



1

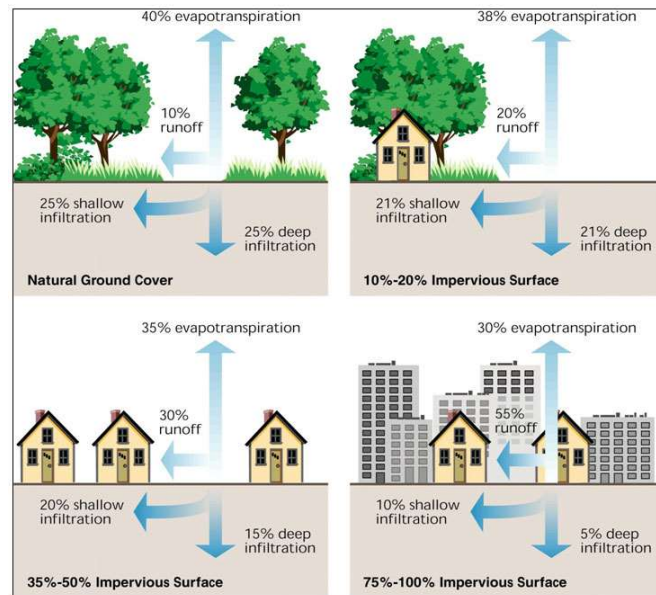
Common Acronyms & Definitions

- **SCM** – Stormwater Control Measure: Used to refer to practices and infrastructure for managing stormwater quantity or quality, also known as BMP.
- **MS4** – Municipal Separate Storm Sewer System: Any conveyance or system of conveyances that are owned or operated by a state or local government entity and are designed for collecting and conveying stormwater
- **LID** – Low Impact Development: Refers to a method of development or actual structures that are implemented for restoring natural hydrology particularly for small storms
- **MDCIA** – Minimize Directly Connected Impervious Area: A strategy for reducing runoff volume and velocity
- **EDB** – Extended Detention Basin: Type of permanent SCM
- **PICP** – Permeable Interlocking Concrete Pavers/Pavement: Type of permanent SCM

2

The Stormwater Problem

Urbanization changes the hydrologic regime of the watershed



3

The Stormwater Problem

Increased flooding

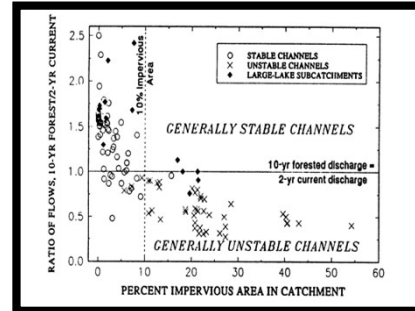


4

The Stormwater Problem



Increased channel instability



5



The Stormwater Problem

6

**THIS AREA
CLOSED**
TO ALL DIGGING
OR
CLAMS, MUSSELS, QUAHOGS,
OYSTERS, CARNIVOROUS WHELMS
OR SNAILS
BECAUSE OF POLLUTION
PARALYTIC SHELLFISH POISON

DEIVER AND THE WEST
Some Denver waterways too contaminated for safe summer play
By Bruce Finley
The Denver Post
POSTED: 07/18/2015 01:00:00 AM MDT | UPDATED: 3 YEARS AGO | 28 COMMENTS

The South Platte River and Cherry Creek deteriorate rapidly as they meander through the Denver area, picking up arsenic, ammonia and fecal contaminants at levels exceeding health standards by up to 50 times, the latest state and city data show.

Denver Environmental Health officials have posted warnings at Confluence Park.

Yet residents, including parents with kids, splash and swim anyway to escape the heat, as many did in Saturday's 102-degree temperature.

"It's a concern," said Steve Gunderson, director of water quality for the Colorado Department of Public Health and Environment.

People sickened by contaminants such as E. coli while swimming often don't grasp the cause, linking stomach ailments to food instead of water, health officials say.

Water quality when mountain snowmelt enters the metro area generally rates superior. State data indicate no standards are violated in Chatfield Reservoir — at the metro area's southwestern edge.

The Stormwater Problem

Increased pollution

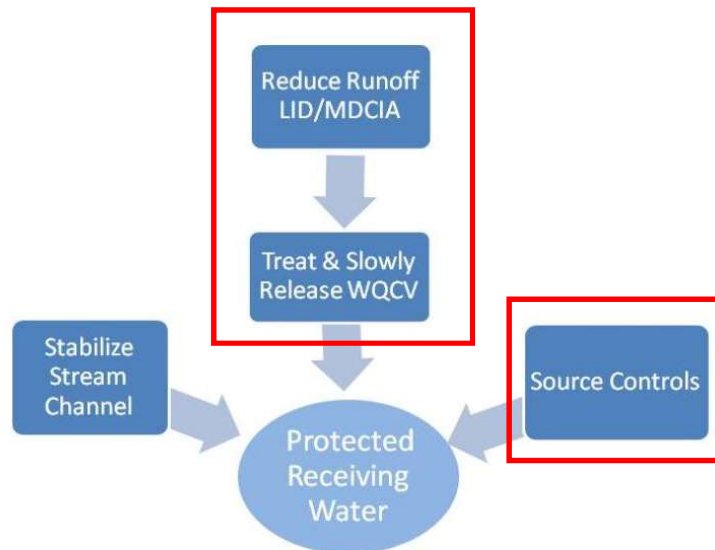
7

SCM Regulations

- SCMs are required by law under EPA Clean Water Act
- Municipal Separate Storm Sewer System (MS4) Permit issued/regulated by State health/environmental departments
- MS4 permits require appropriate installation & long-term operation of SCMS
- State health/environmental departments & the EPA conduct periodic audits of MS4 programs to verify permit compliance

8

4-Step Process for Stormwater Management



Urban Storm Drainage Criteria
Manual, Volume 3 (UDFCD 2010)

9

Role of Stormwater Control Measures

Permanent Water Quality SCM - "A constructed facility that is desired to reduce stormwater runoff volume, peak flow and/or pollutants before discharging to receiving waters"

1. Helps mitigate the impacts of urbanization after construction is complete.
2. Does not mean temporary or construction SCMs for erosion and sediment control throughout the construction process

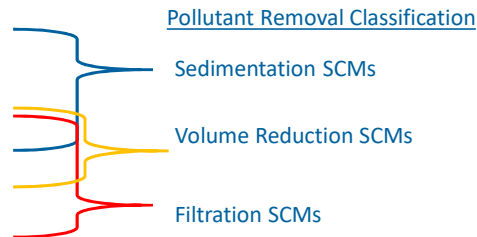
10

Role of Stormwater Control Measures

Permanent Water Quality SCM - “A constructed facility that is desired to reduce stormwater runoff volume, peak flow and/or pollutants before discharging to receiving waters”

Types of SCMs

- Extended Detention Basins
- Wet Ponds
- Constructed Wetlands
- Grass Swales/Grass Buffers
- Disconnection
- Rain Gardens
- Sand Filters
- *Permeable Pavement*
- *Proprietary Systems*



11

Need for SCM Installation Inspection

- SCMs are facilities that help to mitigate impacts of urbanization
- Improper construction can become a problem for SCM operation



12

Categories for SCMs

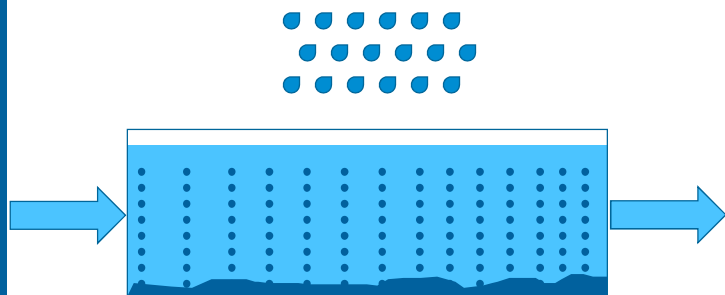
- Sedimentation SCMs
- Filtration SCMs
- Volume Reduction SCMs
- Permeable Pavement SCMs
- Proprietary SCMs



13

Sedimentation SCMs

Capture/store runoff long enough for most particulate pollutants to settle out



14

Sedimentation SCMs

Common Sedimentation SCMs

Extended Detention Basins (EDBs)

Constructed Wetland Basins

Retention Ponds

May or may not incorporate flood control in addition to water quality

Are typically vegetated

15



Extended Detention Basins (EDBs)

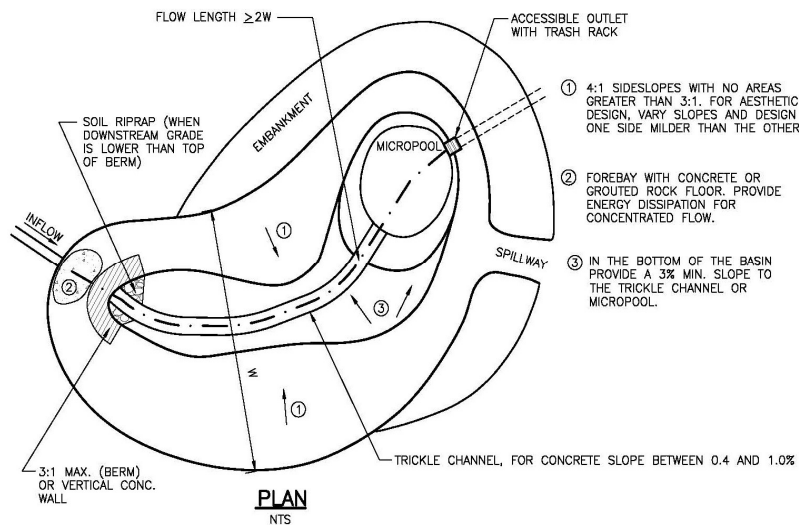
16

Components for EDBs

| | |
|---------------------------------|---|
| Inlet | Allow stormwater to enter |
| Energy Dissipation | Protect against erosion |
| Forebay | Capture debris and facilitate maintenance |
| Trickle Channel | Convey small flows & facilitate maintenance |
| Initial Surcharge Volume | Limit the area of standing water in the basin |
| Micropool | Minimize clogging |
| Outlet Structure | Slowly release treated water |

17

EDB (Conceptual Plan)



18

Inlet

- Function:
 - Allows stormwater to enter facility and dissipates energy
- Installation Activities:
 - Ensure correct grade
 - Provide energy dissipation



19

Forebay

- Function:
 - Captures debris and facilitates maintenance
- Installation Activities:
 - Keep forebay clean during construction
 - Avoid soft bottom forebays
 - Must have maintenance access



20

Trickle Channels

- **Function:**
 - Quickly conveys small flows through facility to facilitate maintenance
- **Installation Activities:**
 - Ensure that there is proper grading to the trickle channel
 - Avoid riprap trickle channels



21

Trickle Channels

Riprap tends to be difficult to maintain over time because it's difficult to remove sediment from the rock without removing the rock

22

Micropool

- Function:
 - Permanent pool to minimize clogging of the outlet structure



23

Micropool – Basic Design Theory

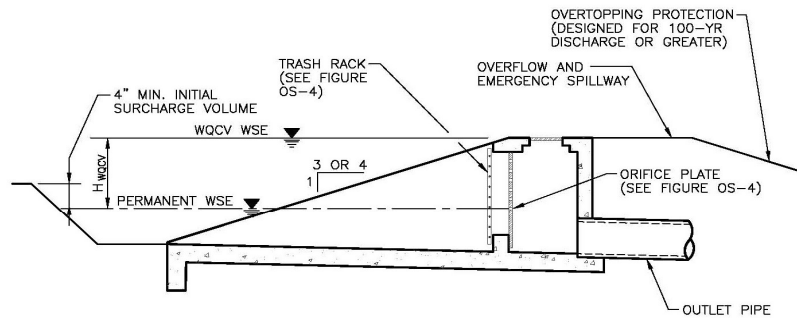


FIGURE OS-3 TYPICAL OUTLET STRUCTURE FOR WQCV TREATMENT AND ATTENUATION

Urban Storm Drainage Criteria Manual, Volume 3 (UDFCD 2010)

24

Outlet Structure

- Function:
 - Slowly release treated water
- Components:
 - Orifice Plate
 - Trash Rack
 - Safety Grate



25

Outlet Structure – Orifice Plate

Make sure plate is firmly connected to structure

NEVER remove the orifice plate

Check for gaps or modifications



26

Outlet Structure – Trash Rack

Common Trash Racks in Colorado:

- Stainless Steel Well Screen (Johnson Vee Wire)
- Aluminum Bar Grate (Amico Klemp SR Series)

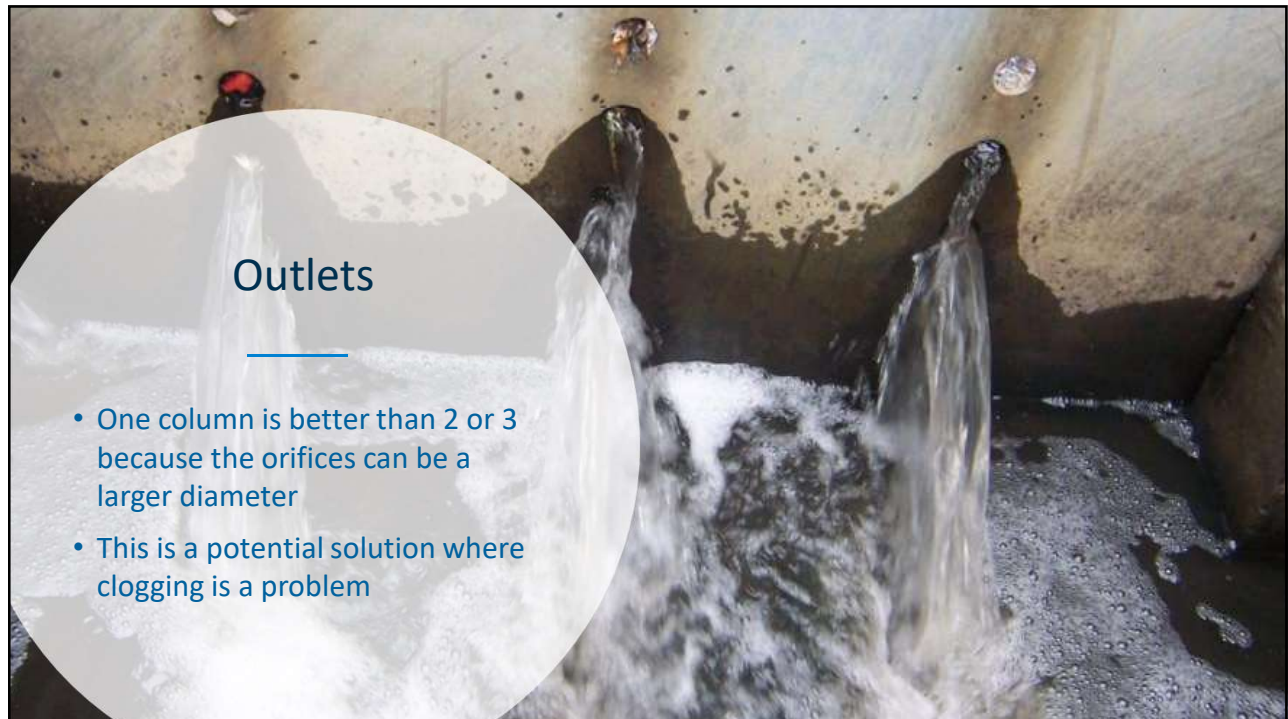
Activities

- Prevent trash/debris from clogging downstream pipes
- Clear trash/debris after large storm events

Use well screen when orifices are less than 1 and 1/4 inch diameter



27



Outlets

- One column is better than 2 or 3 because the orifices can be a larger diameter
- This is a potential solution where clogging is a problem

28

Vegetation & Embankments

- Function:
 - Stabilize basin from erosion and provide aesthetic benefit
- Installation Activities:
 - Provide proper vegetation establishment and erosion protection activities.
 - Temporary irrigation will likely be necessary.
 - Establishing vegetation is the best way to promote long-term success of rain gardens.



29

Design Considerations

- During initial project scoping meeting
 - Stabilized maintenance access to each component
 - Consider including:
 - Forebay
 - Trickle channel
 - Micropool
 - Hard-bottom forebay and trickle channel
 - Trash rack sizing (1 ¼ " threshold)



30

Maintenance Considerations

- Hard-bottom forebay for sediment removal
- Vegetated bottom design slope of 3% (verify during construction)
- Provide initial surcharge volume, micropool, and properly sized trash rack
- Baseflow monitoring when necessary

31

Constructed Wetland Ponds

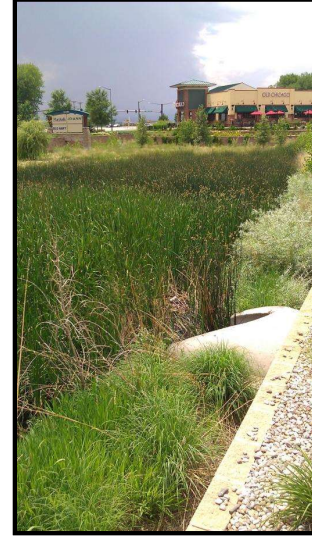


32

Constructed Wetland Ponds



- Full and diverse vegetation = high success
- Ensure there is access for maintenance



33

Constructed Wetland Ponds

- Be aware of 404 permits...

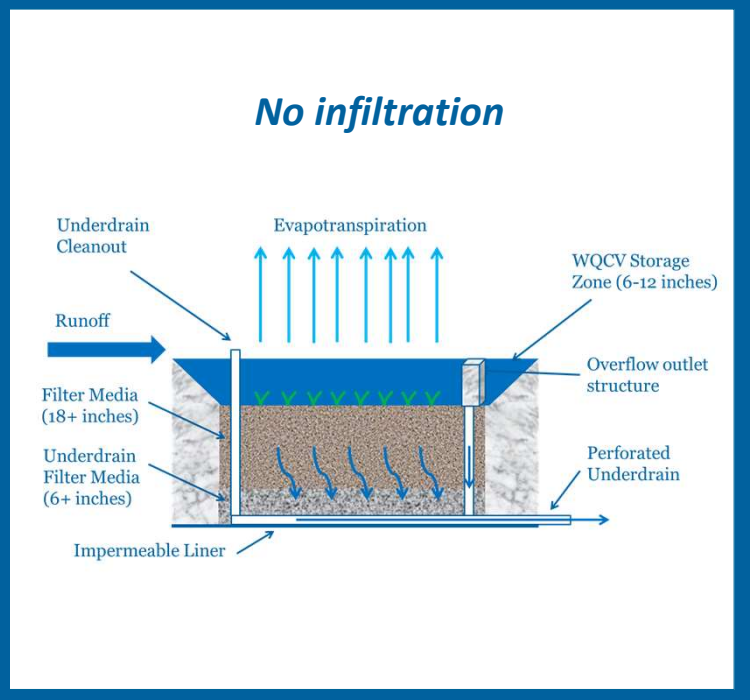
Regulations intended to protect natural wetlands recognize a separate classification of wetlands constructed for water quality treatment. Such wetlands generally are not allowed to be used to mitigate the loss of natural wetlands but are allowed to be disturbed by maintenance activities. Therefore, the legal and regulatory status of maintaining a wetland constructed for the primary purpose of water quality enhancement is separate from the disturbance of a natural wetland. Nevertheless, any activity that disturbs a constructed wetland should be first cleared through the U.S. Army Corps of Engineers to ensure it is covered by some form of an individual, general, or nationwide 404 permit.

- UDFCD Vol. III "Constructed Wetlands"

34

Filtration SCMs

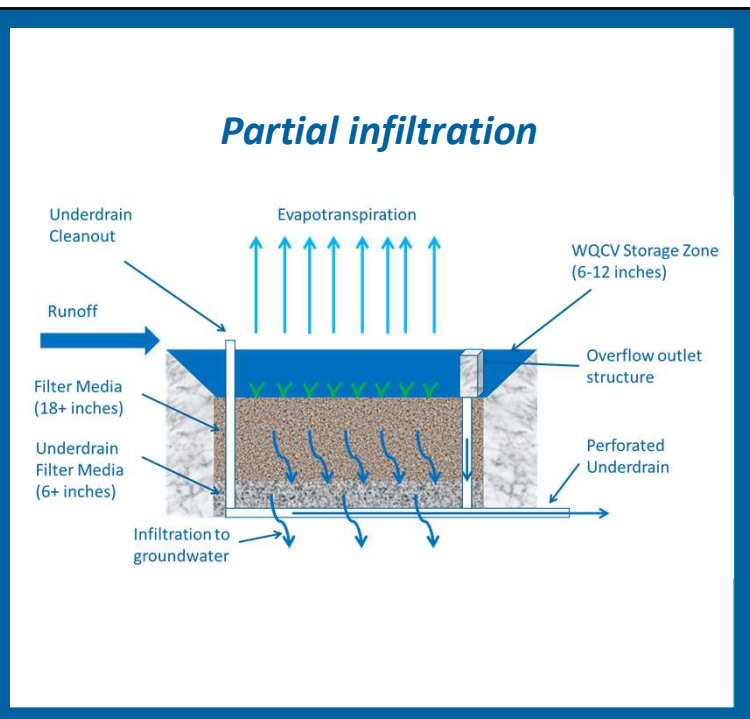
Capture runoff and force through filter media to remove pollutants



35

Filtration SCMs

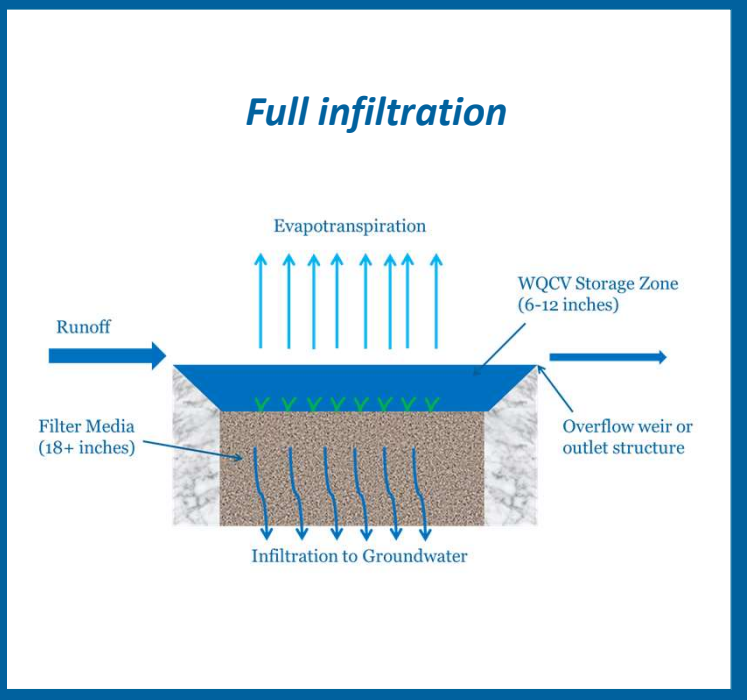
Capture runoff and force through filter media to remove pollutants



36

Filtration SCMs

Capture runoff and force through filter media to remove pollutants



37

Filtration SCMs

Common Filtration SCMs

- Rain Gardens
- Sand Filters
- Infiltration Trenches

Reduces runoff through infiltration to groundwater and evapotranspiration by plants (rain gardens only)

38

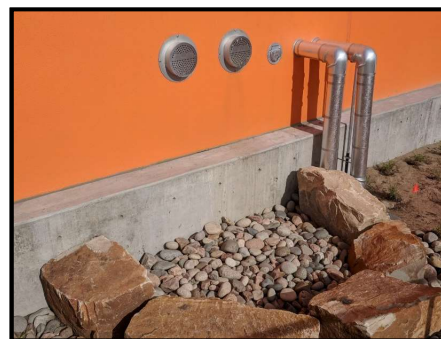
Components of Filtration SCMs

| | |
|-------------------------------------|--|
| Inlet | Allows stormwater to enter the facility |
| Forebay | Capture debris and facilitate maintenance |
| Filter Media | Removes pollutants and provides growing media for vegetation |
| Landscaping & Vegetation | Stabilizes media and embankments, increases volume reduction and improves infiltration rates |
| Overflow Structure | Allows larger storms to bypass the facility |
| Underdrain | Slowly release treated water in partial or no-infiltration facilities |

39

Inlet

- Function:
 - Allows stormwater to enter facility and dissipates energy
- Installation Activities:
 - sfd



40

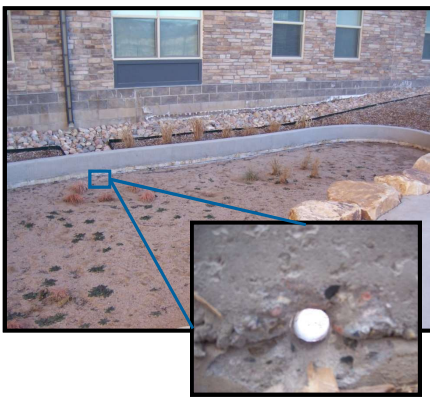
Forebay

- Function:
 - Captures debris and facilitates maintenance
- Installation Activities:
 - sfd



41

Inlet issues...



Water does not
enter the SCM



42

Filter Media

- Function:
 - Filter media removes pollutants before runoff infiltrates into groundwater or discharges through underdrain
- Installation Activities:
 - sfd



43

Filter Media

Media mix for sand filter or rain garden

Sand Filter Media
Clean-course sand
AASHTO C-33
Or
CDOT Class C Filter Material

- Bioretention Media
- 80-90% Clean Sand (0.05-2.0 mm)
- 3-17% Silt (0.002-0.5 mm)
- 3-17% Clay (<0.002 mm)
- 3-5% Shredded Mulch
- DO NOT USE:
 - Topsoil only
 - Clay-grown sod

44

Vegetation/Landscaping

- Function:
 - Stabilizes media and embankments, increases volume reduction and improves infiltration rates
- Installation Activities:
 - sfd



45

Overflow Structure

- Function:
 - Allows larger storms to bypass the facility
- Installation Activities:
 - sfd



46

Underdrain

- Function:
 - Slowly release treated water in partial or no-infiltration facilities
- Installation Activities:
 - sfd

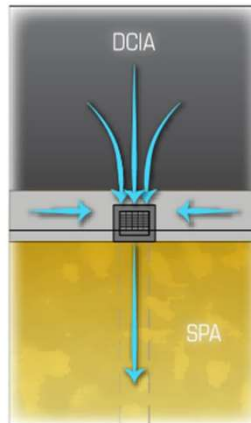


47

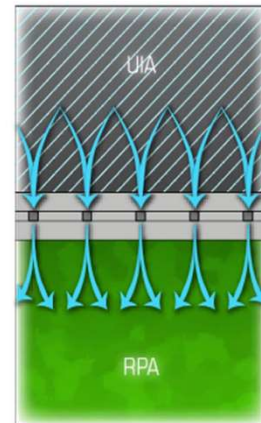
Volume Reduction SCMs

- DCIA – Directly Connected Impervious Area
- UIA – Unconnected Impervious Area
- SPA – Separate Pervious Area
- RPA – Receiving Pervious Area

Conventional
Curb and Gutter w/ Inlet



Runoff Reduction
Slotted Curb



48

Volume Reduction SCMs

“Minimum vegetation cover of about 65% is required for concentration reduction to occur, although a rapid decline in performance occurs below about 80%”

Caltrans November 2003



49



Grass Swales

50

Components for Grass Swales

| | |
|----------------------------|---|
| Inlet/Vertical Step | Allow stormwater to enter |
| Energy Dissipation | Protect against erosion |
| Healthy Vegetation | Provide water quality treatment and stabilization |
| Underdrain | Help drain swales with mild slopes (< 2%) |
| Protection | Minimize compaction disturbance over time |

51



Inlet/Vertical Step

- With protection (discontinuous curb)
- No vertical step (note sediment deposit along the curb)

52

Energy Dissipation



53



Protection

54



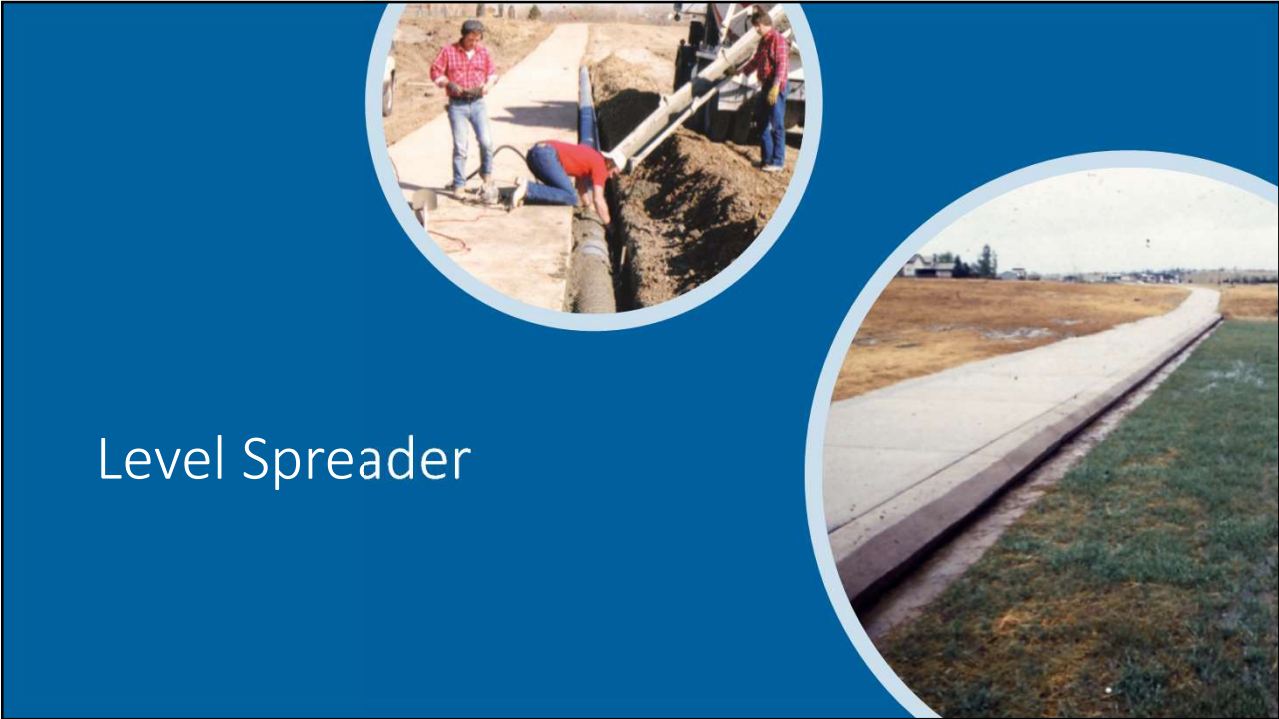
Grass Buffers

55

Components for Grass Buffers

| | |
|----------------------------|---|
| Inlet/Vertical Step | Allow stormwater to enter via level spreader |
| Energy Dissipation | Protect against erosion |
| Healthy Vegetation | Provide water quality treatment and stabilization |
| Protection | Minimize compaction disturbance over time |


56



Level Spreader

57

Grass Buffer



The original design did not include the gravel strip.

Lack of protection at this location cause rutting adjacent to the road. Flows were conveyed in the damaged area – bypassing the buffer.

A gravel strip was added post construction to address the damage.

58

Permeable Pavement SCMs

Types of Permeable Pavement

- Pervious concrete
- Porous asphalt
- Permeable interlocking concrete pavers



59

Typical Sections

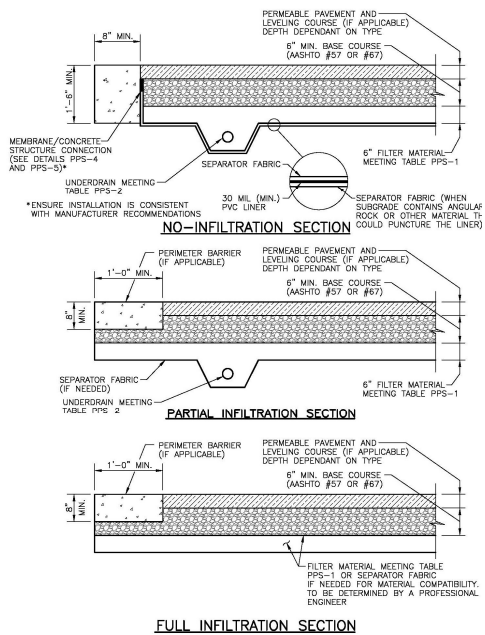


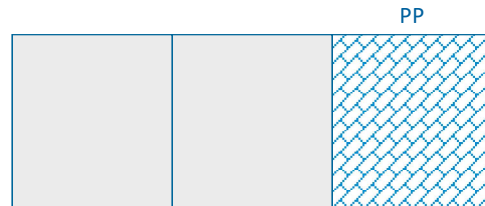
Figure PPS-1 from Volume 3 of the USDCM

60

Impervious Run-on Ratio

- Impervious Run-on Ratio

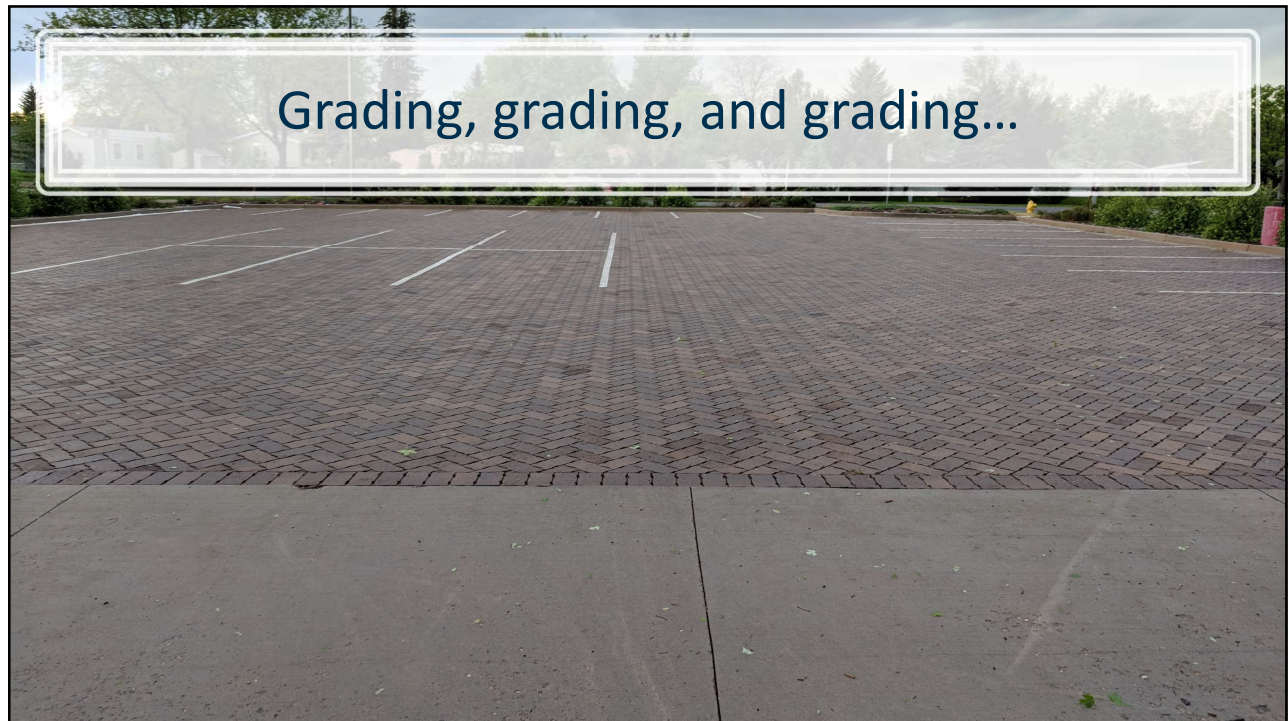
$$\frac{Area_{imp}}{Area_{pp}} \leq 2$$



2:1 impervious run-on ratio (maximum)

- Recommended to reduce maintenance frequency

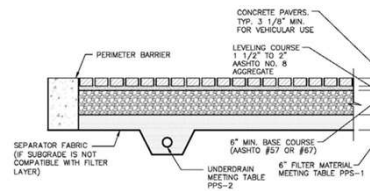
61



62

Permeable Interlocking Pavement

- Ensure bricks are not cut to less than 40% of full size
- Length to thickness ratio 3:1 at most for vehicular applications
- Pattern of pavement – Herringbone (vehicular)



- NOTES:
1. THIS SECTION IS DESIGNED FOR PARTIAL INFILTRATION AS DESCRIBED IN BMP FACT SHEET T-10. SEE FIGURE PPS-1 FOR MODIFICATIONS FOR USE WITH NO INFILTRATION OR FULL INFILTRATION SECTIONS.
 2. A PAVEMENT DESIGN SHOULD BE PERFORMED IN AREAS OF VEHICULAR USE.

63



PICP Joint Filler

Fill joints & leveling course
1 1/2" - 2" of #89 aggregate

64

Snow Control

- No sand on ANY permeable pavement
- Don't store snow on the permeable pavement
- No chemical deicers on porous concrete
- Use rubber snow plow blades



65

Designing for Maintenance

- Pre-construction meeting
- Add observation well (for full-infiltration sections)
- Specify light-weight (low ground pressure LGP) equipment
- Prevent storage of loose materials
- Protect pavement with fencing
- Place wearing course after landscaping and adjacent construction is complete

66

Underground SCMs



67

Background

- Most underground SCMs are proprietary systems
- Each system requires unique I&M activities
- Objectives of this section:
 - Identify the most common systems
 - Describe how each system operates
 - Describe typical I&M activities
- Our Disclaimer:
 - Inappropriate maintenance may void system warranty
 - ALWAYS refer to manufacturer's I&M manual
 - All information presented herein is based on manufacturer literature

68

Maintenance Considerations

Sediment/pollutant loading varies considerably from site to site

For first year after construction, visit site after large rainfall events (> 0.25 inches) and measure sediment/oil accumulation

OSHA confined space certification may be necessary

Determine how often each facility needs to be inspected and maintained

Frequency range: every large storm event to annually

69

Maintenance Considerations

- Some vendors will provide first 1-2 years of maintenance...follow along to learn proper I&M
- Major maintenance should be scheduled during winter months (little/no rainfall)
- Keep track of location carefully
 - Underground SCMs tend to be forgotten!

70

Conclusions

Maintenance is an often neglected component of post-construction water quality SCMs

Maintenance can vary greatly from SCM to SCM

Designing with maintenance in mind can dramatically impact the successfulness of maintenance programs

Understanding the purpose and function of each SCM and component helps ensure proper maintenance

If you don't know ask

71

Thank you.

• Contact

- 📞 970.491.8015
- @ costormwatercenter@gmail.com
- 🌐 StormwaterCenter.colostate.edu



Educate, Enhance, Explore



Connecting world class research with
real-world water challenges

72