NATURAL RESOURCES CONSERVATION SERVICE
MONTANA CONSERVATION PRACTICE STANDARD

GRASSED WATERWAY (ACRE)

CODE 412

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.

PURPOSE

- To convey runoff from terraces, diversions, or other water concentrations without causing erosion or flooding.
- To prevent gully formation.
- To protect/improve water quality.

CONDITIONS WHERE PRACTICE APPLIES

This practice is applied in areas where added water conveyance capacity and vegetative protection are needed to prevent erosion and improve runoff water quality resulting from concentrated surface flow.

CRITERIA

General Criteria Applicable to All Purposes

Plan, design, and construct grassed waterways to comply with all Federal, state, **tribal,** and local laws and regulations.

Capacity. Design the waterway to convey the peak runoff expected from the 10-year frequency, 24-hour duration storm. Increase capacity as needed to account for potential volume of sediment expected to accumulate in the waterway between planned maintenance activities. When the waterway slope is less than 1 percent, out-of-bank flow may be permitted if such flow will not cause excessive erosion. Ensure that the design capacity, at a minimum, will remove the water before crops are damaged.

Stability. Determine the minimum depth and width requirements for stability of the grassed waterway using the **Tractive Stress Method** 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; **or the Limiting Velocity Method in the Engineering Field Manual, Chapter 7, Grassed Waterways**.

Tractive Stress Method

When implementing the Tractive Stress Method, soil properties such as unified soil classification, plasticity index, and 75th percentile particle diameter (d75) can be estimated from information found on the Web Soil Survey or Soil Data Mart.

The recommended Cover Factor, C_F, for typical grass mixes in Montana is 0.75. The recommended Stem Density, M, is 200 stems per square foot.

Where stone centers, perforated grid pavers, plastic erosion control mats, or other erosion-resistant materials are used to supplement the vegetative lining, the maximum allowable velocity or tractive stress may be increased to the recommendation of the manufacturer.

Software, NRCS Field Engineering Field Tools, "Grassed Waterway," is available to implement the Tractive Stress Method.

Limiting Velocity Method

When using the Limiting Velocity Method, the design velocity shall not exceed the permissible velocity shown in Table 1 unless the waterway is lined or reinforced.

Flow retardance (Manning's "n" value) varies with the height and type of vegetation. The vegetation tends to bend and oscillate under the influence of velocity and depth of flow. The retardance curves shown in Figure 1 and described in Table 2 below shall be used to select the appropriate "n" value.

Conservation practice standards are reviewed periodically and updated if needed. To obtain the current version of this standard contact the Natural Resources Conservation Service.

NOTE: This type of font **(AaBbCcDdEe 123..)** indicates NRCS National Standards.
This type of font (AaBbCcDdEe 123..) indicates Montana Supplement.

Table 1. Permissible velocity for grassed waterways.

Cover	Slope Range[2]	Permissible Velocity[1]	
		Erosion Resistant Soils[3]	Easily Eroded Soils[4]
	Percent	*m/s (ft/s)*	*m/s (ft/s)*
Bermudagrass	< 5	2.43 (8)	1.82 (6)
	5-10	2.13 (7)	1.22 (4)
	over 10	1.82 (6)	0.91 (3)
Bahiagrass Buffalograss Kentucky bluegrass Smooth brome Blue grama Tall fescue	< 5	2.13 (7)	1.52 (5)
	5-10	1.82 (6)	1.22 (4)
	over 10	1.52 (5)	0.91 (3)
Grass mixture Reed canarygrass	[2] <	1.52 (5)	1.22 (4)
	5-10	1.22 (4)	0.91 (3)
Sericea lespedeza Weeping lovegrass Yellow bluestem Redtop Alfalfa Red fescue	[5] < 5	1.06 (3.5)	0.76 (2.5)
Common lespedeza[6] Sudangrass[6]	[7] < 5	1.06 (3.5)	0.76 (2.5)

[1] Use velocities exceeding 1.52 m/s(5ft/s) only where good covers and proper maintenance can be obtained.
[2] Do not use on slopes steeper than 10 percent except for vegetated side slopes in combination with a stone, concrete, or highly resistant vegetative center section.
[3] Cohesive (clayey) fine-grain soils and coarse-grain soils with cohesive fines with a plasticity index of 10 to 40 (CL, CH, SC, and CG).
[4] Soils that do not meet requirements for erosion-resistant soils.
[5] Do not use on slopes steeper than 5 percent except for vegetated side slopes in combination with a stone, concrete, or highly resistant vegetative center section.
[6] Annuals—use on mild slope or as temporary protection until permanent covers are established.
[7] Use on slopes steeper than 5 percent is not recommended.

Figure 1. Manning's "n" related to velocity, hydraulic radius, and vegetal retardance (Ref: SCS-TP-61, Handbook of Channel Design for Soil and Water Conservation).

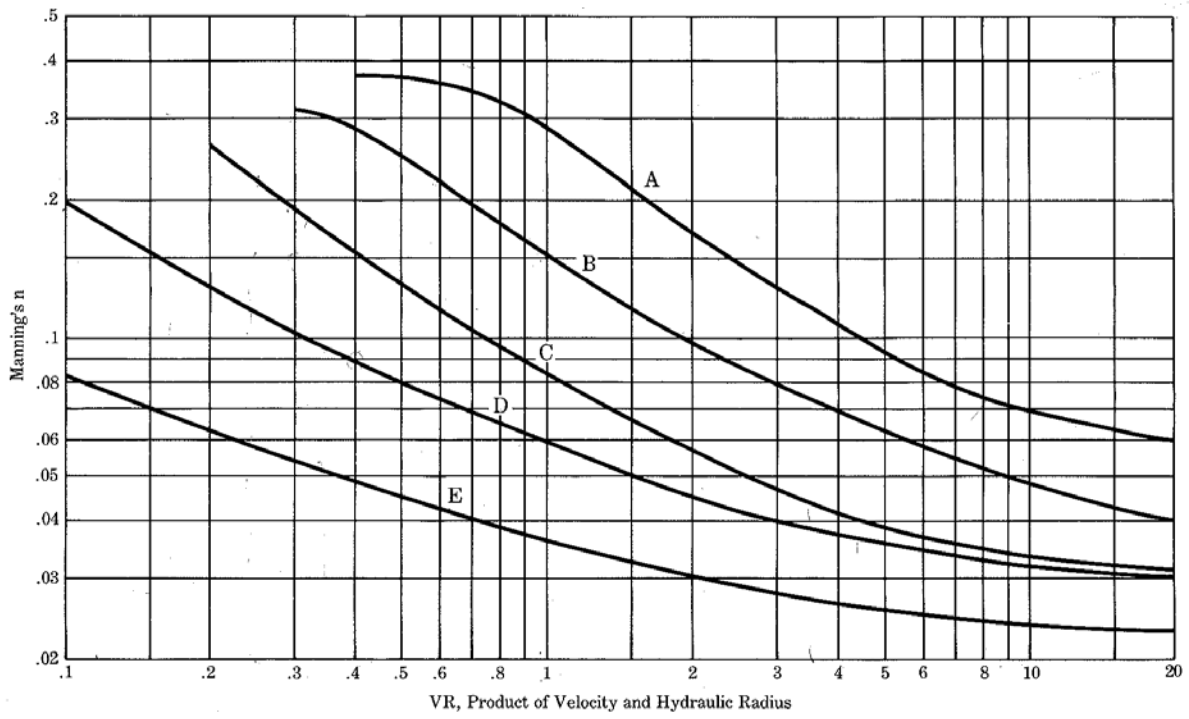

Table 2. Classification of vegetation cover as to degree of retardance

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

Waterway capacity is evaluated assuming the thickest vegetative condition. Retardance Class "C" is typically used in Montana.

The vegetative retardance curve selected for capacity shall be at least one curve prior (alphabetically) to that used for stability.

Stability is evaluated assuming the thinnest vegetative condition. Retardance Class "D" is typically used in Montana.

Software, OHIO Engineering Program, is available to implement the Limiting Velocity Method. This software can be downloaded from the Ohio NRCS website at www.oh.usda.gov.

Ensure that the vegetation species selected are suited to the current site conditions and intended uses. Select species that have the capacity to achieve adequate density, height, and vigor within an appropriate time frame to stabilize the waterway.

Width. Keep the bottom width of trapezoidal waterways less than 100 feet unless multiple or divided waterways or other means are provided to control meandering of low flows.

Side slopes. Keep the side slopes flatter than a ratio of two horizontal to one vertical. Reduce the side slopes as needed to accommodate the equipment anticipated to be used for maintenance and tillage/harvesting equipment so that damage to the waterway is minimized.

Where agricultural equipment must cross the waterway, the side slopes shall be 8:1 or flatter.

Consideration shall be given to 10:1 side slopes where large equipment must cross at relatively high speeds. If crossing the waterway is unnecessary, 4:1 side slopes are common and conducive to mowing.

Depth. The capacity of the waterway must be large enough so that the water surface of the waterway is below the water surface of the tributary channel, terrace, or diversion that flows into the waterway at design flow.

Provide 0.5 foot freeboard above the designed depth at maximum retardance when flow must be contained to prevent damage **to structures**.

Drainage. When needed to establish or maintain vegetation on sites having prolonged flows, high water tables, or seepage problems, use Subsurface Drain (606), Underground Outlet (620), or other suitable measures. **Subsurface drains shall be installed under the waterway shoulder, with the drain invert at least 24" below the waterway bottom.**

Where drainage practices are not practicable or sufficient to solve these seepage problems, use conservation practice Lined Waterway or Outlet (468) in place of Grassed Waterway (412).

Water-tolerant vegetation may be an alternative on some wet sites.

Outlets. Provide a stable outlet with adequate capacity. The outlet can be another vegetated channel, an earthen ditch, a grade-stabilization structure, filter strip or other suitable outlet.

Vegetative Establishment. Establish vegetation as soon as possible using the criteria listed under "Establishment of Vegetation" in the conservation practice standard Critical Area Planting (Code 342) and/or the state **job sheets**.

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.

Fabric Barriers. Fabric barriers used to prevent head cuts or gullies during vegetative establishment shall be spaced 50 to 100 feet apart. The fabric must be 36 inches wide; 18 inches buried and 18 inches lapped over the ground. Barriers shall extend across the waterway bottom and up the side slopes to a minimum depth of one foot.

Provide livestock and vehicular crossings as necessary to prevent damage to the waterway and its vegetation.

CONSIDERATIONS

Where environmentally-sensitive areas need to be protected from dissolved contaminants, pathogens, or sediment in runoff, consider establishment of an increased width of vegetation on the waterway above the flow area. Increasing the width of the waterway above the flow area will increase filtering of sediment and pathogens as well as increase infiltration of runoff and increase nutrient removal. Where sediment control is the primary concern, consider using vegetation in the waterway which can withstand partial burial and adding sediment control measures above the waterway such as residue management. Consider increasing the channel depth and/or designing areas of increased width or decreased slope to trap and store sediment to reduce the amount of sediment that leaves a field. Be sure to provide for regular cleaning out of the waterway when trapping sediment in this manner.

A minimum design velocity of 1.5 fps should be achieved at least during the 10-year, 24-hour duration storm in order to prevent significant sediment deposition. If this velocity cannot be achieved, the potential deposition problem and associated maintenance requirements shall be addressed in the Operation and Maintenance Plan.

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 constructing short diversions or small swales can direct this preferential flow into the grassed waterway periodically along the waterway length**.

Consideration should be given to lateral flow rates entering the waterway in order to prevent head-cutting. Waterway laterals, side-inlet structures (chutes, drops, and linings) may be used to introduce lateral flows.

Avoid areas where unsuitable plant growth limiting subsoil and/or substratum material such as salts,

acidity, root restrictions, etc., may be exposed during implementation of the practice. Where areas cannot be avoided, seek recommendations from a soil scientist for improving the condition or, if not feasible consider over-cutting the waterway and add topsoil over the cut area to facilitate vegetative establishment.

Avoid or protect, if possible, important wildlife habitat, such as woody cover or wetlands when determining the location of the grassed waterway. If trees and shrubs are incorporated, they should be retained or planted in the periphery of grassed waterways so they do not interfere with hydraulic functions. Medium or tall bunch grasses and perennial forbs may also be planted along waterway margins to improve wildlife habitat. Waterways with these wildlife features are more beneficial when connecting other habitat types; e.g., riparian areas, wooded tracts and wetlands. When possible, select plant species that can serve multiple purposes, such as benefiting wildlife, while still meeting the basic criteria needed for providing a stable conveyance for runoff.

Water-tolerant vegetation may be an alternative to subsurface drains or stone center waterways on some wet sites.

Use irrigation in dry regions or supplemental irrigation as necessary to promote germination and vegetation establishment.

Wildlife habitat benefits can be provided by adding width of appropriate vegetation to the sides of the waterway. Care should be taken to avoid creating small isolated planting zones that could become population sinks where wildlife attracted to an area experience reproductive loss due to predation.

Consider including diverse legumes, forbs, and flowering plants such as milkweeds that provide pollen and nectar for native bees and other pollinators. In dry regions, these sites may be able to support flowering forbs with higher water requirements and thus provide bloom later in the summer.

The construction of a grassed waterway can disturb large areas and potentially affect cultural resources. Be sure to follow state cultural resource protection policies before construction begins.

PLANS AND SPECIFICATIONS

Prepare plans and specifications for grassed waterways that describe the requirements for applying the practice according to this standard. As a minimum include:

- A plan view of the layout of the grassed waterway.
- Typical cross sections of the grassed waterway(s).
- Profile(s) of the grassed waterway(s).
- Disposal requirements for excess soil material.
- Site-specific construction specifications that describe in writing the installation of the grassed waterway. Include specification for control of concentrated flow during construction and vegetative establishment.
- Vegetative establishment requirements.

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 **during establishment** by using diversion of runoff or mechanical means of stabilization such as **fabric barriers,** 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.

REFERENCES

USDA, ARS. 1987. Stability design of grass-lined open channels. Agriculture Handbook 667.

USDA, NRCS. 2007. National Engineering Handbook, Part 650, Engineering Field Handbook, Chap. 7, Grassed waterways.