

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, or other permanent material. The lined section extends up the side slopes to a designed depth. The earth above the permanent lining may be vegetated or otherwise protected.

**Scope**

This standard applies to waterways or outlets having linings of nonreinforced, cast-in-place concrete; flagstone mortared in place; rock riprap; or similar permanent linings. It does not apply to irrigation water conveyance, grassed waterways with stone centers or small lined sections to carry prolonged low flows. The maximum capacity of the waterway flowing at designed depth shall not exceed 200 ft<sup>3</sup>/s.

**PURPOSES**

To provide for safe disposal of runoff from other conservation structures or from natural concentrations of flow, without damage by erosion or flooding, where unlined or grassed waterways would be inadequate. Properly designed linings may also control seepage, piping, and sloughing or slides.

**CONDITIONS WHERE PRACTICE APPLIES**

This practice applies if the following or similar conditions exist:

1. Concentrated runoff is of 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 of such that use by people or animals preclude use of vegetated waterways or outlets.
4. High-value property or adjacent facilities warrant the extra cost to contain design runoff in a limited space.

5. Soils are highly erosive or other soil or climatic conditions preclude using vegetation.
6. Installation of nonreinforced concrete or mortared flagstone linings, shall be made only on low shrink-swell soils that are well drained or where subgrade facilities are installed.

**CRITERIA**

**Capacity**

The minimum capacity shall be adequate to carry the peak rate of runoff from a 10-year 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	0.012-0.14
Float finish	0.013-0.017
Shotcrete	0.016-0.022
Flagstone	0.020-0.025
Riprap	Determine from figure 1

**Velocity**

Maximum design velocity shall be :

- |                                          |        |
|------------------------------------------|--------|
| a) Concrete/Shotcrete                    | 20 f/s |
| b) Riprap w/ adequate filter base        | 15 f/s |
| c) Grouted riprap with geotextile fabric | 15 f/s |
| d) flagstone w/mortar bed                | 15 f/s |
| e) Precast stone w/ geotextile fabric    | 15 f/s |

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 dissipater to reduce velocity to less than critical.

### Cross section

The cross section shall be triangular, parabolic, or trapezoidal. Cross section 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 side slopes. No freeboard is required if vegetation can be grown and maintained.

### 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 screened concrete or mortared in place  
flagstone

Height of lining, less than 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

### Lining thickness

Minimum lining thickness shall be:

Concrete      4 in. (In most problem areas, minimum thickness shall be 5 in. with welded wire fabric reinforcing.)

Rock riprap      Maximum stone size plus thickness of filter or bedding

Flagstone      4 in, including mortar bed

Pre-cast stone      4 in, with approximate filter

### Related structures

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

### 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 procedures outlined in NEH-26. Weep holes may be used with drains if needed. Geotextile fabric may be permitted.

### 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.<sup>2</sup>. Cement used shall be Portland cement, Types I, II, or if required, Types IV or V. Aggregate used shall have a maximum size of 1-1/2 in.

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

### Rock riprap of 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.

## CONSIDERATIONS

### Water Quantity

1. Effects upon components of the water budget, especially effects on volumes and rates of runoff, infiltration, evaporation transpiration, deep percolation, and ground water recharge.
2. Variability of the practice's effect caused by seasonal and climatic changes.

### Water Quality

1. Filtering effects of vegetation on the movement of sediment and dissolved and sediment attached substances will be evaluated.
2. Effects on the visual quality of the water resources.
3. Short-term and construction effects on the quality of water resources.

### Endangered Species Considerations

Determine if installation of this practice with any others proposed will have any effect on any federal or state listed Rare, Threatened or Endangered species or their habitat. NRCS's objective is to benefit these species and others of concern or at least not have any adverse effect on a listed species. If the Environmental Evaluation indicates the action may adversely affect a listed species or result in adverse modification of habitat of listed species which has been determined to be critical habitat, NRCS will advise the land user of the requirements of the Endangered Species Act and recommend alternative conservation treatments that avoid the adverse effects. Further assistance will be provided only if the landowner selects one of the

alternative conservation treatments for installation; or at the request of the landowners, NRCS may initiate consultation with the Fish and Wildlife Service, National Marine Fisheries Service and/or California Department of Fish and Game. If the Environmental Evaluation indicates the action will not affect a listed species or result in adverse modification of critical habitat, consultation generally will not apply and usually would not be initiated. Document any special considerations for endangered species in the Practice Requirements Worksheet.

Some species are year-round residents in some streams, such as, freshwater shrimp. Other species, such as steelhead and salmon, utilize streams during various seasons. Be aware that critical periods, such as spawning, eggs in gravels, and rearing of young may preclude activities in the stream that may directly affect the stream habitat during those periods. For example there should be no disturbance of stream gravel beds that may have eggs in them. That could include any equipment in the stream or even walking in the stream or work upstream that may result in sediment depositing in the gravel beds. Document any special considerations for endangered species in the Practice Requirements Worksheet.

## 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.

Figure 1 to be provided by SCE.

## OPERATION AND MAINTENANCE

Provisions must be made for timely maintenance to insure lined waterways function properly.