SUBMERGED GRAVEL WETLANDS: *a low-impact, highly versatile stormwater BMP for use at Delaware Brownfields, "Hot Spots" and other challenged sites*

By: Bill Stephens, PG

Stephens Environmental Consulting, Inc.

SUBMERGED GRAVEL WETLANDS:

(Bill's) Preferred Stormwater Best Management Practice for Brownfield Sites, Hot Spot Runoff Treatment and Retrofits, TMDL Compliance and Other Challenging Site Conditions

- **At out Last HAC Committee Meeting, I issued a memo that was intended to advocate for SGWs as a stand-alone addition to Section 15 (say 15.030, numerically advancing all other subsections as appropriate) of the "Draft" Green Infrastructure & Ecological Revitalization section submitted for our review. This Presentation is a follow-up intended to inform and reinforce the need to single out this BMP within Section 15.**

- **SGWs are a low-impact, highly versatile and high stormwater credit Best Management Practice (BMP) approved for use in Delaware, but poorly documented in the technical guidance document and not currently included in DURMM V.2 for direct analysis. As a result, the BMP did not make it into the first draft of Section 15.**

- **So why should we care??**

Benefits of SGWs I offered at our December HAC Committee Meeting

1. DNREC now give 100% Credit for SGW's that treat 100% of RPv

2. SGW's are the only BMP permitted to be in direct contact with the water table. The BMP is ideal for sites with high water table or limited relief or both.

3. Construction costs are reported to be similar to Bio retention BMPs, and have been reported to be $4 to $5 per SF.

4. The 12" submergence rule that applies to rain gardens and other Bio-Retention BMPs does not apply. Bonus storage can be accommodated in the same footprint or the footprint may be reduced by adding depth.

5. One of the only BMPs that may be employed in Hot Spots. BMP may be lined with HDPE, GCL or other liner material to minimize or eliminate infiltration at Hot Spots.

Benefits of SGWs I offered at our December HAC Committee Meeting (5 More Bennies)

1. Ideal for retrofitting existing sites, redevelopment of existing sites, particularly Hot Spots, and can be integrated into existing storm drain systems based on this flexibility. When lined, SGW's can be used in Hot Spots where other systems based on infiltration cannot.

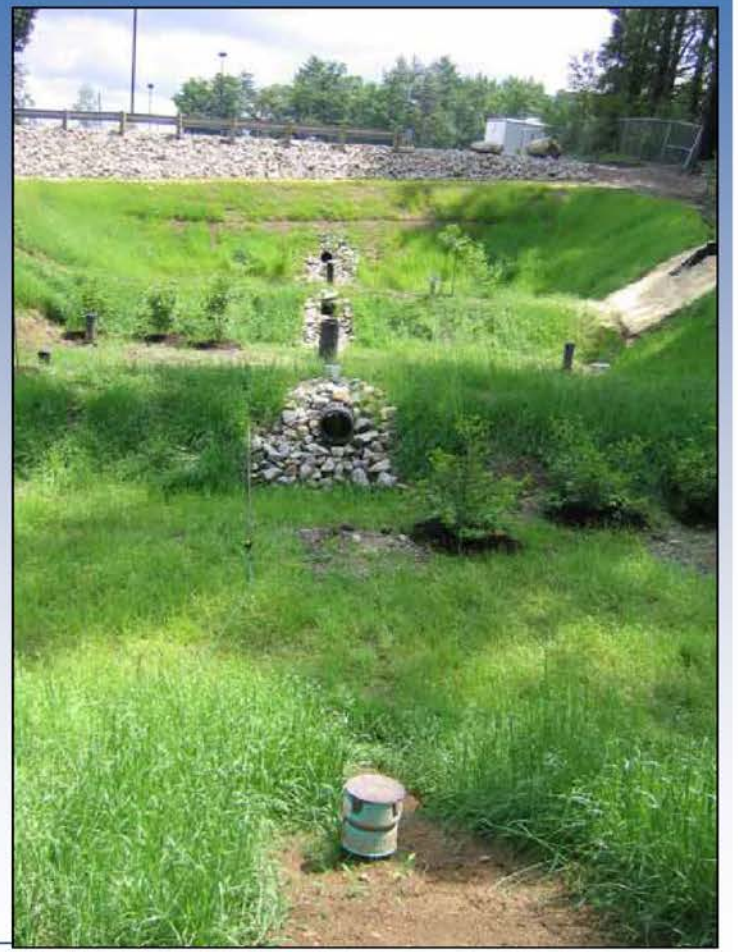
2. SGWs are wetlands that can be planted with native vegetation adapted to a wide range of site specific conditions and is an essentially emergent marsh with attendant functional values. [Note: "Innovative Technologies" generally refers to structural practices not approved by the agency. SGWs are non-structural practices and should not be lumped in this category]

3. Once established, plantings are generally low maintenance though maintenance costs are similar to Bio-retention facilities and are potentially pricey.

4. Accomplishes a high rate of nutrient mineralization/reduction for TMDL Compliance.

5. Provides the required separation distance from underlying contamination to meet DNREC cover requirements.

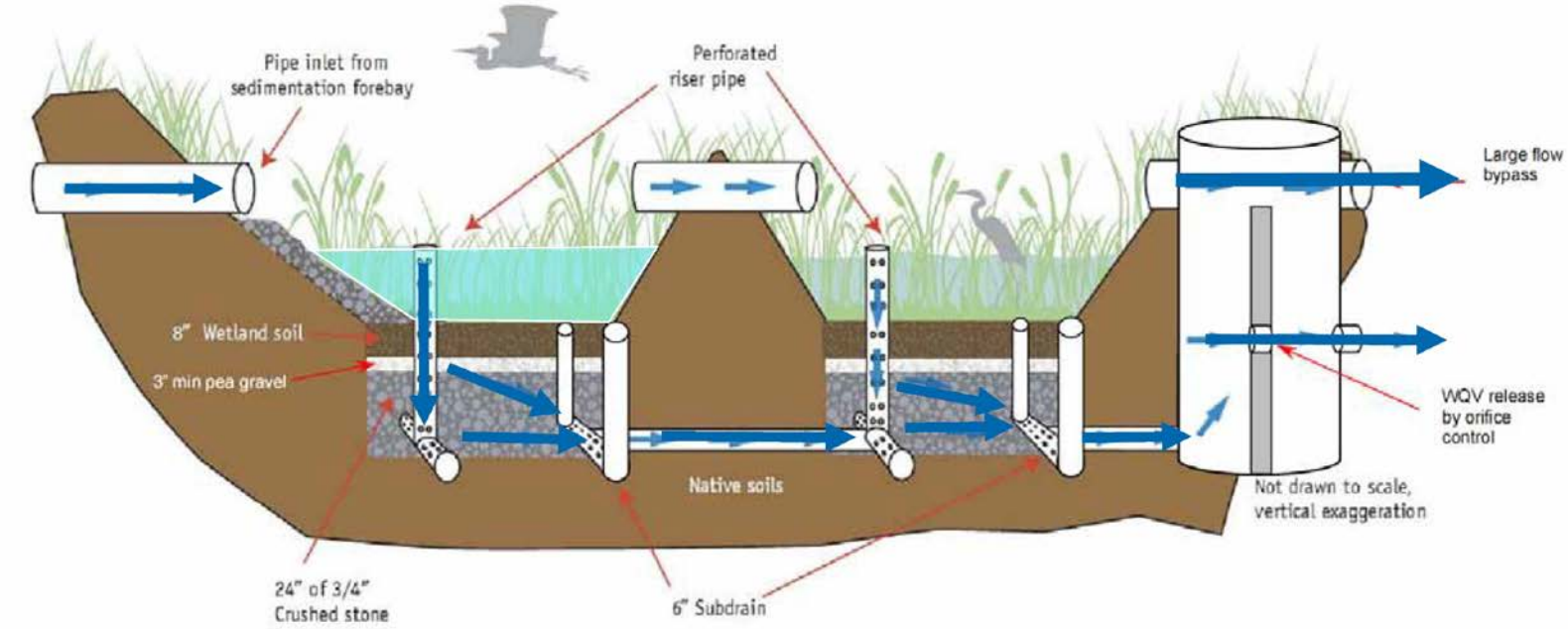
Gravel Wetland



UNIVERSITY OF NEW HAMPSHIRE STORMWATER CENTER

University of New Hampshire Stormwater Center (UNHSC)
Actual Gravel Wetlands Studied

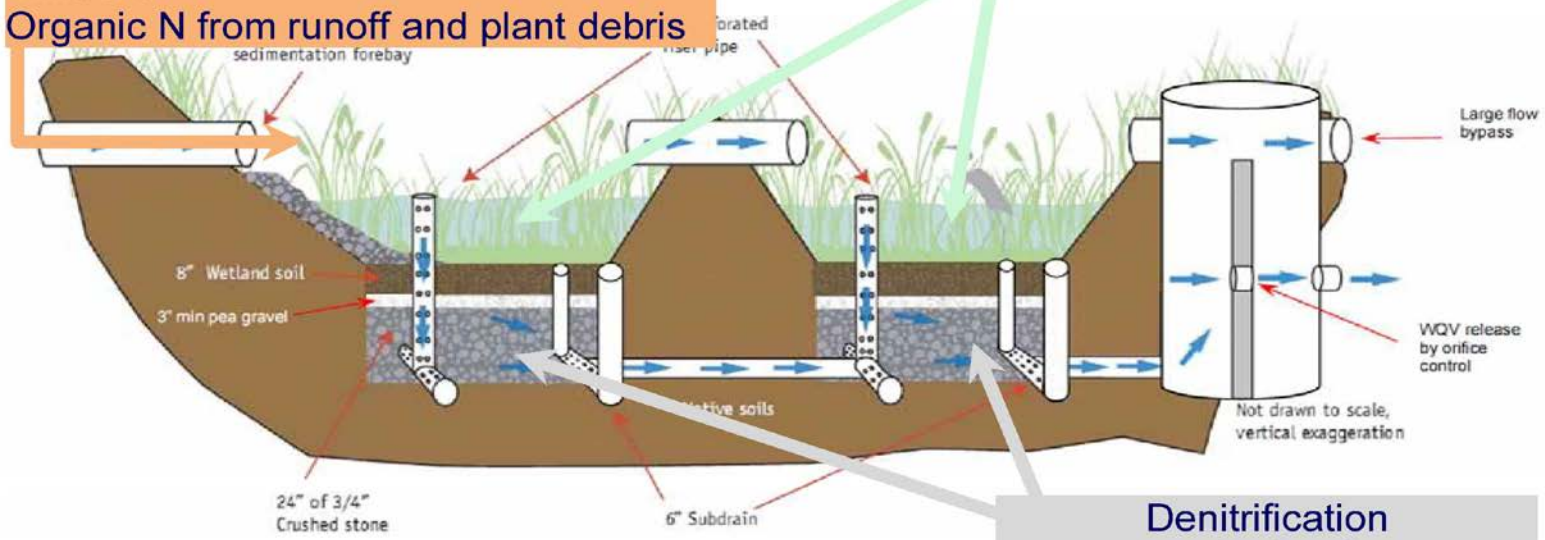
Subsurface Gravel Wetland



Design Sources:
Claytor, R. A., and Schueler, T. R. (1996). Design of Stormwater Filtering Systems, Center for Watershed Protection, Silver Spring, MD.
Georgia Stormwater Management Manual, Volume 2: Technical Handbook, August 2001, prepared by AMEC Earth and Environmental, Center for Watershed Protection, Debo and Associates, Jordan Jones and Goulding, Atlanta Regional Commission.

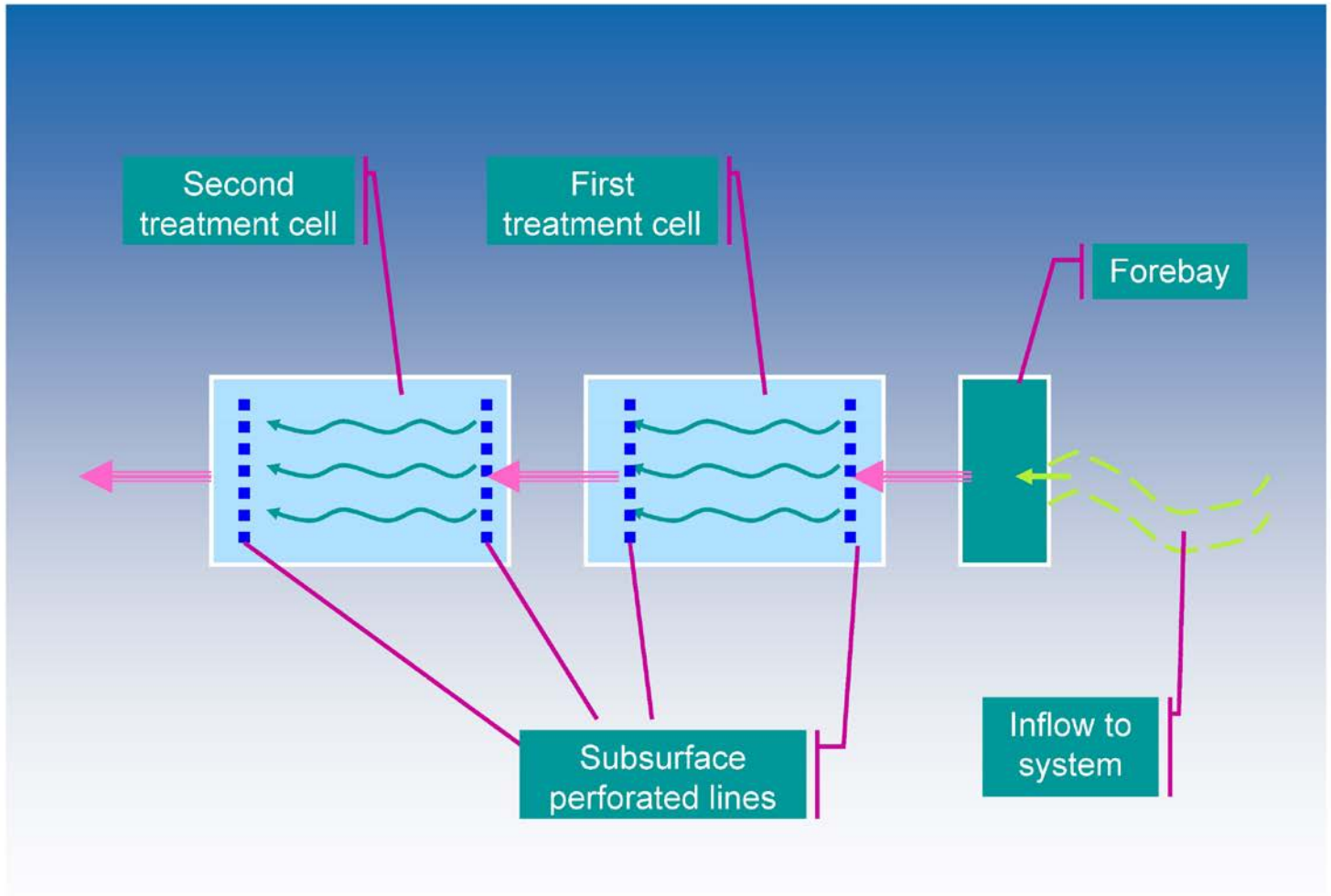
Nitrification
$NH_4 \rightarrow N0_2 \rightarrow NO_3$
Aerobic Zone
Forebay and surface of wetland

Influent
Organic N from runoff and plant debris



Denitrification
$\rightarrow N_2$ (gas)

Anaerobic Zone
Subsurface gravel



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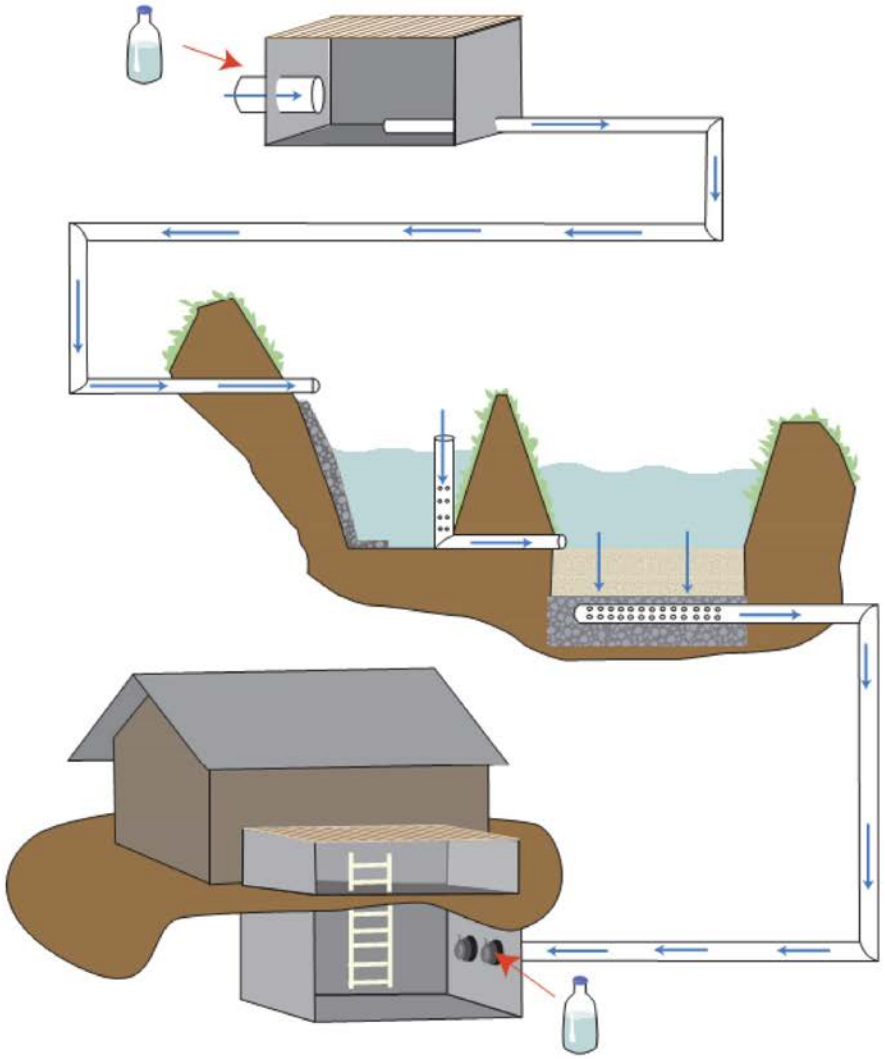
University of New Hampshire Stormwater Center

Parallel Performance Evaluation

- Each system uniformly sized to treat 1" runoff for 1 acre of impervious area
- WQV=3300 cf
- Q_{wqv}=1 cfs
- Uniform contaminant loading
- Uniform storm event characteristics
- Systems lined for mass balance
- Long term record of hydrology and contaminants



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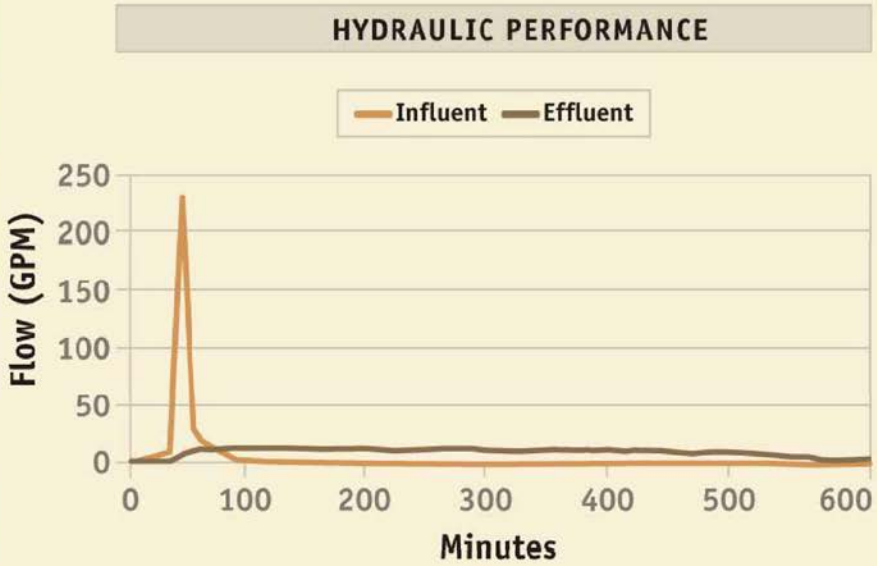
Subsurface Gravel Wetland Hydraulic Performance



	Winter	Summer	Annual Average
Average Peak Flow Reduction	85%	77%	81%
Average Lag Time (minutes)	318	313	315

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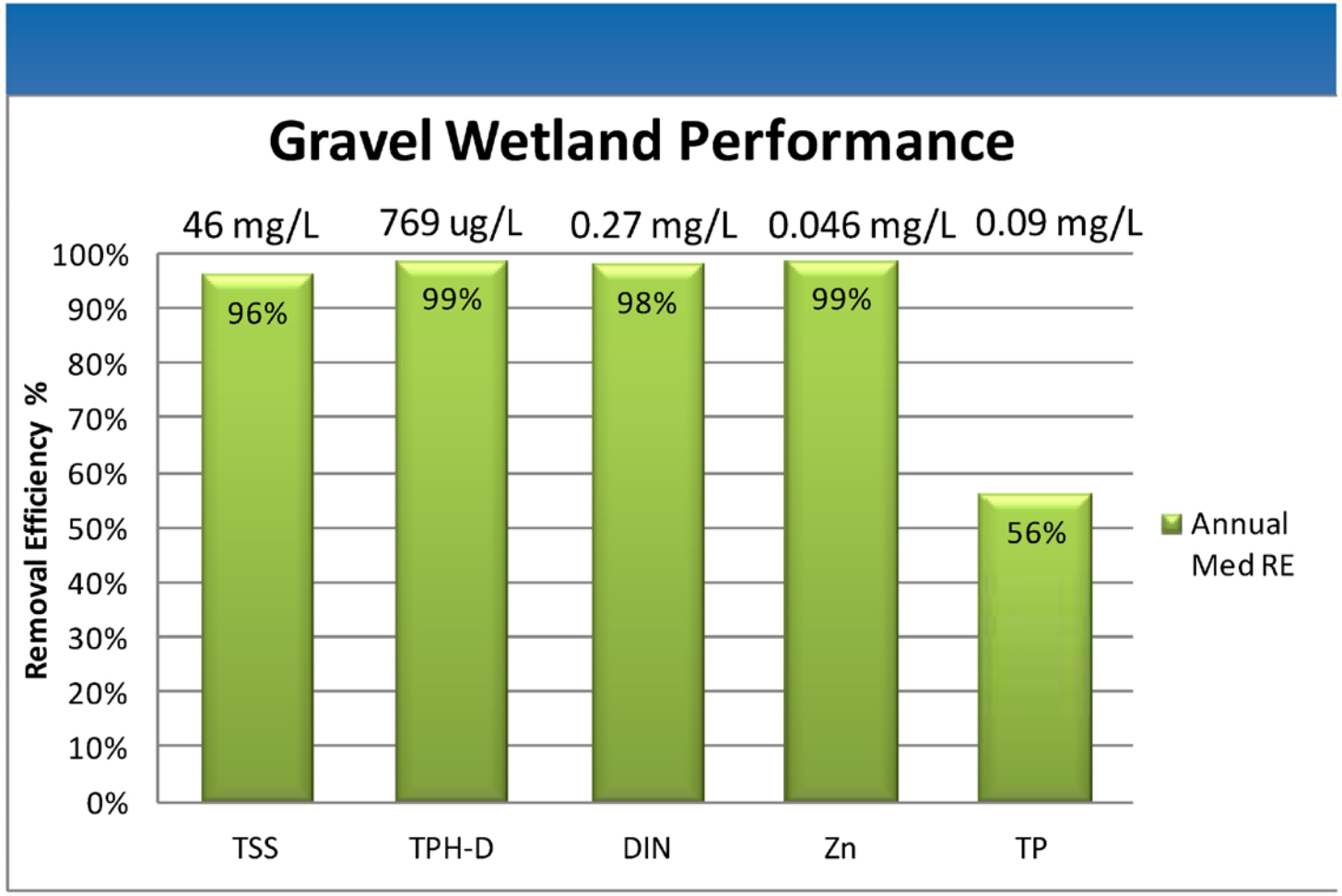

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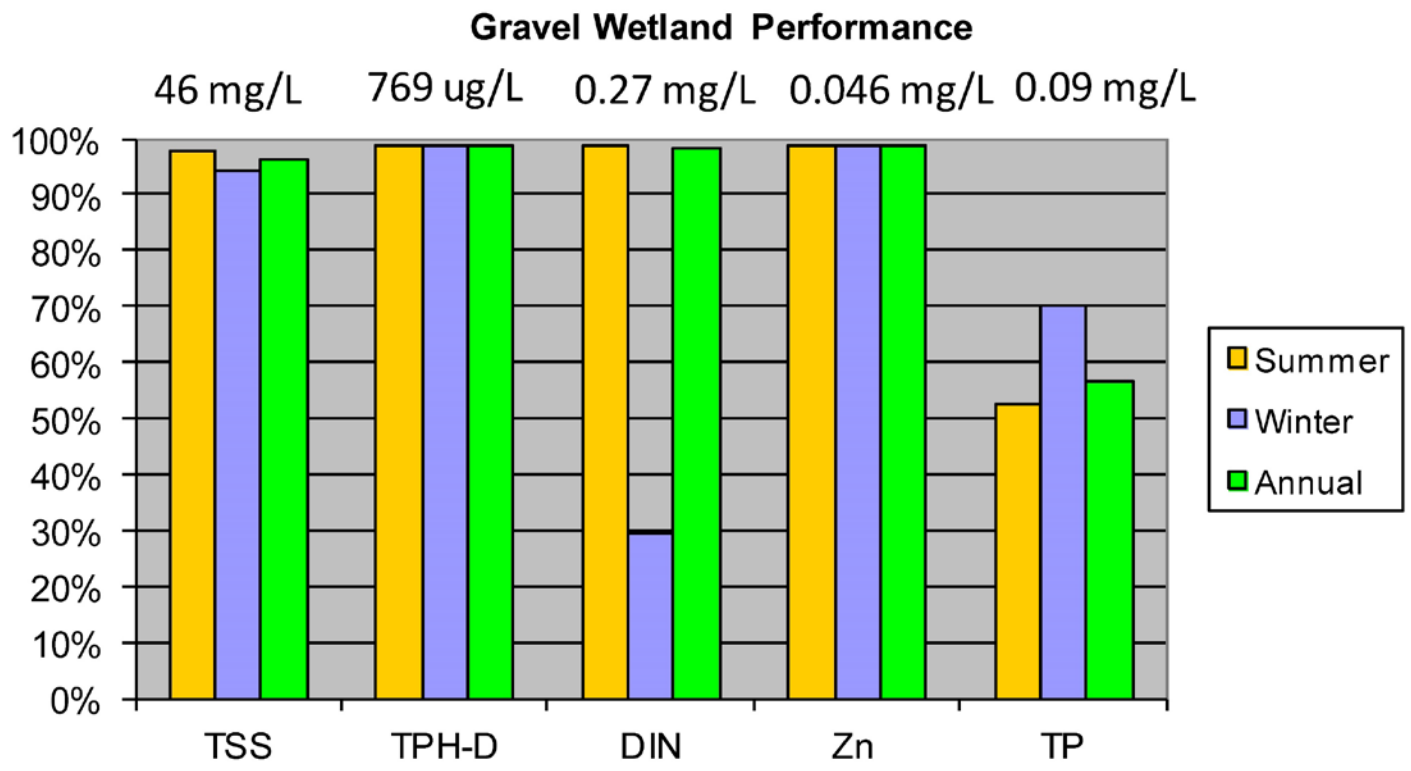
Seasonal Performance



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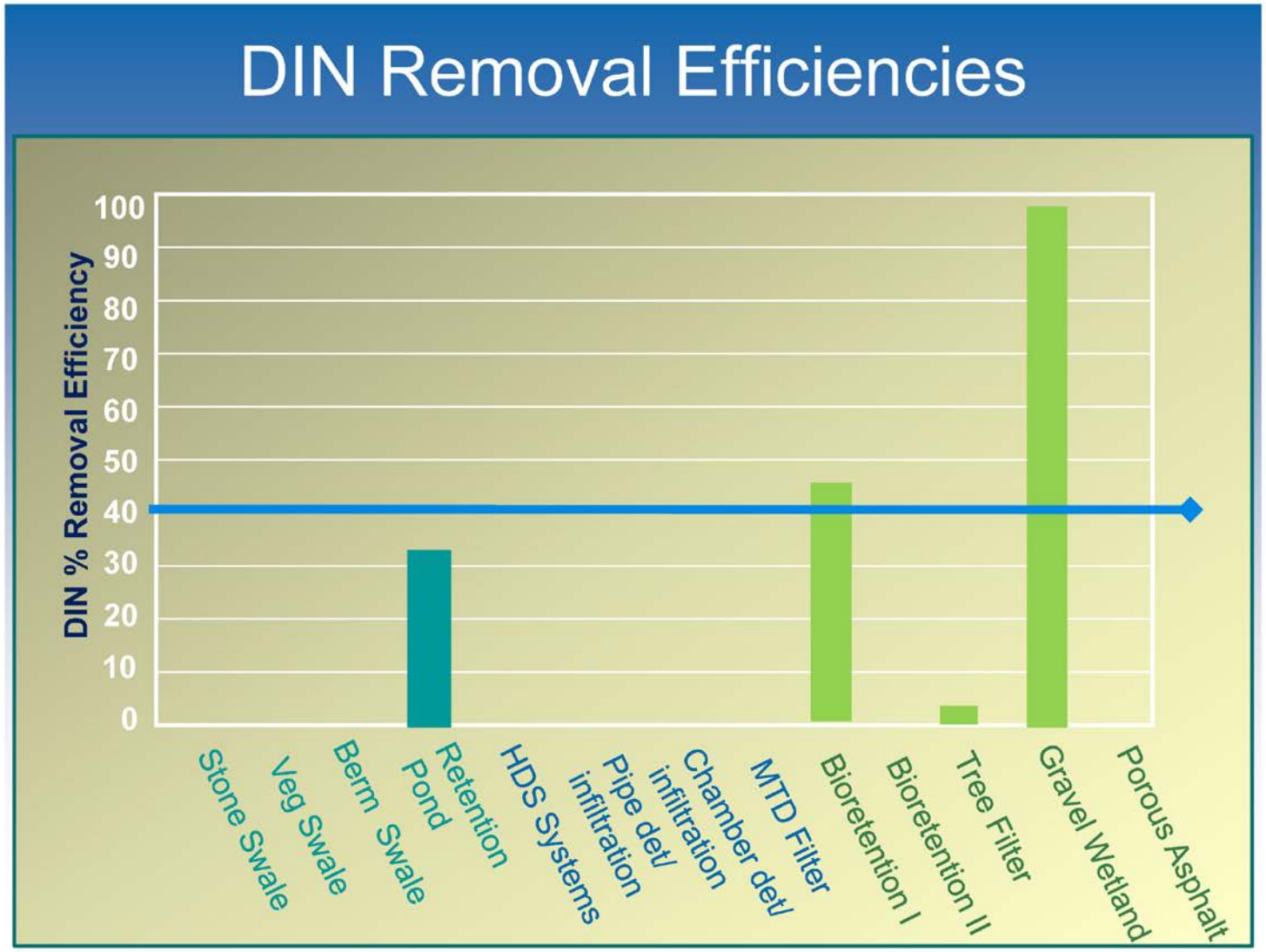

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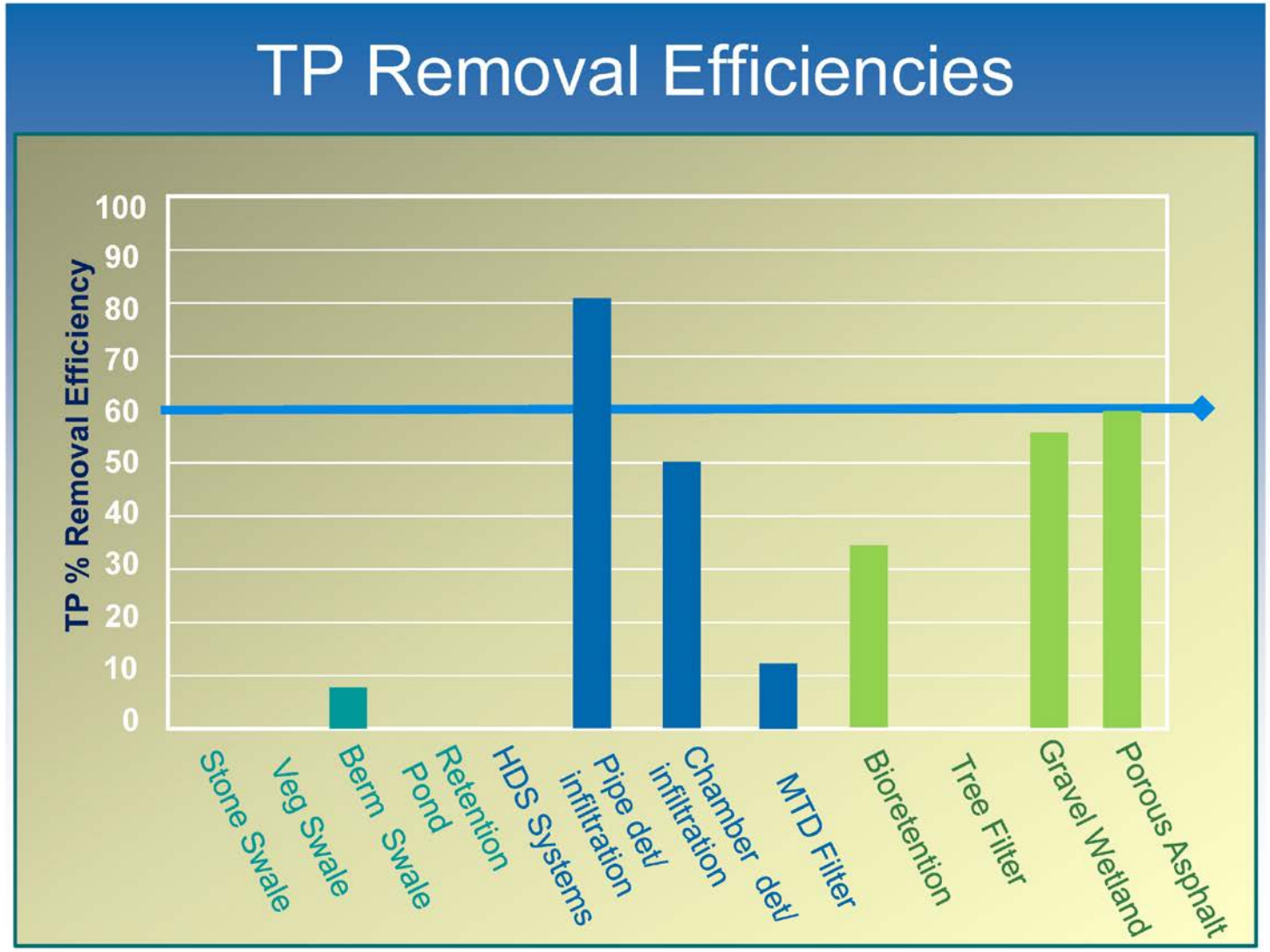
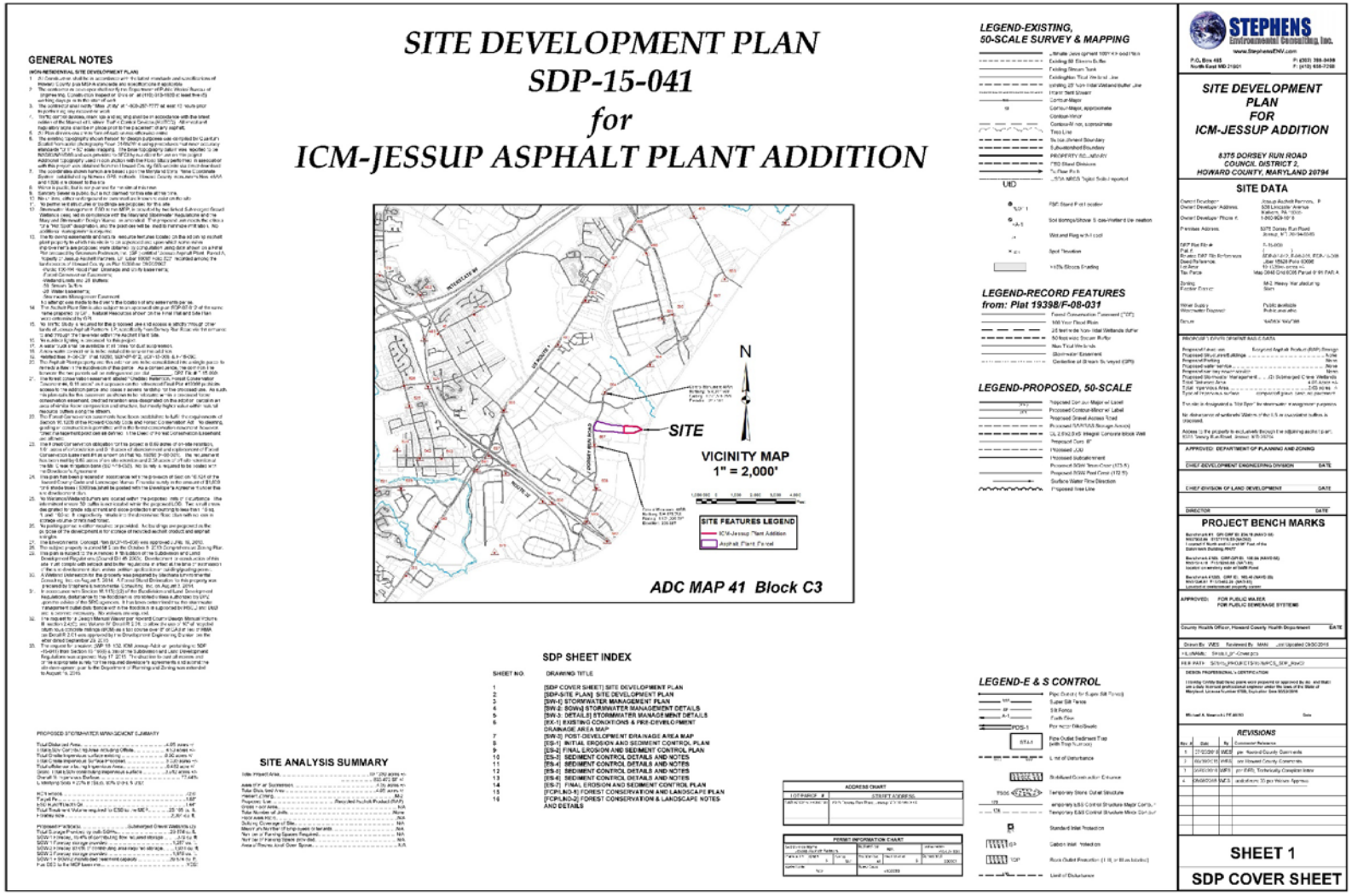


University of New Hampshire Stormwater Center (UNHSC)

Approved Plan Examples from Maryland and Delaware

- Example #1 – Maryland ICM Jessup
- Example #2 – Delaware Sinclair

DESIGN EXAMPLE #1



SITE DEVELOPMENT PLAN
SDP-15-041
for
ICM-JESSUP ASPHALT PLANT ADDITION

GENERAL NOTES

SITE ANALYSIS SUMMARY

SDP SHEET INDEX

VICINITY MAP
1" = 2,000'

SITE

ADC MAP 41 Block C3

LEGEND-EXISTING, 50-SCALE SURVEY & MAPPING

LEGEND-RECORD FEATURES from: Plat 19398/F-08-031

LEGEND-PROPOSED, 50-SCALE

LEGEND-E & S CONTROL

STEPHENS Environmental Consulting, Inc.

SITE DEVELOPMENT PLAN FOR ICM-JESSUP ADDITION

8375 DORSEY RUN ROAD
COUNCIL DISTRICT 2
HOWARD COUNTY, MARYLAND 20794

SITE DATA

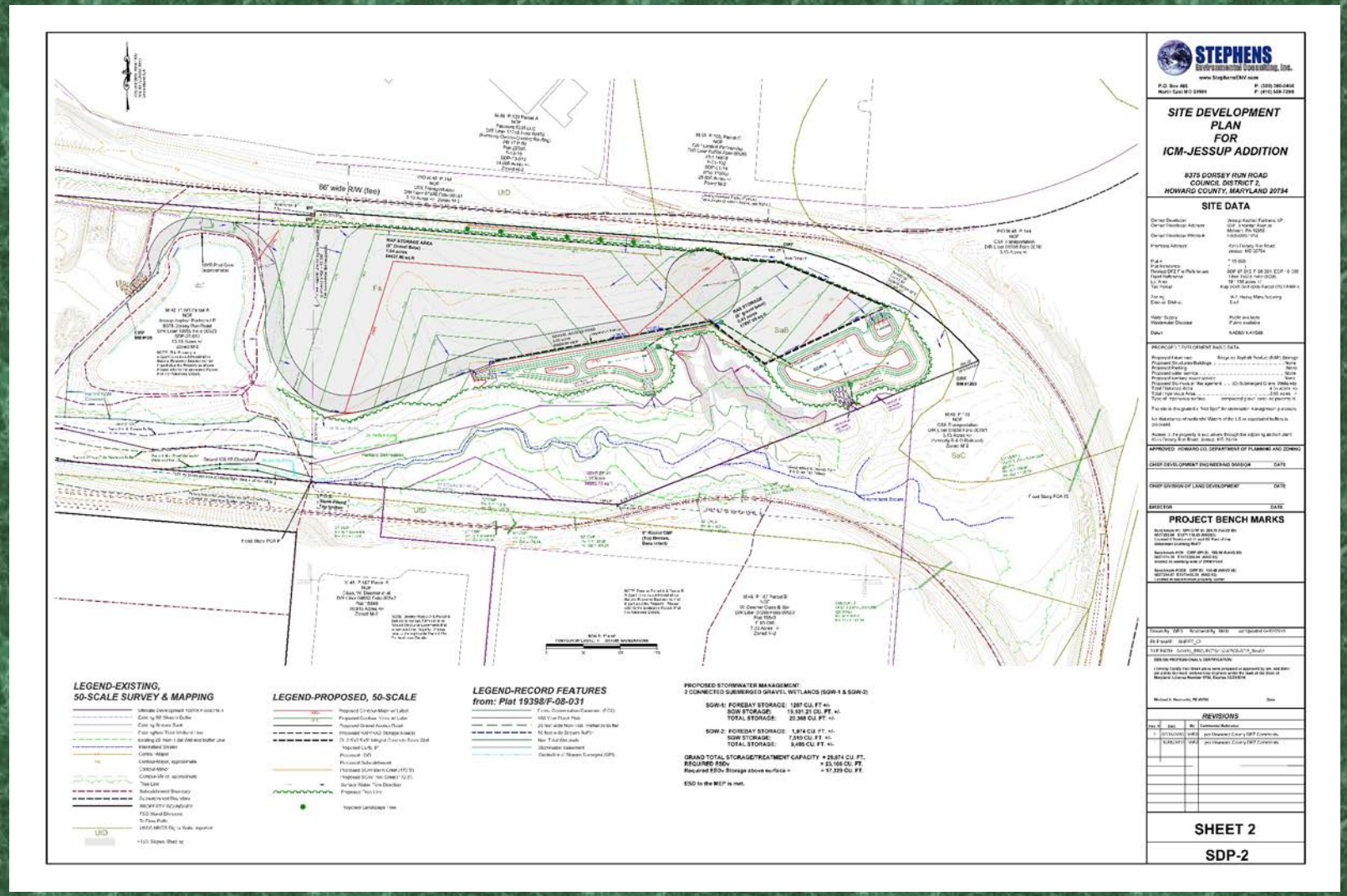
PROJECT BENCH MARKS

REVISIONS

SHEET 1

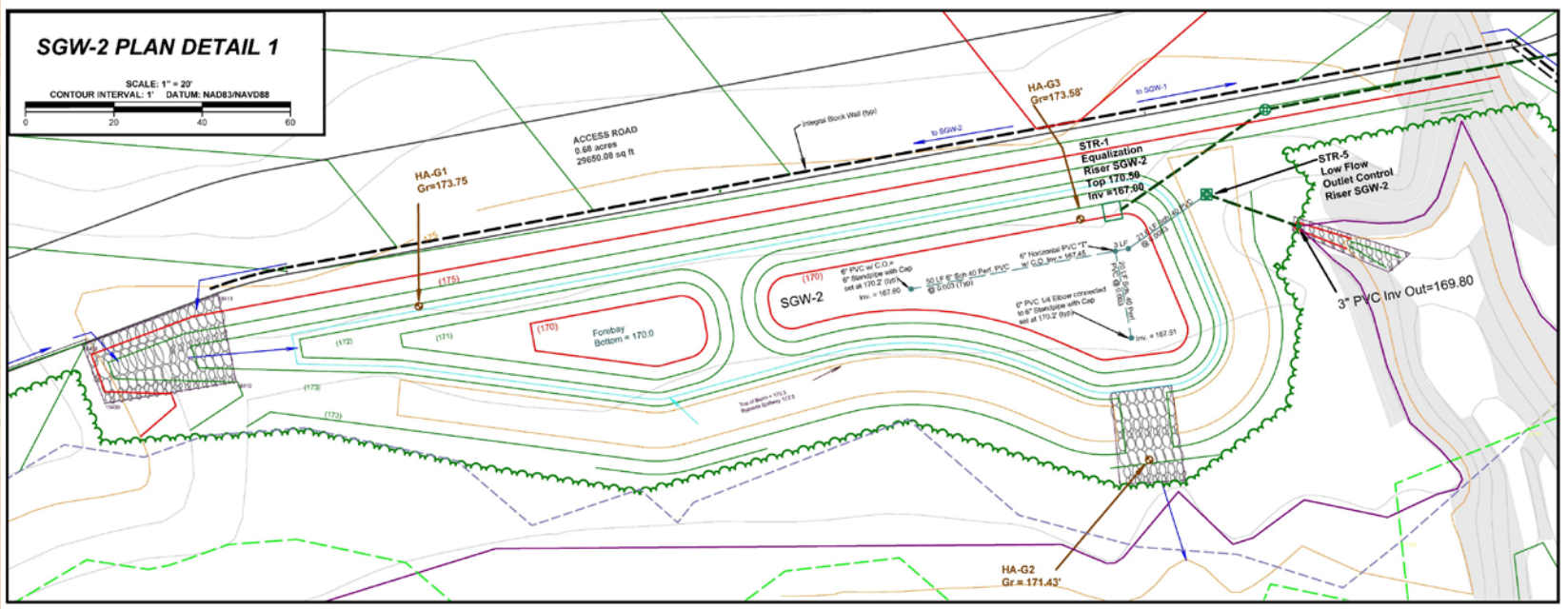
SDP COVER SHEET

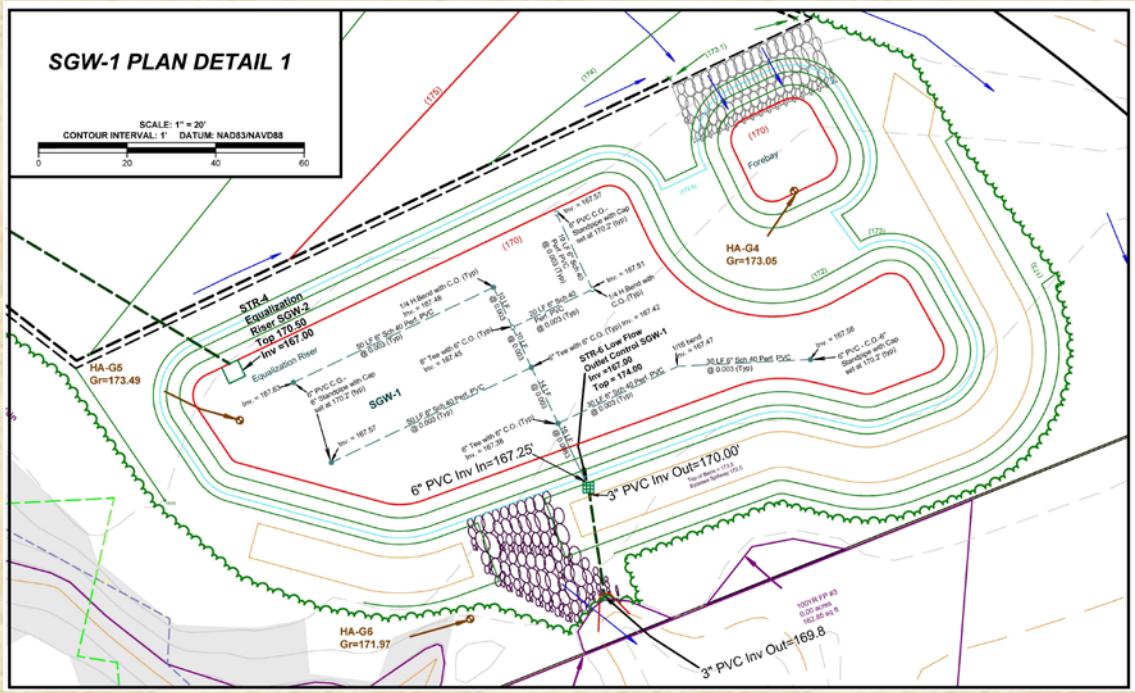
DESIGN EXAMPLE #1



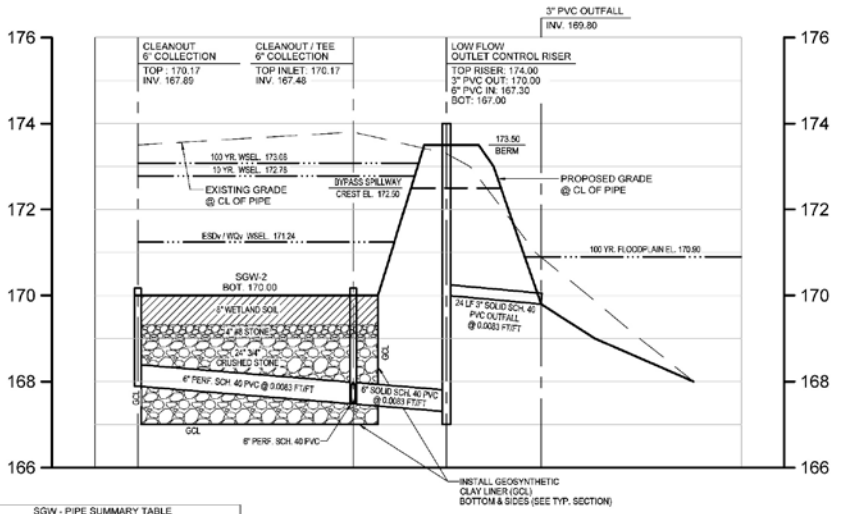
Note: This site was challenged by non-delineated flood plain, wetlands, and stream buffers. Solution involved incorporating an equalization system that allows the two SGW's to function hydraulically as a single unit

SGW PLAN VIEW





SGW-2 is smaller but serves the larger contributing area
Note: SGW-2 forebay is sized for the contributing area. SGW-1 is oversized and accommodates overflow from SGW-2

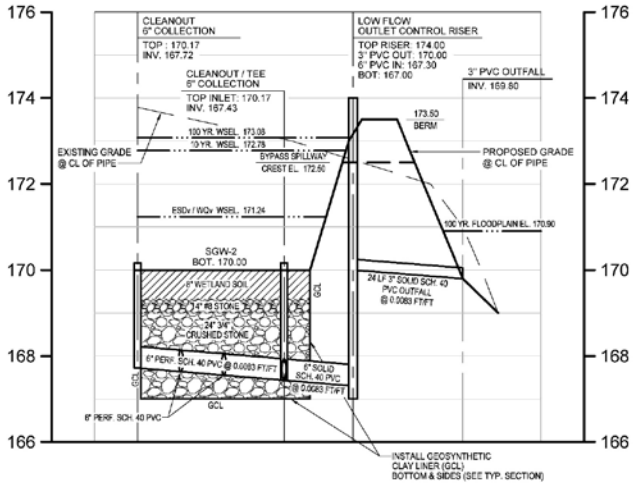


SGW - PIPE SUMMARY TABLE

SIZE	TYPE	QUANTITY	REMARKS
6 IN.	PVC	24 LF	SCH. 40

LOW FLOW OUTFALL - SGW 2

SCALE: 1"= 20' HORIZ.
1"= 2' VERT.

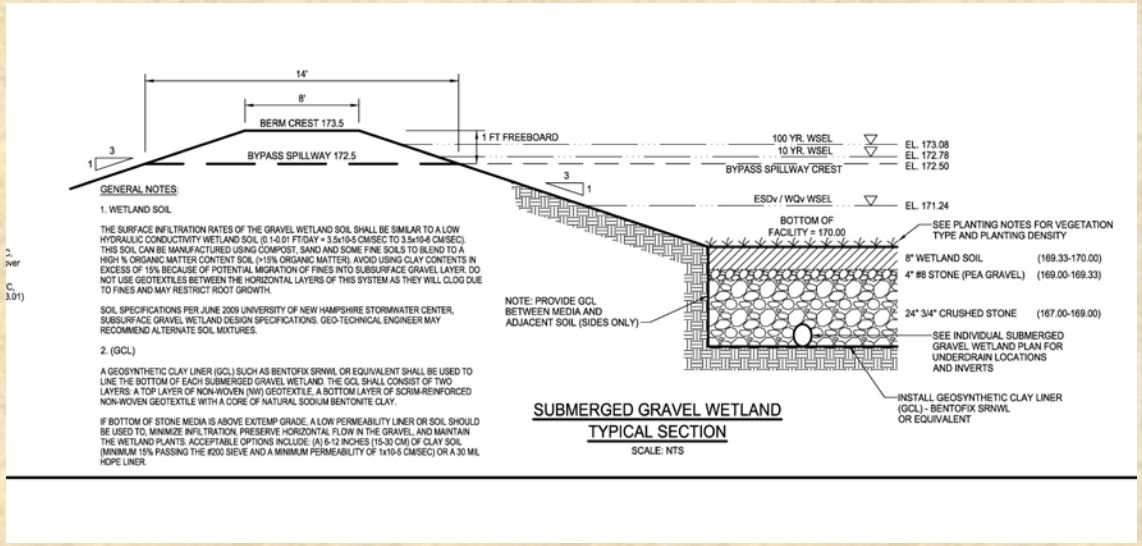


LOW FLOW OUTFALL - SGW 1

SCALE: 1"= 20' HORIZ.
1"= 2' VERT.

Note: Low flow Orifice in details above have identical size, slope, length, and invert elevations.

Typical Section



PROPOSED STORMWATER MANAGEMENT:
2 CONNECTED SUBMERGED GRAVEL WETLANDS (SGW-1 & SGW-2)

SGW-1: FOREBAY STORAGE: 1287 CU. FT +/-
SGW STORAGE: 19,101.21 CU. FT. +/-
TOTAL STORAGE: 20,388 CU. FT. +/-

SGW-2: FOREBAY STORAGE: 1,974 CU. FT. +/-
SGW STORAGE: 7,510 CU. FT. +/-
TOTAL STORAGE: 9,485 CU. FT. +/-

GRAND TOTAL STORAGE/TREATMENT CAPACITY = 29,874 CU. FT.
REQUIRED ESDv = 23,105 CU. FT.
Required ESDv Storage above surface = = 17,329 CU. FT.

ESD to the MEP is met.

(ESD Summary)

Construction Phase- Subgrade Prep.

Construction Phase- Liner Placement and Riser Installation.

Construction Phase- Underdrain & Stone Placement.

Construction Phase- Wetland Soil Placement.

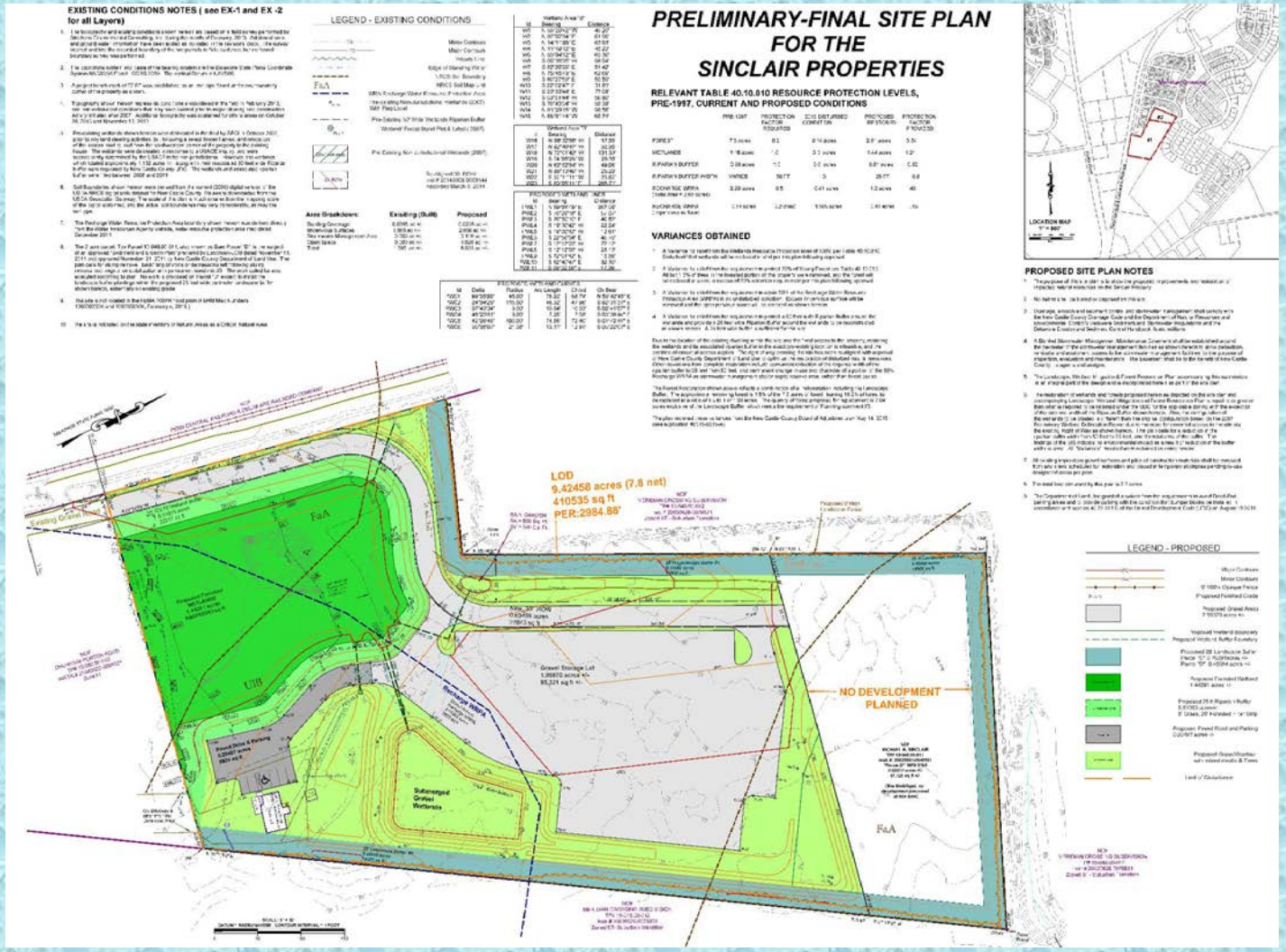
Large SGW Construction Phase Photos

Source: UNHSC – Greenland Meadow Case Study.
SGW treats site with 15,000 ADT, impaired receiving waters.
Studied from 2005 to 2012

3 years later

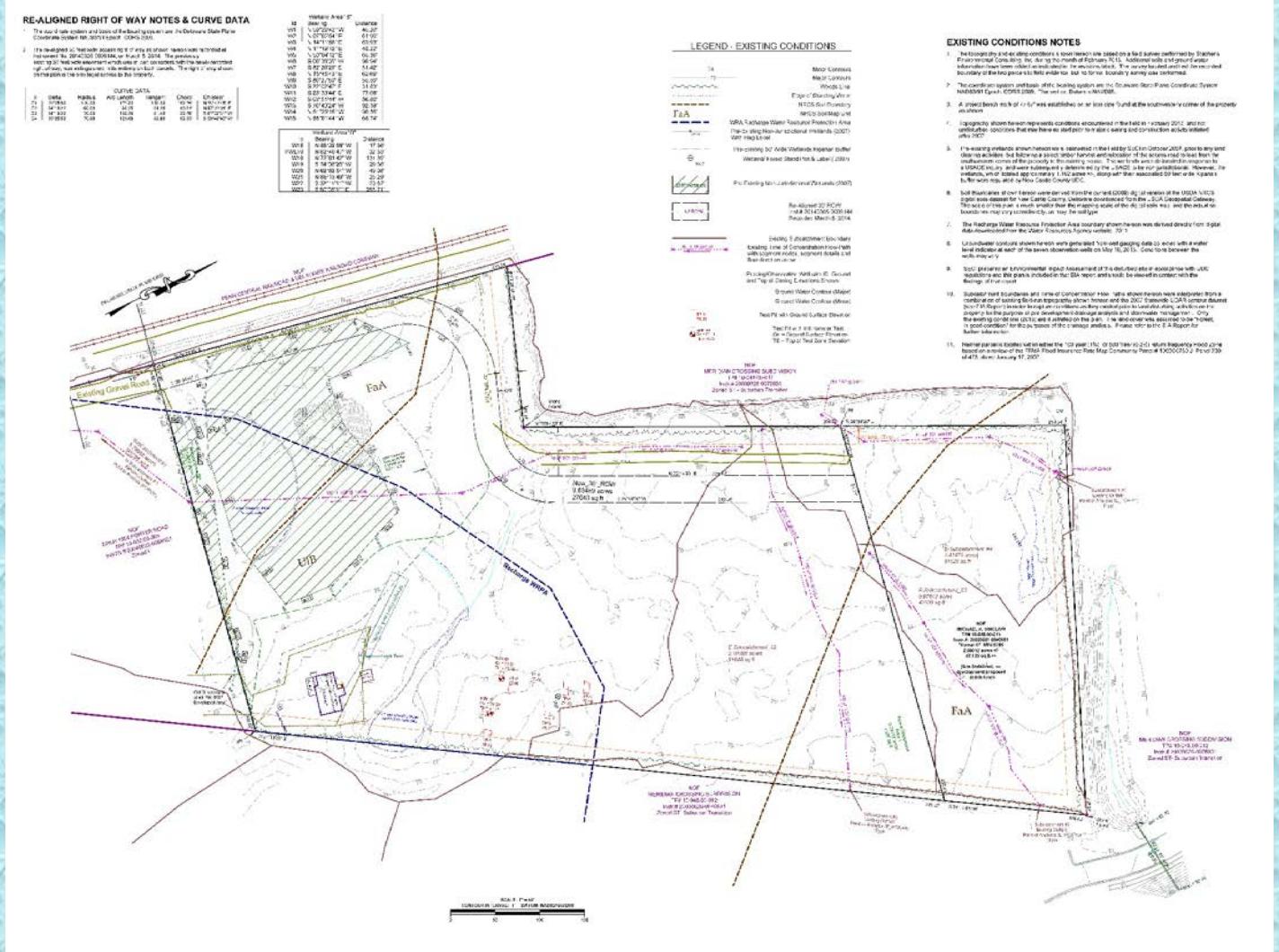
DESIGN EXAMPLE #2 (DELAWARE)

- Site in Violation, lots of challenges to attain compliance
- 4 variances required along with realignment of 1960 access easement just to make it possible to move through the design process
- 1.5:1 Restoration of forested wetlands, Recharge WRPA Forest and OS restoration etc.
- Choice of DURMM V1 or DURMM V2, SGWs not permitted under DURMM V1 and adequate separation from water table infeasible for DURMM V1 compliance



DESIGN EXAMPLE #2

- Existing Conditions- woods cleared completely, crushed concrete in previously delineated forested wetland, only access through the wetland, much of parcel that can be developed drains to another watershed.
- Must maximize capacity of primary treatment structure to offset RPv deficiencies elsewhere, and to reduce CPv and Fv peak outflow to protect downstream conditions.

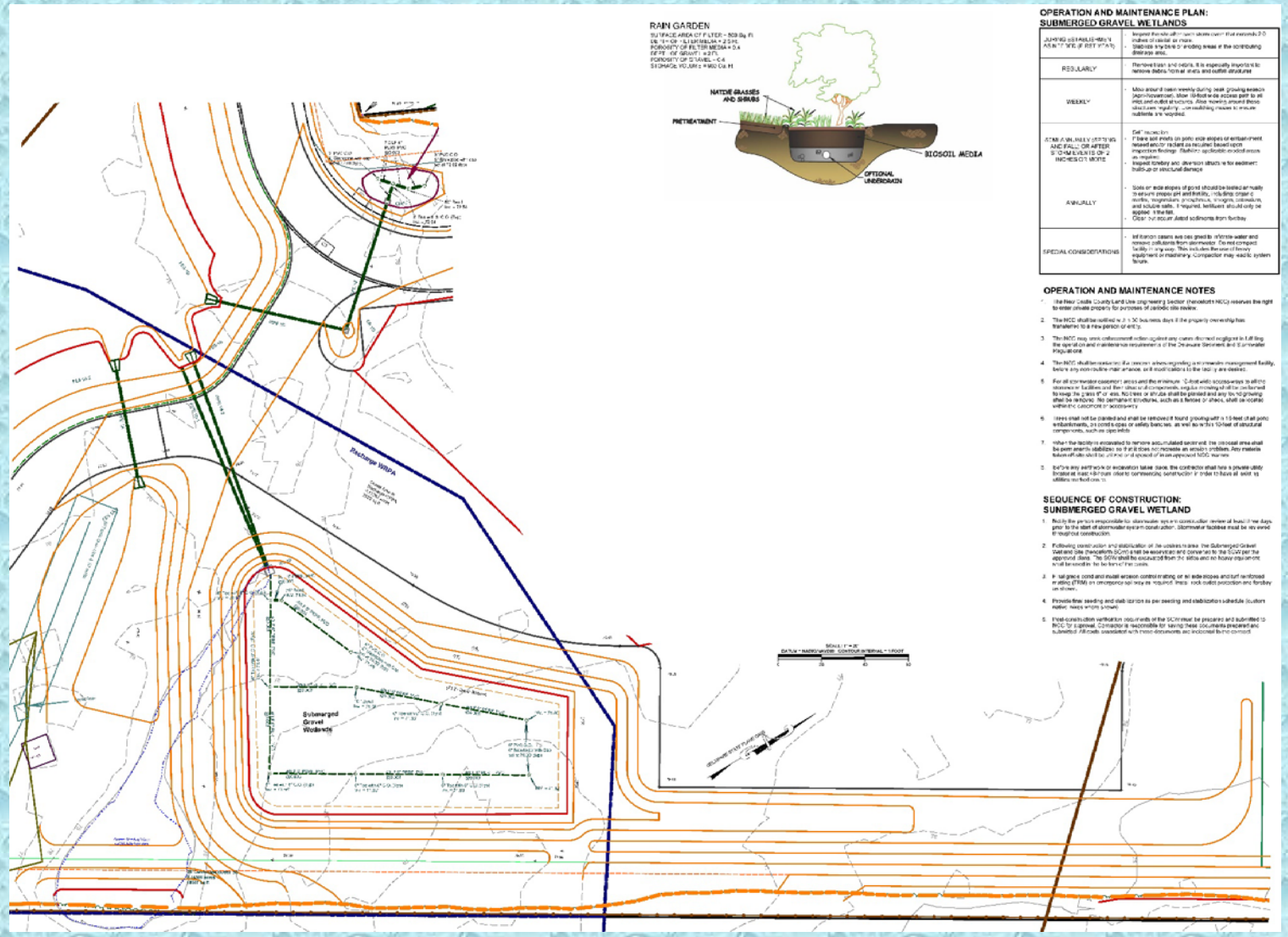


DESIGN EXAMPLE #2

- Post-Development Proposed Conditions-
- Access granted via essential access right in part, use new aligned easement for road to Parcel 2
- Accommodate required restoration of wetlands, forest etc and provide landscape buffer
- Waiver for dead end road/parking lot
- Use SGW with bonus storage
- Max-out storage pad, grab 1.8 acres from the other watershed, direct into SGW
- Per DNREC, use Bioretention with infiltration to model SGW credits in DURMM V2

DESIGN EXAMPLE #2

- Grass swale serves as primary pre-treatment for SGW in lieu of forebay, and is part of DURMM Treatment train
- Massive credit of over 1645 cu. ft. applied to overall site summary to offset deficiencies from other contributing subareas
- H&H analysis for POA's at critical offsite areas downstream indicate no significant increase in peak flow for CPv and Fv
- Mission Accomplished!



In Review & Some Important Considerations

1. In addition to its nutrient, hydrocarbon and TSS crushing capabilities, has some temperature moderation and other water quality benefits not discussed today or listed in my December 2016 memo. See References for more.
2. SGWs are ideal for large contributing drainage areas and are up-scalable. The minimum recommended contributing area is 1 acre!
3. Our understanding of quality performance criteria comes from studies conducted by UNHSC, CWP and others, but must model performance credits using DNREC DURMM V.2 BMP 2-A Traditional Bioretention-Infiltration in order to attain compliance.
4. Whether in DE or MD, we must use MDE's design manual criteria for SGW design
5. SGWs can be used alone or in treatment trains in DE DURMM V.2, but anyone applying for variance to use DURMM V.1 and old regs does not have option to use.
6. The literature talks about designing for Wqv, the water quality volume + 1" of runoff, but ESD to the MEP in MD and DURMM V.2 are usually about twice that runoff depth for highly impervious sites as Cpv is also considered.
7. Quick rule of thumb for impervious runoff in DE is more like 2". So, 1 acre imp needs about 7,260 CF or 0.1667 acre-ft of storage.

QUESTIONS?

COMMENTS?

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