CHAPTER III

SELECTING PROTECTION FOR STREAM BANKS

A. Design Criteria

Design frequency for stream bank stabilization and erosion control should be established as a function of risk. Normally, stream bank protection projects should be designed to withstand much more frequent flood events than flood control projects as long as the consequences of failure do not result in extensive damage to public or private facilities or severe environmental damage.

WEST FORK- ROWLETT CREEK DOWNSTREAM OF NEW CUSTER ROAD, ALLEN, TEXAS

Recommended design frequencies for typical erosion control and stream bank stabilization analysis range from the 2-year to the 100-year flood peak discharge and shall be determined by each individual city's erosion control policies. The 100-year flood has a 1 percent chance of occurrence in any given year and is the base or regulatory flood in the National Flood Insurance Program. The 2-year flood has a 50 percent chance of occurrence in any given year. This design level will typically provide protection against 60 to 70 % of the 100 year storm depth based on an analysis of streams ranging from 0.1 to 10 square miles in a community near the project area. If the 2-year flood is not known or calculated for the stream in question, the 10-year flood from the most current flood insurance study results could be used. In any case, proposed stream bank stabilization projects should be evaluated for impacts on the regulatory 100-year flood plain in addition to other impacts as directed by the city engineer. No adverse impacts on upstream or downstream land owners will be allowed.

Setbacks or erosion hazard zones shall be permanently established for the purpose of erosion damage mitigation by plat or recorded instrument according to guidelines presented in Part D of this chapter. The erosion setback shall be required of all projects in which natural streams are to be preserved or where variations in the design recommendations of this manual are desired by the developer or land owner.

Projects designed within these guidelines should have a reasonably low risk of damage due to stream bank erosion. If developers or landowners propose projects with higher risk, those projects should be protected against failure due to erosion based on the 100-year flood. For example, if a developer desires to locate fill or structures within the erosion hazard zone, those channel banks should be evaluated for stream bank stability based on the 100-year flood. Since all of the study area's stream banks erode at some rate, this will require the developer to construct permanent stabilization measures such as walls or other measures as described in this manual.

B. Site Analysis

1. Site Inspection

All streams with drainage basins larger than 130 acres, or any stream that is earmarked for preservation in its natural state or exhibits stream stability problems requiring correction should be physically inspected by the Design Engineer for the purpose of stream bank stability assessment. The engineer should be accompanied by a Geotechnical Engineer or geologist, landscape architect and environmental scientist if at all possible.

a) Geology

The inspection team should examine the stream's bed and bank material and classify it as to soil and strata. Areas of existing erosion should be closely inspected and preliminary assessments of cause should be made.

b) Vegetation

Native and existing vegetation should be noted as to type, location and condition.

c) Documentation

A complete documentation of the field inspection should be compiled and made a part of the engineering study for the stream. This should include photographs and map locations of critical features such as existing vertical banks and significant trees. Features such as these can be located relatively easily using existing maps or with handheld GPS units.

2. Channel Morphology

Based on the field visit and best available maps, assessments should be made of such channel features as sinuosity, channel shape (depth, width, etc.) and vegetation. The causes of existing channel bank instability or anticipated future problems shall be determined.

C. Stream Hydraulic Analysis

Detailed stream hydraulic analysis is needed to correctly assess stream bank erosion problems. Typically, the analysis can begin with Flood Insurance Study computer models. However, these models will probably require updating due to their age and supplemental cross sections to provide an accurate portrayal of channel velocity in the study reach. As a general rule, additional cross sections should be inserted be sections with velocity changes greater than 20 percent. If supplemental cross sections are necessary, those sections shall be based on field surveys or detailed topographic mapping. Interpolated cross sections shall not be allowed. The hydrologic basis of the analysis should be based on discharges reflecting a fully urbanized watershed. The analysis should be performed or supervised by an experienced hydraulic engineer or hydrologist.

1. Velocity Determinations.

Velocity determinations come directly from the hydraulic computer model. In some cases, more detailed velocity distributions should be developed across the section to accurately reflect conditions in wide flood plains or complex channels. HEC-RAS, the USACE's replacement for HEC-2, provides an excellent graphical presentation of velocity variations across the cross section as seen in the example Figure III-1(USACE, 1997).

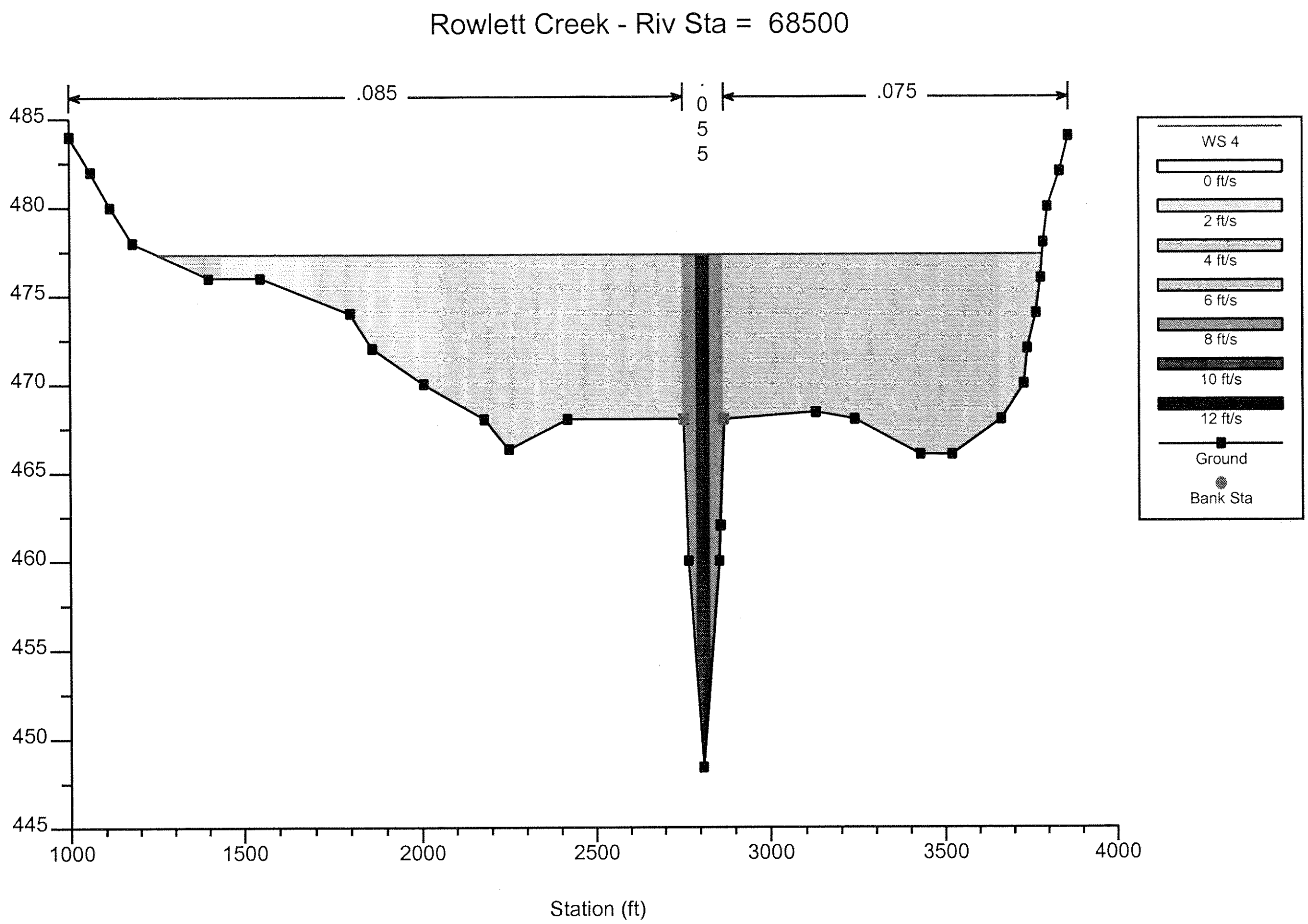

Figure III-1

HEC-RAS Velocity Distribution Plot

2. Tractive Force Calculations.

Tractive Force computations can be determined as described in Chapter I. Tractive force is a better means of assessing erosion potential than velocity. Both HEC-RAS and HEC-2 will compute tractive force (boundary shear stress). However, velocity guidelines will be used in this manual until more design experience is gained in North Central Texas using tractive force. Appendix C contains sample stream hydraulic analyses using HEC-RAS.

D. Erodibility Index

An erodibility index shall be computed for each erosion site within the proposed project. Erosion hazard sites shall be defined as follows:

- Areas of high velocity (greater than 5 feet per second based on design flows)
- outside banks of meanders
- steep banks (greater than 3:1)
- areas exhibiting existing stream bank erosion based on visual observation.

The erodibility index shall be a function of urbanization, stream velocities, sinuosity, and channel bank material.

1. Urbanization.

The watershed upstream of the project area in question shall be evaluated for urbanization influences on hydrology based on it’s ultimate or fully developed land use. Watersheds that are undergoing urbanization influences (including redevelopment) shall be assigned a factor of 2 unless the entire watershed is stable having been urban for at least 50 years. This determination shall be made by the City Engineer. Watersheds that will remain in open space or natural conditions are assigned a factor of 1. This factor may be weighted to reflect the presence of parks and permanent open spaces. Urban watersheds that have significant storm water detention facilities and hydrologic analysis demonstrating that post development design flows will not exceed predevelopment design flows for stream bank stabilization evaluation shall be assigned an urbanization factor of 1.

2. Sinuosity.

Sinuosity is related to meander geometry and is defined as the ratio of stream length to valley length (Rosgen, 1996). Chapter I of this manual discussed how actual tractive force could exceed allowable values in meanders. even when average values are within acceptable limits. The degree of sinuosity or meandering of the subject stream shall be assessed and assigned an index as follows:

- Pronounced meanders (sinuosity > 1.5)- 3
- Moderate meanders (1.26 - 1.5)- 2
- Relatively straight (1.0 -1.25) 1

A minimum stream length of 500 feet shall be used, centered on the project or site in question for the purposes of determining the degree of sinuosity.

3. Channel Bank Soils

The effect of channel bank soils on erosion potential is quantified based on the following soils index:

- Rock- 1
- Predominately clay- 2
- Clay interspersed with sandy and/or silty seams- 3
- Sands and silts- 4

4. Channel Velocity.

Channel velocity, and indirectly tractive force, is reflected in the erodibility index as follows:

- less than 5 ft/sec- 1
- 5 to 8 ft/sec- 2
- greater than 8 ft/sec- 3

5. Erodibility Index Computation.

To compute the Erodibility Index, sum the individual indices for channel velocity, sinuosity and bank materials. Multiply this total by the urbanization factor. The resulting erodibility index will range from 3 to 20. Areas with stream bank erodibilty indices of 3 to 8 should exhibit mild erosion, 8-12 moderate erosion and 12-20 would indicate severe erosion potential. If the erodibilty index is 8 or greater, the applicant should develop a stream bank protection plan as a part of the flood plain evaluation study for the project.

E. Erosion Hazard Setback Determination

Erosion setbacks or hazard zones shall be determined for every stream in which natural channels are intended to be preserved. The setback should be determined as described in this chapter. If variations to the setback policy are intended, adjusted setback limits should also be clearly shown on site plans, plats and the erosion control exhibit. Technical backup supporting the request for a variance should be included in the engineering report. Technical backup can be in the form of detailed slope stability analysis.

The following is a suggested setback program designed for use in the preservation of natural streams in North Central Texas. It is based on the philosophy of maintainable slopes and allows the natural erosion processes to continue without threatening structures. The stream bank erosion setback zone would be established as follows:

- locate the toe of the natural stream bank
- from this toe, construct a 4(H) to 1(V) line away from the stream and intersect natural ground
- continue past the intersection an additional 15 feet to the edge of the setback.

A typical setback established by this technique is shown in Figure III-2a. Setbacks established for the purposes of stream bank erosion hazard protection may extend beyond the limits of the regulatory flood plain.

It may be desirable to reduce the stream bank erosion hazard setback line in areas where stream banks consist entirely or partly of rock. In these areas, the interface of the stream bank with the top of the unweathered rock strata should be located with the assistance of a qualified geotechnical engineer or geologist. This point on the surface of the slope will be the toe of a 3:1 slope intersecting natural ground. The actual setback line should then be located 15 feet beyond this intersection. This is illustrated in Figure III-2b.

When natural channel banks are protected in this manner, no building, fence, wall, deck, swimming pool or other structure, should be located, constructed or maintained within the area encompassing the setback.

As an alternative to the setback, the developer or landowner may submit to the City Engineer a plan to stabilize and protect stream banks threatened by erosion. Stabilization shall be of a permanent nature, consistent with the guidelines of this manual, and shall be designed and sealed by a licensed professional engineer.

F. Matrix of Allowable Stream Bank Erosion Control Methods

Table III-1 is a summary of stream stabilization techniques and their suitability for solving mild, moderate and severe erosion problems.

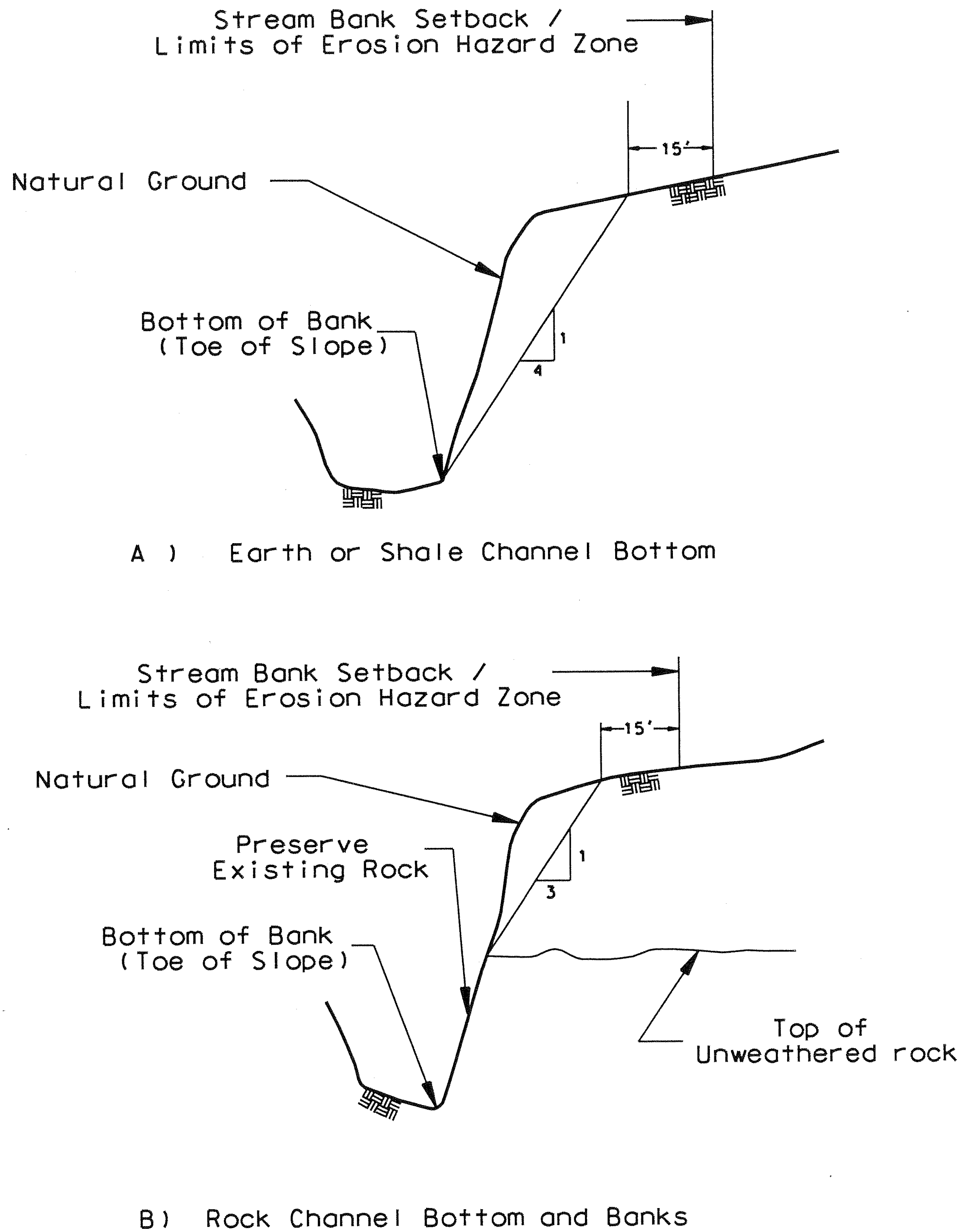

Figure III-2

EROSION HAZARD
SETBACKS

(ALLEN, 1985)

G. Stream Bank Stabilization Plan Requirements

Stream bank stabilization plans shall be comprehensive and shall include the following information:

- detailed topography of the site at a scale of 1”=100’ or better.
- location of all hydraulic model cross sections both pre- and post-project
- hydraulic models reflecting both the erosion hazard design discharge and the 100-year flood reflecting pre- and post-project conditions.
- cross section plots reflecting pre- and post-project conditions showing velocity distribution
- profile plots of pre- and post-project conditions
- tabulation of pre- and post-project velocities
- photographs covering the stream in general and all erosion problem areas with locations referenced on the site plan
- geologists or geotechnical engineers report on stream channel bank conditions
- drainage area map with permanent open space and/or park land uses shown
- tabulated Erodibility Indices at each cross section and erosion hazard site with special attention at channel meanders
- proposed site plan showing erosion hazard setback line along stream, proposed erosion mitigation measures and regulatory flood plain and floodway
- construction phases for the overall project and erosion control features should be clearly indicated on the site plan
- details of proposed stream bank stabilization measures
- details of proposed erosion control measures at storm sewer and drainage outfalls to the stream channel
- supporting design computations as necessary for proposed stream bank stabilization and erosion control methods
- construction schedules
- temporary erosion control plan for construction phase
- hydrologic summary report including model and data if performed
- hard copy of computer model output
- electronic copy of computer model input
- copies of all required permits
- Stream bank stabilization plans shall be prepared under the supervision of a professional engineer licensed in the State of Texas. This will be witnessed by the engineer affixing his seal and signature to each erosion hazard site plan and details and any reports or calculations submitted to support the plan

H. Summary of Procedures

Figure III-3 summarizes the stream bank stabilization plan and approval process. Existing stream hydraulic models can be used to assist in the initial determination of the erodibility index. The preliminary report should also include photographs, a summary geology/geotechnical report and other findings.

I. Ranking of Stream Bank Stabilization Projects

The erodibility index allows the determination of erosion hazard. Given the hazards, a procedure is necessary for ranking the multiple problems so that needed corrective measures can be implemented prudently in light of budget limitations. The following is a modification of the procedures currently used by the City of Plano. The ranking is based on a summation of the scores from the following six evaluation criteria:

1. Threat to Major Structure

- Residences- 20
- Existing Drainage Facilities- 20
- Roadways- 15
- Water and Sanitary Sewer Lines- 10

2. Threat To Minor Structures

- Pools- 20
- Decks- 15
- Retaining Walls- 15
- Fences- 10
- Headwalls- 10

3. Threat To Environment

- Major (large trees, etc)- 10
- Minor- 5
-

4. Erosion Outside of Easement

- Known- 20
- Highly Likely- 15
- Probable- 10

5. Potential to Erode Outside of Easement(estimated distance from top of stream bank to edge of easement)

• Less Than 5 Feet-	10
• 5 to 10 Feet-	7
• 10 to 15 Feet-	5
• 20 Feet +-	0

6. Erodibility Index

- Ranges from 3 to 20
- Use as computed in Section III.D

The maximum possible score is 100.

Table III-1

Application of Stream Bank Stabilization and Erosion Control Methods

Method	Mild Erosion $EI < 8$	Moderate Erosion $8 \leq EI < 12$	Severe Erosion $EI \geq 12$
A. Structural and Armor Methods			
1. Concrete Lined Channel	x	x	x
2. Rock Riprap Revetment	x	x	x
3. Gabion Lined Channel	x	x	x
4. Pilot Channels			
a.. w/ Grassed-lined Channel	x	x	
b. w/ Gabion-lined Channel	x	x	x
c. w/ Rock Riprap	x	x	x
5. Articulated Blocks	x	x	
6. Walls and U-shaped Channels			
a. Reinforced Concrete	x	x	x
b. Gabion	x	x	x
c. Stone	x	x	
d. Crib Wall	x	x	
e. Bulkheads	x	x	
f. Precast Systems	x		
6. Sand-Cement Bag Revetment	x		
7. Fabric Formed Concrete Systems	x		
8. Vane Dike/Debris Fin (see note 1)			
9. Soil Cement	x	x	
10. Bendway Weirs	x	x	
B. Control Structures			
1. Check Dams	x	x	x
2. Drop Structures	x	x	x
3. Stilling Basins	x	x	x
4. Transitions	x	x	x
5. Durable Obstructions	x	x	x
C. Soil Bioengineering Practices	x		
D. Other Nonstructural Methods			
1. Grass-lined Channels	x	x(see note 2)	
2. Geogrids/geotextiles/Cellular Confinement	x		
3. Blankets, Mats, Netting	x	x	
4. Removal of Obstructions	x		
E. Setbacks and Buffer Zones	x	x	x
F. Stream Restoration	x(see note 3)		
G. Diversion Channels (see note 4)			
H. Swales (see note 4)			
I. Detention (see note 4)			

NOTES:

1. Used for sediment and debris deposition control
2. When used with approved flexible channel liner
3. Restored streams in urban settings may still require supplemental erosion hazard mitigation measures
4. Effectiveness is a function of specific application and application may itself require use of one or more of erosion control methods listed above

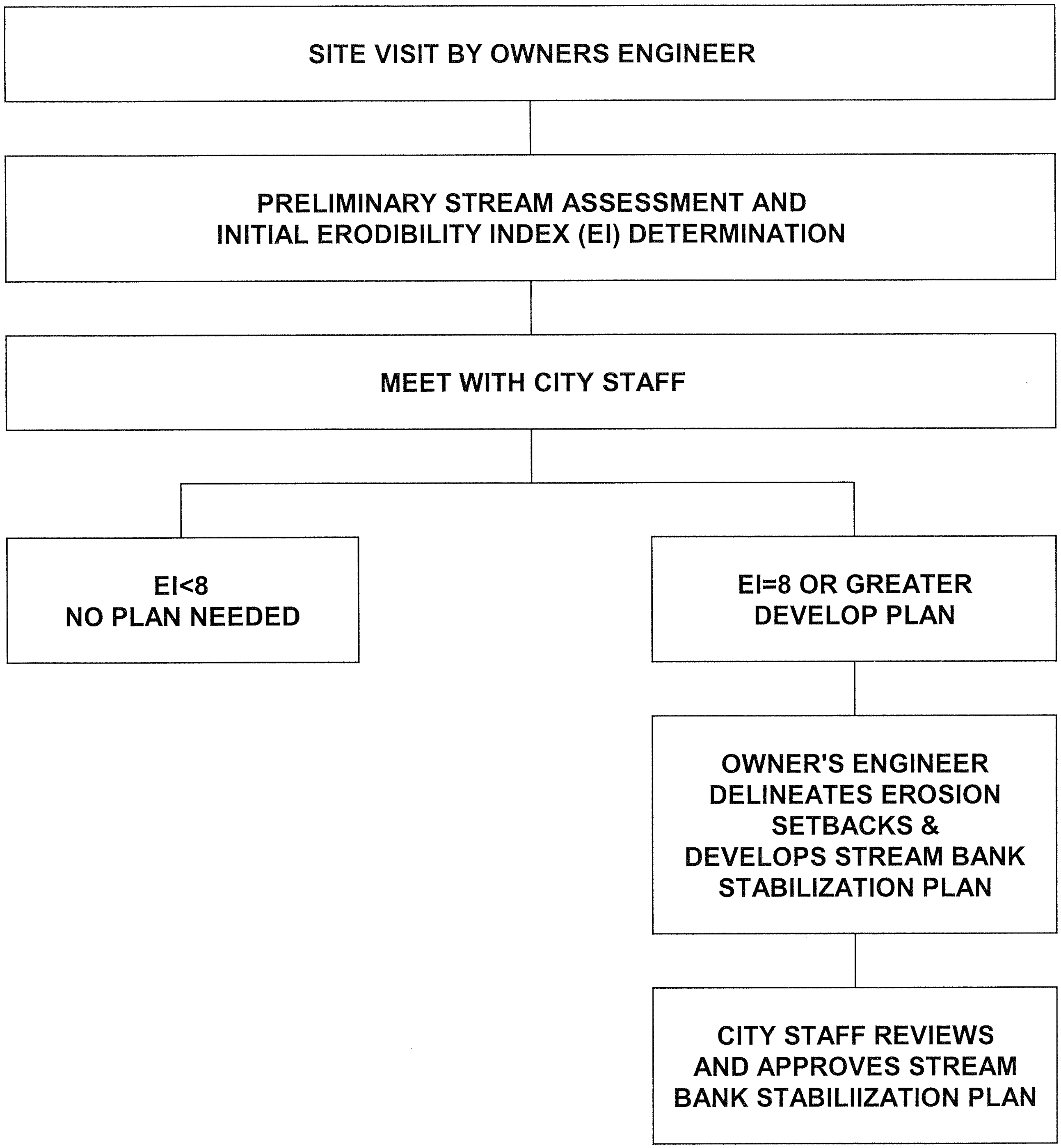

FIGURE III-3

STREAM BANK STABILIZATION PLAN AND APPROVAL PROCESS