Introducing the New England Stormwater Retrofit Manual

National Stormwater Roundtable 2022

Jamie Houle

Director – University of New Hampshire Stormwater Center

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Manual Team and Manual Funding

Presenting Today:

James Houle

Director – University of New Hampshire Stormwater Center

Additional Authors:

Nate Pacheco

Water Resources Specialist - VHB

Theresa McGovern

Water Resources Engineer - VHB

Mark Voorhees

Environmental Engineer - EPA

Technical Advisory Committee:

- CTDEEP
- EPA
- MADEP
- MassDOT
- MEDEP
- NHDES
- RIDEM
- RIDOT
- VTDEC
- UNHSWC

This manual was funded by a technical assistance grant provided by the EPA's Southeast New England Program (SNEP). https://snepnetwork.org/stormwater-retrofit-manual/

Southeast New England Program (SNEP) Network Context

2021 - 2025 PRIORITY ACTIONS

SNEP Goals

Resilient Ecosystem of Safe and Healthy Waters; Thriving Watersheds and Natural Lands; Sustainable Communities

- Increase Local Capacity to Complete Projects and Adopt New Policies
- Increase Available Solutions
- Demonstrate Ways to Address Common Challenges
- Increase Community Leaders' Understanding of the Benefits of Restoration Projects
- Ensure Diverse Representation

Source: [Southeast New England Program Fact Sheet, February 2021 (epa.gov)]

Goals of New England Stormwater Retrofit Manual

- Provide research-based guidance on **planning, siting, and designing** retrofit stormwater control measures (SCMS) **where regulatory requirements to not dictate prescribed specifications**
- Present an approach for **crediting pollutant and runoff volume reductions** associated with these SCMs
- Present a framework for **selecting the optimal SCM** for a specific project/site

Why this Manual Matters

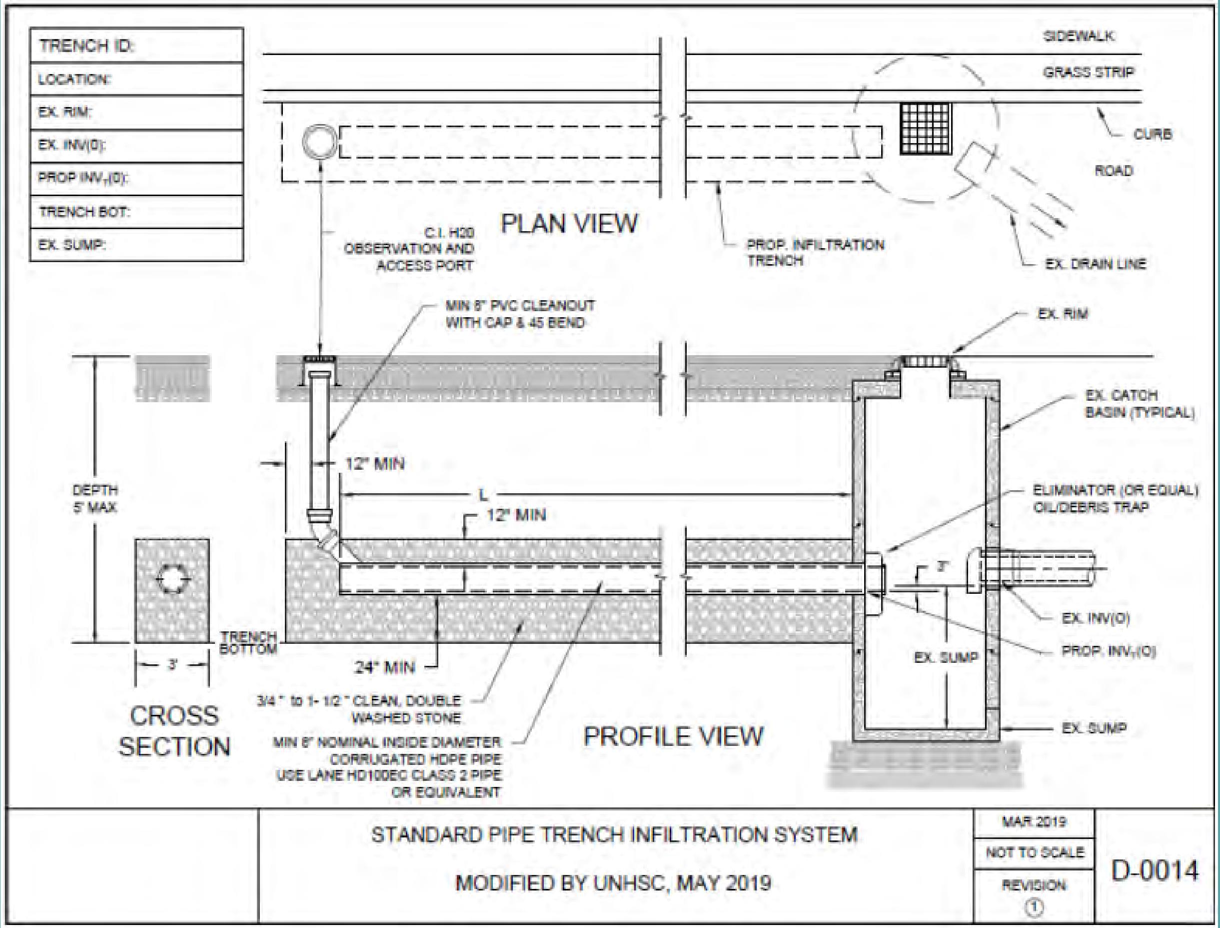
- This manual fills a gap in existing retrofit guidance by…
  - Encouraging designers to **move beyond prescriptive new/redevelopment mindset**
  - Helping designers **piece SCM components together to arrive at the best SCM** to meet project and site-specific needs
  - **Promoting the use of EPA-developed water quality crediting methods** to quantify SCM impact

Manual Highlights: Planning and Crediting

Retrofit Approach: Opportunistic Approach

- Incorporation of SCMs into already planned and needed construction projects
- Key Considerations:
  - **Be proactive in identifying opportunities.**
  - **Develop a suite of typical SCMs.**
  - **Be willing to be flexible with the project specifications**
  - **Tailor the scale and type of SCMs to the project**

Arlington, MA Standardized Trench Design



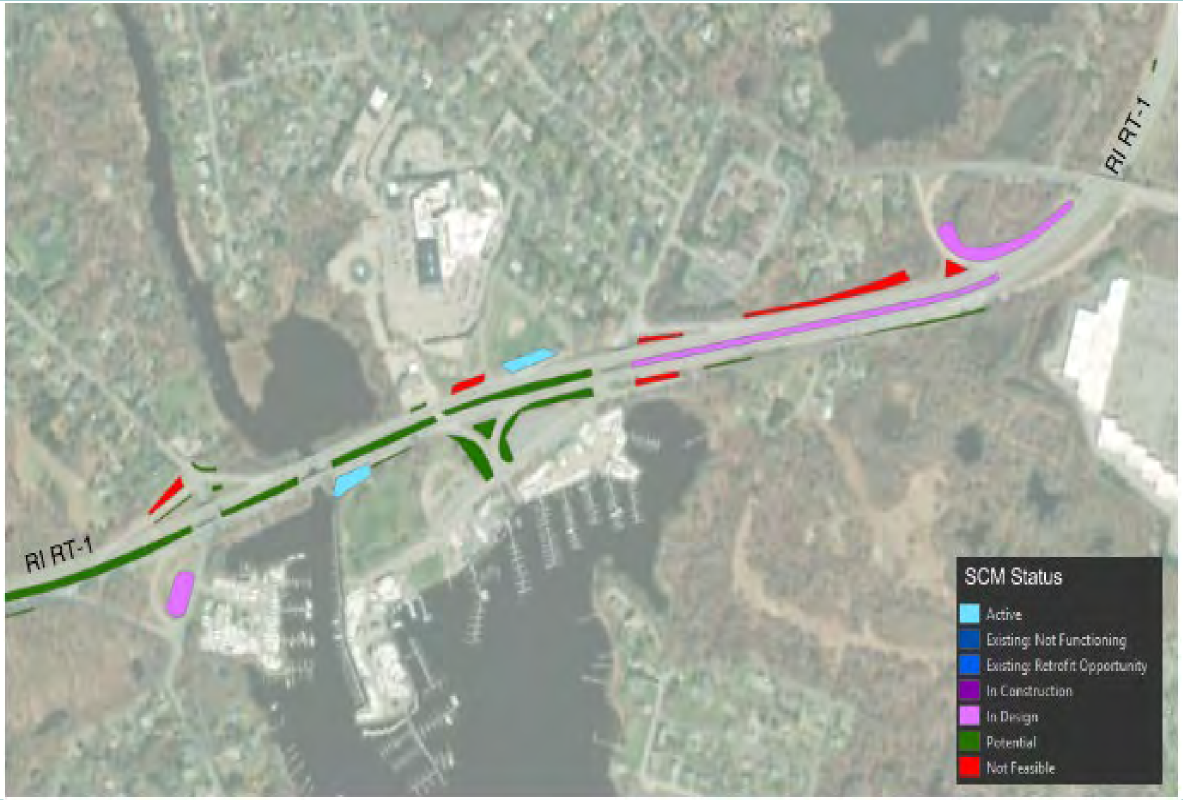
Source: https://www3.epa.gov/region1/npdes/stormwater/tools/arlington-ma-infiltration-trench-conceptual-design.pdf

Retrofit Approach: Planning Approach

- Proactively planning retrofits and prioritizing sites
- Steps:

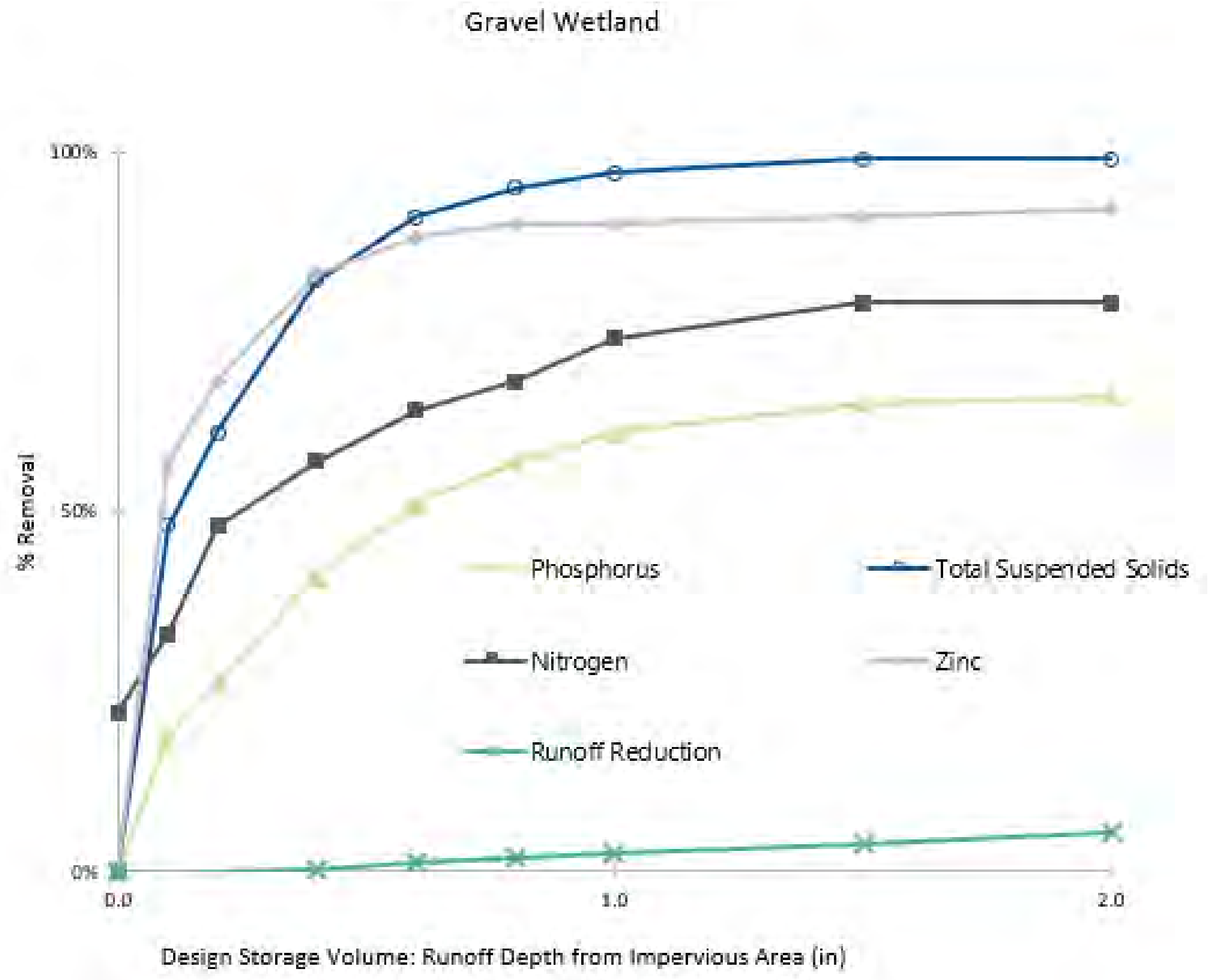
1. **Understand and Quantify Goals**
2. **Identify Potential Sites**
3. **Identify SCMs**
4. **Prioritize Sites and Controls**
5. **Implement SCMs**

RIDOT Stormwater Control Plans

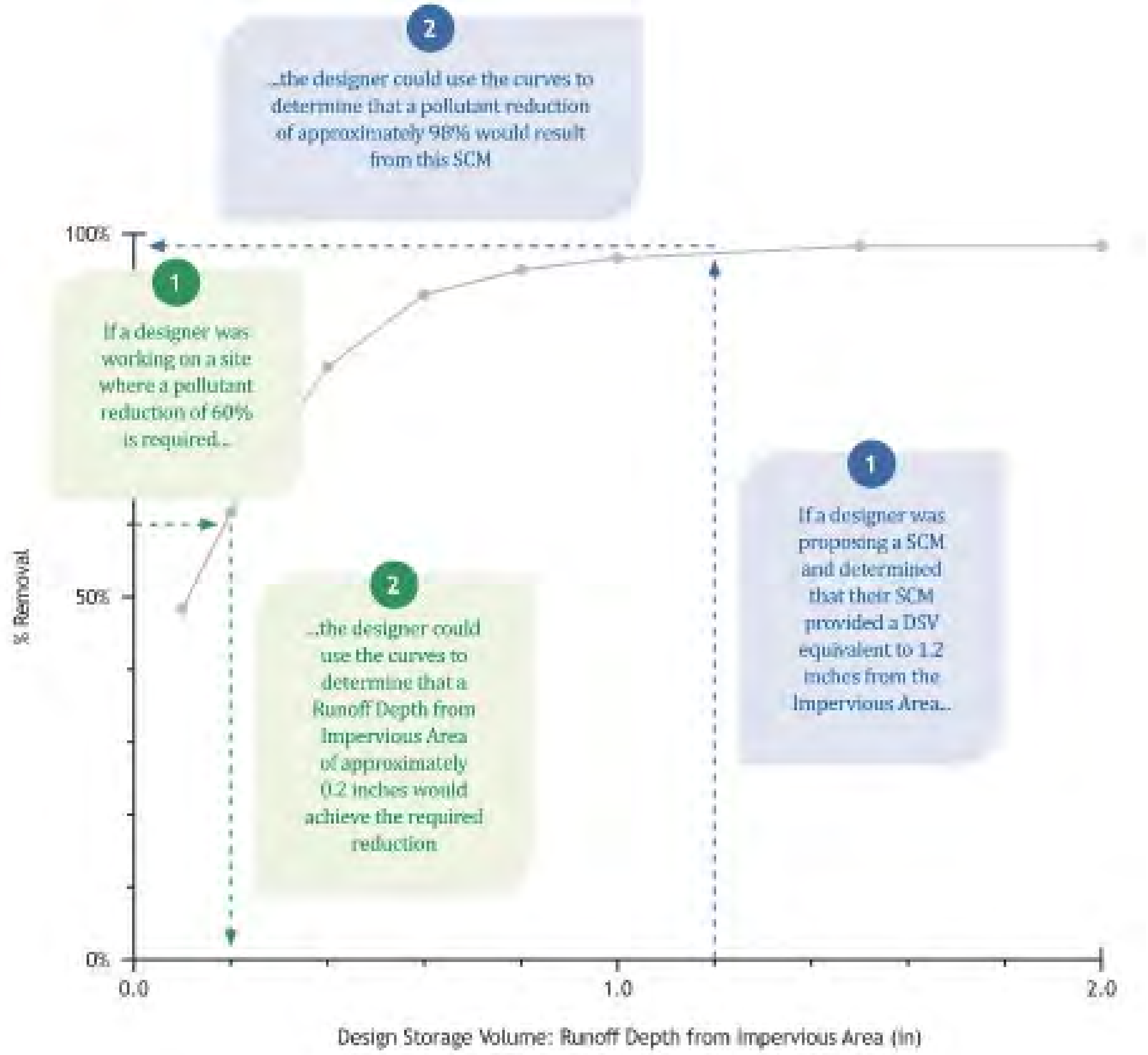


Source: https://www.arcgis.com/apps/webappviewer/index.html?id=b516ed62a55847e28d0243ac07206856

Crediting Approach: SCM Performance Curves



See our handout for more information on SCM Performance Curves and how to utilize them!


2
...the designer could use the curves to determine that a pollutant reduction of approximately 98% would result from this SCM
100%
1
If a designer was working on a site where a pollutant reduction of 60% is required...
1
If a designer was proposing a SCM and determined that their SCM provided a DSV equivalent to 1.2 inches from the Impervious Area...
50%
% Removal
2
...the designer could use the curves to determine that a Runoff Depth from Impervious Area of approximately 0.2 inches would achieve the required reduction
0%
0.0
1.0
2.0
Design Storage Volume: Runoff Depth from Impervious Area (in)

Sizing for Performance

Sizing Details

System	WQV ft^3 (m^3)	Actual WQV ft^3 (m^3)	% of normal design	Rain Event in (mm)	Sizing Method
SGWSC	7,577 (214.6)	720 (20.4)	10%	0.10 (2.5)	Static
IBSCS	1,336 (37.8)	310 (8.8)	23%	0. 23 (5.8)	Dynamic

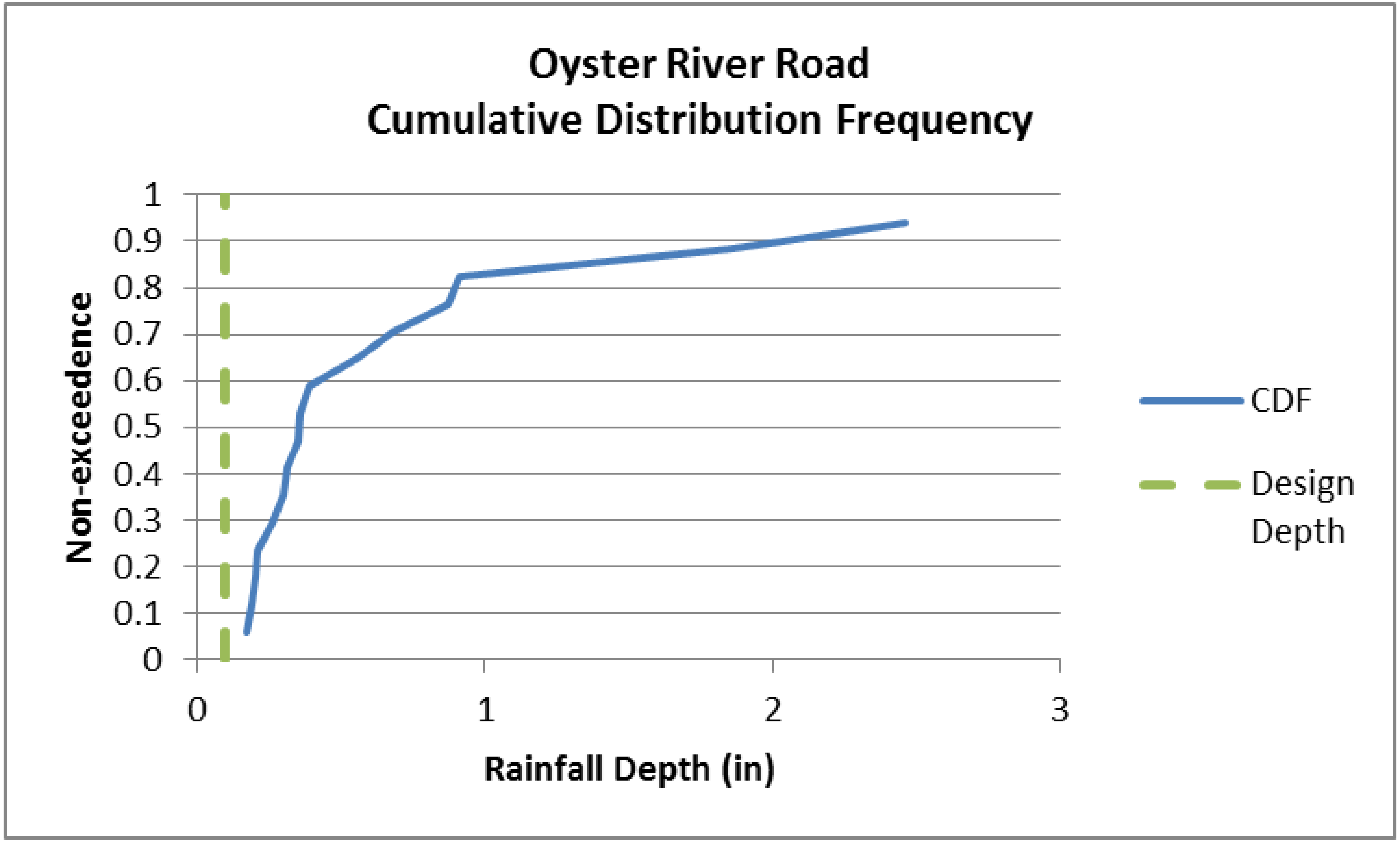
$$WQV = \left(\frac{P}{12}\right) x\ IA$$

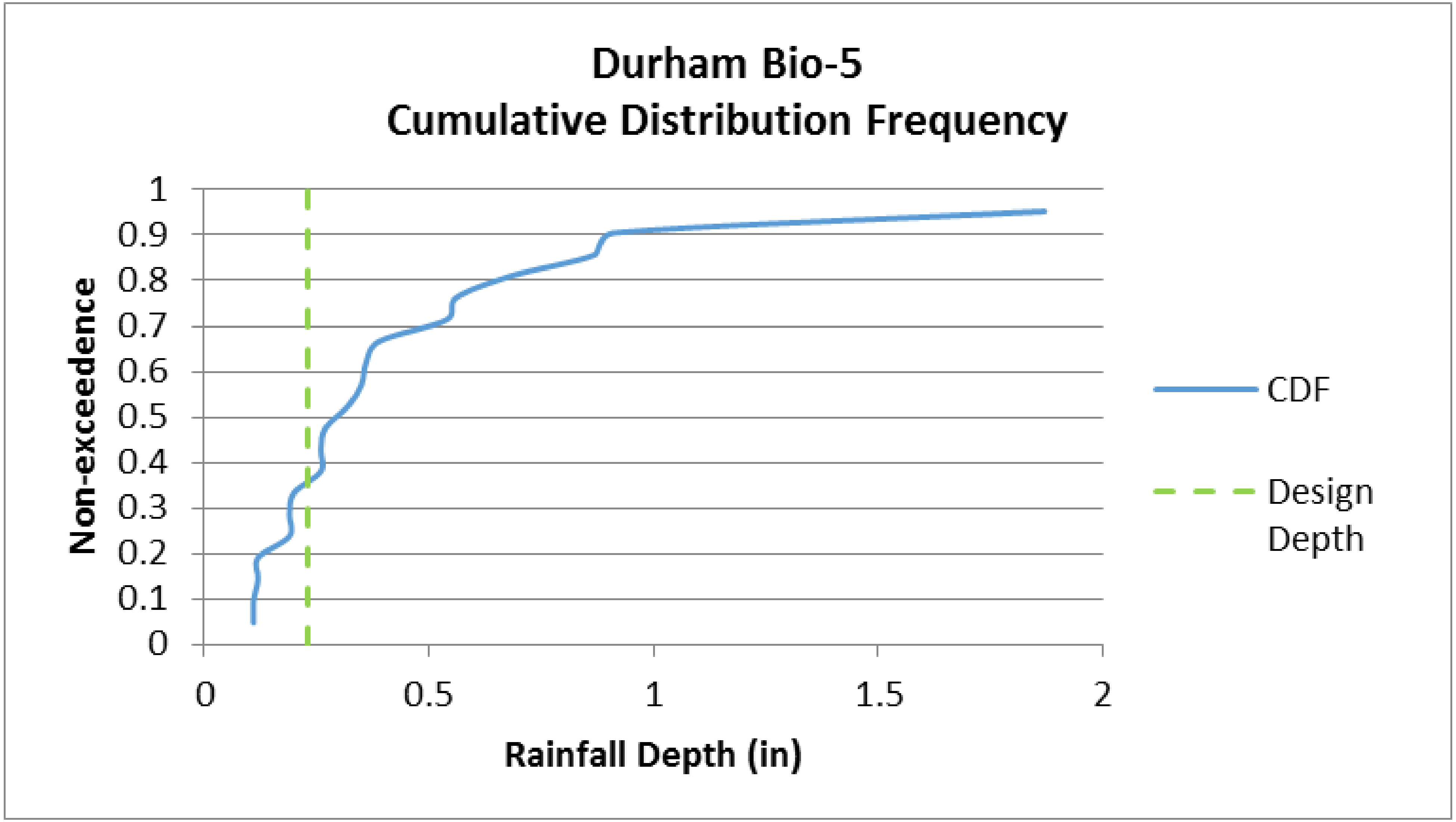
Dynamic Bioretention Sizing

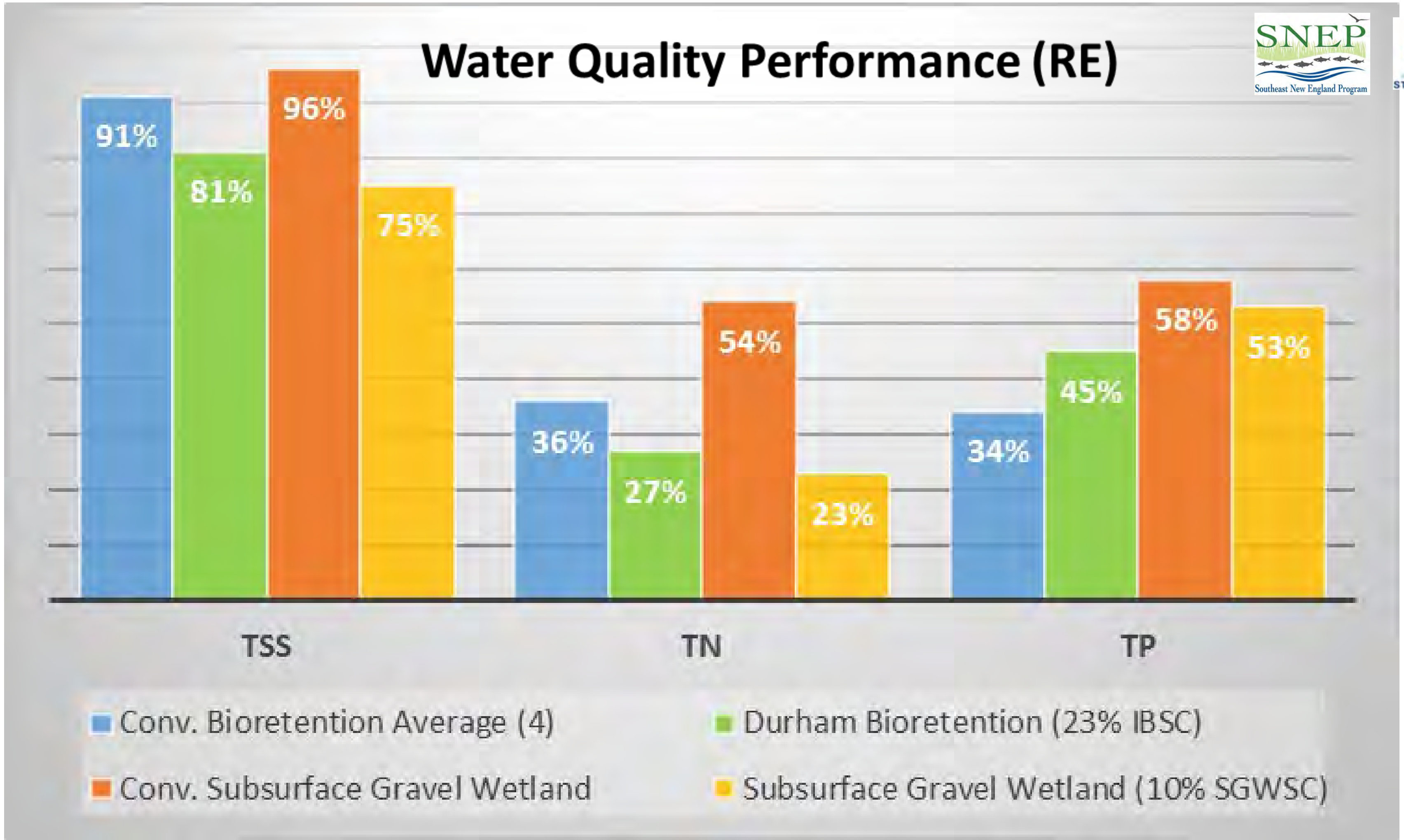
$$Af = Vwq * \frac{df}{(i(hf + df)tf)}$$

Static SGW System Sizing

$$Q = CdA\sqrt{2gh}$$


Oyster River Road
Cumulative Distribution Frequency
Non-exceedence
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
1
2
3
Rainfall Depth (in)
CDF
Design Depth


Durham Bio-5
Cumulative Distribution Frequency
Non-exceedence
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
0.5
1
1.5
2
Rainfall Depth (in)
CDF
Design Depth



System	TSS	TN	TP
Conv. Bioretention Average (4)	91%	36%	34%
Durham Bioretention (23% IBSC)	81%	27%	45%
Conv. Subsurface Gravel Wetland	96%	54%	58%
Subsurface Gravel Wetland (10% SGWSC)	75%	23%	53%

Manual Highlights: SCM Selection and Design

SCM Selection and Design: Treatment Unit Operations and Processes (UOPs)

UOPs: Unit Operations and Processes

Operations: methods of treatment in which application of *Physical* and *Hydrologic* forces dominate.

Processes: methods of treatment in which *Chemical* or *Biological* activities are involved.

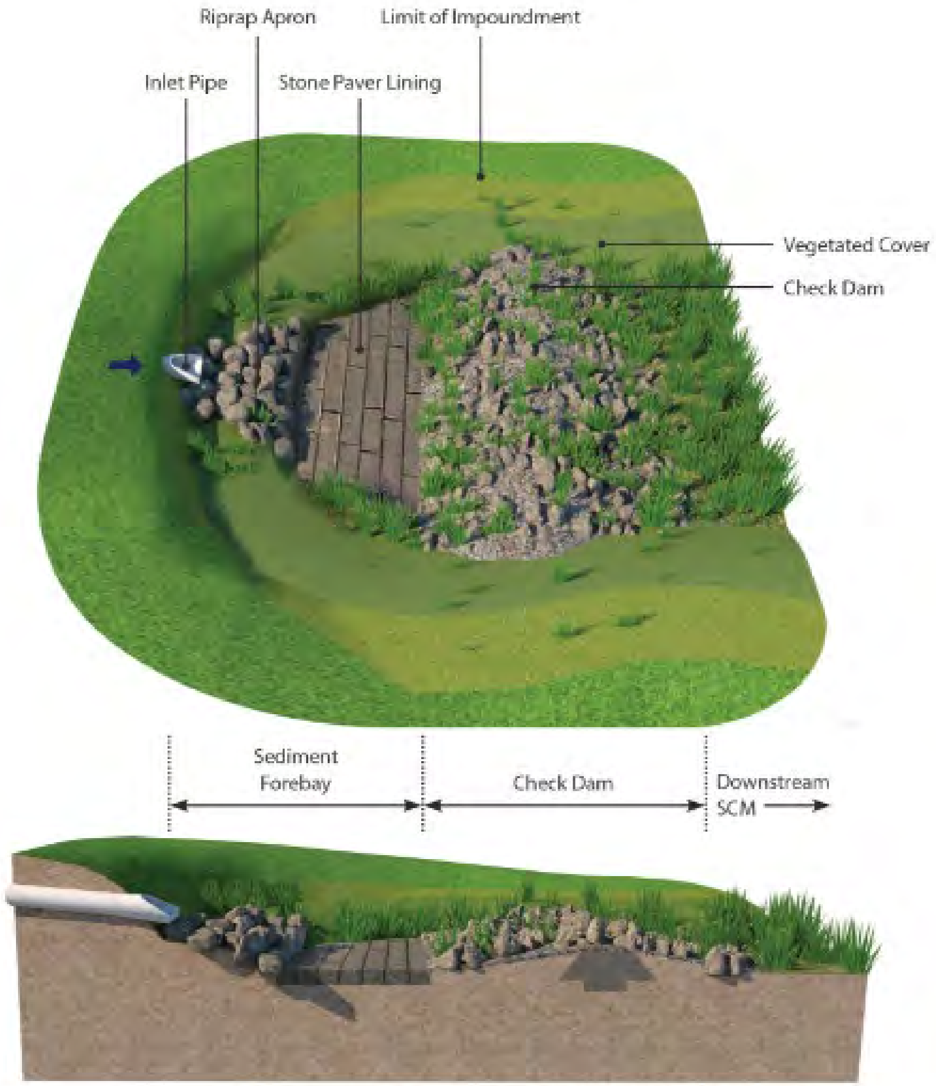
Hydrologic Physical Chemical Biological

Selection and Design: Linking SCMs to UOPs and Performance Curves

SCM Type		Primary UOP		Performance Curve Category
Infiltration Swale	⟷	Hydrologic: Infiltration	⟷	Infiltration Basin
Rain Garden (with underdrain)	⟷	Physical: Filtration	⟷	Bio-Filtration
Gravel Wet Vegetated Treatment System	⟷	Biological: Nitrification/ Denitrification	⟷	Gravel Wetland

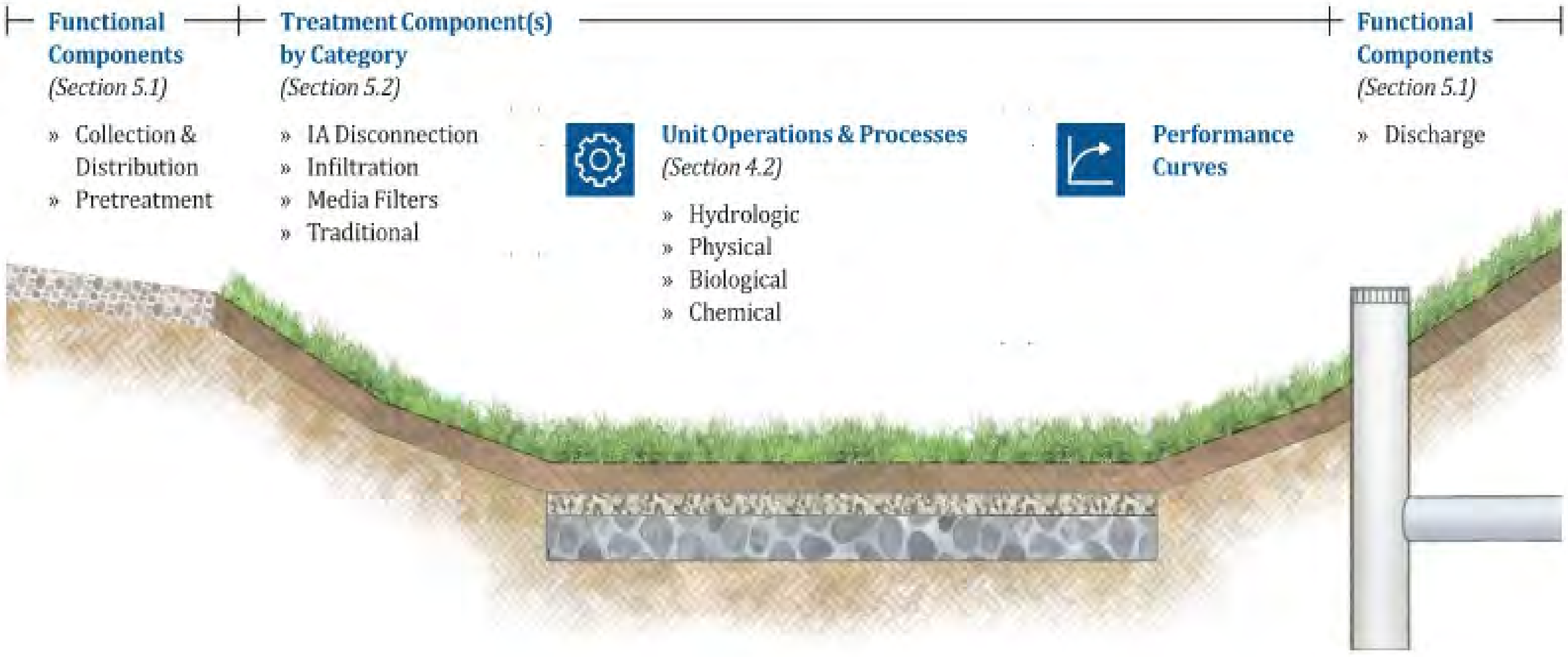
SCM Guidance: Functional Components

- Determine form and function of SCM
- Can be broken down as follows:
  - Collection and Distribution
  - Pretreatment
  - Discharge



Source: MassDOT Stormwater Design Guide, 2022

SCM Guidance: Putting It All Together



Manual Highlights: Breaking through Prescriptive Guidance

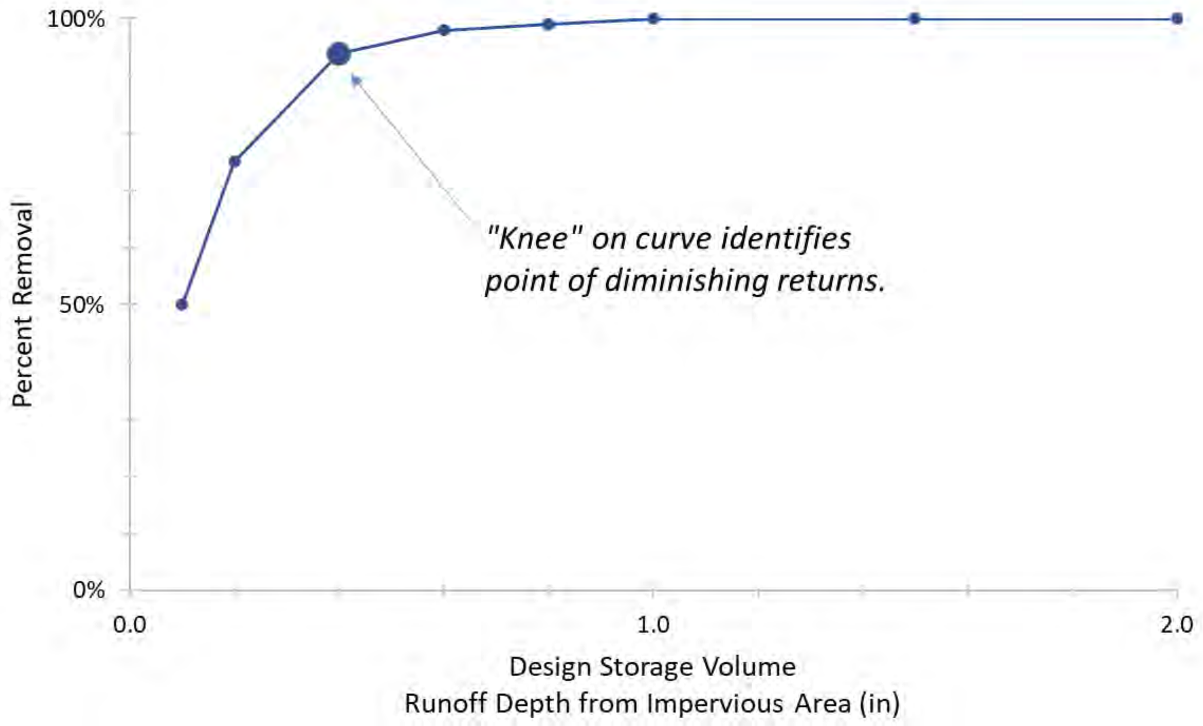
Breaking Through Prescriptive Guidance:
Sizing Requirements

Current Typical Requirement:

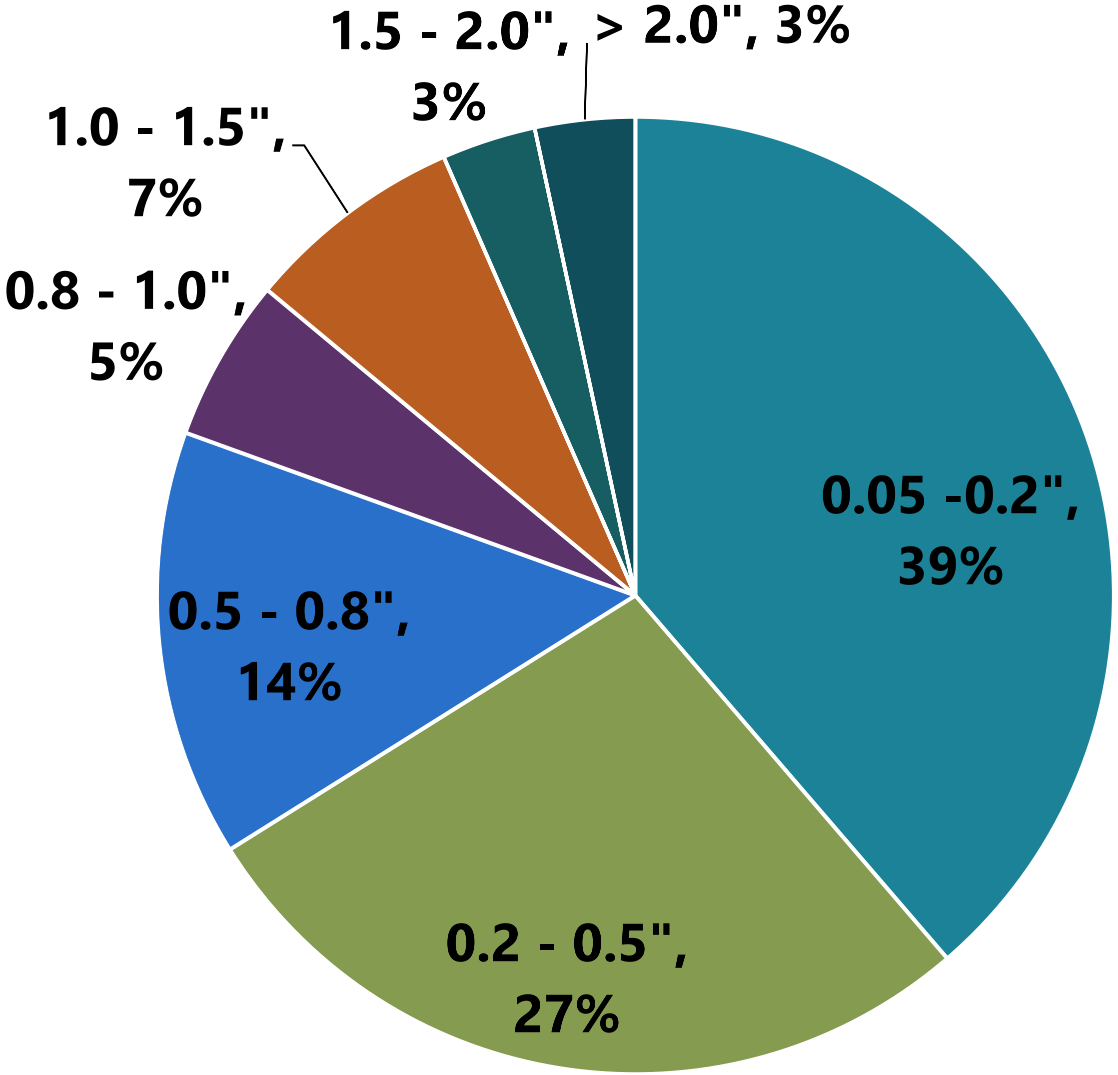
Size SCMs to meet the required WQV (typically 1 inch)

Proposed Retrofit Guidance:

Use SCM Performance Curves to size optimal cost-effective SCMs within a site



Distribution of Precipitation Events by Depth; Boston, MA 1992-2014



Precip Depth (in)	Probability %
0.05-0.2	39
0.2-0.5	66
0.5-0.8	80
0.8-1.0	85
1.0-1.5	92
1.5-2.0	95
>2.0	98

Breaking Through Prescriptive Guidance:
Separation to Groundwater/Bedrock

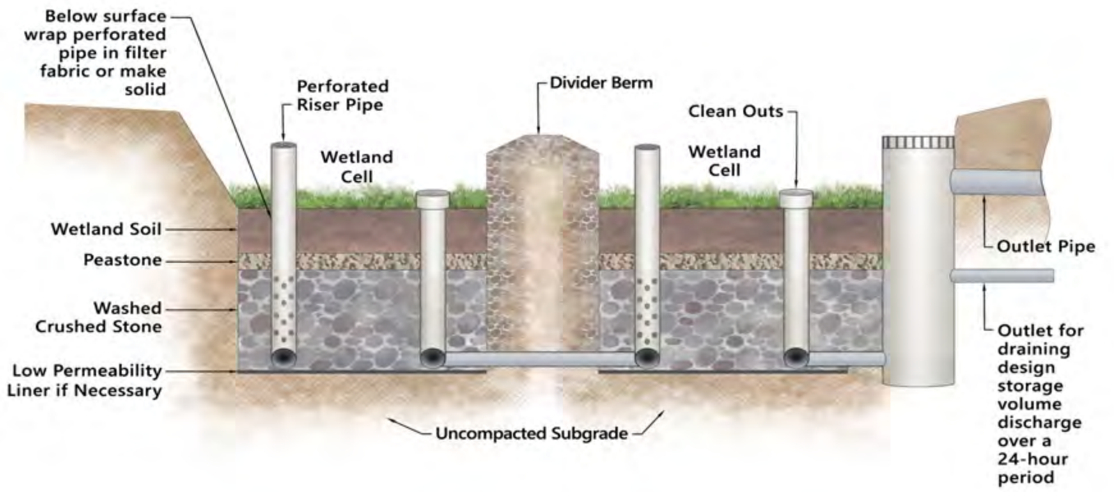
Current Typical Requirement:

Provide 1-3 ft of separation to ESHGWT

Proposed Retrofit Guidance:

Provide 1 ft of separation to ESHGWT when possible (SCMs with a filtering layer should always provide 1 ft)

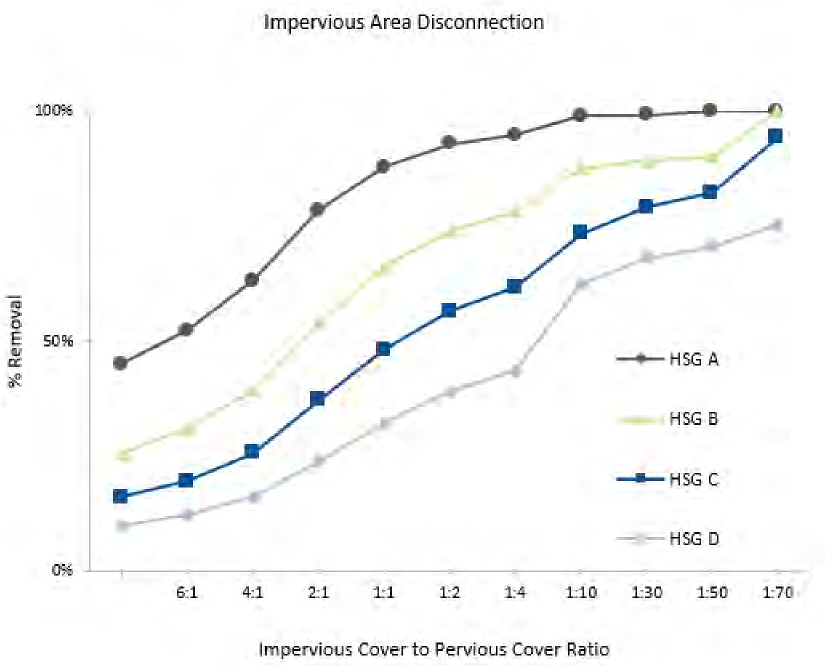
Gravel Wetland



Breaking Through Prescriptive Guidance:
Flexibility for IA Disconnection Design Criteria

Current Typical Requirement:

Meet slope, length/width, contributing area, soils, vegetation, setback, and ownership criteria



Proposed Retrofit Guidance:

Provide IA Disconnection wherever possible and use the SCM performance curves to determine credit

Breaking Through Prescriptive Guidance:
Pretreatment as an O+M Measure

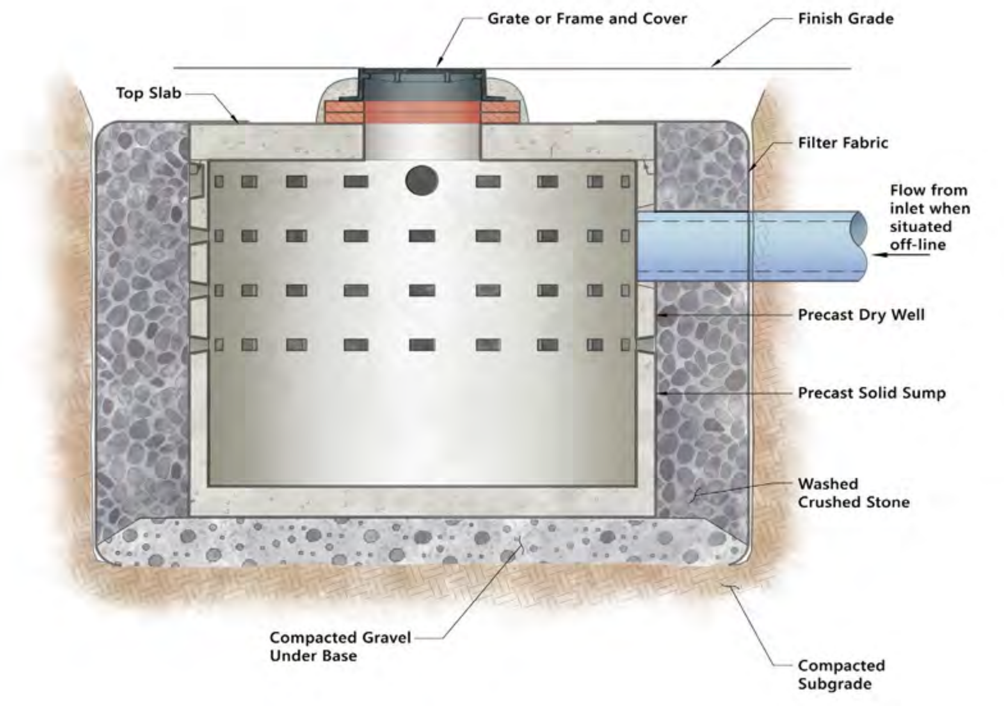
Current Typical Requirement:

Prescribed pretreatment measure types and sizing criteria

Proposed Retrofit Guidance:

Provide pretreatment whenever possible

Leaching Basin



In Summary…

- Be creative in retrofit scenarios!
- Some treatment (even small!) is better than none at all
- The SCM Performance Curves are powerful tools for sizing and crediting SCMs
- Construct an SCM that works best for your site/project
- Don’t be constrained!

Acknowledgments

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    - Cody Ray – EPA
    - Matthew Reardon – MADEP
    - Alisa Richardson – RIDOT
    - Michael Sadler – VT
    - Laura Schifman – MADEP
    - Newt Tedder – EPA

Additional Content

Why a retrofit manual

Historic Municipal WaterWorks,

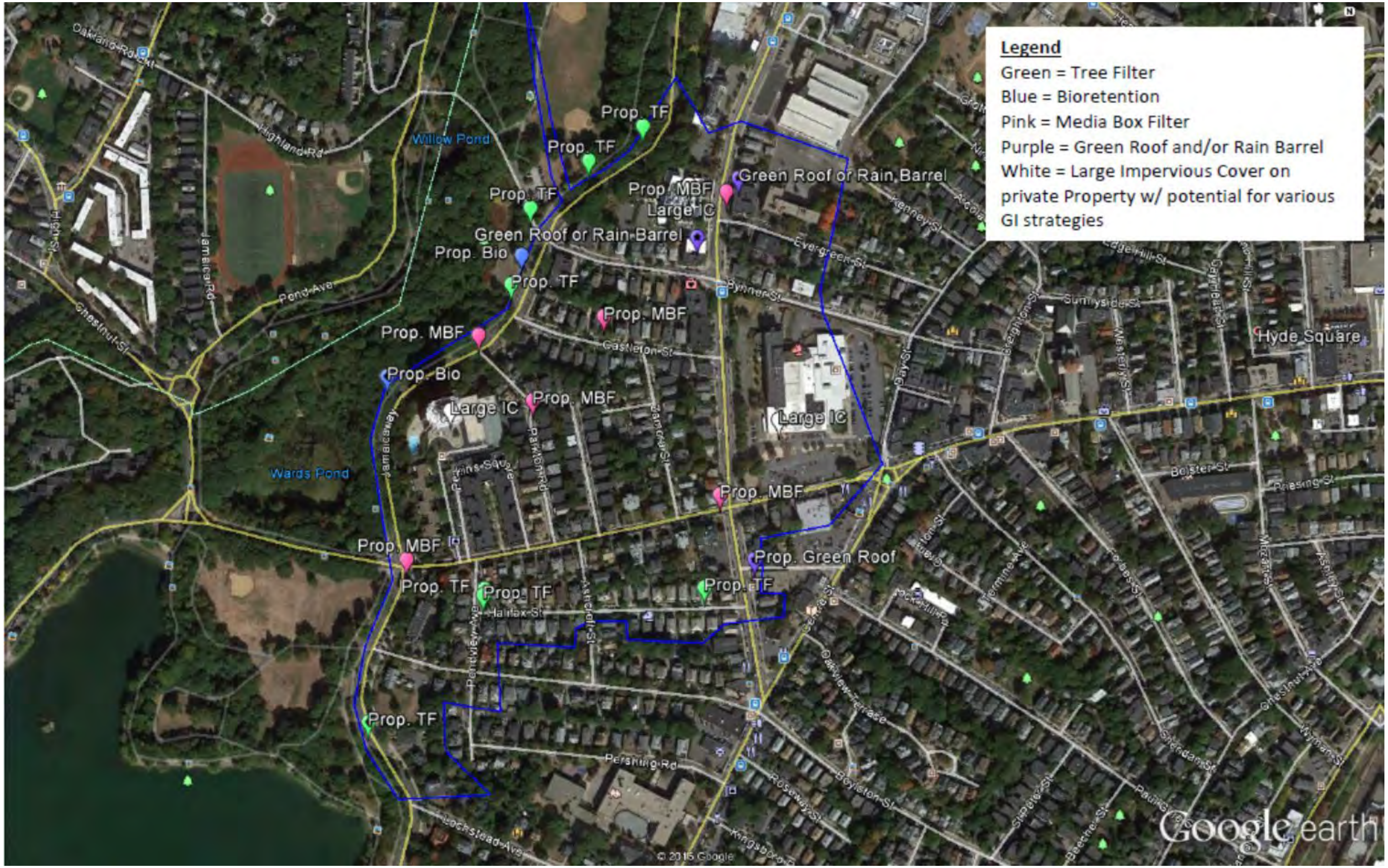
Dover, NH

Why a retrofit manual

Historic Municipal Water Works

Dover, NH

Where did the idea of a manual come from?



Watershed Approach

Location	Best Management Practice	Rationale
Along west side of Jamaica Way	Tree Filters (5)	Existing storm drain line and several catch basins. There are also some recently planted trees that could be transplanted into tree filter units. These would provide some treatment through filtration, infiltration, rhizosphere, and flow attenuation. Media amendments would be added to remove phosphorus.
Halifax St and Pondview Ave	Tree Filters (2)	There is an existing storm drain line and catch basins on each side of the Halifax St. The existing street scape includes trees.
Halifax St near S. Huntington St	Tree Filter	There is an existing storm drain line and a catch basin that could be converted to a tree filter.
• Parkwood Terrace and Jamaica Way • Perkins St and Jamaica Way	Media Box Filters	Existing storm drain line and catch basin. Large vegetated strip between road and sidewalk that is likely in City right-of-way. Large trees are in this proximity so an MBF would be a better fit.
• North end of Parkton Rd • Perkins St and S. Huntington • Castleton St • Evergreen St and S. Huntington	Media Box Filters	Existing storm drain line and catch basins on each side of Perkins St. No vegetated area but an MBF might fit under the road depending on other utilities.
Just south of Highland Rd and Jamaica Way intersection	Bioretention	Existing storm drain line and room for a bioretention cell that could treat surface runoff and then be piped into existing line.
West of Jamaica Way near Wards Pond	Bioretention	Plenty of area for a bioretention cell but some trees may need to be removed. Effluent could discharge cool treated water to Wards Pond.
• El Mundo Newspaper • Intersection of Bynner St and South Huntington • Intersection of Evergreen St and South Huntington	Green Roof and Rain Barrel installations	These are flat roof buildings with concrete block or brick exteriors, which may be strong enough for green roof systems. There are several other buildings in the drainage area that could be identified if this is a viable strategy.
• MSPCA, Animal Care & Adoption Center • Perkins Square – Sagamore Advisors • Mt. Pleasant Home	Tree Filters, Bioretention(s), media box filters	Three of the largest, privately owned impervious cover areas in the watershed. There are media strips, large parking areas, and large roof tops that could all be managed using various GI strategies.

And then reality

"Hi, Tim and I were just chatting about siting systems. Is there any reason why we could not put a system where the orange oval is in the pic below?"

"I'm going to say almost definitively no. It's private property and we have no way to get those property owners to work with us. Additionally, my understanding is that we want a visible area for public education (a park in this tributary area). "

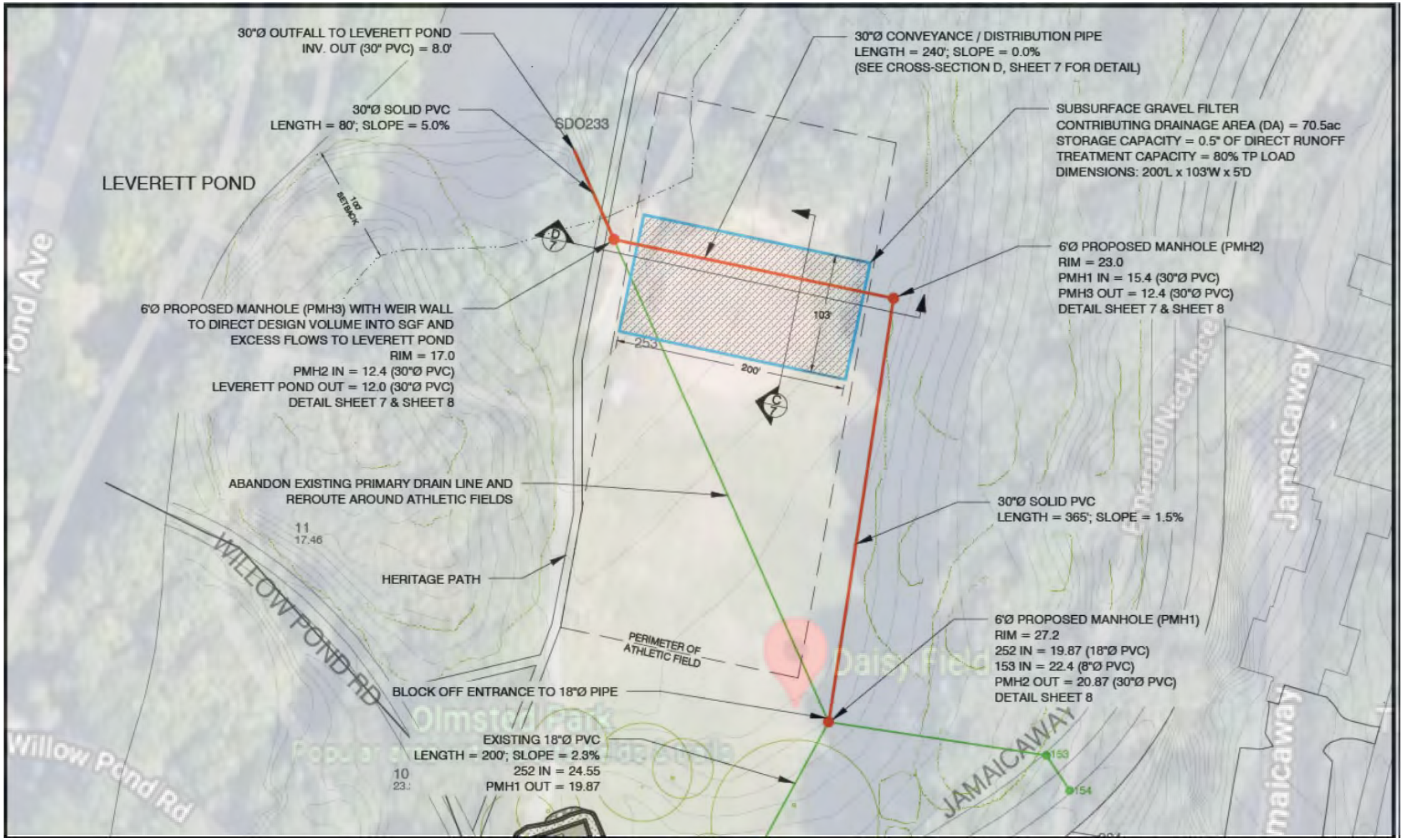
Other Considerations

In the "TOPOGRAPHY" layer there are several sub-layers that seem to be paired for identical points on the map. They consistently differ by 6.5′. Which surface elevation layer is correct or relative to the Pipe Invert Elevation layers? For example:

Sub-Layer Name	Elevation	Elevation	Elevation	General Location of Point
Topo DETBCB Elevation	29.0	34.8	28.3	East of Jamaica Way / Willow Pond Rd intersection.
Topo DET Elevation	22.5	28.3	21.8	Same as above
Difference	6.5	6.5	6.5	
Topo INDBCB Elevation	26.5			On contour line southeast of Jamaica Way / Willow Pond Rd. int.
Topo INDD Elevation	20			Same as above
Difference	6.5			
Topo BCB Elevation	33.0	31.8	34.2	In vicinity of Jamaica Way / Willow Pond Rd. intersection
TOP GEN Elevation	26.5	25.3	27.7	Same as above
Difference	6.5	6.5	6.5	

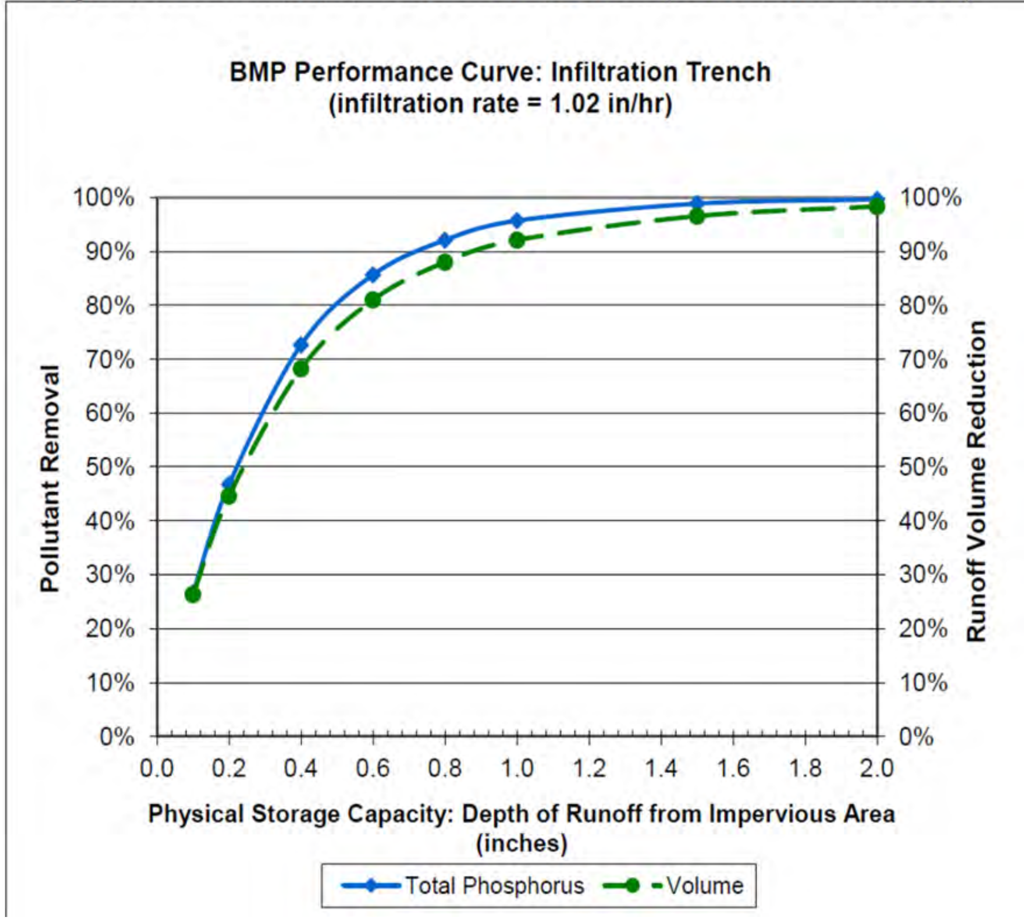
Why a retrofit manual

Why a retrofit manual



Infiltration Trench (IR = 1.02 in/hr) BMP Performance Table: Long-Term Phosphorus Load Reduction								
BMP Capacity: Depth of Runoff Treated from Impervious Area (inches)	0.1	0.2	0.4	0.6	0.8	1.0	1.5	2
Runoff Volume Reduction	26.3%	44.6%	68.2%	81.0%	88.0%	92.1%	96.5%	98.
Cumulative Phosphorus Load Reduction	27%	47%	73%	86%	92%	96%	99%	10

Figure 3- 4: BMP Performance Curve: Infiltration Trench (infiltration rate = 1.02 in/hr)



Stormwater Management Design - 70.5 acre Ultra-Urban Drainage Area			
Sizing Comparison of Capital Costs and Relative Phosphorus Load Removal Efficiency			
Best Management Practice Size	Depth of Runoff Treated from Impervious Area (in)	*Storage Volume Cost ($/ft³)	**Total Phosphorus Removal Efficiency (%)
Subsurface Gravel Filter - Minimum Size	0.35	$1,016,912	62%
Subsurface Gravel Filter - Moderate Size	0.5	$1,452,732	80%
Subsurface Gravel Filter - Full Size	1.0	$2,905,463	96%

*Storage Volume Cost estimates provided by EPA-Region 1 for Opti-Tool methodology, 2015-Draft

**Total Phosphorus %RE based on Appendix F Massachusetts MS4 Permit

What can the manual do for me

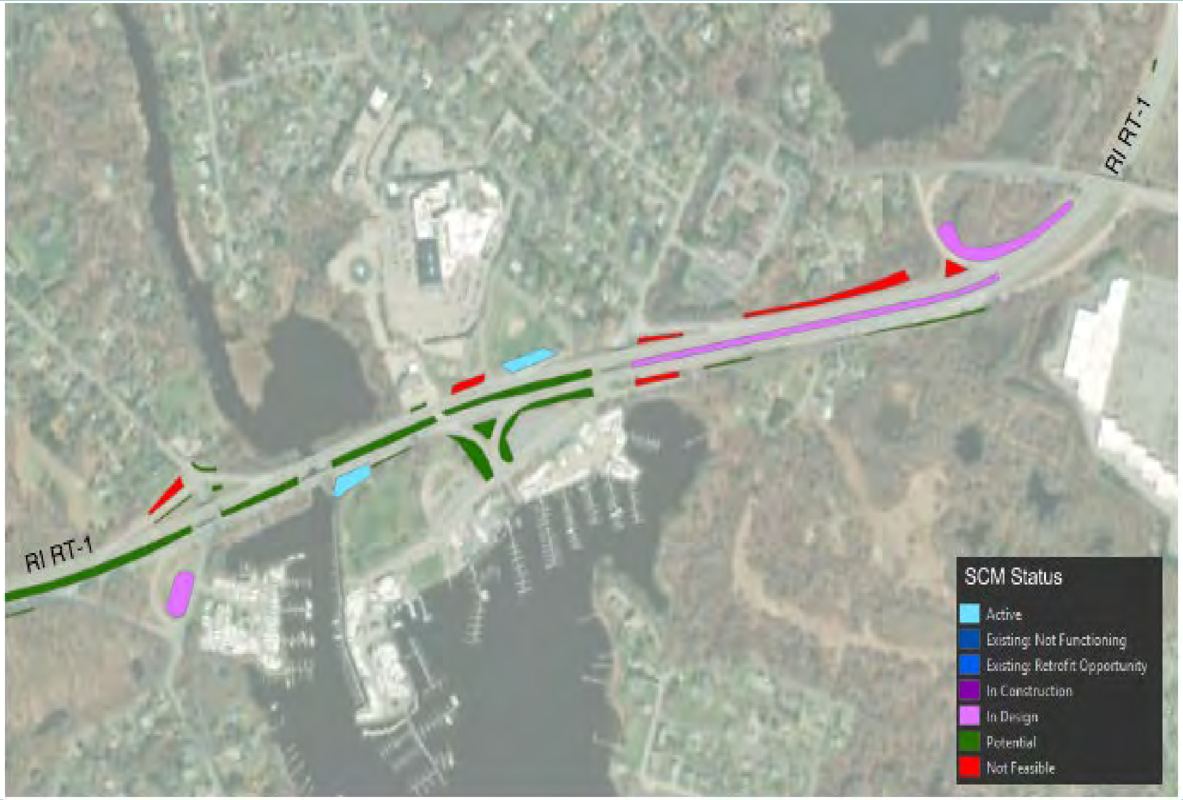
Chapter 2 – Retrofit Approach: This chapter defines what a retrofit is and discusses the approaches to identifying and implementing SCMs in a retrofit situation. It reviews the opportunistic approach (including measures as part of other efforts) and the planning approach (proactive planning and prioritization).

Retrofit Approach: Planning Approach

- Proactively planning retrofits and prioritizing sites
- Steps:

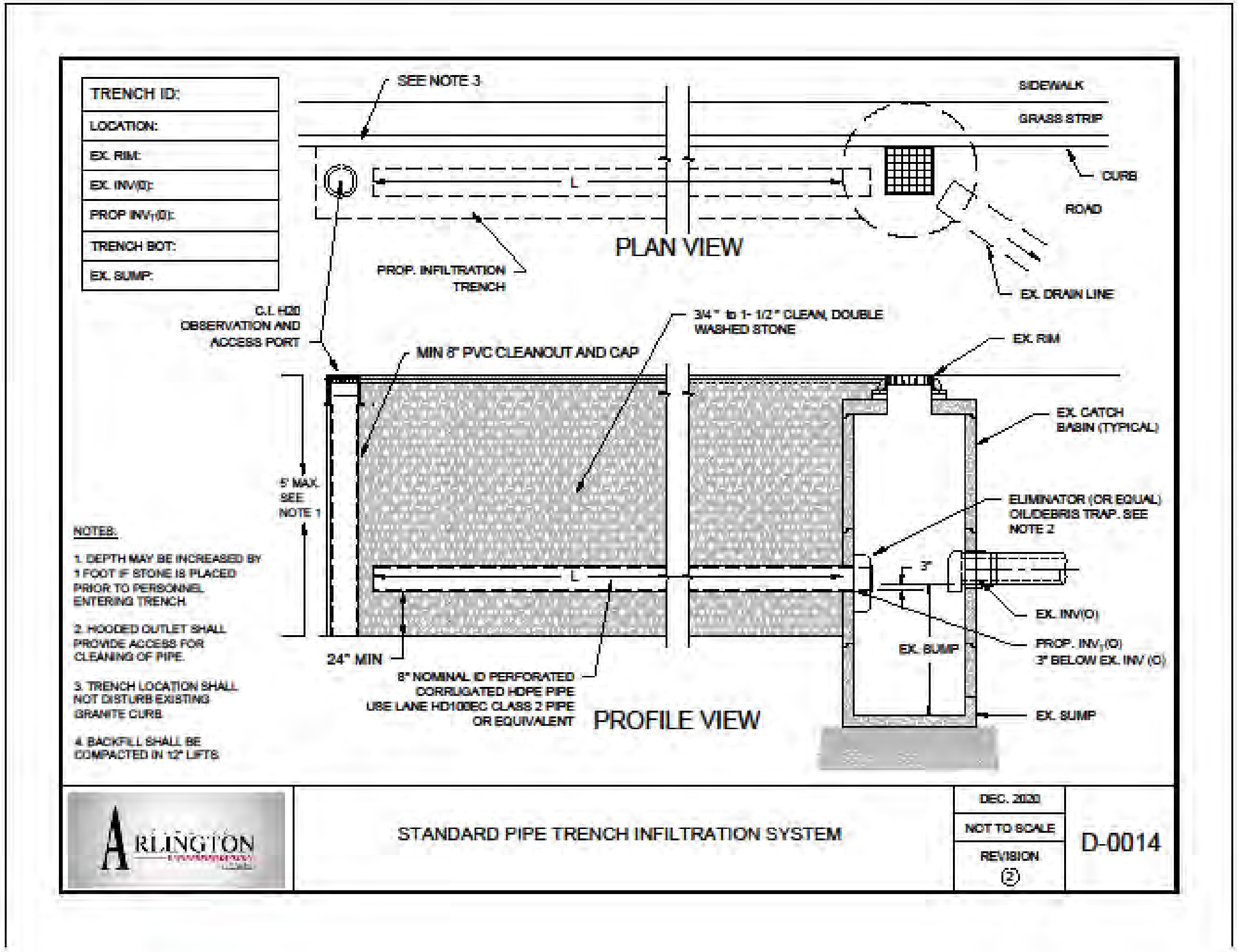
1. **Understand and Quantify Goals**
2. **Identify Potential Sites**
3. **Identify SCMs**
4. **Prioritize Sites and Controls**
5. **Implement SCMs**

RIDOT Stormwater Control Plans



Source: https://www.arcgis.com/apps/webappviewer/index.html?id=b516ed62a55847e28d0243ac07206856

Planning Approach:



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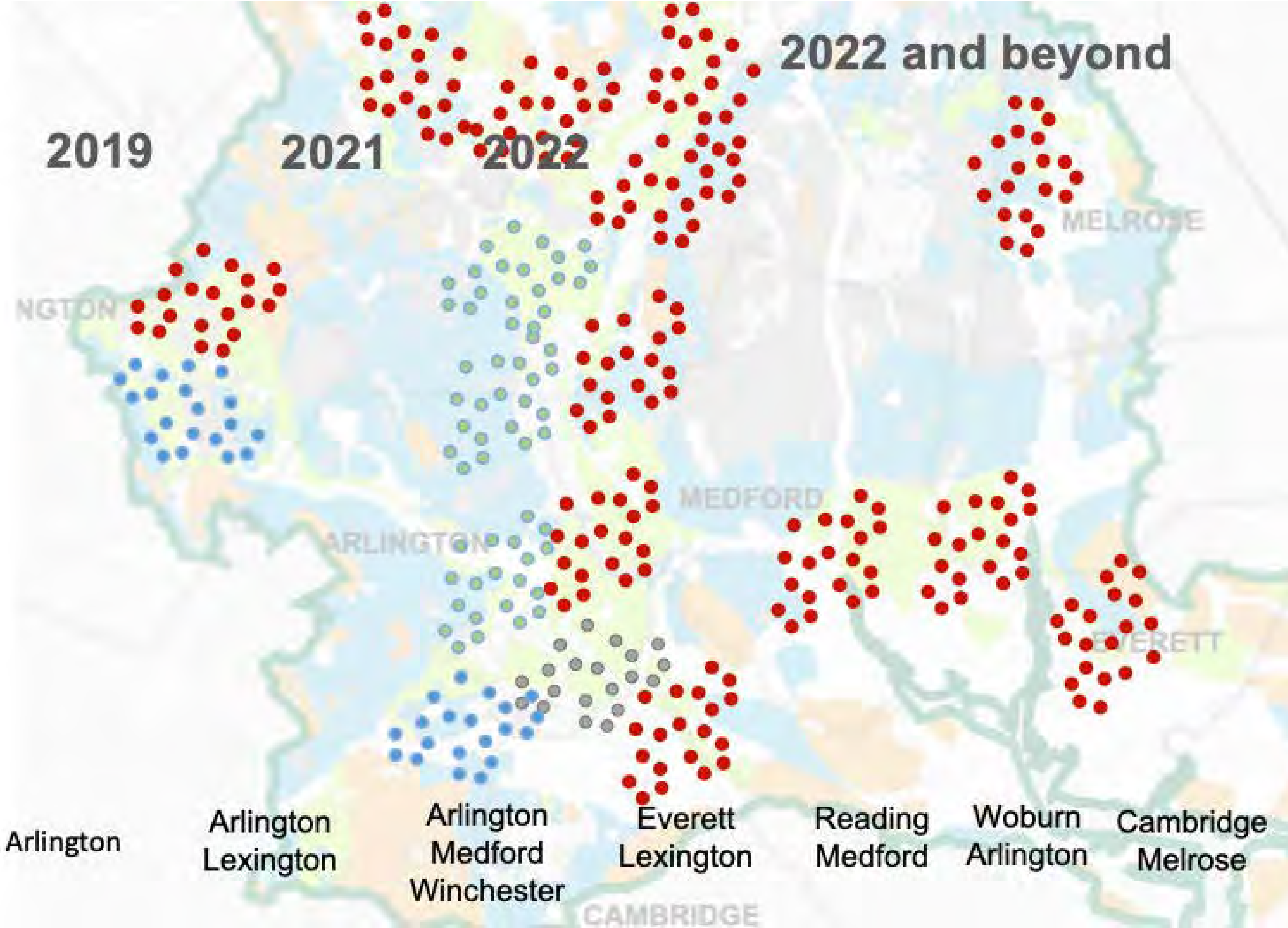
Courtesy of Wayne Chouinard, Arlington DPW

Courtesy of Wayne Chouinard, Arlington DPW

Taking a pilot project to scale

360 trenches



Mystic River Watershed Association

Courtesy of Wayne Chouinard, Arlington DPW

Credits

Chapter 3 – Credits: This chapter discusses credits, or the quantification of a SCM's stormwater benefits. It explains the need for credits and presents the SCM Water Quality Treatment Performance Curves, a crediting scheme that is becoming widely accepted in New England for quantifying benefits. The credits show that small scale controls that do not necessarily meet widely implemented sizing standards can still provide significant benefit.

Table 1. Modeled costs and infiltration trench performance*

Unit	Cost ($)
System	2,200
IC treated per acre (per ha)	18,857 (44,000)
TP per lb (per kg)	24,750 (55,000)
TN per lb (per kg)	3,930 (8,609)
TSS per lb (per kg)	86 (190)
Volume eliminated per cf (per m^3)	0.11 (4)

Other Benefits

DA = 10.47 acres

IC = 3.14 acres

DSV = 1,200 cf

PSC = 0.11

N

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SC UNIVERSITY OF NEW HAMPSHIRE STORMWATER CENTER

University of New Hampshire
35 Colovos Road
Durham, NH 03824
Phone (603) 862-2818
Fax (603) 862-3957
http://www.unh.edu/unhsc

No.	Date	Revision

Designed: JJH | Checked: JJH | Approved: JJH

Graphic Scale
0 15 30 60 90
Feet
Original Drawing Size: 11 x 17 in.

Project: Oyster River Road Drainage Improvement, Durham, NH

Date: 02-05-2015

Sheet No. 1 of 1

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How it looks then and now

SCM Selection and Guidance

Chapter 4 – Stormwater Control Measures Selection: This chapter steps through typical unit operations and processes utilized by SCMs. This chapter also provides information on the selection and design process for SCMs and provides sizing guidance. Additional Tools/Resources for SCM selection and sizing are also provided in this chapter.

Chapter 5- Stormwater Control Measure Guidance – This chapter steps through the functional components and treatment categories used to construct a SCM. It also steps through SCM variations within each treatment category and provides information on design considerations and Operations and Maintenance (O&M) activities for each variation.

Output	*Intermediate Calculations*	Design Storage Volume	DSV	cf	1,200
		Impervious to Pervious Ratio *(range of 0.04 - 8)*	IA/PC	ac/ac	N/A
		Physical Storage Capacity: Depth of Runoff from IA *(range of 0 - 2, goal > 0.1, optimal 0.4)*	PSC	in	0.11
		PSC Notes			DSV small, increase for optimal range 0.3 ≤ PSC ≤ 0.6
	Performance Curve Removal Efficiencies	Removal Efficiency: Volume	Vol_{RE}	-	0%
		Removal Efficiency: P	P_{RE}	-	20%
		Removal Efficiency: N	N_{RE}	-	23%
		Removal Efficiency: TSS	TSS_{RE}	-	49%
		Removal Efficiency: Zn	Zn_{RE}	-	59%
		Removal Efficiency: Bacteria	FIB_{RE}	-	32%
	Loading Rate	Load: Volume	Vol_{LER}	Mgal/yr	3.29
		Load: P	P_{LER}	lb/yr	6.2
		Load: N	N_{LER}	lb/yr	44.3
		Load: TSS	TSS_{LER}	lb/yr	1,378
		Load: Bacteria	FIB_{LER}	Billion MPN/y	20
	Reductions	Reduction: Volume	Vol_{Red}	Mgal/yr	0.00
		Reduction: P	P_{Red}	lb/yr	1.2
		Reduction: N	N_{Red}	lb/yr	10.1
		Reduction: TSS	TSS_{Red}	lb/yr	682
		Reduction: Bacteria	FIB_{Red}	%/yr	32%
	Costs	Estimated Total Costs		$	$22,000
		Removal Costs: Volume		$/Mgal-yr	N/A
		Removal Costs: P		$/lb-yr	$17,940
		Removal Costs: N		$/lb-yr	$2,170
		Removal Costs: TSS		$/lb-yr	$30
		Removal Costs: Bacteria		$/%-yr	$700
	O&M	Estimated O&M Hours		hr/yr	68

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Other Important Components – Appendix A

Sizing Requirements

Proposed Retrofit Guidance: New site developments should fully size SCMs. Size retrofit SCMs within existing developed landscapes using the Performance Curves to optimize cost-effective pollutant reduction and encourage the installation of SCMs distributed across the landscape where runoff is generated.

Bedrock and Groundwater Separation for Infiltration SCMs

Proposed Retrofit Guidance: Infiltration systems that include a filtering layer, must have one foot or more of separation from the bottom of the filter course to the SHWT at all times. Can include the filter layer in the groundwater separation calculation.

Soils for Infiltration SCMs

Proposed Retrofit Guidance: Consider infiltration SCMs for all soil groups where infiltration is appropriate.

Pretreatment

Proposed Retrofit Guidance: Provide pretreatment whenever possible. The goal is a viable and accessible maintenance access point.

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vhb

James.Houle@unh.edu
npacheco@vhb.com