IS IT TIME TO GET THE CITIES INVOLVED?

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PREPARED
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INTRODUCTION

Abstract

Economic pressures often result in developers and land planners maximizing land use without regard to geologic processes. This can result in use of property along water courses which is susceptible to bank erosion and slope instability.

A significant number of failures have occurred in the Dallas and Fort Worth areas, indicating some regulatory control may be justified to protect owners and taxpayers from disproportionate economic impact. This paper identifies one condition which can generally be mitigated during planning; erosional bank loss associated with stream cut banks. It is suggested municipalities require this condition be addressed by planners during development in a manner similar to identification of the effects of flood events.

Case studies of ground loss associated with erosion and slope failure on residential property in Dallas and Tarrant Counties are presented. Susceptible geologic conditions, magnitude of loss, and costs associated with post-construction remediation are identified. Alternative means to address the condition prior to construction are also presented.

General Conditions

Development along stream banks and water ways has significant cosmetic appeal to both commercial and residential owners. However, construction along stream banks which encroach upon the waterway frequently restrict natural geologic forces associated with stream development. Without an awareness of the processes involved and proper design, significant property loss can occur.

Geologic processes such as stream erosion are usually brought to the forefront during flood conditions, and therefore may occur long after initial development. Any loss that occurs is frequently born by the property owner or in some cases, the municipality, not the developer. This condition can create a disproportionate economic burden on the current owner. Additional burden can be created if the solution extends beyond property boundaries and the municipality does not take an active role in remediation.

An example of the type of geologic processes and loss, which are the subject of this paper, is shown in Photograph 1. Erosion of the stream bank resulted in continued undermining of a building foundation. To protect the apartment building from further undermining, a thin section gabion wall with rock anchors was designed and constructed at a cost of $300,000. The completed section is shown in Photograph 2.

Photograph 1. Erosion and steepening of a cut bank within the Austin Chalk Formation. Note undermining of front corner of foundation.

Photograph 2. Constructed thin section gabion wall with rock anchors. Construction cost $300.000.

The purpose of this discussion is to present an easily identifiable condition related to development along stream banks. It is suggested governmental entities review proposed plans and, if the condition warrants, require the developer to address stream bank stability before construction. Specific engineering principles involved in solving various conditions are not discussed.

Geologic Setting

One condition in particular which results in failure frequently reoccurs; development of property on the cut bank side of creeks and streams. The cut bank side of a creek is the outside edge of a meander bend. An idealized meandering stream with identified cut banks is shown in Figure 1.

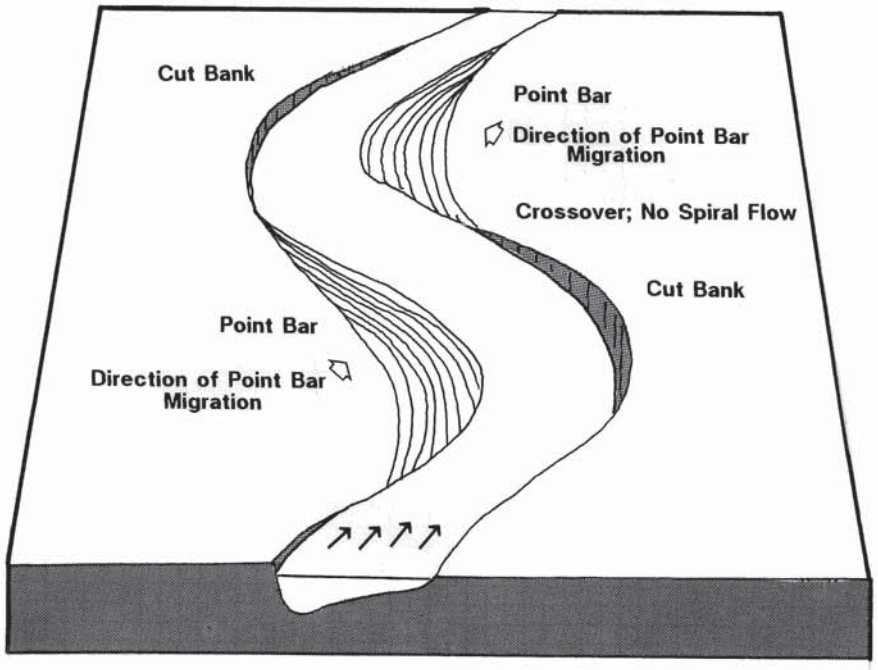

Figure 1. Meandering stream with cut banks.

The outside edge of the stream meander is subject to deepening and lateral erosion. The magnitude and time rate of erosion is dependent upon stream velocity and the geologic setting. These processes are hastened by high stream flow and are therefore time (or weather) dependent.

CASE STUDIES

General

The problem of lateral stream bank erosion is not isolated to any particular geologic formation or locality. Within the period 1990 through 1993, the writer's firm investigated over 40 sites on cut banks. Repair costs have ranged from $40,000 to $550,000, with a total estimated construction cost on these 40 projects exceeding $10,000,000. The median cost of the average post-construction repair is on the order of $150,000. Of the 40 projects studied, approximately 60 percent of the remediation cost was borne by individual owners, with the remainder paid by municipalities.

Figure 2 illustrates locations of various erosion projects on cut banks within Dallas County. A partial listing of various projects with their associated repair costs within the greater Dallas/Fort Worth metroplex is provided in Table 1.

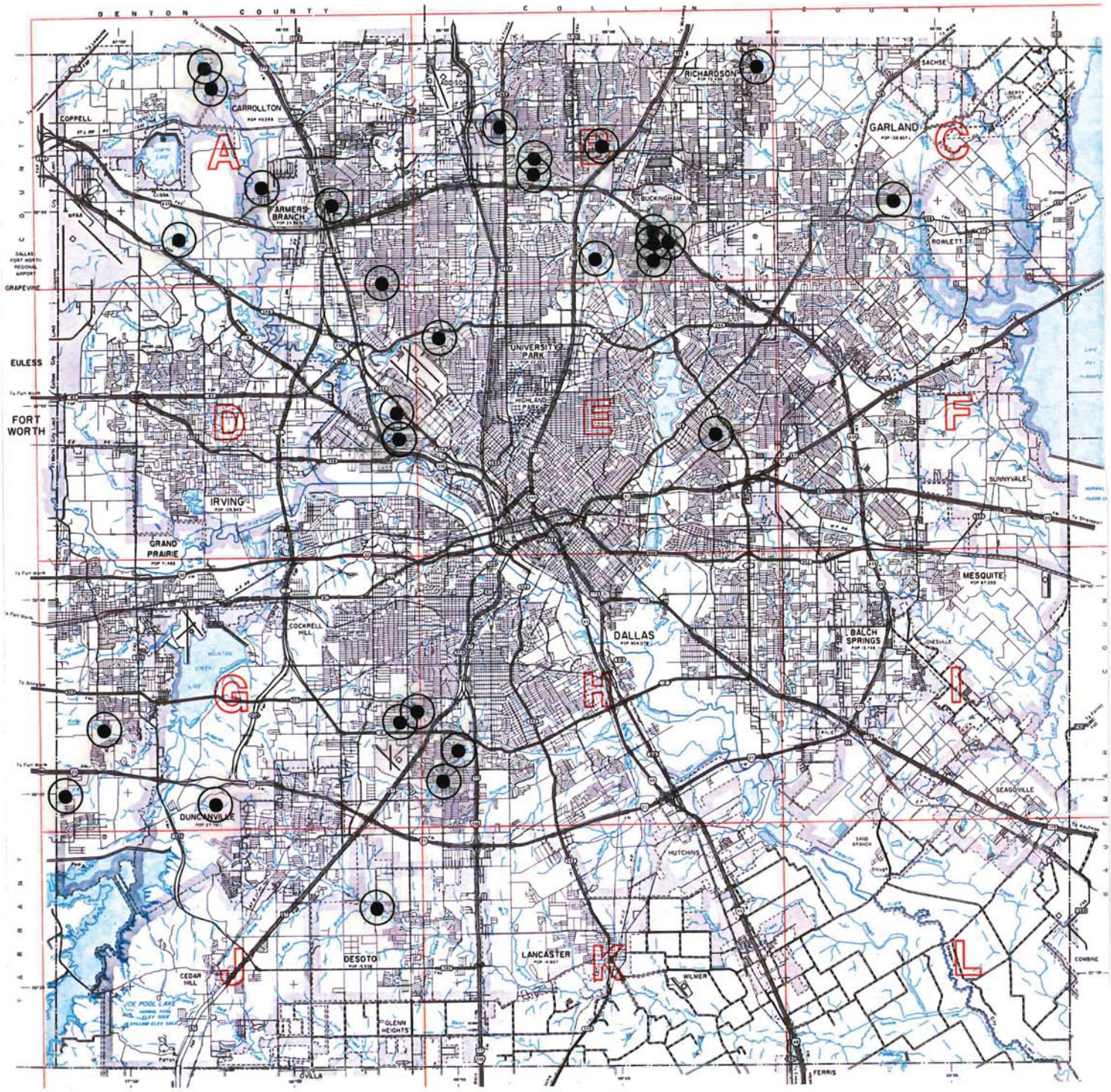

Figure 2. Location of stream erosion studies at cut banks. Dallas County.

TABLE 1

Selected Listing of
Erosion Control Projects on Cut Banks

Private Residences, Arlington, Texas - Estimated Cost $350,000
Gravity gabion structure, 250 to 300 linear feet, 10 to 28 feet in height, Woodbine Formation

Rock Creek Apartments, Dallas, Texas - Cost $300,000
Thin section gabion wall with rock anchors, 160 linear feet, 24 feet in height, Austin Chalk Formation

Hidden Ridge Apartments, Dallas, Texas - Cost $490,000
Two, thin section gabion walls with rock anchors, 360 and 120 feet long, 21 to 27 feet in height, Austin Chalk Formation

Gleneagles Country Club, Plano, Texas - Cost $40,000
Thin section gabion wall with rock anchors, 70 feet long, 15 feet high, Austin Chalk Formation

Private Residences, Kirby Creek, Grand Prairie, Texas - Cost $398,000
Slope re-construction and flattening with rock rip-rap, 300 linear feet, slope height 20 to 30 feet, Alluvial over Eagle Ford

Private Residences, Fish Creek, Grand Prairie, Texas - Cost $310,000
Slope re-construction, flattening and rock rip-rap, 450 feet in length, slope height 20 feet, Alluvial over Eagle Ford

Private Residences, Dallas, Texas - Estimated Cost $250,000
Contiguous pier retaining wall system, height 25 to 30 feet, 120 feet in length, Fill over Eagle Ford

Dallas Child Guidance Center, Dallas, Texas - Cost $85,000
Thin section gabion wall with rock anchors and drilled piers, 210 linear feet, Alluvial over Eagle Ford

Sanitary Sewer Crossings, Benbrook, Texas - Estimated Cost $85,000
Concrete retaining walls and rock rip-rap, estimated length 300 feet

Woodland Condominiums, White Rock Creek, Dallas, Texas - Cost $550,000
Thin section gabion wall with rock anchors, two walls total length 580 feet, 24 to 27 feet in height, Austin Chalk

Rush Creek at Bowen Road, Arlington, Texas - Cost $160,000
Gravity and reinforced earth retaining structure, 180 feet long, 27 feet high, Woodbine Formation

Two case studies are discussed in the following sections. Both cases represent residential lots located adjacent to cut banks of meandering streams. Fill was placed on the lots backing up to the creek, with no provision to protect the fill embankment from lateral stream erosion. Both examples involve residential construction because this type of development generally results in the greatest potential for economic burden. Residential development also represents one of the easier situations to correct during the development process, provided it is recognized and the developer or civil engineer appropriately addresses the condition.

The first case illustrates the difficulty of a single homeowner in achieving a workable solution if the municipality does not get involved. The second case involves active participation by the municipality.

Case 1: Residential Property, Arlington Texas

This example consists of three residential lots located on Kee Branch of Rush Creek, in Arlington Texas. This portion of Rush Creek is located within the Woodbine Formation of Cretaceous Age.

Two specific houses are at the apex of the meander bend, and suffered the worse damage. An aerial view of the study area is shown in Photograph 3. The homes in question are labeled A through C for discussion purposes. Homes A and B are currently abandoned.

Photograph 3. Aerial view of residences, case study 1 showing proximity to the creek and location of meander bend.

The residential area was developed around 1982. The lots studied are located along the outside bend of Kee Branch of Rush Creek. Although grading plans were not available, site grades and conditions indicate 5 to 10 feet of fill was required along the creek side of the lots to achieve a buildable condition. This resulted in encroachment within the natural floodplain and oversteepening of the creek bank.

The homeowners attempted to mitigate damages associated with flood events by the use of railroad retaining walls. Home B suffered continuing erosion, with a significant flood and erosion occurring in 1989 which resulted in undermining of the foundation. Conditions after the 1989 event are shown in Photograph 4.

Photograph 4. Composite photograph of conditions at Residence B after 1989 flood event.

Homeowner B opted to construct a gabion retaining wall system; however, because the adjacent homes were not suffering damage effecting the foundations, Homeowner B could not obtain agreements to financially assist with construction of a wall throughout the affected area of the stream bank. In addition, he could not obtain easements for site access from the property owner across the creek. Homeowner B opted for construction of a gabion wall system within his property boundary, and attempted to separate erosion on his section of the creek from adjacent neighbors. The completed wall system is shown in Photographs 5 and 6.

Photograph 5. Completed gabion section prior to November 1991 flood.

Photograph 6. Completed gabion section prior to 1991 flood. Camera pointed west towards residential Lot A.

Following extreme flooding events in November 1991, the west end of the gabion wall system failed as a result of a deep slide centered on the upstream lot (Lot A). The condition of the wall and foundations on Lots A and B are shown in Photographs 7 through 9.

Photograph 7. Condition of gabion wall after November 1991 flood. Camera pointed west. Residence on Lot A is located in the upper right corner of the photograph.

Photograph 8. Condition of east end of gabion wall after 1991 flood.

Photograph 9. Head scarp on Lot A. Portion of foundation on Lot A is visible on the right side of photograph.

The gabion system cost Homeowner B approximately $110,000 to construct. The value of the home was estimated at approximately $80,000 in 1992. Loss of the initial railroad retaining wall systems in 1989 resulted in development of an erosional scarp to the edge of the house foundation. Loss of the gabion system in 1992 resulted in undermining of the foundation. Claims by Homeowner B to a home warranty insurance were denied in both 1989 and 1992. Homeowner B filed suit against the design engineer, the contractor and the home warranty insurance company. The suit was settled out of court, and Lots A and B are presently vacant.

The affected homeowners received sympathy from the municipality but no assistance in construction of a system along the creek to limit further erosion. With a lack of cooperation and/or resources from adjacent property owners, limiting erosion along the creek bank was next to impossible for a single homeowner. Analysis of the existing conditions indicates approximately 450 linear feet of bank will require some type of reinforcement and erosion protection. A gabion system was estimated to cost approximately $325,000. To date, nothing has been done.

A gabion protection system could have been incorporated into the initial development costs for the subdivision, or the lots left as part of an amenity or park. An argument could be made that this cost would have "killed" the project; however, by developing the three lots in question, the cost for the protection was transferred from the developer to single land owners. From the perspective of a governmental agency, review of the development plans could have triggered concern associated with development along the outside edge of the meander bend. The municipality could have then required the developer to engage the proper engineering disciplines to analyze the potential for erosion.

Case 2: Kirby Creek, Grand Prairie, Texas

This case involves a slope failure along a cut bank of Kirby Creek, Grand Prairie, Texas. Geologically, the site is located within Quaternary alluvial deposits overlying shale of the Cretaceous Age Eagle Ford Formation.

The slope failure encompassed approximately 160 linear feet of stream bank, comprising three residential lots. An aerial photograph and topographic survey of the conditions are shown in Photograph 10 and Figure 3, respectively. Conditions shortly after failure are shown in Photographs 11 and 12.

Photograph 10. Aerial view of residences and creek prior to slope failure. Note proximity of rear yards to creek bank.

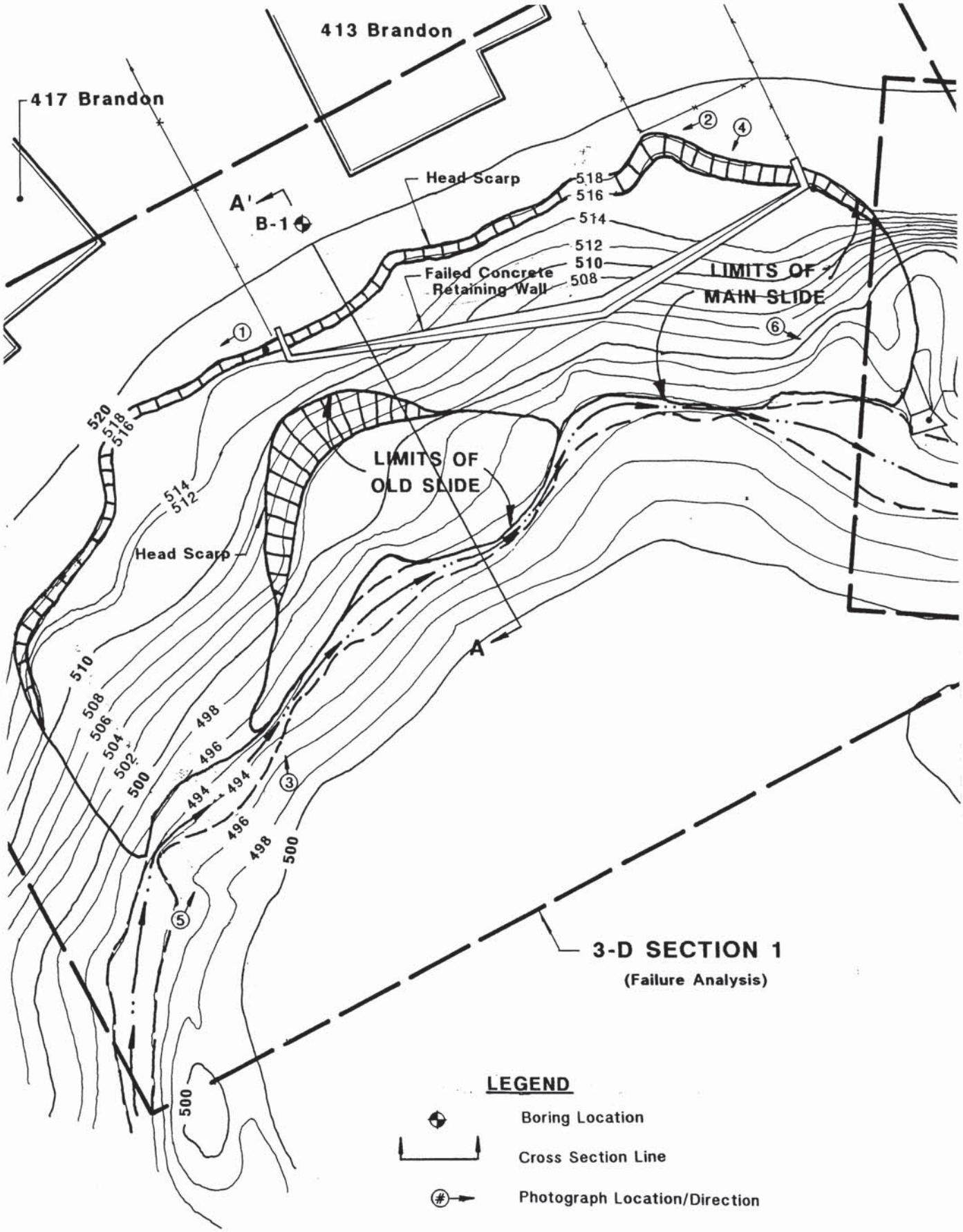

Figure 3. Topographic survey of slide area. Case Study 3.

Photograph 11. Head scarp at 417 Brandon Street.

Photograph 12. Head scarp of slope failure at 413 Brandon Street.

Numerous solutions were evaluated, with the chosen repair consisting of slope reconstruction, flatting and use of rock rip-rap for slope armor. This alternative incorporated relocation of the creek channel. Engineering services and construction costs were paid for by the municipality. The total cost of reconstruction was $398,000. The completed section is shown in Photograph 13.

Photograph 13. Completed section of re-graded creek and armored slope. Residences at 417 and 413 Brandon Street in the middle and right of photograph.

Again, pre-construction review and analysis may have prevented the failure by providing erosion protection along the creek bank, or limiting development of the referenced lots. As an alternative, the natural slope could have been flattened to a stable condition, then armored against erosion.

CONCLUSIONS

Development of raw land is an important part of urban planning; however, when land will be developed adjacent to streams and water courses, natural geologic processes must be accounted for. The particular condition sighted in this paper is land use along the cut bank of meander bends.

Municipalities should consider the economic consequences associated with stream erosion. During the review process, municipalities could easily require developers to employ geotechnical engineers or engineering geologists to analyze the effects of erosion on the performance of the project. Proper design of erosion protection could then be incorporated into the overall development costs.

Civil engineers designing developments along stream channels should recognize the geologic processes associated with bank erosion and encourage use of appropriate engineering disciplines to analyze the potential for loss. As a minimum, civil engineers must recognize potential liability associated with property loss.