

~~— BORING~~ REALLY EXCITING ENGINEERING METHODS, EQUATIONS AND OTHER NERDY THINGS

Hunter Freeman, PE



So we have 2 land use scenarios, how do we quantify runoff volume?



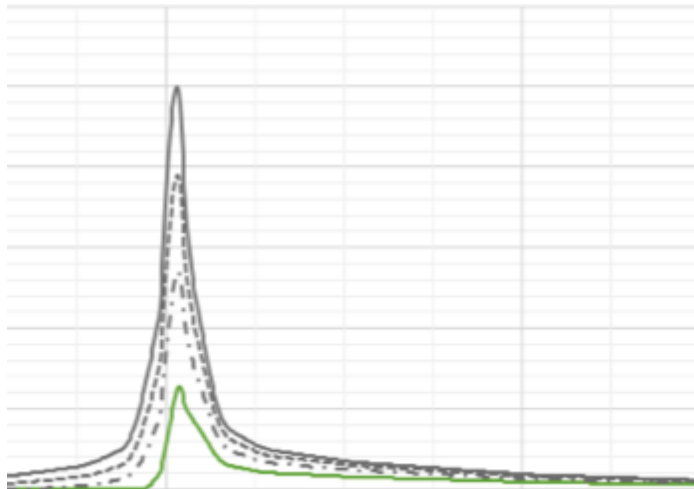
Watershed EZ Tool

South Atlantic Alliance Watershed Plan

Project Information	
Project Name:	South Atlantic Alliance
Project Address:	Wrightsville Beach, NC
Contact Information:	
Watershed Information	
Description:	
Total Site Area (Ac):	
Total Baseline Impervious Area (Ac):	
River Basin:	

Pre-Treatment Runoff Hydrographs

— Baseline — Goal #1 - - - - Goal #2 - · - Goal #3



Baseline Conditions

Description:				
Total Drainage Area (ac):		100.00		
HSG	Land Use	CN	Area (acres)	%
Land Use				
B	Open Space	61	55.00	55%
B	Open Space	61	45.00	45%
User Defined Land Uses				
Baseline Composite Curve Number =		61		
Baseline T_c				
User Defined T_c (hours)		0.12		
<div> <div>Summary</div> <div>Watershed Data</div> <div>OP</div> <div>Volume Reduction</div> <div>References</div> </div>				

Data Collection

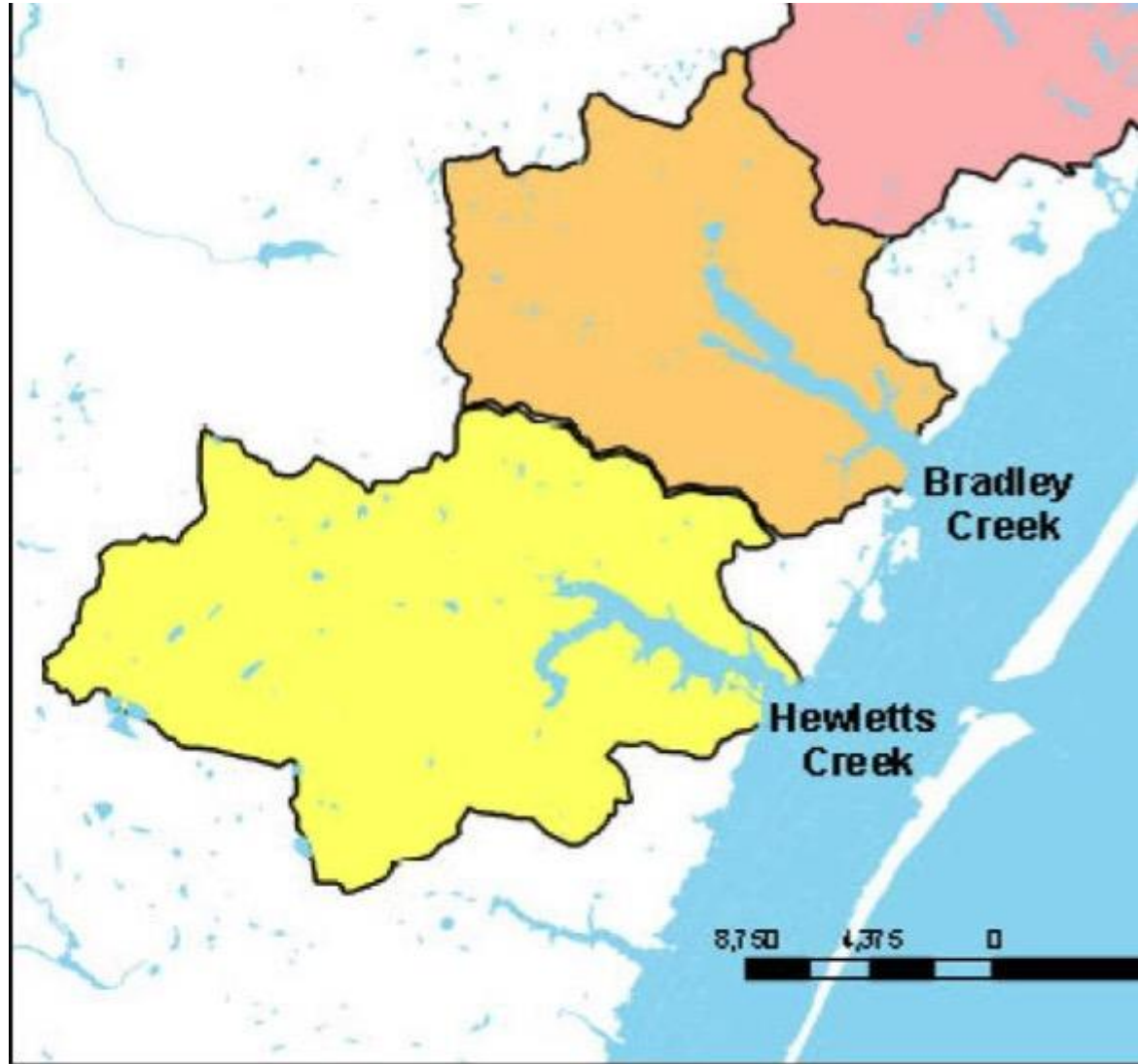
Watershed Boundary

Land Use

- Impervious cover
- Open space
- Woods
- Others?

Soil Type

Rainfall Data



CN Method



United States
Department of
Agriculture

Natural
Resources
Conservation
Service

Conservation
Engineering
Division

Technical
Release 55

June 1986

Urban Hydrology for Small Watersheds

TR-55



WithersRavenel
Our People. Your Success.

Methodology



WithersRavenel
Our People. Your Success.

Rainfall Data

precipitation depth ▾ Units: english ▾ time series type: partial duration ▾

LOCATION

Location (decimal degrees, use "-" for S and W): latitude: longitude:

Location (click here for a list of stations used in frequency analysis for NC):



Rainfall Data

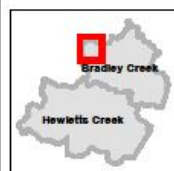
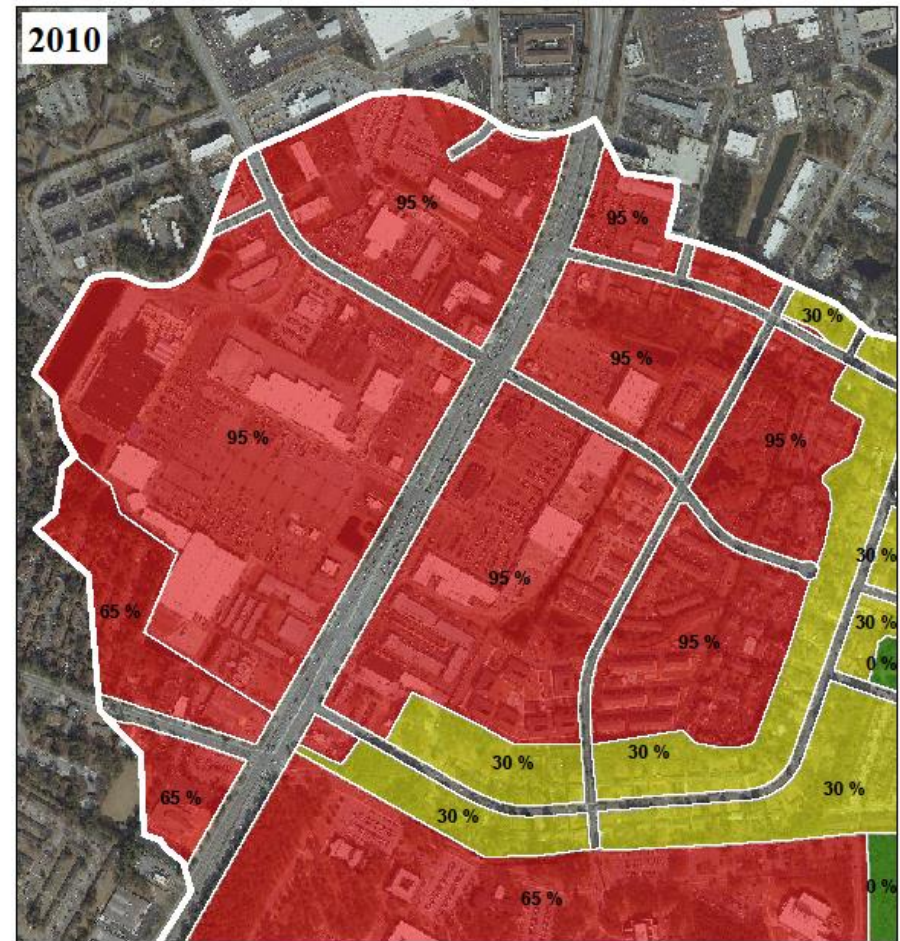
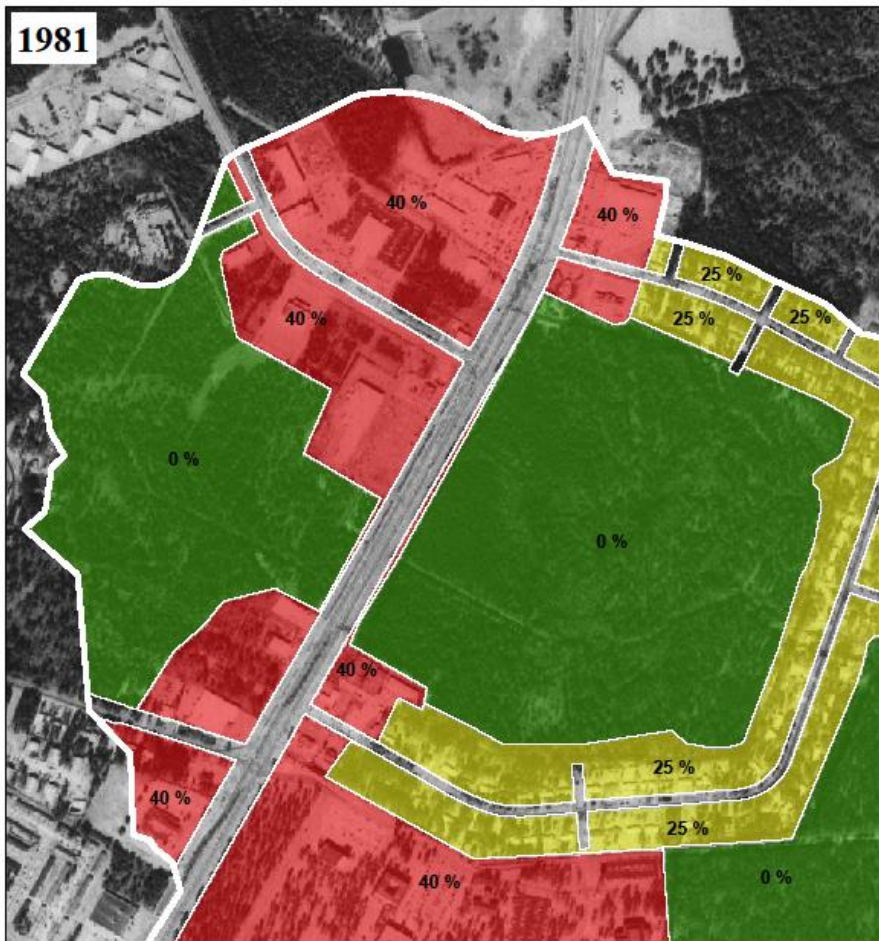
PDS-based precipitation frequency estimates with 90% confidence intervals (in inches)¹

Duration	Average recurrence interval (years)									
	1	2	5	10	25	50	100	200	500	1000
5-min	0.525 (0.489-0.566)	0.624 (0.581-0.672)	0.729 (0.678-0.785)	0.812 (0.752-0.874)	0.917 (0.845-0.984)	0.995 (0.914-1.07)	1.08 (0.983-1.16)	1.16 (1.05-1.25)	1.26 (1.13-1.36)	1.35 (1.20-1.46)
10-min	0.839 (0.782-0.904)	0.997 (0.929-1.07)	1.17 (1.09-1.26)	1.30 (1.20-1.40)	1.46 (1.35-1.57)	1.58 (1.46-1.70)	1.71 (1.56-1.84)	1.83 (1.66-1.97)	2.00 (1.79-2.15)	2.12 (1.89-2.29)
15-min	1.05 (0.977-1.13)	1.25 (1.17-1.35)	1.48 (1.37-1.59)	1.64 (1.52-1.77)	1.85 (1.71-1.99)	2.01 (1.84-2.16)	2.16 (1.98-2.32)	2.31 (2.10-2.49)	2.51 (2.26-2.71)	2.67 (2.37-2.88)
30-min	1.44 (1.34-1.55)	1.73 (1.61-1.87)	2.10 (1.95-2.26)	2.38 (2.21-2.56)	2.74 (2.53-2.94)	3.02 (2.78-3.25)	3.31 (3.02-3.56)	3.60 (3.27-3.88)	4.00 (3.59-4.32)	4.32 (3.84-4.67)
60-min	1.79 (1.67-1.93)	2.17 (2.02-2.34)	2.69 (2.50-2.90)	3.10 (2.87-3.33)	3.65 (3.37-3.92)	4.10 (3.76-4.40)	4.56 (4.17-4.90)	5.05 (4.58-5.44)	5.74 (5.15-6.19)	6.30 (5.61-6.81)
2-hr	2.12 (1.95-2.31)	2.58 (2.37-2.82)	3.28 (3.02-3.58)	3.87 (3.55-4.22)	4.71 (4.30-5.14)	5.43 (4.93-5.92)	6.22 (5.61-6.77)	7.08 (6.34-7.69)	8.34 (7.39-9.09)	9.42 (8.29-10.3)
3-hr	2.26 (2.08-2.48)	2.75 (2.53-3.01)	3.52 (3.23-3.85)	4.18 (3.82-4.57)	5.16 (4.69-5.62)	6.01 (5.43-6.55)	6.95 (6.24-7.58)	8.01 (7.12-8.71)	9.60 (8.44-10.4)	11.0 (9.55-12.0)
6-hr	2.81 (2.59-3.09)	3.42 (3.15-3.77)	4.38 (4.03-4.82)	5.22 (4.77-5.72)	6.46 (5.87-7.07)	7.55 (6.81-8.26)	8.77 (7.86-9.58)	10.1 (8.98-11.1)	12.2 (10.7-13.3)	14.1 (12.1-15.4)
12-hr	3.29 (3.00-3.65)	4.01 (3.65-4.44)	5.17 (4.70-5.72)	6.18 (5.60-6.83)	7.71 (6.92-8.49)	9.07 (8.10-9.97)	10.6 (9.39-11.6)	12.3 (10.8-13.5)	15.0 (13.0-16.5)	17.4 (14.8-19.1)
24-hr	3.89 (3.54-4.33)	4.72 (4.31-5.27)	6.11 (5.56-6.81)	7.34 (6.65-8.16)	9.22 (8.27-10.2)	10.9 (9.69-12.1)	12.8 (11.3-14.2)	15.0 (13.0-16.7)	18.4 (15.6-20.6)	21.4 (17.8-24.1)
2-day	4.61 (4.22-5.10)	5.58 (5.10-6.17)	7.16 (6.53-7.93)	8.54 (7.75-9.45)	10.6 (9.56-11.8)	12.5 (11.1-13.9)	14.6 (12.8-16.2)	16.9 (14.7-18.9)	20.6 (17.5-23.1)	23.8 (19.8-26.9)
3-day	4.91 (4.50-5.42)	5.93 (5.43-6.55)	7.55 (6.90-8.35)	8.96 (8.16-9.91)	11.1 (9.99-12.3)	12.9 (11.6-14.3)	15.0 (13.3-16.7)	17.3 (15.1-19.3)	20.9 (17.9-23.5)	24.0 (20.2-27.2)

Natural Volume Reduction



WithersRavenel
Our People. Your Success.



Landuse

- Commercial
- Residential
- Woods and Open Space

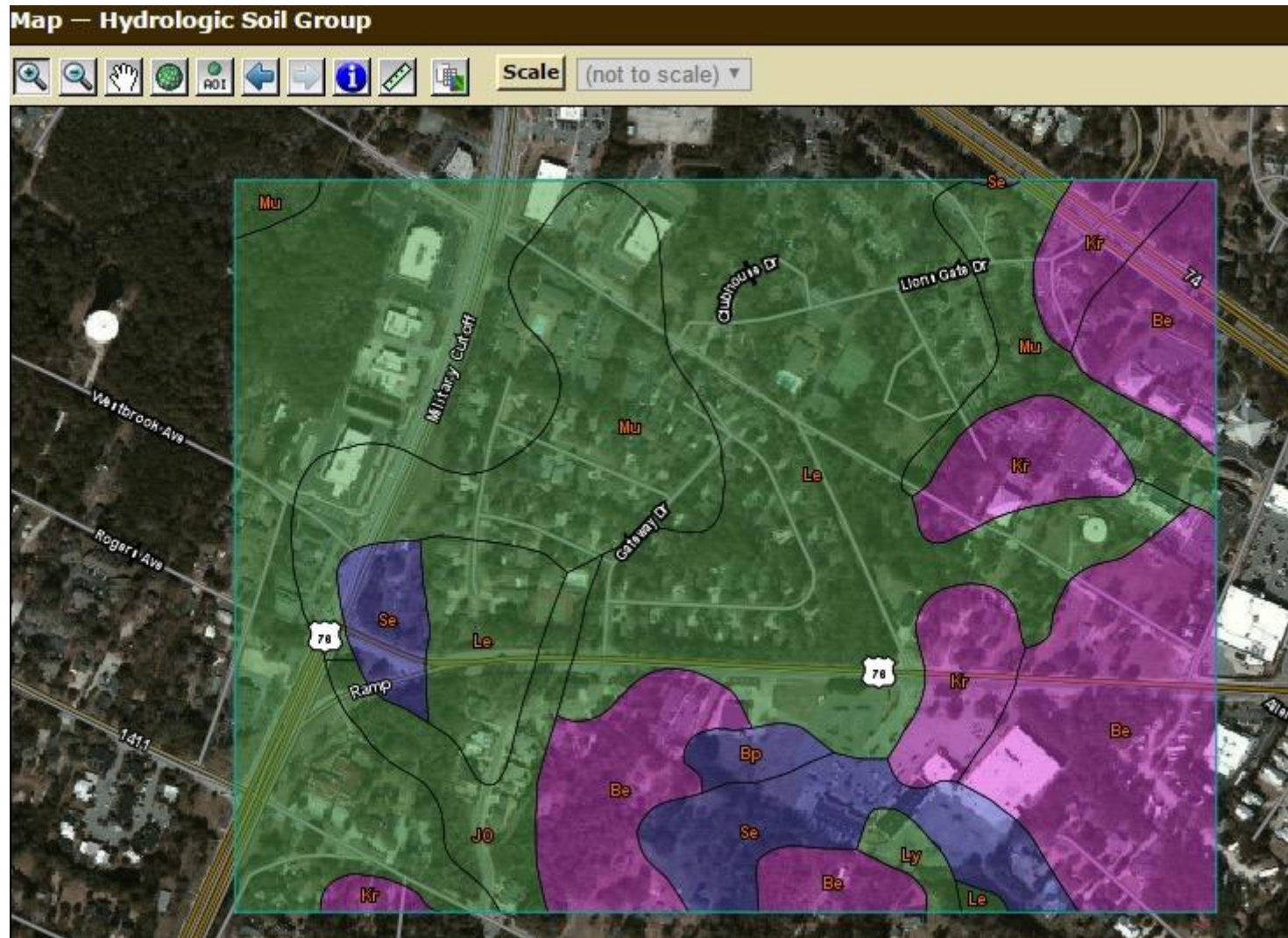
Change in Land Use 1981 to Present High Density Commercial Area

WITHERS & RAVENEL
ENGINEERS | PLANNERS | SURVEYORS
111 MacKean Drive Cary, North Carolina
Telephone: 919.469.7347 www.withersravenel.com

0 300 600 1,200 Feet
1 inch = 600 feet

N

Soil Type



CN Method

From NEH-4, Chapter 10, NRCS (SCS) 1985

S = Maximum Soil Storage (inches)

$$S = \frac{1000}{CN} - 10$$

CN Method

From NEH-4, Chapter 10, NRCS (SCS) 1985

$$Q = \frac{(P - 0.2S)^2}{(P + 0.8S)}$$

$$I_a = 0.2S$$

where

Q = runoff (in)

P = rainfall (in)

S = potential maximum retention after runoff begins (in) and

I_a = initial abstraction (in)

$$S = \frac{1000}{CN} - 10$$

Volume Reduction

$$\begin{array}{ccccc} \boxed{\text{Rainfall Volume}} & - & \boxed{\text{Natural Losses}} & = & \boxed{\text{Surface Runoff}} \\ \text{P x Area} & & \text{S \& Ia} & & \text{Q x Area} \end{array}$$

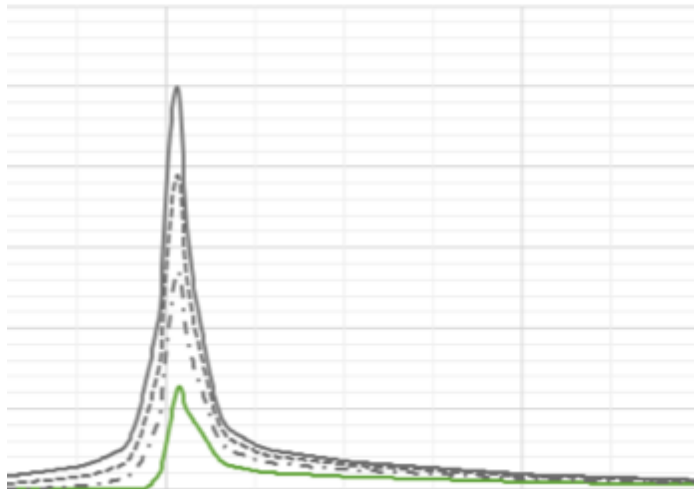
Watershed EZ Tool

South Atlantic Alliance Watershed Plan

Project Information	
Project Name:	South Atlantic Alliance
Project Address:	Wrightsville Beach, NC
Contact Information:	
Watershed Information	
Description:	
Total Site Area (Ac):	
Total Baseline Impervious Area (Ac):	
River Basin:	

Pre-Treatment Runoff Hydrographs

— Baseline — Goal #1 - - - - Goal #2 - · - Goal #3



Baseline Conditions

Description:				
Total Drainage Area (ac):		100.00		
HSG	Land Use	CN	Area (acres)	%
Land Use				
B	Open Space	61	55.00	55%
B	Open Space	61	45.00	45%
User Defined Land Uses				
Baseline Composite Curve Number =		61		
Baseline T_c				
User Defined T_c (hours)		0.12		
<div> <div>Summary</div> <div>Watershed Data</div> <div>OP</div> <div>Volume Reduction</div> <div>References</div> </div>				

Methods of Treating Runoff



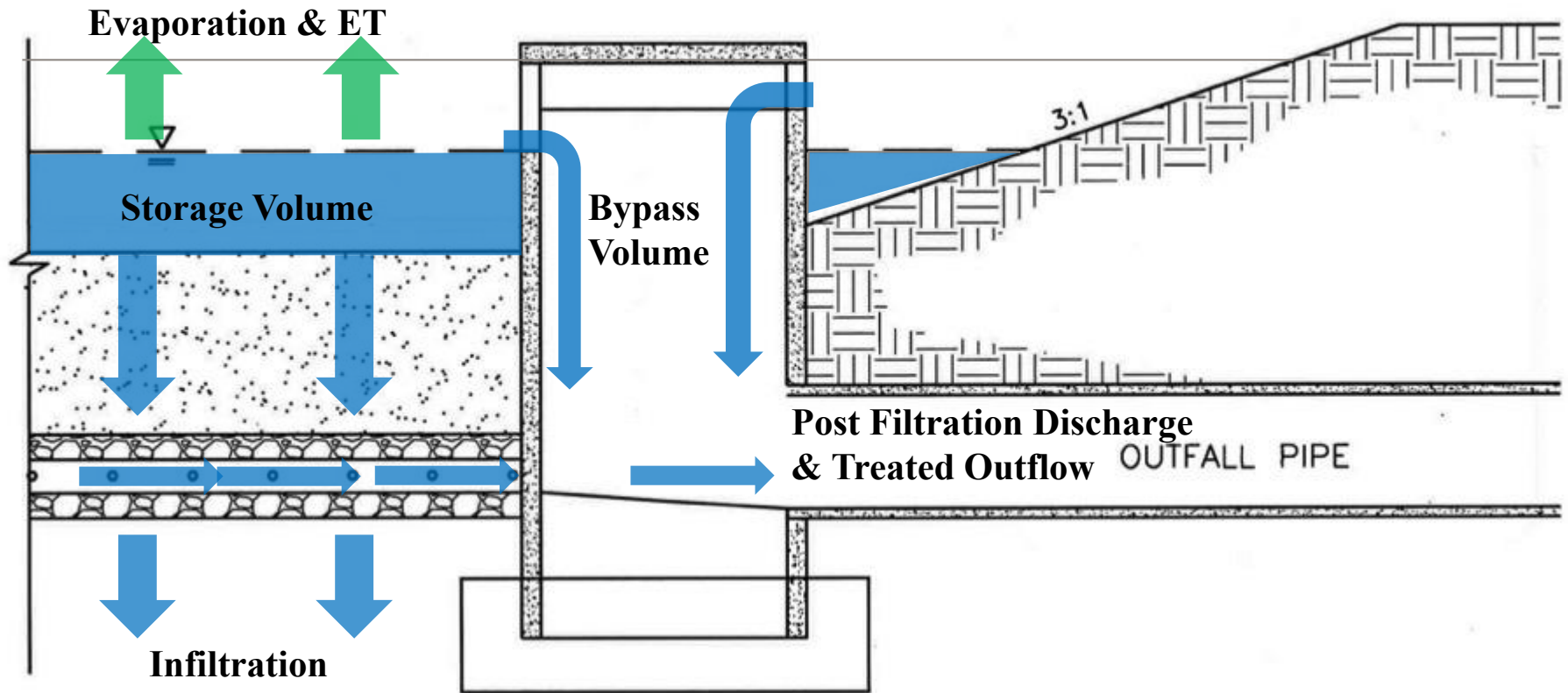
Volume Reduction BMPs



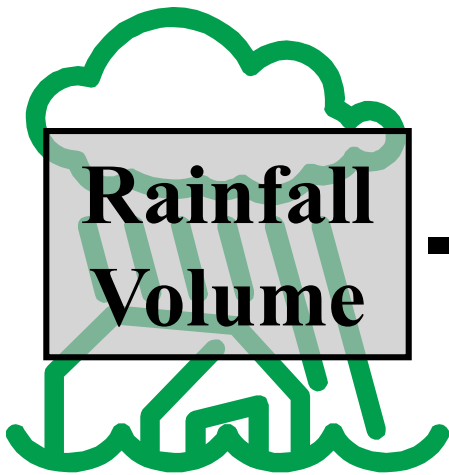
Volume Reduction BMPs



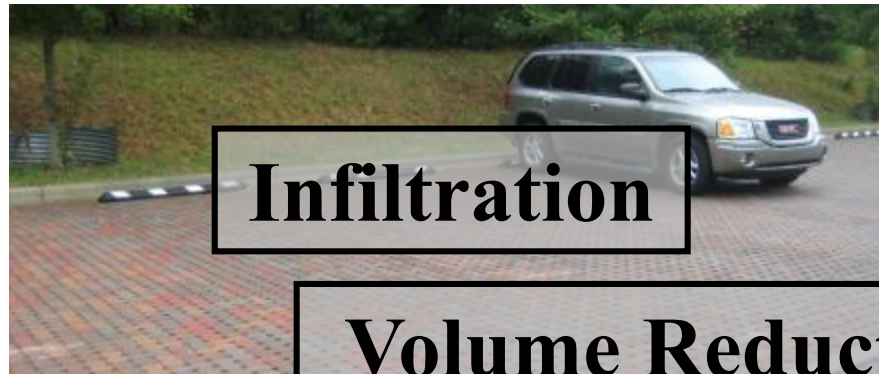
BMP Functions / Data



Volume Reduction Summation



**Rainfall
Volume**



Infiltration



Reuse



DIS

**Volume Reduction
Measures**

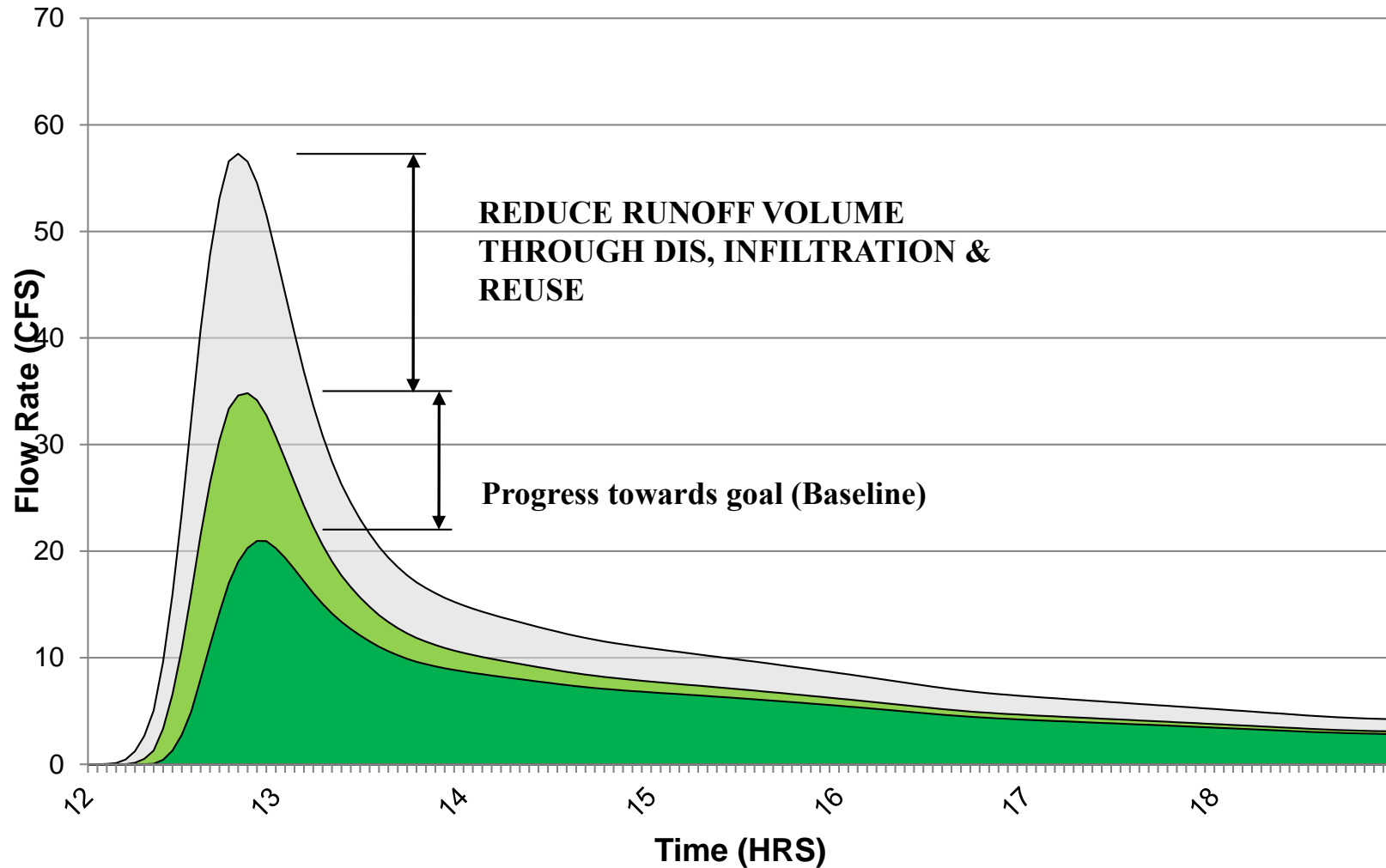
**Runoff
Volume**

**Evaporation /
Transpiration**

Natural Losses

Watershed EZ

- Easy to analyze impact of small scale BMPs



Wet Ponds



WithersRavenel
Our People. Your Success.

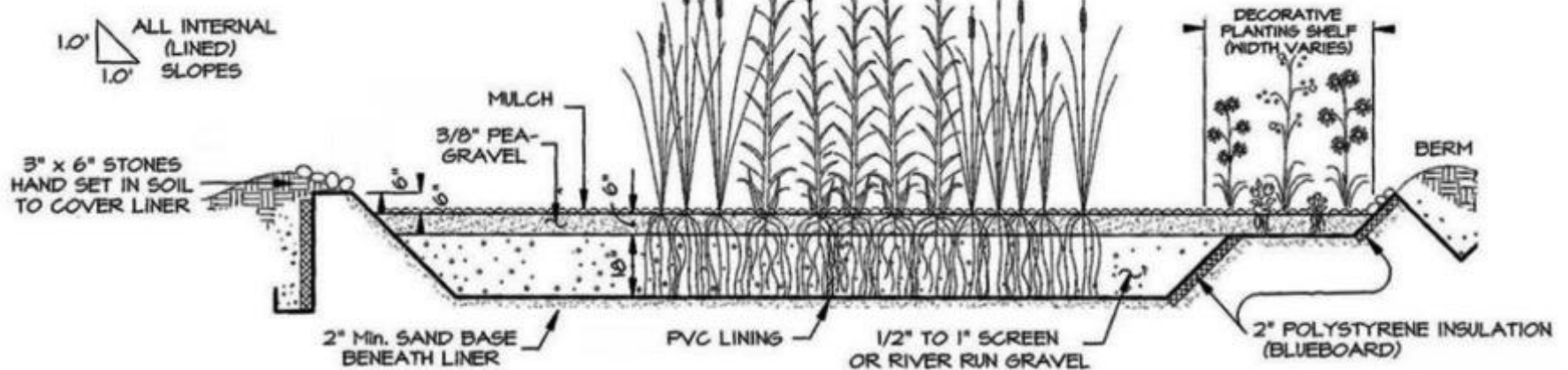
Dry Ponds



Constructed Wetland

Cross Section

Figure 6



Constructed Wetlands



Location:

Large Footprint
Habitat
Detention

Performance:

Low Volume Removal
Flood Control
Evaporation
High Water Table

Bioretention

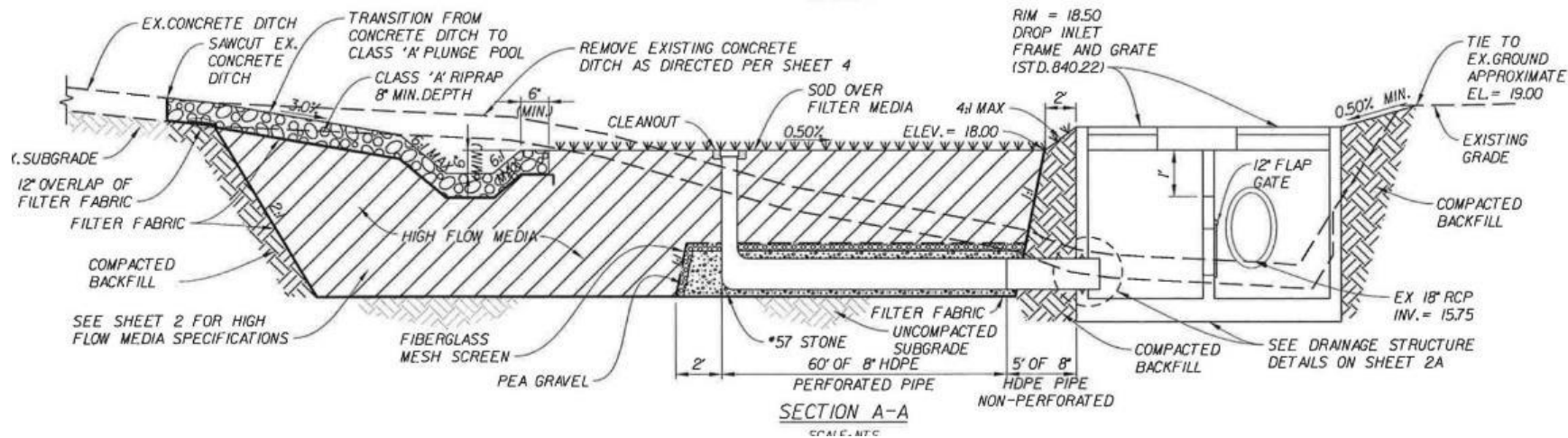
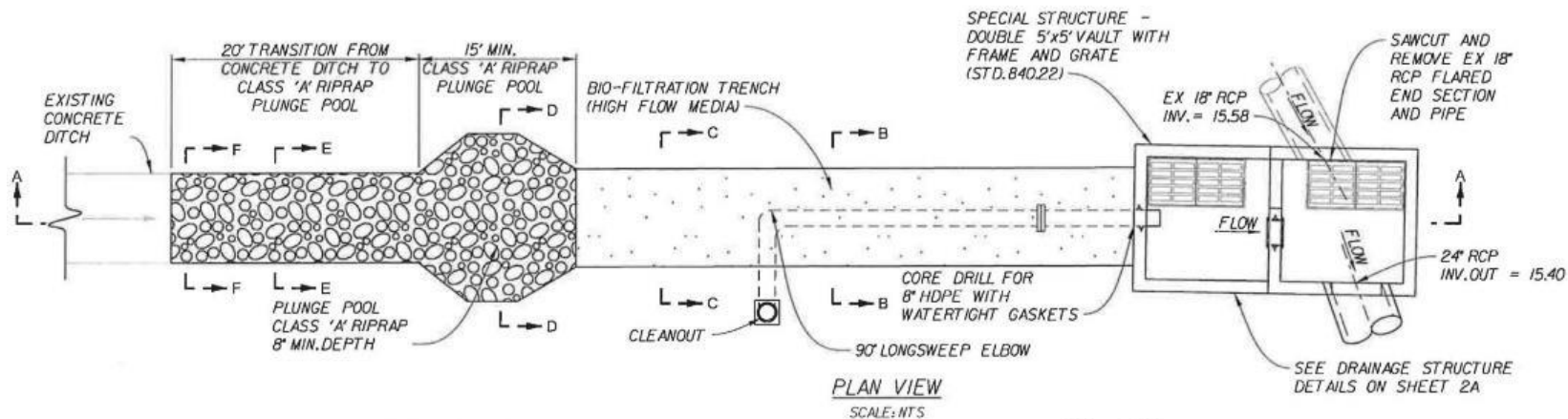
Location:

Great for Urban Areas
Infiltration for Bad Soils

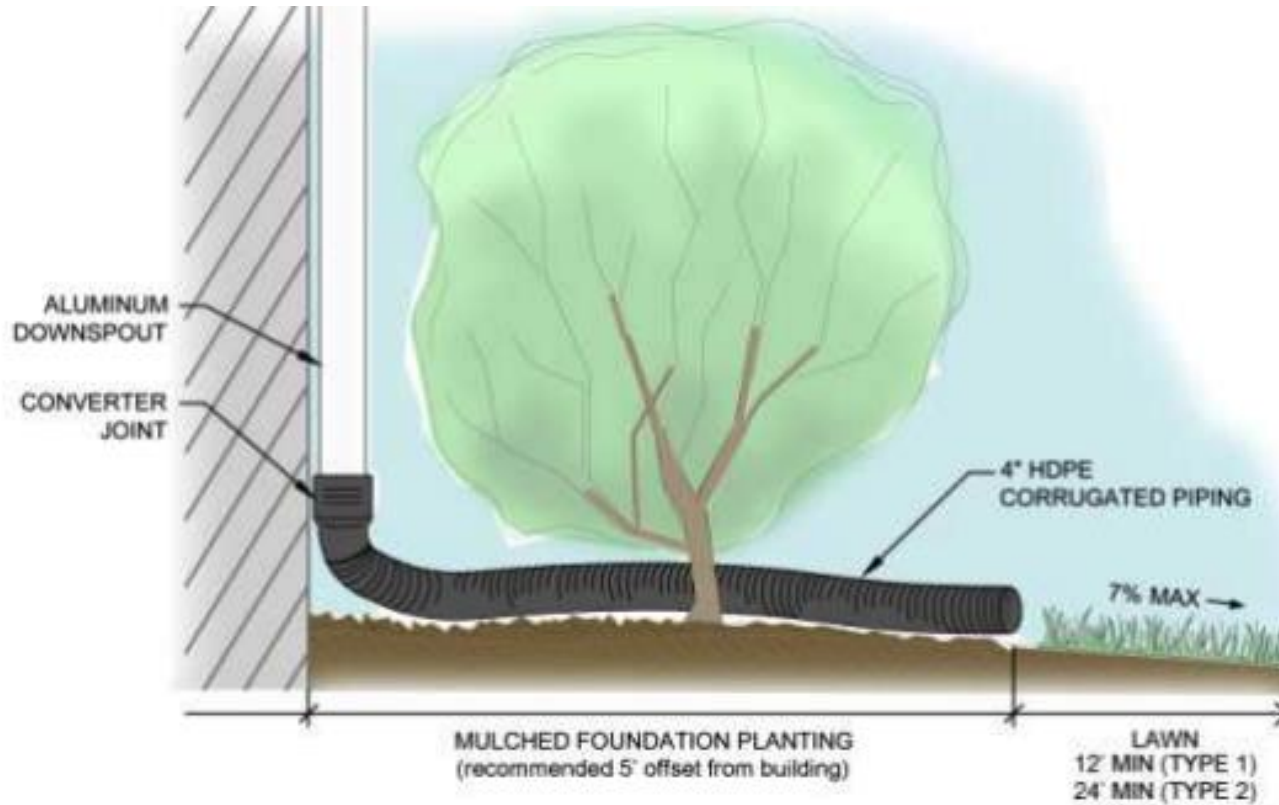
Performance:

High Pollutant Removal
- but not always runoff
reduction
Low Water Table
High Cost





Downspout Disconnection



Location:

Low Impact

Blends In

Small Footprint

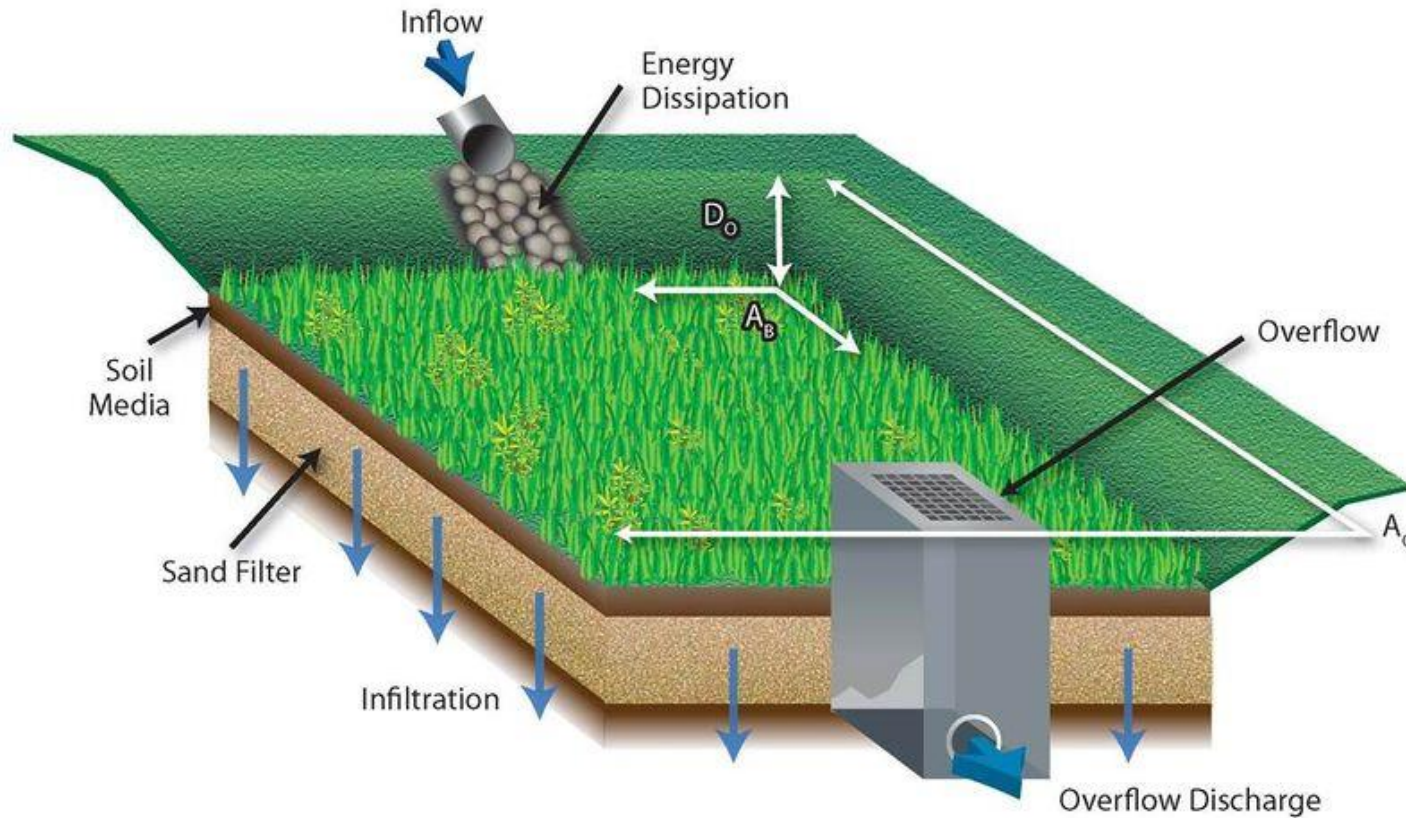
Performance:

Highly Efficient

High Water Table OK

Low Cost

Infiltration Basin / Rain Gardens



Location:

Any setting

Any Size

Underground?

Performance:

Checks all the boxes

Good soils

Low Water Table

Infiltration Systems



Urban Options

Location:

Small Footprints

Multi Functional Spaces

Get What You Can



Urban Options



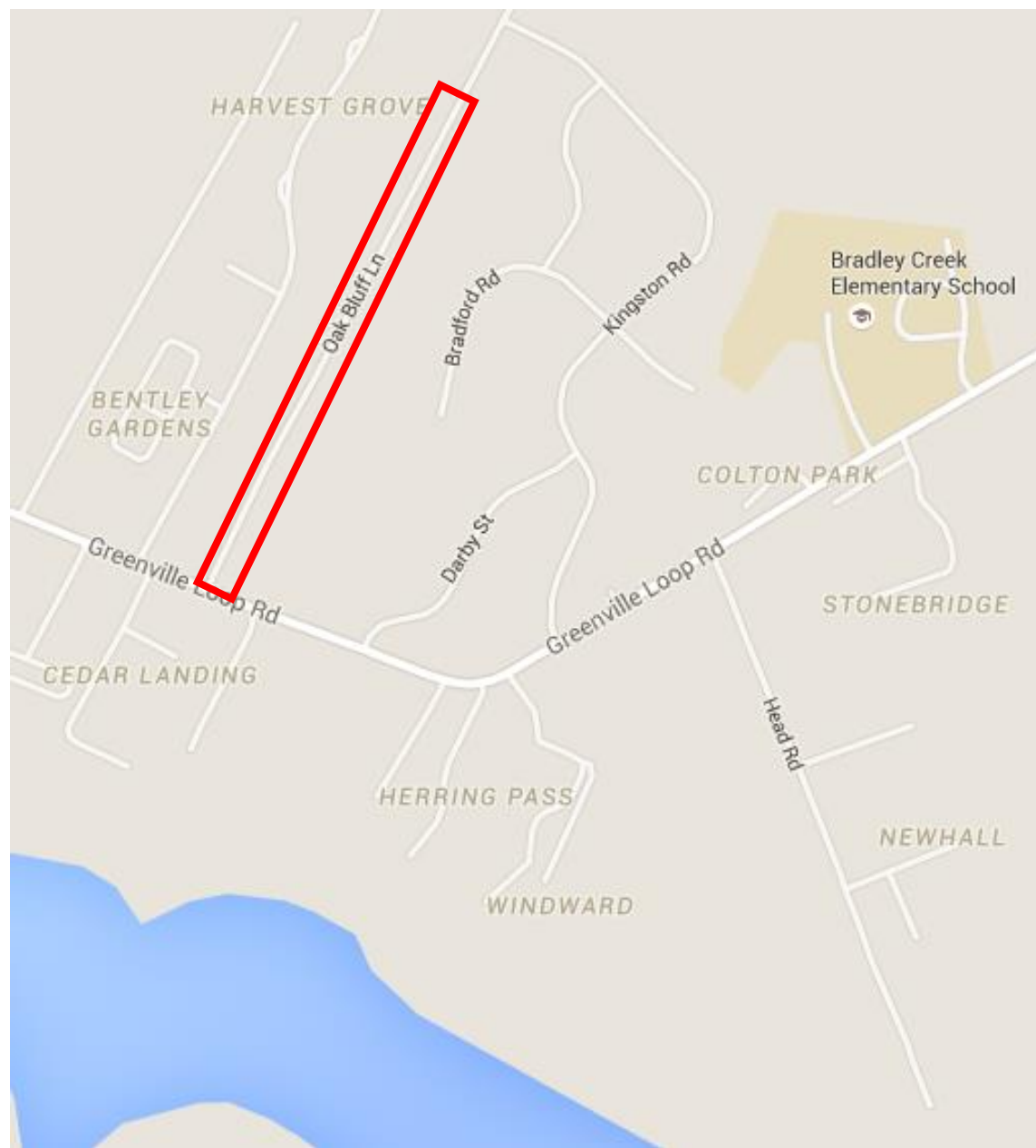
Easy to find....if you're looking



Raintree Retrofit Sites

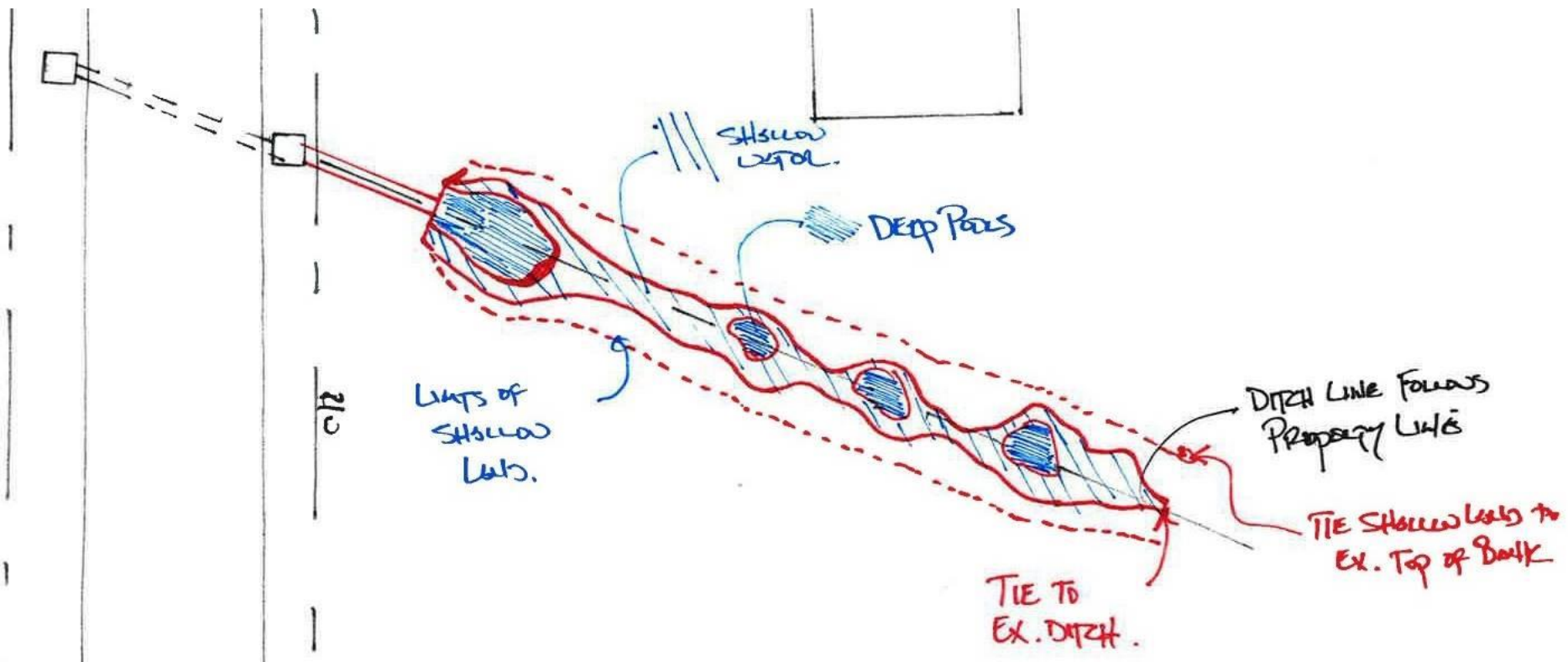
Residential Subdivison

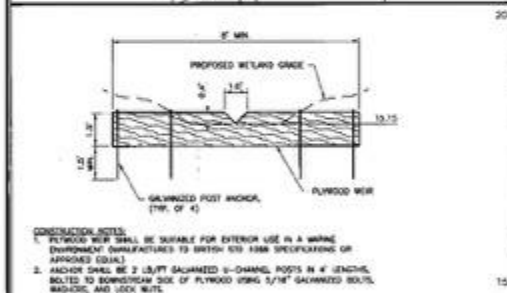
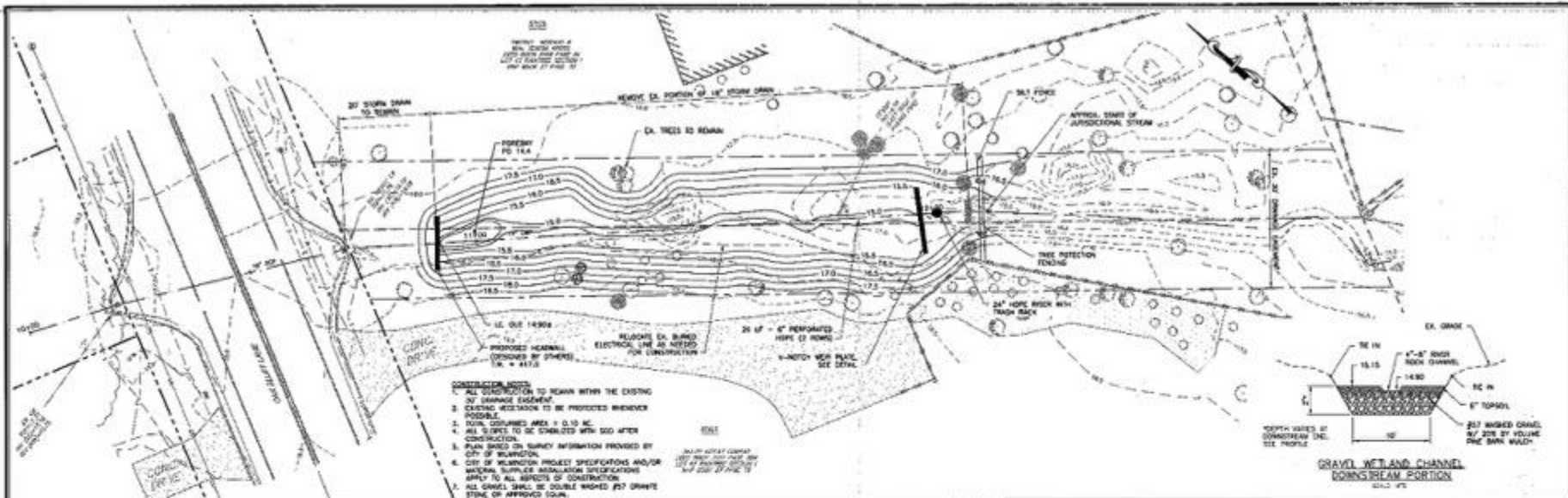
- Cisterns
- Permeable Driveways
- Infiltration Trenches
- Subsurface Gravel Wetland









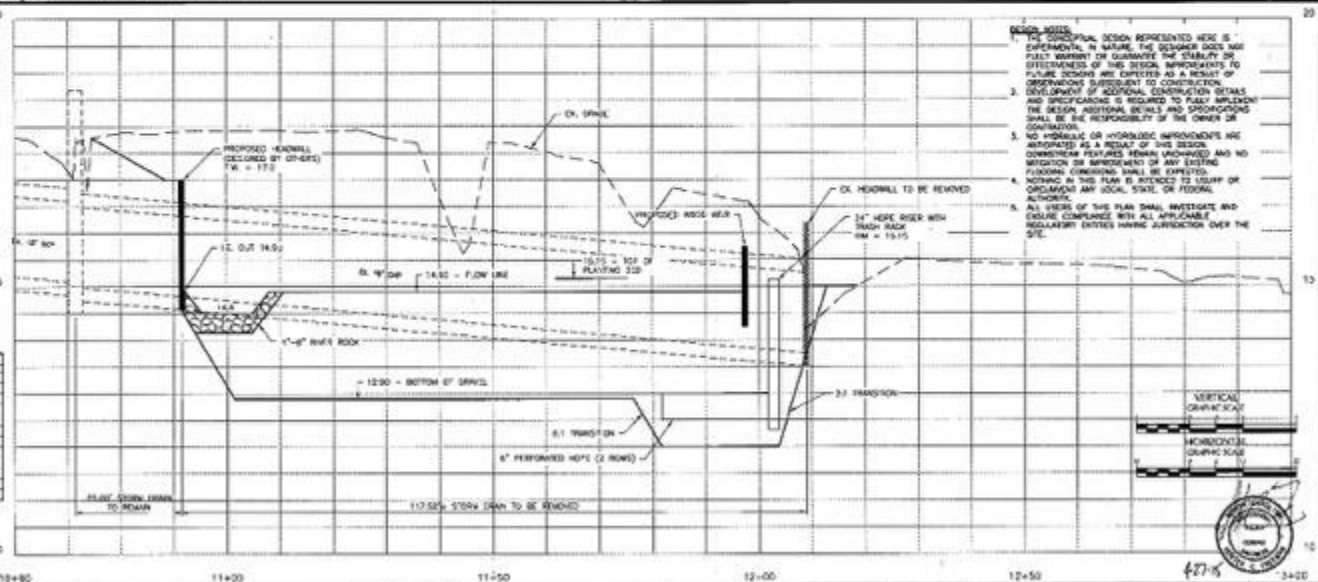


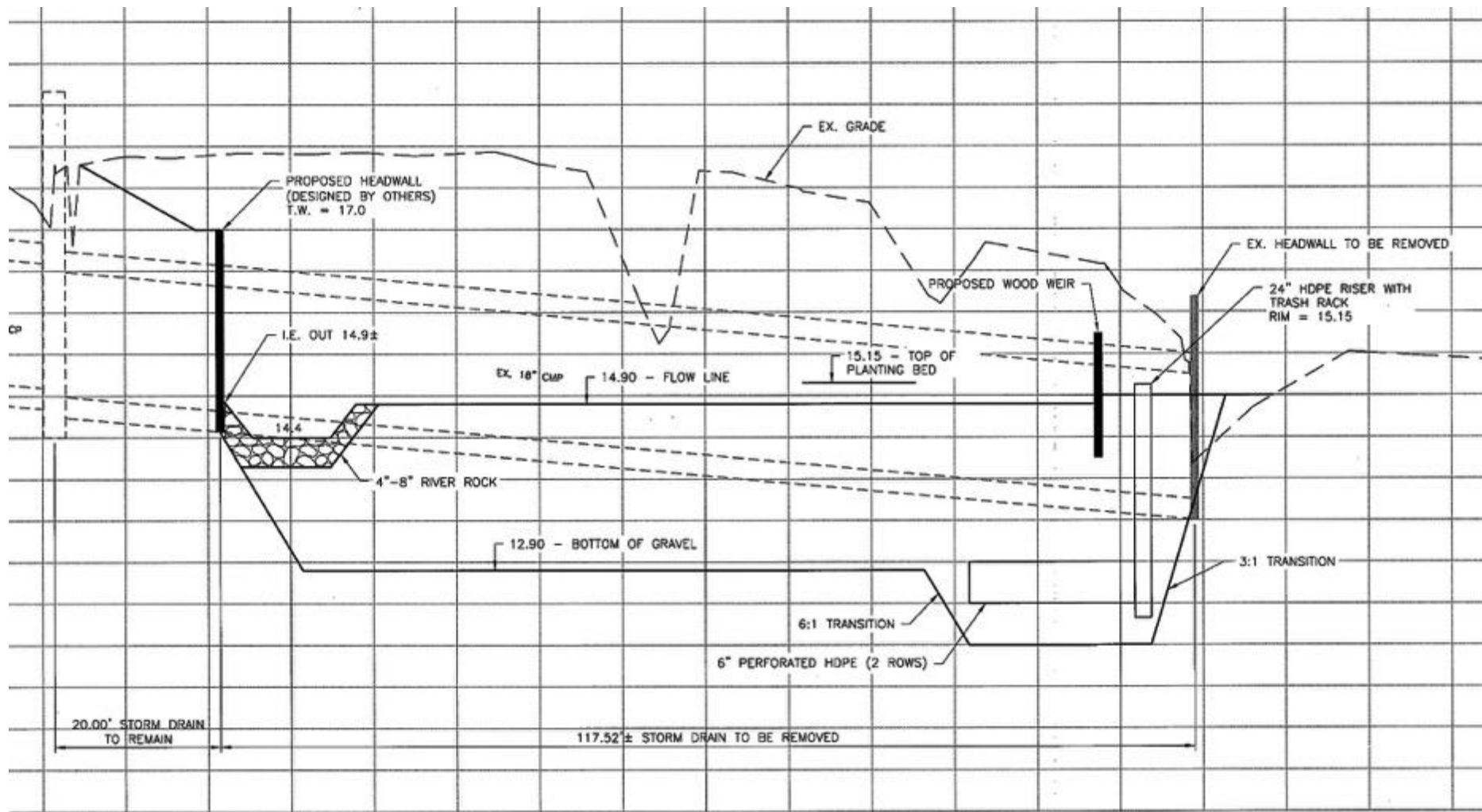
VEGETATION SCHEDULE

NO.	SYMBOL	VEGETATION NAME	QUANTITY	UNIT	PRICE	TOTAL
1	1	Grass	1000	SQ. YD.	1.00	1000.00
2	2	Grass	1000	SQ. YD.	1.00	1000.00
3	3	Grass	1000	SQ. YD.	1.00	1000.00
4	4	Grass	1000	SQ. YD.	1.00	1000.00
5	5	Grass	1000	SQ. YD.	1.00	1000.00
6	6	Grass	1000	SQ. YD.	1.00	1000.00
7	7	Grass	1000	SQ. YD.	1.00	1000.00
8	8	Grass	1000	SQ. YD.	1.00	1000.00
9	9	Grass	1000	SQ. YD.	1.00	1000.00
10	10	Grass	1000	SQ. YD.	1.00	1000.00
11	11	Grass	1000	SQ. YD.	1.00	1000.00
12	12	Grass	1000	SQ. YD.	1.00	1000.00
13	13	Grass	1000	SQ. YD.	1.00	1000.00
14	14	Grass	1000	SQ. YD.	1.00	1000.00
15	15	Grass	1000	SQ. YD.	1.00	1000.00
16	16	Grass	1000	SQ. YD.	1.00	1000.00
17	17	Grass	1000	SQ. YD.	1.00	1000.00
18	18	Grass	1000	SQ. YD.	1.00	1000.00
19	19	Grass	1000	SQ. YD.	1.00	1000.00
20	20	Grass	1000	SQ. YD.	1.00	1000.00
21	21	Grass	1000	SQ. YD.	1.00	1000.00
22	22	Grass	1000	SQ. YD.	1.00	1000.00
23	23	Grass	1000	SQ. YD.	1.00	1000.00
24	24	Grass	1000	SQ. YD.	1.00	1000.00
25	25	Grass	1000	SQ. YD.	1.00	1000.00
26	26	Grass	1000	SQ. YD.	1.00	1000.00
27	27	Grass	1000	SQ. YD.	1.00	1000.00
28	28	Grass	1000	SQ. YD.	1.00	1000.00
29	29	Grass	1000	SQ. YD.	1.00	1000.00
30	30	Grass	1000	SQ. YD.	1.00	1000.00
31	31	Grass	1000	SQ. YD.	1.00	1000.00
32	32	Grass	1000	SQ. YD.	1.00	1000.00
33	33	Grass	1000	SQ. YD.	1.00	1000.00
34	34	Grass	1000	SQ. YD.	1.00	1000.00
35	35	Grass	1000	SQ. YD.	1.00	1000.00
36	36	Grass	1000	SQ. YD.	1.00	1000.00
37	37	Grass	1000	SQ. YD.	1.00	1000.00
38	38	Grass	1000	SQ. YD.	1.00	1000.00
39	39	Grass	1000	SQ. YD.	1.00	1000.00
40	40	Grass	1000	SQ. YD.	1.00	1000.00
41	41	Grass	1000	SQ. YD.	1.00	1000.00
42	42	Grass	1000	SQ. YD.	1.00	1000.00
43	43	Grass	1000	SQ. YD.	1.00	1000.00
44	44	Grass	1000	SQ. YD.	1.00	1000.00
45	45	Grass	1000	SQ. YD.	1.00	1000.00
46	46	Grass	1000	SQ. YD.	1.00	1000.00
47	47	Grass	1000	SQ. YD.	1.00	1000.00
48	48	Grass	1000	SQ. YD.	1.00	1000.00
49	49	Grass	1000	SQ. YD.	1.00	1000.00
50	50	Grass	1000	SQ. YD.	1.00	1000.00
51	51	Grass	1000	SQ. YD.	1.00	1000.00
52	52	Grass	1000	SQ. YD.	1.00	1000.00
53	53	Grass	1000	SQ. YD.	1.00	1000.00
54	54	Grass	1000	SQ. YD.	1.00	1000.00
55	55	Grass	1000	SQ. YD.	1.00	1000.00
56	56	Grass	1000	SQ. YD.	1.00	1000.00
57	57	Grass	1000	SQ. YD.	1.00	1000.00
58	58	Grass	1000	SQ. YD.	1.00	1000.00
59	59	Grass	1000	SQ. YD.	1.00	1000.00
60	60	Grass	1000	SQ. YD.	1.00	1000.00
61	61	Grass	1000	SQ. YD.	1.00	1000.00
62	62	Grass	1000	SQ. YD.	1.00	1000.00
63	63	Grass	1000	SQ. YD.	1.00	1000.00
64	64	Grass	1000	SQ. YD.	1.00	1000.00
65	65	Grass	1000	SQ. YD.	1.00	1000.00
66	66	Grass	1000	SQ. YD.	1.00	1000.00
67	67	Grass	1000	SQ. YD.	1.00	1000.00
68	68	Grass	1000	SQ. YD.	1.00	1000.00
69	69	Grass	1000	SQ. YD.	1.00	1000.00
70	70	Grass	1000	SQ. YD.	1.00	1000.00
71	71	Grass	1000	SQ. YD.	1.00	1000.00
72	72	Grass	1000	SQ. YD.	1.00	1000.00
73	73	Grass	1000	SQ. YD.	1.00	1000.00
74	74	Grass	1000	SQ. YD.	1.00	1000.00
75	75	Grass	1000	SQ. YD.	1.00	1000.00
76	76	Grass	1000	SQ. YD.	1.00	1000.00
77	77	Grass	1000	SQ. YD.	1.00	1000.00
78	78	Grass	1000	SQ. YD.	1.00	1000.00
79	79	Grass	1000	SQ. YD.	1.00	1000.00
80	80	Grass	1000	SQ. YD.	1.00	1000.00
81	81	Grass	1000	SQ. YD.	1.00	1000.00
82	82	Grass	1000	SQ. YD.	1.00	1000.00
83	83	Grass	1000	SQ. YD.	1.00	1000.00
84	84	Grass	1000	SQ. YD.	1.00	1000.00
85	85	Grass	1000	SQ. YD.	1.00	1000.00
86	86	Grass	1000	SQ. YD.	1.00	1000.00
87	87	Grass	1000	SQ. YD.	1.00	1000.00
88	88	Grass	1000	SQ. YD.	1.00	1000.00
89	89	Grass	1000	SQ. YD.	1.00	1000.00
90	90	Grass	1000	SQ. YD.	1.00	1000.00
91	91	Grass	1000	SQ. YD.	1.00	1000.00
92	92	Grass	1000	SQ. YD.	1.00	1000.00
93	93	Grass	1000	SQ. YD.	1.00	1000.00
94	94	Grass	1000	SQ. YD.	1.00	1000.00
95	95	Grass	1000	SQ. YD.	1.00	1000.00
96	96	Grass	1000	SQ. YD.	1.00	1000.00
97	97	Grass	1000	SQ. YD.	1.00	1000.00
98	98	Grass	1000	SQ. YD.	1.00	1000.00
99	99	Grass	1000	SQ. YD.	1.00	1000.00
100	100	Grass	1000	SQ. YD.	1.00	1000.00

NOTES:

1. SURFACE AREA OF 11.30 AC.









Runoff Reduction Scenario Tool

[illegible]