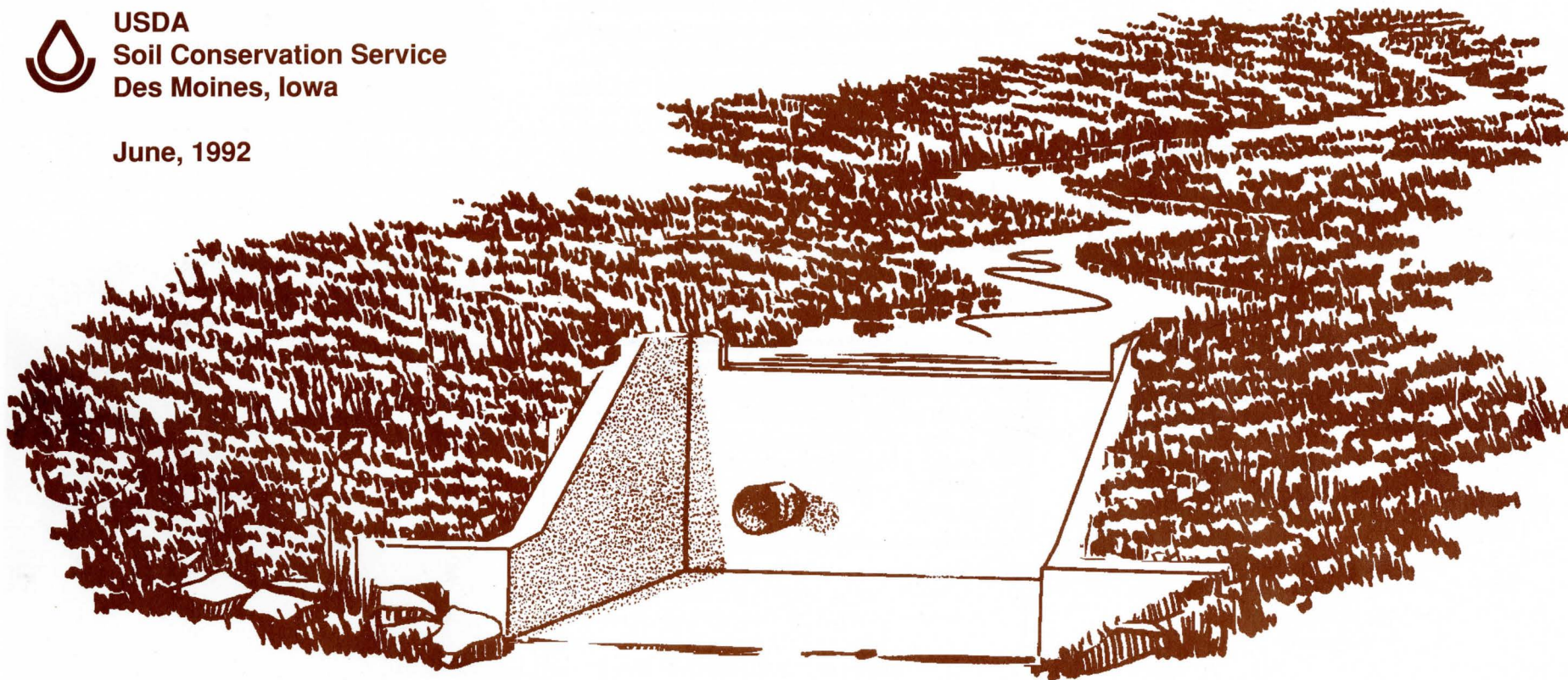


Designing, Constructing, Seeding and Maintaining Grassed Waterways with 30 to 100 Acres Drainage Area



USDA
Soil Conservation Service
Des Moines, Iowa

June, 1992



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Using this booklet

The Soil Conservation Service in Iowa has simplified the design of grassed waterways with a drainage area of 30 to 100 acres. The procedure is outlined in this booklet.

A "Design and Construction Record Sheet" has also been prepared to provide an easy method to record design decisions. Contact your local SCS office prior to designing or constructing waterways if unusual or complex geologic, topographic, or hydrologic conditions exist, or if you have questions.

A waterway design example is shown throughout this booklet, in order by steps. Look for this kind of double-lined box for each part of the example.

Steps to design in this booklet:	page
Step 1 - Determine drainage area	2
Step 2 - Determine average watershed slope	3
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Step 10 - Seeding, fertilizing and maintaining the waterway	14

Step 1 Determine drainage area

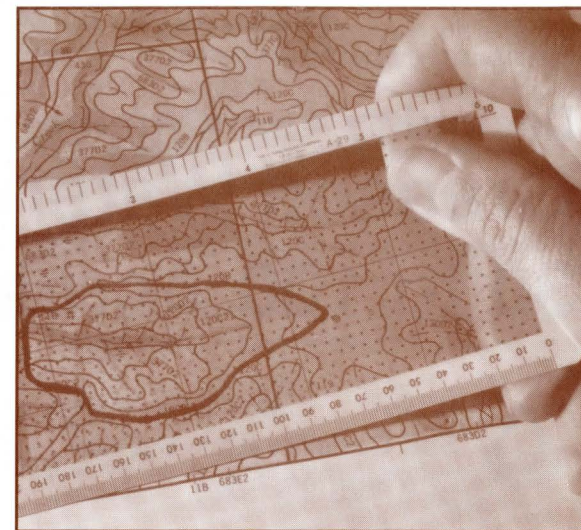
Method 1. Determine the drainage boundaries by field observation. Using known field sizes, distances, landmarks, etc., estimate the acres draining into the waterway.

Method 2. Draw the boundaries of the drainage area on a United States Geological Survey (USGS) topographic map, soil survey map, or aerial photo. Measure the area which has been delineated with a planimeter, dot counter, or equivalent method. Generally this will give an area in square inches. This can be converted to acres using the following formula:

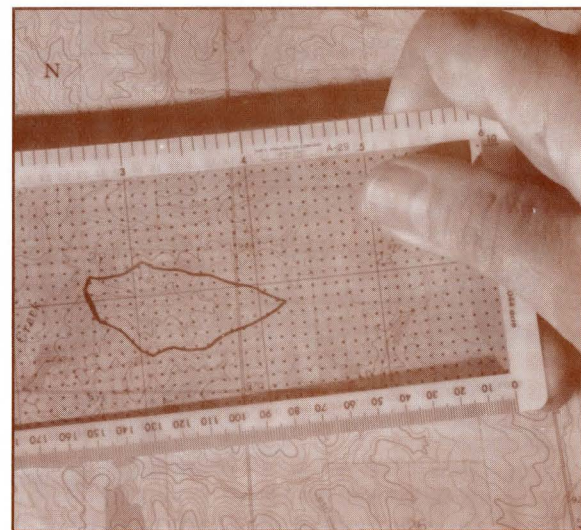
$$\text{Area} = (\text{X square inches}) (\text{Y ft./in.}) (\text{Y ft./in.}) / 43,560 \text{ square ft./acre}$$

where: X = the area measured in square inches and Y = the map scale in ft. per inch. (For example — 7.5 minute USGS topographic maps have a scale of 1 inch equals 2,000 ft. Therefore, Y = 2,000).

The number of dots counted within the drainage area on the soil survey map at right is 91. Since each dot equals .01 square inch, the map area is .91 square inches. Using the formula from step 1 to convert a map with a scale of 2,000 ft. per inch to acres the area is $.91 \times 2,000 \times 2,000 / 43,560$ - or 84 acres.



A dot counter is one of several ways to measure the drainage area of a waterway, using a soil survey map (above) or a topographic map (below).



Determine average watershed slope

It is important to note that this is the average slope of the entire drainage area, not just the slope of the waterway. The average slope of the watershed can be estimated by several methods. Some of the most common methods are described below.

Method 1. Determine the slope of several typical areas in the field. This can be done with a hand level and survey rod, abney hand level, clinometer, or any properly mounted slope meter. Be sure to measure typical areas and make sure to measure the slope perpendicular to the contour. After obtaining several readings, take an average of the readings.

Method 2. Measure several typical slopes from a USGS topographic map. To estimate the slope, draw a line perpendicular to the contour lines. Measure the distance between the contour lines. To get the slope, divide the vertical difference between the contour lines by the horizontal distance between the contour lines as measured from the map.

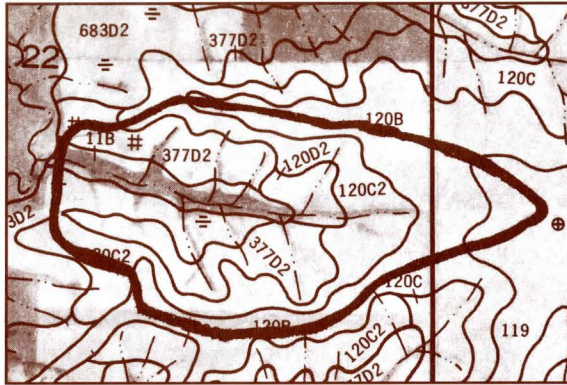
Method 3. Using a soils map, determine the percentage of the drainage area in the A, B, C, D, E, and F slope ranges as shown by the soil map symbol. Using these percentages and the average slope of each group, compute a weighted average slope for the watershed.

To select the proper design chart for sizing the waterway:

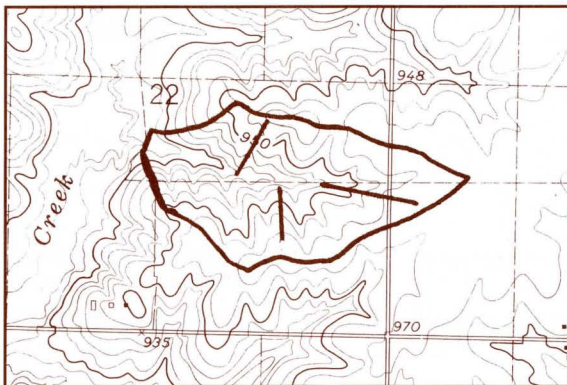
If the average slope is less than 2%, use the “flat” design chart.

If the average slope is between 2% and 8%, use the “moderate” design chart.

If the average slope is over 8%, use the “steep” design chart.



A soil map (above) or a USGS Quad Map (below) may be used to determine the average watershed slope. Check a soil survey to find the range of % slope for each group, and then use a mid-range number for the slope. In the case of the soils above, the A slope is 0-2%, B is 2-5%, C is 5-9%, D is 9-14%, E is 14-18%, and a F slope is 18-25%.



Using the USGS Quad Map, drawing three perpendicular lines from the waterway center to the top of the drainage area, lengths are 550, 1000, and 650 feet. Respective drops in elevation are 47, 35 and 50 feet, for slopes of 8.5%, 3.5% and 7.7%. The average is 7%; use the "moderate" design chart.

Using the soil map and a dot counter, estimate the percentage of the watershed in each slope group. Here, 5% is in an A slope, 42% is in B, 25% is in C and 28% is in D slope. Using the mid-range for each (1, 3.5, 7 and 11.5%) the weighted average for the slope is $[5(1) + 42(3.5) + 25(7) + 28(11.5)] / 100$ or 6%. Since 6% falls within the 2-8% range, use the "moderate" design chart.

Step 3 Determine slope of waterway

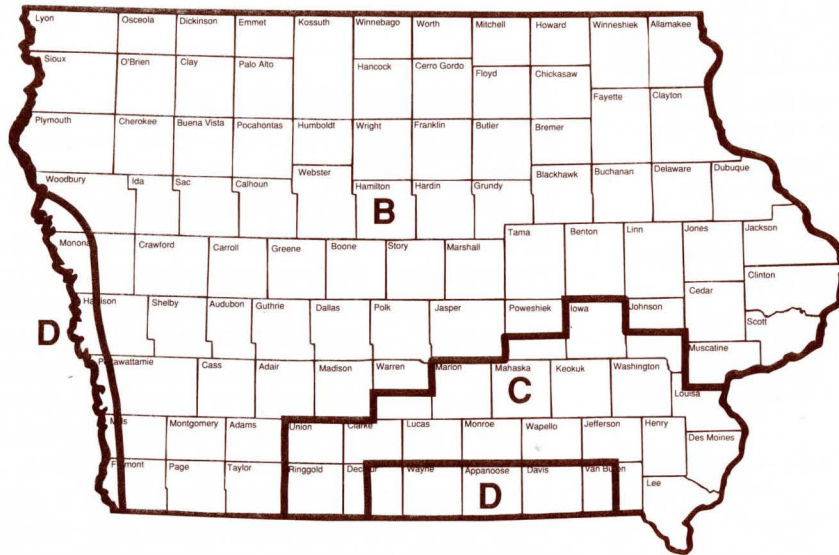
The slope of the waterway can be determined by several methods in the field. Generally, some survey will be required to make this determination. Waterways with slopes less than 2% should have a complete profile survey with survey shots at 100 ft. spacings. If a waterway has several breaks in grade, a more detailed survey and design should be completed. If the grade in a waterway is uniform and greater than 2%, it could be determined by use of a hand level and survey rod, abney hand level, or clinometer. In all cases, breaks in grade should be identified by length of reaches and slope.

For the example, use a 3% waterway slope.

Determine the soil group

Determine the appropriate "Soil Group" to use for design from the map. Based on the location within the state, select soil group "B", "C", or "D".

Soil Groups



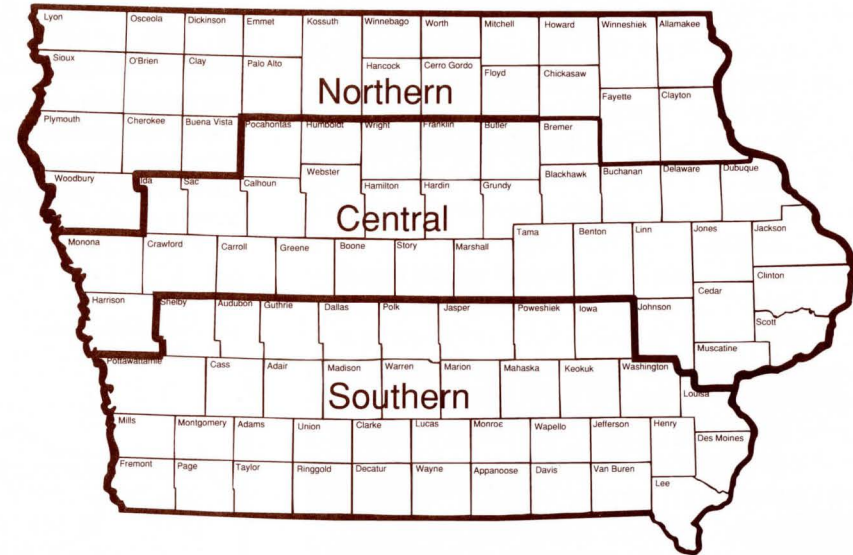
The example is a site in Marshall County. The soil group to use is "B."

Step 5

Select the rainfall zone

Determine the proper rainfall zone to use from the map. Based on the location in the state, select the “Northern”, “Central”, or “Southern” rainfall zone.

Rainfall Zones



The Marshall County site used in the example is in the Central rainfall zone.

Step 6 Select design chart to size the waterway

Select the proper design chart to use for sizing the waterway.

- a. Select the chart for Northern, Central, or Southern Iowa.
- b. Select the flat, moderate, or steep columns.
- c. Select the B, C, or D column.
- d. Read down the column to the drainage area size shown which is equal to or larger than the actual drainage area.
- e. Read horizontally across the chart to the grouping of dimensions which is below the actual waterway slope.
- f. Three alternative dimensions may be shown. These are labeled columns 1, 2, and 3.
 - Use column 1 if the soil in the waterway is an easily erodible soil. Silts and silty sands would be examples of easily erodible soils. Column 1 should be considered if the topsoil depths are shallow or if there is a concern about bedrock being close to the surface.
 - Use column 2 for average conditions.
 - Use column 3 if the soil at the site is erosion resistant. Soils with high clay content would be examples of this type of soil. Column 3 could be considered if the land treatment within the watershed is poor and a large amount of sediment is anticipated to move through the waterway.
- g. The centerline waterway depth is shown at the bottom of the chart under the appropriate column number. The top width of the waterway is shown in the selected column horizontally across from the drainage area from step e. above.

From earlier determinations, use the Central Iowa chart on page 7. Select the B column under the moderate soil group. Reading down the column to find the drainage area, select 102 (the next higher drainage area greater than 84). Reading across, find three numbers (alternative top widths) under the 3% waterway slope column. Assume average soil conditions, and select column 2. The top width is 58 feet. Reading at the bottom of the chart in the same column, the center depth is 1.3 feet.

Note: If ground water conditions are too wet to establish a good seeding in the waterway, a tile line may need to be installed down the side of the waterway. Contact your local SCS office or a tiling contractor for size of tile needed.

Design Chart for Parabolic Grassed Waterways Northern Iowa

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Design Chart for Parabolic Grassed Waterways Central Iowa

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Design Chart for Parabolic Grassed Waterways Southern Iowa

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Step 7 Evaluate and design a stable outlet

The condition of the outlet should be evaluated in the field. It is important that the waterway have a stable outlet. Several types of outlet conditions could occur. Some of these include:

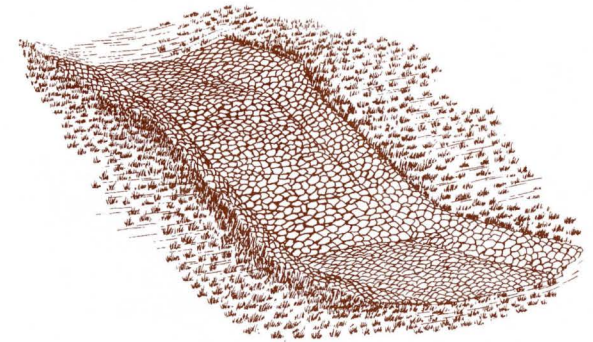
- The lower end of the waterway could outlet onto a valley where the flow spreads out in a non-erosive manner. Generally, if this is the situation, there will not be a well defined drainage pattern noticeable in the field. In this situation, blend the outlet of the waterway into the existing topography to minimize the chances of sedimentation or cutting occurring at that point.
- The waterway could outlet into another waterway or shallow ditch. In some cases when this occurs, the waterway outlet can be graded to blend into the flowline of the existing ditch or waterway. Abrupt changes in grade should not be made in the waterway as this could cause a weak point where cutting could begin. Generally, when grading a waterway outlet into an existing ditch, the break in grade should begin several hundred feet upstream so there will not be a short section of the waterway with a steep grade. If the outlet appears to be unstable, a small grade control structure may be required.
- The waterway outlet will be into a deeper gully where it is not feasible to grade out the outlet. If it appears the outlet will be unstable, some type of structure or mechanical protection will be needed.

Mechanical or structural protection can be a wide variety of practices or structures. Some examples of practices which could be considered for drops of less than five feet are shown in drawings at the right and on page 10.

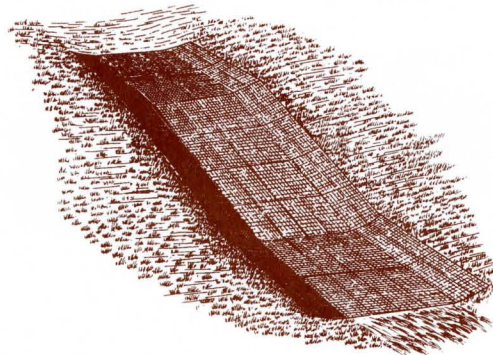
Generally, if the drop from the waterway outlet to the gully bottom exceeds five feet and it is likely that the outlet will be unstable, larger drop structures may be required. These would usually be rock, concrete, or gabion structures.



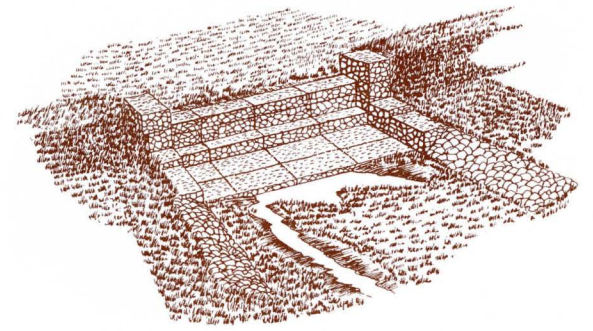
sodded outlet



rock chute

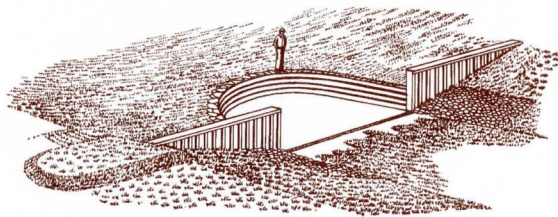


shaped, seeded outlet with geotextile fabric

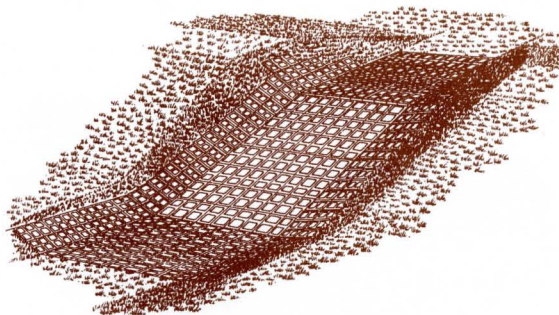


gabion drop structure

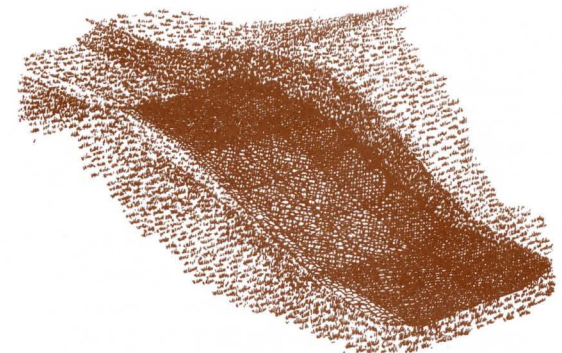
Types of outlets



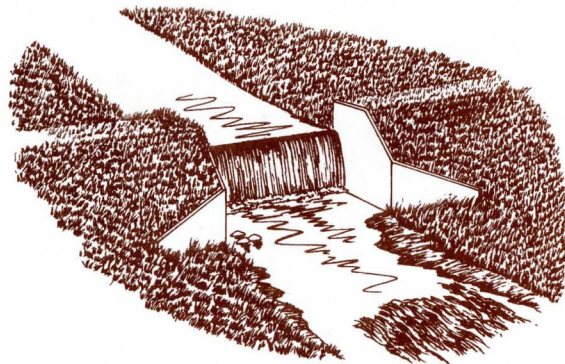
aluminum toewall structure



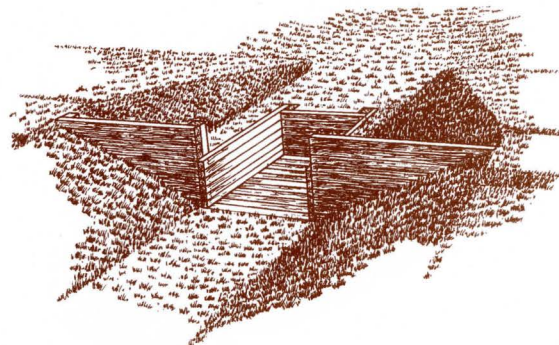
concrete block chute



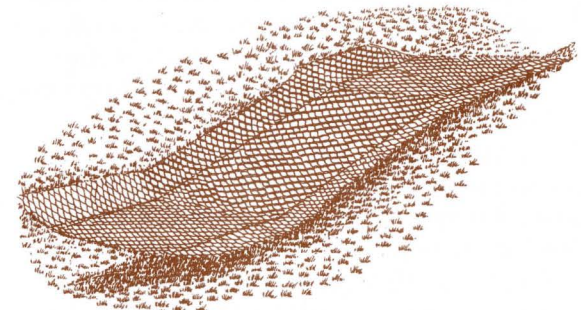
pre-fabricated concrete mats



concrete structure



wooden structure



manufactured geotextile products

Step 8 Construction specifications

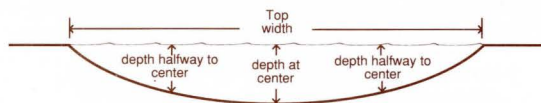
Remove all trees, brush, stumps, and other objectionable material from the site. In areas of the waterway where a deep gully will require earth fill, trees and stumps may be sawed off within 12 inches of the ground surface, if the final surface is three or more feet above the top of the stumps.

Construct the waterway to the dimensions selected from the waterway design charts. The fill material should be free of frozen earth, brush, roots, and other material which will not allow for the desired compaction.

Place all earth fill in layers of 9 inches or less, with each layer compacted by the wheels and/or tracks of the construction equipment. Spread or dispose of excess excavated material so it will not interfere with the functioning of the waterway.

If infertile subsoil will be exposed by construction operations, strip and stockpile topsoil. When excavation is complete, spread the topsoil over the exposed infertile soil.

Grade and shape the soil so that the area to be seeded is reasonably smooth, free of rills and gullies, and has the designed cross section. After the seedbed is prepared, seed and fertilize according to instructions.



Shape a parabolic waterway so that the depth halfway to the center is 3/4 of the depth at the center. (Example - if center depth is 1 foot, depth halfway to center is .75 foot.)

Note: Contact utility companies to verify location of any utilities that may be present.

Step 9 Recording design and construction information

The Soil Conservation Service has designed a record sheet for design and construction records for grassed waterways with drainage areas from 30 to 100 acres (see miniature version below). Both the landowner and SCS should keep a copy of the records. Follow instructions given on the "Design and Construction Record Sheet."

Design and Construction Record Sheet
Grassed Waterways with Drainage Areas from 30 to 100 Acres

Tract # _____
Landowner _____

Design

- Record landowner and tract number on upper right corner.
- Record last number for the proposed waterway from the construction plan in the first column on the left below.
- Record the waterway number assigned on the construction plan map.
- Record drainage area in acres for the waterway.
- Record average slope of the waterway (feet).
- Record slope of the waterway (feet).
- Record soil group from map on page 4 of booklet.
- Record rainfall zone from map on page 4.

Construction

- Record constructed length of waterway in feet.
- Record actual top width of waterway in feet.
- Record the waterway center depth in feet.
- Record waterway depth half way to center (use cross section drawing for both sides of waterway).

Shape a parabolic waterway so that the depth halfway to the center is 3/4 of the depth at the center. (Example - if center depth is 1 foot, depth halfway to center is .75 foot.)

Design Records		Construction Records	
Field #	Waterway Number	Length	Top Width
1	2	3	4
5	6	7	8
9	10	11	12
13	14	15	16
17	18	19	20
21	22	23	24
25	26	27	28
29	30	31	32
33	34	35	36
37	38	39	40
41	42	43	44
45	46	47	48
49	50	51	52
53	54	55	56
57	58	59	60
61	62	63	64
65	66	67	68
69	70	71	72
73	74	75	76
77	78	79	80
81	82	83	84
85	86	87	88
89	90	91	92
93	94	95	96
97	98	99	100

Seed and Fertilizer Records

waterway number(s) _____ species / lbs. pure live seed/lb.

species 1 _____ Protophate (P₂O₅) #/ac _____

species 2 _____ Nitrogen #/ac _____

species 3 _____ Phosphorus (P₂O₅) #/ac _____

Protein (N-20) #/ac _____

I certify that these waterways have been designed and constructed according to the records furnished on this sheet. Signing was completed (check one):

8/1 9/15 _____ Date _____

Signature (check one) _____ Landowner _____ Contractor _____

Other _____ Tenant _____

Note: If this record form is used for cost share purposes, make a copy and return with request to the SCS office. SCS must certify upon completion.

Signature _____ Date _____

Step 10 Seeding, fertilizing, and maintaining the waterway

After shaping and smoothing a waterway, it's important to get a protective seeding established before heavy rains form new rills or gullies.

In areas where grass is difficult to establish, divert water from the waterway during the seeding establishment period.

Follow these guidelines:

1. A firm seedbed will greatly increase the chances of a good grass stand. So before you plant, be sure the seedbed is firm. A good way to check is to step on the seedbed. If your footprint is less than a half inch deep, you've got a firm seedbed. You may need to use a roller or cultipacker to get a firm seedbed.

2. Apply fertilizer and seeding at rates recommended in the chart. Plant grass seed $\frac{1}{4}$ " to $\frac{1}{2}$ " deep. The best row direction is across the area; next best is a figure 8. If you broadcast, cover the seed lightly with a harrow. Seeding may be completed during the spring seeding period, March 1 to May 15 or during the late summer seeding period, August 1 to September 15. Warm season grasses should be seeded between April 1 and June 1.

3. If construction is completed at any time other than the above seeding periods, seed 1-2 bushels of wheat or rye or 2-3 bushels of oats per acre as a temporary cover. Then seed permanent species during the next seeding period.

4. Oats may be seeded as a nurse crop at the rate of one bushel per acre during the spring. Mow oats before they head out.

5. Mulch the area with straw, if possible, to protect the area until a seeding is established. Anchor the mulch using a straight disk. Make only one trip over the mulch.

Recommended statewide seeding species and rates*

Dry or tiled waterways

• Smooth bromegrass	25 lbs/ac
• Smooth bromegrass	15 lbs/ac
Switchgrass	5 lbs/ac
• Smooth bromegrass	15 lbs/ac
Tall fescue	10 lbs/ac

Alternative for wet/dry waterways

• Smooth bromegrass	15 lbs/ac
Reed canarygrass	5 lbs/ac

Alternatives for wet waterways

• Reed canarygrass	10 lbs/ac
• Switchgrass	10 lbs/ac

* A local recommendation may be preferable. If so, it is:

species	lbs/ac
_____	_____
_____	_____
_____	_____

Recommended fertilizers

Bromegrass, fescue, reed canarygrass

Nitrogen	80 lbs/ac
Phosphate (P_2O_5)	120 lbs/ac
Potash (K_2O)	80 lbs/ac

Switchgrass

Nitrogen	None
Phosphate (P_2O_5)	120 lbs/ac
Potash (K_2O)	80 lbs/ac

The fertilizer rates are for average waterway conditions after construction. If considerable subsoil is exposed, increase rates by 50%. If there is sufficient topsoil remaining, the rates should be reduced by 50%.

Maintaining the practice

Proper maintenance will protect your investment in a grassed waterway. The following tips will help ensure longevity of the waterway:

- Lift implements out of the ground before crossing the waterway.
- Bring row crop patterns into the waterway nearly on the contour, or use it as the turn area. Don't plant end rows along the side of the waterway - they contribute to failure.
- Fertilize periodically.
- Inspect the area frequently for places needing reseeding and eroding areas. Repair minor rills or gullies by reshaping and reseeding.
- Maintain the width of the grass area when tilling and planting adjacent fields.
- Don't let herbicide spray continue into the waterway.
- Don't use the waterway as a road. Vehicle tire tracks can lead to the formation of a gully.
- Don't mow the grass until a good sod is established. Once it is, the waterway should be mowed. To benefit wildlife nesting, delay mowing until July 15.
- Maintain outlets to prevent new gullies from forming at the outlet. This may include reshaping and reseeding the outlet, or repairing or replacing components of structural outlets.

Design and Construction Record Sheet

Grassed Waterways with Drainage

Areas from 30 to 100 Acres

Tract # _____

Landowner _____

Instructions:

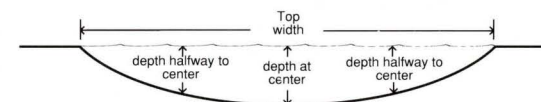
Design

- 1** Record landowner and tract number on upper right corner. Record field numbers for the proposed waterways from the conservation plan in the first column on the left below.
- 2** Record the waterway number assigned on the conservation plan map.
- 3** Record drainage area in acres for the waterway.
- 4** Record average slope of the watershed (drainage area).
- 5** Record slope of the waterway itself.
- 6** Record soil group from map on page 4 of booklet.
- 7** Record rainfall zone from map on page 4.

- 8** Note design column number used from step 6f on page 5 of waterway booklet.
- 9** Record needed top width in feet (obtain from design chart). See step 6, page 5 and appropriate table on page 6, 7 or 8.
- 10** Record needed waterway depth in feet from appropriate design chart.

Construction

- 11** Record constructed length of waterway, in feet.
- 12** Record actual top width of waterway, in feet.
- 13** Record the waterway center depth, in feet.
- 14** Record waterway depth half way to center (see cross section drawing) for both sides of waterway.



Shape a parabolic waterway so that the depth halfway to the center is 3/4 of the depth at the center. (Example - if center depth is 1 foot, depth halfway to center is .75 foot.)

Design Records

1	2	3	4	5	6	7	8	9	10	11	12	13	14	
Field #	Waterway Number	Drainage Area	Watershed Slope (%)	Waterway Slope (%)	Soil Group	Rainfall Zone	Design Column #	Top Width	Depth	Length	Top Width	Depth at center	Depth halfway to center (right) (left)	
Example: 1	1	84	7	3	B	Central	2	58	1.3	800	58	1.3	1.0	1.0

Construction Records

Seed and Fertilizer Records

waterway number(s) _____
species / lbs. pure live seed/ac

species 1 _____ / _____

species 2 _____ / _____

species 3 _____ / _____

Nitrogen #/ac _____ Phosphate (P₂O₅) #/ac _____

Potash (K₂O) #/ac _____ Lime #/ac _____

I certify this/these waterways have been designed and constructed according to the records furnished on this sheet. Seeding was completed (check one):

_____ 3/1-5/15 _____ 4/1-6/1
_____ 8/1-9/15 _____ Other Date

Signature _____ Date _____
(check one) _____ Landowner _____ Contractor
_____ Other _____ Tenant

Note: If this record form is used for cost-share purposes, make a copy and return with receipts to the SCS office; SCS must certify upon completion.

Signature _____ Date _____