Thinking Outside The Pipe

Better Stormwater Management Solutions for Southwestern Illinois

HEARTLANDS CONSERVANCY
Investing In The Nature Of Southwestern Illinois
(formerly Southwestern Illinois RC&D)
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HeartLands Conservancy envisions healthy and sustainable agricultural, natural and social communities for current and future generations. We hope this handbook aids the southwestern Illinois region in better management of its stormwater.

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A clogged stormwater pipe (www.egpublicworks.org)
Executive Summary

Low Impact Development (LID) strategies for stormwater management are an excellent alternative to traditional measures for communities, developers and homeowners throughout southwestern Illinois. Many benefits can be realized by capturing and infiltrating stormwater on-site (for a residential or commercial development) as opposed to treating stormwater like a toxic substance and removing it from the site as quickly as possible. LID strategies help to reduce erosion, non-point source pollution, and flooding, as well as replenish groundwater supplies. This is achieved through small-scale techniques that mimic the way the natural system handles stormwater – reduction of impervious surfaces, temporary retention, reuse of retained water, and infiltration. Utilization of LID for stormwater management is also economical. Developers save money in the reduction of grading and infrastructure costs. Municipalities see a savings in their public works operation and maintenance – since much of that stormwater is being diverted from storm sewers – especially if the municipality is utilizing a combined sewer overflow system. Homeowners see a savings in the lack of property damage done by fast-moving, polluted stormwater. These “natural mimicry” LID techniques are also more attractive, can increase property values and provide much-needed open space, which benefits all citizens in a community.

These techniques and strategies have been implemented in a demonstration case study at Rock Hill Trails, a conservation subdivision construction site in Wood River, Illinois (Madison County). Ten different types of LID Best Management Practices (BMPs) were constructed and installed on the 40 acre development, both for stormwater management for the site, and as a learning tool for other developers, engineers, and municipal leaders in the southwestern Illinois area. The information learned from this case study, and outlined in this handbook, provides answers to many questions about the use of LID for stormwater management in our area, as well as a framework for other developments as southwestern Illinois works to find the balance between economic growth and the preservation of our natural resources for current and future generations.

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The Challenges of Stormwater
A single rain drop may not present a management challenge, but working together with other rain drops in a “rain event”, they are a formidable opponent for public works departments across the country. In the past, stormwater has been treated like a toxic substance. Because it has the potential to do damage to property, traditional strategies have been to remove it from a site as quickly as possible. These strategies are failing in multiple ways and in multiple places. While they were implemented with the best of intentions and the best of engineering science, there are new players in the stormwater scene—mainly water quality, erosion, and groundwater supply and demand. When these are taken into consideration, along with the biology and ecology of stormwater (more on that later), a new need emerges. Stormwater must not only be prevented from damaging personal and public property, it must also be allowed to play its integral role in our surrounding environment.

Figure 1 helps to explain why incorporating “low impact development” stormwater strategies is a necessity. In a natural ground cover system, stormwater is treated 1 of 4 ways: it is infiltrated, it runs off, it is utilized by plants, or it evaporates. As development starts to occur, and the amount of natural ground cover is reduced, the balance of those three treatments gets upset. Less water is infiltrated, less water is evaporated and more water becomes runoff. This increase in runoff is at the heart of stormwater management problems: pollution, erosion and flooding. Additionally, since none of that water has had a chance to infiltrate along its travels through traditional stormwater systems, there is a subsequent increase in the volume of water that is being dumped into stream systems. Refer again to figure 1—through traditional stormwater techniques, stream systems are being asked to handle an increase of up to 45% more water. This increase leads to flooding, erosion of property and hazardous situations for people that come into contact with flash floods.

This point is illustrated further in figures 2 & 3. Figure 2 visually demonstrates what happens to the floodplain of a particular watershed when developed. The increase in impervious surface increases the stormwater that runs to the stream, increasing the stream’s volume and thus increasing the size of the floodplain. Without making accommodations for stormwater infiltration, stormwater becomes a real problem, especially for property owners along streams and floodplains.
Figure 3 is a more technical interpretation of why stormwater is such a problem post-development. This hydrograph represents a storm event and its effects on stream flow rate/discharge over time (pre- and post-construction). The flow and speed of stormwater runoff in a natural setting is shown by the reddish line—the influx of water happens gradually, does not peak at a very high flow rate and then decreases gradually, creating a system of peaks and lows that are not very different from each other and can be handled by a healthy stream. Stormwater runoff post-construction is shown by the blue line—the amount of water increases very rapidly, with peak volumes much greater than in a natural setting. And stormwater handled by traditional detention basins is shown by the yellow line. While this graph represents the same amount of rainfall during the three situations, the imperviousness associated with development causes more stormwater to come together faster and much more quickly than natural systems are used to handling.

The Biology & Ecology of Stormwater

So the question becomes: how can we continue to develop and not suffer the negative side effects of increased stormwater runoff? The answer: try to have stormwater management techniques mimic the natural system in such a way that the surrounding environment can function as if there was no development. In order to accomplish this, it is imperative to understand the biology and ecology of stormwater so the mimicry is effective.

Stormwater has many “jobs” in the natural world. One of them is to recharge our groundwater supplies. As shown in figure 1, 50% of stormwater infiltrates into the ground in an undeveloped situation. Figure 4 shows what happens to that water during infiltration. Stormwater infiltrates through permeable ground cover over days, months, years, and even decades, recharging underground aquifers along with above-ground wetlands, lakes & rivers. The water is also cleaned during this process of any impurities, providing drinking water for communities and drinking water and habitat for the region’s wildlife and ecosystems.

Post-construction or post-urbanization, the situation is entirely different (figure 5). The water that reaches stream systems through storm drains has flown over numerous impervious surfaces: rooftops, driveways, streets, parking lots, and even lawns. As it travels over these surfaces, it picks up pollutants that get deposited—automobile oil, trash, paint, fertilizers, insecticides and pet waste, just to name a few. These all
end up in a water system that is unprepared to deal with such a large influx of pollutants. This is known as **non-point source pollution** and it reeks havoc on the delicate ecosystems of streams, wetlands, rivers and lakes, causing algal growth, fish deaths and water not suitable for recreational activities.

Another important aspect of the biology and ecology of stormwater is plant life—more specifically, native plants. As illustrated in figure 6, native plants have extremely deep and voluminous root systems that create natural channels for stormwater to infiltrate into underground water supplies. Turf grasses, such as those used in lawns, have minimal root systems—the turf grass in figure 6 is circled in red. Since their root systems do not provide a place for stormwater to infiltrate, they sheet stormwater, much like a driveway or parking lot, contributing to the overall amount of impervious surface in a community. Native plants thrive in their natural climate. They need minimal maintenance and can survive all seasons and extremes. They need more time than turf grasses or to fully mature and establish themselves in an area, but once established, they will remain in that location until forcibly removed.

### Practical Application

By using the techniques outlined in this handbook, developers, engineers, and municipalities can rely on the principles of the natural stormwater system to treat and manage stormwater in a “low impact” way. These **small-scale** techniques help recharge groundwater supplies, filter stormwater before it reaches stream systems, and slow down the flow of stormwater, reducing flooding and erosion. While this may sound too good to be true, this handbook is based on a case study that demonstrates the theory and practice of low impact development—**developing land for economic gain while decreasing the negative impact that development has on the surrounding environment**. This case study is Rock Hill Trails, a 39.5 acre residential development in Wood River, Illinois (Madison County). Ten types of stormwater **Best Management Practices (BMPs)** were implemented on this site to manage and treat stormwater runoff (see figure 7). BMPs are the accepted terminology for these different techniques and their design is centered around the biology and ecology of the natural water cycle. While these BMPs were constructed in a residential setting, they would all be appropriate and useful in commercial settings as well. Additionally, this handbook covers other types of low impact development—please see pages 14 & 15 for more information.
The benefits of low impact development are not all environmental—there is a major economic component of this alternative method of managing stormwater. Aside from preventing loss of property from erosion, damage to property from flooding, and helping prevent wells from going dry, LID methods involve the removal of most, if not all, traditional curb, gutter & piping. Utilizing the natural topography of a site for stormwater infiltration limits the need for dirt removal and grading. Additionally, because LID methods center around retaining and infiltrating most, if not all, stormwater on-site, it reduces the need for stormwater management on a municipal level. Pages 22-25 go further into the economics of LID.

One major question that arises during the discussion of LID BMPs is: How do we know they work? It is easy to see traditional stormwater systems carrying stormwater, and other than being able to see the BMPs hold and infiltrate water after a storm event, it is helpful to know some information about these BMPs before design and construction. Utilizing a model from the U.S. Environmental Protection Agency (USEPA) called the Spreadsheet Tool for Estimating Pollutant Load (STEPL), the amount of pollutants each BMP will remove from stormwater runoff can be estimated. The results of this model for our ten BMPs are shown in figure 7. On average, these ten BMPs are projected to remove 29% nitrogen, 35% phosphorous, and 46% sediment. Keep in mind that these figures are for each BMP operating individually. When utilized together as a natural stormwater management system they are able to perform at a higher level. Actual reduction numbers can be calculated for non-vegetated BMPs relatively soon after construction. Vegetated BMPs, however, can take up to three years to mature and reach full effectiveness (and reach their full aesthetic value). Actual pollutant reductions could be calculated at that time. However, the estimated numbers are a reliable source of information for policy-makers, permitting agencies and regulatory agencies and should be utilized as such.

Another measure of LID BMP effectiveness is the amount (volume) of stormwater runoff they can handle (infiltrate and/or retain). On average, the BMPs at Rock Hill Trails can handle one cubic foot of stormwater runoff for each square foot of BMP area. The least effective BMP (runoff handled per sq. ft.) is the permeable pavement, which handles 0.08 cubic feet of runoff per sq. ft., and the most effective are the vegetated swales, which handle 2.2 cubic feet of runoff per sq. ft.

**Thinking Outside The Pipe**

The key in all of this is the ratio of impervious surface to pervious surface. The goal is to have post-construction sites infiltrate as much water as the site did in its natural state. That balance between pervious and impervious surface is the key to developing a growing economy in harmony with the surrounding environment. If we let the natural state of land dictate its use and layout, we can reduce cost, prevent damage, and increase not only the economic viability of our communities, but maintain their environmental viability for current and future generations. One assessment of the potential impacts of climate change suggests that the Midwest can expect an increase of annual rainfall of around 20%\(^3\). It is clear that we will need to “think outside the pipe” to solve our current and future stormwater challenges. LID is one way to start tackling these issues. And because success in LID lies in mimicking natural systems, the creative possibilities are endless.

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%N—Percentage of nitrogen removed; %P—Percentage of phosphorous removed; %Sed—Percentage of sediment removed

**Figure 7:** Estimated pollutant load reductions. (AES, Trumpet & STEPL)

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“Low impact development strategies are important because they represent a "source specific" way at looking at storm water management policy. LID is vitally important because it takes a natural approach at enhancing our ability to protect surface and groundwater quality, maintain healthy ecosystems and preserve the integrity of existing streams and waterways.”

Frank Miles, Director of Planning, Madison County, Illinois

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One cubic foot of stormwater runoff for each square foot of BMP area. The least effective BMP (runoff handled per sq. ft.) is the permeable pavement, which handles 0.08 cubic feet of runoff per sq. ft., and the most effective are the vegetated swales, which handle 2.2 cubic feet of runoff per sq. ft.
WHAT? The main functions of a rain garden are to temporarily store and infiltrate rain water. Situated near the lowest point in a small drainage area (such as an individual home site), they operate as small basins that capture and hold stormwater runoff as it slowly infiltrates.

Because infiltration is the end goal, a rain garden must be designed and constructed properly. Frequently mistaken for simple ditches with plantings, they require knowledge of the soil’s infiltration capacity, and what needs to be done to that soil to achieve the appropriate infiltration speed. Once infiltrated, the stormwater is either piped to another area or allowed to filter into the un-augmented soil below. The advantage of sending the water through the rain garden before it reaches local water bodies or waterways is that two major activities have happened: the flow of water has been significantly slowed down and water quality has been improved. The infiltration layers along with the established vegetation within the rain garden function as cleansers, facilitating the uptake and removal of pollutants and sediment.

In order to avoid any possible mosquito issues, a rain garden must process stormwater within 72 hours, although most are designed to infiltrate within 48 hours.

Another important aspect are the types of plants used in construction. The plants must be able to withstand both wet and dry conditions. They must have extensive root systems (see page 8).

HOW? Three rain gardens were constructed at Rock Hill Trails through this project. Their locations were selected to intercept stormwater runoff along shallow slopes, allowing maximum infiltration. They cover approximately 7,000 square feet, drain 2 acres of land, and can handle 7,300 cubic feet of runoff.

From a design perspective, the ponding depth of the rain gardens were restricted to six inches or less. The planting soil was a mixture of sand, loam and clay to provide water and nutrients for the plants. To increase permeability of the soil, compost was added. A drain tile system should be added if permeability continues to be a problem.

Native species tolerant to both wet and dry cycles were used. See the list of plants used on the various BMPs in this project on page 26. After planting was completed, rain gardens should be lined with mulch and organic material for moisture retention and removal of metals.

Each rain garden was planted a minimum of 10 feet from building foundations.

Maintenance of this and all BMPs is very important. A properly maintained BMP will be able to achieve maximum functionality and also remain an attractive component of the landscape. Maintenance for the rain gardens should be conducted in the spring and summer of each year. Activities will include inspecting each for functionality after a rain event, removing weeds, mowing and adding mulch. If a rain garden is properly maintained, once it has been properly constructed and allowed to establish itself, it will only need the top 2-3 inches of growth medium replaced every 3-5 years.
Filter Strips

WHAT? A filter strip’s main job is to convey water to another location. More often than not, that location is an additional BMP. The various low impact development BMPs at Rock Hill Trails operate together in a treatment system, depending on each other to infiltrate as much water as possible and clean any water that leaves the site.

Filter strips collect and convey stormwater to another BMP (or water body) that is designed to detain and infiltrate the stormwater. The advantage of filter strips over traditional conveyance methods such as concrete channels and piping is that since a filter strip is made up of natural infiltration materials, the stormwater that is being conveyed is slowed, allowed to infiltrate and be cleaned as it travels. While most of the water will not infiltrate before reaching its destination, more infiltrates than in traditional methods. In this sense, filter strips are similar to level spreaders (see page 15).

Filter strips accept sheet flow runoff from small adjacent surfaces, slowing this runoff, filtering out sediment and pollutants, and conveying it to larger BMPs. However, most filter strips can only handle 1- to 2-year storm events and are usually not able to totally reduce flows from larger storms.

Filter strips are ideal for placement next to parking lots, driveways and small residential streets. Because these areas receive a high volume of runoff, they are prone to erosion—filter strips can prevent and reduce erosion by spreading the runoff out, infiltrating a portion, and transporting the majority to other types of management.

HOW? At Rock Hill Trails, a vegetated filter strip was constructed between two single-family home lots west of the large bioretention cell to collect and convey sheet-flow runoff and transport it to the stream behind the lots. This filter strip will slow down the runoff that enters the stream, reducing erosion and improving the quality of the water in the stream. It will also protect the lot to the south of the filter strip. It occupies an area of 1,700 square feet, drains 0.6 acres of land and can handle 2,200 cubic feet of runoff.

Depending on the type of vegetation and size of a filter strip, effectiveness will vary. Filter strips with dense, tall vegetation (and their corresponding deep root systems) can remove up to 80% of suspended solids.

Filter strip design should be based on the amount of stormwater runoff you desire it to handle. Level spreaders can be incorporated into the design to both aid in increased infiltration in a smaller or less pervious space, or as back-up devices for assisting the filter strip in handling larger storm events.

They should be designed to handle flows from 1- to 2-year storm events, as they lose efficiency in larger events. However, other measures (BMPs) can and should be put in place or paired with the filter strip to assist with handling larger (5-100 year) events.

The main design components of the filter strip include plants that are able to withstand flowing water and both wet and dry periods, and a flat as possible slope that will encourage sheet flow.
WHAT? The vegetated swales within Rock Hill Trails make up the major conveyance system within the development, operating much like natural, above-ground pipes. Vegetated swales are located along a gentle ditch known as a “swale” with gently sloping sides used to convey the overland flow of stormwater down a subtle gradient. Swales accomplish many of the same functions provided by filter strips (slowing and cleaning water, encouraging infiltration, etc.), while also providing directed conveyance. This conveyance function is particularly important when managing concentrated flows and during severe storm events when stormwater needs to be directed to a destination, such as a wetland.

Additionally, the sides of a swale allow this BMP to “hold” more stormwater, providing more opportunities for infiltration (thus cleaning) than a filter strip. Their design components make them very effective in slowing stormwater and reducing significant amounts of runoff. They are capable of removing 20-40% of the pollutants and sediments in a runoff event, with some instances reaching as high as 80%!

Because many development sites already contain one or more landscape features similar to a swale, this BMP can easily be incorporated into the natural, existing landscape of a development, reducing the need and cost of grading. Another cost-saving feature is that while periodic cleaning may be required, swales should never need to be replaced, in contrast to conventional stormwater systems.

HOW? Four vegetated swales were constructed at Rock Hill Trails, between residences, in drainages at the base of slopes, and along roadways, occupying an area of approximately 8,800 square feet, draining 5.4 acres of land and handling 19,600 cubic feet of runoff.

One of the primary design considerations is size—it is imperative to determine the necessary space and length of the swale to achieve stormwater management and water quality goals. If a normal flood event overtops the “banks” of a swale, their effectiveness is reduced and the low-impact system is not properly managing stormwater on-site.

As with the previous two BMPs, vegetated swales also need the appropriate infiltration layers included in their design and construction; increasing infiltration and runoff cleansing. More specifically, the flat-bottom channel will typically be between two and eight feet wide to ensure sufficient filtering surface for water quality treatment. The bottom of the swale needs to be at least three feet above groundwater in order to prevent the swale bottom from remaining too wet.

A swale will typically have trapezoidal or parabolic cross-section with relatively flat side slopes (less than 3:1—see figure at left)².

Check dams were utilized in the swale behind the display homes to reduce stormwater velocities and increase infiltration. As with filter strips, vegetated swales need to include plants that are able to withstand flowing water and both wet and dry periods. Maintenance involves removing weeds twice per year until establishment is accomplished and removing sediment and debris once per year every other year.

Bioretention Cells

**WHAT?** Similar in construction to its cousin the rain garden, this BMP strives to mimic natural water retention areas with vegetated systems that control hydrology (through infiltration and evapotranspiration). As with natural systems, bioretention cells pack a big bang for their buck as far as space—they can minimally consume developable land, while infiltrating and cleaning a large amount of stormwater runoff.

Bioretention cells can be constructed one of two ways: they can strictly operate to infiltrate stormwater, or they can contain an underdrain that conveys partially filtered stormwater to another BMP (see figure at right). The latter is the situation with the bioretention cell at Rock Hill Trails. Both mechanisms create a location for stormwater “ponding”, evaporation and infiltration. If the first option is chosen, this BMP also operates to replenish groundwater supplies.

About 90% of the US freshwater supply is ground water and 80 billion gallons of ground water are withdrawn daily in the US, supplying 53% of Americans with their drinking water. The US government projects that 36 states will face drinking water shortages by 2012, so the need to replenish this resource is high.

According to estimates, bioretention cells have the potential to remove 90% of suspended solids, 65% of phosphorous, 50% of nitrogen, and 80% of metals from stormwater.

Bioretention cells are an excellent candidate for a stormwater retrofit system, replacing traditional landscaping and stormwater management techniques.

**HOW?** One large bioretention cell was constructed at Rock Hill Trails, occupying 18,850 square feet of area, draining 1.3 acres of land, and handling 4,700 cubic feet of runoff.

If the bioretention cell is expected to handle a large amount of stormwater, an underdrain system can be installed to transport excess (but cleaner!) stormwater away from the bioretention area to another BMP. This excess will be moving much more slowly than the original runoff, and can thus be handled very easily by additional BMPs, or even traditional stormwater systems. Due to this flexibility, bioretention cells can be utilized in any soil type, since runoff percolates through a created soil bed.

If an underdrain system is utilized, it consists of a perforated pipe in a gravel bed installed along the bottom of the cell. The filtered runoff is directed to an outflow. For maximum success, bioretention cells are best applied to areas with relatively shallow slopes (less than 5%).

As with all natural system mimicry, plants are an important part of this bioretention system. They remove water through transpiration, remove pollutants, enhance soil biological activity, and promote water infiltration. The plant species selected should replicate a moist forest (if in a shaded area) or moist/wet prairie system (if in a sunny area) and be able to survive flooded and drought conditions. Maintenance involves removing weeds twice per year every three years, removing sediment and debris once per year every other year, and replacing top 2-3 inches of growth media of 3-5 years.

Top: A cross-section of a bioretention cell underdrain (Trumpet Builders & Land Services). Middle: The bioretention cell during construction at Rock Hill Trails (Megan Riechmann); Bottom: The bioretention cell at Rock Hill Trails after construction (Megan Riechmann).
Green Roof
A green roof is a great location for reducing impervious surfaces—by utilizing the square footage taken up by residential and commercial rooftops, green roofs absorb stormwater, slowing and reducing runoff and preventing non point source pollution. Green roofs do add significant weight to a structure, so the home or commercial building must be able to support it or be reinforced.
A typical green roof cross-section. (www.epa.org)

Narrow Street Widths
Reducing street widths reduces impervious surfaces and stormwater runoff. Low traffic residential streets can be as narrow as 18 feet to accommodate a fire truck. Roads with cul-de-sacs can utilize recessed center islands to reduce surfaces. These narrow widths can be supplemented by reinforced vegetated shoulders for wide vehicles, parking needs and emergency stops.
A narrow roadway. (www.mapc.org/lid)

Stream Buffers
Vegetated stream buffers, either preserved or restored, can play a major role in reducing stormwater problems. These filter strips along streams (up to 100 feet on each side) not only slow down and infiltrate water before it reaches the stream channel, they also reinforce the banks and sides of the stream, reducing possible erosion. Stream buffers should be preserved from development, but could be utilized as trail corridors.
A stream buffer in an agricultural setting. (www.oh.nrcs.usda.gov)

Conservation Subdivision Design (CSD)
CSD involves clustering homes, reducing lot sizes, and shortening road lengths in a residential development, placing the homes away from resource-sensitive areas. Smaller lot sizes allows for preservation of natural common-ground which can be used for recreation as well as stormwater storage and infiltration.
An example of conservation subdivision design. (www.elements.nb.ca)

Planned Construction to Avoid Unnecessary Compaction of Soil
This BMP involves careful planning of construction activities to avoid damage to natural areas. If a large amount of natural open space is included in the design of a development, compaction of that open space by construction equipment will damage the top soil, preventing plants from growing and requiring expensive tilling and replanting.
The tree on the left is in un-compacted soil while the tree on the right is trying to grow in compacted soil. (www.dpi.nsw.gov.au)
Best Management Practices

**Shared Driveways & Parking Areas**

This BMP can vastly reduce the amount of impervious surface in a residential setting. By combining this little-used but necessary surface in a subdivision, each homeowner’s impact is reduced and more stormwater can be infiltrated as opposed to being converted to runoff. Shared parking lots can be utilized in a commercial setting, used by a doctor’s office during the day and retail in the evening, for example.  
An example of a shared driveway. (home.comcast.net)

**Level Spreaders**

This BMP captures stormwater runoff from culverts and other conveyance systems, holds it in the main chamber (see figure) and then slowly distributes that water over a large area of open space to facilitate infiltration and slow the speed of collected runoff. Level spreaders need a relatively large area of open space to distribute their collected runoff.  
How a level spreader works. (www.ourwater.org)

**Treating Retention Pond as Feature**

Instead of placing a retention or detention pond in the back of a development as an eyesore and possible safety hazard, these stormwater components can become attractive features of a development. Replacing the typical rim of rip rap seen in many retention ponds with native vegetation will not only make it an aesthetic amenity, but will also facilitate infiltration of stormwater and prevent erosion of the banks.  
An attractive, landscaped retention pond. (extension.oregonstate.edu)

**Hydrodynamic Separator**

Placed inside a curb-side storm drain, hydrodynamic separators rely on the natural flow of stormwater to remove debris and other pollution from runoff before it is conveyed to local streams and bodies of water. As the stormwater enters the separator, it creates a vortex motion that moves heavy debris, sediment and other pollutants down to a receptacle while still allowing the water to flow into the conveyance system—traditional or low impact.  
A cross-section of a hydrodynamic separator. (www.ongov.net)

**Preservation of Existing Open Space**

This BMP involves preserving resource-rich areas on an undeveloped site for use as aesthetic amenities and stormwater infiltration mechanisms upon completion of the development. Some areas will need to be restored, but both preservation and restoration are less expensive and more successful from a stormwater perspective than bulldozing and subsequently recreating open space.  
A home next to preserved native prairie. (www.sanctuaryoffbv.com)
WHAT? Allowing native plants to grow in their natural habitat may not seem like an innovative stormwater technique, but it is actually one of the best practices you can do to infiltrate stormwater into the ground. How is this possible? It has everything to do with what is happening below the surface of the soil.

As outlined on page eight, the extensive and deep root system of native wet meadow plants creates opportunity for absorption of rainwater. Not just mimicry of a native system, this BMP is a literal recreation of a native vegetated system accustomed to playing a key role in the water cycle.

Usually located above bottomlands and floodplains, wet meadows are rarely flooded, and usually maintain a moist/wet character, periodically dry.

By incorporating these native species and their deep root systems into a stormwater system, there are additional benefits to the development and the surrounding environment, including reducing erosion, adding aesthetic value for the homeowners and general public, and providing wildlife habitat.

See the list of plants used in this project on page 26.

Wet meadows often make up the core of a non-traditional stormwater treatment system. Because wet meadows often replace turf grasses in landscaping (which behave similarly to pavement in their runoff behavior), the overall runoff of a site is reduced from the first moment of rainfall, slowing the runoff that is not infiltrated and reducing the possibility for adding pollutants to the runoff.

HOW? Two formal wet meadows cover approximately 36,200 square feet, drain 4.2 acres of land, and can handle 15,250 cubic feet of runoff.

If successfully implemented, wet meadows play a major role in achieving predevelopment hydrology. The key to the success of this BMP is allowing it to operate as it would in the natural world. Wet meadows need to be left relatively undisturbed, with occasional maintenance (mowing, herbicide application & prescribed burning) to keep invasive, non-native species at bay. Due to this “requirement”, it is easy to see why this BMP requires less maintenance than traditional landscaping.

Since this BMP is comprised of large, open spaces, care must be taken during construction of the site. Proper planning can save time, money and environmental damage. Do not allow the site to be compacted by construction equipment, as compaction will limit/prevent plant growth. Also, ensure that the site is not allowed to erode during construction. Some vegetative clearing may be necessary, but if the top soil and its seed bank is eroded, it will need to be replaced at the expense of the developer. Since many conventional erosion control methods are expensive, soy beans were planted (and harvested) at Rock Hill Trails.

Native prairies serve as a tourist and recreation destination for many people. This BMP is a prime partner for trails through a development, and Rock Hill Trails has incorporated this concept into their development. This feature has also shown to increase property values when incorporated into the development design.

Top: One of the wet meadows during construction at Rock Hill Trails (Preston Lacy); Middle: A meadow during a prescribed burn (www.pgc.state.pa.us). Bottom: A restored wet meadow following tree removal and prescribed burning (Tim Tunnell)
**WHAT?** Wetlands are very important in that they improve water quality through filtration and uptake of pollutants and nutrients. Wetland plants, soils and microbes cleanse the water entering the wetland, recharge groundwater, store stormwater, reduce high water flows and provide food and habitat for wildlife. An extremely unique ecosystem, wetlands bridge the gap between aquatic and terrestrial environments, containing elements of both. Their anatomy is a staged or “ringed” system, with the wetland itself really starting in the ring of completely dry plant and animal life (known as the buffer). The water filtration (and infiltration!) starts here and moves through stages of increasing wet environments until it reaches the “pool”.

Their role in the natural world is to capture and hold water, allowing sediments and pollutants to filter out or be removed by plant life. The water that “runs off”, or more accurately overflows, is much cleaner than it was when it entered the wetland. So not only do they purify runoff, wetlands are capable of holding a large amount of water during a rain event, preventing it from flowing directly into stream systems.

Shallow, wetland marshy systems contain “emergent” vegetation—plants that are happy having their bottoms under water and their tops above water. So the location of wetlands needs to ensure a relatively regular flow of water to stay “alive”.

Wetlands can also be used in conjunction with other BMPs and even in a system with other wetlands—a kind of stair-step system: smaller wetlands leading to larger.

Properly designed wetlands can remove significant amounts of nitrogen and phosphorous, suspended solids, and other pollutants, with removal rates ranging from 40-80%.

**HOW?** This project involved the construction of five constructed wetlands at Rock Hill Trails. The total area of these wetlands is approximately 52,600 square feet. They drain 12.5 acres of land and can handle 45,375 cubic feet of runoff.

The size of a constructed wetland is very important. As the wetland-to-watershed ratio increases, the time the runoff resides in the wetland increases, allowing more time for pollutants and sediment to be removed.

Since wetlands need a somewhat constant pool of water to maintain their role in the stormwater treatment system, the soils underlying the wetland must allow limited infiltration.

As with wet meadows, the treatment of the area of the constructed wetlands is sensitive to construction activity and special care must be taken. The area of the constructed wetlands at Rock Hill Trails were used as runoff storage during construction, holding and storing polluted water. The future wetland actually held so much water that plants and animals moved in and a true wetland began to evolve (the expense of purchasing nursery plants to populate constructed wetlands may not be necessary—since wetlands are such a unique environment, volunteers will often show up on their own). Once construction was completed, the wetland site was dredged of sediment and debris.

All constructed wetlands must have an overflow drain that prevents flooding. Before the outlet, a four- to six-foot micropool should be included in the design to prevent the outlet from clogging. The micropool should hold at least 10% of the total volume of the wetland. Maintenance involves removing sediment from the micropool annually and should be done carefully.
WHAT? Pervious, or permeable, pavement is an innovative stormwater best management practice that provides a paved surface for cars and recreation needs while allowing stormwater to percolate through gaps in the pavement to either the soil below or a perforated pipe that carries the stormwater to another site. The process of this percolation not only cleans the water, but also allows it to maintain the same flow speeds as the original rain event, preventing large sheet flows of stormwater and possible flash flooding.

Since paved areas such as parking lots and driveways are one of the biggest culprits of pollutants, such as automobile oil, salt, and paint, treating runoff may not be enough. By utilizing a permeable surface in place of paved surfaces, pollutants are prevented from being washed into local stream systems, and the overall runoff volume for a site is reduced, limiting the need for other methods of stormwater conveyance. Studies of existing pervious pavement indicate removal rates of over 80% for sediment and for a number of other pollutants.

A wide variety of materials can be used in this BMP, such as brick, concrete, asphalt, plastic, rock & gravel. Some materials also utilize plants in the open spaces, increasing the infiltration capacity, and reducing the need for maintenance on those open spaces. These innovative materials can be used for parking lots, driveways, access roads, fire lanes, alleys and trails. The limitation of pervious pavement is speed, not weight—so they would not be appropriate for interstates, but can handle the weight of vehicles such as school buses or utility vehicles.

HOW? Pervious pavement is demonstrated on the shared driveway of the two model homes at Rock Hill Trails. It covers 2,090 square feet of area, drains 0.05 acres (display home roofs), and can handle 175 cubic feet of runoff. It was installed during construction of the model homes, and consists of permeable pavers placed over a porous base of two-inch rock. This design will allow water to drain below the driveway to the BMPs behind the homes.

Because the structure of pervious pavement allows the chemicals and pollutants that fall on paved surfaces to infiltrate quickly, this BMP should not be located near groundwater supplies to allow time for cleansing of runoff to take place.

A common concern for this BMP is winter conditions. However, this BMP is very suitable for snow and ice. The gravel beds beneath the permeable surface retain heat and this leads to melting of snow and ice as it falls, allowing it to infiltrate. Therefore, little to no “black ice” can form on permeable surfaces, reducing the need for deicers, which are a major source of non point source pollution. Snow plowing should be conducted with caution, though, to prevent damage to the paving units/material. Setting the blade about an inch higher than normal is a good rule of thumb. If deicing is still desired, sand should not be used as it will clog the pervious surface. Salt may be used, however, nontoxic organic deicers are preferred, as the contaminated water can go directly to the water table.

Maintenance of pervious pavers involves periodic sweeping and/or vacuuming of the system to unclog the gaps and maintain maximum functionality. Additionally, aggregate may need to be added back to those gaps if necessary.
**WHAT?** This BMP is the natural cousin to the raised islands that are a part of most commercial and street landscape plans. Depressed or sunken street and parking lot islands consist of shallow depressions underlain with sub-drains that filter and infiltrate runoff from surrounding streets, parking lots, and sidewalks. They can be installed in a variety of sizes and styles, integrating a variety of plants to suit any architectural style.

Because of this flexibility, recessed street and parking lot islands work well in any setting. Recessed islands have excellent capability to reduce significant amounts of runoff, with limitations based on the receiving area of runoff flowing to the island, and the size of the island itself. For runoff that enters the parking island, removal of sediments and pollutants is high, often exceeding 80%.

Native plants can also play a key role in the infiltration of stormwater in this BMP. Low-growing deep-rooted plants should be used in situations like the cul-de-sac islands at Rock Hill Trails to prevent any visibility issues. But large shrubs and even small trees can be utilized in parking lots and along streets, much as they are in traditional raised island landscaping.

Another attractive characteristic of this BMP is its ability to assist with snow and ice removal. In a commercial setting, snow plows can push snow and ice into these sunken islands and as the material melts, it will be absorbed by the infiltration layers. The snow should be clean of pollutants such as chemical deicers and sand as these can severely damage the makeup and inhabitants of these recessed islands.

**HOW?** Three recessed street islands were constructed in the cul-de-sac circles on the south side of Phase 1a of Rock Hill Trails. They occupy an area of 3,060 square feet, drain 0.8 acres of land, and can handle 2,800 cubic feet of drainage. The street islands are bordered by an attractive ribbon curb that will allow surface runoff from the street to flow into the island and infiltrate into the soil and/or sub-drain.

Recessed islands are similar to bioretention cells and rain gardens in structure. The success of this BMP depends on the infiltration component. A sub-drain constructed within each recessed island will facilitate drainage of excess water to one of the wetlands nearby. Additionally, recessed islands require soils that allow at least two inches of infiltration per hour. The depth of the island should allow up to six inches of standing water to accumulate in less than 12 hours, but the infiltration of that water within 72 hours. A minimum of three feet permeable materials (washed gravel or other aggregate will work well) were placed below the topsoil.

Maintenance involves removing weeds, sediment and debris on a bi- to tri-yearly basis after establishment and ensuring that the sub-drain remains clear of debris and root material from the plants in the island. Replacement of the top 2–3 inches of growth medium every 3–5 years may also be necessary for maximum functionality. Periodic testing of the outfall can determine if this BMP is operating successfully. As with many BMPs, some of this “testing” can be done visually—if the stormwater drains within 72 hours and the outfall is clear, the BMP is most likely functioning at a high success rate.
Rain Barrels

Rain barrels are used to capture, store and reuse rainwater for residential or commercial landscaping needs. Instead of letting rain water wash down stormwater drains, homeowners and business owners can utilize rain barrels to capture that water for later use. Hooked up to a building’s existing downspout, the rain is captured and can be used at a later time to water a garden or lawn. This saves money for the homeowner on their water utility bill, and reduces the volume of water in the local stormwater system. Three rain barrels were permanently placed on one of the display homes in Rock Hill Trails, demonstrating this BMP to all potential and future homeowners.

Rain barrels should be sized to adequately capture runoff based on precipitation patterns in an area. A 1 inch rainfall on a 1,000 square foot roof will generate approximately 600 gallons of water. Occasional cleaning may be necessary to remove debris, such as leaves. The barrel must also be sealed or covered with a fine mesh screen during warm months to avoid mosquito breeding, and should be drained prior to winter months to prevent freeze damage. Water in the barrel should be used between rainfall events to maximize effectiveness.

Rain barrels can be purchased from a number of retailers or they can be constructed relatively easily and economically (be sure to use food-grade barrels to prevent chemical contamination of the captured water!).

Cisterns

Cisterns are another tool for capturing, storing, and reusing rainwater. They are generally designed for below-ground use and typically provide much greater water storage, requiring more complex construction techniques. In addition to using a cistern’s supply to water gardens, lawns and flowerbeds, this “gray water” can be treated and reused inside the home as well—supplying water for toilets, dishwashers, laundry and even showers. A 2,000 gallon cistern was permanently placed in the back yard of one of the display homes in Rock Hill Trails, demonstrating this BMP to all potential and future homeowners.

As with rain barrels, cisterns should also be sized to adequately capture runoff based on precipitation patterns in an area.

The basic components of a rain cistern are much the same as with rain barrels, but with a much larger storage tank that is buried underground. This means a pump must also be installed to bring water out of the cistern (see figure at left).
WHAT? BMP number 10 is an innovative take on stabilizing weak, damaged or eroding streambanks. Traditional, or “hard”, methods of stabilization involve materials such as rip rap, concrete, and steel. These methods are expensive, often fail, and replace vital vegetation. By utilizing bioengineering (natural-mimicry or “soft”) methods, a municipality or developer can save money, provide more effective stabilization, and reduce overall pollution going into the stream.

Eroding streambanks are a major source of non point source pollution. Without a strong bank, a stream will pull dirt and plants into its flow, cutting farther into the land with each rain event. Many homeowners have watched their backyards shrink due to this effect.

What makes this type of streambank stabilization special is that it is happening on the other side of the streambank. The stream at Rock Hill Trails has a very steep natural streambank that needs to be reinforced/stabilized, but any attempt to stabilize it would probably create additional erosion.

So the solution is to create a series of small berms, or “nutrient uptake strips” on the other side of the bank that will work together to slow down and absorb stormwater before it reaches the stream. The stormwater that does reach the stream will be moving more slowly and be cleaner of pollutants.

HOW? Bioengineered streambank stabilizations incorporating nutrient uptake strips were constructed at three locations at Rock Hill Trails. Each location was selected due to the existence of significant stabilization issues.

As their name implies, these vegetative strips provide more benefits than just stormwater absorption. The plants utilized in these strips depend on the presence of nutrients such as nitrogen and phosphorous that are pollutants in stormwater. These plants will absorb these pollutants along with the stormwater, storing them in their root systems.

Slope is a very important aspect of this BMP, and none of the nutrient uptake zones have a slope of greater than 10%, which will allow for maximum absorption of stormwater. Additionally, the total zones are a minimum of 15 feet from the base of the bank to the top. This was based on expected amount of stormwater, and should be adjusted according to projected runoff volumes in different areas.

In addition to the expected deep-rooted native plants necessary to facilitate infiltration, the speed of stormwater expected at these locations is high.

Therefore, the plants utilized in the uptake strips should be heavily rooted and accustomed to high water speeds.

Top: A typical berm detail (Trumpet Builders and Land Services); Middle: The unstabilized streambank (Megan Riechmann); Bottom: The stabilized streambank after grading and seeing (Megan Riechmann).
The Cost of Rain
A major deterrent to the implementation of any new idea is uncertainty of costs. Fortunately, there are many already-implemented Low Impact Development projects showing cost savings for developers, municipalities and citizens when LID is designed or retrofitted into urbanized areas. When flooding events deteriorate a community’s stormwater infrastructure and natural systems, tax payers must pay for repairs, restoration, and further flood prevention measures. Citizens and business owners in flood prone areas must also deal with the costs of flood damage to their homes and businesses. LID Best Management Practices (BMPs) are an economically savvy way to reduce the expense of long-term maintenance of public infrastructure as well as the costs of restoration of degraded natural systems. Additionally, LID design can provide many incentives to developers including: lowering infrastructure costs, increasing marketability, and protecting the environment. This creates a win-win situation for residents, communities in a watershed and the environment.

Economic measures of traditional methods of stormwater management focus solely on the design, installation, and on-going maintenance costs of stormwater infrastructure. These variables of cost can be compared to LID projects as well. However, **Low Impact Development provides many additional benefits**, or “positive externalities”, adding a whole new layer of economic benefits that conventional stormwater techniques simply lack. These additional economic benefits are simultaneously realized by all citizens of a community, the developer, the municipality and the environment. In order to properly compare a conventional system versus a low impact development stormwater system it is essential to analyze their entire life-cycles and their role in an entire watershed. This can only be done by adding up the many additional benefits provided by LID to the typical equation of capital and maintenance cost comparisons.

It is important to note that there are many site-specific variables that effect the costs of any development. A recent report by the EPA completed a cost comparison for twelve BMP projects and found all but one provided **cost savings** compared to conventional design, construction, operation and management⁷. These results show that even site specific cost comparisons lean in favor of LID even before other larger-scale economic and environmental benefits are considered. The economics of low impact development can be broken down in the following categories: Design/Construction, Operation & Maintenance, and Positive Externalities.

**Design/Construction:**
Infrastructure in a traditional development often creates more impervious surfaces than are necessary. Planning a development using LID techniques such as Conservation Subdivision Design (CSD) successfully lowers the costs of infrastructure because homes are clustered close together, creating a shorter total length of roads, pipes and other infrastructure. Additionally, the installation of infiltration BMPs defrays the costs of curb and gutter construction and allows for narrower street widths. A study based in South Kingstown, RI found infrastructure costs for lots in CSD developments to be an average of $7,400 less than in conventional subdivisions⁸. Another study conducted by the Center for Watershed Protection found average construction cost savings to be: $1,100 for each parking space eliminated;
Low Impact Development

$150 per linear foot of road eliminated (for standard 26’ wide road); and $25 to $50 per linear foot for narrower road widths. Costs for installing BMPs vary from $500-$1000 per acre for residential development and $1,000 to $10,000 for commercial sites. Savings are also realized through reduced grading costs of the site. Low Impact Development requires minimum disturbance of the soil and topography in order to allow maximum infiltration and avoid compaction and destruction of soil layers. Up to $5,000 per acre may be saved for each acre not cleared or controlled for erosion and sediment control. The figure below shows an example of cost savings which of course will vary from site to site.

An potential increase in the number of lots can also provide an economic advantage for developers because areas that would be traditionally used for large structural stormwater controls can now be used. Some municipalities also offer density bonuses for cluster and CSD subdivisions allowing for more lots than would normally be constructed with a conventional development. Developers may also benefit from fewer impact fees and stormwater regulatory requirement fees by gaining stormwater credits in municipalities that reward this type of development.

Operation & Maintenance:
LID and traditional stormwater systems both have on-site operation and maintenance (O&M) costs. Only traditional systems have additional off-site O&M costs like stream restoration and water quality issues that municipalities and tax payers must bear. Proper design and construction of BMPs successfully mitigates these off-site costs produced from traditional stormwater systems. BMPs can also help reduce the load on existing traditional systems allowing for less maintenance needs. Some BMPs are even maintained by other organizations such as homeowners associations, relieving the on-site stormwater maintenance pressure for municipalities.

On-site maintenance costs for LID systems focus on maintaining a combination of fertile soil layer, mulch layer and native plant landscaping depending on the BMP. A fertile soil layer is essential to the effective uptake of pollutants and an annual soil test should be conducted in bioretention BMPs. Replenishing soil in a bioretention area may become necessary five to ten years after construction, depending on the amount of pollutants filtered. This costs between $1,000 to $2,000 for a BMP draining one acre. Other BMPs require more maintenance only for the first three to four years during establishment of native vegetation. After four years, other vegetation based BMPs have significantly fewer maintenance needs.

Traditional stormwater infrastructure increases rates and volume of water as more land becomes developed. This leads to rapid degradation of natural stream channels throughout a watershed. The planning, permitting, construction, and monitoring of restoring an entire degraded stream channel costs approximately $1,000 per linear foot. The importance of properly maintaining natural systems such as streams is even further emphasized when considering water treatment costs. The average costs of water quality restoration range from $400 to $1,600 per acre. Implementing LID techniques provides municipalities, developers, and citizens with cost savings for all of the above variables both on- and off-site.

“It is difficult to do an apples to apples comparison of the cost of LID to traditional stormwater infrastructure since the end product is quite different in terms of scale and benefits. On paper, the cost of LID appears to be at or below that of traditional. However, the resulting LID infrastructure offers many more tangible and intangible benefits. With traditional, you have a system that offers no additional benefits.”
Christopher Schroeder, Vice President, Wellspring Development Company
Positive Externalities:
Many of the greatest benefits from BMPs are the most difficult to place a value on. However, these techniques create some of the greatest economic and environmental benefits to the communities we live in. These positive externalities benefit all living things that need clean water to survive. The sections below represent Economic Benefits seen only by people and Environmental and Economic Benefits seen by people and other living things such as wildlife and vegetation.

Economic Benefits:
- $ Improved aesthetics—increased property values
- $ Expanded recreational opportunities—healthier communities and lower health costs
- $ Increased property values due to desired lots with proximity to open space—One study found LID residential homes sold for 12% to 16% higher per acre than conventional development homes\(^8\).
- $ Increased marketing potential and faster sales—One study found LID lots sold twice as quickly as conventional subdivision lots\(^8\).
- $ Flood Damage Costs—One study estimates each acre of upstream LID development results in $380-$590 in savings from mitigated flood damage for private and public property downstream\(^11\).

Environmental and Economic Benefits:
- Reduced runoff volumes and polluted streams
- Reduced incidences of combined sewer overflows
- Protection of downstream water sources
- Ground water recharge
- Habitat improvements
- Reduced illness from recreation such as swimming and fishing

When all costs and benefits are considered, growing our communities in a way that sustains and protects all watershed resources is clearly more economical than depleting and deteriorating these resources.

CSS’s and Separated Systems: Different systems different kinds of economic and environmental benefits
Low Impact Development provides positive benefits no matter what system a municipality uses to manage stormwater. However, economic benefits are derived in different ways depending whether a city uses a combined sewer and stormwater system or separated sewer and stormwater systems.

Combined Sewer Systems (CSS) are found in many older cities throughout the US especially in the Northeast and Great Lakes Regions. These systems successfully transfer the combination of all sewage and stormwater through the same pipe system to the public water treatment facility during normal weather patterns. However, large storm events force larger volumes of stormwater to “flood” the system thus dumping untreated raw sewage, industrial pollutants and stormwater out at Combined Sewer Overflow (CSO) pipes directly into streams and rivers. These systems were originally designed to only hold three to five times the average dry weather flow. There are currently 828 NPDES permits that authorize 9,348 CSO outfalls in 32 states\(^12\).
Tuscany Hills: O’Fallon, Illinois
In 2007, the City of O’Fallon hosted a charette to determine what a proposed conventional design subdivision would be like if it was actually developed using a conservation design ordinance. The site used was an approved 80-acre site planned for single family development. The costs of traditional stormwater management were going to be above what the developer had anticipated, so they brought in a consultant to conduct a LID plan for the site. The numbers in the figure at right represent noticeable savings—including over 54% savings in storm sewer costs. The greatest increase in costs (133%) was in landscape/ restoration of the BMPs. Overall, using LID techniques would save approximately $665,763 or approximately 13% less than the originally planned design. The total open space of the site increased from 7 acres to nearly 38 acres or from 10% to 50% of the total development. Even with a forty percent increase in open space the new conservation design was able to add six new lots bringing the grand total from 202 to 208 marketable new homes. This leads to a lot size decrease of nearly 48% from 11,836 square feet to 5,653 square feet. This loss in lot size however has not proven to be a deterrent in marketability of LID subdivisions as residents have paid a premium for common open space and LID practices.

Rock Hill Trails: Wood River, Illinois
Rock Hill Trails is the case study for this handbook and is located in Wood River, Illinois. This LID will be a mixed-use development (single family, multi-family residential and commercial). It is a Planned Unit Development (PUD) which incorporates the preservation of significant open space that will be connected with trails. Phase 1a of the Rock Hill Trails Development is currently under construction and consists of 39.5 acres. This Phase will include a total of ten different types of BMPs. The total development will eventually include 170 acres. Approximately 43% of Phase 1a will be preserved as public open space. Every lot will have direct access to the 17 acres of common area. The remaining acreage will consist of single family residential, multi-family residential and public right of way.

Operation and Maintenance Costs for the BMPs on this phase are estimated to be approximately $2,000 to $3,500 annually. The homeowner’s association will take over operation and maintenance of the BMPs. The goal of the BMPs is to create no new stormwater runoff from the site. This is especially beneficial for the City of Wood River where approximately 80-85% of the city is still functioning with a Combined Sewer System. Developments on the East side of the city have had separated stormwater systems for approximately 20-30 years.
Resources & References

List of Plants Used in the BMPs at Rock Hill Trails (in alphabetical order):

- Barnyard Grass (*Echinochloa crus-galli*)
- Big Bluestem, 'Southlow', MI Ecotype (*Andropogon gerardii*)
- Blue Vervain (*Verbena hastate*)
- Blunt Broom Sedge, PA Ecotype (*Carex tribuloides*)
- Brown Eyed Susan (*Rubeckia triloba*)
- Canada Wild Rye (*Elymus Canadensis*)
- Common Sneezeweed (*Helenium autumnale*)
- Cup Plant (*Silphium perfoliatum*)
- Fowl Mannagrass, PA Ecotype (*Glyceria striata*)
- Fox Sedge (*Carex vulpinoidea*)
- Great Blue Lobelia, IA Ecotype (*Lobelia siphilitica*)
- Green Bulrush, WI Ecotype (*Scripus atrovirens*)
- Maximilian’s Sunflower (*Helianthus maximiliani*)
- New England Aster, PA Ecotype (*Symphyotrichum novae-angliae*)
- Oats, Ogle, Untreated (*Avena sativa*)
- Prairie Cordgrass (*Spartina pectinata*)
- Rice Cutgrass, PA Ecotype (*Leersia oryzoides*)
- Soft Rush (*Juncus effuses*)
- Soft Stem Bulrush, PA Ecotype (*Scripus tabernaemontani*)
- Square Stemmed Monkey Flower, PA Ecotype (*Mimulus ringens*)
- Swamp Milkweed, WI Ecotype (*Asclepias incarnata*)
- Switchgrass, ‘Shelter’ (*Panicum virgatum*)
- Virginia Wild Rye (*Elymus virginicus*)
- Water Hemlock (*Cicuta douglasii*)

Citations From Text

2. The Wisconsin Storm Water Manual: Grassed Swales (G3691-7)
5. Pavement Interactive (http://pavementinteractive.org)
6. Low Impact Development Center (www.lid-stormwater.net)
Resources & References


Resources

- Dane County Erosion Control and Stormwater Management Manual. Appendix 1—Native Plants 01/02/07.
- Massachusetts Low Impact Development Toolkit (www.mapc.org/LID)
- Pavement Interactive—Www.pavementinteractive.org
- Permeable Interlocking Concrete Pavement: A comparison guide to Porous Asphalt and Pervious Concrete (www.romanstone.com/pdfs/PICPComparisonGuide.pdf)
- Water Resources Research Center—University of Arizona (ag.arizona.edu/azwater)

Much of the information in this handbook is specific to the project at Rock Hill Trails and was taken from the project plans for the 10 different BMPs. The two firms that wrote these plans are:

Applied Ecological Services (www.appliedeco.com)
HeartLands Conservancy is a 501(c)3 non-profit corporation, formed in 1989, and registered in the state of Illinois. Our mission is to provide leadership and solutions to sustain and enrich the diverse environmental resources of Southwestern Illinois. The organization has three defined program areas:

**Conserving Land**
Protecting our land resources: our rich farmland, distinctive natural areas, and properties of vital importance and benefit to current and future generations. Applying a comprehensive land conservation strategy, providing leadership in land stewardship and offering conservation tools for communities will focus and facilitate our efforts.

**Building Greener Communities**
We provide leadership in community planning and in the implementation of initiatives that improve the overall environmental health within our communities. We assist communities in addressing complex development issues by offering education and training, guidance on land use planning and ordinances, natural resource mapping, and grant development and implementation.

**Engaging Individuals and Communities**
Fostering continued appreciation and care for our region’s natural resources and engaging individuals and communities in our endeavors.

Our work is undertaken within the seven counties making up southwestern Illinois (Bond, Clinton, Madison, Monroe, Randolph, St. Clair and Washington). As environmental and recreational resources often do not align with political boundaries, additional work may be undertaken in adjoining watersheds or counties.

**Our Vision:**
Communities with healthy and sustainable air, land, and water resources for current and future generations.

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