

## **17.18.090: SLOPE MANAGEMENT GUIDELINES:**

When sloped areas are disturbed, the area needs to be stabilized and revegetated as part of the trail construction process to prevent subsequent soil erosion and frequent maintenance problems.

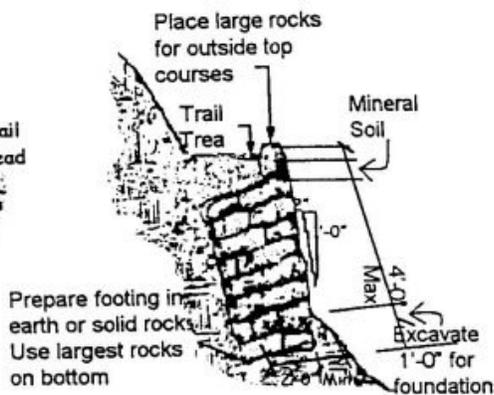
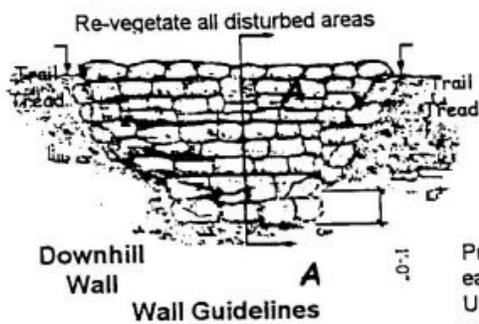
### **A. Permanent Slope Stabilization:**

1. Retaining Walls: Permanent slope stabilization includes native stacked rock or wood retaining walls, rock filled gabions, wire baskets, wattling, planting or placing plant materials, and slope serration.

Where necessary for safety, retaining walls should be installed to prevent erosion of cut or fill slopes, to reduce cut and fill slopes or to minimize disturbance on environmentally or aesthetically sensitive sites. Retaining walls should be constructed of indigenous or natural materials. Walls located on visually sensitive sites should be designed to blend with the natural surroundings. Materials, texture, color, and height all affect the visual prominence of a retaining wall. Walls exceeding a height of four feet (4') must conform to the requirements set forth in the uniform building code.

Following are some guidelines for various techniques. All uninterrupted cut or fill slopes will not exceed six (6) vertical feet unless a site specific analysis is performed to justify otherwise. Some method of permanent slope stabilization should be required for all slopes in excess of two to one (2:1) vertical unless a site specific soils analysis is performed to justify otherwise.

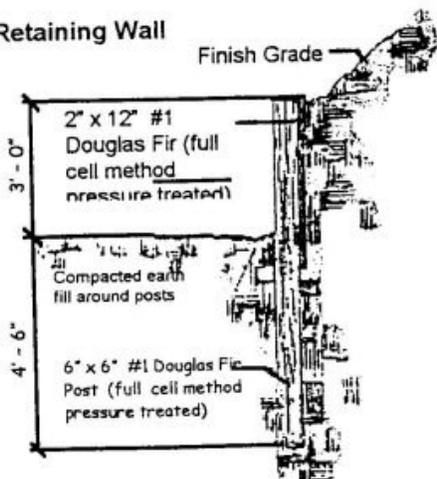
NOTES: Wall shall be 2" wide or 1/2 the wall height, whichever is greater



- Use stone which is native to the site wherever possible:
- To stabilize the trail in less than adequate situations.
- To widen a trail that otherwise would be too narrow.
- To taper up or down in areas where typical tread construction will not work.
- Walls should be built in areas where adequate footings can be dug.
- All stones should be angular free, free from defects, projections and impressions.
- Approximately 25-33% of wall should be tie stones.
- Maximum height of wall should be 4'-0"

- Use wherever natural trees or otherwise significant vegetation can be saved with the use of walls.
- Uniformly distribute sizes and shapes over the entire face of the wall.
- Shape stones for best fit. Use a 4" hammer if available.
- All walls must be battered: 3 in 12 through 12 in 12 are acceptable.
- Trench should slope inward as shown and drain to daylight. The stones shall completely penetrate wall. Miscellaneous backfill must be free from organic matter. Select backfill less than 1/2" maximum dimension, 4" depth optimum.
- Walls which are greater than 4'-0" in heights shall be engineered.
- Use where either cut or fill slopes for trail construction exceeds 4 vertical feet.

#### Retaining Wall



- Cut and fill slopes should be a maximum of 2:1 unless site specific soil analysis is performed to justify stability of steeper slopes.
- A maximum of 4 vertical feet of cut or fill is allowed environmentally or visually sensitive areas may be less.
- Areas which require steeper cut or fill slopes than the allowable shall use retaining walls as shown in these details.
- All disturbed areas shall be re-vegetated. Species for re-vegetation shall be appropriate and wherever possible shall match the surrounding species.

2. Cut And Fill Slopes: Combined cut and fill slopes should not exceed twelve (12) vertical feet and individual cut or fill slopes should not exceed six (6) vertical feet (less in environmentally and visually sensitive areas). Slopes that exceed these parameters should consider low retaining walls or alternate routing of the trail to a more acceptable location.

Cut or fill finish grades should not exceed a two to one (2:1) vertical unless a site specific soil analysis is performed to justify the stability of steeper slopes. All cut and fill slopes will be stabilized and revegetated as per the revegetation and slope stabilization guidelines.

3. Existing Vegetation Protection: Existing significant vegetation that is to be saved will be

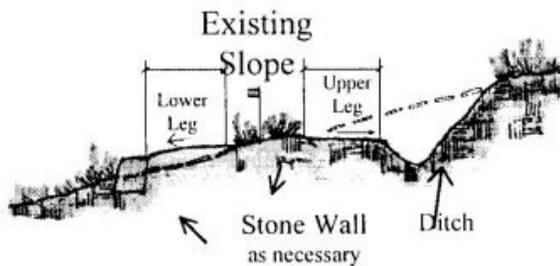
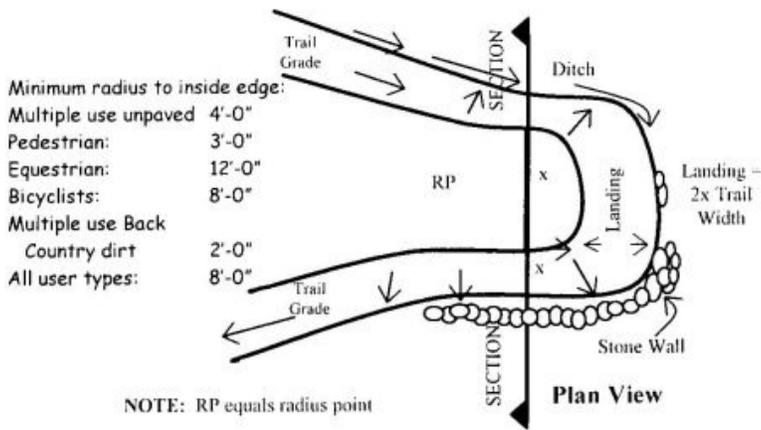
protected with temporary fencing along the limits of disturbance. Trees that are to be saved should not be disturbed within the drip line of the tree, if possible, and the protective limits of disturbance fencing should extend to the drip line. Where this is not possible, all work within the drip line should be done by hand and mechanical equipment should not be allowed within the drip line. If filling is necessary above the root zone, perforated pipe along the drip line and vertical air wells should be installed. If cutting of roots or interception of natural drainage to the root zone is necessary, temporary irrigation may be required to compensate for the disturbance.

4. Temporary Runoff Management: During construction and establishment of revegetation, techniques, such as temporary erosion control, runoff measures, and slope stabilization may be necessary. Techniques, such as hydro mulching, straw mulch, jute matting, wood excelsior matting, tackifiers, straw bales, siltation fences, matting in drainage channels and stone mulching are examples of temporary runoff management. The following treatment guidelines provide some direction for the use of these measures. All are temporary measures and are intended to last from one to two (2) years until permanent stabilization techniques are effective.

5. Wattling: Bundles of branches are used to both stabilize and revegetate slopes that are nearly stable but continue to erode. Wattling is only recommended after initial methods have failed and where the unstable areas are minor.

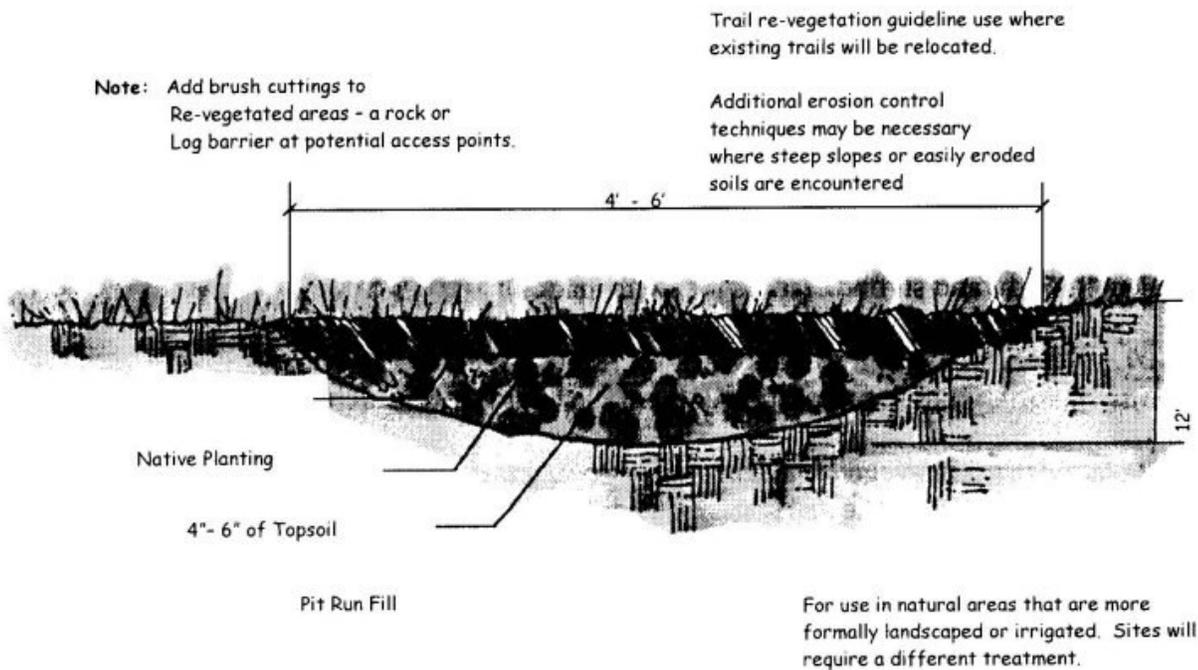
6. Slope Serration: Small steps or indentations are cut in the slope face and are useful for providing small favorable sites for vegetation establishment. This technique should be used only on soils that are fairly cohesive. Sites that have severe exposure to heat, sun or wind and have slopes that are excessively steep benefit most from this method.

7. Switchbacks: Switchbacks are expensive to construct but are necessary when steep slopes are encountered. When switchbacks are required, they should be designed to discourage crosscutting and subsequent erosion. Locate switchbacks where natural barriers exist: installing physical or visual barriers or providing sufficient separation between the switchbacks all help to discourage crosscutting. If crosscutting cannot be discouraged through design or construction then the installation of stairs or relocation of the trail should be considered.



8. Revegetation: Revegetation consists of seeding and planting operations. Seed and plant species and application rates will be submitted and approved with the construction plans. In general the revegetation of natural sites will match that of the undisturbed areas in species, density and vegetation patterns. Revegetation will be accomplished as soon as grading work is completed and weather permits. Unless the site is irrigated, native plant species indigenous to the site should be used. All revegetation work on nonirrigated sites will be done between October 15 and April 15 unless approval is granted otherwise. Sites that are revegetated between June 1 and September 1 will require temporary irrigation.

- a. Seedbed Preparation: Subgrade soils should be scarified to a depth of three to four inches (3-4") and topsoil placed to a minimum depth of four inches (4").
- b. Seeding: Seeds will be broadcast or hydro seeded and raked into topsoil before the application of mulch, matting or other surface stabilization materials. Seeding can be used for grasses and forbs, but container stock should be used for all trees and shrubs.
- c. Planting: Planting of container grown materials on nonirrigated sites will be confined to tubling stock unless there is sufficient natural moisture present to sustain larger plants.
- d. Maintenance: Revegetated sites will be maintained until sufficient establishment has occurred to reasonably stabilize the site. Security bond will be posted for all revegetation work for a minimum of one year at which time it will be reviewed and released if it meets the above requirements.



## B. Temporary Slope Stabilization:

1. **Hydro Mulching:** Hydro mulching is a mechanized, rapid method for mulching large areas and is generally used with seeding to revegetate disturbed areas. Use may be limited on sites where equipment access is limited. Only one hundred percent (100%) wood fiber mulch will be used and applied at a rate of three thousand (3,000) pounds per acre.
2. **Straw Mulching:** Straw mulching can be used over small areas where it is applied by hand or on large sites where it is installed mechanically. Straw mulching is generally used in combination with seeding to revegetate disturbed sites. Straw must be held in place by matting, crimping or other method. Apply at a rate of two (2) tons per acre or a uniform depth of two to three inches (2-3").
3. **Jute Matting:** Jute matting can be used alone or in combination with hydro mulching or straw mulching for erosion control and slope stabilization. It is generally used in combination with seeding to revegetate disturbed areas. Apply up and down the slope, never along the slope. Overlap edges a minimum of four inches (4") and use wire staples that are a minimum of six inches (6") long and spaced approximately five feet (5') apart down the sides and middle of the role. Extend the mat a minimum of three feet (3') beyond the top and bottom of the slope and bury the mat end in an eight inch (8") deep trench at the top of the slope. Uniform contact of the mat to the slope underneath is critical.
4. **Wood Excelsior Matting:** Wood excelsior matting is used for erosion control generally in combination with revegetation. Care must be taken during installation to prevent concentrated flows under the mat. Apply up and down the slope, never along the slope. Edges should butt snugly together and held down with wire staples, a minimum of eight inches (8") long spaced approximately two feet (2') along the edges and four (4) down the center. Extend the mat a minimum of three feet (3') beyond the top and bottom of the slope and bury the mat end in an eight inch (8") deep trench at the top of the slope.
5. **Tackifiers:** Generally, tackifiers are mixed with mulches to provide better adhesion to steep

and/or windy slopes. Tackifiers should be applied at a rate of eighty (80) pounds dry ingredients per acre or two hundred (200) gallons wet ingredients per acre.

6. Straw Bales: Straw bales can be used in a variety of ways to protect areas from impact, straw bales reduce uninterrupted flow in low and intermittent flow channels. Straw bales also provide a siltation device for slopes or gullies until revegetation can be established. When installing, anchor bales in place with steel rebar stakes, driven a minimum of twelve inches (12") into the subgrade, in a six inch (6") deep trench which has soil tamped firmly along the uphill side.

7. Siltation Fences: Siltation fences are used to protect undisturbed down slope areas from up slope erosion.

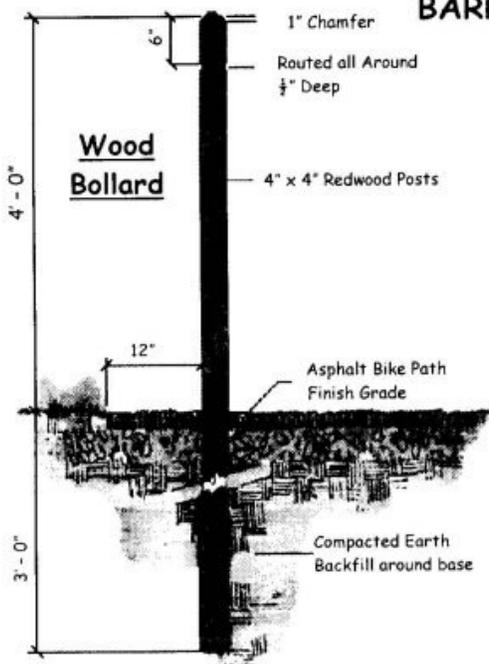
8. Matting In Drainage Channels: Jute matting or fiberglass roving are typically installed in open drainage channels for temporary erosion control. Use this technique only where flow velocities do not exceed two feet (2') per second. Apply from the top and overlap edged a minimum of four inches (4"). Secure the top and bottom ends in an eight inch (8") deep trench secured with steel staples every twelve inches (12"). Edges should be stapled every two inches (2").

9. Stone Mulching: Stone mulching may be used during construction to control erosion, mud or dust.

10. Gabions: Gabions are rock filled wire baskets used to retain steep slopes or stabilize drainageways and may be preferable to stacked rock walls where the native rock is too small or too rounded for effective stacking. They are particularly effective when seepage is anticipated. Empty gabions are placed in position, wired together and filled with rock that is a minimum of four to six inches (4-6") in diameter. When used as a retaining wall the bottom basket should be buried a minimum of six inches (6") at the toe. Gabions should be keyed into the slope and laid back at a maximum of six inches (6") vertical to one inch (1") horizontal.

11. Bollards And Barriers: Barriers should be installed at trailheads to control access of motor vehicle traffic and to direct and/or protect trail users from steep or hazardous areas along the trail.

## BARRIER AND BOLLARD



Use where motorized access could be a problem, such as at trailheads, where trails intersect or cross streets and where trails parallel roads at points where access is likely.

Bollards are used within the trail surface to prohibit or limit access.

Use along trail where downslope grades are steep and hazardous.

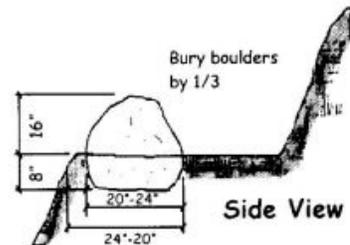
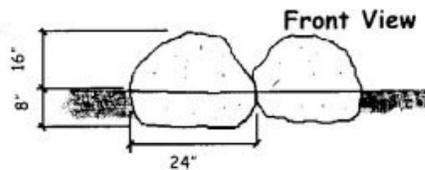
Use along outside edge of trail curves where slopes are steep and exposed.

Use where switchback cutting could be a problem.

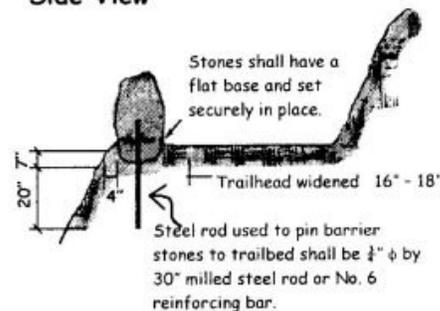
Use at trailheads or road crossings to discourage or prohibit motorized access.

Use to direct trail users to stay on the trail.

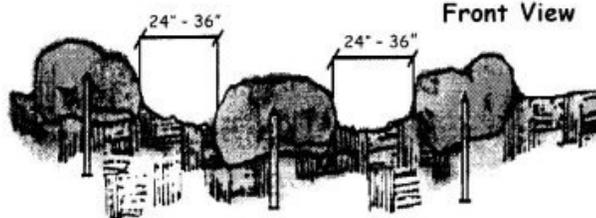
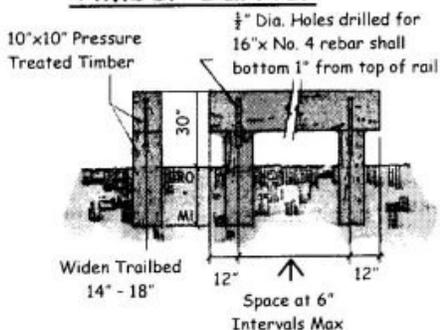
## Rock Barriers



### Side View



## Timber Barrier



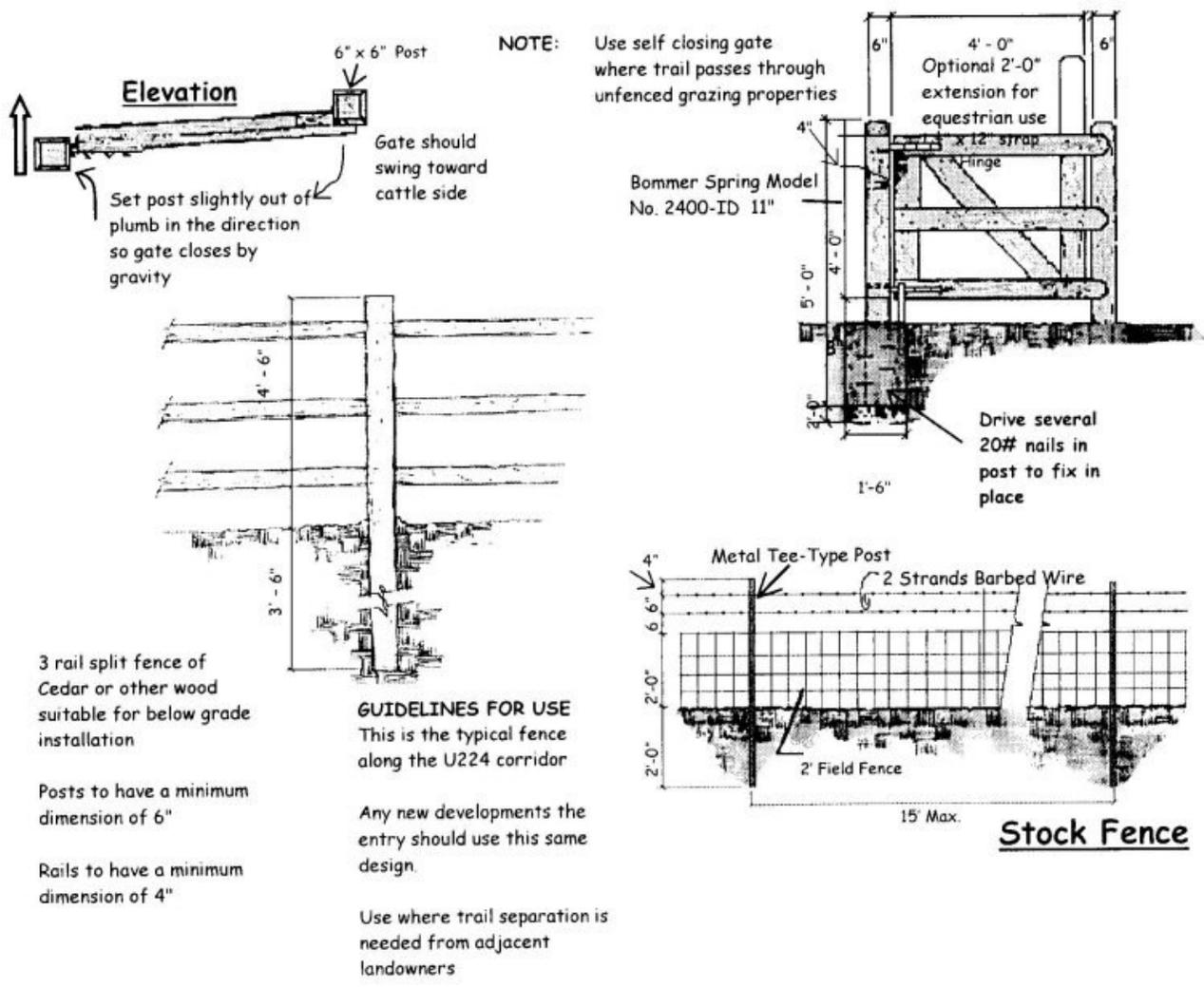
**Note:** Size of barrier stones shall be approximately 14"-24" in height, width and length. Minimum dimensions shall not be less than 12" for height and width and 18" for length.

Three (3) types of barriers are generally used: large boulders, timber barriers and wood bollards. All three (3) types of barriers are effective in stopping motorized access when placed at the trailhead. The location of such barriers is usually where trails intersect or cross streets and where trails parallel roads at points where access is likely. Rock barriers can also be used along portions of a trail where the down slope grades are hazardous, where switchback cutting can be a problem and along outside edges are exposed to steep slopes. The placement and spacing of barriers are dependent upon unique trail site characteristics and use requirements.

12. Fencing: Fencing should be installed only where physical separation is necessary for safety and/or to preserve adjacent landowner privacy. Fences should not create a narrow corridor effect for long stretches along the trail. Where possible fencing should be located only on one side of the trail at a time.

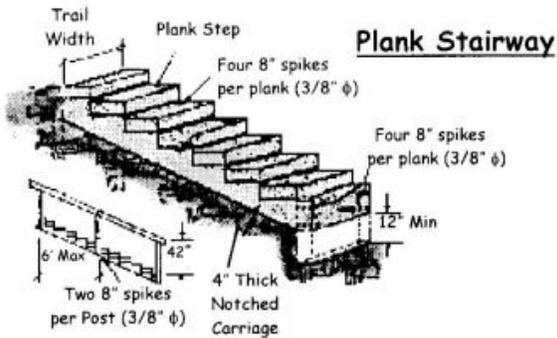
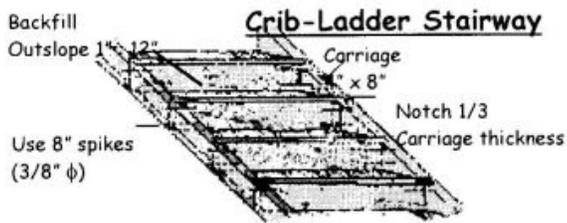
Fences should be no closer than five feet (5') from the trail edge. Where fences are necessary along both sides of a trail, the minimum width should be twenty feet (20').

Gates are required for trails that cross stock grazing area. They will be a self-closing lever latch type gate, such as those manufactured by Powder River or another manufacturer with similar design characteristics.



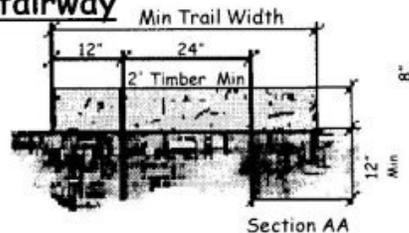
13. Stairways: Trails in excess of the slopes indicated on the trails matrix should consider stairways. Stairways may be required to conform to the requirements set forth in the uniform building code. Stairs should not be used on trails that are used by horses, road bikes or the disabled.

- a. Wooden Stairs: Will be constructed of pressure treated or approved rot resistant timber.



NOTE: Where stairs are located in developed areas of the community, compliance with the uniform building code is required.

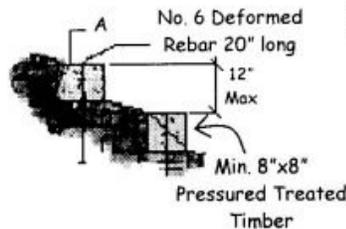
**Pinned Stairway**



Treads to be dug into the slope and set into place.

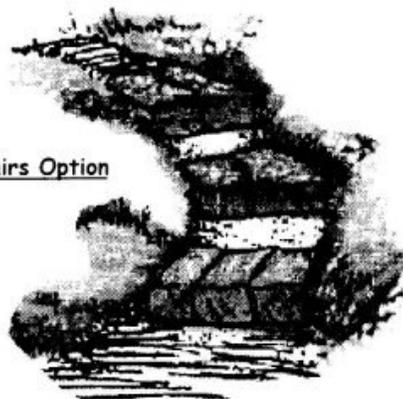
Drill holes through each tread for each rebar stake.

Drive rebar stakes through treads and into ground below.



b. Stone Stairs: Can be used where trail grades exceed the maximum allowable slopes and where the grade must be gained quickly. Stone stairs should be built with the intent that intensive use should not impact the stairs in the slightest.

**Stairs Option**



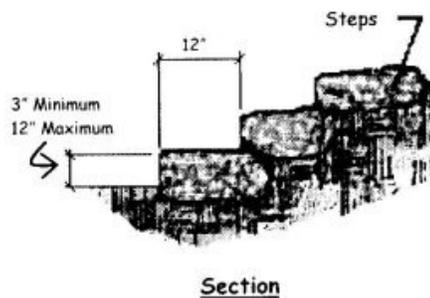
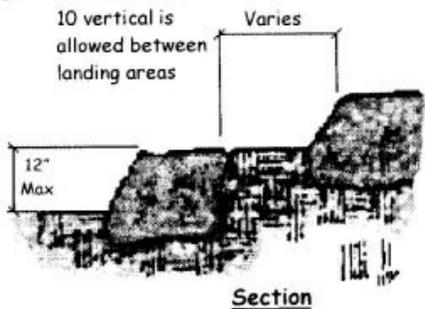
**Stone Stairs:**

Details are included for reference only. Choose stones with a good shape for stairs. Minimum sizes are shown, start at the bottom and work up. Use the biggest stones possible to span the trail. One stone would be the best, two are fine and three is maximum.

Completely cross the trail. Route the trail so people will stay on the trail and stairs. Build to the dimensions shown and make each set of stairs are uniform. Keep the height of each step and the distance between steps as uniform as possible within each set of stairs. Maximum grade at top and bottom of stairs as well as between stairs should be 8%. Walk your staircase to ensure it is smooth and uniform.

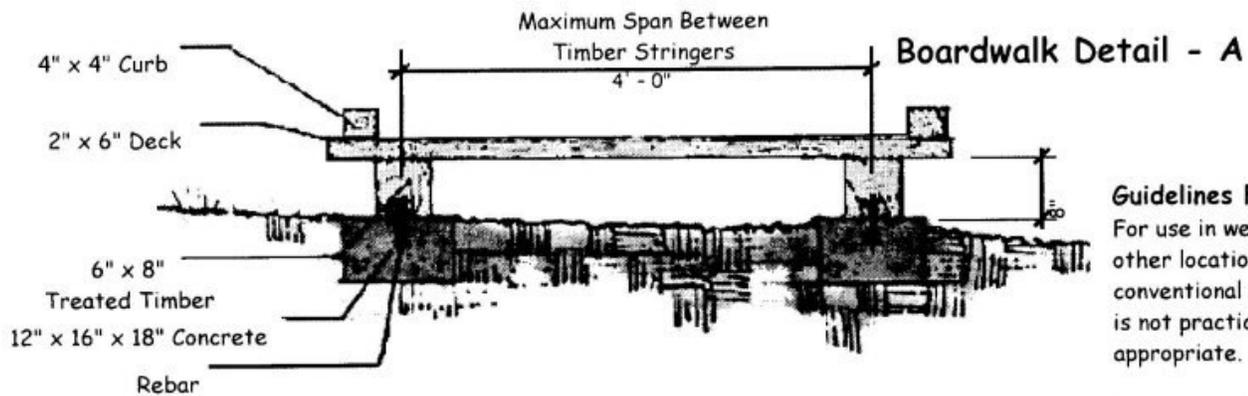
**Stone Stairs for Back Country**

NOTE: A maximum of 10 vertical is allowed between landing areas



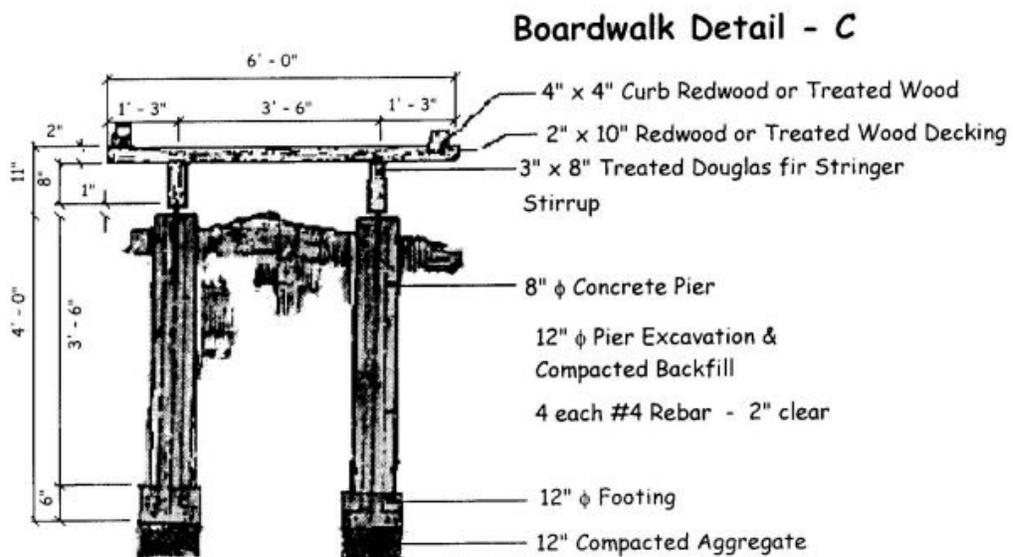
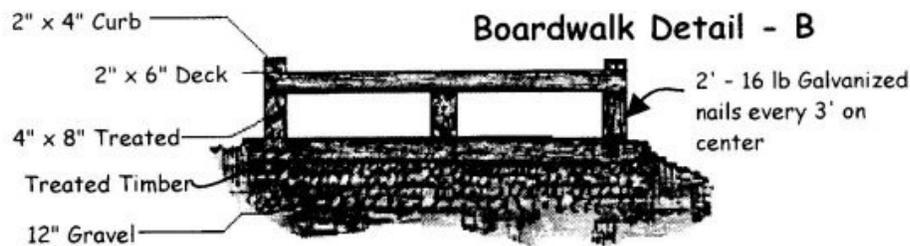
14. Boardwalks: All wood used in boardwalk construction will be pressure treated or approved

rot resistant timber.



**Guidelines For Use**  
For use in wetlands or other locations where conventional pavement is not practical or appropriate.

Do not use where motorized vehicles or horses are expected.



15. **Root Barriers:** Root barriers should be installed along the edges of trails where riparian or vegetation that aggressively seeks out water is present. Willows, Gamble's oak, aspens and cottonwoods are examples of aggressively spreading plants. In situations where irrigated land is on one side of the trail and nonirrigated land is on the other, water seeking vegetation in the nonirrigated side may send roots to the irrigated side, a root barrier should be installed. (Ord. 2002-04, 3-20-2002)