Erosion Practices

VACDE Graves Mountain Training

8/23/2017

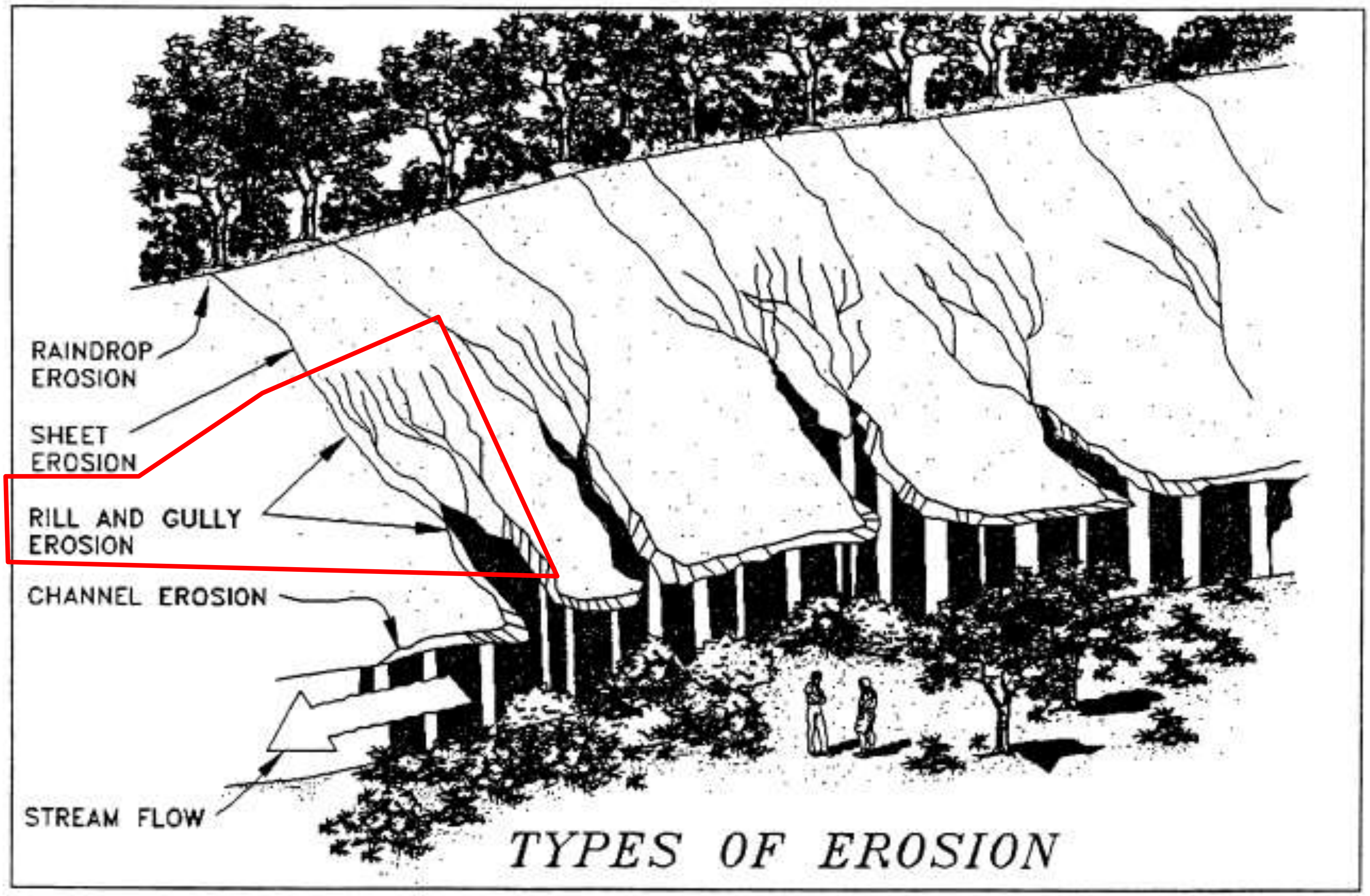
Amanda Pennington, P.E., DCR-DSWC

Raleigh Coleman, DCR-DSWC

Topics

- Erosion Fundamentals
- Overview of Upland Erosion Stabilization Practices
  - Grassed Waterways, Drop Structures, Critical Area Stabilization, Lined Waterways
  - NOT Covered: Streambank Stabilization, Diversions, etc.
- Hydrologic and Hydraulic Calculations
- Design of Grassed Waterways
- Drop Structure & Lined Waterway Design
- Case Studies

Erosion Fundamentals



Erosion Fundamentals

- Factors influencing erosion:
  - Soil characteristics
  - Vegetative Cover
  - Topogrpahy
  - Climate (frequency, intensity, duration of rainfall)

Description — K Factor, Whole Soil

Erosion factor K indicates the susceptibility of a soil to sheet and rill erosion by water. Factor K is one of six factors used in the Universal Soil Loss Equation (USLE) and the Revised Universal Soil Loss Equation (RUSLE) to predict the average annual rate of soil loss by sheet and rill erosion in tons per acre per year. The estimates are based primarily on percentage of silt, sand, and organic matter and on soil structure and saturated hydraulic conductivity (Ksat). Values of K range from 0.02 to 0.69. Other factors being equal, the higher the value, the more susceptible the soil is to sheet and rill erosion by water.

"Erosion factor Kw (whole soil)" indicates the erodibility of the whole soil. The estimates are modified by the presence of rock fragments.

Erodibility - The major soil consideration from an erosion and sediment control standpoint is its erodibility. An erodibility factor (K) indicates the susceptibility of different soils to the forces of erosion. A soil survey report includes the K factor for each soil found in the survey area. These K factors are used in the Universal Soil Loss Equation to determine soil loss from an area over a period of time due to splash, sheet, and rill erosion. K factors in Virginia range from about .10 (lowest erodibility) to about .50 (highest erodibility). K factors can be grouped into three general ranges:

0.23 and lower	-	low erodibility
0.23 to 0.36	-	moderate erodibility
0.36 and up	-	high erodibility

Cohesiveness of soil particles varies with different layers of the same soil, causing varying degrees of erodibility at different depths. Therefore, depth of excavation must be considered in determining soil erodibility on a construction site.

Virginia Department of Conservation & Recreation

Virginia Erosion and Sediment Control Handbook

TABLE 3.18-B?

PERMISSIBLE VELOCITIES FOR EARTH LININGS

Soil Types	Permissible Velocities (ft./sec.)
Fine Sand (noncolloidal)	2.5
Sandy Loam (noncolloidal)	2.5
Silt Loam (noncolloidal)	3.0
Ordinary Firm Loam	3.5
Fine Gravel	5.0
Stiff Clay (very colloidal)	5.0
Graded, Loam to Cobbles (noncolloidal)	5.0
Graded, Silt to Cobbles (colloidal)	5.5
Alluvial Silts (noncolloidal)	5.5
Alluvial Silts (colloidal)	5.0
Coarse Gravel (noncolloidal)	6.0
Cobbles and Shingles	5.5
Shales and Hard Plans	6.0

Virginia Department of Conservation & Recreation

Virginia Erosion and Sediment Control Handbook

TABLE 3.18-A

PERMISSIBLE VELOCITIES FOR GRASS-LINED CHANNELS

Channel Slope	Lining	Velocity* (ft./sec.)
0 - 5%	Bermudagrass	6
	Reed canarygrass Tall fescue Kentucky bluegrass	5
	Grass-legume mixture	4
	Red fescue Redtop Sericea lespedeza Annual lespedeza Small grains Temporary vegetation	2.5
5 - 10%	Bermudagrass	5
	Reed canarygrass Tall fescue Kentucky bluegrass	4
	Grass-legume mixture	3
Greater than 10%	Bermudagrass	4
	Reed canarygrass Tall fescue Kentucky bluegrass	3

* For highly erodible soils, decrease permissible velocities by 25%.

Common Erosion Stabilization Practices

- Grassed Waterways: NRCS CPS 412 Grassed Waterway
- Drop Structures: NRCS CPS 410 Grade Stabilization Structure
- Lined Waterways: NRCS CPS 468 Lined Waterway or Outlet
- Critical Area Stabilization: NRCS CPS 342 Critical Area Planting

Important for SWCD technicians to be able to make conservation planning decisions about which practices are appropriate.

Reminder: All *engineering* practices require EJAA for I&E, Design, and Construction.

Grassed Waterways (CPS 412)

- DCR Practice Spec: WP-3

A. <u>Description and Purpose</u>

A natural or constructed waterway shaped or graded and established in suitable vegetation, to safely convey water across areas of concentrated flow.

To improve water quality by reducing the movement of sediment and nutrients from agricultural non-point sources.

- Stabilize eroded drainage swale areas in crop fields
- Maintained in grass

DEFINITION

A shaped or graded channel that is established with suitable vegetation to convey surface water at a non-erosive velocity using a broad and shallow cross section to a stable outlet.

Drop Structures (CPS 410)

- DCR Practice Spec: WP-1

A. Description and Purpose

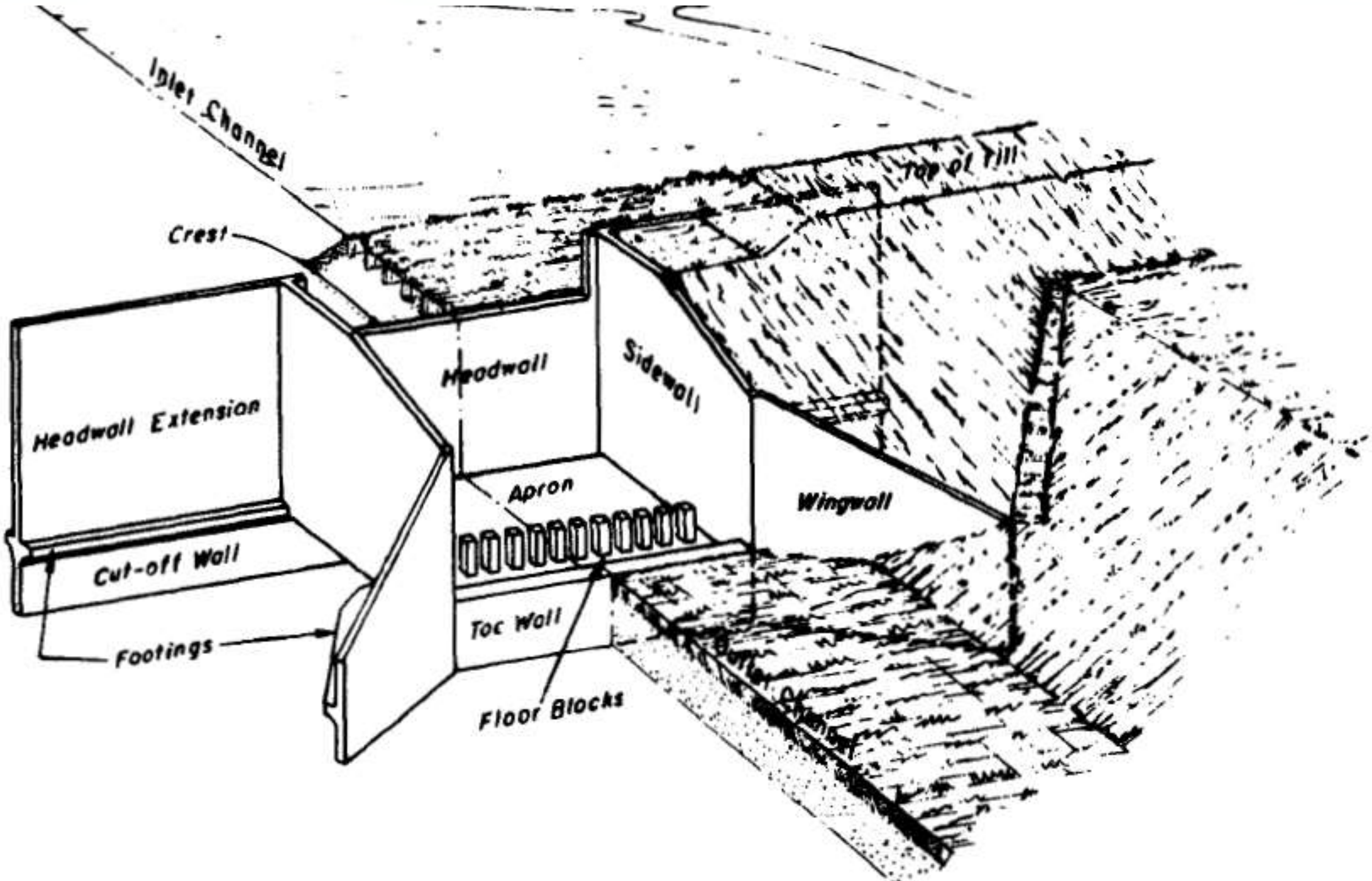
This practice will promote structures that will collect and store debris or control the grade of drainage ways.

The purpose of this practice is to improve water quality by reducing the movement of sediment and materials from agricultural land to receiving streams.

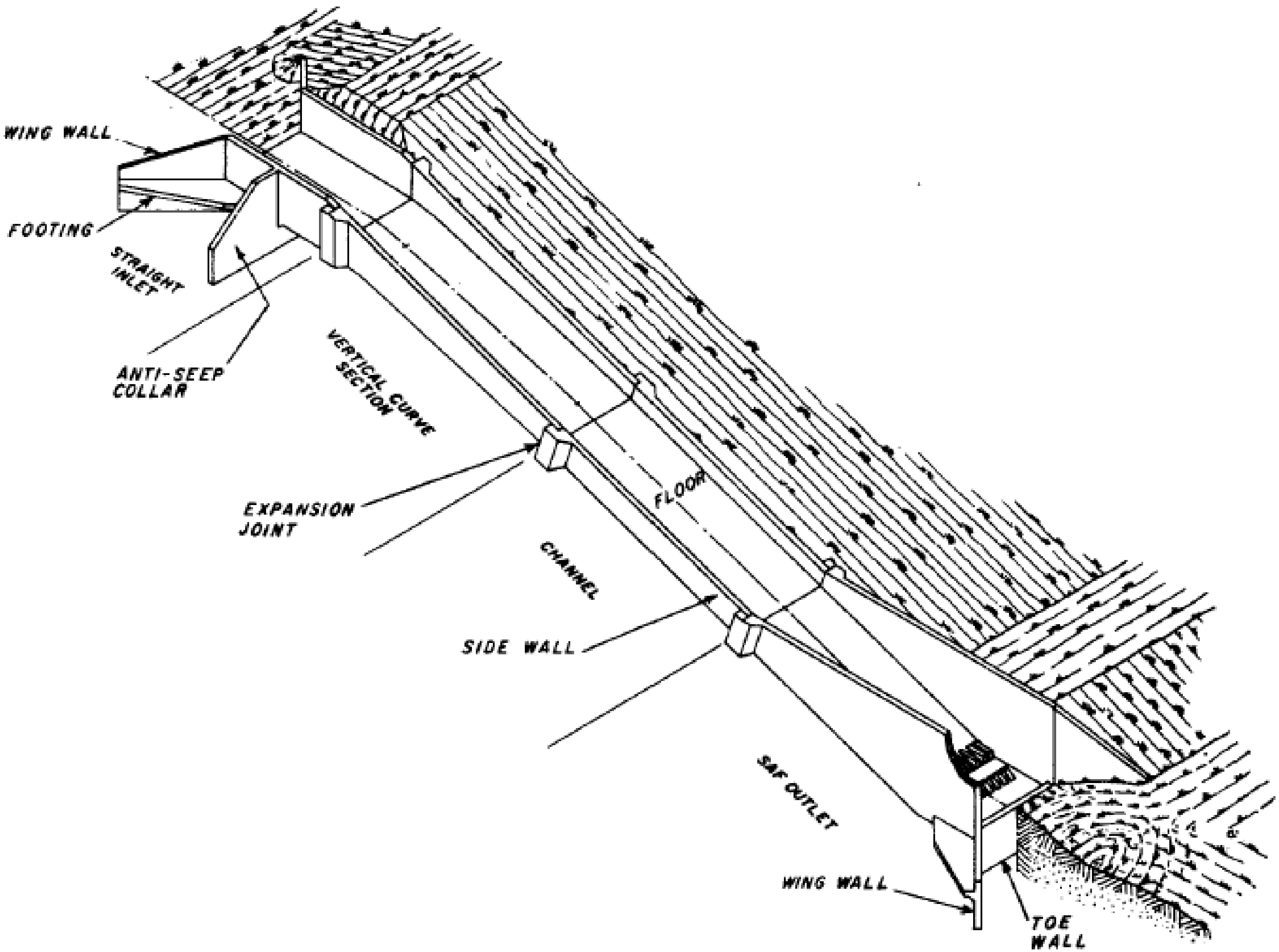
- Stabilize headcut areas & gullies (vs. rills)
- More engineering work and more expensive to construct than grassed waterways

DEFINITION

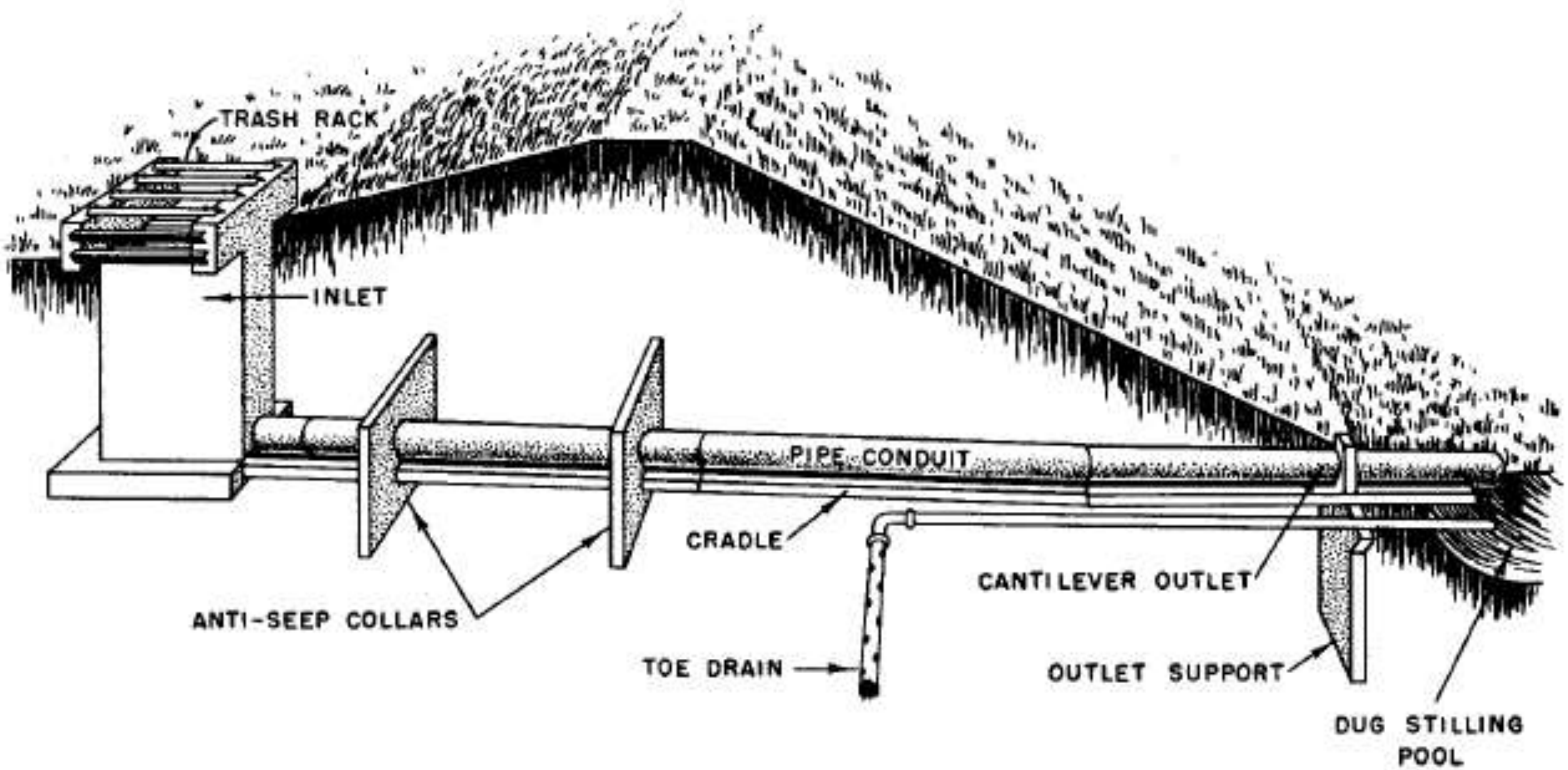
A grade stabilization structure is a structure used to control the grade in natural or constructed channels.



STRAIGHT DROP SPILLWAY



CHUTE SPILLWAY



DROP INLET SPILLWAY

DCR
Virginia Department of Conservation & Recreation

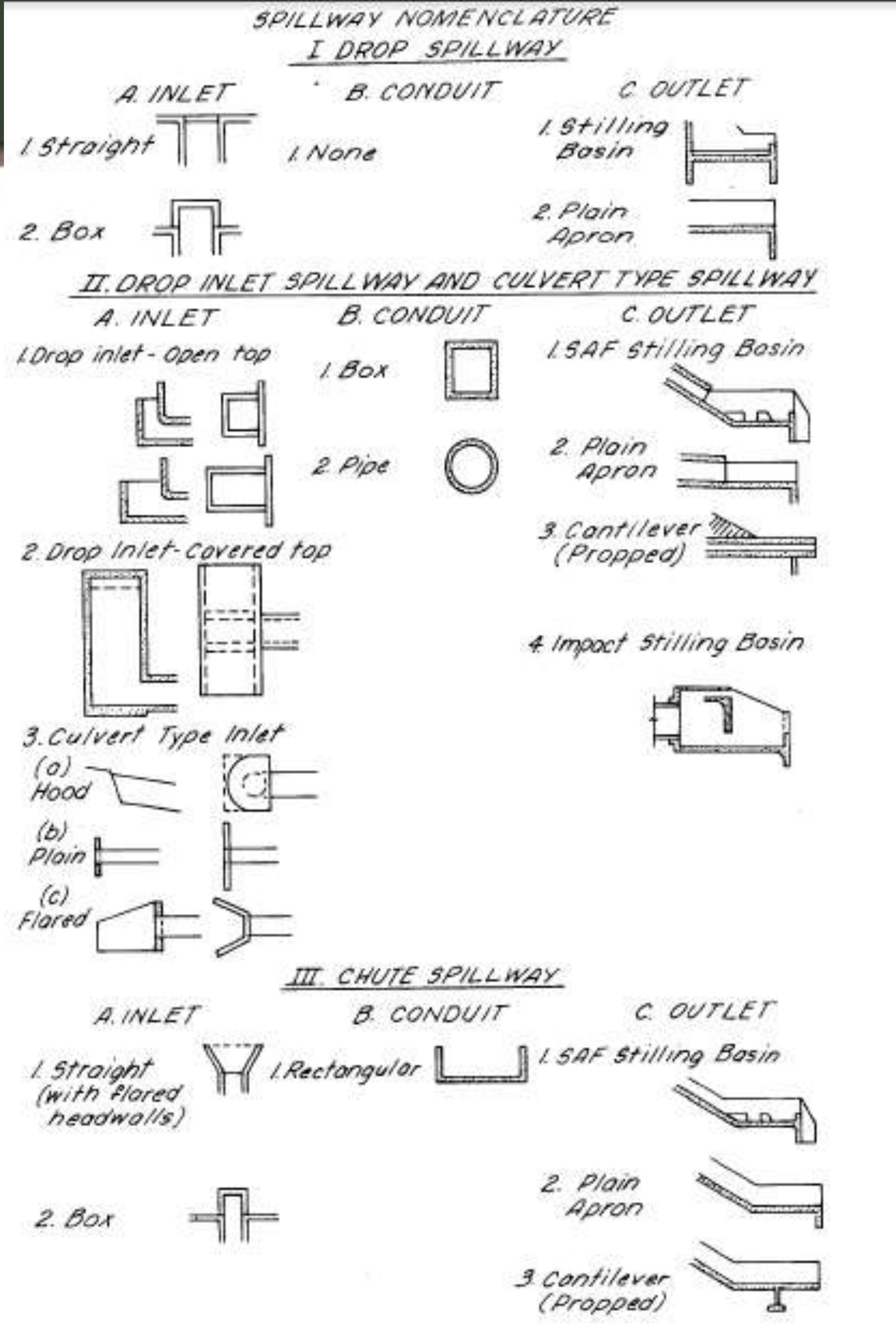
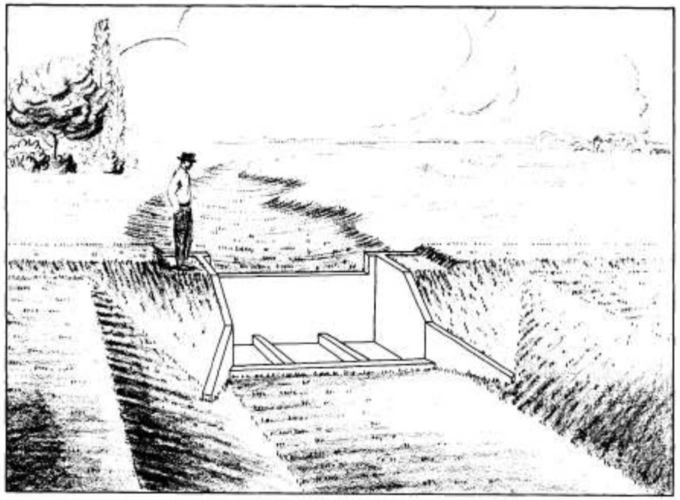
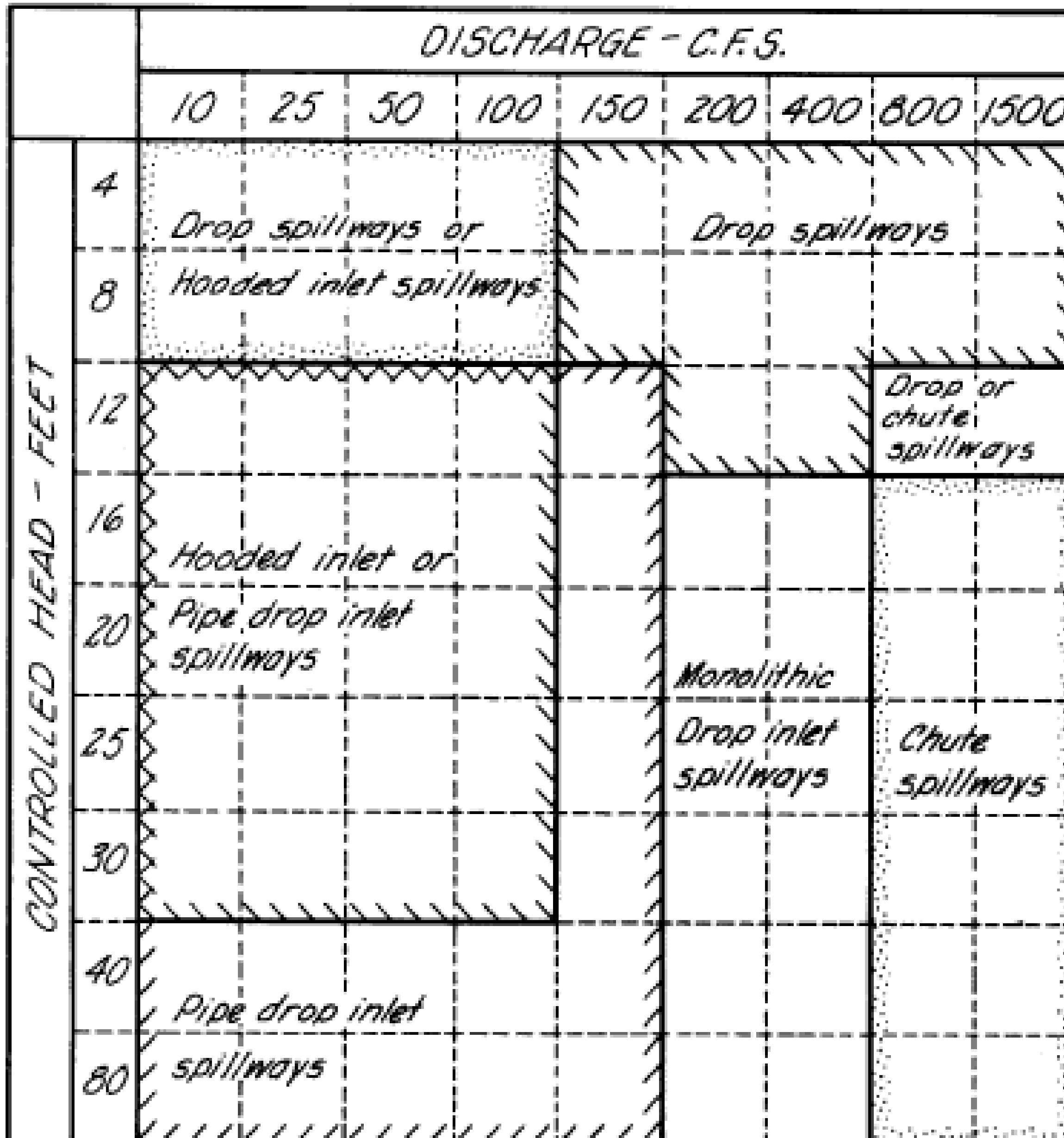


Figure 6-3 Nomenclature for inlet, conduit and outlet of spillway



Reinforced concrete



Note: Chart shows most economical structure as related to discharge and controlled head providing site conditions are adequate.

DCR

Virginia Department of Conservation & Recreation

Vs.

Potential Grassed Waterway

Potential Drop Structure

Lined Waterway or Outlet (CPS 468)

- DCR Practice Spec: WP-1

A. Description and Purpose

This practice will promote structures that will collect and store debris or control the grade of drainage ways.

The purpose of this practice is to improve water quality by reducing the movement of sediment and materials from agricultural land to receiving streams.

- Stabilize eroding channels where grassed waterways will not be sufficient

DEFINITION

A waterway or outlet having an erosion-resistant lining of concrete, stone, synthetic turf reinforcement fabrics, or other permanent material.

Critical Area Stabilization: CPS 342

- DCR Practice Spec: SL-11

A. Description and Purpose

This practice will promote land shaping and planting permanent vegetative cover on critically eroding areas.

The purpose of this practice is to improve water quality by stabilizing soil, thus reducing the movement of sediment and nutrients from the site.

- Stabilize eroding areas
- NOT for areas where runoff concentrates (unlike grassed waterways, drop structures, lined waterways)
- Not an engineering practice

DEFINITION

Establishing permanent vegetation on sites that have, or are expected to have, high erosion rates, and on sites that have physical, chemical or biological conditions that prevent the establishment of vegetation with normal practices.

Conservation Planning Considerations:

Is there an *active* erosion problem creating a water quality concern?

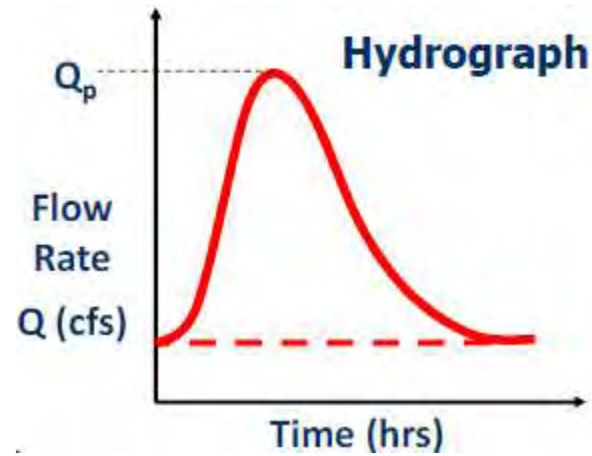
Conservation Planning Considerations

What is *causing* the problem, and will the practice solve the problem?

Background: Hydrologic Calculations

- Design of grassed waterways, drop structures, and lined waterways requires hydrologic calculations
- We need to determine how much water the waterway or structure needs to carry

Practice	Design Storm Requirement
Grassed Waterway	Peak 10-yr, 24-hr
Drop Structures	Depends on type, vertical drop, receiving channel depth
Lined Waterways	Peak 10-yr, 24-hr



cfs = cubic feet per second = ft^3/sec (This is a volume per time.)
Velocity is measured in feet per second and will depend on the channel shape, slope, and roughness.

Flow Rate vs. Velocity

MANNING'S EQUATION

The most widely used open channel formulas express mean velocity of flow as a function of the roughness of the channel, the hydraulic radius, and the slope of the energy gradient. They are equations in which the values of constants and exponents have been derived from experimental data. Manning's equation is one of the most widely accepted and commonly used of the open channel formulas:

$$v = \frac{1.486}{n} r^{2/3} s^{1/2} \qquad \text{(Eq. 3-15)}$$

- v = mean velocity of flow in feet per second
- r = hydraulic radius in feet
- s = slope of the energy gradient
- s_o = slope of channel bottom
- n = coefficient of roughness

The elements of cross sections of an open channel required for hydraulic computations are:

- a, the cross-sectional area of flow;
- p, the wetted perimeter, that is, the length of the boundary of the cross section in contact with the water;
- $r = \frac{a}{p}$, the hydraulic radius, which is the cross-sectional area of the stream divided by the wetted perimeter.

Since Q = av, Manning's equation may also be written:

$$Q = \frac{1.486}{n} a\, r^{2/3} s^{1/2} \qquad \text{(Eq. 3-16)}$$

where a = cross-sectional area in square feet.

EFH-2 vs. USGS Regression Analysis

	EFH-2	USGS Regression Analysis
Description	Computer program based on NRCS Engineering Field Handbook Ch. 2	Spreadsheet or StreamStats web application
Inputs	Drainage Area, watershed length, avg. watershed slope, curve number (based on land use and hydrologic soil group)	Location, Drainage Area
Accuracy	Very good, site specific	Marginal (typically no better than ±22%)
Ease of Use	Fairly time-consuming	Very Easy and Quick

For Grassed Waterways, Drop Structures, Lined Waterways

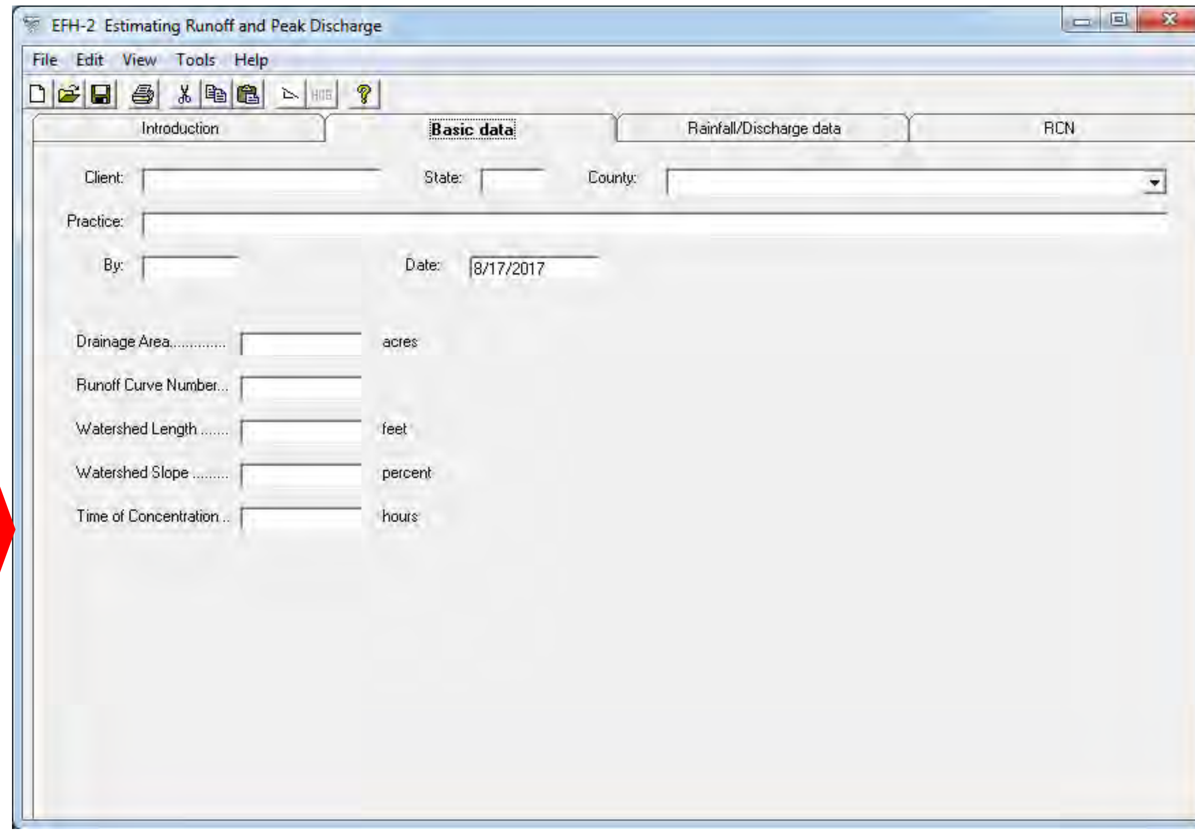
- **Summary:** EFH-2 requires a little bit more work but will generally produce much more accurate results. The USGS method may provide a good starting point, but EFH-2 is generally preferred.
- The **Rational Method** may also be used where appropriate.

Virginia Department of Conservation & Recreation

Contents

SCS Engineering Field Handbook, Chapter 2

EFH-2



- Can use WinTR-55 for watersheds with more impervious or sub-watersheds

EFH2 Limitations

- Watershed is accurately represented by a single runoff curve number between 40 and 98.
- Watershed area is between 1 and 2,000 acres.
- Watershed length is between 200 and 26,000 feet.
- Average watershed slope is between 0.5 and 64%.
- No valley or reservoir routing is required.
- Urban land use within the watershed does not exceed 10%.

What are HSGs?

For EFH2, you will need the "Hydrologic Soil Group" of the soil types in the watershed.

Description

Hydrologic soil groups are based on estimates of runoff potential. Soils are assigned to one of four groups according to the rate of water infiltration when the soils are not protected by vegetation, are thoroughly wet, and receive precipitation from long-duration storms.

The soils in the United States are assigned to four groups (A, B, C, and D) and three dual classes (A/D, B/D, and C/D). The groups are defined as follows:

Group A. Soils having a high infiltration rate (low runoff potential) when thoroughly wet. These consist mainly of deep, well drained to excessively drained sands or gravelly sands. These soils have a high rate of water transmission.

Group B. Soils having a moderate infiltration rate when thoroughly wet. These consist chiefly of moderately deep or deep, moderately well drained or well drained soils that have moderately fine texture to moderately coarse texture. These soils have a moderate rate of water transmission.

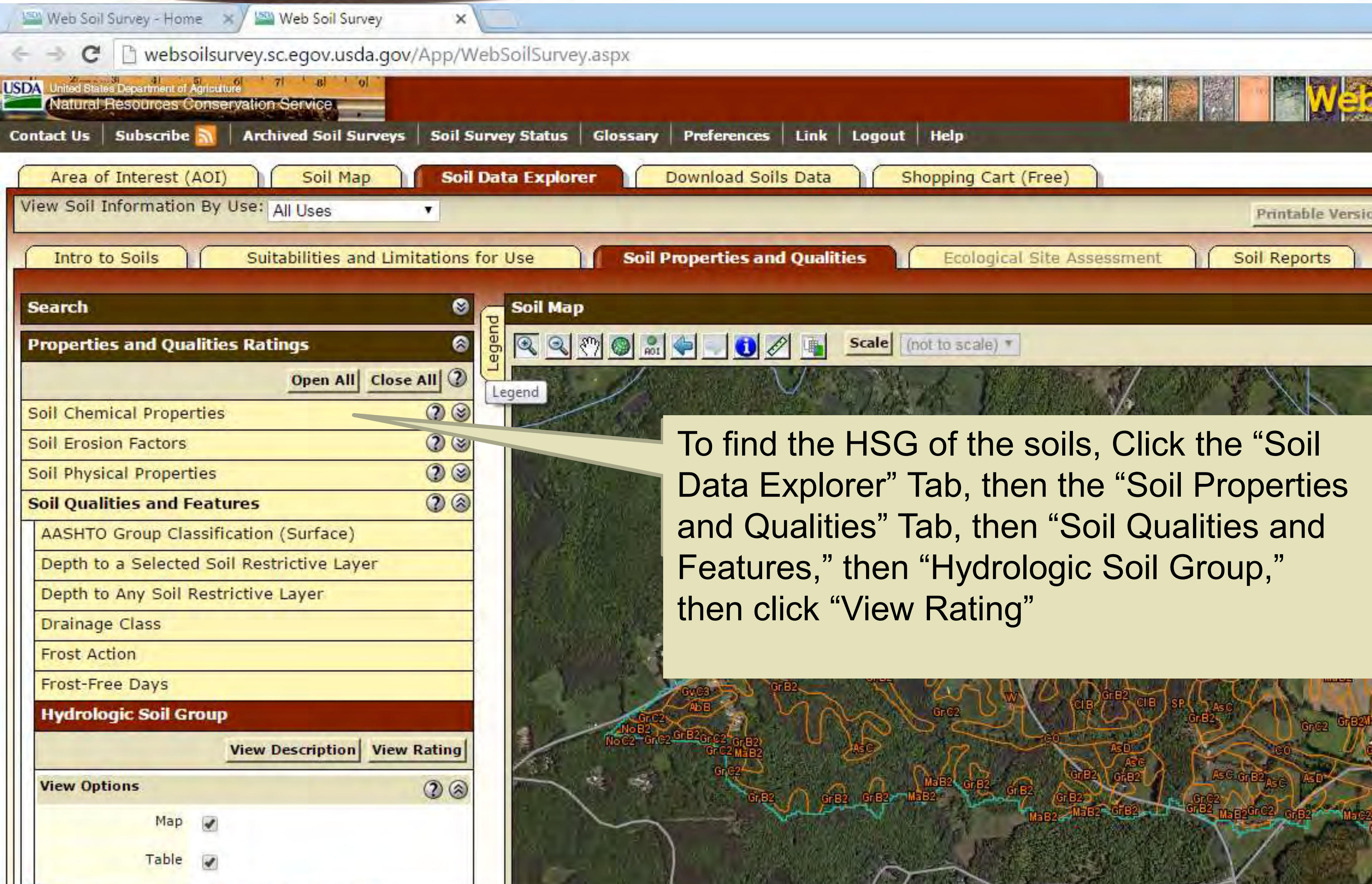
Group C. Soils having a slow infiltration rate when thoroughly wet. These consist chiefly of soils having a layer that impedes the downward movement of water or soils of moderately fine texture or fine texture. These soils have a slow rate of water transmission.

Group D. Soils having a very slow infiltration rate (high runoff potential) when thoroughly wet. These consist chiefly of clays that have a high shrink-swell potential, soils that have a high water table, soils that have a claypan or clay layer at or near the surface, and soils that are shallow over nearly impervious material. These soils have a very slow rate of water transmission.

If a soil is assigned to a dual hydrologic group (A/D, B/D, or C/D), the first letter is for drained areas and the second is for undrained areas. Only the soils that in their natural condition are in group D are assigned to dual classes.

DCR

Virginia Department of Conservation & Recreation



To find the HSG of the soils, Click the “Soil Data Explorer” Tab, then the “Soil Properties and Qualities” Tab, then “Soil Qualities and Features,” then “Hydrologic Soil Group,” then click “View Rating”

DCR
Virginia Department of Conservation & Recreation

Hydrologic Soil Group— Summary by Map Unit XXX County, Virginia (VA113)				
Map unit symbol	Map unit name	Rating	Acres in AOI	Percent of AOI
BeD	Brandywine loam, very deep, 15 to 25 percent slopes	A	3.3	3.0%
BeF	Brandywine loam, very deep, 25 to 45 percent slopes	A	3.6	3.2%
BnF	Brandywine stony loam, very deep, 25 to 50 percent slopes	A	11.2	10.1%
DkC2	Dyke loam, 7 to 15 percent slopes, eroded	B	5.1	4.6%
ElC2	Elioak fine sandy loam, 7 to 15 percent slopes, eroded	B	0.6	0.5%
EmD2	Elioak loam, 15 to 25 percent slopes, eroded	B	2.3	2.1%
EyC	Eubanks-Lloyd loams, 7 to 15 percent slopes	A	2.2	2.0%
EyC2	Eubanks-Lloyd loams, 7 to 15 percent slopes, eroded	A	10.0	9.1%
EyD2	Eubanks-Lloyd loams, 15 to 25 percent slopes, eroded	A	0.5	0.5%
GlC2	Glenelg loam, 5 to 15 percent slopes, eroded	B	0.6	0.5%
HaC	Hazel loam, 7 to 15 percent slopes	B	2.1	1.9%
HaD	Hazel loam, 15 to 25 percent slopes	B	18.4	16.6%
HaF	Hazel loam, 25 to 55 percent slopes	B	37.2	33.7%
LoD	Louisburg sandy loam, 15 to 25 percent slopes	A	3.0	2.7%
MvB	Meadowville loam, 2 to 7 percent slopes	A	10.5	9.5%
Totals for Area of Interest			110.7	100.0%

Results

HSG	Total Percentage
A	40.1
B	59.9
C	0
D	0

Add the "like" HSGs together to determine the total acreage of each HSG in the drainage area.

EFH2 Inputs

Input	Units	Description
Drainage Area	Acres	Area draining to proposed practice location
Curve Number	-	EFH-2 has a curve number calculating tab – you input the breakdown of area by HSG and land use
Watershed Length	Feet	Length of longest flow path from watershed boundary to the outlet
Watershed Slope	Percent	Average slope of WATERSHED – NOT slope of flow path
Rainfall Information	-	Electronic files available by county, OR get pinpoint accurate data from NOAA PFDS

This is different from most other hydrologic methods and is the most commonly seen problem in EFH2 calculations

Map unit symbol	Map unit name	Rating	Acres in AOI	Percent of AOI
BeD	Brandywine loam, very deep, 15 to 25 percent slopes	A	3.3	3.0%
BeF	Brandywine loam, very deep, 25 to 45 percent slopes	A	3.6	3.2%
BnF	Brandywine stony loam, very deep, 25 to 50 percent slopes	A	11.2	10.1%
DkC2	Dyke loam, 7 to 15 percent slopes, eroded	B	5.1	4.6%
ElC2	Elioak fine sandy loam, 7 to 15 percent slopes, eroded	B	0.6	0.5%
EmD2	Elioak loam, 15 to 25 percent slopes, eroded	B	2.3	2.1%
EyC	Eubanks-Lloyd loams, 7 to 15 percent slopes	A	2.2	2.0%
EyC2	Eubanks-Lloyd loams, 7 to 15 percent slopes, eroded	A	10.0	9.1%
EyD2	Eubanks-Lloyd loams, 15 to 25 percent slopes, eroded	A	0.5	0.5%
GlC2	Glenelg loam, 5 to 15 percent slopes, eroded	B	0.6	0.5%
HaC	Hazel loam, 7 to 15 percent slopes	B	2.1	1.9%
HaD	Hazel loam, 15 to 25 percent slopes	B	18.4	16.6%
HaF	Hazel loam, 25 to 55 percent slopes	B	37.2	33.7%
LoD	Louisburg sandy loam, 15 to 25 percent slopes	A	3.0	2.7%
MvB	Meadowville loam, 2 to 7 percent slopes	A	10.5	9.5%
Totals for Area of Interest			110.7	100.0%

Average Watershed Slope

Average watershed slope

The average watershed slope (Y) is the slope of the land and not the watercourse. It can be determined from soil survey data or topographic maps. Hillside slopes can be measured with a hand level, Locke level, or clinometer in the direction of overland flow. Average watershed slope is an average of individual land slope measurements.

The average watershed slope can be determined using the following relationship:

$$Y = \frac{100CI}{A} \quad \text{(Eq. 2-6)}$$

where Y = average watershed slope in percent,
C = total contour length in feet,
I = contour interval in feet, and
A = drainage area in square feet.

OR, the soils report can also be used to estimate the average "Watershed Slope" for EFH2.

Calculate a weighted average of the slope of the soil types in the watershed.

Watershed Slope

(A) Slope Range of Soil Type	(B) Avg. Slope of Soil Type	(C) Total Percentage of Area	(D) Decimal Percentage	(E) Weighted Slope
2-7%	5%	9.5	0.095	0.48
7-15%	11%	16.1	0.161	1.77
5-15%	10%	0.5	0.005	0.05
15-25%	20%	26.9	0.269	5.38
25-55%	40%	33.7	0.337	13.5
25-45%	35%	3.2	0.032	1.12
25-50%	38%	10.1	0.101	3.84
			Total: **(Average Slope):**	**26.1**

Column B: Average the slope range in Column A
Column C: Add together the "Percent of AOI" of all of the soil types with this slope range
Column D: Column C/100
Column E: Multiply Columns B and D

~~(Avg. Slope of Flow Path = 7.2%)~~

Curve Number Calculation

COVER DESCRIPTION		Percent (CN)			
		Hydrologic Soil Group			
		A	B	C	D
OTHER AGRICULTURAL LANDS					
Pasture, grassland or range	poor	16.04(68)	23.96(79)	-	-
Woods	fair	24.06(36)	35.94(60)	-	-
Total Area (by Hydrologic Soil Group)		40.1	59.9		
TOTAL DRAINAGE AREA: 100 Percent		WEIGHTED CURVE NUMBER: 60			

Considerations:

-The 2-yr storm is most likely to happen during summer months (thunderstorm), so it may be conservative to consider the highest runoff-producing land cover conditions expected during summer.

-If cropland, consider early July when straw is baled, or April/May for full tillage corn

-If pasture, consider the "summer slump" of cool-season forages

-Think about management tendencies of the landowner.

-If you know of imminent land development, go ahead and factor it in to your calculation.

DCR
Virginia Department of Conservation & Recreation

Rainfall Information

- More accurate (site-specific) precipitation data can be obtained from NOAA at: http://hdsc.nws.noaa.gov/hdsc/pfds/index.html

POINT PRECIPITATION FREQUENCY (PF) ESTIMATES
WITH 90% CONFIDENCE INTERVALS AND SUPPLEMENTARY INFORMATION
NOAA Atlas 14, Volume 2, Version 3

PF tabular | PF graphical | Supplementary information

PDS-based precipitation frequency estimates with 90% confidence intervals (i

Duration	Average recurrence interval (years)							
	1	2	5	10	25	50	100	2
5-min	0.343 (0.310-0.379)	0.410 (0.372-0.454)	0.485 (0.438-0.536)	0.549 (0.495-0.606)	0.622 (0.557-0.685)	0.679 (0.606-0.747)	0.735 (0.651-0.808)	0. (0.695
10-min	0.546 (0.494-0.604)	0.654 (0.593-0.723)	0.774 (0.700-0.855)	0.872 (0.786-0.963)	0.986 (0.884-1.09)	1.08 (0.960-1.19)	1.16 (1.03-1.28)	1. (1.09
15-min	0.680 (0.616-0.752)	0.819 (0.742-0.906)	0.975 (0.881-1.08)	1.10 (0.991-1.22)	1.24 (1.12-1.37)	1.36 (1.21-1.49)	1.46 (1.30-1.61)	1. (1.37
30-min	0.929 (0.840-1.03)	1.13 (1.02-1.25)	1.38 (1.25-1.52)	1.58 (1.43-1.75)	1.83 (1.64-2.02)	2.03 (1.81-2.23)	2.22 (1.97-2.44)	2. (2.12
60-min	1.16 (1.05-1.28)	1.41 (1.28-1.56)	1.76 (1.59-1.95)	2.06 (1.85-2.27)	2.43 (2.18-2.68)	2.74 (2.44-3.01)	3.05 (2.70-3.35)	3. (2.96
2-hr	1.38 (1.24-1.54)	1.68 (1.50-1.87)	2.11 (1.89-2.35)	2.48 (2.22-2.77)	2.97 (2.64-3.31)	3.38 (2.98-3.77)	3.81 (3.34-4.23)	4. (3.70
3-hr	1.51 (1.35-1.70)	1.83 (1.63-2.07)	2.30 (2.04-2.60)	2.70 (2.39-3.05)	3.23 (2.84-3.64)	3.69 (3.22-4.14)	4.16 (3.61-4.67)	4. (4.01
6-hr	1.92 (1.71-2.18)	2.32 (2.06-2.64)	2.89 (2.55-3.28)	3.40 (3.00-3.86)	4.09 (3.58-4.65)	4.70 (4.08-5.32)	5.34 (4.59-6.05)	6. (5.13
12-hr	2.40 (2.13-2.73)	2.89 (2.57-3.30)	3.61 (3.20-4.11)	4.27 (3.76-4.85)	5.19 (4.54-5.89)	6.02 (5.20-6.82)	6.92 (5.91-7.83)	7. (6.67
24-hr	2.95 (2.65-3.31)	3.57 (3.21-4.01)	4.55 (4.08-5.10)	5.37 (4.80-6.02)	6.58 (5.85-7.36)	7.62 (6.72-8.50)	8.76 (7.67-9.76)	1 (8.68

- Enter the lat. & long. for the site and it will give you the rainfall amounts for different storm events
- Can be entered manually into EFH2

EFH-2 ESTIMATING RUNOFF AND PEAK DISCHARGE Version 1.1.2

Client: Example
County: \A-C State: VA
Practice: Waterway
Calculated By: [illegible] Date: 4/6/2016
Checked By: ________ Date: ________

Drainage Area:	132	Acres	(user entered value)
Curve Number:	60		(provided from RCN Calculator)
Watershed Length:	2158	Feet	
Watershed Slope:	26.3	Percent	
Time of Concentration:	0.33	Hours	(calculated value)
Rainfall Type:	II		

Storm Number	1	2	3	4	5	6	7
Frequency (yrs)	1	2	5	10	25	50	100
24-Hr rainfall (in)	2.90	3.50	4.40	5.30	6.50	7.50	8.60
Ia/P Ratio	00.46	00.38	00.30	00.25	00.21	00.18	00.16
Used	00.46	00.38	00.30	00.25	00.21	00.18	00.16
Runoff (in)	.30	.53	.97	1.48	2.26	2.96	3.79
(ac-ft)	03.30	05.83	10.67	16.28	24.86	32.56	41.69
Unit Peak Discharge (cfs/acre/in)	00.544	00.715	00.849	00.892	00.928	00.950	00.968
Peak Discharge (cfs)	21	50	108	174	276	371	484

Q_{10} = 174cfs

Overarching Engineering Concepts

Ensure inlet can accept all runoff

Once runoff is concentrated, it is difficult to un-concentrate

Avoid concentrating runoff on unprotected fill

- Try to achieve final grades by cut

Ensure elevations within design do not conflict

- Profile vs. Cross-Sections
- Convergence Point of Multiple Conveyances

Ensure outlet is stable

- May require outlet protection, stilling basin, level spreader, etc.

For all lined outlets and waterways, it is CRITICAL that the armored area is low enough to accept the runoff!

DCR
Virginia Department of Conservation & Recreation

Design of Grassed Waterways

DCR
Virginia Department of Conservation & Recreation

United States Department of Agriculture

Natural Resources Conservation Service

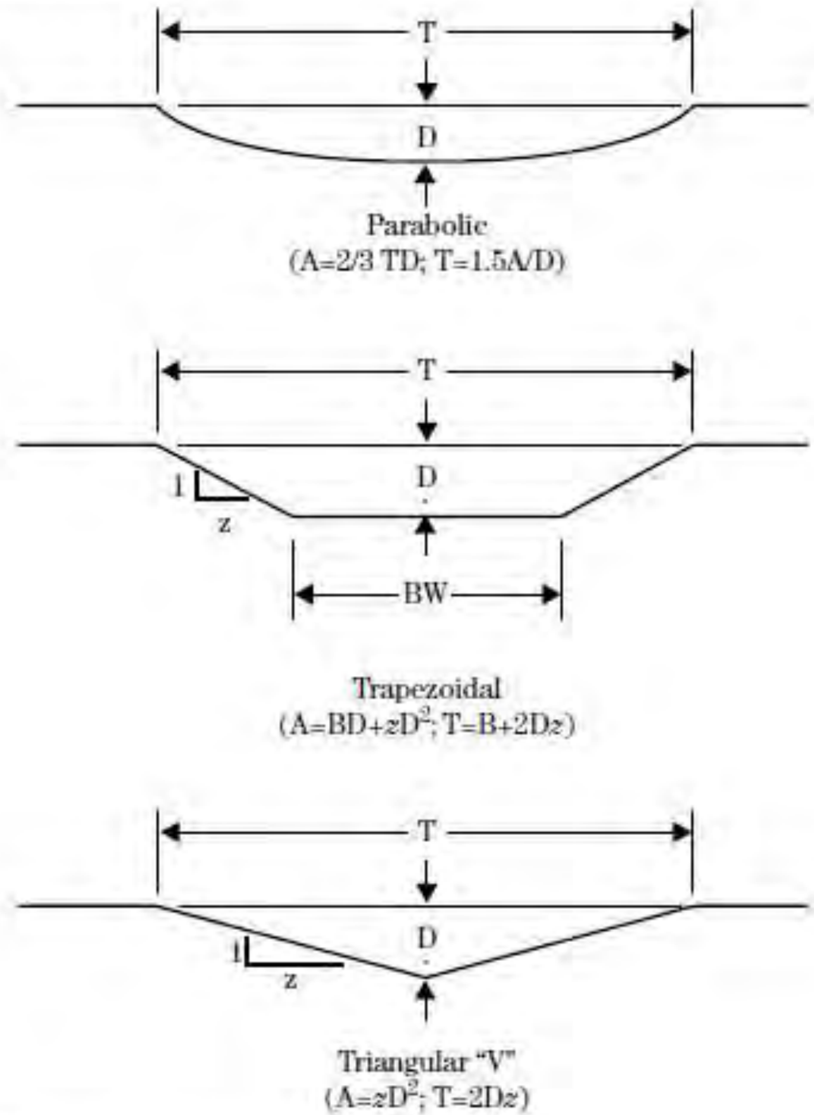
Part 650 Engineering Field Handbook

Chapter 7 Grassed Waterways

Stability. Determine the minimum depth and width requirements for stability of the grassed waterway using the procedures in the NRCS National Engineering Handbook, Part 650, Engineering Field Handbook, Chapter 7, Grassed Waterways or Agricultural Research Service (ARS) Agriculture Handbook 667, Stability Design of Grass-Lined Open Channels.

Grassed Waterway Types

Figure 7–1 Typical waterway cross sections



Where: A=cross section
D=design depth
T=design top width
B=design bottom width
z=side slope ratio

DESIGN DATA

1. Completed Environmental Evaluation and subsequent requirements.
2. Soils investigation.
3. Survey and plot data: profile(s) of the grassed waterway(s) and typical cross-sections.
4. Design computations, including purpose of practice and references used. Provide data for each segment of the main or lateral.
   a. Drainage area
   b. Peak runoff
   c. Channel stability
   d. Channel capacity
5. Plan view of the layout of the grassed waterway with existing and planned features, including dimensions, distances, etc.
6. Standard Cover Sheet (VA-SO-100).
7. Materials and quantities needed. Identify borrow material and/or spoil area, as needed.
8. Vegetation and/or ground cover requirements.
9. Identification of needed Erosion & Sediment Control measures.
10. Supplemental practices required.
11. Virginia Conservation Practice Specifications (700 Series). Include specifications for control of concentrated flow during construction and vegetation establishment.
12. Operation and Maintenance Plan.

(1) Engineering surveys

A preliminary site investigation is recommended to determine the feasibility of using a natural watercourse or constructing a waterway. Such a survey includes a study of resource information such as soil maps, aerial photography, and contour maps; visual examination of potential alignment; topographic surveys; and estimating required capacity. A preliminary investigation should provide enough information to select a final alignment.

Steps in the Design of a Waterway

(a) Steps in the design of a waterway

Step 1 Plan the optimum location of the waterway centerline.

Step 2 Select design points along the waterway where grades, drainage areas, and/or type of lining change significantly.

Step 3 Determine the watershed area for the points in step 2 and for the outlet.

Step 4 Compute the peak runoff produced by the design storm.

Step 5 Determine the slope of each reach of the channel from the topographic map, profiles, or cross sections.

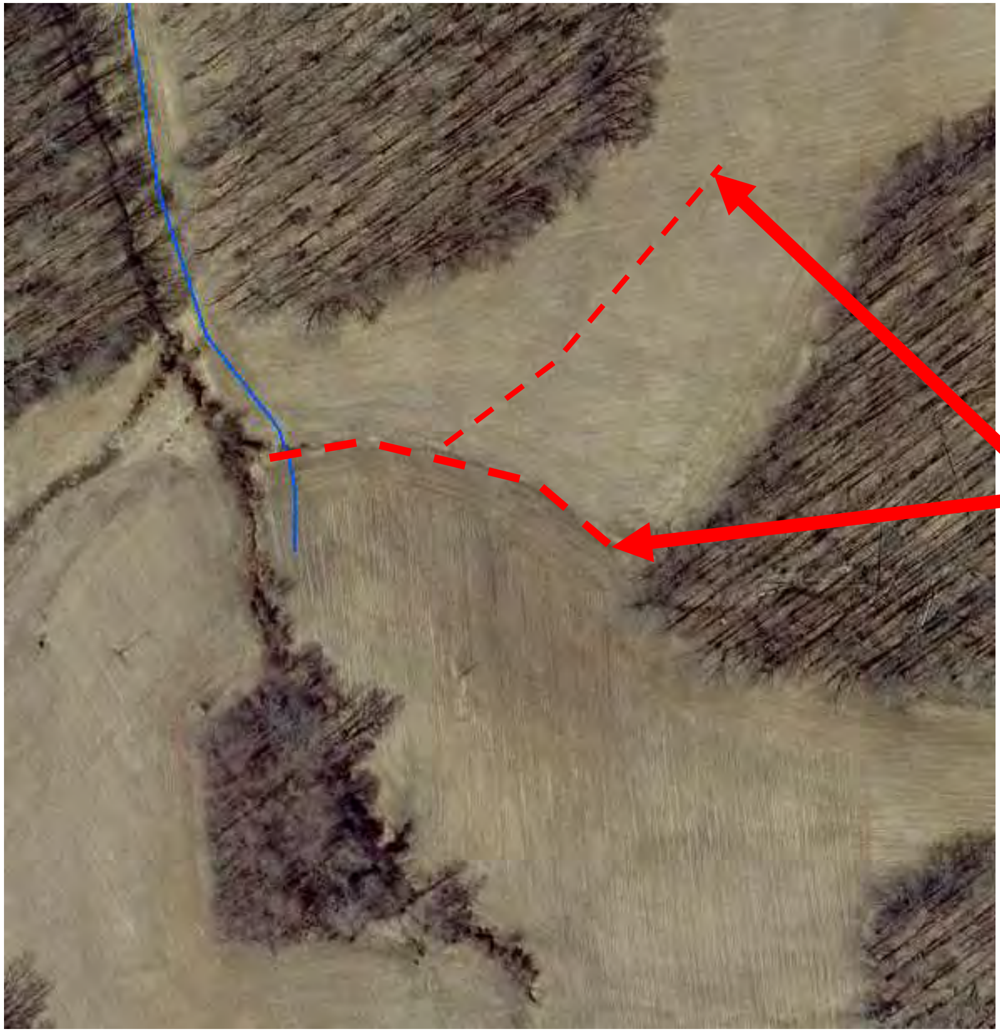
Step 6 Select the appropriate channel cross section and the type of channel lining(s) to be used.

Step 7 Design the channel for stability, typically based on the sparsest and shortest vegetation expected.

Step 8 Adjust the depth to obtain adequate capacity based on the densest and longest vegetation expected.

Step 9 Add appurtenant structures as needed to allow for prolonged flows.

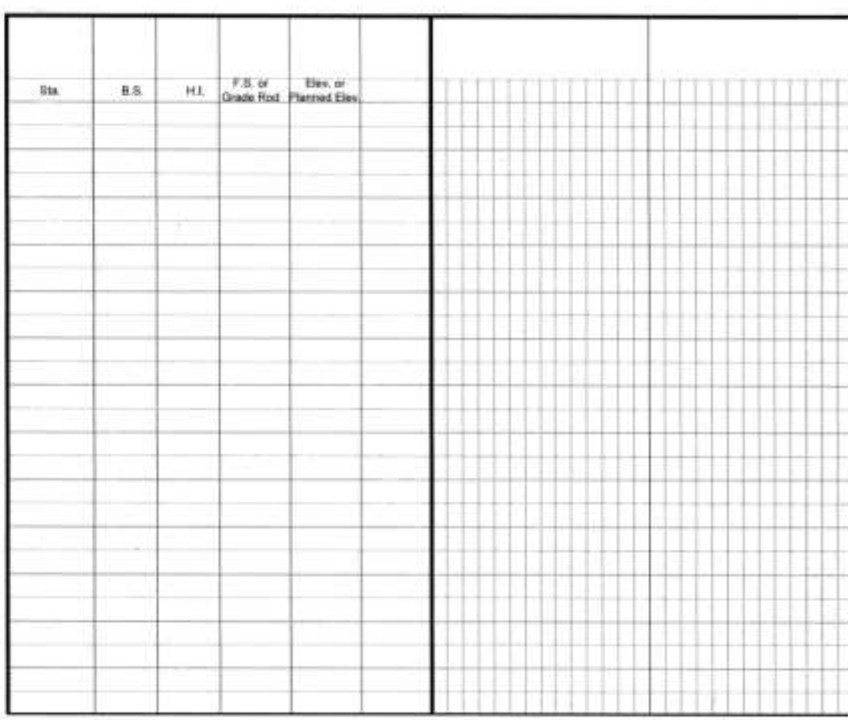
Step 1: Plan the optimum location of the waterway centerline



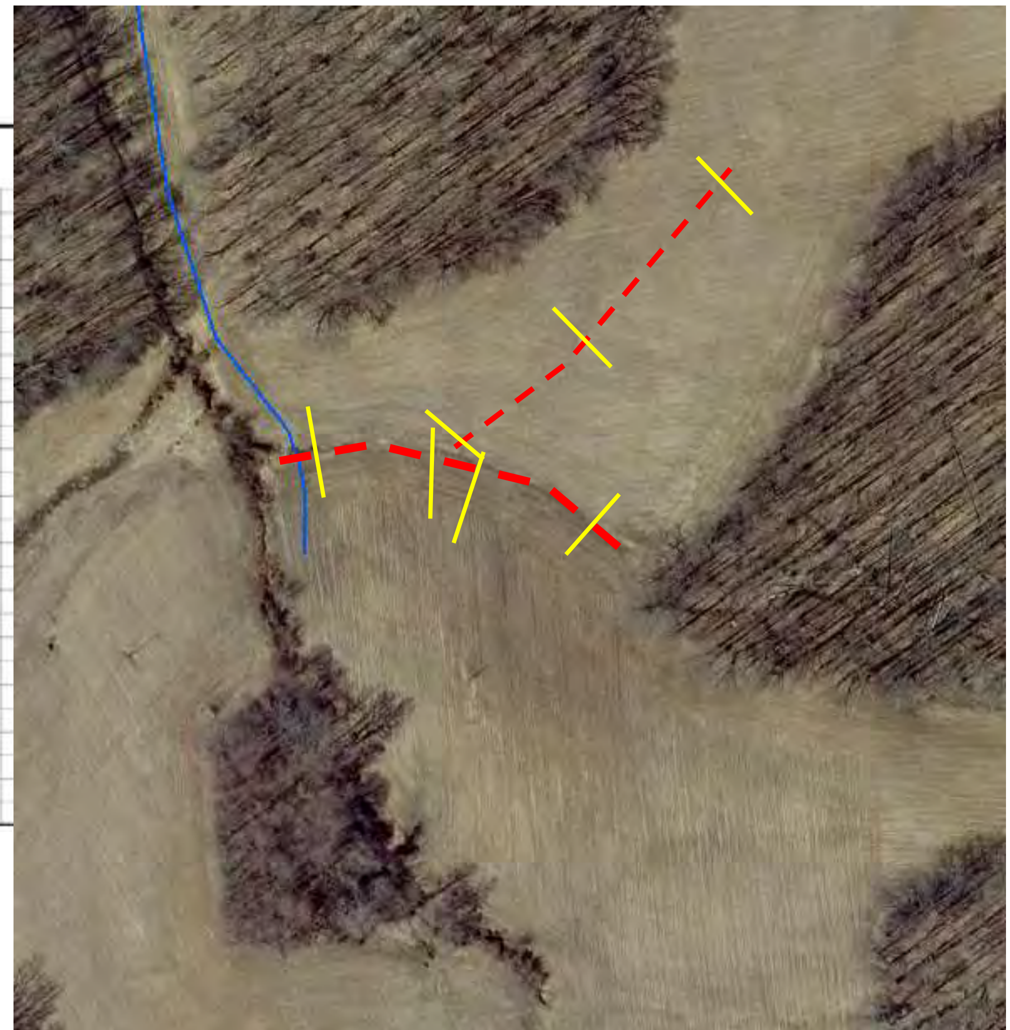
- Optimum location usually easily determined during site investigation
- Can also often be seen on aerial photographs (especially aerials taken over winter)

Virginia Department of Conservation & Recreation

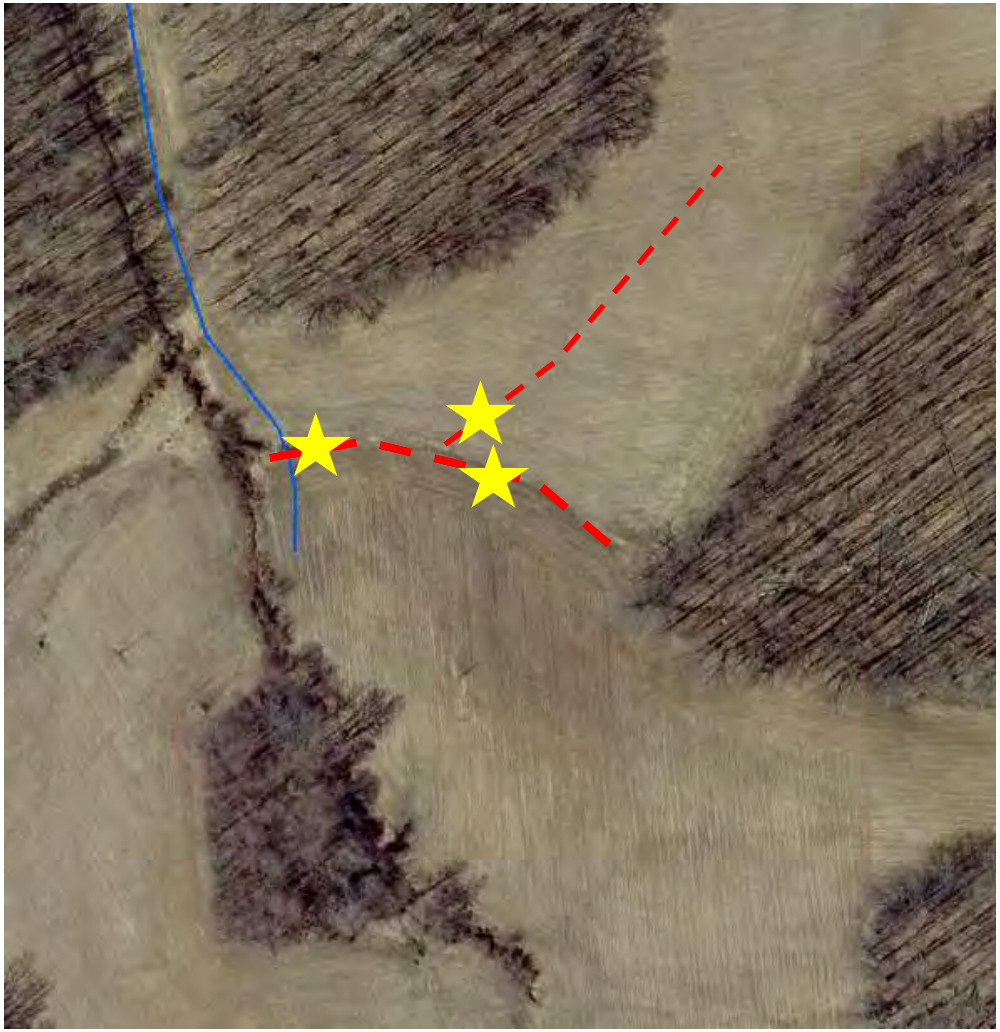
Step 2: Select design points along the waterway where grades, drainage areas, and/or type of lining change significantly.



Sta.	B.S.	H.I.	F.S. or Grade Rod	Elev. or Planned Elev.	



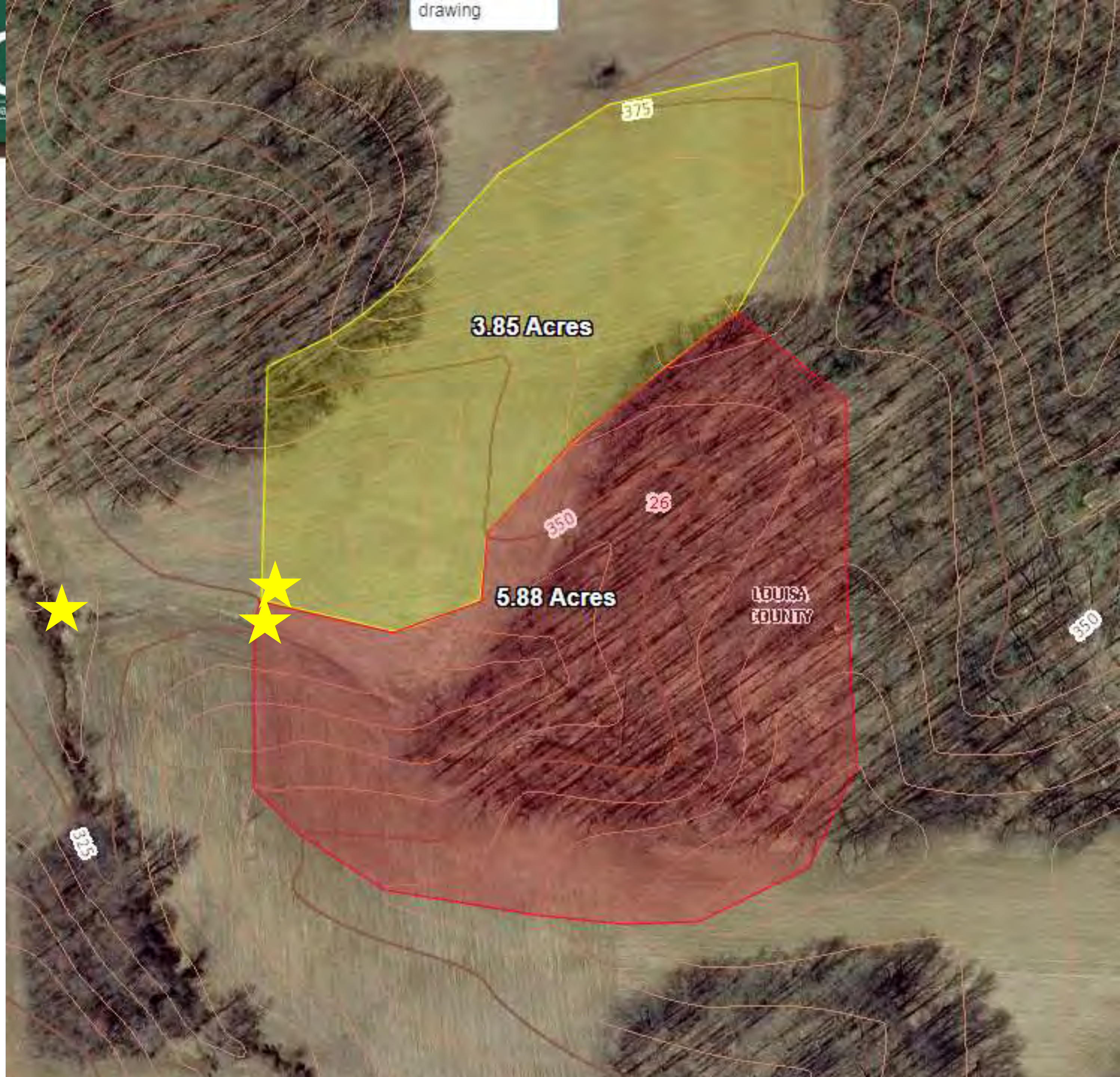
Step 3: **Determine the watershed area for the points in step 2 and for the outlet.**

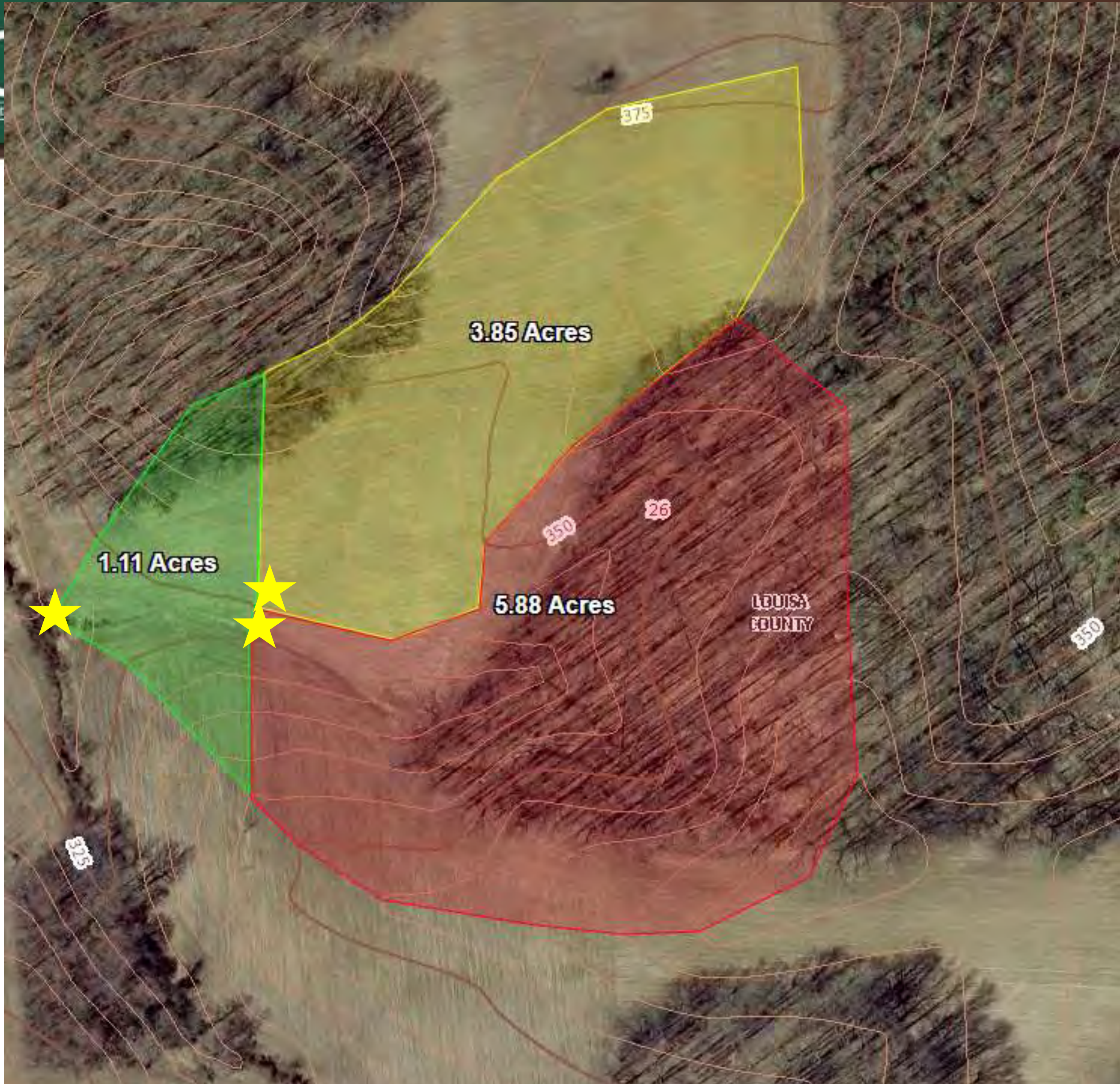


- For this site, where should watersheds be analyzed?
- Analyze for each portion of the waterways.

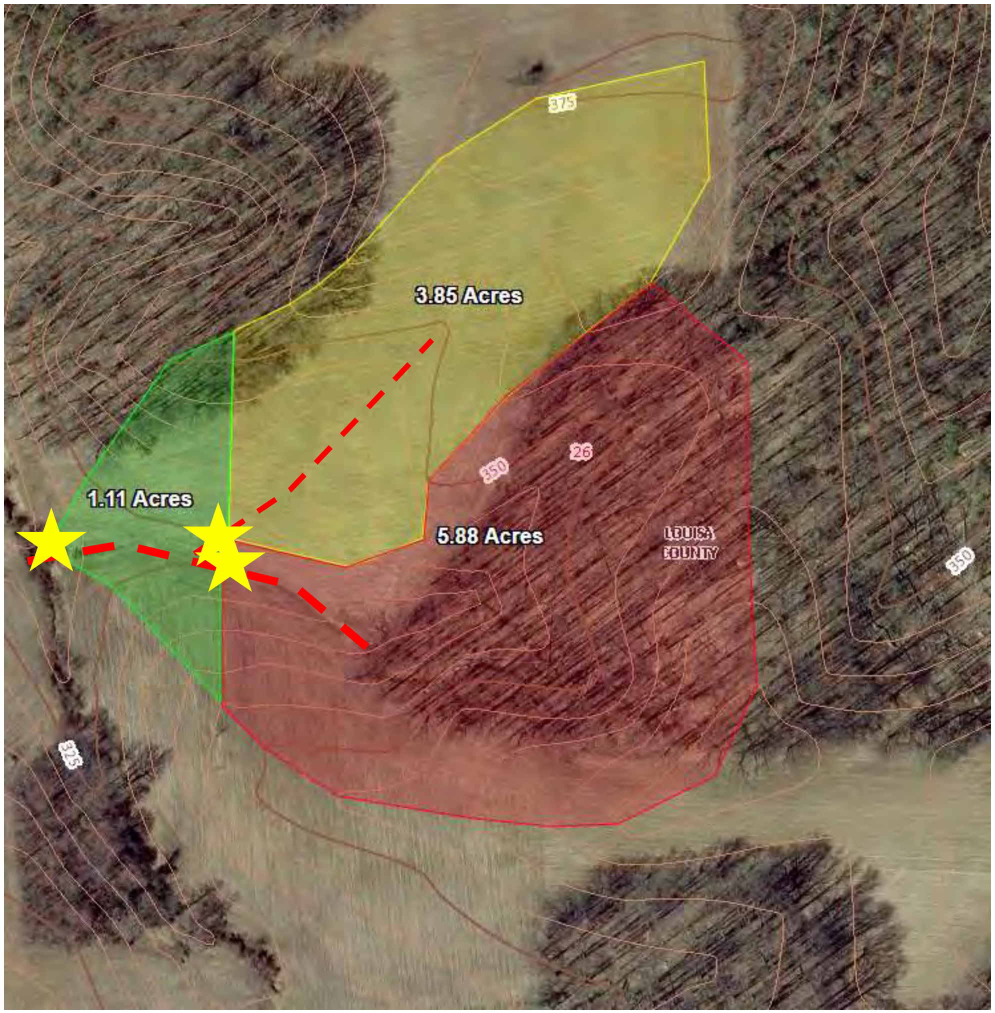
Virginia Department of Conserva

Virginia Department of Conserva

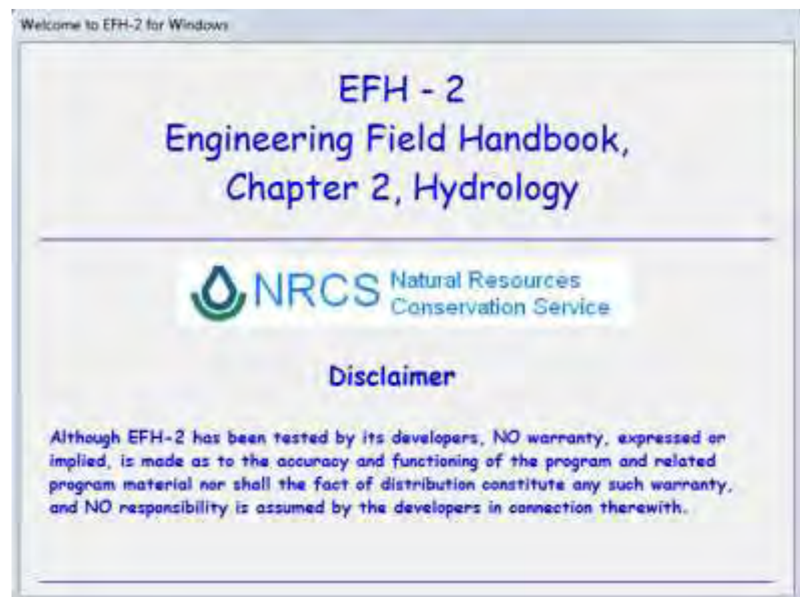



375
3.85 Acres
26
350
1.11 Acres
5.88 Acres
LOUISA
COUNTY
350
325

Step 4: Compute the peak runoff produced by the design storm.

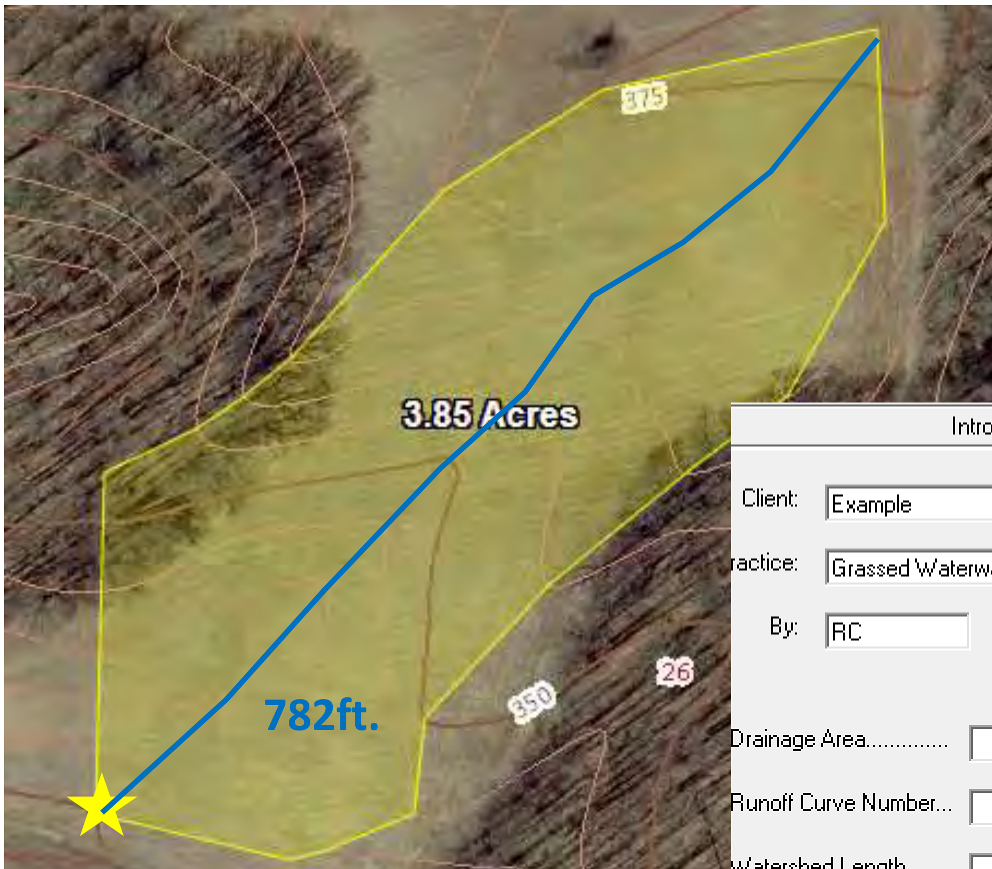


- Design storm for Grassed Waterway is 10-yr, 24-hr
- Analyze for each portion of the waterways.



Step 4: Compute the peak runoff produced by the design storm.

- Design storm for Grassed Waterway is 10-yr, 24-hr
- Analyze for each portion of the waterways.



Introduction | **Basic data**

Client: Example State: VA County: Louisa NOAA-C

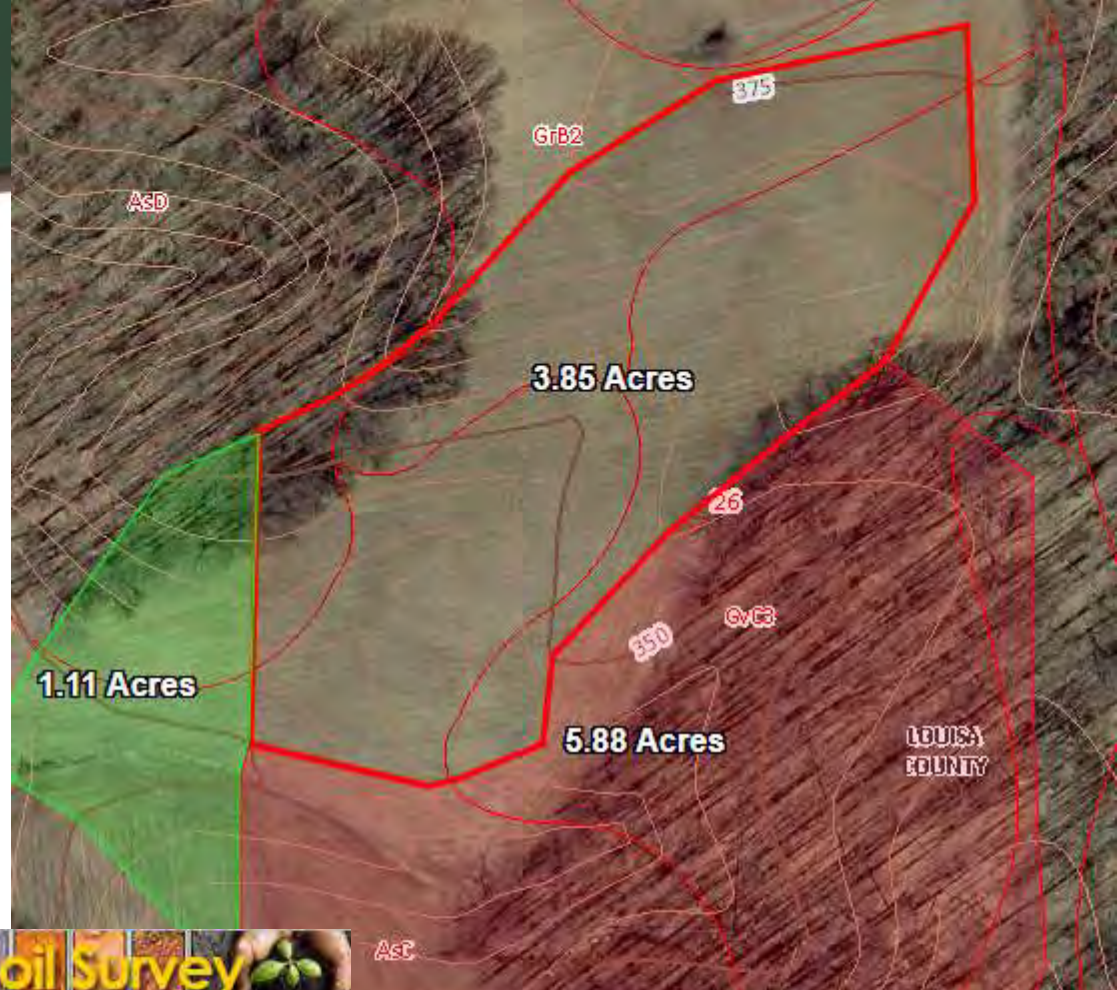
ractice: Grassed Waterway - Area 1

By: RC Date: 8/18/2017

Drainage Area.............	3.85	acres	from RCN Calculator
Runoff Curve Number...	74		from RCN Calculator
Watershed Length	782	feet	
Watershed Slope	9.5	percent	
Time of Concentration ..	0.17	hours	calculated

DCR
Virginia Department of Conservation & Recreation

- All soils are HSG B
  - 3.6ac. row crops
  - 0.25ac. woods



Web Soil Survey

Tables — Hydrologic Soil Group — Summary By Map Unit

Summary by Map Unit — Louisa County, Virginia (VA109)

Map unit symbol	Map unit name	Rating
AsC	Ashlar sandy loam, 7 to 15 percent slopes	B
AsC3	Ashlar sandy loam, 7 to 15 percent slopes, severely eroded	B
AsD	Ashlar sandy loam, 15 to 25 percent slopes	B
GrB2	Grover sandy loam, 2 to 7 percent slopes, eroded	B
GvC3	Grover sandy clay loam, 7 to 15 percent slopes, severely eroded	B

Virginia Department of Conservation & Recreation

EFH-2 ESTIMATING RUNOFF AND PEAK DISCHARGE Version 1.1.2

Curve number Computation

Client: Example
County: Louisa NOAA-C State: VA
Practice: Grassed Waterway - Area 1
Calculated By: RC Date: 8/18/2017
Checked By: __________ Date: ____________

COVER DESCRIPTION			Acres (CN) Hydrologic Soil Group			
			A	B	C	D
CULTIVATED AGRICULTURAL LANDS						
Row crops	SR + Crop residue	good	-	3.6(75)	-	-
OTHER AGRICULTURAL LANDS						
Woods		good	-	.25(55)	-	-
Total Area (by Hydrologic Soil Group)				3.85		

TOTAL DRAINAGE AREA: 3.85 Acres WEIGHTED CURVE NUMBER: 74

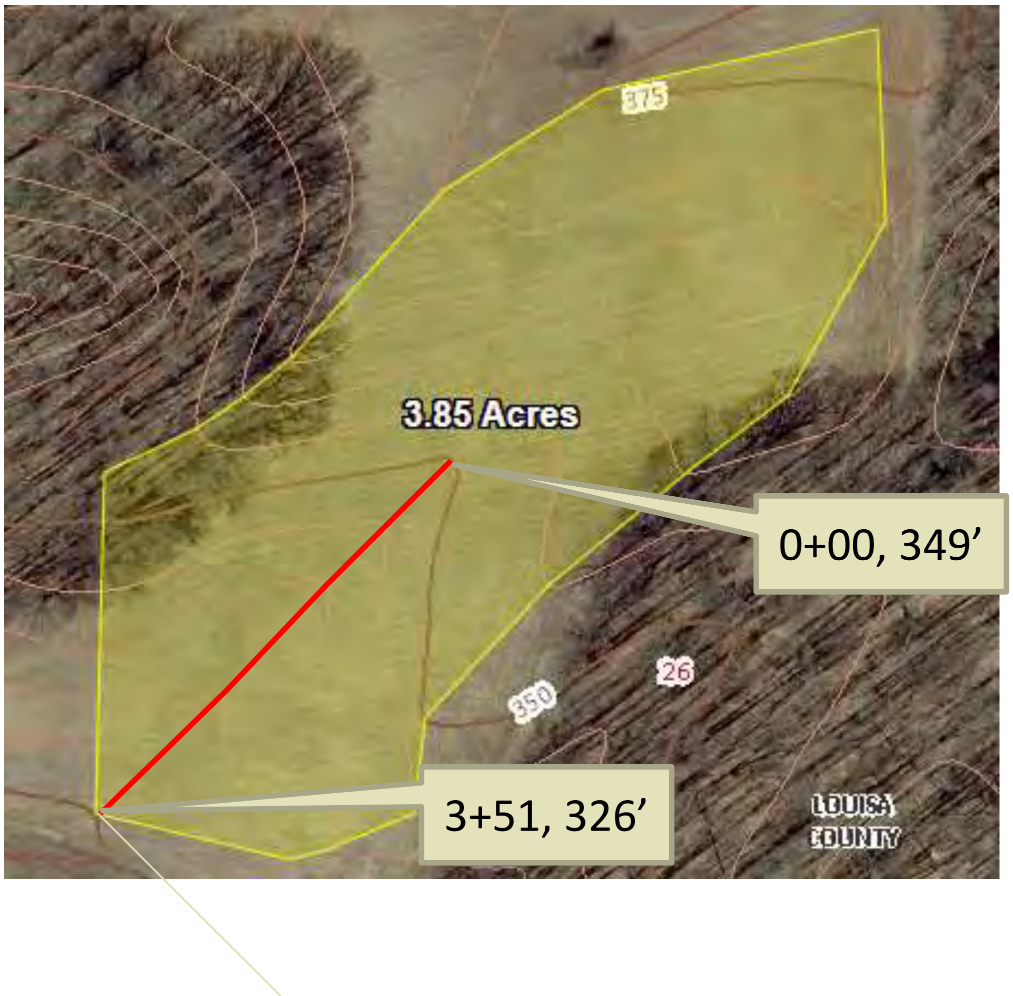
DCR
Virginia Department of Conservation & Recreation

Drainage Area:	3.85	Acres	(provided from RCN Calculator)
Curve Number:	74		(provided from RCN Calculator)
Watershed Length:	782	Feet	
Watershed Slope:	9.5	Percent	
Time of Concentration:	0.17	Hours	(calculated value)
Rainfall Type:	II		

Storm Number	1	2	3	4	5	6	7
Frequency (yrs)	1	2	5	Q 10	25	50	100
24-Hr rainfall (in)	2.70	3.30	4[illegible]	5.00	6.20	7.20	8.30
Ia/P Ratio	00.26	00.21	[illegible].17	00.14	00.11	00.10	00.08
Used	00.26	00.21	00.17	00.14	00.11	00.10	00.10
Runoff (in)	.72	1.10	1.74	2.36	3.35	4.22	5.19
(ac-ft)	00.23	00.35	00.56	00.76	01.07	01.35	01.67
Unit Peak Discharge (cfs/acre/in)	01.208	01.245	0[illegible]280	01.301	01.322	01.332	01.332
Peak Discharge (cfs)	3	5	9	12	17	22	27

Design Flow = Q_{10} = 12cfs

Step 5: Determine the slope of each reach of the channel from the ~~topographic map,~~ profiles, or cross sections.



Determine slope of waterway:

$$\text{Slope(\%)} = \frac{\Delta\text{Elevation}}{\Delta\text{Distance}} \times 100$$

ΔElevation = 349’ – 326’ = 23’

ΔDistance = 3+51 – 0+00 = 351’

$$\text{Slope(\%)} = \frac{\Delta\text{Elevation}=23'}{\Delta\text{Distance}=351'} \times 100$$

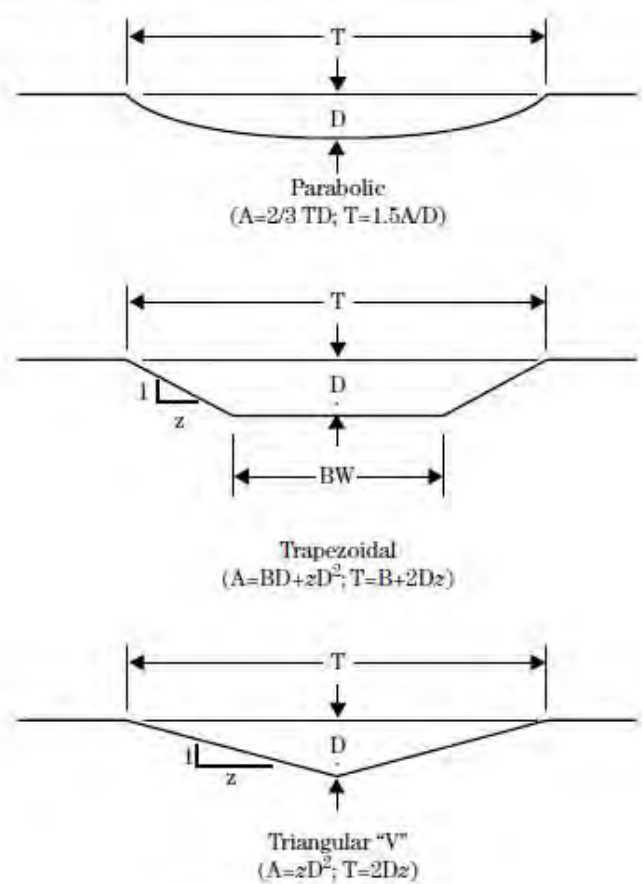
Slope(%) = **6.6%**

What if the slope of your waterway varies?

- Use *highest* measured slope for *stability* calculation
  - Make sure the channel won't *erode* where water is moving the *fastest*
- Use *lowest* measured slope for *capacity* calculation
  - Make sure the channel won't *overtop* where water is moving the *slowest*

Step 6: Select the appropriate channel cross-section and the type of channel lining(s) to be used.

Figure 7–1 Typical waterway cross sections

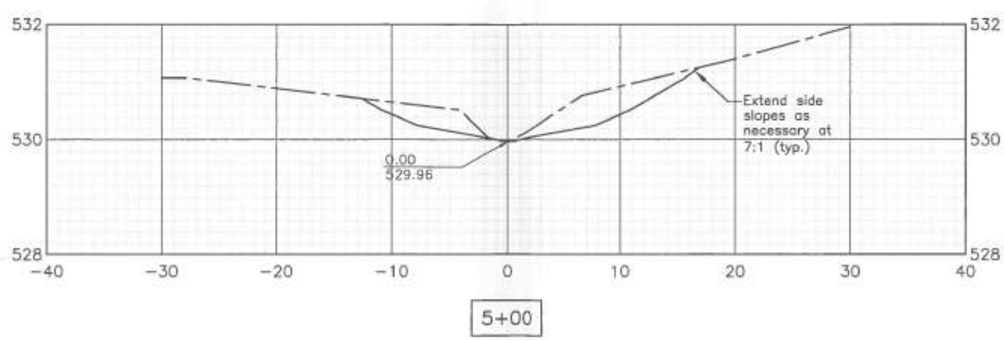


Advantages	Disadvantages
-Mimics natural shape of most drainage swales -"Most common & generally the most satisfactory"	-Sometimes difficult to install true parabolic shape
-Easy shape to form in field -Steep side slopes can make it difficult for equipment to cross (can be an advantage if you don't want equipment to cross it)	-Steep side slopes can make it difficult for equipment to cross -If bottom is not perfectly level, flow concentrates on one side
-May be easy to install for contractors who install a lot of road ditches	-Low flows concentrate at bottom of "V" and cause erosion -Sharp "V" can make it difficult for equipment to cross

Virginia Department of Conservation & Recreation

Step 6: Select the appropriate channel cross-section and the type of channel lining(s) to be used.

- Check with producer:
  - What type of grading equipment is available for use?
  - What type of equipment and implements will he need to cross the waterway with?
    - NOTE: CPS 412 says to “Avoid using waterways as turn-rows during tillage and cultivation operations” and “Avoid crossing with heavy equipment when wet”
- Look at your surveyed cross-sections: which type of channel can be installed most efficiently?



- Can try several channel types as you move through the calculations to see which would require the smallest footprint
  - Less expense to install (benefit to State and producer)
  - Less land taken out of production (benefit to producer)

Step 7: Design the channel for stability, typically based on the sparsest and shortest vegetation expected.

- Stability → Making sure the channel will not ERODE

To accomplish this requires limiting the stress on the soil and vegetation such that soil particles will not be detached and the vegetation will not be damaged.

$$\tau_e = \gamma DS(1 - C_F)\left(\frac{n_s}{n}\right)^2 \qquad \text{(eq. 7–1)}$$

where:

γ = unit weight of water, 62.4 lb/ft³
D = maximum flow depth in the cross section
C_F = a vegetal cover factor
n_s = roughness associated with soil grain size
n = Manning's roughness coefficient
S = channel bed slope, ft/ft

Step 8: Adjust the depth to obtain adequate capacity based on the densest and longest vegetation expected.

- Capacity → Making sure the channel will not OVERTOP

Calculate capacity when channel looks like this (thick grass reduces capacity):

Calculate velocity when channel looks like this (thin grass increases velocity):

DCR
Virginia Department of Conservation & Recreation

Steps 7 & 8

Steps in waterway design are as follows:

Step 1 Determine allowable effective stress based on an evaluation of the soil material.

Step 2 Determine the flow retardance and the allowable stress on the vegetation based on the sparsest and shortest vegetation expected (typically winter vegetation) and the flow retardance offered by the densest and longest vegetation (typically summer vegetation).

Step 3 Determine the vegetal cover factor associated with sparsest vegetation expected.

Step 4 Determine the bed slope.

Step 5 Choose a cross section shape.

Step 6 Use design aids or equations to size channel for sparsest and shortest vegetation.

Step 7 Use design aids or equations to determine depth required to contain the flow for densest and longest vegetation.

Step 8 Add freeboard as appropriate.

Steps in waterway design are as follows:

Step 1 Determine allowable effective stress based on an evaluation of the soil material.

Step 2 Determine the flow retardance and the allowable stress on the vegetation based on the sparsest and shortest vegetation expected (typically winter vegetation) and the flow retardance offered by the densest and longest vegetation (typically summer vegetation).

Step 3 Determine the vegetal cover factor associated with sparsest vegetation expected.

Step 4 Determine the bed slope.

Step 5 Choose a cross section shape.

Step 6 Use design aids or equations to size channel for sparsest and shortest vegetation.

Step 7 Use design aids or equations to determine depth required to contain the flow for densest and longest vegetation.

Step 8 Add freeboard as appropriate.

(1) Determination of allowable effective stress

The erodibility of the soil may be estimated to fall into one of these categories:

- easily eroded (sand textural soil classification)
- erodible (silt textural soil classification)
- erosion resistant (clay textural soil classification)
- very erosion resistant (based on local information or experience) (gravel textural soil classification)

Table 7–1 Allowable effective stress for categories of soil erodibility

Category	Allowable stress, τ_a, lb/ft²
Easily eroded	0.02
Erodible	0.03
Erosion resistant	0.05
Very erosion resistant	0.07

Virginia Department of Conservation & Recreation

Table 7–3 Properties of grass channel linings; values apply to good uniform stands of each cover[1/]

Cover factor, C_F	Covers tested	Reference stem density (stem/ft²)
0.90	Bermudagrass	500
	Centipedegrass	500
0.87	Buffalograss	400
	Kentucky bluegrass	350
	Blue grama	350
0.75	Grass mixture	200
0.5	Weeping lovegrass	350
	Yellow bluestem	250
	Alfalfa[2/]	500
	Lespedeza sericea[2/]	300
	Common lespedeza	150
	Sudangrass	50

1/ Multiply the stem densities given by 1/3, 2/3,1, 4/3, and 5/3, for poor, fair, good, very good, and excellent covers, respectively. The equivalent adjustment to C_F remains a matter of engineering judgment until more data are obtained or a more analytic model is developed. A reasonable, but arbitrary, approach is to reduce the cover factor by 20 percent for fair stands and 50 percent for poor stands. C_F values for untested covers may be estimated by recognizing that the cover factor is dominated by density and uniformity of cover near the soil surface. Thus, the sod-forming grasses near the top of the table exhibit higher C_F values than the bunch grasses and annuals near the bottom.

2/ For the legumes tested, the effective stem count for resistance (given) is approximately five times the actual stem count very close to the bed. Similar adjustment may be needed for other unusually large-stemmed, branching, and/ or woody vegetation.

$C_F = 0.75$

Virginia Department of Conservation & Recreation

Steps in waterway design are as follows:

Step 1 Determine allowable effective stress based on an evaluation of the soil material.

Step 2 Determine the flow retardance and the allowable stress on the vegetation based on the sparsest and shortest vegetation expected (typically winter vegetation) and the flow retardance offered by the densest and longest vegetation (typically summer vegetation).

Step 3 Determine the vegetal cover factor associated with sparsest vegetation expected.

Step 4 Determine the bed slope.

Step 5 Choose a cross section shape.

Step 6 Use design aids or equations to size channel for sparsest and shortest vegetation.

Step 7 Use design aids or equations to determine depth required to contain the flow for densest and longest vegetation.

Step 8 Add freeboard as appropriate.

Table 7–4 Classification of vegetation cover as to degree of retardance

Retardance	Cover	Condition
A	Weeping lovegrass	Excellent stand, tall (average 30 in)
	Reed canarygrass or Yellow bluestem ischaemum	Excellent stand, tall (average 36 in)
B	Smooth bromegrass	Good stand, mowed (average 12 to 15 in)
	Bermudagrass	Good stand, tall (average 12 in)
	Native grass mixture (little bluestem, blue grama, and other long and short midwest grasses	Good stand, unmowed
	Tall fescue	Good stand, unmowed (average 18 in)
	Sericea lespedeza	Good stand, not woody, tall (average 19 in)
	Grass-legume mixture—Timothy, smooth bromegrass, or orchardgrass	Good stand, uncut (average 20 in)
	Reed canarygrass	Good stand, uncut (average 12 to 15 in)
	Tall fescue, with birdsfoot trefoil or ladino clover	Good stand, uncut (average 18 in)
	Blue grama	Good stand, uncut (average 13 in)
C	Bahiagrass	Good stand, uncut (6 to 8 in)
	Bermudagrass	Good stand, mowed (average 6 in)
	Redtop	Good stand, headed (15 to 20 in)
	Grass-legume mixture—summer (orchardgrass, redtop, Italian ryegrass, and common lespedeza)	Good stand, uncut (6 to 8 in)
	Centipedegrass	Very dense cover (average 6 in)
	Kentucky bluegrass	Good stand, headed (6 to 12 in)
D	Bermudagrass	Good stand, cut to 2.5-in height
	Red fescue	Good stand, headed (12 to 18 in)
	Buffalograss	Good stand, uncut (3 to 6 in)
	Grass-legume mixture—fall, spring (orchardgrass, redtop, Italian ryegrass, and common lespedeza)	Good stand, uncut (4 to 5 in)
	Sericea lespedeza or Kentucky bluegrass	Good stand, cut to 2-in height. Very good stand before cutting
E	Bermudagrass	Good stand, cut to 1.5-in height
	Bermudagrass	Burned stubble

Steps in waterway design are as follows:

0.02 *Step 1* Determine allowable effective stress based on an evaluation of the soil material.

C_F = 0.75 *Step 2* Determine the flow retardance and the allowable stress on the vegetation based on the sparsest and shortest vegetation expected (typically winter vegetation) and the flow retardance offered by the densest and longest vegetation (typically summer vegetation).

D *Step 3* Determine the vegetal cover factor associated with sparsest vegetation expected.

Step 4 Determine the bed slope.

Step 5 Choose a cross section shape.

Step 6 Use design aids or equations to size channel for sparsest and shortest vegetation.

Step 7 Use design aids or equations to determine depth required to contain the flow for densest and longest vegetation.

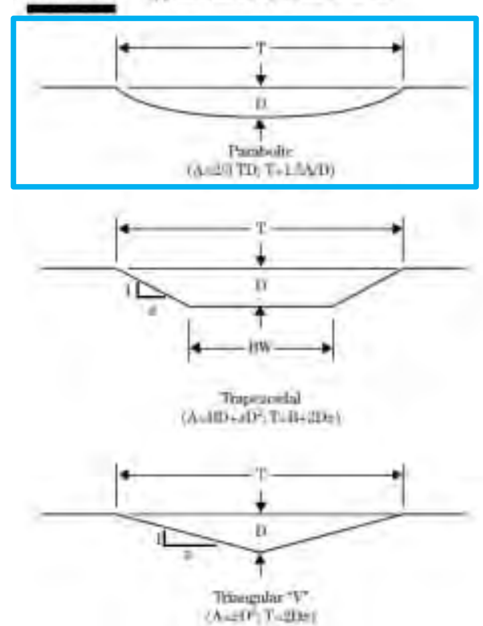
Step 8 Add freeboard as appropriate.

Determine slope of waterway:

$$\textbf{Slope(\%)} = \frac{\Delta \text{Elevation}}{\Delta \text{Distance}}$$

Slope(%) = 6.6%

Figure 7-1 Typical waterway cross sections



Virginia Department of Conservation & Recreation

Steps in waterway design are as follows:

0.02 *Step 1* Determine allowable effective stress based on an evaluation of the soil material.

C_F = 0.75 *Step 2* Determine the flow retardance and the allowable stress on the vegetation based on the sparsest and shortest vegetation expected (typically winter vegetation) and the flow retardance offered by the densest and longest vegetation (typically summer vegetation).

D *Step 3* Determine the vegetal cover factor associated with sparsest vegetation expected.

6.6% *Step 4* Determine the bed slope.

P *Step 5* Choose a cross section shape.

Step 6 Use design aids or equations to size channel for sparsest and shortest vegetation.

Step 7 Use design aids or equations to determine depth required to contain the flow for densest and longest vegetation.

Step 8 Add freeboard as appropriate.

Table 7–4 Classification of vegetation cover as to degree of retardance

Retardance	Cover	Condition
A	Weeping lovegrass	Excellent stand, tall (average 30 in)
	Reed canarygrass or Yellow bluestem ischaemum	Excellent stand, tall (average 36 in)
B	Smooth bromegrass	Good stand, mowed (average 12 to 15 in)
	Bermudagrass	Good stand, tall (average 12 in)
	Native grass mixture (little bluestem, blue grama, and other long and short midwest grasses	Good stand, unmowed
	Tall fescue	Good stand, unmowed (average 18 in)
	Sericea lespedeza	Good stand, not woody, tall (average 19 in)
	Grass-legume mixture—Timothy, smooth bromegrass, or orchardgrass	Good stand, uncut (average 20 in)
	Reed canarygrass	Good stand, uncut (average 12 to 15 in)
	Tall fescue, with birdsfoot trefoil or ladino clover	Good stand, uncut (average 18 in)
	Blue grama	Good stand, uncut (average 13 in)
C	Bahiagrass	Good stand, uncut (6 to 8 in)
	Bermudagrass	Good stand, mowed (average 6 in)
	Redtop	Good stand, headed (15 to 20 in)
	Grass-legume mixture—summer (orchardgrass, redtop, Italian ryegrass, and common lespedeza)	Good stand, uncut (6 to 8 in)
	Centipedegrass	Very dense cover (average 6 in)
	Kentucky bluegrass	Good stand, headed (6 to 12 in)
D	Bermudagrass	Good stand, cut to 2.5-in height
	Red fescue	Good stand, headed (12 to 18 in)
	Buffalograss	Good stand, uncut (3 to 6 in)
	Grass-legume mixture—fall, spring (orchardgrass, redtop, Italian ryegrass, and common lespedeza)	Good stand, uncut (4 to 5 in)
	Sericea lespedeza or Kentucky bluegrass	Good stand, cut to 2-in height. Very good stand before cutting
E	Bermudagrass	Good stand, cut to 1.5-in height
	Bermudagrass	Burned stubble

DCR
Virginia Department of Conservation & Recreation

Steps in waterway design are as follows:

0.02 *Step 1* Determine allowable effective stress based on an evaluation of the soil material.

C_F = 0.75 *Step 2* Determine the flow retardance and the allowable stress on the vegetation based on the sparsest and shortest vegetation expected (typically winter vegetation) and the flow retardance offered by the densest and longest vegetation (typically summer vegetation).

D *Step 3* Determine the vegetal cover factor associated with sparsest vegetation expected.

6.6% *Step 4* Determine the bed slope.

P *Step 5* Choose a cross section shape.

Step 6 Use design aids or equations to size channel for sparsest and shortest vegetation.

B *Step 7* Use design aids or equations to determine depth required to contain the flow for densest and longest vegetation.

Step 8 Add freeboard as appropriate.

Finally…

- Now we have enough information to use the charts in Appendix C of EFH7

The tables are organized according to input parameters:

Steps in waterway design are as follows:

0.02 *Step 1* Determine allowable effective stress based on an evaluation of the soil material.

0.75 *Step 2* Determine the flow retardance and the allowable stress on the vegetation based on the sparsest and shortest vegetation expected (typically winter vegetation) and the flow retardance offered by the densest and longest vegetation (typically summer vegetation).

D *Step 3* Determine the vegetal cover factor associated with sparsest vegetation expected.

6.6% *Step 4* Determine the bed slope.

P *Step 5* Choose a cross section shape.

Step 6 Use design aids or equations to size channel for sparsest and shortest vegetation.

B *Step 7* Use design aids or equations to determine depth required to contain the flow for densest and longest vegetation.

Step 8 Add freeboard as appropriate.

- Channel Type: Parabolic
- Cover Factor: 0.75
- Allowable Soil Stress: 0.02
- __-__ Design: B-D
- Side Slope (for trapezoids) (n/a)

Find the table that matches ALL of these parameters.

In our example, it can be found on page 7D-5

Input Parameters:

Channel Type = Parabolic

Cover factor = 0.75

Allowable Soil Stress = 0.02

B-D Design

Q	S = 0.1%		S = 0.25%		S = 0.5%		S = 0.75%		S = 1%		S = 1.25%		S = 1.5%		S = 1.75%		S = 2%		S = 3%		S = 4%		S = 5%		S = 6%		S = 8%		S = 10%	
	D(ft)	T(ft)	D(ft)	T(ft)	D(ft)	T(ft)	D(ft)	T(ft)	D(ft)	T(ft)	D(ft)	T(ft)	D(ft)	T(ft)	D(ft)	T(ft)	D(ft)	T(ft)	D(ft)	T(ft)	D(ft)	T(ft)	D(ft)	T(ft)	D(ft)	T(ft)	D(ft)	T(ft)	D(ft)	T(ft)
10													1.5	9	1.3	9	1.3	10	1.1	13	0.9	16	0.9	19	0.8	21	0.7	25	0.6	28
20							2	11	1.7	13	1.5	15	1.4	17	1.3	19	1.2	21	1	27	0.9	32	0.9	37	0.8	41	0.7	50	0.6	55
30							1.9	16	1.7	19	1.5	22	1.4	25	1.3	28	1.2	31	1	40	0.9	48	0.9	56	0.8	62	0.7	74	0.6	83
40					2.4	16	1.9	21	1.7	26	1.5	30	1.4	34	1.3	38	1.2	41	1	54	0.9	64	0.9	74	0.8	83	0.7	99	0.6	110
50					2.3	20	1.9	26	1.7	32	1.5	37	1.4	42	1.3	47	1.2	51	1	67	0.9	80	0.9	93	0.8	104	0.7	124		
60					2.3	23	1.9	31	1.6	39	1.5	45	1.4	51	1.3	56	1.2	62	1	80	0.9	97	0.9	111	0.8	124				
70					2.3	27	1.9	37	1.6	45	1.5	52	1.4	59	1.3	66	1.2	72	1	94	0.9	113	0.9	130	0.8	145				
80			3.5	19	2.3	31	1.9	42	1.6	51	1.5	60	1.4	68	1.3	75	1.2	82	1	107	0.9	129	0.9	148						
90			3.5	21	2.3	35	1.9	47	1.6	58	1.5	67	1.4	76	1.3	85	1.2	92	1	120	0.9	145	0.9	167						
100			3.4	23	2.3	39	1.9	52	1.6	64	1.5	75	1.4	85	1.3	94	1.2	103	1	134	0.9	161								

Q=12cfs

S=6.6%

Luckily… ParabolicChannel.xlsx

Velocity/Stress Check

Design Flow, Q	12	cfs
Channel Slope, S	0.066	ft/ft
SCS Retardance Class	D	
Retardance Curve Index, Ci	4.44	
Cover Factor, Cf	0.75	
Allowable Stress, Ta	0.02	lb/ft^2
Trial Depth, D	0.41	ft
Calculated Top Width, T (ft)	21	

Depth/Stress Check

Design Flow, Q	12	cfs
Channel Slope, S	0.066	ft/ft
SCS Retardance Class	B	
Retardance Curve Index, Ci	7.64	
Cover Factor, Cf	0.75	
Allowable Stress, Ta	0.02	lb/ft^2
Trial Top Width, T	21	ft
Vegetal Stress Check	OK	

Final Dimensions (with Freeboard)

Total Top Width, T	26.2	ft
Total Depth, D	1.4	ft
Side Slope at D	4.68	:1

Final Dimensions (without Freeboard)

Total Top Width, T	21.0	ft
Total Depth, D	0.9	ft
Side Slope at D	5.83	:1

Can also check TrapezoidalChannel.xlsx

Velocity/Stress Check

Design Flow, Q	12	cfs
Channel Slope, S	0.066	ft/ft
Side Slope, z	6	:1
SCS Retardance Class	D	
Retardance Curve Index, Ci	4.44	
Cover Factor, Cf	0.75	
Allowable Stress, Ta	0.02	lb/ft^2
Trial Depth, D	0.34	ft
Calculated Top Width, T (ft)	12	

Depth/Stress Check

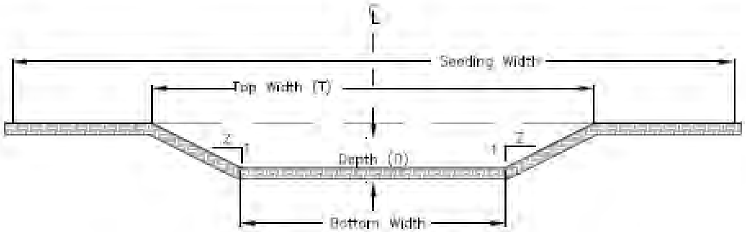
Design Flow, Q	12	cfs
Channel Slope, S	0.066	ft/ft
Side Slope, z	6	:1
SCS Retardance Class	B	
Retardance Curve Index, Ci	7.64	
Cover Factor, Cf	0.75	
Allowable Stress, Ta	0.02	lb/ft^2
Trial Top Width, T	12	ft
Vegetal Stress Check	OK	

Final Dimensions (with 0.5 ft of Freeboard)

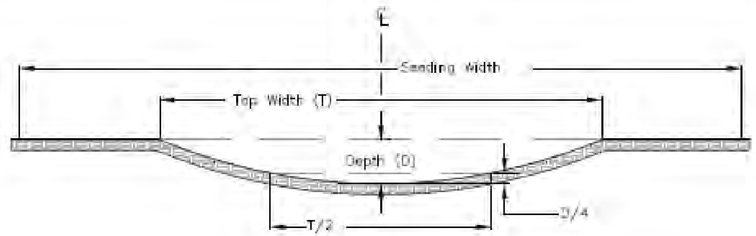
Total Top Width, T	26.4	ft
Total Bottom Width, B	12.0	ft
Total Depth, D	1.2	ft

Final Dimensions (without Freeboard)

Total Top Width, T	20.4	ft
Total Bottom Width, B	12.0	ft
Total Depth, D	0.7	ft



Trapezoidal (T) Cross Section



Parabolic (P) Cross Section

Construction Data

Waterway No.	1					
Reach No.	A					
Slope (%)	6.6					
Shape (P or T)	P					
Depth D (ft.)	0.9					
Top Width T (ft.)	21					
Depth/4 (ft.)	0.23	0	0	0	0	
Top Width/2 (ft.)	10.5	0	0	0	0	
Bottom Width (ft.)	N/A					
Side Slopes Z (Z:1)	N/A					
Length (ft.)	351					
Seeding Width (ft.)	40					
Seeding Area (sq. ft.)	14,000	0	0	0	0	
Seeding Area (acres)	Total sq. ft./43560 = acres				0.0	Total acres

Material Quantities

Materials	Type	Rate	Total Lbs
Seed			0.0
			0.0
			0.0
			0.0
Fertilizer			0.0
Lime			0.0
Mulch			0.0
			0.0

The applicable seeding period for this job is ______ to ______

Grassed Waterway

Quantities for Seed Establishment

- CPS 412 references CPS 342 Critical Area Planting

Amend soil to eliminate conditions inhibiting plant establishment. If practical, base rates on soil testing. Otherwise, incorporate fertilizer equivalent to 1,000 lbs of 10-10-10 per acre and lime equivalent to two tons per acre into soil during final seedbed preparation immediately ahead of plant establishment.

Mulch as needed for successful plant establishment and erosion prevention. Typically, provide 70% cover (approx. 2,000 lbs. straw per acre) with appropriate erosion control netting to hold the seed and straw in place. Refer to Mulching Standard (VA-484) as needed.

Choose species and associated planting specifications (seeding rates, dates, depths, and methods) consistent with the Plant Establishment Guide for Virginia (use seeding rates from the erosion prevention section coupled with appropriate nurse crop) or other Virginia technical notes and approved guidance.

NRCS Plant Establishment Guide

Species #	Species	Seeding Rate (lb/acre) PLS B:broadcast; D:drill (4-9" row)	Plant Depth (in.)	Mountain/Valley/Northern Piedmont		Southern Piedmont		Coastal Plain	
				Best Dates	Possible Dates	Best Dates	Possible Dates	Best Dates	Possible Dates
	Average La			1-May		15-Apr		1-Apr	
	PERENNIAL GRASSES[1]								
1	**Tall Fescue** (use in high velocity and highly erosive situations	B: 60	¼-½	Aug 15-Sep 10; Mar 15-Apr 10	Aug 1-Sep 30; Mar 1-Apr 30	Sep 1-Sep 20; Mar 1-Apr 1	Aug 25-Nov 1; Feb 15-Apr 15	Sep 1-Oct 10; Feb 1-Mar 10	Sep 1-Nov 10; Feb 1-Mar 20
2	**Switchgrass**	D:10; B:15	¼	Mar 15-Jun 30		Mar 1-Jun15		Feb 15-Jun 1	
	MIXTURES								
3	**Tall Fescue + Ladino Clover**	B:40+3	¼	Aug 15-Sep 10; Mar 15-Apr 10	Aug 1-Sep 30; Mar 1-Apr 30	Sep 1-Sep 20; Mar 1-Apr 1	Aug 25-Nov 1; Feb 15-Apr 15	Sep 1-Oct 10; Feb 1-Mar 10	Sep 1-Nov 10; Feb 1-Mar 20
4	**Tall Fescue + Red Clover**	B:40+6	¼	Aug 15-Sep 10; Mar 15-Apr 10	Aug 1-Sep 30; Mar 1-Apr 30	Sep 1-Sep 20; Mar 1-Apr 1	Aug 25-Nov 1; Feb 15-Apr 15	Sep 1-Oct 10; Feb 1-Mar 10	Sep 1-Nov 10; Feb 1-Mar 20
5	**Tall Fescue + Annual Lespedeza**	B:40+10; D:30+8	¼	Mar 1-Apr 15		Feb 15-Apr 1		Feb 1-Mar 15	
6	**Tall Fescue + Redtop**	D/B: 40+10	¼-½	Jul 25-Sep 1; Mar 20-Apr 20	Jul 15-Sep 15; Mar 1-May 15	Aug 25-Sep 15	Aug 25-Oct 25; Feb 15-Mar 31	Sep 1-Sep 30	Sep 1-Oct 31; Feb 15-Mar 20
7	**Switchgrass + Red Fescue + Partridge Pea**	D/B: 10+15+4	¼	Mar 15-April 30	Mar 15-Jun 30	Mar 1-Apr 15	Feb 15-May 31	Feb 15-Mar 31	Feb 1-April 30
8	**Switchgrass + Indiangrass + Big Bluestem**	D/B: 5 each	¼	Mar 15-Jun 30		Mar 1-Jun15		Feb 15-Jun 1	
9	**Tall Fescue + Redtop + Birdsfoot Trefoil**	D/B: 60+6+10	¼-½	Jul 25-Sep 1; Mar 20-Apr 20	Jul 15-Sep 15; Mar 1-May 15	Aug 25-Sep 15	Aug 25-Oct 25; Feb 15-Mar 31	Sep 1-Sep 30	Sep 1-Oct 31; Feb 15-Mar 20
10	**Switchgrass + Deer tongue + Partridge Pea**	D/B: 8+8+4	¼	Mar 15-April 30	Mar 15-Jun 30	Mar 1-Apr 15	Feb 15-May 31	Feb 15-Mar 31	Feb 1-April 30
11	**Perennial Ryegrass + Redtop**	D:5+2; B:7+3	½-¾	Mar 1-Apr 15	Aug 1-Sep 15	Feb 15-April 1	Aug 15-Oct 1	Not adapted	

[1]For critical area establishment and grayays use an acceptable nurse crop.

VA Plant Establishment Guide | **Erosion Prevention** | Forage | Wildlife Herbaceous | Cov ...

- Seeding quantity recommendations from Permanent Seeding Spec from *Virginia Erosion and Sediment Control Handbook:*

TABLE 3.32-D
SITE SPECIFIC SEEDING MIXTURES FOR PIEDMONT AREA

General Slope (3:1 or less)

- Kentucky 31 Fescue	128 lbs.
- Red Top Grass	2 lbs.
- Seasonal Nurse Crop *	20 lbs.
	150 lbs.

* Use seasonal nurse crop in accordance with seeding dates as stated below:

February 16th through April	Annual Rye
May 1st through August 15th	Foxtail Millet
August 16th through October	Annual Rye
November through February 15th	Winter Rye

Erosion Control Matting:

From EFH7:

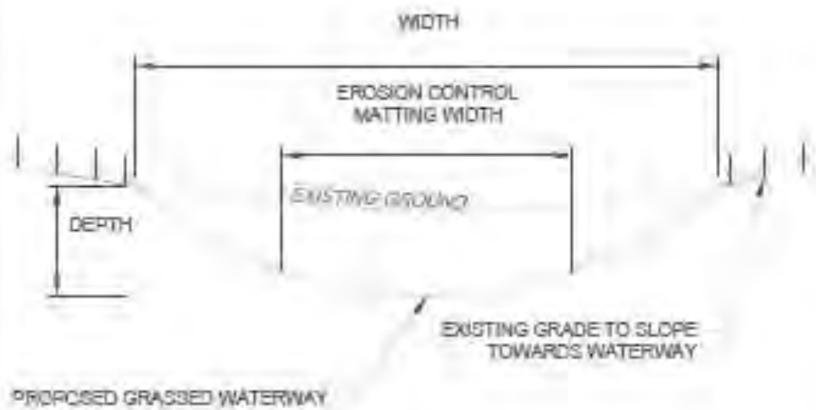
Mulching materials such as straw, hay, jute, paper, or plastic mesh should be used to protect new seeding. At least the center-third portion of the cross section should be anchored. If temporary seedings or nurse crops are used, they should be mowed to reduce competition to permanent seeding. All seeding, planting, sodding, and mulching should conform to standards as given in the local Field Office Technical Guide.

From CPS 412:

Vegetative Establishment. Establish vegetation as soon as possible using the criteria listed under "Establishment of Vegetation" in the Virginia NRCS CPS *Critical Area Planting (Code 342)*.

Establish vegetation as soon as conditions permit. Use mulch anchoring, nurse crop, rock or straw or hay bale dikes, fabric or rock checks, filter fences, or runoff diversion to protect the vegetation until it is established. Planting of a close growing crop, e.g. small grains or millet, on the contributing watershed prior to construction of the grassed waterway can also significantly reduce the flow through the waterway during establishment.

DCR
Virginia Department of Conservation & Recreation



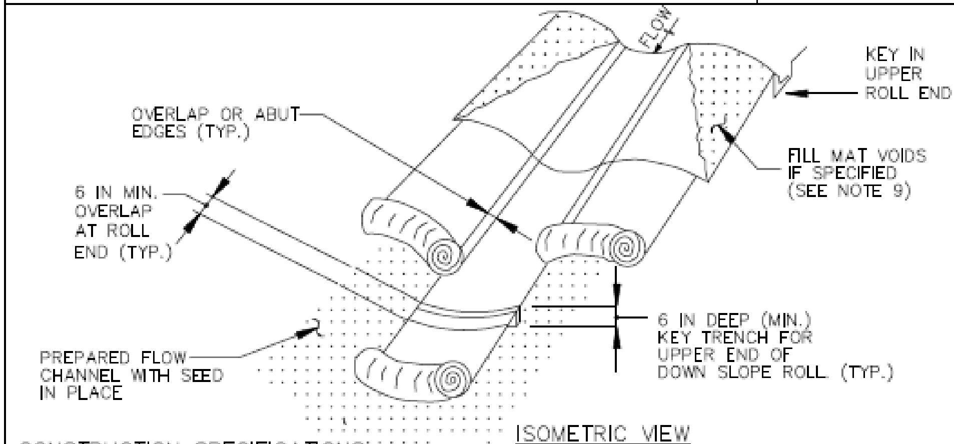
TYPICAL CROSS SECTION
NOT TO SCALE

GENERAL NOTES:
- REMOVE TOPSOIL PRIOR TO GRADING AND STOCKPILE OUTSIDE LIMITS OF WATERWAY CONSTRUCTION
- INSTALL EXCELSIOR TYPE EROSION CONTROL MATTING ACCORDING TO MANUFACTURE'S RECOMMENDATIONS. MATTING SHALL MEET MINIMUM SHEAR STRESS OF 1.75 LB/FT² AND MAXIMUM VELOCITIES OF 7FT/S (SEE EROSION CONTROL MATTING DETAIL SHEET FOR INSTALLATION INSTRUCTIONS)
- EROSION CONTROL MATTING WIDTH SHALL BE A MINIMUM OF 2/3 OF THE WATERWAY WIDTH OR SHOWN AS ABOVE
- A MINIMUM OF 4" OF TOPSOIL SHALL BE PLACED ALONG ENTIRE LENGTH AND WIDTH OF CONSTRUCTED WATERWAY
- LIME, FERTILIZER AND SEED SHALL BE PLACED IN WATERWAY PRIOR TO INSTALLING EROSION CONTROL MATTING (SEE SEEDING DETAILS)
- WATERWAY SHALL BE MAINTAINED AS NEEDED TO MINIMIZE EROSION THROUGHOUT THE REQUIRED MAINTENANCE LIFE OF 10 YEARS

USDA	412-A-GRASSED WATERWAY	DRAWING NO. 412-A-GWW
		ISSUE DATE 6/2014

DETAIL B-4-6-C PERMANENT SOIL STABILIZATION MATTING CHANNEL APPLICATION

STANDARD SYMBOL
PSSMC – * lb/f
(* INCLUDE SHEAR STRESS)



ISOMETRIC VIEW

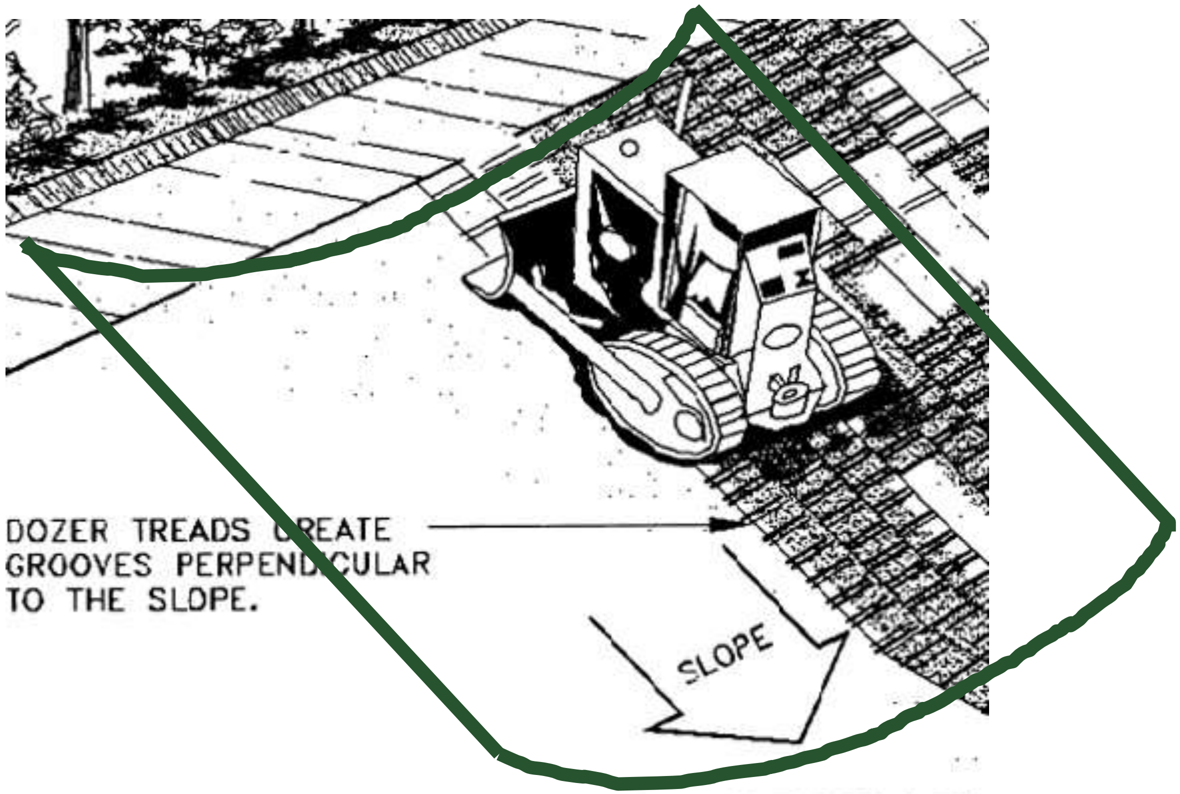
CONSTRUCTION SPECIFICATIONS:

1. USE MATTING THAT HAS A DESIGN VALUE FOR SHEAR STRESS EQUAL TO OR HIGHER THAN THE SHEAR STRES DESIGNATED ON APPROVED PLANS.
2. USE PERMANENT SOIL STABILIZATION MATTING MADE OF OPEN WEAVE SYNTHETIC, NON–DEGRADABLE FIBERS O ELEMENTS OF UNIFORM THICKNESS AND DISTRIBUTION THROUGHOUT. CHEMICALS USED IN THE MAT MUST BE NON–LEACHING AND NON–TOXIC TO VEGETATION AND SEED GERMINATION AND NON–INJURIOUS TO THE SKIN. I PRESENT, NETTING MUST BE EXTRUDED PLASTIC WITH A MAXIMUM MESH OPENING OF 2x2 INCHES AND SUFFICIENTLY BONDED OR SEWN ON 2 INCH CENTERS ALONG LONGITUDINAL AXIS OF THE MATERIAL TO PREVENT SEPARATION OF THE NET FROM THE PARENT MATERIAL.
3. SECURE MATTING USING STEEL STAPLES OR WOOD STAKES. STAPLES MUST BE "U" OR "T" SHAPED STEEL WIRE HAVING A MINIMUM GAUGE OF NO. 11 AND NO. 8 RESPECTIVELY. "U" SHAPED STAPLES MUST AVERAGE 1 TO 1 ½ INCHES WIDE AND BE A MINIMUM OF 6 INCHES LONG. "T" SHAPED STAPLES MUST HAVE A MINIMUM 8 INCH MAIN LEG, A MINIMUM 1 INCH SECONDARY LEG, AND MINIMUM 4 INCH HEAD. WOOD STAKES MUST BE ROUGH–SAWN HARDWOOD, 12 TO 24 INCHES IN LENGTH, 1x3 INCH IN CROSS SECTION, AND WEDGE SHAPE AT THE BOTTOM.
4. PERFORM FINAL GRADING, TOPSOIL APPLICATION, SEEDBED PREPARATION, AND PERMANENT SEEDING IN ACCORDANCE WITH SPECIFICATIONS. PLACE MATTING WITHIN 48 HOURS OF COMPLETING SEEDING OPERATIONS, UNLESS END OF WORKDAY STABILIZATION IS SPECIFIED ON THE APPROVED EROSION AND SEDIMENT CONTROL PLAN.
5. UNROLL MATTING IN DIRECTION OF WATER FLOW, CENTERING THE FIRST ROLL ON THE CHANNEL CENTER LINE. WORK FROM CENTER OF CHANNEL OUTWARD WHEN PLACING ROLLS. LAY MATTING SMOOTHLY AND FIRMLY UPO THE SEEDED SURFACE. AVOID STRETCHING THE MATTING.
6. OVERLAP OR ABUT EDGES OF MATTING ROLLS PER MANUFACTURER RECOMMENDATIONS. OVERLAP ROLL ENDS BY 6 INCHES (MINIMUM), WITH THE UPSTREAM MAT OVERLAPPING ON TOP OF THE NEXT DOWNSTREAM MAT.
7. KEY IN THE TOP OF SLOPE END OF MAT 6 INCHES (MINIMUM) BY DIGGING A TRENCH, PLACING THE MATTING ROLL END IN THE TRENCH, STAPLING THE MAT IN PLACE, REPLACING THE EXCAVATED MATERIAL, AND TAMPIN TO SECURE THE MAT END IN THE KEY.
8. STAPLE/STAKE MAT IN A STAGGERED PATTERN ON 4 FOOT (MAXIMUM) CENTERS THROUGHOUT AND 2 FOOT (MAXIMUM) CENTERS ALONG SEAMS, JOINTS, AND ROLL ENDS.
9. IF SPECIFIED BY THE DESIGNER OR MANUFACTURER AND DEPENDING ON THE TYPE OF MAT BEING INSTALLED, ONCE THE MATTING IS KEYED AND STAPLED IN PLACE, FILL THE MAT VOIDS WITH TOP SOIL OR GRANULAR MATERIAL AND LIGHTLY COMPACT OR ROLL TO MAXIMIZE SOIL/MAT CONTACT WITHOUT CRUSHING MAT.
10. ESTABLISH AND MAINTAIN VEGETATION SO THAT REQUIREMENTS FOR ADEQUATE VEGETATIVE ESTABLISHMENT ARE CONTINUOUSLY MET IN ACCORDANCE WITH SECTION B–4 VEGETATIVE STABILIZATION.

MARYLAND STANDARDS AND SPECIFICATIONS FOR SOIL EROSION AND SEDIMENT CONTROL

U.S. DEPARTMENT OF AGRICULTURE NATURAL RESOURCES CONSERVATION SERVICE	2011	MARYLAND DEPARTMENT OF ENVIRONMENT WATER MANAGEMENT ADMINISTRATION

Construction



TRACKING

DCR
Virginia Department of Conservation & Recreation

OPERATION AND MAINTENANCE

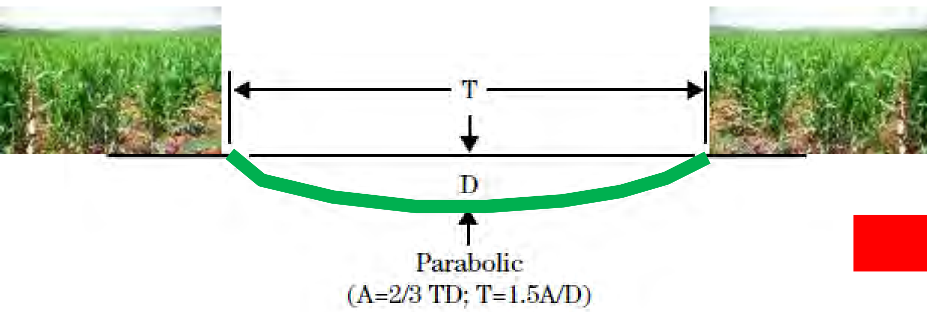
Provide an operation and maintenance plan to review with the landowner. Include the following items and others as appropriate in the plan.

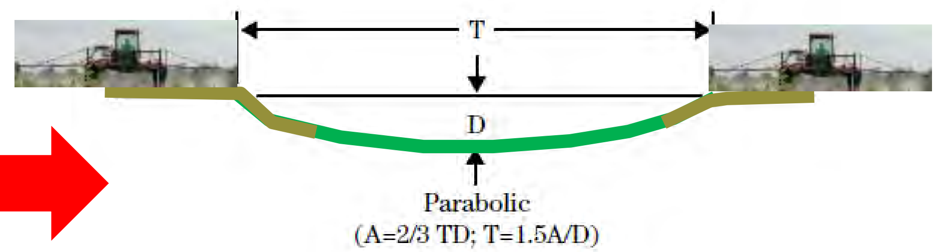
- Establish a maintenance program to maintain waterway capacity, vegetative cover, and outlet stability. Vegetation damaged by machinery, herbicides, or erosion must be repaired promptly.
- Protect the waterway from concentrated flow by using diversion of runoff or mechanical means of stabilization such as silt fences, mulching, hay bale barriers and etc. to stabilize grade during vegetation establishment.
- Minimize damage to vegetation by excluding livestock whenever possible, especially during wet periods. Permit grazing in the waterway only when a controlled grazing system is being implemented.
- Inspect grassed waterways regularly, especially following heavy rains. Fill, compact, and reseed damaged areas immediately. Remove sediment deposits to maintain capacity of grassed waterway.
- Avoid use of herbicides that would be harmful to the vegetation or pollinating insects in and adjacent to the waterway area.
- Avoid using waterways as turn-rows during tillage and cultivation operations.
- Mow or periodically graze vegetation to maintain capacity and reduce sediment deposition. Mowing may be appropriate to enhance wildlife values, but must be conducted to avoid peak nesting seasons and reduced winter cover.
- Apply supplemental nutrients as needed to maintain the desired species composition and stand density of the waterway.
- Control noxious weeds.
- Do not use waterways as a field road. Avoid crossing with heavy equipment when wet.
- Lift tillage equipment off the waterway when crossing and turn off chemical application equipment.

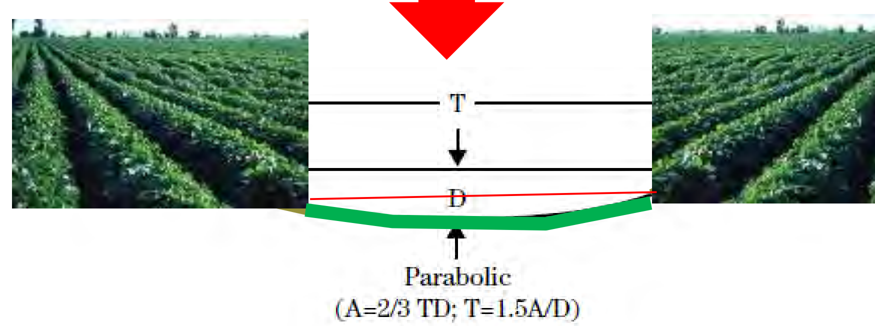
- Potential Herbicide Problems:
  - Drift into the waterways when spraying along the edges
  - Contract sprayers who aren’t familiar with the field may spray the entire field (including waterways) – especially when killing cover crops

Herbicide Drift: Effect on Waterway

- Avoid use of herbicides that would be harmful to the vegetation or pollinating insects in and adjacent to the waterway area.





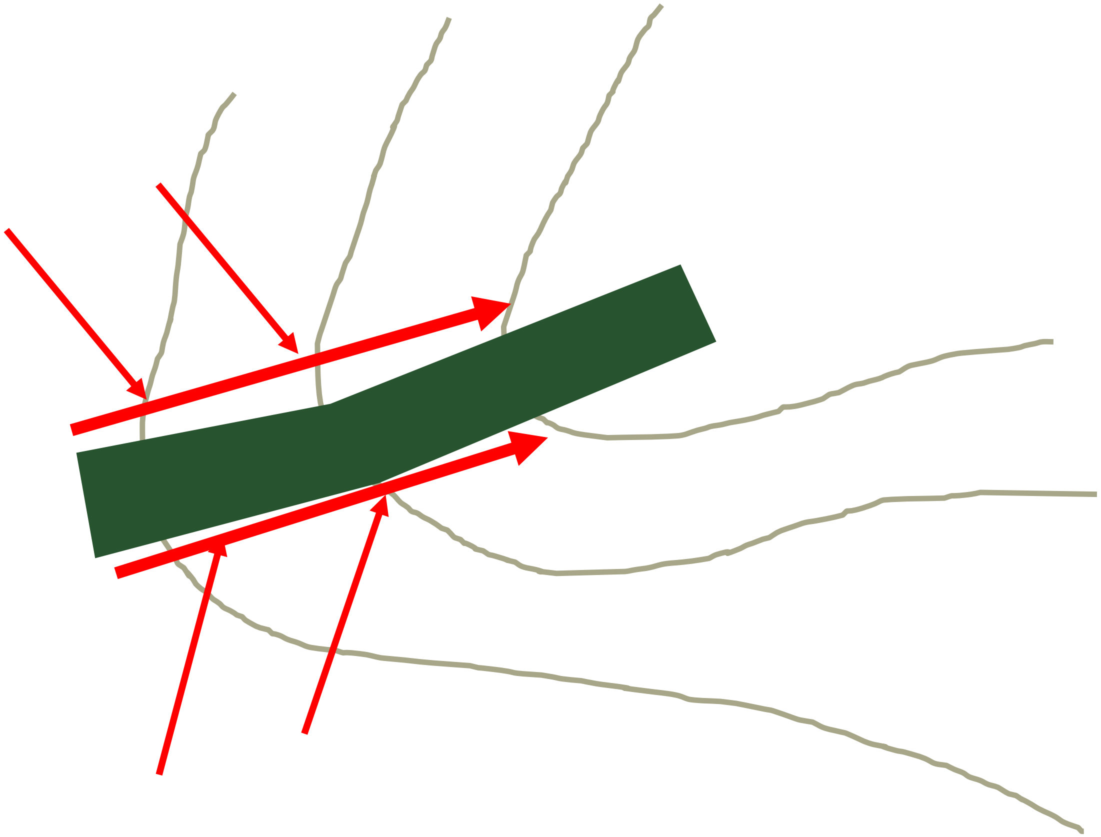


Reduced waterway capacity

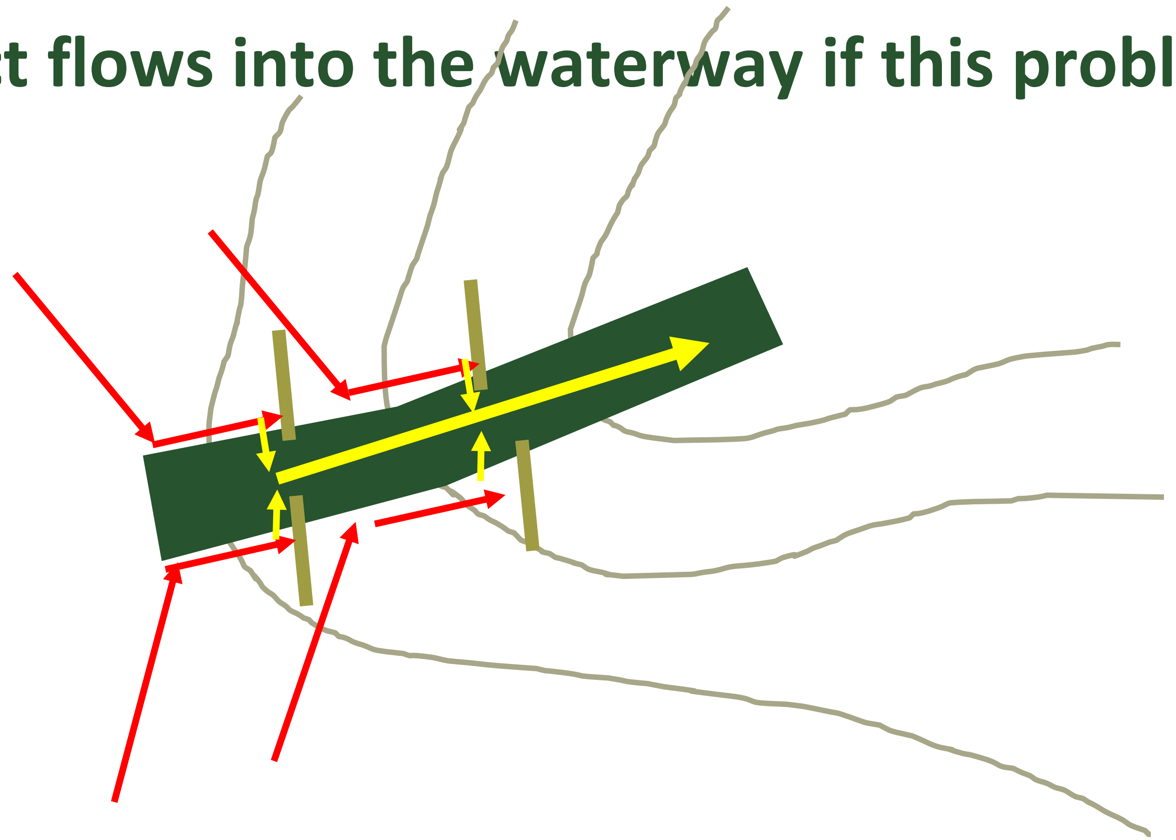
Problem in Continuous Full-Till:

From CPS 412:

Tillage and crop planting often takes place parallel to the waterway, resulting in preferential flow – and resulting erosion – along the edges of the waterway. Consider installation of measures that ensure that runoff from adjacent areas will enter the waterway. Measures such as directing spoil placement or small swales can direct this preferential flow into the grassed waterway.



Diversions can be installed as an O&M practice to redirect flows into the waterway if this problem arises:



DCR
Virginia Department of Conservation & Recreation

Scale 1 Inch = 2000 feet

Notes

1. The landowner/operator is responsible for obtaining and complying with all permits and easeme This includes all federal, state and local permits.
2. The landowner/operator is responsible for checking and complying with all state and local ordinances that may affect the project.
3. MISS UTILITY (Virginia telephone number 811) must be contacted at least 3 working days before construction begins. The landowner/operator is responsible for ensuring that the contractor contacts MISS UTILITY. The contractor must be able to provide the MISS UTILITY ticket number within 24 hours upon request by the NRCS/SWCD representative. The landowner/operator is responsible for locating any buried utilities (water lines, electric lines, telephone lines, gas lines, sewer lines, etc.) in the work area that are not covered by the MISS UTILITY program.
4. NRCS/SWCD makes no representation of the existence or nonexistence of utilities. The presenc or absence of utilities on the construction drawings does not assure that there are or are not utilities in the work area.
5. The contractor is responsible for knowing and following the appropriate safety standards require by the Virginia Safety and Health Codes Board.
6. The landowner/operator must notify the local NRCS/SWCD representative at least one week prio to beginning construction, and at all other times specified in these construction drawings and attached specifications.
7. Any deviation from these construction drawings and specifications without written approval from NRCS/SWCD representative may result in in failure of this practice to meet NRCS Standards an the withdrawal of technical assistance for this project.
8. Prior to beginning construction, the cover sheet must be signed by the landowner/operator, the contractor, and the NRCS/SWCD representative. The landowner/operator is responsible for inform the contractor of these responsibilities by providing the contractor a copy of this cover sheet. The contractor must sign the cover sheet acknowledging that these responsibilities are understo and the landowner/operator must return the signed cover sheet to the NRCS/SWCD Representat If requested by NRCS/SWCD, the landowner/operator must arrange for a meeting between the contractor and NRCS/SWCD to review the construction

The NRCS or SWCD Representative for thi

The NRCS or SWCD office telephone numb

Benchmark Descriptions

TBM 1 Assumed Elev. 492.52
Description: Pt. 105, Nail in a tree 64' northeast of the proposed location of the chute structure.

TBM 2 Assumed Elev. 496.78
Description: Pt. 106: Nail in a tree 91' southwest of the proposed location of the chute structure.

Index of Sheets

Sheet No.	Title
1	Cover Sheet
2	Plan View & Details
3	Profile View & Details
4	Section View
5	Section View

Specification Table

No.	Title
VA705	Pollution Control
VA706	Seeding
VA707	Site Preparation
VA708	Salvaging & Spreading Topsoil
VA721	Excavation
VA727	Diversions & Waterways
VA761	Loose Rock Riprap
VA795	Geotextile

Table of Estimated Quantities

Item	Unit	Quantity
Seeding	AC	0.7
Grassed Waterway	AC	0.8
Rock	TONS	40
Geotextile	SY	50

Engineering Job Class:

811 Know what's belo Call before y

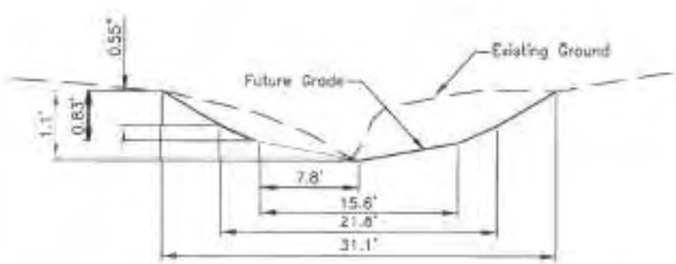
"As Built" Documentation
Certified By and Date

Practice Completion Date

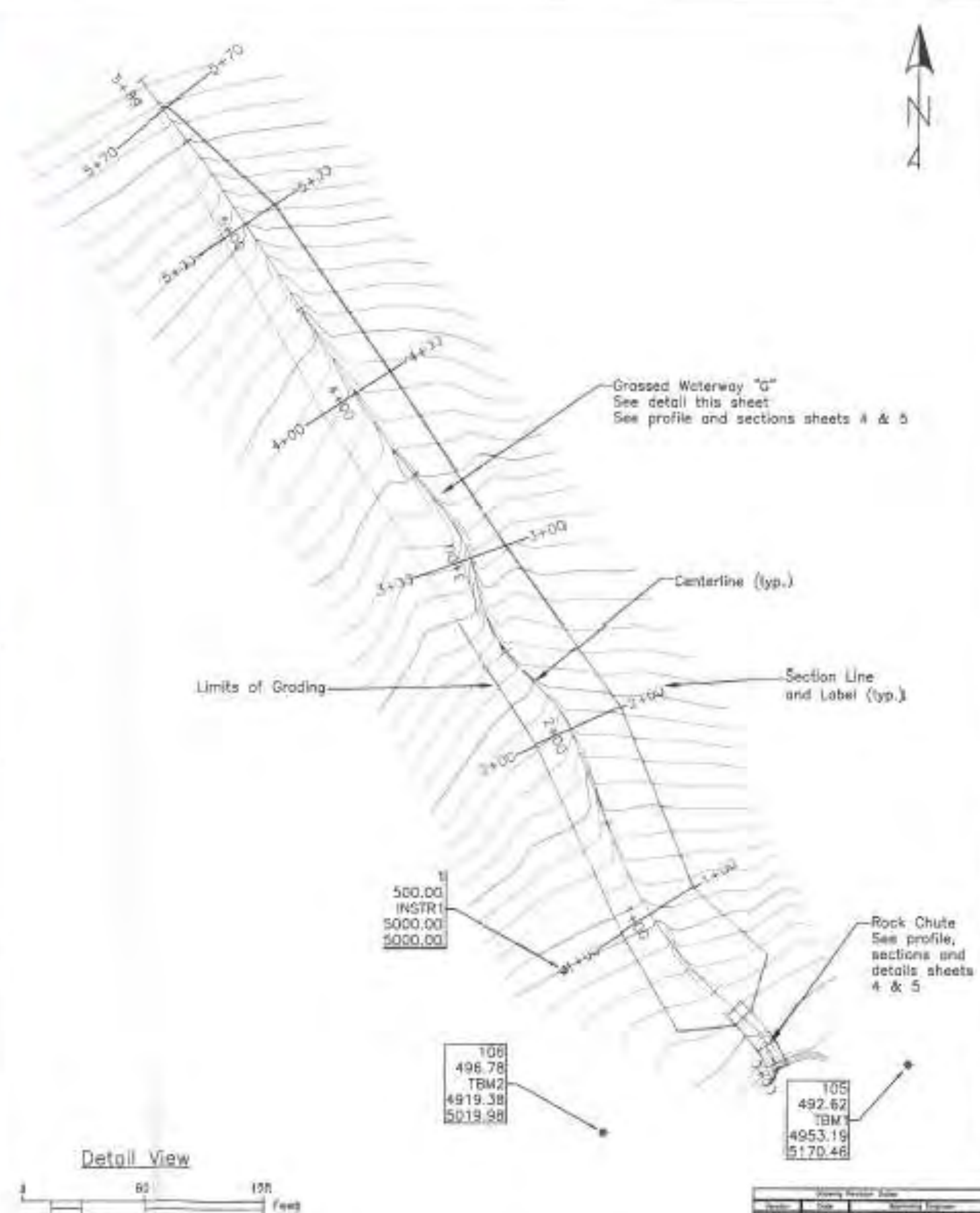
Drawing No.
Sheet 1 of 5

DCR

Aerial Image View

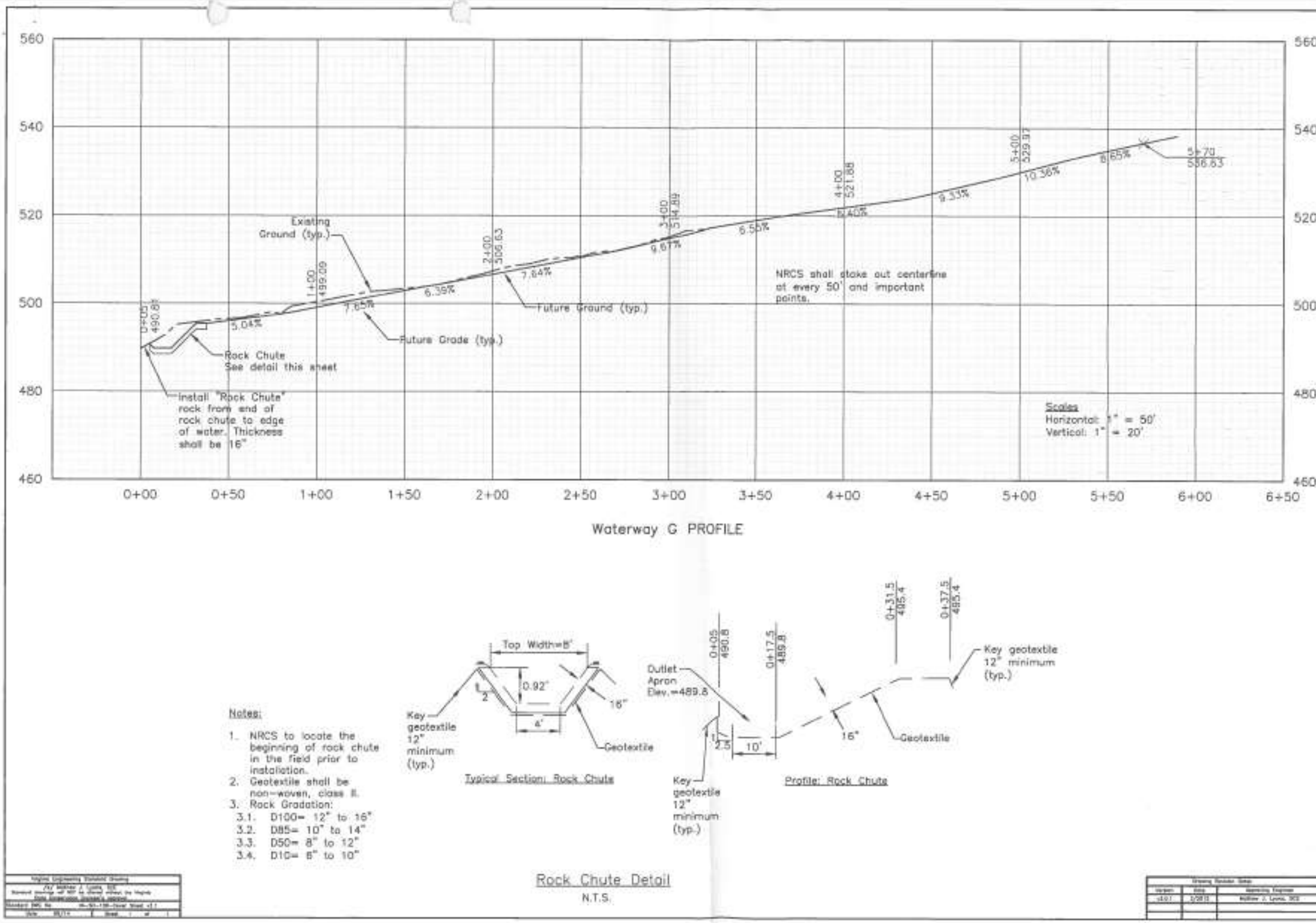


Typical Grassed Waterway Section
N.T.S.



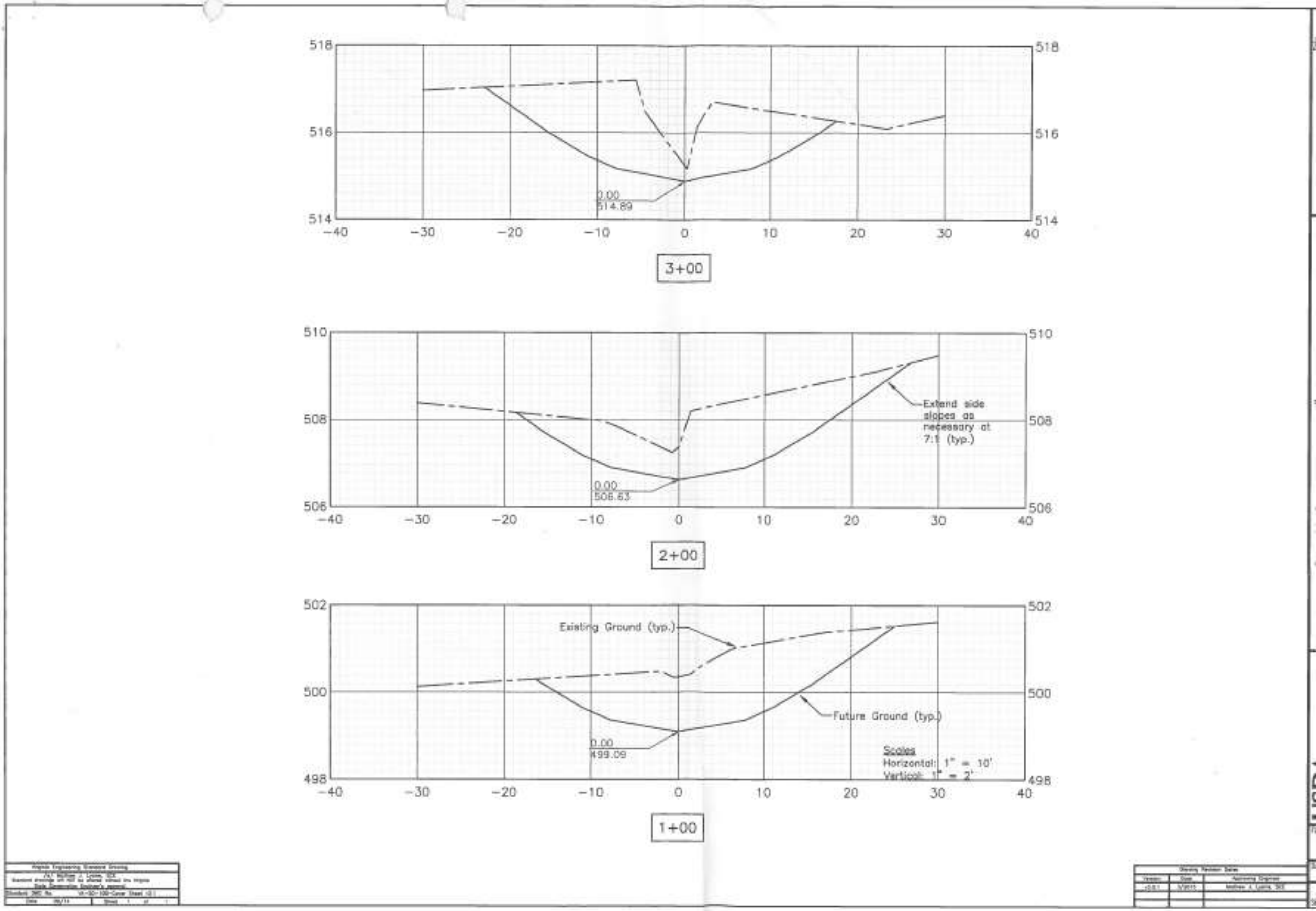
Detail View

DCR



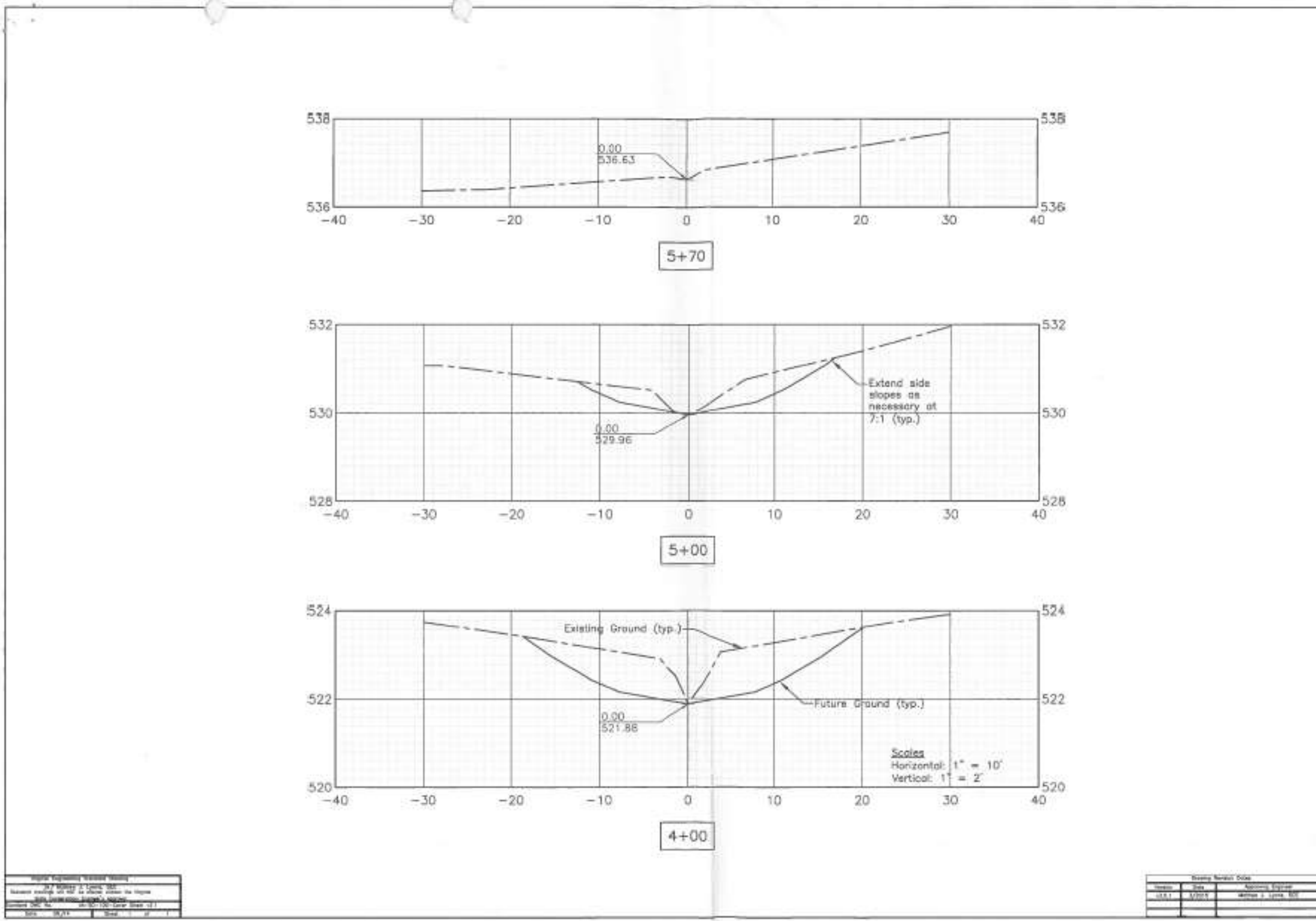
560
540
520
500
480
460
0+00
0+50
1+00
1+50
2+00
2+50
3+00
3+50
4+00
4+50
5+00
5+50
6+00
6+50
Existing Ground (typ.)
0+05 490.8
1+00 499.09
2+00 506.63
3+00 514.89
4+00 521.88
5+00 529.37
5+70 536.63
5.04%
7.65%
6.39%
7.64%
9.67%
6.55%
6.40%
9.33%
10.36%
8.65%
Future Grade (typ.)
Future Ground (typ.)
Rock Chute See detail this sheet
Install "Rock Chute" rock from end of rock chute to edge of water. Thickness shall be 16"
NRCS shall stake out centerline at every 50' and important points.
Scales
Horizontal: 1" = 50'
Vertical: 1" = 20'
Waterway G PROFILE
Notes:
1. NRCS to locate the beginning of rock chute in the field prior to installation.
2. Geotextile shall be non-woven, class II.
3. Rock Gradation:
3.1. D100= 12" to 16"
3.2. D85= 10" to 14"
3.3. D50= 8" to 12"
3.4. D10= 6" to 10"
Top Width=8'
0.92'
2
1
4'
16"
Key geotextile 12" minimum (typ.)
Geotextile
Typical Section: Rock Chute
Outlet Apron Elev.=489.8
0+05 490.8
0+17.5 489.8
0+31.5 495.4
0+37.5 495.4
1
2.5
10'
16"
Key geotextile 12" minimum (typ.)
Geotextile
Profile: Rock Chute
Rock Chute Detail
N.T.S.

DCR



518
516
514
-40 -30 -20 -10 0 10 20 30 40
0.00
514.89
3+00
510
508
506
0.00
506.63
Extend side slopes as necessary at 7:1 (typ.)
2+00
502
500
498
Existing Ground (typ.)
Future Ground (typ.)
0.00
499.09
Scales
Horizontal: 1" = 10'
Vertical: 1" = 2'
1+00

DCR



0.00
536.63
5+70
Extend side slopes as necessary at 7:1 (typ.)
0.00
529.96
5+00
Existing Ground (typ.)
Future Ground (typ.)
0.00
521.86
Scales
Horizontal: 1" = 10'
Vertical: 1" = 2'
4+00

Lined Waterway Design

DCR
Virginia Department of Conservation & Recreation

Lined Waterway Design

- CPS 468 is one of the better standards for providing calculation guidance

General Criteria Applicable to All Purposes

Capacity. The maximum capacity of the waterway flowing at designed depth shall not exceed 200 ft^3/s. The minimum capacity shall be adequate to carry the peak rate of runoff from a 10-year, 24-hour frequency storm. Velocity shall be computed by using Manning's Formula with a coefficient of roughness "n" as follows:

Lining	"n" Value
Concrete	
Trowel finish..................	0.011– 0.015
Float finish..................	0.013 - 0.016
Shotcrete........................	0.016 – 0.025
Flagstone........................	0.020 – 0.025
1/ Riprap - (Angular Rock)	$n = 0.047(D_{50} S)^{0.147}$
Synthetic Turf Reinforcement Fabrics and Grid Pavers	Manufacturer's recommendations

1/ Applies on slopes between 2 and 40% with a rock mantle thickness of 2 x D_{50}

where:

D_{50} = median rock diameter (in.),
S = lined section slope (ft./ft.) ($.02 \le S \le 0.4$)

Velocity. Maximum design velocity and rock gradation limits for rock riprap-lined channel sections shall be determined using National Engineering Handbook (NEH), Part 650, Engineering Field Handbook, Chapter 16, Appendix 16A, or NEH 654.14C, unless a detailed design analysis appropriate to the specific slope, flow depth and hydraulic conditions indicate that a higher velocity is acceptable.

Maximum design velocity for concrete-lined sections should not exceed those using Figure 1.

Maximum design velocity for synthetic turf reinforcement fabrics and grid pavers shall not exceed manufacturer's recommendations.

Stable rock sizes and flow depths for rock-lined channels having gradients between 2 percent and 40 percent may be determined using the following detailed design process. This design process is from **Design of Rock Chutes** by Robinson, Rice, and Kadavy.

For channel slopes between 2% and 10%:

$$D_{50} = [q\,(S)^{1.5}/4.75(10)^{-3}]^{0.53}$$

For channel slopes between 10% and 40%:

$$D_{50} = [q\,(S)^{0.58}/3.93(10)^{-2}]^{0.53}$$

$$z = [n(q\,)/1.486(S)^{0.50}]^{0.6}$$

where:

D_{50} = Particle size for which 50% (by weight) of the sample is finer, in.

S = Bed slope, ft./ft.

z = Flow depth, ft.

n=Manning's roughness coefficient

q = Unit discharge, $ft^3/s/ft$

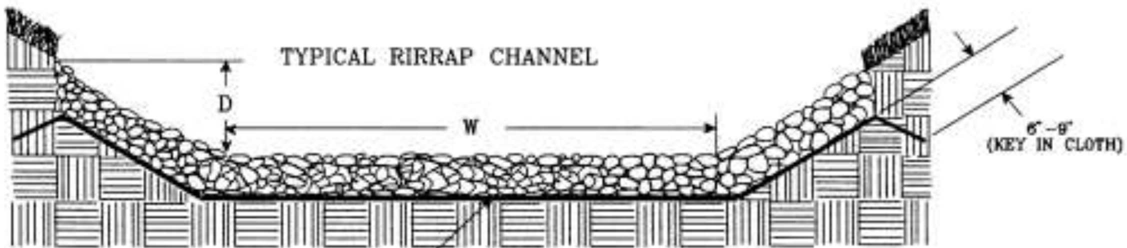
Side slope. The steepest permissible side slopes, horizontal to vertical, shall be:

Nonreinforced concrete:
Hand-placed, formed concrete
Height of lining, 1.5 ft or less ....Vertical
Hand-placed screeded concrete or mortared in place flagstone
Height of lining, less that 2 ft ....1 to 1
Height of lining, more than 2 ft ....2 to 1
Slip form concrete:
Height of lining, less than 3 ft ....1 to 1
Rock riprap ....2 to 1
Synthetic Turf Reinforcement Fabrics ...2 to 1
Grid Pavers...1 to 1

Cross section. The cross section shall be triangular, parabolic, or trapezoidal. Cross sections made of monolithic concrete may be rectangular.

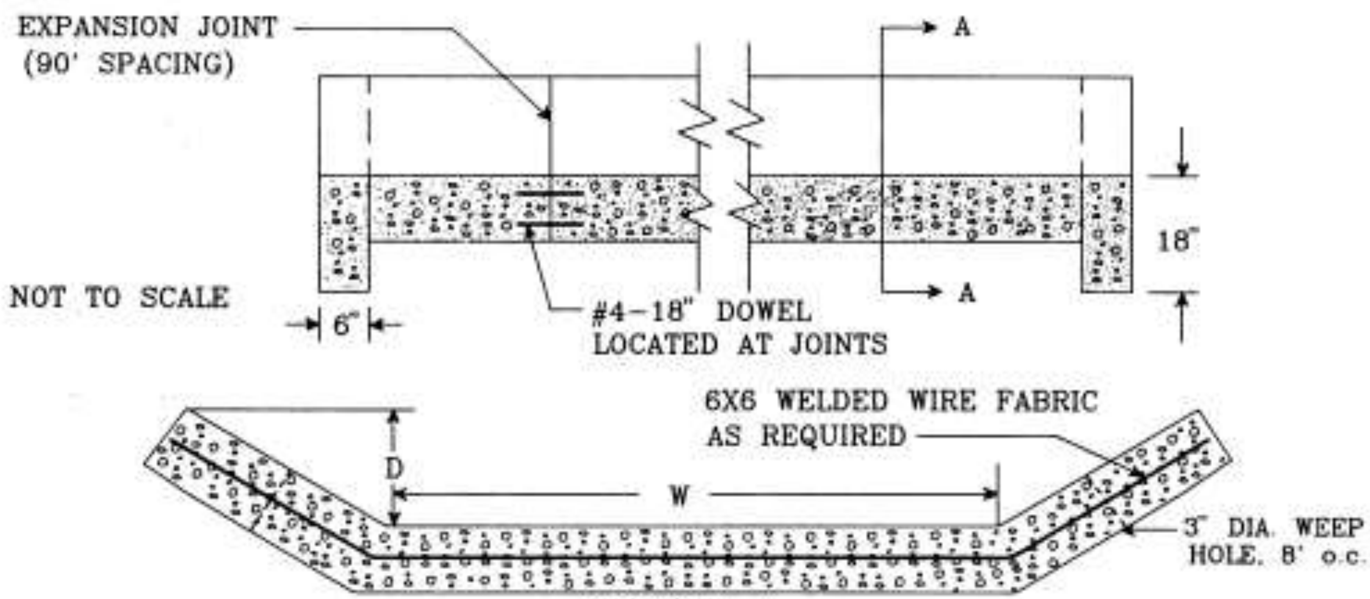
Freeboard. The minimum freeboard for lined waterways or outlets shall be 0.25 ft above design high water in areas where erosion-resistant vegetation cannot be grown adjacent to the paved or reinforced side slopes. No freeboard is required if vegetation can be grown and maintained.

TYPICAL WATERWAY CROSS-SECTIONS



NOTE: ALTHOUGH FILTER CLOTH IS PREFERED, A GRANULAR FILTER MAY BE SUBSTITUTED FOR FILTER CLOTH. (FOR PHYSICAL REQUIREMENTS, SEE STD. & SPEC. 3.19, RIPRAP)

TYPICAL CONCRETE CHANNEL



SECTION A-A

TRAPEZOIDAL WATERWAY CROSS-SECTIONS

The Stream Crossing Worksheet can be used to analyze velocities and capacities of channels.

Stream Crossing Worksheet

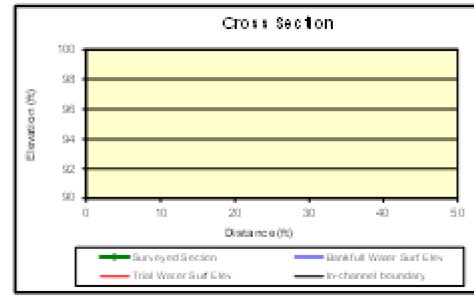
Version 01.12

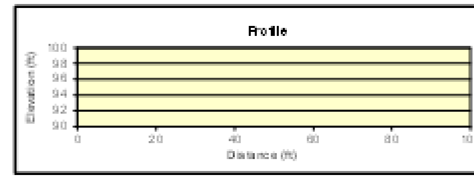
ENABLE macros to use the buttons on this spreadsheet. For culvert crossings, compute the peak flow rate for the desired design storm for the watershed draining to the proposed crossing. Use EFH-2 or other means to perform this calculation. (Use the 2-yr, 24 hr storm for culvert crossings, according to VA CPS 578.)

Project Description:
Prepared by: 8/21/2017

1. Enter Survey Data (ft):

	Distance (ft)	Elevation (ft)
Cross Section:		
Left Floodplain		
Top Left Bank		
Toe Left Bank		
Center		
Toe Right Bank		
Top Right Bank		
Right Floodplain		
Profile (riffle to riffle):		
Upstream station:		
Downstream station:		
Slope:		





Note: Plot scales can be modified by right-clicking them and then choosing "Format Axis."

2. Compute In-channel "n" value:

(See Cowan as referenced in VA Erosion & Sediment Control Handbook)

Channel character	n1 =	
Irregularity	n2 =	
Size & shape variations	n3 =	
Obstructions	n4 =	
Vegetation	n5 =	
Sum of n1 through n5	ns =	0.000
Coefficient for meander: *(Use 0 for Minor, 0.3 for Severe)*		
	n6 =	0.000
Bankfull channel "n":		0.000
User-defined "n" for Left Floodplain:		
User-defined "n" for Right Floodplain:		

3. Determine Water Surface Elevation for Design Flow:

(Use for culvert crossings.)

Design Q from other tools:		cfs
Storm Return Period:		yrs
Method (EFH2, USGS, etc.):		
Trial water surface elev. (ft): *(To approximate design flow.)*		
Area of channel, A:		sq. ft.
Composite n value:		
Flow rate, Q:		cfs
Resulting avg. velocity = Q/A:		fps

4. Bankfull Flow:

Bankfull water surface elev. (ft):
(Select the lower top of bank elevation.)

Area of channel, A:		sq. ft.
Wetted perimeter, P:		ft.
Hydraulic radius, R:		ft.
Slope (decimal), S:		
Bankfull channel n:		
Manning's equation: $V = (1.486/n) * R^{2/3} * S^{1/2}$		
Bankfull velocity, V =		fps
Flow rate, Q = VA =		cfs

5. Stone Size Required for Ford Crossing:

Velocity	Stone	Min. Depth
0.0-6.0 fps	d_{50} = 2", d_{100} = 4"	8"
>6.0 fps	consult Engineering staff	

6. Design Capacity for Culvert Flow

Q = lesser of Q2 and bankfull flow =	cfs
Tailwater surface elevation to use in Culvert Flow Tool (ft):	ft

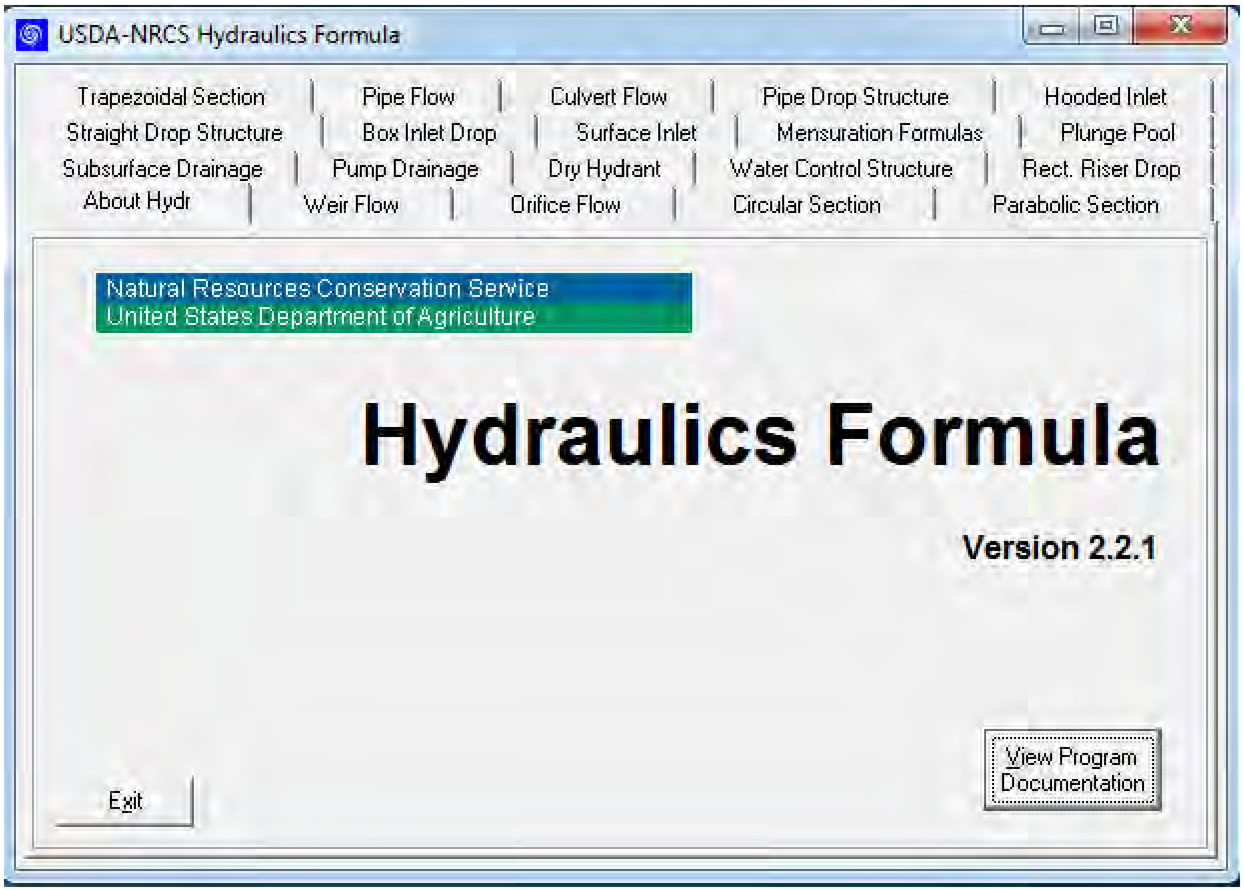
Drop Structure Design

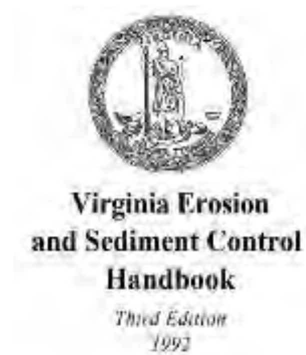
Design Tools

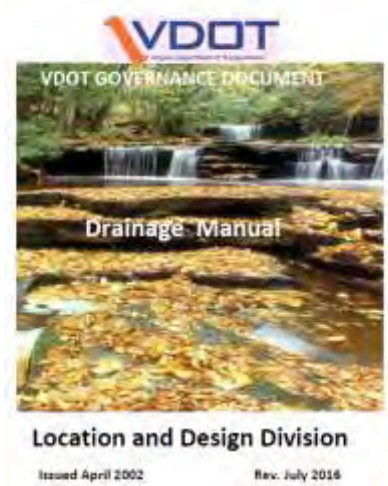
ENGINEERING FIELD MANUAL

CHAPTER 6. STRUCTURES

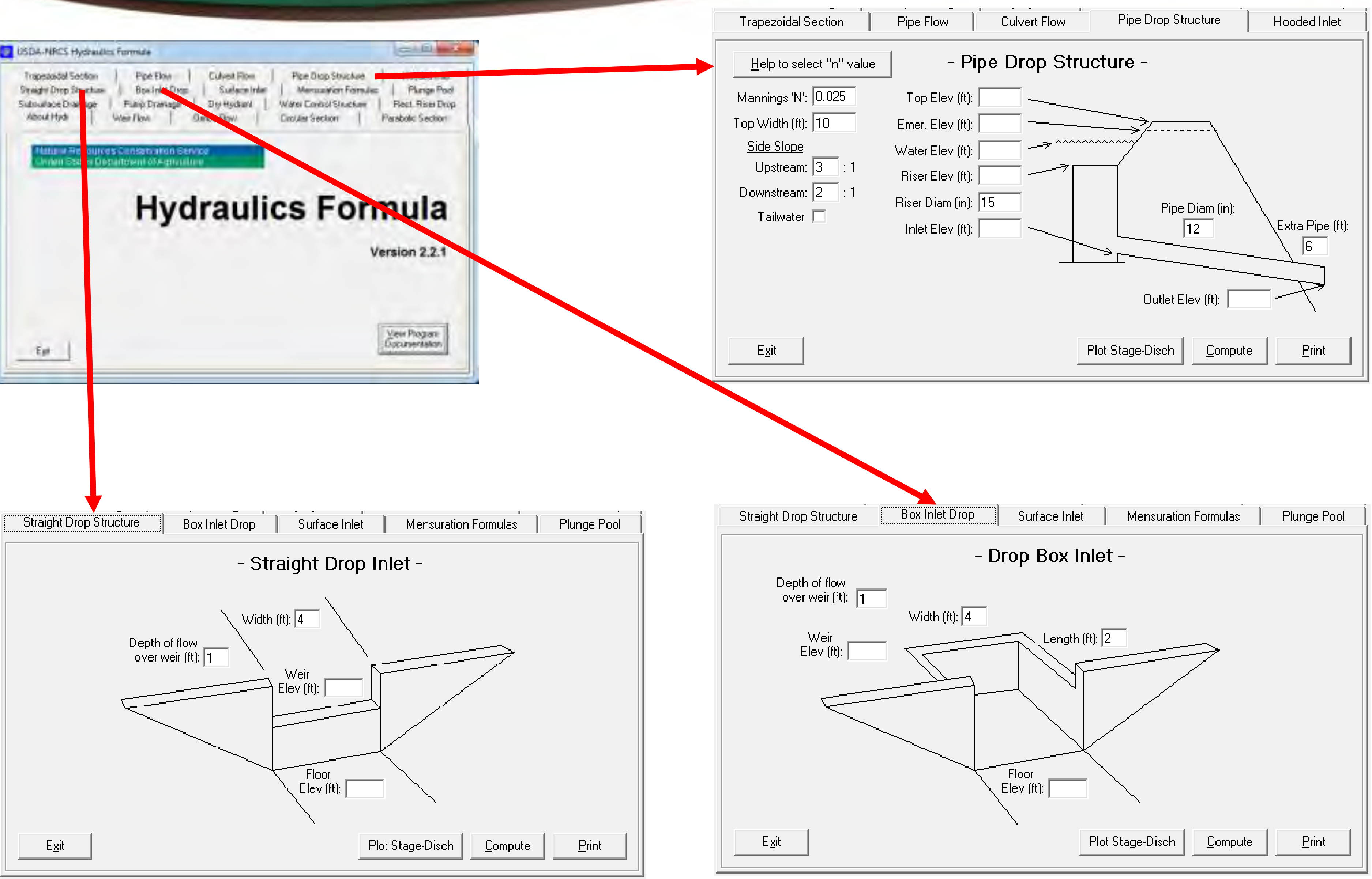
Compiled by: Keith H. Beauchamp, Agricultural Engineer, SCS, Lincoln, Neb.







DCR
Virginia Department of Conservation & Recreation



Drop Structures- when to use them


04.27.2015


04.27.2015

DCR
Virginia Department of Conservation & Recreation


04 27 2015


04 27 2015


04 27 2015


04 27 2015


05.08.2015


05 08 2015

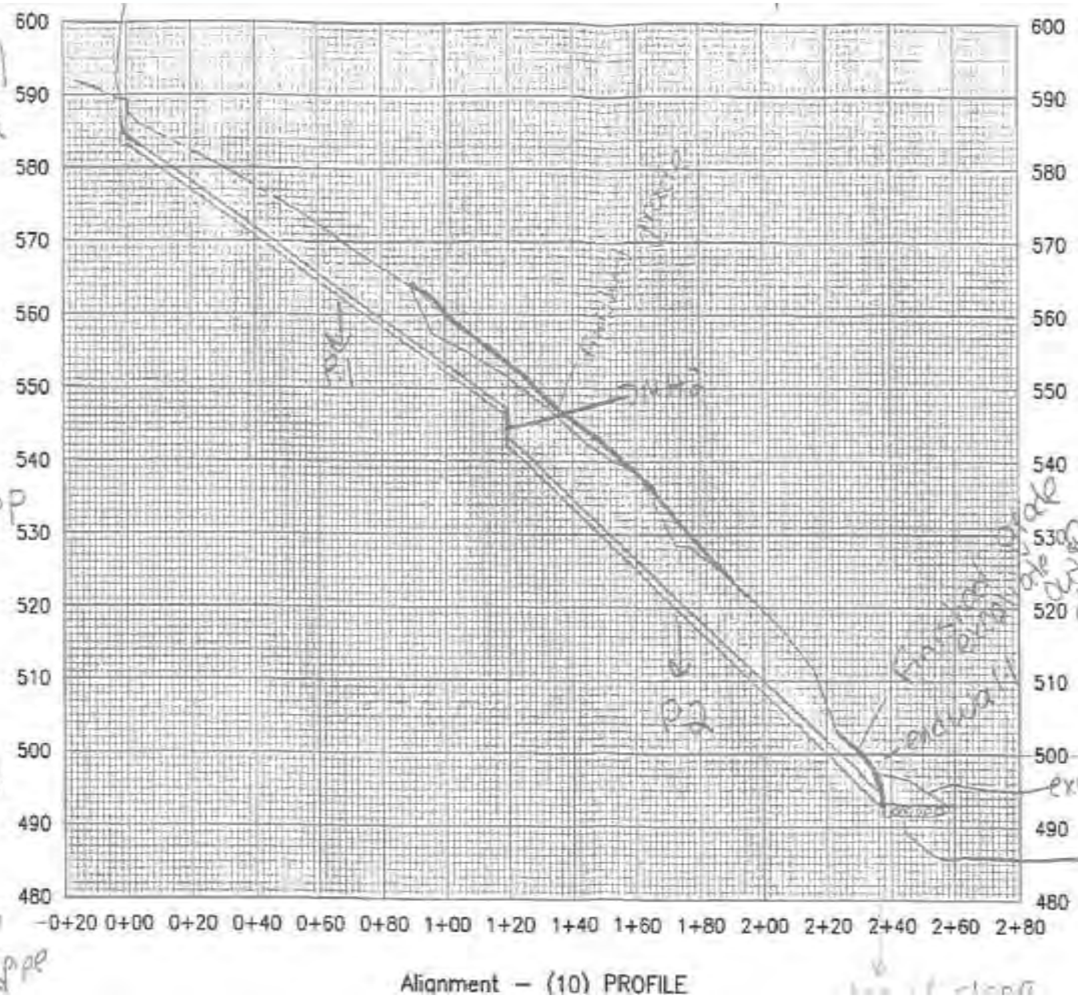
(4) EW-1 => Endwall,
see VDOT detail
101.01 or 101.02

(4) MH's 1 & 2 =>
see VDOT detail
106.01

(4) MH #1 grate cover:
see VDOT detail
104.23 for grate top

(4) M#2 cover;
use standard,
closed manhole
cover, does not
have to be approved
for use in roads

(7) Outlet Protection:
L= 10' (to edge of
stream) pipe



(4) MH 1: Top
Matc
of existi
flume
Heig
STA

(4) MH 2: TOP
Heig
STA

(4) P1: HDPE
D= 1
L=
S=

(4) P2: HDPE
D=16
L=1
S=

10' @ 0%, ins
outlet
of stream
excavate


500

DCR
Virginia Department of Conservation & Recreation

Case Study #1:
Drop Structure vs. Lined Waterway

- Three eroded channels
- Caused by barnyard runoff and cattle
- Fine sandy loam soils

Case Study #1:
Drop Structure vs. Lined Waterway

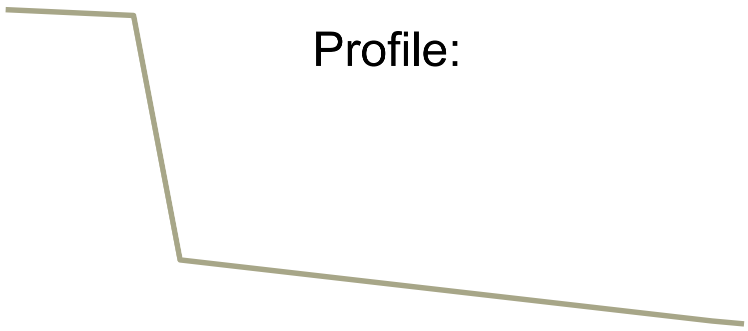
Channel 2

Channels 1 & 3

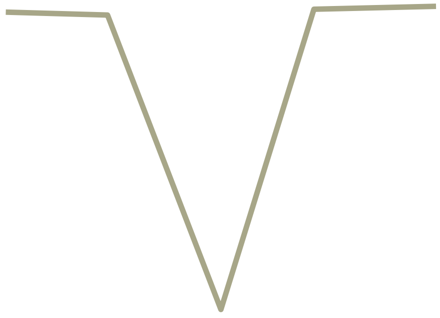
Case Study #1:
Drop Structure vs. Lined Waterway

Channel 2

Profile:

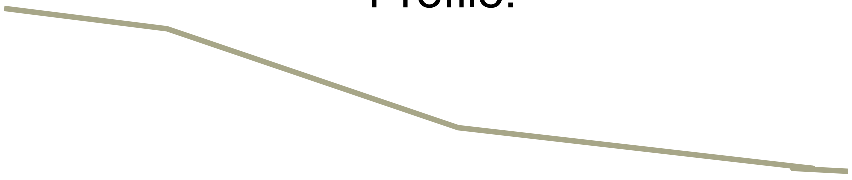


Cross-Section

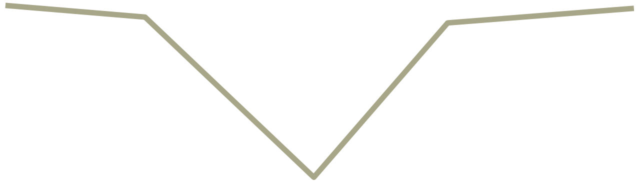


Channels 1 & 3

Profile:



Cross-Section



Site Location Map

Scale 1 inch = N/A feet

Notes

1. The landowner/operator is responsible for obtaining and complying with all permits and easements. This includes all federal, state and local permits.
2. The landowner/operator is responsible for checking and complying with all local ordinances that may affect the project.
3. MISS UTILITY (Virginia telephone number 811) must be contacted at least 3 working days before construction begins. The landowner/operator is responsible for ensuring that the contractor contacts MISS UTILITY. The contractor must be able to provide the MISS UTILITY ticket number within 24 hours upon request by the DCR/SWCD representative. The landowner/operator is responsible for locating any buried utilities (water lines, electric lines, telephone lines, gas lines, sewer lines, etc.) in the work area that are not covered by the MISS UTILITY program.
4. DCR/SWCD makes no representation of the existence or nonexistence of utilities. The presence or absence of utilities on the construction drawings does not assure that there are or are not utilities in the work area.
5. The contractor is responsible for knowing and following the appropriate safety standards required by the Virginia Safety and Health Codes Board.
6. The landowner/operator shall notify the DCR/SWCD representative at least one week prior to beginning construction, and at all other times specified in this construction plan and attached specifications.
7. Any deviation from these construction drawings and specifications without written approval from DCR/SWCD representative may result in in failure of this practice to meet NRCS Standards and the withdrawal of technical assistance for this project.
8. Prior to beginning construction, the cover sheet must be signed by the landowner/operator, the contractor, and the DCR/SWCD representative. The landowner/operator is responsible for informing the contractor of these responsibilities by providing the contractor a copy of this cover sheet. The contractor must sign the cover sheet acknowledging that these responsibilities are understood and the landowner/operator must return the signed cover sheet to the DCR/SWCD Representative. If requested by DCR/SWCD, the landowner/operator shall arrange for a meeting between the contractor and DCR/SWCD to review the construction drawings and specifications prior to construction.

The SWCD Representative (include [redacted]
The SWCD office telephone number [redacted]
The SWCD office address is: [redacted]

Benchmark Descriptions

TBM # CP1 Assumed Elev. 429.00
Description:
Top of discharge end of existing 15" diameter culvert approx. 40' west of planned riser location. See Sheet 3

TBM # N/A Assumed Elev. N/A
Description:
N/A

Acknowledgment Signatures

These construction drawings and attached specifications have been reviewed I understand what is required. (Sign and date below)

Landowner/Operator ______

Contractor ______

SWCD Representative ______

Engineering Job Class: ______

811 Know what's below. Call before you dig.

"As Built" Documentation

Certified By and Date ______

Practice Completion Date ______

Index of Sheets

Sheet No.	Title
1	Cover Sheet
2	Site Location - Aerial Photograph
3	Plan View on Existing Topo
4	Grading Plan
5	Existing Channel Profile
6	Planned Channel Profile
7	Berm/Inlet Detail
8	Pipe Drop Structure & Outlet Details
9	Riser & Barrel Details
Attachments	NRCS Construction Specifications
	NRCS CPS 410 O&M Agreement

Specification Table

No.	Title
VA-705	Pollution Control
VA-706	Seeding
VA-707	Site Preparation
VA-708	Salvaging & Spreading Topsoil
VA-721	Excavation
VA-723	Earthfill
VA-727	Diversions & Waterways
VA-731	Concrete Construction
VA-745	Plastic Pipe
VA-761	Loose Rock Riprap
VA-795	Geotextile

Table of Estimated Quantities

Item	Unit	Quantity
15" I.D. Dual-Wall HDPE Pipe	LN.FT	340
18" I.D. Dual-Wall HDPE Pipe	LN.FT	4
Pipe Anchors for 15" Pipe per Mfg.	JOB	1
VDOT #357, #25, or #26 Stone	TONS	87
Bar Guard for 18" Riser	EA	1
Concrete Reinforcement (See Sheet 6)	JOB	1
3000psi Concrete	CU.YDS.	1
Core Material for Cut-Off Trench (See Sheet 7)	JOB	1
Nonwoven Geotextile (Class I or II)	SQ FT *	128
*Estimate is for sq ft. of coverage, extra needed for overlap		
Class A1 Riprap (D50 = 10", D100 = 12")	TONS	55
EC-2 Matting, Seed, Mulch, Soil Amendments to meet VA-706	JOB	1

Designed: Raleigh Coleman
Drawn: Raleigh Coleman

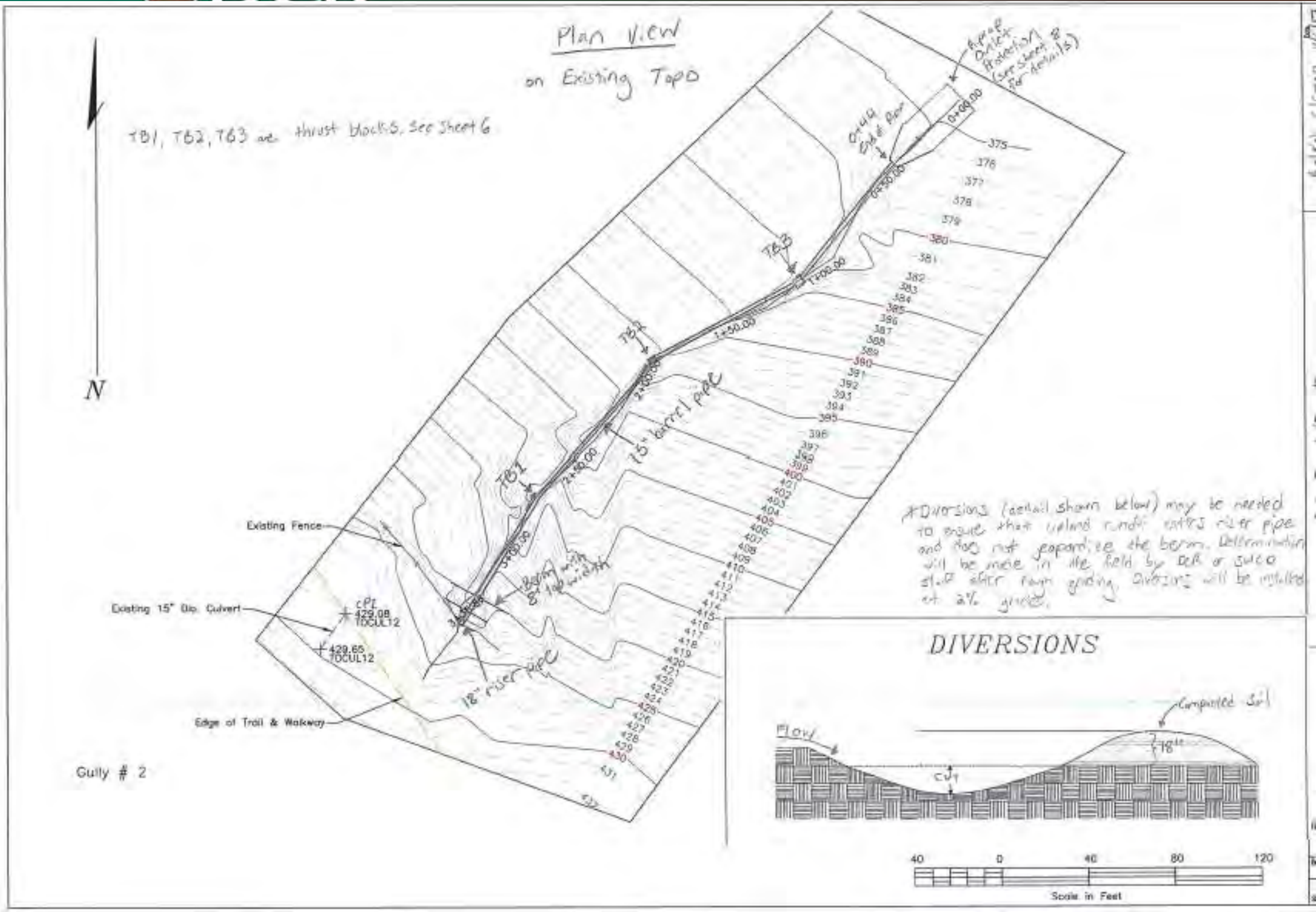
Engineering Design Cover Sheet [redacted]

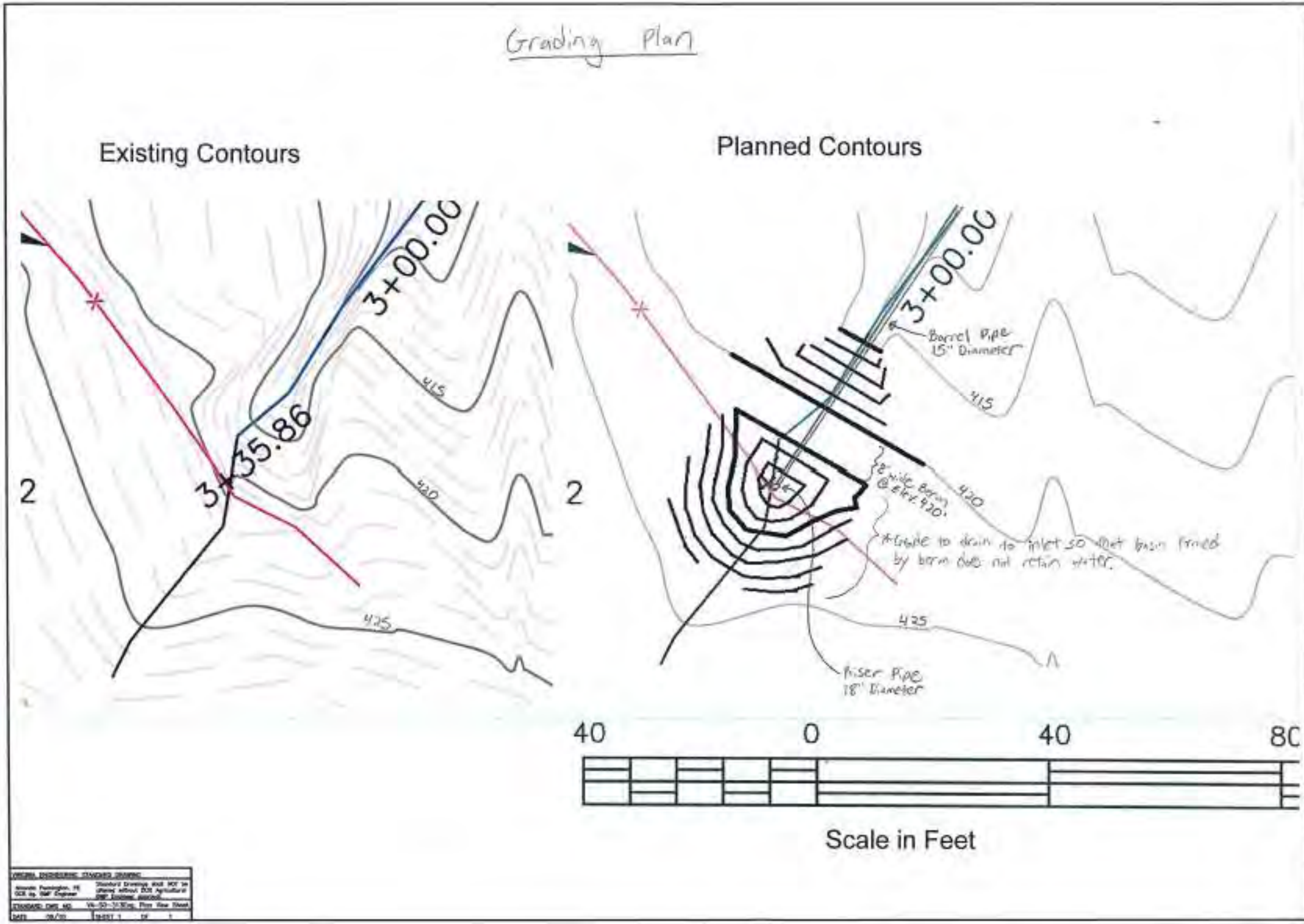
DCR
This drawing adapted from NRCS Standard Drawing VA-SO-100 v2.4.0

Sheet 1 of 9


Site 3
Site 2
Site 1
N
654
654
Google
Photo Not To Scale

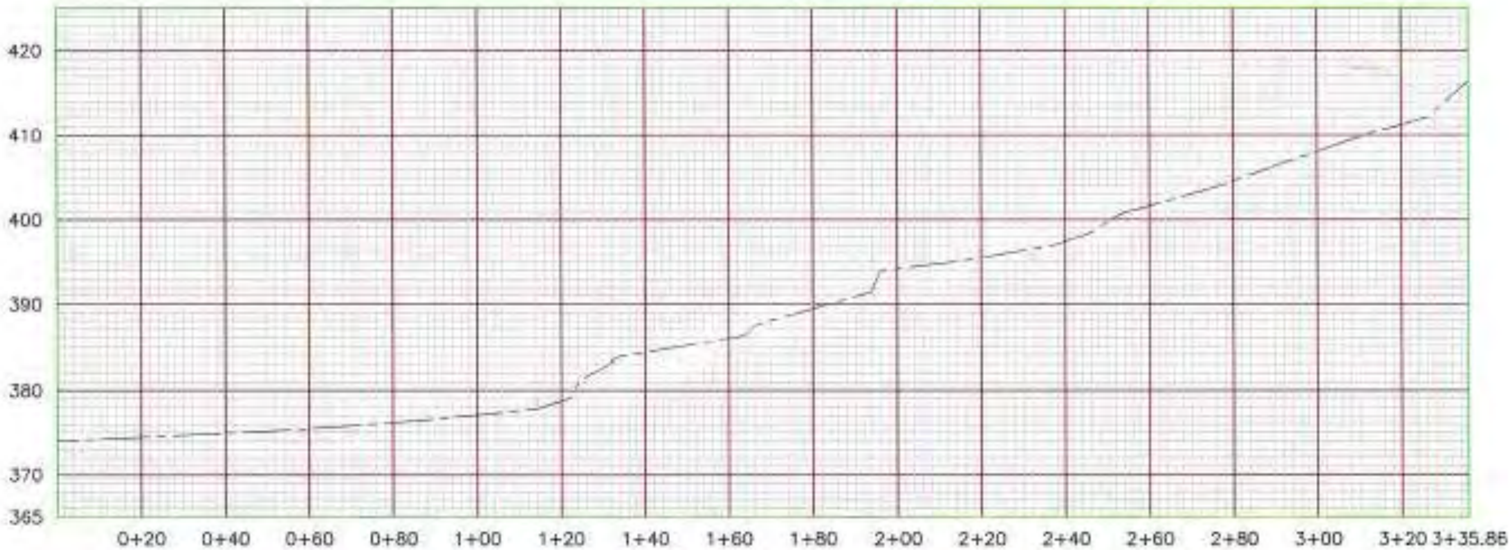
DCR


Plan View
on Existing Topo
TB1, TB2, TB3 are thrust blocks, see Sheet 6
N
TB3
TB2
TB1
15" barrel pipe
18" riser pipe
Existing Fence
Existing 15" Dip. Culvert
CPI 429.08 TOCUL12
429.65 TOCUL12
Edge of Trail & Walkway
Gully # 2
0+00.00
0+50.00
1+00.00
1+50.00
2+00.00
2+50.00
3+00.00
375
376
377
378
379
380
381
382
383
384
385
386
387
388
389
390
391
392
393
394
395
396
397
398
399
400
DIVERSIONS
Flow
Compacted Soil
18"
40
0
40
80
120
Scale in Feet


Grading Plan
Existing Contours
Planned Contours
3+00.00
3+35.86
2
415
420
425
2
3+00.00
Barrel Pipe
15" Diameter
415
8' wide Berm @ Elev. 420'
420
*Grade to drain to inlet so that basin formed by berm does not retain water.
425
Riser Pipe
18" Diameter
40
0
40
80
Scale in Feet

DCR

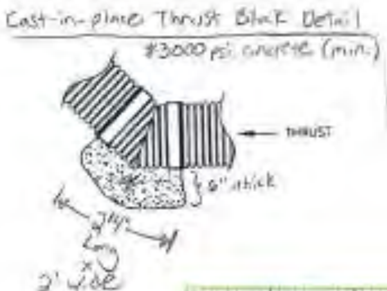
Existing channel profile

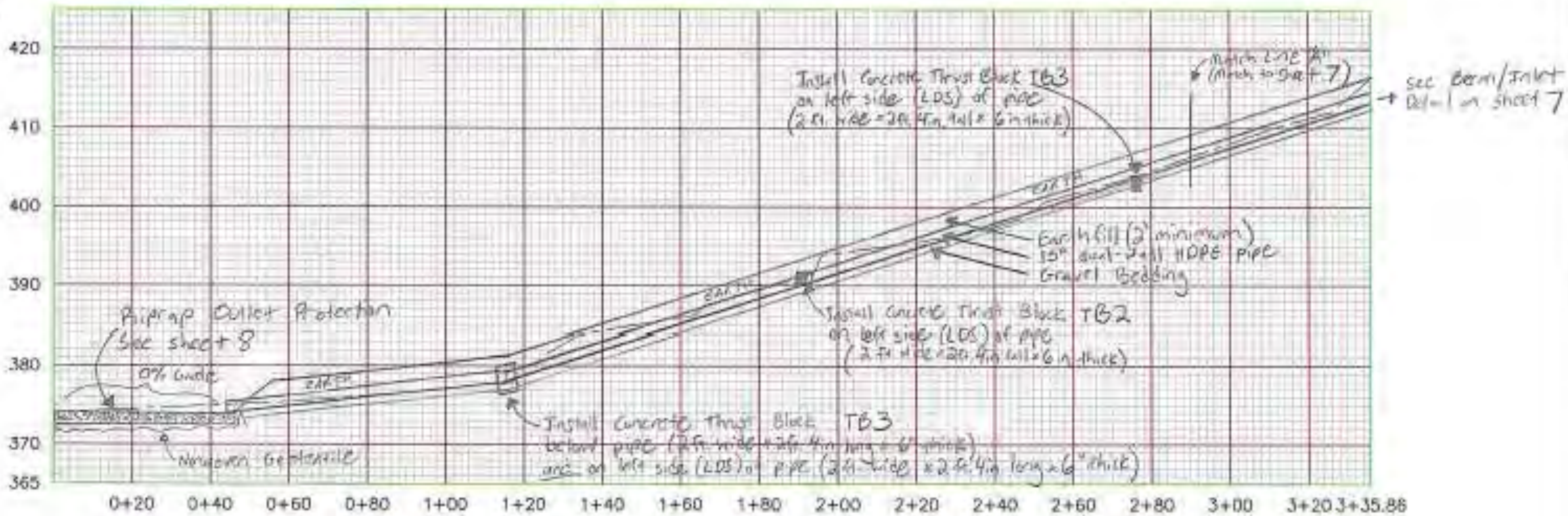


Center Line Profile (Site 2)

- Site preparation of channel will include excavating to clear all undesirable materials from the construction area and achieve uniform grades shown on sheet 6.
- Trench will be as linear as possible to allow pipe to be installed with linear alignment shown on sheet 3.

Planned Channel Profile





Center Line Profile (Site 2)

- Install pipe anchors according to manufacturer's recommendations. Contractor to obtain approval from design engineer prior to installation.
- Pipe must be installed on a steady, uniform grade and in a linear alignment. Any deflections at joints must be less than the maximum allowable deflection specified by the manufacturer.
- Thrust block locations shown are based on estimated alignment bend locations and may need to be adjusted in the field. Thrust blocks to be located at major pipe alignment and grade changes.

Thrust Block 3 will be V-shaped to serve as both a vertical and horizontal thrust block.

Virginia Department of Conservation & Recreation

United States
Department of
Agriculture

Natural
Resources
Conservation
Service

Part 636 Structural Engineering
National Engineering Handbook

Chapter 52 Structural Design of Flexible Conduits

Figure 52–14 Thrust forces

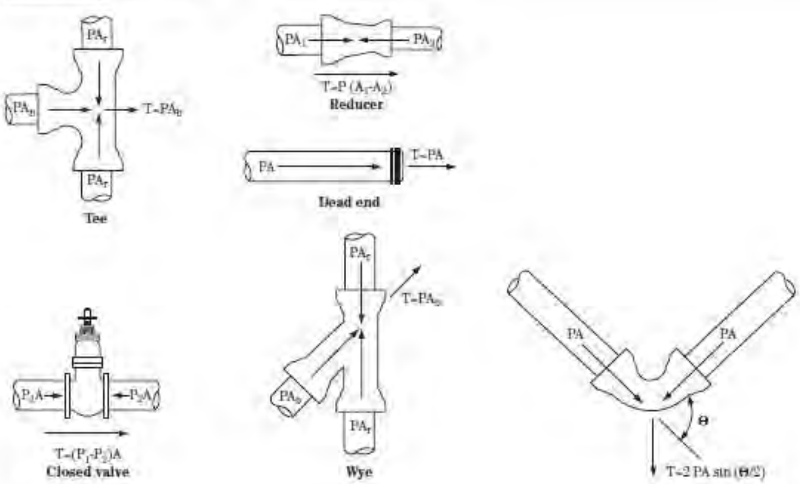
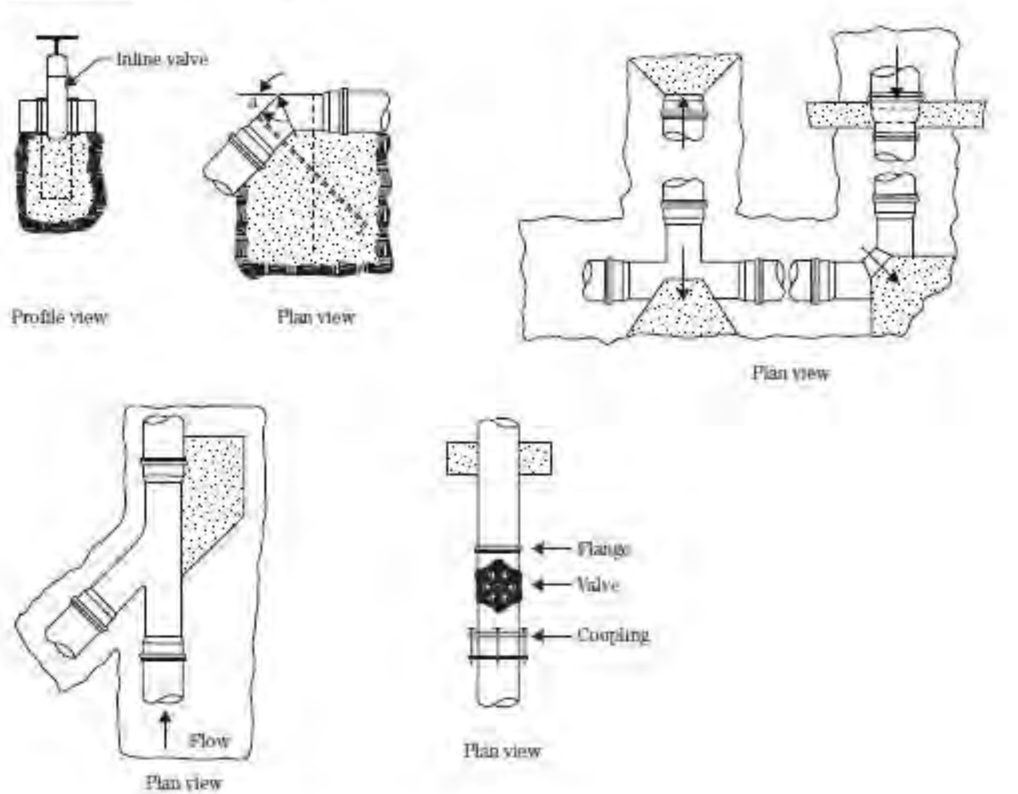


Figure 52–15 Thrust block types



Berm/Inlet Detail

NOTES

Cutoff Trench

- Install along centerline of dam
- Must extend at least 1 ft. deep into stable native soil
- 4 ft. minimum bottom width
- Side slopes: no steeper than 1:1 (H:V)
- Material for trench to be approved by DCR/PSWCD
- Trench will extend a minimum of 10 ft. on either side of the barrel pipe

Berm

- Must have a minimum top width of 8 ft.
- Location to be staked by DCR/PSWCD prior to construction
- Elevation of top to be 420'
- Side slopes to be 2.5:1 (H:V)
- Earthfill material to be approved by DCR/PSWCD

Concrete

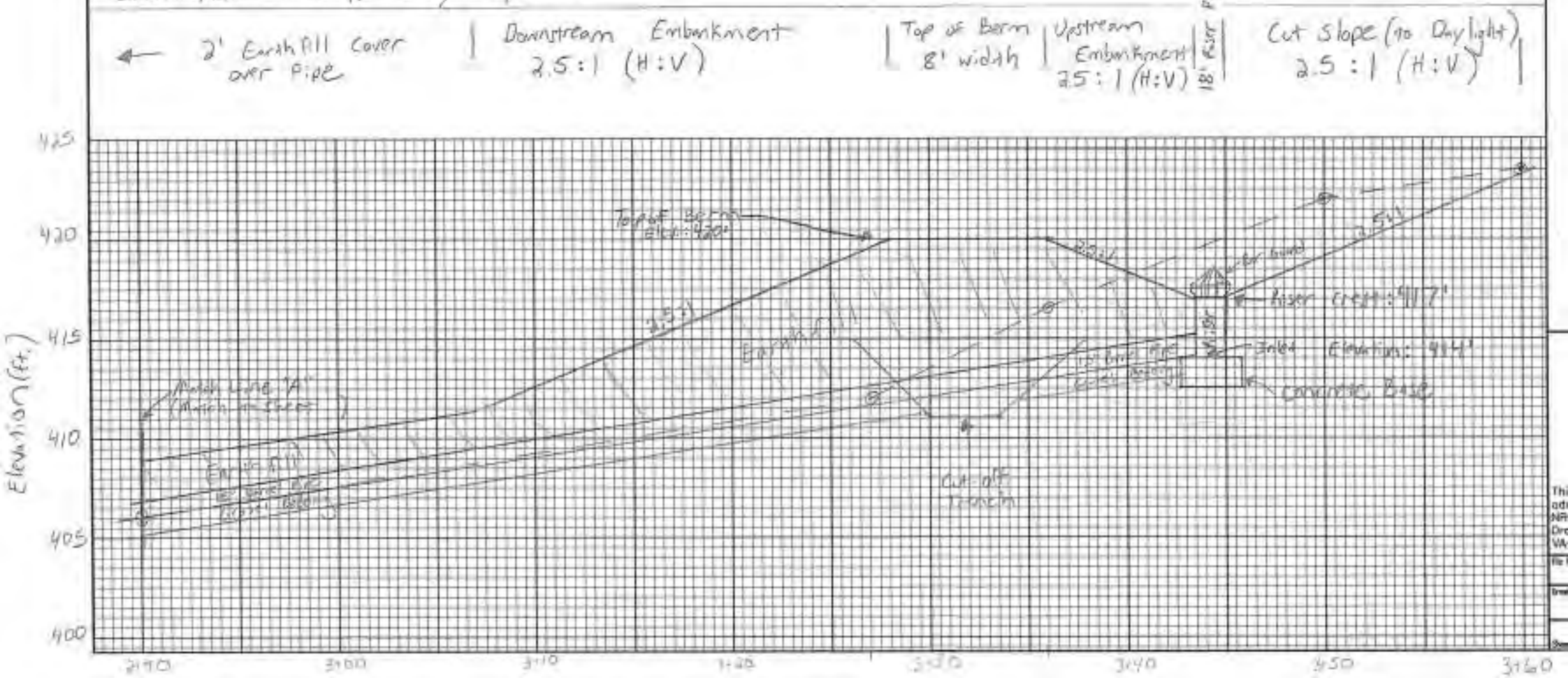
- Concrete to be 3,000 psi, 28 day
- See VA-731

Pipe

- Pipe to be dual-wall HDPE (smooth-lined corrugated)
- Install gasketed water-tight couplers according to manufacturer
- Install pipe according to manufacturer's requirements

LEGEND

- Existing Grade
- Planned Grade
- ⊙ Survey Point



Natural Resources Conservation Service
United States Department of Agriculture

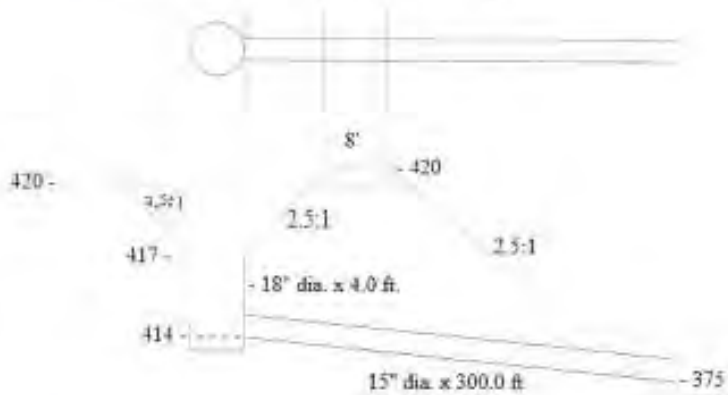
Pipe Drop Structure

Participant: Benson
Location: Amelia County
County: County, VA
Designer: RC
Date: 04/06/2017

Checker: ___________
Date: ___________

Hydraulics Formula, Version 2.2.1

Site 2 Pipe Drop Structure - Gully 2



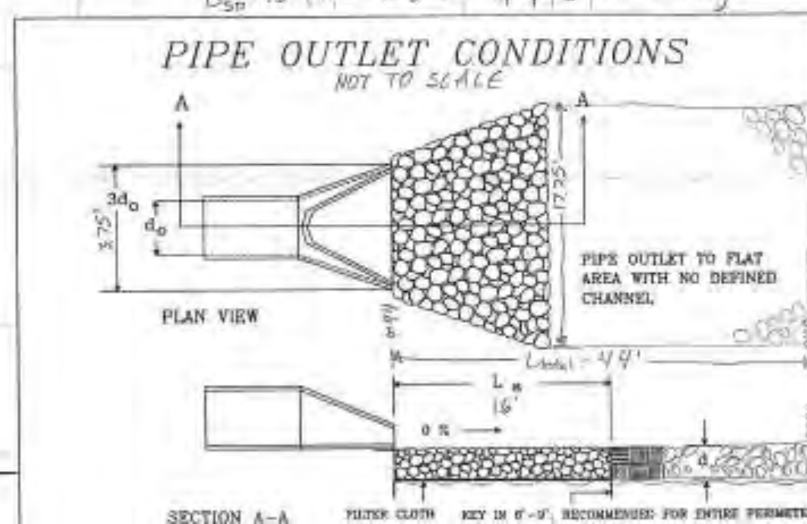
'n' value: 0.012
Discharge: 12.0 cfs
Pipe diameter: 15 in.
Riser diameter: 18 in.
Pipe length: 300.0 ft. (including 172 feet beyond the toe.)
Riser length: 4.0 ft.
High Orifice Controls Flow.

Elevation of top: 420
Elevation of emergency: 420
Elevation of design storm: 419
Elevation of riser: 417
Elevation of inlet: 414
Elevation of outlet: 375

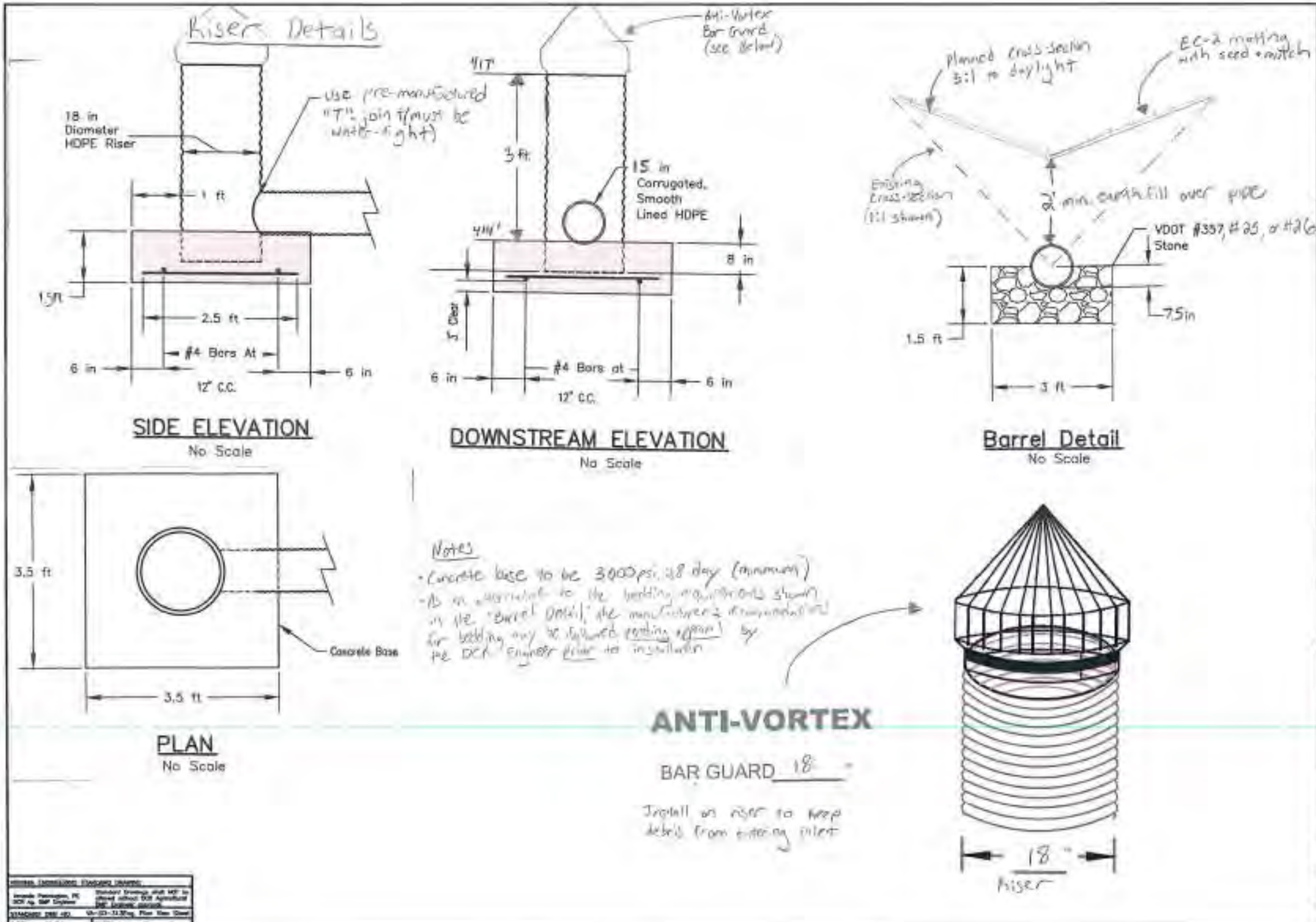
Top Width: 8 ft.
Upstream sideslope: 2.5:1
Downstream sideslope: 2.5:1

Pipe Outlet Detail

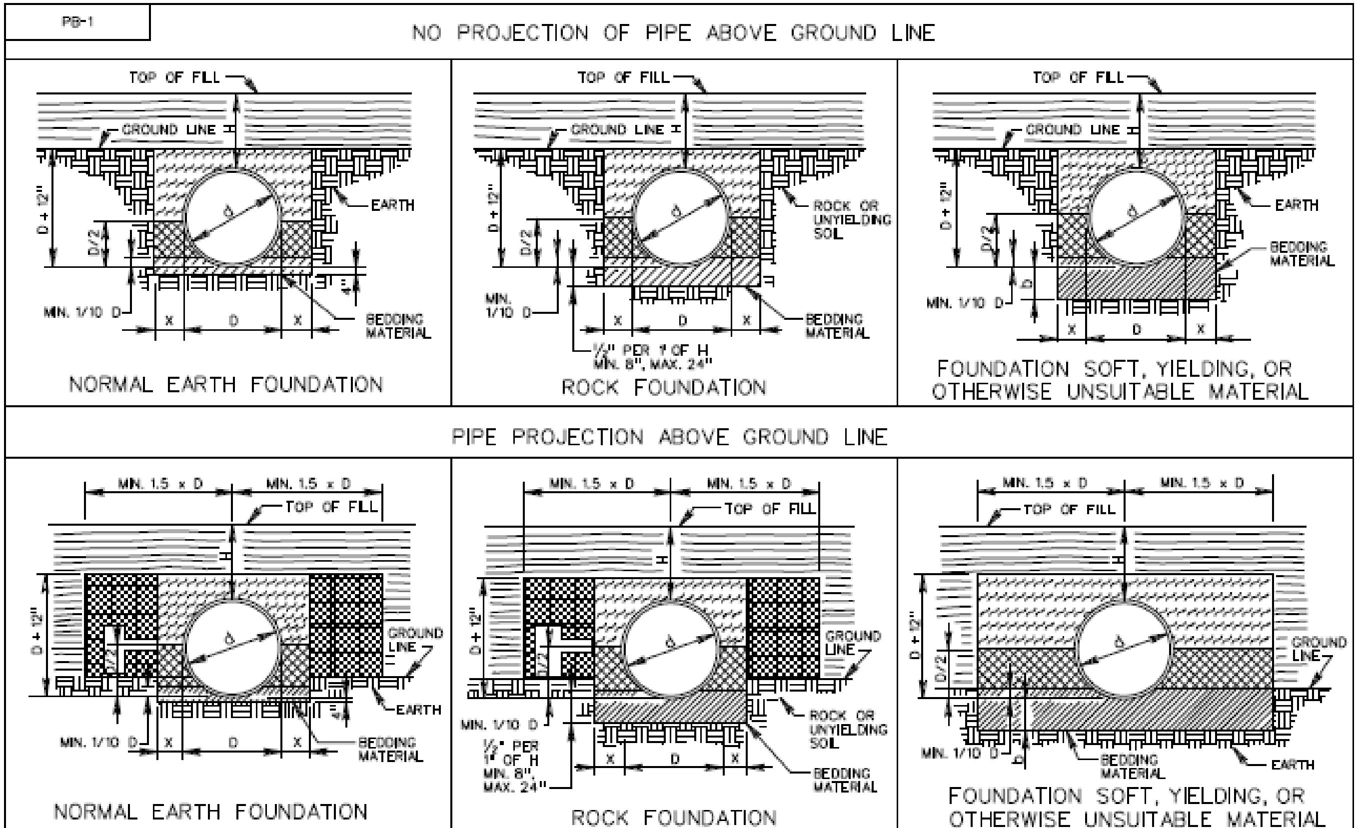
L_a = 16'
L_{total} = 46' (continue 17.25' width to Sta. 0+00)
Width = 17.25'
d = 18" (depth of stone)
d_{50} = 10" (Use Class A1 Riprap, 8-12" stone)



DCR



Riser Details
18 in
Diameter
HDPE Riser
Use pre-manufactured "T" joint (must be water-tight)
1 ft
1.5 ft
2.5 ft
#4 Bars At
6 in
12" C.C.
6 in
SIDE ELEVATION
No Scale
Anti-Vortex
Bar Guard
(see below)
3 ft
15 in
Corrugated,
Smooth
Lined HDPE
8 in
3" Clear
6 in
#4 Bars at
12" C.C.
6 in
DOWNSTREAM ELEVATION
No Scale
Planned cross-section
3:1 to daylight
EC-2 matting
with seed + mulch
Existing
Cross-section
(1:1 shown)
2' min. earth fill over pipe
VDOT #357, #25, or #26
Stone
7.5 in
1.5 ft
3 ft
Barrel Detail
No Scale
3.5 ft
Concrete Base
3.5 ft
PLAN
No Scale
Notes
- Concrete base to be 3000 psi, 28 day (minimum)
ANTI-VORTEX
BAR GUARD 18"
Install on riser to keep debris from entering inlet
18"
Riser



BEDDING MATERIAL IN ACCORDANCE WITH SECTION 302 OF THE ROAD AND BRIDGE SPECIFICATIONS.

CLASS I BACKFILL MATERIAL IN ACCORDANCE WITH SECTION 302 OF THE ROAD AND BRIDGE SPECIFICATIONS.

FOR PLASTIC PIPE CLASS I BACKFILL MATERIAL IN ACCORDANCE WITH SECTION 302 OF THE ROAD AND BRIDGE SPECIFICATIONS.

FOR ALL OTHER PIPE REGULAR BACKFILL MATERIAL IN ACCORDANCE WITH SECTION 302 OF THE ROAD AND BRIDGE SPECIFICATIONS.

EMBANKMENT

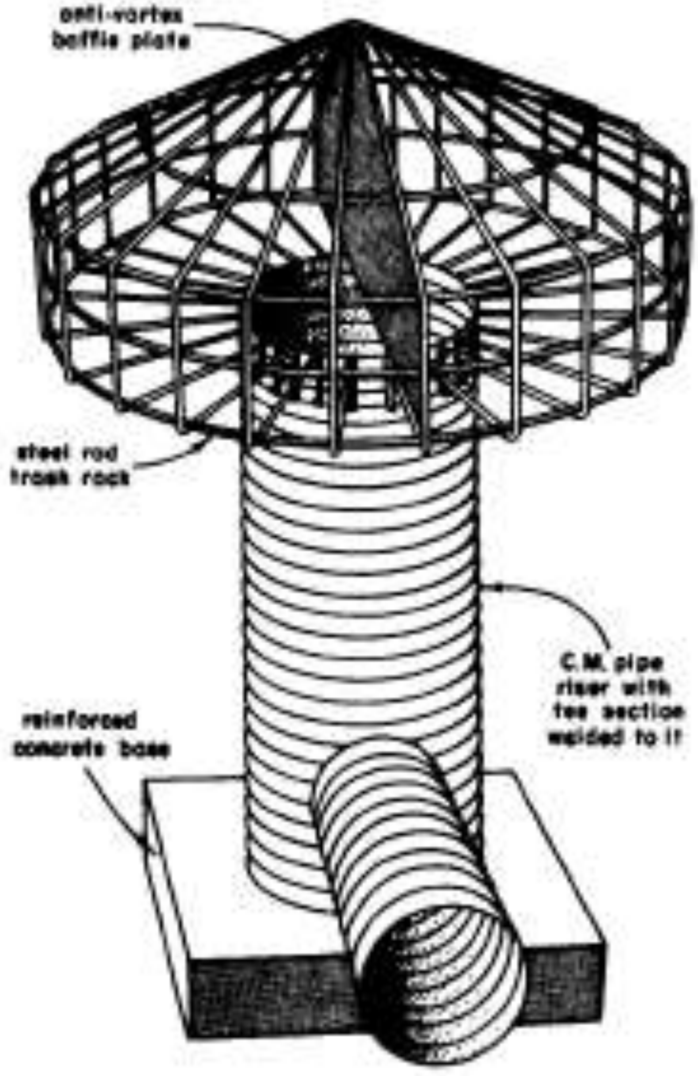
REGULAR BACKFILL MATERIAL IN ACCORDANCE WITH SECTION 302 OF THE ROAD AND BRIDGE SPECIFICATIONS.

NOTES:

FOR GENERAL NOTES ON PIPE BEDDING, SEE INSTALLATION OF PIPE CULVERTS AND STORM SEWERS GENERAL NOTES ON SHEET 107.00.

CRUSHED GLASS CONFORMING TO THE SIZE REQUIREMENTS FOR CRUSHER RUN AGGREGATE SIZE 25 AND 26 MAY BE USED IN PLACE OF CLASS I BACKFILL.

VDOT ROAD AND BRIDGE STANDARDS		INSTALL. OF PIPE CULVERTS AND STORM SEWERS CIRC. PIPE BEDDING AND BACKFILL - METHOD "A"	SPECIFICATION REFERENCE
SHEET 1 OF 4	REVISION DATE	VIRGINIA DEPARTMENT OF TRANSPORTATION	302
107.01	07/12		303



CORRUGATED METAL PIPE RISER
WITH CONICAL TRASH RACK AND BAFFLE

DCR
Virginia Department of Conservation & Recreation

Site Location Map

Scale 1 inch = n/a feet

Notes

1. The landowner/operator is responsible for obtaining and complying with all permits and easements. This includes all federal, state and local permits.
2. The landowner/operator is responsible for checking and complying with all local ordinances that may affect the project.
3. MISS UTILITY (Virginia telephone number 811) must be contacted at least 3 working days before construction begins. The landowner/operator is responsible for ensuring that the contractor contacts MISS UTILITY. The contractor must be able to provide the MISS UTILITY ticket number within 24 hours upon request by the DCR/SWCD representative. The landowner/operator is responsible for locating any buried utilities (water lines, electric lines, telephone lines, gas lines, sewer lines, etc.) in the work area that are not covered by the MISS UTILITY program.
4. DCR/SWCD makes no representation of the existence or nonexistence of utilities. The presence or absence of utilities on the construction drawings does not assure that there are or are not utilities in the work area.
5. The contractor is responsible for knowing and following the appropriate safety standards required by the Virginia Safety and Health Codes Board.
6. The landowner/operator shall notify the DCR/SWCD representative at least one week prior to beginning construction, and at all other times specified in this construction plan and attached specifications.
7. Any deviation from these construction drawings and specifications without written approval from DCR/SWCD representative may result in in failure of this practice to meet NRCS Standards and the withdrawal of technical assistance for this project.
8. Prior to beginning construction, the cover sheet must be signed by the landowner/operator, the contractor, and the DCR/SWCD representative. The landowner/operator is responsible for informing the contractor of these responsibilities by providing the contractor a copy of this cover sheet. The contractor must sign the cover sheet acknowledging that these responsibilities are understood and the landowner/operator must return the signed cover sheet to the DCR/SWCD Representative. If requested by DCR/SWCD, the landowner/operator shall arrange for a meeting between the contractor and DCR/SWCD to review the construction drawings and specifications prior to construction.

The SWCD Representative (include
The SWCD office telephone numbe
The SWCD office address is:

Benchmark Descriptions

TBM # CP1 | Assumed Elev. 422.08

Description:

Top of discharge end of existing 15" diam. culvert approx. 40' west of planned riser structure at Gully #2.

TBM # n/a | Assumed Elev. n/a

Description:

n/a

Acknowledgment Signatures

These construction drawings and attached specifications have been reviewed I understand what is required. (Sign and date below)

Landowner/Operator

Contractor

SWCD Representative

Engineering Job Class: II

Know what's below. Call before you dig.

"As Built" Documentation

Certified By and Date

Practice Completion Date

Index of Sheets

Sheet No.	Title
1	Cover Sheet
2	Site Location Aerial
3	Plan View
4	Typical Channel Cross Section Detail
5	Channel Center-Line Profile
6	Alignment (Cross-Section) Plan View
7-12	Cross-Sections 8-20
Attachments	NRCS O&M Agreement
	NRCS Construction Specifications

Specification Table

No.	Title
VA-705	Pollution Control
VA-706	Seeding
VA-707	Site Preparation
VA-708	Salvaging & Spreading Topsoil
VA-721	Excavation
VA-723	Earthfill
VA-727	Diversions and Waterways
VA-761	Loose Rock Riprap
VA-795	Geotextile

Table of Estimated Quantities

Item	Unit	Quantity
Gabion Stone (4-8" diameter) D50 = 5", D100 = 8"	tons	150
Nonwoven Class I or II Geotextile	sq.ft.	1670
--(Geotextile estimate is for sq.ft. of coverage; extra needed for	-	-
key and overlap)	-	-
Seed, mulch, soil amendments to meet VA-706	job	1

Engineering Design Cover Sheet

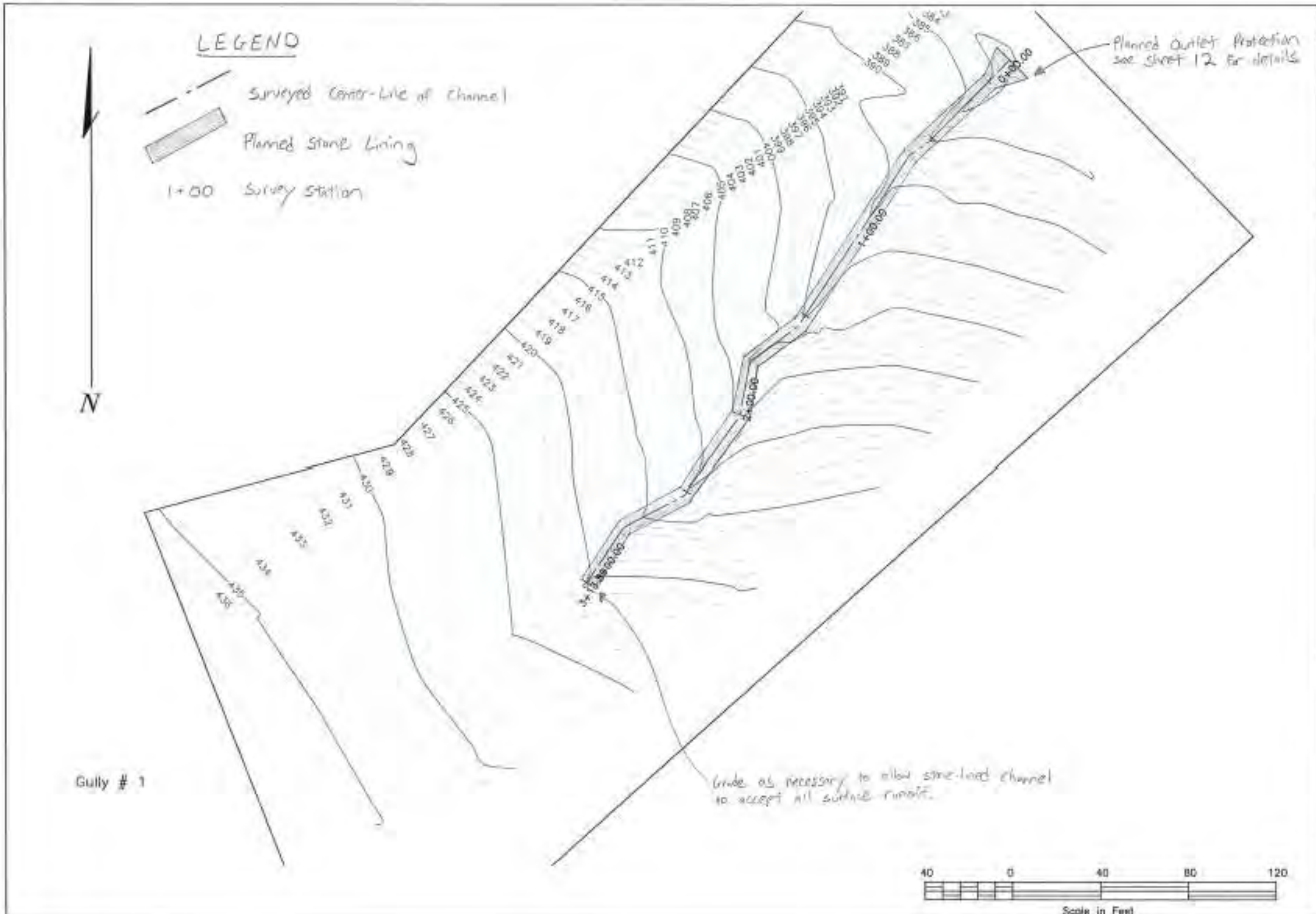
Designed: Raleigh Coleman 5/15/17
Drawn: Raleigh Coleman 5/15/17

This drawing adapted from NRCS Standard Drawing VA-SD-100 v2.4.0

Sheet 1 of 12

DCR

DCR

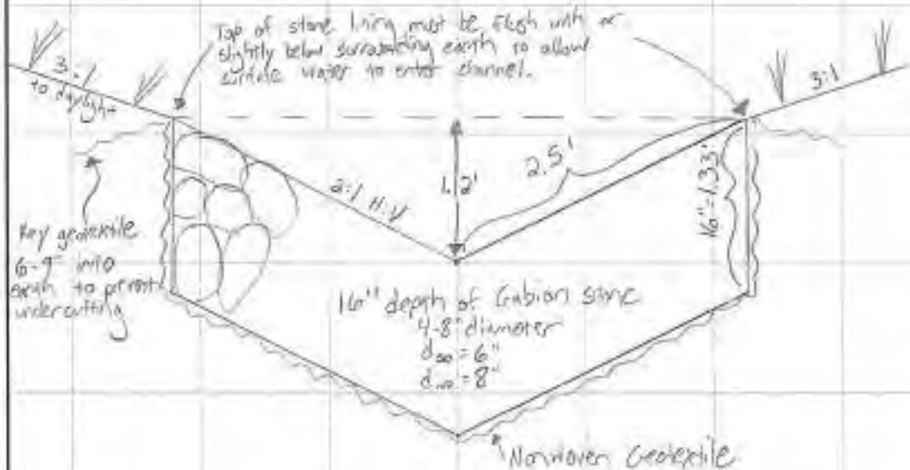

LEGEND
Surveyed Center-Line of Channel
Planned Stone Lining
1+00 Survey Station
N
Planned Outlet Protection see Sheet 12 for details
0+00.00
1+00.00
2+00.00
Grade as necessary to allow stone-lined channel to accept all surface runoff.
Gully # 1
40 0 40 80 120
Scale in Feet

Scale
Horizontal: 1" = 1'
Vertical: 1" = 1'

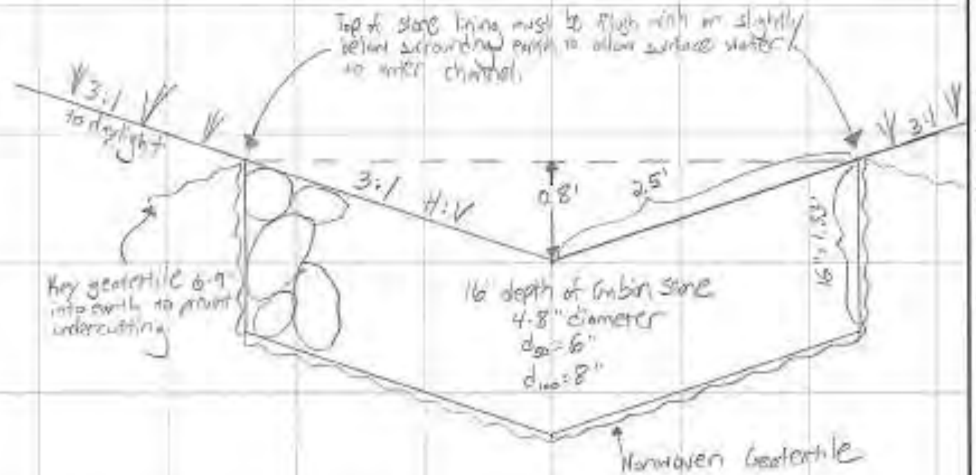
Typical Channel Cross-Sections

Sta. 3+13 → 0+14

2:1 Side Slopes



3:1 Side Slopes

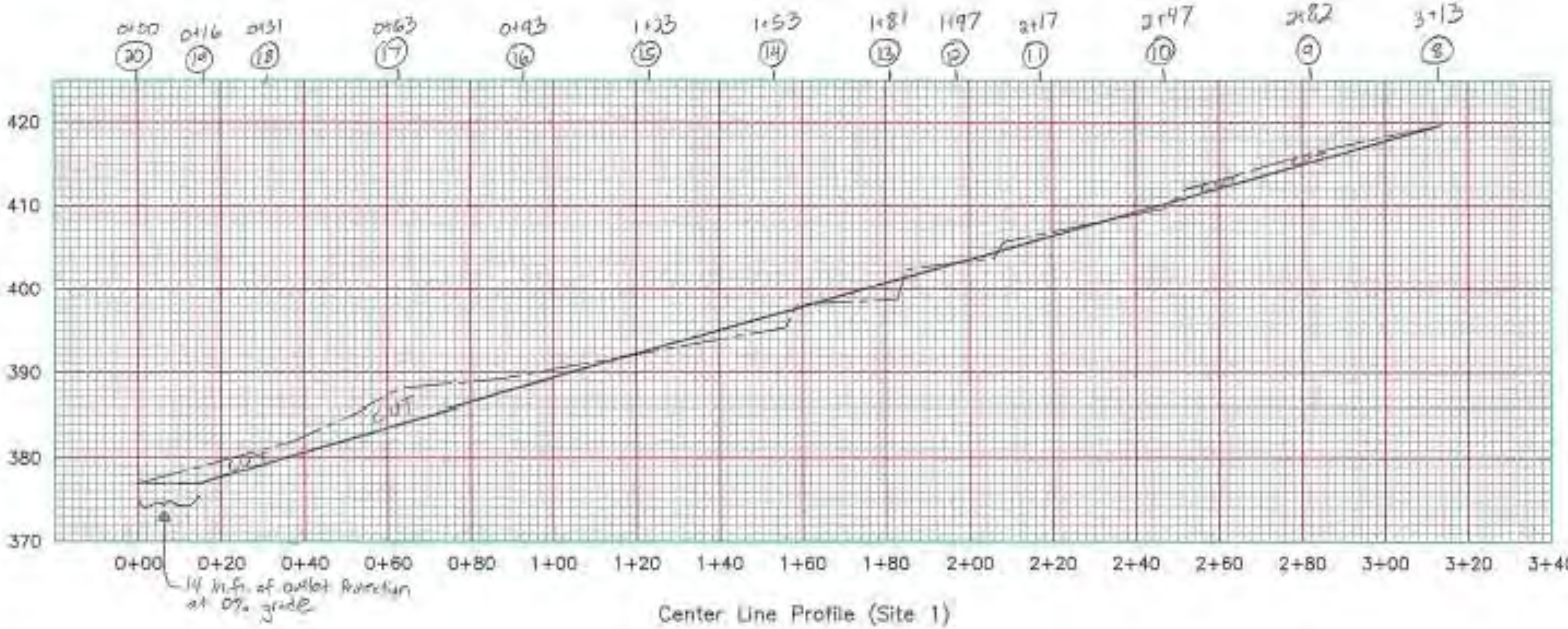


NOTES

- Side slopes of rock lined channel will be between 2:1 (Horizontal:Vertical) and 3:1 (H:V). Select side slope based on the "best fit" for each portion of channel. See sheets 7-12 for proposed grades.
- All earthen cut areas along channel will be 3:1 or flatter to daylight. Seed, mulch, and soil amendments must be applied according to VA-706
- Lining width of channel to be 5' and to a minimum depth of 1.12' for 2:1 areas and 0.8' for 3:1 areas.

DCR

Channel Center-Line Profile



Center Line Profile (Site 1)

Maximum Channel slope: 15%

LEGEND

- - — Existing Grade

—— Planned Grade (Top of stone lining in center of channel)

0+00 Survey Station

(20) Alignment (cross section) number

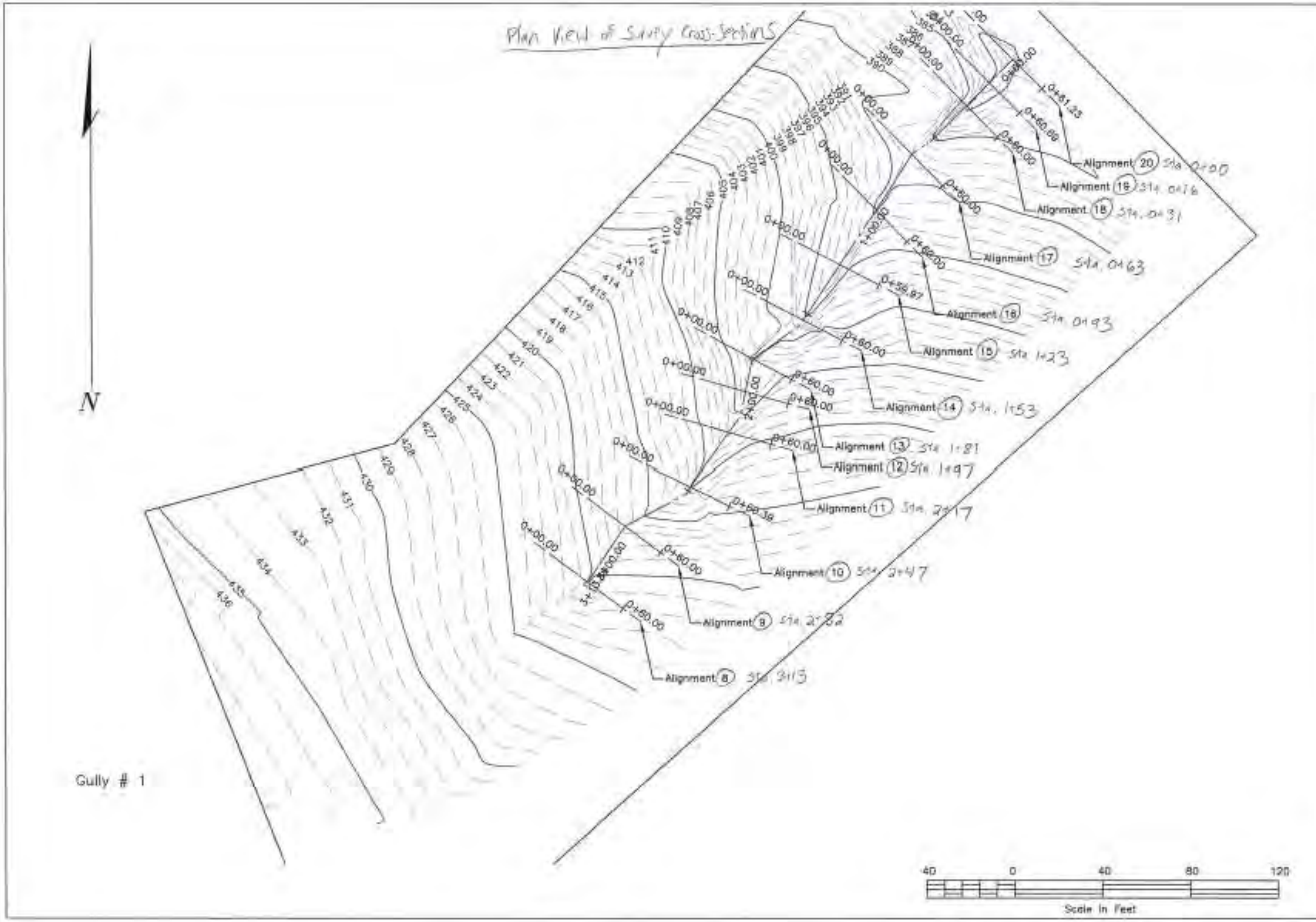
30 0 30 60 90

Scale in Feet

Notes

- Last 14 ft of channel will be outlet protection apron at 0% grade. see sheet 12 for details.
- Grade channel from Sta. 3+13 to Sta. 0+14 at a uniform grade (approx 14.4%)

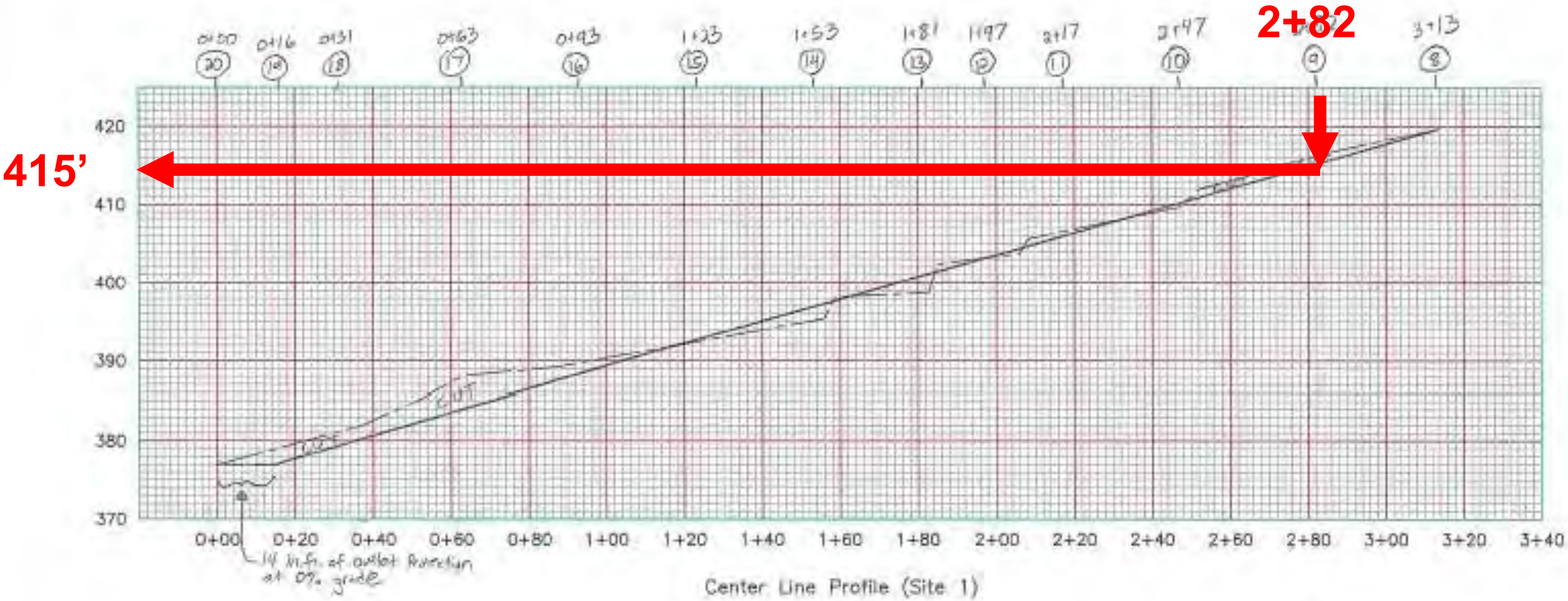
DCR



Plan View of Survey Cross-Sections
N
Alignment 20 Sta. 0+00
Alignment 19 Sta. 0+16
Alignment 18 Sta. 0+31
Alignment 17 Sta. 0+63
Alignment 16 Sta. 0+93
Alignment 15 Sta. 1+23
Alignment 14 Sta. 1+53
Alignment 13 Sta. 1+81
Alignment 12 Sta. 1+97
Alignment 11 Sta. 2+17
Alignment 10 Sta. 2+47
Alignment 9 Sta. 2+82
Alignment 8 Sta. 3+15
Gully # 1
40 0 40 80 120
Scale in Feet

Channel Center-Line Profile

After drawing the planned slope line, need to make the center-line elevation equal for each of the planned cross-sections to avoid conflicting elevations.



Maximum channel slope: 15%

LEGEND

Existing Grade

Planned Grade (Top of stone lining in center of channel)

0+00 Survey Station

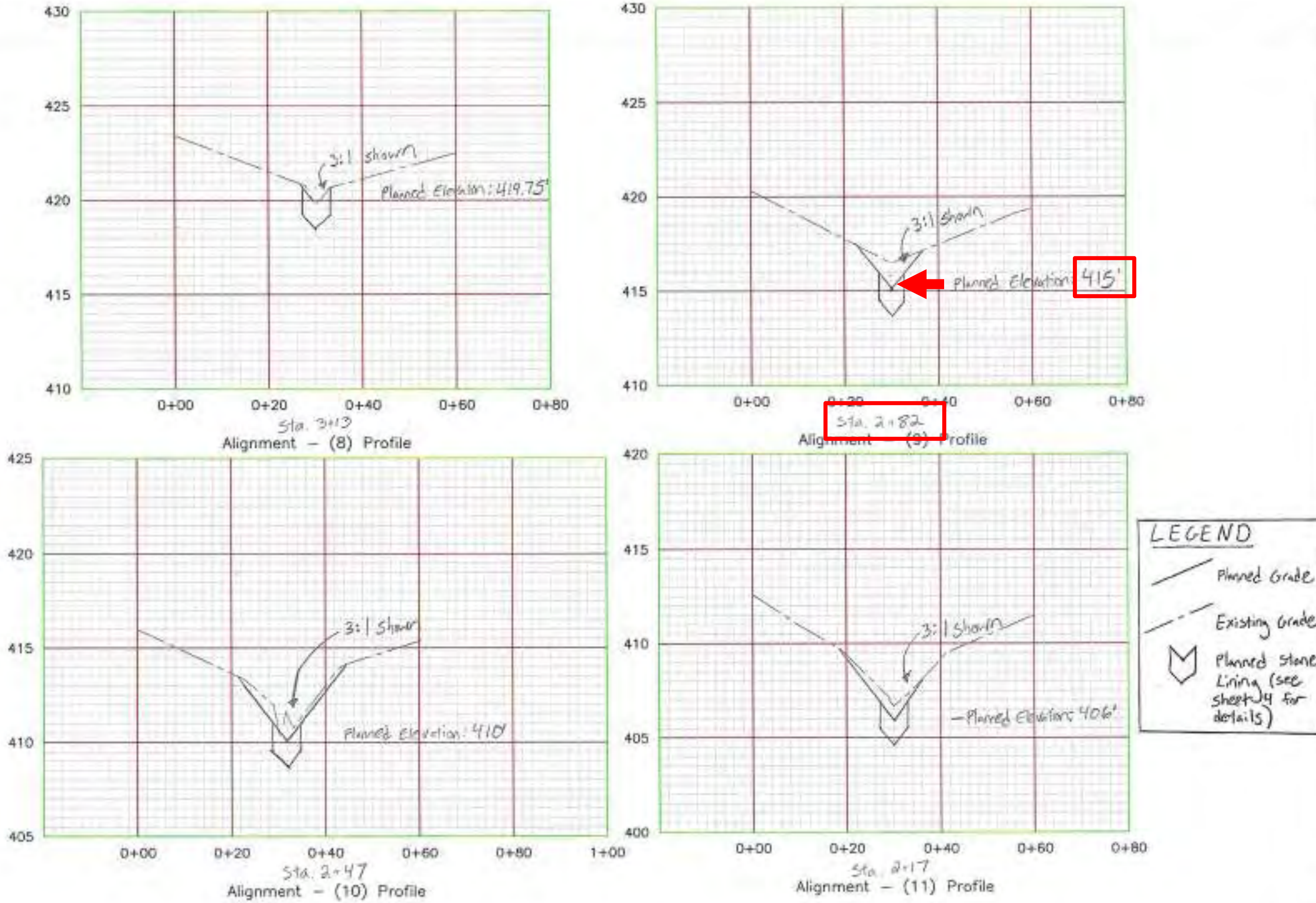
(20) Alignment (cross-section) number

Notes

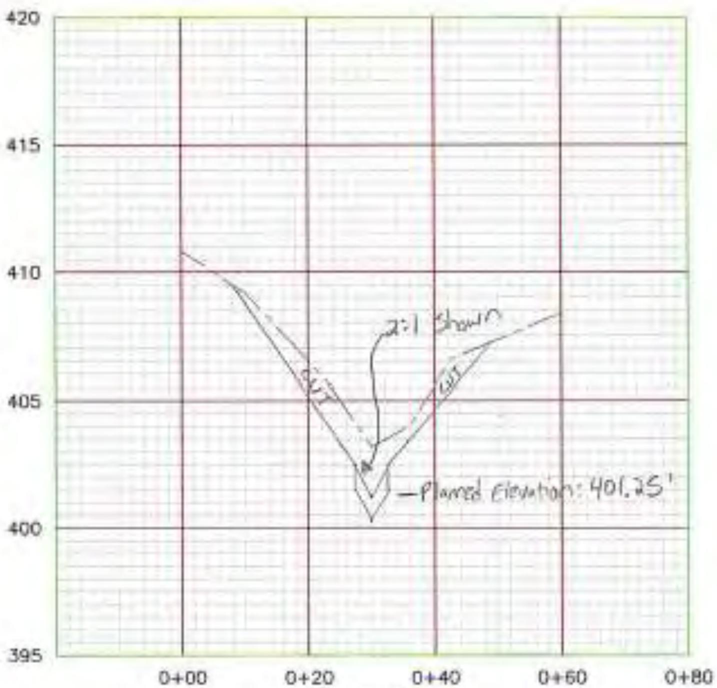
- Last 14 ft of channel will be added protection apron at 0% grade. See sheet 12 for details.
- Grade channel from Sta. 3+13 to Sta. 0+14 at a uniform grade (approx 14.4%)

30 0 30 60 90

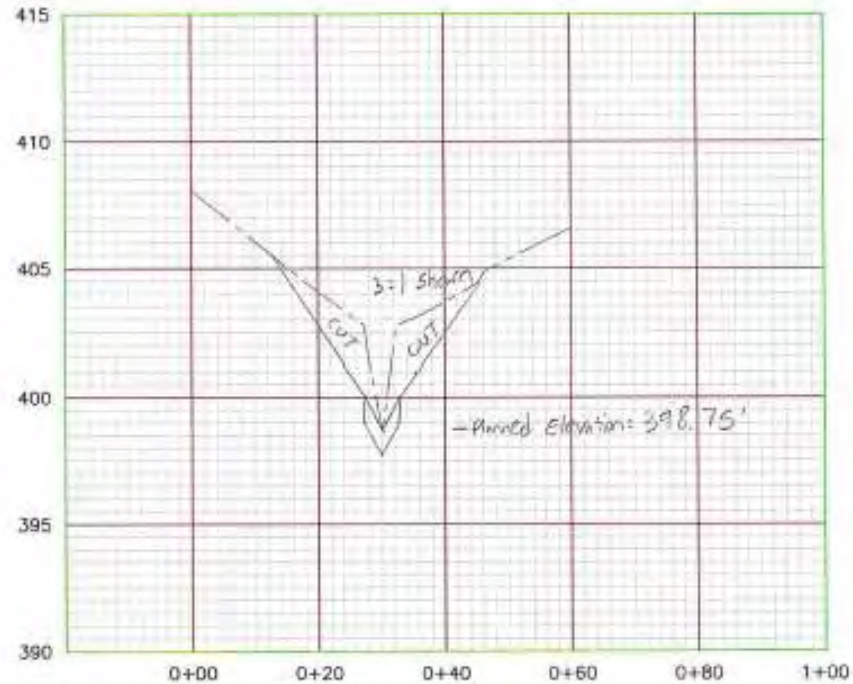
Scale in Feet



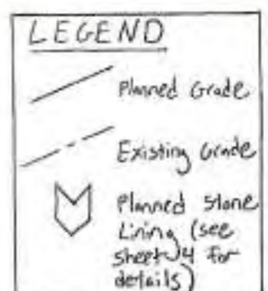
430
425
420
415
410
0+00
0+20
0+40
0+60
0+80
3:1 shown
Planned Elevation: 419.75'
Sta. 3+13
Alignment – (8) Profile
3:1 shown
Planned Elevation: 415'
Sta. 2+82
Alignment – (9) Profile
3:1 shown
Planned Elevation: 410'
Sta. 2+47
Alignment – (10) Profile
1+00
3:1 shown
Planned Elevation: 406'
Sta. 2+17
Alignment – (11) Profile
LEGEND
Planned Grade
Existing Grade
Planned Stone Lining (see sheet 4 for details)

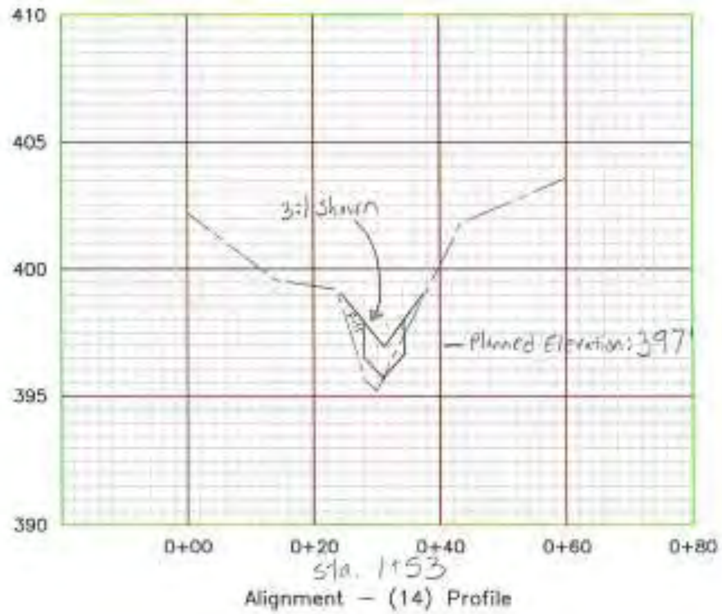


Sta. 1+97
Alignment – (12) Profile

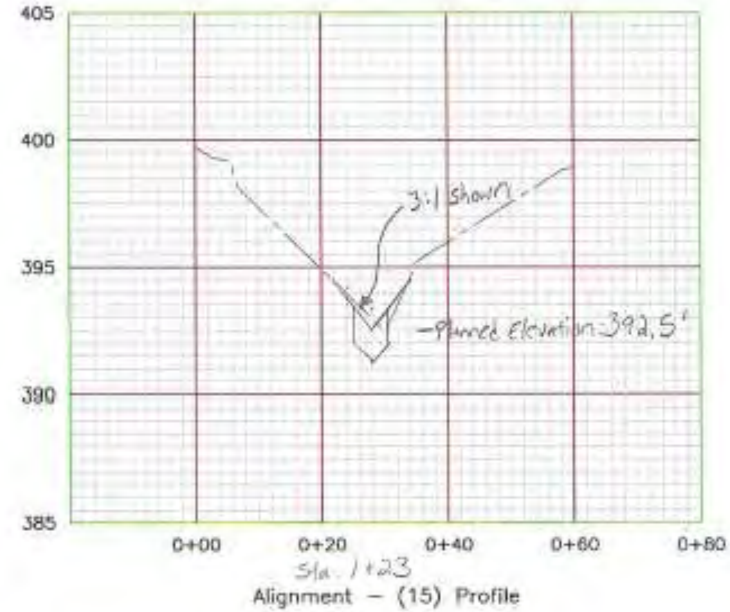


Sta. 1+81
Alignment – (13) Profile



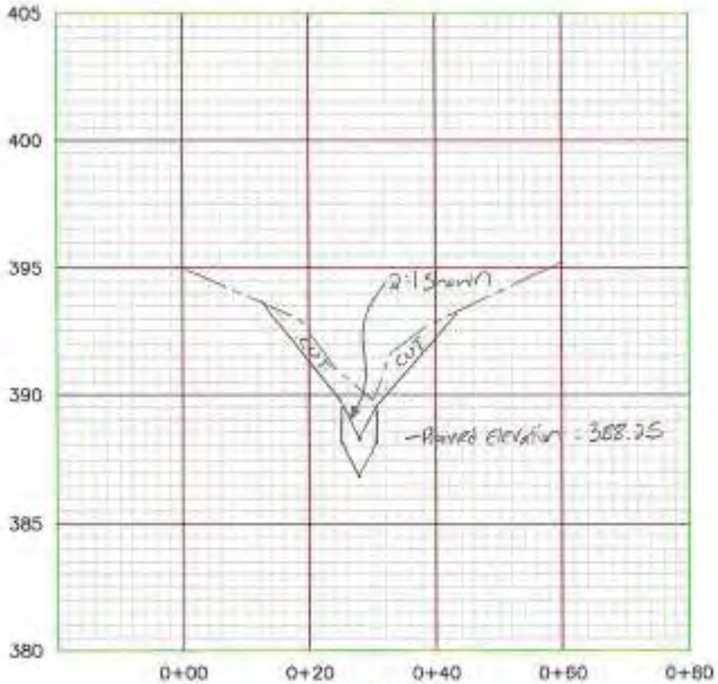


410
405
400
395
390
3:1 shown
Planned Elevation: 397'
0+00
0+20
0+40
0+60
0+80
Sta. 1+53
Alignment — (14) Profile



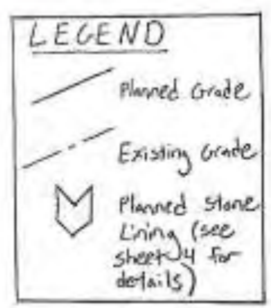
405
400
395
390
385
3:1 shown
Planned Elevation: 392.5'
0+00
0+20
0+40
0+60
0+80
Sta. 1+23
Alignment — (15) Profile

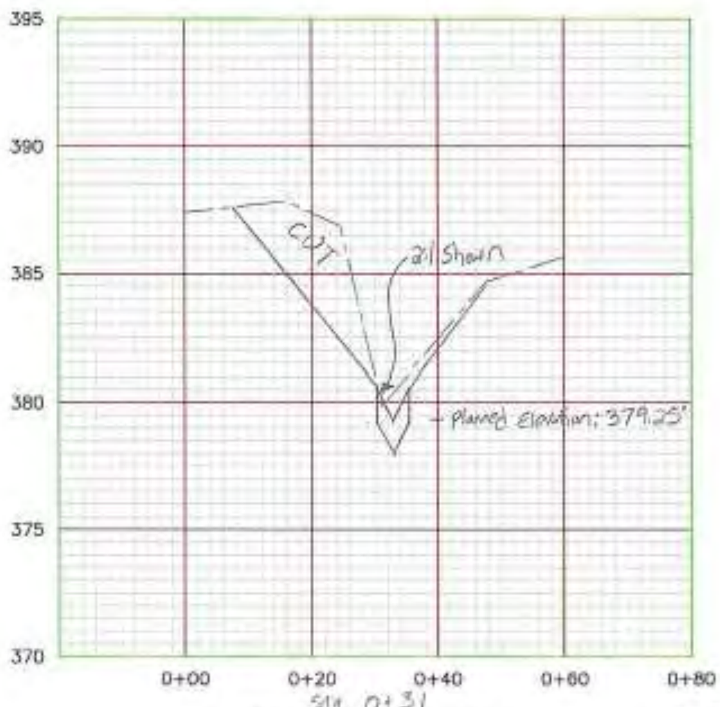
LEGEND
Planned Grade
Existing Grade
Planned Stone Lining (see sheet 4 for details)



Sta 0+73
Alignment – (16) Profile

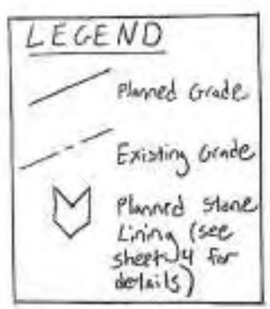
Sta. 0+63
Alignment – (17) Profile



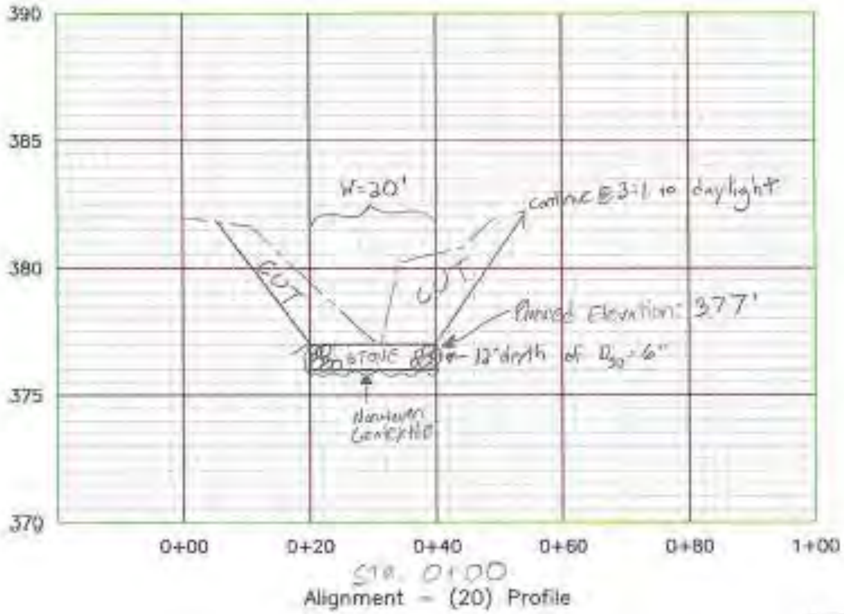


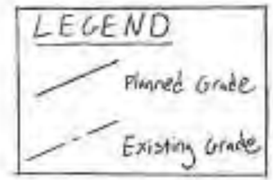
Alignment – (18) Profile

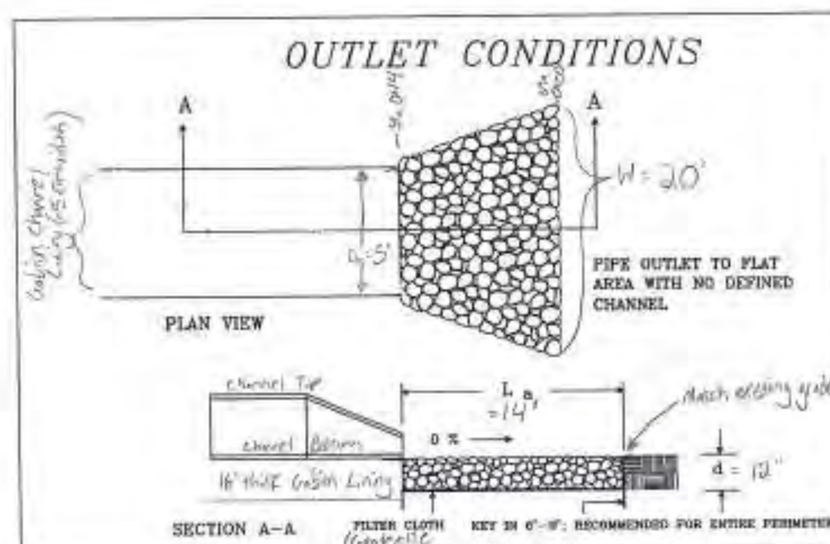
Alignment – (19) Profile



Outlet Protection Details



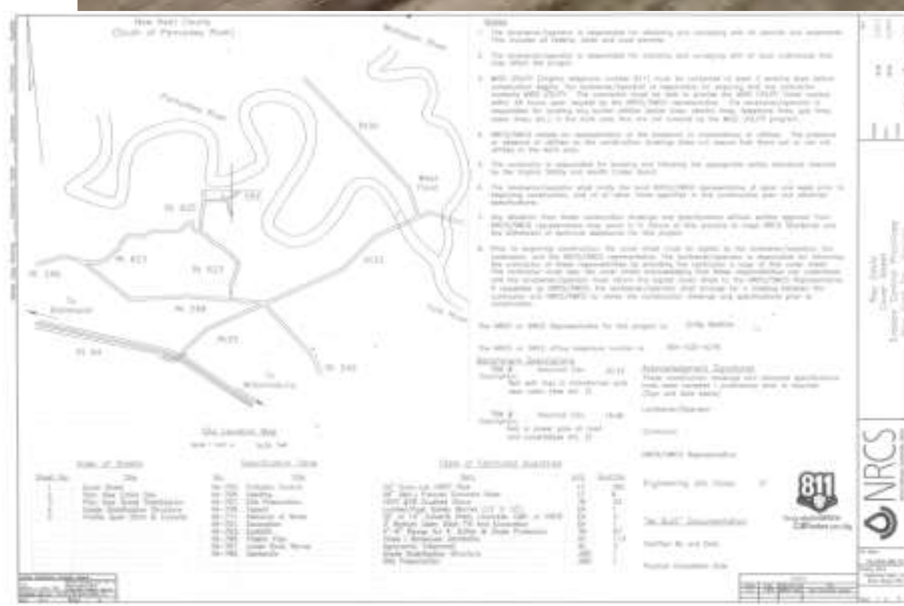


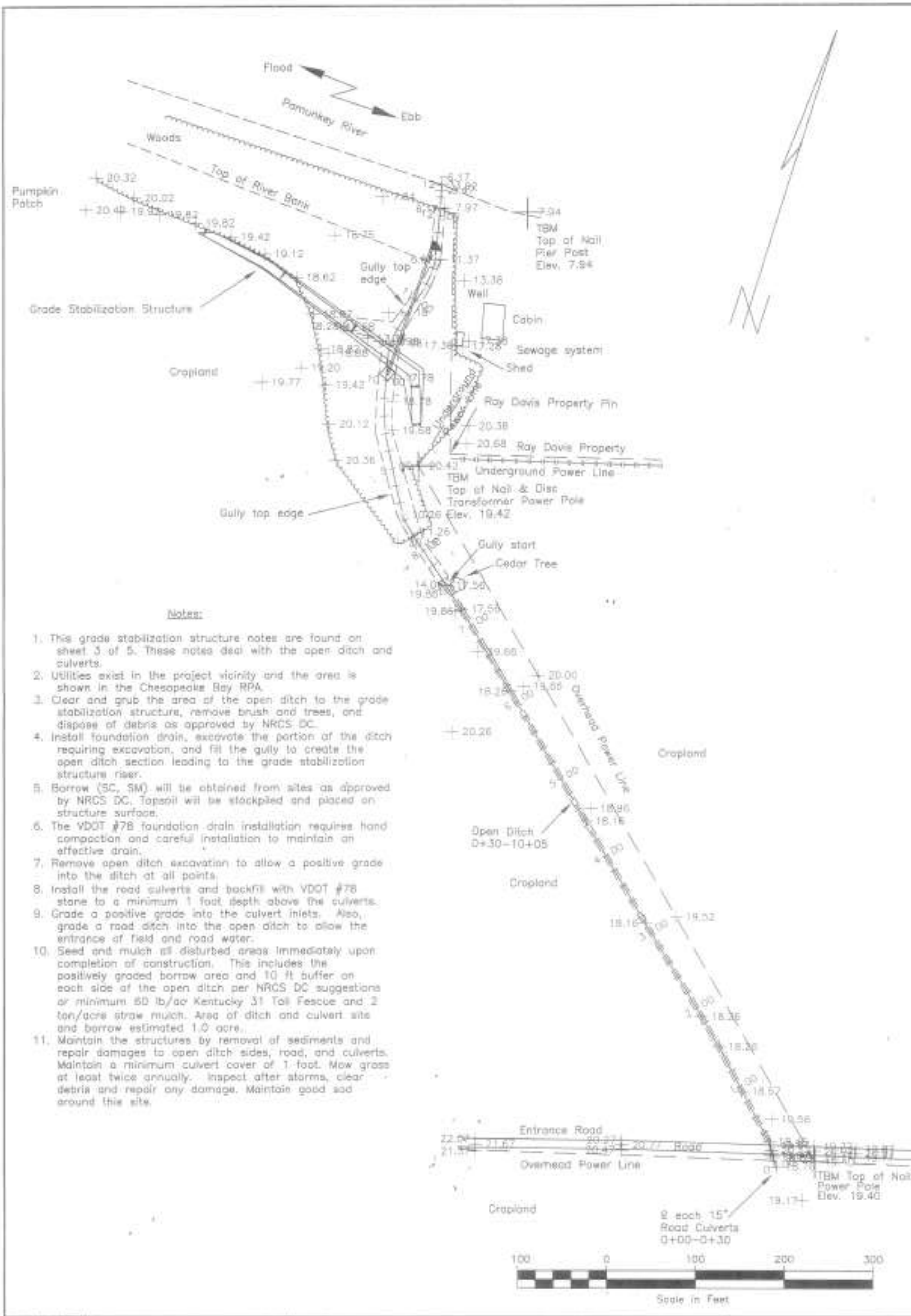


Virginia Department of Conservation & Recreation

Case Study #2: Coastal Plain Drop Structure

- Major eroding gully
- 5’ wide at bottom, 5-10’ deep
- Direct discharge into Pamunkey River
- Soils: fine sandy loam, K=0.37 to 0.43
- NRCS-designed, District-funded
- New Kent County, LC Davis & Sons Farm

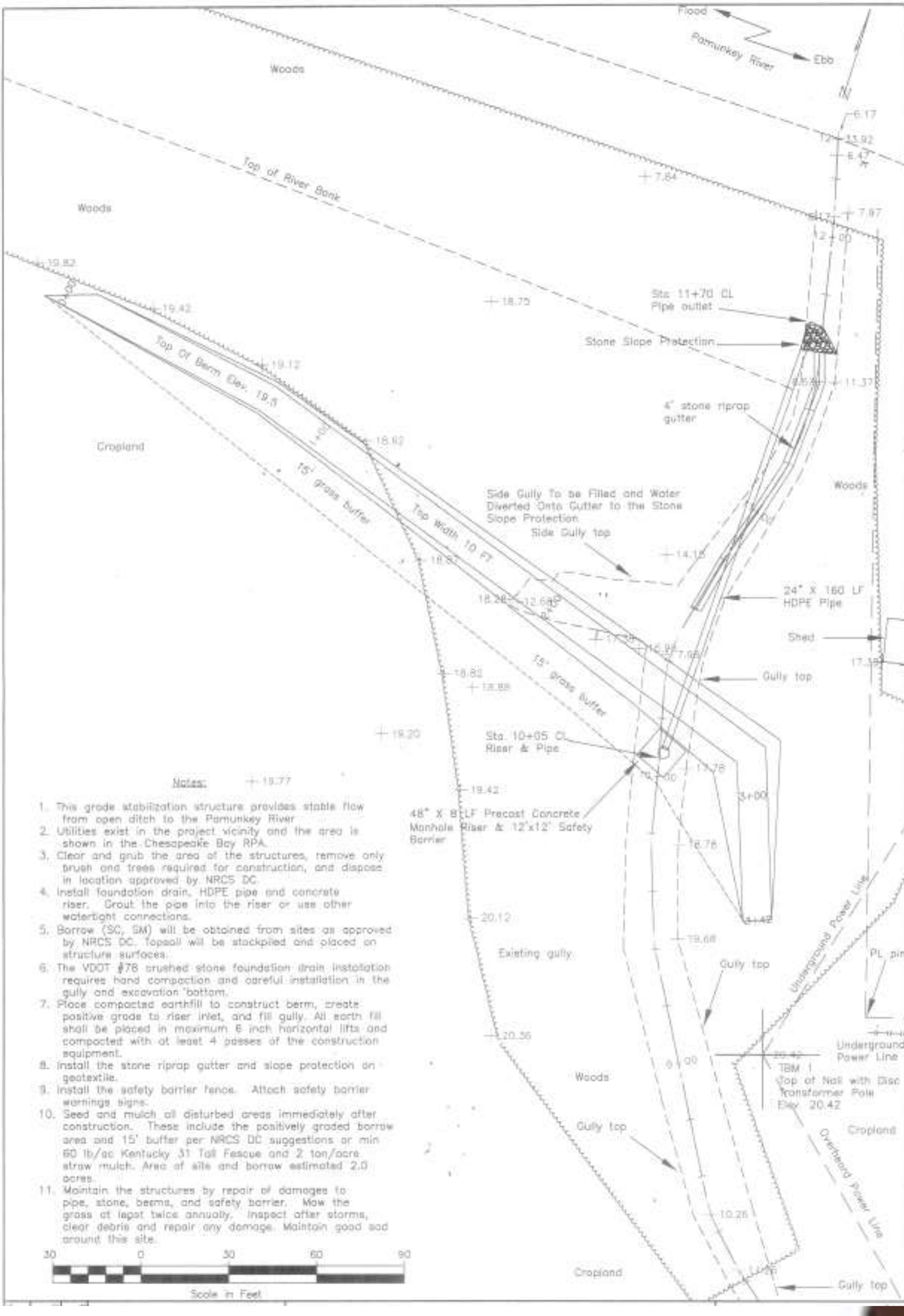


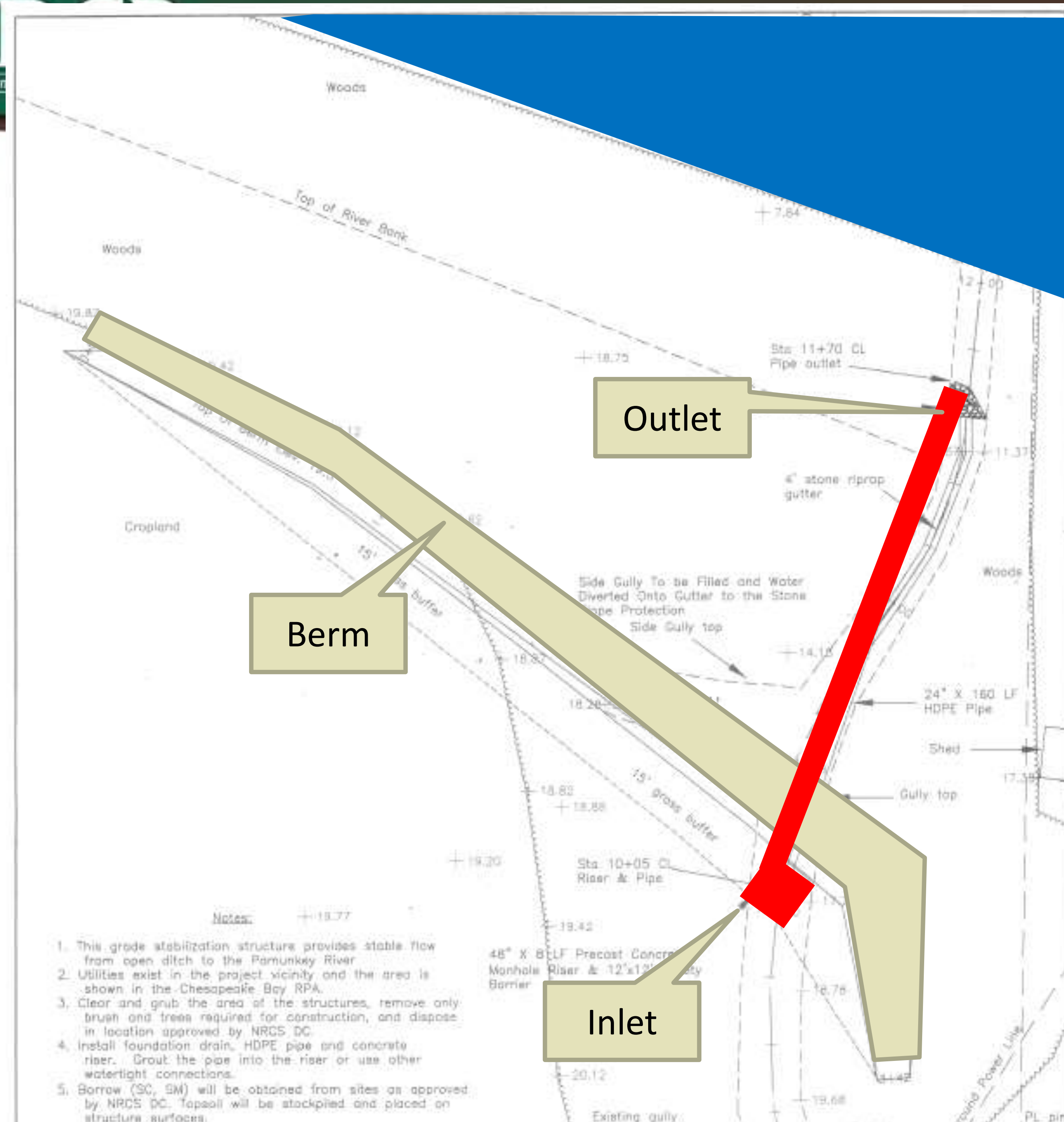


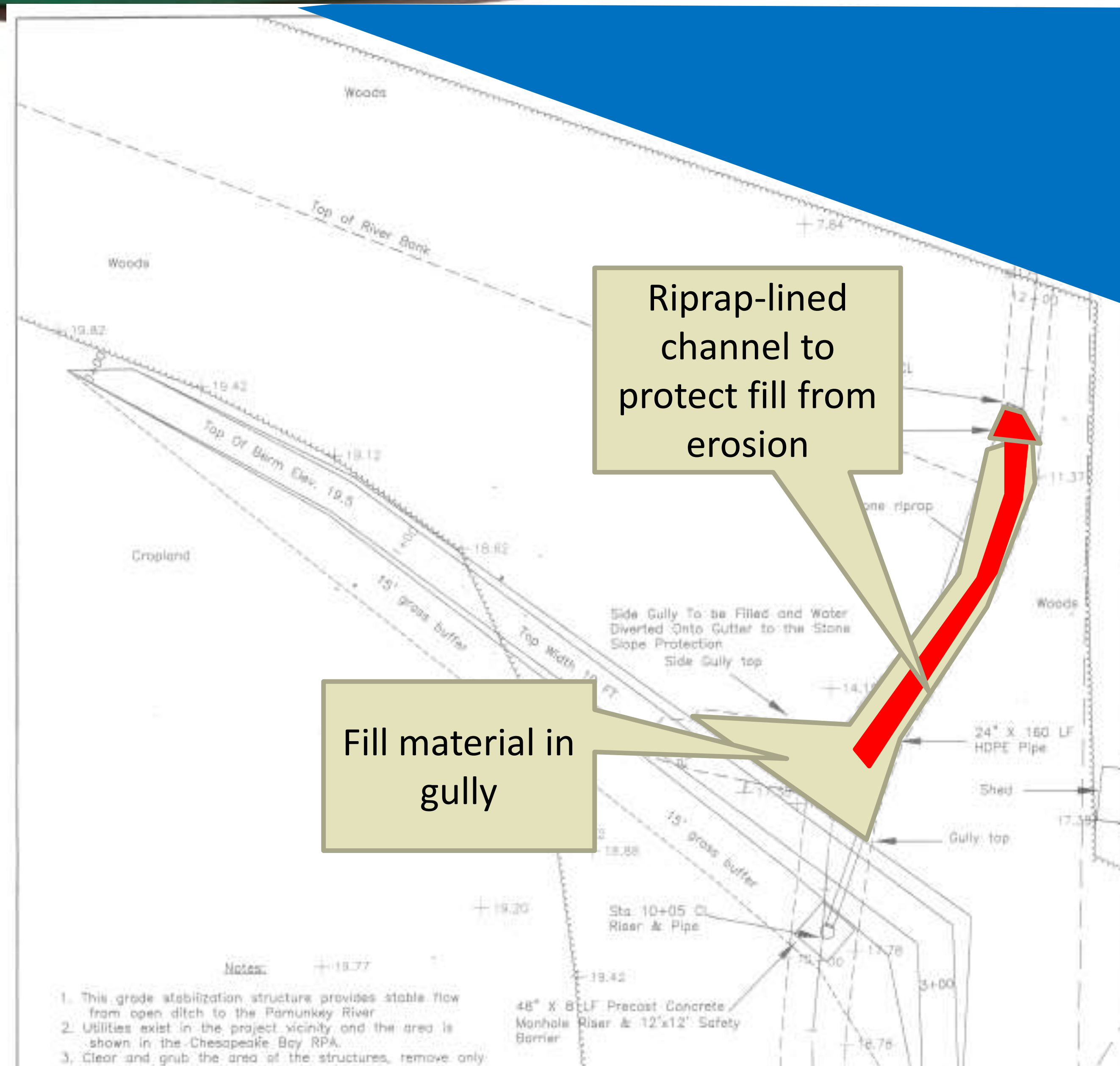
Notes:

1. This grade stabilization structure notes are found on sheet 3 of 5. These notes deal with the open ditch and culverts.
2. Utilities exist in the project vicinity and the area is shown in the Chesapeake Bay RPA.
3. Clear and grub the area of the open ditch to the grade stabilization structure, remove brush and trees, and dispose of debris as approved by NRCS DC.
4. Install foundation drain, excavate the portion of the ditch requiring excavation, and fill the gully to create the open ditch section leading to the grade stabilization structure riser.
5. Borrow (SC, SM) will be obtained from sites as approved by NRCS DC. Topsoil will be stockpiled and placed on structure surface.
6. The VDOT #78 foundation drain installation requires hand compaction and careful installation to maintain an effective drain.
7. Remove open ditch excavation to allow a positive grade into the ditch at all points.
8. Install the road culverts and backfill with VDOT #78 stone to a minimum 1 foot depth above the culverts.
9. Grade a positive grade into the culvert inlets. Also, grade a road ditch into the open ditch to allow the entrance of field and road water.
10. Seed and mulch all disturbed areas immediately upon completion of construction. This includes the positively graded borrow area and 10 ft buffer on each side of the open ditch per NRCS DC suggestions or minimum 60 lb/ac Kentucky 31 Tall Fescue and 2 ton/acre straw mulch. Area of ditch and culvert site and borrow estimated 1.0 acre.
11. Maintain the structures by removal of sediments and repair damages to open ditch sides, road, and culverts. Maintain a minimum culvert cover of 1 foot. Mow grass at least twice annually. Inspect after storms, clear debris and repair any damage. Maintain good sod around this site.

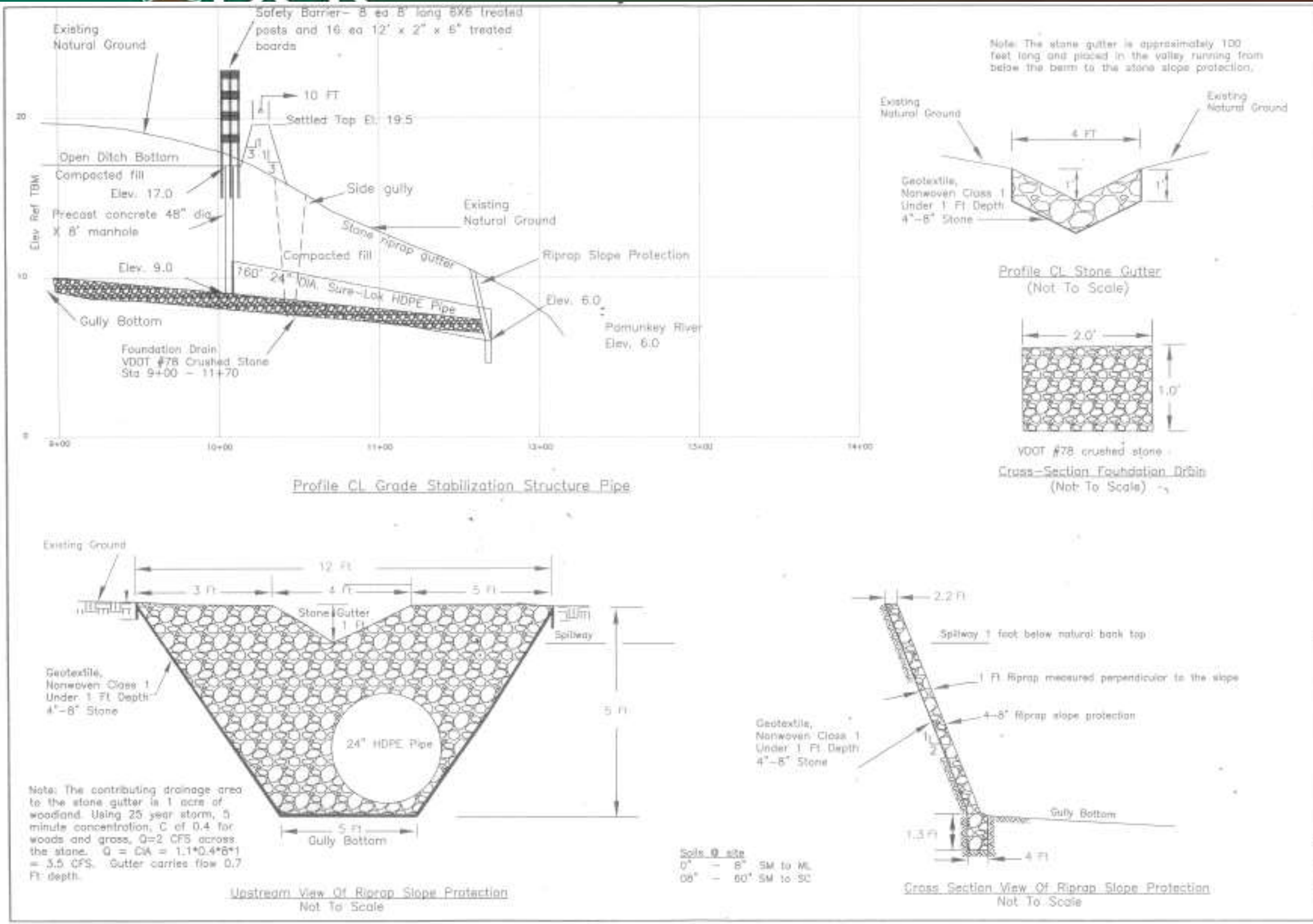
DCR


Flood
Pamunkey River
Ebb
Woods
Top of River Bank
Woods
Cropland
Top Of Berm Elev. 19.5
15' grass buffer
Top Width 10 FT
15' grass buffer
Sta. 11+70 CL
Pipe outlet
Stone Slope Protection
4" stone riprap
gutter
Woods
Side Gully To be Filled and Water
Diverted Onto Gutter to the Stone
Slope Protection
Side Gully top
24" X 160 LF
HDPE Pipe
Shed
Gully top
Sta. 10+05 CL
Riser & Pipe
48" X 8 LF Precast Concrete
Manhole Riser & 12'x12' Safety
Barrier
Existing gully
Gully top
Underground Power Line
PL pin
Underground
Power Line
TBM 1
Top of Nail with Disc
Transformer Pole
Elev. 20.42
Cropland
Overhead Power Line
Woods
Gully top
Cropland
Gully top
Notes:
1. This grade stabilization structure provides stable flow from open ditch to the Pamunkey River.
2. Utilities exist in the project vicinity and the area is shown in the Chesapeake Bay RPA.
3. Clear and grub the area of the structures, remove only brush and trees required for construction, and dispose in location approved by NRCS DC.
4. Install foundation drain, HDPE pipe and concrete riser. Grout the pipe into the riser or use other watertight connections.
5. Borrow (SC, SM) will be obtained from sites as approved by NRCS DC. Topsoil will be stockpiled and placed on structure surfaces.
6. The VDOT #78 crushed stone foundation drain installation requires hand compaction and careful installation in the gully and excavation bottom.
7. Place compacted earthfill to construct berm, create positive grade to riser inlet, and fill gully. All earth fill shall be placed in maximum 6 inch horizontal lifts and compacted with at least 4 passes of the construction equipment.
8. Install the stone riprap gutter and slope protection on geotextile.
9. Install the safety barrier fence. Attach safety barrier warnings signs.
10. Seed and mulch all disturbed areas immediately after construction. These include the positively graded borrow area and 15' buffer per NRCS DC suggestions or min 60 lb/ac Kentucky 31 Tall Fescue and 2 ton/acre straw mulch. Area of site and borrow estimated 2.0 acres.
11. Maintain the structures by repair of damages to pipe, stone, berms, and safety barrier. Mow the grass at least twice annually. Inspect after storms, clear debris and repair any damage. Maintain good sod around this site.
30 0 30 60 90
Scale in Feet


Woods
Top of River Bank
Woods
Cropland
Sta. 11+70 CL
Pipe outlet
Outlet
4" stone riprap
gutter
Woods
15' grass buffer
Berm
Side Gully To be Filled and Water
Diverted Onto Gutter to the Stone
Slope Protection
Side Gully top
24" X 160 LF
HDPE Pipe
Shed
Gully top
15' grass buffer
Sta. 10+05 CL
Riser & Pipe
48" X 8 LF Precast Concrete
Manhole Riser & 12'x12' Safety
Barrier
Inlet
Existing gully
Notes:
1. This grade stabilization structure provides stable flow from open ditch to the Pamunkey River
2. Utilities exist in the project vicinity and the area is shown in the Chesapeake Bay RPA.
3. Clear and grub the area of the structures, remove only brush and trees required for construction, and dispose in location approved by NRCS DC.
4. Install foundation drain, HDPE pipe and concrete riser. Grout the pipe into the riser or use other watertight connections.
5. Borrow (SC, SM) will be obtained from sites as approved by NRCS DC. Topsoil will be stockpiled and placed on structure surfaces.

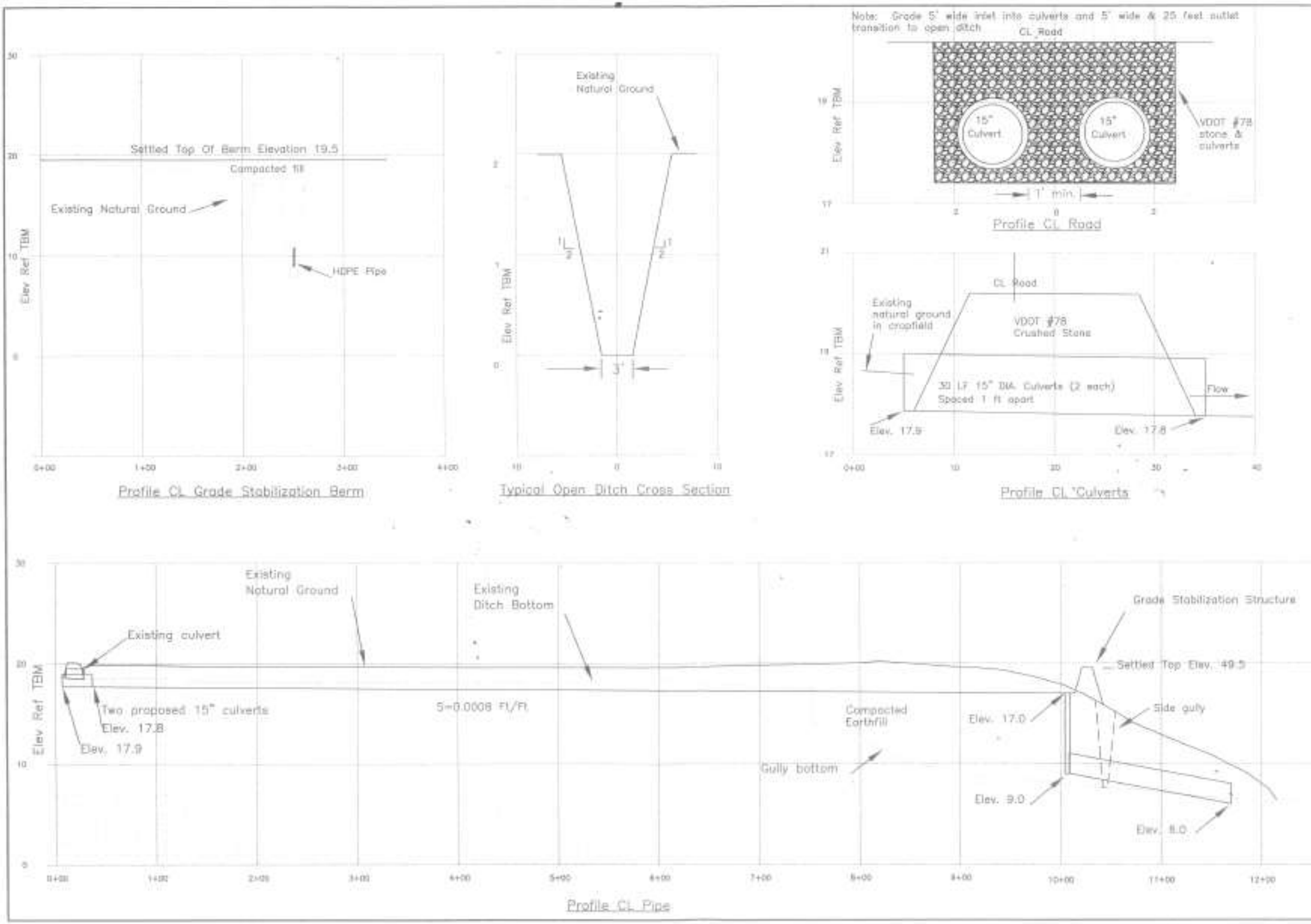

Riprap-lined channel to protect fill from erosion
Fill material in gully
Woods
Top of River Bank
Woods
Cropland
Top Of Berm Elev. 19.5
15' grass buffer
Top Width 10 FT
Side Gully To be Filled and Water Diverted Onto Gutter to the Stone Slope Protection
Side Gully top
Woods
24" X 160 LF HDPE Pipe
Shed
Gully top
15' grass buffer
Sta. 10+05 CL Riser & Pipe
48" X 8 LF Precast Concrete Manhole Riser & 12'x12' Safety Barrier
Notes:
1. This grade stabilization structure provides stable flow from open ditch to the Pamunkey River
2. Utilities exist in the project vicinity and the area is shown in the Chesapeake Bay RPA.
3. Clear and grub the area of the structures, remove only

DCR



Safety Barrier- 8 ea 8' long 6X6 treated posts and 16 ea 12' x 2" x 6" treated boards
Existing Natural Ground
10 FT
Settled Top El. 19.5
Open Ditch Bottom
Compacted fill
Elev. 17.0
Side gully
Existing Natural Ground
Precast concrete 48" dia X 8' manhole
Stone riprap gutter
Compacted fill
Riprap Slope Protection
Elev. 9.0
160' 24" DIA. Sure-Lok HDPE Pipe
Elev. 6.0
Gully Bottom
Pamunkey River Elev. 6.0
Foundation Drain VDOT #78 Crushed Stone Sta 9+00 - 11+70
Elev Ref TBM
9+00
10+00
11+00
12+00
13+00
14+00
Profile CL Grade Stabilization Structure Pipe
Note: The stone gutter is approximately 100 feet long and placed in the valley running from below the berm to the stone slope protection.
Existing Natural Ground
Existing Natural Ground
4 FT
Geotextile, Nonwoven Class 1 Under 1 Ft Depth 4"-8" Stone
Profile CL Stone Gutter
(Not To Scale)
2.0'
1.0'
VDOT #78 crushed stone
Cross-Section Foundation Drain
(Not To Scale)
Existing Ground
12 Ft
3 Ft
4 Ft
5 Ft
Stone Gutter 1 Ft
Spillway
Geotextile, Nonwoven Class 1 Under 1 Ft Depth 4"-8" Stone
24" HDPE Pipe
5 Ft
5 Ft Gully Bottom
Note: The contributing drainage area to the stone gutter is 1 acre of woodland. Using 25 year storm, 5 minute concentration, C of 0.4 for woods and grass, Q=2 CFS across the stone. Q = CIA = 1.1*0.4*8*1 = 3.5 CFS. Gutter carries flow 0.7 Ft depth.
Upstream View Of Riprap Slope Protection
Not To Scale
Soils @ site
0" - 8" SM to ML
08" - 60" SM to SC
2.2 Ft
Spillway 1 foot below natural bank top
1 Ft Riprap measured perpendicular to the slope
4-8" Riprap slope protection
Geotextile, Nonwoven Class 1 Under 1 Ft Depth 4"-8" Stone
Gully Bottom
1.3 Ft
4 Ft
Cross Section View Of Riprap Slope Protection
Not To Scale

DCR



Settled Top Of Berm Elevation 19.5
Compacted fill
Existing Natural Ground
HDPE Pipe
Elev Ref TBM
Profile CL Grade Stabilization Berm
Existing Natural Ground
3'
Typical Open Ditch Cross Section
Note: Grade 5' wide inlet into culverts and 5' wide & 25 feet outlet transition to open ditch
CL Road
15" Culvert
15" Culvert
VDOT #78 stone & culverts
1' min.
Profile CL Road
CL Road
Existing natural ground in cropfield
VDOT #78 Crushed Stone
30 LF 15" DIA. Culverts (2 each) Spaced 1 ft apart
Flow
Elev. 17.9
Elev. 17.8
Profile CL Culverts
Existing Natural Ground
Existing Ditch Bottom
Existing culvert
Grade Stabilization Structure
Settled Top Elev. 49.5
Two proposed 15" culverts
Elev. 17.8
Elev. 17.9
S=0.0008 Ft/Ft
Compacted Earthfill
Elev. 17.0
Side gully
Gully bottom
Elev. 9.0
Elev. 8.0
Profile CL Pipe

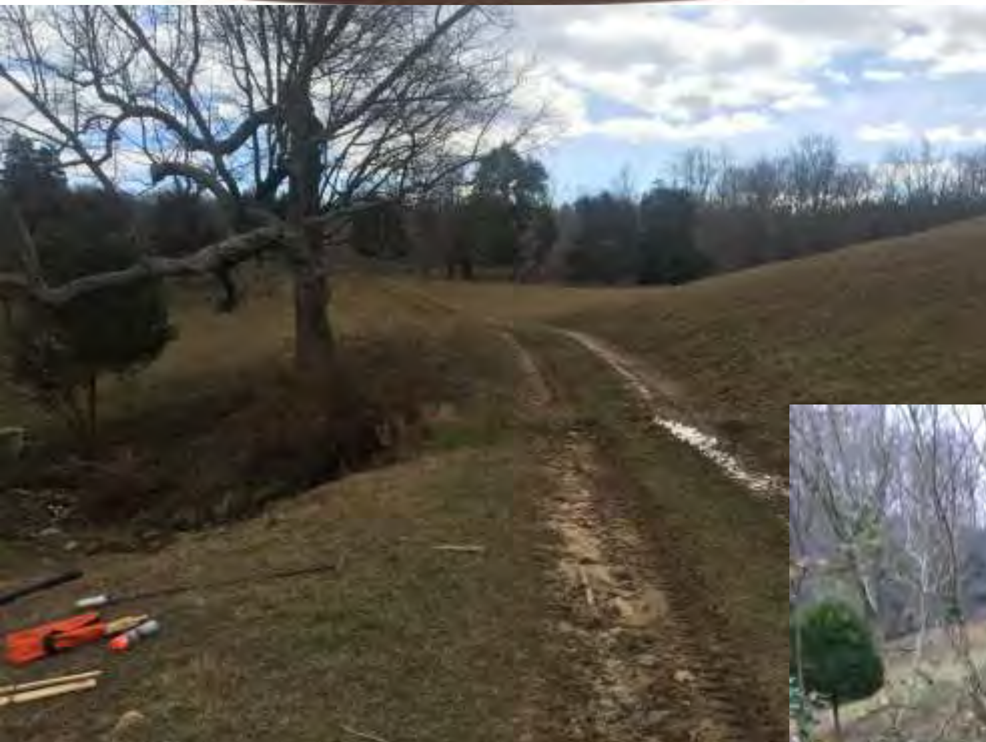
Virginia Department of Conservation & Recreation

DCR

Virginia Department of Conservation & Recreation

Case Study #3:
Drop Structure / Lined Waterway

- Huge headcut area
- Farm road and steep hill above limited available space
- Huge pile of field stone available

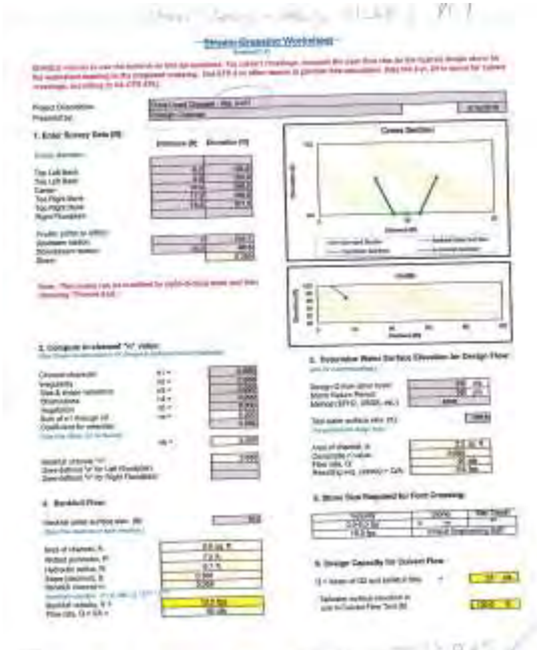


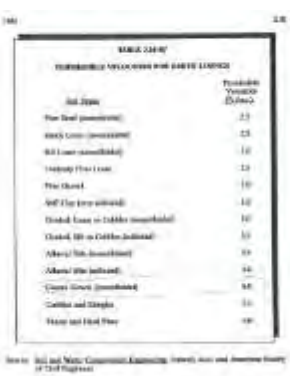
Not as simple as dumping a bunch of stone in the gully!

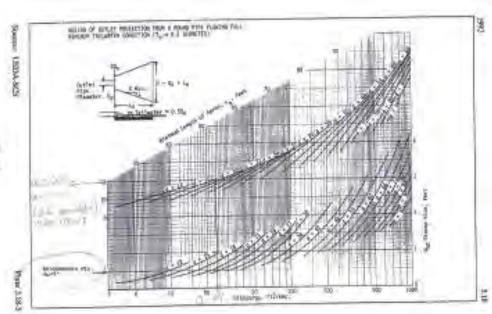
Client: Duca
County: Fauquier NOAA-8 State: VA
Practice: Lined Waterway
Calculated By: RC Date: 5/4/2016
Checked By: ________ Date: ________

Drainage Area: 9.31 Acres (user entered value)
Curve Number: 74 (provided from RCN Calculator)
Watershed Length: 1075 Feet
Watershed Slope: 10 Percent
Time of Concentration: 0.21 Hours (calculated value)
Rainfall Type: II

Storm Number	1	2	3	4	5	6	7
Frequency (yrs)	1	2	5	10	25	50	100
24-Hr rainfall (in)	3.80	3.20	4.00	4.80	5.80	6.90	8.00
Ia/P Ratio	00.27	00.22	00.18	00.15	00.12	00.10	00.09
Used	00.27	00.22	00.18	00.15	00.12	00.10	00.10
Runoff (in)	.67	1.04	1.60	2.21	3.10	3.96	4.93
(ac-ft)	00.52	00.81	01.24	01.71	02.41	03.07	03.82
Unit Peak Discharge (cfs/acre/in)	01.088	01.130	01.185	01.169	01.211	01.225	01.228
Peak Discharge (cfs)	7	11	17	24	35	45	56










For all lined outlets and waterways, it is CRITICAL that the armored area is low enough to accept the runoff!

Virginia Department of Conservation & Recreation

Site Location Map

Scale 1 inch = N/A feet

Notes

1. The landowner/operator is responsible for obtaining and complying with all permits and easements. This includes all federal, state and local permits.
2. The landowner/operator is responsible for checking and complying with all local ordinances that may affect the project.
3. MISS UTILITY (Virginia telephone number 811) must be contacted at least 3 working days before construction begins. The landowner/operator is responsible for ensuring that the contractor contacts MISS UTILITY. The contractor must be able to provide the MISS UTILITY ticket number within 24 hours upon request by the NRCS/SWCD representative. The landowner/operator is responsible for locating any buried utilities (water lines, electric lines, telephone lines, gas lines, sewer lines, etc.) in the work area that are not covered by the MISS UTILITY program.
4. NRCS/SWCD makes no representation of the existence or nonexistence of utilities. The presence or absence of utilities on the construction drawings does not assure that there are or are not utilities in the work area.
5. The contractor is responsible for knowing and following the appropriate safety standards required by the Virginia Safety and Health Codes Board.
6. The landowner/operator shall notify the local NRCS/SWCD representative at least one week prior to beginning construction, and at all other times specified in this construction plan and attached specifications.
7. Any deviation from these construction drawings and specifications without written approval from NRCS/SWCD representative may result in in failure of this practice to meet NRCS Standards and the withdrawal of technical assistance for this project.
8. Prior to beginning construction, the cover sheet must be signed by the landowner/operator, the contractor, and the NRCS/SWCD representative. The landowner/operator is responsible for informing the contractor of these responsibilities by providing the contractor a copy of this cover sheet. The contractor must sign the cover sheet acknowledging that these responsibilities are understood and the landowner/operator must return the signed cover sheet to the NRCS/SWCD Representative. If requested by NRCS/SWCD, the landowner/operator shall arrange for a meeting between the contractor and NRCS/SWCD to review the construction drawings and specifications prior to construction.

The SWCD Representative for this project is:

The SWCD office telephone number is:

Benchmark Descriptions

TBM # 1 Assumed Elev. 100.00
Description: Nail in base of 30" DBH hardwood tree approx 20 ft. southwest of existing spring box

TBM # N/A Assumed Elev. N/A
Description: N/A

Acknowledgment Signatures

These construction drawings and attached specifications have been reviewed I understand what is required. (Sign and date below)

Landowner/Operator

Contractor

SWCD Representative

Engineering Job Class: II

811 Know what's below. Call before you dig.

"As Built" Documentation

Certified By and Date

Practice Completion Date

Index of Sheets

Sheet No.	Title
1	Cover sheet
2	Plan View
3	Profile (0+00 - 0+26)
4	Profile (0+26 - 0+48)
5	Cross-Sections

Specification Table

No.	Title
VA-705	Pollution Control
VA-706	Seeding
VA-707	Site Preparation
VA-721	Excavation
VA-761	Loose Rock Riprap
VA-795	Geotextile

Table of Estimated Quantities

Item	Unit	Quantity
Riprap D_{50} = 12.6"	tons	52
Riprap D_{50} = 6"	tons	11
Nonwoven Geotextile	sq.ft.	600
(extra will be needed for key + overlap)		
Seed, mulch and soil amendments - see VA-706	job	1
Erosion control blankets (EC-2 / Type 1)	sq.yd.	50

Engineering Design Cover Sheet

Designed: 5/10/16
Drawn: 5/10/16
Approved: 9/7/16

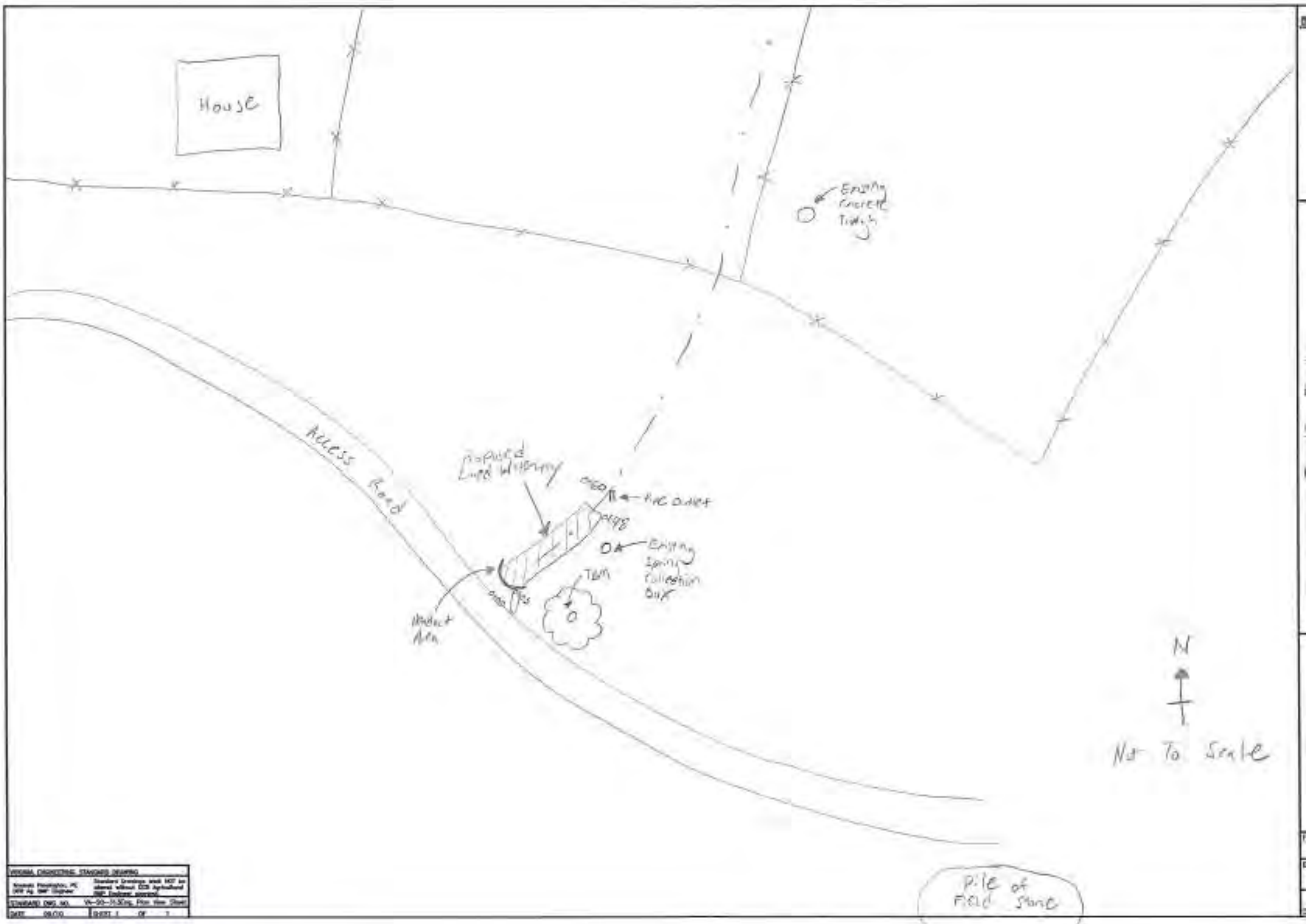
This drawing adapted from NRCS Standard Drawing VA-SO-100 v2.4.0

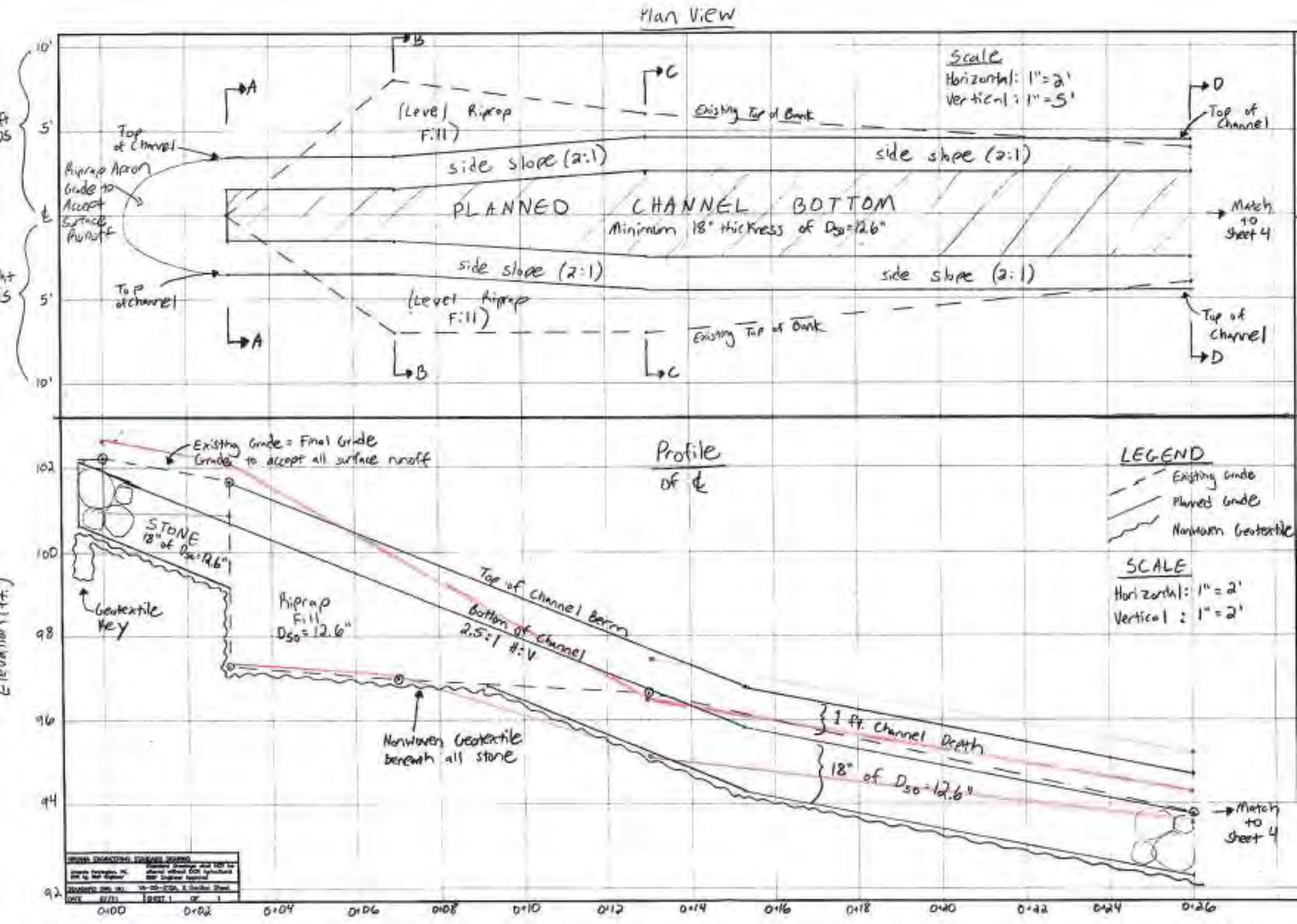
File Name

Drawing Name

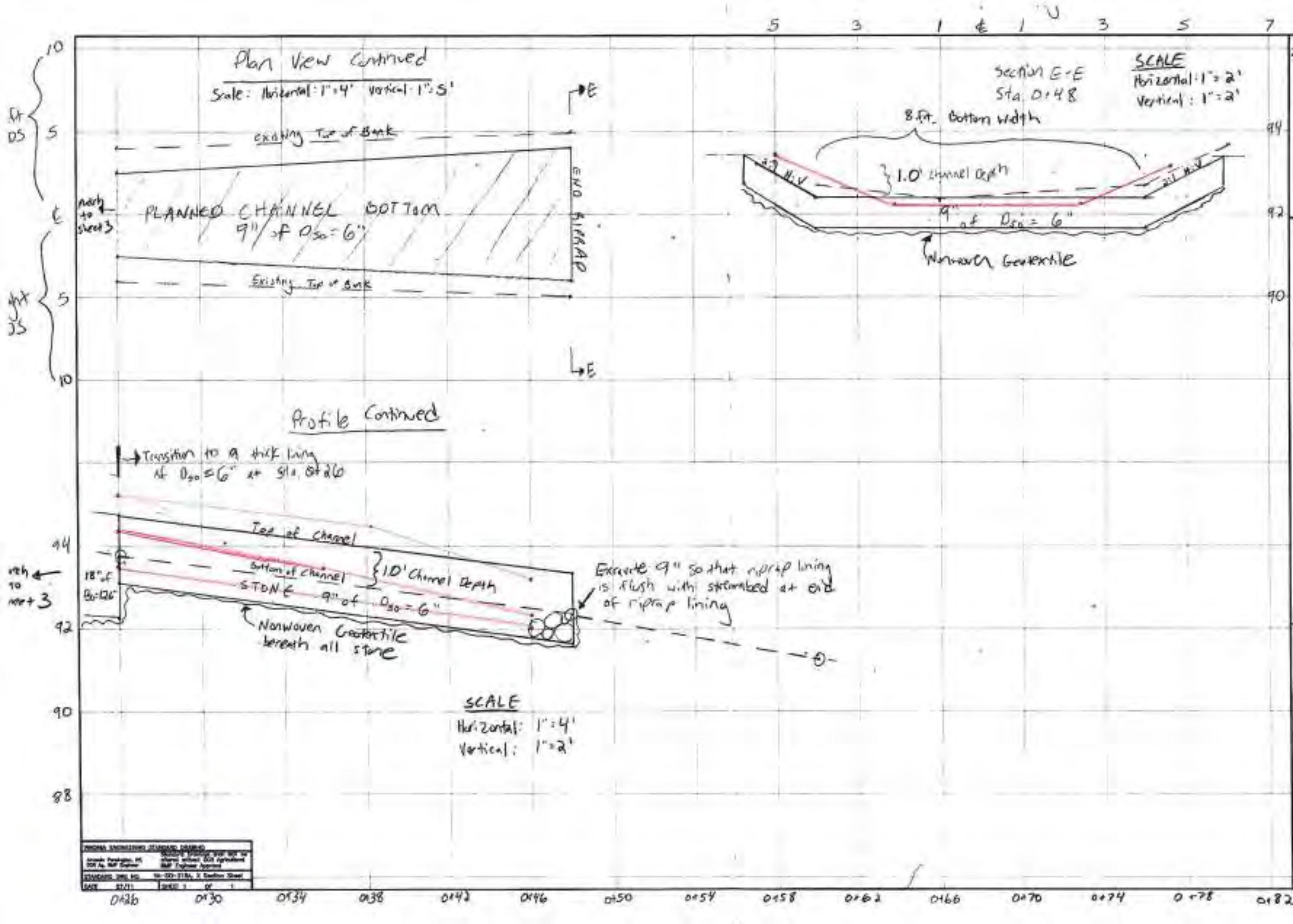
Sheet 1 of 5

Design Copy Routing: Cooperators Folder ___ Landowner ___ Contractor ___ Supplier

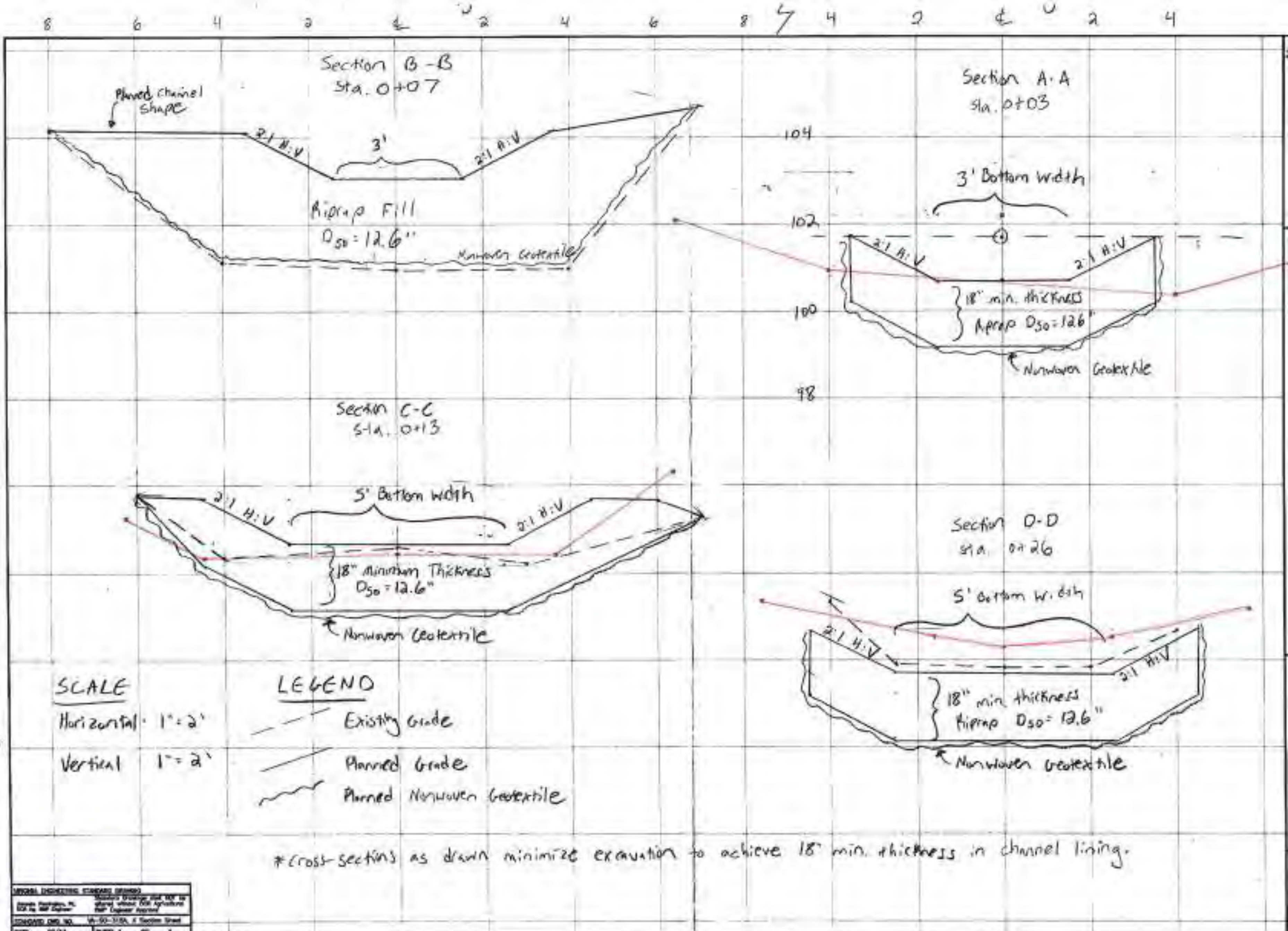

House
Existing Concrete Trough
Access Road
Proposed Lined Waterway
PVC Outlet
Existing Spring Collection Box
TBM
Outlet Area
N
Not To Scale
Pile of Field Stone



Plan View
Scale
Horizontal: 1" = 2'
Vertical: 1" = 5'
Top of Channel
Riprap Apron
Grade to Accept Surface Runoff
(Level Riprap Fill)
Existing Top of Bank
side slope (2:1)
PLANNED CHANNEL BOTTOM
Minimum 18" thickness of D50=12.6"
Match to Sheet 4
Profile of ℄
LEGEND
Existing Grade
Planned Grade
Nonwoven Geotextile
SCALE
Horizontal: 1" = 2'
Vertical: 1" = 2'
Existing Grade = Final Grade
Grade to accept all surface runoff
STONE 18" of D50=12.6"
Geotextile Key
Riprap Fill D50=12.6"
Top of Channel Berm
Bottom of Channel
2.5:1 H:V
1 ft. Channel Depth
18" of D50=12.6"
Nonwoven Geotextile beneath all stone
Elevation (ft)
0+00
0+02
0+04
0+06
0+08
0+10
0+12
0+14
0+16
0+18
0+20
0+22
0+24
0+26



Plan View Continued
Scale: Horizontal: 1"=4' Vertical: 1"=5'
Existing Top of Bank
PLANNED CHANNEL BOTTOM
9" of D50 = 6"
END RIPRAP
Existing Top of Bank
Profile Continued
Transition to a thick lining of D50 = 6" at Sta. 0+26
Top of Channel
Bottom of Channel
1.0' Channel Depth
STONE 9" of D50 = 6"
Nonwoven Geotextile beneath all stone
Excavate 9" so that riprap lining is flush with streambed at end of riprap lining
SCALE
Horizontal: 1"=4'
Vertical: 1"=2'
Section E-E
Sta. 0+48
SCALE
Horizontal: 1"=2'
Vertical: 1"=2'
8 ft. Bottom Width
1.0' Channel Depth
9" of D50 = 6"
Nonwoven Geotextile
0+26
0+30
0+34
0+38
0+42
0+46
0+50
0+54
0+58
0+62
0+66
0+70
0+74
0+78
0+82



Section B-B
Sta. 0+07
Planed channel shape
2:1 H:V
3'
2:1 H:V
Riprap Fill
D50 = 12.6"
Nonwoven Geotextile
Section A-A
Sta. 0+03
3' Bottom width
2:1 H:V
2:1 H:V
18" min. thickness
Riprap D50 = 12.6"
Nonwoven Geotextile
Section C-C
Sta. 0+13
5' Bottom width
2:1 H:V
2:1 H:V
18" minimum Thickness
D50 = 12.6"
Nonwoven Geotextile
Section D-D
Sta. 0+26
5' Bottom width
2:1 H:V
2:1 H:V
18" min thickness
Riprap D50 = 12.6"
Nonwoven Geotextile
SCALE
Horizontal 1" = 2'
Vertical 1" = 2'
LEGEND
Existing Grade
Planned Grade
Planned Nonwoven Geotextile
*Cross-sections as drawn minimize excavation to achieve 18" min. thickness in channel lining.

Contact Information

Amanda Pennington, P.E.
District Engineering Services Manager
804-786-0113
Amanda.pennington@dcr.virginia.gov

Raleigh Coleman
Ag BMP Engineering Specialist
540-270-0039
Raleigh.coleman@dcr.virginia.gov