NATURAL RESOURCES CONSERVATION SERVICE

CONSERVATION PRACTICE STANDARD

Lined Waterway or Outlet

(Feet)

Code 468

DEFINITION

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

PURPOSE

This practice may be applied as part of a resource management system to support one or more of the following purposes:

- Provide for safe conveyance of runoff from conservation structures or other water concentrations without causing erosion or flooding.
- Stabilize existing and prevent future gully erosion.
- Protect and improve water quality.

CONDITIONS WHERE PRACTICE APPLIES

This practice applies if the following or similar conditions exist:

1. Concentrated runoff is such that a lining is needed to control erosion.
2. Steep grades, wetness, prolonged base flow, seepage, or piping would cause erosion.
3. The location is such that use by people or animals preclude use of vegetated waterways or outlets.
4. Limited space is available for design width which requires higher velocities and lining.
5. Soils are highly erosive or other soil or climatic conditions preclude using vegetation.

This practice is not applicable to watercourses where construction of a waterway would destroy woody wildlife cover and the present watercourse is capable of handling the concentrated runoff without serious erosion. Such situations are usually recognized by a meandering condition, steep side slopes that are stabilized by woody plants or herbaceous vegetation, and the watercourse is without rapidly advancing overfalls.

CRITERIA

The planning, installation and maintenance of the lined waterway or outlet shall comply with all federal, state and local laws, rules, and regulations.

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 found in Table 1.

Table 1: "n" Values of materials

Lining	"n" Value
Concrete	
Trowel finish	0.012 to 0.013
Float finish	0.013 to 0.017
Gunite	0.016 to 0.022
Flagstone	0.020 to 0.025
Riprap	Determine from figure 1.

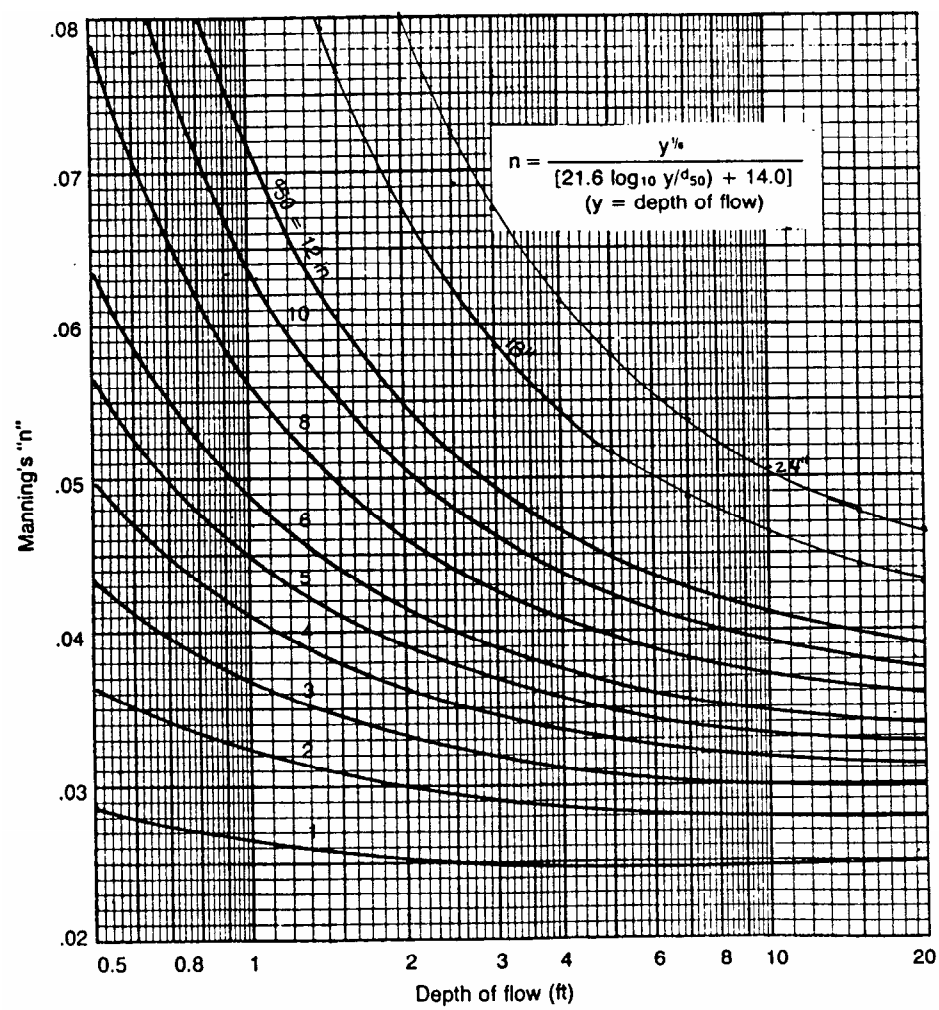

Figure 1. Values of n for riprap-lined channels, d_{50} size vs. depth of flow.

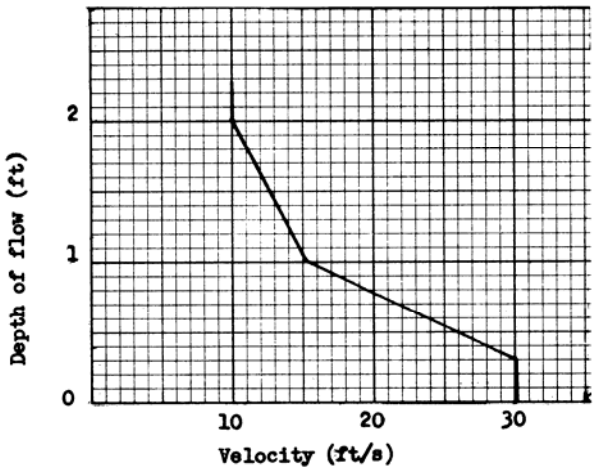

Figure 2. Maximum velocity vs depth of flow for concrete channels.

Velocity

Maximum design velocity for concrete channels shall be as shown in figure 2. Maximum design velocities for riprap sections shall be less than velocities listed in Table 2.

Table 2: Maximum Velocity in Relation to Rock Size

D50 Rock Size (inches)	Allowable Velocity (feet per second)
4	5.8
5	6.4
6	6.9
7	7.4
8	7.9
9	8.4
10	8.8
11	9.2
12	9.6

Except for short transition sections, flow in the range of 0.7 to 1.3 of the critical slope must be avoided unless the channel is straight. Velocities exceeding critical shall be restricted to straight reaches.

Waterways or outlets with velocities exceeding critical shall discharge into an energy dissipator to reduce velocity to less than critical.

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 feet above the designed high water level in areas where erosion-resistant vegetation cannot be grown adjacent to the paved side slopes. No freeboard is required if vegetation is established and maintained.

Lining thickness

Minimum lining thickness shall be determined using Table 3.

Table 3: Minimum Lining Thickness of Various Materials

Material	Minimum Lining Thickness
Concrete	4 inches (in most problem areas, minimum thickness shall be 5 inches with welded wire fabric reinforcing).
Riprap	Maximum stone size plus thickness of filter or bedding.
Flagstone	4 inches including mortar bed.

Side slope

The steepest permissible side slopes, horizontal to vertical will be as found in Table 4.

Table 4: Side Slopes in Relation to Material and Height of Lining

Material	Height of Lining	Side Slope
Hand-placed, formed concrete	1.5 feet or less	vertical
Hand-placed, screened concrete	less than 2 ft more than 2 ft	1 to 1 2 to 1
Mortared in-place flagstone	less than 2 ft more than 2 ft	1 to 1 2 to 1
Slip form concrete	less than 3 feet	1 to 1
Rock riprap		2 to 1

Related structures

Side inlets, drop structures, and energy dissipaters shall meet the hydraulic and structural requirements for the site.

Outlets

All lined waterways and outlets shall have a stable outlet with adequate capacity to prevent erosion and flooding damages.

Geotextiles

Geotextiles shall be used where appropriate as a separator between rock, flagstone, or concrete linings and soil to prevent migration of soil particles from the subgrade, through the lining material. Geotextiles shall be designed according to American Association of State Highway and Transportation Officials (AASHTO) M288, Section 7.3.

Filters or bedding

Filters or bedding shall be used to prevent piping. Drains shall be used to reduce uplift pressure and to collect water, as required. Filters, bedding, and drains shall be designed according to Natural Resources Conservation Service (NRCS) standards. Weep holes may be used with drains if needed.

Concrete

Concrete used for lining shall be proportioned so that it is plastic enough for thorough consolidation and stiff enough to stay in place on side slopes. A dense durable product shall be required. Specify a mix that can be certified as suitable to produce a minimum strength of at least 3,000 lb/in^2. Cement used shall be Portland cement, Types I, II or if required, Types IV or V. Aggregate used shall have a maximum size of 1½ inches.

Mortar

Mortar used for mortared in-place flagstone shall consist of a workable mix of cement, sand, and water with a water-cement ratio of not more than 6 gallons of water per bag of cement.

Contraction joints

Contraction joints in concrete linings, if required, shall be formed transversely to a depth of about one-third the thickness of the lining at a uniform spacing in the range of 10 to 15 feet.

Provide for uniform support to the joint to prevent unequal settlement.

Rock riprap or flagstone

Stone used for riprap shall be dense and hard enough to withstand exposure to air, water, freezing, and thawing. Flagstone shall be flat for ease of placement and have the strength to resist exposure and breaking.

Vegetation

All areas to be vegetated shall be planted as soon as practical after construction. All disturbed areas shall be vegetated according to Indiana (IN) Natural Resources Conservation Service (NRCS) Electronic Field Office Technical Guide (eFOTG) Standard (342) Critical Area Planting.

CONSIDERATIONS

Consider using a Rock Lined Chute or other practice when overfall is greater than two (2) feet (vertically) at a waterway outlet.

Effects on water quantity and quality should be considered. This practice may have a minor effect on the quantity of surface and ground

water. This practice will reduce the erosion in concentrated flow areas resulting in the reduction of sediment and substances delivered to the receiving waters. When used as a stable outlet for another practice, lined waterways may increase the likelihood of dissolved and suspended substances being transported to surface water due to high flow velocities.

Special attention should be given to maintaining and improving visual resources and habitat for wildlife where applicable.

PLANS AND SPECIFICATIONS

Plans and specifications for constructing lined waterways or outlets shall be in keeping with this standard and shall describe the requirements for applying the practice to achieve its intended purposes. Items needed in the plans are:

- Plan view of system layout.
- Topographic map (where applicable).
- Profiles and cross sections.
- Soil borings (where applicable).
- Hydraulic design data.
- Quantities and bill of materials.
- Seeding and fertilizer requirements (when applicable).

OPERATION AND MAINTENANCE

A maintenance program shall be established by the landowner/user to maintain capacity and vegetative cover. The plan shall include the following items or others as appropriate:

1. Do not graze lined waterway during establishment and when soil conditions are wet.
2. Protect lined waterway from damage by farm equipment and vehicles. Do not use lined waterway as a roadway and practice care when crossing to prevent tillage marks or wheel tracks.
3. Maintain constructed width by lifting or disengaging tillage equipment properly, and avoid farming operations along lined waterway that would hinder water entry.
4. Observe lining for any deterioration or movement of rock in riprap lined waterways. Perform needed maintenance as soon as possible to eliminate further deterioration or damage.
5. Do not spray with herbicides or cross lined waterways during spray operations unless the equipment is completely shut off.
6. Fertilize vegetated portions of lined waterways the first spring after seeding and thereafter as necessary to maintain a vigorous stand of grass. Caution should be used with fertilization to maintain water quality.
7. Mow vegetated portions of lined waterways regularly to maintain a healthy, vigorous sod. Time the first mowing after ground-nesting birds have hatched (August 1 or later). Remove excess top growth. Do not burn or overgraze.
8. Repair all broken subsurface drain lines adjacent to or in the waterway.
9. Re-establish vegetative cover immediately where scour erosion has removed established seeding or vegetated portion of lined waterway.
10. Maintain effective erosion control of the contributing watershed to prevent siltation and the resulting loss of capacity.

REFERENCES

National Engineering Handbook, Part 650, Engineering Field Handbook; Chapter 16, Streambank and Shoreline Protection.

Robinson, K.M., C.E. Rice, and K.C. Kadavy. 1998, Design of Rock Chutes, Transactions of ASAE, Vol. 41(3): 621-626.