## Section F - LAND GRADING AND STRUCTURAL STABILIZATION

## 17.0 STANDARDS AND SPECIFICATIONS

## FOR

## STABILIZED CONSTRUCTION ENTRANCE

### Definition

A stabilized layer of aggregate that is underlain with Geotextile Class C[25]. Stabilized entrances are located at any point where traffic enters or leaves a construction site.

### Purpose

Stabilized construction entrances reduce tracking of sediment onto streets or public rights-of-way and provide a stable area for entrance or exit from the construction site.

### Conditions Where Practice Applies

1. Stabilized construction entrances shall be located at points of construction ingress and egress.

2. For single family residences, the entrance should be located at the permanent driveway.

3. Stabilized construction entrances should not be used on existing pavement.

### Design Criteria

1. Length - minimum of 50' (30' for single residence lot).

2. Width - 10' minimum, should be flared at the existing road to provide a turning radius.

3. Geotextile Class C shall be placed over the existing ground prior to placing stone. The plan approval authority may not require geotextile fabric for single family residences.

4. Stone - crushed aggregate (2" to 3")[26], or recycled concrete equivalent shall be placed at least 6" deep over the length and width of the entrance.

5. Surface Water - all surface water flowing to or diverted toward construction entrances shall be piped under the entrance to maintain positive drainage. Pipe installed under the construction entrance shall be protected with a mountable berm. The pipe shall be sized according to the drainage, with the min. diameter being 6". A pipe will not be necessary when the SCE is located at a high spot.

6. Location - A stabilized construction entrance shall be located at every point where construction traffic enters or leaves a construction site. Vehicles leaving the site must travel over the entire length of the stabilized construction entrance.



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[25] Refer to Table 27.

[26] Refer to Table 28

## Maintenance

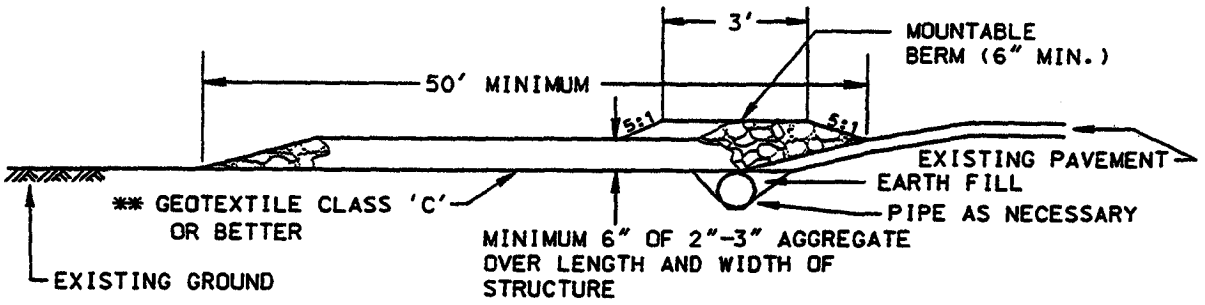
The entrance shall be maintained in a condition which will minimize tracking of sediment onto public rights-of-way. This may require adding stone or other repairs as conditions demand. All sediment spilled, dropped, or tracked onto public rights-of-way must be removed immediately by vacuum sweeping, scraping, or sweeping.

When necessary, wheels shall be cleaned or washed to remove sediment prior to entrance onto public rights-of-way. When washing is required, it shall be done on an area stabilized with stone and which drains into an approved sediment trapping device. Daily inspection and maintenance is required.

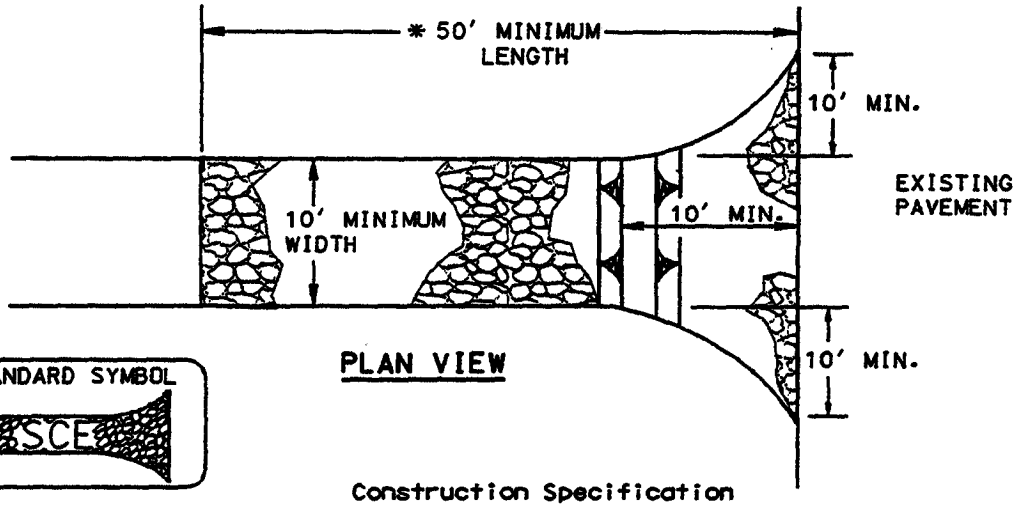
## Removal

After construction is complete and the site is stabilized, the stabilized construction entrance will be removed and the area stabilized unless it will be used as an underlayment for a driveway.

# DETAIL 24 – STABILIZED CONSTRUCTION ENTRANCE




PROFILE




PLAN VIEW




Construction Specification

1. Length – minimum of 50' (*30' for single residence lot).

2. Width – 10' minimum, should be flared at the existing road to provide a turning radius.

3. Geotextile fabric (filter cloth) shall be placed over the existing ground prior to placing stone. **The plan approval authority may not require single family residences to use geotextile.

4. Stone – crushed aggregate (2" to 3") or reclaimed or recycled concrete equivalent shall be placed at least 6" deep over the length and width of the entrance.

5. Surface Water – all surface water flowing to or diverted toward construction entrances shall be piped through the entrance, maintaining positive drainage. Pipe installed through the stabilized construction entrance shall be protected with a mountable berm with 5:1 slopes and a minimum of 6" of stone over the pipe. Pipe has to be sized according to the drainage. When the SCE is located at a high spot and has no drainage to convey a pipe will not be necessary. Pipe should be sized according to the amount of runoff to be conveyed. A 6" minimum will be required.

6. Location – A stabilized construction entrance shall be located at every point where construction traffic enters or leaves a construction site. Vehicles leaving the site must travel over the entire length of the stabilized construction entrance.

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# 18.0 STANDARDS AND SPECIFICATIONS

# FOR

# ROCK OUTLET PROTECTION

## Definition

Rock placed at the outfall of channels or culverts.

## Purpose

To reduce the velocity of flow in the receiving channel to non-erosive rates.

## Conditions Where Practice Applies

This practice applies where discharge velocities and energies at the outlets of culverts are sufficient to erode the next downstream reach. This applies to outlets of all types such as sediment basins, stormwater management ponds, and road culverts.

## Design Criteria

**The design method presented here applies to sizing rock rip-rap and gabions to protect a downstream area. It does not apply to rock lining of channels or streams.** The design of rock outlet protection depends entirely on the location. Pipe outlets at the top of cuts or on slopes steeper than ten percent cannot be protected by rock aprons or rip-rap sections due to reconcentration of flows and high velocities encountered after the flow leaves the apron.

Be aware that many counties and state agencies have regulations and design procedures established for dimensions, type and size of materials, and locations where outlet protection is required.

1. Tailwater Depth

The depth of tailwater immediately below the pipe outlet must be determined for the design capacity of the pipe. If the tailwater depth is less than half the diameter of the outlet pipe and the receiving stream is wide enough to accept divergence of the flow, it shall be classified as a Minimum Tailwater Condition. If the tailwater depth is greater than half the pipe diameter and the receiving stream will continue to confine the flow, it shall be classified as a Maximum Tailwater Condition. Pipes which outlet onto flat areas with no defined channel may be assumed to have Minimum Tailwater Condition.

2. Apron Size

The apron length and width shall be determined from the curves according to the tailwater condition:

| | |
|---|---|
| Minimum Tailwater | Use Table 19 |
| Maximum Tailwater | Use Table 20 |

If the pipe discharges directly into a well-defined channel,the apron shall extend across the channel bottom and up the channel banks to an elevation one foot above the maximum tailwater depth or to the top of the bank, whichever is less. The upstream end of the apron adjacent to the pipe shall have a width two times the diameter of the outlet pipe or conform to pipe end section if used.

3. Bottom Grade

The outlet protection apron shall be constructed with no slope along its length. There shall be no obstruction at the end of the apron. The elevation of the downstream end of the apron shall be equal to the elevation of the receiving channel or adjacent ground.

4. Alignment

The outlet protection apron shall be located so that there are no bends in the horizontal alignment.

5. Materials

The outlet protection may be done using rock rip-rap, or gabions. Rip-rap shall be composed of a well-graded mixture of stone sized so that fifty (50) percent of the pieces, by weight, shall be larger than the size determined by using the charts. The minimum $d_{50}$ size to be used shall be nine (9) inches. A well-graded mixture as used herein is defined as a mixture composed primarily of larger stone sizes but with a sufficient mixture of other sizes to fill the smaller voids between the stones. The diameter of the largest stone in such a mixture shall be 2.0 times the size selected on the chart located in the following paragraph.

6. Thickness

For SHA rip-rap specifications the following values are used:

Table 18

Rip-rap Sizes and Thicknesses (SHA Specifications)

| | $D_{50}$ | $D_{100}$ | Thickness |
|---|---|---|---|
| Class I | 9.5" | 15" | 19" |
| Class II | 16" | 24" | 32" |
| Class III | 23" | 34" | 46" |

7. Stone Quality

Stone for rip-rap shall consist of field stone or rough and hewn quarry stone. The stone shall be hard and angular and of a quality that will not disintegrate on exposure to water or weathering. The specific gravity of the individual stones shall be at least 2.5. Recycled concrete equivalent may be used provided it has a density of at least 150 pounds per cubic foot and does not have any exposed steel or reinforcing bars.

8. Filter

A filter is a layer of material placed between the rip-rap and the underlaying soil surface to prevent soil movement into and through the rip-rap to prevent piping, reduce uplift pressure, and collect water. Rip-rap shall have a filter placed under it in all cases. A filter can be of two general forms: a gravel layer or a Geotextile Class C[27].

9. Gabions

Gabion baskets may be used as rock outlet protection, provided they are made of hexagonal triple twist mesh with heavily galvanized steel wire. The maximum lined dimension of the mesh opening shall not exceed 4 1/2 inches. The area of the mesh opening shall not exceed ten (10) square inches. Gabions shall be fabricated in such a manner that the sides, ends, and lid can be assembled at the construction site into a rectangular basket of the specified sizes. Gabions shall be of single unit construction and shall be installed according to the manufacturer's specifications. The area on which the gabion is to be installed shall be graded as shown on the drawings. Foundation conditions shall be the same as for placing rock rip-rap. Geotextile Class C shall be placed under all gabions. Gabions must be keyed in to prevent undermining of the main gabion structure. Refer to Table 28 for Gabion stone sizes.

## Maintenance

Once a rip-rap outlet has been installed, the maintenance needs are very low. It should be inspected after high flows to see if scour beneath the rip-rap has occurred or if any stones have been dislodged. Repairs should be made immediately.

## Design Procedure

1. Investigate the downstream channel to assure that non-erosive velocities can be maintained.

2. Determine the tailwater condition at the outlet to establish which curve to use.

3. Enter the appropriate chart with the depth of flow and discharge velocity to determine the rip-rap size and apron length required. References to pipe diameters in the charts are based on full flow. For other than full pipe flow, the parameters of depth of flow and velocity must be used.

4. Calculate apron width at the downstream end if a flared section is to be employed.

## Examples

Example 1: Pipe Flow (Full) with Discharge to Unconfined Section :

Q = 280 cfs, diameter = 66", tailwater is 2' above pipe invert (min. tailwater condition).

Read $d_{50}$ = 1.2 feet, and apron length = 38 feet.

Apron width = diameter + L a = 5.5 + 38 = 43.5 feet.



[27] Refer to Table 27

Example 2: Box Flow (Partial) with High Tailwater:

A box culvert is flowing under partial flow conditions:

A concrete box 5.5 feet x 10 feet is flowing 5.0 deep; Q = 600 cfs, and tailwater (surface) is 5' above invert (maximum tailwater condition);

V = Q/A = 600/(5 x 10) = 12 fps

At the intersection of the curve, d = 60 inches, V = 12 fps, read $d_{50}$ = 0.4 feet.
Since $d_{50}$ 9 inches, use $d_{50}$ = 9 inches.

Then reading to the d = 60 inch curve, read apron length = 40 feet.

Apron width, W = conduit width + 0.04 L a = 10 + (0.4)(40) = 26 feet.

Example 3: Open Channel Flow with Discharge to Unconfined Section:

A trapezoidal concrete channel 5 feet wide with 2:1 side slopes is flowing 2 feet deep;

Q = 180 cfs (velocity = 10 fps); and the tailwater (surface) downstream is 0.8 foot (minimum tail water condition).

At the intersection of the curve, d = 24 inches, V = 10 fps, read $d_{50}$ = 0.7 feet.
Since $d_{50}$ 9 inches, use $d_{50}$ = 9 inches.

Then reading to the d = 24 inch curve, read apron length = 22 feet.
Apron width, W = bottom of width of channel + L a = 5 + 22 = 27 feet.

Example 4: Pipe Flow (Partial) with Discharge to a Confined Section:

A 48 inch pipe is discharging with a depth of 3 feet;

Q = 100 cfs and the discharge velocity of 10 fps (established from partial flow analysis) to a confined trapezoidal channel with a 2 foot bottom, 2:1 side slopes, n =.04, and a grade of 0.6 %.

Calculation of the downstream channel (Manning's Equation) indicates a normal depth of 3.1 feet and a normal velocity of 3.0 fps. Since the receiving channel is confined, the maximum tailwater condition controls.

At the intersection of the curve, d = 36 inches, and V = 10 fps, read d50 = 0.3 feet.

Since $d_{50}$ 9 inches, use $d_{50}$ = 9 inches.

Then reading to the d = 36 inch curve, read apron length = 30 feet.

Since the maximum flow depth in this reach is 3.1 feet, then the minimum depth of the rip-rap must be 4.1 feet.

Construction Specifications

1. The subgrade for the filter, rip-rap, or gabion shall be prepared to the required lines and grades. Any fill required in the subgrade shall be compacted to a density of approximately that of the surrounding undisturbed material.

2. The rock or gravel shall conform to the specified grading limits when installed respectively in the rip-rap or filter.

3. Geotextile Class C[28] or better shall be protected from punching, cutting, or tearing. Any damage other than an occasional small hole shall be repaired by placing another piece of geotextile fabric over the damaged part or by completely replacing the geotextile fabric. All overlaps whether for repairs or for joining two pieces of geotextile fabric shall be a minimum of one foot.

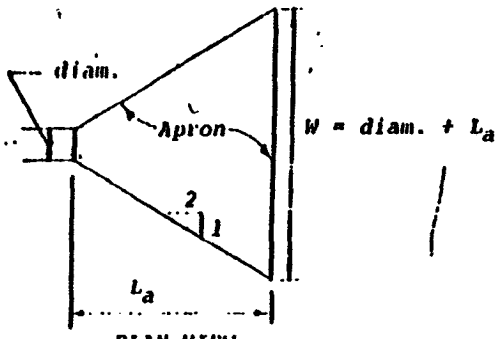
4. Stone for the rip-rap or gabion outlets may be placed by equipment. They shall be constructed to the full course thickness in one operation and in such a manner as to avoid displacement of underlying materials. The stone for rip-rap or gabion outlets shall be delivered and placed in a manner that will ensure that it is reasonably homogenous with the smaller stones and spalls filling the voids between the larger stones. Rip-rap shall be placed in a manner to prevent damage to the filter blanket or geotextile fabric. Hand placement will be required to the extent necessary to prevent damage to the permanent works.

5. The stone shall be placed so that it blends in with the existing ground. If the stone is placed too high then the flow will be forced out of the channel and scour adjacent to the stone will occur.



[28] Refer to Table 27

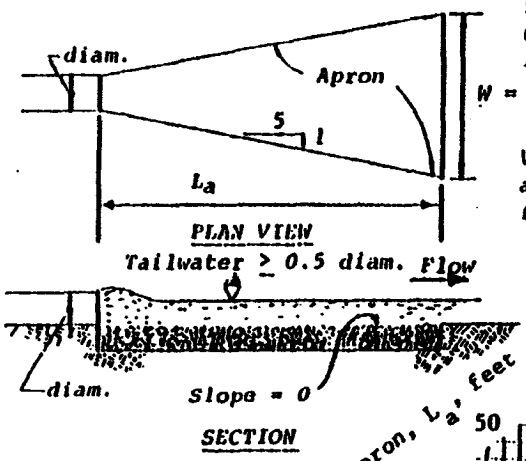
## DESIGN OF OUTLET PROTECTION
## MINIMUM TAILWATER CONDITION (Tw <0.5 diam.)




*Median stone diameter, d50, is the stone size which 50% of the riprap mixture, by weight, is larger than.*

*Velocities shown are for pipes flowing full.*

## DESIGN OF OUTLET PROTECTION
## MAXIMUM TAILWATER CONDITION (Tw ≥ 0.5 diam.)

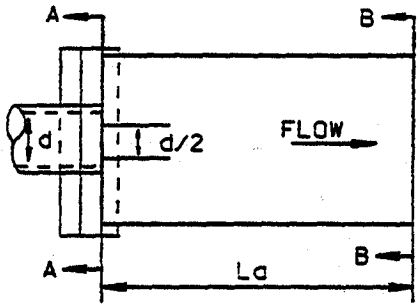



Median stone diameter, $d_{50}$, is the stone size which 50% of the riprap mixture, by weight, is larger than.

$W$ = diam. + 0.4 $L_a$

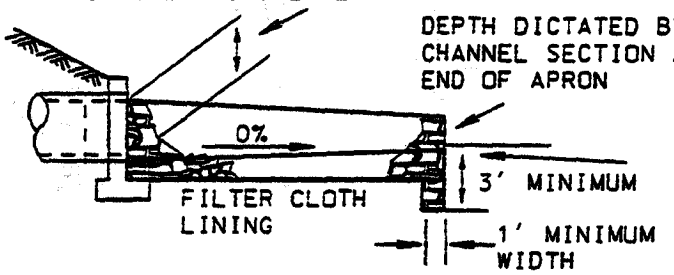
Velocities shown are for pipes flowing full.

# DETAIL 25 – ROCK OUTLET PROTECTION I



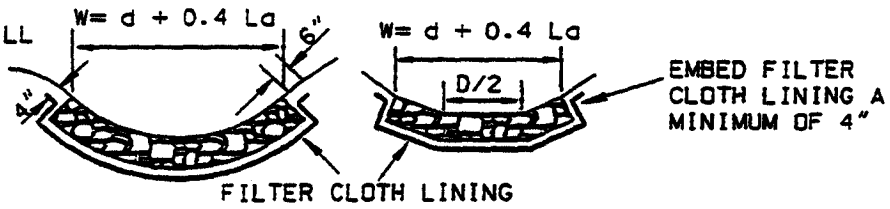

DISCHARGE TO SEMI CONFINED SECTION (MAXIMUM TAILWATER CONDITION)

MINIMUM DEPTH = DISCHARGE OR TAILWATER DEPTH. WHICHEVER IS GREATER




NOTE: FILTER CLOTH MUST EXTEND A MINIMUM OF 6" BEYOND APRON AND SIDES

CHANNEL CROSS SECTION WILL VARY FROM A–A TO B–B




SECTION B–B SECTION A–A

# ROCK OUTLET PROTECTION I

Construction Specifications

1. The subgrade for the filter, rip-rap, or gabion shall be prepared to the required lines and grades. Any fill required in the subgrade shall be compacted to a density of approximately that of the surrounding undisturbed material.

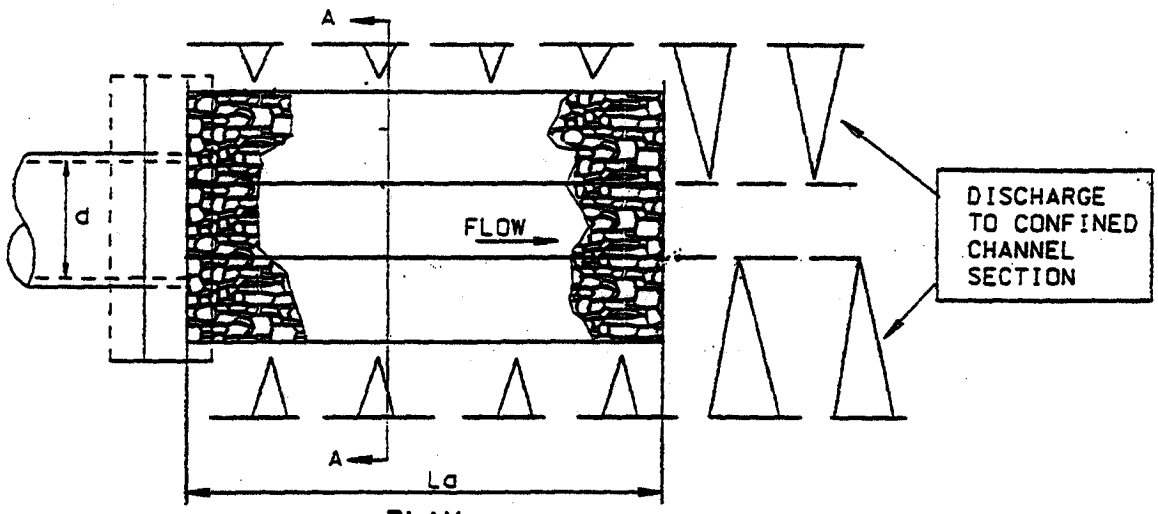
2. The rock or gravel shall conform to the specified grading limits when installed respectively in the rip-rap or filter.

3. Geotextile shall be protected from punching, cutting, or tearing. Any damage other than an occasional small hole shall be repaired by placing another piece of geotextile over the damaged part or by completely replacing the geotextile. All overlaps whether for repairs or for joining two pieces of geotextile shall be a minimum of one foot.

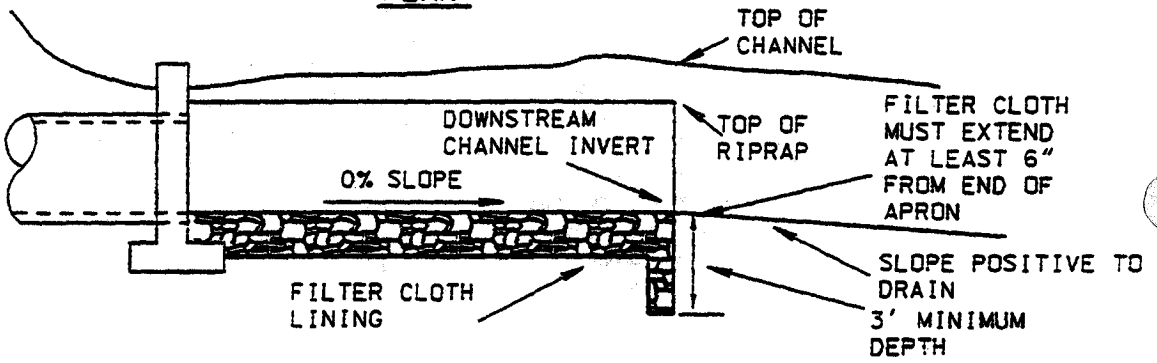
4. Stone for the rip-rap or gabion outlets may be placed by equipment. They shall be constructed to the full course thickness in one operation and in such a manner as to avoid displacement of underlying materials. The stone for rip-rap or gabion outlets shall be delivered and placed in a manner that will ensure that it is reasonably homogeneous with the smaller stones and spalls filling the voids between the larger stones. Rip-rap shall be placed in a manner to prevent damage to the filter blanket or geotextile. Hand placement will be required to the extent necessary to prevent damage to the permanent works.

5. The stone shall be placed so that it blends in with the existing ground. If the stone is placed too high then the flow will be forced out of the channel and scour adjacent to the stone will occur.

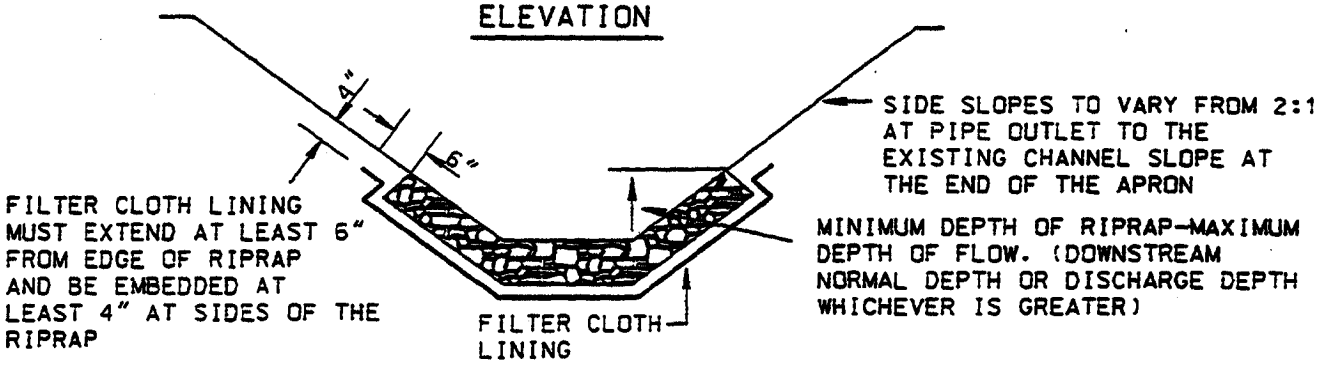
# DETAIL 26 - ROCK OUTLET PROTECTION II




PLAN




ELEVATION




SECTION A-A

# ROCK OUTLET PROTECTION II

Construction Specifications

1. The subgrade for the filter, rip-rap, or gabion shall be prepared to the required lines and grades. Any fill required in the subgrade shall be compacted to a density of approximately that of the surrounding undisturbed material.

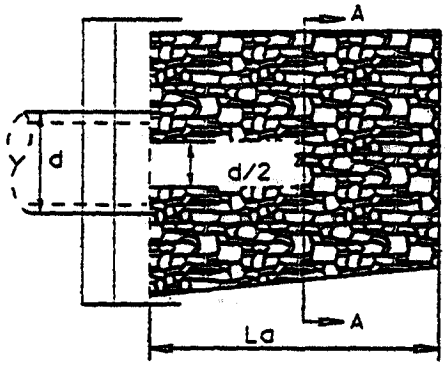
2. The rock or gravel shall conform to the specified grading limits when installed respectively in the rip-rap or filter.

3. Geotextile shall be protected from punching, cutting, or tearing. Any damage other than an occasional small hole shall be repaired by placing another piece of geotextile over the damaged part or by completely replacing the geotextile. All overlaps whether for repairs or for joining two pieces of geotextile shall be a minimum of one foot.

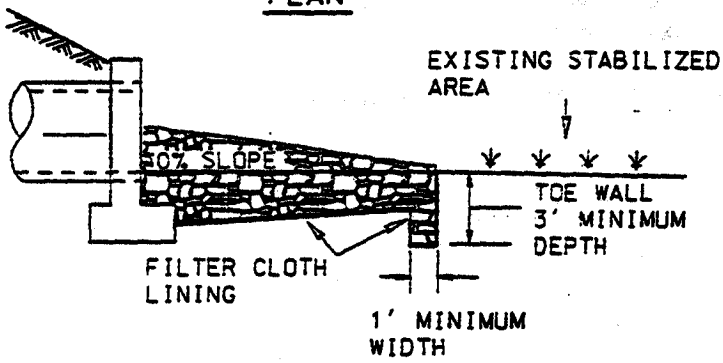
4. Stone for the rip-rap or gabion outlets may be placed by equipment. They shall be constructed to the full course thickness in one operation and in such a manner as to avoid displacement of underlying materials. The stone for rip-rap or gabion outlets shall be delivered and placed in a manner that will ensure that it is reasonably homogeneous with the smaller stones and spalls filling the voids between the larger stones. Rip-rap shall be placed in a manner to prevent damage to the filter blanket or geotextile. Hand placement will be required to the extent necessary to prevent damage to the permanent works.

5. The stone shall be placed so that it blends in with the existing ground. If the stone is placed too high then the flow will be forced out of the channel and scour adjacent to the stone will occur.

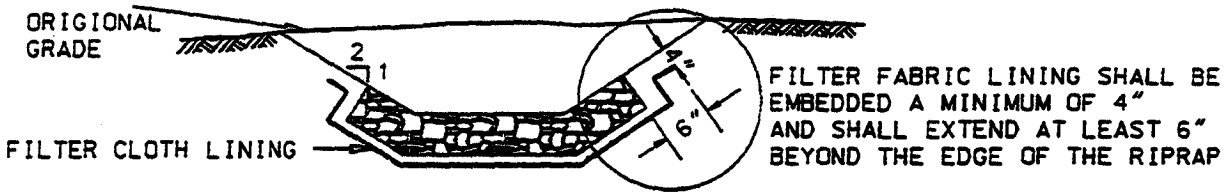
# DETAIL 27 – ROCK OUTLET PROTECTION III




PLAN




ELEVATION




SECTION A–A

# ROCK OUTLET PROTECTION III

Construction Specifications

1. The subgrade for the filter, rip-rap, or gabion shall be prepared to the required lines and grades. Any fill required in the subgrade shall be compacted to a density of approximately that of the surrounding undisturbed material.

2. The rock or gravel shall conform to the specified grading limits when installed respectively in the rip-rap or filter.

3. Geotextile shall be protected from punching, cutting, or tearing. Any damage other than an occasional small hole shall be repaired by placing another piece of geotextile over the damaged part or by completely replacing the geotextile. All overlaps whether for repairs or for joining two pieces of geotextile shall be a minimum of one foot.

4. Stone for the rip-rap or gabion outlets may be placed by equipment. They shall be constructed to the full course thickness in one operation and in such a manner as to avoid displacement of underlying materials. The stone for rip-rap or gabion outlets shall be delivered and placed in a manner that will ensure that it is reasonably homogeneous with the smaller stones and spalls filling the voids between the larger stones. Rip-rap shall be placed in a manner to prevent damage to the filter blanket or geotextile. Hand placement will be required to the extent necessary to prevent damage to the permanent works.

5. The stone shall be placed so that it blends in with the existing ground. If the stone is placed too high then the flow will be forced out of the channel and scour adjacent to the stone will occur.

# 19.0 STANDARDS AND SPECIFICATIONS

# FOR

# LAND GRADING

## Definition

Reshaping of the existing land surface in accordance with a plan as determined by engineering survey and layout.

## Purpose

The purpose of a land grading specification is to provide for erosion control and vegetative establishment on those areas where the existing land surface is to be reshaped by grading according to plan.

## Design Criteria

The grading plan should be based upon the incorporation of building designs and street layouts that fit and utilize existing topography and desirable natural surroundings to avoid extreme grade modifications. Information submitted must provide sufficient topographic surveys and soil investigations to determine limitations that must be imposed on the grading operation related to slope stability, effect on adjacent properties and drainage patterns, measures for drainage and water removal and vegetative treatment, etc.

Many counties have regulations and design procedures already established for land grading and cut and fill slopes. Where these requirements exist, they shall be followed. The plan must show existing and proposed contours of the area(s) to be graded. The plan shall also include practices for erosion control, slope stabilization, safe disposal of runoff water and drainage, such as waterways, lined ditches, reverse slope benches (include grade and cross section), grade stabilization structures, retaining walls, and surface and subsurface drains. The plan shall also include phasing of these practices. The following shall be incorporated into the plan:

1. Provisions shall be made to safely conduct surface runoff to storm drains, protected outlets or to stable water courses to insure that surface runoff will not damage slopes or other graded areas.

2. Cut and fill slopes that are to be stabilized with grasses shall not be steeper than 2:1. (Where the slope is to be mowed the slope should be no steeper than 3:1; 4:1 is preferred because of safety factors related to mowing steep slopes.) Slopes exceeding 2:1 shall require special design and stabilization considerations that shall be adequately shown on the plans.

3. Reverse benches shall be provided whenever the vertical interval (height) of any 2:1 slope exceeds 20 feet; for 3:1 slope it shall be increased to 30 feet and for 4:1 to 40 feet. Benches shall be located to divide the slope face as equally as possible and shall convey the water to a stable outlet. Soils, seeps, rock outcrops , etc., shall also be taken into consideration when designing benches.

   a. Benches shall be a minimum of six-feet wide to provide for ease of maintenance.

   b. Benches shall be designed with a reverse slope of 6:1 or flatter to the toe of the upper slope and with a minimum of one foot in depth. Bench gradient to the outlet shall be between 2 percent and 3 percent, unless accompanied by appropriate design and computations.

c. The flow length within a bench shall not exceed 800' unless accompanied by appropriate design and computations. For flow channel stabilization see temporary swale.

4. Surface water shall be diverted from the face of all cut and/or fill slopes by the use of earth dikes, ditches and swales or conveyed downslope by the use of a designed structure, except where:

a. The face of the slope is or shall be stabilized and the face of all graded slopes shall be protected from surface runoff until they are stabilized.

b. The face of the slope shall not be subject to any concentrated flows of surface water such as from natural drainageways, graded swales, downspouts, etc.

c. The face of the slope will be protected by special erosion control materials, to include, but not limited to: approved vegetative stabilization practices (see section G), rip-rap or other approved stabilization methods.

5. Cut slopes occurring in ripable rock shall be serrated as shown on the following diagram. These serrations shall be made with conventional equipment as the excavation is made. Each step or serration shall be constructed on the contour and will have steps cut at nominal two-foot intervals with nominal three-foot horizontal shelves. These steps will vary depending on the slope ratio or the cut slope. The nominal slope line is 1:1. These steps will weather and act to hold moisture, lime, fertilizer and seed thus producing a much quicker and longer lived vegetative cover and better slope stabilization. Overland flow shall be diverted from the top of all serrated cut slopes and carried to a suitable outlet.

6. Subsurface drainage shall be provided where necessary to intercept seepage that would otherwise adversely affect slope stability or create excessively wet site conditions.

7. Slopes shall not be created so close to property lines as to endanger adjoining properties without adequately protecting such properties against sedimentation, erosion, slippage, settlement, subsidence or other related damages.

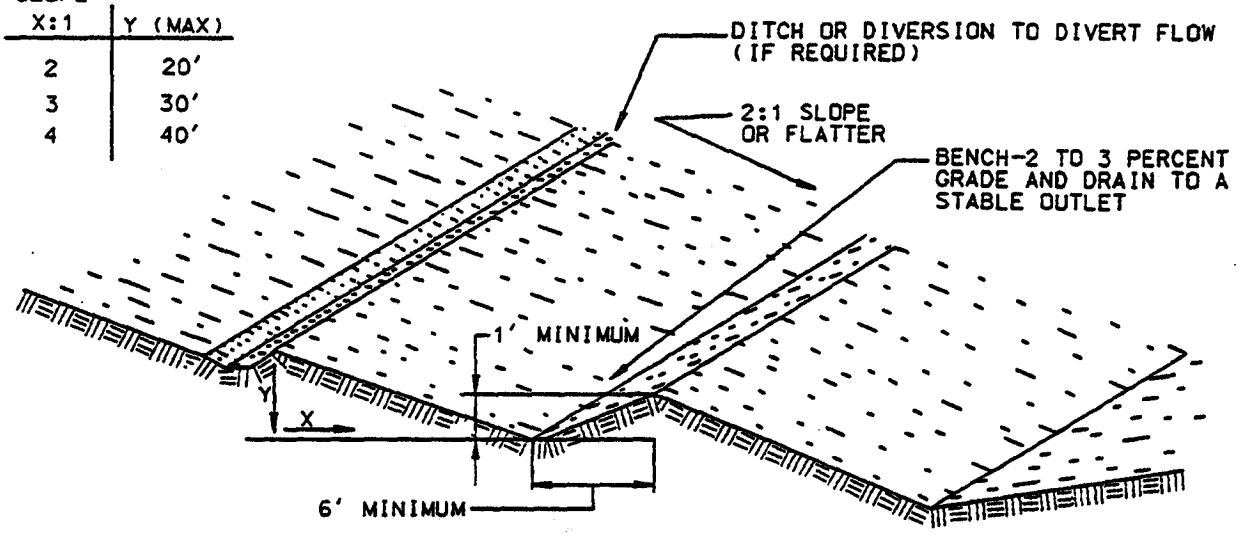
8. Fill material shall be free of brush, rubbish, rocks, logs, stumps, building debris, and other objectionable material. It should be free of stones over two (2) inches in diameter where compacted by hand or mechanical tampers or over eight (8) inches in diameter where compacted by rollers or other equipment.Frozen material shall not be placed in the fill nor shall the fill material be placed on a frozen foundation.

9. Stockpiles, borrow areas and spoil shall be shown on the plans and shall be subject to the provisions of this Standard and Specifications.

10. All disturbed areas shall be stabilized structurally or vegetatively in compliance with 20.0 Standards and Specifications for Vegetative Stabilization.

# DETAIL 28 - BENCHED SLOPES

| SLOPE X:1 | Y (MAX) |
|---|---|
| 2 | 20' |
| 3 | 30' |
| 4 | 40' |




Construction Specifications

1. All fills shall be compacted as required to reduce erosion, slippage, settlement, subsidence or other related problems. Fill intended to support buildings, structures and conduits, etc., shall be compacted in accordance with local requirements or codes.

2. All fill shall be placed and compacted in layers not to exceed 8" in thickness.

3. Except for approved landfills or nonstructural fills, fill material shall be free of brush, rubbish, rocks, logs, stumps, building debris and other objectionable materials that would interfere with or prevent construction of satisfactory fills.

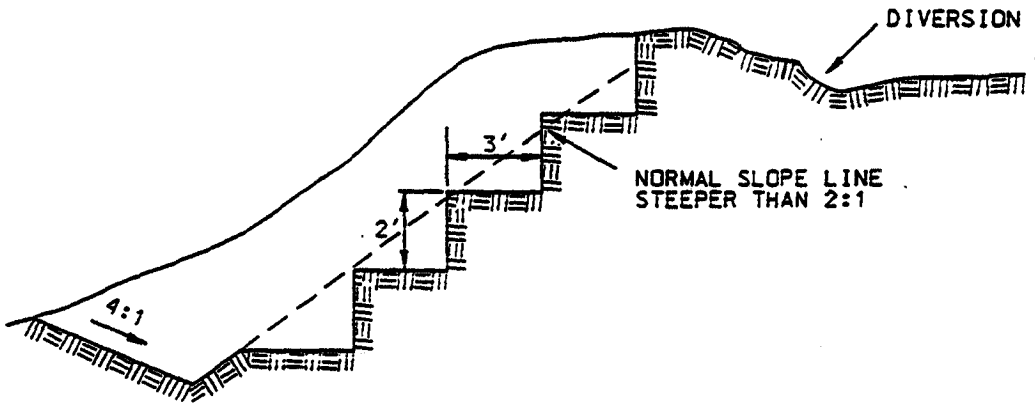
4. Frozen material or soft, mucky or highly compressible materials shall not be incorporated into fill slopes or structural fills. Fill shall not be placed on a frozen foundation.

5. All benches shall be kept free of sediment during all phases of development.

6. Seeps or springs encountered during construction shall be handled in accordance with the Standard and Specification for Subsurface Drain or other approved methods.

7. All graded areas shall be permanently stabilized immediately following finished grading.

# DETAIL 29 - SERRATED SLOPES




TYPICAL SECTION

Construction Specifications

1. All fills shall be compacted as required to reduce erosion, slippage, settlement, subsidence or other related problems. Fill intended to support buildings, structures and conduits, etc., shall be compacted in accordance with local requirements or codes.

2. All fill shall be placed and compacted in layers not to exceed 8" in thickness.

3. Except for approved landfills or nonstructural fills, fill material shall be free of brush, rubbish, rocks, logs, stumps, building debris and other objectionable materials that would interfere with or prevent construction of satisfactory fills.

4. Frozen material or soft, mucky or highly compressible materials shall not be incorporated into fill slopes or structural fills. Fill shall not be placed on a frozen foundation.

5. All benches shall be kept free of sediment during all phases of development.

6. Seeps or springs encountered during construction shall be handled in accordance with the Standard and Specification for Subsurface Drain or other approved methods.

7. All graded areas shall be permanently stabilized immediately following finished grading.