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Lexington-Fayette Urban County Government

Stormwater Management
Low Impact Development Guidelines for New Development and Redevelopment

FOR QUESTIONS ABOUT THIS DOCUMENT

PLEASE CONTACT:

LFUCG NEW DEVELOPMENT SECTION

859-258-3410

-or-

LFUCG DIVISION OF WATER QUALITY

859-425-2400

FOR QUESTIONS ABOUT

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PREFACE

PURPOSE OF DOCUMENT

The Lexington-Fayette Urban County Government (LFUCG) is committed to promoting the use of low impact development (LID) concepts in stormwater management throughout Fayette County. This document, *LFUCG Stormwater Management Low Impact Development Guidelines for New Development and Redevelopment* provides engineers, architects, planners, developers, builders, and interested public groups with guidance on how to incorporate LID into development projects occurring in Fayette County. This document relates only to commonly used **stormwater related LID practices**, and not the broader use of LID utilized across multiple disciplines. In addition, the document may be helpful to property owners who wish to retrofit their existing developed sites that are not subject to LFUCG regulations.

In 2008, LFUCG negotiated a Consent Decree with the U.S. Environmental Protection Agency (EPA) and the Kentucky Energy and Environment Cabinet (KY EEC). As part of the Consent Decree and LFUCG's Kentucky Pollutant Discharge Elimination System (KPDES) Municipal Separate Storm Sewer System (MS4) Permit, LFUCG has established a Stormwater Quality Management Program (SWQMP) that requires the development of this document.

LFUCG has several programmatic goals related to the promotion and implementation of these LID Guidelines in Fayette County. They include:

- Complying with the Consent Decree and the MS4 permit;

- Reducing stormwater runoff from future development and existing developed sites;
- Improving water quality and flow regimes in the receiving streams in Fayette County and downstream counties;
- Providing guidance on LID options and approaches to stormwater management;
- Providing cost-effective and sustainable alternatives to gray (e.g., pipe) infrastructure;
- Laying the groundwork for design standards for stormwater related LID Best Management Practices[1] (BMPs) to ensure safe and effective implementation of LID;
- Encouraging retrofit of existing developed sites; and
- Coordinating with LFUCG Division of Planning goals related to the Comprehensive Plan and Complete Streets Manual.

[1] Best Management Practices (BMPs): operational and structural controls that treat, detain, or mitigate stormwater runoff.

How to Use this Document

As guidance, this document is not regulatory to the same level as LFUCG's Engineering Manuals which are official documents, referenced by the LFUCG Code of Ordinances, which include:

- LFUCG Procedures Manual
- LFUCG Stormwater Manual
- LFUCG Geotechnical Manual
- LFUCG Sanitary Sewer Manual
- LFUCG Roadway Manual
- LFUCG Structures Manual
- LFUCG Construction Inspection Manual
- LFUCG Standard Drawings

This document is a supplemental document to the *LFUCG Stormwater Manual* that provides additional information. Readers are referred to the *LFUCG Stormwater Manual* for **design** standards and criteria related to design and construction of BMPs mentioned in this document. For BMPs mentioned herein that are not yet incorporated into the *Stormwater Manual*, this document, along with standard industry practice, serves as guidance to LFUCG staff and design professionals in preparation and review of site plans incorporating LID for stormwater management. You may find the body of this document will be most helpful during the planning and conceptual design phase, providing concept ideas for various site applications**.** The **BMP Fact Sheets** provide more detailed information that should be considered during design.

Organization of the Manual

Chapter 1: Introduction and Background – Provides context and foundational information for Fayette County and introduces general LID concepts.

Chapter 2: Using Stormwater LID in Fayette County – List of LID BMPs, meeting water quantity and quality control requirements with LID, operation and maintenance responsibilities, how LID relates to the Water Quality Management Fee, planning and approval process.

Appendix A: BMP Fact Sheets contains design fact sheets for all listed LID BMPs.

Appendix B: BMP Planting List includes detailed plant list, specific to Fayette County, to help with LID BMP design.

1 INTRODUCTION AND BACKGROUND

1.1 EFFECTS OF URBANIZATION ON SURFACE WATER AND GROUNDWATER

Stormwater runoff is a natural part of the hydrologic cycle. In natural, undeveloped landscapes, the hydrologic processes of groundwater infiltration, evapotranspiration, and transpiration work to cycle rainwater through plants and soil, and minimize the transfer of pollutants to surface water and groundwater. As land development and urbanization occur, natural and vegetated areas are replaced with streets, parking lots, buildings and compacted soils. Such impervious surfaces modify the natural hydrology, decrease the permeability of the landscape, reduce groundwater recharge, and dramatically affect natural hydrologic cycles.

The percentage of impervious land cover in urban and suburban watersheds generally indicates the level of impact on receiving waters. In most cases, impervious cover in excess of 30 percent results in streams that are considered "degraded," while impervious cover between 10 and 30 percent causes "impacts" on the receiving waters. Specific impacts from urban runoff are associated with the volume, flow velocity, flow duration, timing, and pollutants generated by traditional stormwater management. Volume concerns arise when water cannot infiltrate. When this is the case, groundwater recharge decreases, and the flow through the soil that keeps streams and wetlands saturated can dry up. Stream base-flows tend to decrease, while the flashiness and volume and rate of peak-flows increase. Increased volume

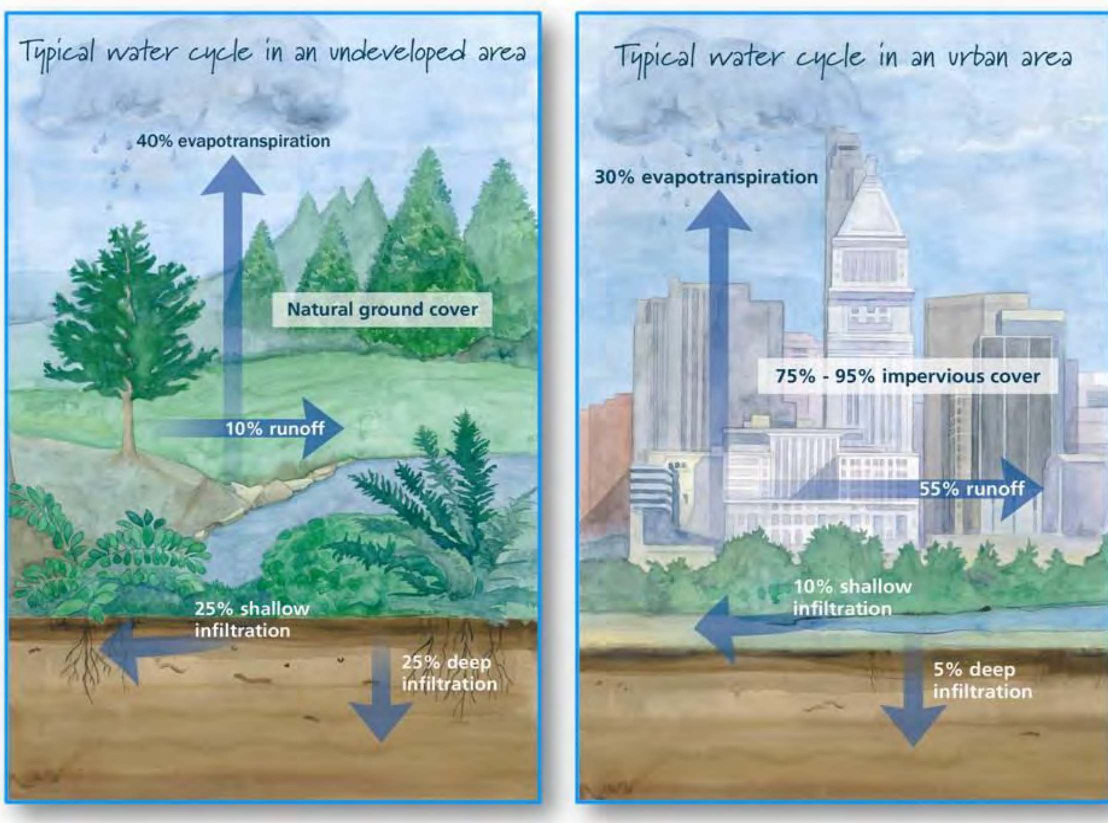

Figure 1-1. Typical water cycle in an undeveloped area versus an urban setting.

and rates during peak flows can destabilize and erode stream banks, while the decrease in base-flows can permanently alter the riparian and aquatic life.

Another concern of increased urban runoff is connected to the conveyance of pollutants from developed land into receiving surface waters. Stormwater runoff washes off pollutants that accumulate on buildings, paved areas, and other impervious surfaces. Because many traditional conveyance systems provide minimal treatment of runoff, the pollutants picked up by the stormwater ultimately are conveyed into nearby surface waters. Pollutants commonly associated with urban runoff include sediment, trash, nutrients (particularly phosphorous and nitrogen), hydrocarbons such as gasoline and oil, pesticides/herbicides, fertilizers, metals, and bacteria or viruses associated with fecal waste.

1.2 Changes in Stormwater Management

Traditional "gray infrastructure" stormwater conveyance systems have been designed to efficiently capture and convey runoff away from developed areas and into nearby streams, rivers, and lakes. This approach results in directing flows from impervious surfaces (such as streets, parking lots, sidewalks, and buildings) to curbs and gutters and, ultimately, to surface waters in such an efficient manner that it decreases natural storage and runoff travel time, and increases pollutant transfer (Arnold et. al., 2009). Primarily for these reasons, stormwater has been identified as a major source of pollution for all waterbody types (EPA, 2007). Like other communities, Lexington-Fayette County is

experiencing the problems that come along with urbanization and increased imperviousness, including flooding, eroding channels and streams, increased pollution in our streams and

waterways, old and undersized drainage infrastructure, etc.

In addition to conveyance, stormwater management approaches through the 1980s focused on detaining runoff and discharging it at slower rates during flood events, while runoff was released with no controls for smaller storms. This approach did nothing to change the significant increases in runoff volume that results from increased impervious surfaces. Streams received larger flows for smaller storms, and higher flows were maintained for much longer periods of time after rainfall events. These changes exacerbated erosion and did not address pollutants.

With the advent of the Clean Water Act and the National Pollutant Discharge and Elimination System (NPDES) federal program that required permits for stormwater discharges, water quality became the focus in stormwater management in the 1990s. Initial efforts focused on "good housekeeping" and spill prevention to stop pollutants from entering our waterways via straight discharge (point source) or via stormwater runoff (non-point source). Water Quality BMPs were added as an engineered mechanism to remove pollutants that have entered the stormwater system prior to discharge into waters of the United States (e.g. streams). While improvements in water quality have been made, efforts are now turning to Low Impact Development as the "next step" in stormwater management.

1.3 LID Goals in Stormwater Management

LID in Stormwater Management is a design approach that serves to reduce stormwater runoff, both peak flow rates and volume, from developed sites. **The goal of LID is to mimic pre-development hydrologic conditions in a post-developed condition**, and can be implemented through two basic processes:

1. **MINIMIZING IMPERVIOUS AREA**
2. **MINIMIZING STORMWATER RUNOFF AT THE SOURCE**

The objective then is to use natural and engineered processes to mitigate both flow and volume changes at the source caused by impervious area. Methods to achieve this include infiltration into the soil, evapotranspiration into the air and vegetation, and storage for future reuse.

LID is a fundamentally different approach from traditional stormwater management. LID does not rely on end-of-pipe or in-pipe treatment methods.

To do this, LID designs use the inherent properties of a natural system by minimizing alterations to natural settings; mimicking the natural hydrologic regime; and reducing the extent of impervious surfaces and compacted soils. Natural LID processes provide for distributed storage and use vegetation and organic media to (a) increase infiltration, filtration, retention, and evapotranspiration; (b) utilize biological processes (biological uptake) and adsorption of pollutants (metals and nutrients); and (c) promote deposition of sediment on-site through increased travel time as part of stormwater treatment.

LID utilizes natural and engineered processes to mimic pre-development hydrology from impervious surfaces.

INFILTRATION – EVAPOTRANSPIRATION – REUSE/STORAGE

1.4 Benefits of LID in Stormwater Management

An LID approach to stormwater management can help in reducing flooding, trapping pollutants, and improving aquatic habitat in the receiving streams. Using properly designed and implemented LID BMP techniques also provides a variety of expanded benefits and applications (see table to the right).

1.5 Applying LID Principles

LID practices offer creative ways to integrate stormwater management into developed landscapes, minimizing alterations to the natural hydrologic regime and reducing the volume of site runoff. Offering considerable versatility with redevelopment and retrofit implementation, LID concepts can be incorporated into existing developments and can, in some cases, be less cost intensive than traditional, structural stormwater management systems (EPA 2007).

A site assessment serves as the first step towards successful development that minimizes site alterations. The primary objective of the site assessment process is to identify development opportunities and potential limitations specific to LID. To make the best and most optimal use of LID techniques on a site, a comprehensive site assessment must be completed that includes an evaluation of existing site topography, soils, vegetation, and hydrology including surface water and groundwater features.

POTENTIAL BENEFITS OF STORMWATER LID

Economic:

- Reduces gray (e.g. hard) infrastructure construction costs
- Increases land values
- Increases life cycle cost savings

Environmental:

- Improves surface water quality
- Reduces stormwater runoff
- Protects drinking water sources
- Replenishes groundwater
- Improves watershed health
- Protects/restores wildlife habitat
- Restores impaired waters
- Helps meet regulatory requirements for receiving waters
- Creates additional recreational space
- Promotes efficient land use

Social:

- Enhances urban greenways
- Creates attractive streetscapes and green spaces that enhance livability
- Educates the public about their role in stormwater management
- Mitigates urban heat island effects

Source: Adapted from EPA, 2010.

2 USING STORMWATER LID IN FAYETTE COUNTY

2.1 POST-CONSTRUCTION CONTROL BEST MANAGEMENT PRACTICES (BMPS)

Chapter 10 of *LFUCG's Stormwater Manual* provides design standards for "post-construction" BMPs to manage both stormwater quantity and quality on sites proposed for development. These BMPs are called "post-construction" controls because they are meant to manage stormwater on a developed site after the completion of construction and in perpetuity. This is in contrast to construction site control BMPs that are temporary in nature and relate to controlling erosion, sediment, and pollutants generated during the construction process.

LFUCG has specific requirements for new development and redevelopment, as well as design criteria for post-construction BMPs to meet those requirements. Please refer to the *LFUCG Stormwater Manual* for a description of LFUCG's water quantity and quality control requirements.

There are many types of post-construction BMPs, and they can serve single or multiple purposes depending upon the BMP type and design criteria. In general, post-construction controls serve to detain for peak flow reduction, treat for removal of pollutants, and/or as in the case of LID, reduce the volume of runoff generated by impervious area. Common terminologies for the various types of BMPs and their intended uses are summarized in Table 2-1.

Table 2-1. Types of Stormwater Management Practices Based on Hydrologic Function.

	Detain stormwater runoff (reduce peak flow)	Treat stormwater runoff (remove pollutants)	Reduce Stormwater Runoff Volume (reduce volume)
Water Quantity BMPs	All	None	None
Water Quality BMPs	None	All	Some
Dual Water Quantity and Water Quality BMPs	All	All	Some
LID BMPs	Some	Some	All

Table 2-2 and Table 2-3 summarize the BMPs that LFUCG has designated as LID, utilizing the concepts of infiltration, evapotranspiration, reuse, and/or reduction of impervious area. Table 2-2 categorizes these LID BMPs by their basic functional process. Table 2-3 organizes them by their stormwater management classification.

Table 2-2. LFUCG post-construction LID BMPs by function.

REDUCE IMPERVIOUS AREA	INFILTRATION	EVAPO-TRANSPIRATION	REUSE
	Infiltration Trench		Above ground Rainwater Harvesting Underground Rainwater Harvesting
Engineered Pervious Surfaces Groundcover for Vehicular Parking Gravel for Equine Vegetated Roofs Permeable Pavements			
	Bio-infiltration Swale Tree Trench/Planter Box Bio-retention		

As shown in Table 2-2, there are four LID BMPs that are classified by LFUCG as "Engineered Pervious Surface," meaning that they are engineered to function with a permeability rate equal to or greater than a typical grassed pervious surface. These include:

1. Permeable Pavements
2. Vegetated Roofs
3. Gravel for Equine
4. Groundcover for Vehicular Parking

Note that these BMPs can be used to lower a site's computed impervious area and this has implications in design calculations (see Section 2.2.1).

Table 2-3. LFUCG LID BMPs by Stormwater Management Classification

Stormwater Management Classification of LID BMPs		
Practices that Reduce Impervious Area	**Water Quality BMPs (capture WQV)**	**Water Quantity BMPs (provide Detention Volume)**
		If designed for additional storage:
Groundcover for Vehicular Parking	Rainwater Harvesting	
Vegetated Roofs	Infiltration Trench	Infiltration Trench
Gravel for Equine	Bio-infiltration Swale	Bio-infiltration Swale
Permeable Pavements	Tree Trench/Planter Box	Tree Trench/Planter Box
	Bio-retention	Bio-retention
	Permeable Pavements	Permeable Pavements

2.2 Meeting Stormwater Control Requirements using LID BMPs

Stormwater BMPs are used to protect, preserve, and enhance water quantity and water quality in Fayette County. The water quantity design criteria include designing adequate **Detention Volume with outlet controls** to produce post-development peak discharges that do not exceed pre-development peak discharges for several rainfall events. Water quality design criteria are based upon a **Water Quality Volume (WQV)** to be treated. The use of LID BMPs has some unique advantages and impacts on how these design criteria are met. These are described in more detail below.

2.2.1 Water Quantity/Quality Requirements & LID

The design of stormwater BMPs to control water quantity uses approved methods of hydrological analysis described in Section 5 of the *LFUCG Stormwater Manual*. These hydrologic analyses estimate the amount and rates of runoff from all impervious and pervious surfaces on, and draining to, the project site.

In basic terms, typical water quantity controls are for larger storm events (10-year design storm and larger) and based upon Detention Volume. This storage volume, along with a designed outlet, allows water to be stored and released over time to mimic pre-development peak rates of discharge.

LFUCG's post-construction control requirements for water quality are based on capturing and treating 90 percent of the total annual runoff volume. The removal of solid particles in the runoff provides significant removal of common stormwater pollutants such as nitrogen, phosphorus, and oil and grease. For Fayette County, the runoff depth necessary for 90 percent runoff capture is approximated as a function of percent impervious area. This is further explored in Section 2.7, LID Design. Design of Water Quality BMPs is based on several variables. For example, some BMPs, such as proprietary devices, are sized based on peak flows. In contrast, the primary input parameter in LID BMP design is the WQV.

LID BMPs are designed to reuse, infiltrate, and/or evapotranspirate the WQV and effectively remove it permanently from the site runoff. More information on design of LID BMPs for water quality is provided in **Appendix A: BMP Fact Sheets**.

Engineered Pervious Surface LID BMPs can affect design calculations as follows:

A. **Engineered Pervious Surfaces – Runoff Characteristics**
These surfaces have permeability rates equal to typical pervious surfaces. Coefficients such as the SCS Curve Number or the Rational Method "C" factor represent the amount of permeability a surface has. The designer should utilize "CN" and "C" factors appropriate for the surface.

B. **Engineered Pervious Surfaces for Storage**
Permeable pavements (i.e., concrete, pavers, and asphalt) are designed to have a stone base for support. This base can be enlarged to allow for additional storage within the void spaces of the larger (i.e., #57 or #2 stone) stone layer. If offsite area is conveyed onto the Engineered Pervious Surface, the stone reservoir may have to be enlarged to provide Detention Volume and/or WQV. See Figure 2-1 for an example of this design.

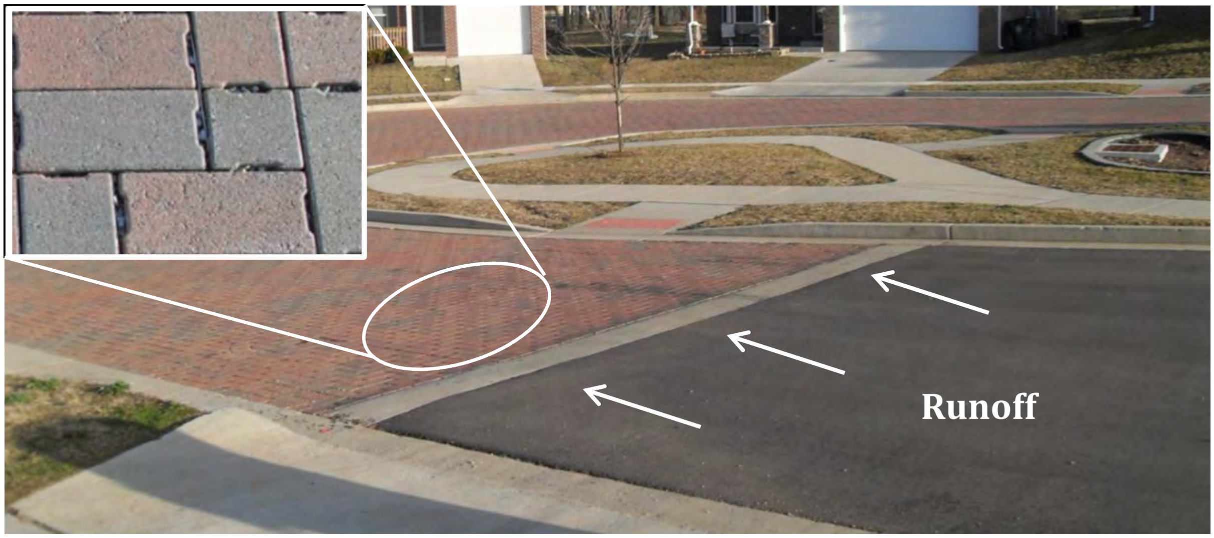

Figure 2-1. Example of Impervious runoff routing to a pervious surface (permeable paver stones)

THE RISK OF USING PERMEABLE PAVEMENTS

A designer may choose to utilize permeable pavements to reduce the impervious area, provide Detention Volume, or provide WQV. **However, there is an inherent risk associated with using permeable pavements, and the risk increases if it is used to achieve all of the above objectives.** The designer, developer, and property owner need to understand those risks. All BMPs require routine maintenance to ensure proper function of the system. In the case of permeable pavements, lack of proper maintenance can cause the pervious nature of the surface to become reduced or eliminated. In addition, unexpected events such as spillage of materials or dirt or certain deicing chemicals and salts can damage the surface and reduce and even eliminate perviousness.

If a site is designed with permeable pavement to meet water quality treatment and detention volume criteria, and if the pavement surface's permeability and/or storage functions are compromised sometime in the future, then the site will become out of compliance with the *LFUCG Stormwater Manual*. **In such a case, the current property owner would be responsible to either replace or repair the permeable pavement, or, provide equivalent on-site detention and/or water quality replacement controls to keep the site in compliance with all *LFUCG Stormwater Manual* standards.**

2.3 OPERATION AND MAINTENANCE OF STORMWATER LID

The goal of BMP Operation and Maintenance is to ensure that the installed BMPs are meeting their intended function, and that the specified design criteria for stormwater flow rate, volume, and water quality control functions are being met. If BMPs are not properly installed or maintained, effectiveness can be reduced and possibly eliminated.

LFUCG has established roles and responsibilities related to future maintenance of all stormwater management post-construction structural BMPs. LFUCG's Division of Water Quality oversees maintenance of LFUCG owned and operated BMPS, and also tracks the maintenance of privately owned and operated BMPs. Maintenance responsibilities are summarized in Table 2-4.

Table 2-4. Maintenance Responsibilities and Responsible Parties for Post-Construction Controls.

Type of Development	Maintenance Responsibilities	Responsible Party
Non-Residential (i.e., Commercial, Institutional, Industrial, Multi-Family, etc.)	All	Property Owner
Residential without Public Drainage Easements	All	Homeowner Association, Property Owner
Residential with Public Drainage Easements	Routine Mowing, Litter Pick-up	Homeowner Association, Property Owner
	Structural Maintenance	LFUCG
LFUCG Property	LFUCG	LFUCG

Please refer to the LFUCG Code of Ordinances Sections 16-84 to 16-88 for the complete description of roles and responsibilities.

When selecting BMPs, it is important to weigh the future maintenance requirements and ensure that a funding source and resources are available to meet the obligations. Most BMP maintenance work is not technically complicated, such as mowing, watering vegetation, removing trash and debris, removing sediment, replacing aggregate, and repairing erosion areas. More specialized maintenance training might be needed, however, to sustain BMP effectiveness for more sophisticated systems. Training should be included in program development to ensure that maintenance staff has the proper knowledge skills and abilities. It is important that regular maintenance and any need-based repairs for a BMP be completed according to schedule or as soon as practical after the problem is discovered for effective stormwater control. If a BMP is

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If you have questions about your maintenance responsibilities, contact the **LFUCG Division of Water Quality, MS4 Permit Coordinator (859-425-2400).**

improperly managed, detrimental effects on the landscape and increased potential for water pollution and local flooding could occur.

An annual inspection report certified by a Professional Engineer is required for underground facilities that cannot be visibly inspected without confined space entry (e.g., Underground Detention Pipes/Vaults). Responsibilities of the property owner are in perpetuity and apply to future property owners.

2.4 MANAGING CHANGES TO YOUR STORMWATER FACILITIES

If you are proposing to modify stormwater management facilities on a site that contains controls required by the *LFUCG Stormwater Manual*, contact the LFUCG Division of Water Quality (859-425-2400). Changes may also require a review by the Division of Engineering New Development Section (859-258-3410).

If any stormwater control BMP is removed from service, it must be replaced by another equivalent control. Changes to existing stormwater management facilities require notification and review by the LFUCG Division of Engineering and Division of Water Quality.

2.5 LFUCG'S WATER QUALITY MANAGEMENT FEE AND STORMWATER LID

In January 2010, LFUCG instituted the Water Quality Management Fee (WQMF). This fee provides revenue to fund all of LFUCG's stormwater related activities. The fee is applied to single-family residences and farm parcels at a fixed monthly rate. The fee is applied to all other parcels based upon the amount of impervious area on the parcel. A property's fee is adjusted up or down based upon changes in the amount of impervious surface.

Use of certain LID practices can provide an added benefit to a non-residential property owner by lowering the WQMF on any given parcel. Surface areas classified by LFUCG as having an "Engineered Pervious Surface" (See Section 2.1), meaning that they are engineered to function with a permeability rate equal or greater than a typical grassed pervious surface, are excluded when calculating the WQMF.

If you are proposing to utilize these LID BMPs on your site, please contact the **LFUCG Division of Water Quality MS4 Permit Coordinator** at the **start** of design for a consultation. This is needed to ensure that the proposed BMP meets LFUCG's classification and to allow tracking of the development to ensure proper updating of the WQMF billing. The Division of Water Quality performs routine

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If you are proposing to include "engineered pervious surfaces" in your site design, contact the LFUCG **Division of Water Quality, MS4 Permit Coordinator (859-425-2400)** at the start of design for a consultation.

inspections on sites given this classification to ensure the BMP is continuing to function as a pervious surface. Deficiencies that prevent proper function of the BMP will result in the surface being reclassified as "impervious" and the bill being increased to accurately reflect site conditions.

2.6 APPROVAL PROCESS

Stormwater quantity and quality BMPs are required for new development and redevelopment projects that disturb one or more acres of land. The New Development Section reviews the stormwater management plans to ensure that they comply with the requirements of the *Stormwater Manual*. If the proposed stormwater management plan includes elements that are in conflict with the Zoning Ordinance or Subdivision Regulations, the applicant must obtain approval from the Planning Commission as required by Article 1.5(d) of the Subdivision Regulations. An example would be a proposed plan that includes swales instead of curbs and gutters on a public street.

> Article 1.5(d) of the Subdivision Regulations
> *ALTERNATE DESIGNS FOR ENVIRONMENTAL WATER QUALITY CONSIDERATIONS*
> *The Commission may approve alternative development designs and/or development infrastructure and low impact development techniques where such designs are consistent with the basic intent of these Regulations. For any such approval request, the applicant shall provide a written report to the Commission outlining the environmental benefits to be obtained through the alternate design being proposed and the consistency of the alternate designs with low impact development guidance endorsed by the United States Environmental Protection Agency, including an analysis and justification of the merits of the proposal. The report shall be prepared by an engineer licensed to practice in the Commonwealth of Kentucky. For any such request, the Planning Commission shall seek input from the Department of Environmental Quality in its review of the proposal prior to taking action.*

Table 2-5 lists the permits that must be obtained prior to beginning construction, where applicable. Table 2-6 shows the typical application of LID in Fayette County.

Table 2-5. Potential Permits/Approvals Required for Development Projects

Permit/Approval	Agency	Type of Submittal	When Required
LFUCG Approval of Alternative Design for Environmental Water Quality Considerations	LFUCG Planning Commission	Submittal of Report	When the proposed stormwater management plan conflicts with the Zoning Ordinance or Subdivision Regulations.
LFUCG Land Disturbance Permit	LFUCG Division of Engineering	Application	When 5000 square feet or more of land will be disturbed
LFUCG Authorization to Construct	LFUCG Division of Water Quality and Division of Planning (New Development Section)	Submittal of plans	As part of the Improvement Plans for a proposed development
Federal 404 Permit	U.S. Army Corps of Engineers - Louisville District	Application	When construction is proposed within a stream
KY 401 Water Quality Certification	KY Division of Water	Application	When construction is proposed within a stream
KY Stream Construction Permit	KY Division of Water	Application	When construction is proposed within a floodplain
LFUCG Special Permit for Floodplain Construction	LFUCG Division of Engineering	Application	When construction is proposed within a floodplain
LFUCG Lane Closure Permit	LFUCG Division of Traffic Engineering	Application	When necessary to close a lane of traffic
LFUCG Right-of-Way Encroachment	LFUCG Division of Engineering	Application	When construction will occur within LFUCG right- of-way
KY Right-of-Way Encroachment	KY Transportation Cabinet, District 7	Application	When construction will occur within state right-of-way
LFUCG Building Permit	LFUCG Division of Building Inspection	Application	When the activity will involve construction of a building
LFUCG Demolition Permit	LFUCG Division of Building Inspection	Application	When demolition of a building or parking lot is proposed
LFUCG Curb Cut Permit	LFUCG Division of Building Inspection	Application	When a public curb is to be cut
EPA Class V Injection Well*	EPA	Application	When an infiltration practice is proposed and it is deeper than it is wide

*Refer to EPA's 2008 Class V Well Identification Guide to determine which infiltration practices have the potential to be regulated as a Class V well.

Table 2-6. Typical Applications for LID Practices in Fayette County for New and Redevelopment

LID Practice	LFUCG Roads and Rights-of-Way	LFUCG Parking Lots and Buildings	Single Family Residential	Commercial, Industrial, Apartments, Private Streets
Bio-infiltration Swale	✓	✓	✓ *	✓ *
Bio-retention	✓	✓	✓ *	✓ *
Gravel for Equine				✓
Groundcover for Vehicular Parking		✓		✓
Infiltration Trench	✓	✓	✓ *	✓ *
Permeable Pavers Porous Asphalt Pervious Concrete		✓		✓ *
Tree Trench / Planter Box	✓	✓		✓ *
Rainwater Harvesting		✓		✓
Vegetated Roofs		✓		✓

*Easements may be necessary to delineate the location of post-construction BMPs.

2.7 Design Process

Stormwater BMPs shall be designed to protect, preserve, and enhance water quantity and water quality in Fayette County. The water quantity design criteria include designing to produce post-development peak discharges that do not exceed pre-development peak discharges. For water quality, the design is focused on the capture of solid particles to effectively remove pollutants from stormwater runoff, which is based on a water quality capture volume. These are described in more detail below.

2.7.1 Water Quantity Controls

The design of stormwater BMPs to control water quantity uses approved methods of hydrological analysis described in Chapter 5 of the *LFUCG Stormwater Manual*. Table 2-7 contains guidance on how to analyze LID pervious surfaces.

Table 2-7. Technical Guidance for Hydrologic Analysis of Engineered Pervious Surfaces in Fayette County

LID Practice	Hydrologic Analysis
Gravel for Equine	Model the surface as pervious
Groundcover for Vehicular Parking	Model the surface as pervious
Permeable Pavers Porous Asphalt Pervious Concrete	With no reservoir storage for Detention Volume Model the surface as pervious. With reservoir storage for Detention Volume Model the surface as impervious. Model the storage volume of the underlying stone reservoir as Detention Volume.
Vegetated Roofs	Model the surface as pervious

Post-development peak discharges are based on the design storms outlined in Table 5-1 of the *LFUCG Stormwater Manual*. In Table 5-1, design storms for several stormwater facilities are indicated as the 1-year, 10-year, and 100-year storm events. Stormwater facilities outlined in this table include detention ponds, inlets, storm sewers, culverts, constructed channels, and sediment ponds. It is expected that LID designs consider water quality standards as determined in the *LFUCG Stormwater Manual*, but also consider conveyance and public safety when routing to larger regional facilities during larger events (10-year and greater). Distributions of these design storms are found in Appendix 5a of the *LFUCG Stormwater Manual*.

2.7.2 Water Quality Controls

The design of water quality controls is based on capturing and treating runoff from the 90th percentile rainfall event, which in Fayette County is 1.6”. The removal of solid particles in the runoff from these frequent, smaller storms provides significant removal of common stormwater pollutants such as nitrogen, phosphorus, and oil and grease. The values shown in Table 2-8 represent the water quality depth that should be treated given a site’s imperviousness. This value multiplied by the development area results in the water quality volume (WQV). The *LFUCG Stormwater Manual* includes design criteria for water quality BMPs.

Table 2-8. Water quality depth versus percent impervious surface

% Impervious Surface	Water Quality Depth (inches)
0 to 9	0
10	0.4
20	0.5
30	0.6
40	0.7
50	0.85
60	1.0
70	1.15
80	1.3
90	1.45
100	1.6

Source: From the *LFUCG Stormwater Manual*

Throughout the design process, it is important to document the design procedure and related details that were critical in decision making and the final product. This includes maps, field survey information, source references, photographs, engineering calculations and analyses, and measured and other data. Critical plans to be documented are the 50 percent design, final design, and record drawing. Specific components for each of these are detailed in the *LFUCG Stormwater Manual*.

Table 2-9 contains guidance on how to determine the WQV captured by various LID BMPs.

Table 2-9. Technical Guidance for Calculating the Water Quality Volume Captured (WQV_c) for LID Practices

LID Practice	Design WQV Captured
Bio-infiltration Swale	See *Stormwater Manual*
Bio-retention	See *Stormwater Manual*
Gravel for Equine	NA, surface is considered pervious
Groundcover for Vehicular Parking	NA, surface is considered pervious
Infiltration Trench	WQV_c = volume available for storing runoff within the stone reservoir
Permeable Pavers Porous Asphalt Pervious Concrete	WQV_c = volume available for storing runoff within the underlying stone reservoir
Tree Trench/Planter Box	Same as Bio-retention
Rainwater Harvesting	WQV_c = Available storage in the cistern or tank planned for consistent re-use on a 2-week schedule
Vegetated Roofs	NA, surface is considered pervious

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APPENDIX A: BMP FACT SHEETS

- ✓ Fact Sheet Matrix
- ✓ Bio-infiltration Swales
- ✓ Bioretention
- ✓ Gravel for Equine
- ✓ Groundcover for Alternative Parking
- ✓ Infiltration Trenches
- ✓ Permeable Pavement
- ✓ Rainwater Harvesting
- ✓ Tree Trenches / Planter Boxes
- ✓ Vegetative Roofs

Appendix A - LID management practice selection matrix according to site characteristics

Attribute		LID practice type												
		Bio-retention		Bio-infiltration swale		Permeable Pavement		Infilt-ration trench	Planter boxes	Gravel for Equine	Tree Trench	Cisterns/ rain barrels	Ground-cover for Parking	Vegetated Roof
		(no UD)	(UD)	(no UD)	(UD)	(no UD)	(UD)							
Contributing drainage area (acres)		< 5		< 2		< 5		< 5	< 0.35	< 1	< 0.35	Rooftop	< 5	Rooftop
Soil infiltration rate (inches/hour)		> 0.5	< 0.5	> 0.5	< 0.5	> 0.5	< 0.5	> 0.5	> 0.5	> 0.5	> 2	N/A	> 0.5	N/A
Water table separation (feet)		> 5	> 2	> 5	> 2	> 5	> 2	> 5	> 5	> 5	> 5	Below-grade tanks must be above the water table and bedrock	> 5	N/A
Depth to bedrock (feet)		> 10	> 2	> 10	> 2	> 10	> 2	> 10	> 10	> 10	> 10		N/A	N/A
Unit slope		< 2%		< 2%		< 6%		<2%	N/A	< 6%	< 2%	<5%	< 5%	N/A
Pollutant removal	Sediments	High		High		Medium		Medium	High	Medium	High	Pollutant removal provided by downstream BMP, refer to specific BMP for removal efficiency.	Medium	Medium
	Nutrients	Medium		High		Low		Low	Medium	Low	Medium		Low	Low
	Trash	High		High		High		High	High	High	Low		High	Low
	Metals	High		High		Low		Low	High	Low	Low		Low	Medium
	Bacteria	High		Medium		Low		Low	High	Low	Low		Low	Low
	Oil & grease	High		Medium		Low		Low	High	Low	Low		Low	Low
	Organics	High		High		Low		Low	High	Low	Medium		Low	Low
Runoff volume reduction		High	Medium	High	Medium	High	Medium	High	High	High	Medium	High	Medium	Medium
Peak flow control		Medium		Medium		Medium		Medium	Medium	Medium	Medium	Medium	Medium	Low
Groundwater recharge		High	Low	High	Medium	High	Low	High	High	High	Medium	Low	Medium	N/A
Setbacks (ft)	Structures	> 10		> 10		> 10		> 10	> 5	> 10	> 10	> 5	> 10	N/A
	Steep slopes	> 50		> 50		> 50		> 50	> 50	> 50	> 50	> 50	> 50	N/A

Notes:
UD: Underdrain

Bio-infiltration Swale

Description

A bio-infiltration swale (or bioswale), often referred to as linear bio-retention, is a shallow stormwater conveyance channel densely planted with a variety of grasses, shrubs, and trees designed to slow, filter, and infiltrate stormwater runoff. Bio-infiltration swales serve as an excellent alternative to traditional curb and gutter conveyance systems. Different design variations such as check dams, media type and underdrains can be incorporated into bio-infiltration swales. As with bio-retention, a bio-infiltration swale is underlain with specialized planting soil media that promotes infiltration and plant growth. Bio-infiltration swales reduce stormwater runoff through infiltration and improve water quality by filtration through vegetation and media, sedimentation, adsorption and biological uptake through native plants. Unlike bio-retention, bio-infiltration swales serve dual purposes, and are designed both for stormwater conveyance and treatment. Therefore, the swale design must typically account for higher velocities and more concentrated flow than bio-retention.

Environmental Benefits

- Reduces stormwater runoff volume
- Promotes infiltration and groundwater recharge
- Targeted pollutants: suspended solids, sediment, trash, bacteria, organics, nutrients, metals, oil & grease

Allowable Locations in New Development and Redevelopment

☑ Single Family Residential
☑ Commercial, Industrial, Apartments, Private Streets
☑ LFUCG Roads and Rights-of-Way
☑ LFUCG Parking Lots

Meeting LFUCG Design Criteria for New Development and Redevelopment

☑ Provides **Water Quality Volume** capture and treatment
☑ Provides detention storage for **Water Quantity** (if designed with detention controls)
☑ Functions as a pervious surface for **Water Quantity** hydrologic calculations

LFUCG Site Design Requirements

Drainage Area: The contributing drainage area for bio-infiltration swales is typically less than 2 acres. If concentrated flow is directed into a bioswale, velocity dissipation measures are required to prevent scour.

Proximity to Existing Features: Bio-infiltration swales shall be located at least 10 feet from existing buildings and sanitary sewer lines. If known sanitary sewer or basement infiltration problems exist, a greater distance shall be used.

Soil Type: An underdrain shall be provided if the underlying soils have an infiltration rate of less than 0.5 inches per hour. Underdrains must freely discharge into a swale or be connected to a receiving storm drainage system.

Overflow: Design shall account for safe bypass of high flows from the swale into a storm drainage system.

Pretreatment: A minimum 10' grass border shall be provided where possible.

Drain Time: Maximum drain time (i.e. ponding) for the swale is 24 hours. Total drawdown through the soil media is 3 days maximum.

Prohibited Areas: Bio-infiltration swales shall not be placed in areas subject to the formation of sinkholes, in areas of soil contamination, or over existing utilities.

Design Guidance

Bio-infiltration swales shall be designed in accordance with Chapter 10 of the LFUCG Stormwater Manual (bio-retention and biofiltration swales). Due to their use for stormwater conveyance, mulch should be avoided in bioswales. For additional guidance see *EPA's National Menu of Stormwater BMPs* for post-construction.

Maintenance

The property owner shall maintain the bio-infiltration swale per Chapter 12 of the LFUCG Stormwater Manual.

Easements

Stormwater conveyance swales are typically demarcated with a "Drainage Easement". When a bio-infiltration swale is being used to meet detention requirements, a "Detention and Storm Drainage Easement" shall be used.

Submittal Requirements

The following items shall be submitted to the LFUCG Division of Engineering for review:

1. Calculation of the WQV draining to the swale. See Table 10-1 of the *LFUCG Stormwater Manual*.
2. Design calculations for swale area, drawdown time, swale conveyance capacity, freeboard, etc.
3. Stage/Storage/Discharge calculations (i.e. routing) of the swale if it is being used for detention.
4. Infiltration tests of the underlying in-situ soils.
5. Landscaping plan showing the proposed plants.
6. Construction drawings showing the plan, profile, and section views, and underdrain system.

Description

A bio-retention facility is a stormwater management practice that promotes infiltration of stormwater in order to reduce its volume, improve its quality, and increase groundwater recharge. A bio-retention facility, commonly referred to as a rain garden, is a landscaped, shallow depression that receives stormwater from nearby impervious surfaces. Bioretention detains runoff in a surface reservoir, filters it through plant roots and a biologically active soil mix, and then infiltrates it into the ground. Where native soils are less permeable, an underdrain conveys treated runoff to a storm drain or surface drainage. The facility typically consists of a structure to spread flow, a pretreatment filter strip or grass channel, a sand bed, pea gravel overflow curtain drain, a shallow ponding area, a surface organic layer of mulch, a planting soil bed, planting material, a gravel underdrain system, and an overflow system.

Environmental Benefits

- Reduces stormwater runoff volume
- Promotes infiltration and groundwater recharge
- Targeted pollutants: suspended solids, sediment, trash, bacteria, organics, nutrients, metals, oil & grease

Allowable Locations in New Development and Redevelopment

☑ Single Family Residential
☑ Commercial, Industrial, Apartments, Private Streets
☑ LFUCG Roads and Rights-of-Way
☑ LFUCG Parking Lots

Meeting LFUCG Design Criteria for New Development and Redevelopment

☑ Provides **Water Quality Volume** capture and treatment
☑ Provides detention storage for **Water Quantity** (if designed with detention controls)
☑ Functions as a pervious surface for **Water Quantity** hydrologic calculations

LFUCG Site Design Requirements

Drainage Area: The contributing drainage area shall be less than 5 acres.

Proximity to Existing Features: Bio-retention facilities shall be located at least 10 feet from existing buildings and sanitary sewer lines. If known sanitary sewer or basement infiltration problems exist, a greater distance shall be used.

Soil Type: An underdrain shall be provided if the underlying soils have an infiltration rate of less than 0.5 inches per hour. Underdrains must freely discharge into a swale or be connected to a receiving storm drainage system.

Overflow: Design shall account for safe bypass of high flows from the BMP into a storm drainage system.

Pretreatment: A minimum 10' grass border shall be provided where possible.

Drain Time: Maximum drain time (i.e. ponding) for the BMP is 24 hours. Total drawdown through the soil media is 3 days maximum.

Prohibited Areas: Bio-retention shall not be placed in areas subject to the formation of sinkholes, in areas of soil contamination, or over existing utilities.

Design Guidance

Bio-retention facilities shall be designed in accordance with Chapter 10 of the *LFUCG Stormwater Manual*. Additional guidance can be found on EPA's *National Menu of Stormwater BMPs* for post-construction.

Maintenance

The property owner shall maintain the bio-retention facility per Chapter 12 of the *LFUCG Stormwater Manual*.

Easements

Areas of stormwater conveyance, including bio-retention, are typically demarcated with a "Storm Drainage Easement". When a bio-retention area is being used to meet detention requirements, a "Detention and Storm Drainage Easement" shall be used.

Submittal Requirements

The following items shall be submitted to the LFUCG Division of Engineering for review:

1. Calculation of the WQV draining to the BMP. See Table 10-1 of the *LFUCG Stormwater Manual*.
2. Design calculations for bio-retention area, drawdown time, etc.
3. Stage/Storage/Discharge (i.e. routing) calculations of the BMP if it is being used for detention.
4. Infiltration tests of the underlying in-situ soils.
5. Landscaping plan showing the proposed plants.
6. Construction drawings showing the plan, profile, and section views, and underdrain system.

Gravel for Equine

Description

Gravel for Equine is a specialty classification for some aggregate surfaces used on horse tracks and horse farms in Fayette County. Equine surfaces are typically made out of types or combinations of rubber granules, sand, crushed aggregate, crushed glass, etc. This surface is applicable only to areas used primarily for horse and pedestrian traffic, with minimal vehicular traffic. Design alternatives under this category could include use of geotextiles underneath the surface to provide for more frequent and/or higher loads. In some cases, these alternatives may best fit under the Groundcover for Vehicular Parking category.

For new and re-development in Fayette County, Gravel for Equine surfaces are classified as an **"engineered pervious surface"** unless the surface is underlain with an impermeable barrier.

Environmental Benefits

- Reduces stormwater runoff volume
- Promotes infiltration and groundwater recharge

Allowable Locations in New Development and Redevelopment

- ☐ Single Family Residential
- ☐ Commercial, Industrial, Apartment, Private Streets
- ☐ LFUCG Roads and Rights-of-Way
- ☐ LFUCG Parking Lots and Buildings
- ☑ Equine Facilities

Meeting LFUCG Design Criteria for New Development and Redevelopment

- ☐ Provides **Water Quality Volume** capture and treatment
- ☐ Provides detention storage for **Water Quantity**
- ☑ Functions as a pervious surface for **Water Quantity** hydrologic calculations

LFUCG Site Design Requirements

Drainage Area: N/A

Proximity to Existing Features: N/A

Soil Type: N/A

Pretreatment: N/A

Drain Time: N/A

Prohibited Areas: High vehicular traffic.

Design Guidance

N/A

Maintenance

Note: If an engineered pervious surface becomes impervious, for whatever reason, it can be replaced with new material to restore its original condition. Gravel for Equine areas classified as an "engineered pervious surface" that are found to have become impervious shall be noted on LFUCG's Impervious Area GIS coverage for inclusion in the Water Quality Management Fee billing.

Easements

N/A

Submittal Requirements

The following items shall be submitted to the LFUCG Division of Engineering:

1. Plan sheet showing the proposed location of the Equine Gravel.
2. Detail of section (if applicable), type of material, etc.

Groundcover for Vehicular Parking

Description

Groundcover for vehicular parking is an alternative to conventional pavements and may be used to reduce imperviousness. Unlike permeable pavements, which provide substantial subsurface storage using an aggregate layer, groundcover for vehicular parking is focused on a pervious grid system underlain by a few inches of bedding material. The groundcover is a manufactured concrete or plastic grid system with topsoil and grass or aggregate used to fill the voids. Some systems are 2-dimensional geotextiles and some are 3-dimensional grids. Grid systems can be specified to handle heavier, although fairly static, loads, appropriate for areas where utility trucks may need access. These surfaces are often used for temporary and overflow parking locations.

For new and re-development in Fayette County, these types of ground covers are classified as an **"engineered pervious surface."** They are not classified as a water quality control BMP, but can serve to decrease existing site imperviousness or minimize site imperviousness for new development. If used for this purpose and later replaced with an impervious surface, replacement stormwater controls may be required to offset the increase in impervious area.

Environmental Benefits

- Reduces stormwater runoff volume and pollutant discharge

Allowable Locations in New Development and Redevelopment

☐ Single Family Residential
☑ Commercial, Industrial, Apartments, Private Streets
☐ LFUCG Roads and Rights-of-Way
☑ LFUCG Parking Lots

Meeting LFUCG Design Criteria for New Development and Redevelopment

☐ Provides **Water Quality Volume** capture and treatment
☐ Provides detention storage for **Water Quantity**
☑ Functions as a pervious surface for **Water Quantity** hydrologic calculations

LFUCG Site Design Requirements

Drainage Area: N/A

Proximity to Existing Features: N/A

Soil Type: N/A

Pretreatment: N/A

Drain Time: N/A

Prohibited Areas: N/A

Design Guidance

Groundcover shall be designed and installed in accordance with manufacturer's recommendations. Be sure to consider vehicular loading uses when selecting an appropriate surface. Check with LFUCG's Department of Planning and the Division of Engineering to ensure compliance with the LFUCG Zoning Ordinance and Land Subdivision Regulations when proposing to use alternative ground cover.

Maintenance

The property owner shall maintain the groundcover in accordance with manufacturer's recommendations. If an engineered pervious surface is used to lower site imperviousness for a new development or redevelopment, and it later becomes impervious for whatever reason, the site may become out of compliance with the *LFUCG Stormwater Manual*. The surface could either be replaced with new material to restore its original condition or replacement stormwater controls may be required to offset the increase in impervious area. In addition, Groundcover for Vehicular Parking areas classified as an "engineered pervious surface" that are found to have become impervious shall be noted on LFUCG's Impervious Area GIS coverage for inclusion in the Water Quality Management Fee billing.

Easements

N/A

Submittal Requirements

The following items shall be submitted to the LFUCG Division of Engineering for review:

1. Plan sheet showing the proposed locations of the groundcover.
2. Manufacturer's specifications and installation/maintenance manual.

Infiltration Trenches

Description

Infiltration trenches are shallow excavations filled with stone, designed to capture sheet flow or piped inflow. Runoff is stored in the void space between the stones and infiltrates through the bottom and into the soil matrix. Infiltration trenches are used in conjunction with sediment removal practices so that most suspended solids are removed before runoff enters the infiltration trench. Pretreatment may include techniques like vegetated filter strips or grass swales. Infiltration trenches are very adaptable practices and the availability of practical configurations make them ideal for small urban drainage areas. Infiltration trenches improve water quality through treatment of runoff percolating through the soil, volume reduction, and some removal of sediments and pollutants.

Environmental Benefits

- Reduces stormwater runoff volume
- Targeted pollutants: suspended solids, sediment, trash, nutrients, metals, bacteria
- Promotes infiltration and groundwater recharge

Allowable Locations in New Development and Redevelopment

☑ Single Family Residential
☑ Commercial, Industrial, Apartments, Private Streets
☑ LFUCG Roads and Rights-of-Way
☑ LFUCG Parking Lots

Meeting LFUCG Design Criteria for New Development and Redevelopment

☑ Provides **Water Quality Volume** capture and treatment
☑ Provides detention storage for **Water Quantity** (if designed with detention controls)
☑ Functions as a pervious surface for **Water Quantity** hydrologic calculations

LFUCG Site Design Requirements

Drainage Area: The contributing drainage area shall be less than 5 acres.

Proximity to Existing Features: Infiltration trenches shall be located at least 10 feet from existing buildings and sanitary sewer lines. If an adjacent building has a basement known to have seepage problems, a different type of treatment BMP should be considered.

Soil Type: An underdrain shall be provided if the underlying soils have an infiltration rate of less than 0.5 inches per hour. Underdrains must freely discharge into a swale or be connected to a receiving storm drainage system.

Overflow: Design shall account for safe bypass of high flows from the BMP into a storm drainage system.

Pretreatment: A minimum 10' grass border shall be provided where possible.

Drain Time: Maximum drain time (i.e. ponding) for the BMP is 24 hours.

Prohibited Areas: Infiltration trenches shall not be placed in areas subject to the formation of sinkholes, in areas of soil contamination, or over existing utilities.

Configuration Restrictions: In order to avoid possible classification as a Class V Injection Well by the EPA, infiltration trench width should be greater than its depth. Use of perforated plastic chambers is often used for this BMP, but may be more likely to be classified as a Class V Injection Well. (EPA Memorandum, June 13, 2008, Linda Boornazian and Steve Heare, *Clarification on which stormwater infiltration practices/technologies have the potential to be regulated as "Class V" wells by the Underground Injection Control Program*)

Design Guidance

The Water Quality Volume captured and treated (WQVc) is calculated as WQVc = volume of the stone trench multiplied by the stone porosity. Additional design guidance can be found in the *Louisville-Jefferson County MSD Green Infrastructure Design Manual*, and on EPA's *National Menu of Stormwater BMPs* for post-construction.

Maintenance

The property owner shall maintain the Infiltration Trench as described in Chapter 12 of the *LFUCG Stormwater Manual* for infiltration practices.

Easements

Areas of stormwater conveyance, including infiltration trenches, are typically demarcated with a "Drainage Easement". When this BMP is being used to meet detention requirements a "Detention and Storm Drainage Easement" shall be used.

Submittal Requirements

The following items shall be submitted to the LFUCG Division of Engineering for review:

1. Calculation of the WQV draining to the facility. See Table 10-1 of the *LFUCG Stormwater Manual*.
2. Design calculations for infiltration trench, including surface area, depth, WQVc based on the volume of the trench and the porosity of the stone, drawdown time, etc.
3. Stage/Storage/Discharge calculations (i.e. routing) if it is being used for detention.
4. Infiltration tests of the underlying in-situ soils.
5. Construction drawings showing the plan, profile, and section views, and underdrain system.

Permeable Pavement

Description

Permeable pavements are alternatives to conventional pavements that may be used to reduce imperviousness. A wide variety of permeable pavements is available and can be classified into three basic types: porous (bituminous) asphalt, pervious concrete and permeable interlocking concrete paver stones (pavers). Permeable pavements are designed to infiltrate stormwater, thereby reducing runoff, promoting groundwater recharge, and filtering stormwater pollutants.

For new and re-development in Fayette County, permeable pavements are classified as an **"engineered pervious surface."** Permeable pavements differ from *Groundcover for Vehicular Parking* in that they have a stone subgrade that is designed not only for structural strength required for the vehicular load, but also to contain the Water Quality Volume and optionally a Detention Volume within the voids in the stone. If permeable pavement is used to reduce site imperviousness or meet stormwater control requirements for new or redevelopment, and later becomes impervious for whatever reason, the site may become out of compliance with the *LFUCG Stormwater Manual*. The surface could either be repaired/replaced or replacement stormwater controls may be required to offset the changes.

Environmental Benefits

- Reduces stormwater runoff volume and promotes infiltration and groundwater recharge
- Targeted pollutants: sediment, suspended solids, nutrients, metals, oil & grease

Allowable Locations in New Development and Redevelopment

☐ Single Family Residential
☑ Commercial, Industrial, Apartment, Private Streets
☐ LFUCG Roads and Rights-of-Way
☑ LFUCG Parking Lots

Meeting LFUCG Design Criteria for New Development and Redevelopment

☑ Provides **Water Quality Volume** capture and treatment if the underlying stone reservoir is sized to contain the WQV and release it slowly over the designed drain time.
☑ Provides detention storage for **Water Quantity** if the underlying stone reservoir and outlet structure is designed to reduce peak flows to predevelopment levels for the LFUCG design storms.
☑ Functions as a pervious surface for **Water Quantity** hydrologic calculations, <u>unless</u> the stone reservoir is being used for detention storage in which case the pervious surface area shall be considered impervious (e.g. functions as a pond with 100% of rainfall volume entering the storage reservoir).

LFUCG Site Design Requirements

Drainage Area: The area draining to permeable pavements should be free of loose dirt and grit. Stockpiled materials should not be placed on or adjacent to permeable pavements.

Proximity to Existing Features: Permeable pavements shall be located at least 10 feet from existing buildings and LFUCG sanitary sewer lines. If known sanitary sewer or basement infiltration problems exist, a greater distance shall be used.

Soil Type: An underdrain shall be provided if the underlying soils have an infiltration rate less than 0.5 inches per hour. Underdrains must freely discharge into a swale or be connected to a receiving storm drainage system.

Pretreatment: If upstream areas have potential sources for erosion/sediment, pretreatment should be provided.

Drain Time: Based upon industry standard design.

Prohibited Areas: Permeable pavements shall not be placed in areas subject to the formation of sinkholes, in areas of soil contamination, or over existing utilities.

Design Guidance

Porous asphalt shall be designed in accordance with **Plantmix Asphalt Industry of KY (PAIKY)** guidelines.
Pervious concrete shall be designed in accordance with the **Portland Cement Association (PCA) and National Ready Mix Concrete Association** guidelines. Pavers shall be designed in accordance with **Interlocking Concrete Pavement Institute (ICPI)**. Note: All stone subgrade materials shall be washed with less than 1% passing No. 200 sieve. Stone materials should be certified as meeting this specification and proof of certification shall be provided to the project owner prior to placement.

Maintenance

The property owner shall maintain the facility in accordance with PAIKY, PCS, and ICPI recommendations.

Special note on deicing agents: Please consult industry professionals on the best type of surface appropriate for a given site. The property owner shall have control over snow removal operations to prevent possible damage to the surface. In particular, deicing agents should not be applied to pervious concrete surfaces less than one year old, and after only sparingly. Agents containing magnesium chloride or fertilizer agents (ammonium sulfate and ammonium nitrate) are prohibited. Surface damage that may occur from improper snow removal is the sole responsibility of the property owner and may require repair/replacement if being used to meet water quality or detention control criteria.

Easements

When this BMP is used to meet detention requirements a "Detention and Storm Drainage Easement" shall be used.

Submittal Requirements

The following items shall be submitted to the LFUCG Division of Engineering:

1. Calculation of the WQV draining to the BMP. See Table 10-1 of the *LFUCG Stormwater Manual*.
2. Design calculations for the BMP, including surface area, depth, drawdown time, etc.
3. Stage/Storage/Discharge calculations (i.e. routing) if it is being used for detention.
4. Infiltration tests of the underlying in-situ soils.
5. Construction plans showing the plan, profile, section view, and underdrains.

Tree Trenches / Planter Boxes

Description

Planter boxes and tree trenches, as similar to bio-retention facilities, are designed to infiltrate and/or temporarily store stormwater runoff. Tree trenches are a system of trees that are connected by an underground infiltration structure, and are designed to capture runoff from adjacent impervious areas. On the surface, a stormwater tree trench looks just like a series of street tree pits; however, under the sidewalk there is an engineered system to manage the incoming runoff. This system commonly consists of a trench dug along the sidewalk that is lined with a permeable geotextile fabric, filled with gravel or stone, and topped off with engineered soil and trees. Tree trenches are applicable in linear areas with limited space such as along streets and in pedestrian areas. Planter boxes receive runoff from multiple impervious surfaces, including roadways, sidewalks and buildings. Planter boxes can be used as a traffic calming device. Planter boxes can be designed adjacent to buildings to directly receive roof gutter flow. When well designed, installed, and maintained, planter boxes are extremely attractive additions to commercial businesses and office buildings.

Environmental Benefits

- Reduces stormwater runoff volume
- Promotes infiltration and groundwater recharge
- Enhances tree health and longevity
- Targeted pollutants: suspended solids, sediment, trash, bacteria, organics, nutrients, metals, oil & grease

Allowable Locations in New Development and Redevelopment

☐ Single Family Residential
☑ Commercial, Industrial, Apartments, Private Streets
☑ LFUCG Roads and Rights-of-Way **(must obtain LFUCG approval if proposed for public infrastructure)**
☑ LFUCG Parking Lots

Meeting LFUCG Design Criteria for New Development and Redevelopment

☑ Provides **Water Quality Volume** capture and treatment
☑ Provides detention storage for **Water Quantity** (if designed with detention controls)
☑ Functions as a pervious surface for **Water Quantity** hydrologic calculations

LFUCG Site Design Requirements

Drainage Area: The contributing drainage area shall be less than 15,000 square feet.

Proximity to Existing Features: Tree trenches shall be located at least 5 feet from existing buildings without basements, and 10 feet from sanitary sewer lines or buildings with basements. If an adjacent building has a basement known to have seepage problems, a different type of treatment BMP should be considered.

Soil Type: An underdrain shall be provided if the underlying soils have an infiltration rate of less than 2 inches per hour. Underdrains must freely discharge into a swale or be connected to a receiving storm drainage system.

Overflow: Design shall account for safe bypass of high flows from the BMP into a storm drainage system.

Pretreatment: None

Drain Time: Maximum drain time (i.e. ponding) for the BMP is 4 hours in pedestrian areas, 24 hours in other areas. Maximum Ponding depth should not exceed 6 inches in pedestrian areas, 9 inches in other areas.

Prohibited Areas: Tree trenches/planter boxes shall not be placed in areas subject to the formation of sinkholes, in areas of soil contamination, or over existing utilities. They shall not be used for water quantity control (i.e. detention) when placed in the right-of-way or pedestrian areas.

Design Guidance

Tree Trenches/Planter Boxes shall be designed similarly to a bio-retention facility.

Maintenance

The property owner shall maintain the facility in a manner similar to a bio-retention facility.

Easements

When used as a stormwater control and outside of the right-of-way, Tree Trenches/Planter Boxes are typically demarcated with a "Storm Drainage Easement." When this BMP is being used to meet detention requirements a "Detention and Storm Drainage Easement" shall be used.

Submittal Requirements

The following items shall be submitted to the LFUCG Division of Engineering:

1. Calculation of the WQV draining to the BMP. See Table 10-1 of the LFUCG Stormwater Manual.
2. Design calculations for the BMP, including surface area, depth, drawdown time, etc.
3. Stage/Storage/Discharge calculations (i.e. routing) if it is being used for detention.
4. Infiltration tests of the underlying in-situ soils.
5. Landscaping plan showing the proposed plants.
6. Construction plans showing the plan, profile, section view, underdrains and overflow system.

Description

Rainwater harvesting is the practice of capturing, storing, and re-using rainfall or stormwater runoff. Potential uses include landscape irrigation, toilet flushing, cooling water, and wash or process water. Storage can be interior or exterior, and above ground or below ground. Typically, structures are designed to intercept and store runoff from rooftops although units can be designed to collect runoff from parking lots and other surfaces. In either case, the intent for the captured runoff is to be used following the rain event, thus preventing the runoff from leaving the site. The most common variations of rainwater harvesting are cisterns (both underground and above ground) and rain barrels. For new and re-development in Fayette County, rainwater harvesting systems can be designed to capture all, or a portion of, the Water Quality Volume. In order to be eligible to meet the water quality treatment requirement, a water balance model is required to determine tank size, as well as an operation plan to document expected water usage. Cisterns and rain barrels can be a useful method of reducing stormwater runoff volumes in urban areas where site constraints limit the use of other BMPs.

Environmental Benefits

- Reduces stormwater runoff volume and peak flow
- Roofwater capture removes pollutants from atmospheric deposition and roof/gutter metal sources
- Filtering of stormwater runoff can remove suspended solids, trash, bacteria, nutrients, oil & grease, etc.

Allowable Locations in New Development and Redevelopment

☐ Single Family Residential
☑ Commercial, Industrial, Apartments
☐ LFUCG Roads and Rights-of-Way
☑ LFUCG Buildings

Meeting LFUCG Design Criteria for New Development and Redevelopment

☑ Provides **Water Quality Volume** capture and treatment
☐ Provides detention storage for **Water Quantity**
☐ Functions as a pervious surface for **Water Quantity** hydrologic calculations

LFUCG Site Design Requirements

Drainage Area: Typically impervious areas only (e.g. rooftop, parking lots).

Proximity to Existing Features: Can be located indoors or outdoors.

Pretreatment: Filters are required to filter larger debris and grit from entering the tank. A screen filter, as well as a first flush diverter, are typical elements.

Overflow: Once the storage tank is full, design shall account for safe bypass of conveyed water into a storm drainage receiving system.

Drain Time: A water balance simulation is typically used to design the tank size. Rainwater harvesting models include variables such as daily runoff, daily stormwater captured, daily overflow, daily demand and daily ending balance of the cistern. Simulations are typically 10 to 20 years of historical rainfall data.

When using rainwater harvesting to meet Water Quality Volume capture (WQVc) requirements, the WQVc shall equal, but not exceed, the average 2-week usage volume from the demand calculations, or the tank size, whichever is smaller.

Design Guidance

Full-year operation is expected for BMPs meeting water quality treatment requirements of the *LFUCG Stormwater Manual.* Consider winter conditions in tank designs to minimize potential shutdown.

Various system vendors provide runoff reduction calculators. Recommended references for design guidance, including tank size, configuration, pump requirements, water treatment, etc. include:

- American Rainwater Catchment Systems Association (ARCSA)
- Virginia Rainwater Harvesting Manual

Maintenance

When this BMP is used to meet *LFUCG Stormwater Manual* water quality treatment standards, an Operations Plan is required documenting the facility's water usage for the intended re-use purpose(s) meeting or exceeding that shown in the calculations for daily demand. An operations log of system use, including shutdowns, is required. The property owner shall maintain the facility in accordance with a Maintenance Plan. Extended periods of system shutdown may result in the site being out of compliance with the *LFUCG Stormwater Manual*.

Easements

Storm Drainage Easements can be used to denote the area of the tank if external to a building. Underground systems should be denoted in a similar manner to Underground Detention systems.

Submittal Requirements

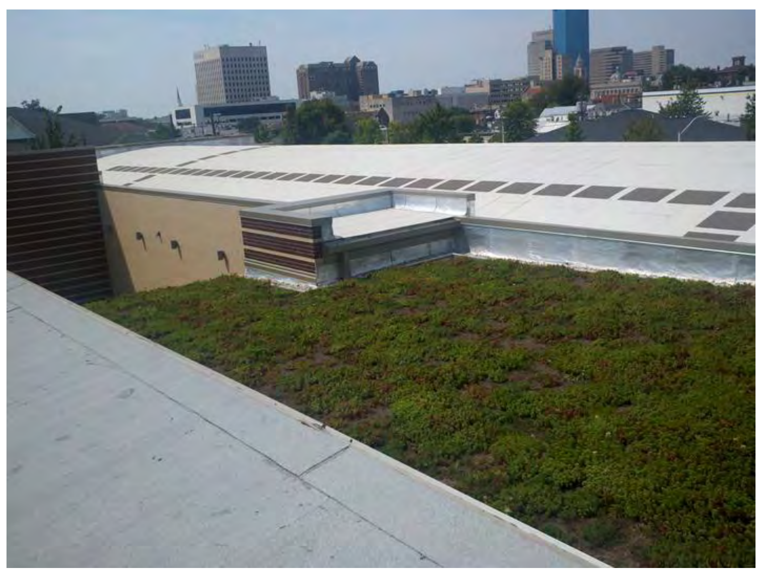
The following items shall be submitted to the LFUCG Division of Engineering:

1. Calculation of the WQV draining to the facility. See Table 10-1 of the LFUCG Stormwater Manual.
2. Design calculations, including water balance simulation, tank sizing, pump sizing, plumbing, etc.
3. Construction plans showing the plan, plumbing, details of pump, tank, filters, bypass etc.
4. Operations Plan and Maintenance Plan for the facility.

Description

Vegetative roofs (or green roofs) are alternatives to conventional rooftops that provide a protective covering of plant media and vegetation. Vegetative roofs may be used in traditional flat or pitched roofs to reduce impervious cover and absorb less heat than conventional systems. Vegetative roofs consist of vegetative cover, growing media, a drainage layer, and a waterproof membrane. There are two basic vegetative roof designs distinguished by media thickness: extensive vegetative roofs and intensive vegetative roofs. Extensive vegetative roofs are lightweight systems where the media layer ranges from 2 to 6 inches thick and are limited to herbs, grasses, and mosses. Intensive vegetative roofs have greater soil depths of 8 inches or more and include a variety of grasses, shrubs, and trees. Vegetative roofs reduce the rate and runoff volume released during storm events. The water retention and detention properties of vegetative roof covers can be enhanced through proper selection of engineered media and plants.

For new and re-development in Fayette County, vegetated roofs are classified as an **"engineered pervious surface."** They are not classified as a water quality control BMP, but can serve to decrease site imperviousness. If used for this purpose and later removed, replacement stormwater controls may be required to offset the increased imperviousness.



Environmental Benefits

- Reduces stormwater runoff volume and peak flow
- Removes pollutants from atmospheric deposition

Allowable Locations in New Development and Redevelopment

☐ Single Family Residential
☑ Commercial, Industrial, Apartments
☑ LFUCG Buildings

Meeting LFUCG Design Criteria for New Development and Redevelopment

☐ Provides **Water Quality Volume** capture and treatment
☐ Provides detention storage for **Water Quantity** (if designed with detention controls)
☑ Functions as a pervious surface for **Water Quantity** hydrologic calculations

LFUCG Site Design Requirements

Drainage Area: Typically the rooftop only.

Building Structure: If retrofitting an existing building, a structural analysis is required to determine if the structure can hold the weight of the proposed roof. If installing on a new building, the structural design shall include the additional weight in the design.

Proximity to Existing Features: N/A

Soil Type: Special media specified for vegetated roof plant species (e.g. sedum, etc.)

Pretreatment: N/A

Drain Time: N/A

Design Guidance

Vegetated roofs shall be designed in accordance with industry standards (e.g. , http://www.greenroofs.org/index.php/resources/designstandards)

When designing and constructing vegetated roofs, the following issues are of special concern:

- Fire, wind, and root penetration protection
- Flashing design and installation for watertight seal
- Gutters to handle runoff during heavy rain events
- Building code
- Access and future Operation & Maintenance Plan

Maintenance

The property owner shall maintain the vegetated roof in accordance with an Operation and Maintenance plan submitted to LFUCG. If an engineered pervious surface is used to lower site imperviousness for a new development or redevelopment, and it later becomes impervious for whatever reason, the site may become out of compliance with the *LFUCG Stormwater Manual*. The surface could either be replaced with new material to restore its original condition or replacement stormwater controls may be required to offset the increase in impervious area. In addition, Vegetated Roofs classified as an "engineered pervious surface" that are found to have become impervious shall be noted on LFUCG's Impervious Area GIS coverage for inclusion in the Water Quality Management Fee billing.

Easements

Easements are not required for vegetated roofs.

Submittal Requirements

The following items shall be submitted to the LFUCG Division of Engineering for review:

1. Roof design report by a structural engineer.
2. Operation and Maintenance plan prepared by a structural engineer and landscape specialist.
3. Roof design plan showing cross-section, drainage, plumbing, flashing detail, landscaping plan, etc.

APPENDIX B: PLANT LIST

Eight plant lists are included, one for each of the Best Management Practices (BMPs) that use vegetation as part of the treatment system. Some plants may appear on a number of the lists, others only on a single list. The vegetated roof list, for example, is almost totally different from any of the others.

Selecting plants from the list for any particular BMP should be based on a number of considerations: whether the site is in full sun, partially, or totally shaded; available soil moisture; the location and its aesthetics; the ultimate size of the plant; whether the plant is an annual or perennial; is shallow or deeply rooted; and its cost and availability, to mention just a few.

Some plants are more shade tolerant than others, some only do well in full sun, and others require full shade to survive. If the planting site is open to full sun, pick a group of plants that are compatible. A mix of sun requiring and shade requiring plants will result in the former out competing the latter and the shade requiring plants will soon be eliminated.

Moisture availability is one of the most important factors to consider. Bioretention facilities, more commonly called rain gardens, imply wet conditions but the opposite is generally true. These facilities may have standing water for 24 hours but may subsequently be very dry for the next 10 days.

Aesthetic considerations could differ considerably if a bioretention facility (rain garden) is located on a downtown street as opposed to the edge of greenway, where it is rarely seen. Spring and summer blooms or good fall color are important to the former, less so to the latter. Time of flowering is also a consideration, such that at least one species is blooming throughout the growing season. Several of the grasses listed are ornamental and should not be mowed during the growing season so that they can achieve their full height.

Plant size is important where tall plants may hide or shade shorter species. Both may be used but their location to each other, the sun, and the view should be considered. Size is particularly important when picking trees and shrubs - will the BMP have enough soil space to support the pencil thin seedling when it is 10 years old and 25 feet tall? Are there overhead utilities that would limit the height of trees but not be a problem for lower growing shrubs or under-story trees?

Annuals are plants that die each year but return from seed dropped by the parent plant. Some annuals do a better job of re-seeding themselves than others. The tops of herbaceous perennials die back each year but come back from the living root. Woody perennials do not die back but continue to gain size for years.

Rooting depth and type is important in several ways. BMPs with underdrains should not receive trees or shrubs with deep roots that could clog the drains in a few years. For that reason, willows are not recommended. Shallow soil may not adequately support trees that will reach considerable height unless they have an extensive lateral root system. Annuals are almost always shallow rooted, while perennials tend to be deeper rooted.

The large majority of plants listed are not expensive, particularly in relation to the cost of the entire BMP. Most should also be readily available at local or regional suppliers. Plants for a green roof may be the exception and may be obtainable from a limited number of sources.

Last but certainly not least, the decision whether to use seed or plants or a mixture of the two. Small plugs or container grown plants are initially more expensive than seed but may be cheaper in the long run. Establishing many species by seed can be a slow or difficult process. Where plants will be inundated for hours to days, seedlings would be much more vulnerable to anoxic conditions than larger plants of the same species. Planting healthy plugs, root cuttings, or larger container grown plants can result in better establishment and quicker BMP functioning. For some species, however, such as black-eyed Susan or grasses, seeding is the best option. Whatever species or mix of types is chosen, they will all require some maintenance to become well established. At minimum, watering and weeding will likely be necessary during the first growing season.

Table B- 1. Bioretention Species

Bioretention Species			
Common Name	**Scientific Name**	**Height (Feet)**	**Notes**
Grasses and Sedges			
Beaked Panicgrass	*Panicum anceps*	2-3	Can Be Mowed
Bluegrass	*Poa pratensis*	1-2	Full Sun; Can be Mowed; Non-native
Bottlebrush Grass	*Elymus hystrix*	2-3	Full Sun to Partial Shade; Dry, Well-Drained Soils; Do Not Mow
Canada Wild Rye	*Elymus canadensis*	2-4	Full Sun to Shade; Do Not Mow
Drooping Sedge	*Carex crinita*		
Fox Sedge	*Carex vulpinoidea*		
Indian Grass	*Sorghastrum nutans*	4-6	Open Sun; Do Not Mow
Little Bluestem	*Schizachyrium scoparium*	2-4	Full Sun; Can Be Mowed
Orchard Grass	*Dactylis glomerata*	2-3	Bunchgrass; Non-native; Can Be Mowed
Purpletop	*Tridens flavus*	2-3	Full Sun; Can Be Mowed
Redtop	*Agrostis alba*	1-3	Full Sun; Can Be Mowed
River Oats	*Chasmanthium latifolia*	2-4	Full Sun to Shade; Wet to Dry Soils; Do Not Mow
Switchgrass	*Panicum virgatum*	3-7	Open Sun; Deep Rooted; Late Spring Planting
Virginia Wild Rye	*Elymus virginicus*	2-4	Full Sun to Shade; Do Not Mow
Woolgrass	*Scirpus cyperinus*	3-5	Open Sun; Wet to Dry Soils; Do Not Mow
Forbs			
Bee Balm	*Monarda didyma*	2-4	Full Sun; Attracts Butterflies; May Spread
Black-eyed Susan	*Rudbeckia hirta*	2	Full Sun
Blazing Star	*Liastris spicata*	1-2	Full Sun
Blue False Indigo	*Baptisia australis*	3-4	Full Sun; Drought Tolerant; Blue Leaf Clusters
Blue Lobelia	*Lobelia siphilitica*	3-5	Full Sun
Bluestar	*Amsonia tabernaemontana*	1-2	Sun to Partial Shade
Bundleflower	*Desmanthus illinoensis*	2-3	Full Sun; Drought Tolerant
Butterfly Milkweed	*Asclepia tuberosa*	2	Full Sun

Bioretention Species			
Common Name	**Scientific Name**	**Height (Feet)**	**Notes**
Cardinal Flower	*Lobelia cardinalis*	1-3	Sun to Partial Shade; Moist Soil; Not Drought Tolerant
Cream Indigo	*Baptisia leucophae*	2-4	Full Sun; Slow Growing
Culvers Root	*Veronicastrum virginicum*	3-6	Full Sun to Partial Shade; Moist Soil
Downy Sunflower	*Helianthus mollis*	2-4	Full Sun; Drought Tolerant
Dwarf Larkspur	*Delphinium tricorne*	1	Full Sun
Gray Headed Coneflower	*Ratibida pinnata*	3-4	Full Sun; Drought Tolerant
Joe-Pye Weeds	*Eupatorium fistulosum purpureum*	5-8	Sun to Partial Shade; Moist Soil; Not Drought Tolerant
Marsh Milkweed	*Asclepias incarnata*	2-5	Sun; Moist Soil; Not Drought Tolerant
Mist Flower	*Conoclinum coelestinum*	2-3	Sun to Partial Shade; Moist Soil
Monkey Flower	*Mimulus ringens*	1-3	Sun to Partial Shade; Moist Soil; Not Drought Tolerant
New England Aster	*Aster novae-angliae*	2-4	Sun to Light Shade; Moist to Moderately Well-Drained
Obedient Plant	*Physostegia virginiana*	2-3	Sun to Light Shade; Moist Soil; May Spread
Orange Coneflower	*Rudbeckia fulgida*	2-3	Full Sun; May Spread
Prairie Dock	*Silphium terebinthenaceum*	3-10	Full Sun; Slow Growing; Drought Tolerant
Purple Coneflower	*Echinacea purpurea*	2-4	Full Sun; Large Flower; Drought Tolerant
Rattlesnake Master	*Eryngium yuccifolium*	2-5	Full Sun; Does Not Tolerate Standing Water; Unusual Appearance
Sneezeweed	*Helenium autumnale*	2-4	Full Sun; Moist Soil
Wild Bergamot	*Monarda fistulosa*	2-3	Full Sun; May Spread
Wild Blue Phlox	*Phlox divaricata*	1-2	Partial to Full Shade; Not Drought Tolerant

Table B- 2. Bio-infiltration Species

Bio-infiltration Species			
Common Name	**Scientific Name**	**Height (Feet)**	**Notes**
Grasses and Sedges			
Beaked Panicgrass	*Panicum anceps*	2-3	Can Be Mowed
Bluegrass	*Poa pratensis*	1-2	Full Sun; Can be Mowed; Non-native
Bottlebrush Grass	*Elymus hystrix*	2-3	Full Sun to Partial Shade; Dry, Well-Drained Soils; Do Not Mow
Canada Wild Rye	*Elymus canadensis*	2-4	Full Sun to Shade; Do Not Mow
Drooping Sedge	*Carex crinita*		
Fox Sedge	*Carex vulpinoidea*		
Indian Grass	*Sorghastrum nutans*	4-6	Open Sun; Do Not Mow
Little Bluestem	*Schizachyrium scoparium*	2-4	Full Sun; Can Be Mowed

Bio-infiltration Species			
Common Name	**Scientific Name**	**Height (Feet)**	**Notes**
Orchard Grass	*Dactylis glomerata*	2-3	Bunchgrass; Non-native; Can Be Mowed
Purpletop	*Tridens flavus*	2-3	Full Sun; Can Be Mowed
Redtop	*Agrostis alba*	1-3	Full Sun; Can Be Mowed
River Oats	*Chasmanthium latifolia*	2-4	Full Sun to Shade; Wet to Dry Soils; Do Not Mow
Switchgrass	*Panicum virgatum*	3-7	Open Sun; Deep Rooted; Late Spring Planting
Virginia Wild Rye	*Elymus virginicus*	2-4	Full Sun to Shade; Do Not Mow
Woolgrass	*Scirpus cyperinus*	3-5	Open Sun; Wet to Dry Soils; Do Not Mow
Forbs			
Bee Balm	*Monarda didyma*	2-4	Full Sun; Attracts Butterflies; May Spread
Black-eyed Susan	*Rudbeckia hirta*	2	Full Sun
Blazing Star	*Liastris spicata*	1-2	Full Sun
Blue False Indigo	*Baptisia australis*	3-4	Full Sun; Drought Tolerant; Blue Leaf Clusters
Blue Lobelia	*Lobelia siphilitica*	3-5	Full Sun
Bluestar	*Amsonia tabernaemontana*	1-2	Sun to Partial Shade
Bundleflower	*Desmanthus illinoensis*	2-3	Full Sun; Drought Tolerant
Butterfly Milkweed	*Asclepia tuberosa*	2	Full Sun
Cardinal Flower	*Lobelia cardinalis*	1-3	Sun to Partial Shade; Moist Soil; Not Drought Tolerant
Cream Indigo	*Baptisia leucophae*	2-4	Full Sun; Slow Growing
Culvers Root	*Veronicastrum virginicum*	3-6	Full Sun to Partial Shade; Moist Soil
Downy Sunflower	*Helianthus mollis*	2-4	Full Sun; Drought Tolerant
Dwarf Larkspur	*Delphinium tricorne*	1	Full Sun
Gray Headed Coneflower	*Ratibida pinnata*	3-4	Full Sun; Drought Tolerant
Joe-Pye Weeds	*Eupatorium fistulosum purpureum*	5-8	Sun to Partial Shade; Moist Soil; Not Drought Tolerant
Marsh Milkweed	*Asclepias incarnata*	2-5	Sun; Moist Soil; Not Drought Tolerant
Mist Flower	*Conoclinum coelestinum*	2-3	Sun to Partial Shade; Moist Soil
Monkey Flower	*Mimulus ringens*	1-3	Sun to Partial Shade; Moist Soil; Not Drought Tolerant
New England Aster	*Aster novae-angliae*	2-4	Sun to Light Shade; Moist to Moderately Well-Drained
Obedient Plant	*Physostegia virginiana*	2-3	Sun to Light Shade; Moist Soil; May Spread
Orange Coneflower	*Rudbeckia fulgida*	2-3	Full Sun; May Spread
Prairie Dock	*Silphium terebinthenaceum*	3-10	Full Sun; Slow Growing; Drought Tolerant
Purple Coneflower	*Echinacea purpurea*	2-4	Full Sun; Large Flower; Drought Tolerant

Bio-infiltration Species			
Common Name	**Scientific Name**	**Height (Feet)**	**Notes**
Rattlesnake Master	*Eryngium yuccifolium*	2-5	Full Sun; Does Not Tolerate Standing Water; Unusual Appearance
Sneezeweed	*Helenium autumnale*	2-4	Full Sun; Moist Soil
Wild Bergamot	*Monarda fistulosa*	2-3	Full Sun; May Spread
Wild Blue Phlox	*Phlox divaricata*	1-2	Partial to Full Shade; Not Drought Tolerant
Shrubs and Trees			
American Plum	*Prunus americana*	8-10	Full Sun to Partial Shade; Early White Flowers; Spreads
Azalea sp.	*Azalea sp.*	5-8	Open to Shade; Several Kentucky Species
Blackgum	*Nyssa sylvatica*	30-80	Full Sun to Shade; Great Fall Color
Blackhaw	*Viburnum prunifolium*	10-15	Full Sun to Partial Shade; Clusters of White Flowers; Fall Color Varies
Bladdernut	*Staphylea trifolia*	5-20	Partial to Full Shade; Average to Moist Soil
Carolina Buckthorn	*Frangula caroliniana*	12-15	Best in Partial Shade
Black and Red Chokeberry	*Aronia sp.*	3-10	Full Sun to Partial Shade; Fall Color; Fruit
Elderberry	*Sambucus canadensis*	8-12	Open to Partial Shade; Clusters of White Flowers; Black Fruit
Ironwood	*Carpinus carolina*	20-30	Full Sun to Shade; Moist, Acidic Soil
Ninebark	*Physocarpus opulifolius*	5-8	Full Sun to Partial Shade; White Flowers
Roughleaf Dogwood	*Cornus drummondii*	5-15	Full Sun to Partial Shade; Clusters of White Flowers; Fall Color
Rusty Blackhaw	*Viburnum rifidulum*	10-30	Full Sun to Partial Shade; White Flowers and Fall Color
Smooth Sumac	*Rhus glabra*	5-15	Full Sun; Brilliant Red Fall Color; Plant in Clusters
Spicebush	*Lindera benzoin*	5-15	Partial to Full Shade; Red Berries
Winged Sumac	*Rhus copallina*	10-25	Full Sun to Partial Shade

Table B- 3. Green Roof Species

Green Roof Species			
Common Name	**Scientific Name**	**Height (Feet)**	**Notes**
Pussytoes	*Antennaria plantaginifolia*	1	Common in Kentucky; Drought Tolerant
Butterfly Milkweed	*Asclepias tuberosa*	1-2	Drought Tolerant
Side Oats Grama	*Bouteloua curtipendula*	1-2	
Purple Prairie Clover	*Dalea purpurea*	2-3	
Poverty Grass	*Danthronia spicata*	1	
Bottlebruss Grass	*Elymus hystrix*	2-3	

Green Roof Species			
Common Name	**Scientific Name**	**Height (Feet)**	**Notes**
Rattlesnake Master	*Eryngium yuccifolium*	3-4	
Alumroot	*Heuchera americana*	1-2	
Blazing Star	*Liatris sp.*	1-3	Several Native Species
Beardstongue	*Penstemon hirstutus and laevigatus*	2	
Cinquefoil	*Potentilla simplex*	1	Sprawling
Black-eyed Susan	*Rudbeckia hirta*	1-2	
Wild Petunia	*Ruellia humilis*	1-2	
Stonecrop	*Sedum sp.*	0.5	A Number of Kentuck Species are Available; Two Kentucky Species include *S. pulchellum* and *S. ternatum*.
Fameflower	*Talinum calycium*	0.5-1	
Spiderwort	*Tradescantea ohioensis*	2	
Birdsfoot Violet	*Viola pedata*	1	
Glade Violet	*Viola egglestonii*	0.5	A "Special Concern" Species in Kentucky

Table B- 4. Planter Box Species

Planter Box Species			
Common Name	**Scientific Name**	**Height (Feet)**	**Notes**
Forbs			
Bee Balm	*Monarda didyma*	2-4	Full Sun; Attracts Butterflies; May Spread
Black-eyed Susan	*Rudbeckia hirta*	2	Full Sun
Blazing Star	*Liastris spicata*	1-2	Full Sun
Blue False Indigo	*Baptisia australis*	3-4	Full Sun; Drought Tolerant; Blue Leaf Clusters
Blue Lobelia	*Lobelia siphilitica*	3-5	Full Sun
Bluestar	*Amsonia tabernaemontana*	1-2	Sun to Partial Shade
Bundleflower	*Desmanthus illinoensis*	2-3	Full Sun; Drought Tolerant
Butterfly Milkweed	*Asclepia tuberosa*	2	Full Sun
Cardinal Flower	*Lobelia cardinalis*	1-3	Sun to Partial Shade; Moist Soil; Not Drought Tolerant
Cream Indigo	*Baptisia leucophae*	2-4	Full Sun; Slow Growing
Culvers Root	*Veronicastrum virginicum*	3-6	Full Sun to Partial Shade; Moist Soil
Downy Sunflower	*Helianthus mollis*	2-4	Full Sun; Drought Tolerant
Dwarf Larkspur	*Delphinium tricorne*	1	Full Sun
Gray Headed Coneflower	*Ratibida pinnata*	3-4	Full Sun; Drought Tolerant
Marsh Milkweed	*Asclepias incarnata*	2-5	Sun; Moist Soil; Not Drought Tolerant
Mist Flower	*Conoclinum coelestinum*	2-3	Sun to Partial Shade; Moist Soil
Monkey Flower	*Mimulus ringens*	1-3	Sun to Partial Shade; Moist Soil; Not Drought Tolerant

Planter Box Species			
Common Name	**Scientific Name**	**Height (Feet)**	**Notes**
New England Aster	*Aster novae-angliae*	2-4	Sun to Light Shade; Moist to Moderately Well-Drained
Obedient Plant	*Physostegia virginiana*	2-3	Sun to Light Shade; Moist Soil; May Spread
Orange Coneflower	*Rudbeckia fulgida*	2-3	Full Sun; May Spread
Prairie Dock	*Silphium terebinthenaceum*	3-10	Full Sun; Slow Growing; Drought Tolerant
Purple Coneflower	*Echinacea purpurea*	2-4	Full Sun; Large Flower; Drought Tolerant
Rattlesnake Master	*Eryngium yuccifolium*	2-5	Full Sun; Does Not Tolerate Standing Water; Unusual Appearance
Sneezeweed	*Helenium autumnale*	2-4	Full Sun; Moist Soil
Wild Bergamot	*Monarda fistulosa*	2-3	Full Sun; May Spread
Wild Blue Phlox	*Phlox divaricata*	1-2	Partial to Full Shade; Not Drought Tolerant
Shrubs and Trees			
American Plum	*Prunus americana*	8-10	Full Sun to Partial Shade; Early White Flowers; Spreads
Azalea sp.	*Azalea sp.*	5-8	Open to Shade; Several Kentucky Species
Blackgum	*Nyssa sylvatica*	30-80	Full Sun to Shade; Great Fall Color
Blackhaw	*Viburnum prunifolium*	10-15	Full Sun to Partial Shade; Clusters of White Flowers; Fall Color Varies
Bladdernut	*Staphylea trifolia*	5-20	Partial to Full Shade; Average to Moist Soil
Bottlebrush Buckeye	*Aesculus parviflora*	6-12	Open Sun; Large White Blooms
Carolina Buckthorn	*Frangula caroliniana*	12-15	Best in Partial Shade
Black and Red Chokeberry	*Aronia sp.*	3-10	Full Sun to Partial Shade; Fall Color; Fruit
Dwarf Red Buckeye	*Aesculus pavia*	6-8	Open Sun; Red Flowers
Elderberry	*Sambucus canadensis*	8-12	Open to Partial Shade; Clusters of White Flowers; Black Fruit
Flowering Dogwood	*Cornus florida*	20-30	Full Sun to Shade but Partial Shade Optimal; Shallow Roots; Early White Flower
Ironwood	*Carpinus carolina*	20-30	Full Sun to Shade; Moist, Acidic Soil
Ninebark	*Physocarpus opulifolius*	5-8	Full Sun to Partial Shade; White Flowers
Redbud	*Cercis candensis*	20-30	Full Sun to Partial Shade; Early Spring Blooms
Roughleaf Dogwood	*Cornus drummondii*	5-15	Full Sun to Partial Shade; Clusters of White Flowers; Fall Color
Rusty Blackhaw	*Viburnum rifidulum*	10-30	Full Sun to Partial Shade; White Flowers and Fall Color
Smooth Sumac	*Rhus glabra*	5-15	Full Sun; Brilliant Red Fall Color; Plant in Clusters

Planter Box Species			
Common Name	**Scientific Name**	**Height (Feet)**	**Notes**
Spicebush	*Lindera benzoin*	5-15	Partial to Full Shade; Red Berries
Winged Sumac	*Rhus copallina*	10-25	Full Sun to Partial Shade
Yellow-wood	*Cladastris lutea*	25-50	Full Sun to Partial Shade; Large Clusters of White Flowers

Table B- 5. Tree Trench Species

Tree Trench Species			
Common Name	**Scientific Name**	**Height (Feet)**	**Notes**
Shrubs and Trees			
American Plum	*Prunus americana*	8-10	Full Sun to Partial Shade; Early White Flowers; Spreads
Azalea sp.	*Azalea sp.*	5-8	Open to Shade; Several Kentucky Species
Blackhaw	*Viburnum prunifolium*	10-15	Full Sun to Partial Shade; Clusters of White Flowers; Fall Color Varies
Bladdernut	*Staphylea trifolia*	5-20	Partial to Full Shade; Average to Moist Soil
Bottlebrush Buckeye	*Aesculus parviflora*	6-12	Open Sun; Large White Blooms
Carolina Buckthorn	*Frangula caroliniana*	12-15	Best in Partial Shade
Black and Red Chokeberry	*Aronia sp.*	3-10	Full Sun to Partial Shade; Fall Color; Fruit
Dwarf Red Buckeye	*Aesculus pavia*	6-8	Open Sun; Red Flowers
Elderberry	*Sambucus canadensis*	8-12	Open to Partial Shade; Clusters of White Flowers; Black Fruit
Flowering Dogwood	*Cornus florida*	20-30	Full Sun to Shade but Partial Shade Optimal; Shallow Roots; Early White Flower
Ironwood	*Carpinus carolina*	20-30	Full Sun to Shade; Moist, Acidic Soil
Ninebark	*Physocarpus opulifolius*	5-8	Full Sun to Partial Shade; White Flowers
Redbud	*Cercis candensis*	20-30	Full Sun to Partial Shade; Early Spring Blooms
Roughleaf Dogwood	*Cornus drummondii*	5-15	Full Sun to Partial Shade; Clusters of White Flowers; Fall Color
Rusty Blackhaw	*Viburnum rifidulum*	10-30	Full Sun to Partial Shade; White Flowers and Fall Color
Smooth Sumac	*Rhus glabra*	5-15	Full Sun; Brilliant Red Fall Color; Plant in Clusters
Spicebush	*Lindera benzoin*	5-15	Partial to Full Shade; Red Berries
Winged Sumac	*Rhus copallina*	10-25	Full Sun to Partial Shade
Yellow-wood	*Cladastris lutea*	25-50	Full Sun to Partial Shade; Large Clusters of White Flowers