



Willow Creek Preserve: *Step Pool Conveyance Stabilization & Wetland Restoration*

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AQUALIS, Project Engineer

AQUALIS

About Us



AQUALIS is the nationwide leader delivering sustainable water compliance management for stormwater, wastewater and drinking water. We offer planning and design, maintenance, repairs, rehabilitation, engineering, inspection and consultation services to assist in the sustainability of water management systems.

Engineering Services

- Stormwater Management
- Green Infrastructure Design
- Stormwater Integrated Site Design
- Drainage Design & Erosion Control
- Hydraulic Analysis & Reports
- Regenerative Stormwater Conveyance
- Grant Application Support... AND MORE!



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ECOLOGICAL

Native Range Ecological is a hands-on ecological planner, providing ecological and wildlife habitat assessments, vegetation surveys, and wetland and waterway restoration design throughout Wisconsin.

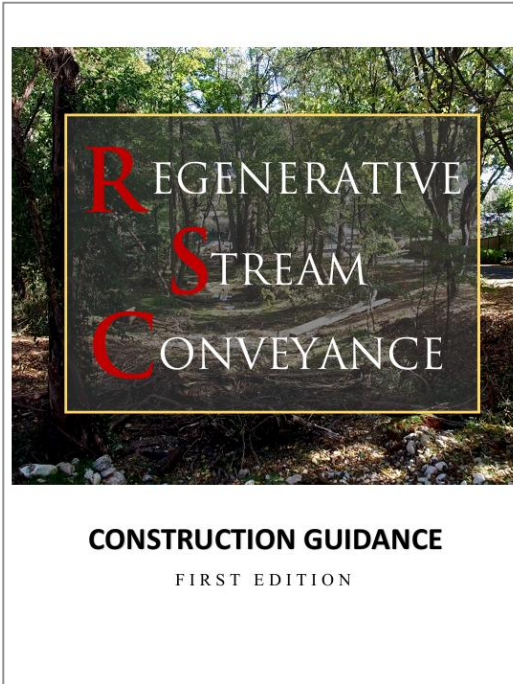
What is Regenerative Stormwater Conveyance (or Step Pool Conveyance)?

- Originally used to retrofit failing channels, swales, and pipe outfalls
- Now used for variety of stormwater management applications
- Adaptable to space constraints of roadway medians and ditches
- Unlike traditional bioretention systems, RSCs can be designed on steeper slopes
- Considered lower maintenance over time as system matures
- Implemented first on East Coast
 - Now recognized in Midwest, including Wisconsin



Available Design Guidance

- [Maryland](#)
 - [Anne Arundel County](#)
- North Carolina
 - [Greenville County, NC](#)
- Georgia
 - [Augusta, GA](#)
- [U.S. Fish & Wildlife Service](#)



Description: A regenerative stormwater conveyance (RSC) system provides treatment, infiltration and conveyance through the combination of sand, wood chips, native vegetation, riffles (with either cobble rocks or boulders), and shallow pools. RSCs are designed to convey water while minimizing the effects of erosion.

LID/GI Consideration: RSCs repair and restore eroded and damaged drainage channels by mimicking natural drainage patterns. They provide water quality volume treatment for TSS and dissolved pollutants, while also providing mitigation of thermal impacts of stormwater runoff. This is considered to be green infrastructure IMP.

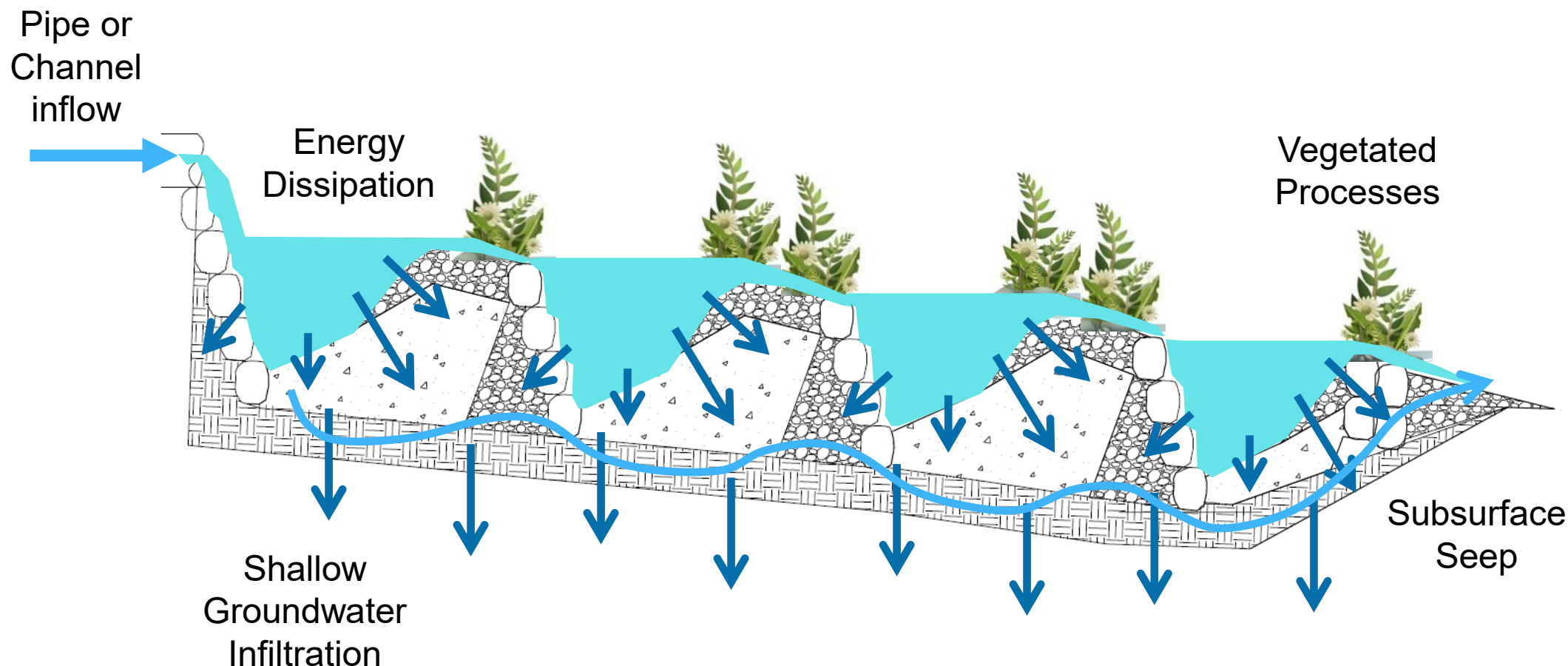
U.S. Fish & Wildlife Service
**Regenerative Storm
Conveyance Design
Review Checklist**

CBFO-S15-04
February 2015

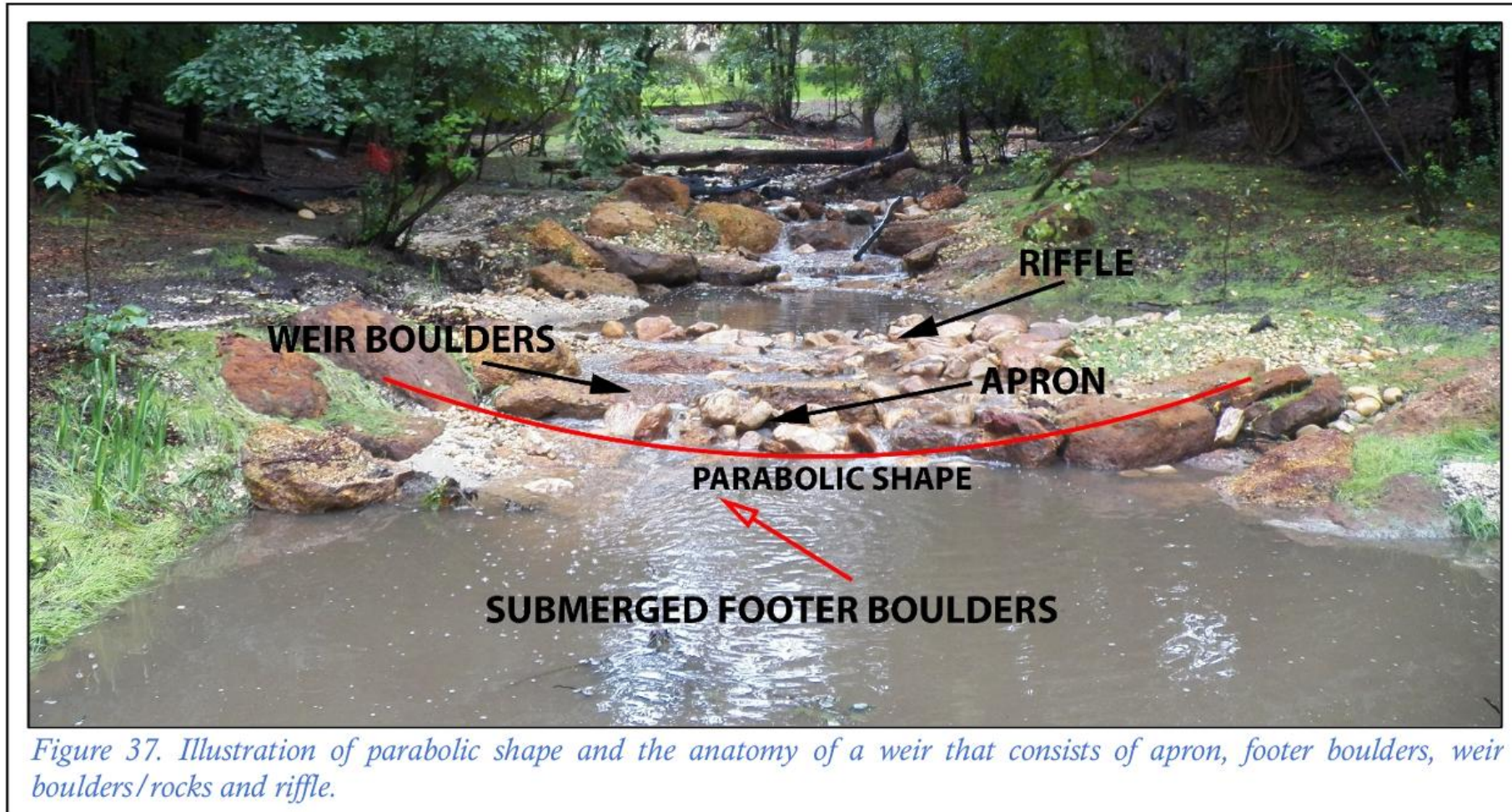


What is Regenerative Stormwater Conveyance (or Step Pool Conveyance)?

RSCs are a series of pools and riffles designed to convey, capture, and treat stormwater runoff while protecting and preserving site soils



Riffle/Weir Structure

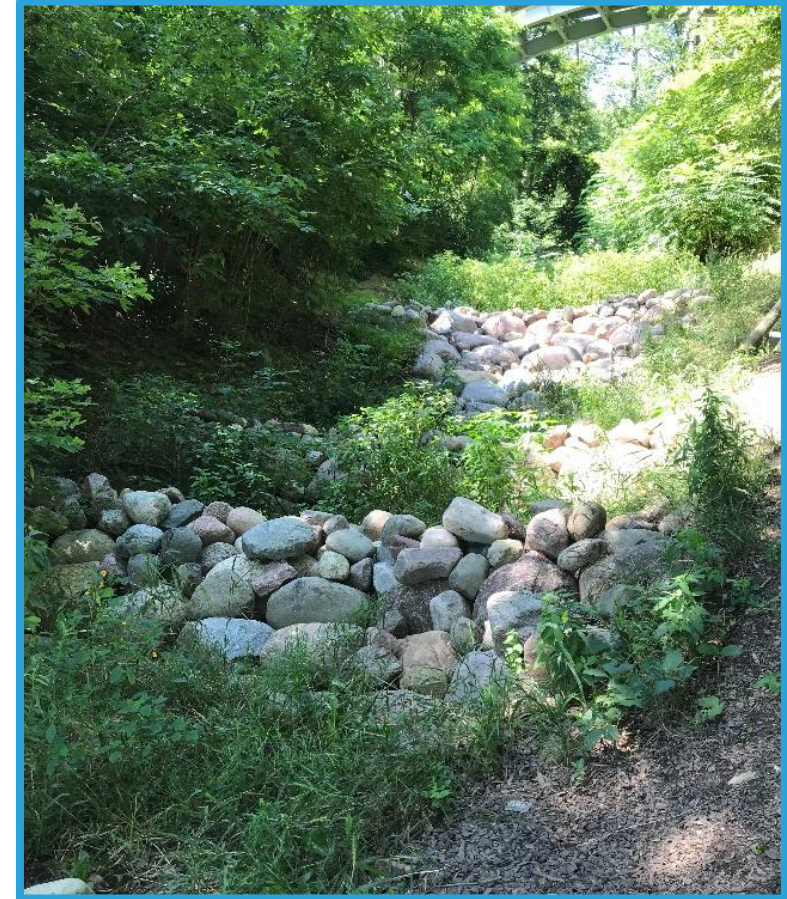


Actaeon, D.A. (2018). *Regenerative stream conveyance: Construction guidance, first edition*. Maryland Department of Natural Resources. https://dnr.maryland.gov/ccs/Documents/RSC_Training/RSC-Guidance.pdf

Project Examples: Outfall Restoration



Project Examples: Conveyance/Ravine Stabilization





Introduction

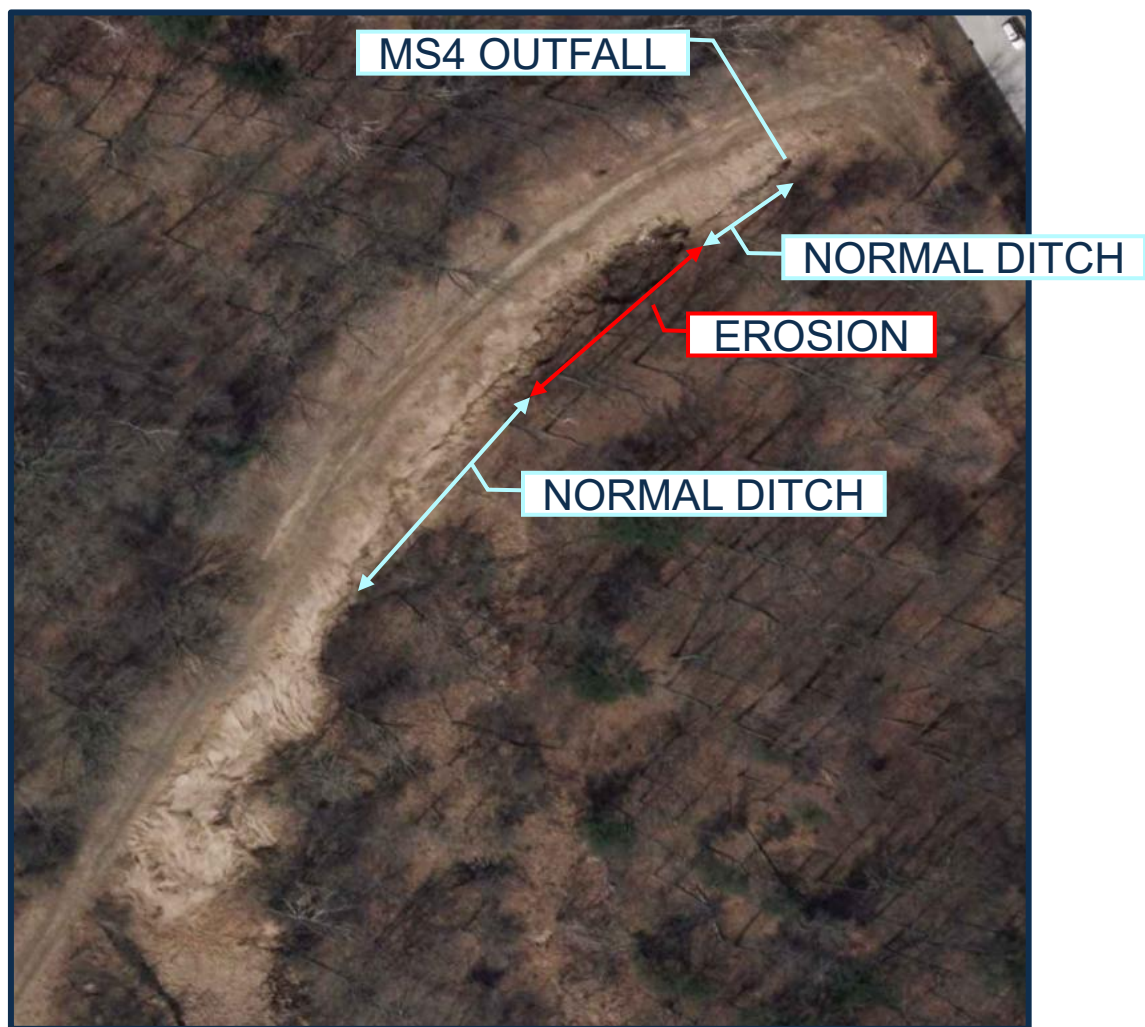
- Sheboygan, WI
- Willow Creek Preserve



Path adjacent to conveyance



Erosion Timeline



2009



2022

Problem: MS4 Outfall



Problem: Headcut 1



Problem: Side Slope Erosion



Problem: Headcut 2



Problem: Headcut 3



Problem: Downstream Wetland



Existing Conditions Report



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Site Conditions

The conveyance is located on the southern, east slope of the Preserve. An MS4 outfall crosses under S. Taylor Dr. and directs stormwater runoff from a shopping center and adjacent Taylor Heights Frontage Rd into the conveyance. The conveyance then runs along the south side of the east-west walking path, downslope to where it flattens into the floodplain wetland of the Willow Creek tributary. Attachment 1 provides a photo log of the conveyance. Over 25 years of concentrated flow onto the Preserve has caused severe headcutting and sloughing along its discharge pathway, creating the gully we see today. The vulnerable soils exposed by erosion then experience accelerated headcutting and sloughing, creating a positive feedback loop with the worst of the cutting happening over the past few years. See Figure 1 of the conveyance in 2009, prior to severe headcutting conditions, and after headcutting, in 2022.

Hydrologic Conditions

Under existing conditions, stormwater runoff from 6.59 acres of developed land is collected in the City of Sheboygan's MS4 and discharged to the project conveyance on the Preserve (Attachment 2). The conveyance discharges to a tributary to Willow Creek, then to Willow Creek, a tributary to the Sheboygan River, then ultimately to Lake Michigan. The land within the contributing sewershed is comprised of 3.27 acres of paved parking, 1.4 acres of commercial rooftop, 1.27 acres of grass cover, and 0.66 acres of paved roads. The 21" concrete storm sewer delivering runoff from these combined drainage areas to the Preserve fully conveys up to a 5-year storm. Runoff from larger events will bypass the MS4 to the Preserve and travel south down the frontage road. Using the TR-55 method, storm runoff volume and peak rate of discharge from the MS4 were calculated as 640,624 gallons and 19.72 cubic feet per second, respectively. Velocity through the storm sewer varies between 6.95 fps and 8.5 fps for the 2- and 100-year recurrence intervals, which is considered erosive. However, large riprap placed at the end of the pipe appears to be stable, with vegetation and moss present, suggesting that the flow velocity may quickly dissipate once leaving the pipe to closer to 2 fps. Hydrologic calculations are provided in Attachment 3.

In addition to the sewershed described above, there are also two drainage areas within the Preserve which contribute runoff to the conveyance. The first of these is the subcatchment surrounding the conveyance, including some partially wooded areas to the north and east. The second is the subcatchment surrounding a small side channel to the east that contributes to the conveyance, which includes a wooded area and high-quality, perched wetland. Total flows throughout the SPC are calculated to be approximately 25 cfs, resulting in 20 ft wide grade control structures for safe conveyance of the 100-year runoff event. Placement and use of such structures are highly dependent on the additional site conditions, as described in the following sections

Structural Conditions

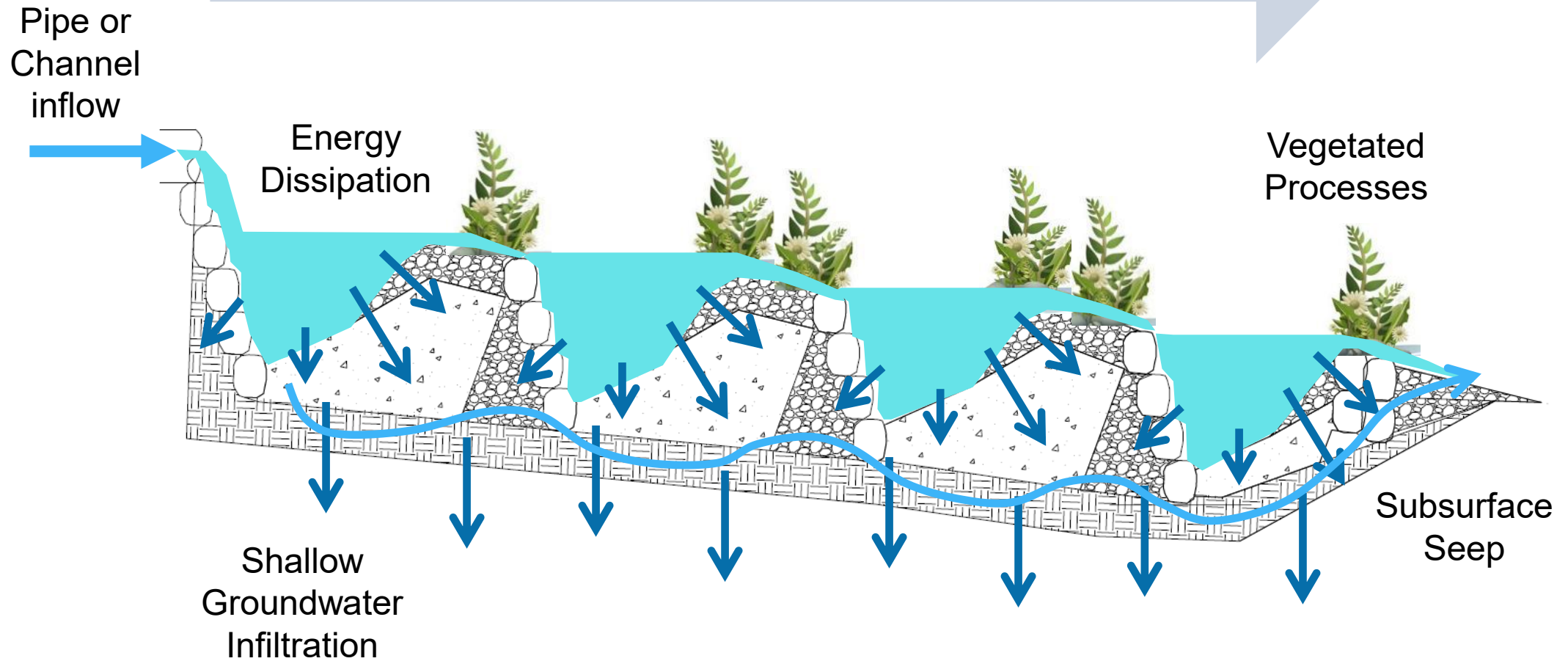
AQUALIS and NRE observed and recorded the structural conditions of the conveyance at various site visits. The conveyance is in poor condition from the top of the slope until its confluence with a side channel to the east and the slope begins to flatten. The headcutting starts approximately 10-ft downstream from the outfall pipe apron. Nearing the confluence, the conveyance becomes a shallower channel where side slopes are in fair to good condition.

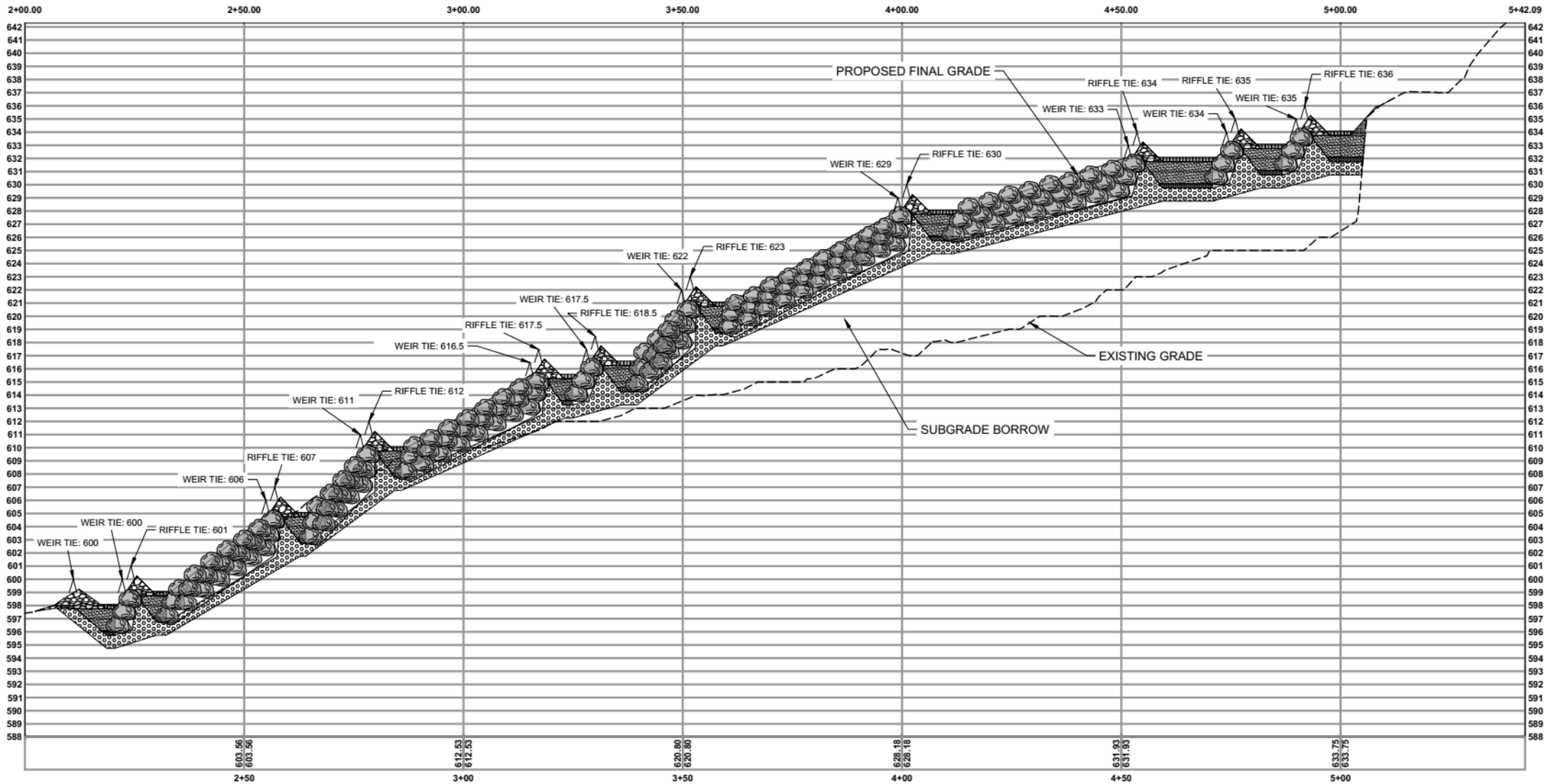


Solution: Step Pool Conveyance

Goal: Stabilize channel erosion & Safely convey flow

Method: Step Pool Conveyance





LEGEND

- NO. 1 CLEAR STONE
- ENGINEERED SOIL MEDIA
- COMPOST
- 8" TO 12" COBBLE
- 3/8" PEA GRAVEL
- EXISTING TOPSOIL
- BOULDERS (WEIR)
- BOULDERS (CASCADE)
- TIE IN POINTS



EROSION CONTROL SCHEDULE

ITEM	UNIT	TOTAL	SHEET
TRACKING PAD	SA	1	C000
CONSTRUCTION FENCING	LF	700	C000
SILT SOCK (POOLS)	LF	110	C000
SILT SOCK (POOLS)	LF	400	C000
FLOW DIVERSION	SA	1	C000
SILT SOCK - PERIMETER CONTROL	LF	600	C000
PAW POLYMER, AGGREGATE	SF	8,500	C000
CLAYB. TYPE B-SAND	SF	5,400	C000
SILT SOCK/POST CONSTRUCTION	LF	500	C000
SEDIMENT LOSS/PERFORATED SLOPE INTERCEPTION	LF	100	C000
SEDIMENT LOSS/PLANTED AREAS	LF	800	C000, VMP

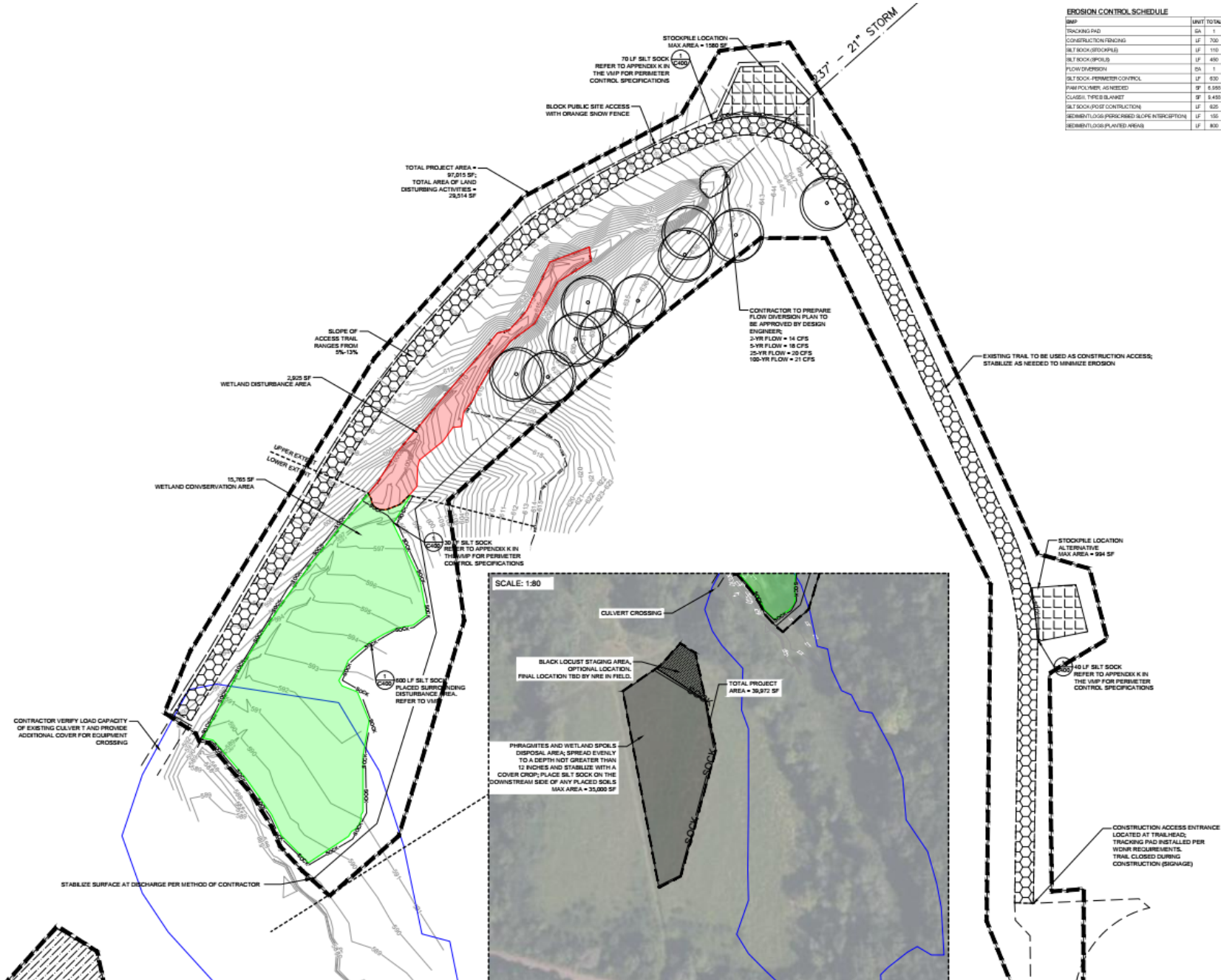


LEGEND:

- PROJECT EXTENTS
- FEMA 1% AC FLOOD HAZARD ZONE
- WETLAND DISTURBANCE PERMIT AREA
- WETLAND CONSERVATION PERMIT AREA
- BLACK LOCUST STAGING AREA
- CONSTRUCTION ACCESS ROUTE
- MATERIAL/EQUIPMENT STOCKPILE
- SILT SOCK
- ACCESS RESTRICTION FENCING
- EXISTING 5' MAJOR CONTOUR
- EXISTING 1' MINOR CONTOUR
- PROTECT EXISTING TREE

GENERAL NOTES:

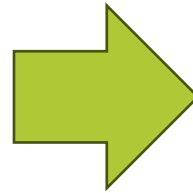
1. BYPASS DIVERSION, TO BE APPROVED BY ENGINEER, AND SHALL MEET WDR PERMIT REQUIREMENTS.
2. STABILIZATION OF SURFACE AT DIVERSION DISCHARGE PER METHOD OF CONTRACTOR.
3. CONTRACTOR TO GET ALTERNATE STOCKPILE LOCATIONS APPROVED BY ENGINEER AND CLIENT.
4. EROSION CONTROL EVALUATION COMPLETED USING WDR SOIL LOSS AND SEDIMENTATION DISCHARGE TOOL, VERSION 2.1. THE WORK IS EXPECTED TO RESULT IN 2.1 TONS OF SEDIMENT PER ACRE PER YEAR.



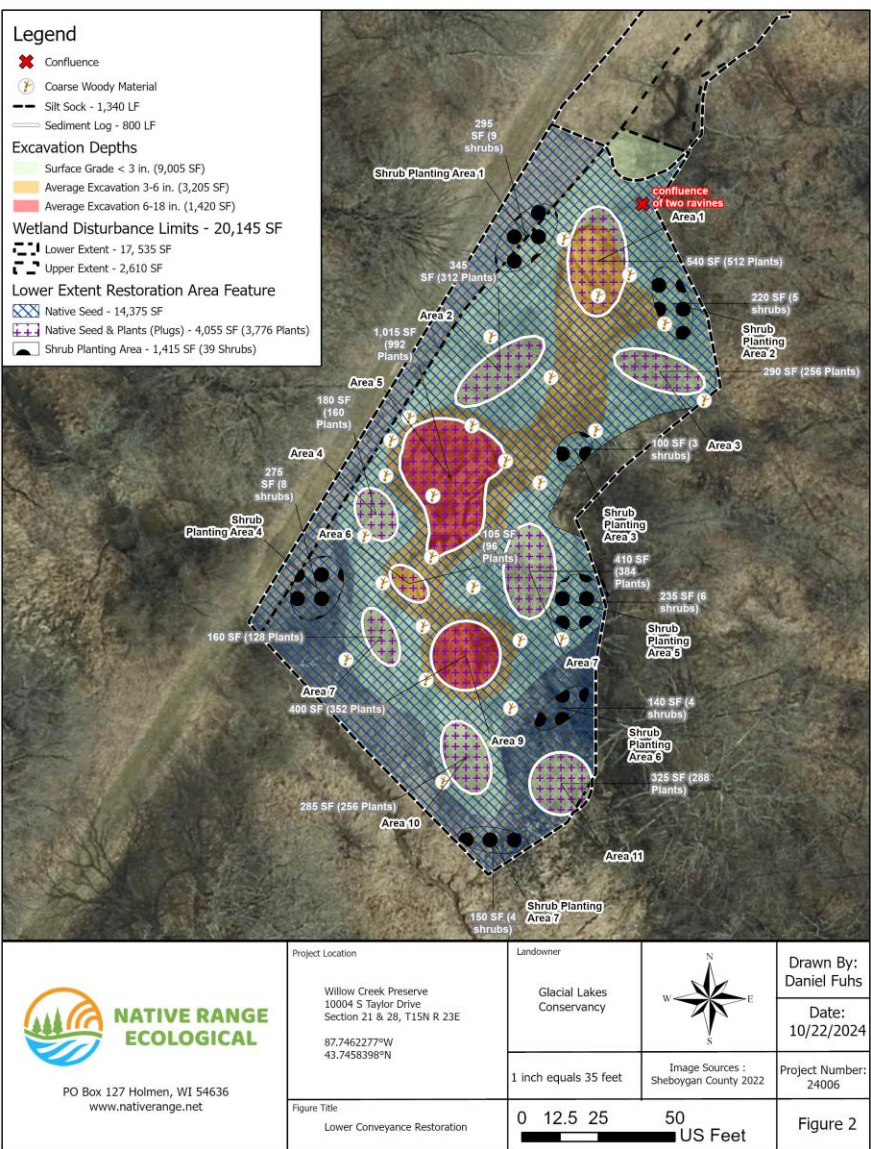
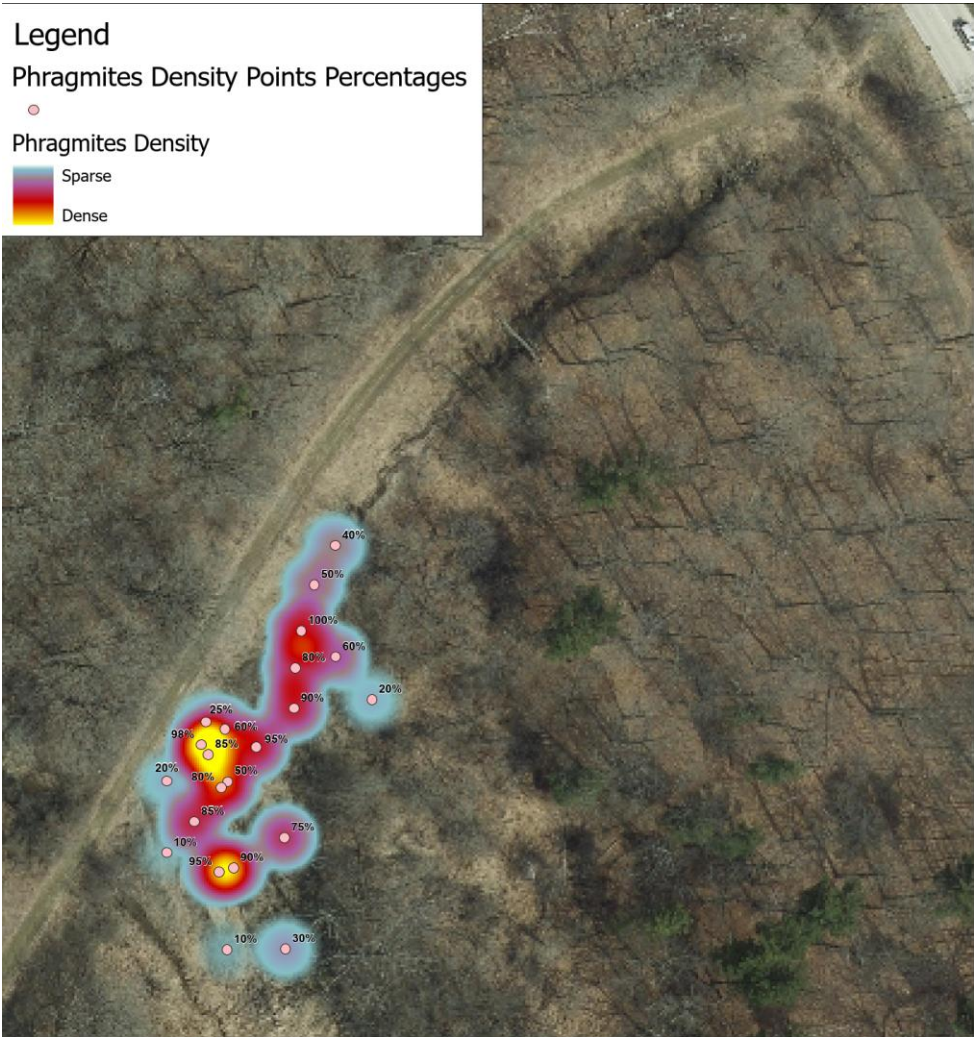
Hillside seep wetland next to conveyance



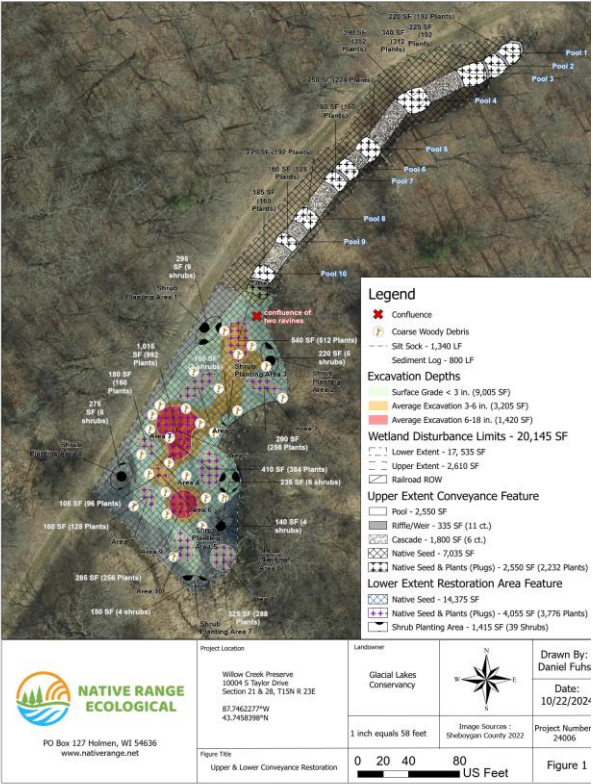
Invasive Plant Negative Feedback Loop



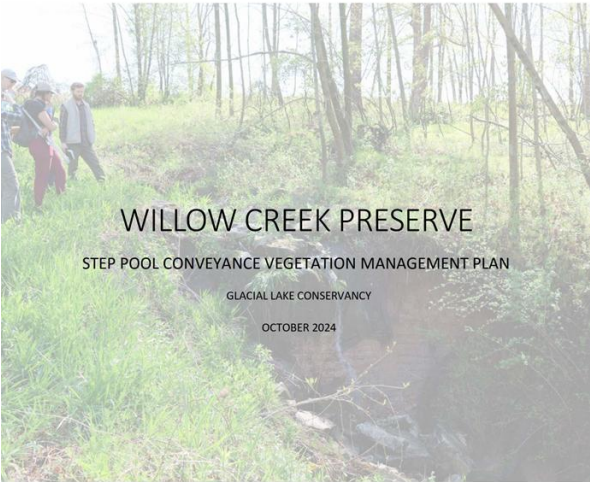
Phragmites Locations Informs Excavation Depths and Locations



Vegetation Management Plan (VMP)

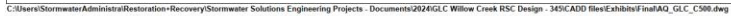


VMP Components



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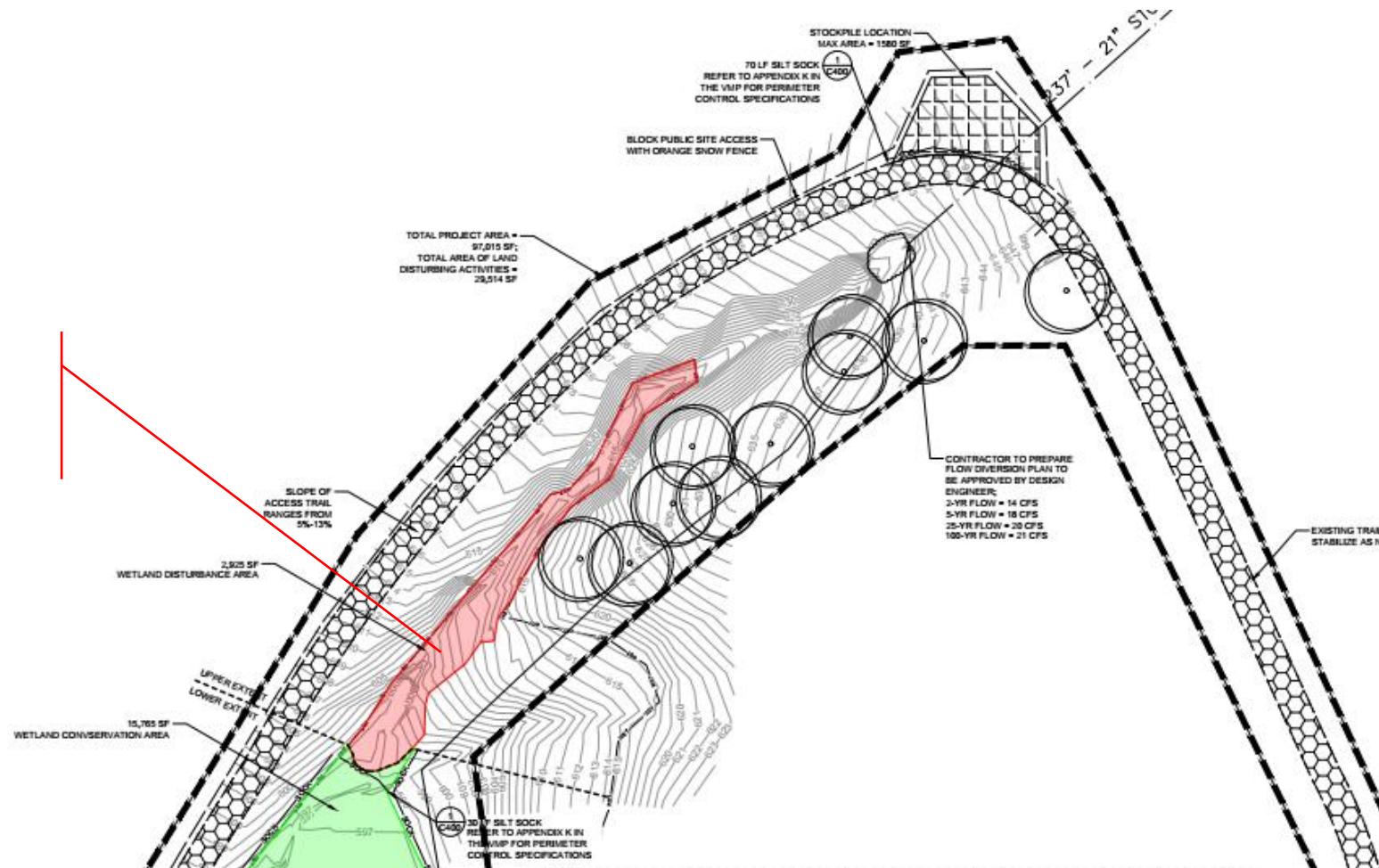
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Permits – WDNR-GP24 for Wetland Disturbance – Recreational Development

- Wetland Disturbance – Recreational Development
 - <10,000 SF of disturbance

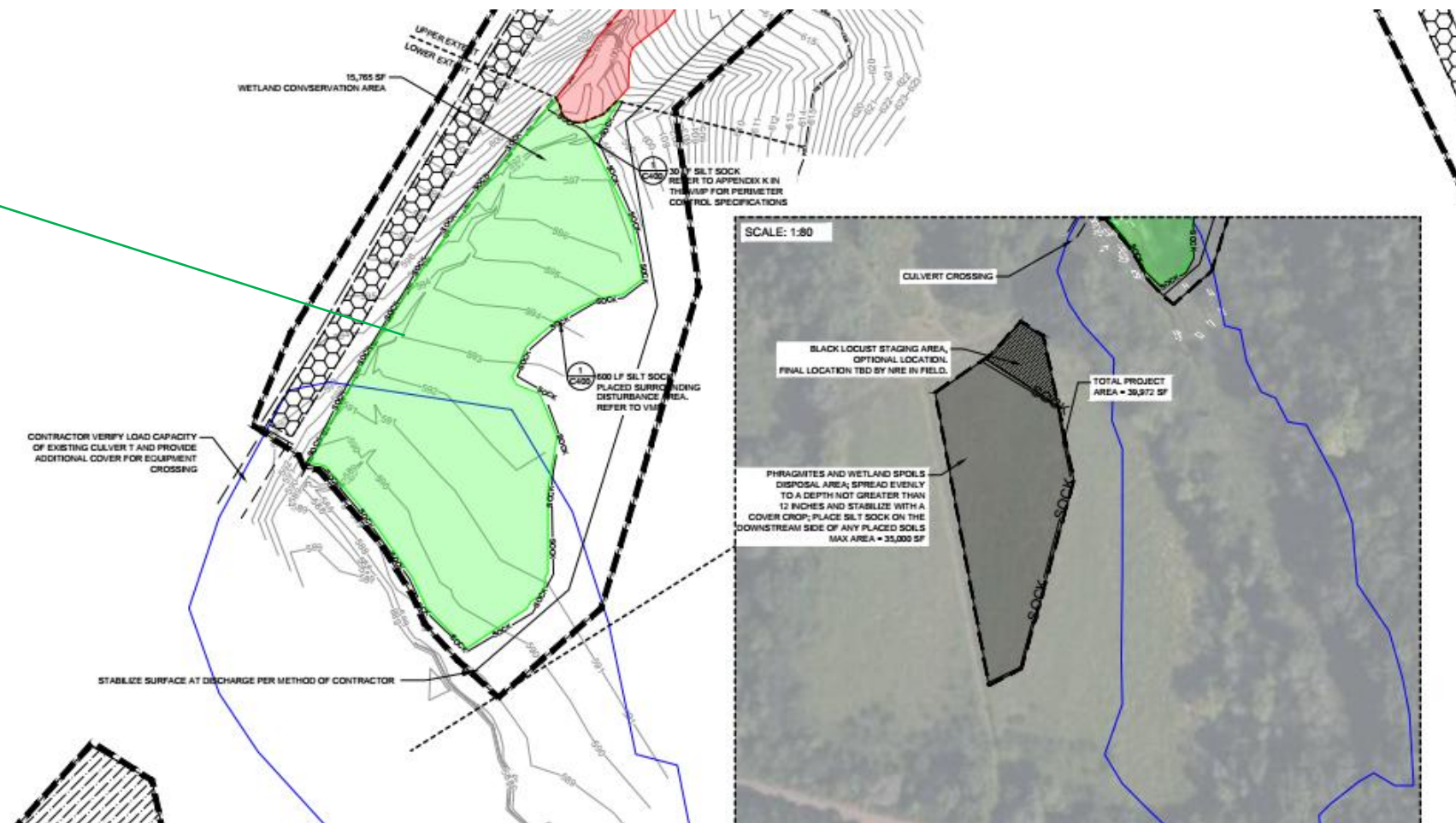
2,925 SF
Disturbance



Permits – WDNR-GP24 for Wetland Conservation Activities

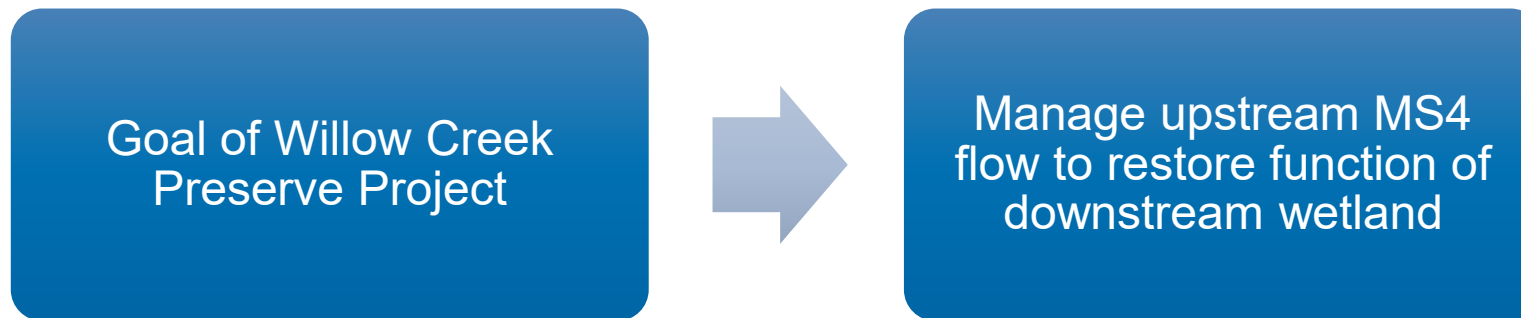
- Wetland Conservation Activities
 - <10,000 SF of disturbance

15,765 SF
Restoration



NEW! – WDNR-GP22 Hydrologic Restoration General Permit

- **Previously**, Wisconsin wetland general permits focused ONLY on:
 - Protecting wetlands from development (residential/commercial/industrial)
 - Maintaining no water surface elevation change in floodplains
- **Previously**, general permits often limited options or prevented wetland restoration.
- **Now**, WDNR-GP22 opens more paths for wetland restoration.
- WDNR-GP22 projects are intended to:
 - “Restore hydrology of wetlands, streams and/or floodplains to a natural, self-regulating condition” (WDNR, 2025)



Wisconsin Department of Natural Resources. (2025). *Hydrologic restoration general permit: GP22 fact sheet* [Fact Sheet]. https://dnr.wisconsin.gov/sites/default/files/topic/Waterways/GP22_Factsheet.pdf

QUESTIONS?

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