SECTION 4
BIOTECHNICAL MEASURES
FOR EROSION AND SEDIMENT CONTROL

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BIOTECHNICAL SLOPE PROTECTION MEASURES FOR EROSION AND SEDIMENT CONTROL

Introduction

Biotechnical slope protection is the specialized use of woody plant materials to stabilize soil. As noted in Section 1, one of the factors that affects erosion is vegetative cover. The more cover soil has, the more protected it is from the attacking forces of rainfall and runoff. Also working to hold the soil in place is the root mass that vegetation produces. Biotechnical measures generally combine basic engineering principles with plant science to create a system of stability for critical areas such as streambanks or roadside slopes. These systems may combine structural measures, such as those detailed in Section 5, with woody plants and shrubs to effect a strengthening of the soil structure and improved vegetative cover to resist surface erosion.

There are many advantages to biotechnical slope protection measures:

- they are often less expensive to install
- they do not require specialized skills to install
- generally, heavy equipment is not required
- they are environmentally compatible
- they provide a natural aesthestic appearance
- they provide wildlife habitat and cover
- they can be self repairing during and after stress
- they use natural/native materials

On the other hand, there are some disadvantages to these measures:

- higher risk due to less control with vegetation compared to structural practices
- require higher maintenance attention
- need an establishment period
- more sensitive to seasonal changes

Biotechnical slope protection is actually an old technology. These techniques have been practiced for centuries in Europe. The Natural Resource Conservation Service used and promoted this technology in the 1940's in Vermont on the Winooski River and also in New York on Buffalo Creek, where plant materials (willows) were used in combination with rock riprap, concrete slabs, pinned rock, and cellular modules to halt streambank erosion.

These biotechnical approaches are being "rediscovered" primarily due to their cost effectiveness over more traditional structural measures and for their environmental compatiblity, aesthetics, and wildlife benefits. There are many areas in towns and counties in New York that experience erosion on streambanks or sloughs on roadside slopes that could be controlled with biotechnical protection measures. The low cost and ease of installation is very attractive to units of government and highway departments looking to maximize their budget dollars.

Principles of Biotechnical Slope Protection

Generally a biotechnical slope protection system consists of both a structural or mechanical element and vegetative elements working together to stabilize a site-specific condition. Structural components are employed to allow establishment of vegetative elements, while at the same time providing a level of protection for stability. The vegetative components are not just landscaping plantings for a structural project; they also perform a functional role in preventing erosion by protecting the surface, while also stabilizing soil by preventing shallow mass movements.

Woody plant materials (usually dormant shrub willow branches) are placed into the soil in ways that provide an immediate degree of stability to the slope. As the branches take root and grow, the slope becomes more and more resistant to failure by shallow mass movements due to:

1. Mechanical reinforcement from the root system,

2. Soil moisture depletion through transpiration and interception, and

3. Buttressing and soil arching action from embedded stems.

The vegetation also tends to prevent surficial (surface or rainfall) erosion by:

1. Binding and restraining soil particles in place,

2. Filtering soil particles from runoff,

3. Intercepting raindrops,

4. Retarding velocity of runoff, and

5. Maintaining infiltration.

As the stability improves, native vegetation will volunteer, helping to blend the site into the surroundings.

There are many techniques used in biotechnical work. Some of the most common are:

Vegetated Rock Gabions—This is a combination of vegetation and rock gabions generally used for slope stabilization. Live branch cuttings are layered through the rock gabion structure to anchor in select earthfill. The cuttings protrude beyond the face of the gabion. The gabion standard is covered in the "standard specifications for retaining walls" in Section 5B. See Figure 4.1 for vegetative details.

Live Fascines—This technique uses bundles of branches which are staked into shallow trenches, then filled with soil. They are oriented along the contour and are placed in multiple rows to help stabilize a slope. See Standard and Specifications for Live Fascines.

Brush Mattress—This method uses hardwood brush layered along a streambank as a mattress and anchored in place with a grid of stakes and wire. The toe below the waterline is anchored by rock. This living blanket acts as a mulch for seedlings and plantings established in the bank. It also prevents erosion of sloped surfaces. See Standards and Specifications for Brush Mattress.

Live Staking—These are large stakes or poles sharpened at the bottom end and forced vertically into the soft earth along the waterline, usually about 1 foot apart. Depending on the size of the poles and the composition of the streambank, machinery may be required to force them into the ground or to prepare holes for planting. The poles will grow forming a very thick barrier to flow. See Figure 4.4 and Figure 4.4A.

Brush Layering—This technique is generally used to stabilize slope areas above the flow line of streambanks as well as cut and fill slopes. It involves the use of long branches that are placed with cut ends into the slope on bulldozed terraces. The tops protrude outside the finished slope. A layer usually includes three layers of brush separated with a thin (3 in.) layer of soil. On this layer a "lift" of 3-5 feet of soil is placed to form the next terrace and so forth. See Figure 4.5.

Live Cribwall—This is a combination of vegetation and structural elements generally used along streams where flowing water is a hazard. Layers of logs are alternated with long branches protruding out between them. The logs are spiked together and anchored into the bank with earthfill behind them to create a wall. The live stems help tie the logs together and screen the wall. See Figure 4.6.

Tree Revetment—This method incorporates entire trees (without the root wad) for bank stabilization in areas that are eroded or undercut, but not flashy or in need of heavy maintenance. Trees are overlapped and anchored to the earth for the purpose of absorbing energy and reducing velocity, capturing sediment, and enhancing conditions for colonization of native species. See Figure 4.7.

Branchpacking—This technique alternates live branch cuttings with tamped backfill to repair small, localized slumps and holes in slopes. The alternating layers of branches and soil are placed between long posts driven in to the ground for support. This method is inappropriate for areas larger than 4-feet deep or 6-feet wide. See Figure 4.8.

Fiber Roll—A fiber roll is a coconut fiber, straw, or excelsior woven roll encased in netting of jute, nylon, or burlap used to dissipate energy along bodies of water and provide a good medium for the introduction of herbaceous vegetation. This technique works best where water levels are relatively constant. The roll is anchored into the bank and, after suitable backfill is placed behind the roll, herbaceous or woody vegetation can be planted. See Figure 4.9.

Properly designed structural measures may be necessary to help protect the toe or face of a slope against scour or erosion from moving water and against mass-moving of soil. These structures are generally capable of resisting much higher lateral earth pressures and higher shear values than vegetation. They can be natural, such as fieldstone, rock and timbers; or, they can be artificial like concrete and steel. Some structural measures can be a combination like gabions, which are wire baskets containing stone. Gabions can be used as retaining walls, grade stabilization structures and slope protection. Many of these types of structures can be planted or vegetated with materials to strengthen the system. See Figure 4.1.

Planning Considerations

There are many facets that need to be considered when designing a biotechnical system for a site:

Method – What is the appropriate method for the particular problem encountered?

Materials – What type should be selected? How much is needed to do the job? Where can they be obtained?

Schedule – When is the best time to maximize the successful rooting or germination of materials?

Equipment – Since this process is somewhat labor intensive, it is necessary to make sure the proper type and amount of tools, such as shovels, pick axe, tile spade, hammers, etc. are available for proper installation of material.

Site characteristics – The need for engineering structures will depend on potential hazards, management of site water, soil conditions, and site access. Aesthetics and follow-up

maintenance are also important considerations. Protection from livestock is mandatory.

Streambanks – Generally applicable where flows are less than 6 feet per second and the stream bottom is not subject to degradation and scour. Protection should be carried to the average high water elevation.

Plant Materials

Plant materials for biotechnical slope protection may be obtained in two basic ways. One method is to locate stands of appropriate species and obtain easements to harvest materials from these stands for incorporation into the project. Criteria for selecting native species are: easy rooting; long, straight, flexible whips; and plentiful supply near the site.

A second method is to grow and harvest materials from managed production beds that are maintained for commercial distribution. This allows selection of cultivars that have proven performance records and high survival rates.

The most popular materials in use today are the shrub willows. Willows have a tremendous ability to sprout roots and stems when in contact with moist soil. Willows are found growing in all parts of the world, so biotechnical slope protection techniques employ them more than any other group of plants. Two of the tested, proven willow cultivars in the Northeast are:

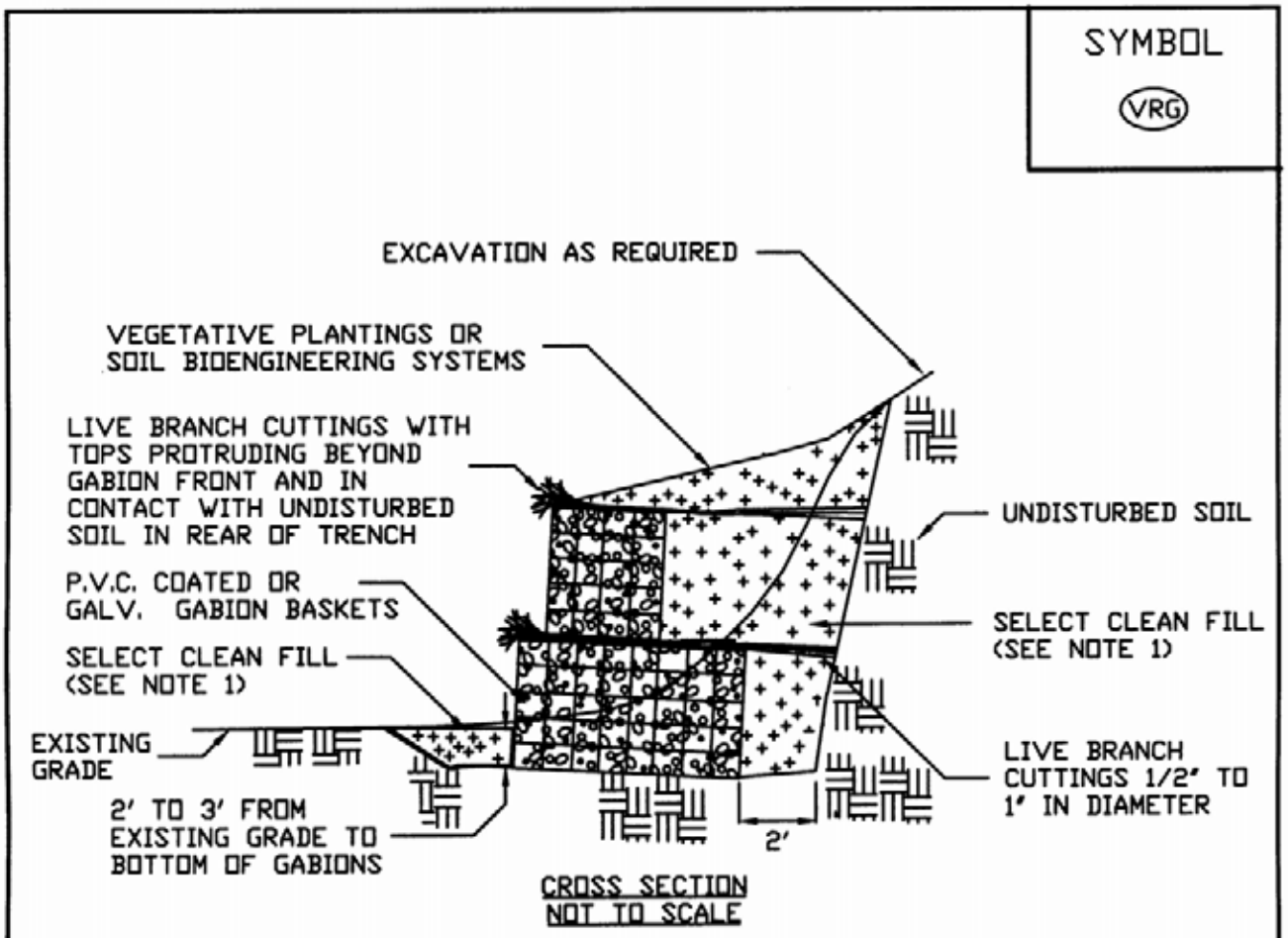
- 'Streamco' purpleosier willow (*Salix purpurea*)
- 'Bankers' dwarf willow (*Salix cottetii* – hybrid)

'Streamco' and 'Bankers' willow are both shrubs. 'Streamco' has an ultimate height of 15-20 feet, while 'Bankers' is limited to 6-8 feet. Commercial and state nurseries in the Northeast are producing supplies of both species.

In addition to willows, redosier dogwood and poplars are other groups of plants effective for use in biotechnical systems. Species such as elderberry or forsythia can also be used to add biodiversity to a site.

All plant materials should be installed on site within 8 hours of cutting, unless provisions for proper storage are made. Materials should be fresh, dormant, and non-desiccated when installed.

Figure 4.1
Vegetated Rock Gabions



CONSTRUCTION SPECIFICATIONS

1. BACKFILL BEHIND GABIONS HAND TAMPED IN 6" LIFTS.
2. A 1" LAYER OF BACKFILL SHALL BE PLACED ON TOP OF THE ROW OF GABIONS AND RAKED. THE CUTTINGS SHALL BE PLACED ON THE BACKFILL MATERIAL AND ANOTHER 1" LAYER OF BACKFILL SHALL BE PLACED ON THE CUTTINGS BETWEEN THE GABIONS.
3. CLASS 2, TYPE B OR C, INTERMEDIATE EROSION CONTROL PRODUCT SHALL BE INSTALLED ON THE FRONT INSIDE FACE AND ANY OTHER EXPOSED VERTICAL SURFACE OF THE GABIONS.

ADAPTED FROM DETAILS PROVIDED BY: USDA - NRCS, NEW YORK STATE DEPARTMENT OF TRANSPORTATION, NEW YORK STATE DEPARTMENT OF ENVIRONMENTAL CONSERVATION, NEW YORK STATE SOIL & WATER CONSERVATION COMMITTEE	VEGETATED ROCK GABIONS

STANDARD AND SPECIFICATIONS FOR LIVE FASCINES

Definition

The placement of groups or bundles of twigs, whips, or branches in shallow trenches, on the contour, on either cut or fill slopes.

Purpose

To stabilize slopes by slowing water movement down the slope, increasing infiltration, trapping slope sediments, and increasing soil stability with root systems.

Conditions Where Practice Applies

On sloping areas such as road cuts, slumped areas, road fills, gullies, and streambanks subject to erosion, seepage, or weathering, which have a low to medium hazard potential should slope failure occur. Slopes must be 1:1 or flatter.

Design Criteria

Materials—Shall be a native or nursery grown cultivar that is capable of performing the intended function.

Fascines—Shall be made by forming the bundles 8-15 feet long, 4 inches minimum in diameter, from stems no more than 1 inch in diameter.

Overlap—Fascines should be overlapped at the tapered ends a minimum of 1-foot.

Vertical Spacing—The spacing of the contours for the fascines is dependent on the degree of erosion or potential erosion at the site. Factors include slope steepness, soil type, drainage, and existing ground cover. The following is a general guide to selecting contour interval:

Slope	Contour Interval
1:1	3’
1.5:1	3’
2:1	4’
2.5:1	4’
3:1	5’
3.5:1	5’
4:1	6’
6:1	8’

See Figure 4.2 for details.

Construction Specifications

1. Fascines shall be 4 inches minimum in diameter.

2. Prior to placing the fascines, the slope shall be smoothed and graded with obstructions removed. Any structural measures for revetment, drainage, or surface water management will be installed first.

3. Working from the bottom of the slope to the top, excavate the fascine trench. Place fascines in trench and anchor with stakes spaced at 24 inches. Cover fascines with soil leaving about 10% exposed to view. Fascines shall be overlapped 12 inches minimum in the trench.

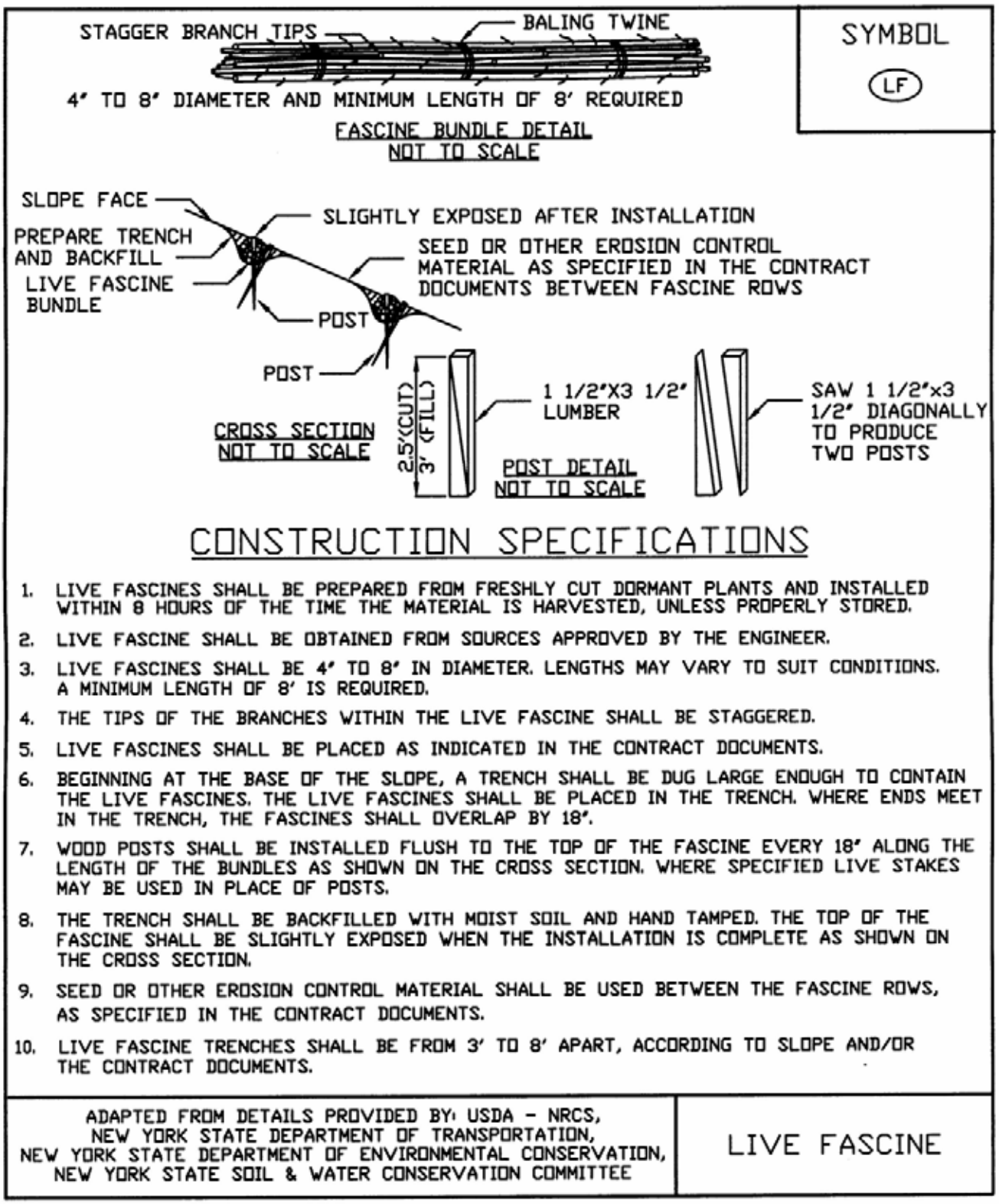
4. Soil shall be worked into the fascine and compacted by walking on the fascine being covered.

5. All disturbed areas should be seeded upon completion of fascine placement.

Maintenance

Regular inspection and maintenance of fascine installations should be conducted especially during the first year of establishment. Loose stakes should be reset and settled fill areas should be brought back to grade. Prompt corrections to gullies, sloughs or other evident problems shall be made.

Figure 4.2
Live Fascine



STANDARD AND SPECIFICATIONS FOR BRUSH MATTRESS

Definition

A mulch or mattress of brush laid on a slope and fastened down with stakes and wire.

Purpose

To protect the soil surface on slopes from erosive forces through the generation of a dense stand of woody vegetation.

Conditions Where Practice Applies

Brush mattresses are used primarily on streambanks where the velocity is less than 6 feet per second and excessive runoff from streamflow has created erosive conditions. This practice can resist temporary inundation, but not scour or undercutting.

Design Criteria

Layer Thickness—The brush shall be a minimum of 3 inches thick (excluding top soil layer).

Height—The mattress shall be placed up the bank to the bankfull elevation. The toe of the mattress should be located in a fascine trench.

Slope—The maximum slope shall be 1.5:1.

Anchoring—The mattress shall be anchored on the slope by a grid of 3-foot stakes driven on 3-foot centers each way. No. 9 wire is then wound between the stakes, which are driven to secure the mattress. The upstream edge of the mattress should be keyed into the bank 2 feet.

Materials—The plant materials should be willow and dogwood brush placed as shown in Figure 4.3.

Construction Specifications

1. Prepare slope surface by grading to a uniform, smooth surface, clear of obstruction. Slopes should be graded before the brush mattress is installed.

2. The fascine toe should be installed first. Then lay brush beginning at the downstream end of the work.

3. The butt end of the brush will be placed upstream and plant materials inclined approximately 30 degrees.

4. The upstream edge of the mattress will be keyed into the slope 2 feet. Stakes will be driven throughout the mattress on 3-foot centers each way beginning along the toe of the mattress.

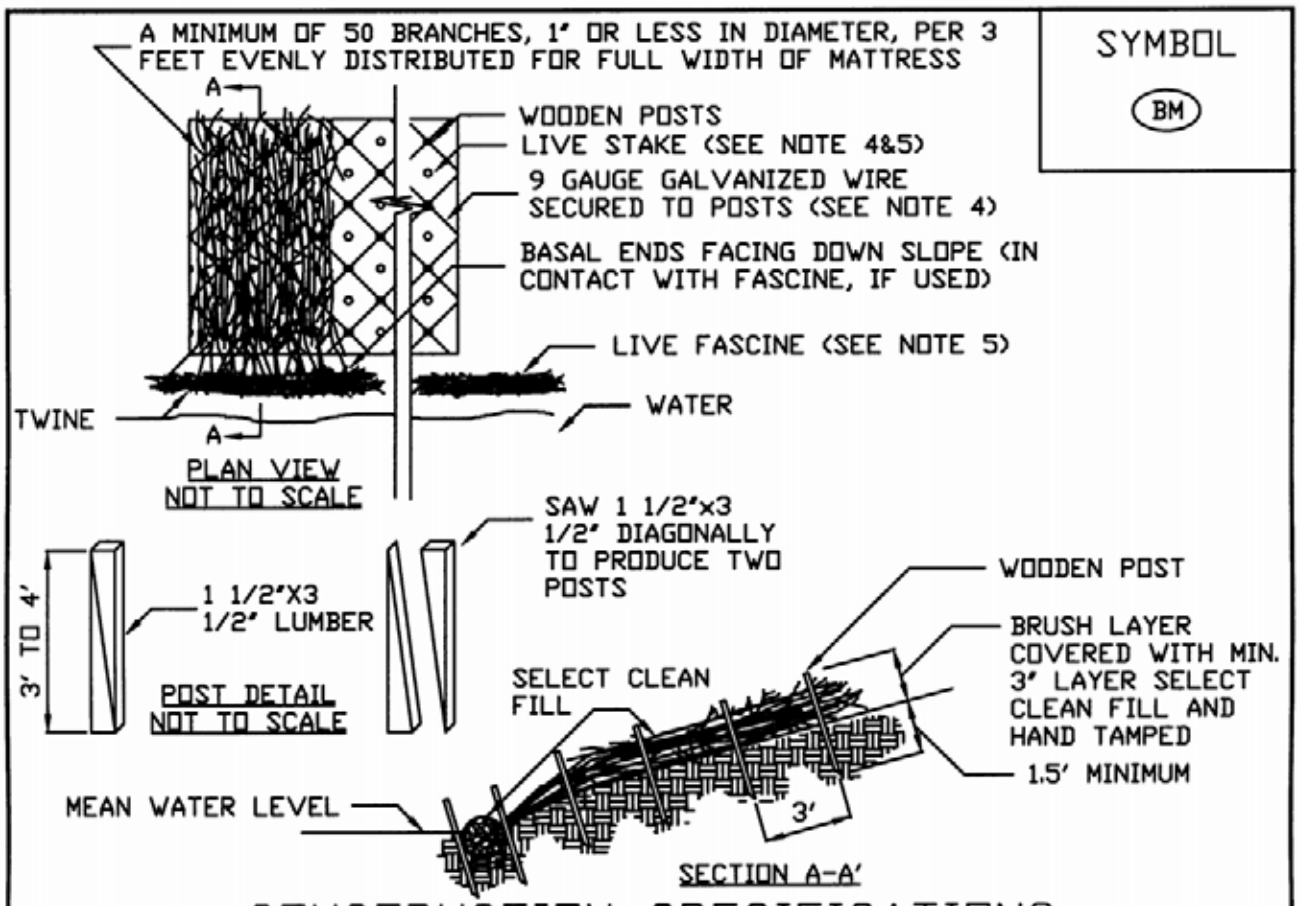
5. No. 9 wire will be attached to the stakes and tightened to secure the mattress.

6. Slope areas above the mattress will be shaped and seeded.

Maintenance

Scheduled inspections the first year are necessary to make sure the anchoring system is sound. Broken wire or missing stakes shall be replaced immediately. Any missing toe material missing shall be replaced.

Figure 4.3
Brush Mattress



CONSTRUCTION SPECIFICATIONS

1. LAYERS SHALL BE COMPRISED OF LIVE QUICK-ROOTING SPECIES. SEE CONTRACT DOCUMENTS.
2. FILL MATTRESS WITH SOIL AND EVENLY DISTRIBUTE TO APPROXIMATELY 4" IN DEPTH AND HAND TAMP.
3. PLACE POSTS EVENLY OVER THE GRADED FACE USING 3' SQUARE SPACING. IF LIVE STAKES ARE SPECIFIED, ALTERNATE EVERY OTHER ON WITH THE POSTS.
4. STRETCH 9 GAUGE GALVANIZED WIRE DIAGONALLY FROM ONE POST TO ANOTHER BY TIGHTLY WRAPPING WIRE AROUND POSTS, NO CLOSER THAN 6" FROM THE TOP OF POST. WIRE SHALL NOT BE ATTACHED TO LIVE STAKES, IF THEY ARE SPECIFIED. POUND STAKES TO COMPRESS MATTRESS.
5. LIVE FASCINES AND LIVE STAKES ARE INSTALLED WHEN AND WHERE DIRECTED ON THE PLAN SHEET.

ADAPTED FROM DETAILS PROVIDED BY: USDA - NRCS, NEW YORK STATE DEPARTMENT OF TRANSPORTATION, NEW YORK STATE DEPARTMENT OF ENVIRONMENTAL CONSERVATION, NEW YORK STATE SOIL & WATER CONSERVATION COMMITTEE

BRUSH MATTRESS