CHAPTER II

STREAM BANK PROTECTION AND EROSION DAMAGE MITIGATION MEASURES

Optimum erosion control and management of the flood plain should combine sound flood-control engineering with preservation and enhancement of the streams natural qualities. In order to insure the flood plain's utility, versatility, and compatibility with urban improvements, this manual has taken into account required flood conveyance, the safety of citizens and property, the visual impact of the land, and land uses to be derived from the area.

CHECK DAM IN RAWHIDE PARK, FARMERS BRANCH, TEXAS

All stream bank stability methods focus on the boundary between the water and its channel banks. Structural and non-structural methods can be employed to control erosion. Some methods will improve the channel's ability to withstand greater boundary shear stresses such as vegetation, gabions or other forms of channel armor, while others, such as detention basins, check dams, stilling basins and diversion channels, will reduce the boundary shear stress in critical areas altogether. Last, but not least, stream preservation techniques such as the establishment of buffer zones, setbacks and erosion hazard zones prior to land development can reduce and even eliminate the economic damage that stream bank erosion can cause along urban streams.

Several design issues are common to many of the structural stream bank stabilization methods. In the selection and application of a particular erosion protection method, care must be taken to avoid merely transfering the erosion problem to another location. This requires the designer to not only understand the causes of stream bank erosion at the site in question, but to also take a comprehensive look at the entire stream reach, or even, basin. In addition, the transition of structural erosion controls to and from natural stream banks is critical, but often overlooked and should be carefully analyzed and designed. Special provisions, such as riprap and soil retention mats may be utilized to protect the termination of the proposed control and provide a smooth transition to the existing stream bank. In many cases, two or more of the methods presented can be combined to create effective, environmentally sensitive stream bank stabilization plans.

WEST FORK- ROWLETT CREEK, ALLEN, TEXAS

Stream bank stabilization is needed in areas where an existing structure is jeopardized, where the rate of and/or the potential for erosion could threaten future planned improvements, or where the actual or potential erosion puts significant environmental features at risk. The following summarizes the advantages and disadvantages of methods that have been or could be used in the North Central Texas area. **Chapter III** provides guidance for the selection of methods and **Chapter IV** contains more detailed design guidelines.

A. Stream Preservation

One of the most effective flood plain management tools available to stream corridor planners today is the preservation of our natural streams and flood plains. Preserving these areas as open space and greenbelt accomplishes the multiple goals of flood control, water quality enhancement, habitat protection, recreation and often economic development. However, stream bank erosion in these areas can still be a problem particularly if the watershed is undergoing urbanizing influences. Therefore, stream bank stability assessments and possible erosion mitigation measures will be evaluated, even along those streams whose channels and flood plains remain natural.

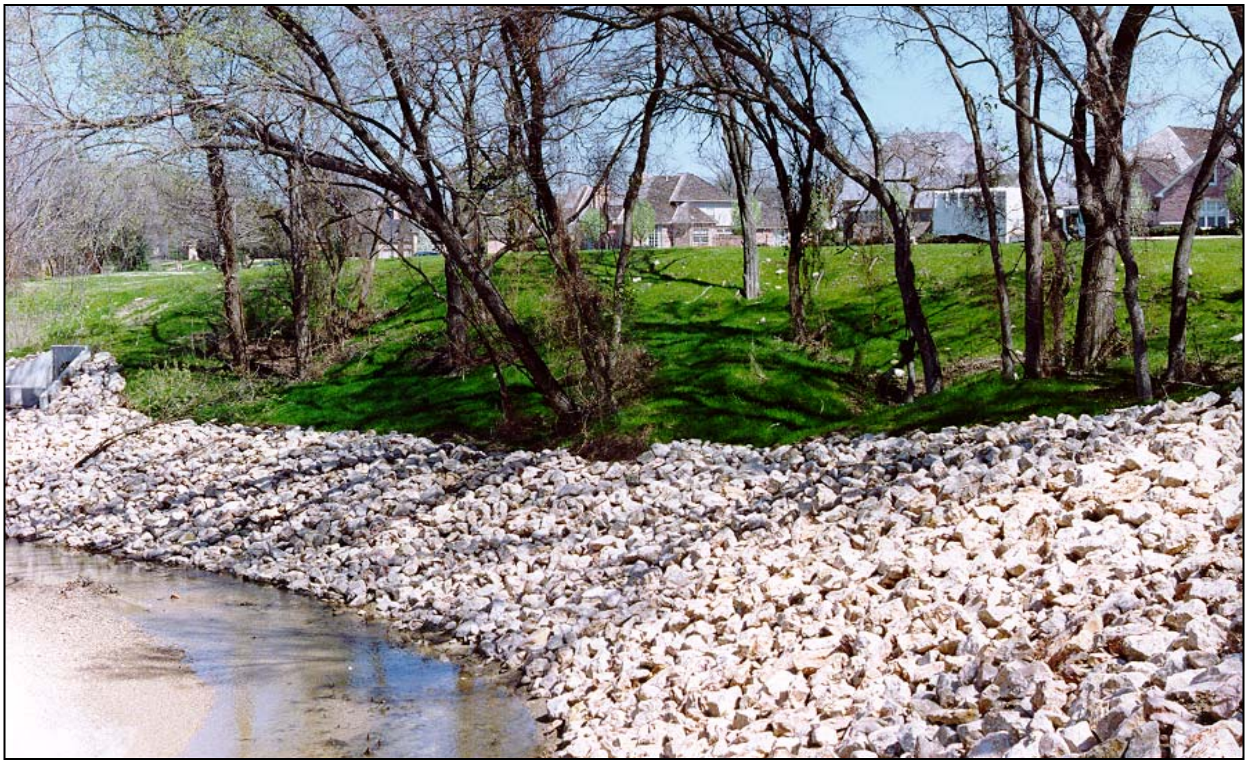
B. Channel Bank Armoring

1. Concrete-Lined Channels

Concrete lined channels have historically been the choice of drainage designers for high velocity design flows. Typically they are more expensive than grass-lined channels. However, they can be placed in a narrower right-of-way and enable the use of steep side slopes in the presence of swiftly running water. Generally, this alternative can provide long life with a minimum of maintenance, but has negative impacts in terms of aesthetics and habitat along stream corridors. In addition, watersheds with significant amounts of channelization will experience more frequent flooding and higher flood peaks than will similar watersheds where natural channels and flood plains are preserved, due to the loss of valley storage in the stream (Halff, 1989). Therefore, concrete-lined channels should only be used where existing channel right-of-way is restricted or as a transition to bridges and culverts.

2. Rock Riprap

Riprap is an excellent channel liner and is less expensive than reinforced concrete channel liners. Riprap is loose rock or stone placed along the channel, sometimes strengthened by grouting with mortar. Sometimes immense rocks are required for shoreline protection at large lakes, while 9-inch to 12-inch rocks are adequate for channel protection in some applications. Since the durability of rip-rap is dependent on the stability of each individual rock to resist dislodgement, a conservative size rock is needed as a safety factor against extreme flow conditions. Rock riprap is effective in areas of high velocity and boundary shear stress. The rock riprap blanket has the ability to conform to irregularities in bank slopes. Usually, rock riprap is cheaper than concrete or gabion lining. The most common mistake in rock riprap applications is to provide rock that is too small for the tractive forces encountered. Rock riprap can be grouted to form monolithic armor. The result may be rigid but is usually not strong or long lasting. Often such applications begin to break apart after a few years due to these forces of rushing water and expansive soils. Grouted rock riprap must be provided with weepholes to offset hydrostatic pressure buildup and toe protection to prevent undermining.



ROCK RIPRAP AT BEND ON FARMERS BRANCH CREEK, FARMERS BRANCH, TEXAS

3. Gabions

Gabions are wire baskets, filled with four to nine inch rock and bound together to form a structure. The advantages of gabions are that they conform to minimal shifts in the soil, and are adaptable to a wide variety of applications. Generally speaking, the appearance of gabion structures is considered less intrusive than similarly configured concrete structures. The disadvantage of gabions is that maintenance is necessary to preserve the integrity of the structure. Trees and branches carried by turbulent floodwaters can damage the wire baskets by either lodging themselves in the basket, or by pulling the wire and deforming the boxed configuration. If gabions are to be used in a structural application, this damage could lead to the loss of a large portion of the gabion structure during a single storm event. Special design considerations are needed for structures which are frequently inundated by turbulent floodwaters and subjected to bombardment of damaging debris.

GABION WALL ON TRIBUTARY OF ROWLETT CREEK IN PLANO, TAXAS

4. Landscaping and Vegetative Erosion Controls

a) Vegetation

Vegetation is the first defense against erosion. Grasses, ground covers, shrubs and trees can effectively protect the soil provided the slope is not steeper than 3(h) to 1(v) and the water velocity is not more than five feet per second. The plants must be compatible with the various habitats in the project area. In general, those selected for the channel must be able to withstand significant periods of inundation, have a rhizome-type of root network, and should not excessively restrict water flow. Plants for the overbank shall be both heat and drought tolerant. In difficult areas, such as steep slopes, a geotextile fabric should be placed and anchored to the soil before the vegetation is planted.

Typically, natural stream channels in the project area exhibit four vegetative zones as shown in Figure II-1. In the toe zone and splash zone, the plants listed can be inundated up to a week and can regenerate damaged top growth rapidly following river flood events. Species that commonly occur in similar environments are the submerged and emergent aquatic plants, such as Typha, Scripus, Polygonum, and Pharagmites. These varieties offer resistance to low flows, but offer only minimal flow resistance

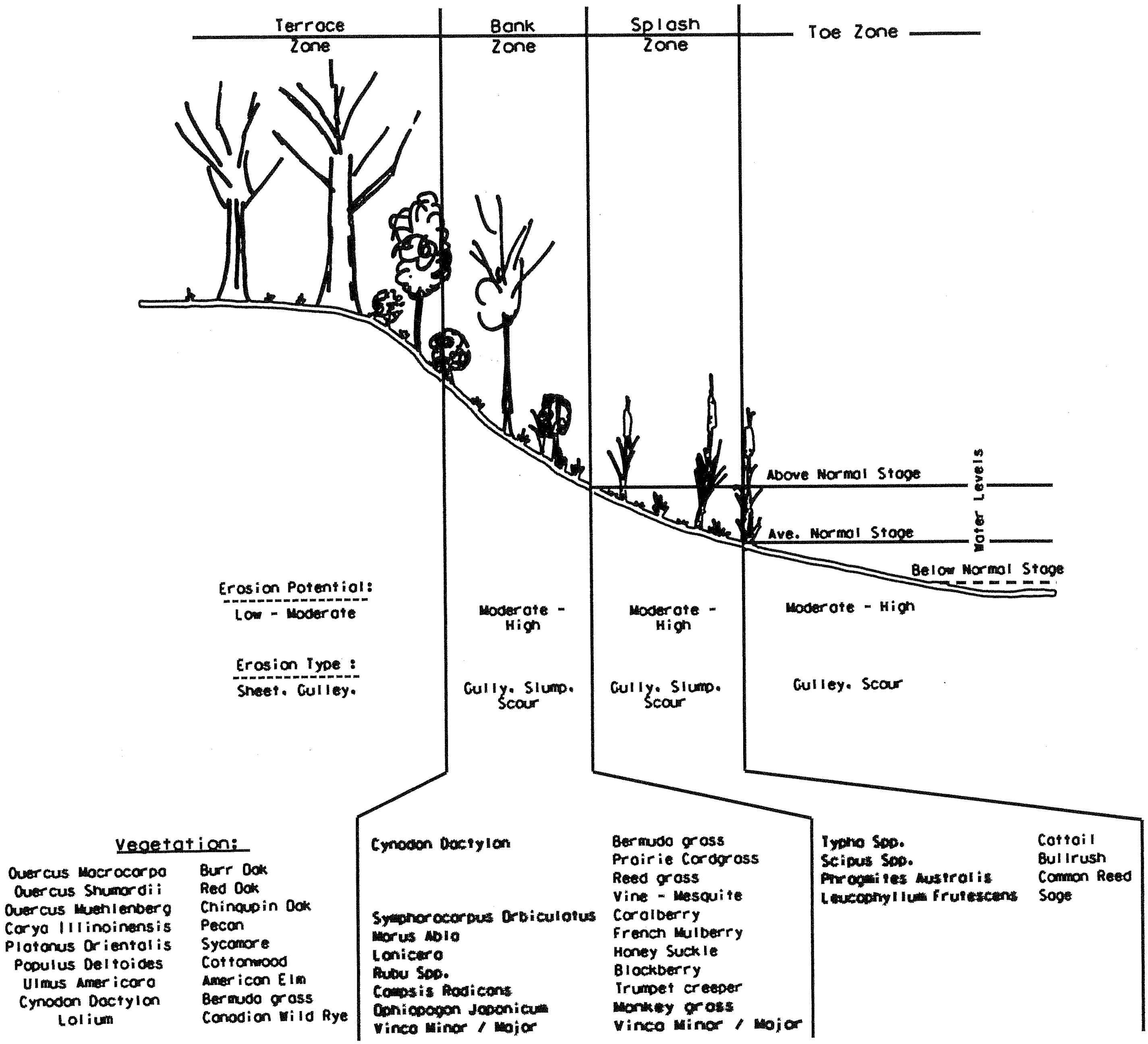


FIGURE II - 1

EROSION CONTROL VEGETATION

(HALFF. 1985)

E:\FIGURE\Fig II-1.dgn 4/23/2003 2:22:31 PM during high flows when the plants are flattened by the water. Therefore, planting a mixture of cattails, common reed, softstem, hardstem, and American bulrush along the channel would reduce its capacity for conveying small floods by increasing the roughness coefficient, n, from 0.035 to as high as 0.050 which is typical of natural channels with weeds (Chow, 1959).

The upper vegetative zones, bank zone, and terrace zone are normally dry. The vegetation selected for the bank and terrace zones should be tolerant of both the summer drought and the periodic flooding. Grass and trees suitable for the flood plain include Bermuda grass, buffalo grass, Canadian wild rye, and cottonwood, sycamore, pecan, American elm, burr oak, red cedar, and chinquapin oak. These trees add habitat and help other vegetation to survive, but must be carefully maintained. Their branches should be pruned high enough to avoid hindering flow and thinned so that sufficient sunlight will penetrate the ground to illuminate the shade-sensitive Bermuda grass and buffalo grass beneath.

b) Grass-Lined Channels

Grass-lined channels are common for several reasons. Grass- lined channels are inexpensive, can be visually attractive and are relatively easy to establish and maintain if properly designed and installed. Grassed channels can often repair themselves unless the erosion damage is very severe.

Grass-lined channels with relatively mild side slopes (3(h) to 1(v) or 4(h) to 1(v)) require additional protection at vulnerable points such as transitions and bends. The types of grasses preferred for a channel lining are those which have rhizomes (roots which sprout additional plants). Selected species should be compatible with local and/or native vegetation and should be capable of being established within a reasonable length of time.

The permissible velocity in a grass-lined channel is that which can be sustained for reasonable lengths of time without experiencing severe erosion. The permissible velocity will vary with type of grass, channel slope, and soil classification. Erosion-resistant soils would include **Houston Black** and similar clays. Easily-eroded soils would be sands, silts and clays with significant percentages of silt or silt seams, which are common along the streams in the project area. Permissible velocities are shown in Table II-1.

c) Cut or Filled Slopes

A 4(h):1(v) side slope in the soils of project area streams is generally stable and easily maintained by machine mowing. If the vertical height of the slope is greater than 15 feet, a 10 to 15 foot wide bench or shelf should be installed at mid slope and every 10 feet of vertical elevation change thereafter. Steeper side slopes of 3(h):1(v) may be allowed in areas of restricted right of way, subject to approval by the City Engineer. These areas will experience more frequent slope failures.

d) Soil Retention Blankets

Soil retention blankets of natural or synthetic materials can be used to hold the seed and soil in place until new vegetation is established on channel banks or stream beds.

Table II-1
Permissible Velocities for Channels Lined with Grass*

Cover	Bed slope range, %	Permissible velocity, fps: Erosion-resistant soils	Permissible velocity, fps: Easily eroded soils
	0-5	8	6
Bermuda grass	5-10	7	5
	>10	6	4
Buffalo grass, Kentucky bluegrass, smooth brome, blue grama	0-5	7	5
	5-10	6	4
	>10	5	3
Grass mixture	0-5	5	4
	5-10	4	3
	Do not use on slopes steeper than 10%		
Lespedeza sericea, weeping love grass, ischaemum (yellow blue-stem), kudzu, alfalfa, crabgrass	0-5 Do not use on slopes steeper than 5%, except for side slopes in a combination channel	3.5	2.5
Annuals-used on mild slopes or as temporary protection until permanent covers are established, common lespedeza, Sudan grass	0-5 Use on slopes steeper than 5% is not recommended	3.5	2.5

Remarks. The values apply to average, uniform stands of each type of cover. Use velocities exceeding 5 fps only where good covers and proper maintenance can be obtained.

*U.S. Soil Conservation Service , 1947.

5. Pilot Channels

Often grass-, gabion-, and stone riprap channels are combined with reinforced concrete pilot channels in the stream bed. Pilot channels can improve flood conveyance, especially for small, frequent flood events and provide an all weather surface for stream maintenance. Pilot channels should be designed to carry normal base flows and that of relatively small storm events to reduce as much as possible the frequency of erosive overflows. Often this results in channels with vertical sides 2 to 4 feet deep. In areas of heavy pedestrian traffic, the depth of the pilot channel wall may need to be limited for safety purposes.

GRASSED CHANNEL WITH CONCRETE PILOT CHANNEL ON COTTONWOOD CREEK, McKINNEY, TEXAS

6. Articulated and Interlocking Concrete Blocks

Concrete blocks cemented to a fabric liner or linked by cables form a flexible and porous mat that allows grasses and other plants to grow through the openings in the mat. The blocks are available from several manufacturers in numerous shapes, sizes, and colors. The block mats are limited to mild slopes and moderate velocities because the mats can be undermined by turbulent, debris-filled floodwaters.

Numerous hand-placed individual blocks are being marketed as erosion-control methods. Their effectiveness is dependent on their mass and their ability to resist being dislocated and transported by flowing water. The same limitations that apply to rip rap apply to these systems.

7. Sand- Cement Bag Revetments

Many types of systems, including several into which mortar, gravel or concrete are pumped into fabric liners are available. Locally, a system of individual paper bags filled with aggregate and cement has been used in public and private stream bank stabilization projects. Installation and maintenance complexity are minimal, since vegetation does not grow through the fabric. Floating debris can damage sacks although some fabrics are more resistant to these types of forces. Proper installation must include adequate foundations and anchoring of the liners and bags. Applications of these systems are limited in terms of their height, steepness of slope and ability to withstand high levels of boundary shear stress.

SAND- CEMENT BAG WALL ON HERNDON BRANCH IN McKINNEY, TEXAS

8. Poured-In-Place Concrete Grid Mats

Poured-in-place concrete grid mats have had success in their limited applications. In England, the reinforced grid has been successfully used on the face of a dam or spillway. Successful establishment of grass can require significant amounts of irrigation, especially in areas of significant vehicular or pedestrian traffic.

C. Walls

1. General.

Sometimes walls are constructed to function as channel banks in areas of limited right-of-way. Walls are typically formed out of reinforced concrete, gabions, steel pilings or stone. Reinforced concrete and gabion walls have some of the same advantages and disadvantages as described in their use as lined channels. Grouted and dry-stack stone walls are attractive but should be restricted in height to less than four feet unless used in combination with anchoring systems and accompanied by structural analysis prepared by a licensed engineer.

2. Reinforced Earth:

This system consists of layers of reinforcing strips attached to a precast reinforced concrete facing. The reinforcing strips are extend into the backfill zone behind the wall. The wall is backfilled in lifts separating the strips. The structure is made stable through the transfer of stress created by earth pressure to the reinforcing strips, by friction created between the soil and the strips. This type of reinforcing system can also be used with gabion walls, sand-cement bag revetments and other precast retaining wall systems. Typically, the installation requires a large area at the back of the wall and may not be practical in areas where space is limited. Design elements of reinforced earth walls such as the limits of the backfill zone should be specified by a licensed and qualified engineer.

3. Bulkheads.

A bulkhead is a vertical wall used to support a slope and/or protect it from erosion. As such, it must be designed to resist the forces of overturning, bending and sliding. Bulkheads can be constructed out of sheet pile, sheet metal or timber and are most useful at the following locations:

- braided (many parallel channels crisscrossing) streams with erodible sandy banks
- where stream banks have failed by sliding
- at lake and pond edges to provide depth at the edge and protect against erosion by wave action

4. Precast Retaining Wall Systems

This system consists of a gravity retaining wall, utilizing precast, interlocking, reinforced concrete modules. Typically, these modules are filled with select backfill and compacted. Generally speaking, these systems should be installed as per manufacturers recommendations.

D. Control Structures

In contrast to the preceding methods that improve a channel's ability to resist erosion, the following structures focus on reducing the erosive power of the water. Energy dissipating structures force the water to yield its kinetic energy. Since kinetic energy can be expressed as being proportional to the flow mass (m) and the square of the velocity (v), water with less kinetic energy has a slower velocity and is less erosive than that which has high kinetic energy. For example, in a stilling basin or plunge pool, turbulence consumes the water's kinetic energy. The desired result of energy dissipating structures is slower water and less channel erosion.

SMALL CHECK DAMS IN PARK, McKINNEY, TEXAS

1. Check Dams

Check dams are effective in reducing channel or stream erosion. The dam ponds water and increases the cross-sectional area of the stream and hence, reduces the velocity. The decrease in the slope of the hydraulic gradient lowers the shear stress, thereby reducing the erosive forces. The creek will deposit sediment behind the check dam, which should be periodically removed. Since check dams will be frequently inundated, they are constructed of concrete, gabions, or other durable materials capable of withstanding high-water velocities. The dam should be anchored into bedrock material and designed to prevent undermining and overturning. The area immediately downstream of the structure should be protected unless the formation of a scour pool is desired.

GRAPEVINE CREEK DROP STRUCTURE DOWNSTREAM OF IH 35, COPPELL, TEXAS

2. Drop Structures

Channel drop structures can be used to maintain stable, nonerosive conditions in upstream and downstream reaches or to arrest head cutting. Like check dams, local scour can occur downstream of the drop structure and undermining must be prevented usually by constructing the drop structure foundation deeper than computed scour depths. As an option, the change in grade can be achieved along a sloping apron as opposed to a vertical drop. In this case , the apron must be able to withstand the high velocities and turbulence at its downstream end. In some cases, a series of drop structures may be used to minimize drop height and structure cost.

In some cases, it may be acceptable to allow a plunge pool to form downstream of a check dam or drop structure. The scour depth downstream of the structure must be determined and can be predicted by Veronese:

$$d = (1/32)\ H^{0.225}\ q^{0.54}$$

where: d = depth of scour below the water level in feet;

H = difference in elevation between the reservoir level and the tailwater elevation in feet; and
q = discharge in cubic feet per second per foot of width.

The depth of scour is dependent more on the energy of the stream (i.e. weight of water and velocity of flow) than on the durability of the armoring material.

> "Depths of scour are influenced initially by the erodibility of the stream material or the bedrock and by the size or the gradation of sizes of any armoring material in the pool. However, the armoring or protective surfaces of the pool will be progressively reduced by the abrading action of the churning material to a size which will be scoured out and the ultimate scour depth will, for all practical considerations, stabilize at a limiting depth irrespective of the material size."(USBR, 1987)

3. Stilling Basins

Stilling basins are effective in reducing downstream erosion at the downstream ends of check dams, drop structures and larger dams. They are designed to increase turbulence, reduce the total energy, and increase the downstream depth of flow (Peterka,1984).

4. Durable Obstructions.

Baffles, chute blocks and other kinds of durable obstructions increase the turbulence and are useful in dissipating the energy of low flows. These are often incorporated into stilling basin design and at storm drain outfalls (Peterka, 1984).

E. Other

Channels and swales increase the cross-sectional area of the floodway and thereby lower velocities.

1. Diversion Channel.

Construction of a diversion channel can eliminate the need for total rehabilitation of the natural creek bed. The diversion channel becomes the primary conveyance; only the amount of flow necessary to prevent stagnation is permitted in the natural channel.

2. Swales.

High-water swales are shallow channels excavated parallel to the natural channel. During low-flow conditions, the swale will remain dry and all the water will flow through the natural course. During high-flow conditions flood water will be conveyed via the swale. An example of this type of erosion mitigation feature is found in Dallas' Tennison Memorial Golf Course. A diversion swale along the west side of the course conveys approximately twice as much flow as the natural channel. This reduces the amount and frequency of bankful flows in the natural channel.

F. Soil Bioengineering Practices

The practice of soil bioengineering (SBP) is gaining recognition as a viable tool for controlling erosion and stabilizing slopes. In soil bioengineering, plants provide both a living component and a structural component (roots and stems) in a slope protection system. Using common cuttings, such as willows, the treatment attempts to provide sufficient stability until native vegetation can be established. Some suggest the following advantages for SBP's:

- Economy - SBPs are often less expensive to install than conventional methods.
- Environmental compatibility - SBPs offer benefits of habitat improvement, aesthetic value, ecological utility, and use of native and natural materials.
- Maintenance - Once established, SBPs typically require minimal maintenance and can be self repairing.
- Improved strength over time - Growth of the vegetative components of SBPs increases structural stability.
- Access - Access is often critical to the installation of conventional erosion control and stabilization techniques. Many SBPs require minimal equipment usage and are not restricted by access considerations.

SBPs can fill a need in stabilizing lands susceptible to erosion and instability where traditional or structural methods would be inappropriate or prohibitively expensive. These techniques can also be useful for lands that require reconstruction for environmental restoration purposes. However, there are several limitations to SBPs which should be emphasized and can impact their usefulness by design professionals:

- Installation season - SBPs are most effective when installed during the dormant season of late fall through early spring, depending on the plant material. This season may coincide with poor weather conditions which may discourage or prohibit the use of SBPs.
- Safety or risk factor - Because of ever present liability concerns and difficulties in quantifying the performance of SBPs, engineers may be reluctant to approve their use.
- Availability of plant material - Sufficient quantities of locally adapted plant species may be difficult to obtain.
- Labor considerations - Some SBPs can be labor intensive. Availability of affordable competent labor may be a limiting factor.
- Time - SBP installations may take several seasons to become fully established. This introduces problems with contractor warranty and maintenance practices.
- Installation procedures - While the use of SBPs is increasing, local installers may be unfamiliar with correct procedures. In public works projects, contractors may often bid such work with little or no training in proper installation techniques. As

with all constructed projects, quality assurance must be achieved to ensure that the SBP has a good chance of success.

- Competition from other products - A growing market of other erosion control products, with well developed marketing efforts, may overshadow the existence or application of SBPs.

Chapter IV has specific design details for soil bioengineering practices. Appendix A shows design details. In the following section, several common SBP's will be discussed.

1. Live Staking

Live staking is the insertion by tamping of live rooted vegetaive cuttings into the ground. This is a relatively simple procedure that may be used as a primary treatment or as a means of securing fascines, mattresses or other soil bioengineering components. Typical uses of live stakes are for stream banks near the waterline, for small earth slides and slump areas created by groundwater seepage. Live stakes can also be incorporated into boulder walls or riprap installation. The stakes are tamped into the underlying soil between boulders or through a riprap layer. Subsequent growth strengthens slope and improves aesthetic value (Gray, 1996).

Live Staking is economical and fast to install. Stakes can be installed in wet conditions. However, applications are subject to availability of suitable plant material and restricted to installation in the dormant season.

2. Wattles

This technique, also called live fascines, uses bundles of branch cuttings which are placed and secured into shallow trenches. The bundles are tied together with twine anchored in the trench with wooden stakes. The trenches are typically excavated by hand and follow the contour of the slope or stream bank. Once the wattle has been placed and secured in the trench, the trench is back-filled with soil to a point where just the top of the wattle bundle is exposed. Wattles may have uses for stream bank protection in combination with other SBPs. One variation of wattle use for stream bank protection is the construction of wattle flow deflectors. Wattles are anchored in a streamside trench which is angled downstream. The trench is shorter than the wattle bundle, allowing the wattle to extend out into the moving water. As the vegetation grows, the stems extend the deflector mechanism upward, providing flow control during high water and protecting the stream bank. Care must be taken to ensure that channel flood conveyance is not reduced (IECA, 1995).

3. Brush Layering

Brush Layering involves placing live branches in excavated terraces, covered with soil and compacted to form a series of reinforced benches. The brush layer, with the tips of the branches protruding through the surface, reinforces the slopes in several ways. The physical properties of the branches, even before rooting and growth, add stability to the slope. The protruding tips serve to capture debris and reduce surface erosion. Infiltration properties of the slope may be improved, thereby creating a more favorable environment for vegetation. Once the branches grow, roots add considerable strength to the soil. This technique works best with fill slope construction.

Depending on the size of the slope to be treated, this treatment may lend itself better to equipment use than wattling. It can be, therefore, a very cost effective alternative for slope stabilization when compared to other conventional methods such as retaining walls (IECA, 1995).

4. Brush Mattressing

In this soil bioengineering technique also called brush matting, a mattress-like branch layer is placed on a stream bank and is secured to the bank slope using a variety of anchoring techniques such as live or dead stakes, wire, twine, or other live branches. Brush mattressing is typically used in conjunction with other techniques such as live staking and wattles. As with brush layering, this technique requires large quantities of branch material (IECA, 1995).

5. Live Cribwall

This technique combines a structural element of logs or timbers with live branch cuttings to form a reinforced wall. Live cribwalls are used for slope stabilization, usually at the toe of slopes, or for stream bank protection applications. Vegetation improves the strength of the wall and improves the overall aesthetics by screening the structural components (IECA, 1995).

6. New Soil Bioengineering Technologies

Variations on the techniques described above are being utilized more and more as SBPs integrate the use of a variety of natural and synthetic products. Stream bank protection SBPs can be substantially improved with the use of strong natural or synthetic geotextiles. The added strength can be particularly valuable in the early stages of treatment, prior to rooting and establishment of vegetation. One method described by the King County Dept. of Public Works, Surface Water Management Division (Seattle, Washington) utilizes a strong natural geotextile such as coir to wrap individual lifts of soil which are separated by a brush layer (Johnson and Stypula 1993). The geotextile helps to protect the newly constructed system by protecting against higher stream flows and may also be used, in conjunction with riprap, for structural toe protection. This technique may also allow for steeper slope faces and, therefore, is valuable for sites which cannot be sloped back. This method has been called "vegetated geogrid".

In a similar fashion, plastic geogrids are often used to add structural integrity to SBPs. Geogrids have been used as a component of brush layering systems and of vegetated dikes, a SBP used to prevent bank scour. The grids help primarily to confine small stone, but also add a structural component which continues to strengthen as roots grow throughout the structure (IECA, 1995.)

Tubes of coconut fiber are used to support plant growth along the edges of streams, rivers, lakes and reservoirs (Goldsmith and Bestmann 1992). When used in conjunction with pre-planted pallets of aquatic plant species, this technique is very successful in creating wetland and riparian habitats. The coconut fiber tubes are also an effective shoreline protection against erosion due to small waves.

7. Future Trends

Many SBP procedures are labor intensive. Labor, particularly for public projects, can often be expensive and locally, available workers are unskilled in SBPs. Therefore, SBPs must evolve to a point where labor is minimized and/or equipment use is maximized before widespread acceptance and significant applications occur in North Central Texas.

One way to achieve wider application is to develop modular systems of soil bioengineering components. Nursery grown and prepared wattles; pre-assembled brush layers; sandwich-style modules of plant material, soil, and geotextiles; wave attenuation barriers; prefabricated crib walls and floating islands; and assembled habitat structures such as submerged ledges and platforms for fish - all are potential modules which could make SBPs easier to implement.

Soil Bioengineering Practices have not seen widespread use in North Central Texas. Applications are needed to gain local experience with the practices. The techniques may be useful to local parks departments for inexpensive erosion control in golf courses or nature preserves and to local landowners who cannot afford expensive structural solutions or desire a more natural setting.

G. Setbacks and Buffer Zones

A setback is a strip of land that separates one type of land use from another, usually for protection or aesthetic purposes. The resulting separation, also referred to as a buffer, is usually established by systematic programs involving the location of key physical or environmental components of streams and their adjoining flood plains.

When used as a stream bank erosion control tool, setbacks protect adjoining developed land uses from damage due to potential slope failures, slides and settlement. Many other benefits can be realized in a setback or buffer zone program. Buffer zones can reduce pollutant loadings in storm runoff, reduce storm runoff volumes, provide critical habitats for urban wildlife, protect stream banks from randomly located outfalls originating from adjoining residential and commercial development and protect riparian areas along natural streams and wetlands. However, setback programs designed for these purposes usually result in much wider buffer zones than those needed for stream bank erosion control. Setbacks for erosion hazard purposes are discussed in Chapter III.

H. Stream Restoration

As discussed in Part A of this chapter, stream and flood plain preservation can be one of the most effective flood plain management tools available to stream corridor planners. However, many streams in the urban areas of North Texas have already been altered for drainage or flood control purposes, yet continue to experience stream bank stability problems along and downstream of the channel and flood plain modifications.

In some parts of the country, streams altered by man in the past are being restored to a natural state. This enhances habitat for fish and wildlife and provides a more pleasant setting for surrounding neighborhoods. One possible tool that can be used to help achieve restoration of disturbed streams is storm water detention. Detention can return the watershed's hydrologic response to a state more typical of it's pre-urban condition. Another tool involves reforestation of all or parts of the streams watershed. Reforestation is especially beneficial along riparian areas and achieves multiple goals of water quality enhancement, increased biological diversity and improved habitat.

If located in an urban setting, restored streams may still need erosion protection or mitigation and should be evaluated with appropriate techniques including the use of setbacks. Methods to achieve restoration of urban streams are still in the beginning stages of development and are worthy of future investigation.