

NATURAL RESOURCES CONSERVATION SERVICE
CONSERVATION PRACTICE STANDARD

LINED WATERWAY OR OUTLET

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 designed depth. The earth above the permanent lining may be vegetated or otherwise protected.

PROTECTED

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, in situations where lined or grassed waterways would be inadequate. Properly designed linings may also control seepage, piping, and sloughing or slides.

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 ditch and canal lining, 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 100 cfs.

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 damage from 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 non-reinforced 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 Mannings formula with a coefficient of roughness "n" as follows:

Concrete		
Trowel finish	-	.012-.014
Float finish	-	.013-.017
Gunite	-	.016-.022
Flagstone	-	.020-.025
Riprap	-	.04d ⁵⁰ 1/6 where "d" is in ft.

For design of riprap see National Cooperative Highway Research Program Report 108 – Tentative Design Procedure for Riprap – Lined Channels, or the procedure in the Engineering Field Manual.

Velocity

Maximum design velocity shall be as shown below. 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 will be restricted to straight reaches.

<u>Design Flow Depth</u>	<u>Maximum Velocity</u>
0- .5'	25 fps
.5- 1.0'	15 fps
> 1.0'	10 fps

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. Monolithic concrete may be rectangular.

Freeboard

The minimum freeboard for lined waterways or outlets shall be 1.0' above design high water.

Side Slope

Steepest permissible side slopes, 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, screeded 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
- Flagstone - 4 inches including mortar bed

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 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. The concrete shall have a minimum of six (6) bags of cement per cubic yard and a maximum of seven (7) gallons of water per bag of cement. Cement used shall be Portland Cement, Type I, II, or if required, Type IV or V. Aggregate used shall have a maximum size of 1-1/2 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 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.

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 for application of the practice to achieve its intended purposes.

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ENGINEERING STANDARD

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Specification shall include consideration of the following items in addition to those required in the standard:

The foundation area shall be cleared of trees, stumps, roots, sod, loose rock, or other material.

The cross-section shall be excavated to the neat lines and grades as shown on the plans. Over-excavated areas shall be backfilled with moist soil compacted to the density of the surrounding material.

No abrupt deviations from design grade or horizontal alignment shall be permitted.

Concrete linings shall be placed to the thickness shown on the plans and finished in a workmanlike manner. Adequate precautions shall be taken to protect freshly placed concrete from freezing or extremely hot temperature and to ensure proper curing.

Filter, bedding, and rock riprap shall be placed to line and grade and in the manner specified.

Construction operations shall be done in such a manner that erosion, air and water pollution will be minimized and held within reasonable and legal limits. The completed job shall be workmanlike and present a good appearance. All disturbed areas shall be vegetated or otherwise provided cover to protect against soil erosion.