SECTION 4
BIOTECHNICAL MEASURES FOR EROSION AND SEDIMENT CONTROL

Contents

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List of Figures

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 influences 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 don't 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 Soil 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 compatibility, 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, but 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 which 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 water depletion through transpiration and interception.
3. Buttressing and soil arching action from embedded stems.

The vegetation also tends to prevent surficial (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
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:

- wattling
- brush layering
- brush matting
- live cribwall
- live staking
- reed trench terracing
- gully - lead plugs

- breast - wall staking
- check dams for gully control
- wattle flow deflectors

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 field stone, rock and timbers; or they can be artificial like concrete, and steel. Some can be a combination like gabions which are wire baskets containing stone. These 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.

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 hazard, management of site water, soil conditions and providing site access. Aesthetics and follow-up maintenance are also important considerations. Protection from livestock is mandatory.

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 strands for incorporation in 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 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 10-15 feet, while 'Bankers' is limited to 6-8 feet. Supplies of both are being developed by commercial and state nurseries in the Northeast.

In addition to willows, redosier dogwood and poplars are other groups of plants effective for use in biotechnical systems.

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-dessicated when installed.

STANDARD AND SPECIFICATIONS FOR WATTLING

Definition

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

Purpose

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

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.

Wattles - Shall be made by forming the bundles 6-8 feet long, 4 inches minimum in diameter, from stems no more than 1 inch in diameter. The wattles should be tapered in each end in a manner that the wattle length is 18 inches longer than the individual stem length.

Lap - Wattles should be overlapped at the tapered ends a minimum of 1.5 feet.

Vertical Spacing - The spacing of the contours for the wattles 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 4.1 on page 4.4 for details.

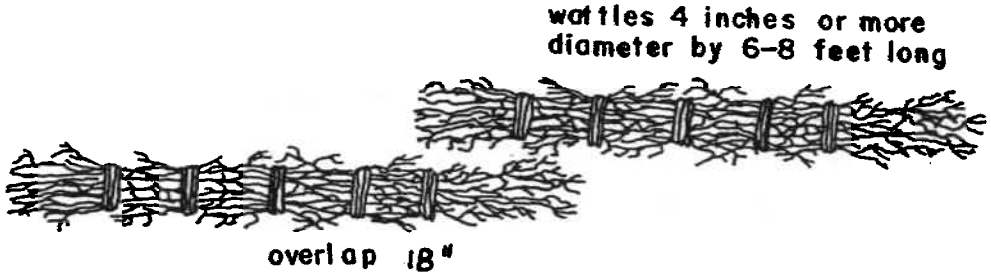
Construction Specifications

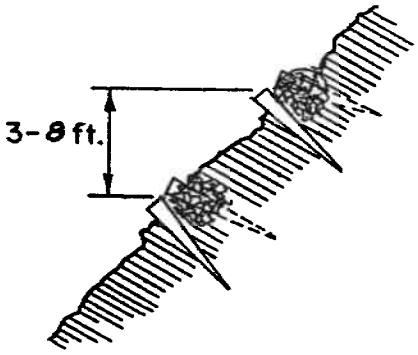
1. Wattles shall be 4 inches minimum in diameter and bundled with tapered ends to an overall length 18 inches longer than the stems.
2. Prior to wattling slope shall be smoothed and graded with obstructions removed. Any structural measures for revetment, drainage or surface water management will be installed first.
3. Anchor stakes will be placed on the slope at the designed contour interval.
4. Working from the bottom of the slope to the top, excavate wattle trench just above stakes. Place wattles in trench and anchor with additional stakes spaced at 18 inches. Cover wattles with soil leaving about 10% exposed to view. Wattles shall be overlapped 18 inches minimum in the trench.
5. Soil shall be worked into the wattle and compacted by walking on the wattling being covered.
6. All disturbed areas should be seeded upon completion of wattling operations.

Maintenance

Regular inspection and maintenance of wattling 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 should be made.

Figure 4.1
Wattling Details





DESIGN TABLE					
SLOPE	1:1	2:1	3:1	4:1	6:1
CONTOUR INTERVAL	3	4	5	6	8

CONSTRUCTION SPECIFICATIONS

1. WATTLES SHALL BE 4" MINIMUM DIAMETER AND BUNDLED WITH TAPERED ENDS TO AN OVERALL LENGTH 18 INCHES LONGER THAN THE STEMS.

2. STRUCTURAL MEASURES SUCH AS REVETMENT, DRAINAGE, SURFACE DITCHES WILL BE INSTALLED PRIOR TO WATTLING. SLOPE SHALL BE GRADED AND SMOOTHED WITH OBSTRUCTIONS REMOVED.

3. ANCHOR STAKES WILL BE PLACED ON THE SLOPE AT THE DESIRED CONTOUR INTERVAL.

4. WORKING FROM THE BOTTOM OF THE SLOPE TO THE TOP, EXCAVATE WATTLE TRENCH JUST ABOVE THE STAKES. TRENCH SHALL BE HALF THE DIAMETER OF THE WATTLES. PLACE WATTLES IN TRENCH ANCHORING WITH ADDITIONAL STAKES AT 18 INCH INTERVALS. LOWER WATTLES WITH SOIL LEAVING ABOUT 10% EXPOSURE.

5. SOIL SHALL BE WORKED INTO THE WATTLES AND COMPACTED BY FOOT TRAFFIC.

6. ALL DISTURBED AREAS SHALL BE SEEDED UPON COMPLETION OF WATTLING OPERATIONS.

U.S. DEPARTMENT OF AGRICULTURE SOIL CONSERVATION SERVICE SYRACUSE, NEW YORK	WATTLING	STANDARD SYMBOL (W)

STANDARD AND SPECIFICATIONS FOR BRUSH MATTING

Definition

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

Purpose

To protect the soil surface on slopes from erosive forces and act as a mulch for seeding and plant use until they are established.

Conditions Where Practice Applies

Brush matting is 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 12 inches thick.

Height - The matting shall be placed up the bank to the point of average high water. The toe of the matting should be located in a rock trench that extends from the normal water line to the channel bottom or 2 feet which ever is greater.

Slope - The maximum slope shall be 1.5:1.

Anchoring - The matting shall be anchored on the slope by a grid of 3 foot stakes driven on 3 foot centers each way. No. 9 galvanized wire is then tied between the stakes and tightened to secure the mat. The upstream edge of the mat should be keyed into the bank 2 feet.

Materials - The plant materials should be willow or dogwood brush placed downstream to upstream with stems inclined at approximately 30 degrees with the butt end placed upstream.

See figure 4.2 on page 4.6 for details.

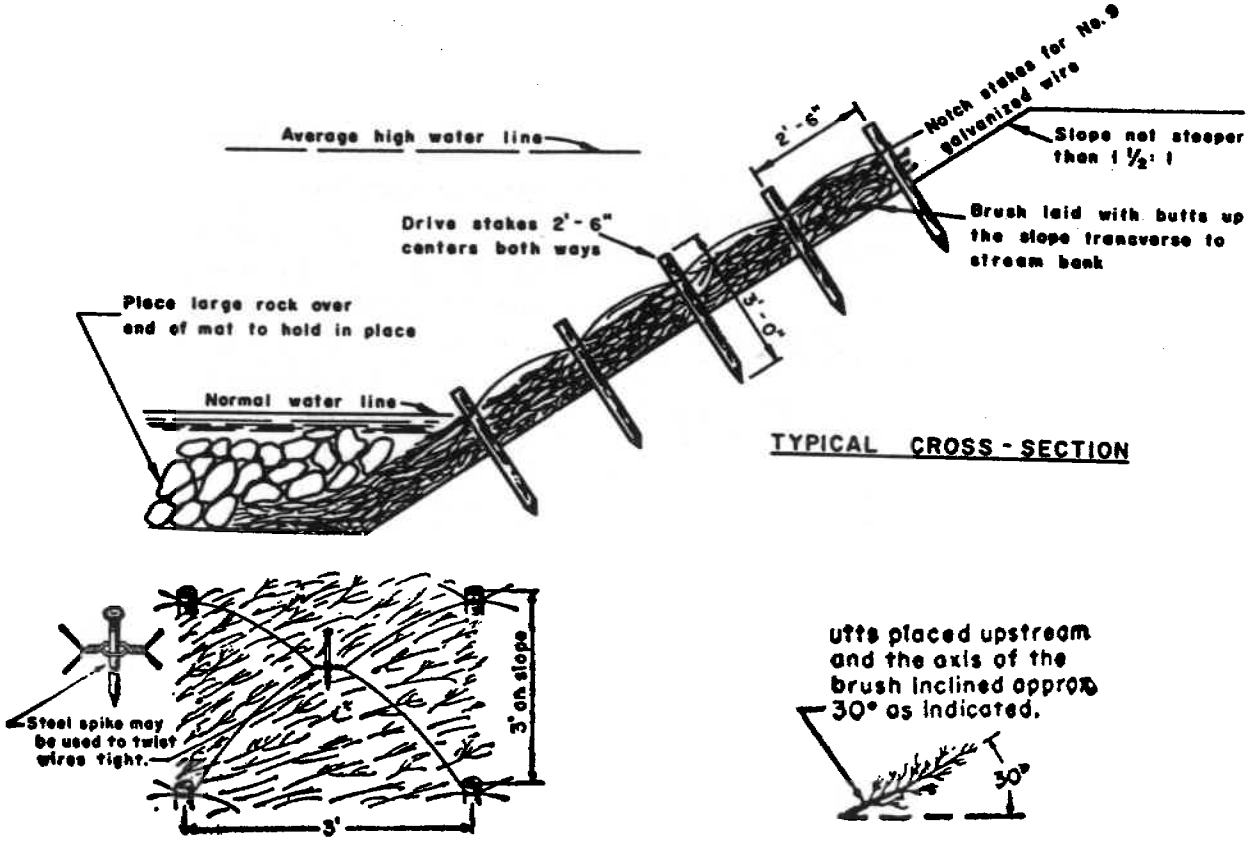
Construction Specifications

1. Prepare slope surface by grading to a uniform, smooth surface clear of obstruction. Slopes should be planted before the brush matting is installed.
2. Lay hardwood brush beginning at the downstream end of the work. The toe should be installed first.
3. The butt end of the brush will be placed upstream and plant materials inclined approximately 30 degrees.
4. The upstream edge of the mat will be keyed into the slope 2 feet. Stakes will be driven throughout the mat on 3 foot centers each way beginning along the toe of the mat.
5. No. 9 galvanized wire will be attached to the stakes and tightened to secure the mat.
6. Slope areas above the matting 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 should be replaced immediately. Any toe material missing should be replaced.

Figure 4.2
Brush Matting Details



CONSTRUCTION SPECIFICATIONS

1. PREPARE SLOPE SURFACE BY GRADING TO A UNIFORM, SMOOTH SURFACE.
2. LAY HARDWOOD BRUSH IN AN UPSTREAM DIRECTION BEGINNING AT THE DOWN-STREAM END. THE TOE SHOULD BE ESTABLISHED FIRST.
3. THE BUTT END OF THE BRUSH WILL BE PLACED UPSTREAM AND THE PLANT MATERIALS INCLINED APPROXIMATELY 30 DEGREES.
4. THE UPSTREAM EDGE OF THE MAT WILL BE KEYED INTO THE SLOPE 2 FEET. STAKES WILL BE DRIVEN THROUGHOUT THE MATTING ON 3 FOOT CENTERS EACH WAY BEGINNING ALONG THE TOE OF THE MAT.
5. NO. 9 GALVANIZED WIRE WILL BE ATTACHED TO THE STAKES OVER THE MAT AND TIGHTENED TO SECURE THE MAT.
6. SLOPE AREAS ABOVE THE MAT WILL BE SLOPED AND SEEDED.

U.S. DEPARTMENT OF AGRICULTURE SOIL CONSERVATION SERVICE SYRACUSE, NEW YORK	BRUSH MATTING	STANDARD SYMBOL BM

STANDARD AND SPECIFICATIONS FOR VEGETATIVE STREAMBANK PROTECTION

Definition

Stabilization of eroding streambanks by the use of designed vegetative measures.

Purpose

To protect exposed or eroded streambanks from the erosive forces of flowing water.

Conditions Where Practice Applies

Generally applicable where flows are less than 6 feet per second and the stream bottom is not subject to degradation and scour. Structural elements may be used at points of concentration such as toes to help establish the practice on the streambank.

Design Criteria

Each channel is unique and measures designed for vegetative streambank protection will depend on soil type, size of the stream, drainage area, bedload, ice flow potential and availability of plant materials.

Protection measures should carry up the bank slope to the average high water elevation. If this is not available use the 10 year storm to evaluate limits of the protection.

Streambank protection should begin at a stable location and end at a stable location along the bank. The channel bottom should be stable or stabilized prior to installing protective measures.

Ensure that all requirements of state law and all permit requirements of local, state and federal agencies are met.

Wattling - This technique uses bundles of branches which are staked into shallow trenches, then covered with soil. They are oriented along the contour and are placed in multiple rows to help stabilize a slope. See Standard and Specifications for Wattling on page 4.3

Brush Layering - This technique is generally used to stabilize slope areas above the flowline 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") 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 4.3 on page 4.8

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 4.4 on page 4.8

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 4.5 on page 4.9

Wattle Flow Deflectors - This describes the use of wattles along the stream or river banks to deflect flow or current away from the streambank. The wattles are placed in a trench, staked and backfilled at the appropriate downstream orientation. As the willows grow, the vertical stems extend the deflector upward improving the flow control during high water. Caution should be exercised when employing this method since deflecting flow can result in the creation of erosion problems in another location. See figure 4.6 on page 4.9

Brush Matting - 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 Matting on page 4.5

Maintenance

Due to the susceptibility of plant materials to the physical constraints of the site, climate conditions and animal populations, it is necessary to inspect installations frequently. This is especially important during the first year or two of establishment. Plant materials missing or damaged should be replaced as soon as possible. Sloughs or breaks in drainage pattern should be reestablished for the site as quickly as possible to maintain stability.

Figure 4.3
Brush Layering Method

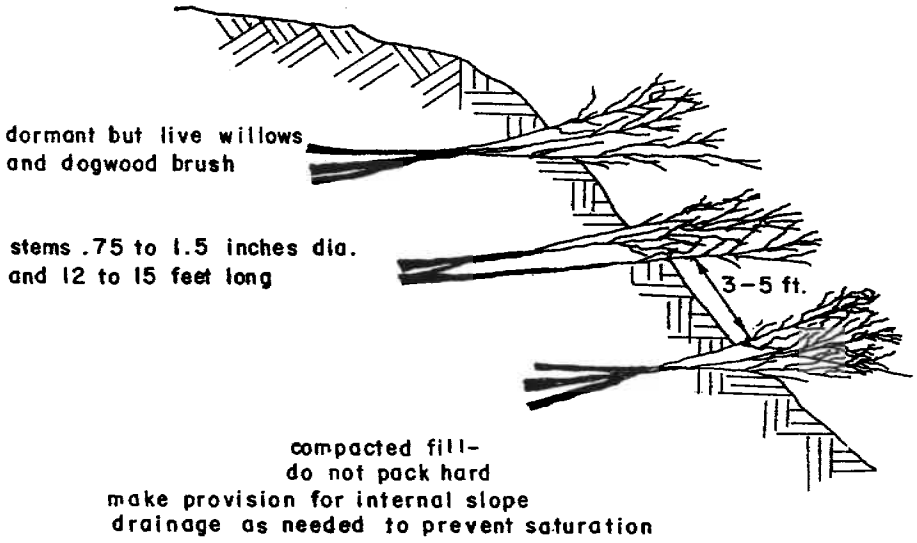


Figure 4.4
Live Cribwall Along Streambank

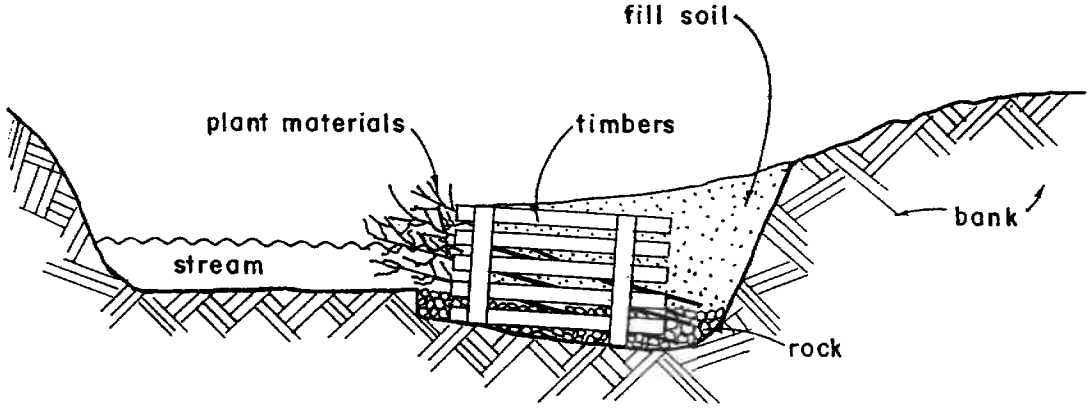


Figure 4.5
Live Staking Along Waterline

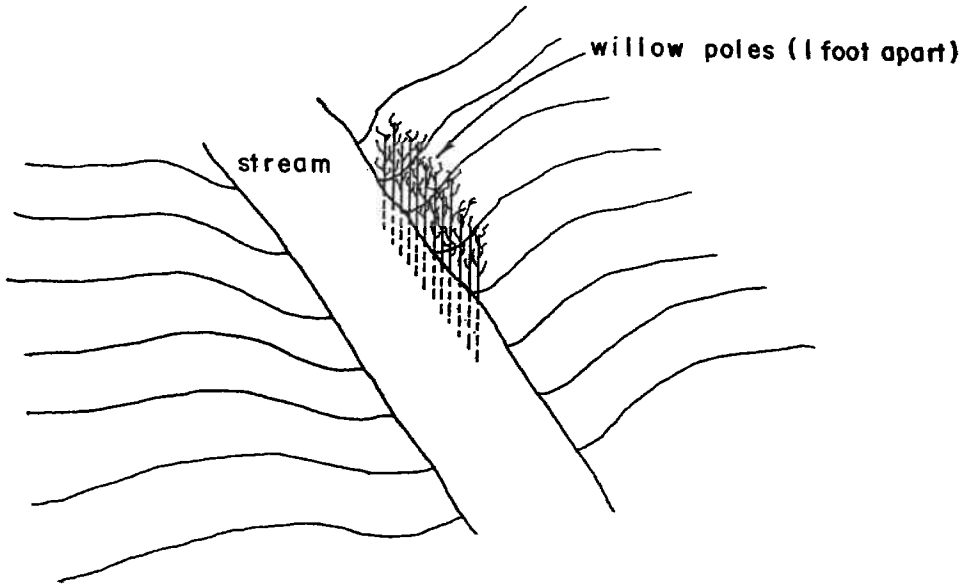
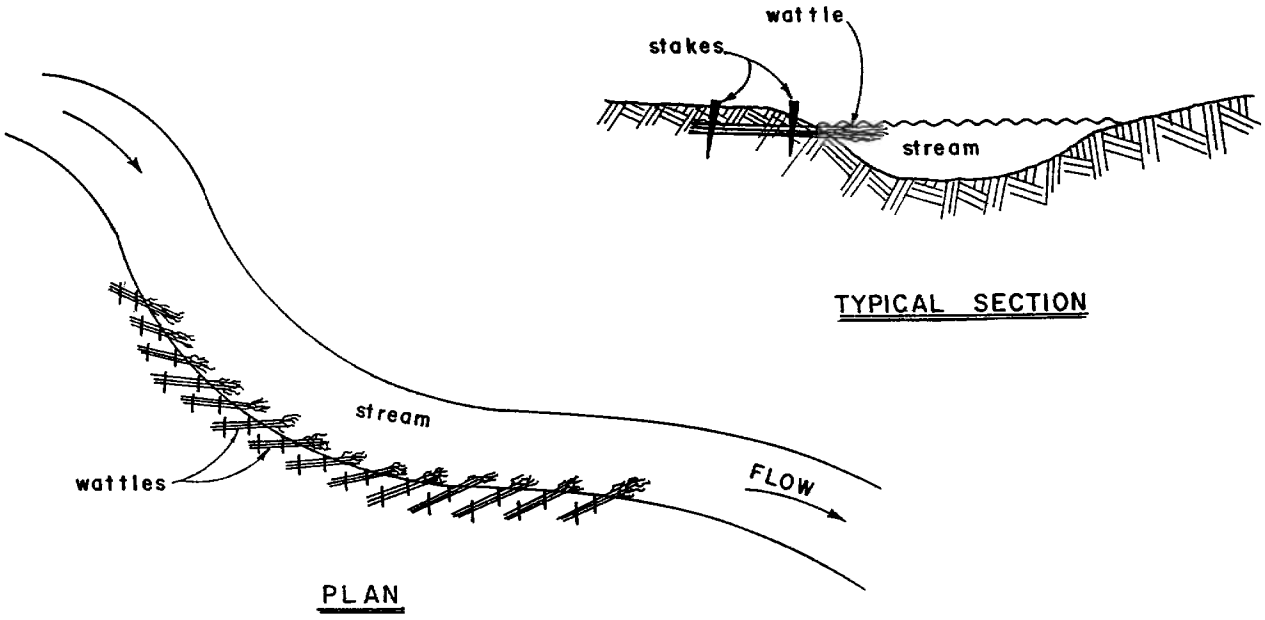


Figure 4.6
Wattle Flow Deflectors Along Waterline



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