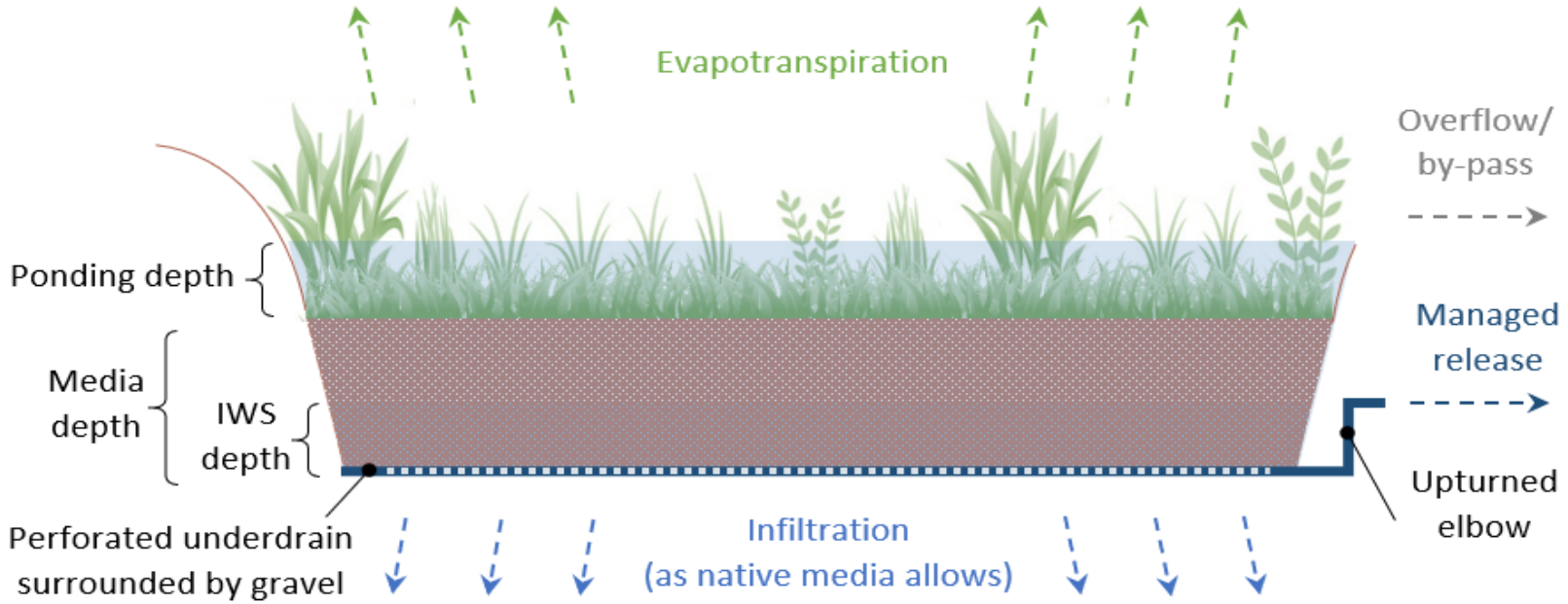
Managed Release SCMs – Main Concepts

Villanova University: Amanda Hess, PhD, PE and Robert Traver, PhD, PE
DEP: Sean Furjanic, PE



Outline

- Background: VUSP/VCRWS at Villanova University
- Where MRC SCMs can be used
- How MRC SCM meet the intent of stormwater management in PA
  - Storage
  - Filtration
  - Release Rate
  - Geomorphologic protection
- Design Concepts for MRC SCMs
  - Pretreatment
  - Diversion

Villanova Urban Stormwater Partnership



VUSP Stormwater Symposium 2024

October 16 & 17

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AERO AGGREGATES
HRG
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FERGUSON WATERWORKS
sbn
JMT
NV5
ATERRA SOLUTIONS
Stantec
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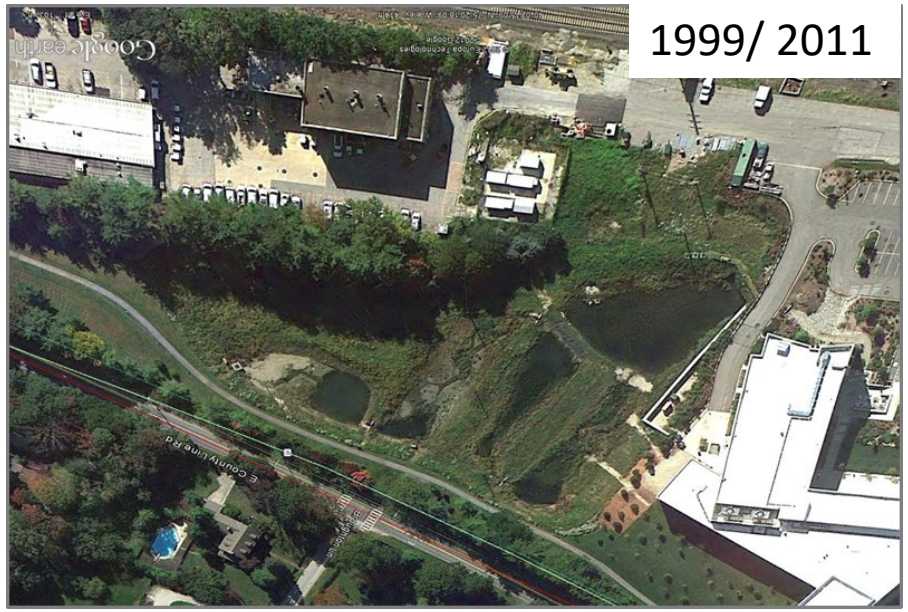
VCRWS GSI Research and Demonstration Park





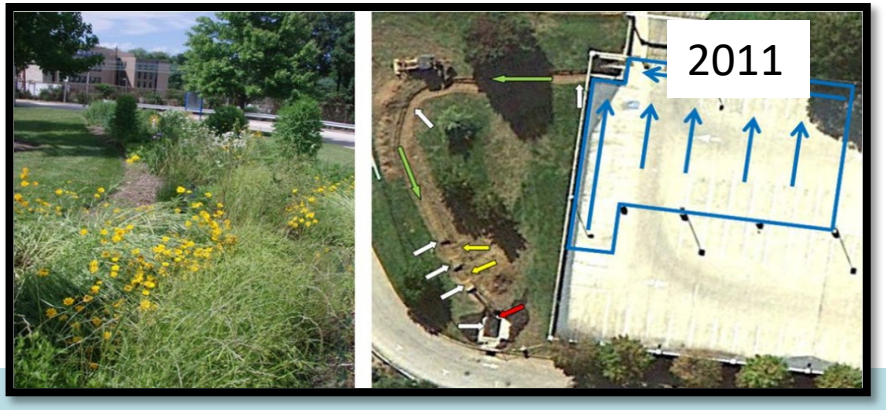




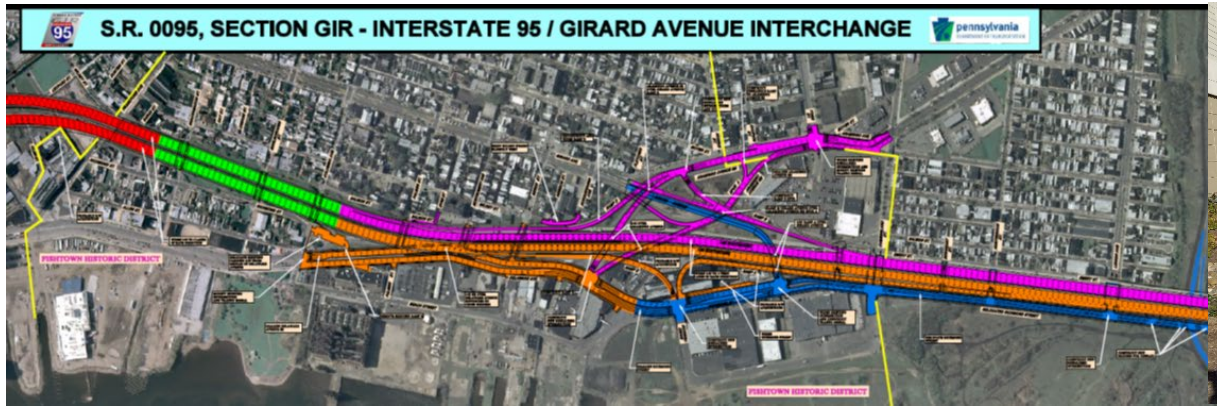




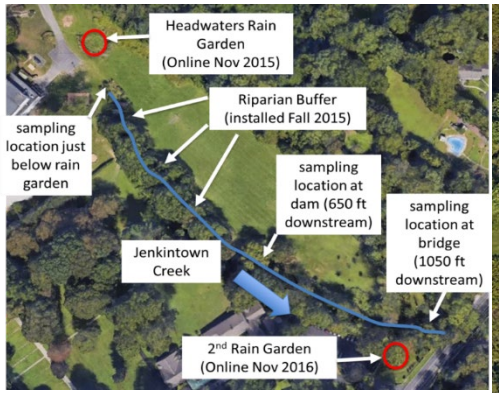




VCRWS Off-Campus Sites











- NSF: Multiple Awards
- Department of Defense
- PADEP
  - "Growing Greener" & "319"
  - New Stormwater Manual
- PADOT: Via AECOM

- Past: USEPA PWD, CZM, CICEET
- William Penn Foundation – Delaware River Watershed Initiative

Where can MRC be used?

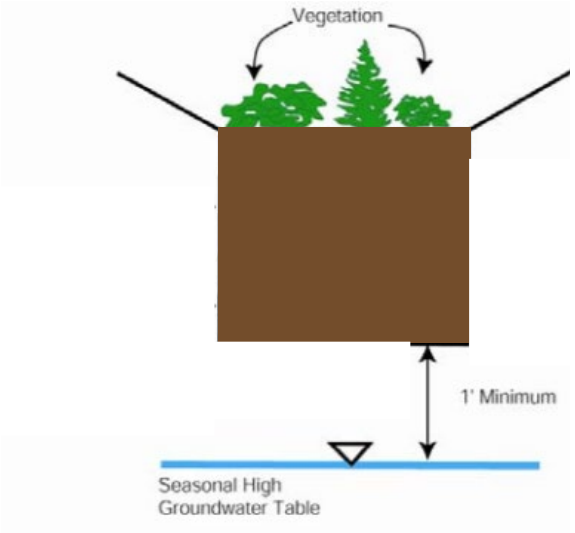
- MRC is limited to project areas or subareas where infiltration:
  - is extremely limited - saturated hydraulic conductivity rates ≤ 0.25 in/hr



Where can MRC be used?

- MRC is limited to project areas or subareas where infiltration:
  - is extremely limited - saturated hydraulic conductivity rates ≤ 0.25 in/hr
  - not feasible - groundwater and/or regularly occurring seasonally high-water tables within 1’ of the bottom of the BMP’s soil media

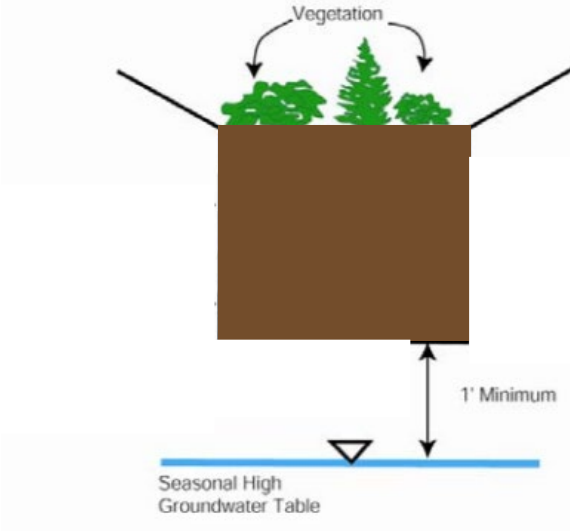


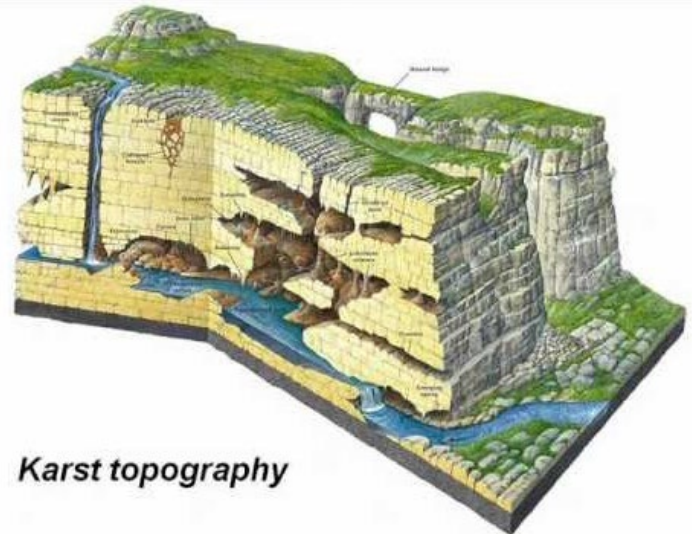


Where can MRC be used?

- MRC is limited to project areas or subareas where infiltration:
  - is extremely limited - saturated hydraulic conductivity rates ≤ 0.25 in/hr
  - not feasible - groundwater and/or regularly occurring seasonally high-water tables within 1’ of the bottom of the BMP’s soil media
  - undesirable - sinkhole-prone areas or contaminated soils









The use of MRC must be justified

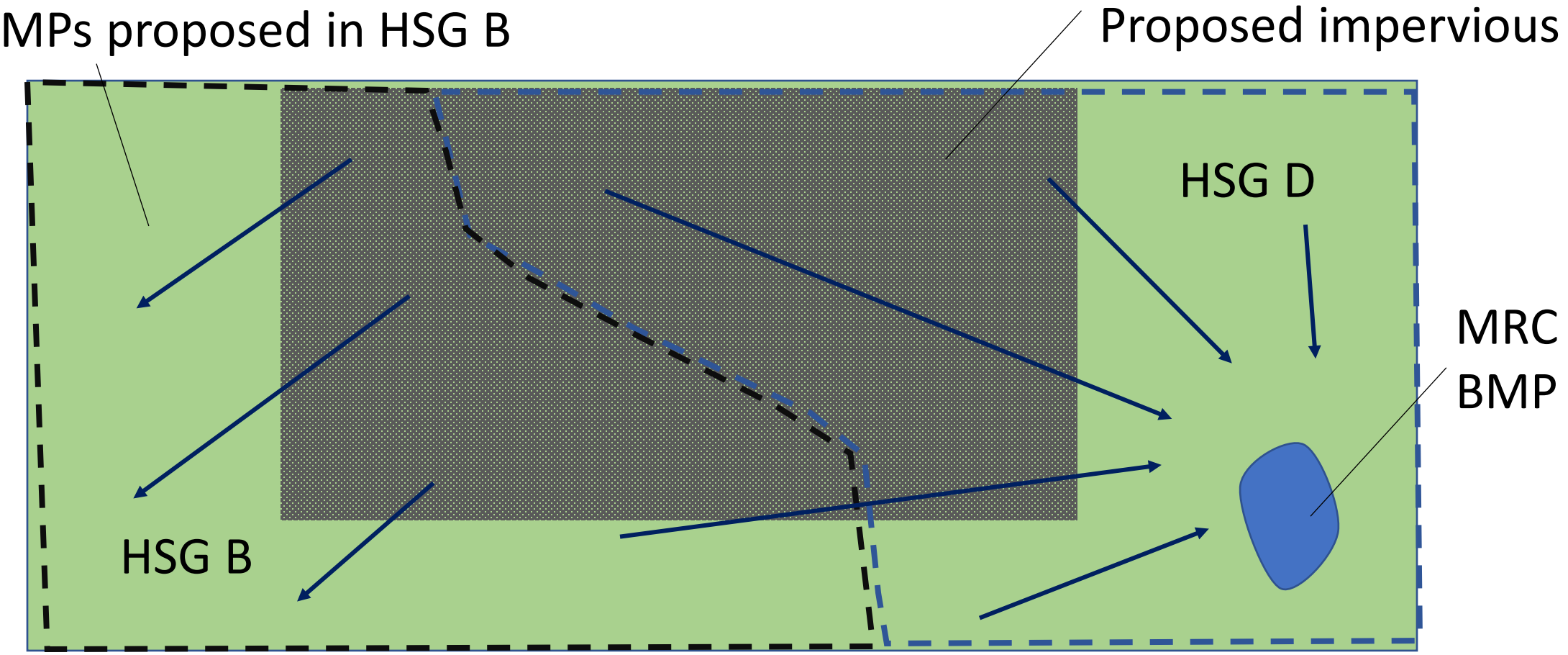
Applicant must:

- show a thorough pre-development site characterization and assessment of soil and geology of the project site (not just the proposed location of the SCM), and has determined that
  - it is not feasible to remove the Δ2 volume through infiltration and ET alone
  - structural and non-structural SCMs are not sufficient to remove the Δ2 volume
  - MRC is not being used to manage stormwater that could reasonably be infiltrated elsewhere

Δ2 = change in 2-year/24-hour storm from postconstruction to preconstruction

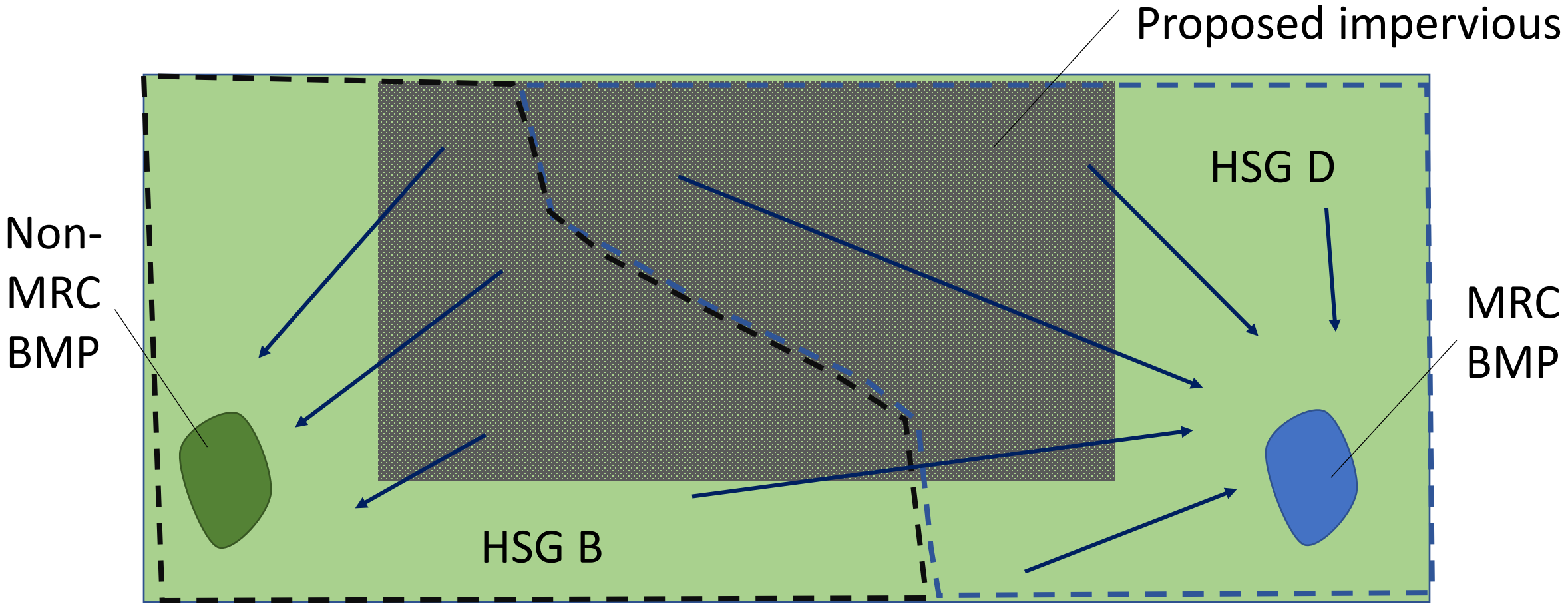
Where can it be used? - Example

Assume no environmental or SHWT limitations



Where can it be used? - Example

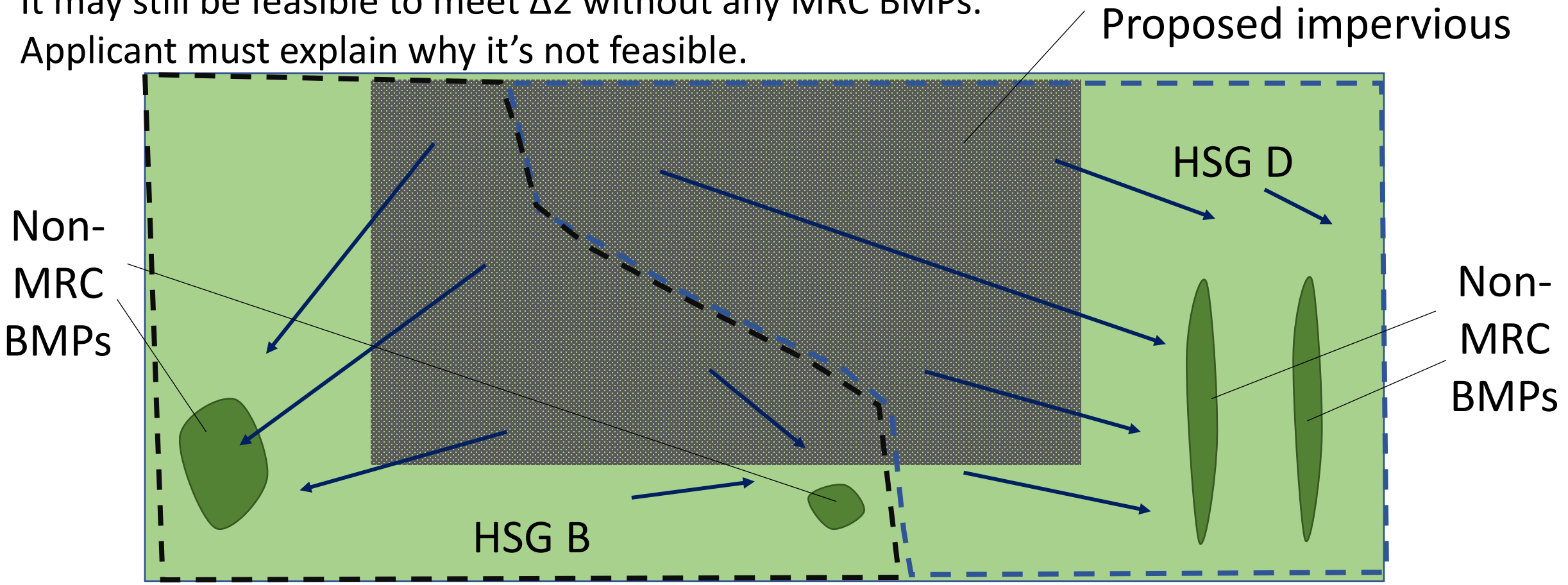
Assume no environmental or SHWT limitations



Where can it be used? - Example

Assume no environmental or SHWT limitations

It may still be feasible to meet Δ2 without any MRC BMPs. Applicant must explain why it's not feasible.



Back to 2006 Stormwater Manual

Table 3-4 Recommended Site Control Guidelines

TYPE	GUIDELINE *	GOALS
Volume CG-1	*Do not increase runoff volume, pre-development to post-development, for up to the 2-year frequency, 24-hour duration rainfall. ***	Groundwater/ Water Table/ Stream Base Flow & Stream Conservation/ Stream Channel Protection
Volume CG-2	*Capture and remove runoff generated by 1.5 inches of rainfall with infiltration of the runoff from the initial 0.5 inches of rainfall.*	
Extended Detention (CG-2 only)	*Provide 24-hour extended detention of the 1-year frequency, 24-hour duration rainfall.*	Stream Conservation/ Stream Channel Protection
Peak Rate (CG-1 and CG-2)	*Do not increase peak rate of runoff for larger storms (1-, 2-, 10-, 25-, 100-year storms at minimum), pre-development to post-development; as necessary, provide additional peak rate control for largest storms through the Act 167 planning.*	Flood Protection: 1- through 100-Year Storms, Site by Site
		Cumulative Flood Protection as Needed through Act 167 Planning
Water Quality (CG-1 and CG-2)	*A reduction of 85% of particulate-associated pollutants (as represented by TSS), including 85% of Total Phosphorus. In addition, removal or prevention of 50% of solutes (as represented by NO3-N) is required. BMPs shall not result in a temperature increase of 3 degrees Fahrenheit.*	Groundwater Quality
		Surface Water Quality - reduction of 85% particulate-associated NPS; reduction of 50% solute loads
		Temperature

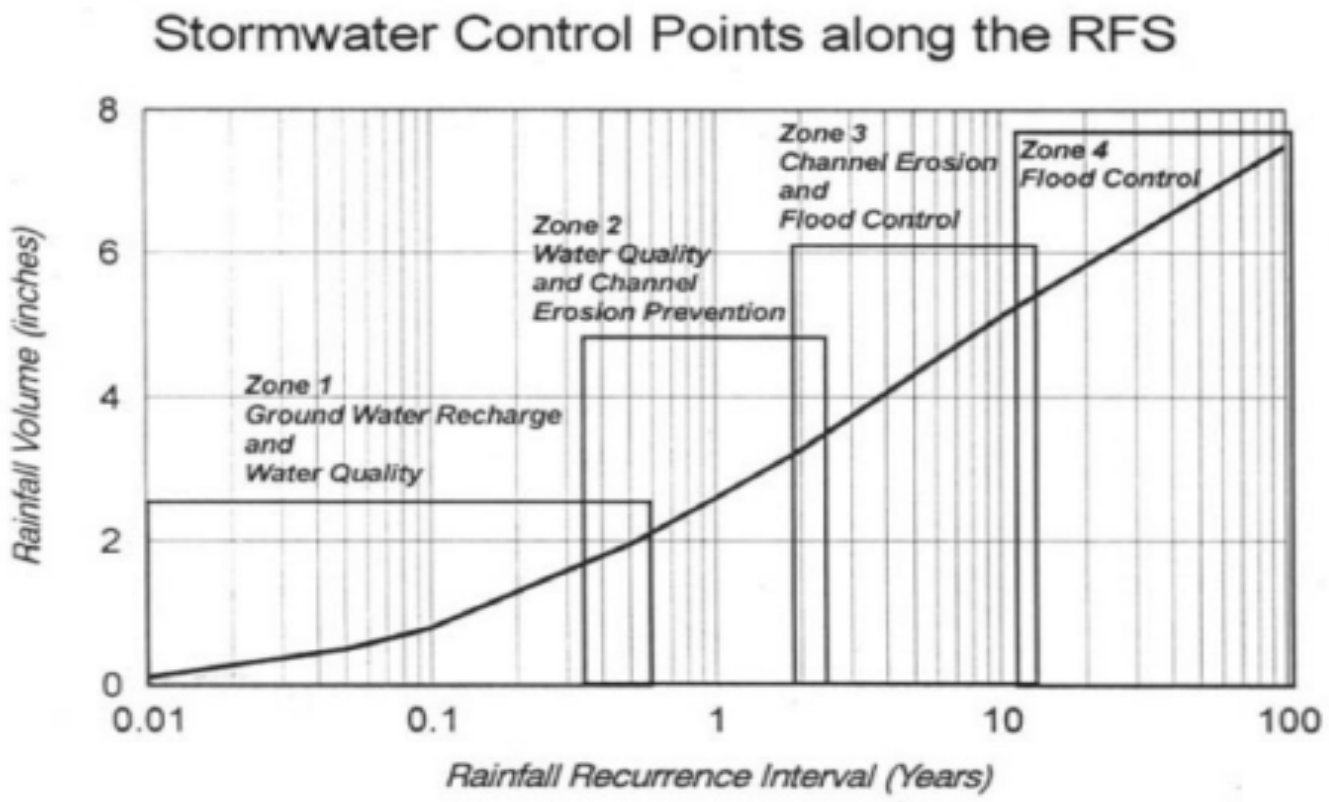
** These guidelines are recommended for use in watersheds throughout Pennsylvania. Guidelines may be further modified in Special Stormwater Management Areas and other zones where different stormwater guidelines for quantity and quality control are warranted.*

*** Existing (pre-development) non-forested pervious areas must be considered meadow or its equivalent.*

Back to 2006 Stormwater Manual

The New Guidance Manual (Draft 2023) Volume Control Goals:

- Protect stream channel morphology;
- Maintain groundwater recharge;
- Prevent downstream increases in flooding; and
- Replicate the natural hydrology on site before development to the greatest extent possible.



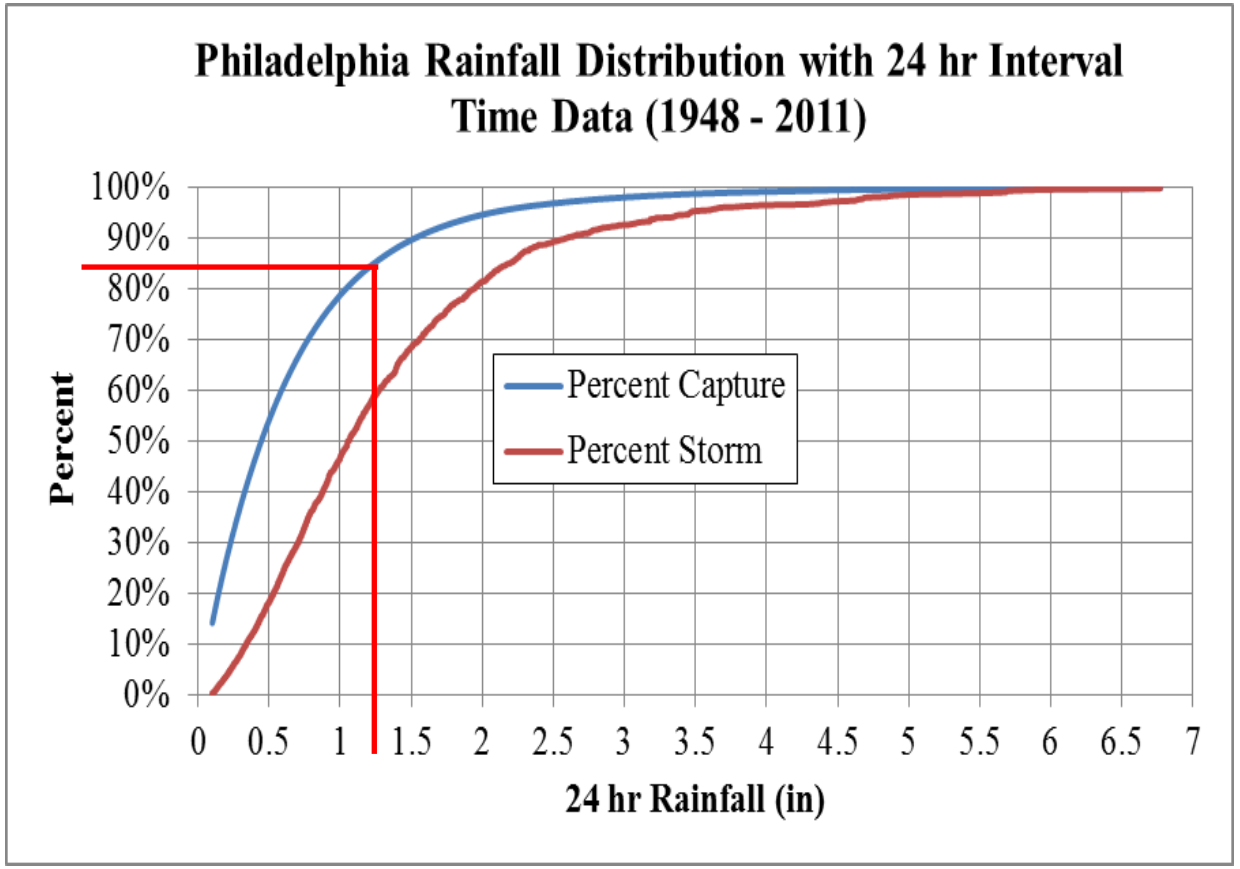
To meet the intent of management of Δ2 for MRC, the MRC SCM must:

Management using MRC	Goal
	Store, filter, and slow release a portion of the 2-year/24-hour storm
	Provide geomorphological protection

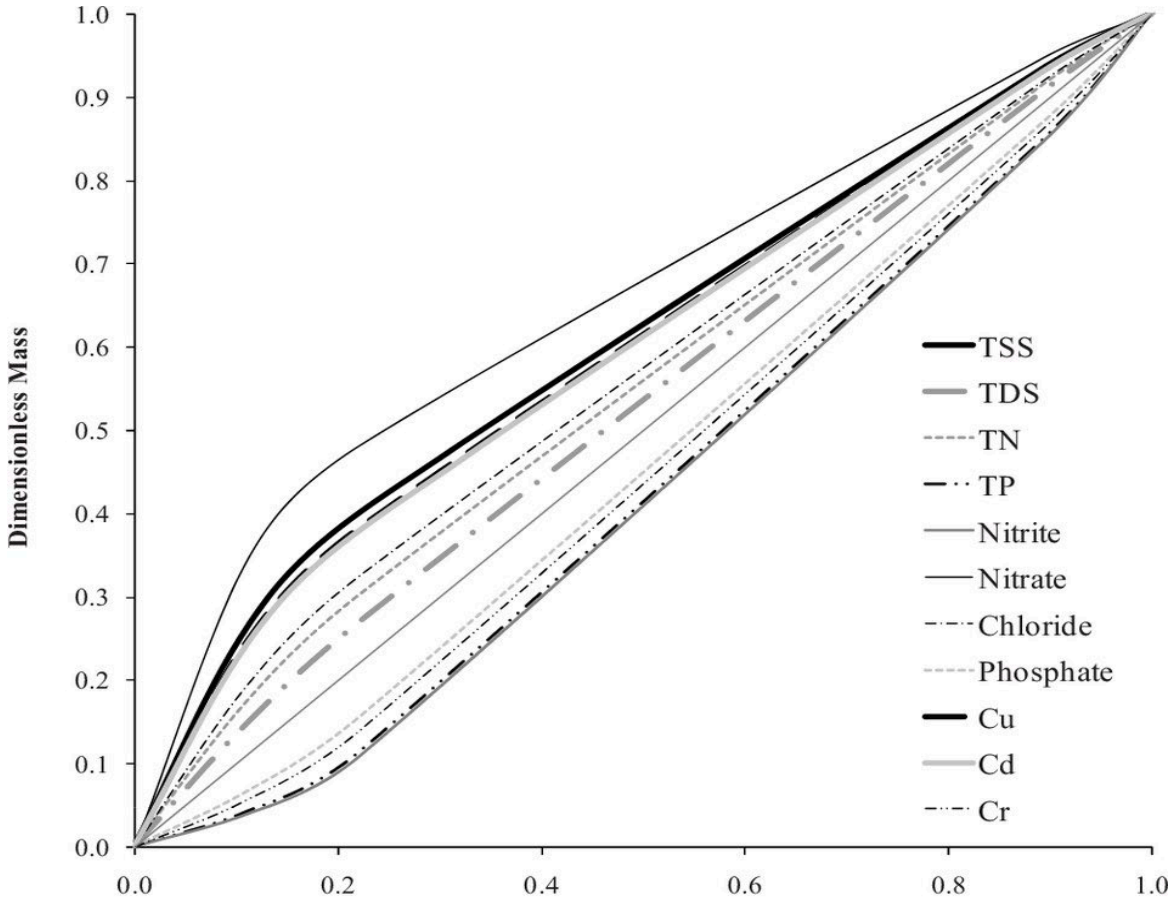
To meet the intent of management of Δ2 for MRC, the MRC SCM must:

Management using MRC	Goal	Attributed Value	
	Store, filter, and slow release a portion of the 2-year/24-hour storm	Store	Store 1.2-inch/2-hour storm event
		Filter	Provide Treatment via IWS and/or equivalent treatment (via MTD, for ex)
		Release	Slow release to level of 0.02 cfs per equivalent impervious acre
	Provide geomorphological protection	Mange the 2-year/24-hour peak rate back postconstruction to 1-year/24-hour preconstruction peak either in MRC SCM or other SCM	

Store 1.2-inch/2-hour storm event



1-Year/2-hour Storm at Villanova University: 1.42”
Harrisburg: 1.26”
Pittsburgh: 1.12”



TECHNICAL PAPERS | Jul 23, 2009

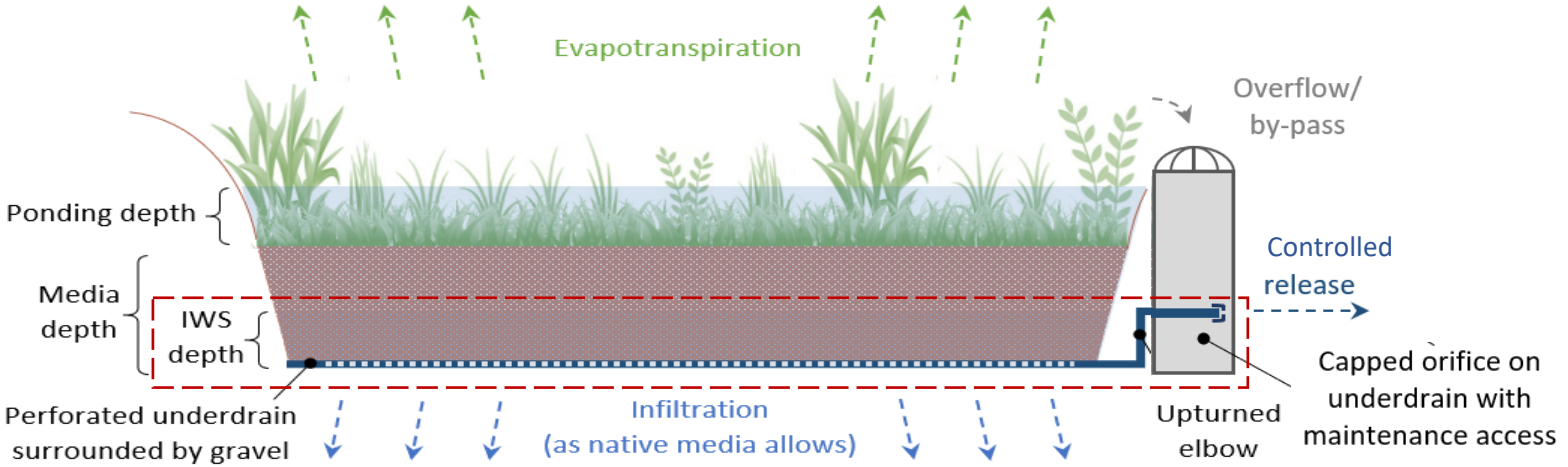
Parking Deck’s First Flush

Authors: Thomas Batroney, Bridget M. Wadzuk, M.ASCE, and Robert G. Traver, M.ASCE | AUTHOR AFFILIATIONS

Publication: Journal of Hydrologic Engineering • Volume 15, Issue 2 • https://doi.org/10.1061/(ASCE)HE.1943-5584.0000167

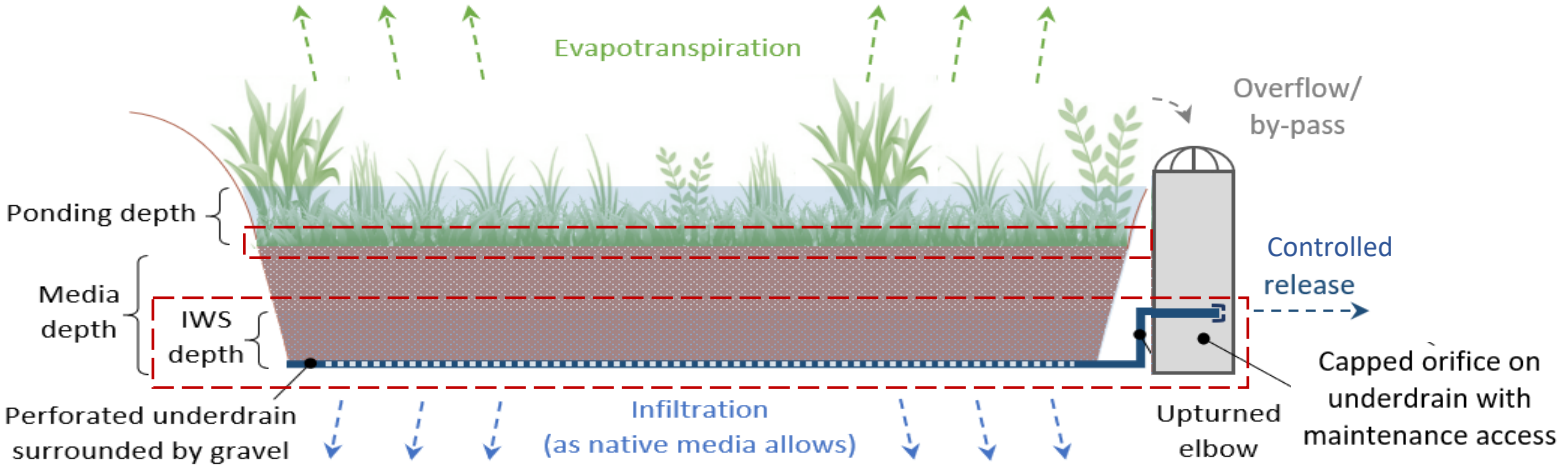
Filter

- Internal Water Storage (IWS) have been found to provide additional water quality benefits such as denitrification and ET (if vegetated)



Filter – with 2-year/24-hour routed or less

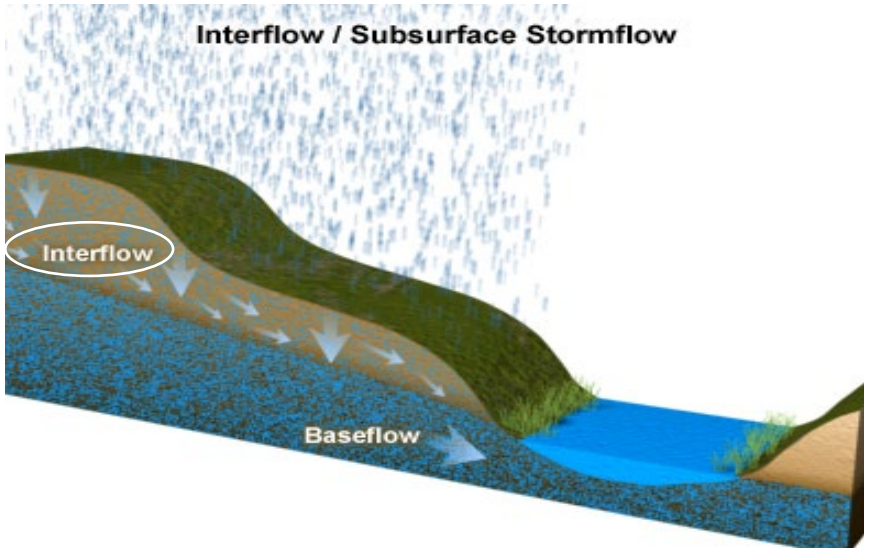
- For surface systems, pretreatment of the soil surface and treatment through the soil media with IWS is sufficient

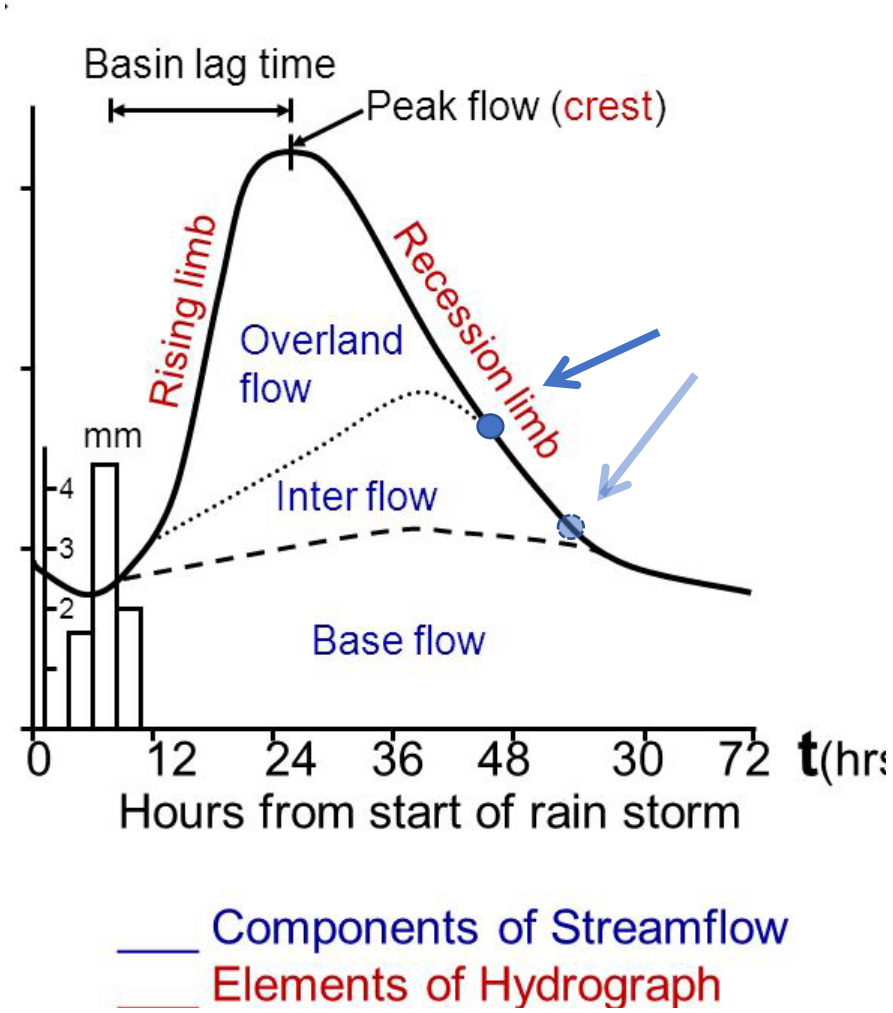


- For subsurface systems, there are options in which to meet the intent of water quality treatment

Release Rate

- Approximates the expected rate of interflow after a 2-year/24-hour storm event for a Pennsylvania non-Karst watershed based on the NRCS curvilinear unit hydrograph.





Release Rate



TECHNICAL NOTES | Sep 4, 2010

Bioretention Outflow: Does It Mimic Nonurban Watershed Shallow Interflow?

Authors: Kathy M. DeBusk, A.M.ASCE, William F. Hunt, Ph.D., M.ASCE, and Daniel E. Line, M.ASCE | AUTHOR AFFILIATIONS

Publication: Journal of Hydrologic Engineering • Volume 16, Issue 3 • https://doi.org/10.1061/(ASCE)HE.1943-5584.0000315

Results indicate that there is **no statistical difference** between flow rates in streams draining undeveloped watersheds and bioretention outflow rates for the first 24 h following the commencement of flow. Similarly, there is no statistical difference between the cumulative volumes released by the two systems during the 48 h following the start of flow. These results indicate that bioretention cells behave comparably to watersheds in natural or nonurban conditions, with respect to both flow rates and flow volumes, and suggest that bioretention outflows may mirror post–storm event shallow groundwater interevent stream recharge flow.

Release Rate

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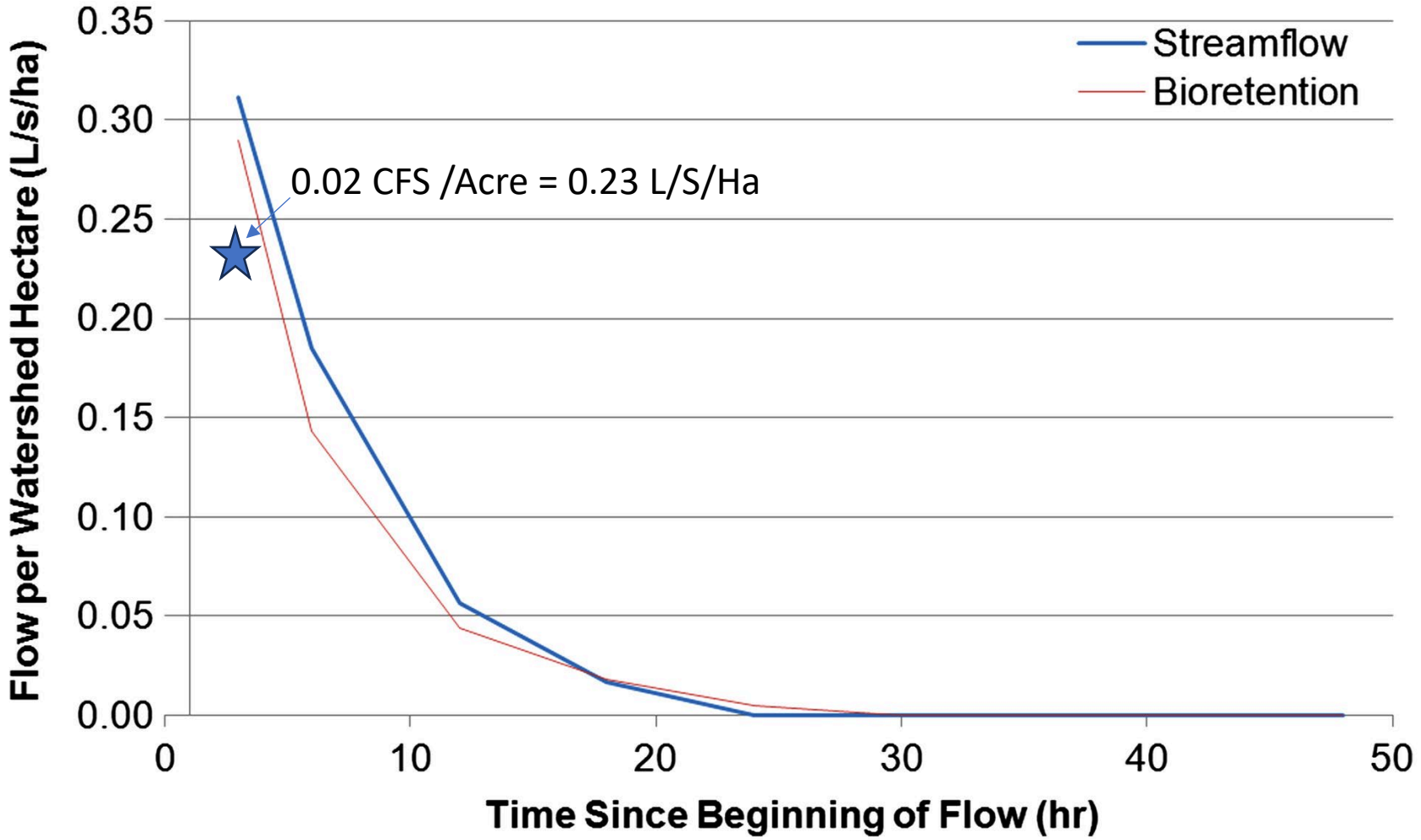


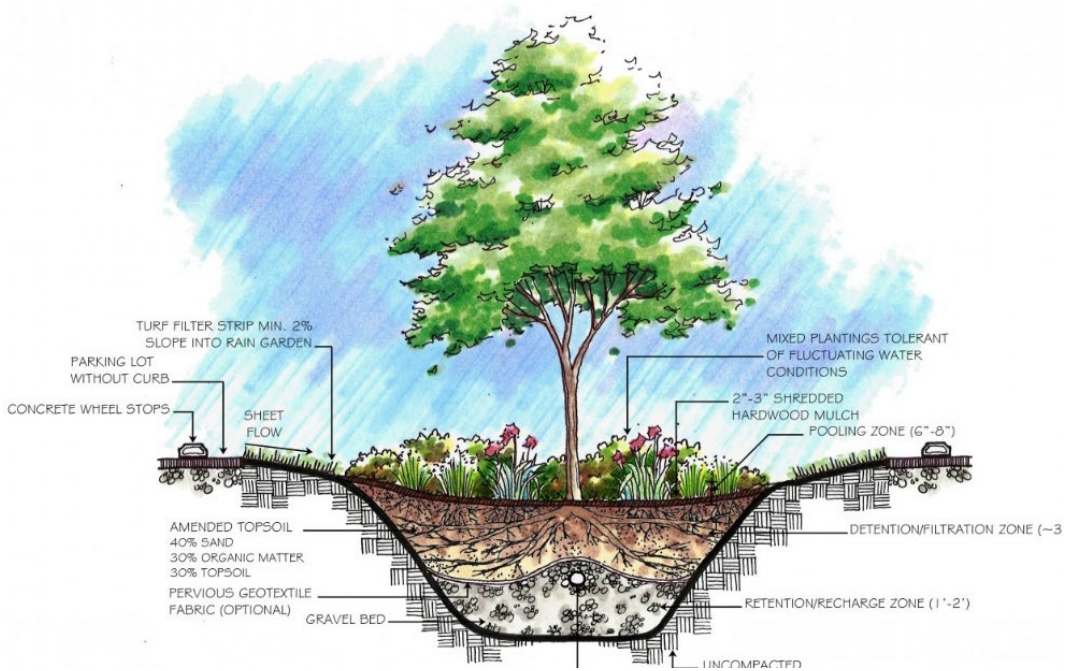
Results indicate that there is **no statistical difference** between flow rates in streams draining undeveloped watersheds and bioretention outflow rates

Debusk et al 2010

What does an MRC SCM look like?

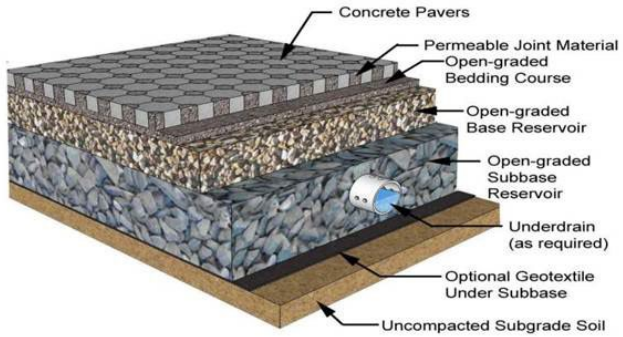
MRC can be incorporated within specific BMPs

Surface: MRC Bioretention, MRC Bioswale



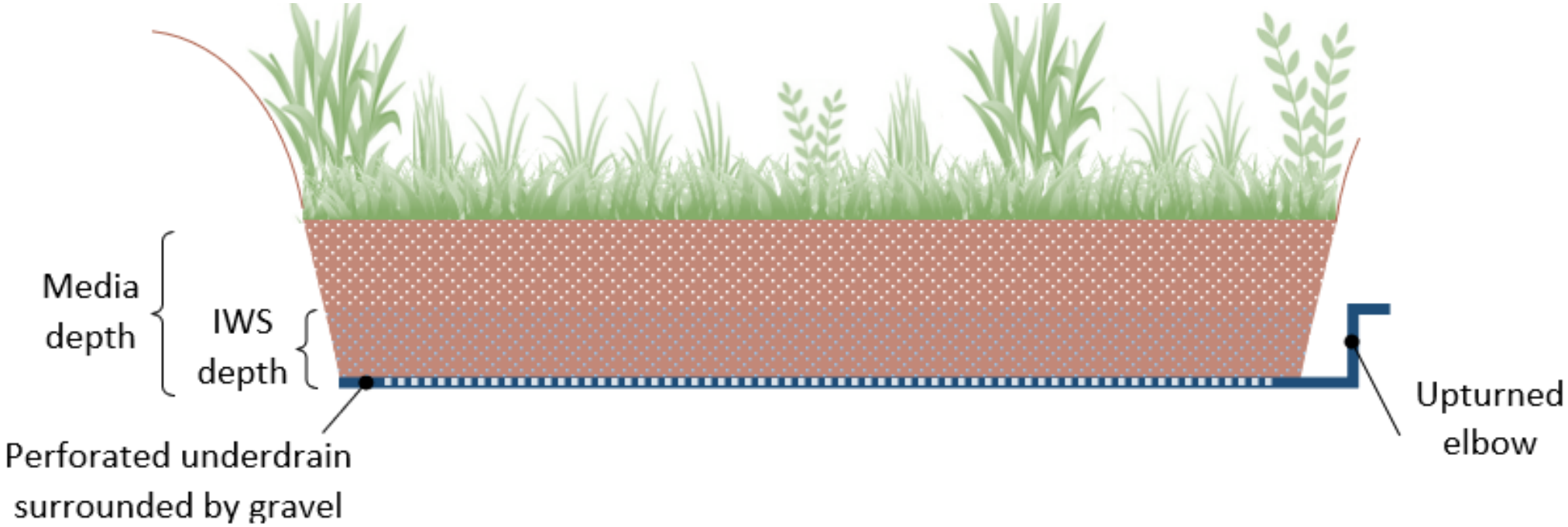
Subsurface: Underground storage basins, permeable pavement with storage basin





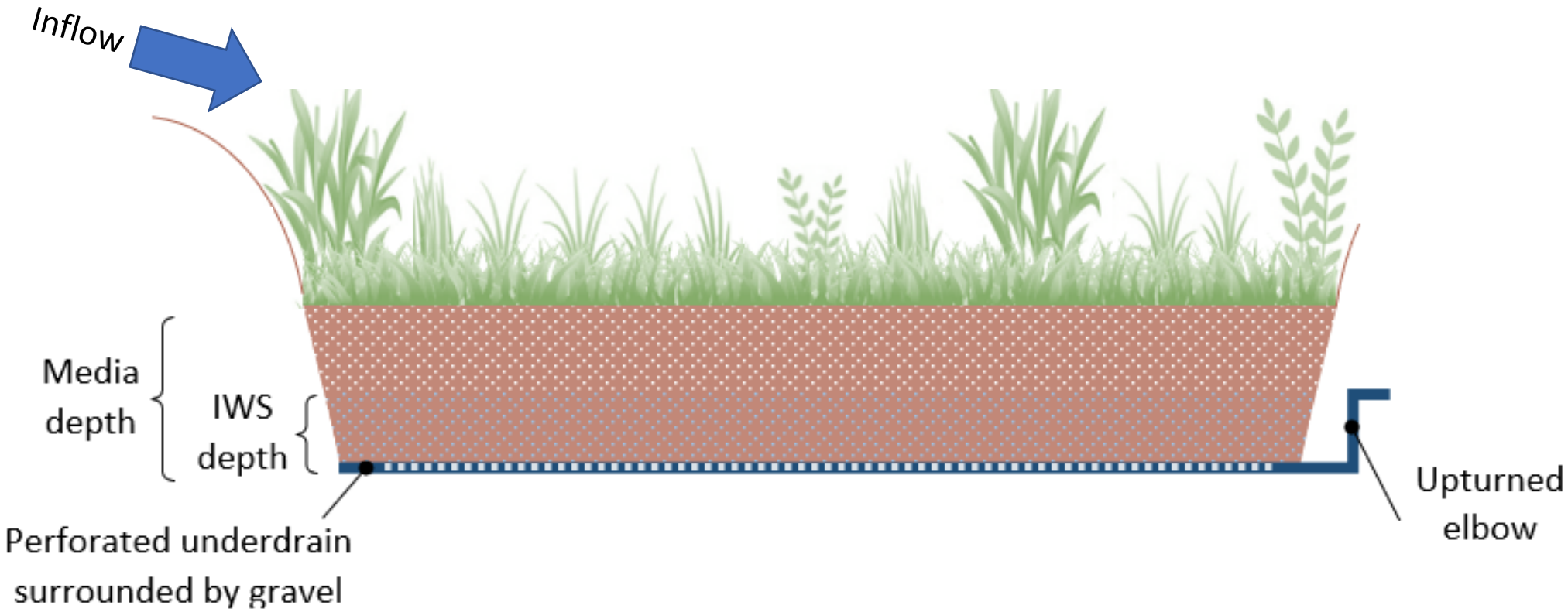
How do MRC BMPs work?

MRC Bioretention Example



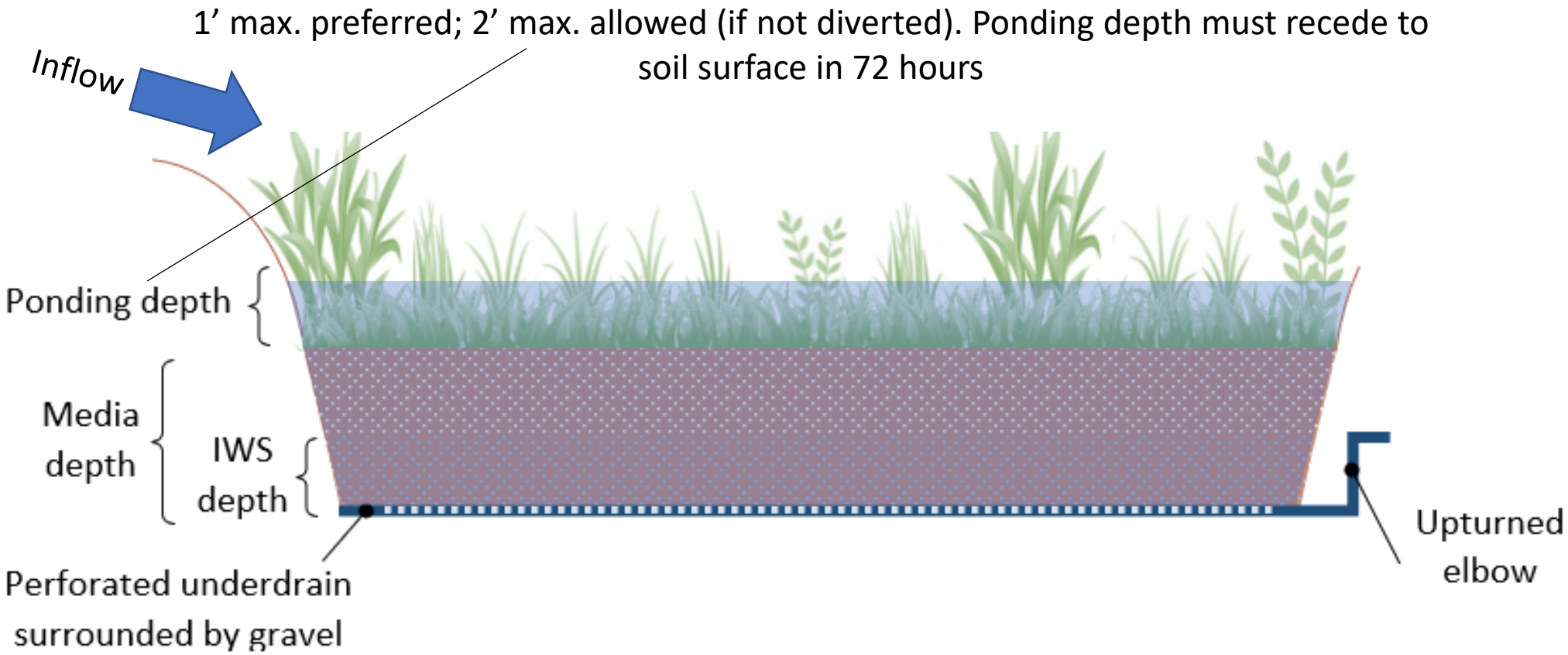
How do MRC BMPs work?

Storm just has started



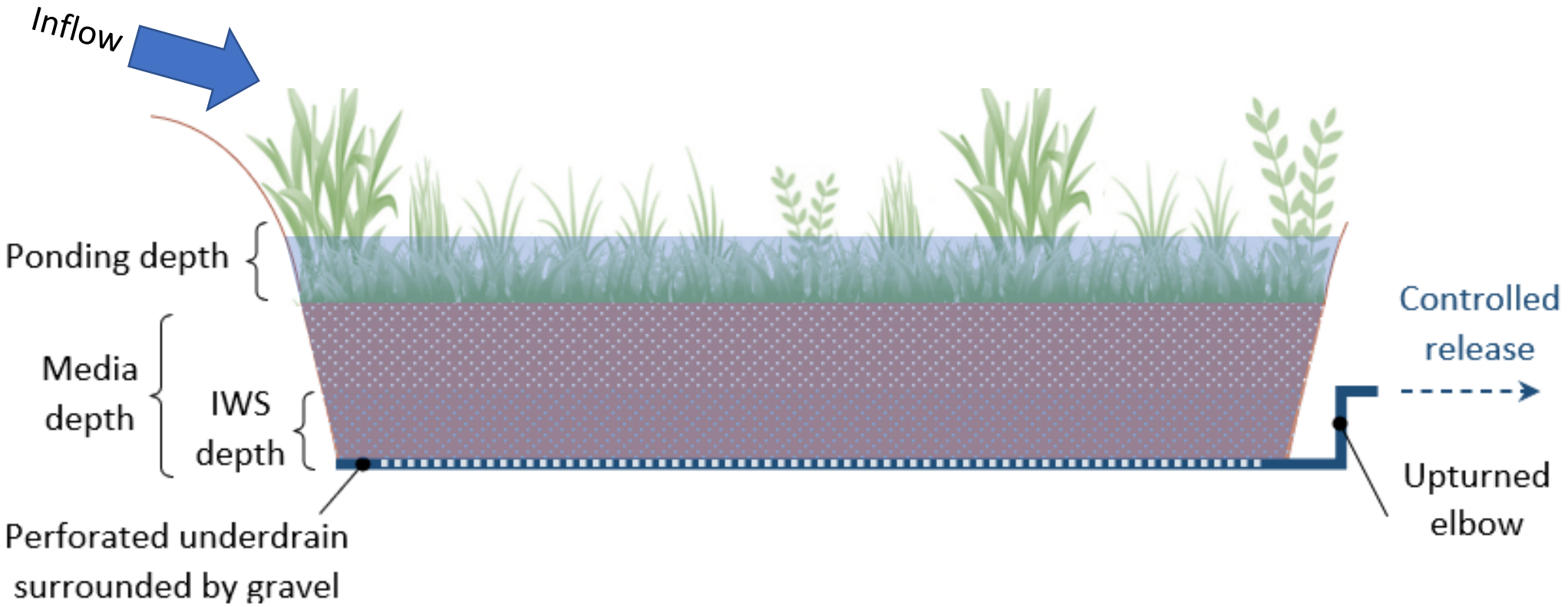
How do MRC BMPs work?

BMP fills up



How do MRC BMPs work?

Controlled release from the underdrain occurs



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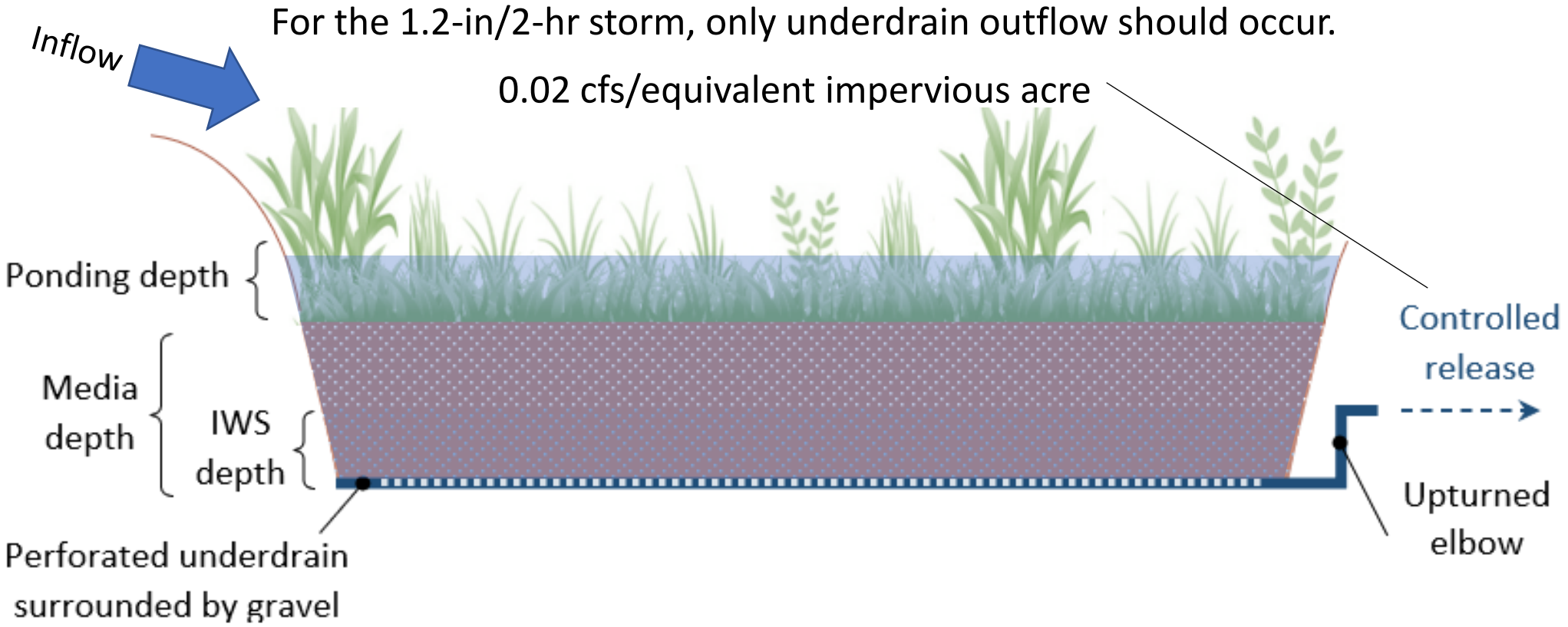
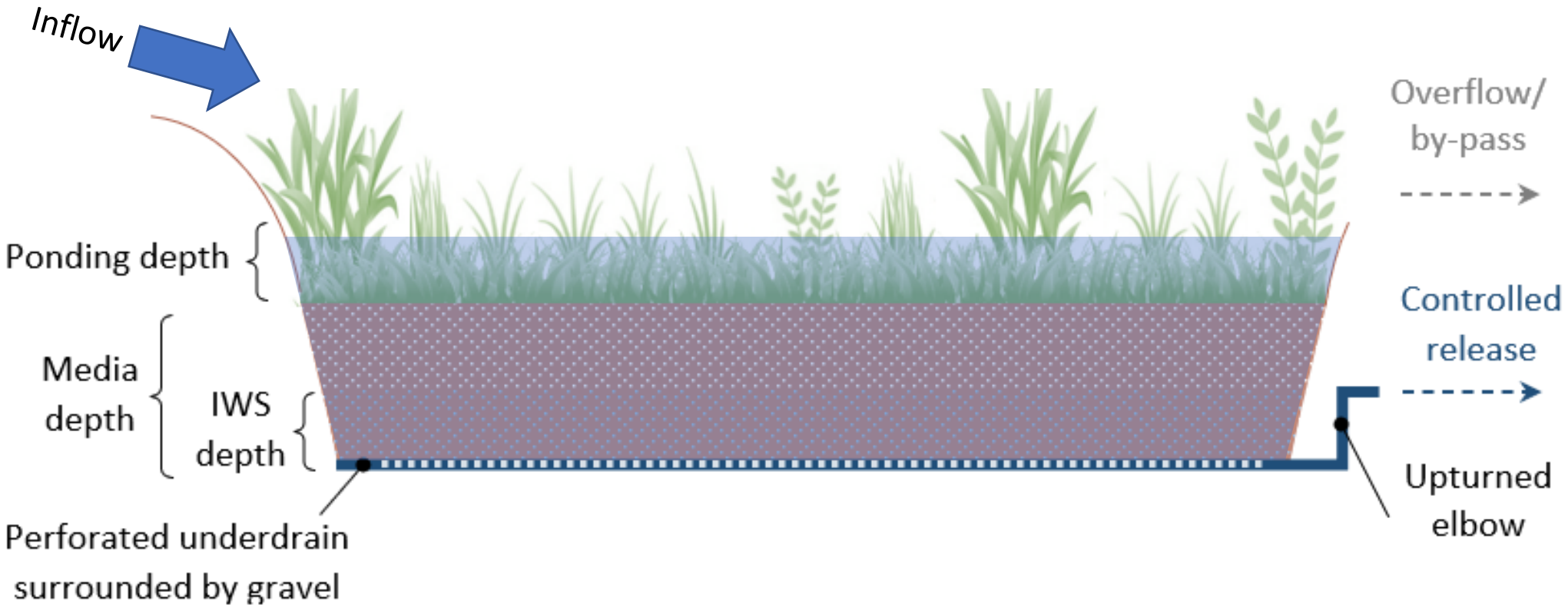


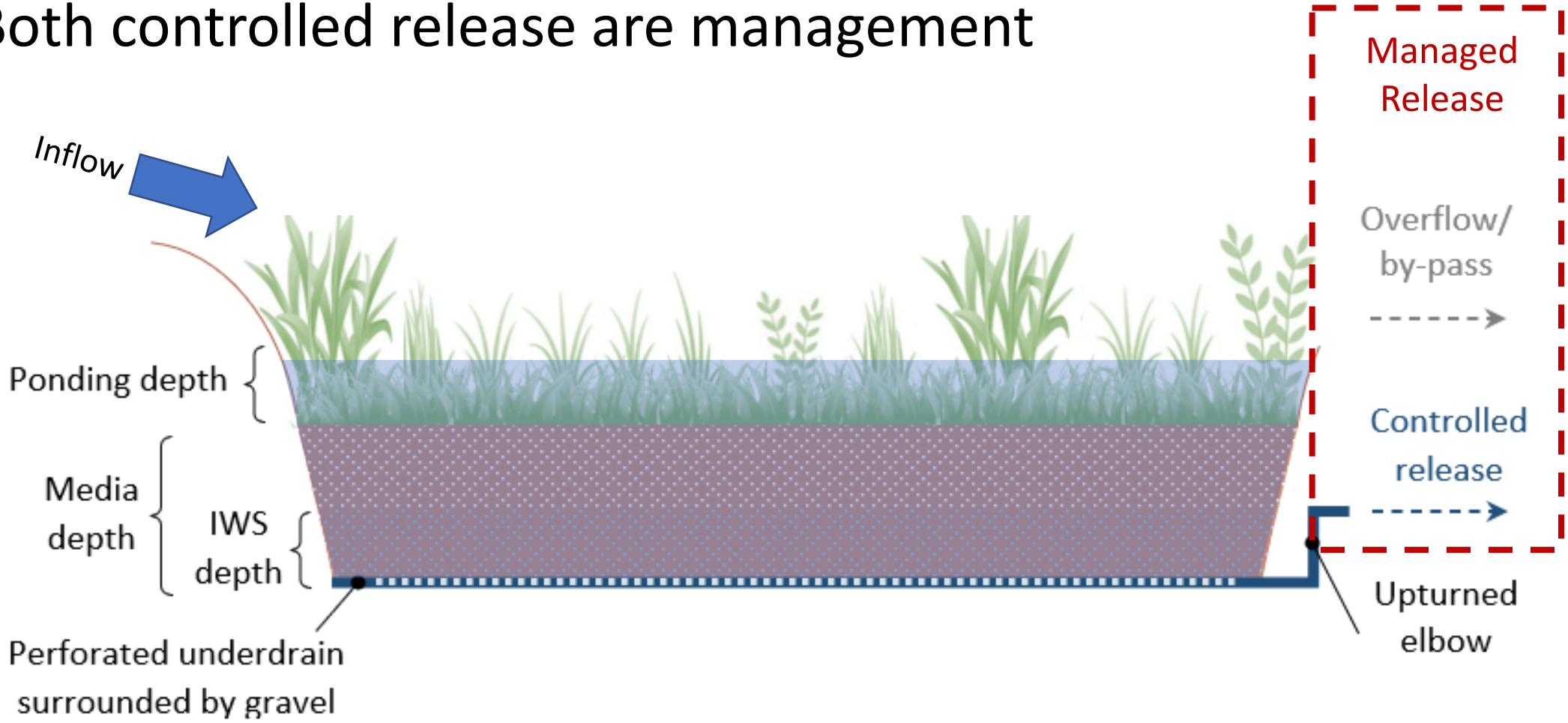
How do MRC BMPs work?

Controlled release from the overflow/bypass of the MRC SCM occurs



How do MRC BMPs work?

Both controlled release are management



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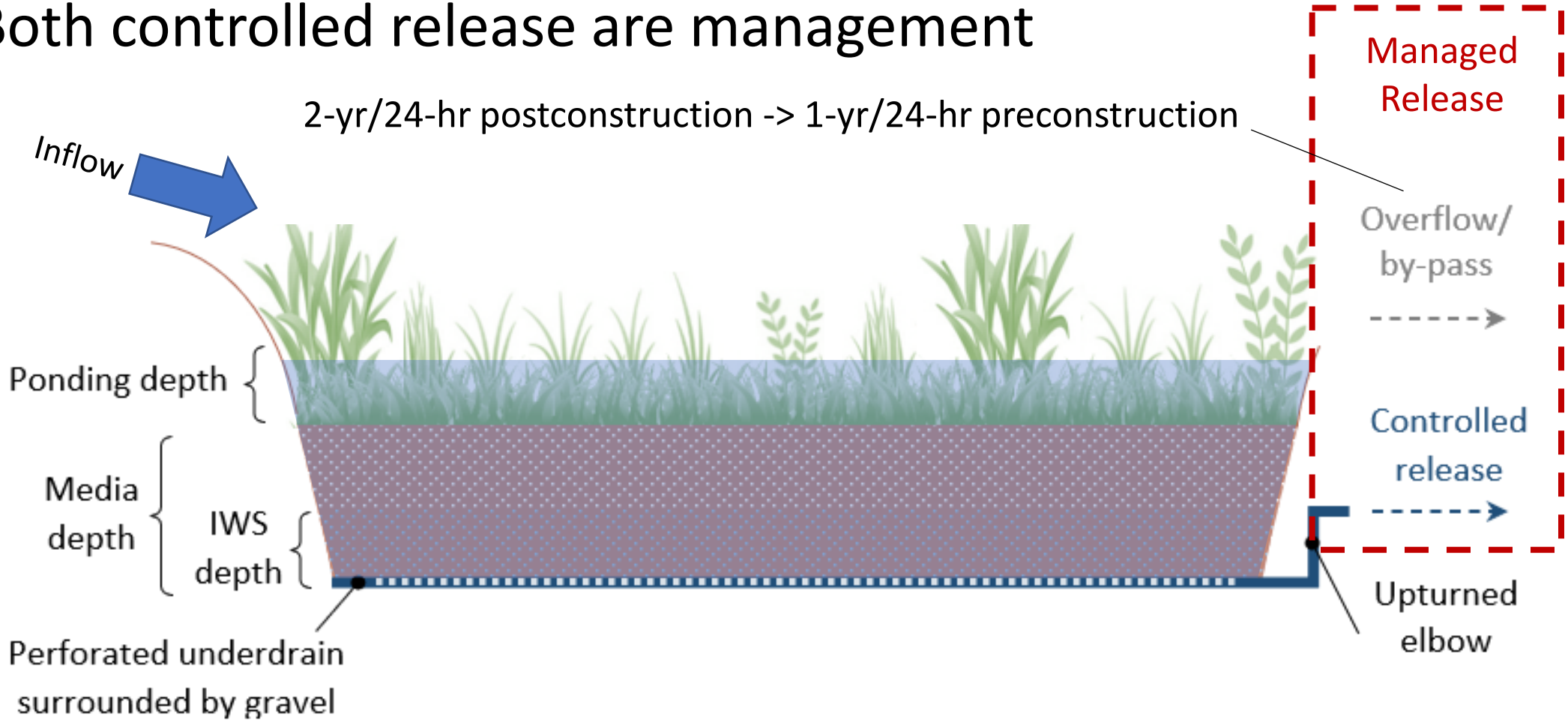
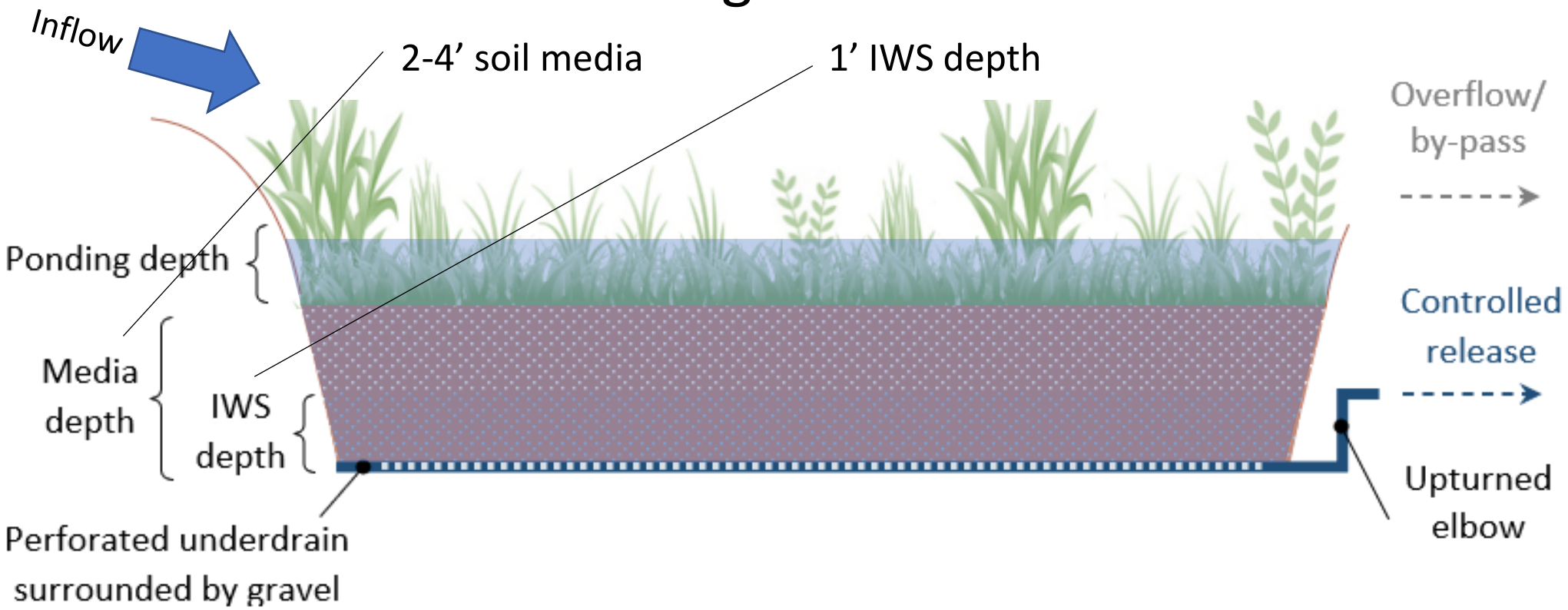


How do MRC BMPs work?

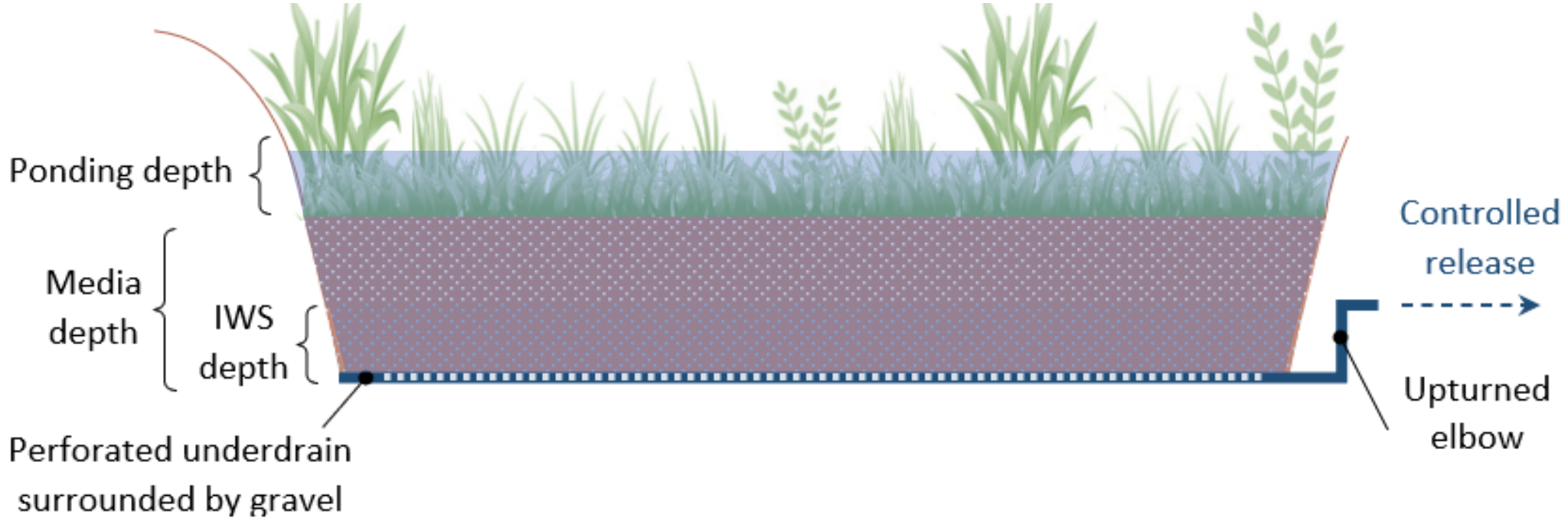
Filtering through a soil media & IWS provide water quality management



How do MRC BMPs work?

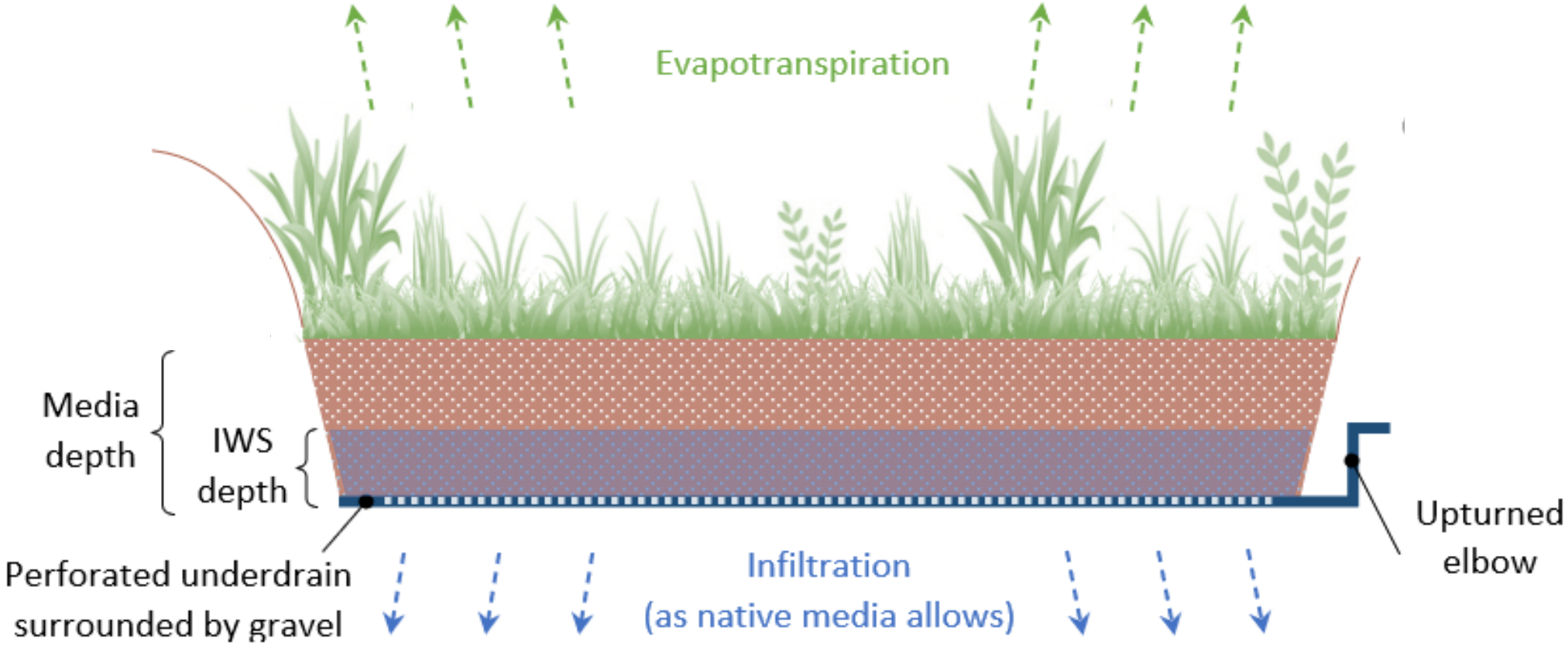
Inflow stops

Ponding recedes to top of IWS



How do MRC BMPs work?

IWS water is removed (at least halfway) during interevent time



Allows the use of 50% of soil media void space to be accounted for in calculations

Pretreatment Requirements

Depends on:

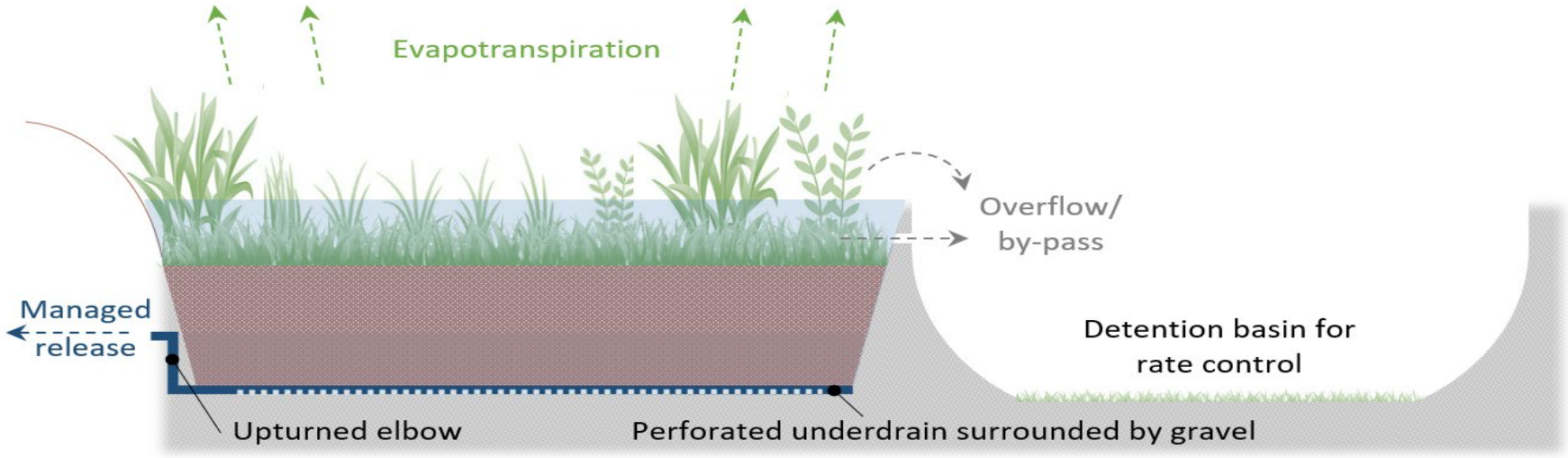
- Surface or Subsurface MRC type
- Diversion of flows

Maximum Storm Routed to the MRC SCM:	**2-Year/24-Hour Storm or less**	**Greater than the 2-Year/24-Hour Storm**
Surface	Vegetated surface acts as pretreatment	Forebay
Subsurface	Manufactured Treatment Device; Upstream Vegetated Component, or Adequate Permeable Pavement Maintenance	Settling chamber (in addition to 2-Year/24-Hour Storm or less pretreatment)

Diversion concept – Strongly Recommended

Flows Greater Than 2-Year/24-Hour Storm or 1.2-inch/2-Hour Storm

- Bypass the 10-, 50- and 100-year/24-hour storm events to rate control facility



If large flows are routed through the MRC, this can cause:

- Erosion of MRC surface
- Resuspension of sediments

Goal to reduce maintenance requirements, and increase life span to make sure it is ready to go

Diversion concept

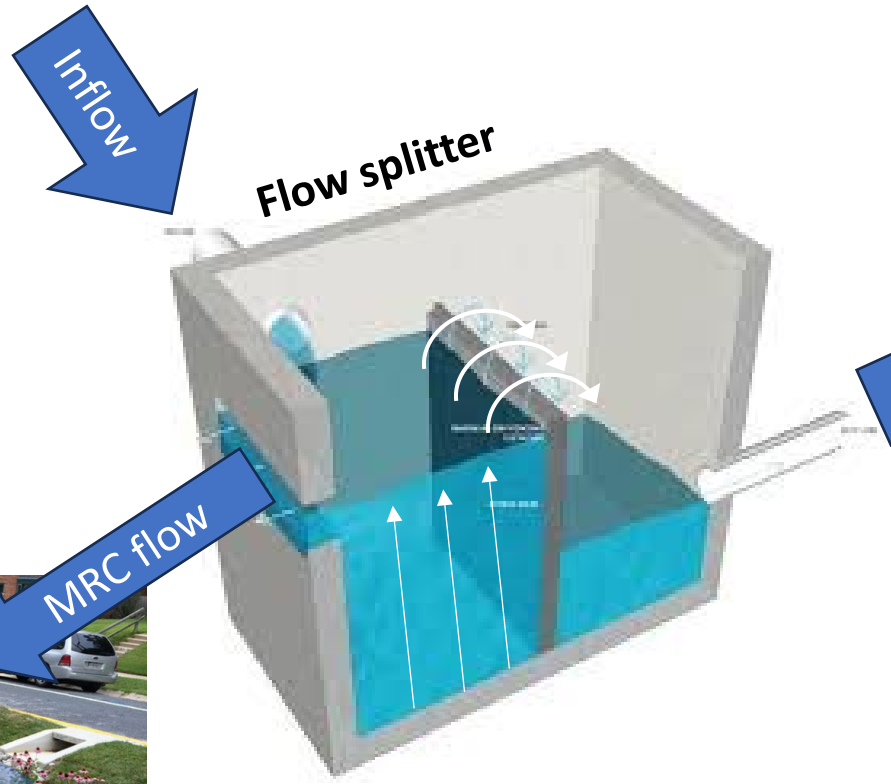
Maximum Drainage Area Depends on:

- Diversion of flows
- Presence of PCSM Objective A SCMs

Maximum Storm Event Routed to SCM	Maximum Equivalent Impervious Drainage Area (acres)
1.2-Inch/2-Hour Storm (or less), **with** 10% PCSM Objective A	6
1.2-Inch/2-Hour Storm (or less), **without** 10% PCSM Objective A	5
2-Year/24-Hour Storm (or less but greater than 1.2-Inch/2-Hour Storm), **with** 10% PCSM Objective A	2.5
2-Year/24-Hour Storm (or less but greater than 1.2-Inch/2-Hour Storm), **without** 10% PCSM Objective A	2
> 2-Year/24-Hour Storm, **with** 10% PCSM Objective A	1.5
> 2-Year/24-Hour Storm, **without** 10% PCSM Objective A	1

Diversion concept

How to divert-
Flow splitter

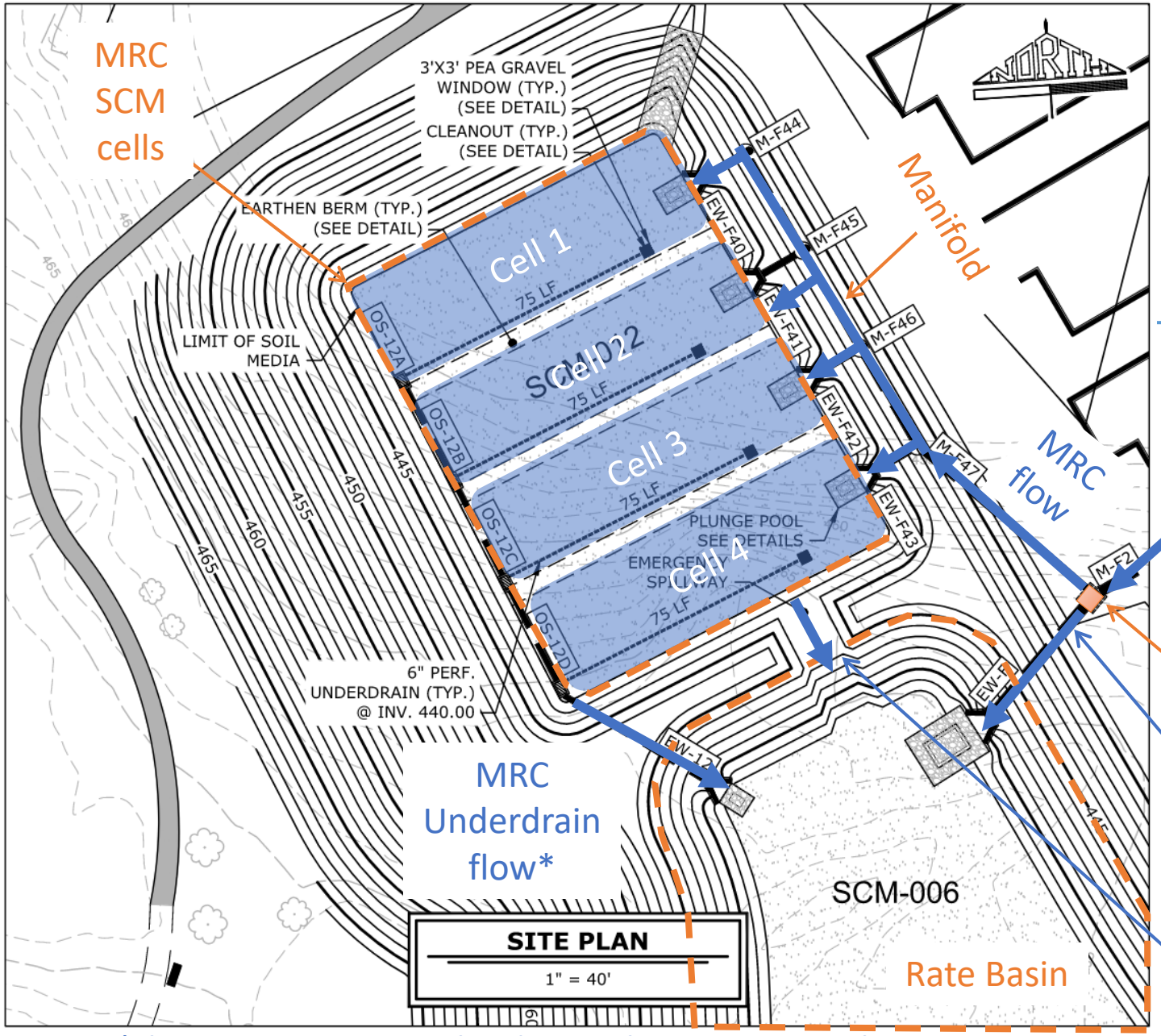






Diversion concept

How to divert- Flow splitter with multiple MRC SCM cells



*this may or may not be directed to rate control

Courtesy of RGS Associates

Diversion concept

How to divert

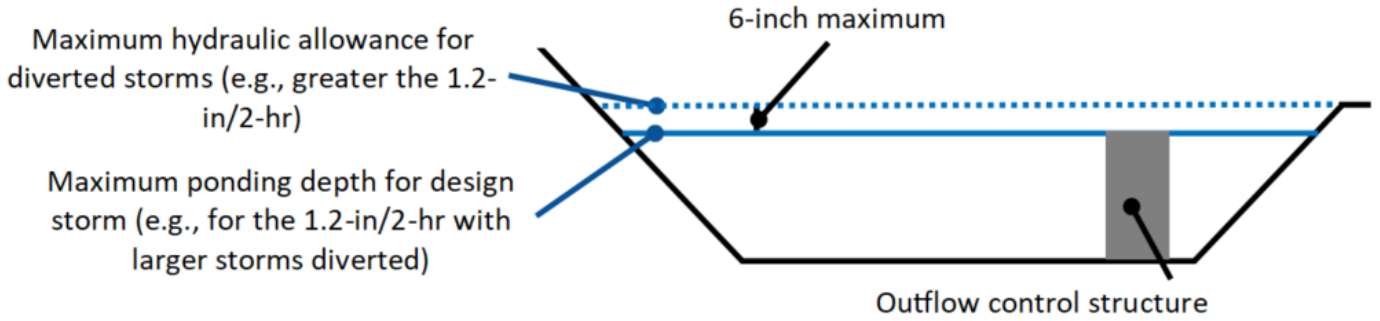




Diversion concept – Hydraulic Allowance

How to divert





Some take away thoughts:

- Do you really need an MRC?
  - Take advantage of any infiltration you can get
- If you do,
  - Minimize maintenance by protecting media surface (diversion)
  - Check for maximum ponding depth (hydraulic allowance is in addition)
  - Does the runoff from the impervious surface get there?
  - Make sure it is routed using a hydrologic model

QUESTIONS?