2 Sustainable Site Design, Development Plan and Land Use Planning

Sustainable site design is one of the most economical and critical tools for incorporating green infrastructure into development projects. Green infrastructure serves to protect water quality in streams, lakes and wetlands and thereby can meet community needs and regulatory requirements. Specifically, sustainable site design incorporates stream buffers, bioswales, rain gardens, reduced hard surfaces and similar low impact development practices into a network of green spaces can help improve or reasonably mimic preconstruction runoff conditions. Efforts to reasonably mimic pre-construction runoff in new development can help to prevent flash floods, store and treat stormwater runoff as nature would and provide for community values such as recreation and aesthetic green space.

Green infrastructure can be incorporated into new, redevelopment or retrofit projects. Unfortunately, many communities have found that their own development codes and standards can actually work against this goal. For example, local codes and standards often create needless impervious cover in the form of wide streets, expansive parking lots and large-lot subdivisions and they often require excessive clearing and grading. At the same time, local codes often give developers little or no incentive to conserve natural areas that are important for watershed protection.

This chapter addresses the integration of green infrastructure using a nested approach at different scales, including:

- Project or site level.
- Municipal/watershed scales.
- Regional scale.

EPA's Water Quality Scorecard is a useful tool for communities to use in considering all the elements discussed in Chapter 2. The scorecard offers policy options for protecting and improving water quality across different scales of land use and across multiple municipal departments. (United States Environmental Protection Agency, October 2009). Refer to Chapter 4 for addition discussion on policies and ordinances.

In particular, green infrastructure is identified as a critical component of sustainable site design criteria, an important consideration of the plan review and approval process, and a corresponding tool

"A comprehensive approach to stormwater management involves developing stormwater management practices that can be applied at the regional, district/neighborhood, and site scales. It also involves looking at where and how development occurs within the community. This is best done by examining common land development regulations and policies that dictate the location, quantity or density, and design of development" (Center for Watershed Protection, 2008).

in comprehensive municipal planning. Therefore, planning departments have a critical role to play in municipal stormwater management, alongside public works departments.

This chapter also includes a discussion and consideration of Missouri's physiographic regions.

2.1 Sustainable Development Planning and Site Design

Integrating green infrastructure into the site design requires integrating its principles into site master planning. This will optimize land use, pedestrian and vehicular circulation and access, natural resource preservation and protection, parking, utilities, runoff management, recreation and landscaping.

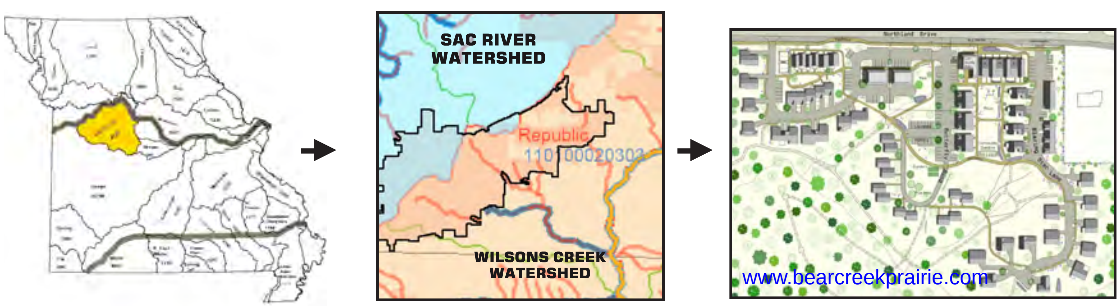
Principles and goals tied to these items will affect the design development of every relevant discipline and, they can be utilized whether the site is urban, suburban, commercial or industrial and whether the site is new, redevelopment or retrofit focused.

On-site low impact development practices can then be selected, sited, calculated for performance and implemented to aid the integration of green infrastructure into the community and its connecting green networks.

The incorporation of green infrastructure needs to be considered at all scales of planning, analysis and design in order to most economically achieve water quality protection or improvement (Figure 2.1 and Table 2.1). Municipalities often sit atop multiple watersheds or portions thereof. Hence, it is important municipalities utilize watershed planning as they incorporate the protection, incorporation or improvement of green infrastructure into comprehensive planning and carry it through to checklists for site plan review.

Watershed planning goes hand in hand with green infrastructure planning as outlined in the article *Green Infrastructure Plan Evaluation Frameworks* (McDonald –King, et al, 2005). In the article, these authors lay out a green infrastructure planning framework that municipalities and their stakeholders can easily use for goal setting, analysis, synthesis and implementation – complete with checklists, applicable at any scale and useful to any planning entity according to the authors.

Municipalities can make great progress toward water quality goals, requirements and recommendations by developing their own green infrastructure plan, related criteria and review checklists for new growth, redevelopment and even stormwater retrofit projects.



Regional Scale | Municipal/ Watershed Scale | Neighborhood/Site Plan Scale

Figure 2.1 Green infrastructure planning scales. Source: Missouri Department of Natural Resources

Sustainable Planning Scales			
Planning Scale	**Stakeholders**	**Planning and Policy Goals**	**Planning and Design Tools**
Regional	Regional planning commissions. Rural networks. Levee districts. Transportation departments. Multiple municipalities. Environmental organizations. Recreational organizations.	Transit systems. Large scale parks, contiguous trails and vegetated corridors. Federal and state regulation compliance. Comprehensive planning. Watershed planning. Green infrastructure planning. Solid waste management systems. Renewable energy systems.	Land use planners. Economic developers. Professional stormwater modelers. Landscape and land use modeling. System for Urban Stormwater Treatment and Analysis INtegration, or SUSTAIN Model. Sanitary Sewer Overflow Analysis and Planning Toolbox.
Watershed/Municipal	Municipalities. Economic developers. Environmental organizations. Patrons. Citizens. Homeowner associations. Recreationists. Developers. Builders and consultants.	Jurisdictional planning. Infill and redevelopment. Policy development. Flood control. Plan review criteria. Federal and state regulation compliance.	Stormwater regulations. Zoning. Stream buffer ordinances. Water quality criteria for new development, redevelopment and retrofit projects. Modeling programs. Plan review checklists.
Neighborhood, Residential, Commercial, or Individual Sites	Municipalities. Patrons. Citizen and homeowner organizations. Developers. Designers. Engineers. Consultants.	Sustainable site designs. Pocket parks. Contiguous buffers. Walkable/bikable trails and connections to larger trail systems. Urban fishing, swimming, other recreation. General overall sense of community. Desirable home and work facilities and structures.	Project site reconnaissance. Analysis and design. SUSTAIN model. Stormwater Management Model. Sanitary Sewer Overflow Analysis and Planning Toolbox, www.epa.gov/nrmrl/wswrd/mmd.html. Best management practice selection and design. International BMP database www.bmp.database.org.

Table 2.1 Sustainable Planning Scales. Source: Adapted from Shockey Consulting Services

Figure 2.2 Green infrastructure infill, redevelopment and retrofit features. Graphic by Williams Creek Consulting

Many tools as shown in Figure 2.2, exist to aid the planners, modelers, designers and reviewers. Examples of design tools include the System of Urban Stormwater Treatment and Analysis, or SUSTAIN model and the international best management practice performance database. For example, the SUSTAIN model can aid the designer in locating and selecting an appropriate best management practice, such as a bioswale or rain garden, and the best management practice database can provide information on what type of water quality or volume function will be provided in a particularly sized or designed best management practice.

The following low impact development principles listed by the Natural Resource Defense Council go hand in hand with the green infrastructure goals in this chapter.

- Integrate stormwater management early in site planning activities.
- Use natural hydrologic functions as the integrating framework.
- Focus on prevention rather than mitigation.
- Emphasize simple, non-structural, low-tech and low cost methods.
- Manage as close to the source as possible.
- Distribute small-scale practices throughout the landscape.
- Rely on natural features and processes.
- Create a multifunctional landscape.

www.nrdc.org/water/pollution/storm/chap12.asp

During concept development, stormwater management planning has often consisted of setting aside placeholders for basins or other centralized management features, and often these features have been designed at the end of the design process. Even where distributed storage and conveyance systems such as rain gardens and swales are included in planning, these features are responses to problems created by the proposed change in land use.

The non-structural stormwater control measures, such as stream setback requirements and similar regulatory tools, can be used to promote runoff source control through minimizing land alterations and taking advantage of existing natural features to help manage runoff. Principles such as those promoted by green infrastructure can be given more weight during concept development and preliminary design. Integrating green infrastructure into plans is much easier to accomplish when considered at the beginning of the site design process, rather than at the end. Implementing this concept can be simplified into three questions (Brown, et al 2007), to the maximum extent practicable:

1. Does this minimize land disturbance?
2. Does this preserve vegetation?
3. Does this minimize impervious cover?

These questions are not meant to prevent land development, but rather help it occur with minimal cost – both financially and environmentally. Where program goals can be achieved while minimizing earthwork, clearing and construction of stormwater management infrastructure, it also helps minimize environmental impacts while reducing the cost of construction. It can also reduce operation and maintenance costs.

2.1.1 Sustainability in Site Master Planning

Master site planning must consider green infrastructure design goals at the beginning of the process where the greatest opportunity exists to:

- Preserve natural systems.
- Engineer management systems to enhance natural systems and reasonably mimic natural, pre-construction functions through practices that:
  - Enhance evapotranspiration.
  - Enhance infiltration.
  - Minimize increases in surface runoff rates and volume.

Planning principles (design goals) differ from design techniques. Planning principles set project goals such as minimizing impervious surface, creating green space connectivity and similar non-structural stormwater controls. In contrast, design techniques include specific details such as where pervious pavements are needed, where road widths can be minimized to meet those goals or prescribe specific structural stormwater control measures needed to manage runoff from defined areas.

It is useful to employ plan review checklists, such as that provided by Southeast Michigan Council of Governments in their *Low Impact Development Manual for Michigan.* (Southeast Michigan Council of Governments, 2008) See Figure 2.3.

This is also an opportunity to employ incentives for green infrastructure and low impact developments, such as reduced setbacks, reduced fees, credits and streamlined reviews.

Plan Review Checklist

- Is this project consistent with comprehensive, watershed or green infrastructure plans.
- What are the major or minor watersheds?
- What is the state stream use/standards disignation/classification?
- Are any streams classified or 303(d) impaired streams?
- Is additional development anticipated for the area that could lead to further opportunities?
- Have the important natural site features been inventoried or mapped?
- Is the development concept consistent with other plans in the community?
- Is development consistent with local existing regulations?
- Will there be concentrated or clustered uses and lots?
- Are the lots or development configured to fit natural topography?
- Does the development connect open space or sensitive areas with larger community greenways plans?
- Does the development consider re-forestation or re-vegetation opportunities?

Figure 2.3 Plan review checklist.
Source: Southeast Michigan Council of Governments, 2008

Planning for the following green infrastructure design principles will provide the conceptual basis on which the design will be created. Sustainability in master planning typically goes beyond minimum regulatory requirements and can address not only physical site issues, but also programmatic, building, operational and geographic issues.

Preserve, Enhance and Protect Natural Resource Areas

Natural resources should be identified during the due diligence of a proposed project. Streams, undisturbed green spaces, wetlands and riparian areas are all efficient low-cost natural stormwater management features. They are the existing stormwater management system and should be preserved, enhanced and utilized where practical. Replacing the free services provided by these natural systems with man-made systems requires significant capital investment and time, creates the need for ongoing operation and maintenance of these systems and reduces the community's quality of natural resources.

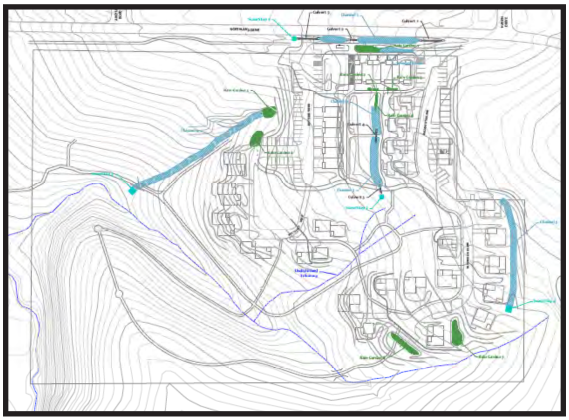


Figure 2.4 Proposed Bear Creek Prairie Project, Columbia, MO.
Source: Andy Guti

Existing site conditions can be evaluated to identify areas most suitable for development, preservation or integration into site programming needs. Unsuitable development areas can be steep slopes or mature forests. Areas that may be unsuitable for development but may be integrated into stormwater management include wetlands or intermittent streams. Once identified, the planning and design process can focus on how to meet programming goals within available suitable areas while integrating or enhancing unsuitable development areas.

Minimize Impervious Surface and Direct Runoff Connections

Building structures, parking areas, parcels and transportation networks can be oriented within areas designated suitable for development in order to minimize their impact on runoff while meeting site objectives. During the planning and design phases:

- Parcels can be placed to minimize infrastructure connection distances.
- Green spaces can be connected in a stormwater treatment series.
- Structures can be converted to multiple-stories to decrease their roof area without sacrificing square footage.
- Road widths can be minimized and still provide emergency vehicle access.
- Parking areas can be laid out to minimize drive aisle widths and better integrate stormwater features into buffers and parking islands.

The result of these efforts should minimize costs associated with construction and maintenance of structural stormwater control measures and also reduce costs associated with earthwork, clearing, pavement and stormwater collection systems.

Figure 2.5 Boulevard Brewery, Kansas City, MO.
Source: Boulevard Brewing Company

Programming to the Triple Bottom Line

Defining the project goals drives the spatial requirements, character and budget. Program goals include land use type, the type(s) of internal and external access and connectivity. The program can determine the interaction of the site's residents and visitors with the proposed development and help set the overall design principles for a sustainable development. Consistency can be checked with comprehensive, watershed and green infrastructure plans.

Program decisions include "big picture" items such as whether the proposed project will be a commercial, residential or mixed use development; or whether a residential development may be traditional, conservation, estate or other sub-type. Example sustainability principles relevant to site programming include the following:

1. Environmental

Is the proposed land use appropriate or does it pose unusual risks to the environmental setting? If not, what alternatives may there be?

- For example, a proposed project may be located in a zoned industrial park but adjacent to a protected stream. Project goals could include exceeding protection standards prescribed in local ordinances.
- Although the site is zoned industrial, the project owner may choose to use a non-structural stormwater control measure such as:
  - Excluding heavy industrial tenants.
  - Creating a larger stream setback than required by ordinance.
  - Locating loading docks and other material handling areas as far from the stream as possible.

2. Social

Is the project near a wetland or other valuable natural resource area? If so, how can program goals enable the area to be integrated into green space and pedestrian connectivity improved?

- For example, the project may set goals to enhance pedestrian access to these areas while minimizing disturbance during connection. The corresponding design technique could be at grade trail construction using pervious materials.
- Non-structural stormwater control measures could include placing the area in a permanent conservation easement to ensure its long-term availability as a public amenity and natural stormwater management area.
- Trading project locations in exchange for protection of critical area.

Figure 2.6 Prairie Crossing Homes.
Source: www.planningwithpower.org

3. Financial

Is the project near a wetland or other valuable natural resource area? If so, how can program goals promote this feature in marketing the proposed project?

- Wetlands, streams and other natural resource areas cost money to fill, move and mitigate. Many of these areas can serve as part of a stormwater management area if adequate pretreatment is provided.

Minimizing Building Footprints

The relative type, size and location of buildings needed to support program goals. Considering building needs at this point in the project helps avoid large changes during design development. Example sustainability principles relevant to building facilities may include:

1. Environmental

Is the proposed building footprint restricted to one-story or can two-story units be used? If not, what alternatives may there be?

- A proposed project may be zoned residential at a density of two units per acre. Program goals could include requiring two story homes on a greater percentage of lots than typically required or desired by a developer. The smaller footprint of homes would reduce roof area and associated runoff volumes, allow the use of smaller lot sizes to minimize land disturbance during construction and free up more land area for green space.
- Other non-structural stormwater control measures include requiring downspout disconnection in site architectural standards.

2. Social

Is the proposed building footprint restricted to one-story or can two-story units be used? If not, what alternatives may there be?

- Again, program goals requiring two story homes on a greater percentage of lots than typically required could allow smaller lot sizes to free up area for green space and increase opportunities for parks and trails.

3. Financial

Is the proposed building footprint restricted to one-story or can two-story units be used? If not, what alternatives may there be?

- Minimizing building footprints can improve opportunities for clustering of homes near existing utility connections. Clustering can shorten utility runs and associated installation costs.
- Clustering and minimizing building footprints also decreases road lengths, which decreases impervious surface, which decreases runoff volumes, which decreases the cost and size of stormwater management systems needed to manage the runoff.

Operational Issues

Project implementation, operations, finances and functional issues. Planning for long term viability during master planning helps ensure the project can be successfully marketed through completion and properly maintained once constructed. Perimeter sand filters for example do not provide volume reduction, but they may be used to provide pre-treatment prior to stormwater discharging to a rain garden or similar green infrastructure practice. This practice will require routine maintenance. In another example, a hydrodynamic separator can result in very poor water quality when not maintained properly.

Example sustainability principles relevant to operational issues may include:

1. Environmental

Does the site contain stormwater control measures with special maintenance needs?

- Easements and maintenance responsibilities need to be clarified during planning. Assuming who the long term maintenance entity may be without confirmation can result in changes to the types of stormwater control measures applied during design. For example, if the owner assumes that pervious concrete in the right of way is going to be maintained by the municipality, confirmation is needed to ensure that the city has the proper equipment and is willing to perform the service.

Figure 2.7 Perimeter sand filter. Source: Center for Watershed Protection

2. Social

Does the site contain conservation areas that will serve as amenities?

- Easements guaranteeing the preservation and maintenance of these areas need to be committed to during planning and design.

3. Financial

Who will maintain common areas that serve dual purpose park and stormwater management needs?

Identifying whether the owner or tenants will maintain common areas may drive the type of amenities offered within them. For example, trail materials and other features with longer service life may be selected where the anticipated maintenance entity is not likely to have the resources or technical expertise to properly maintain them.

Geographic Issues

Unique or special natural resources need to be highlighted, not hidden. (See Section 2.5 in Chapter 2 for consideration of Physiographic Regions.) Example sustainability principles relevant to building facilities may include:

1. Environmental

Is the proposed project near significant rock outcrops, lakes or shallow groundwater?

- Program goals can include a full suite of non-structural low impact development principles to help ensure and maintain long term integrity of existing scenic waterbodies. Specifically, minimizing land disturbance and rock excavation during construction can be a highly effective tool, as phosphorus or fine grained sediments released during construction can permanently damage waterbodies.
- Groundwater resources should also be considered when selecting practices. See Table 2.2: Existing Natural Resources Considerations and Table 5.4: Groundwater Contamination Potential for Stormwater Pollutants Post-Treatment.

Figure 2.8 English Landing Park, Parkville, MO.
Source: Shockey Consulting

2. Social

Is the proposed project near significant rock outcrops or lakes?

- Program goals can include setbacks from significant geographic features to help maintain viewsheds. Public access to lakes can be promoted through placing stormwater management or conservation easements between areas of development on the shoreline.

3. Financial

Is the proposed project near significant rock outcrops or lakes?

- Minimizing land disturbance, particularly rock excavation, can lower costs during construction. Maintaining viewsheds and public access to natural resource amenities through proper planning can help market and maintain property values.

Construction Issues

The construction process for sustainable sites that include green infrastructure and other innovative elements is in many ways unchanged. Construction documents are issued, bid and awarded to a qualified contractor; then, the owner or their designated representative oversees the construction process, inspecting the process at predetermined milestones. However, potential elements that may be atypical to the construction process include types of materials, construction sequence and maintenance.

Construction Material Installation - A primary green infrastructure strategy includes the use of pervious pavements – concrete, asphalt or pavers. Material installation may require special training and contractors should submit training certifications related to the material being installed.

Native Landscape Installation - Use of native vegetation can create landscapes that are unfamiliar to many urban and suburban areas. Design and installation of these landscapes is a specialty field. While mature native landscapes are typically hardy and require less maintenance than most non-native landscapes, they may take longer to establish and require more maintenance during the first one to three years following installation. Designers may need to consult with local native plant nurseries to help developing materials lists and maintenance specifications.

Construction Sequencing - Infiltration and other stormwater control measures can be damaged or otherwise degraded due to poorly planned or implemented construction sequencing. Two factors important to green infrastructure elements include:

- Soil compaction. Infiltration areas need to be protected to avoid compaction or over excavation after site work in order to help ensure adequate soil permeability. Field testing can be required during construction to decide whether or not over excavation is required.
- Sedimentation. Construction phase best management practices are used to control suspended solids in runoff. These areas can be revised as post construction stormwater control measures assuming they are inspected and rehabilitated after construction is completed
- Contractor Oversight. Additional oversight is needed in green infrastructure projects where contractors are inexperienced or otherwise unfamiliar with green infrastructure installation and function. Because many non-structural and structural methods are uncommon to traditional construction practices, contractors may misinterpret plans based on a perceived need to “fix” things that may not be broken.

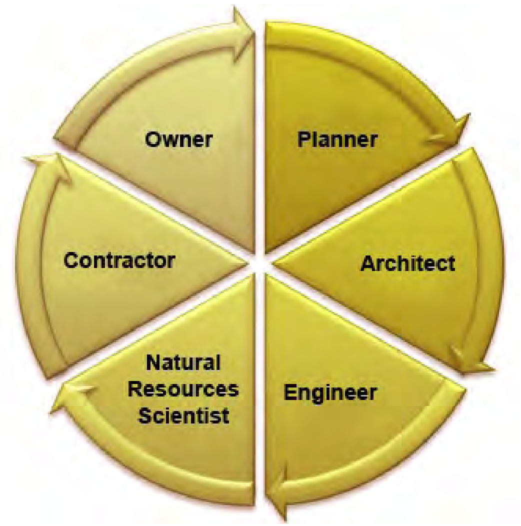
Expensive mistakes can be made when contractors don't understand the change in design approach. For example, a parking lot may be designed to sheet flow across infiltration practices, but the contractor "corrects" the design by grading a slope that directs runoff to a curb - a curb the contractor believed was accidentally left out of the design.

Special inspections may also be required to ensure subgrades in infiltration areas are not over-compacted, lime stabilized or otherwise damaged during construction.

Building Your Team

Similar to planning at the regional or municipal level, integrating sustainability concepts into a site design generates opportunities and constraints that require input from a multi-disciplined team. Each team member should understand how their specialty fits into the overall needs of the project and prepare to find solutions where perceived conflicts of interests or goals occur. Pending the size of the project and resources available, some team roles will be combined and be the responsibility of one team member.

In practice, assembling complete teams can cost more and require more time for planning and design than conventional projects. However, case studies in this and other documents support the cost benefit of added investment of time and money up front. Where resources may not support the creation of a complete multi-disciplined team, the owner may be able to rely on direct coordination with stormwater coordinators, economic development directors, local or state environmental agency personnel and other relevant agency personnel.



Owner

The owner can be an individual or a private or public entity that provides resources that make the project design and implementation possible. The owner identifies the objectives or purpose of the project and provides consistent and clear direction on expectations, budget and schedule. The owner also makes decisions where multiple feasible options exist

Planner

Helps the team organize the vision and goals for the project and develops concept plans to portray the vision. Planners may need to revise programmed passive recreation areas to accommodate infrastructure needs. Examples may include integrating green space into a network of parks that can also serve to collect, convey and treat stormwater runoff; review community needs relevant to locally available goods and services to help estimate the need and frequency of street uses and alternative transportation options; and relocation of proposed development areas to accommodate natural resource areas or their buffers.

Architect

Building and landscape architects help the team integrate function and form - placing one ahead of the other only when necessary to support the goals or requirements of the project. Building architects may need to minimize building footprints, incorporate on-lot stormwater control measures or reduce on-lot impervious surface percentages through shared drives or revised sidewalk details to include pervious pavement and subsurface infiltration. Architects may also need to evaluate green roof options to help control runoff, conserve building energy or provide urban rooftop open space.

Landscape architects will likely need to consider several atypical factors. Irrigation may not be available, native plant materials may be required and landscapes may be prone to frequent inundation.

- Temporary irrigation may be required in non-stormwater management areas in order to establish plant materials. However, the deeper root systems associated with many native plant species used in sustainable design should prevent or minimize the need for long term irrigation systems.
- Native plant selection will require a balance between diversity (which is good for ecology) and appearance (which is required for long term acceptance in most communities). Native plant nurseries can assist landscape architects in selecting materials, specifically regarding the seasonality and height of different species, to help create a year-round aesthetically pleasing environment.

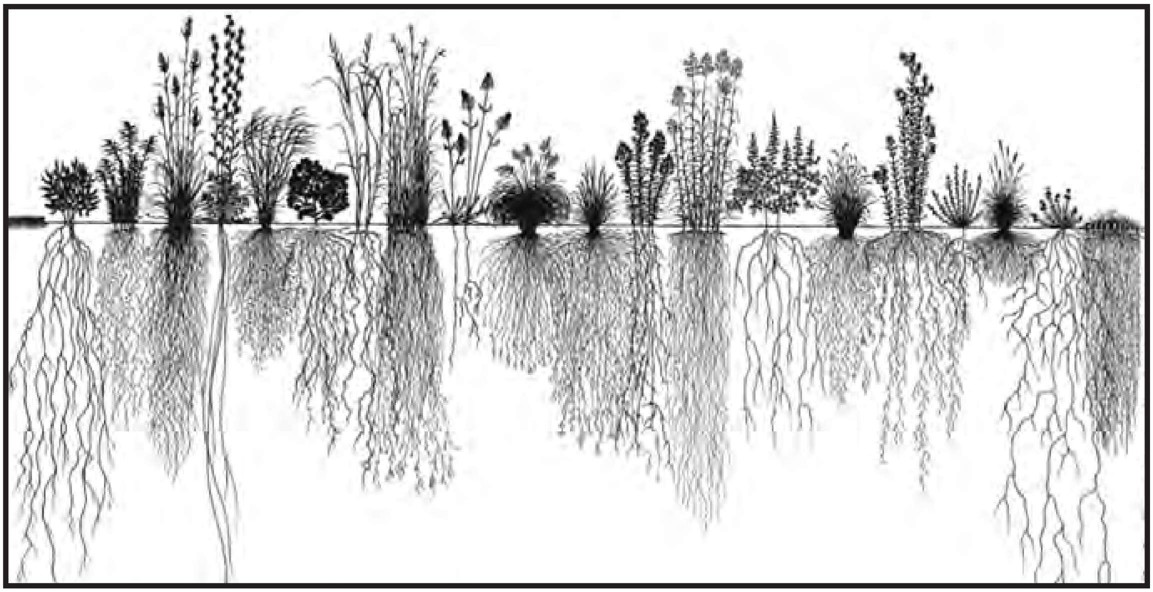


Figure 2.9 Comparative root systems. Source: *Native Plant Guide for Streams and Stormwater Facilities in Northeastern Illinois* Prepared by USDA-NRCS Chicago Metro Urban and Community Assistance Office in Cooperation with EPA Region 5, U.S. Fish and Wildlife Service, Chicago Field Office and U.S. Army Corps of Engineers, Chicago District, December 1997 (Revised May 2004).

- Plants that can undergo extremes in wet conditions need to be chosen for many green infrastructure systems. Periodic inundation for several days can kill many plants, making trial and error expensive. Testing plants for specific sites, can help determine survivability.
- Native plant nurseries are becoming more common. Some municipal or nonprofits establish native plant nurseries for this purpose, creating green collar jobs.
- Most native grasses and forbs spend one to three years developing the deep root systems that make them hardy and more drought tolerant than their non-native counterparts. Note the short turf grass roots in Figure 2.9. While these root systems play a major role in sustaining long-term infiltration capacity of soils, the time period for root development may create aesthetic and maintenance issues in the short term.

  To help minimize the potential for aggressive weed development and maximize the potential for a quicker developing native landscape, designers should specify weed-free topsoil, live plant material in lieu of seed and require adequate thickness of leaf compost or other appropriate mulch.
- The stormwater engineer should be able to provide the architect with guidance on the maximum allowable amount of impervious surface per lot and should be able to assist the landscape architect with information such as frequency, duration and depth of flooding that can be expected in landscaped stormwater management areas.

Engineer

Engineers are needed with special skills and training in the area of green infrastructure to compliment their skills in drainage designs. While Missouri does not require certification for stormwater quality, some states do. Advanced contractor training is very important, also.

Engineers provide design, modeling and infrastructure coordination to support concepts and designs developed by the project team. They are responsible for evaluating site plan concepts to quantify the size, type and location of structural stormwater control measures, and they develop the grading plans necessary to minimize disturbance during construction.

Engineers also design the transportation and parking network to the necessary level of service while minimizing impervious surface, including developing the typical road cross sections to help minimize the widths. Streets, greenways and in some cases public transit facilities, should be designed to minimize their cost and ecological footprint while still providing safe, reliable access for motorized vehicles, bikes and pedestrians.

In context of sustainable site design, transportation networks should consider integrating stormwater management through retention in the right of way where feasible, use of permeable pavements, narrow streets, and stabilized vegetated shoulders where possible as substitutes for grey infrastructure. They may also need to consider regional greenway plans, public transportation initiatives or other external connectivity issues. See Green Highways Partnership at www.greenhighways.org and Green Streets at www.lowimpactdevelopment.org/greenstreets/.

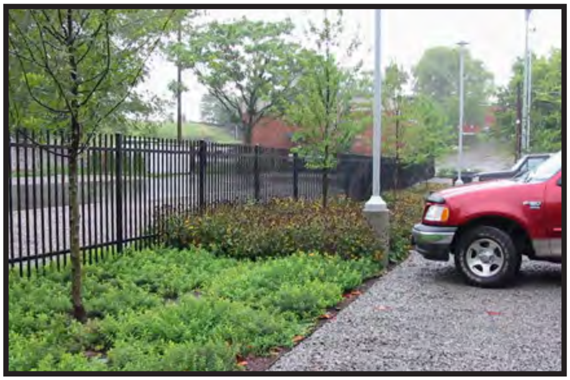


Figure 2.10 Bioretention. Source: *Green Infrastructure Digest*

Design development provides the opportunity to collect and analyze anticipated intensity of use and other relevant data to assess which alleys, collectors or arterial roads can best be modified or minimized beyond local standards in support of project sustainability goals. Transportation studies should be shared with other project team members to ensure compatibility with future land use

Natural Resource Scientist

Wetland, stream, soil, wildlife or other natural resource scientists may be a critical part of the team where sensitive ecological issues are affected by site development. Natural resource specialists may need to help develop alternative solutions to better integrate wetlands, streams or other natural resource features or begin preparing mitigation plans and permit applications. They may also serve as an advisor on native landscape vegetation issues related to hardiness, behavior or maintenance requirements.

Natural resource professionals should review site plans to recommend integrating natural resources where possible. Planners, engineers and other team members will need to provide site use and functions to help integrate the natural resource (without degradation) or will need to provide the basis and need for unavoidable impacts. Example solutions include providing water quality treatment prior to discharging to wetlands, thus maintaining water flow to the wetland and taking advantage of its natural stormwater management function. This technique is allowable in most areas providing that the natural hydrologic conditions of the wetland are not altered in any way that would decrease its functions and values.

Contractor

Experienced contractors, trained in green infrastructure, can verify assumptions made during the design development process. Contractors can help designers verify pricing, because many green infrastructure elements may cost more or less than their conventional counterparts. They may also lend insight to construction sequencing. How to construct integrated infrastructure in the field can influence design decisions on paper. For example, substitutions can be made for some stormwater control measures that may not be readily constructible due to soil types, high groundwater table or other concerns. Training and experience can be very important, because many devices can fail due to overfilling or compacting the soil media. Contractors may think they are improving or correcting the specification.

Land Use Issues

Structural and non-structural stormwater control measures can be restricted or otherwise affected by proposed land use. Urban sites have a natural scarcity of land areas available for large dedicated stormwater management areas. Suburban areas have land, but can lack pedestrian connectivity and usable green space due to disconnection by large stormwater management features. Greenfield commercial/industrial sites with large percentages of impervious area can generate unusually high increases in post-development runoff rates and volumes relative to suburban or urban improvements. Due to these different challenges, different tools may be needed to address stormwater management for different land uses.

Urban Tools

1. Minimize impervious surface and direct connections.

- Substitute pervious pavements when repairing or replacing curb, gutter and sidewalk sections.
- Eliminate unnecessary or rarely used parking areas and replace with vegetation.
- Allow minimal on-site parking where adequate on-street parking is available nearby.
- Allow and encourage green roof technologies to increase open space for building tenants while decreasing runoff.
- Disconnect downspouts from collection systems or connect to storage systems.
- Use pervious pavements with infiltration capacity in parking areas and driveways.

2. Maximize infiltration and reuse.

- Apply distributed storage in the right of way using bioretention in place of elevated landscapes.
- Connect treatment practices in a stormwater treatment train when possible.
- Create distributed pocket parks in vacant or abandoned properties to manage overflows from water quality stormwater control measures.
- Use rain barrels, storage tanks or cisterns where possible to harvest rainwater for reuse.
- Reduce volume.

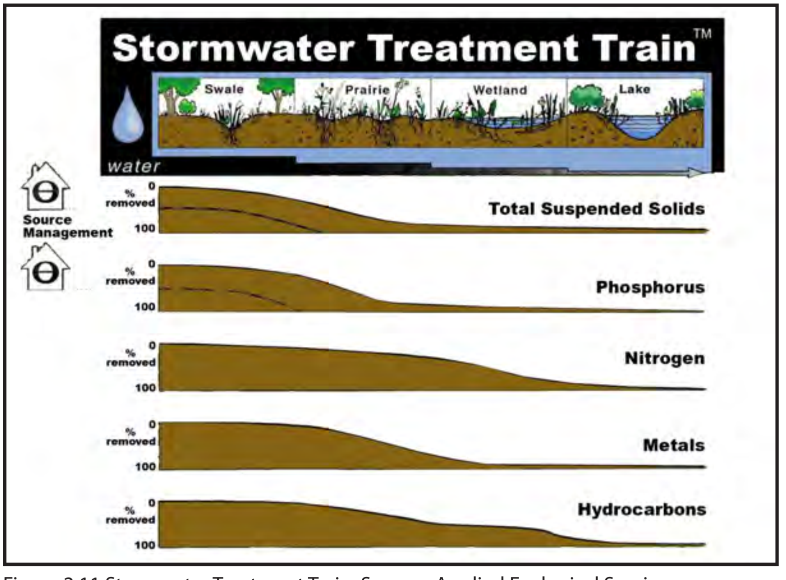


Figure 2.11 Stormwater Treatment Train. Source: Applied Ecological Services. See www.appliedeco.com for more STT information and project examples.

The Stormwater Treatment Train,™ or STT, graphic was created by Applied Ecological Services Inc. in the early 1980's. It was developed after working on a study of the Des Plaines river and to study how discharge in the river has changed since mid-1800's. This STT graphic shows the elements developed for the Prairie Crossing project, Grayslake, IL. The dashed line in the graphic is expected reductions in nutrients, road de-icing salts, fertilizers and other contaminant constituents from source control. This aids changing landowner behavior to reduce home lawn fertilizer, herbicide, and pesticide uses. This graphic is stylized modeling output from the USGS HSPF model. Any questions about this graphic or the studies behind it can be directed to Steven I. Apfelbaum (steve@appliedeco.com) at Applied Ecological Services, Inc.

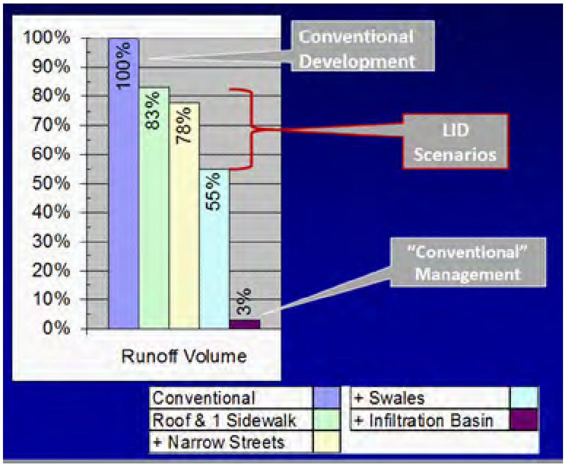


Figure 2.12 Runoff Reductions by Site Components. Source: Dr. Robert Pitt, Personal Communication, February, 2012.

Water volume should also be represented. Figure 2.12 is from an actual large-scale monitoring project by Wisconsin DNR/USGS in Cross Plains, one of the more comprehensive reports on the performance of conservation design. It shows the benefits of the treatment trains, and the need for multiple components using green infrastructure and sedimentation and large scale infiltration. The results were as predicted before construction using WinSLAMM which was used to help design the project.

3. Maximize native plantings, favoring hardy species. Plantings can increase the aesthetic value of communities, and also manage stormwater. In an urban setting, vegetation must fight for space with competing land uses.

Some issues to consider are:

- Select hardy vegetation resistant to urban stresses such as road salt, limited groundwater recharge and air pollution.
- Favor shade trees over ornamentals where possible to help reduce heat island effects and increase carbon sequestering. Trees also provide the greatest water uptake.
- Consider root patterns that may affect adjacent pavements.
- Provide adequate structural or other planting soil to support the mature tree size.
- Select deep rooted herbaceous species and favor perennials over annuals to decrease watering needs and seasonal replanting.

4. Make green infrastructure features part of public outreach programs.

- Sustainable features can increase a community's value and can be the start of economic revitalization.
- Provide educational signage to define these methods and how they work.
- Manage stormwater within otherwise necessary site features – the limited land area available makes this principle more important in urban areas than other land uses. Capture, treat, infiltrate and otherwise manage runoff in the right of way, beneath parking, on the roof and in the landscape.
- Combine Funds – Urban redevelopments often have multiple potential stakeholders interested in assisting with green infrastructure. Community development corporations, municipal governments and parks departments all may be interested in partnering to help bring a green infrastructure project to their area.
- Enhance community spirit and sense of place. Green infrastructure can be used as identifying features for a community. The design and location of these features can define neighborhood boundaries without expensive signage.

Suburban Development Tools

1. Minimize impervious surface and direct connections as part of development.

- Minimize roadway lengths and widths using planning techniques.
- Allow shared driveways.
- Cluster homes.
- Minimize building footprints using multi-story product types.
- Use pervious pavements in low traffic areas.

2. Maximize infiltration and reuse.

- Apply distributed storage in the right of way using bioretention in place of elevated landscapes, and use flat curbs, curb cutouts and pervious walkways in place of impervious concrete.
- Infiltrate runoff in common areas or "stormwater parks."
- Use rain barrels, storage tanks or cisterns where possible to harvest rainwater for reuse.

3. Maximize native plantings, favoring hardy species. Plantings can increase the aesthetic value of communities, but can serve the dual purpose of also managing stormwater. Some issues to consider are:

- Select hardy vegetation resistant to right-of-way stresses such as road salt.
- Favor shade trees over ornamentals where possible to help reduce heat island effects, and increase carbon sequestering and water uptake.
- Consider root patterns to help decrease risks to adjacent pavements.
- Provide adequate planting soil to support the mature tree size.

Figure 2.13 Rain garden in roundabout designed to capture/ infiltrate stormwater, Milwaukee, WI. Source: Bob Newport, EPA Region 5

Figure 2.14: Residential rain barrel. Source: *ABCs of BMPs*

Figure 2.15 Green roof- Orthwein Animal Nutrition Center, St. Louis Zoo. Source: SWT Design. Source: Shockey Consulting

- Select deep rooted herbaceous species and favor perennials over annuals to decrease watering needs and seasonal replanting.

4. Make green infrastructure features part of public outreach programs.

- Sustainable features can increase a community's value and can be the start of economic revitalization.
- Provide educational signage to define these methods and how they work.

5. Use linear vegetated stormwater features to treat, store and convey stormwater runoff and to produce increased pedestrian connectivity.

6. Detention areas can also be used as parks and open recreation. These areas can be designed to only be inundated during large, infrequent rain events when most people are not outside for recreational purposes due to unpleasant weather.

Commercial/ Industrial Development Tools

1. Minimize impervious surface and direct connections.

- Use angled, one-way directional parking to minimize impervious surface.
- Use extensive green roof technologies to decrease runoff from large roof areas.
- Minimize parking counts.
- Use turf pavers or other permeable material for seasonal overflow parking areas.
- Incorporate green parking lot, features. See www.greenparkingcouncil.org, for example.

2. Integrate stormwater management into otherwise necessary site features.

- Substitute bioretention for parking islands.
- Manage runoff in the perimeter buffer.
- Integrate infiltration trenches into pervious curb and gutter at the parking lot perimeter.
- Use long, linear islands parallel to parking aisles in lieu of isolated parking islands at aisle ends.
- Design parking lots to include stormwater management features.

3. Use linear vegetated stormwater features to treat, store and convey stormwater runoff and to minimize the need for earthwork on large sites with little or no slope.

4. Limit turf areas. They require frequent mowing, excessive watering and increase the need for chemical application.

5. Implement low impact development techniques as part of planning.

- Minimize clearing.
- Minimize earthwork.
- Minimize impacts to wetlands and watercourses.

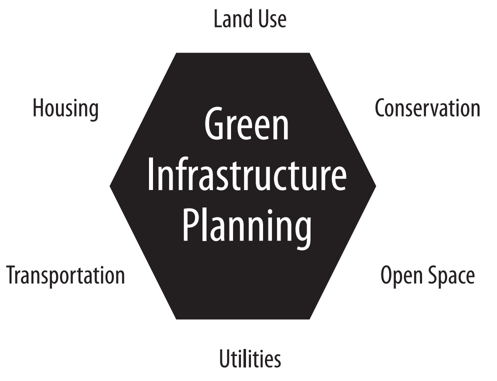
Figure 2.16 Parking Lot Bioswale- Anita B. Gorman Conservation Discovery Center, Kansas City, MO. Source: Shockey Consulting

2.2 Planning and Permitting at the Municipal Scale

Municipal scale planning areas may or may not be regulated MS4s. They often do not control the entire watershed or other natural resource areas in which they are located, but do have regulatory authority to enforce land use management programs and ordinances. In addition to considering regulatory compliance requirements, municipal stormwater planning should integrate the goals, priorities and desired land uses of geographically relevant regional, watershed or other municipal comprehensive plans.

"Increasingly, communities are looking for ways to maximize the opportunities and benefits associated with growth while minimizing and managing the environmental impacts of development. Balancing these priorities is playing out in planning commission meetings, boardrooms, mayor's offices and public meetings throughout the United States" (Brown et al 2007).

Example Goal: *City of Cape Girardeau, Missouri*



Comprehensive Planning

"Policy 3.3.5: Create minimum standards and encourage the use of Green Infrastructure through programs, policies, regulations and incentives."

Figure 5.17 Theis Park rain garden- Kansas City, MO.
Source: Shockey Consulting

Green Infrastructure and Municipal Planning

Typical municipal planning elements may include:

Land Use - Designates the general location and intensity of housing, business, industry, open space, education, public buildings and grounds, waste disposal facilities and other land uses.

Conservation - Addresses the conservation, development and use of natural resources including water, forests, soils, rivers and mineral deposits.

Open Space - Details plans and measures for preserving open-space for natural resources, the managed production of resources, outdoor recreation, public health and safety and the identification of agricultural land.

Utilities - Details plans for the location of utilities such as wastewater, water supply, stormwater, electricity and telecommunications.

Transportation - Identifies the general location and extent of existing and proposed major roads, transportation routes, terminals and public utilities and facilities. It must be correlated with the land use element.

Housing - Provides a comprehensive assessment of current and projected housing needs for all segments of the community and region. It sets forth local housing policies and programs to implement those policies.

Land Use and Green Infrastructure

A comprehensive plan includes descriptions or definitions of specific land use designations that can have positive impacts on water quality. Some examples include:

- Restricting development within floodplains.
- Providing buffers around environmentally sensitive areas, such as streams, wetlands and the like.
- Consistency with watershed or regional scale planning, where available.
- Allow for mixed use developments to promote connectivity, conservation development to increase open space and high density development to help prevent sprawl – but require all types of development to meet environmental quality goals.

The following steps (Brown et al, 2007) are helpful when integrating stormwater management into land use decisions:

- Minimize the need for impervious cover and set long term goals for reductions in impervious cover. Introduce maximums where minimums may currently exist – placing limits on parking spaces, road widths and side yard setbacks can all help minimize impervious cover.
- Remove requirements for direct runoff connection to collection systems where possible. Restrict direct connection of building downspouts and limit the number of inlets per curb length.
- Develop relationships between planners, engineers, managers and other stakeholders through public outreach programs.
- Use watersheds as the broader organizing tool where practicable.

Existing Natural Resource Considerations		
Natural Resource	**Questions**	**Mapping Actions**
Wetlands	Are wetlands on-site? Are permits needed (e.g., 404/401 permits) from the Army COE or Missouri Department of Natural Resources?	Show all wetlands on map. Obtain COE/DNR permits or documentation before plan approval.
Streams and Floodplains	Are major waterways on the site? Are permits needed from the Army COE or Missouri Department of Natural Resources? Is the site located within the 100- or 500-year flood plain? Is the municipal or county stream buffer (setback) shown? Is the site in a flooding or erosion prone area?	Show major waterways. Obtain COE/DNR permits or documentation before plan approval. Obtain local floodplain Development permit if applicable Show 100- and 500-year flood plains on map. Show stream buffer, areas prone to flooding and stream bank erosion areas.
Karst	Are sinkholes, springs or seeps located on the site? What is the depth to bedrock?	Local buffer requirements may apply and should be shown. Show sinkholes, springs, seeps and other karst features. Show areas with shallow depth to bedrock.
Existing Topography	What is the existing topography? Are there areas with slopes steeper than 20 percent? What are the site's soil types? What is the existing stormwater drainage area and flow path?	Show existing topography, identify areas with slopes greater than 20 percent. Show site soil type. Show areas with erodible soils. Show gullies, swales, ditches, etc.
Ponds	Are there existing ponds on or adjacent to the property? Does the pond provide recreational benefits? Does the pond provide flood detention benefits? What is the condition of existing ponds (i.e., depth of sediment in pond, bank erosion, invasive plants)?	Show all ponds on map, including any existing detention basins.
Vegetated Cover	Is the site forested? Are grassy/prairie areas on the site?	Show forest and prairie areas. Show large trees (>12" diameter).
Existing Property Use	What is the site's current use? What buildings, structures and other impervious surfaces are present? Are there utilities through the site?	Show existing impervious areas and utilities.
Surrounding Property Use	What is the surrounding property use?	Show property boundary and surrounding property uses.

Natural Resource	Questions	Mapping Actions
Groundwater	What are the opportunities for infiltration, and how might it help to maintain base flow? What is the potential for groundwater contamination?	Define how green infrastructure features will provide water quality and help to maintain base flow. Define the effectiveness of green infrastructure features in preventing concentrated contaminants from travelling through the soils and vadose zone to the groundwater.

Table 2.2 Existing natural resource consideration. Source: Adapted from MSD et al., 2009

Site Development Goals, Questions and Methods

Goal	Questions	Methods (To the Maximum Extent Practicable)
Minimize the Generation of Stormwater Runoff	Can land disturbance be minimized? Can additional green space be preserved? Can proposed development be located in already developed areas?	Limit clearing, grading, and earth disturbance. Use clustered development with open space designs. Use narrower, shorter streets, right-of-way and sidewalks. Allow smaller radii for cul-de-sacs. Reduce parking space requirements. Preserve and protect forested areas, especially areas with large trees. Show tree preservation areas on plans. Allow for shared driveways and parking areas. Provide incentives for site redevelopment.
	Can stormwater safely flow overland to buffer areas (i.e., avoid piping)?	Grade to allow stormwater to sheet flow into buffer or conservation easement areas. Limit use of conventional curb and gutter streets, using hybrid curb systems or flat curbs where appropriate. Use grass channels for street drainage and stormwater conveyance. Allow roof downspouts to flow overland into vegetated cover.
	Can stormwater be captured and infiltrated into the ground?	Rainwater infiltration systems. Examples include rain gardens, dry wells and other landscape infiltration methods. Emphasize managing stormwater at the point of generation.
Minimize Erosion of Site Soils	Can land disturbance be restricted to less sensitive areas? Is the development located outside the 100-year flood plain?	Land disturbance SWPPP requirements apply. Avoid grading areas with steep slopes and erodible soils. Limit disturbance areas within the 100-year floodplain.

Minimize Stream Bank Erosion	Is the development located outside the stream bank setback buffer? Does the development warrant engineering channel protection controls (because of development size or stream bank erosion problems)?	Development should not encroach municipality's stream bank buffer. **Show stream buffer on preliminary plan.** MSD rules and regulations require channel protection detention for the 1-year 24-hour rainfall event. **Show detention basin on preliminary plan.** Locate outside limits of 100-year floodplain. If feasible, stabilize the stream bank using other engineered methods.
Minimize Impact Environmentally Sensitive Areas	Does the development plan avoid sensitive areas?	**Untreated stormwater should not discharge into sinkholes, wetlands, fishing ponds, and other sensitive areas.** Provide a buffer around sensitive areas. Preserve the existing stormwater flow path.
Adequately Treat Stormwater Before Discharge	Does the site development plan utilize stormwater credits? Does the development plan show structural BMPs? What is the acreage of drainage to the BMP? Will the BMP be above or below ground?	Show locations of any (non-structural) "credit" areas and show locations of any structural stormwater BMPs on preliminary plan. Locate structural BMPs outside the 100-year flood plain. Provide a BMP drainage area map. Only certain wet ponds and wetlands may be used for drainage areas larger than 10 acres. Encourage stormwater credits, managing stormwater at the point of generation, and aboveground stormwater BMPs. "Regional BMPs" and underground BMPs should be avoided when possible. As a rule of thumb, the development should provide 35% minimum green space for a structural BMP(s).
(Bold items reflect {MSD} project requirements)		

Table 2.3 Site deveolpment goals, questions and methods. Source: Metropolitan et al., 2009

Open Space and Green Infrastructure

When municipalities make decisions regarding park and open space planning, they typically face three decisions associated with incorporating parks or open space policies into a plan:

- Where are new parks needed?
- What should be done with existing park land?
- How do we better connect people and parks?

Stormwater management should play a role in all of these decisions. When preserving new park land and open space, municipalities should identify natural areas that already function as natural green infrastructure stormwater management systems.

A typical example of a natural green infrastructure stormwater system would be stream corridors and associated floodplains, wetlands and woodlots. All can provide valuable water quality and flood management services as well as wildlife habitat and passive and active recreational opportunities for citizens.

For existing active use park lands, designed green infrastructure stormwater management will require careful planning and installation, such as playgrounds and athletic fields, so as not to create public hazards and liability for the municipality. Rain gardens, infiltration trenches and swales may all work well in public access areas, but steep-sided detention ponds for example could potentially be hazardous.

A popular integration tool is the use of hybrid curb-sides, using conventional curb and gutters along with swales. The curbs drain to the adjacent swales and provide an edge to protect the pavement, gives snow blades an edge, and keeps cars off the infiltration area. Public works employees seem to like these in contrast to typical swales, for example.

Figure 2.18 Residential Rain Garden - Parkville, MO.
Source: Shockey Consulting

Communities that acquire park land in floodplains must consider how to develop the property to tolerate occasional flooding. Potential maintenance costs associated with how the floodplain property is developed should be included in the decision making process. The use of facilities that are less severely affected by floods, such as non-habitable buildings and structures, is more appropriate.

Utilities and Green Infrastructure

If a community develops utility management policies as part of the comprehensive plan, the community can proactively determine where future utilities can be placed to minimize the impacts on the natural green infrastructure.

The following factors should be considered when planning utility corridors in floodplains:

- Wastewater pipes can leak or break allowing untreated sewage to be discharged to streams.
- Disturbance during construction may result in sediment and other pollutants being carried into streams.
- Installation in major right-of-ways is often too difficult, given the number of utilities therein.
- Construction techniques should be reviewed when putting utilities in stream corridors. Often it is not necessary to "clear cut" a 100-foot swath.

  Native vegetation or other stream restoration practices can be effective in minimizing pavement impacts after construction.
- Utilities can be damaged during flood events.

Green infrastructure opportunities relevant to utility corridors include:

- Distributed infiltration practices, which can minimize the size of collection (grey infrastructure) systems by preventing runoff from entering pipes upstream of the floodplain. Smaller pipes can mean smaller disturbance and in combined sewer communities, infiltration can help prevent overflows during storm events.
- Stream Protection Corridor Zones, or SPCZs, are an administrative control for protecting the riparian area and the floodplain through specifying the allowable type and conditions of utility work in the zone. SCPZs formulas can be a set arbitrary distance from stream center line or can be derived from regional analysis of stream meander width to drainage basin size. Deriving the distance allows the user to enter a drainage area into the formula for a given point in a watershed and yields a width that is appropriate to allow the stream to naturally meander over time. SCPZs are further discussed in Chapter 4.
- Utility corridors typically require maintenance access. Access roads can serve as managed open spaces for use as trails and wildlife habitat, both along streams and in the uplands of a watershed.
- Funding opportunities for natural resource improvements in utility corridors can be in the form of easement fees from private utilities or voluntary donation depositories at trail heads.
- If green infrastructure is going to be placed in existing utility corridors, communities should consider whether any upgrades of existing utilities are needed before installation.

Transportation and Green Infrastructure

Transportation systems, such as roads and parking lots, impact the quantity and quality of stormwater runoff. Large impervious areas created by roadways and parking lots increase the quantity of runoff in urban and suburban areas. Pollutants such as oil, grease, heavy metals, thermal load, salt and sediments will decrease water quality as stormwater runoff from streets, highways and parking lots carries these pollutants into surface water and groundwater.

Municipalities can outline goals, policies and plans to reduce both the volume of stormwater and quantity of pollutants entering water systems from roadways. *Controlling Non point Source Runoff Pollution from Roads, Highways and Bridges* (www.epa.gov/owow/nps/roads.html) is one resource that addresses the impacts of stormwater runoff from transportation systems on water quality. Green infrastructure strategies include:

- Reducing the quantity of impervious surface.
- Allowing narrower street width requirements in residential areas.
- Limiting commercial developments to a maximum amount of parking spaces in addition to minimums.
- Allowing shared parking for adjacent facilities that operate at different hours.
- Allowing vegetated swales or eliminating minimum slope requirements.
- Capturing and treating stormwater at the source.
- Allow or require stormwater control measures in the public right-of-way for all utility or public capital improvement projects.
- Allow or require low-maintenance, hardy, native landscaping on the roadway right-of-way to improve infiltration and filter pollutants.

Figure 2.19 Vegetated Swale - MN.
Source: Ramsey-Washington Watershed District - BMP Descriptions

Housing and Green Infrastructure

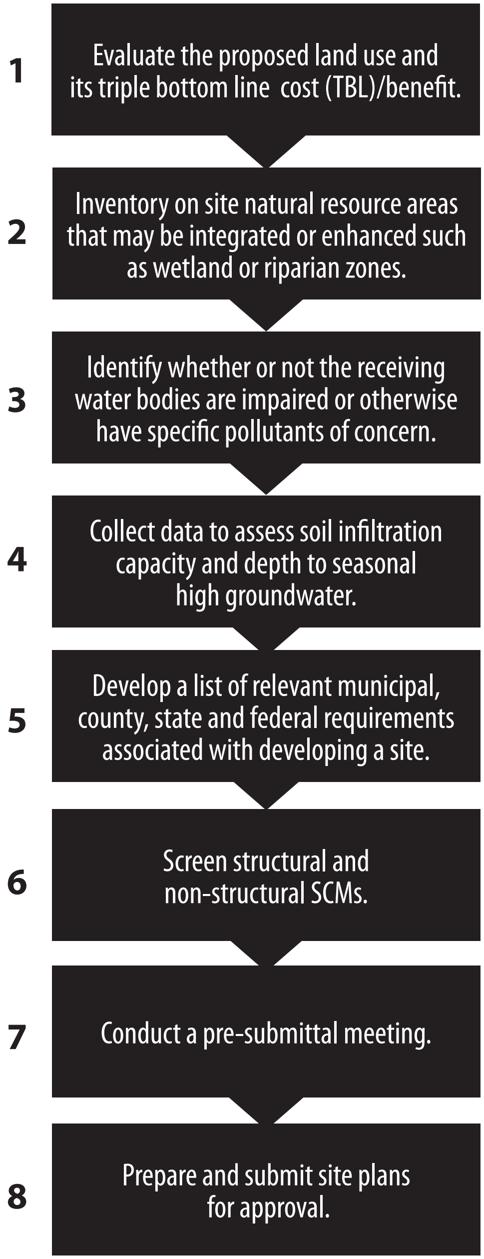
Municipalities can incorporate green infrastructure principles and tools into housing policies outlined in the comprehensive plan. Policies can be developed for the site scale and encouraged at the individual lot scale. Policies that encourage the use of stormwater control measures during the development and redevelopment reduce the stormwater runoff off site which can have positive impacts on local waterways, quality of life and economic development. Details about typical stormwater control measures that are used can be found in Chapter 5.

Create Green Infrastructure Submittal Checklists

Green infrastructure checklists for submittals can help in the preparation and review of plans.

Checklist items may include:

- Evaluate the proposed land use and the triple bottom line cost/benefit against relevant municipal, watershed and regional plan.
- Inventory on-site natural resource areas that may be integrated or enhanced such as wetland or riparian zones.
- Identify whether or not the receiving water bodies are impaired or otherwise have specific pollutants of concern.
- Collect data to assess soil infiltration capacity and depth to seasonal high groundwater.



- Develop a list of relevant municipal, county, state and federal requirements associated with developing a site. Evaluate each for green infrastructure constraint such as prohibitions against stormwater management in the right of way, requirements for direct connection of downspouts to storm sewers and public access restrictions to designated stormwater management areas.
- Screen structural and non-structural stormwater control measures for applicability to the proposed land uses, citing why or why not some stormwater control measures were retained for further consideration.
- Conduct a pre-submittal meeting with local regulatory and plan review personnel to discuss green infrastructure and any atypical design elements.
- Prepare and submit site plans for approval. Include a narrative and supporting graphics showing how the proposed plan compares to issues identified in the checklist.

Additional Green Infrastructure Municipal Planning Opportunities

Municipalities may believe that integrating stormwater management policies and plans into the comprehensive planning is too complex for a small department with limited staff or for municipalities that may not have a planner. In these municipalities, planning can occur at many different levels that may not be as formal as a comprehensive planning process.

The following are some additional examples of planning processes that can incorporate stormwater management into its process.

- Strategic planning or community visioning.
- Budgetary planning.
- Capital improvement program.

Incentives and Credits for Green Infrastructure and Low Impact Development

Incentives and credits can be used to encourage developers to preserve natural resources on their sites, to use st to improve runoff water quality and volume of stormwater runoff. Incentives and credits can also be given to property owners who retrofit green infrastructure improvements on their property. Some incentives for developers may include:

- Allowing an increase in the number of residential lots by reducing lot size requirements. This allows a typical or higher density development the added benefit of increasing the open space and area of resource protection.
- Allowing an increase in the amount of square footage for a commercial development. The footprint of the development is often required to be smaller, but the overall square footage of the development can be larger. This is an incentive to build multiple story units.
- Providing assurances of higher priority and reduced review times. This is accomplished by establishing criteria for receiving the assurances. Some criteria may include providing certain levels of runoff treatment, providing stream buffers and preserving other natural resources beyond levels required in the community's ordinances.
- Providing recognition in a locally-defined program would publicize the efforts of the developers that are employing green infrastructure and low impact development practices. The development could receive an official title such as "Certified Green Development."
- Providing reduced fees or credits. There are many ways credits can be used to reduce the fees paid by developers such as reducing plan review fees for new or redevelopment. However, stormwater utility fees may already be underfunded, making credit programs difficult to implement.
- Education and outreach programs. Programs describing the cost benefit of green infrastructure in context of land development can be provided free of charge.

Some incentives for individual property owners include:

- Providing reimbursements. Some communities have reimbursement programs where individuals receive money for installing stormwater control measures on their property. Many of the reimbursement programs provide a cost-share so that the individual pays for the installation up front and then applies for reimbursement.
- Providing materials and supplies. Some materials that help improve water quality on a property can be provided to property owners at a free or reduced cost. Rain garden planting kits and rain barrels are the most common materials that are provided.
- Providing credits on utility fees. Credits also can be achieved through reduced stormwater utility fees paid by the residents or property owners who have constructed on-site improvements that address site runoff or runoff treatment. Because credit programs may not fully compensate the residents for their investment, this incentive may need to be coupled with other programs described herein.
- Providing recognition. Similar to the incentive provided to developers, property owners can receive recognition by planting a rain garden in their yard. They would then be able to post a sign in their yard and could be added to a database of local rain gardens.

2.3 Green Infrastructure Planning at the Watershed Scale

A watershed is the geographic area where all water running off the land drains from the highest ridges to a given stream, river, lake or wetland. Watershed scale planning can be similar to regional planning (Section 2.4), but areas are specifically defined by their watershed boundaries.

A watershed approach to planning is typically used as a framework where managing water resource quality and quantity within a specified drainage area is the primary goal of the planning agency. Many watersheds have established management programs that encompass multiple towns and other incorporated areas, but also address land use in unincorporated rural areas.

Because a watershed can include multiple government jurisdictions, a watershed management framework can be used to create intergovernmental land development and stormwater runoff management plans (Brown, Claytor, Holland, Kwon, Winer, & Zielinski, 2007).

Figure 2.20 A watershed diagram. Source: Pennsylvania Department of Environmental Protection.

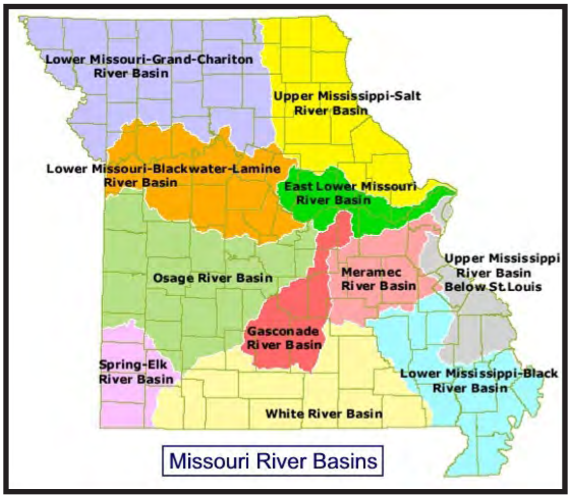


Figure 2.21 Missouri River Basins.
Source: Laclede County SWCD, MO

Watershed-scale planning structures the intergovernmental relationships within a basin or smaller watershed area to promote common interests in water resource management policies and practices. As municipal and site based planning occur, the objectives of those smaller scales should remain consistent with the broader objectives outlined in the regional and watershed planning.

Watersheds can be defined by their hydrological unit codes, or HUC. As of 2010 there are six levels in the HUC hierarchy, from two to 12 digits long, referred to as regions, sub regions, basins, sub basins, watersheds and sub watersheds. Figure 2.21 shows Missouri major river basins.

Watershed plans typically include assessments of current conditions with identification of sources of impairment, estimates of load reductions of identified source impairments to achieve water quality goals, management measures to achieve these goals and estimates of potential capital cost associated with the recommended management measures.

EPA has identified nine elements of a watershed management plan that should be addressed in order to ensure the plan's success:

1. Recognize the causes of impairment and pollutant sources.

2. Estimate pollutant load reductions needed to meet water quality goals.

3. Design management measures that will be needed to achieve load reductions.

4. Estimate amount of technical and financial resources needed and the sources and authorities needed to help.

5. Inform and educate stakeholders to enhance understanding of the project plan and encourage early and continued participation in selecting, designing and implementing nonpoint source management measures.

6. Develop an implementation schedule to manage implementation that is reasonably expeditious.

7. Set interim milestones for measuring implementation progress.

8. Develop criteria for measuring load reductions and progress toward attaining water quality standards.

9. Create monitoring program in accordance with the schedule, implementation milestones and assessment criteria to validate design plan.

2.4 Green Infrastructure Planning at the Regional Scale

Comprehensive land use plans can encompass large geographical areas, address a broad range of topics and cover a long-term time horizon. Regardless of scale, the goal of the process is to determine community goals and aspirations in terms of land use. The outcome is the public policy foundation for infrastructure and economic development.

Regional scale planning is necessary to manage shared resources, such as water or air, so that individuals or groups of individuals acting rationally but in their own self-interest do not degrade or deplete these resources beyond their practical use by others downstream or downwind. As such, regional scale planning areas are defined by political or geographic boundaries that can encompass multiple watersheds, counties, cities and towns. At this scale, no specific entity below the state level is typically regulated, although stakeholders share a common interest in one or more elements of land use planning in their region. See Figure 2.22.

Many varieties of regional agencies have been formed to define region-wide development concerns, prescribe regional strategies and coordinate local actions (Porter, 1997). Examples include state agencies, regional transportation planning agencies and regional economic development corporations.

In Missouri, there are three large metropolitan planning organizations that act as clearinghouses for planning issues and policies in their areas:

- Capital Area Metropolitan Planning Organization.
- East-West Gateway Council.
- Mid-America Regional Council.

In counties that are prohibited from making zoning laws or in small communities with limited planning resources, it may be beneficial to work with an metropolitan planning organization or other regional planning commission (www.macogonline.org/) or refer to guidance from organizations such as the International City / County Management Association (ICMA, http://icma.org/en/icma/home) and the National Nonpoint Education for Municipal Officials Network (http://nemonet.uconn.edu/).

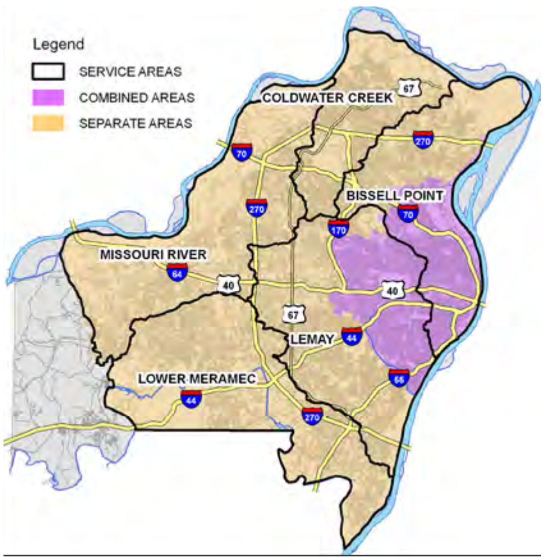


Figure 2.22 St. Louis Area Sewersheds.
Source: Metropolitan St. Louis Sewer Distrct

Regional Planning and Green Infrastructure

In context of green infrastructure, regional planners need to consider TBL costs and benefits to better integrate infrastructure at the regional scale. Example regional green infrastructure can include park systems, transportation networks, water and sewer districts and energy utilities.

Regional park and trail systems and regional transportation networks can be designed to help provide pedestrian connectivity, improve public health, preserve natural resources and wildlife habitat, integrate floodplain and stormwater management and stimulate economic development.

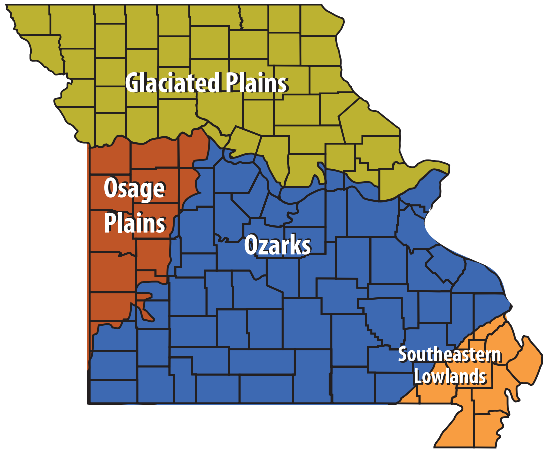


Figure 2.23 Physiographic regions of Missouri.
Source: Department of Natural Resources.

2.5 Physiographic Regions

It is a common misconception that Missouri is home to one soil type – clay. Yet, Missouri is one of the most geologically diverse states in the nation. And its soil types are diverse as well. It's true that urban soils tend to be more compacted and therefore exhibit a higher percentage of clay in areas. However, undisturbed areas can be quite diverse in soil type and they tend to be more permeable without compaction.

Physiographic regions are broad-scale subdivisions based on terrain texture, rock type and geological structure and history. Missouri contains three primary physiographic regions - the Dissected Till or Glaciated Plains, the Ozarks and the Southeastern Lowlands. The Ozarks region is subdivided into the Osage Plains and the Ozarks with several additional subdivisions (DNR, 2002).

Each physiographic region is defined by unique geological strata, soil type, drainage patterns, moisture content, temperature and degree of slope. These conditions often dictate the predominant vegetation and can have significant affect on runoff management techniques.

Dissected Till or Glaciated Plains

Located in the northern part of Missouri, the Dissected Till or Glaciated Plains was created by large glaciers of ice. The topography consists of rolling hills dissected by streams that typically drain south to the Missouri River.

The soils consist of easily erodible glacial tills of clay, silt, sand, gravel and boulders in widely varying amounts. The glacial till has low permeability with limited infiltration capacity. Furthermore, the region is extensively row cropped for the production of corn, soy beans and other grains. The combination of these two factors lead to high suspended sediment loads in many streams and rivers (Vandike, 1995).

Osage Plains and the Ozark Highlands

The Ozarks contain the Osage Plains and the Ozark Highlands. Part of the Great Plains of America, the Osage Plains are relatively flat with thin soils overlying limestone, shale and sandstone bedrock. Runoff in this area is rapid and there is very little groundwater recharge (Missouri, 2002).

Agriculture in the region is a mixture of grain crops and livestock. Coal mining is also important in this region.

The Ozark Highlands is known for its steep hills and rocky soil. It is the largest region in the state and tourism is a large part of the economy. Many people visit the Ozarks to see its beauty, rugged hills, caves, lakes, springs, rivers and forest.

The Ozarks contain large areas of karst topography. Karst topography is formed where the limestone bedrock is soluble. Over time, surface and subsurface water create solution cavities, allowing runoff to enter groundwater and springs quickly with little or no filtering from passage through soils. Aquifers in these areas are vulnerable to pollutants carried in stormwater runoff.

The remainder of the Ozarks region is an area of uplifted bedrock that has variable terrain compared to the other regions of Missouri. Soils are relatively thin and derived from weathered limestone and are generally well-drained and runoff is moderate (Missouri, 2002).

Southeastern or Mississippi Lowlands

The Southeastern or Mississippi Lowlands, also known as the bootheel of Missouri, was once a swamp. The rich, black soil and temperate climate attracted farmers who drained much of the swamp to grow cotton, rice and soybeans. The area is relatively flat, with relatively well drained soils, increasing the effectiveness and ease of installation for many structural stormwater control measures relative to other regions of the state (Missouri, 2002).

Alluvial River Plains

The Alluvial River Plains are relatively small geographic regions located along Missouri's two great rivers: The Missouri River and The Mississippi River. Missouri's two largest cities are partially located in this region: St. Louis and Kansas City.

Figure 2.24 St. Francois State Park - rock outcrop. Photo by Scott Myers, Missouri Department of Natural Resources.

Introduction to Case Studies

Throughout the U.S., there is a growing recognition of the benefits green infrastructure provides to communities. Many municipalities and other jurisdictions have begun to effectively incorporate these practices. The following case studies were selected to showcase both site and landscape scale GI projects which have successfully been implemented. Additional case studies are included in Chapter 6. Readers are encouraged to follow the links or titles provided for each case study to learn more about these projects.

Case Study: 16 Better Site Design Principles (CWP, 2007)

Better Site Design Principles - Center for Watershed Protection

Conservation of Natural Areas

1. Conserve trees and other vegetation at each site by planting additional vegetation, clustering tree areas and promoting the use of native plants. Wherever practical, manage community open space, street right-of-ways, parking lot islands and other landscaped areas to promote natural vegetation.

2. Clearing and grading of forests and native vegetation at a site should be limited to the minimum amount needed to build lots, allow access and provide fire protection. A fixed portion of any community open space should be managed as protected green space in a consolidated manner.

Lot Development

3. Promote open space development that incorporates smaller lot sizes to minimize total impervious area, reduce total construction costs, conserve natural areas, provide community recreational space and promote watershed protection.

4. *Relax side yard setbacks and allow narrower frontages to reduce total road length in the community and overall site imperviousness. Relax front setback requirements to minimize driveway lengths and reduce overall lot imperviousness.

Photos source: Center for Watershed Protection, 2007

5. *Promote more flexible design standards for residential subdivision sidewalks. Where practical, consider locating sidewalks on only one side of the street and providing common walkways linking pedestrian areas.

6. Reduce overall lot imperviousness by promoting alternative driveway surfaces and shared driveways that connect two or more homes together.

Residential Streets and Parking Lots

7. Design residential streets for the minimum required pavement width needed to support travel lanes, on-street parking and emergency maintenance.

8. Reduce the total length of residential streets by examining alternative street layouts to determine the best option for increasing the number of homes per unit length.

9. Residential street right-of-way widths should reflect the minimum required to accommodate the travel-way, the sidewalk and vegetated open channels. Utilities and storm drains should be located within the pavement section of the right-of-way wherever feasible.

Photo source: Center for Watershed Protection, 2007

10. Minimize the number of residential street cul-de-sacs and incorporate landscaped areas to reduce their impervious cover. The radius of cul-de-sacs should be the minimum required to accommodate emergency and maintenance vehicles. Alternative turnarounds should be considered.

11. Where density, topography, soils and slope permit, vegetated open channels should be used in the street right-of-way to convey and treat stormwater runoff.

12. *The required parking ratio governing a particular land use or activity should be enforced as both a maximum and a minimum in order to curb excess parking space construction. Existing parking ratios should be reviewed for conformance taking into account local and national experience to determine if lower ratios are warranted and feasible.

13. *Parking codes should be revised to lower parking requirements where mass transit is available or enforceable shared parking arrangements are made.

14. Reduce the overall imperviousness associated with parking lots by providing compact car spaces, minimizing stall dimensions, incorporating efficient parking lanes and using pervious materials in the spillover parking areas where possible.

15. *Provide meaningful incentives to encourage structured and shared parking to make it more economically viable.

16. Provide stormwater treatment for parking lot runoff using bioretention areas, filter strips or other practices that can be integrated into required landscaping areas and traffic islands.

* Practice likely requires action at the municipal level and may not be within the control of the design team.

Case Study: Assessing Conservation Value of Natural Areas

In context of sustainable site design, natural resource inventories can also collect information to better assess conservation value of natural areas (Ratcliffe et al 1997):

Size:	Importance to nature conservation increases with size. Larger areas of trees have higher priority than smaller areas.
Diversity:	The more diverse, the better. Areas with greater numbers of species types of flora and fauna have higher priority than those lower numbers.
Naturalness:	The less anthropogenic modification, the better. Recently timbered areas have lower priority than older timber management stands.
Representation:	Natural communities not well represented locally have higher priority than those that may be common. Although a type of natural community may not be endangered, or threatened, it may not be common in the local area.
Rarity:	Sites containing rare elements have higher priority. Endangered species habitat is one example.
Fragility:	Unusually fragile systems require higher degrees of protection. For example, vernal pool wetlands are more fragile than an open water marsh wetland.
Typicalness:	Maintaining good examples of common species is good. Tree surveys can be performed to improve timber stands and remove diseased or dying specimens or to flag trees to be preserved in areas of development.
Recorded History:	Researching is better than supposition. Using local knowledge, published data or aerial photos can help assess pre-developed conditions and check for degradation of natural resource areas.
Landscape Position:	Contiguous features are better than fragmented ones. Applied to development, bridges or bottomless culverts provide better connectivity within stream habitat than piped culverts.
Potential Value:	Diminished sites that can be restored to previous condition are important. Former wetland areas may have been drained for agriculture and may be readily restored pending proposed development patterns.
Intrinsic Appeal:	Protection of conspicuous specimens such as large live oaks may increase public awareness for nature conservation. Specimen trees also provide signature opportunities for marketing purposes.

Case Study: Campus Master Plan Planning Principles

University of Missouri 2010 Campus

1. Reinforce the University mission and values: organize facilities and places to promote MU's mission and values.

2. Pride of the state: express the importance of the campus to the state, nation and world.

3. Diversity with the unity: create and maintain campus settings that bring together the diversity of people, heritages and culture.

4. Strong 'sense of place': make the campus a distinctively meaningful and memorable place for all members of the university community and for the citizens of Missouri.

5. Respect natural and architectural heritage: Design facilities to respect the scale, materials and textures embodied in the historic architecture and natural landscape of the campus.

6. Environmental sustainability: Embrace suitable strategies in promoting sustainable sites, water efficiency, energy and atmosphere, materials and resources and indoor environmental quality.

7. Recruitment-retention: emphasize the qualities of the campus that help attract and keep students, faculty and staff.

8. Planning and design integrity: provide facilities and grounds that meet the functional needs of the institution and that comply with the intent of the design principles to provide an overall aesthetical and pleasing campus experience.

9. Enhance community spirit: locate campus functions in close proximity to enhance scholarly activities and social interaction within a safe and secure campus.

10. Allow for prudent expansion of campus functions: provide for facilities expansion in ways that respect neighbors and effectively utilize limited land resources, while conserving and protecting natural resources.

11. Pedestrian dominance: maintain a pedestrian-dominant campus recognizing and gracefully accommodating the need for bicycles and vehicles.

12. Transportation and vehicle circulation: maintain a safe, functional and aesthetically compatible system of transportation, vehicle circulation and parking.

13. Respond to accessibility needs: continue the tradition of providing optimal access to persons with disabilities.

14. Facilities and grounds stewardship: preserve the quality and utility of existing facilities for sustainable use of established resources.

(University of Missouri, 2011)

Case Study: Bear Creek Prairie

Columbia, MO

The Bear Creek Prairie development is located in Columbia and is planned and designed using the concepts of conservation design. To facilitate the concept the property was ultimately zoned as a planned unit development where the owner could propose integrating multiple land uses at one property. The owners goal for the development was to build a community using ecologically sensitive development techniques and construction practices to preserve portions of an existing remnant prairie.

After years of consideration the owners and the Missouri University Department of Architectural Studies, assembled an integrated planning team to conduct the initial design charrette. The charrette included planners, architects, natural resource specialists, engineering professionals and home builders from around the country. To obtain a larger range of suggestions and ideas, the owners also included city officials, potential residents, neighbors, other university faculty and state organizations.

- Cluster the homes around common areas to create a setting that is conducive to resident interaction.
- Create quality homes that are visually interesting, in a moderate price range, with low utility costs and minimal maintenance.
- Have a range of unit sizes and styles, such as townhomes, cottages and flats.
- Use all feasible "green" building techniques to create a healthy living environment.
- Preserve a significant portion of the land for native habitat and wildlife as well as for the residents and future generations.

The culmination of the charrettes shaped the design which follows the principles of the conservation community concept, where homes are generally clustered around common green spaces while minimizing infrastructure. This encourages interaction among residents while retaining use of wooded and open areas for trails, gardens, gathering areas and other amenities (Bear Creek Prairie, 2011).

Proposed Bear Creek Prairie Project, Columbia, MO.
Image Courtesy of Andy Guti.

Case Study: Big Darby Watershed

Franklin County, OH

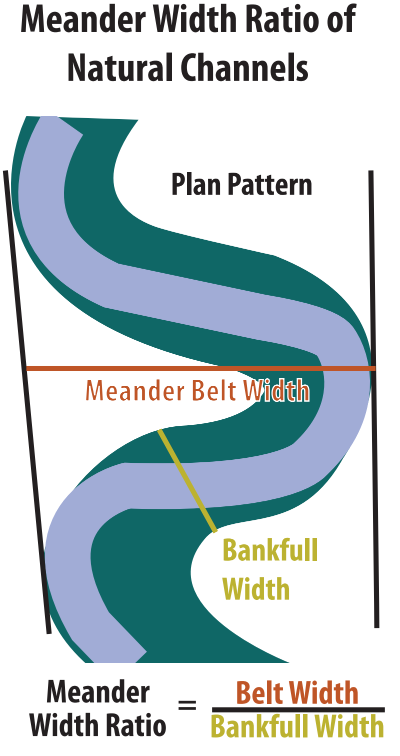
Brown Township. Big Darby Accord. Source: www.brown.twp.franklin.oh.us/big_darby_accord.htm.

Conservation Planning

The Big Darby Accord performed a qualitative assessment of hydrogeologic, hydrologic and environmental criteria to prioritize the sensitive areas in their planning for the value in maintaining a healthy watershed and to begin to recognize degrees of sensitivity as they relate to proposed future land uses. Based on existing conditions, areas were ranked as high, moderate, low or lacking environmentally significant factors for purposes of watershed health. All areas of high, moderate and low environmental sensitivity should be considered as having important values worthy of preservation.

High Sensitivity Area

- Resources that relate to protecting water quality, both surface and groundwater or critical habitat areas recognized by federal or state agencies.
- Areas with well drained, sandy soils exhibit a high degree of flow exchange or high groundwater pollution potential due to hydrogeologic characteristics.
- Linear features such as 100-year floodplains or meander belt widths for their recognized value in maintaining healthy waterways, providing habitat areas in streams and along water ways and minimizing flood damage and personal property loss.



Moderate Sensitivity Area

- Moderate degree of flow exchange between ground and surface water.
- Wooded areas of three or more acres were assigned a medium value to emphasize their importance in providing habitat areas and creating a network of green corridors

Low Sensitivity Area

- Contain hydric soils.
- Land within the 500 year floodplain and beyond the 100 year floodplain boundary.
- Wooded areas between one half and three acres (EDAW, 2006).

Big Darby – Land Use Planning

The Big Darby Land Use Plan is an example of a watershed land use plan based on a multi-jurisdictional district accord in the Big Darby watershed in Franklin County, Ohio.

The goal of this plan was to balance the needs of development with protection and conservation of a highly valuable resource, the Big Darby Creek.

Land use strategies included:

- Focus on higher density development in a designated town center.
- Incorporate additional areas of higher density adjacent to where utility service is already available.
- Provide designated conservation development areas where future sewer service is unlikely.
- Incorporate sensitive natural areas that should be targeted for protection in Tiers 1, 2 and 3.

The Big Darby Accord also provides definitions and allowable uses of open space. The accord provides guidance on where to locate open space relevant to environmentally sensitive features, topography and other land use features. Allowable open space uses are divided into three categories:

- Permitted uses: passive recreation including trails, vegetative enhancement, reforestation, removal of damaged or diseased trees, stream bank stabilization/restoration, public utilities, non-structural best management practices, minor disturbances related to the construction of the permitted use, land application of waste water effluent (outside SCPZ or wetlands).
- Conditional uses: active recreational uses limited to multi-purpose fields, playgrounds.
- Prohibited uses: grading activities and land uses commonly associated with a development process, development.

(EDAW, 2006)

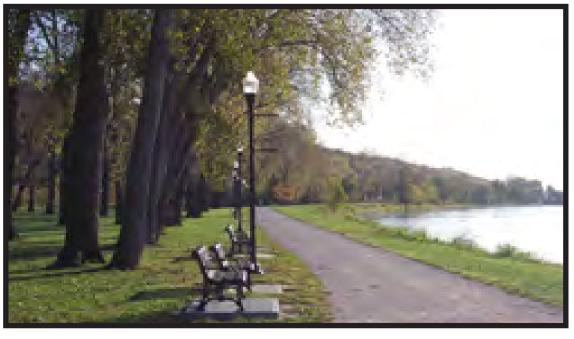
Case Study: Parks and Stormwater Management

English Landing Park

English Landing Park in Parkville, MO is the largest park in the city's relatively young park system, it is nestled between the overlooking hills, adjacent to the city's downtown historic district and the Missouri River. The 68-acre facility has several amenities including 3 miles of walking trails, a large playground area, boat ramp, picnic shelters, a disc golf course, in addition to baseball and soccer fields.

English Landing Park attracts a wide variety of users, including bicyclists, walkers, runners, and nature enthusiasts. For the young to the old- there is a recreation outlet for all to enjoy. The park's scenic walking trails and athletic fields are close in proximity and are designed to be flood tolerant for when the river overflows. Green infrastructure elements include:

- English Landing in close proximity to historic downtown district.
- Multi-use trail.
- Flood tolerant vegetation.



English Landing Park. Parkville, MO
Source: Shockey Consulting.

Earl Road flood control facility. Photo Source: Williams Creek Consulting.

- Integrated natural resources into open space.

Earl Road Flood Control Facility

The Earl Road Flood Control Facility located in Michigan City, Ind., is designed to manage regional stormwater quantity and improve water quality control during peak flows. The facility also serves the dual purpose of passive recreation while creating the opportunity to demonstrate the need to manage nonpoint source pollutants prior to discharge in Lake Michigan.

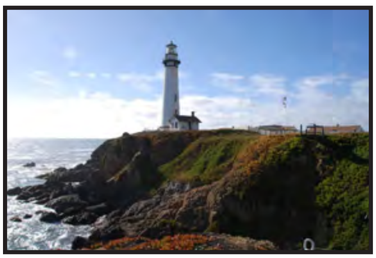
Case Study: St. Louis Great Streets Initiative, 2007

The goal of the Great Streets Initiative is to generate economic and social benefits for communities by providing interesting, lively and attractive streets that serve all modes of transportation.

- Great Streets are representative of their places. A Great Street reflects the neighborhood through which it passes and has a scale and design appropriate to the character of the abutting properties and land uses.
- Great Streets allow people to walk comfortably and safely. The pedestrian environment on, along and near the street is well-designed and well-furnished. The relationship between the street and its adjacent buildings is organic, conducive to walking and inviting to people.
- Great Streets contribute to the economic vitality of the city. Great Streets facilitate the interaction of people and the promotion of commerce. They serve as destinations, not just transportation channels. They are good commercial addresses and provide location value to businesses that power the local economy.
- Great Streets are functionally complete. Great Streets support balanced mobility with appropriate provision for safe and convenient travel by all of the ground transportation modes: transit, walking, bicycling, personal motor vehicles and freight movement.
- Great Streets provide mobility. Great Streets strike an appropriate balance among the three elements of modern mobility: through travel, local circulation and access. The right balance varies with the function of the street and the character of its neighborhoods and abutting properties.
- Great Streets facilitate placemaking. Great Streets incorporate within them places that are memorable and interesting. These may include plazas, pocket parks, attractive intersections and corners or simply wide sidewalks fostering an active street life.
- Great Streets are green. Great Streets provide an attractive and refreshing environment by working with natural systems. They incorporate environmentally sensitive design standards and green development techniques, including generous provision of street trees and other plantings and application of modern storm water management practices.

St. Louis Great Streets Initiative. Learn Share Plan Build.
Source: www.greatstreetsstlouis.net/

Case Study: San Mateo County, California



Source: www.ci.sanmateo.ca.us/

Stormwater Management and Transportation

The San Mateo County Sustainable Green Streets and Parking Lots Design Guidebook provides a variety of ideas for methods to minimize runoff from streets and parking lots, including:

1. Streets including narrower streets and on-street parking.

- Narrow travel lanes.
- Consolidate travel lanes/on-street parking.
- Convert unused asphalt space to stormwater management.

2. Parking lots.

- Shorten stall length and include green space between parking stalls.
- Balance parking spaces with green space.

3. Conveyance.

- Use overland flow to convey stormwater.
- Transform traditional landscape areas to stormwater conveyance (depressed green space).

4. Tree canopy

- Trees contribute to slowing, absorbing and filtering stormwater.
- Other benefits include energy, air quality and economic.

These suggestions should be considered or incorporated into site design/layout to facilitate stormwater management through SCM's. SCM's are categorized by vegetated swale, stormwater planter, curb extension, pervious pavers, green gutter and rain gardens.

(Nevue Ngan Associates; Sherwood Design Engineers, 2009)

Case Study: Complete Streets

Complete streets are designed and operated to enable safe access for all users – cars, bikes, pedestrians and public transportation. Complete street policies direct transportation planners and engineers to consistently design with all users in mind, in line with the elements of complete streets policies. An ideal complete streets policy:

- Includes a vision for how and why the community wants to complete its streets.
- Specifies that 'all users' includes pedestrians, bicyclists and transit passengers of all ages and abilities, as well as trucks, buses and automobiles.
- Encourages street connectivity and aims to create a comprehensive, integrated, connected network for all modes.
- Is adoptable by all agencies to cover all roads.
- Applies to both new and retrofit projects, including design, planning, maintenance and operations, for the entire right of way.
- Makes any exceptions specific and sets a clear procedure that requires high-level approval of exceptions.
- Directs the use of the latest and best design criteria and guidelines while recognizing the need for flexibility in balancing user needs.
- Directs that complete streets solutions will complement the context of the community.
- Establishes performance standards with measurable outcomes.
- Includes specific next steps for implementation of the policy.

(National Complete Streets Coalition, 2005-2011)

Before and after images of Lester Intersection located in Orange Beach, AL. Source: Photovisualization created by the WALC Institute for AARP, www.walklive.org

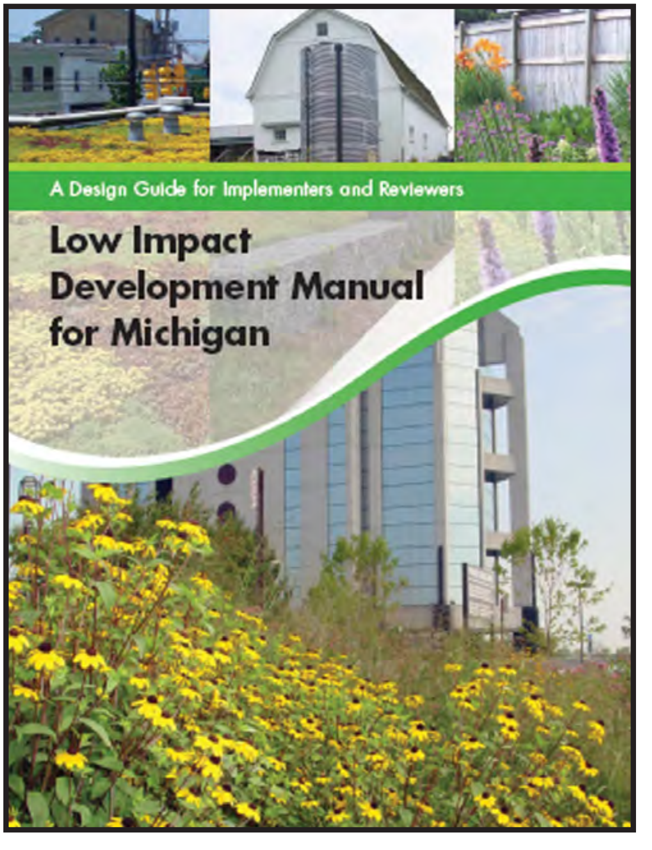
Case Study: SEMCOG Low Impact Development Area

LID Checklist

Southeast Michigan Council of Government has developed a description of the site development process specific to Low Impact Development that provides a checklist of questions to ask. The complete checklist is included in Appendix F, but some example questions that should be asked in the process include (Low, 2008):

- What are the major/minor watersheds?
- What is the state stream use/standards designation/classification?
- Are any streams classified as 303d/ impaired streams?
- Is additional development anticipated for the area that could lead to further opportunities (e.g. partnerships in multi-site or regional water quality or quantity controls)?
- Have the important natural site features been inventoried or mapped?
- Is the development concept consistent with other plans in the community?
- Is development consistent with local existing regulations?
- Will there be concentrated/clustered uses and lots?
- Are the lots/development configured to fit natural topography?
- Does the development connect open space/ sensitive areas with larger community greenways plan?
- Does the development consider re-forestation and re-vegetation opportunities?

(Southeast Michigan Council of Governments, 2008)



Case Study: Stormwater Credit Manuals for Non-Residential Property Owners

Stormwater Credits

Wetland Swale. Source: Olsson Associates

Indianapolis, Ind. and Bloomington, Ill. have similar rate reduction credits for non-residential property owners who discharge a portion of their stormwater directly into a major waterway without sending it through public stormwater facilities or have stormwater control facilities in place to manage runoff and reduce the impact on the drainage system (City of Indianapolis Department of Public Works, 2003; City of Bloomington, Illinois Engineering Department, 2006)

Franklin, Tennessee provides credits to non-residential properties whose impact on the city's stormwater drainage system is significantly limited or has been effectively reduced through specific controls.

The credits available are in four categories:

- Water quantity credits for facilities that convey stormwater runoff.
- Water quality credits for facilities that reduce pollution.
- Education credits for most public and private schools or school systems.
- NPDES stormwater permitted facilities credits for facilities with a Tennessee Department of Environment and Conservation Stormwater Permit on file (Franklin, 2003).

In December 2009, the St. Charles, MO, adopted a green points rating system and incentive program (sustainable zoning ordinance) for non-residential building projects. The program is the product of a partnership formed between the St. Charles and the

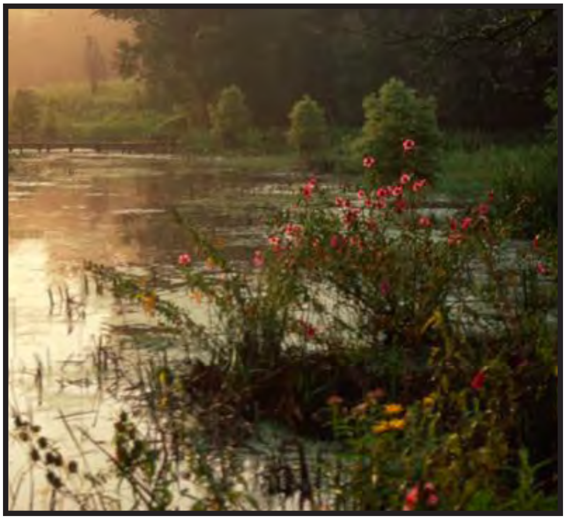
Parking Lot Swale- Kansas City, MO. Source: David Dods

St. Charles County Partners for Progress in early 2009. It is a key piece of a larger effort in the St. Charles to promote environmental sustainability and responsible land use.

The green point rating system is a voluntary program that allows developers and business owners to accumulate points for sustainable building and site enhancements. The number of points accumulated during the planning and development phases determines the types of incentives that are made available for the project. Program incentives include expedited permitting, reduced building permit fees and zoning exceptions that allow for a larger buildable area.

This program is unique in that it does not use LEED designations as a standard and has no requirement for LEED certification. In discussions with small business owners, concerns were expressed that LEED certification requirements would be cost prohibitive. As a result of those discussions, the city devised its own point rating system with the assistance of Partners for Progress and Buro Happold.

This is the first program of its type in the St. Louis metropolitan area and one of a handful in the Midwest region. It has received a great deal of local attention and city staff has presented the program to numerous municipalities and organizations, including the American Planning Association.



Constructed Wetland- Shaw Nature Preserve- Gray Summit, MO.
Source: Missouri Botanical Garden www.shawnature.org

Case Study: Lake of the Ozarks Watershed Alliance or LOWA

Watershed Planning

The Lake of the Ozarks Watershed Alliance, or LOWA, narrowed to the focus of its watershed management plan from the lake's formidable 14,000 square mile watershed to two densely populated and fast growing areas - The Buck Creek and Lick Branch 12-digit HUCs. Water quality in these watersheds has been affected by waste and pollution from dense populations and largely unregulated development. Stresses include failing septic systems, eroding sediments from land disturbance and other non point source pollution. LOWA adopted the mission statement:

"Citizens will protect, preserve and improve the Lake of the Ozarks, its watershed and natural resources while maintaining our economic, social and environmental health."

The Buck Creek and Lick Branch sub-watersheds encompass the first 18 miles of the main channel of the Lake of the Ozarks, as well as its many side coves. These two areas contain parts of multiple governmental jurisdictions, including Osage Beach, Lake Ozark, Laurie and Sunrise Beach. This densely populated area includes many marinas, businesses, condominiums and single family residences.

Long-term strategy goals are to reduce the bacteria load, the nutrient load and the amount of sediment reaching the lake. A long term goal is to reduce the phosphorus and nitrogen levels to the nutrient criteria levels established for the Lake of the Ozarks by implementing a 20-year strategy to reduce nutrient levels incrementally each year until the nutrient criteria levels are reached. Unlike nutrient loads, the WMP prescribes short term 4-year plans

Lake of the Ozarks watershed and sub-watersheds Buck Creek and Lick Branch. Source: Donna Swall

to reduce sediment loads and an immediate plan to reduce bacteria loads can be reduced significantly within a relatively shorter period of time.

To meet these goals, LOWA plans to establish programs to reduce the amount of wastewater dumped by boats and leaking from inefficient septic tanks, monitor best management practices at land disturbance sites, establish green awards and other incentives for businesses to go beyond their legal requirements and a cost-share incentive program to help citizens create and install rain gardens, rain barrels and LOWA low-impact landscapes. In addition, LOWA established a regional wastewater management system to replace septic systems and address projected economic growth. The WMP also integrates issues beyond water quality, including a designated captain program to improve boating safety and dock slip sizes.

Case Study: Multi-Family Site Design - National Apartments

Urban Redevelopment

National Apartments is located in Indianapolis, Indiana Smart Growth Renewal District. The 2.31 acre site obtained drainage approval for traditional stormwater management design. The project owner contracted both conventional and green infrastructure designs in order to compare and select which provided the most cost and benefit. Both plans were designed to meet city standards for water quality management and peak rate control.

The table below summarizes relevant infrastructure costs for both designs. The proposed green infrastructure drainage improvements on-site consist of 14,000 square feet of permeable paver parking area, 800 square feet of parking lot rain gardens and 500 feet of pervious concrete curb and gutter. It will infiltrate up to 53,000 gallons of stormwater runoff per water quality storm event and control peak release rates from the 10 and 100 year storm events to the two year and 10 year release rate, respectively, prior to discharging to the city combined sewer collection system.

NATIONAL APARTMENTS SITE REDEVELOPMENT
INDIANAPOLIS, INDIANA

Traditional Option National Apartments Site Redevelopment			Sustainable Infrastructure Option National Apartments Site Redevelopment		
Manholes, catch basins, and inlets	$	52,150	Manholes and catch basins	$	5,900
Storm Sewer and Underdrains	$	63,864	GI Storm Sewer and Underdrains	$	10,704
Concrete curb, gutter and walks	$	9,464	Pervious concrete curb, gutter, walks, and parking bumpers	$	28,066
Mechanical Separator and Underground Storage	$	96,000	Bioretention	$	8,000
Light Duty Asphalt pvt (converted area only)(3.5" section @ $90/ton)	$	19,532	Permeable Paver Section	$	60,720
	$	-	Stone Storage under Permeable Paver Section for Water Quality Volume	$	15,225
TOTAL	$	241,010	TOTAL	$	128,615
			Potential Sustainable Infrastructure Savings	$	112,395

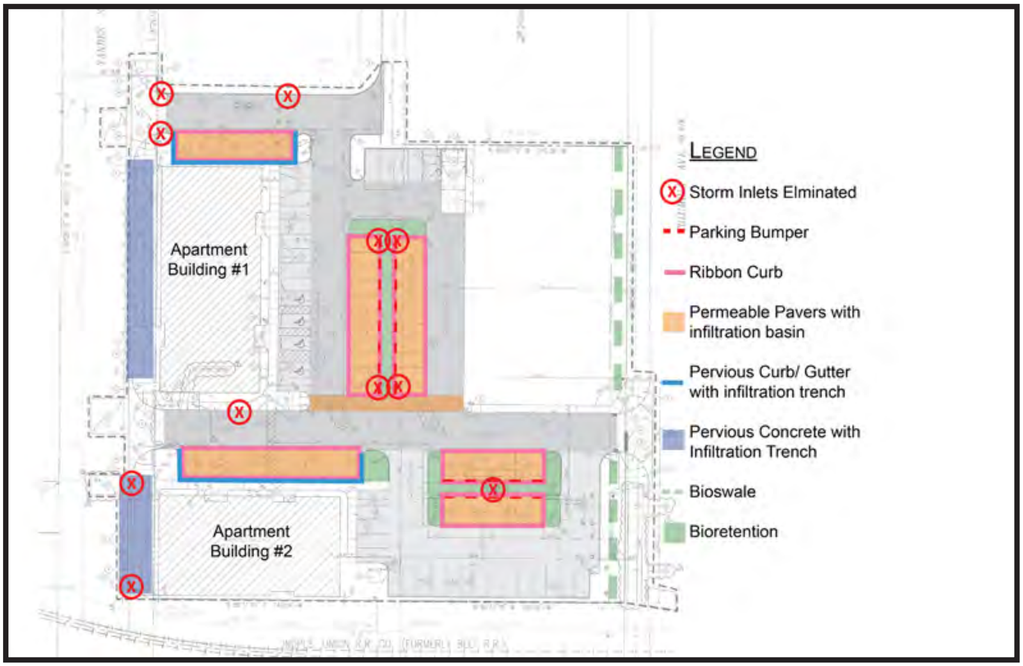
Sustainable Infrastructure Material and Installation cost comparison (only items and quantities altered are included. All other items remain the same between options.)

Comparison based upon best available information for Plans

From Owner:
Site Grading $386,200; Trenching $5,000; Layout $9,500; Paving $93,880; Landscaping $10,000; Temp Fencing $5,130. Total 509,710

Source: Williams Creek Consulting

Green Infrastructure Elements

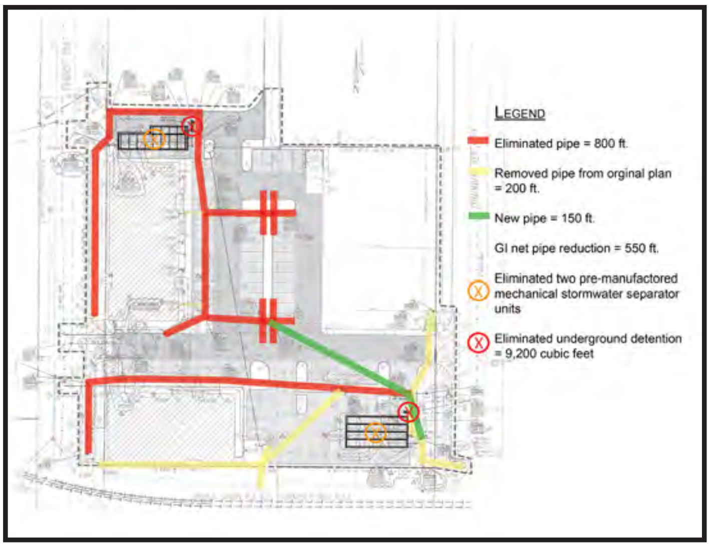


Source: Williams Creek Consulting

Stormwater Collection System Reduction

Benefits:

- Stormwater infiltration – aquifer recharge.
- Eliminated $40,000 in infrastructure cost.
- Added traffic calming elements.
- Increased overall aesthetics.



Source: Williams Creek Consulting

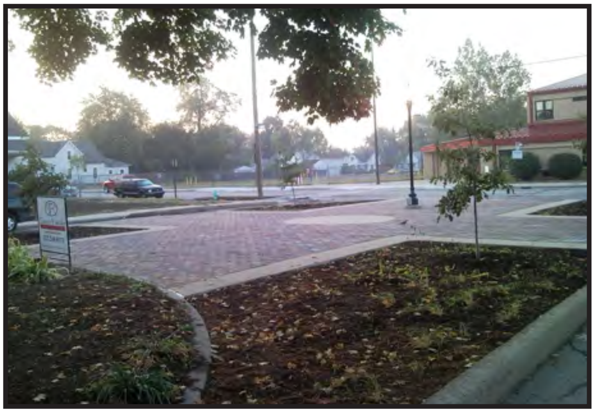
Case Study: Street Retrofit
The Alabama Street Pilot Project

The Alabama Street Pilot Project is in an urban residential neighborhood in Indianapolis, Indiana. The project is located in the city's combined sewer service area adjacent to a boulevard median. The green infrastructure improvements extended and enhanced the existing boulevard median into a previously paved area, introduced bump out rain gardens, pervious concrete curbs and a 2,500 square foot permeable paver pedestrian plaza.

The project was completed as part of a greater Southeast Neighborhood Development revitalization initiative and manages approximately three acres of mixed use runoff. More than 1,000,000 gallons of stormwater are projected to be removed from the CSO annually.

The previously under-utilized median, new plaza streetscape and surrounding rain gardens now function as a neighborhood gathering space, a center to the community, an economic generator to encourage the upkeep of homes which improve the overall neighborhood value and an integrated stormwater management feature. The rain garden bump outs and raised plaza provide traffic calming and safe route for pedestrian connectivity to Lincoln School located across the street from the new plaza.

The retrofit was originally priced at $52,000 to construct and maintain the site for one year. Volunteer labor, material and maintenance agreements through Southeast Neighborhood Development lowered the cost by approximately $8,000.



Source: Williams Creek Consulting

Case Study: Urban Retrofit

Source: Williams Creek Consulting

Ohio Street, Indianapolis, IN

The Ohio Street Green Infrastructure Pilot Project was a partnership effort to improve the East Ohio Street gateway into the downtown area from Interstate 65. The project improved drainage, handicap accessibility and rehabilitated curb and sidewalks to capitalize as a means to continue strengthening the Cole-Noble neighborhood pedestrian environment.

The project incorporated 2,650 square feet of pervious concrete sidewalk, 900 linear feet of pervious concrete curb and gutter and approximately 750 square feet of rain garden. These green infrastructure retrofits manage runoff from approximately 60,000 square feet of impervious surface and will infiltrate more than 1,350,000 gallons of stormwater in a typical year in an area that had no stormwater infrastructure in place, while creating a safer pedestrian corridor.

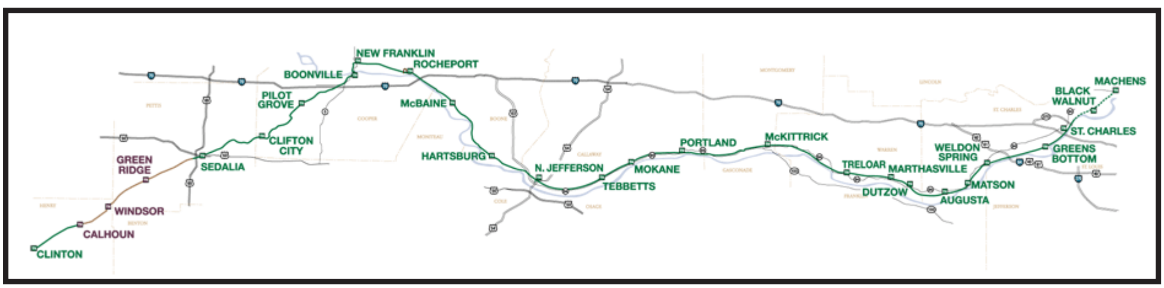
The $53,000 project included a $5,000 grant from United Water to Indianapolis Downtown Inc. for the construction of the rain garden. The remainder of the project was funded through county-wide stormwater budget.

Case Study: Katy Trail State Park

The 225-mile Katy Trail is an example regional park. The trail stretches across most of the state of Missouri, first following the path taken by Lewis and Clark's path up the Missouri River, then through prairies, forests, farmland and small towns. The Katy Trail is the longest "rails-to-trail" project in the country and is ideal for pedestrian travel.

mostateparks.com/page/58605/2011-katy-trail-ride.

Cyclists enjoy a beautiful day on the Katy Trail. mostateparks.com/park/katy-trail-state-park#.



Complete map of the Katy Trail State Park. mostateparks.com/page/57750/entire-trail.

Case Study: MARC - Mid America Regional Council

MetroGreen®

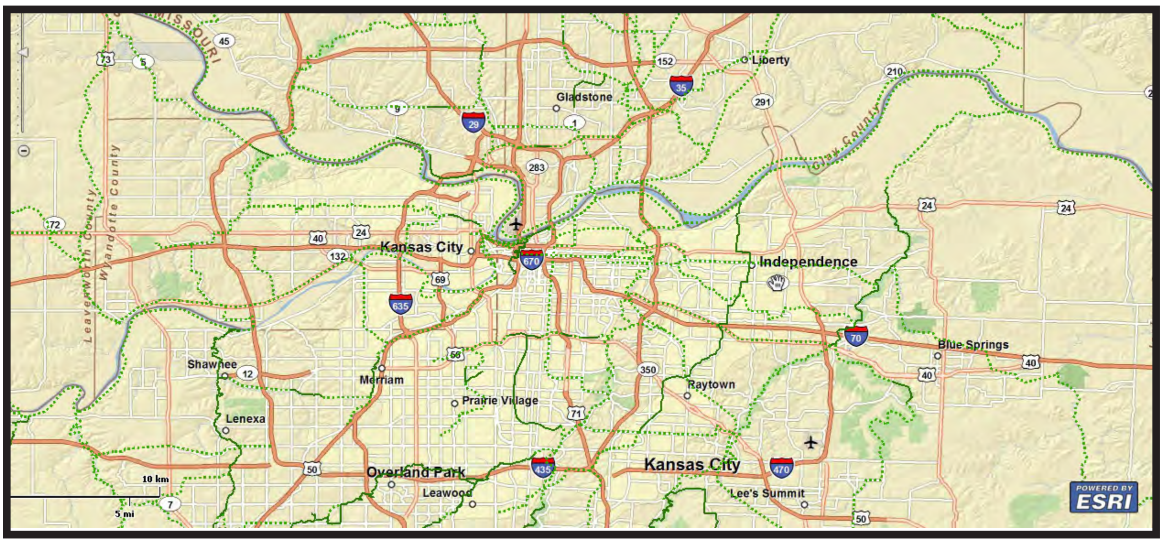
MetroGreen® is an interconnected system of public and private natural areas, greenways and trails linking communities throughout the Kansas City metropolitan area.

The 1,144-mile greenway plan covers Leavenworth, Johnson and Wyandotte counties in Kansas and Cass, Clay, Jackson and Platte counties in Missouri.

The concept of a metro greenway system is not new. MetroGreen extends the "parkways and boulevards" concept of the 1894 Kessler Plan for Kansas City, MO; builds on existing local greenway plans and systems; and is the next step in a project begun in 1991 by the Prairie Gateway Chapter of the American Society of the Landscape Architects. Read more about MetroGreen's history at www.marc.org/metrogreen/about/history.

MetroGreen® identifies more than 75 separate corridors that will form a regional network to connect many of the area's most valuable natural assets. Over 200 miles of the system have been constructed and an additional 100 miles are planned for construction in the next 10 years.

MetroGreen® 2002 defines the critical relationship between environmental stewardship and urban growth management.
(Mid-America. 2002)



Source: Mid America Regional Council, Kansas City MO