

USDA-SCS  
Alabama

All Field Offices  
Technical Guide  
Section IV  
September 1989 (Rev.)

## 468 - LINED WATERWAY OR OUTLET

### 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.

### 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

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 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 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. Installation of non-reinforced concrete or mortared flagstone linings shall be made only on low shrink-swell soils that are well drained or where subgrade drainage facilities are installed.

### Planning Considerations for Water Quantity and Quality

A lined waterway is used to either stabilize an active gully or serve as a stable outlet for contour farming, contour strip cropping, diversions, terraces, buffer strips, water and sediment control basins, and underground outlets. This practice's effect on ground water and surface water is in reducing soil erosion and sedimentation downstream. Lined waterways may reduce concentrated flow erosion and reduce sediment and pollutants to receiving waters.

1. Lined waterways can be used to control concentration flow erosion and prevent erosion and gulying of cropland where grassed waterway outlets cannot be easily maintained.
2. Lined waterways may increase dissolved and suspended substances being transported to surface waters due to increased velocities.
3. Good vegetation is an essential part of the waterway system and must be well established and maintained. Good vegetation will reduce sediment and pollutant delivery to receiving waters.
4. The direction of plowing and chiseling of the land area should be varied to avoid buildup of ridges at the edge of the system.
5. Proper planning, design, layout, and installation is essential for erosion control and extended life.

### DESIGN CRITERIA

#### CAPACITY

The minimum capacity shall be adequate to carry the peak rate of runoff from a 10-year, 24-hour frequency storm. Capacity shall be computed using Mannings formula with a coefficient of roughness "n" as follows:

Concrete	
Trowel Finish .....	0.012 - 0.014
Float Finish .....	0.013 - 0.017
Gunite .....	0.016 - 0.022
Flagstone .....	0.020 - 0.025
Riprap .....	Determine from Figure 1.

For design of riprap see National Cooperative Highway Research Program Report 108 - Tentative Design Procedure for Riprap - Lined Channels, or determine the required riprap size relative to slope of waterway and depth of flow from the Nomograph 468-1 or as shown of V-section and rounded section in Exhibit 7.3, Engineering Field Manual, or the procedure in Chapters 16 and 17 of the Engineering Field Manual for Conservation Practices.

#### VELOCITY

Maximum design velocity shall be as shown in Figure 2. 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.

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

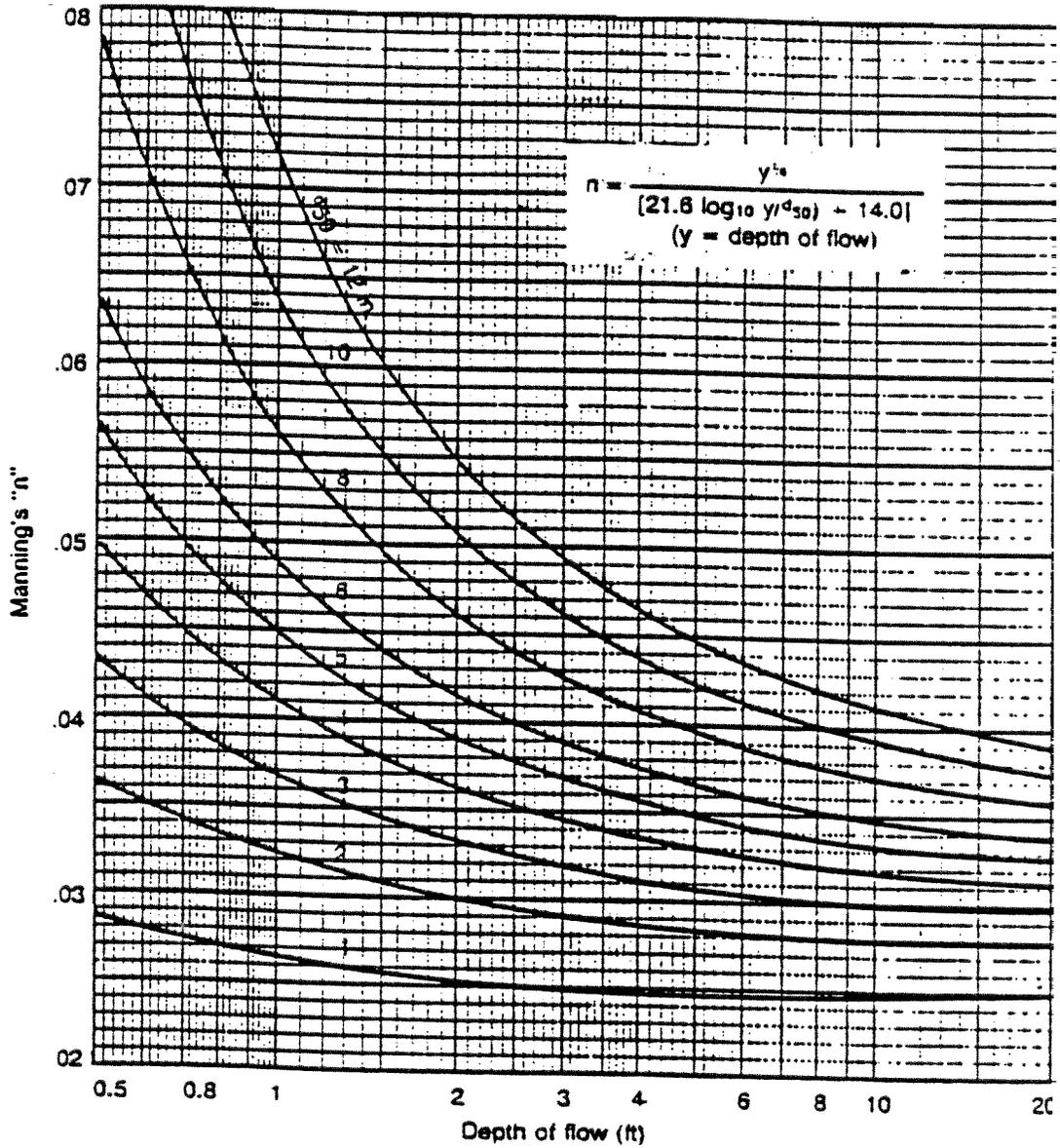
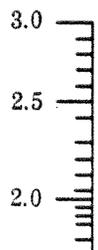
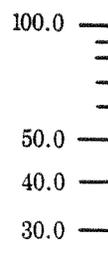


Figure 1 — Values of n for grass-lined channels,  $d_{50}$  size vs depth of flow.

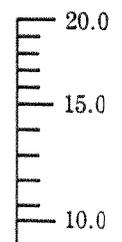
Design depth "d"  
(in feet)



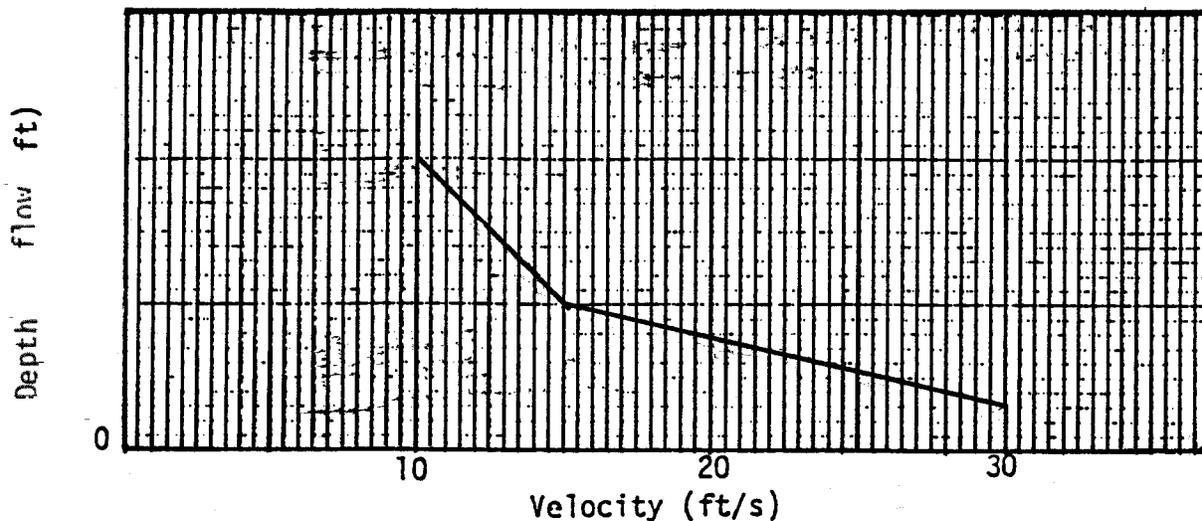
Max. size - " $D_{75}$ "  
75% of the rock  
(in inches)



Slope "S"  
of drain  
(in %)







**Figure 2 - Maximum velocity vs depth of flow**

#### CROSS SECTION

The cross section shall be triangular, parabolic, 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 maintained.

#### 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 to 1

#### Lining Thickness

Minimum lining thickness shall be as follows:

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

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

Flagstone - 4 inches including mortar board.

Manufactured Block - 3 inches including filter cloth.

### 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 SCS standards. Weep holes may be used with drains if needed. Appropriate filter cloth may be used in lieu of fillers or bedding.

### 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 shall be required. Concrete for minor structures shall produce a minimum 28-day strength of 3000 pounds per square inch. Cement used shall be Portland Cement Type I, II, or equal. Aggregate shall have a maximum size of 1 1/2 inches. On non-project work, see Construction Specification CS-468, Concrete, for recommended ratio of concrete mixture.

### Mortar

Mortar used for mortared in-place flagstone shall consist of workable mix of cement, sand, and water. The water-cement ratio shall not be 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 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, Flagstone or Manufactured Block

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

### Approval

Plans and specifications for each lined waterway or outlet will be approved by an engineer. The Engineering Job Approval Classification Chart for 410-Grade Stabilization Structure will be followed in approvals. Plans for any structure on drainage area in excess of 100 acres or velocity greater than 15 feet/second will be discussed with the State Conservation Engineer prior to approval.

## VEGETATIVE SPECIFICATIONS

Vegetative treatment of the adjacent disturbed area shall be applied as follows or as specified in Standard 342 or as specified in the plan.

1. Use high rates of lime and fertilizer. Use soil test information for areas that have a reasonable amount of topsoil when soil test information is available. In absence of soil test, apply 1000 to 1200 pounds of 13-13-13, or equivalent, per acre for areas seeded to grasses or 1000 to 1200 pounds of 4-12-12, or equivalent, per acre when sericea is included in the mixture.
2. The seedbed shall be well prepared (min. 4 inches deep), firm, and compact. Lime and fertilizer shall be worked into the soil during seedbed preparation.

3. Select long lived, sod forming perennial plants. One of the following base plants should be used alone or in mixtures:

<u>Species</u>	<u>Planting Rates</u> Per Acre*	<u>Seeding Dates</u>		
		<u>North Ala.</u>	<u>Central Ala.</u>	<u>South Ala.</u>
Tall Fescue	30 lbs. (PLS)	8-15 to 11-1	8-15 to 11-15	8-15 to 12-1
Common Bermuda	8 lbs. (PLS)	4-1 to 6-15	3-15 to 7-1	3-1 to 7-15
Bermuda, Common or Hybrid (Sprigs)	30 lbs. (PLS)	4-1 to 7-15	3-15 to 7-15	3-1 to 7-15
Bahiagrass**	40 lbs. (PLS)	3-15 to 6-15	3-1 to 7-1	2-1 to 7-15
Johnsongrass	40 lbs. (PLS)	4-1 to 7-31	4-1 to 7-31	4-1 to 7-31
Dallisgrass	20 lbs. (PLS)	3-15 to 6-15	3-1 to 7-1	2-1 to 8-1
Sericea***	60 lbs. (PLS)	3-15 to 7-15	3-1 to 8-1	2-1 to 8-1
Improved Lawn Grasses	Solid Sod	All Year	All Year	All Year

\*When two grasses are used in a mixture, reduce seeding rates of each by about one-third. Do not reduce seeding rates of legumes when used in mixtures.

\*\*Bahia should not be seeded alone. It should be seeded with either a quick-growing grass such as Bermuda or planted with a summer annual nurse crop. If a summer annual crop is planted, it should be removed as soon as it has established enough growth to leave a protective stubble.

\*\*\*Sericea should be used with a sod-forming grass. Compatible mixtures are usually more successful than single species.

4. Mulch should be used. (See specifications for Mulching).
5. Plantings damaged by erosion, drought, livestock, or other means shall be repaired as soon as possible.
6. See Plant Guide for plant(s) used for maintenance requirements.

\*Bahia should be used with quick-growing grass such as Bermuda or planted with a summer annual companion crop.

#### Temporary Vegetation

1. Temporary vegetation may be used to provide cover and a "grown-in-place" mulch when the waterway or outlet is constructed at a time of the year other than during the optimum planting period.
2. Use quick growing plants for temporary cover. Select from FOTG Standard 342, Plant Guide.
3. Seedbeds, planting rates, planting dates, lime, and fertilizer shall be conducive for the plant(s) used.
4. Seedbeds for the perennial plant(s) will be prepared with disk, chisel plow or other equipment that will keep most of the temporary vegetation residue on the surface of the soil.

#### Operation and Maintenance

An operation and maintenance plan will be made and discussed with the landuser. Provisions will be made for timely maintenance to insure that lined waterways function properly. The plan will include such items as repairing lining materials, soil rills, breaks in sod, removing or spreading silt deposits, fertilizing, mowing and proper land preparation and tillage operations adjacent to the waterways.

#### Plans and Specifications

Plans and specifications for construction lined waterways or outlets shall be in keeping with this standard and shall describe the requirements for applying the practice to achieve its intended purpose.

#### References

Alabama Engineering Field (Design) Manual for Conservation Practices  
Engineering Field Manual for Conservation Practices  
SCS-TP-61 Handbook of Channel Design for Soil and Water Conservation  
Specification for Construction Contracts, South  
National Cooperative Highway Research Program Report 108 - Tentative Design Procedure for Riprap  
Lined Waterway  
Urban Hydrology for Small Watersheds, Technical Release No. 55, USDA-SCS, June 1986

CONSTRUCTION SPECIFICATIONS  
FOR  
468 - LINED WATERWAY OR OUTLET

Scope

This item shall consist of the clearing, excavation, backfill, shaping, concrete, drain material, and other appurtenances required for the construction of the lined waterway or outlet and the disposal of all cleared and excavated materials.

Construction operations shall be carried out in such a manner that erosion, air, water, and noise pollution will be minimized and held within legal limits as established by state regulations.

Obstruction Removal

All brush, trees, stumps, fence rows, and other objectionable material shall be removed and disposed of so that they will not interfere with construction, shaping, or proper functioning of the waterway or outlet.

Cross Section

The waterway or disposal area shall be shaped or constructed to the specified dimensions and shall be free of bank projections, abrupt changes, or other irregularities.

Slope

Waterways, outlets, and disposal areas shall have uniform continuous slope in the direction of flow within a given reach.

Disposal

All earth removed and not needed in construction shall be spread or disposed of so that it will not interfere with the functioning of the waterway. Care must be taken in spreading waste material so that no ridges or holes are formed along the sides of the waterway that will restrict drainage from rows, terraces, diversions, roads, or other structures. All portions of the waterway or outlet shall be finished and smoothed in such a manner that farm equipment can proceed with the establishment and maintenance of vegetative cover.

Shaping

Shaping and filling shall be compacted as needed to prevent uneven settlement that would cause damage in the completed waterway. The completed waterway shall conform as nearly to the lines and grades, top width, and side slopes shown on the plans as skillful operations of the construction equipment will permit.

Bedding or Filter

When a bedding filter layer or filter cloth is specified for placement beneath the concrete, riprap, flagstone, or manufactured block, the material shall be spread uniformly on the prepared subgrade surface to the depth indicated. Compaction of the bedding material will not be required but the surface of such layers shall be finished free from mounds and dips.

Materials

All of the component parts of the lined waterway including pipe, rock riprap, flagstone, manufactured block, trash rack, concrete, drain fill, and appurtenances shall be as specified on the plans. All work shall be completed in a workmanship like manner.

### Concrete

The work shall consist of furnishing, forming, placing, finishing, and curing Portland cement concrete as required in the construction of the work.

Concrete used for lined waterways, concrete flumes, and related structures shall have a minimum of 6 bags of cement per cubic yard. The consistency of the concrete shall be such as to allow the concrete to be worked into place without segregation or excessive laitance.

The concrete mixture shall be as follows: A standard brand Type 1 Portland cement, washed sand, and gravel. Clean water shall be used in the mix. (Suggested ratio of aggregates in mix: 94 lbs. cement (1 bag), 6 gals. water, 170 lbs. clean dry sand, 315 lbs. dry gravel. Smaller batches: 1 part cement, 2 parts sand, and 3 parts gravel and water at the rate of 1 gal. per 16 lbs. of cement).

Cement shall not be placed when the atmospheric temperature may be expected to fall below 40°F at the time concrete is delivered and placed at the work site.

All concrete shall be cured by keeping the exposed surfaces continuously moist for at least 7 days after being placed or spraying it with two coats of curing compound when other concrete will not be bonded to the concrete surface. Concrete shall not be exposed to freezing temperature during the curing period.

### Vegetation

Vegetative treatment shall be established as specified or as shown on the plans. Vegetation shall be applied as critical area planting and will include liming, fertilizing, seedbed preparation, seeding and mulching.