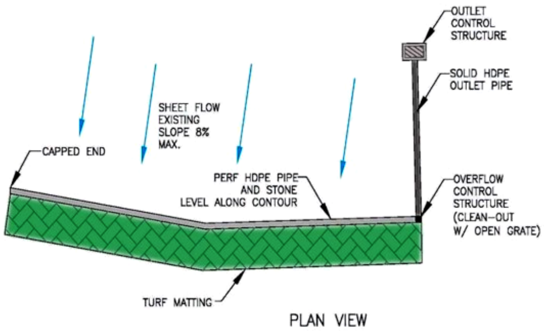
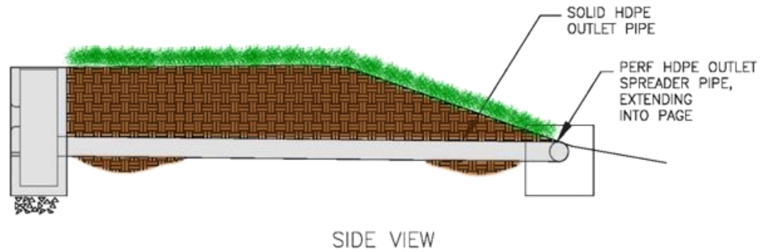
BMP 6.8.1: Level Spreader



Level Spreaders are measures that reduce the erosive energy of concentrated flows by distributing runoff as sheet flow to stabilized vegetative surfaces. Level Spreaders, of which there are many types, may also promote infiltration and improved water quality.



Key Design Elements

- Level spreaders must be level.
- Specific site conditions, such as topography, vegetative cover, soil, and geologic conditions must be considered prior to design; level spreaders are not applicable in areas with easily erodible soils and/or little vegetation.
- Level spreaders should safely diffuse at least the 10-year storm peak rate; bypassed flows should be stabilized in a sufficient manner.
- Length of level spreaders is dependent on influent flow rate, pipe diameter (if applicable); number and size of perforations (if applicable), and downhill cover type.
- It is always easier to keep flow distributed than to redistribute it after it is concentrated; multiple outfalls/level spreaders are preferable to a single outfall/level spreader.

Potential Applications

Residential: Yes
Commercial: Yes
Ultra Urban: Limited
Industrial: Yes
Retrofit: Yes
Highway/Road: Yes

Stormwater Functions

Volume Reduction: Low
Recharge: Low
Peak Rate Control: Low
Water Quality: Low

Water Quality Functions

TSS: 20%
TP: 10%
NO3: 5%

Description

Ensuring distributed, non-erosive flow conditions is an important consideration in any stormwater management strategy and particularly critical to the performance of certain BMPs (e.g. filter strips). Level spreading devices diffuse flows (both low and high), promote infiltration, and improve water quality by evenly distributing flows over a stabilized vegetated surface. There are many different types and functions of level spreaders. Examples include concrete sills (or lips), curbs, earthen berms, and level perforated pipes.

For the purposes of the Manual, there are essentially two categories of level spreaders. The first type of level spreader (Inflow) is meant to evenly distribute flow entering into another structural BMP, such as a filter strip, infiltration basin, or vegetated swale. Examples of this type of level spreader include concrete sills (or lips), curbs, and earthen berms. The second type of level spreader (Outflow) is intended to reduce the erosive force of low to moderate flows while at the same time enhancing natural infiltration opportunities. Examples of this second type include a level, perforated pipe in a shallow aggregate trench (similar to an Infiltration Trench) and earthen berms. While the first type of level spreader can be a very effective measure, it is already discussed in some detail as a design consideration in other structural BMPs and particularly in BMP 6.4.10 Infiltration Berms. This section therefore, focuses primarily on the second category of level spreaders.

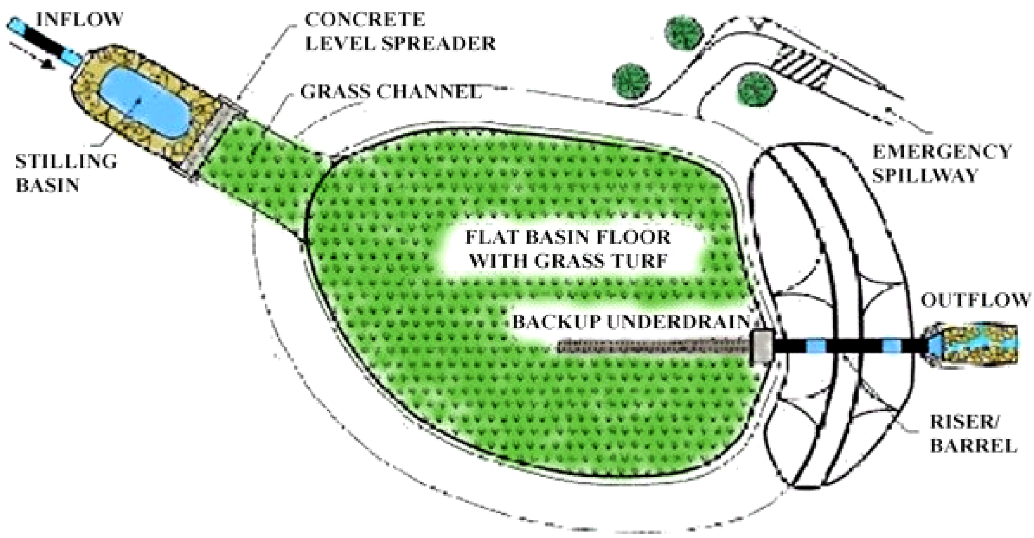
Outflow level spreaders are often used in conjunction with other structural BMPs, such as BMP 6.4.2 Infiltration Basins and BMP 6.4.3 Subsurface Infiltration Bed. However, in certain situations, they can be used as “stand alone” BMPs to dissipate runoff from roofs or other impervious areas. In either case, level spreaders might account for some level of volume and rate reduction, the degree to which depends on the specific design, natural infiltration rate of the soil, amount of influent runoff, vegetation density and slope of downhill area, and extent (length of level spreader). Specific credit, as defined in BMPs 5.8.1 and 5.8.2, is given to stand alone level spreaders for impervious areas greater than 500 square feet.

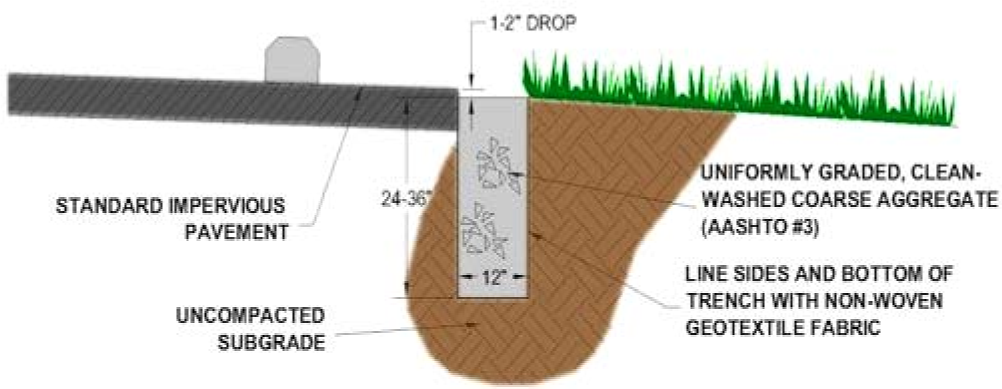
A typical level spreader that is used in conjunction with another structural BMP is a level perforated pipe in a shallow aggregate trench. Though the actual design will vary, a “level spreader pipe” should be designed to at least distribute to the 10-year storm. Depending on the computed flow rate and available space, the designer may provide enough length of pipe to distribute the 100-year storm (see Design Considerations). If space is limited, then flows above the 10-year storm may be allowed to bypass the level spreader. The level spreader pipe must be installed evenly along a contour at a shallow depth in order to ensure adequate flow distribution and discourage channelization. In some cases, a level spreader pipe may be “upgraded” to an Infiltration Trench if additional volume and rate reduction is required (see BMP 6.4.4, Infiltration Trench).

The condition of the area downhill of a level spreader should be considered prior to installation. For instance, the slope, density and condition of vegetation, natural topography, and length (in the direction of flow) will all affect the effectiveness of a distributed flow measure. Areas immediately downhill from a level spreader may need to be stabilized, especially if they have been recently disturbed. Erosion control matting and/or compost blanketing are the recommended measures for achieving permanent downhill stabilization. Permanent vegetative stabilization should be in place prior to placing the level spreader into operation. Manufacturer’s specifications should be followed for chosen stabilization measure.

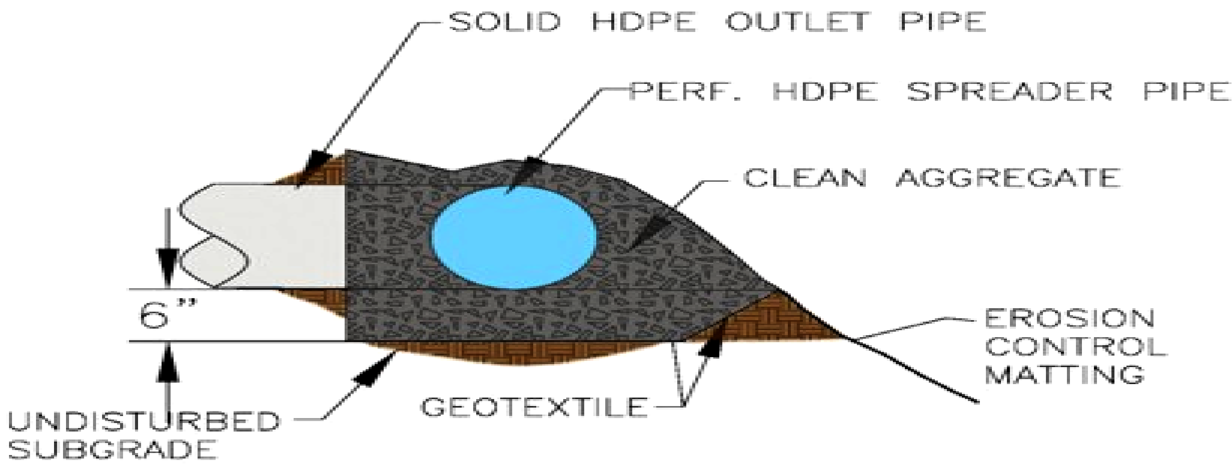
Variations

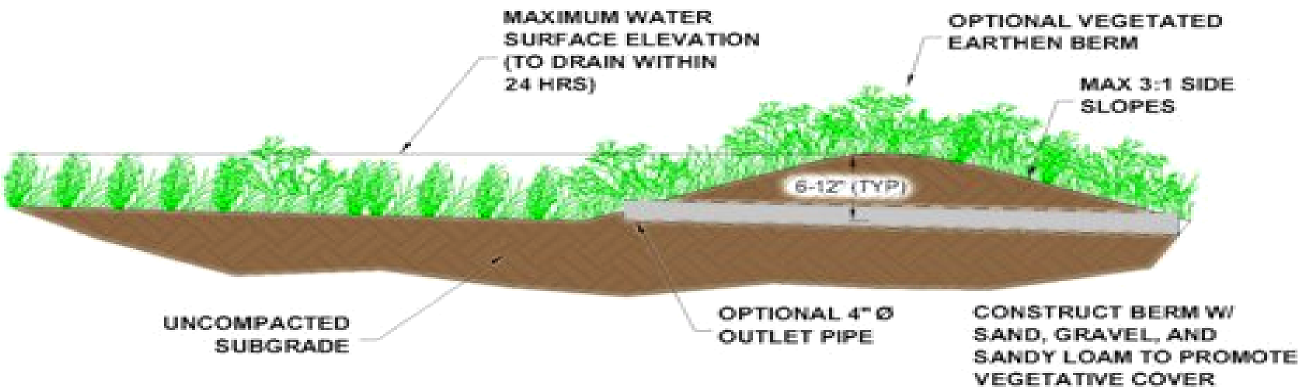
- **Inflow Level Spreaders**
  Evenly distribute flow entering into another structural BMP, such as a filter strip or infiltration basin. Examples include concrete sills (or lips), curbs, concrete troughs, ½ pipes, short standing PVC-silt fence, aggregate trenches, and earthen berms (see Infiltration Berms and Filter Strips). To ensure even distribution of flow, it is critical that these devices be installed as levelly as possible. More rigid structures (concrete, wood, etc.) are often preferable to earthen berms, which have the potential to erode.





- **Outflow Level Spreaders (in conjunction with structural BMP)**
  Reduces the erosive force of low to moderate flows while at the same time enhancing natural infiltration opportunities. Examples include a level perforated pipe in a shallow aggregate trench (similar to an Infiltration Trench) and earthen berms.





- **Outflow Level Spreader (stand alone)**
  Distribute runoff from roofs or other impervious areas of 500 square feet or less. Unless modified to approximate an Infiltration Trench, stand-alone level spreaders do not usually account for substantial volume or rate reductions. However, if designed and installed properly, they still represent effective flow diffusion devices with some water quality benefits.

Applications

- **Ultimate outlet from structural BMPs not discharging directly to a receiving stream**
- **Roof downspout connections (roof area < 500sf)**
- **Inlet connections (impervious area < 500sf)**
- **Inflow to structural BMP, such as filter strip, infiltration basin**

Design Considerations

1. It is usually preferable to not initially concentrate stormwater and provide as many outfalls as possible. This can reduce or even eliminate the need for devices to provide even distribution of flow.

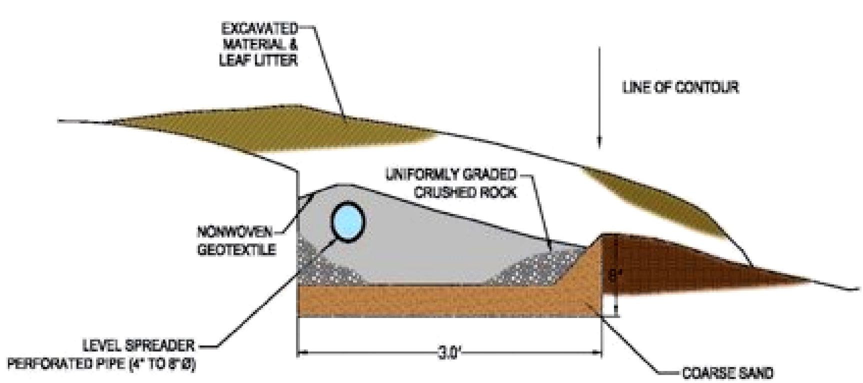
2. Receiving soils and land cover should be undisturbed or stabilized with vegetation or other permanent erosion-resistant material prior to receiving runoff. Level spreaders are not applicable in areas with easily erodable soils and/or little vegetation. The slope below the level spreader should be relatively smooth in the direction of flow to discourage channelization. The minimum flow length of the receiving area should be 75 feet.

3. For design considerations of earthen berm level spreaders refer to BMP 6.4.10 Infiltration Berm.

4. Level spreaders should not be located in constructed fill. Virgin soil is much more resistant to erosion than fill.

5. Level spreaders should not be used for sediment removal. Significant sediment deposition in a level spreader will render it ineffective.

6. A perforated pipe level spreader may range in size from 4 to 12 inches in diameter. The pipe should be laid in an envelope of AASHTO #57 stone, the thickness of which is based upon the desired volume reduction. A deeper trench will provide additional volume reduction and should be included in the calculations (see BMP 6.4.4 Infiltration Trench). Non-woven geotextile should be placed below the aggregate to discourage clogging by sediment.



7. The length of level spreaders is primarily a function of the calculated influent flow rate. The level spreader should be long enough to freely discharge the calculated peak flow rate. At a minimum, the peak flow rate shall be that resulting from a 10-year/24-hour design storm. This flow rate should be safely diffused without the threat of failure (i.e. creation of erosion gullies or rills). Diffusion of the storms greater than the 10-year/24-hour storm is permissible if space permits. Generally, level spreaders should have a minimum length of ten feet and a maximum length of 200 feet.

   Conventional level spreaders designed to diffuse all flow rates should be sized based on the following:

   For grass or thick ground cover vegetation:

   a) 13 linear feet of level spreader for every 1 cfs flow
   b) Slopes of 8% or less from level spreader to toe of slope

   For forested areas with little or no ground cover vegetation:

   a) 100 linear feet of level spreader for every 1 cfs flow
   b) Slopes of 6% or less from level spreader to toe of slope

   Determining the perforation discharge per linear foot of pipe may further refine the length of a perforated pipe level spreader. A level spreader pipe shall safely discharge in a distributed manner at the same rate of inflow. Perforated pipe manufacturers' specifications provide the discharge per linear foot of pipe, though it is typically based on the general equation for flow through an orifice. Manufacturer's specifications can be used to find the right combination of length and size of pipe. If the number of perforations per linear foot (based on pipe diameter) and average head above the perforations are known, then the flow can be determined by the following equation:

   L (length of level spreader pipe) = Q / Q_L

   Q_L (discharge per linear foot) = Q_O * # of perforations per linear foot of pipe (provided by manufacturer, based on perforation diameter)

   Q_O (perforation flow rate) = $C_d * A * (2 * g * H)^{0.5}$

   Q_O = the free outfall flow rate through one perforation (ft^3/sec)
   C_d = Coefficient of discharge (typically 0.60)
   A = Cross sectional area of one perforation (ft^2)
   g = 32.2 ft/sec^2
   H = head, average height of water above perforation (ft) (provided by manufacturer)

   For example, the 10- and 100-year design flows for a site were determined to be 2 and 5 cfs, respectively. Assuming a 12-in diameter pipe with thirty-six 0.375-in. diameter perforations per linear foot and an H value of 0.418 feet, the discharge per linear foot is calculated at 0.086 cfs/ft. When the two design flows are divided by the discharge per linear foot, the resulting required lengths are 24 and 59 feet, respectively.

This calculation assumes a free flow condition. Since the level spreader pipe is encased in aggregate (which is around 40% void space) this assumption is usually acceptable. However, for this reason and to account for the potential for clogging of perforations over time, the length of pipe should be multiplied by minimum factor of safely of 1.1.

8. Flows (> 10-year storm peak rate) may bypass a level spreader in a variety of ways, including an overflow structure or up-turned ends of pipe. (The ends of the perforated pipe could be turned uphill at a 45-degree angle or more with the ends screened.) Cleanouts/overflow structures with open grates can also be installed along longer lengths of perforated pipe. The designer shall provide stabilization measures for bypassed flows in a manner consistent with the Pennsylvania Erosion and Sedimentation Pollution Control Program Manual.

9. Erosion control matting or compost blanketing is recommended immediately downhill and along the entire length of the level spreader, particularly in those areas that are unstable or have been recently disturbed by construction activities. Generally, low flows that are diffused by a level spreader do not require additional stabilization on an already stabilized and vegetated slope. The installation requirements for erosion control methods will vary according to the manufacturer's specifications.

   There are a variety of permanent erosion control alternatives to riprap currently on the market. Turf/reinforcement matting is a manufactured product that combines vegetative growth and synthetic materials to reduce the potential for soil erosion on slopes. It is typically made of synthetic materials that will not biodegrade and will create a foundation for plant roots to take hold, extending the viability of grass beyond its natural limits.

   Compost blankets are an emerging technology that serves a similar function to permanent erosion control matting. When compost is applied as a "blanket" over a disturbed area, it encourages a thicker, more permanent vegetative cover due to its ability to improve the infrastructure of the soil. Compost blankets reduce runoff volume by holding water in its pores and improve water quality by binding and degrading specific chemical contaminants.

Detailed Stormwater Functions

Volume Reduction Calculations

In general, level spreaders do not substantially reduce runoff volume. However, for level spreaders designed similar to Infiltration Trenches, a volume reduction can be achieved. Also, for level spreaders serving as stand-alone BMPs (for contributing impervious up to 500 square feet), volume reduction credits, as discussed in BMPs 5.8.1 and 5.8.2, can be achieved for runoff disconnection. The true amount of volume reduction will depend on the length of level spreader, the density of vegetation, the downhill length and slope, the soil type of the receiving area, and the design runoff. Large areas with heavy, dense vegetation will absorb some flows, while barren or compacted areas will absorb limited amounts of runoff. See Section 9 for detailed calculation methodologies.

Peak Rate Mitigation Calculations

The influent peak rate to a level spreader will be diffused (or dissipated) over the length of the level spreader; the number of perforations in a level spreader pipe will essentially divide the concentrated flow into many smaller flows. To be conservative, and to allow for the possibility of re-convergence, the peak rate should be taken prior to diffusion from the level spreader. See Section 9 for detailed calculation methodologies.

Water Quality Improvement

Water quality improvements occur if the area down gradient of the level spreader is vegetated, stabilized, and minimally sloped. See Section 9 for Water Quality Improvement methodology, which addresses pollutant removal effectiveness of this BMP.

Construction Sequence

1. Level spreaders are considered a permanent part of a site's stormwater management system. Therefore, the uphill development should be stabilized before diverting runoff to any dispersing flow techniques. If the level spreader is used as an erosion and sedimentation control measure, it must be reconfigured (flush perforated pipe, clean out all sediment), to its original state before use as a permanent stormwater feature.

2. All contributing stormwater elements (infiltration beds, inlets, outlet control structures, pipes, etc) should be installed.

3. Perforated pipe should be installed along a contour, with care taken to construct a level bottom. The pipe can be underground in a shallow infiltration trench (see Infiltration Trench for design guidance), or closer to the surface and covered with a 12-inch thick layer of AASHTO #57 stone. If the perforated pipe is in a trench, excavate to the design dimensions. If the pipe is to be at or near the surface, some minor excavation or filling may be necessary to maintain a level bottom.

4. If necessary, install erosion control matting along the length of the level spreader and to a distance downhill, as specified by the manufacturer/supplier. Cover the pipe with AASHTO #57 stone.

5. For construction sequence of earthen berms, see BMP 6.4.10 Infiltration Berm.

Maintenance Issues

Compared with other BMPs, level spreaders require only minimal maintenance efforts, many of which may overlap with standard landscaping demands. The following recommendations represent the minimum maintenance effort for level spreaders:

- Catch Basins and Inlets draining to a level spreader should be inspected and cleaned on an annual basis.

- The receiving land area should be immediately restored to design conditions after any disturbance. Vegetated areas should be seeded and blanketed.

- It is critical that even **sheet flow conditions** are sustained throughout the life of the level spreader, as their effectiveness can deteriorate due to lack of maintenance, inadequate design/location, and poor vegetative cover.

    - **Inspection -** The area below a level spreader should be inspected for clogging, density of vegetation, damage by foot or vehicular traffic, excessive accumulations, and channelization. Inspections should be made on a quarterly basis for the first two years following installation, and then on a semiannual basis thereafter. Inspections should also be made after every storm event greater than 1-inch.

    - **Removal -** Sediment and debris should be routinely removed (but never less than semiannually), or upon observation, when buildup occurs in the clean outs. Regrading and reseeding may be necessary in the areas below the level spreader. Regrading may also be required when pools of standing water are observed along the slope. (In no case should standing water be allowed for longer than 72 hours.)

    - **Vegetation -** Maintaining a vigorous vegetative cover on the areas below a level spreader is critical for maximizing pollutant removal efficiency and erosion prevention. If vegetative cover is not fully established within the designated time, it may need to be replaced with an alternative species. (It is standard practice to contractually require the contractor to replace dead vegetation.) Unwanted or invasive growth should be removed on an annual basis. Biweekly inspections are recommended for at least the first growing season, or until the vegetation is permanently established. Once the vegetation is established, inspections of health, diversity, and density should be performed at least twice per year, during both the growing and non-growing season. Vegetative cover should be sustained at 85% and replaced if damage greater than 50% is observed.

Cost Issues

As there are various types of level spreaders, their associated costs will vary. Per foot material and equipment cost will range from $5 to $20 depending on the type of level spreader desired. Concrete level spreaders may cost significantly more than perforated pipes or berms. (For more detailed cost information in BMP 6.4.4 Infiltration Trenches and BMP 6.4.10 Infiltration Berms.)

Specifications

The following specifications are provided for information purposes only. These specifications include information on acceptable materials for typical applications, but are by no means exclusive or limiting. The designer is responsible for developing detailed specifications for individual design projects in accordance with the project conditions.

1. **Stone** shall be 2-inch to 1-inch uniformly graded coarse aggregate, with a wash loss of no more than 0.5%, AASHTO size number 3 per AASHTO Specifications, Part I, 19th Ed., 1998, or later and shall have voids ³ 35% as measured by ASTM-C29.

2. **Non-Woven Geotextile** shall consist of needled non-woven polypropylene fibers and meet the following properties:
   a. Grab Tensile Strength (ASTM-D4632) ³ 120 lbs
   b. Mullen Burst Strength (ASTM-D3786) ³ 225 psi
   c. Flow Rate (ASTM-D4491) ³ 95 gal/min/ft^2
   d. UV Resistance after 500 hrs (ASTM-D4355) ³ 70%
   e. Heat-set or heat-calendared fabrics are not permitted
   Acceptable types include Mirafi 140N, Amoco 4547, and Geotex 451.

3. **Topsoil** amend with compost (See BMP 6.7.3, Soil Amendment & Restoration)

4. **Pipe** shall be solid or continuously perforated, smooth interior, with a minimum inside diameter of 4-inches. High-density polyethylene (HDPE) pipe shall meet AASHTO M252, Type S or AASHTO M294, Type S.

5. **Vegetation** see Native Plant List in Appendix B.

References

Maine Department of Transportation, 1992. *Maine Department of Transportation BMP Manual for Erosion and Sedimentation Control*.

NC Division of Water Quality. *Level Spreader Design Suggestions.* October 10, 2001.

Idaho Department of Environmental Quality. *Idaho Catalog of Stormwater BMPs.*

Auckland Regional Council, 2003. *Stormwater Management Devices: Design Guidelines Manual*, Auckland, New Zealand

US EPA, NPDES, *Construction Site Storm Water Runoff Control – Permanent Diversions*

Designing Level Spreaders to Treat Stormwater Runoff (W.F. Hunt, D.E. Line, R.A. McLaughlin, N.B. Rajbhandari, R.E. Sheffield; North Carolina State University, 2001.)