West Virginia Stormwater Runoff Reduction Workshops

Center for Watershed Protection

Site Design Practices

1. Alternative Surface: Vegetated Roof
2. Impermeable Surface Disconnection
3. Permeable Pavement
4. Grass Channel
5. Dry Swale
6. Bioretetnion
7. Infiltration
8. Extended Detention Pond
9. Sheet Flow To Vegetated Filter or Open Space

1. Vegetated Roof

Green (Vegetated) Roofs

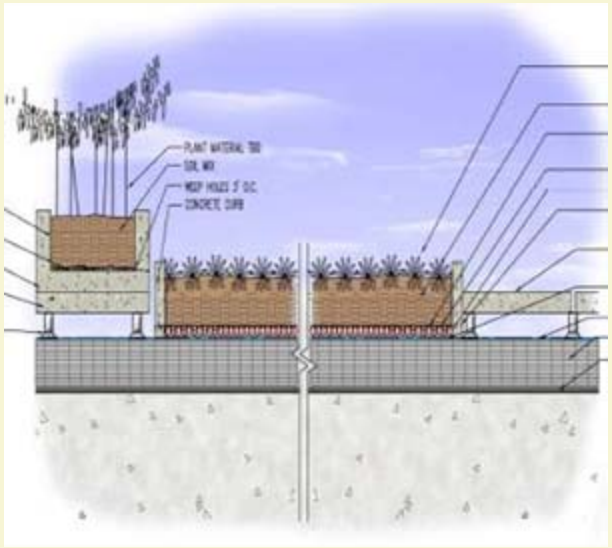
Function:

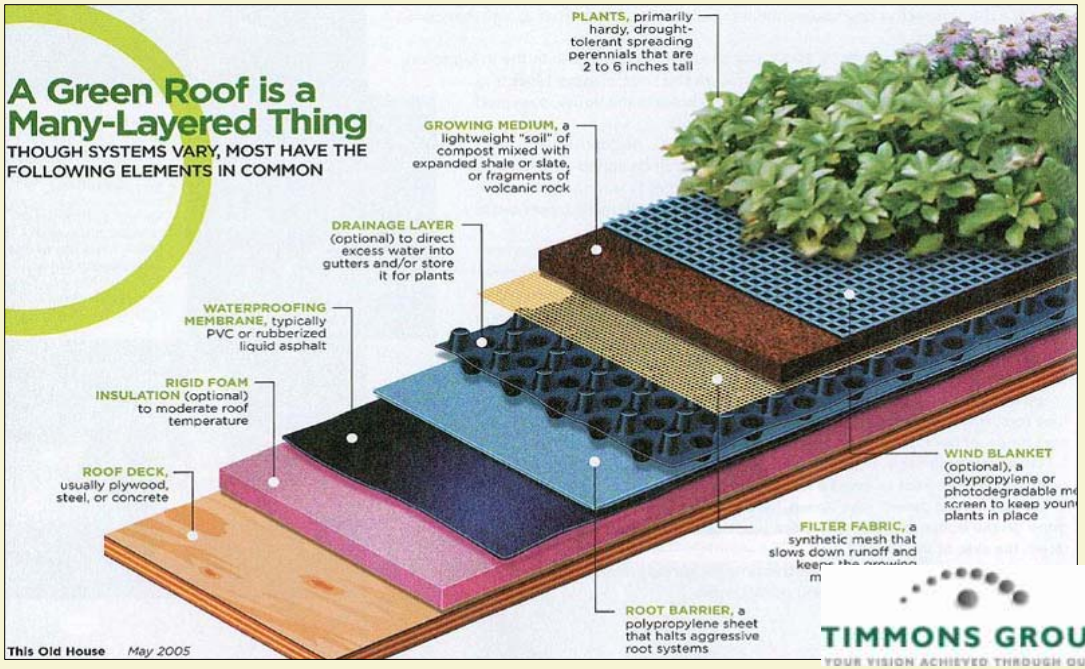
- Green roofs capture and temporarily store stormwater runoff in the growing media before it is conveyed into the storm drain system.
- A portion of the captured stormwater evaporates or is taken up by plants, which helps reduce the runoff volume and the peak rate of discharge from the roof.

Vegetated Roof: Elements

Intensive: deeper growing media layer that ranges from **6 inches to 4 feet** thick;

Extensive: much shallower growing media (**2 to 6 inches**), which is planted with carefully selected drought tolerant vegetation





Runoff Reduction Credit: Vegetated Roof

Summary of Stormwater Functions Provided by Vegetated Roofs [1]	
Stormwater Function	Reduction Credit
Annual Runoff Reduction (RR)	45% - 60%[3]
Channel Protection & Flood Mitigation [2]	Use the following Curve Numbers (CN) for Design Storm events: 1-year storm = 64; 2-year storm = 66; 10-year storm = 72; and the 100 year storm = 75

[1] Sources: CWP and CSN (2008) and CWP (2007).
[2] See Miller (2008), NVRC (2007) and MDE (2008)
[3] This credit is based on the available runoff reduction research. The credit provided for stormwater design in West Virginia is 100% (assuming adequate practice sizing) due to the consideration of extended filtration benefits in addition to runoff reduction.

Green Roof: Benefits

1050K Street, Washington, DC

- Economic
  - Heating and cooling energy use
  - Extended roof life – anecdotal evidence from Germany shows 2-3 X roof life, from 20 to 40-60 years.
- Social
  - Habitat – Living Space
  - Aesthetics –view-scape
- Environmental
  - Urban heat island reduction
  - Temperature
  - Stormwater

Image courtesy of Timmons Group

3. Permeable Pavement

Permeable Pavements

- Permeable Interlocking Concrete Pavers (PICP)

- Pervious Concrete (PC)

- Porous Asphalt (PA)

Permeable Pavements

- Due to high surface infiltration rates:
  - Reduce runoff quantity
  - Lower peak runoff rates
  - Delay peak flows
- Even in applications with underdrains

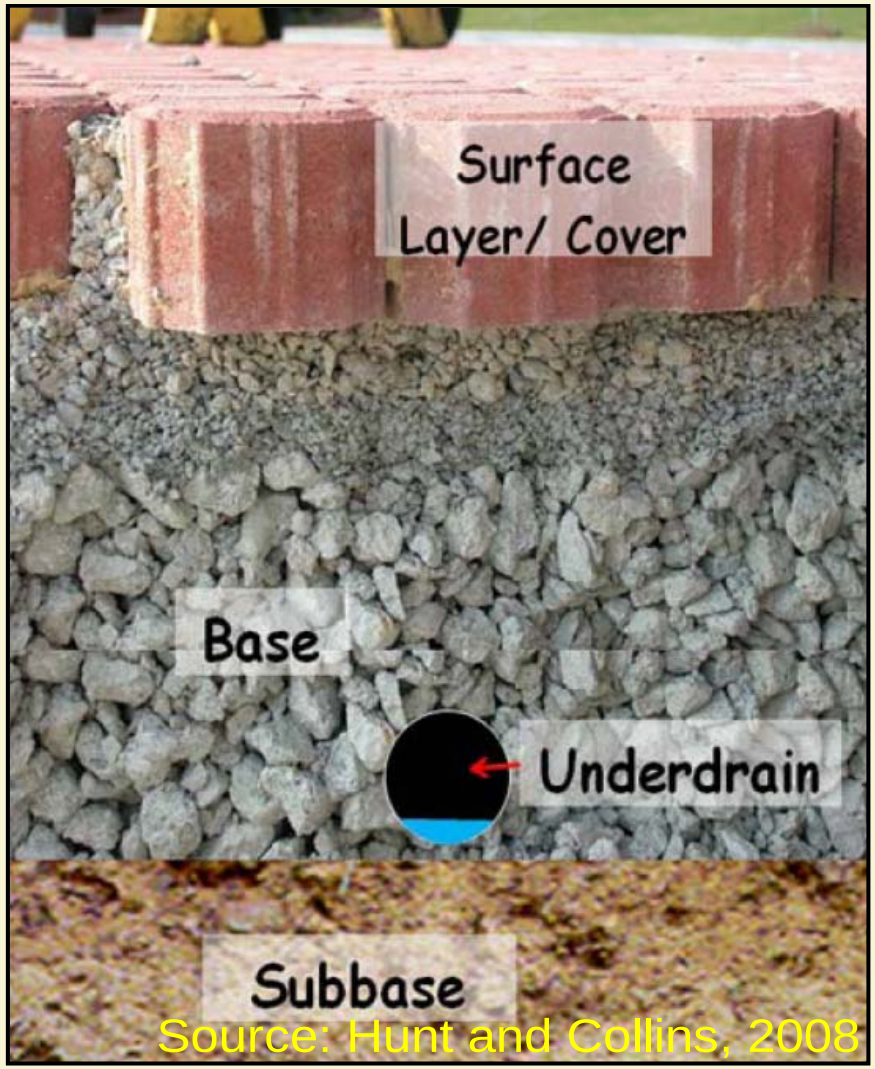
Runoff Reduction Credit: Permeable Pavements

Summary of Stormwater Functions Provided by Permeable Pavement [1]		
Stormwater Function	With Underdrain	Without Underdrain
Annual Runoff Reduction	**45%**[2]	**75%**[2]
Channel Protection	**Moderate.** May be able to provide some or all within the reservoir layer	
Flood Mitigation	**Partial.** May be able to provide some in the reservoir layer	

[1] **Sources:** CWP and CSN (2008) and CWP (2007).

[2] This credit is based on the available runoff reduction research. The credit provided for stormwater design in West Virginia is 100% (assuming adequate practice sizing) due to the consideration of extended filtration benefits in addition to runoff reduction.

Permeable Pavement (PP) Basic Sizing



- Maximum ratio of external pavement to PP is 2:1
- Pavement slope ≤ 5%
- Limit pervious "runon"
- Soil infiltration rate ≥ 0.5 in/hr (HSG A or B); **or**
- Underdrain with 12" gravel sump;
- Stone layer porosity = 0.4
- 48 hr drawdown of storage reservoir w/ control structure

4. Grass Channels

Grass Channels

- Grass Channels can replace C&G or Storm drain for up to five acres contributing DA;
- Allowable %IC will be determined by flow and velocity limits;
- Shorter "headwater" channels can be used prior to drop inlets to storm drain pipes in denser developments

Runoff Reduction Credit: Grass Channels

Summary of Stormwater Functions Provided by Grass Channels [1]				
Stormwater Function	**HSG Soils A and B**		**HSG Soils C and D**	
	No CA [2]	**With CA**	**No CA**	**With CA**
Annual Runoff Reduction Rate (RR)	20%	NA [3]	10%	30%
Channel & Flood Protection	**Partial.** Designers can use the RR spreadsheet to adjust curve number for each design storm for the contributing drainage area, based on annual runoff reduction achieved; and Designers can account for the Tc for the grass swale flow path reflecting the effective slope and appropriate roughness for the intended vegetative cover.			

[1] CWP and CSN (2008) and CWP (2007).

[2] CA= Compost Amended Soils.

[3] Compost amendments are generally not applicable for undisturbed A & B soils, although it may be advisable to incorporate them on mass-graded and/or excavated soils to maintain runoff reduction rates. **In these cases, the 30% runoff reduction rate may be claimed, regardless of the pre-construction HSG**.

Grass Channels: Basic Sizing

- Bottom width 4 to 8 feet.
- Side-slopes 3H:1V or flatter.
- The maximum total contributing drainage area 5 acres.
- The longitudinal slope less than 4% (check dams may be used to reduce the effective slope to meet velocity requirements).
- The maximum flow velocity of the channel must be less than 1 foot per second during a 1-inch storm event.
- Flows non-erosive during the 2-year and 10-year design storm events
- 10-year design flow is contained within the channel (minimum of 6 inches of freeboard).

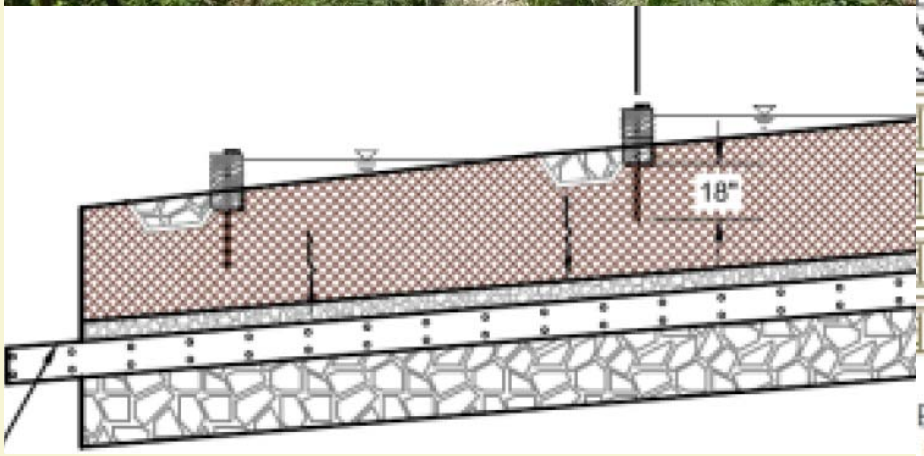
Grass Channel Applications

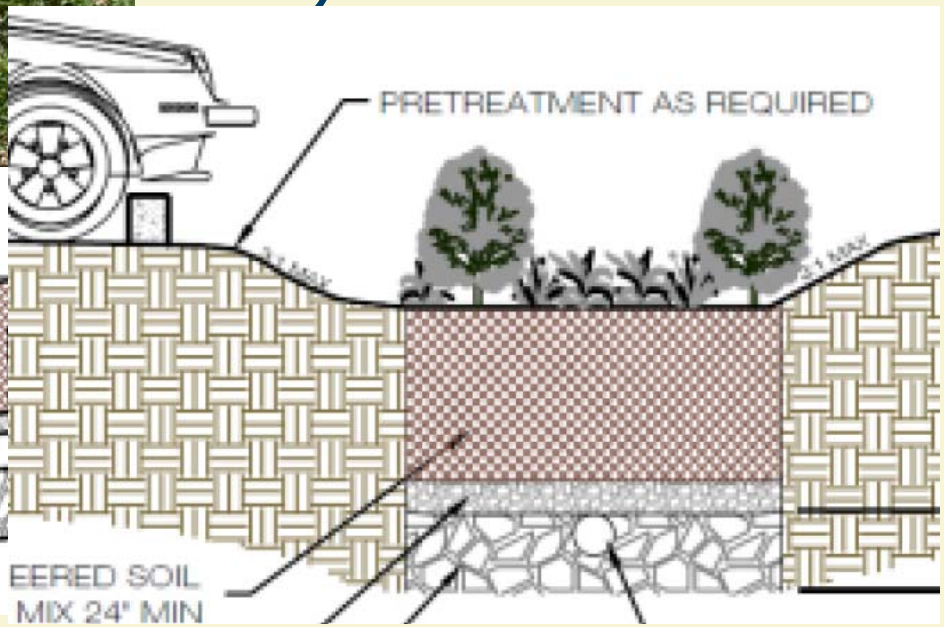
- Best Applications
  - Low density residential
  - To treat turf areas
  - As pretreatment to another practice
  - Along highways.
- Limitations
  - Highly impervious areas
  - Steep slopes
  - Large drainage areas
  - Hotpot runoff

5. Dry Swales

Dry Swale Design Choices

Linear Bioretention: similar design choices (e.g.. sizing, soil testing, filter depth, media recipe, etc.)





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Dry Swale Design Choices

- Connected dry swale storage cells
- Expanded within "treatment train" to street bioretention or street planter boxes (expanded tree pits)

Dry Swale Design Choices

Steep Slopes

- Terracing to break up steep slopes (rather than check dams);
- Stone or concrete weirs become a major design element to prevent erosion from major events

Dry Swale Performance

- Excellent research in recent years
- Significant reduce runoff volume (mean 40%)
- May be as high as 80% with greater ET and less efficient underdrain collection

Runoff Reduction Credit: Dry Swales

Summary of Stormwater Functions Provided by Dry Swales [1]		
Stormwater Function	**Level 1 Design**	**Level 2 Design**
Annual Runoff Reduction (RR)	40%[2]	60%[2]
Channel & Flood Protection	**Partial.** Designers can use the RR spreadsheet to adjust curve number for each design storm for the contributing drainage area, based on annual runoff reduction achieved; and Designers can account for the Tc for the grass swale flow path reflecting the effective slope and appropriate roughness for the intended vegetative cover.	

[1] CWP and CSN (2008) and CWP (2007)

[2] This credit is based on the available runoff reduction research. The credit provided for stormwater design in West Virginia is 100% (assuming adequate practice sizing) due to the consideration of extended filtration benefits in addition to runoff reduction.

Dry Swales: Basic Sizing

- Bottom width of swale: 4 ft to 8 ft;
- Swale side slopes: 3H:1V or flatter;
- Effective swale slope ≤ 1%;
- Soil media depth: 18″ to 36″
- Soil Infiltration: 0.5″/hr (HSG Soils A&B) **or**
- Underdrain with minimum 12″ gravel sump;
- Pre-treatment required:
  - Forebay;
  - Grass filter strip
  - Gravel diaphragm level spreader

Dry swales: Basic Sizing

- Basic Sizing:
  - Storage volume provided:

    SA*{(soil depth*0.25)+(gravel depth*0.4)+(surface ponding*1.0)}
  - Additional storage may be provided within the soil depth, ponding behind check dams, gravel depth, or other subsurface storage (chambers, etc.,)
  - Flows from larger storms may be conveyed through the dry swale if sufficient capacity is provided.

6. Bioretention

Bioretention Design Choices: Inflow

- Concentrated inflow;
- Sheet flow inflow

Bioretention Design Choices: Pretreatment

Nature of pretreatment depends on size of bioretention area and type of flow it experiences

- Concentrated flow: two cell design with a small trapping "forebay" and level spreader
- Sheet flow: grass filter strip, stone diaphragm, stone ring berm

Runoff Reduction Credit: Bioretention

Summary of Stormwater Functions Provided by Bioretention Areas [1]		
Stormwater Function	With Underdrain	Without Underdrain
Annual Runoff Reduction	40%[2]	80%[2]
Channel & Flood Protection	**Partial.** Designers can use the RR spreadsheet to adjust curve number for each design storm for the contributing drainage area.	

[1] **Sources:** CWP and CSN (2008) and CWP (2007).
[2] This credit is based on the available runoff reduction research. The credit provided for stormwater design in West Virginia is 100% (assuming adequate practice sizing) due to the consideration of extended filtration benefits in addition to runoff reduction.

Bioretention: Basic Sizing

- Contributing Drainage Area:
  - Max contributing DA ≤ 2.5 ac.
  - CDA as close to 100% IC as possible
  - Small and micro-scale preferred
- Pre-treatment:
  - Forebay
  - Grass Filter Strip
  - Gravel Diaphragm level spreader
- Soil Infiltration Rate: 0.5”/hr (HSG Soils A & B) **or**
- Underdrain with 12” sump

Bioretention: Basic Sizing

- Basic Sizing:
  - Surface Area≈5% to 6% of contributing DA
  - Max ponding depth: 12”
  - Minimum soil media depth: 24”
  - Maximum soil media depth: 36”
- Storage Volume Provided:
  - SA*{(soil depth*0.25)+(gravel depth*0.4)+(surface ponding*1.0)}
  - Additional storage may be provided within the soil depth, ponding behind check dams, gravel depth, or other subsurface storage (chambers, etc.,)
  - Flows from larger storms may be conveyed through the dry swale if sufficient capacity is provided.

7. Infiltration

Infiltration Systems

Design Variations

- Infiltration trench
- Infiltration basin

Clogging Concerns

Infiltration Systems: Pretreatment

No Pretreatment

Good Pretreatment:
Grass Swale

Infiltration: Required Pretreatment

- Pretreatment Options:
  - Forebay
  - Grass channel or filter strip
  - Gravel diaphragm level spreader
  - Other methods
- Non erosive exit velocities from pretreatment;
- Distribute flow evenly across the width of the practice

Runoff Reduction Credit: Infiltration

Summary of Stormwater Functions Provided by Infiltration	
Stormwater Function	Runoff Reduction Credit
Annual Runoff Reduction (RR)	50% - 90%[2]
Channel and Flood Protection	• Use the RRM spreadsheet to calculate the Curve Number (CN) adjustment;

[1]CWP and CSN (2008); CWP (2007)

[2] This credit is based on the available runoff reduction research. The credit provided for stormwater design in West Virginia is 100% (assuming adequate practice sizing) due to the consideration of extended filtration benefits in addition to runoff reduction.

Infiltration: Basic Sizing

- Minimum soil infiltration rate: 0.52”/hr (HSG Soils A & B);
- Minimum 2 ft between bottom of practice and seasonal high water or bedrock;
- Pre-treatment is required

8. Extended Detention Pond

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Runoff Reduction Credit: Extended Detention

Summary of Stormwater Functions Provided by Extended Detention Ponds	
Stormwater Function	**Annual Runoff Reduction Credit**
Annual Runoff Reduction (RR)	10%
Channel & Flood Protection	Yes; storage volume can be provided to accommodate the full Channel Protection requirements (1-yr; 2-yr, etc.) and Flood Protection requirements (10-yr)
[1]CWP and CSN (2008); CWP (2007)	

Extended Detention Pond: Basic Sizing

- A & B soil types can yield to significant volume reductions;
- Karst terrain (may need to limit the applicability);
- Pretreatment required
  - Forebay;
  - Micropool;
- Length to width ratio ≥ 3:1
- 12-hour extended detention time for the runoff reduction volume.

Extended Detention Pond