speed areas such as overflow parking areas, shopping centers, residential driveways, parking stalls, alleys, sidewalks, and road shoulders. Porous

paving is a good BMP practice for dense urban areas because it does not require any additional land.

Porous paving is not ideal for high traffic/high speed areas because it has lower load-bearing capacity than conventional pavement. Nor should it be used on stormwater hotspots with high pollutant loads because stormwater cannot be pretreated prior to infiltration. Heavy winter sanding may clog joints and void spaces.

Porous paving is a recommended BMP in the Omaha Regional Stormwater Design Manual. This BMP can be incorporated in the development planning of watersheds in Omaha to provide water quantity and quality management.

#### Key Benefits

Porous pavement systems can provide key stormwater benefits as well as other environmental advantages. These major benefits include:

 Reduce storm water runoff. (Even when a porous pavement structure is saturated, its rough surface texture continues to slow surface flow of stormwater).

- Replenish groundwater.
- Reduce flooding which may overload combined sewer sewage treatment plants.
- Require less land set aside and cost for development of retention basins.
- Reduce pollutants in run-off through infiltration.
- Reduce irrigation of area plantings based on the seepage of rain into the sub soil surfaces.
- Reduce the need for stormwater structures and piping.

#### References

For more information about porous pavement technology see the following key references:

City of Omaha. 1996. Omaha Regional Stormwater Design Manual. Omaha, Nebraska.

EPA Stormwater Technology Fact Sheet: Porous Pavement. www.epa.gov/owm/mtb/porouspa.pdf

Federal Highway Administration. 1996. Evaluation and Management of Highway Runoff Quality. Washington, DC.

Metropolitan Washington Council of Governments. 1987. Controlling Urban Runoff: A Practical Manual for Planning and Designing Urban BMPs.

Prince George's County Department of Environmental Resources. 1997. Low Impact Development. Laurel, MD.

#### Sand Filters

#### Description

Sand filters are typically two-chambered stormwater treatment practices. The first chamber is for settling, and the second is a filter bed filled with sand or another filtering media. As stormwater flows into the first chamber, large particles settle out, and the fine particles and other pollutants are removed as stormwater flows through filtering media. There are several modifications of the basic sand filter design, including the surface sand filter, underground sand filter, perimeter sand filter, and organic medial filter.

Sand filters have been demonstrated to be effective in removing many of the common pollutants found in urban stormwater runoff, especially those found in particulate form.

Figure 1 shows a typical stormwater sand filter design suited for highly impervious areas (photos courtesy of EPA).

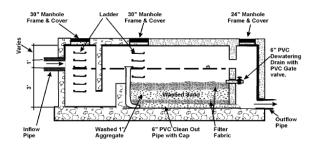


FIGURE 1

#### BMP Applicability

Sand filters can be applied in most regions of the country, and on most types of sites. Although sand filters can be used in both cold and arid climates, several design modifications may be necessary. Generally,

in urban areas, sand filters are good options because they consume little to no surface space. Sand filters are an excellent option to treat runoff from stormwater hotspots because stormwater treated by sand filters has no interaction with, and thus no potential to contaminate groundwater.

Sand filters are recommended BMPs in the Omaha Regional Stormwater Design Manual. These BMPs can be incorporated in the development planning of watersheds in Omaha to provide water quantity and quality management.

#### Key Benefits

Sand filters can provide key stormwater benefits as well as other environmental advantages. These major benefits include:

- Can provides high pollutant removal
- May require less space than other treatment control BMPs.
- Good retrofit capability.
- Take up little space and can be used on highly developed steeply sloped sites.

#### **Public Education**

#### Description

A public education and outreach program helps to promote a greater awareness within the community regarding the importance of minimizing stormwater impacts as well as the personal responsibilities expected of them. Public support is especially important when municipalities attempt to institute new programs or seek volunteers to help implement programs.

There are a variety of BMPs that could be incorporated into a public education program, such as:

- Brochures or fact sheet educating the general public or specific audiences about stormwater related pollution and the importance of proper stormwater practices.
- Recreational guides to educate groups such as golfers, hikers, paddlers, windsurfers, climbers, fisherman, and campers about stormwater related pollution and the importance of proper stormwater practices.
- Alternative information sources such as web sites, bump stickers, refrigerator magnets, and posters for bus stops. A library of educational materials - for community and school groups.
- Volunteer citizen educators staff for a public education task force to educate the general public or specific audiences about stormwater related pollution and the importance of proper stormwater practices.

- Event participation with educational displays at home shows, community festivals, libraries and other public buildings educating the general public or specific audiences about stormwater related pollution and the importance of proper stormwater practices.
- Educational programs for schoolage children educating them on stormwater related pollution and what they can do to help.
- Economic incentives to citizens and businesses (e.g., rebates to homeowners purchasing mulching lawnmowers or biodegradable lawn products.
- *Tributary signage* to increase public awareness of local water resources.

Figures 1 and 2 show two examples of public education brochures from EPA. The first brochure "Make Your Home the Solution to Stormwater Pollution" is targeted directly to homeowners and provides tips on a wide variety of simple things that homeowner's can do to prevent stormwater pollution. The second brochure describes the benefits of water-efficient, low-impact landscaping.



FIGURE 1

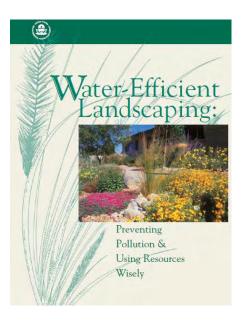


FIGURE 2

#### BMP Applicability

Public education programs are applicable almost everywhere. Education and outreach are key components to any successful stormwater program. Brochures and fact sheets containing relevant pollution prevention information as well as training programs can be made available for residential, commercial, and industrial use.

#### Key Benefits

Public education programs can provide key stormwater benefits as well as other environmental advantages. These major benefits include:

- Educate the public on measures to conserve water and minimize pollution.
- Educate the public on the many environmental and aesthetic benefits of landscaping, such as rain gardens.
- Provide leadership to the public by demonstrating practical water efficient devices and landscapes.
- Encourage active participation in local, state, and regional conservation initiatives.

#### References

For more information about public education programs see the following key references:

EPA Stormwater Technology Fact Sheet. www.epa.gov/npdes/pubs/fact2-3.pdf

EPA Stormwater Outreach Material and Reference Documents. http://cfpub.epa.gov/npdes/stormwatermonth.cfm

### **Pollution Prevention**

#### Description

Pollution prevention is aimed at reducing and/or preventing the contamination of stormwater runoff at its source, before it has an opportunity to pollute the runoff flow and enter the conveyance system. Stormwater pollution prevention practices are an important way to prevent water quality problems in stormwater runoff from coming in contact with pollutants in the first place rather than using downstream structural controls to treat the runoff and remove pollutants. The most common pollution prevention practices are street sweeping, hazardous waste collection, and litter receptacles.

Street and parking lot sweeping on a regular basis can remove sediment, debris, little, and other pollutants from road and parking lot surfaces that are potential sources of stormwater pollution. Recent improvements in street sweeping technology have enhanced the ability of present day machines to pick-up the finegrained sediment particles that carry a substantial portion of the stormwater pollutant load. The frequency of and location of street sweeping is an important consideration for any program. How often and what roads to sweep are determined by the program budget and the level of pollutant removal is to be achieved. Figure 1 shows a street sweeping truck along a road (photo courtesy of the City of Austin, TX).

Household hazardous wastes can include a variety of materials used in the home including paints, solvents, pesticides, herbicides and cleaners. Residents often dispose of the unused portion of these products down a drain (which goes to a wastewater treatment plat or septic tank),

or may dump them in their yard, a storm drain or even a drainage ditch or stream. Ideally, a community should establish a center for household hazardous wastes. Citizens would be able to drop off their wastes, which can then be categorized and disposed of at an approved hazardous waste facility. A complimentary option is to encourage the use of nonhazardous or less hazardous alternatives for particular products. Figure 2 shows a photo of the City of Austin free Hazardous Waste Facility. Staff at the facility will ensure that products are safely disposed of.

Trash receptacles could provide a convenient way for citizen's to dispose of refuse, recyclables, bulk items, and yard waste in designated areas rather than potentially leaving it in undesirable locations where it could become a potential pollutant source. In order to be effective pollution prevention practices, trash receptacles need regular inspection, repair, cleaning, and replacement.



FIGURE 1



FIGURE 2

#### BMP Applicability

Street sweeping, hazardous waste collection, and litter receptacles are applicable almost everywhere. Street sweeping can be conducted throughout the year – weather permitting. Street sweeping typically does not occur during the fall leaf collection season or when snow or ice is present. Weekly collection of solid waste and other waste can be schedule. Additionally, collection events can be provided to residents for the disposal of hazardous waste. Trash receptacles can be located along public sidewalks in areas with high pedestrian traffic for the disposal of trash.

#### Key Benefits

Pollution prevention programs can provide key stormwater benefits as well as other environmental advantages. These major benefits include:

- Reduce potential sources of stormwater pollution.
- Prevent hazardous waste disposal in sinks, yards, storm drains, and streams.
- Discourage and control litter.
- Encourage active recycling.
- Prevent illegal dumping.

#### References

For more information about pollution prevent practices see the following key references:

Colorado Department of Transportation. 2002. Erosion Control and Stormwater Quality Guide. Denver, CO.

EPA Office of Water. www.epa.gov/water

# Rain Gardens, Rain Barrels, and Disconnection of Roof Drains

#### Description

Rain Gardens are gardens containing flowering plants and grasses (preferably native species of both) that can survive in soil soaked with water from rain storms. However they are not gardens that have standing water. Rain Gardens collect and slow stormwater run off and increase its infiltration into the soil. These attractive gardens help reduce the rapid flow of stormwater from homes and businesses to storm drains and thus protect streams and lakes from pollutants that are washed from house roofs and paved areas.

Rain barrels, sometimes called cisterns, are aboveground water storage vessels. They capture rain runoff from a building's roof using the gutter and downspout system. Use of a rain barrel located under gutter downspouts and connected with a hose to the rain garden can help spread rainfall over longer periods of time, thereby further slowing the flow of stormwater and increasing its infiltration.

Directing runoff from roof drains and impervious surfaces to vegetated areas where it will infiltrate decreases peak flows downstream and may qualify for a stormwater credit. Potentially, the "disconnected" area may be deducted from the impervious surface area used to calculate water quality treatment volumes and qualify for a stormwater credit should the City or the state establish such a program in the future. Infiltration of runoff from "disconnected" areas can help to satisfy recharge requirements. Also, older buildings, prior to 1970, may have one or more roof drains piped to discharge to the

sanitary sewer. Stormwater from roof drains is no longer required to be treated by the local waste water treatment facility. Disconnection of roof drains from the sanitary sewer system will assist in preventing heavy rain and storm water overwhelm the sanitary system resulting in environmental pollution and property damage.

Figures 1 and 2 show two rain gardens: one is planted in a front of a drain pipe and another has been installed in a residential area (Photos courtesy of Kansas City Rain Gardens). A typical rain barrel disconnected from the roof drain is shown in Figure 3.



FIGURE 1



FIGURE 2



FIGURE 3

#### BMP Applicability

Rain gardens and disconnected roof drain systems are applicable almost everywhere in the United States. However, in the western United States where rain water is considered surface water, it is illegal to catch and contain rainwater unless you have ownership of surface water rights to contain and use it. Local surface water regulations should be consulted prior to implementing rain barrels.

#### Key Benefits

Rain gardens, rain barrels, and disconnection roof drain systems can provide key stormwater benefits as well as other environmental advantages. These major benefits include:

#### Rain Gardens

 Provide a low maintenance, attractively landscaped property with minimum cost.

- Reduce the amount of household or business stormwater and associated pollutants to area streams and lakesimprove local water quality.
- Reduce potential of basement flooding.
- Improve or eliminate wet spots in yard.
- Increase habitat for beneficial insects, butterflies and birds.

#### Rain Barrels

- Reduce water demand by providing an alternative source for irrigation needs.
- Reduce peak discharge rates and total runoff volume.

#### Disconnection of Roof Drains

- May provide stormwater credit for "disconnect" areas.
- In order developments, disconnection and redirection of roof drains connected to sanitary sewer systems could potentially have a net volume reduction on the sanitary sewer system.

#### Additional information

Additional information on the development of a rain garden in Nebraska can be found in the document, "Stormwater Management: Plant Selection for Rain Gardens in Nebraska." This document should be available in October from Extension Services in Eastern Nebraska.

#### References

For more information about bioretention system technology see the following key references:

EPA Stormwater Technology Fact Sheets. Rain Barrel/Rain Garden. http://www.epa.gov/region03/p2/whatis-rainbarrel.pdf and http://www.epa.gov/reg3esd1/garden/stormwater.htm

Prince George's County Department of Environmental Resources. 1997. Low Impact Development. Laurel, MD

Prince George's County Department of Environmental Resources. 1997. Bioretention Monitoring: Preliminary Data Analysis. Landover, MD

#### **Peak Flow Reduction**

#### Reduction in Downstream Flows

Green solutions preserve and restore the hydrologic functions of watersheds. These practices are innovative stormwater management approaches that manage rainfall at the source using a variety of structural and nonstructural controls. The main goal of green practices is to mimic a site's predevelopment hydrology by using design techniques that infiltrate, filter, store, evaporate, and detain runoff close to its source. Preservation of predevelopment hydrology can accomplish the following:

- Reduce imperviousness Changes in postdevelopment hydrology can be minimized by reducing impervious areas and preserving more trees and meadows to reduce the storage requirements to maintain the predevelopment runoff volume.
- Disconnection impervious surfaces –
   Additional environmental benefits can
   be achieved and the hydrologic
   impacts reduced by disconnecting
   impervious surfaces (such as rooftops)
   as much as possible.
- Preservation and protection of environmentally sensitive site features – Site features to be protected and preserved can include riparian areas, floodplains, stream buffers, wetlands, woodlands, conservation zones, and valuable trees.
- Maintaining predevelopment response of a watershed - Maintaining the response of a watershed to a given storm event at predevelopment levels minimizes peak runoff rates. Green practices lengthen flow paths and reduce the length of the runoff conveyance system.

Green practices are not intended to replace traditional stormwater management systems. Green practices specifically address the frequent or micro-storms that occur on a regular basis (weekly or monthly). Traditional stormwater management systems have been designed to function well under a single design condition such as the 10 and 100 year flood storm. Stormwater management systems designed for these larger flood control events may not perform adequately under other scenarios. A hybrid approach using green and traditional stormwater management practices may be needed in known flooding problem areas to reduce liability and provide a sense of safety.

#### **Erosion and Sediment Control**

Stormwater runoff is the main cause of soil erosion. Green practices can be implemented to achieve stormwater runoff control to reduce erosion and sediment loss at sites. One of the major concepts of green practices is to break up the drainage area of a given site into very small drainage areas to disconnect them hydraulically from each other. This approach benefits erosion and sediment control efforts by diffusing surface flow into many directions and providing flexibility in the use of a variety of erosion and sediment control practices. Runoff control practices reduce the amount of runoff generated on a construction site, prevent off-site runoff from entering the disturbed area, or slow the runoff moving through and exiting the disturbed area.

Green erosion control practices include a variety of vegetative, chemical, and structural measures used to shield soil from the impacts of rainfall or to bind soil in place preventing it from being detached by surface runoff or wind erosion.

Examples of erosion control practices

include vegetative stabilization, topsoiling, mulching, and erosion control matting.

On the other hand, sediment control practices are designed to slow the flow of water by spreading, ponding, or filtering. Therefore, the capacity of the water to transport sediment is reduced, and sediment settles out of suspension. Commonly used green control practices include installation of vegetated buffer areas down slope of the disturbed area to slow and filter the runoff; construction of small depressions or dikes to catch sediment as close to its point of origin as possible; and construction of sediment traps or basins at the perimeter of the disturbed area to capture additional sediment from the runoff.

#### References

For more information about bioretention system technology see the following key references:

Coffman, L.S., 2001: Low Impact Development creating a storm of controversy. Water Resources Impact, 3 (6), 7-9. http://www.awra.org

Low Impact Development Center. http://www.lowimpactdevelopment.org

EPA Office of Water. http://www.epa.gov/owow/nps/urban.html

## **Water Quality**

#### Reduction in Pollutant Loadings

Green solutions enhance the ability to protect surface and ground water quality and preserve the physical integrity of receiving streams. Several studies have been conducted to analyze the effectiveness of various green practices based on hydrology and pollutant removal capabilities. Generally, these practices are good for both pollutant removal and runoff volume reduction. Results from studies indicate that removal efficiencies were quite good for sediment, metals, nutrients, oil and grease, and some practices have potential to remove bacteria from runoff.

Using a green solution approach in smaller drainage areas can potentially make it easier to identify and treat water quality problems at the source on a smaller scale, thus reducing the total pollutant loadings in stormwater runoff in a watershed. These practices enhance the watershed approach by going beyond reducing chemical contamination of water to find creative ways to enhance the overall health of a watershed.

#### Improved Aesthetics

Green practices are often more aesthetically pleasing than, traditional, structural storm-water conveyance systems. These controls can be integrated into multifunctional landscape features where runoff can be managed and controlled at the source. Native plants such as shrubs, grass, herbs, wildflowers, and other plants can be used, creating an aesthetically pleasing landscape.

Figure 1 shows a reinforced grass parking lot installation at the University of Miami Orange Bowl Stadium (photo courtesy of Invisible Structures, Inc.). This parking lot installation used mixed asphalt aisles with reinforced grass pavers in parking bays. Stormwater drainage is instant through the grass and the parking lot is more aesthetically pleasing than asphalt. The quality of water is improved with grass as a natural filter. Additionally, Figure 2 shows a typical parking lot island retrofitted with a bioretention area. The thriving bioretention area compliments the surrounding landscape and filters stormwater runoff.



FIGURE 1



FIGURE 2

# References For more information about water quality and aesthetic benefits see the following key references: Coffman, L.S., 2001: Low Impact Development creating a storm of controversy. Water Resources Impact, 3 (6), 7-9. http://www.awra.org Low Impact Development Center. http://www.lowimpactdevelopment.org EPA Office of Water. http://www.epa.gov/owow/nps/urban.html

# Attachment No. 2 – City Planned Projects

Project Name	Comments
Pawnee Wetland,	Little Papillion Watershed
Saddlebrook Joint Use Facility at 149th & Laurel	Demonstration project site using green roof
Stream asset inventory	Evaluation of Douglas County streams
156th Street. Improvements	Design of LID BMPs
Under the Sink	Design and installation of LID BMPs
Sewer Maintenance Facility at 6880 Q St.	Design and installation of a green roof on existing facility.
Douglas County Health Center	Design and installation of a stormwater reuse system/rain garden
Transportation-related projects	Incorporate LID in Street Projects
World O! Water Festival	
LID/Conservation Design Workshop	Was held Feb 27 to Mar 1, 2007
Green roofs for healthy cities symposium	October 2007
Smart Growth Conference	Spring 2008
Continuing education seminars	
Public information seminars	
Stormwater Education Webcasts	