Module 6

Construction Inspections of 15 Non-Proprietary BMPs

VIRGINIA DEPARTMENT OF ENVIRONMENTAL QUALITY

Module 6 Objectives

- Recognize critical features of BMPs
- Identify and prioritize key BMP inspection points
- Describe key inspection elements across BMPs
- Use BMP specs and approved SWM plans to locate relevant BMP design and construction details

Specs include design criteria table

Table 1.2: Simple Rooftop Disconnection Design Criteria [1]

DESIGN FACTOR	SIMPLE DISCONNECTION
Maximum impervious (Rooftop) Area Treated	1,000 sq. ft. per disconnection
Longest flow path (roof/gutter)	75 feet
Disconnection Length	Equal to longest flow path, but no less than 40 feet [2]
Disconnection slope	< 2%, or < 5% with turf reinforcement [3]
Distance from buildings or foundations	Extend downspouts 5 ft. [4] (15 ft. in karst areas) away from building *if grade is less than 1%*.
Type of Pretreatment	External (leaf screens, etc)

[1] For alternative runoff reduction practices, see the applicable specification for design criteria. See Table 1 in this specification for eligible practices and associated specification numbers.

[2] An alternative runoff reduction practice must be used when the disconnection length is less than 40 feet.

[3] Turf reinforcement may include EC-2, EC-3, or other appropriate reinforcing materials that

Specs include construction sequence

SECTION 8: CONSTRUCTION

8.1. Construction Sequence for Conserved Open Space Areas

The Conserved Open Space must be fully protected during the construction stage of development and kept outside the limits of disturbance on the Erosion and Sediment (E&S) Control Plan.

- No clearing, grading or heavy equipment access is allowed except temporary disturbances associated with incidental utility construction, restoration operations or management of nuisance vegetation.
- The perimeter of the Conserved Open Space shall be protected by super silt fence, chain link fence, orange safety fence, or other measures to prevent sediment discharge.
- The limits of disturbance should be clearly shown on all construction drawings and identified and protected in the field by acceptable signage, silt fence, snow fence or other protective barrier.

Specs include maintenance inspection points

9.2. Maintenance Inspections

Annual inspections are used to trigger maintenance operations such as sediment removal, spot re-vegetation and level spreader repair. Ideally, inspections should be conducted in the non-growing season when it easier to see the flow path. Example maintenance inspection checklists for Sheet Flow to a Filter Strip or Conserved Open Space areas can be accessed in Appendix C of Chapter 9 of the Virginia Stormwater Management Handbook or at the Center for Watershed Protection's website at:

http://www.cwp.org/Resource_Library/Controlling_Runoff_and_Discharges/sm.htm
(scroll to Tool6: Plan Review, BMP Construction, and Maintenance Checklists)

Inspectors should check to ensure that:

- Flows through the Filter Strip do not short-circuit the overflow control section;
- Debris and sediment does not build up at the top of the Filter Strip;
- Foot or vehicular traffic does not compromise the gravel diaphragm;
- Scour and erosion do not occur within the Filter Strip;
- Sediments are cleaned out of Level Spreader forebays and flow splitters; and
- Vegetative density exceeds a 90% cover in the boundary zone or grass filter.

Sample Construction Inspection Checklists (DEQ Training Page)

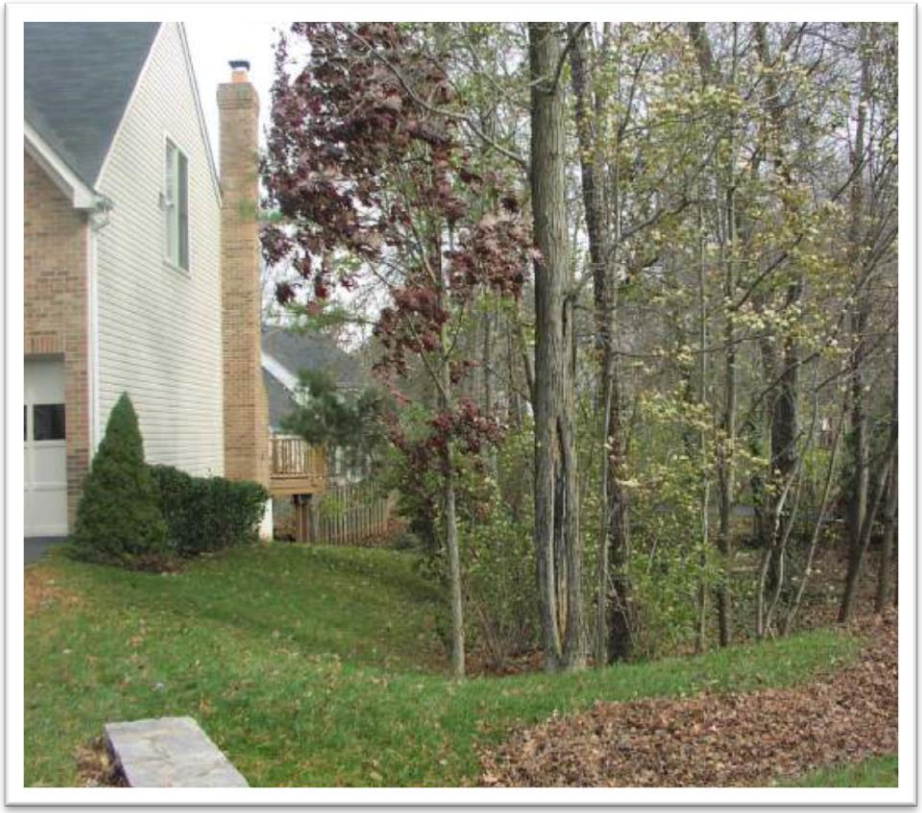
Sample Construction Inspection Checklist: Permeable Pavement

The following checklist provides a basic outline of the anticipated items for the construction inspection of permeable pavement for use as stormwater BMPs. This checklist does not necessarily differentiate between the types of pavement materials and the different construction requirements. The designer and the VSMP Authority personnel should consult with the manufacturer of the material to ensure that proper construction oversight and inspections are provided. Also, users of this information may wish to incorporate these items into a VSMP Authority Construction Checklist format consistent with the format used for erosion and sediment control and BMP construction inspections.

- ☐ **Pre-construction meeting**
  - ☐ Walk through site with builder/contractor/subcontractor to review the SWPPP (erosion and sediment control plan, the stormwater management plan, and the Pollution Prevention plan)
  - ☐ Determine when permeable pavement is built in project construction sequence; before or after building construction and determine measures for protection and surface cleaning.
  - ☐ Identify the tentative schedule for construction and verify the requirements and schedule for interim inspections and sign-off.

Design Specification No. 1

Rooftop (Impervious Surface) Disconnection



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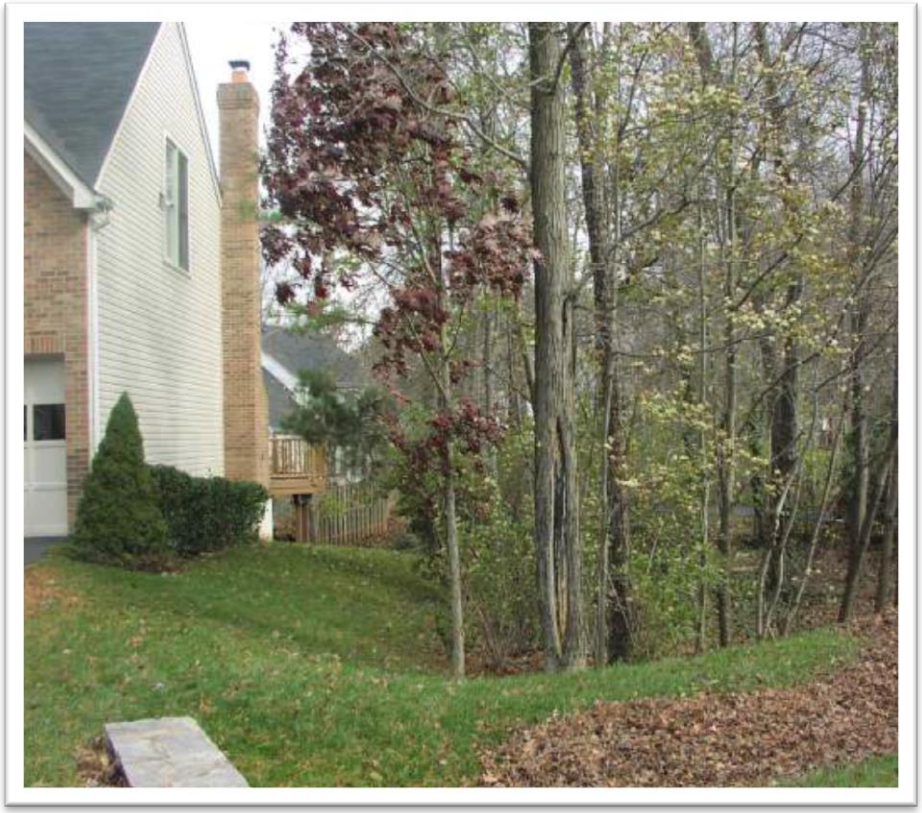
Two disconnection types allowed:

1. Simple
2. Alternative



Type 1. Simple Disconnection

Rooftops and/or on-lot impervious surfaces are directed to pervious areas

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Overview: Simple Disconnection

- Runoff volume reductions achieved by managing runoff as sheet flow close to its source and infiltrating into pervious areas

Key Considerations

- Advisable for lots > 6,000 ft^2
- Filter corridors from downspout
- Level spreader required for concentrated inflow

Simple disconnection design criteria

Design Factor	Simple Disconnection
Maximum impervious (Rooftop) Area Treated	1,000 sq. ft. per disconnection
Longest flow path (roof/gutter)	75 feet
Disconnection Length	Equal to longest flow path (no less than 40 feet)
Disconnection slope	< 2% or < 5% with turf reinforcement
Distance from buildings or foundations	Extend downspouts 5 ft. (15 ft. in karst areas) away from building *if grade is less than 1%.*
Type of Pretreatment	External (leaf screens, etc)

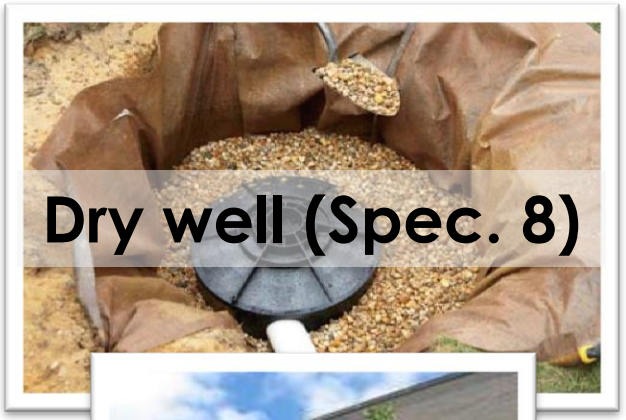
Key Considerations

- Table 1.2
  - Disconnection length
  - Disconnection slope
  - Distance from building or foundations

Key Considerations

- Level Spreader for Concentrated Flow
  - Level spreader length should be equal to width of disconnection area

Type 2. Alternative Disconnection



Inspections: **CONSTRUCTION**

- Before installation:
  - Drainage area stabilized?
  - Downspouts and runoff diverted away?
  - Disconnection paths correctly positioned based on actual topography and downspout locations?

Inspections: **CONSTRUCTION**

- Check during installation:
  - Length, width, slope, elevations of disconnection path - **Must match plan**
  - Depth of soil if amendments used - **Must match plan**

Inspections: **CONSTRUCTION**

- Check during installation:
  - Compaction
  - Erosion control matting or straw is in place
  - Level spreader properly installed - **Must match plan**

Inspections: CONSTRUCTION

- After installation:
  - Ensure vegetation is stable before downspouts diverted back to disconnection path

Design specification No. 2

Sheet Flow to a Vegetated Filter Strip or Conserved Open Space

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Two Types of Filter Strips

1) Conserved open space
2) Designed vegetated filter strips

Remember…

- Stormwater **must** enter as sheet flow
  - Inflow from pipe or channel requires an engineered level spreader

Conserved Open Space

- Outside limits of disturbance
- Marked on all construction drawings
- Protected by signage and erosion controls

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Vegetated Filter Strips

- Maximum slope steepness is 8% to maintain sheet flow through practice

Vegetated Filter Strip

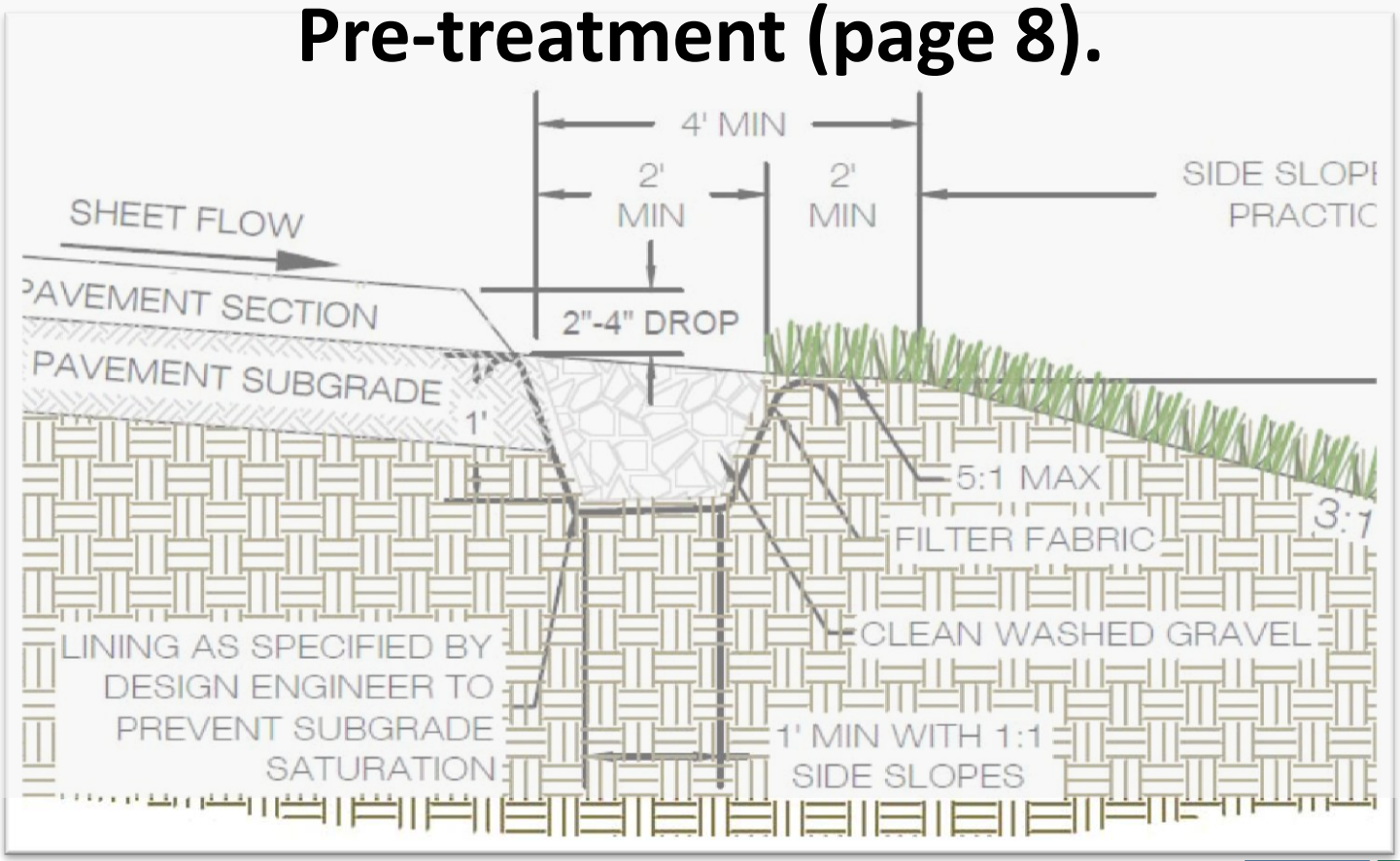
- Planting and Vegetation Management
  - 90% cover after second growing season
  - Seed, not sod
  - Compost soil amendments may be added

Vegetated Filter Strips

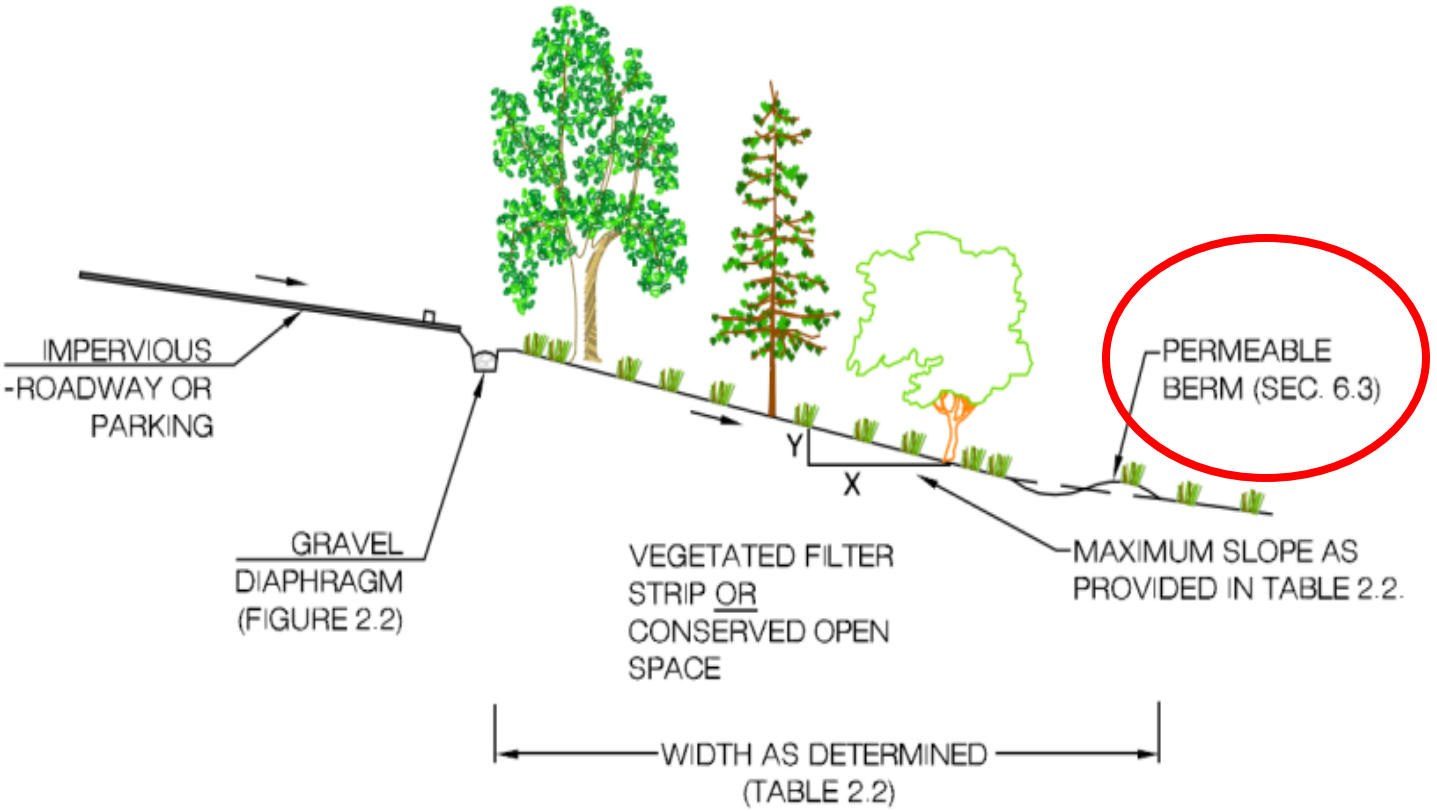
- Gravel Diaphragms:
  - Pea gravel diaphragm at top of slope required for **both** Conserved Open Space and vegetated filter strips that receive sheet flow

Vegetated Filter Strip

Figure 2.5 – Gravel Diaphragm – Sheet Flow Pre-treatment (page 8).



Vegetated Filter Strip



- TYPICAL CONFIGURATION OF SHEET FLOW TO VEGETATED FILTER STRIP OR CONSERVED OPEN SPACE.

Vegetated Filter Strip

- Engineered Level Spreaders
  - Concrete, metal, non-erodible material
  - Well anchored footer
  - Ends of level spreader section should be tied back into slope to avoid scouring around ends

Inspection: CONSTRUCTION

- ✓ Water diverted around filter strip area **prior to** installation?

Inspection: CONSTRUCTION

- ✓ Topsoil and/or compost even across filter strip?

Inspection: CONSTRUCTION

- ✓ Dimensions match approved plan?

Inspection: CONSTRUCTION

- ✓Runoff diverted to filter **only after** vegetation is well established?

Inspection: CONSTRUCTION

- ✓ Filter strip ok after first big storm?

Photo: R. Winston; BAE Stormwater Engineering Group, NCSU

Design Specification No. 3 Grass Channels

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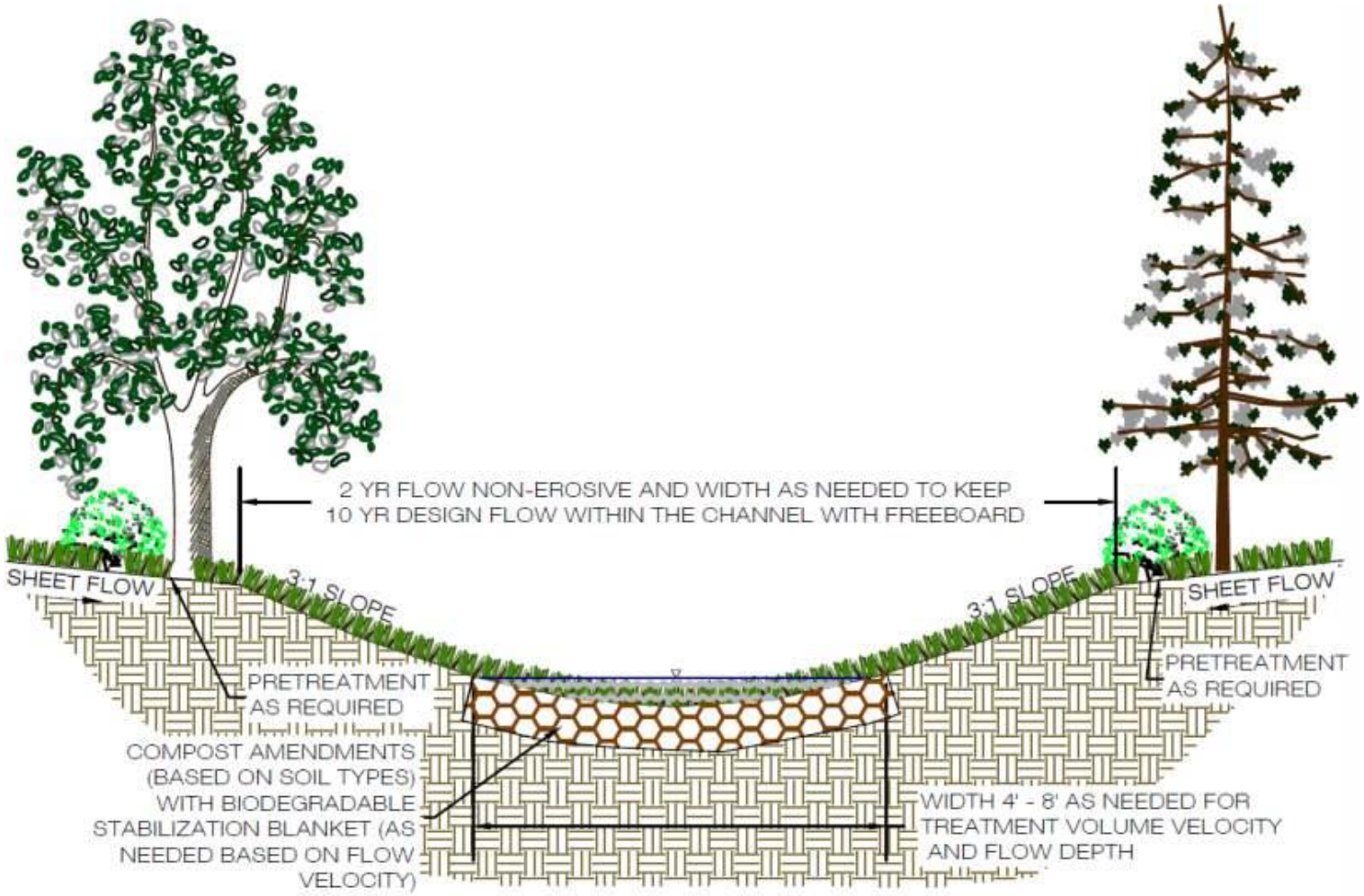
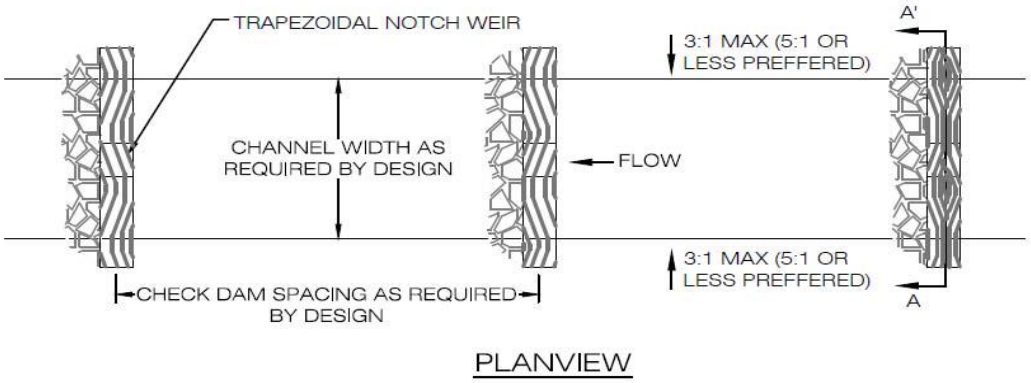
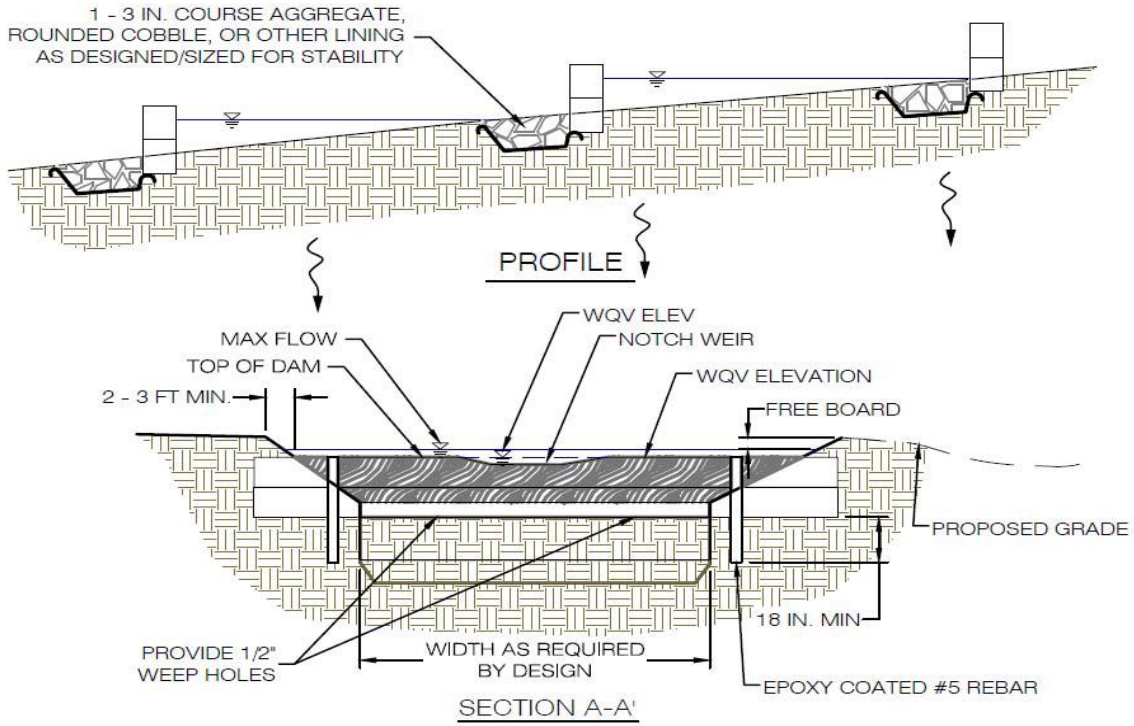
Grass Channel Design Guidance

- Bottom width of channel should be between 4 to 8 feet wide
- Channel side-slopes should be 3:1 or flatter
- Maximum total contributing drainage area to any individual grass channel is 5 acres

Grass Channel with Compost Amendments







NOTE: CHECK DAM CONSTRUCTED OF RAILROAD TIES, PRESSURE TREATED LOGS OR TIMBERS, OR CONCRETE.

Grass channel with check dams

Must match the plan!

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Inspection: CONSTRUCTION

- ✓ Drainage area stable OR water diverted around grass channel area **prior to** installation?
- ✓ Length, width, slope, and elevations of grass channel correct according to plan?
- ✓ Outfall protection/energy dissipation at concentrated inflows stable?

Inspection: CONSTRUCTION

- ✓ Soil amendments (if called for in plan) added at correct depth and distributed evenly across channel bottom?

Inspection: CONSTRUCTION

- ✓Turf coverage achieved and/or proper erosion control fabric installed **following** construction?

Design Specification No. 4 Soil Compost Amendment

Soil Compost Amendments

- Compacted disturbed urban soils: challenge and opportunity

Standard Landscape Development Practices

Cuyahoga Sustainability Network

Applications

- Used to enhance runoff reduction practices

Methods of Incorporation

- Deep Ripping/Subsoiler
- Spread & incorporate compost
- Grass/plant establishment
- NOTE: Some applications with deep incorporation of compost may require excavation and replacing soil/compost in lifts.

Photo Credit: Jeremy Balousek, P.E., Dane County, WI Land and Water Resources Department

Perpendicular to Flow Direction

Photo Credit: Jeremy Balousek, P.E., Dane County, WI Land and Water Resources Department

Smaller Areas

- Rototiller, tiller
- Hand spreading compost
- Seed & straw

Photo Credit: Richard McLaughlin, Ph.D., North Carolina State University

Establish Vegetation

Use Simple E&S Measures For Areas > 2,500 sf

Inspection: CONSTRUCTION

- Drainage Area Stabilized?
- Correct mix?
- Simple E&S measures for larger areas?
- Compost incorporated using right equipment to right depth?

Photo Credit: Richard McLaughlin, Ph.D., North Carolina State University

Inspection: CONSTRUCTION

- Dig test pit to verify depth of compost at one location per 10,000 ft^2

Design Specification No. 5 Vegetated Roof

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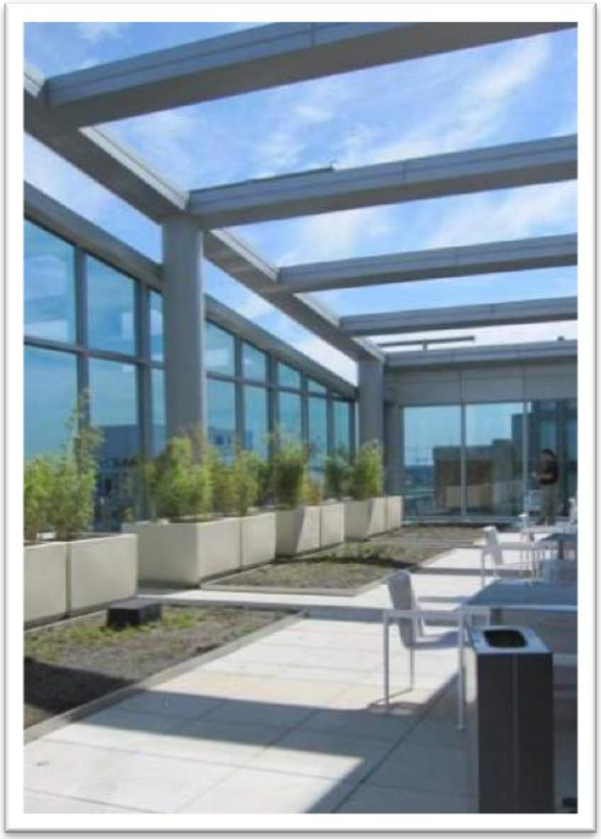
Green Roof Basics

- Extensive
- Intensive



1050K Street
Washington DC

Image courtesy of Timmons Group

Green Roof Design Elements:

Images courtesy of Timmons Group

Inspection: CONSTRUCTION

- Ensure proper coordination is taking place

Design Specification No. 6 Rainwater Harvesting

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Rainwater Harvesting

- Rainwater harvesting systems intercept, divert, store and release rainfall for future non-potable uses:
  - Flushing of toilets and urinals
  - Landscape irrigation
  - Exterior washing
  - Fire suppression (sprinkler) systems

Rainwater Harvesting

Secondary practices can include:

- **Rooftop Disconnection**
  - (Design Specification No. 1)
- **Grass Channel**
  - (Design Specification No. 3)
- **Micro-Bioretention or rain garden**
  - (Design Specification No. 9)

Inspection: CONSTRUCTION

- ✓ This is mostly in the hands of the architect, project engineers, building contractor, and other vendors.
- ✓ Inspector should ensure that proper coordination is taking place.

Inspection: CONSTRUCTION

- ✓ Construction runoff should not enter tank during installation
- ✓ Rooftop area size & materials match plan

Inspection: CONSTRUCTION

✓Tank foundation properly installed

Source: Clay Dills, Dills Architects

Inspection: CONSTRUCTION

- ✓ Diversion system (e.g., downspouts and pipes) is properly sized and installed to deliver roof runoff to tank.

(Source: Rainwater Management Solutions)

Inspection: CONSTRUCTION

- ✓ Pre-treatment properly installed
- ✓ Mosquito screens installed on all openings (as needed).

Source: Rainwater Management Solutions

Inspection: CONSTRUCTION

- ✓ Overflow device installed at proper elevation and with stable erosion control at outfall

Inspection: CONSTRUCTION

- ✓ Secondary runoff reduction practice(s) properly installed.

DESIGN SPECIFICATION

No. 7 Permeable Pavement

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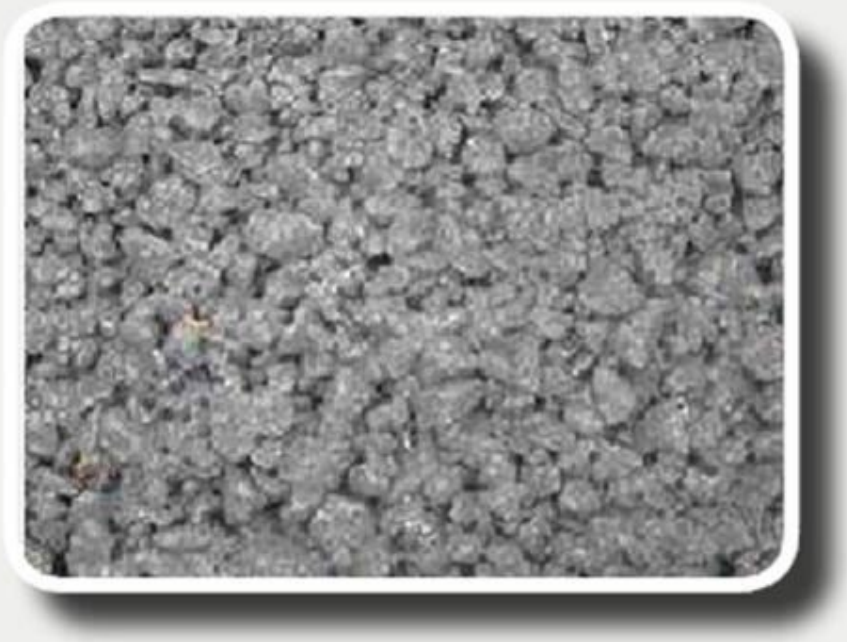
Permeable Pavement



Pervious Concrete (PC)

Permeable Pavement

Porous Asphalt (PA)

Permeable Pavement

Permeable Interlocking Concrete Pavers (PICP)

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Permeable Pavement

Concrete Grid Pavers

Permeable Pavement

- Micro scale
  - 250 – 1,000 ft.^{2}
- Small scale
  - 1,000 – 10,000 ft.^{2}
- Large scale
  - >10,000 ft.^{2}

Inspection: CONSTRUCTION

1. Protect area during construction
2. Stabilize drainage area
3. Excavation
4. Reservoir & bedding layers
5. Pavement surface

1. Protect Area from Heavy Equipment & Construction Traffic

- Keep Pavement Area Outside of Limits of Disturbance

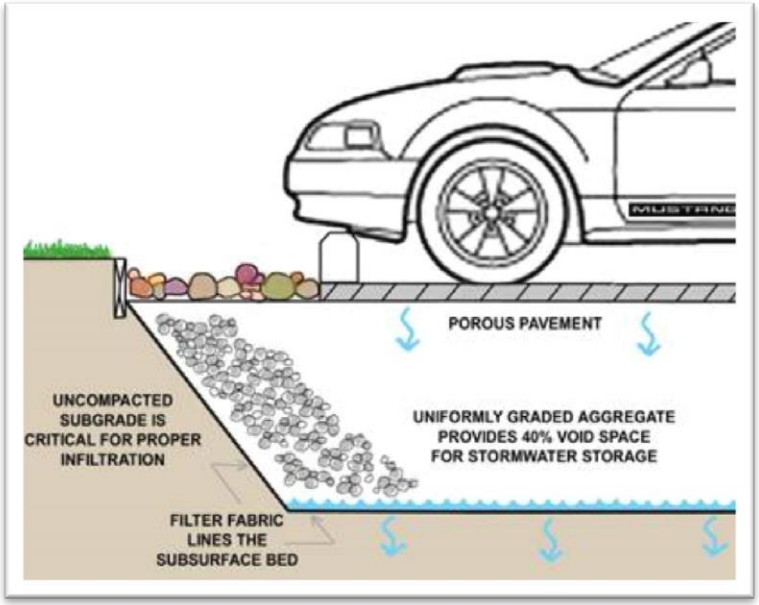


Photo Credit: Rob Roseen, Geosyntec, Inc.

2: Stabilize Drainage Area - Divert Water if Necessary – SEDIMENT IS THE ENEMY!

Installed too early during construction; fouled with construction sediment

Photo Credit: Conservation Design Forum

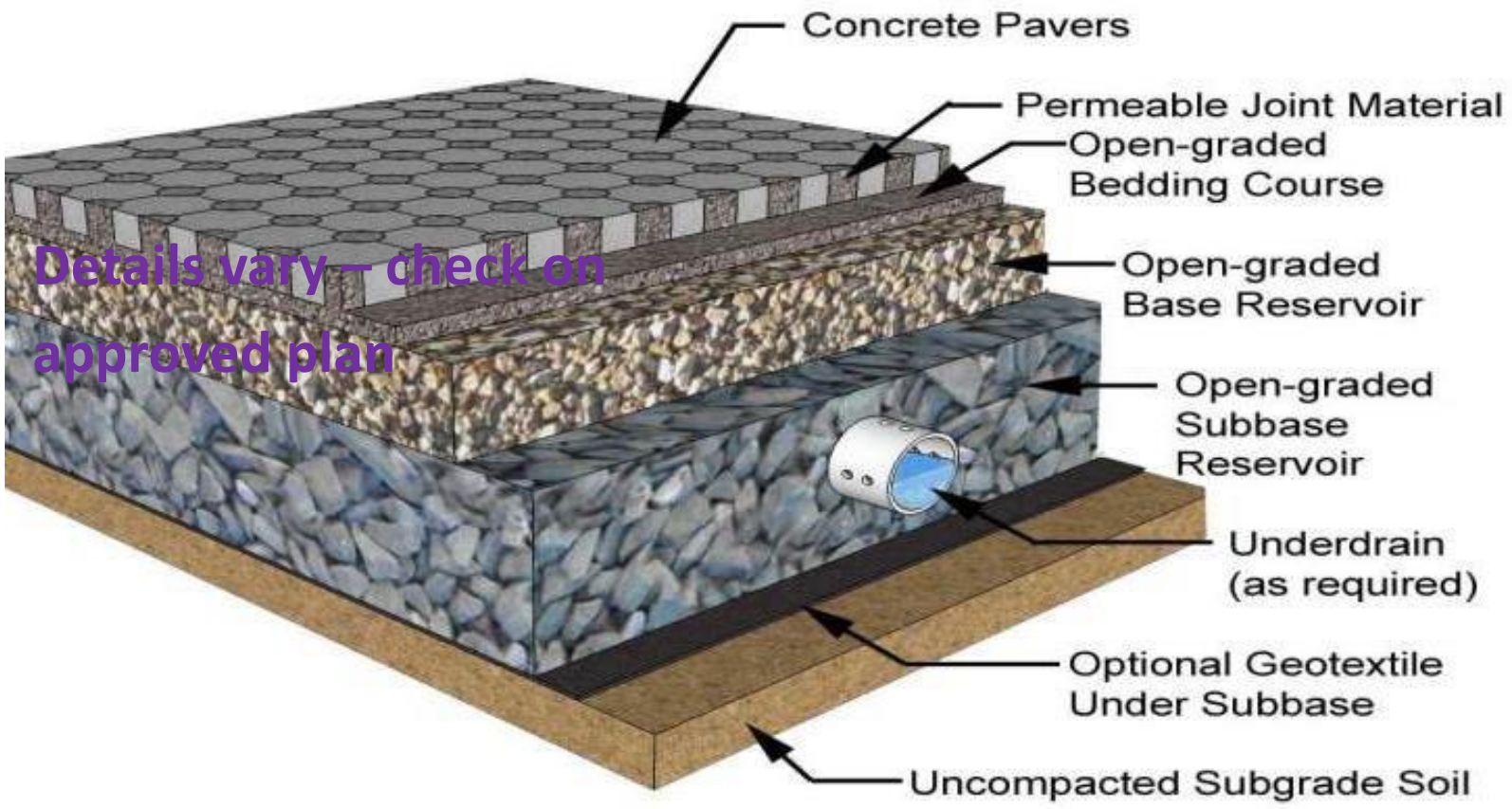
Clean work area, with curb to divert drainage around work site

3: Excavation and Stone Reservoir Installation

In most cases, bottom of excavation should be FLAT.
On slopes, individual cells should be flat.

4: Reservoir & Bedding Layer

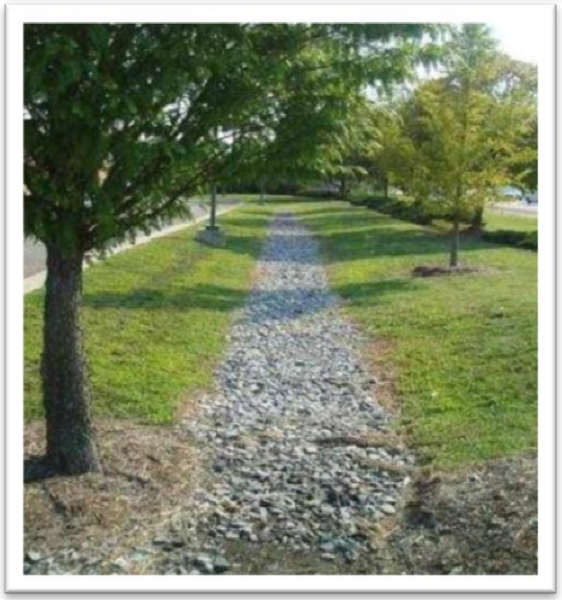
- **Details vary – check on approved plan**



5: Placement of Pavement Surface

DESIGN SPECIFICATION

No. 8 Infiltration Practices



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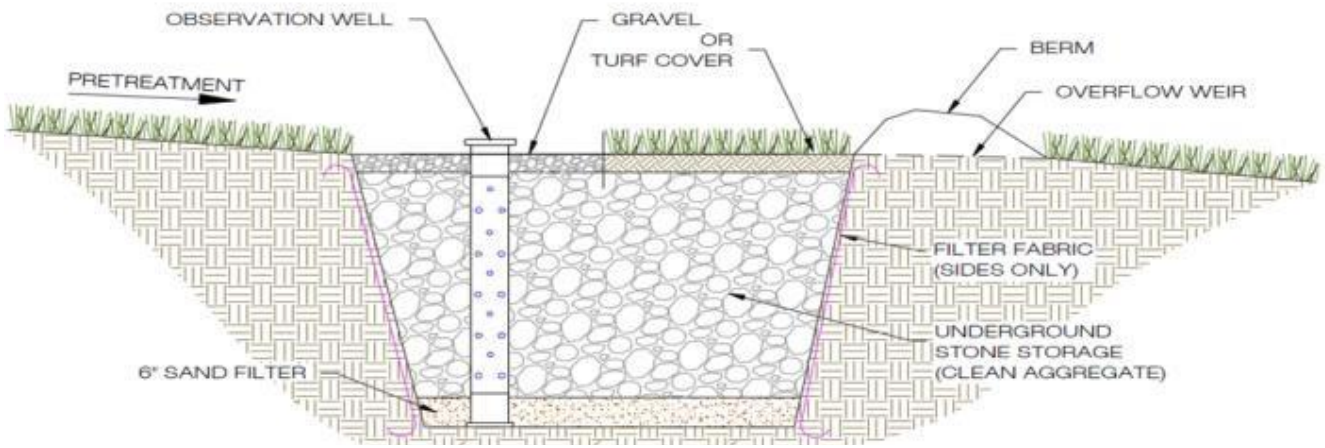
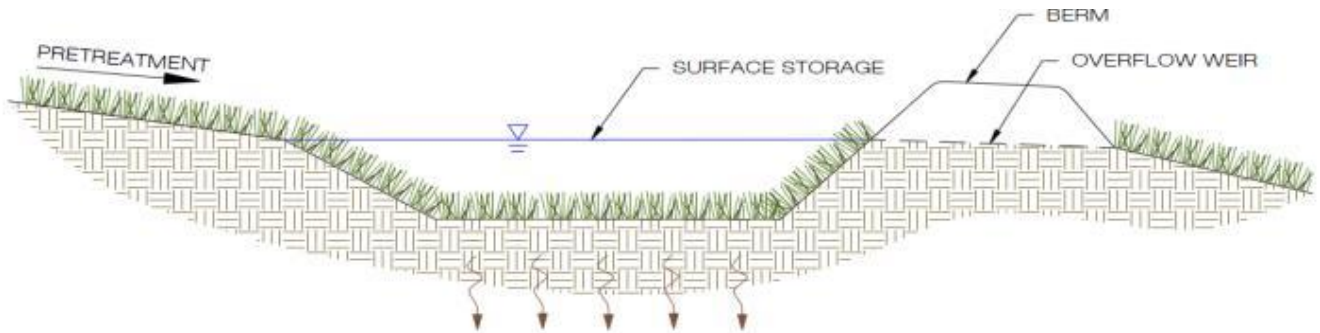
Types of Infiltration Practices

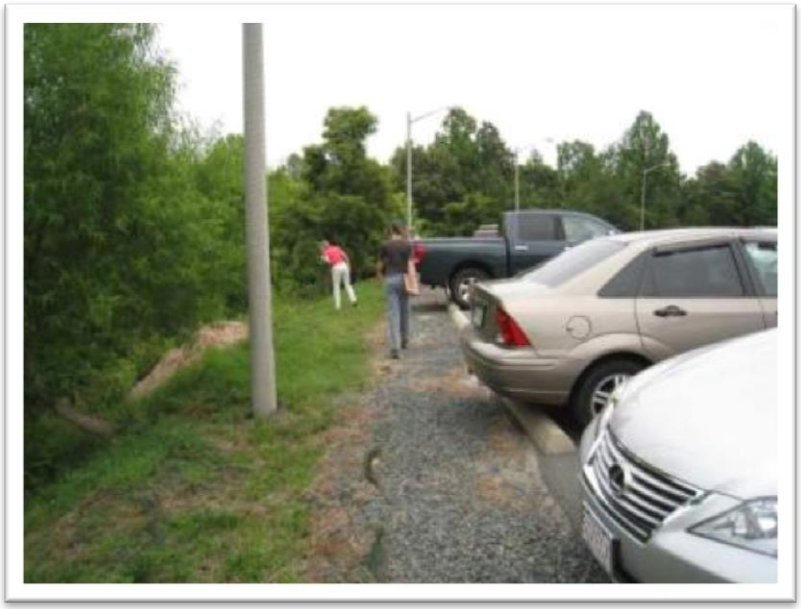


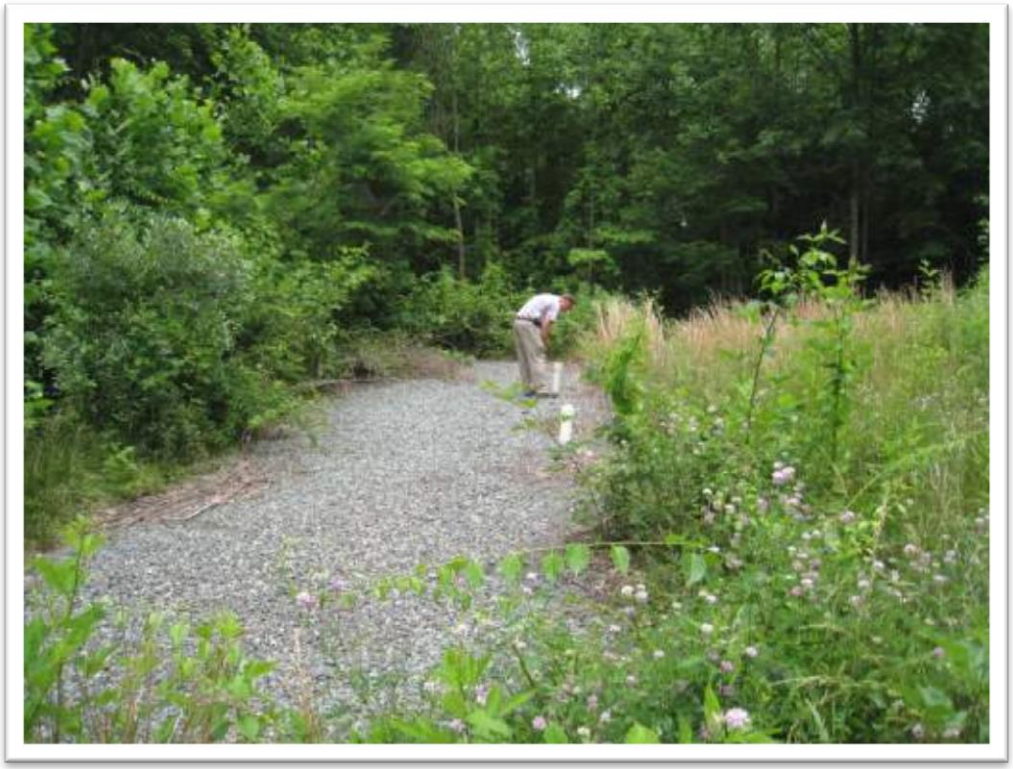
Infiltration Trench



Infiltration Basin

Infiltration Trench

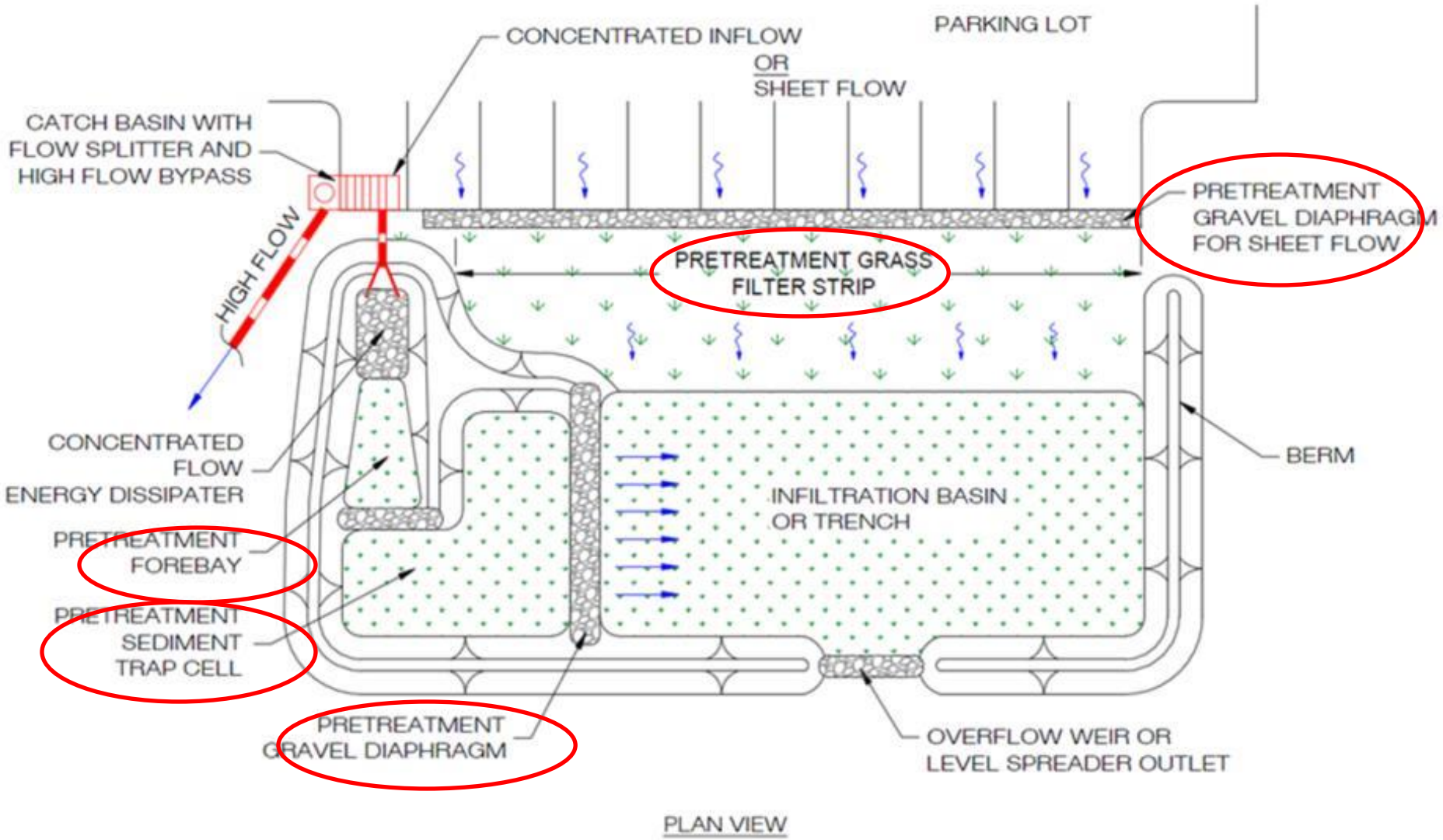




Infiltration Basin

Source: epa.gov

Multiple Types of Pre-Treatment



Examples of Pre-Treatment

- Grass filter strips (pictured);
- Gravel diaphragm
- Sediment forebays

Photo: California Stormwater Quality Association

Inspection: CONSTRUCTION

- Protect area during construction; follow proper sequence
- Soil testing
- Ready to install -E&S measures
- Excavation, filter & reservoir layers
- Pre-treatment
- Open drainage area connection

Avoid Compaction, Disturbance During Construction

- Construction traffic
- Material storage, stockpiles
- Other sources of sediment
- Outside limits of disturbance if possible

Soil Investigation: Verify It's Done

Photo credit: Tim Carter; www.askthebuilder.com

Drainage Area Stabilized

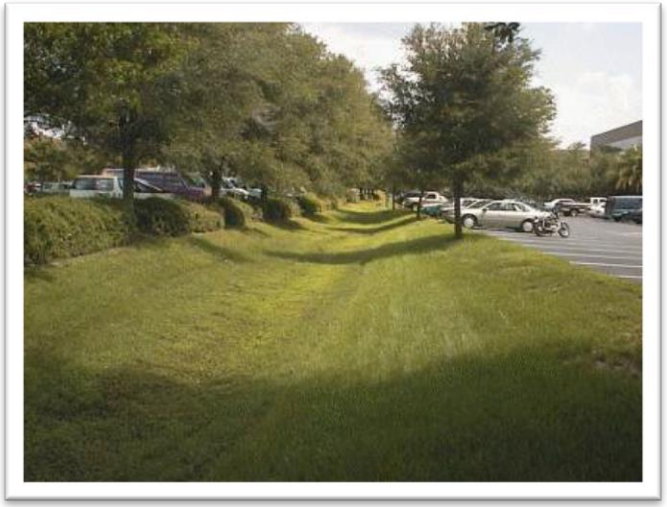
Equipment Operating From Sides

Material Installation

- Filter fabric – on sides only
- Bottom of trench should be scarified
- Observation well
- Stone – installed in 1-foot lift
- Turf cover

DESIGN SPECIFICATION

No. 9 Bioretention & No. 10 Dry Swale



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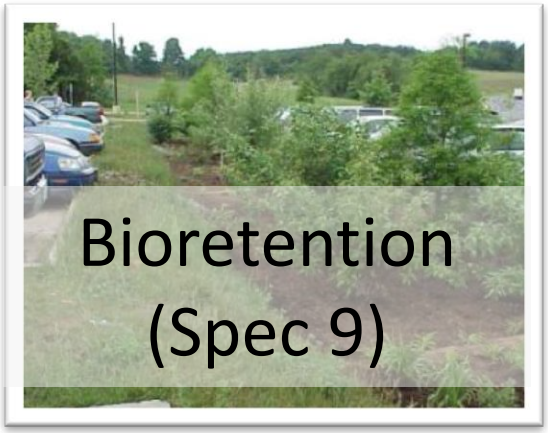
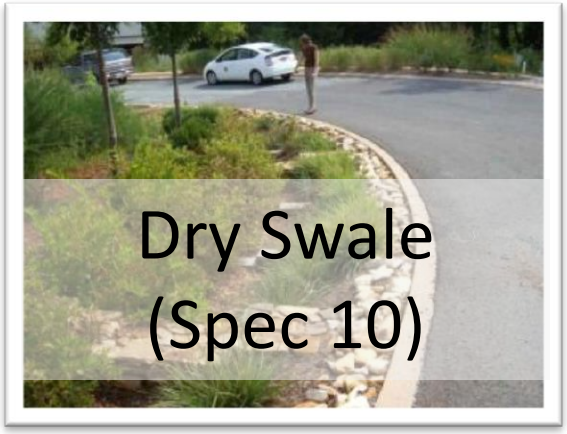
Applications/Types

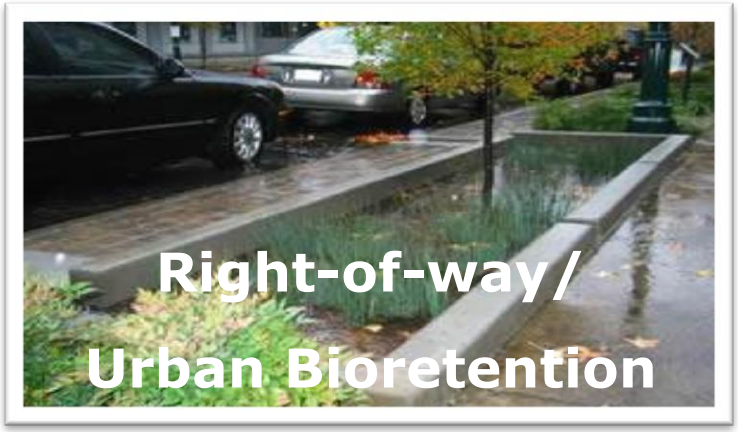




Micro Scale Applications

- Drainage Area = 250 to 2,500 square feet (Mostly impervious)

Typical Scale Applications



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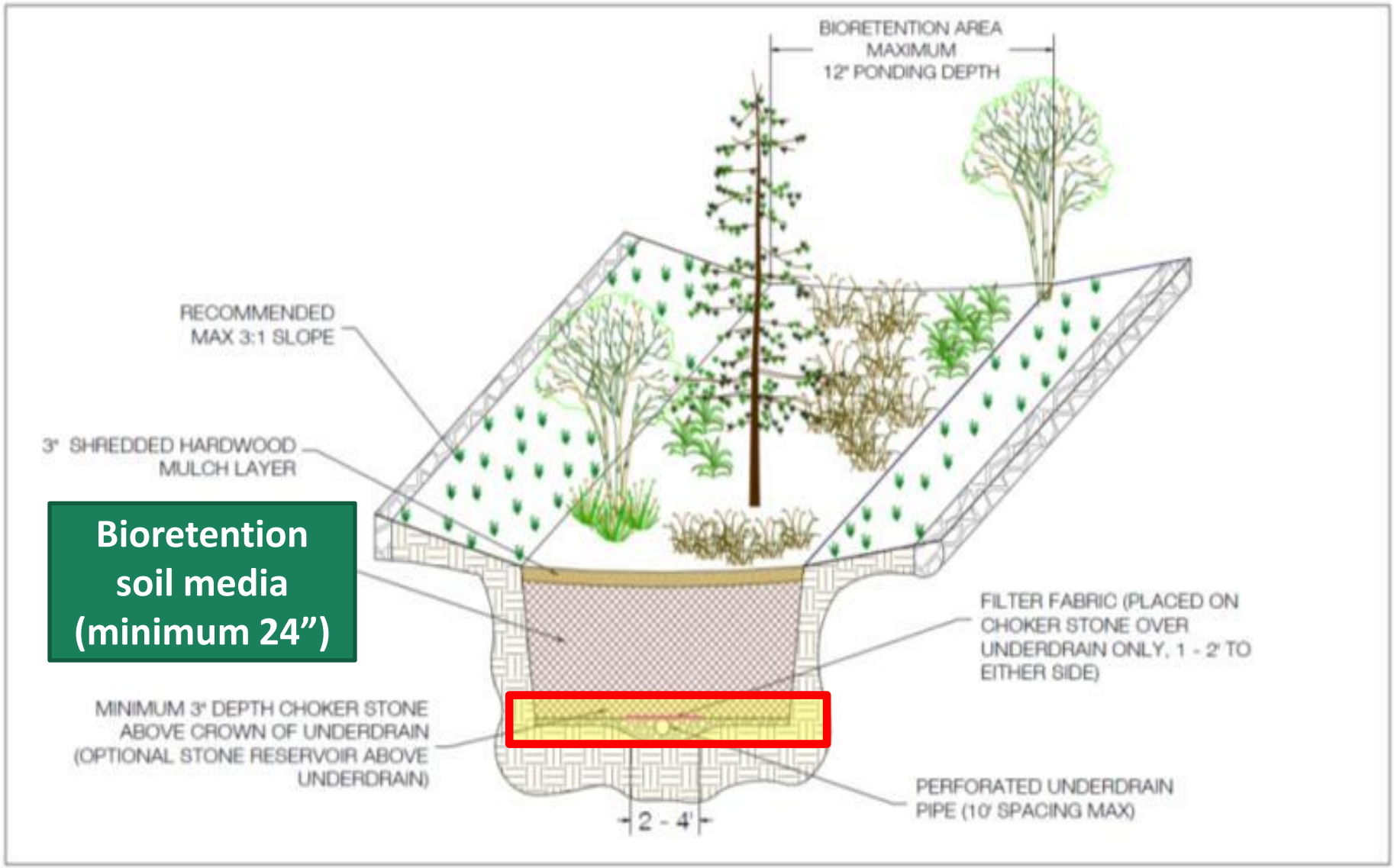
Basin Scale: Bioretention Basins

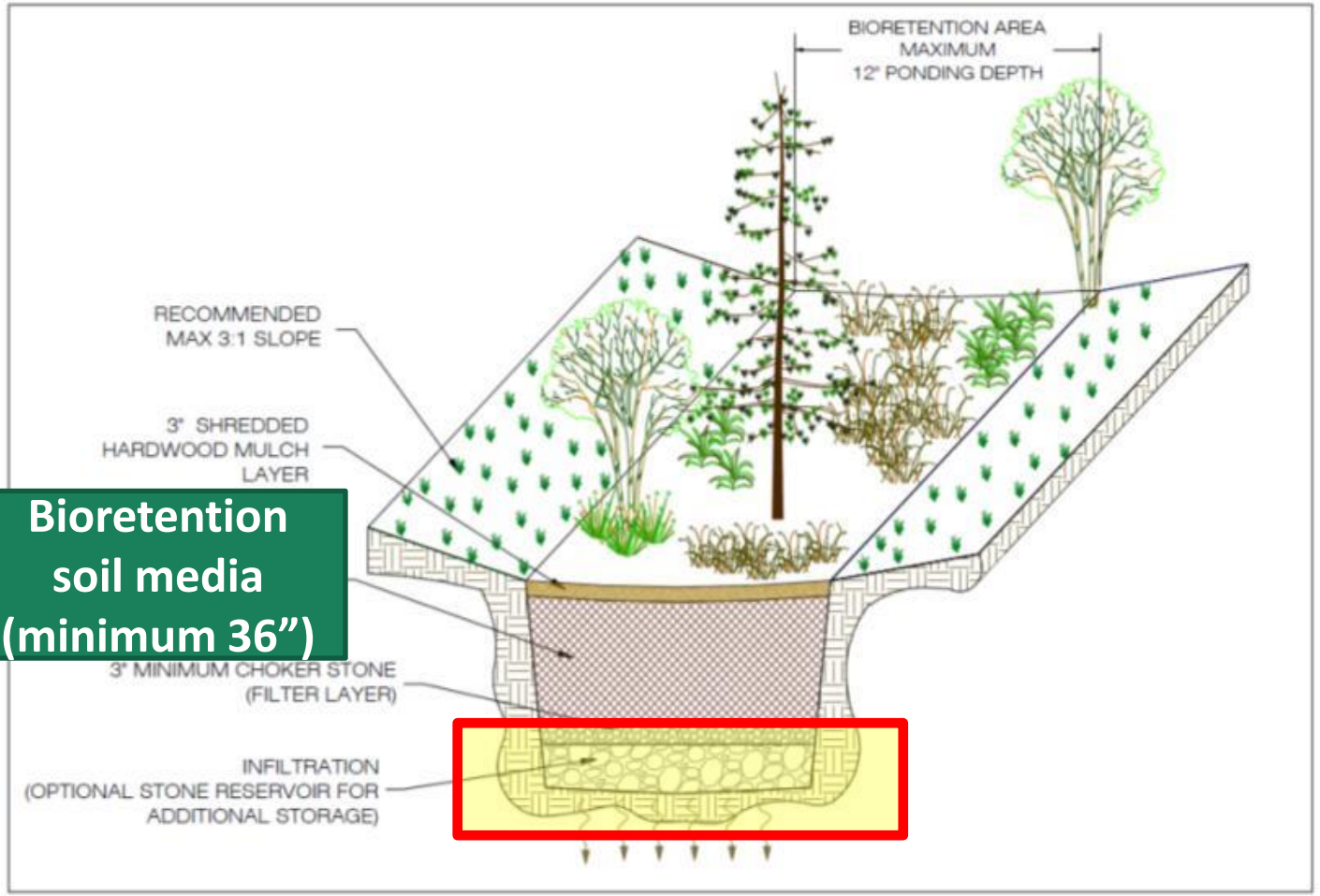
- Impervious Area Treated = Up to 5 acres & 2.5 acres of impervious

Linear Applications: Dry Swale

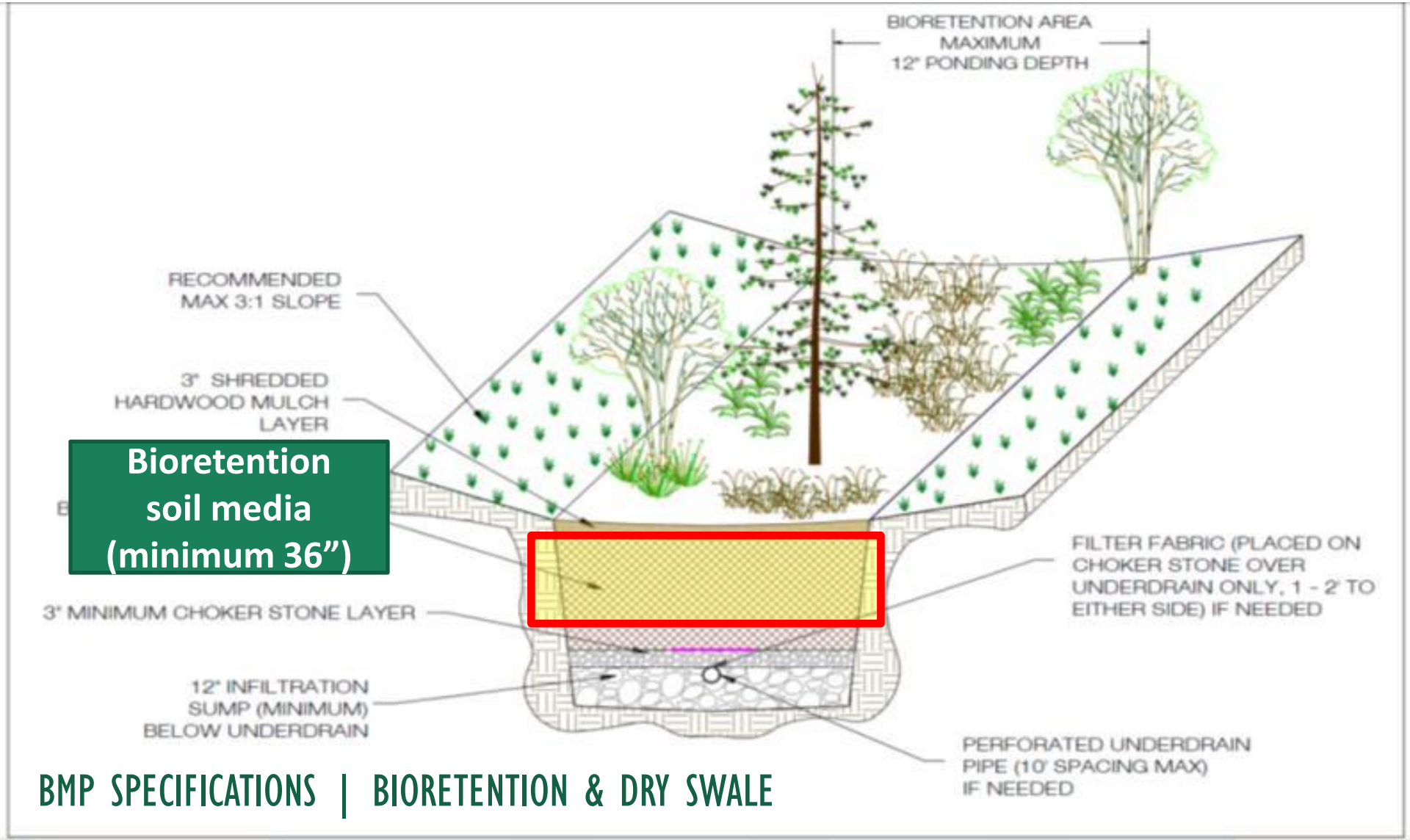
Level 1 Bioretention: Underdrain, No infiltration sump



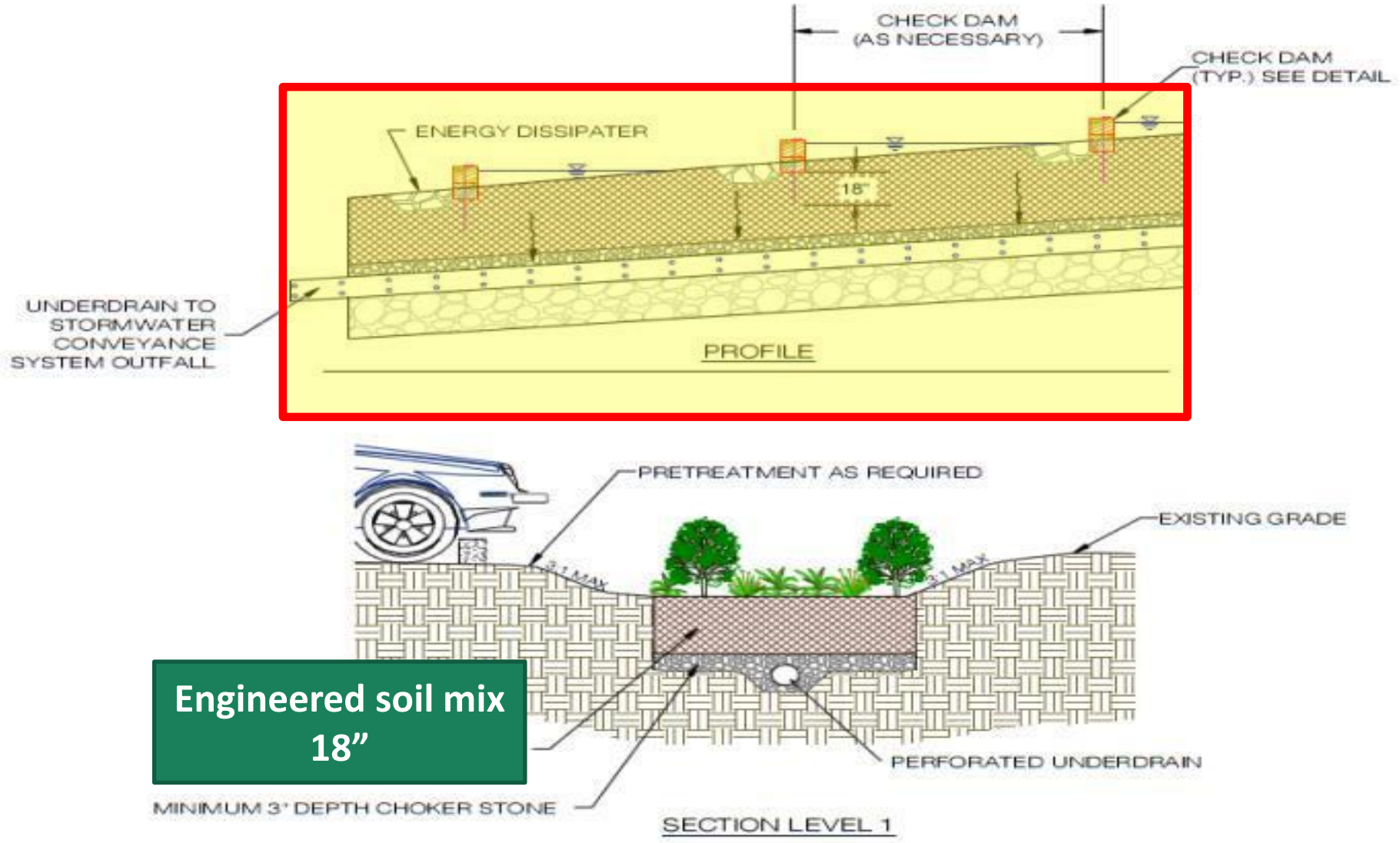
Level 2 Bioretention: Infiltration, No underdrain



Level 2 Bioretention: Infiltration sump as part of underdrain



Dry Swale: On longitudinal slope with check dams (Level 1)



Dry Swale: Longitudinal slope, check dams (Level 2)

Spec. 9 | Pg. 34 and Spec. 10 | Pg.19-20

The BIG 5 Construction Issues

1. Stabilize drainage area
2. Check for Filter Fabric or Choker Stone
3. Verify Soil Media and Depth
4. Make Sure Water Gets In Inlets
5. Check for Level Filter Bed or Correct Slope for Dry Swales

1. Make Sure Drainage Area is Stabilized. Block Inlets and/or Divert Water if Necessary

2. Check for Choker Stone Layer Between Underdrain & Soil; Filter Fabric on Sides Only (optional)

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3. Verify Appropriate Soil Media and Depth

4. Make Sure Water Gets in Inlets!

5. Check for Level Filter Bed

Unlevel filter bed concentrates water in only one area ; uneven filtering

Level filter bed -just like a bathtub - even distribution of flow across surface

Longitudinal Slope for Dry Swales: Possible Use of Check dams

Examples of longitudinal slope with or without check dams

DESIGN SPECIFICATION

No. 12 Filtering Practices

Filtering Practices

- Treat stormwater runoff from small, highly impervious sites
- Specialized treatment at designated stormwater hotspots

Types of Filters

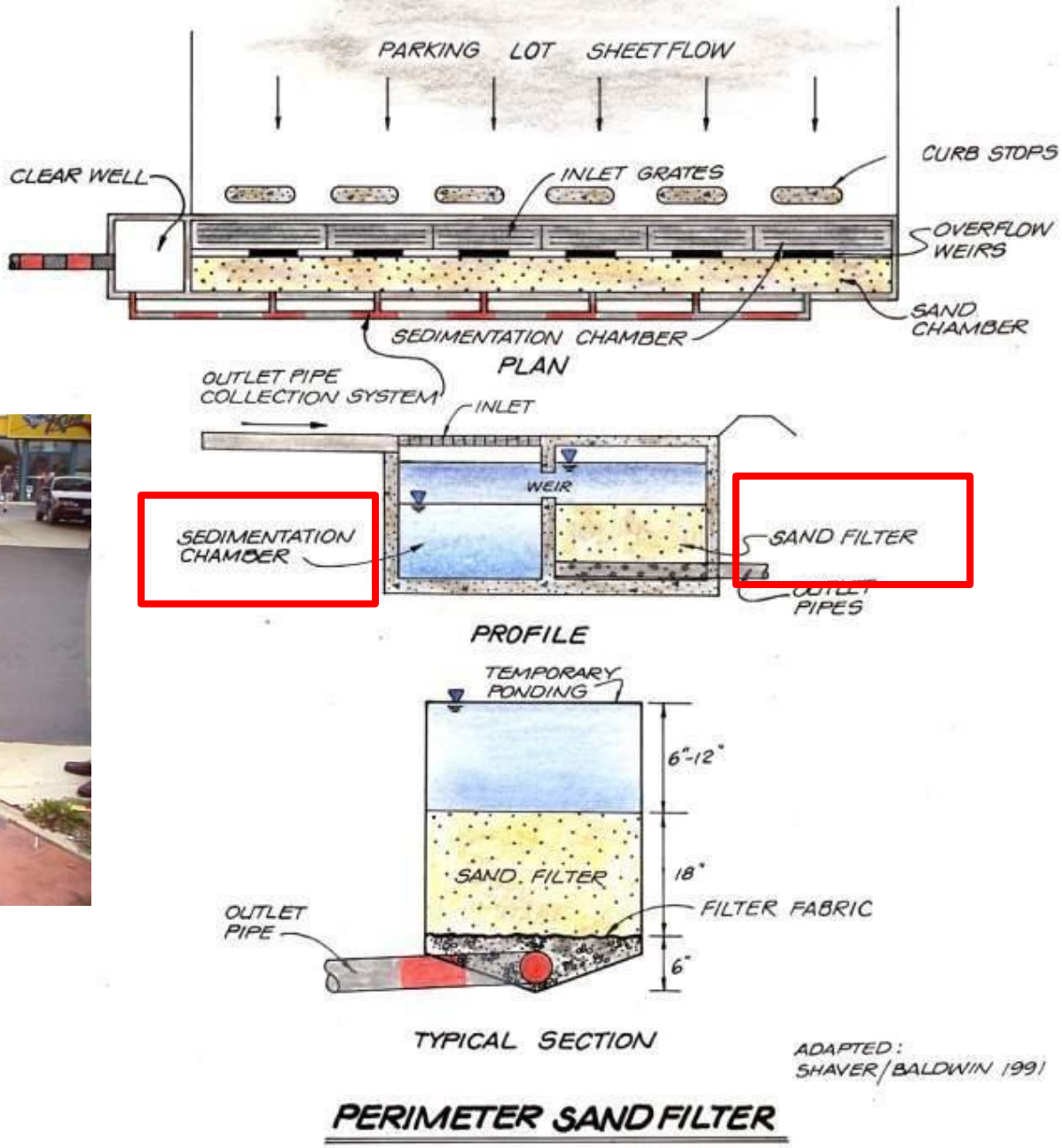
Quite the range of system configurations and filter media:

- Surface Sand Filter
- Pocket Sand Filter
- Organic Filter
- Perimeter Sand Filter
- Underground Sand Filter
- Bioretention*

*Bioretention is a form of a filter media and is covered in detail in Spec. 9.

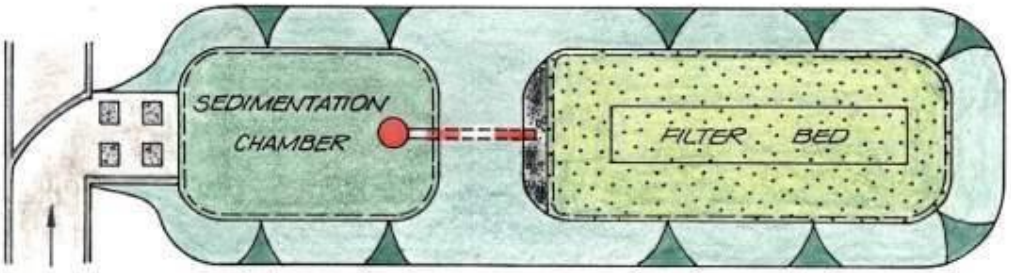
Types of Filters

Perimeter or Delaware Sand Filter

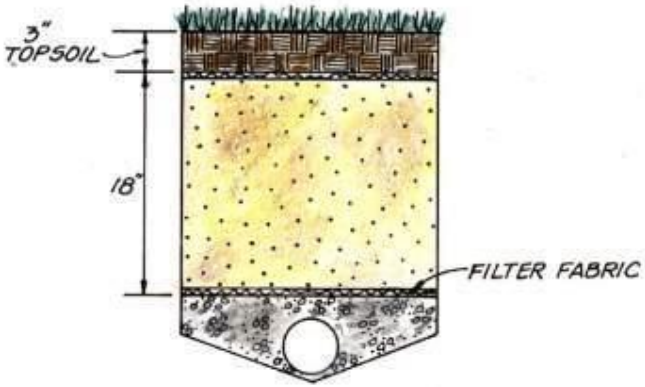


Surface Sand Filter

PROFILE



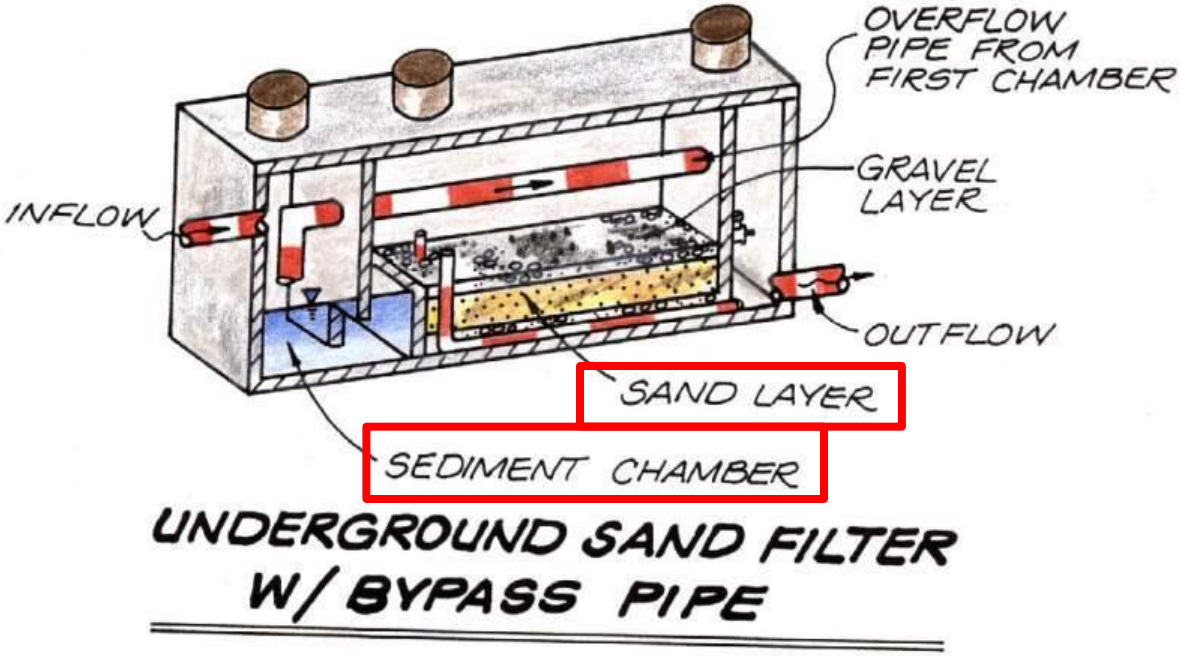
PLAN



TYPICAL SECTION

SURFACE SAND FILTER

Underground Sand Filter



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Other: Organic Media Filters – Modular, Change-Out Design

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Other: Soil Filter – “Bioretention in a Box”

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Inspection: CONSTRUCTION

- Ready to Install?
- Divert Drainage Area Connection
- Grading, Installation of Structure (e.g., concrete box)

Inspection: CONSTRUCTION

- Installation of underdrain & filter media
- Vegetation, stabilization
- Open drainage area connection

Drainage Area Stabilized?

Stabilized?

Inspection: CONSTRUCTION

- Inlets, Weirs, Flow Splitters – Clogging, Debris?
- Filter Bed – Sediment, Trash & Debris, Clogging, Standing Water 48 hours after storm
- Sedimentation Chamber – Need Cleaning Out?
- Observation Wells & Underdrain Clean-Outs – Check for standing water, blockages
- Drainage Area – Sources of sediment, oil, etc.?

DESIGN SPECIFICATION

No. 13 Constructed Wetlands & No. 11 Wet Swales

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Constructed Wetlands

Inspection: CONSTRUCTION

- Check approved plan
- Conversions from E&S basins
- Planting plan

Ready to Install?

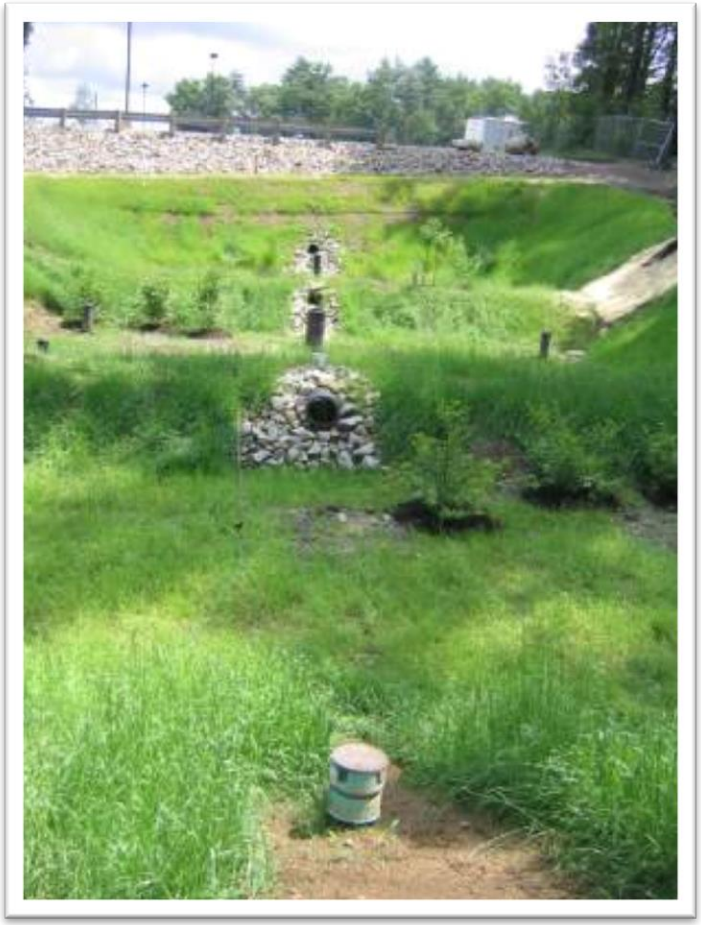
- Drainage area stabilized?
- Secondary E&S measures in place?
- Water diverted around wetland during installation?

Conversions From ESC Facilities

- Dewater
- Dredge
- Re-grade to rough design elevations

Construction Inspection: **Stage 1**

- Critical points:
  - Embankments & Spillways
  - Internal berms/weirs
  - Micro-topographic features
  - Stabilize exposed areas
  - May be necessary to divert drainage area during installation



Internal Weir To Create Cells, Long Flow Path - Elevations Are Critical

Gabion Weirs to Lengthen Flow Path

Multiple Cells: Forebay, Wetland Cells

Triangle Park Stormwater Treatment Wet Swale, Town of Rising Sun, MD

Construction Inspection: **Stage 2**

- Critical Points
  - Soil amendments in wetland areas?
  - Open drainage area connection
  - Check vegetation zones, types, plant stock
  - Consult with contractor, design professional on plant substitutions
  - Goose protection
  - Check inundation zones/status

After Planting: Protect Plants from Geese Predation

- Orange fence along perimeter
- Web of white string criss-crossing over wetland surface
- Keep in place until plants are big enough to not be enticing to geese

Initial Establishment

DESIGN SPECIFICATION

No. 14: Wet Pond

&

No. 15: Extended Detention Ponds

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Wet Ponds & ED Ponds

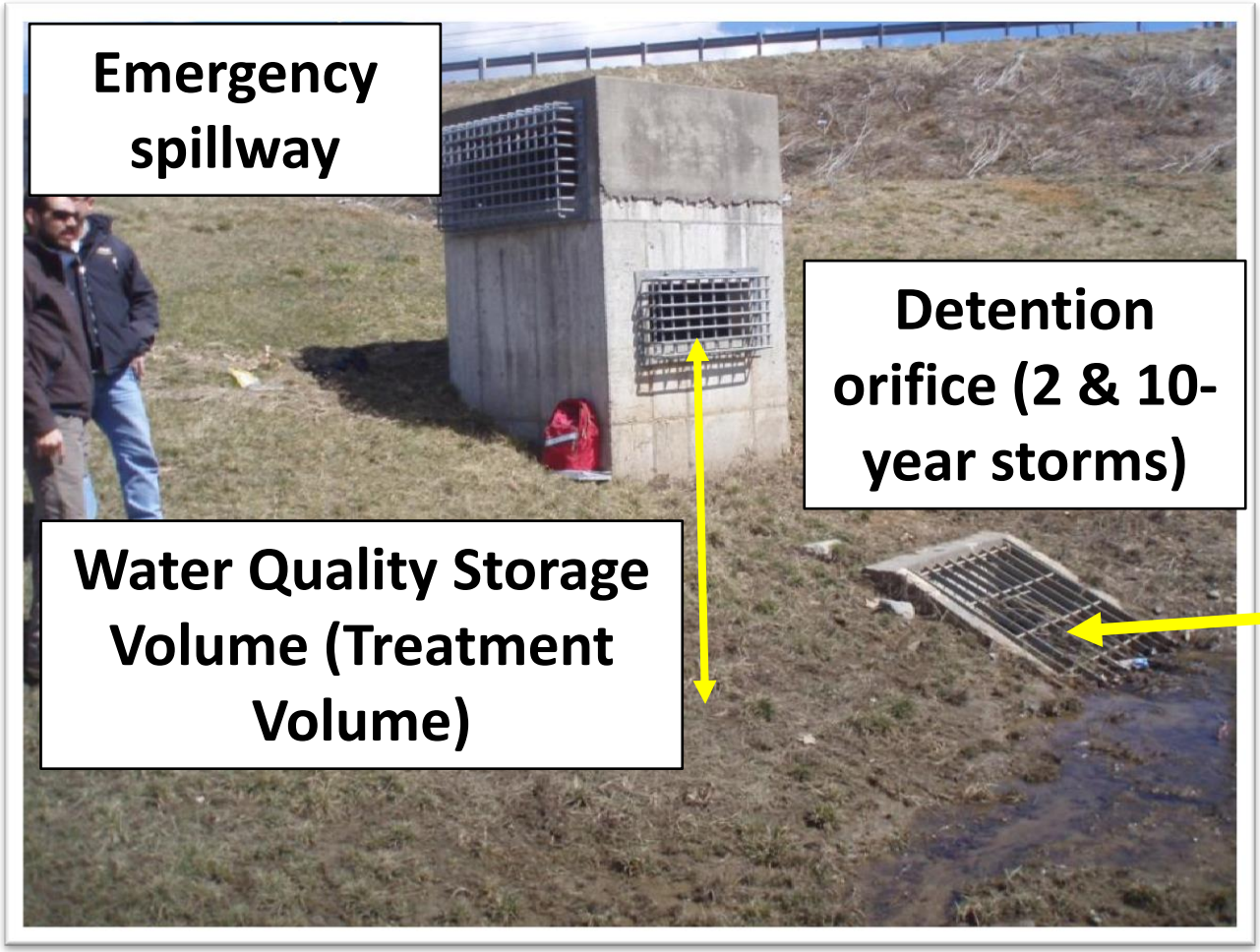
Wet Pond

- Permanent pool
- Incoming water displaces pool water

ED Pond

- Ponds only short time after storm
- Incoming water pools temporarily and allows settling

ED Pond (typical)



ED Pond (typical)

Wet Pond (typical)

Most ponds will do double duty as E&S basins during construction

Inspection: CONSTRUCTION

- Geotechnical
- Ready to convert from E&S basin?
- Dewater & dredge
- E&S measures during conversion
- Re-grade to design
- Riser & spillway configurations
- Design depth in pools
- Landscaping & final stabilization

Coordination with E&S

Soils & Geotechnical

- Geotechnical tests should be conducted by operator to determine infiltration rates and other properties of soils underlying proposed pond

Dewatering Practices During Conversion

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Appendices

- BMP Clearinghouse Appendices:
  - Earthen Embankments
  - Principal & Emergency Spillways
  - Sediment Forebay
  - Pond Landscaping

Questions?

Module 6 Exercise