Level Spreaders (LS) and Grassed Filter Strips (FS)

Level Spreader; Auburn, AL

Synonyms: Water spreader, grass filters, grassed buffer strips, filter strips, engineered buffer strips, engineered filter strips

Site Selection

Site Selection	
Quantity Control	no
Drainage Area	small
Space Required	small
Works with:	
Steep Slopes	---
Shallow Water Table	---
Poorly Drained Soils	✔

General Significance

General Significance	
Construction Cost	low
Maintenance	low
Community Acceptance	high
Habitat	med
Sun / Shade	either

Level spreaders are devices that create diffuse or sheet flow that is evenly distributed or dispersed to decrease flow velocity and discourage erosive forces associated with concentrated flows. Most commonly, level spreaders are paired with grassed filter strips, riparian buffers, or a combination of the two to provide pollutant removal. The primary purpose of a level spreader is to disconnect impervious surfaces by creating non-erosive stormwater connectivity with grassed filter strips.

A grassed filter strip is a linear strip of dense vegetation that receives sheet flow of stormwater runoff from a nearby impervious surface or level spreader in order to reduce peak discharge rates, encourage sediment deposition, and provide limited infiltration. Grassed filter strips are planted with turfgrass, which is easy to maintain and blends seamlessly into urban landscapes. Grassed filter strips are most effective when combined with level spreaders.

Site Selection

Evaluating Soils: Use the USDA Web Soil Survey to identify soil map units and to make initial interpretations for potential uses and limitations of a site. However, since most soil map units have inclusions of other soils that may be quite different, detailed evaluations should be made at the proposed site by a professional soil scientist or soil classifier. On-site evaluations should properly identify a soil or the hydrologic soil group (HSG) and the final decision for use should be made based on the detailed determination of soil series or HSG. For a detailed list of HSG properties, see Table A.3 in Appendix A on Stormwater Hydrology.

Poorly Drained Soil: An underdrain is recommended when infiltration rates are < 1"/hr. See Chapter 5.1 on Rain Gardens for information on infiltration testing.

Practice Pairing: The purpose of a level spreader is to create diffuse flow; therefore, the level spreader is commonly paired with another stormwater control measure (SCM) to provide pollutant removal. Runoff from an impervious drainage area may be directed to level spreader and grassed filter strip systems or they may receive overflow from another SCM, such as a swale or bioretention cell.

Table 4.5.1
Site Selection: Constraints and Limitations for Level Spreaders and Grassed Filter Strips

Regional Stormwater Control	Level spreader/grassed filter strip combinations do not provide regional stormwater control, select another SCM
Slope	Slopes greater than 6% do not allow for adequate treatment in grassed filter strips
Utilities	Call 811 before construction to locate utilities (for more information, visit: www.al1call.com)
Large Drainage Areas	Draining larger watersheds requires longer level spreaders that are difficult to construct
High Sediment loads	Avoid high sediment loads if possible, particularly on sites with active construction

Riparian Buffers: Level spreader/ grassed filter strip systems are commonly sited upslope of riparian buffers where they create sheet flow of stormwater and reduce peak flows into streamside forests.

Drainage Area: Level spreaders are intended to capture runoff in small watersheds; flow volumes from larger watersheds require longer level spreaders that are difficult to construct.

Velocity: No more than 10 feet per second (fps) should be directed into a level spreader/grassed filter strip system. Diffuse flow occurs at velocities of less than 2 fps. Turf reinforced matting (TRM) is recommended if velocities are greater than 4 fps. A flow splitter to divert larger flows to a swale or other SCM can be incorporated.

Slope: Grassed filter strips are designed for areas with a 2 – 6% slope; greater than 6% slope is too steep for effective stormwater treatment and less than 2% slope may result in standing water.

Filter Strip Width: A minimum width of 25’ is recommended for grassed filter strips.

Local Ordinances: Local government stream buffer regulations and ordinances should be consulted prior to design and construction of these systems.

Design

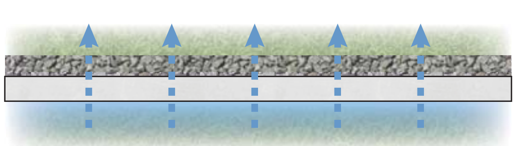
Information should be collected for watershed size, in-situ soil, hydrologic soil group (HSG), slope, and depth to water table. The design layout or level spreader location is specific to the site. When determining the best location for the level spreader/ grassed filter strip system, constraints, retrofit opportunities, and aesthetics should be considered.

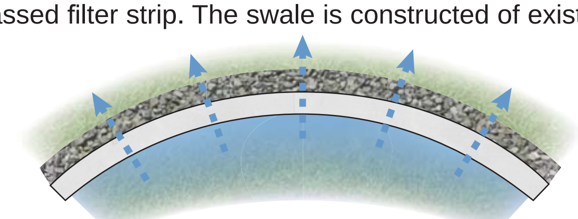
The level spreader/grassed filter strip system consists of four primary components: forebay, channel, level spreader lip, and the grassed filter strip. The size of each of these components is based on the volume or design storm to be captured.

Components

Forebay: A forebay is used as a pretreatment device for level spreader systems. A forebay is a pool that is used for initial storage and as a sediment trap for runoff entering the system, which prevents clogging of the channel behind the level spreader lip. The forebay for this system should be 12 - 18” deep and is used only in situations where standing water is not considered a safety concern. It is deepest at the point of runoff entry and shallower at the point of exit, which allows for energy dissipation within the forebay. If soils on site are poorly drained (<1”/hr), an underdrain may be needed below the forebay, to prevent standing water for extended periods of time. The forebay should be designed to be 0.2% of the watershed drainage area.

Level Spreader Channel/Blind Swale: The level spreader channel or “blind swale” (because of terminal ends) is located directly upslope of the level spreader. This swale is designed so that water fills the swale and spreads evenly over the level spreader creating diffuse flow into the grassed filter strip. The swale is constructed of existing earth


Straight Level Spreader Plan View


Convex Level Spreader Plan View

and soils and may be lined with turfgrass. In urban settings, a concrete channel may be desired for ease of trash and sediment removal. In clayey soils, an underdrain may need to be installed beneath the swale.

Level Spreader: The level spreader is a poured concrete weir constructed level (0% slope), and placed on an appropriate concrete footer. The level spreader should be designed and constructed to remain level. Level spreaders may be straight or convex in plan view, but not concave. This is primarily to prevent concentrated flows downslope.

Level Spreader Lip: The lip of the level spreader on the downslope side should be at least 3" higher than existing grade.

Filter Fabric: Downslope of the level spreader, a minimum 3' wide strip of geotextile filter fabric (40 oz nonwoven is recommended, but should be selected based on in-situ soil conditions) and 3" layer of aggregate stone should be applied (#57, #1, or designer preference).

Grassed Filter Strip: A grassed filter strip is graded to have a consistent and uniform slope. The filter strip is planted with turfgrass and the length of the filter strip may be dependent on local government stream buffer regulations.

Design Guidance

1. **Determine Peak Flow**

   Level spreaders are designed to treat peak flow; the peak flow event is the primary design storm used to design the level spreader channel. The Kirpich Equation and Rational Method are used to determine **Peak Flow (Q_p)** and to calculate level spreader channel geometry. The Kirpich Equation

EQN 4.5.1

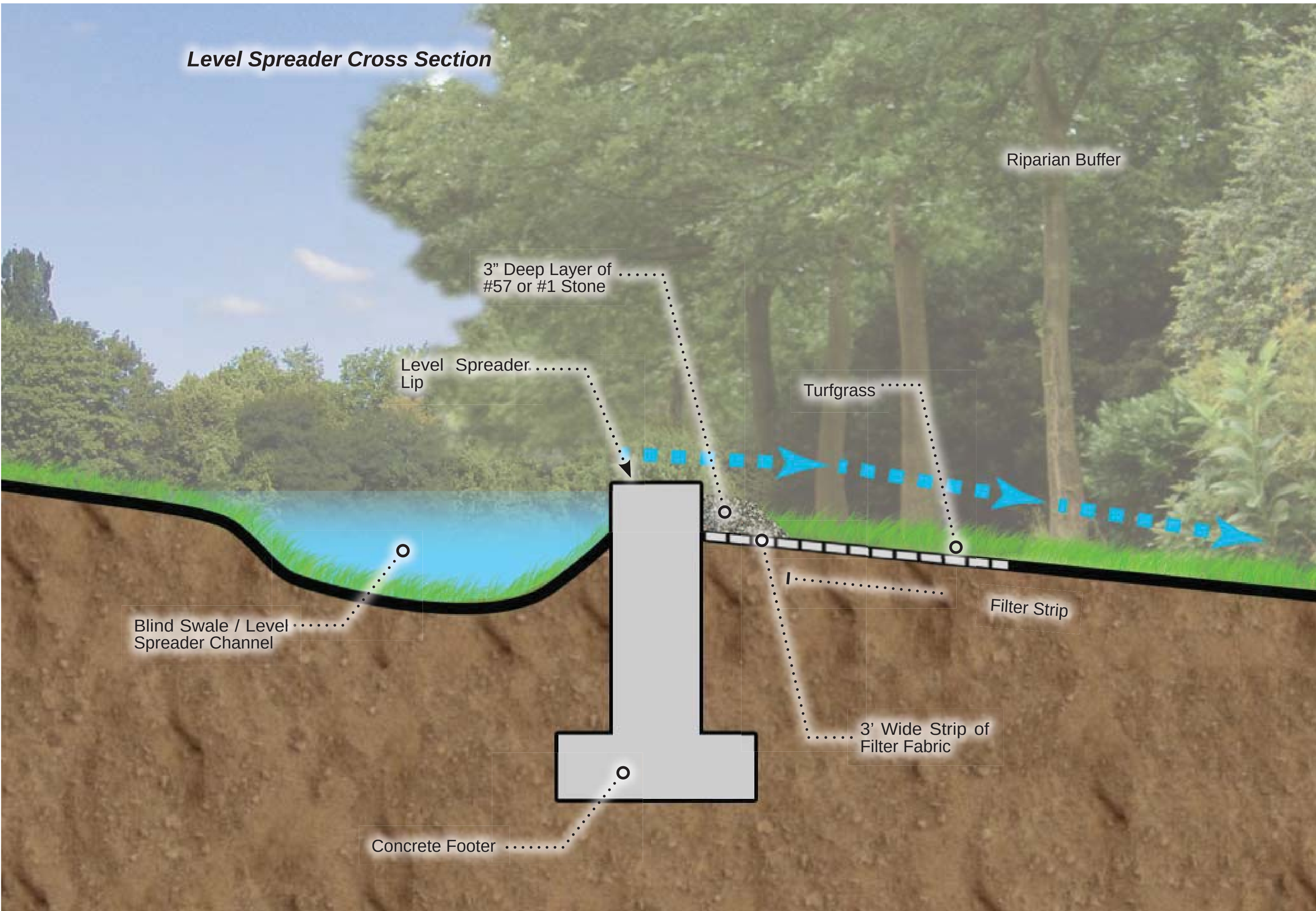
$$T_c = \frac{\left(\frac{L^3}{H}\right)^{0.385}}{128}$$

L = Longest length of drainage area or watershed (ft)
H = Change in Elevation throughout drainage area or watershed (ft)
T_c = Time of concentration (minutes)

EQN 4.5.2

$$Q_p = CiA$$

C = Rational coefficient (dimensionless) See Table A.2 in Stormwater Hydrology, Appendix A
i = Rainfall intensity (in/hr)
A = Watershed area (ac)
Q_p = Peak flow (ft^3/s)



Level Spreader Cross Section

shown in EQN 4.5.1, uses the **Longest Length in the Drainage Area (L)** and the **Change in Elevation (H)** to calculate the **Time of Concentration (T_c)**.

Using the **Time of Concentration (T_c)**, a design storm can be determined and the rainfall **Intensity (i)** is derived. If T_c is 4.6 minutes, round to the nearest given unit of time, 5 minutes. **Peak Flow (Q_p)** is calculated using the Rational Method, EQN 4.5.2.

Q_p = Peak flow (ft^3/s)

2. **Determine Level Spreader Channel Geometry**

Calculating level spreader channel geometry may require several design iterations using Manning's Equation (EQN 4.5.3). Triangular channels are easy to construct and work well in small drainage areas treated by level spreaders. If a trapezoidal level spreader channel geometry is desired, please refer to Chapter 4.4 on Grassed Swales, Infiltration Swales, and Wet Swales.

The **Level Spreader Channel Cross Sectional Area (A) and Hydraulic Radius (R)** are affected by level spreader channel geometry.

Side Slope: A 5:1 side slope is recommended, however a 3:1 is acceptable.

Channel Slope: The level spreader channel slope is not the same as site slope, or side slopes. The channel slope is the slope in the bottom of the level spreader channel and should be as flat as possible. Since the level spreader channel employs a blind swale, the channel slope should be minimal to avoid erosion, scour, and potential breach of the level spreader channel.

Depth (D) is determined using **Peak Flow (Q_p)** calculated from EQN 4.5.2. in Manning's EQN 4.5.3.

A modified Manning's Equation for a triangular channel with 3:1 and 5:1 side slopes is shown in EQNs 4.5.4 and 4.5.5.

Once **D** is calculated, side slopes and channel geometry are used to calculate the swale **Top Width (b)**.

The Continuity EQN 4.5.6, can be used to validate the velocity within the level spreader channel and determine if there is a need for turf reinforced matting (TRM) or additional vegetation to prevent erosion and scour within the swale channel. If **Velocity (V)** exceeds 4fps, TRM is necessary.

EQN 4.5.3

$$Q_p = \left(\frac{1.486}{n}\right) * A * R^{0.667} * S^{0.5}$$

n = Manning's n (dimensionless) – for more information see Appendix A on Stormwater Hydrology.
A = Swale channel cross sectional area (ft^2), based on swale geometry
R= Hydraulic radius (ft)
S = Swale channel slope (ft/ft)

EQN 4.5.4 *for 3 : 1 side slopes*

$$Q_p = \left(\frac{2.71}{n}\right) * D^{2.67} * S^{0.50} \quad \text{-or-} \quad D = \left(\frac{Q_p * n}{2.71 * S^{0.5}}\right)^{\frac{1}{2.67}}$$

EQN 4.5.5 *for 5 : 1 side slopes*

$$Q_p = \left(\frac{4.62}{n}\right) * D^{2.67} * S^{0.50}$$

n = Manning's n
D = Depth (ft)
S = Swale channel slope (ft/ft)
Q_p = Peak flow (ft^3/s)

EQN 4.5.6

$$Q = V * A$$

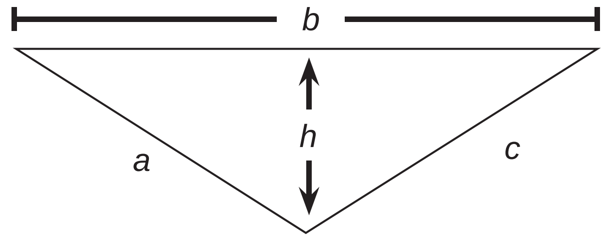
Q = Flow (ft^3/s)
V = Average velocity in channel (ft/s)
A = Swale channel cross sectional area (ft^2), based on swale geometry

Swale Geometry

(illustrations are exaggerated)

for triangular swale geometry:

$$A = 0.5(b*h)$$
$$P = a + b + c$$

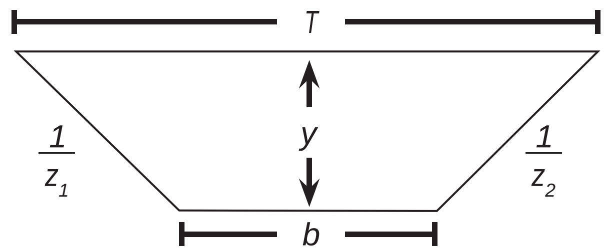


for trapezoidal swale geometry:

$$T = b + y(z_1+z_2)$$

$$A = \frac{y}{2}(b + T)$$

$$P = b + y\left(\sqrt{1 + z_1^2} + \sqrt{1 + z_2^2}\right)$$



Note: typically $z_1 = z_2$

Design Example

1. **Determine Peak Flow**

A residential site in northwest Alabama is used for this design example. The level spreader is treating a small, **1 acre** parking lot that holds a pool house.

A level spreader and grassed filter strip will capture parking lot runoff prior to entering a riparian buffer on the backside of the property. For this example, a triangular level spreader channel will be designed and turfgrass will be planted in the grassed filter strip. The design of the concrete footer, level spreader detail, and grassed filter strip dimensions are not included in this example.

The level spreader channel is designed for the peak flow event, using the Kirpich EQN 4.5.1.

The **Longest Length in the Drainage Area (L)** is 400' and the **Change of Elevation (H)** is 4'.

Therefore the **Time of Concentration** is

EQN 4.5.1

$$T_c = \frac{\left(\frac{L^3}{H}\right)^{0.385}}{128} \qquad T_c = \frac{\left(\frac{400^3}{4}\right)^{0.385}}{128} = \frac{594}{128} = 4.6\text{~}5\ min$$

The T_c is used to calculate rainfall **Intensity (i)** in the Rational Method (Peak Flow Equation). The design storm or rainfall **Intensity (i)** is determined using the 10 - year flow event and closest estimate of the T_c. Since the lowest calculated T_c is **5 minutes, the 10 - year 5 - minute intensity** will be used. For more detail on how to determine storm intensity refer to Appendix A on Stormwater Hydrology.

To determine **Peak Flow (Q_p)** from the **10 - year, 5 - minute event**, the Rational Method (EQN 4.5.2) is used.

EQN 4.5.2

$$Q_p = CiA$$

Continued on next page

A **Rational Coefficient (C) of 0.95 for parking lot runoff (impervious), Intensity (i) of 7.2 in/hr** (from appropriate IDF curve), determined using the **10 - year, 5 - minute event,** and **Area (A)** of **1 acre** for the impervious parking lot are used.

$$Q_p = 0.95*7.2in/hr*1.0ac$$

Converting the **Intensity (i)** 7.2in/hr to ft/s,

$$7.2in/hr \left| \frac{1ft}{12in} \right| 0.6ft/hr \left| \frac{1hr}{3600in} \right| =0.00016666ft/s$$

Converting 1 acre into square feet,

$$1ac \left| \frac{43{,}560ft^2}{1ac} \right| =43{,}560ft^2$$

Therefore,

EQN 4.5.2 $$Q_p = CiA$$

$$Q_p = 0.95*0.00016666*43560=6.8ft^3/s$$

Therefore, the level spreader channel needs to be able to handle peak flows of 6.8 cfs.

2. Determine Level Spreader Channel Geometry

The level spreader channel will have 3:1 side slopes and a triangular shape. Manning's EQN 4.5.3, can be used to confirm the calculated geometry.

EQN 4.5.3

$$Q_p = \left(\frac{1.486}{n}\right) *A*R^{0.667}*S^{0.5}$$

Since the level spreader channel has these dimensions (3:1 side slopes and triangular shape) a modified Manning's EQN 4.5.4 can be used to calculated channel **Depth (D)**.

EQN 4.5.4

$$D= \left(\frac{Q_p*n}{2.71*S^{0.5}}\right)^{\frac{1}{2.67}}$$

Using the calculated $\mathbf{Q_p}$, a **Manning's n 0.03 for grass**, and a **slope of 0.005ft/ft (0.25ft/50ft)**, a level spreader channel **Depth (D)** can be calculated.

$$D= \left(\frac{Q_p*n}{2.71*S^{0.5}}\right)^{\frac{1}{2.67}} = \left(\frac{6.8*0.03}{2.71*0.005^{0.5}}\right)^{0.375} = \left(\frac{0.204}{0.192}\right)^{0.375} =1ft$$

Using a calculated **Depth (D)**, of 1', a channel **Top Width (b)** can be determined by multiplying **D** by the side slope and 2, as shown: $b=1ft*3*2=6ft$

Using the area of a triangle equation as shown in EQN 4.5.7 and 6' as the calculated base,

$A=0.5*b*h,$ where b=6ft and h=D=1ft, area can calculated as $A=3ft^2$

Using **Peak Flow ($\mathbf{Q_p}$)** and the calculated **Area (A)** of 3 ft^2, the Continuity EQN 4.5.6, can be used to verify that the velocity in the level spreader channel does not exceed what can be sustained by vegetation, without causing erosion.

$Q = V*A,$ where $\mathbf{Q_p}$ **i**s used to determine the **Maximum Velocity ($\mathbf{V_{max}}$)** within the designed channel.

$$Q_p = V_{max}*A, \quad \frac{Q_p}{A} = V_{max}= \frac{6.8ft^3/s}{3ft^2} =2.3ft/s$$

Since $\mathbf{V_{max}}$ is less than 4 fps, TRM is not necessary in the channel.

The channel and filter strip will be planted with bermudagrass sod. See the Vegetation section below for information on turf establishment.

Construction

Construction sequencing will ensure that water quality improvement is the primary function of the level spreader and grassed filter strip. Prior to construction, the designer should examine ground contours and specify that the level spreader be parallel to contours to minimize grading.

Existing Riparian Buffers: The designer should visit the site to confirm that the width of the level spreader and grassed filter strip system does not encroach on an existing riparian buffer or wetland areas.

Erosion and Sediment Control: The level spreader system should be protected from sediment deposition and runoff during construction to prevent erosion, compaction, and clogging of the system.

Please review proper sediment control practices in the Alabama Handbook for Erosion Control, Sediment Control and Stormwater Management on Construction Sites and Urban Areas

(http://swcc.alabama.gov/pages/erosion_handbook.aspx).

Compaction: Equipment should be operated outside of the proposed grassed filter strip to prevent compaction. Any compacted soil should be loosened to depth of at least 4" and sod should be installed on the filter strip.

Level Spreader Channel: Following completion of the grassed filter strip, the level spreader channel should be constructed according to the design depth.

Level Spreader Lip: It is recommended that the level spreader lip be constructed using concrete for long-term functionality. Earthen level spreader lips are erodible and likely to encourage vegetation growth on the lip, which inhibits sheet flow. Moreover, earthen and gravel lips often fail in urban settings.

Level Spreader: The level spreader should be cast in place using industry standards for concrete, and constructed on undisturbed soil whenever possible. Forms should be built to cast the level spreader. The top of the forms should be level and approximately 3" higher than soil downslope. The surface of the level spreader lip should be made level using a screed such as a wooden dowel or other tool. The level spreader should be allowed to set up overnight and should be protected during this process. Once forms are removed, the remaining level spreader channel configuration can be constructed.

Underdrain: An underdrain may be necessary under the level spreader channel and forebay if in-situ soil drainage is poor (<1"/hr). Underdrains are corrugated or smooth wall perforated pipe and should be configured to tie in with overflow or discharge into the stormwater conveyance network.

Forebay: Lastly, the forebay should be constructed, typically using a small excavator. Once the forebay is complete, the level spreader channel should be sodded.

Topsoil: If soils on site are poor and lack organic matter, topsoil can be added at a depth of 6" in the filter strip and on any other slope created by grading to aid in plant establishment. Topsoil can be harvested on site during construction or brought in from an external source.

Soil Testing: Prior to planting, a soil sample should be collected for a soil test to determine any fertilizer or lime requirements needed for plant establishment. The soil sample should be submitted to the Auburn University Soil Testing Laboratory or other comparable soil testing lab. The grassed filter strip may be fertilized at planting based on soil test recommendations, but should not be fertilized following initial fertilization as this can result in the export of nitrogen and phosphorus from the filter strip. For more information on soil test protocols, see http://www.aces.edu/pubs/docs/A/ANR-0006-A/ANR-0006-A.pdf.

Sod Installation: Similarly to grassed swales, grassed filter strips should be established using sod rather than seed. Sod should be cut fresh and installed as soon as it is delivered, preferably in the early morning before temperatures rise. Sod should be installed horizontally across a slope and the seams of sod should be alternated similar to a brick pattern to ensure stability and reduce erosion. Refer to the *Alabama Handbook for Erosion Control, Sediment Control and Stormwater Management on Construction Sites and Urban Areas* (http://swcc.alabama.gov/pages/erosion_handbook.aspx) for more information on sod installation. Sod may be harvested on site, temporarily stored in the shade, and kept evenly moist until planting.

Irrigation Systems: Irrigation systems should be calibrated (see Alabama Smart Yards Manual, Chapter 3) to minimize excess irrigation applications. A common mistake made during plant establishment is applying a small volume of water too frequently.

Vegetation

Vegetation for the level spreader channel and filter strip should be a dense coverage to be effective. Although not native, turfgrass is utilized because it is dense and fine textured, promotes diffuse flow when maintained at a low mowing height, can be sodded for quick cover, and is easy to maintain.

Turfgrass should be specified for the portion of the filter strip immediately following the run of aggregate (#57, #1, or designer preference). Warm season turfgrasses that actively grow during warmer months and are dormant during the winter are available in Alabama. Generally, turfgrass will not perform well under fully shaded conditions. As with other LID practices such as bioretention and grassed swales, turfgrass selected for grassed filter strips should be tolerant of brief flooding and most importantly, drought (See Table 4.5.2 for a Turfgrass List).

Turf Establishment: For June to September installation, newly planted turf should be irrigated at planting and watered daily for the first one to two weeks to keep it evenly moist. As the sod begins to grow new roots, irrigation frequency can be decreased, but a larger volume of water should be applied at each watering. Rainfall should be supplemented so that turfgrass receives about 1 – 1.5” per week from all irrigation sources. However, dormant plantings may benefit from irrigation during spring months when sod begins to produce new growth. Sod flourishes best when installed in the spring because this gives the turf an entire growing season to get established before the winter months arrive and the grass goes dormant. Sod will establish better when it is not going into or coming out of dormancy (i.e. not in late fall or late winter).

Table 4.5.2
Turfgrass List*

Name	Prefers	Drought Tolerance	Comments
Bermudagrass	Sun	Excellent	Tolerates foot traffic, spreads above and below ground, fast growth rate, use statewide
Centipedegrass	Sun to Part Shade	Good	Slow growing, sensitive to some herbicides (check label), may be susceptible to cold injury in North AL
St. Augustinegrass	Sun to Part Shade	Good	Spreads above ground, fast growing, can be sensitive to herbicides, most shade tolerant turf, use in Central and South AL
Zoysiagrass	Sun to Part Shade	Excellent	Use statewide, most cold tolerant of warm season turfgrasses, slow growing

*Adapted from Han and Huckabay, 2008a

Maintenance

Sediment Removal: Built up sediment can inhibit sheet flow by forming sandbars and dams throughout the filter strip or grassed channel. Sediment, trash, and debris should be removed twice a year from the level spreader channel, forebay, and vegetated filter strip. Accumulated sediment covers up vegetation, chokes it out, and results in plant die off.

Plant Maintenance: Dead plants should be replaced to maintain a consistent cover. Some areas may need to be re-sodded after accumulated sediment has been removed. Plants growing on the run of aggregate (#57, #1, or designer preference) and in the forebay should also be removed, as these can inhibit flow patterns.

Turf Maintenance: Grassed filter strips will require typical turfgrass maintenance including thatch removal and aeration (for more information on these activities, see Appendix D on Vegetation). Grassed filter strips should be kept at an even, low, dense growth where diffuse flow is desired. Turfgrass requires mowing at least once a month (every other week is better) during the growing season. A general rule of thumb is never to remove more than one third of the leaf during mowing. Turfgrasses such as bermudagrass respond well to frequent mowing. Mowing should not be conducted immediately following a rain event or when the ground is saturated to prevent ruts that can cause areas of compaction or re-concentration of diffuse flow.

Table 4.5.3
Maintenance Schedule

Task	How Often	Comments
Erosion Inspection	During and after major storm events (0.5" or greater) for the first 2 years, annually thereafter	Inspect for eroded areas and determine that flows are properly distributed into the filter strip, check for gulley formation in the channel and grassed filter strip.
Inspection	After 0.5" or greater rainfall event	Visually inspect all components including the level spreader lip, channel, and grassed filter strip for any damage.
Sediment and Trash Removal	At least annually, twice a year preferred	Remove deposited sediment, especially at inlet areas, such as the forebay, where it is most likely to collect, sediment should be removed annually or after a 2 yr 24 hr storm event.
Mowing of Turfgrass	Every other week in growing season	Mowing should be done more often during the growing season; dense low growing vegetation is best to maintain diffuse flow. Maintain at a height of 3 to 6".
Thatch Removal	As needed	Thatch removal should be done when the thatch layer is ¾" or thicker and when grass is actively growing. For more information, see Appendix D on Vegetation.
Aeration	As needed	Core aeration is needed when turfgrass has become compacted and infiltration has slowed. Aeration should only be done following spring green up or when grass is actively growing in summer months.
Plant Removal	Annual minimum	Remove all plants growing on the level spreader lip, in the forebay, or in the run of aggregate stone downslope of the lip.

Pollutant Removal

Table 4.5.4
Grassed Filter Strip Pollutant Removal Table

Sediment	Nutrients		Metals	Pathogens
	N	P		
a.40%	30%	35%	No Data	No Data
b.50%	20%	20%	40%	No Data
c.50%	20%	20%	40%	Insufficient Data

a. NCDENR, 2007
b. City of Auburn, 2011
c. Georgia Manual, 2001

Level spreaders provide minimal pollutant removal, however, when paired with a grassed filter strip, these systems receive reductions in total suspended solids (TSS) and nutrients, such as nitrogen and phosphorus.

Vegetation: The grassed filter strip reduces pollutants through infiltration and filtration processes associated with plants and soil. Dense vegetation cover is expected to increase pollutant removal efficiency, which is why turfgrass is recommended for these practices.

Sedimentation: Grassed filter strips are more effective at reducing runoff velocities and TSS concentrations when stormwater enters from a water-spreading device such as a level spreader or flat surface that encourages sheet flow. When grassed filter strips are used as a stand alone SCM, they reduce TSS loads because their primary pollutant removal mechanism is sedimentation. As sediment drops out, other pollutants attached to sediment particles, such as phosphorus and metals, are removed. Pollutant removal relies heavily on slowing the velocity of stormwater in the filter strip to facilitate sedimentation. Sedimentation has been noted to increase with increasing filter strip widths. Although an average of 25 to 30’ is recommended for filter strips, longer strips are likely to have higher pollutant removal efficiencies.

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