

**NATURAL RESOURCES CONSERVATION SERVICE  
CONSERVATION PRACTICE STANDARD**

**LINED WATERWAY OR OUTLET**

(Ft)

CODE 468

**DEFINITION**

A waterway or outlet with 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 with 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 cfs.

**PURPOSE**

Waterways or outlets are lined 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 where the following or similar conditions exist:

1. Concentrated runoff is such that lining is required 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. 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. For nonreinforced concrete flagstone linings, installation shall be made only on low shrink - swell soils that are well drained or where subgrade drainage facilities are installed.

**DESIGN CRITERIA**

**Capacity**

The minimum capacity shall be adequate to carry the peak rate of runoff from a 10-year frequency storm. Capacity shall be computed using Manning's formula with a coefficient of roughness "n" as follows:

Concrete	
Trowel finish	- .012 - .014
Float finish	- .013 - .017
Gunite	- .016 - .022
Riprap	- .04d <sup>1/6</sup> where "d" is the d50 size in ft.

For design of riprap use the procedure in Chapter 7 of the Engineering Field Manual.

**Velocity**

Expect 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

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

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exceeding critical will be restricted to straight reaches. Maximum design velocity shall not exceed:

Design Flow Depth	Maximum Velocity
0 - .5 ft	25 fps
.5 - 1.0 ft	15 fps
1.0 ft	10 fps

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. 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 where good vegetation can be grown and is maintained.

### Side Slope

Steepest permissible side slope, horizontal to vertical will be as follows:

Non-Reinforced Concrete -

Hand-placed, formed concrete

Height of lining 1.5 feet or less - vertical

Hand-placed, screened concrete or mortared in-place flagstone

Height of lining less than 2 feet - 1 to 1

Height of lining more than 2 feet - 2 to 1

Slip form concrete

Height of lining less than 3 feet - 1 to 1

Rock riprap - 2:1

### Lining Thickness

Minimum lining thickness shall be as follows:

Concrete - 4 inches

Rock riprap - maximum stone size plus thickness of filter or bedding

### Related Structures

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

### Filters or Bedding

Filters or bedding to prevent piping, reduce uplift pressure, and collect water will be used as required and will be designed in accordance with Service standards. Weep holes and drains will be provided as needed.

### Concrete

Concrete used for lining shall be so proportioned that it is plastic enough for thorough consolidation and stiff enough to stay in place on side slopes. A dense durable product will be required. A mix that will produce a minimum strength of at least 3,000 pounds per square inch shall be specified. Cement used shall be Portland Cement, Type I, II, or if required, Type IV or V. Aggregate used shall have a maximum size of 1 ½ 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 where 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.

### Rock Riprap

Stone used for riprap shall be dense and hard enough to withstand exposure to air, water, freezing, and thawing.

## PLANS AND SPECIFICATIONS

Plans and specifications for construction of Lined Waterways or Outlets shall be in keeping with this standard and shall describe the requirements

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for application of the practice to achieve its intended purposes. Refer to S-468-1 for Guide Specifications.