# Guidelines for Bank Stabilization On the Mendenhall River

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TECHNICAL REPORT NO. 99-3
SEPTEMBER 30, 1999

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ACKNOWLEDGEMENTS

The Alaska Department of Fish and Game (ADF&G) would like to thank the U.S. Environmental Protection Agency for providing the majority of the funds to complete this three-year project. Their support provided the needed funds to acquire materials and support work contracts. The ADF&G appreciates the interest of property owners along the Mendenhall River in the sustainability of the Mendenhall River's fish habitat. The ADF&G values the contributions from other agencies that contributed their expertise to develop this final report. These agencies include: U.S. Fish and Wildlife Service, U.S. Geological Service, U.S.D.A. Natural Resource Conservation Service, U.S. Army Corps of Engineers, Alaska Department of Environmental Conservation, Alaska Department of Natural Resources, City and Borough of Juneau, and the National Wetlands Inventory Center. Special appreciation goes to Jullee Beasley of the U.S. Fish and Wildlife Service, Jon Hall of the National Wetlands Inventory Center, Randy Host and Ed Neal of the U.S. Geological Survey, and Sylvia Kreel, Jeanette St. George, Dan Garcia, and Ben Pollard of the City and Borough of Juneau for their contributions. Within the ADF&G, appreciation goes to Janet Hall Schempf and Clayton Hawkes, whom initiated the project, and Mark Schwann and Kevin Brownlee, whom provided valuable fisheries information. Reviews of the manuscript were provided by Lana Shea Flanders and Ben Kirkpatrick. Cori Cashen and Susan Schulte provided valuable publication assistance. Finally, appreciation goes to Carlos Paez, who acquired additional field data on fisheries values, networked with the parties involved, and drafted this final report.

# 1. EXECUTIVE SUMMARY

This document encourages the use of bioengineered bank treatment options as alternatives to traditional stone riprap revetment on the Mendenhall River where bank stabilization is desired and fish habitat must be maintained. Stone riprap has previously been installed to full bank height along several properties abutting the river, and more banks are riprapped every year. Although riprap can be an effective way to prevent local bank erosion, it generally offers no aquatic or terrestrial habitat and is generally held to be aesthetically unappealing. In contrast, bioengineered bank treatments can offer a level of erosion protection comparable to riprap, and provide aquatic and terrestrial habitat and aesthetically pleasing riverbanks.

This report describes the current state of the Mendenhall River, the basic theory behind the use of bioengineering in bank revetment design, and bioengineering methods considered appropriate for use on the Mendenhall River. In addition, example bioengineered bank treatment designs are presented for three sites along the river. The three example sites were chosen to represent the range of conditions found on the Mendenhall River, and thus to provide bank protection solutions that can be readily transferred to other sites. The designs include plan sheets and descriptions of materials, installation, and planting specifications for the example bank treatments. Several alternative planting and bank stabilization methods, as well as a technique for vegetating existing riprap, are also presented. Permitting requirements and the permitting process are also described.

The design of any bank protection system needs to be tailored to specific conditions at the site where the system is to be constructed. Among the more critical elements of such designs are the transitions at both the upstream and the downstream limits of the project. If these transitions are not competently addressed, the intended bank protection system unravels from one end or the other. The height of the bank, the composition of the bed and bank and numerous other variables all need to be considered in the design of a bank protection system. There is no substitute for specialized, professional engineering expertise when it comes to designing these systems.

In preparing this Guide, the participating agencies contracted the services of Inter-Fluve, Inc., a consulting engineering firm with an extensive background in the design of biotechnical bank protection systems nationwide. Inter-Fluve, Inc. surveyed the range of conditions found along the banks of the Mendenhall River from the Back Loop Bridge to the airport. They then developed sets of schematic designs for three sites along the river that span the range of erosive energy along the river. The actual locations of the three sites were surveyed in detail to incorporate as realistic a set of design conditions as practicable. However, the resulting designs were not developed to the degree that they could be used for constructing bank protection systems at those sites. Nor should anyone attempt to use them in that way.

One way to use the Inter-Fluve, Inc. schematic design material is first to find as close a match as possible between the general characteristics of a prospective bank protection site and one of the Inter-Fluve, Inc. three type-localities, with particular attention to the stream gradient and ambient shear stress level. This will indicate the general style of construction that would be the most suitable to the site in question. However, before making any commitment to a project or seeking permits based on this type of construction, prudence would dictate bringing an experienced professional engineer into the project. Using the full text of Inter-Fluve, Inc. design report, the engineering professional will be able to verify the appropriateness of a particular bank protection system at a site and to address the critical transition structures at the upstream and downstream project limits. Perhaps most important of all, the engineer can develop a realistic estimate of the cost of building the project and thus establish project feasibility. Only then could project permitting and construction proceed on a sound footing.

This document and the example designs contained within provide a resource to agency personnel and the public regarding the benefits, capabilities, limitations, and potential application of bioengineering on the Mendenhall River. It is hoped that the information presented herein will assist in managing the river to the benefit of all.

## 2. INTRODUCTION

Rapid urban development in the last 15 years in the Mendenhall Valley has occurred along the east bank of the Mendenhall River, while the west bank remains relatively undisturbed and under park status along a substantial reach. Despite the rapid changes along the east bank, a vigorous sport fishery for steelhead, cutthroat trout, Dolly Varden and four species of salmon still exists in the system. Property owners and development managers with an eye to protecting their land from natural river erosion have been stabilizing their banks with riprap. At the same time, the Alaska Department of Fish and Game is concerned about early indications that the fishery may not be sustainable due to decreases in numbers for some species, such as coho salmon. The primary cause appears to be armored riverbanks, which speed up water velocity and are generally void of natural bank vegetation that helps provide food and cover for fish. A broader approach to address the reduction in fish habitat employs the use of land-use management actions on a watershed scale.

The City and Borough of Juneau, in coordination with the U.S. Geological Survey, U.S. Fish and Wildlife Service, and the Alaska Department of Fish and Game contracted with Inter-Fluve, Inc. for an investigation aimed at evaluating practical, environmentally-friendly bank stabilization alternatives to past bank armoring practices. The effort was divided into four tasks.

> Task 1: Conduct a reconnaissance of the river to assess areas vulnerable to destructive bank erosion, select three target areas that encompass the range of conditions found on the Mendenhall, determine survey needs, and evaluate existing riprapped banks for future enhancement.
>
> Task 2: For each target area, develop example design sheets and specifications which incorporate bio-engineered alternatives.
>
> Task 3: Present findings and proposed design information at a workshop for agencies, design professionals, contractors and the general public.
>
> Task 4: Submit a final report for use in planning, construction and maintaining bank stabilization projects along the Mendenhall River. The report is to address bioengineered bank stabilization techniques, present treatments for the three target sites (treatments that can be readily transferred to other sites on the river), and discuss construction procedures, materials and costs.

"Guidelines for Bank Stabilization on the Mendenhall River" is the end result of this effort and summarizes the investigation as called for under Task 4.

# 3. THE MENDENHALL RIVER

## 3.1. Physical Characteristics of the Mendenhall River

### 3.1.1 River History and Geomorphology

#### *3.1.1.1 Formation of the Mendenhall River*

The Mendenhall River is a relatively young drainage. Prior to the onset of glacial retreat in the mid-1700's, the Mendenhall Glacier discharged directly onto a broad outwash plain that contained multiple channels, including Duck Creek and Jordan Creek. The Mendenhall watershed is the drainage area of the Mendenhall Valley, from ridgetop to ridgetop, where water flowing from the mountains and valley flows down the through the rivers and streams into Gastineau Channel. Retreat of the Mendenhall Glacier has resulted in the impoundment of glacial meltwaters behind a series of recessional moraines in Mendenhall Lake. Sometime between 1750 and 1900, the rising lake overtopped the moraines, and created the present channel of the Mendenhall River, which is currently the principal valley drainage (Barnwell and Boning, 1968). The Mendenhall River rapidly incised, cutting a new channel in the outwash plain.

#### *3.1.1.2 Sediment Supply*

Mendenhall Lake has a maximum depth of 200 feet (Barnwell and Boning, 1968), and has served as a sediment trap at the toe of the glacier since its formation in the mid-1700's. Consequently, throughout its evolution, the Mendenhall River has received a minimal amount of coarse sediment directly from the Mendenhall Glacier. The primary sediment load for the river has historically been derived from the channel incision process and, perhaps Montana Creek.

Air photos from 1948 show extensive unvegetated bars along the entire length of the river. The 1996 photos show that most of those bars have been eroded out or reduced in size. This sequence suggests that the rapid downcutting of the Mendenhall River into the valley fill deposits created high sediment loads and extensive bar deposits, and that the sediment derived from the original downcutting event is being progressively transported out of the system.

Mendenhall Valley Drainage Study (R&M Engineering, 1996) updated the previous Mendenhall Valley drainage studies to both assess the adequacy of construction improvements performed since 1981 and evaluate the impacts of these developments upon the major surface drainage channels. The various stormwater drains which flow into the Mendenhall River are another mechanism which contributes sediment supply to the river. These drainage's along with associated maps for the drainage areas are listed in Table 8.4. and Appendix 8.4. Flow data for these drainage's are not available. However, storms and sporadic high rainfall events influence flow rate and sediment input.

Sediment load is also influenced by seasonality. The warmer midsummer weather increases the amount of glacial melt and glacial flour within the river. Glacial flour is the fine-grained sediment carried by glacial rivers that results from the abrasion of rock at the glacier bed. Its presence turns lake water aqua blue or brown, depending on its parent rock type. These events eventually affect the amount of sediment load and discharge in the Mendenhall River (refer to Sec. 3.1.2 River Hydraulics).

Urban runoff from non-point sources is a leading pollution source for Alaska's impaired surface waters (ADEC 1996). Duck Creek is currently listed by the State of Alaska as an impaired water body, which needs to be brought into compliance with water quality standards (Koski and Lorenz, 1999). On a watershed scale, urbanization has caused widespread detrimental changes to the physio-chemical condition of the aquatic habitats and its salmon habitat including: seasonal loss of stream flow, impaired water quality, loss of riparian zone functions, and fish passage. Best Management Practices (BMP's) are generally considered one of the best means of implementing measures to protect natural resources. BMP's for urban runoff can be defined, generally, as methods required to restrict the discharge of pollutants from human activities to water resources. Most urban stormwater BMP's were developed to prevent impacts to the physical and biological integrity of surface and ground water. BMP's can be either structural (e.g., sediment basins, oil/water separators, fencing) or managerial (e.g., runoff routing, fertilizer management, snow removal management practices).

#### *3.1.1.3 Vertical Stability/Uplift*

The presence of an active knickpoint in Subreach 3 (Figure 1) of the Mendenhall River indicates that downcutting within the system is not complete. A knickpoint is a point of abrupt change or inflection in the longitudinal profile of a stream in its valley resulting from rejuvenation and glacial erosion on the outcropping of a resistant bed. Rejuvenation refers to the action of stimulating a stream to renewed erosive activity, as by uplift or drop in sea level. The knickpoint provides evidence of vertical instability along the channel. Channel incision has likely slowed since the channel has downcut to the level of relatively resistant peat deposits, however that material is not immune to eventual erosion.

Brew and Horner (1993) estimate that the Juneau area is uplifting relative to sea level at a rate of approximately 0.05 ft./yr. (1.5 cm/yr.), or approximately one feet of uplift every 20 years. Regional uplift of the Mendenhall Valley with respect to sea level will result in a continual lowering of base level for the river. Historically, relatively high sediment loads derived from the channel downcutting have probably muted the effects of uplift, as deposition at the mouth would serve to lengthen the channel and minimize oversteepening. Oversteepening refers to an unstable state of the channel that is not in equilibrium. As sediment loads are reduced through time, due to combined trapping effects of Mendenhall Lake and slowed channel downcutting, the mouth of the Mendenhall River may oversteepen due to the uplift, and drive additional incision of the river system. The long-term effects of the uplift will be continued slow incision of the Mendenhall River.

The river was segmented into subreaches in the initial assessment as shown in Figure 1. The channel segments most prone to vertical instability are those downstream of the terminal moraine (Subreaches 1 to 3), where very coarse materials are not available to armor the channel bed. The presence of relatively resistant peat deposits in Subreach 3 may slow erosion within that reach, however, field observations indicate that the unit is erodible.

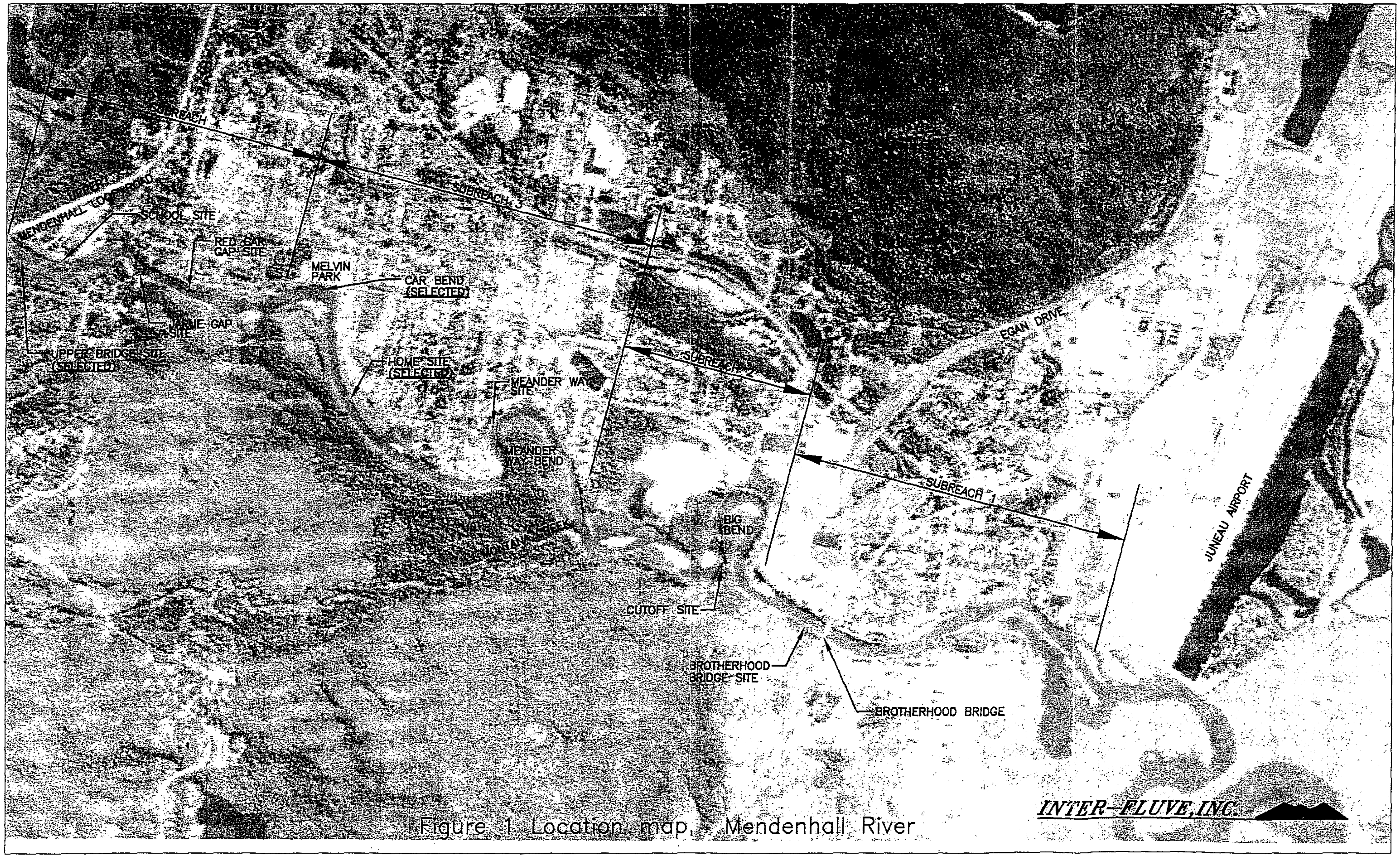


Figure 1 Location map, Mendenhall River

In Subreach 4, very coarse angular boulders deposited as lag deposits during the downcutting through the moraines appear to provide bed stability to that reach. The maintenance of bed stability in Subreach 4 controls the outlet elevation at Mendenhall Lake. If the outlet elevation were lowered sufficiently, sediment trapped in the lake would potentially become accessible to the river, and sediment loads would increase.

### 3.1.2 River Hydraulics

The flow conditions of a river are directly related to the current geomorphologic conditions, as represented by the physical dimensions of the channel profile and boundaries. The 1989 Hydrologic Engineering Center (HEC-2) computer model was developed by the U.S. Army Corps of Engineers and utilized for the Juneau Flood Insurance study. This HEC-2 model was reviewed for hydraulic values pertaining to the design of bank stabilization measures. This model generates water-surface profiles. This information, as it pertains to bank design, was verified and expanded through field review, discussion with agency personnel (including some historical and social perspectives), and reports pertaining to hydrology and revetment installations supplied by the City and Borough of Juneau. The field review allowed for inspection of channel bed material including composition and size, identification of bank soils and structure, relationships of channel alignment with topographic features, and identification of natural controls.

The channel geometry has probably adjusted itself somewhat from the original survey upon which the HEC-2 model is based on, as a consequence of sediment transport and on-going geomorphic processes. There is also some question relating to the correct incorporation of tidal effects into the model. In general, the program is a useful indicator of conditions to be found at a site and the forces which can be expected to act on the channel banks.

As measured at US Geological Survey (USGS) gauging station #15052500, the Mendenhall River encompasses a drainage area of a little over 100 square miles, more than half of which is glacial ice. The river flow averages about 1200 cubic feet per second (cfs), but mean monthly flows typically range from a low of less than 50 cfs in late winter to a high in excess of 3000 cfs in mid summer (USGS, 1997). Extreme events can top 16,000 cfs and produce stream velocities near the bank in excess of 20 feet per second. The banks of the river testify to this variation in flow. Stranded flotsam, logs and other debris mark the level of extreme flood flows. The lower limit of terrestrial vegetation on the banks coincides with the level at which the river flows during the summer; it also marks the high tide level where the river nears its mouth at Fritz Cove.

The USGS has a streamflow monitoring station (#15052500) in Mendenhall Lake. The streamflow monitoring station records lake elevations in 15-minute intervals. Lake elevational data, or stage data, are then plotted against corresponding streamflow measurements made in the vicinity of the Back Loop Bridge. From this plot, stage-discharge relation curves are constructed. From these curves, rating tables indicating the approximate discharge for any stage within the range of measurements are prepared. Daily mean discharges are computed by applying the daily mean stages (gage heights) to the stage-discharge tables. Daily streamflow values can be acquired from the following internet address: http://waterdata.usgs.gov/nwis-w/AK. The station ID number of 15052500 is then entered to obtain the values for the Mendenhall River. An example of the discharge values in cfs for the Mendenhall River from 10/1/96 to 9/30/98 is illustrated in Figure 2. As evident from Figure 2, streamflow discharge (cfs) values tend to

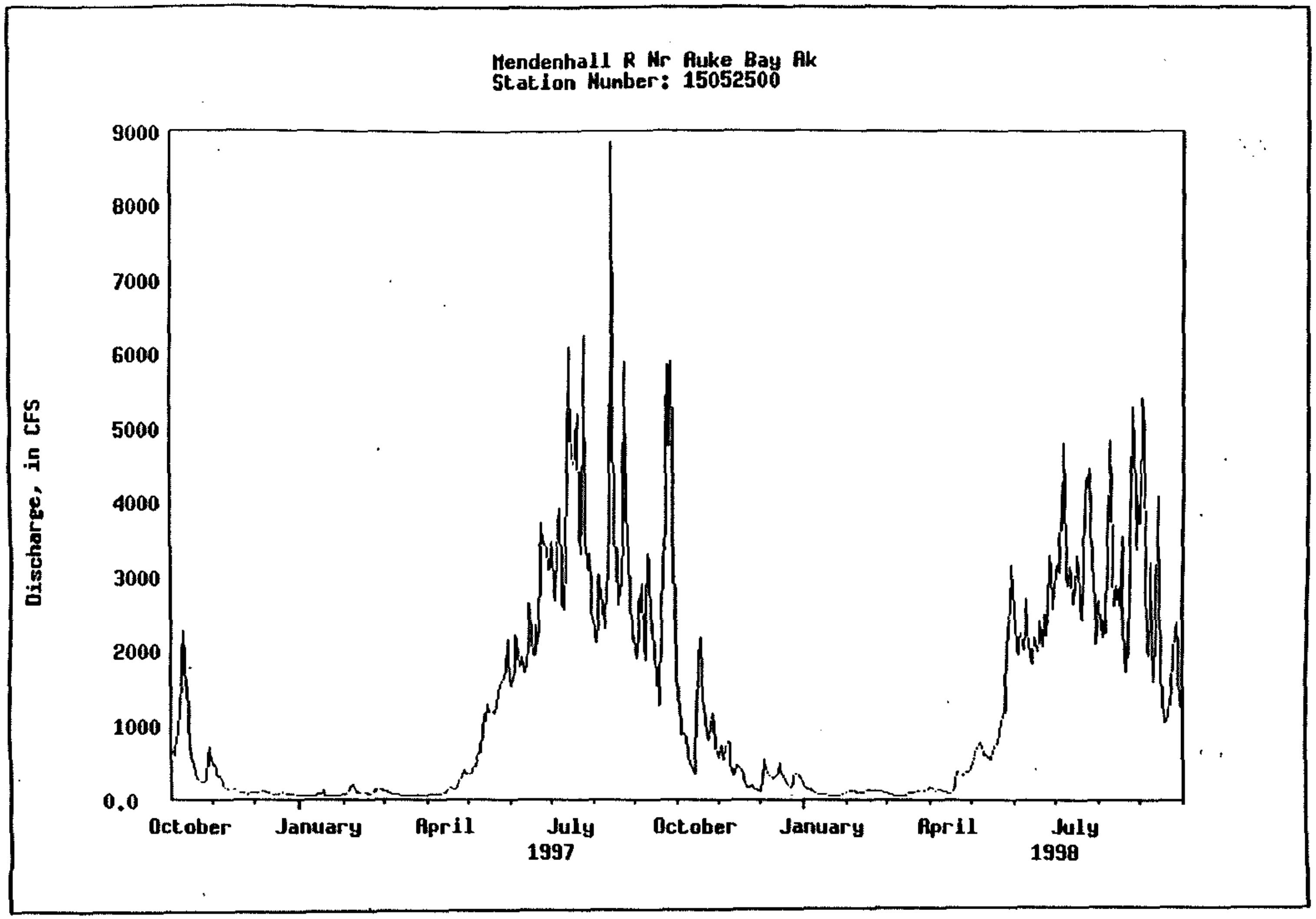



Figure 2. Historical Streamflow Daily Values Graph for Mendenhall River (USGS Station 15052500) from 10/1/96 to 9/30/98

increase dramatically in mid-summer. Seasonal rainfall events do influence discharge values; but temperature is also an influential variable (E.Neal, U.S. Geological Survey, Juneau, Alaska, personal communication). The warm summer months increases glacial melt, which adds directly the base flow of the river. In fall and winter, rainfall events can influence the discharge, especially storm events, but the melting of the glacier during the summer is a greater contributor to base flow of the river. Sediment loads also increase in summer due the increase of glacial flour in the river.

From its mouth to about 3,500 feet above the confluence of Montana Creek, the river is under tidal influence, with the water level in the river rising and falling with the tide. At times in mid winter, the current actually reverses direction and flows upstream during a rising tide. Above Montana Creek, the river gradient steadily increases, and with it the velocity of flow and the coarseness of the gravel banks and bottom. The steepest gradient occurs immediately downstream from the Back Loop Road Bridge, where the river flows over the terminal moraine left by the Mendenhall Glacier after its most recent advance. This reach is studded with large boulders that create white water rapids during the high flows of summer. Further upstream the river is again at a gentle gradient as it emerges from its source in Mendenhall Lake.

Small amounts of bank erosion are common along the length of the river, but the cause varies from reach to reach. In the intertidal reach, it is apparently the effect of the rising and lowering water level that weakens and undermines the banks, which cause them to collapse. Upstream, the river meander bends are migrating down the valley, with high velocity flood flows causing banks to erode on the outside bends and gravel bars to be deposited on the inside bends. One of these meander bends near Riverbend School threatens to cut through in the next few years and leave a loop of the river behind as an oxbow lake. Bank erosion in the steep whitewater reach is a function of extreme current velocity compounded by local turbulence caused by nearby boulders.

#### *3.1.2.1 Longitudinal Profile*

The values for velocity and shear forces can be categorized according to distinct subreaches in the longitudinal profile of the river (Figure 3). These Subreaches can be related to geomorphic influences, and will exhibit varied adjustments with time based on the anthropogenic conditions imposed on the system. There are three major hydraulic controls which influence the longitudinal profile: the tidal elevation at the outlet in Subreach 1, the large rock and boulder deposits from the receding bands of glacial moraine at the upper bridge in Subreach 4, and the boulder deposits at the lake outlet also in Subreach 4. The glacial boulder deposits at the upper bridge are located approximately 3,000 ft downstream of Mendenhall Loop Road Bridge and extend intermittently upstream, to approximately 1,000 ft above the bridge. The slope changes and location of slope changes in the longitudinal profile of the 1989 HEC-2 program correlate with the horizontal controls described.

#### *3.1.2.2 Channel Shear Forces and Velocities from 1989 HEC-2 Model*

The shear force on a channel bed is a primary design tool for assessing bank stability, and is calculated by the HEC-2 water surface model developed by the US Corps of Engineers. The shear values calculated for the Mendenhall River can be divided into two categories, low shear

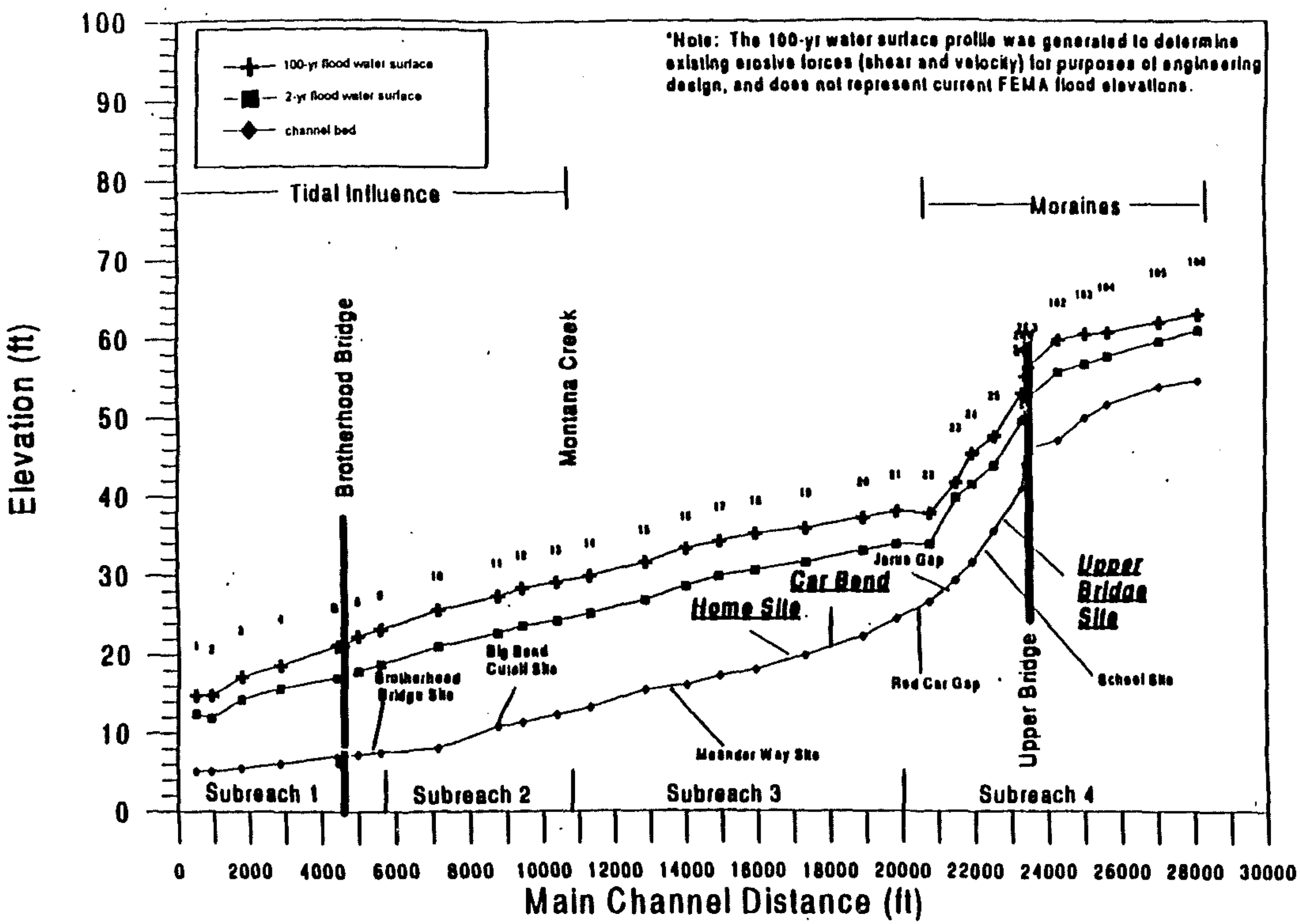



Figure 3. Channel profile of the Mendenhall River showing study subreaches, considered target sites, and selected target sites (underlined).

and high shear, with the low shear category defined in general as values which vegetation can withstand. However, since shear decreases with vertical distance up the riverbank, many of the upper bank regions along high shear portions of the river can be protected from erosion by vegetation. Average velocities calculated by the HEC-2 model would roughly correlate to the bed shear values or shear values operating on the lowest section of a bank. These values, however, are a less accurate indicator of erosive forces along the upper portion of the bank.

The sections of the river from the lake outlet to approximately 1000 ft above the upper bridge in Subreach 4 (Figure 1), and from 3000 ft below the upper bridge to the Fritz Cove outlet, in Subreach 3, 2, and 1, are areas of normally low shear forces (Figure 4). The channel banks in the 4000 ft of river near the upper bridge receives, on the average, considerably higher shear forces. This description is a gross generalization of the shear values to be expected along the Mendenhall River, and the values at specific locations may still exhibit a considerable range.

Two zones where wide variations between shear values calculated in the HEC2 model and shear values found in the field can be expected are: in the tidally-effected reaches, and in the vicinity of river bends (Figure 5). Tidal influences extending from the Fritz Cove outlet as far upstream as 3,500 feet above the confluence of Montana Creek render the calculated values from the HEC2 model suspect in this reach, as this reach may experience higher shear forces during certain periods in the tide cycle. Calculated bed shear forces may also vary noticeably from field conditions in tight meander bends. Shear values in these locations can increase by as much as 2.5 times the channel bed value. Both factors must be considered when making bank shear calculations for designing bank stabilization components.

## 3.2 Biological Resources of the Mendenhall River

### 3.2.1 The Mendenhall River Fishery

The Mendenhall River originates in the meltwater lake at the base of Mendenhall Glacier. The mainstem river and associated tributaries and lakes constitute a watershed rich in fish resources. All five species of eastern Pacific salmon occur in the watershed, as well as cutthroat trout, steelhead trout, Dolly Varden char, and eulachon. The drainage includes: Mendenhall Lake and associated tributaries, the most important being Steep Creek; Mendenhall River; Montana Creek and McGinnis Creek; Moose Lake and Dredge Lakes; and Duck Creek. There are other small lakes that are linked hydrologically, but are not accessible to anadromous fish.

The mainstem Mendenhall River should be viewed as the "underpinning" for maintaining fish production in the watershed, as it provides a migration corridor and critical habitat for all the fish resources in the entire drainage during some part of their lives. The Mendenhall River serves several essential functions: 1) is a migratory corridor for all salmon, trout, and char that are leaving or entering the watershed; 2) is home to resident trout and char throughout the year; 3) provides year-round rearing habitat for juvenile salmon and sea-run trout and char prior to their going to sea; 4) provides spawning habitat for several salmon, trout, and char. Because the mainstem Mendenhall River contains considerable glacial silt and it is difficult to make direct observations of fish utilizing different habitats in the river, these functional values have sometimes been overlooked.

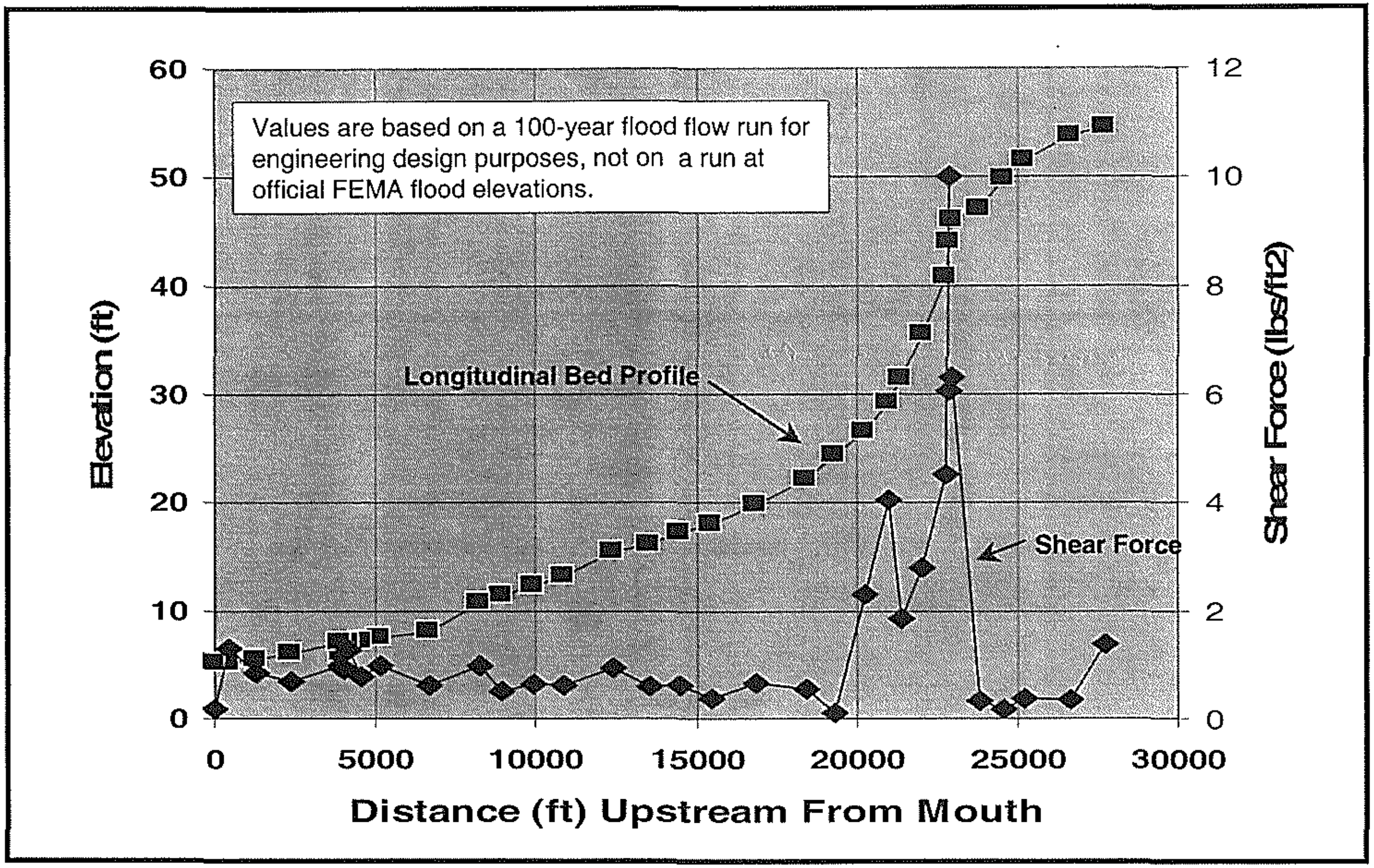
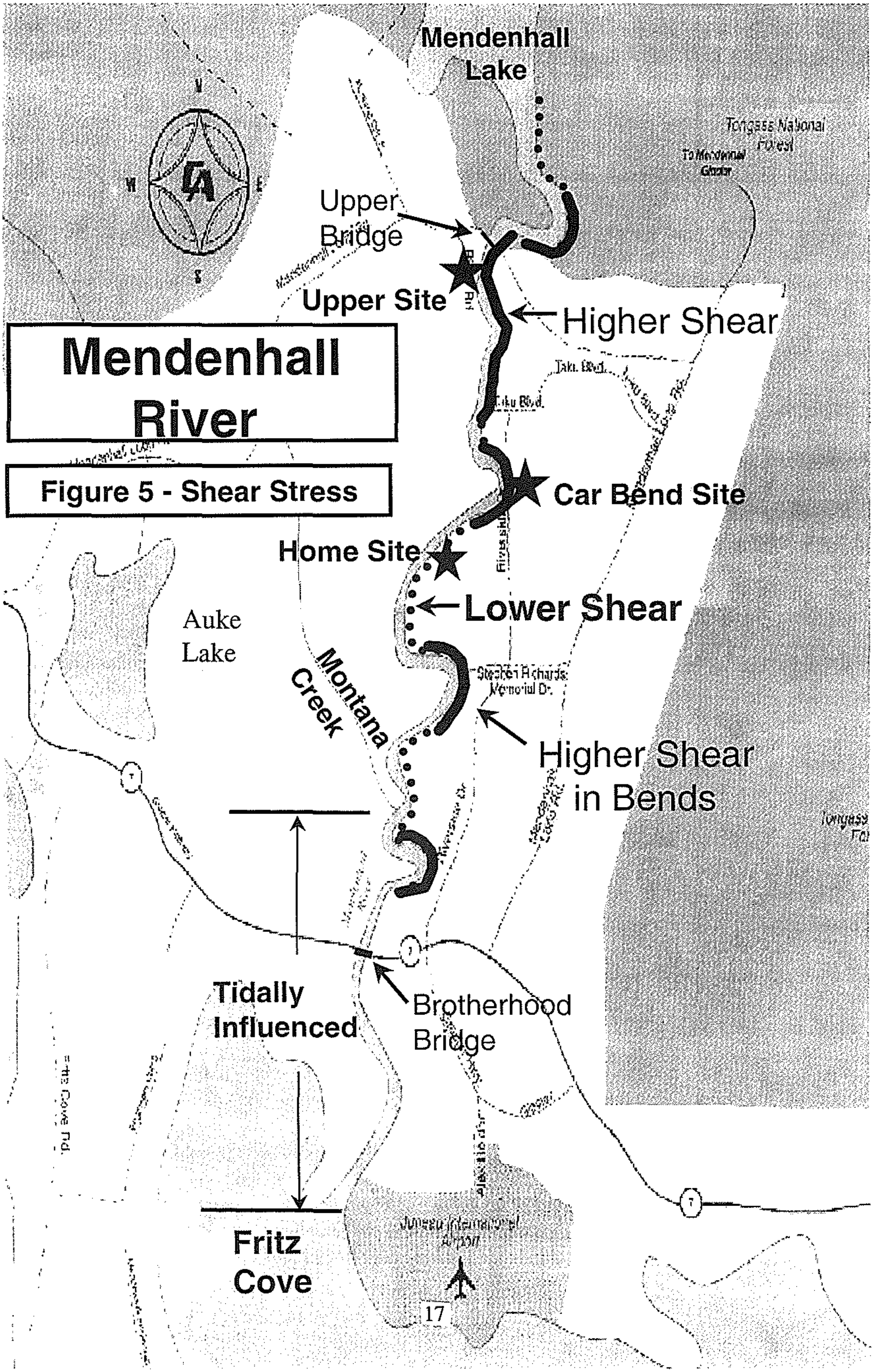



Figure 4. Mendenhall River Bed Shear Forces


Mendenhall Lake
Tongass National Forest
Upper Bridge
Upper Site
Higher Shear
Mendenhall River
Figure 5 - Shear Stress
Car Bend Site
Home Site
Lower Shear
Auke Lake
Montana Creek
Stephen Richards Memorial Dr.
Higher Shear in Bends
Tidally Influenced
Brotherhood Bridge
Fritz Cove
Fritz Cove Rd.

The various salmonid species found in the Mendenhall River can be categorized as rearing and non-rearing species. This refers to the amount of time the fish stay in fresh water after they have emerged from the gravel. Coho, sockeye and chinook salmon are species that live for one or more years in fresh water before going to sea. Chum and pink salmon fry spend very little time in fresh water after emergence, quickly moving downstream and entering salt water to begin their ocean life. Sea-run trout and char all rear for several years in fresh water before going to sea for the first time. What follows is a brief description of the salmonid fishes found in the Mendenhall River and how the river provides important habitat for their existence.

#### 3.2.1.1 Coho Salmon

This opportunistic species is found throughout the entire drainage where habitat is accessible to them. Coho salmon adults begin moving up the Mendenhall River in mid-August, with the run building into September and October. Except for early-maturing "jack" coho salmon that return to spawn in the same year they go to sea, nearly all other coho salmon return as adults to spawn after spending approximately 18 months (two summers and one winter) at sea. The majority of spawning occurs from late October through November. Although some coho salmon spawn in the mainstem Mendenhall River, most of the returning fish spawn in Montana Creek, McGinnis Creek, Steep Creek, and Moose and Dredge Lakes, as well as other small clear water tributaries to the main river or lakes.

The total escapement, or number, of adult coho that return to the watershed is unknown. Portions of Montana Creek and Steep Creek are surveyed annually throughout the adult return by fishery biologists to assess the strength of the return. The highest foot survey count, or peak count, is used as an index of abundance. Peak counts in the Montana-McGinnis Creek index area has averaged approximately 1,300 coho salmon from 1989 through 1998 (ADF&G Escapement Survey, Unpublished Data). Peak counts of coho salmon in Steep Creek for this same time period have averaged just over 230 coho salmon. Mark-recapture experiments at Steep Creek indicate that the peak foot survey count of coho salmon represents approximately 20% of the total escapement to the creek. If a similar relationship holds for the relationship of peak count to total escapement for Montana and McGinnis Creeks, then an annual escapement of coho salmon to Montana, McGinnis, and Steep Creeks approaches 8,000 coho salmon. Therefore, a conservative estimate of the return of coho salmon each year to the entire Mendenhall River drainage likely exceeds 10,000 fish.

Coho salmon eggs and embryos incubate through the winter and fry emerge from the spawning gravel the following spring. These young-of-the-year fry then disperse to other areas in the drainage. Minnow trapping data and coded-wire tag information indicate that juvenile coho salmon move extensively throughout the Mendenhall watershed during their one or two years residence prior to becoming smolts and going to sea. During this freshwater rearing phase of their life, the fish seek out areas of low velocity water that provide food and protection.

Coho fry and fingerlings rear in the Mendenhall River, primarily in side sloughs and backwaters adjacent to the shoreline or bank areas which contain instream woody debris and riparian vegetation along the bank. In such areas, the banks often have undercut zones and recesses that fish can frequent to avoid predators and fast water. Woody debris in the shoreline areas also provides comparable habitat attributes and such areas are relatively rich in invertebrate food items. Use of mainstem habitats by juvenile coho is probably most extensive in winter, when flows are low and water in the river is clear of glacial silt. Minnow trapping during late February 1999 showed juvenile coho salmon over-wintering in the river above the zone of tidal intrusion. Availability of suitable overwintering habitat in the mainstem is critical to survival of juvenile coho and other salmonids. Flow must be sufficient to provide access to vegetated bank habitat, side sloughs, and deep pools. Coho smolts leave the watershed during the spring, with peak migration time in May and early June.

#### 3.2.1.2 Sockeye Salmon

Adult sockeye salmon begin returning to the Mendenhall River in early to mid June and continue through early July. These mature fish comprise varying age-classes and represent several brood years; however, the majority of these fish are in their fifth year of life. Although a small number of returning adults may spawn in Montana Creek, other Mendenhall tributaries, and the mainstem, the vast majority of returning sockeye salmon swim the entire length of the Mendenhall and enter Mendenhall Lake, where they hold and ripen before spawning. Spawning begins in mid to late July and continues through August.

The total escapement of sockeye salmon to Mendenhall Lake is not known. Peak foot survey counts of sockeye salmon spawning in Steep Creek, the primary spawning inlet to the lake, has averaged about 1,430 sockeye salmon from 1989 through 1998. There is likely spawning in the ponds at the mouth of Steep Creek and shoal areas of Mendenhall Lake where there is upwelling water and suitable spawning gravel. After emergence from spawning redds the following spring, juvenile sockeye salmon rear in Mendenhall Lake for one or two years prior to going to sea. Rearing sockeye salmon feed primarily on zooplankton, but also consume terrestrial and aquatic invertebrates.

Some juvenile sockeye salmon disperse to other areas in the watershed for rearing. In such instances, young sockeye salmon will seek food and protection along shore where instream woody debris and intact riparian zones are present. Juvenile sockeye probably use mainstem rearing habitats year round. Studies on other glacial rivers in Alaska showed sockeye adapting and feeding successfully in glacial conditions.

#### 3.2.1.3 Pink and Chum Salmon

Total returns of pink and chum salmon to the Mendenhall River and drainage are not known. Run size varies dramatically from year to year, and on certain years can number into the many thousands. These species return to the watershed in July with spawning commencing rapidly and continuing through August. Most of the returning adults ascend Montana and McGinnis Creeks for spawning, however, there is spawning elsewhere, including the mainstem Mendenhall River, at sites such as the mouth of Duck Creek. All pink salmon adults are two years old, and strong or weak brood years are often perpetuated over time owing to the presence of only one brood year/age class in any given escapement. Chum salmon spend varying amounts of time at sea, and a spawning run on any given year is comprised of fish that are either three, four, or five years of age.

When fry of these species emerge from the gravel the following spring, they quickly migrate to salt water. Pink salmon are exceptionally rapid in their emigration, leaving within days of emergence. Chum salmon fry may take up to a month to enter salt water. The shoreline/riparian zone of the Mendenhall River provides the critical route to salt water for millions of pink and chum salmon fry each year.

#### 3.2.1.4 Dolly Varden Char

Dolly Varden char can take one of two forms, sea-run or resident. Both occur in the Mendenhall River system. Char are basically fall-spawning trout-like salmonid fishes. Other members of the genus *Salvelinus* include Arctic char, eastern brook trout, and lake trout. Resident Dolly Varden tend to be much smaller than their sea-run cousins, as the freshwater environment is not as productive as the ocean, hence growth is reduced, especially in smaller streams. Sea-run and resident Dolly Varden both require suitable spawning, rearing, and over-wintering habitat in the Mendenhall River watershed in order to complete their life history.

Adult Dolly Varden spawn in the upper reaches of Mendenhall tributaries during October and early November. Montana Creek, McGinnis Creek, and Steep Creek are key spawning areas. Mortality is sometimes high, especially on males, but Dolly Varden don't die after spawning, as do salmon. Surviving spawners will leave the spawning areas and generally seek out a lake in which to over-winter. For Dolly Varden in the Mendenhall watershed, there are several suitable over-wintering sites, including Mendenhall Lake and Moose Lake. From November until the following spring, many stocks of Dolly Varden, made up of adult fish and juveniles that have spent one or more summers at sea, will take refuge at the bottom of a lake or small pond with upwelling water. In such places, they are able to simply maintain themselves until the following spring where they migrate again to salt water. Some Dolly Varden likely over-winter in deep pools of the Mendenhall River.

Dolly Varden fry emerge in the spring from the previous fall spawn. They are very small and tend to be more bottom feeders than coho salmon. Young Dolly Varden likely move throughout much of the Mendenhall watershed. Minnow trapping along the shorelines of the Mendenhall River indicate that juvenile Dolly Varden are present year-round. Dolly Varden require similar habitat features for rearing in fresh water as do coho salmon and other rearing juvenile salmon and trout. They seek out shoreline areas that provide food, protection, and refuge from the stronger currents away from the banks.

Dolly Varden that take on the sea-run existence go to salt water for the first time generally at the age of three. It will be another two years before they become sexually mature. Juvenile and adult sea-run Dolly Varden will begin moving into the Mendenhall River as the salmon ascend and commence spawning. Some Dolly Varden will leave and seek out other streams until they either return to their home stream to spawn or move into their preferred over-wintering site. As the summer progresses, the sea-run population of Dolly Varden in the Mendenhall River becomes more comprised of Mendenhall spawners. Then, very late in the year after spawning is complete, adult Dolly Varden from other local streams lacking an over-wintering lake will enter the river and take refuge in Mendenhall Lake for the next five or six months.

The life history of Dolly Varden is complex. The Mendenhall River supports Dolly Varden from many local stocks and all life stages throughout the year.

### 3.2.1.5 Cutthroat Trout

The life history of cutthroat trout has many similarities to that of the Dolly Varden. Coastal cutthroat trout take on both resident and sea-run forms. Sea-run cutthroat trout seek out lakes in which to over-winter. Juvenile cutthroat trout rear in fresh water for several years prior to going to sea for the first time. Cutthroat differ, however, in their spawning time; cutthroat trout spawn in the spring, from late April through June, often at the uppermost reaches of drainage tributaries. As with Dolly Varden, cutthroat trout don't die after spawning, though natural annual mortality can approach or even exceed 40%. Sea-run fish rarely live longer than 8 years.

Both forms of cutthroat trout occur in the Mendenhall River and associated tributaries. The number of cutthroat trout utilizing the river system is unknown but it is clear from anecdotal information and observations during foot surveys that cutthroat trout are not nearly as abundant as Dolly Varden in the Mendenhall watershed. Major spawning areas include Montana/McGinnis Creeks, Steep Creek, and tributaries in the Dredge Lake and Moose Lake areas. Although severely impacted by development, Duck Creek still supports limited cutthroat trout spawning. Cutthroat fry emerge from spawning redds in late mid to late July or early August.

Given their life history attributes, resident and sea-run cutthroats are found throughout much of the watershed year round. The generalized habitat features that are important to other rearing species of salmonids are equally important to cutthroat trout.

### 3.2.1.6 Chinook Salmon and Steelhead Trout

Chinook, or king salmon, and steelhead trout occur in the Mendenhall River drainage in small, undetermined numbers. It is possible that both species have become established in the watershed because of past stocking activities in Montana Creek and Moose Lake. Adult chinook salmon now found in the Mendenhall River could also be the result of local hatchery straying, as there is a large chinook salmon enhancement program in the Juneau area and many chinook return to release sites not far from the mouth of the Mendenhall River.

Adult chinook salmon enter the Mendenhall River in July and spawn during August. Spawning chinook are mostly seen in Montana Creek, below the rifle range and gorge. Resulting fry emerge the following spring and begin their rearing phase there or downstream in the Mendenhall River. Juvenile chinook salmon have been trapped in both Montana Creek and the Mendenhall River. Juvenile chinook rear in fresh water for one year before going to sea. Rearing chinook salmon prefer moving water with woody debris present to provide cover and protection. Chinook salmon tolerate glacially influenced water, and margins of the Mendenhall where habitat values have been maintained serve young chinook well. Out-migrating chinook smolts move down the Mendenhall River from late April to early June, and utilize bank areas that retain habitat values during their short migration to sea.

The extent of their ocean life varies greatly among individuals of any given brood year. Returning adults range widely in total age, from three to seven years. The majority of returning fish have spent two, three, or four years at sea.

Steelhead trout are in essence sea-going rainbow trout. Adults return to fresh water to spawn for the first time after spending two or three years at sea. Approximately 25% of the steelhead that survive spawning, survive to spawn again in a subsequent year, and Southeast Alaska steelhead are interesting for the high number of repeat spawners in the runs. Adult steelhead occur in the river from late April through June, with peak spawning occurring in mid May. Upper Montana Creek and McGinnis Creek are the likely spawning locations. Steelhead fry emerge from the spawning gravel later the same summer, in July or early August, and begin several years of stream rearing before going to sea. Rearing steelhead prefer swift water, in stream reaches with boulder and cobble bottom. However, to date, there are no data from trapping efforts that document specific rearing sites for steelhead in the Mendenhall drainage.

#### 3.2.1.7 Eulachon or Hooligan

Although very poorly described in size and river utilization, there is a spawning run of eulachon in the lower Mendenhall River. These anadromous smelt spend most of their life in salt water, but return to their natal stream in the spring for spawning. Spawning occurs in the lower mainstem Mendenhall River, and is documented primarily through the concentration of bald eagles and species of gulls that either prey or scavenge on these fish while in the river during the month of May.

### 3.2.2 Importance of Mendenhall River Drainage Fish Resources

Describing the importance or placing a value on the Mendenhall fish resources is very difficult. Economic value of fish resources, in terms of a dollar value of fish purchased from commercial fishers, or dollars expended by recreational anglers seeking to catch these fish, are two ways of putting a dollar value on fish contributing to such fishing activities. There have been no economic studies to answer such questions related specifically to the Mendenhall River fish resources. However, it may still be possible to characterize in some fashion, a monetary worth of at least one species, coho salmon, based on other available information.

As stated above, the average annual escapement of coho salmon to the drainage may be in the range of 10,000 fish. Exploitation rate information on coho salmon from nearby Auke Creek has shown that about half, or 50% of the annual return is harvested in commercial and recreational marine fisheries. That means for every fish that makes it back to the river, one is harvested in the ocean (there is additional recreational harvest in fresh water). With an assumption that 95% of the coho salmon are taken in commercial fisheries and 5% are taken in the marine recreational fishery, we can first calculate a dollar value of the fish sold in the commercial fisheries. The average price paid to commercial fishers in 1998 for a coho salmon was $4.62 (C.Farrington, Alaska Department of Fish and Game, Douglas, Alaska, personal communication). If commercial fishers caught 9,000 coho salmon destined for the Mendenhall River drainage, then these coho salmon were worth about $43,890 to commercial fishers. This in no way represents the total economic value of these fish to the local economy, because it does not include money expended by commercial fishers in order for them to participate in the fishery or other related costs in the seafood processing and retail industries.

Given the fish harvested in a recreational fishery are not sold, the best way to approach the economic worth of a recreational fishery is to estimate the dollars expended by participants in the recreational fishery and then calculate an expenditure per fish harvested in the recreational fishery. One study conducted 10 years ago indicated that marine recreational anglers in Southeast Alaska expended $250 dollars for every coho salmon harvested (Jones and Stokes Assoc. Inc., 1991). Assuming the 1998 sport harvest was average (i.e., 500 coho salmon in the marine boat sport fishery), and taking inflation into account since the 1991 study, the dollar value of the Montana Creek coho in the 1998 marine sport fishery was nearly $167,000 dollars. This is based on $333 dollars expended per every coho salmon harvested.

Montana Creek is the most popular freshwater sport fishing location on the Juneau road system. Much of the sport fishing activity takes place at the confluence of Montana Creek and the Mendenhall River. Statewide Harvest Study results show that in 1997, over 3,100 angler-days of fishing effort occurred on the creek and nearly 5,700 salmon, trout, and char were caught, and nearly 800 fish were harvested. There are no economic surveys to apply any meaningful estimators of economic value to this freshwater recreational fishery.

There are other values attributable to the fish resources of the Mendenhall River drainage. For example, there has been considerable research showing the ecological importance to aquatic and adjacent terrestrial ecosystems from the transfer of marine nutrients accumulated by growing salmon which are subsequently transferred to the freshwater and terrestrial ecosystems when salmon are eaten by predators or scavengers and as their carcass decomposes. Without the annual return of thousands of salmon to the drainage, the overall wildlife resources in the watershed would be greatly diminished.

Finally, thousands of people residing in Juneau, and many more that come from around the world to experience Alaska, observe sockeye salmon spawning in Steep Creek when they visit the Mendenhall Glacier. For many of the tourists, it is the first time in their lives they have observed wild salmon spawning in their natural environment. It is one of the most memorable events they experience during their visit to Alaska. The importance of such an opportunity or experience is difficult to evaluate. It might be possible to put an economic value on such an opportunity through some type of "willingness-to-pay" determination via a carefully designed economic survey. However, the true worth of such experiences most certainly transcends such limited evaluations.

### 3.2.3 Wildlife Biological Resources

An abundance of aquatic and terrestrial resources are associated with the Mendenhall River and its river banks and floodplains. The Mendenhall River wetlands provides important feeding and/or nesting habitats for migrating waterfowl. Typical species include: mallards, goldeneyes, ring-necked ducks, scaup, northern shovelers, green-winged teal, northern pintails, harlequin ducks, red-breasted mergansers, red-throated loons, and tundra swans. Other avian species present include shorebirds (killdeer, spotted sandpipers, and semipalmated plovers), terns (arctic), and gulls (herring, glacous-winged, Thayer's, mew, and lesser-black). Raptors, such as the American Bald Eagle, rely on fish and fish carcasses to provide nutrition on a yearly basis.

Mammalian species present within the Mendenhall River area include the following species: Keens mouse, long-tailed vole, hoary marmots, lynx, black bears, red fox, Sitka black-tailed deer, ermine, porcupines, river otters, muskrats, beavers, hares, lynx, and coyotes.

Floodplains, especially those upstream of the rapids (where the river and banks are broader and less developed), are recognized as wildlife concentration areas due to supplies of overwintering fish, and fish carcasses, especially in the tough winter months. Overhanging and instream vegetation also provides woody debris, leaf litter, and invertebrates - all of which are important for fish habitat.

### 3.2.4 Wetlands

Wetlands management is important in Juneau because a significant portion of the community's remaining undeveloped land is wetlands and development pressures on these lands can be great (City and Borough of Juneau, 1997). Table 3.1 lists the losses of Juneau Wetlands from 1948-1984 (Adamus, 1987). Clearly, much of Juneau's growth has occurred on land that formally was wetlands. In general terms, wetlands are lands where saturation with water is the dominant factor determining the nature of soil development and the types of plant and animal communities living in the soil and on its surface (Cowardin et.al., 1979). Uplands refer to any area that does not qualify as a wetland because the associated hydrological regime is not sufficiently wet to elicit development of vegetation, soil, and/or hydrological characteristics associated with wetlands (Environmental Laboratory, 1987). Riparian wetlands are especially important for protecting channel morphology and determine the distribution of anadromous fish habitat (Koski and Lorenz, 1999).

The importance of wetlands can be summarized in the following nine wetland functions (Thompson, 1999):

- floodflow alteration : reducing flood damage and retaining water over prolonged periods;
- groundwater interchange: groundwater discharge and recharge;
- sediment and toxicant retention: maintenance of water quality;
- sediment and shoreline stabilization: avoidance of hard erosion control structures;
- nutrient removal/retention/transformation: trap, store, transform, and release nutrients which; enter the system through runoff water from surrounding wetlands or contiguous wetlands;
- production export: flush organic material (i.e., carbon from net annual and secondary production) to downstream or adjacent deeper waters for use by living organisms;
- wildlife habitat;
- fish habitat; and
- rare, threatened, species of concern or endangered species.

| Table 3.1 | Juneau Wetland Losses 1948-1984[1]. | | | | |
|---|---|---|---|---|---|
| Subunit | Size (acres) | Wetland | Wetland | Development | Development |
| | Of | Acres Filled | Ac/Yr Filled | 1948-1984 | 1948-1984 |
| | Subunit | 1948-1984 | 1948-1984 | % in Wetlands | % in Uplands |
| Auke Bay | 1208.0 | 30.2 | 0.8 | 43.8 | 56.2 |
| Duck Cr. | 1690.0 | 320.6 | 8.9 | 28.2 | 71.8 |
| East Mend. | 2712.0 | 318.2 | 8.8 | 68.7 | 31.3 |
| Jordan Cr. | 484.0 | 4.3 | 0.1 | 9.5 | 90.5 |
| Lower Mon. | 1019.0 | 6.3 | 0.2 | 6.6 | 93.4 |
| Upper Mon. | 1207.0 | 6.5 | 0.2 | 7.8 | 92.2 |
| West Mend. | 1901.0 | 119.6 | 3.3 | 73.2 | 26.8 |
| Totals | 10221.0 | 805.7 | 22.3 | 34.0 | 66.0 |
| | | | | | |
| [1]Data from the U.S. Fish & Wildlife Service | | | | | |

An update of the 1948-1984 wetland trend study was conducted for the Mendenhall Valley area by the U.S. Fish and Wildlife Service, National Wetlands Inventory (NWI), Anchorage, Alaska. The documentation of wetland losses and gains covered the period from 1984 to 1997. The NWI program also developed the data for the earlier analysis of wetland trends between 1948 and 1984 (Adamus 1987).

Study Area

The study area boundaries correspond to watershed subunits defined in Juneau Wetlands - Functions and Values (Adamus 1987). The following subunits associated with the Mendenhall Valley included the following areas (Fig. 6):

> Auke Bay, Duck Creek, East Mendenhall, Jordan Creek, Lower Montana Creek, Upper Montana Creek, West Mendenhall.

Methods

Aerial photography from 1984 and 1997 was used to measure wetland losses and gains in the seven watershed subunits:

| Photo Date | Type | Scale |
|---|---|---|
| 9/24/84 | Black and White | 1:24,000 |
| 8/16/97 | Color | 1:12,000 |

The 1997 photography was analyzed stereoscopically and annotated in accordance with photo interpretation conventions developed by the NWI (USFWS 1995). Wetlands were classified using the Classification of Wetlands and Deepwater Habitats of the U.S. (Cowardin et al., 1979). The information on the photos was transferred to base maps at a scale of 1:12,500. The two base maps used were enlargements of 1:25,000 scale USGS quadrangles (Juneau B-2 SW, and Juneau B-2 NW). The resulting wetland maps showing wetland cover in 1997 are available from the NWI office in Anchorage, Alaska.

The NWI analysts compared the 1984 aerial photography to the 1997 wetland maps. Areas that had changed during the 1984-1997 time frame were delineated. Wetlands lost during the period were classified according to the cause of the loss (i.e., residential development, commercial development, etc.) and according to the City and Borough of Juneau's (CBJ) Wetland

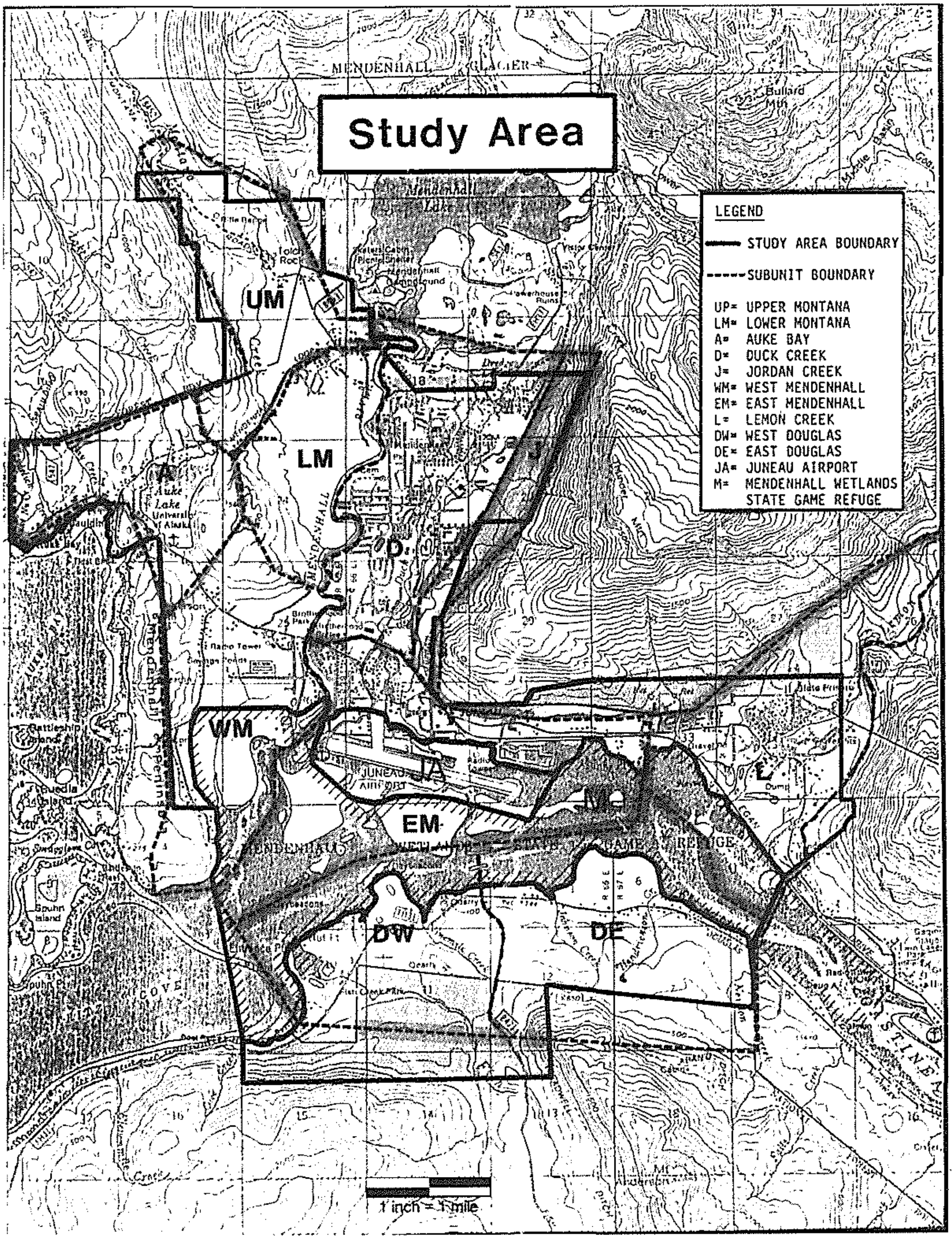



**Figure 6. Study Area Watershed Subunits**

Management Categories. The 1997 wetland maps and the 1984-1997 trend map were digitized and spatially merged in order to develop wetland acreage data on (1) 1984 wetlands, (2) 1984-1997 wetland losses, gains and changes, and (3) 1997 wetlands.

Results

Tables 3.2-3.5 show the results of the wetland trend analysis. Table 3.2 reveals that 116.4 acres of wetland was lost between 1984 and 1997. This loss was offset by a gain of 18.9 acres, resulting in a net loss of 97.5 acres. This equates to a 2.3 percent reduction in wetland cover between 1984 and 1997. The same table presents data on the cause of loss according to four categories. The definition of these categories follows:

Residential Development: Construction of single family homes, condominiums, apartment buildings, etc. This category includes the roads and driveways associated with the residential development.

Commercial Development: Construction of buildings, fill pads, and roads associated with the development of commercial establishments such as retail stores, restaurants and motels. This category also includes public and private office buildings and associated development.

Industrial Development: Construction of light industrial facilities including warehouses and heavy equipment/large vehicle storage yards. This category also includes airport development, development of airport-related facilities (e.g., air cargo businesses), and gravel mining.

Other: This category was used primarily for public roads not specifically built for one of the development types listed above. It was also used where initial development had occurred (e.g., placement of a fill pad), but eventual use of the area could not be determined.

Nearly half of the losses occurred in the East Mendenhall subunit. Much of this loss is a result of airport related development. The Jordan Creek and Upper Montana Creek subunits had less than 2 acres lost during the 13-year time period. The 116.4 acres of wetland lost due to development activities were the result of 84 separate development actions. The average development action resulted in a loss of 1.4 acres of wetland.

**Table 3.2 Cause of Wetland Loss in the Mendenhall Valley area, 1984-1997[1].**
**Data from U.S. Fish and Wildlife Service, National Wetlands Inventory.**

| Subunit | Size (acres) Of Subunit | Wetland Acres 1984 | Cause of Wetland Loss by --------Development Type--------<br>Resi-dental | Commer-ercial | Indus-trial | Other | Total Loss | Wetland Gains | Net Loss or Gain | Wetland Acres 1997 | %Wetland Loss (or Gain) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Auke Bay | 1323.2 | 436.0 | 6.3 | 0.9 | 0.4 | 7.0 | 14.6 | 0.0 | -14.6 | 421.4 | -3.3 |
| Duck Cr. | 1520.2 | 116.4 | 7.4 | 5.5 | 0.0 | 0.0 | 12.9 | 1.1 | -11.8 | 104.6 | -10.1 |
| East Mend. | 2710.5 | 1527.7 | 0.4 | 0.7 | 46.8 | 4.5 | 52.4 | 0.4 | -52.0 | 1475.7 | -3.4 |
| Jordan Cr. | 506.7 | 223.0 | 0.0 | 0.0 | 0.0 | 1.7 | 1.7 | 0.0 | -1.7 | 221.3 | -0.8 |
| Lower Mon. | 987.8 | 485.1 | 3.7 | 0.7 | 0.0 | 1.7 | 6.1 | 0.0 | -6.1 | 479.0 | -1.3 |
| Upper Mon. | 1350.2 | 608.5 | 2.1 | 0.0 | 0.0 | 0.0 | 2.1 | 7.6 | 5.5 | 614.0 | 0.9 |
| West Mend. | 1951.2 | 914.2 | 5.4 | 9.9 | 1.0 | 10.3 | 26.6 | 9.8 | -16.8 | 897.4 | -1.8 |
| Totals | 10349.8 | 4310.9 | 25.3 | 17.7 | 48.2 | 25.2 | 116.4 | 18.9 | -97.5 | 4213.4 | -2.3 |

[1]Data for deepwater habitats (i.e., limnetic portions of lakes, subtidal estuarine areas, and permanently flooded river channels) are excluded from this table.

Table 3.3 correlates the 116.4 total acres lost in the study area with CBJ wetland management categories as described in the Juneau Wetlands Management Plan (CBJ 1997). There were a significant number of losses that occurred (29.5 acres) in areas not identified as wetland in the management plan. Much of this discrepancy is a result of the difficulty in identifying the boundaries of forested wetlands in mature forested areas. Errors of commission and omission related to forested wetland identification are likely present in both the NWI and CBJ mapping.

**Table 3.3 Wetlands Losses 1984-1997 (acres)[2] Correlated to Wetland Management Categories Identified in the Juneau Wetlands Management Plan**

| Subunit | Wetlands Lost 1984-1997 (Acres) | Losses by CBJ Wetland Management Categories: A | A/B | B | B/C | C | D | Refuge | EP | No CBJ Design. |
|---|---|---|---|---|---|---|---|---|---|---|
| Auke Bay | 14.6 | 0 | 0 | 5.9 | 0 | 0.4 | 0.4 | 0 | 0 | 7.9 |
| Duck Creek | 12.9 | 0 | 0 | 6.5 | 0 | 0 | 0 | 0 | 0 | 6.4 |
| East Mendenhall | 52.4 | 0 | 0 | 2.7 | 0 | 6.5 | 0.4 | 38.3 | 1.2 | 3.3 |
| Jordan Creek | 1.7 | 1.7 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Lower Montana | 6.1 | 5.4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.7 |
| Upper Montana | 2.1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2.1 |
| West Mendenhall | 26.6 | 0 | 2 | 5.6 | 3 | 4.9 | 2 | 0 | 0 | 9.1 |
| Totals | 116.4 | 7.1 | 2 | 20.7 | 3 | 11.8 | 2.8 | 38.3 | 1.2 | 29.5 |

2 Data from U.S. Fish and Wildlife Service, National Wetlands Inventory. The last column represents wetlands identified by the U.S. Fish and Wildlife Service that do not appear on the CBJ Wetland Maps

Table 3.4 compares the results of the 1984-1997 trend analysis with previous work conducted by the NWI program for the 1948-1984 time period. The 1948-1984 results previously published (Adamus 1987) have been modified to account for additional wetlands identified as a result of improved mapping techniques used in the 1984-1997 analysis. Subunit sizes have also changed slightly due to the delineation of more accurate study area boundaries. Data in Table 3.4 shows that an average of 22.3 acres of wetlands was lost each year between 1948 and 1984. This average annual loss rate dropped to 7.5 acres/yr. for the 1984-1997 time period.

**Table 3.4 Mendenhall Valley Area Wetland Losses and Gains, 1948-1984 and 1984-1997[3].**

| Subunit | Size (acres) Of Subunit | Wetlands 1948 | Net Losses 1948-1984 | Net Ac/Yr Lost 1948-1984 | Wetlands 1984 | Net Losses (or Gains) 1984-1997 | Net Ac/Yr Lost/Gain 1984-1997 | Wetlands 1997 |
|---|---|---|---|---|---|---|---|---|
| Auke Bay | 1323.2 | 466.2 | -30.2 | -0.8 | 436.0 | -14.6 | -1.1 | 421.4 |
| Duck Cr. | 1520.2 | 437.0 | -320.6 | -8.9 | 116.4 | -11.8 | -0.9 | 104.6 |
| East Mend. | 2710.5 | 1845.9 | -318.2 | -8.8 | 1527.7 | -52.0 | -4.0 | 1475.7 |
| Jordan Cr. | 506.7 | 227.3 | -4.3 | -0.1 | 223.0 | -1.7 | -0.1 | 221.3 |
| Lower Mon. | 987.8 | 491.4 | -6.3 | -0.2 | 485.1 | -6.1 | -0.5 | 479.0 |
| Upper Mon. | 1350.2 | 615.0 | -6.5 | -0.2 | 608.5 | 5.5 | 0.4 | 614.0 |
| West Mend. | 1951.2 | 1033.8 | -119.6 | -3.3 | 914.2 | -16.8 | -1.3 | 897.4 |
| Totals | 10349.8 | 5116.6 | -805.7 | -22.3 | 4310.9 | -97.5 | -7.5 | 4213.4 |

[3] Data from U.S. Fish and Wildlife Service, National Wetlands Inventory. Data for deepwater habitats (i.e., limnetic portions of lakes, subtidal estuarine areas, and permanently flooded river channels) are excluded from this table.

Table 3.5 shows the acreage of wetland/deepwater habitat classes in the study area in 1984 and 1997. The 4th and 5th data columns (*Change in Acres* and *Percent Change*) do not necessarily reflect wetland or deepwater habitat losses and gains. Many wetlands experienced a change in classification over the 13-year period while remaining wetland (e.g., a Palustrine Emergent wetland may become a Palustrine Scrub/Shrub wetland because of natural succession).

**Table 3.5 Changes in wetlands/deepwater habitat classes in the Mendenhall Valley Study Area, 1984- 1997[4].**

| Wetland/Deepwater Habitat Type | Acres 1984 | Acres 1997 | Change in Acres 1984-1997 | Percent Change 1984-1997 |
|---|---|---|---|---|
| Estuarine Subtidal | 435.6 | 443.2 | 7.6 | 1.7 |
| Estuarine Mud Flat | 335.1 | 339.0 | 3.9 | 1.2 |
| Estuarine Salt Marsh | 1234.0 | 1205.8 | -28.2 | -2.3 |
| Lacustrine Limnetic | 249.1 | 247.1 | -2.0 | 0.1 |
| Lacustrine Littoral | 40.6 | 40.6 | 0.0 | 0.0 |
| Palustrine Open Water | 55.0 | 49.3 | -5.7 | -10.4 |
| Palustrine Emergent | 521.1 | 476.5 | -44.6 | -8.6 |
| Palustrine Scrub/Shrub | 654.6 | 663.5 | 8.9 | 1.4 |
| Palustrine Forested | 1452.5 | 1415.3 | -37.2 | -2.6 |
| Riverine | 145.1 | 145.0 | 0.0 | -0.1 |
| Totals for Wetlands & Deepwater Habitats | 5122.7 | 5025.3 | -97.4 | -1.9 |

More than 100 wetland and deepwater habitat categories (Cowardin et al., 1977) were identified during the photo interpretation phase of the wetlands trends study. For data presentation purposes, these types were combined into the 10 classes shown in Table 3.5. Descriptions of the classes follow:

Estuarine Subtidal: Subtidal, low-energy brackish open water. This category includes the subtidal areas of Gastineau Channel and subtidal channels in the Mendenhall Wetlands State Game Refuge.

Estuarine Mud Flat: Intertidal mud flats that are usually unvegetated and composed of sand and silt-sized particles. For purposes of this study, however, the class also includes flats vegetated with algae (e.g., *Fucus* sp. and *Ulva* sp.) and small areas of rocky shore.

Estuarine Salt Marsh: Intertidal marsh that is alternately flooded and exposed by brackish tidal water. This class includes low marsh areas flooded daily by tidal water and high marsh zones that may only be flooded a few times each month. Common species include *Carex lyngbyei, Triglochin maritimum, Plantago maritima, Potentilla egedii, and Elymus arenarius.*

Lacustrine Limnetic: This class includes portions of lakes that are greater than 2 meters in depth. Examples of this class include most of Auke Lake and portions of the Juneau Airport float plane base.

Lacustrine Littoral: Shallow portions of lakes including unvegetated open water, aquatic beds (e.g., *Nymphaea tetragona and Potamogeton* sp.), and sand flats.

Palustrine Open Water: Small open water bodies (ponds). This class also includes (1) ponds that may be vegetated with aquatic beds (e.g., *Nymphaea tetragona and Potamogeton* sp.), and (2) small basins that may only contain water on a seasonal basis. Some of the wetlands in this class are manmade excavations in developed areas.

Palustrine Emergent: Wetlands dominated by herbaceous vegetation such as sedges, grasses, and forbs. Includes wetlands commonly referred to as marshes and wet meadows.

Palustrine Scrub/Shrub: Wetlands dominated by woody vegetation less than 6 m (20 feet) tall. Includes true shrubs such as willow, young trees, and trees that may be stunted because of environmental conditions (e.g., *Pinus contorta* in wet bogs). Other common species dominating Scrub/Shrub wetlands include blueberry, alder, and bog laurel.

Palustrine Forested: Wetlands dominated by woody vegetation greater than 6 m (20 feet) tall. This is the most abundant wetland class in the Mendenhall valley study area. Sitka spruce and western hemlock dominate most of the forested wetlands. Cottonwood and tree-size alder and willow occur in wetlands in a few areas.

Riverine: This class includes wetlands and deepwater habitats contained within the channel banks of rivers, streams and creeks.

### 3.2.4 Potential wetland restoration projects

The Mendenhall Watershed Partnership's Restoration Subcommittee has discussed possible restoration projects that could be accomplished in the Mendenhall Valley (Appendix 8.7). The Mendenhall Watershed Partnership is a community group whose purpose is to maintain and enhance the environmental quality and economic vitality of the Mendenhall watershed. The Restoration Subcommittee includes citizen members of the Partnership, as well as technical advisors from local, State and federal government agencies.

The projects listed in the Restoration Matrix could be accomplished by a number of parties -- including developers required to provide mitigation for projects elsewhere in the watershed, government agencies, the Mendenhall Watershed Partnership, other community groups, citizens, or partnerships involving several of these parties. This list of restoration projects is dynamic, and projects will be added or removed as conditions change in the watershed, projects are completed, or new priorities emerge. The Mendenhall Watershed Partnership has not yet prioritized the restoration projects and discussions about the projects' importance, feasibility and funding are continuing.

The following criteria will be used by the Partnership to establish restoration project priorities:

- Values such as water quality, fish habitat, and drinking water are at current risk of damage or loss;
- Costs are expected to provide reasonable benefit;
- Project is feasible and there is good probability of success;
- Project supports on-going, successful restoration work or programs;
- Project capitalizes on a "partnership" with other agencies or community groups, and there is public interest or other momentum to finish the project; and
- Project furthers the mission of the Mendenhall Watershed Partnership.

### 3.3 Bank Protection on the Mendenhall River

#### 3.3.1 Stone Riprap

Riprap protection has been installed previously by individual landowners and development groups who own property abutting the river. There is also large rock present in the upper reaches of the river from a naturally occurring source. In its traverse of the moraine bands, the river has eroded all but the largest sizes of material leaving large boulders up to 6 ft in diameter in the channel bed. The end result of privately installed revetments and naturally exposed glacial boulders is that residents are conditioned to seeing large rock in the river, and their expectations of the success of bank protection measures may be directly related to the size of the rock employed. The fairly recent and publicized failure of bank revetment at Big Bend adds to the perception that the flow conditions on the Mendenhall River require large rock for effective bank protection. An investigation by Peratrovich Nottingham & Drage, Inc. (1995), however, attributed the Big Bend revetment failure to inadequate toe protection and overly steep side slopes, which deviated widely from both Federal Highway Administration and Corps of Engineers revetment design standards.

#### 3.3.2 Non-riprap Bank Protection

Initial assessments by Inter-Fluve, Inc. personnel indicate that large rock and full bank coverage do not appear to be necessary for successful bank stabilization at many locations on the Mendenhall River. This is based on the site review, shear stress calculations, reports on the Big Bend revetment failure, and discussions with agency representatives. For example, some private landowners have employed bank protection measures comprised primarily of woody material with varying levels of success. In several locations, placements of full-bank riprap have been colonized by, or planted with, woody vegetation on the upper portion of the bank. These observations, and the ability of the local climate to support rapid, dense establishment of riparian species such as willow and alder, indicate a high potential for the implementation of vegetated bank treatments on the river, especially on the upper banks.

# 4. PERMITTING REQUIREMENTS FOR BANK PROTECTION PROJECTS

### 4.1. Introduction

Implementing a bank stabilization project requires knowledge of the regulations that may affect such a project. The designer of the bank stabilization proposal should be aware of the specific permits since it would affect project design and funding. Federal and state permits are generally required for bank protection work in Alaska. Projects that do not meet the Alaska Coastal Management Program (ACMP) habitat standards may be allowed if significant public need is demonstrated; there is no feasible or prudent alternative; and all feasible and prudent steps to maximize conformance with the standards will be taken.

Time required to acquire all required project approvals can be lengthy, especially for complex projects and the environmental sensitivity of the site. Projects developed with an awareness of current regulations can minimize the time required for obtaining permits.

## 4.2. Recommended Procedural Steps

Before initiating a project, review the appropriate regulations and contact the regulatory agencies for assistance. The agencies involved in reviewing permits for bank stabilization projects in Juneau include: ADEC (Alaska Department of Environmental Conservation), ADF&G (Alaska Department of Fish and Game), ADNR (Alaska Department of Natural Resources), CBJ (City and Borough of Juneau), DGC (Division of Governmental Coordination), and the COE (U.S. Army Corps of Engineers).

### 4.2.1 Federal Permit

Bank stabilization activities are regulated by the U.S. Army Corps of Engineers, under Sections 10 & 404 of the Clean Water Act (see 33 Code of the Federal Regulations, part 320.5 of the Federal Register). Nationwide Permits (NWP) are a category of permit which have been issued on a National basis and have been reviewed by State and other agencies and determined to have minimal impacts. Such permits may be issued for bank stabilization activities provided:

1. No material is placed in excess of the minimum needed for erosion prevention;
2. The bank stabilization activity is less than 500 feet in length;
3. The activity will not exceed an average of one cubic yard per running foot placed along the bank below the plane of ordinary high water mark or the high tide line;
4. No material is placed in any special aquatic site, including wetlands;
5. No material is of the type, or is placed in any location, or in any manner, so as to impair surface water flow into or out of any wetland area;
6. No material is placed in a manner that will be eroded by normal or expected high water flows (properly anchored trees and treetops may be used in low energy areas); and
7. The activity is part of a single and complete project.

Bank stabilization activities in excess of 500 feet in length or greater than an average of one cubic yard per running foot may be authorized. However, the permittee must notify the COE District Engineer in accordance with the "Notification" general condition; the COE District Engineer must determine the activity complies with regional and other conditions which apply to the Nationwide Permit (NWP); and the adverse environmental effects will be minimal both individually and cumulatively. Any person, agency, or entity must submit an application to the regional COE office for review.

Some projects with limited impacts may qualify for authorization by a COE Nationwide Permit (NWP) rather than requiring an individual permit. The NWP provides authorization on a quick timeline without public review. Federal and State agencies instead have a 15-day opportunity for review and comment to COE. Bank stabilization specifically is addressed in NWP #13. Additional information concerning the COE 404 permit and conditions thereof can be acquired through the Juneau COE Office at (907) 790-4490.

#### 4.2.2 State and City Permit(s)

Habitats in the project area which are subject to the Alaska Coastal Management Plan (ACMP) and the Juneau Coastal District Plan (JCDP) include the wetlands, bed, banks, and riparian areas of Mendenhall River (ADF&G Stream #10500), Duck Creek (ADF&G Stream #10500-2002), and Montana Creek (ADF&G Stream #10500-2003). The catalog numbers of the waterways that bear anadromous salmon species are listed pursuant to AS 16.05.870(a). These habitats must be managed under the ACMP so as to maintain or enhance the biological, physical, and chemical characteristics of the habitat which contribute to its capacity to support living resources (6 ACC 80.130[a] and [b]). In addition, wetlands must be managed as to ensure adequate water flow, nutrients, and oxygen levels and avoid adverse effects on natural drainage patterns, the destruction of important wildlife habitat, and the discharge of toxic substances. Note, AS and AAC refer to Alaska Statue and Alaska Administrative Code. These legal documents can be found at the Juneau libraries' reference sections or the following Internet address: http://www.legis.state.ak.us/folhome.htm.

##### 4.2.2a Division of Governmental Coordination

The DGC manages the ACMP consistency review process, which serves three functions: 1) coordination of state agency and coastal district review of project; 2) determination if a project is consistent with the standards of the ACMP, which refers to Alaska State Standards (6 AAC 80) and enforceable policies of approved local coastal district program; and 3) coordination of review of state permits with the consistency review. An applicant would have to submit the proposed bank stabilization plans to the DGC to begin the review process. Further information on this procedure can be acquired through the Juneau DGC Office at 465-3562.

##### 4.2.2b Alaska Department of Fish and Game

ADF&G reviews applications for Fish Habitat Permits (AS 16.05.870) if the proposed activity would take place in the portion of the bed(s) and banks, up to the ordinary high water mark of a cataloged anadromous stream as determined by ADF&G. "Ordinary high water mark" is defined as the following: 1) in the non-tidal portion of a river, lake, or stream: the portion of the bed(s) and banks up to which the presence and action of the non-tidal water is so common and usual, and so long continued in all ordinary years, as to leave a natural line or "mark" impressed on the bank shore and indicated by erosion, shelving, changes in soil characteristics; 2) in a braided river, lake or stream: the area delimited by the natural line or "mark" as defined in Part 1 above, impressed on the bank or shore of the outside margin of the most distant channels: or 3) in the tidally influenced portion of a river, lake, or stream: the portion of the bed(s) and banks below the mean high water elevation. A permit is issued if the proposed project will protect anadromous fish habitat.

AS 16.05.870 also requires ADF&G to "specify" or list "the various rivers, lakes, and streams or parts of them that are important for the spawning, rearing, or migration of anadromous fish." Anadromous fish is defined as fish species that spends portions of its life cycle in both fresh and salt waters, entering fresh water from the sea to spawn; these include the anadromous forms of pacific trouts, and salmon of the genus Oncoryhynchus (rainbow and cutthroat trout and chinook, coho, sockeye, chum, and pink salmon), Arctic char, Dolly Varden, sheefish, smelts, lamprey, whitefish, and sturgeon. ADF&G publishes regular updates of the resultant Catalog of Waters Important for Spawning, Rearing, or Migration of Anadromous Fish. This catalog is available at all ADF&G offices.

Alaska Statute Title 16 directs the Commissioner of the ADF&G to "manage, protect, maintain, improve, and extend the fish, game and aquatic plant resources of the state in the interest of the economy and general well-being of the state..." (AS 16.05.020). The Habitat and Restoration Division has the responsibility under this legal mandate to coordinate the department's involvement and policy on a wide range of activities including land use and natural resource planning, large and small development projects, water reservations and appropriations, and public access. The division also provides fish and wildlife resource information and technical assistance to public and private land managers and regulatory governmental agencies.

The Habitat and Restoration Division also fulfills specific statutory responsibilities for 1) providing free passage of anadromous and resident fish in fresh waterbodies (AS 16.05.840); and 2) coordinating the department's management of legislatively designated state game refuges, critical habitat areas, and game sanctuaries (AS 16.20). Contact the ADF&G's Habitat and Restoration Division in Juneau at 465-4182 or 465-4288 for additional information.

#### 4.2.2c Alaska Department of Environmental Conservation

If the applicant is obtaining a COE Section 404 permit for the placement of fill material in waters or wetlands, Section 401 of the Clean Water Act requires the applicant to obtain a certification from the State that the activity will comply with State Water Quality Standards. As of the date of this report, ADEC is waiving its right to issue Section 401 Certifications. The applicant should verify with the COE the status of the ADEC Section 401 certification process in the event ADEC chooses to exercise certification rights in the future.

#### 4.2.2d Alaska Department of Natural Resources

The ADNR requires authorization for any work in a navigable waterbody below the ordinary high water line. Presumably, a landowner with river front property will have an accurate plat or survey of their property line. This survey establishes the line of record for ordinary high water as determined by a surveyor. If their land is eroded by the river slowly over a period of time (imperceptible), they essentially loose their land as it becomes State land (riverbed). If the erosion is due to a catastrophic event (perceptible), they can recover their land out to their original line of ordinary high water as shown on their deed without authorization from DNR.

Any work below the ordinary high water line of record requires authorization from ADNR. This would involve a land use permit, except for the following generally allowed uses: "Placing riprap or other suitable bank stabilization material to prevent erosion of a contiguous privately owned upland parcel if no more than one cubic yard of material per running foot is placed onto state tideland or shoreland and the project is otherwise within the scope of the U.S. Army Corps of Engineers nationwide permit on bank stabilization is generally allowed." (ADNR's Generally Allowed Uses on State Land Fact Sheet). There are enough subtleties that anyone proposing to stabilize a riverbank should contact ADNR to see if a permit is required. The Juneau ADNR can be reached at 465-3400.

4.2.2e City and Borough of Juneau

The CBJ requires a Grading Permit from the General Engineering Division in addition to a determination of consistency with the ACMP. The Grading Permit addresses slope stability and upland drainage concerns. The Grading Permit is issued with a goal of maintaining drainage of the uplands. Contact the CBJ General Engineering Division at 586-5230 for additional information.

# 5. MODERN BANK PROTECTION TECHNOLOGY

## 5.1 Modern Approaches to Bank Protection

In recent years, the use of a variety of naturally occurring and synthetic materials and innovative techniques have commonly been used for bank protection. Some of the more popular new techniques include the use of articulated concrete blocks and synthetic gabions, construction of bendway weirs using a wide variety of materials, and the combination of vegetation and natural or synthetic materials in bioengineered revetments. Articulated concrete blocks and synthetic gabions provide an armored surface to the channel bank, reducing the fish habitat value of the channel bank as does riprap. Bendway weirs, which are jetty-like structures that protrude from the riverbank, deflect hydraulic forces away from banks, requiring little or no armor to be used on the banks themselves. However, bendway weirs redirect the river's energy to another spot along the bank and may impact other properties on the river. The bioengineering strategy provides short-term bank reinforcement using biodegradable (or semi-biodegradable) materials which retain their strength long enough for woody vegetation to establish. Once vegetation is established, the self-propagating plants provide some or all of the needed bank protection.

The multi-agency effort to move away from traditional stone riprap on the Mendenhall river has been fueled by the desire to produce functional and affordable bank protection which does not adversely affect fish habitat. Efforts have met with both success and failure, partly due to the lack of engineering rigor in some revetment and bendway weir projects. However, as a result of improvement through trial and error and the increased use of engineered designs, many of these new techniques have become widely accepted for bank erosion protection.

Numerous books and design manuals are available describing the design and construction of bioengineered riverbanks. The COE and Natural Resource Conservation Service have adopted bioengineering techniques as part of their bank stabilization treatments. Additionally, the ADF&G along with the ADNR developed a guide for streambank protection along the Kenai River entitled, "Streambank Revegetation and Protection – *a Guide for Alaska*, ADF&G Tech. Report # 98-3 (Muhlberg and Moore, 1998).

## 5.2 Appropriate Use of "Hard" and "Soft" Bank Protection Techniques

Although many modern bank treatment techniques are intended to augment or replace the use of "hard" bank treatment techniques like stone riprap, there will always be a need for these in some locations. Often the question before the bank protection designer is not whether to use a "hard" protection (such as stone riprap) or "soft" protection (such as erosion fabric and revegetation), but how to blend the two into a functional bank. This is particularly true on relatively high-gradient rivers and streams which often require a combination of hard and soft treatments to meet multiple goals of strength, durability, aesthetic appeal, and habitat protection.

### 5.2.1 Using Bank Shear Stress as a Tool for Selecting Bank Treatment Types

Velocity has often been used as the main parameter in the hydraulic design of channels. This may be due to the relative ease in calculating, or estimating, mean channel velocity. It is more appropriate, however, to use shear (the shear force exerted by the water upon the channel banks and bed) as a measure of the forces that will be applied to the components of a bank. There are equations available to calculate shear, both in bends and in straight channel segments, and applying these equations for calculation of shear is not significantly more laborious than calculating velocity. Furthermore, as shear represents a more direct measure of the hydraulic forces exerted on a stream bank, the use of shear as the main parameter in the hydraulic design is warranted.

### 5.2.2 Addressing the Zones of Erosional Pressure on River Banks

#### *5.2.2.1 Dividing a Stream Bank into Zones of Erosional Pressure*

Shear varies with elevation above the channel bed, generally decreasing with height above the bed. Additionally, obstructions to flow such as boulders, large woody debris, and man-made structures such as bridge abutments cause localized zones of high shear that often lead to the formation of scour holes. Based on these variations in shear, a stream bank can be divided into zones of lower and upper treatments depending on values of shear (Figure 7). Relatively higher shear areas, which are typically found at the toe of the bank (lower treatment), generally require a much higher degree of protection than treatment areas found higher on the bank. This is compounded by the tendency of undercutting erosion at the toe of the bank to undermine the stability of the entire bank.

By dividing the bank into zones of erosional pressure based on shear, the designer can layer appropriate bank treatment techniques to form a functional stream bank. Each layer is designed to withstand the expected hydraulic forces relative to its position on the bank.

#### *5.2.2.2 The Lower Limit of Perennial Vegetation*

Integral to the bioengineering approach is the concept of the lower limit of perennial vegetation. The vegetation line (Figure 7) denotes the lowest elevation at which woody species such as willows and alders can become established and persist. Thus, above this line one can expect vegetation to aid in bank stabilization. Below this line, vegetation can be expected to contribute little to bank stability, except where deep and thick root masses become established.

The lower limit of perennial vegetation can be approximated on most non-eroding banks simply by observing the lowest elevation of woody-stemmed species. This line is not always clearly defined, but an accurate approximation is usually possible. It is more difficult to determine the lower limit on eroding (non-stabilized) bank surfaces and on rocky or poorly vegetated banks. In these locations, it is recommended that the lower limit of perennial vegetation on adjacent banks, or banks across the channel, be used as a guide. Because the lower limit of perennial vegetation is usually defined by the relationship between inundation frequency and duration, it generally corresponds to a particular river discharge. If this discharge can be determined, and a hydraulic model of the river exists, then the model can be used to determine the approximate elevation of the lower limit of perennial vegetation.

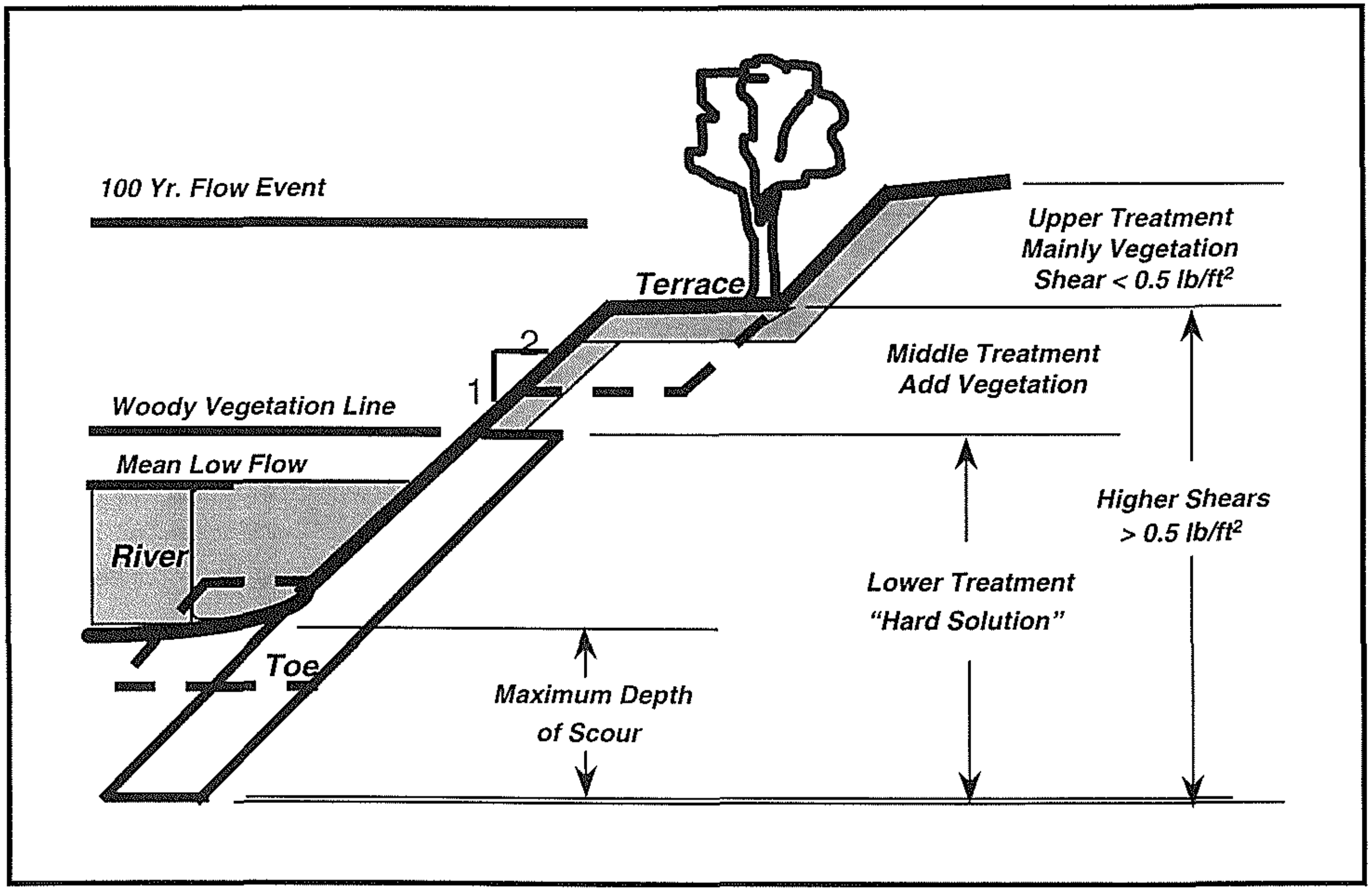



**Figure 7 - Stream Bank Zones**

#### *5.2.2.3 The Bank Toe*

The bank toe, or lower treatment, is generally the portion of the bank subject to the greatest hydraulic forces. It also forms the foundation for the entire bank, as all other portions of the bank rest upon it. Thus, a sound bank toe is critical to the success of any bank protection project. Design of the bank toe (which can be loosely defined as that portion of the bank lying below the lower limit of perennial vegetation) must address issues of erosional resistance, slope stability, and scour. Scour is the hydraulic removal of bed material at the base of the toe, which, if not properly protected against, can undermine the toe. There are numerous stone riprap revetment references available which can be used for the design of stone bank toes. Other types of bank toe, such as wood or stone-and-wood, must be designed based on available riprap revetment references, force calculations, and sound engineering.

#### *5.2.2.4 Middle and Upper Banks*

The middle and upper banks can be loosely defined as those portions of the bank lying above the perennial vegetation line. They again represent zones of erosive pressure, with the middle bank being subject to higher stress than the upper banks. It is not necessary to delineate separate middle and upper bank treatment areas if a single treatment type is to be used everywhere above the bank toe.

It is in the middle and upper treatment areas that vegetation can be employed as a means of bank stabilization and protection. Here, plants can be established to "take over" the bank protection role. If different types of treatment are employed for the middle and upper banks (or sub-zones within them) the location and extent of these treatment layers is usually delineated based on each treatment's shear resistance.

#### *5.2.2.5 Bank Geometry: Slopes and Terraces*

Bank slope affects the stability of the bank. Generally, unreinforced slopes of greater than 3:1 (horizontal: vertical) are not advised. With structural or surface reinforcement, slopes of 2:1 and steeper can be possible. Terracing is a technique that can be used to add variability to a bank, provide a platform for large woody vegetation closer to the water, provide a relatively flat area for a walking path, or better fit a treatment to the existing ground profile. Terraces have the added benefit of providing greater channel capacity at high river discharges. Examples of terraced bank configurations are shown on Sheet 8 (Appendix 8.2).

### 5.3 WEIGHING RISK VERSUS BENEFIT IN BANK PROTECTION PROJECTS

Choosing a bank protection strategy typically involves an assessment of risk. A well-designed and constructed riprap revetment is a durable structure, with a relatively low risk of failure and low maintenance cost. For these reasons, traditional riprap may be the right choice near bridges or other infrastructure, which is considered highly valuable and must be protected at all cost. However, a fully riprapped bank has little to offer in the way of aesthetics or aquatic and terrestrial habitat. Riprapping a bank from toe to top is also excessive in many cases for, as explained previously, erosive forces do not attack banks equally at all levels. Thus, while a bank that includes some bioengineered components may not always be as fail-safe as a completely riprapped bank, it offers many benefits that a riprapped bank does not offer. In addition, properly applied bank bioengineering methods have proven effective in arresting erosion problems and producing durable banks which benefit fish habitat compared to armored banks.

An underlying assumption relating to the future maintenance for a given bioengineered bank stabilization project relates to the level of risk accepted during the design phase. A project with a low budget and little infrastructure protection demands might be able to accept considerable risk, or design to a relatively low design discharge (e.g. 10-year flood). Such projects may require a proportionately higher maintenance budget. Alternatively, projects intended to protect public infrastructure (e.g. roads) may not be willing to accept much risk, and will tend to design to relatively high discharges (e.g. 100 year flood). These latter projects tend to err on the side of "overbuilding", which costs more initially but less for long-term maintenance.

Risk versus benefits must always be considered when planning a bank protection project, especially with projects involving multiple goals such as habitat protection, strength, aesthetic value, initial versus long-term costs, and longevity. To meet multiple goals the designer should avoid becoming too attached to one approach or another.

### 5.4 THE CURRENT STATE OF BIOENGINEERED RIVERBANK TECHNOLOGY

Bioengineering, also called soil bioengineering or biotechnical slope stabilization, is a strategy that utilizes the roots and shoots of riparian vegetation (grasses, shrubs and trees) to stabilize the banks of the streams and river. As a concept, bioengineering is not new. It has been used in Europe for hundreds of years and in this country since the 19th century. It has experienced a recent, dramatic increase in attention, however, as demand has increased for alternatives to as concrete riprap.

Bioengineering has become increasingly used because of the aesthetic and habitat benefits it provides compared to traditional means of riverbank stabilization. Improvements in the availability and diversity of structural materials that are compatible with vegetation have been one reason for the popularity in bioengineering. Examples include numerous biodegradable coconut fiber (coir) products such as woven and non-woven erosion control fabrics, structural logs, and pre-vegetated fabric mats. Increased experience with the performance of these coir fabrics, including decay rates, tensile strength, and shear strength resistance in various applications, allows these materials to be used with more confidence.

A multitude of synthetic fabrics and cellular confinement materials that may be used with vegetation allow bioengineered techniques to be applied in locations where it previously would not have been acceptable.

As geomorphologists, biologists, and hydrologists work more closely with hydraulic engineers, the credibility of bioengineering has increased. Bioengineered designs that are built on a solid foundation, with well-defined design criteria, and approved by professional engineers have helped bioengineering to evolve from a technique formerly done mostly on small projects to one implemented on larger, more difficult public works projects.

## 5.5 Bank Protection Techniques For the Mendenhall River

### *5.5.1.1 Toe Protection*

Toe treatments come in many forms, including such things as stone riprap, biologs (long, biodegradable fiber tubes), gabions of both steel and plastic mesh, articulated concrete blocks, and large woody debris. Recommended toe treatment options on the Mendenhall River include stone, stone and rootwad, and stone and woody debris. These three variations offer the following:

- durable protection against the relatively high erosive forces found on the Mendenhall River;
- utilization of natural materials;
- incorporation of materials that are locally available and relatively inexpensive;
- value as fish habitat elements if woody debris or overhanging banks are incorporated into the design;
- relatively simple and inexpensive construction; and

Gabions and articulated concrete are not recommended because they degrade habitat. Softer toe treatments such as biologs are not recommended for this system because the biologs are not sufficiently durable for most locations on the Mendenhall River, do not offer protection against undermining scour, are difficult to anchor under higher shear stresses, and are relatively expensive.

### *5.5.1.2 Middle and Upper Bank Treatments*

Bioengineering methods are well suited to bank stabilization efforts on the Mendenhall River for several reasons. The abundance and yearly distribution of rainfall and relatively warm climate make Juneau conducive to establishment and growth of riparian vegetation. Second, bioengineering techniques alone can provide necessary bank protection in the middle and upper zones. Third, the use of native vegetation better replicates natural bank habitat and provides long-term source of in-stream woody debris, leaf litter and insects for fish food, and cover for fish to hide under. Lastly, with some planning, it appears there are sufficient quantities of locally available dormant plant materials. In regards to the timing of the planting of plant materials, it is important to plant by spring or early summer in order to provide a sufficient growing season to afford good plant establishment.

Specific bioengineering bank treatments suited to the middle and upper Mendenhall River include several variations of brush layering, fabric-encapsulated soil, and fabric-covered graded slopes, as outlined in the following section.

# 6. BANK PROTECTION DESIGNS FOR THE MENDENHALL RIVER

## 6.1 Three Example Treatment Sites

Three locations were chosen as example sites for designing bank treatments: the Upper Site; the Car Bend Site; and the Home Site (Sheet 1, Appendix 8.2). Table 6.1 describes the three sites.

**Table 6.1. Characteristics of the three example treatment sites.**

| Site | 100-yr Shear at Toe ($lb/ft^2$) | 100-yr Scour Depth (ft) | Average Bank Height (ft) |
|---|---|---|---|
| Upper | 5.7 | 4.5* | 20 |
| Car Bend | 1.7 | 8 | 22 |
| Home | 0.7 | 5 | 10 |

* The scour depth at the Upper Site is low relative to the other sites because of the large river bed material found there.

### 6.1.1 Bank Treatment at the Upper Site

The Upper Site bank treatment is shown on Sheet 4 of the Plans (Appendix 8.2). The Bank Toe consists of stone riprap over filter gravel. This toe was designed to withstand the relatively high shear forces expected at this site and to protect to the estimated 100-yr flood scour depth of 4.5 ft. The bank angle of the toe is 2:1 (horizontal: vertical) or flatter.

The Middle Bank extends from the line of perennial vegetation upwards to the elevation at which the 100-yr flood (Appendix 8.6) produces a bank shear of 1 $lb/ft^2$. The Middle Bank consists of alternating layers of willow cuttings and riprap stone, with soil filling the voids between the stones and the surface seeded with native grasses and/or forbs. This configuration will protect against the expected shear in this region as well as provide vegetation cover. Although the Middle Bank will be composed of at least two layers of stone (as shown on Sheet 4), additional layers may be needed to ensure that the Middle Bank extends up to the 1 $lb/ft^2$ shear line during the 100-yr flood. The bank angle of the Middle Bank is 2:1 (horizontal: vertical) or flatter.

Two treatment types are employed in the Upper Bank. A Fabric-Covered Upper Bank treatment of biodegradable woven coir (coconut fiber) fabric, along with surface seeding and planting with cuttings and/or containerized plants, will protect the Upper Bank up to the elevation of the 5-yr flood. Above that elevation, the bank will be sloped back to 3:1 (horizontal: vertical) or flatter, seeded, and planted with cuttings and/or containerized plants. This treatment is called the Graded Upper Bank.

### 6.1.2 Bank Treatment at the Car Bend Site

The Car Bend Site bank treatment is shown on Sheet 2 of the Plans (Appendix 8.2). The Bank Toe consists of stone riprap, root wads, and other woody debris over filter gravel. This toe was designed to withstand the moderate shear forces expected at this site and to provide aquatic habitat. Since a portion of the woody debris will be live cuttings, this toe offers some latitude in estimating the elevation of the line of perennial vegetation (if the line is lower than estimated, the live cuttings will vegetate the surface of the stone riprap). This configuration will protect to the estimated 100-yr flood scour depth of 8 ft. No root wads will be placed lower than the channel bed level at the time of construction. The bank angle of the toe is 2:1 (horizontal: vertical) or flatter.

The Middle Bank extends from the line of perennial vegetation upwards 3 ft in elevation. Shear calculations show that the 3-ft Middle Bank height is sufficient to bring the top of the Middle Bank above the elevation at which the 100-yr flood produces a bank shear of 1 $lb/ft^2$. The Middle Bank consists of alternating layers of willow cuttings and riprap stone, with soil filling the voids between the stones and the surface seeded with native grasses and/or forbs. This configuration will protect against the expected shear in this region as well as provide vegetation cover. The bank angle of the Middle Bank is 2:1 (horizontal: vertical) or flatter.

As at the Upper Site, the Graded Upper Bank treatment is used in the Upper Bank at the Car Bend Site. A Fabric-Covered Upper Bank treatment of biodegradable woven coir (coconut fiber) fabric, along with surface seeding and planting with cuttings and/or containerized plants, will protect the Upper Bank up to the elevation of the 5-yr flood. Above that elevation, the bank will be sloped back to 3:1 (horizontal: vertical) or flatter, seeded, and planted with cuttings and/or containerized plants.

#### 6.1.3 Bank Treatment at the Home Site

The Home Site bank treatment is shown on Sheet 3 of the Plans (Appendix 8.2). The Bank Toe consists of stone riprap and woody debris over filter gravel. This toe was designed to withstand the moderate-to-low shear forces expected at this site and to provide aquatic habitat. Since a portion of the woody debris will be live cuttings, this toe offers some latitude in estimating the elevation of the line of perennial vegetation (if the line is lower than estimated, the live cuttings will vegetate the surface). This configuration will protect to the estimated 100-yr flood scour depth of 5 ft. The bank angle of the toe is 2:1 (horizontal: vertical) or flatter.

There is no discrete Middle Bank treatment at this site due to the lower shear stress on the banks at this location.

As at the other two sites, the Graded Upper Bank treatment is used in the Upper Bank at the Home Site. A Fabric-Covered Upper Bank treatment of biodegradable woven coir (coconut fiber) fabric, along with surface seeding and planting with cuttings and/or containerized plants, will protect the Upper Bank up to the top of the approximately 10 ft high bank. Beyond the top of bank, disturbed areas will be seeded and planted with cuttings and/or containerized plants.

### 6.2 Alternative Treatment Techniques for the Middle and Upper Banks

#### 6.2.1 Middle Bank Treatment Options

Two alternative Middle Bank Treatments were included in the Plans (Sheet 8, Appendix 8.2). The first option substitutes a fabric-encapsulated gravel/soil mixture for the soil-filled stone riprap layers of Middle Bank. This option would provide a better growing medium for the Middle Bank, but would require the use of relatively expensive synthetic materials and more careful construction than the recommended alternatives.

The second option substitutes a cellular confinement system made of synthetic material for the recommended brush layers. This option would provide a better growing medium for the Middle Bank and excellent erosion protection. However, it would be more costly to supply, install, and would involve the use of synthetic materials.

The incorporation of terraces into the bank treatments are also presented and recommended. Terraces offer several advantages such as the opportunity to introduce larger overhanging woody species closer to the rivers edge, more variability in the planting, and reduced stress on the stream banks.

### 6.2.2 Upper Bank Treatment Options

Several Upper Bank treatment alternatives are shown in the Plans (Sheet 9, Appendix 8.2). The first option is to install the erosion fabric in rows perpendicular to the river channel, rather than parallel to the channel as recommended in the example treatments (Sheet 6, Appendix 8.2). While not as durable as the recommended configuration, this type of fabric installation is easier to complete and requires less intensive construction supervision.

The second option is to grade a 4-inch layer of topsoil onto the slope and revegetate without installing erosion fabric. This option would provide little or no immediate resistance to surface erosion and would require all upper bank slopes to be 3:1 (horizontal: vertical) or flatter, but offers the advantage of lower initial installation cost where a higher level of exposure (and risk) is acceptable. Although this second option is already included as the Graded Upper Bank component of the recommended Upper Bank treatments, it could be used over the entire upper bank.

The third option involves the use of willow fascines (i.e., bundle of sticks bound together) to create a stepped Upper Bank that would protect against surface erosion. In addition to creating steps, which would allow the soil surface in between to be graded at a gentler slope of approximately 5:1 (horizontal: vertical), the fascines would be a ready source of sprouting vegetation. The soil surface between the fascines would be seeded and planted with cuttings and/or containerized plants. This option would provide some degree of immediate resistance to surface erosion, but would require fascine fabrication and installation.

## 6.3 Transitions Between Treated and Non-treated Banks

Transitions between treated and non-treated banks are shown on Sheet 7, Appendix 8.2. These edge treatments are intended to prevent flanking of the installed bank protection, but also to reduce erosion in adjacent unprotected banks. When "hardened" banks abruptly transition into existing, unprotected sections, an erosional scar with a scalloped configuration often develops in the softer bank (Figure 8). This erosion is caused by secondary, high-velocity flows exiting the hardened reach. In the proposed treatments, the rock thickness is intentionally diminished on the edges to encourage some deterioration of the rock treatment and to encourage irregularity at the transition. This irregularity deters the development of erosional secondary currents found at an abrupt edge. For transitions at stabilized banks constructed of materials other than rock, a similar application of this principal can also be useful. Gradual rather than abrupt changes in bank condition (materials) can deter the eroded scallop effect.

## 6.4 Vegetating Existing Riprap

The single most important reason that vegetation tends not to grow well in riprapped banks is due to the large void space and the associated lack of growing medium in riprap treatments. Three general strategies may be used to vegetate riprap. First, the void spaces between rocks may be filled with finer-textured gravel, sands, and silts that will support colonization by plants resulting in a bimodel distribution of materials in the riprap layer. This method is typically implemented during a riprap placement rather than incorporated into an existing riprap bank treatment.

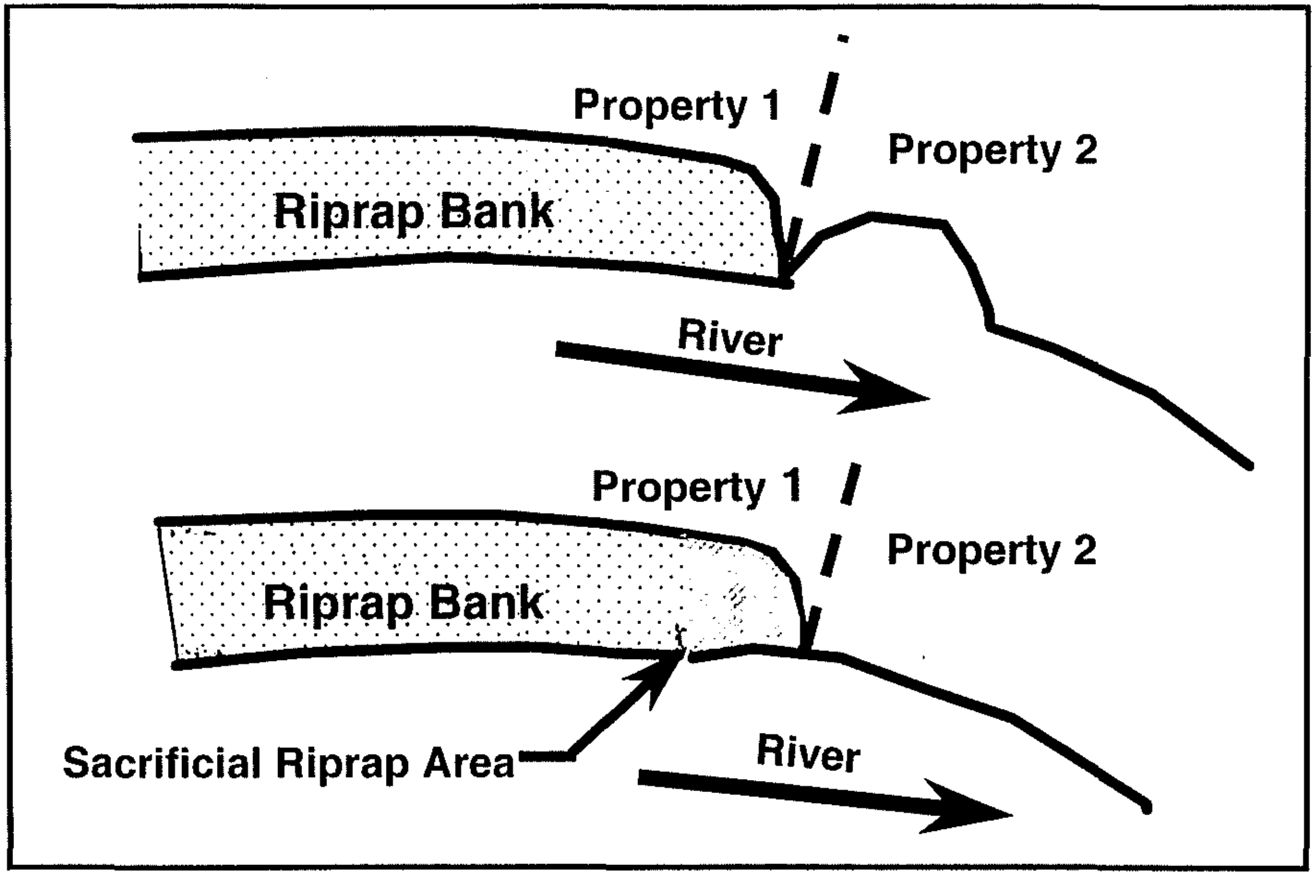



**Figure 8 -Transitions**

The second method, which can be used for existing riprap treatments, is to plant vegetation in areas where the riprap already has a tendency to induce deposition. These locations can be noted in the field from silt deposits on or in the voids of rock. Plantings in this area increase the depositional propensities by raising the roughness of the rock surface. The plantings may require a containerized or sock system that retains soils around the plant roots until depositional processes can naturally provide enough growth media.

A third method appropriate for vegetating existing riprap is a method established by Hoag (1994). The method uses a tool called a "stinger:" a long pointed steel rod that can be attached to the arm of a backhoe and powered by the hydraulics of the bucket. Using the stinger, the backhoe operator can punch holes through the riprap layer at almost any angle needed. The hole is punched through the riprap into permanently moist soil. A metal cap is placed over the cutting and the tip of the stinger is used to push the pole into the soil. Hoag (1994) suggests that 75% of the total pole length should be underground with the end reaching the low flow water table. Since the voids between riprap boulders are not considered a growing medium, this strategy relies on the fact that dormant willow or cottonwood posts will be rooted into the finer-textured soils that underlie the riprap. These finer textured soils will support plant growth as long as a filter fabric has not been used, and if the growing medium remains moist through the growing season.

## 6.5 Design, Material, and construction details

### 6.5.1 Further Design Requirements

To finalize designs for the three example treatment sites, or for other sites to which the example designs are to be applied, would require field reconnaissance and hydraulic modeling to determine:

- elevation of the line of perennial vegetation at all points within the project site (to determine the elevation of the top of the bank toe);
- elevation of the 100-yr flood 1 $lb/ft^2$ shear at all points within sites to receive treatments as shown for the Upper and Car Bend Sites (to determine the minimum elevation of the top of the Middle Bank treatment); and
- elevation of the 5-yr floodwater surface within sites to receive treatments as shown for the Upper and Car Bend Sites (to determine the minimum elevation of the top of the Fabric-Covered Upper Bank treatment).

### 6.5.2 Material and Installation Specifications

Material requirements for recommended treatments include stone, filter gravel, various types of woody debris, coir (erosion) fabric, wooden stakes, willow and cottonwood cuttings, seed, containerized plants, topsoil, and common fill. The topsoil and common fill are generally available on site. All other materials are locally available. Specifications are presented in Appendix 8.3, which include detailed descriptions of materials required to construct the recommended bank treatments. The specifications also include descriptions on proper installation for the recommended bank protection treatments.

### 6.6 Notes on Construction Methods

It is expected that few contractors or machinery operators in the Juneau area have had experience with biotechnical/bioengineering modification of streambanks. While none of the bank stabilization methods proposed for the Mendenhall River are in themselves complex, contractor unfamiliarity with the varied materials and specific construction details requires construction oversight by experienced personnel. There is also, in general, more hand labor associated with bioengineered projects than found in standard earthwork projects, which may at first deter a few contractors or result in some unintentional over or under pricing of initial bids.

In most cases, construction oversight is particularly critical at the early phases of work to help operators and contractors develop an eye for the small details that are integral to project success. Experienced construction oversight can also greatly increase installation rates of specific streambank treatments. Alternatively, the value of creative ideas provided by contractors that are involved with construction problem solving cannot be underestimated. Ultimately, important aspects of project success are positive interactions and idea sharing between contractors/equipment operators and designers/on-site supervisors.

The several components of bioengineering that contractors may need to learn are the incorporation of live plant material and root wads with earthwork activities, installation of erosion control fabric, and the wider assortment of rock or soil mixes required. Some useful details related to installation of these materials are described below.

#### *6.6.1.1 Live Plant Materials*

A number of different plant materials have been proposed for Mendenhall biotechnical/bioengineering designs. These include willow stakes, willow brush layers, willow and cottonwood poles, native grass seed mixes, nursery-grown containerized plants, and salvaged shrubs. It may also be quite feasible to incorporate seed from local alders into various designs.

It is important that on-site supervision ensure planting requirements are satisfied. Examples of details that often go un-noticed include proper storage and maintenance of plant materials, appropriate delivery and planting schedules, orientation of planted cuttings (installed up-side down), compaction around cuttings and root masses, planting depths of cuttings and containers, attention to growing mediums in plant rooting zones, watering plants until fully established, and consistency of seeding rates. Failure to attend to these details can lead to poor plant survival.

#### *6.6.1.2 Root Wads and Woody Debris*

A component of proposed lower bank designs include installation of root wads and woody debris. Often it is difficult for specifications to adequately address all details needed for successful installation of woody debris because of unforeseen site conditions. Construction oversight can provide "fit in field" adjustments to specifications as needed. Examples include root wads that inevitably are sized differently than specified, ensuring adequate anchoring against high flows and scour, or adjustments to anticipated site access due to weather, field conditions, or equipment availability.

#### *6.6.1.3 Erosion Control Fabric*

Probably the most underestimated detail related to long-term integrity of bioengineering designs is erosion control fabric installation (mid and upper bank treatments). Initially, it is critical that the proper materials be ordered, pre-approved and inspected before installation. The number of subtle differences between products in terms of dimensions, fabric weight, fabric seams, and country of origin make for a wide range of qualities between seemingly similar products.

Secondly, the orientation of erosion control fabric relative to slope and stream flow direction has considerable implications on installation rates and performance under flood conditions. For example, fabric in upper bank designs has been oriented so that fabric would be unrolled and secured parallel to river flow. This technique requires trenching at the upstream ends of a treatment, and between overlapping fabric edges. In contrast, an alternative method (as suggested on sheet 9 of drawings) is to orient fabric rolls perpendicular to the river flow or up and down the river bank slope. This approach requires trenching only at the ends of each fabric roll, and fabric edges are simply overlapped in a "shingle" fashion so that flowing water won't get under upstream fabric edges.

If properly done, placement of fabric parallel to river flow is generally more erosion resistant, but requires more expense because considerably more trenching is required than if fabric is placed perpendicular to streamflow. Another installation detail that can affect field construction rates and treatment integrity relate to sequencing of fabric placement (starting upstream or upslope versus starting downstream or downslope).

A third detail essential to fabric installation is securement of placed fabric to the soil surface. Experience has shown that angled wooden stakes provide better anchoring tension than wire "U" stakes or rebar "J" stakes (and are biodegradable). When placing stakes it is important not to cut fabric strands, not to place stakes too close to a "cut" fabric edge, to insert stakes to the proper depth, and to adjust stake density to field conditions. Often considerable time can be saved if stakes are hand placed to several inches in depth, and then inserted to final depth with the bucket of an excavator.

#### *6.6.1.4 Granular Material Shapes, Sizes and Mixes*

Bioengineering projects often call for soil and granular mixes that differ from standard Alaska Department of Transportation and Public Facilities design mixes. Adequate sizes and shape of rock are critical to the stability of the toe and proper soil mixes are important to the establishment of vegetation.

Although standard designs for riprap favor big and angular rock, bioengineered designs strive to use the smallest rock required, and to use rounded rock, which is more compatible with materials found in a natural river system. Most sizing methodologies incorporate a parameter to represent rounded or angular rock to account for the difference in stability.

Non-standard bimodel mixes of material which incorporate finer growing medium are often important for establishing vegetation and can be specified in the design phase. If premixing is not cost effective, finer material may be placed in intermediate layers with the rock and lightly tamped into position with the back of a bucket. Topsoil can also be specified in some bank elements to enhance growth potential.

In contrast to standard earthwork projects, a greater degree of interaction with the contractor at the onset of the project is beneficial to assist the contractor in understanding the type of material required, the importance of the non-standard mix being specified, and to help in locating the appropriate mix. "Can't get that material here" frequently translates to "Don't understand what you want, or why you want it". For example, the discard piles of gravel suppliers can occasional provide key components for what may initially be considered an unobtainable mix.

Inspection of larger materials at the quarry for stone toes or habitat elements, prior to bringing the material on site, can help to prevent owner-contractor disputes and result in a more stable structure. Rejecting material at the quarry which does not meet specifications is more cost effective for the contractor since he will not have expended two-way transportation costs, and may result in the contractor having greater interest in locating a second source which can meet specified requirements.

### 6.7 Monitoring and Maintenance Requirements

The importance of including post-construction monitoring and maintenance activities is hard to underestimate. Monitoring and maintenance allows for assessment of designs, identification of weak links in the project, notable project success and most importantly provides a mechanism for correcting any structural problems that may exist. Bioengineering techniques do not necessarily demand higher maintenance than traditional engineering projects, however the range of techniques that can be applied is more flexible. More options are available which range from selecting treatments with lower installation costs but higher maintenance demands, or, like traditional methods, invest more in bioengineered installation costs to obtain lower maintenance demands. No matter which alternative is chosen, the benefits of monitoring and maintenance are real.

Monitoring generally consists of a minimum of a yearly site review of each reconstructed streambank to determine performance of structural components (rock and wood), vegetation, and erosion control fabric. In many cases, qualitative or descriptive observations and photographs over time will be sufficient. If budget allows, cross-sectional surveys and more quantitative vegetation monitoring may be warranted. The most benefit can be gained from monitoring data when it can be correlated to the frequency and duration of peak hydrologic events.

Regardless of the monitoring scope, monitoring results are best linked to maintenance activities such as additional toe reinforcement, supplemental planting, weed control, or coppicing (heavy pruning of large shrubs/trees).

## 7. CONSTRUCTION COSTS

Estimating costs of specific project designs before project implementation is a valuable tool in selecting and evaluating bank stabilization treatments. However, since estimating costs for techniques and methods not previously applied in a region can be difficult, the estimates should be used with caution. Below, two approaches to estimating bank treatment costs are presented. It should be noted that these approaches do not include design costs, and these costs are based on experience with projects constructed nationwide. Some adjustment will be required for differences in Alaska labor and material costs.

## 7.1 Material Costs

The customary approach to cost estimation is to calculate quantities, determine individual material costs, and estimate labor and equipment costs for the installation of all required elements. Unit costs for a number of bioengineering materials are presented in Table 7.1 below. Installation costs may be estimated by looking at production rates for select bioengineering materials (Table 7.2), and by factoring in equipment and labor costs per hour.

## 7.2 Specific Bank Treatment Costs

A second method of estimating construction costs is to add all materials and installation costs for one type of treatment and determine the unit cost per measure of that treatment. This cost estimating method has the advantage of being easy to apply, but has a drawback in that regional influences on material and labor costs, and volume effects on costs, can cause wide variations in the treatment unit price.

Unit prices for some select treatments are listed in Table 7.3. When it is possible, the unit price measure is listed as face foot rather than linear foot. A face foot is a unit representing a section of stream bank measured vertically as one foot high by one foot long, regardless of slope. Face foot is preferred over lineal foot as a unit of measure for comparative cost estimates, because a face foot can convey the costs associated with the height of the bank.

## 7.1 Unit Bioengineering Material Costs

| Materials | Description | Unit Cost (delivered) | Unit |
|---|---|---|---|
| Woven coir fabric* | KoirMat 900 | $2.50 | $yd^2$ |
| Inner fabric* | 407 GT Poly Jute | $0.40 | $yd^2$ |
| Wooden stakes* | 18" long; diagonal cut from 2" x 4" | $1.50 | ea. |
| Willow stakes* | Locally collected; 4 ft long; 1" diam | $2.00 | ea |
| Cottonwood poles* | Locally collected; 6 ft long; 6" diam | $6.00 | ea. |
| Brush layer cuttings* | Locally collected; 4 ft long | $1.50 | ea. |
| Seed** | Native seed | $10.00 | lb. |
| Containerized plants** | 1 gallon alder ; nursery grown | $4.00 | ea. |
| Topsoil** | Imported off-site | $25.00 | cy |
| Common fill** | Salvaged on-site | $1.00 | cy |
| Angular riprap** | Type 1 delivered | $30.00 | cy |
| Root wads** | hemlock/spruce; 25 ft long | $50.00 to $95.00 | ea. |

* observed cost
**estimated cost

### Table 7.2 Estimated Hourly Production Rates for Installation of Bioengineering Materials

| Task | Machinery/Labor | Rate |
|---|---|---|
| Install 1 ft tall fabric-wrapped lift | One excavator; one loader; one supervisor; 3 laborers | 25-50 LF/hour |
| Install D18 stone toe; 6ft wide x 4 ft. deep | One excavator; one loader; one supervisor | 25 LF/hr |
| Install 25 ft long hemlock root wads with stone | One excavator; one loader; one supervisor | 25 LF/hr |
| Install Brush layer/ with stone lifts | One excavator; one loader, one supervisor; 2 laborers | 25 LF/hr |
| Plant 2 ft long willow cuttings into | 4 laborers | 200 plants/hr |

### Table 7.3 Bioengineering Treatment Costs

| Bank Treatment | Cost/Unit | Comments |
|---|---|---|
| Riprap | $20 to $80/CY | Highly dependent on rock cost; haul distance and rock size and armor thickness |
| Brush layer with stone fill | $25 to $90/CY | See above; best if cuttings locally harvested |
| Fabric-wrapped lifts | $15 to $30/FF | Material costs predictable; installation costs/rates depend on site access and crew production rates |
| Geocell terraces | $20 to $40/FF | Material costs predictable; installation costs/rates depend on site access and crew production rates |
| Fabric-covered graded slope | $5 to $20/FF | Material and installation costs predictable |
| Root wads | $5 to $50/FF | Material cost variable; sometimes difficult to locate; install cost depends on site access, and excavation needs |

## 7.3 FINANCIAL ASSISTANCE PROGRAMS

Sources of financial aid are available for bank stabilization restoration projects. Most of the financial assistance is Federally-based and it may take some time to acquire the funding. Some of the contacts listed below may also be able to provide assistance in the permitting process. The following brief list of phone numbers & internet addresses may assist in the acquisition of funding:

- U.S. Army Corps of Engineers (907) 753-2668, David Martinson Project Manager
  E-mail: David.A.Martinson@poa02.usace.army.mil
  WebSite: http://www.usace.army.mil/alaska/en/cw

- Partners for Fish and Wildlife Program (907) 586-7330, Susan Walker, Project Manager
  E-mail: susan_walker@fws.gov Web Site: http://www.fws.gov/r9dhcpfw

- Wildlife Habitat Incentives Program (WHIP) (907) 271-2424, Dan LaPlant, Manager
  Email : dan.laplant@ak.usda.gov
  Web Site: http://www.nhq.nrcs.usda.gov/OPA/FB96OPA/WhipFact.html

- EPA Five-Star Restoration Program (202) 260-8076 (202) 260-2356 (fax)
  E-mail: pai.john@epa.gov
  Web Site:http://www.epa.gov/owow/wetlands/restore/5star

- Nonpoint Source Implementation Grants (319 Program) (202) 260-7100
  Email: ow-general@epa.gov (202) 260-7024(fax)
  Web Site: www.epa.gov/owow/NPS

# 8. APPENDIX

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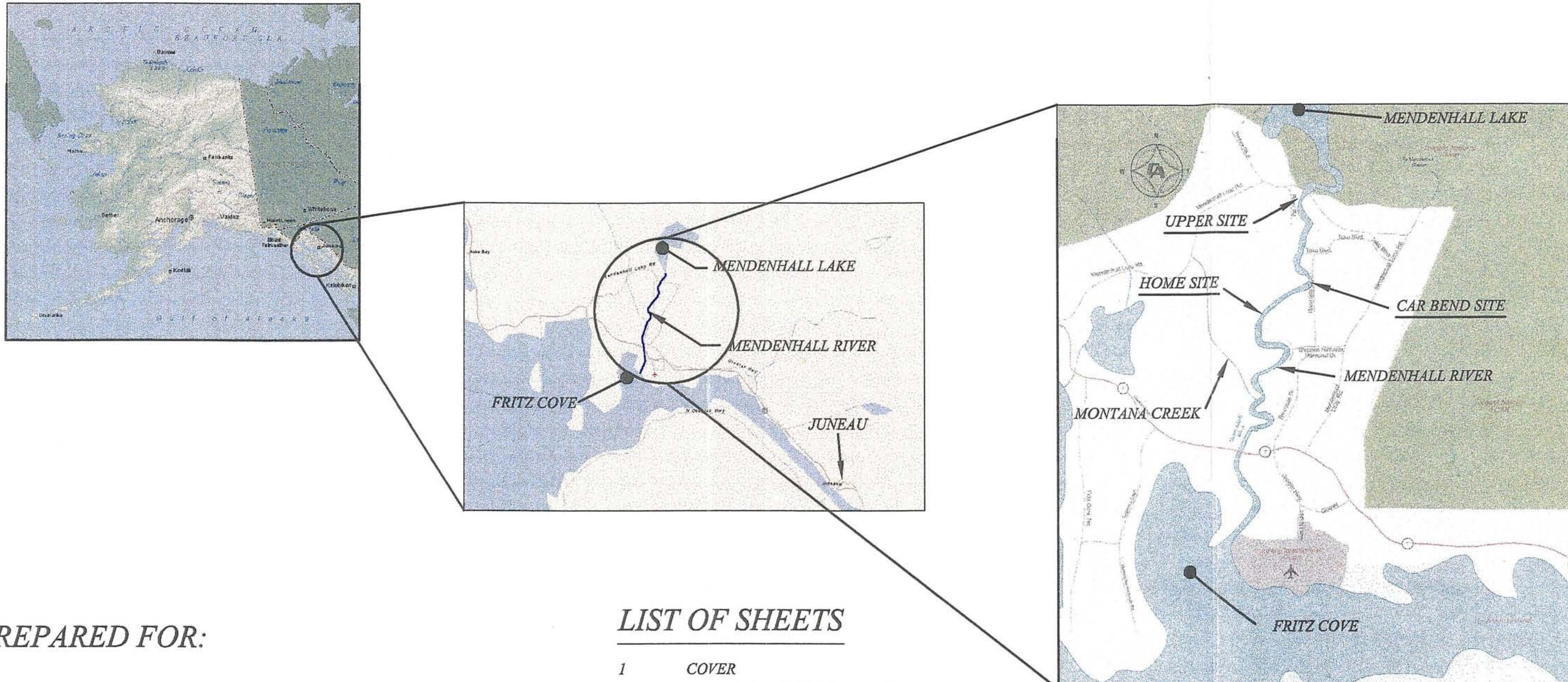
## 8.2 Example Drawings

# BIOTECHNICAL BANK PROTECTION SYTEMS FOR THE MENDENHALL RIVER

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## PREPARED BY:


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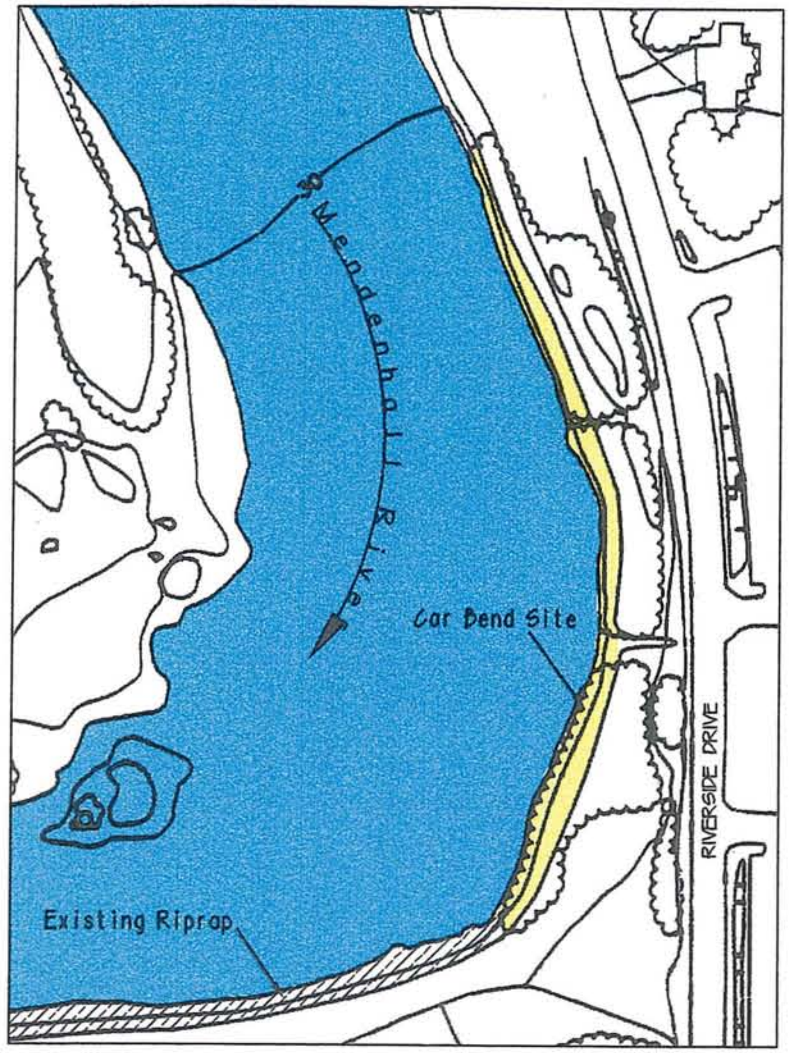
## LIST OF SHEETS




PLAN VIEW OF CAR BEND SITE
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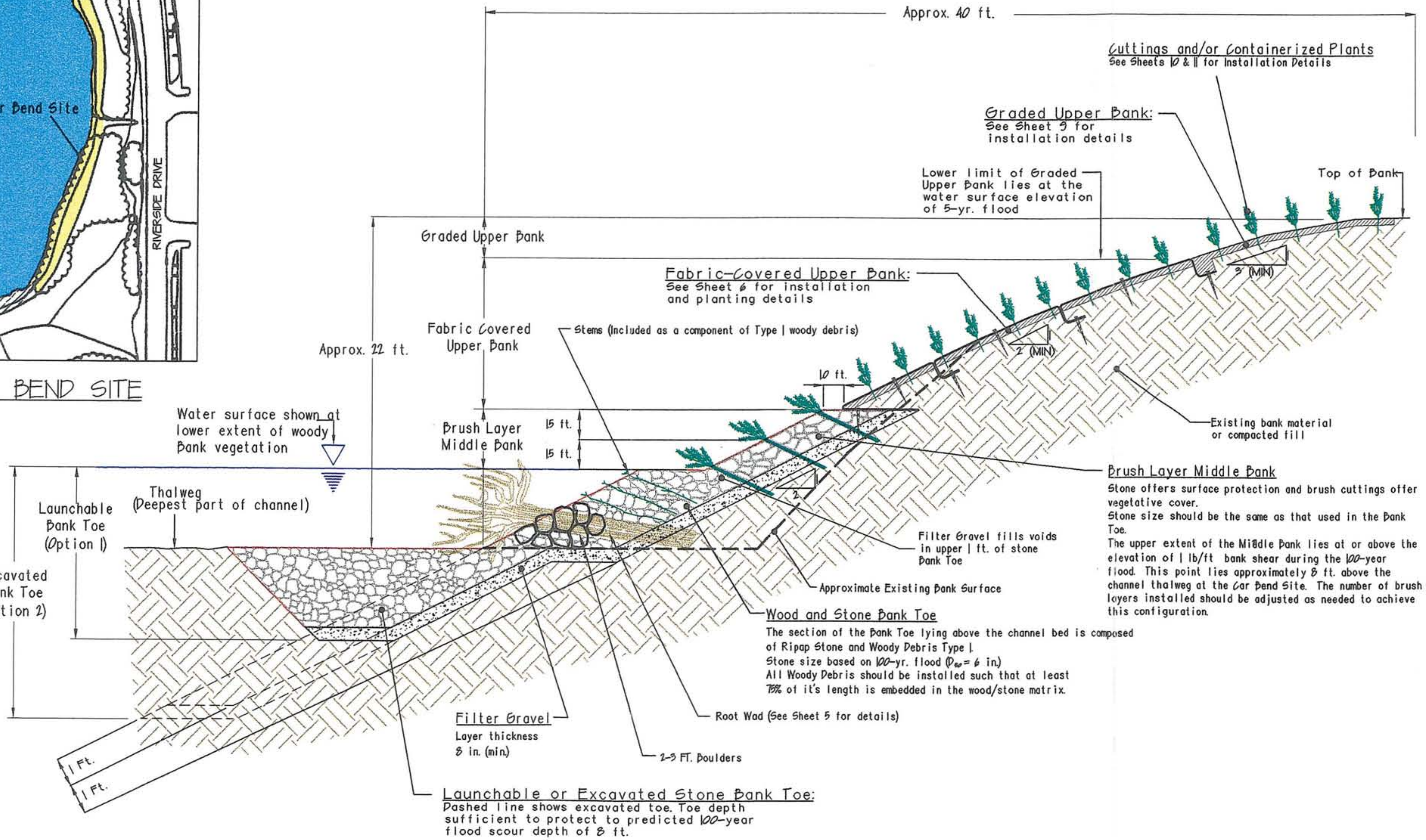


BANK PROTECTION AT CAR BEND SITE: TYPICAL CROSS-SECTION
NOT TO SCALE

BANK PROTECTION AT THE CAR BEND SITE

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BIOTECHNICAL BANK PROTECTION SYSTEMS FOR THE MENDENHALL RIVER

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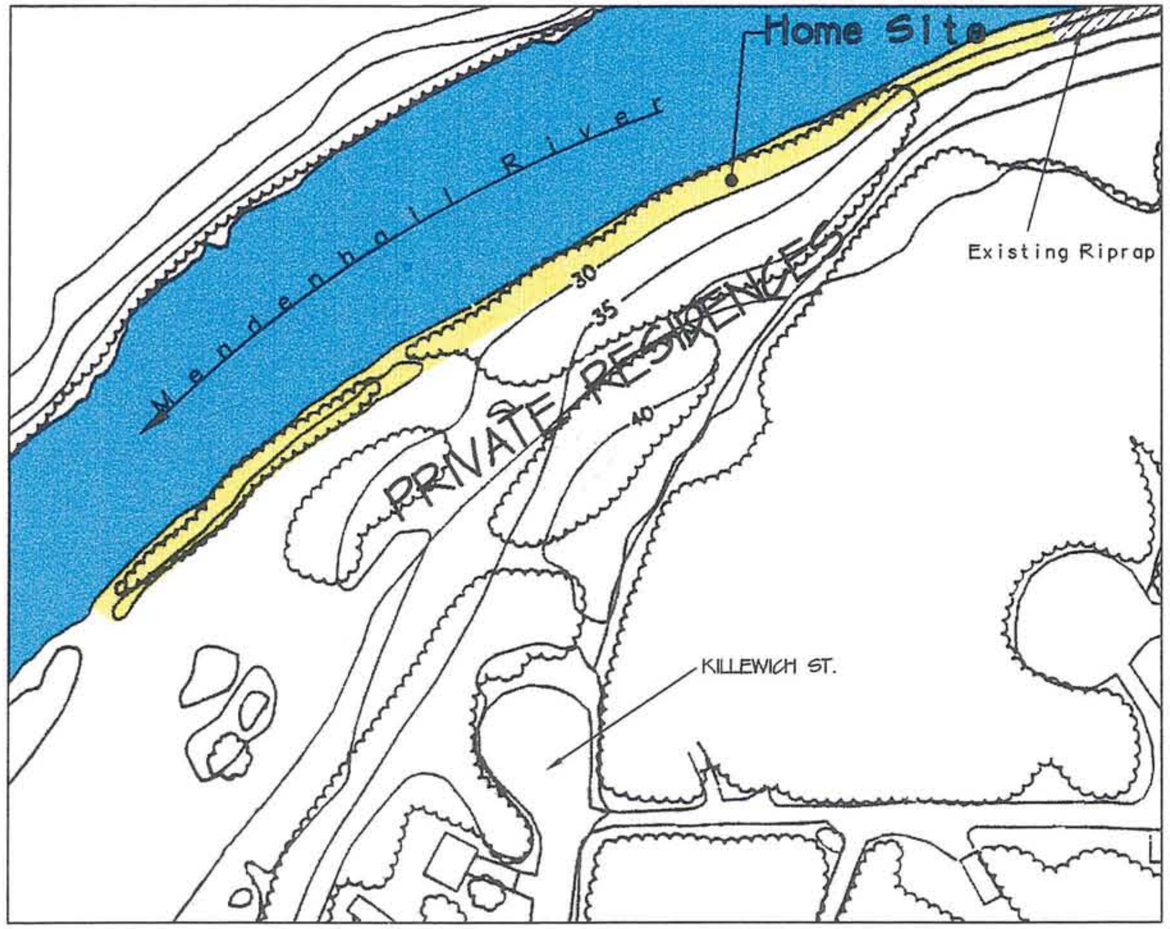


PLAN VIEW OF HOME SITE

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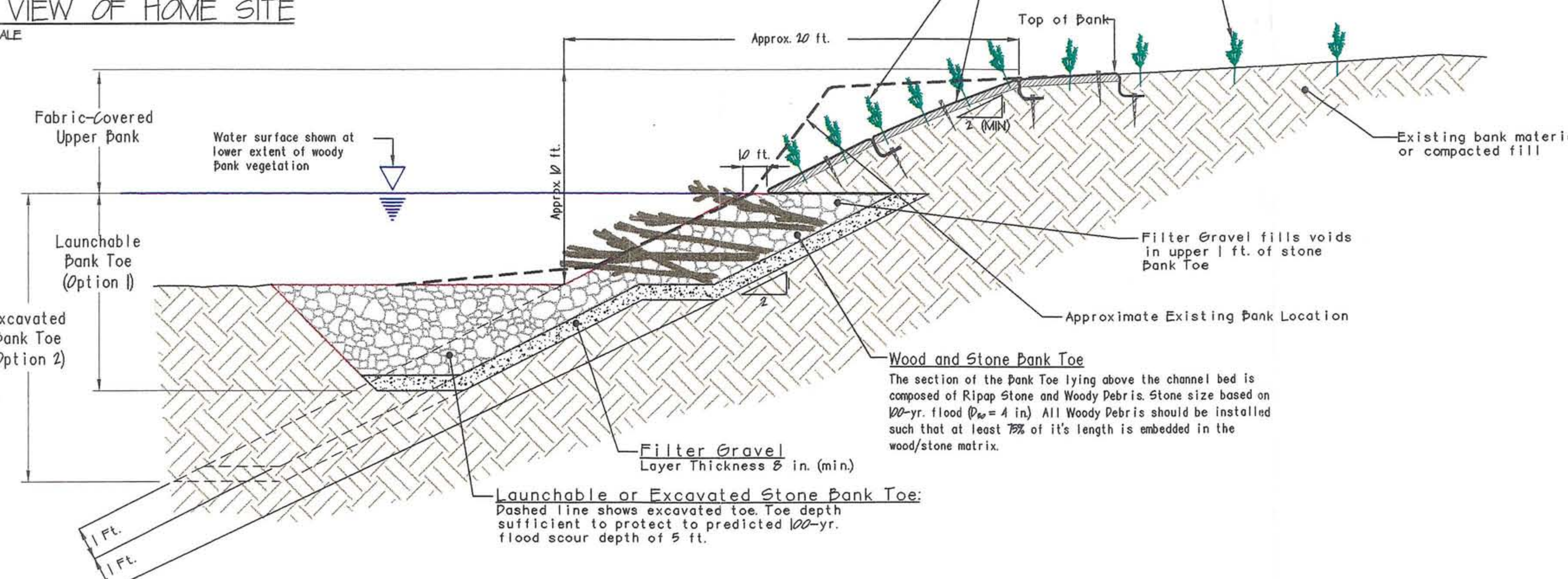


BANK PROTECTION AT HOME SITE: TYPICAL CROSS-SECTION

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BANK PROTECTION AT THE HOME SITE

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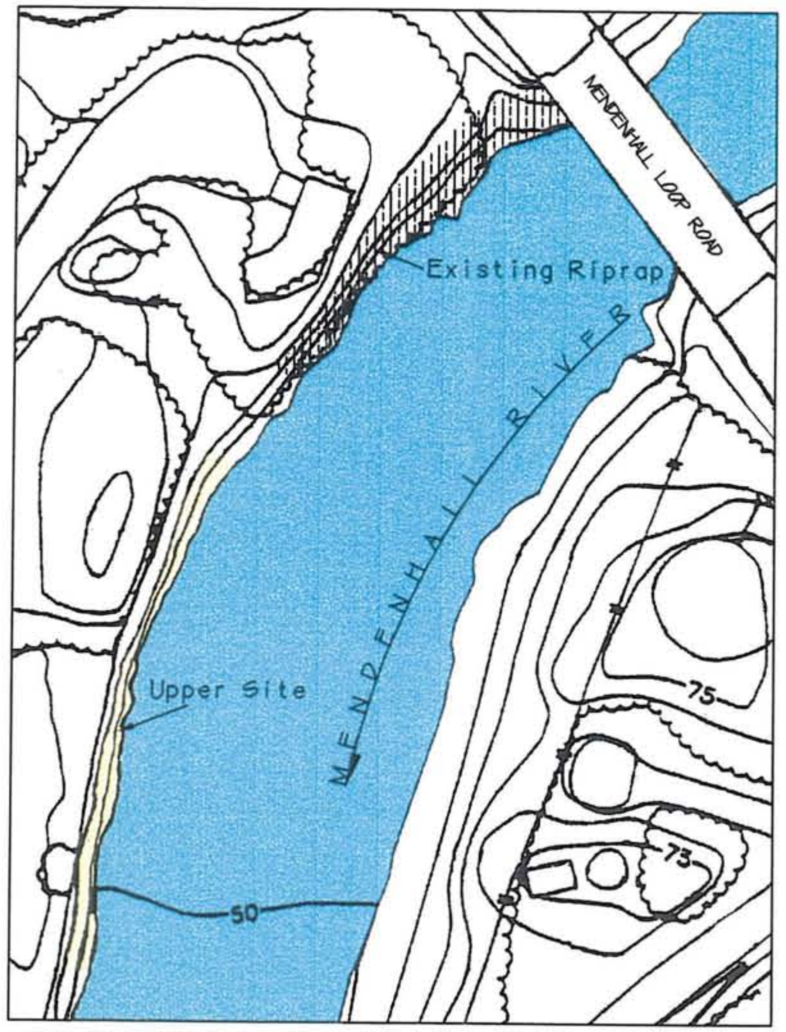


PLAN VIEW OF UPPER SITE
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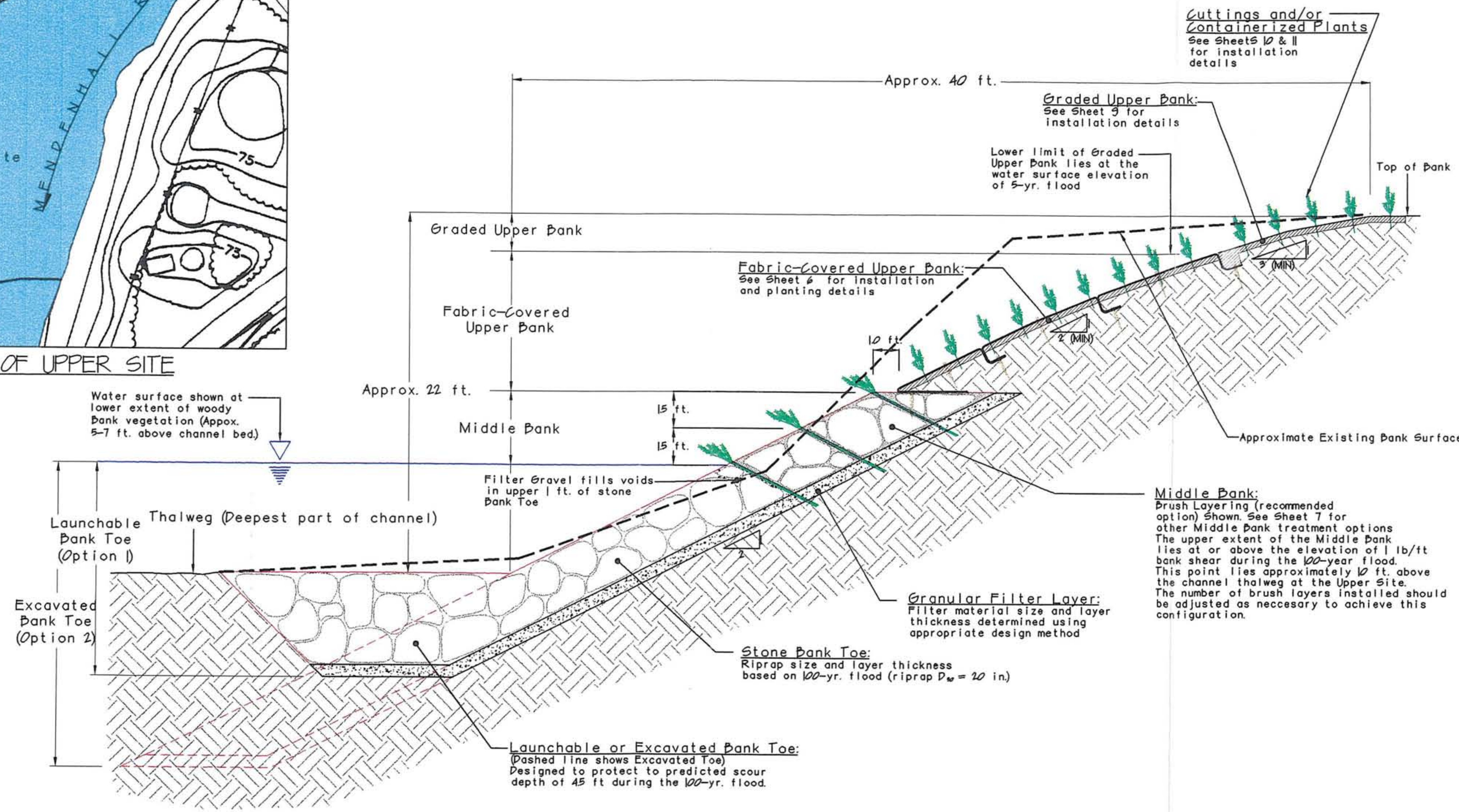


BANK PROTECTION AT UPPER SITE: TYPICAL CROSS-SECTION
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BANK PROTECTION AT THE UPPER SITE

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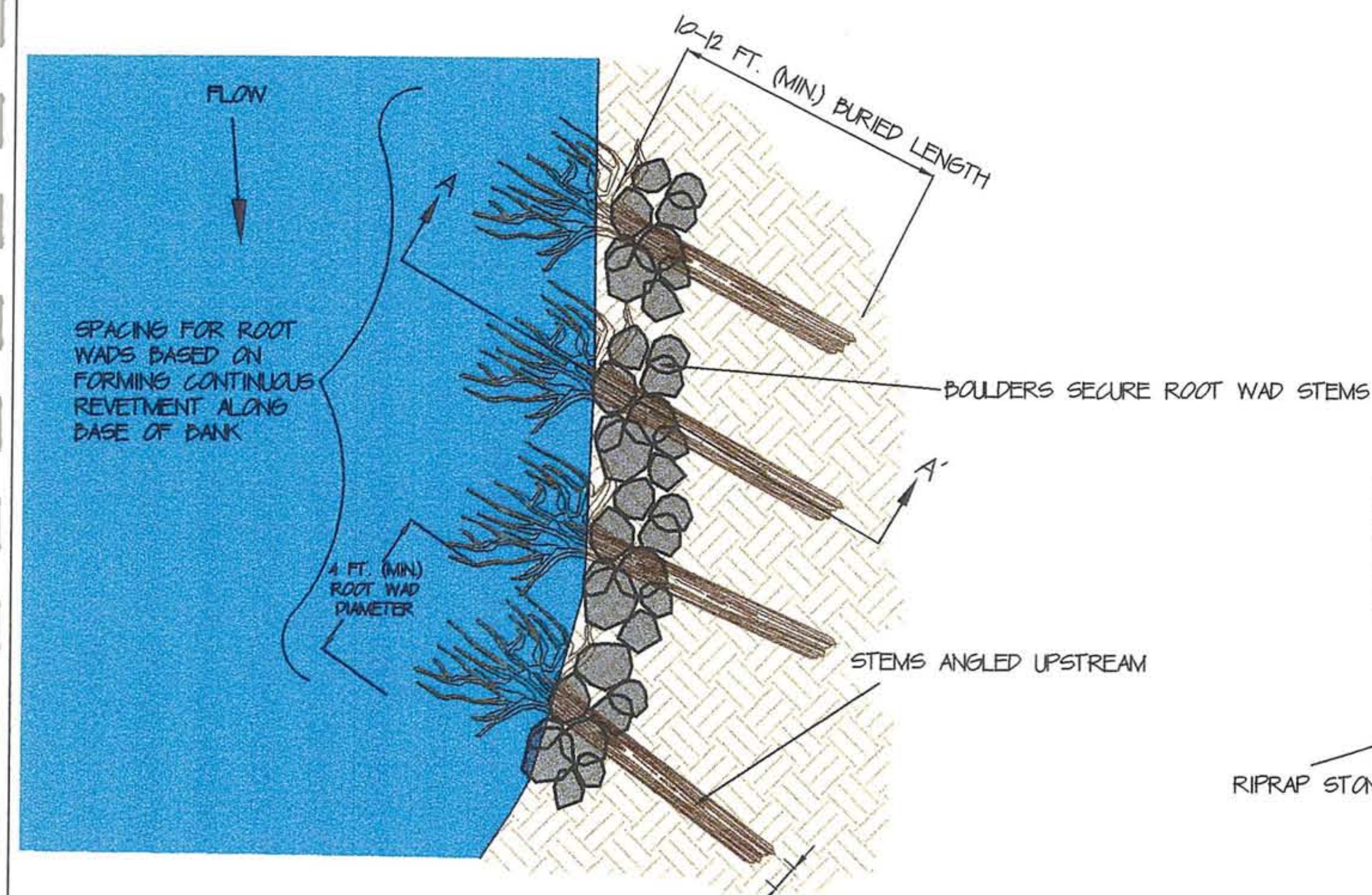
WEIGHT OF OVERLYING BOULDERS AND RIPRAP STONE SHOULD BE AT LEAST 1.5 TIMES THE BOUYANT FORCE OF THE ROOT WAD




PLAN VIEW OF ROOT WAD AND STONE BANK TOE AT CAR BEND SITE

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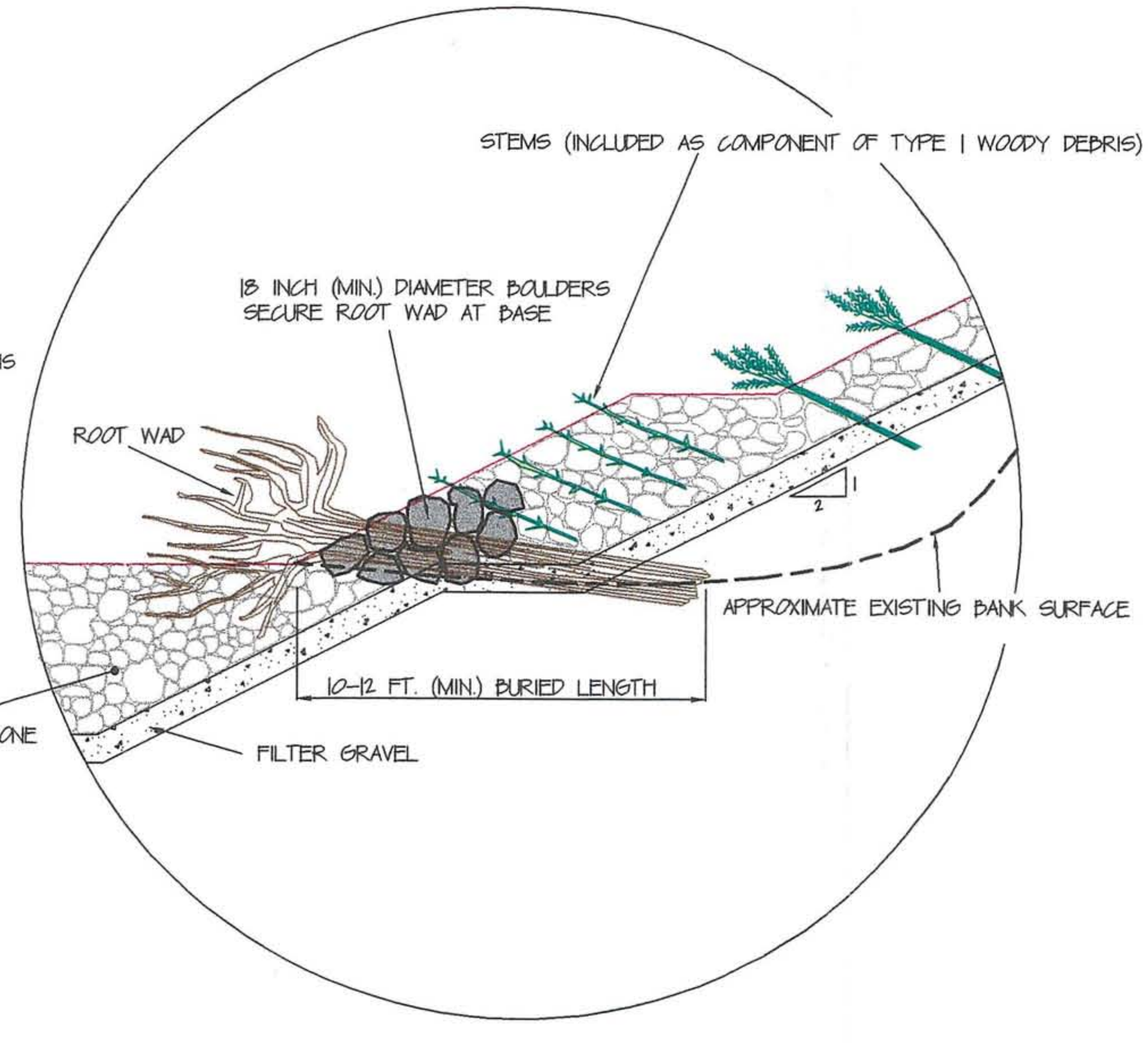


SECTION A-A' DETAIL OF ROOT WAD PLACEMENT

NOT TO SCALE



ROOT WAD AND BOULDER INSTALLATION DETAILS

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BIOTECHNICAL BANK PROTECTION SYSTEMS FOR THE MENDENHALL RIVER

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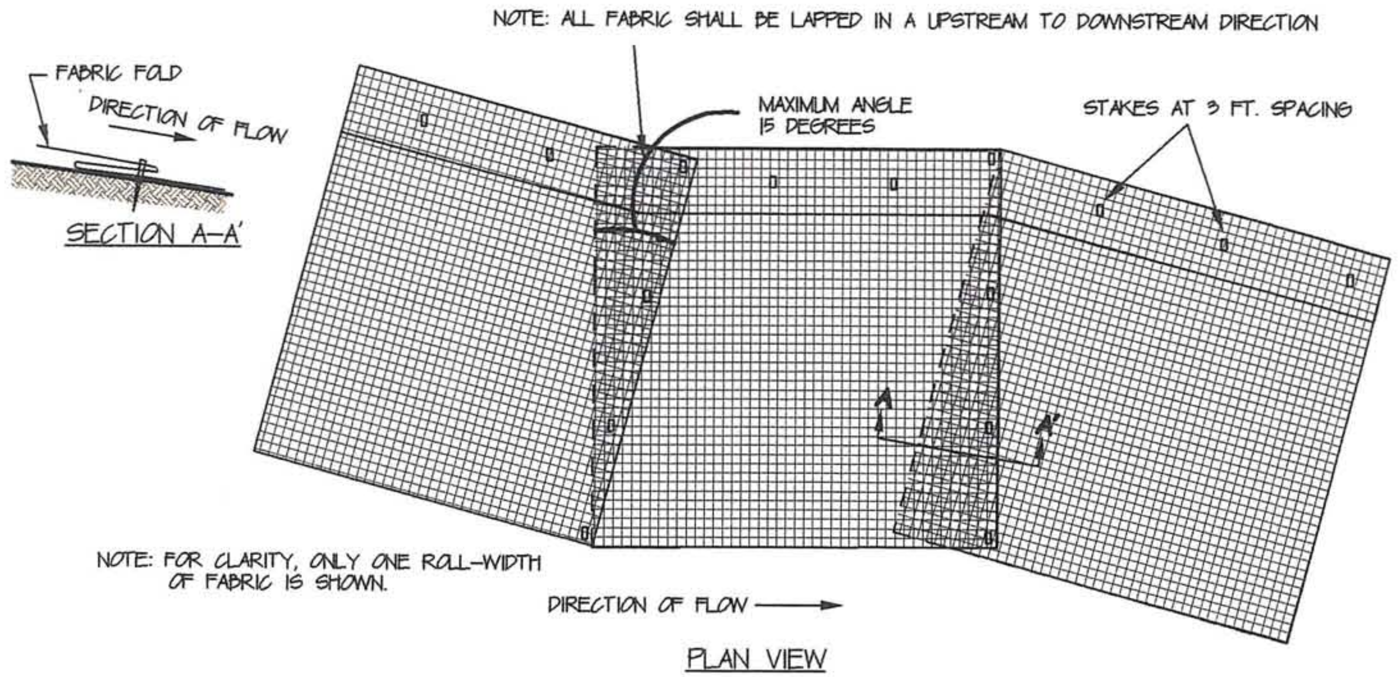


FOLDING OF CONTINUOUS SHEET OF FABRIC AT BENDS

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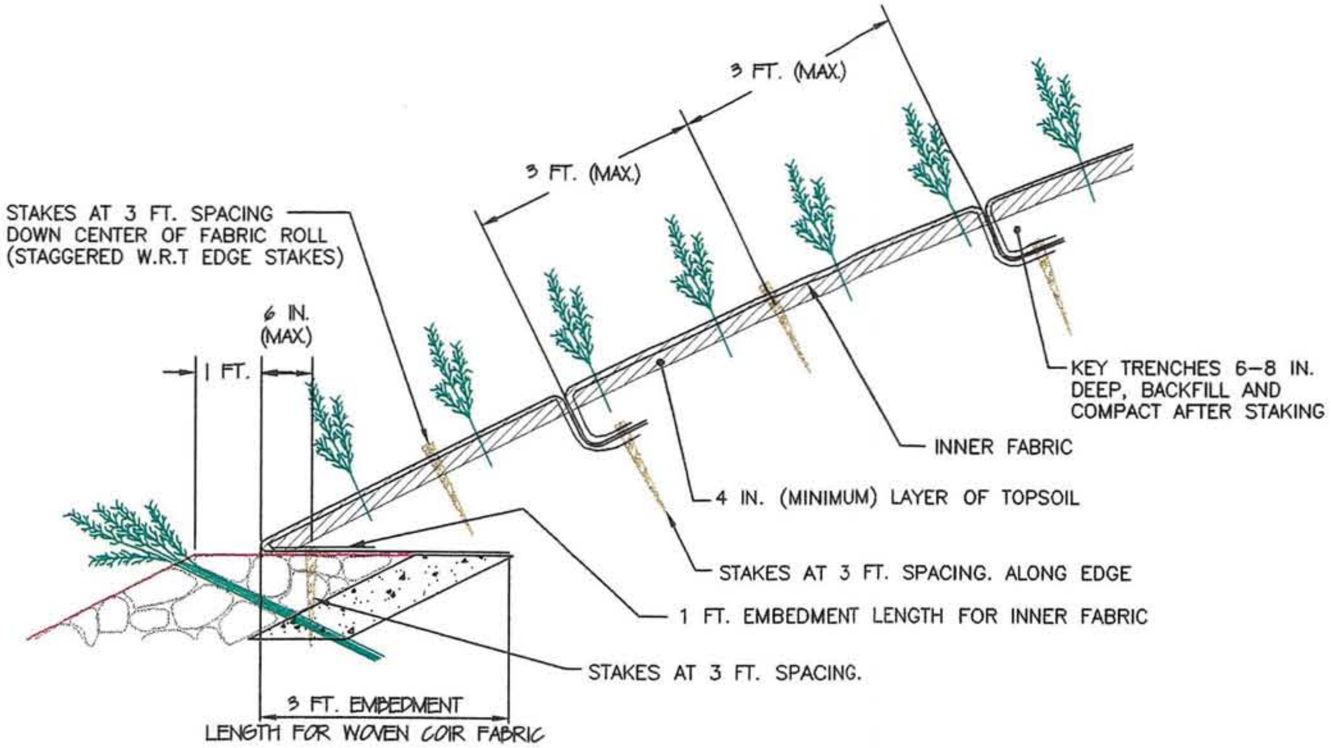


STAKING DETAIL FOR FABRIC COVERED UPPER BANK

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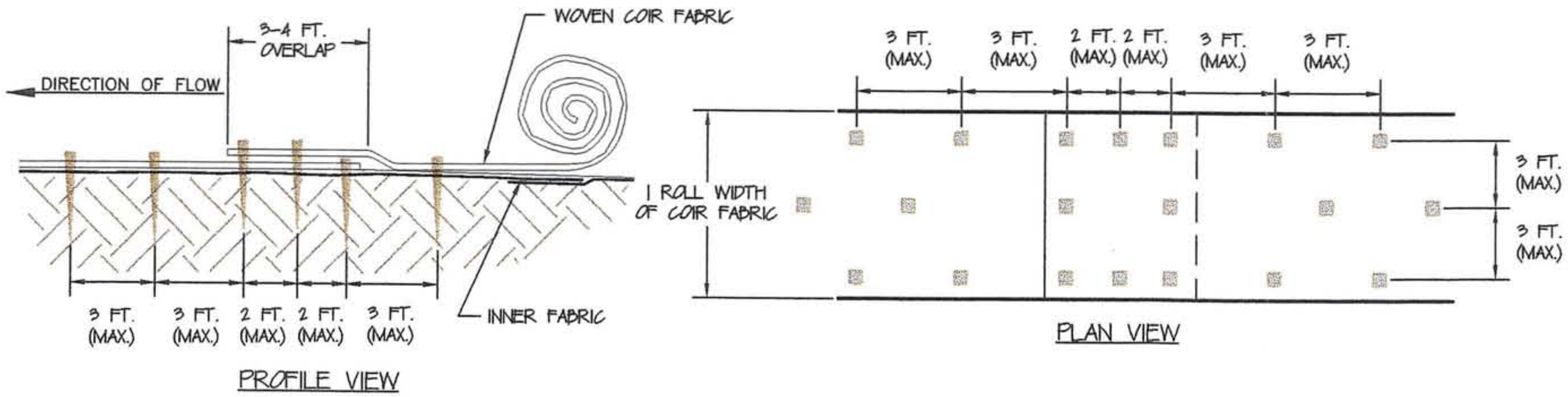


FABRIC JOINING DETAIL- JOINING ENDS OF COIR FABRIC ROLLS

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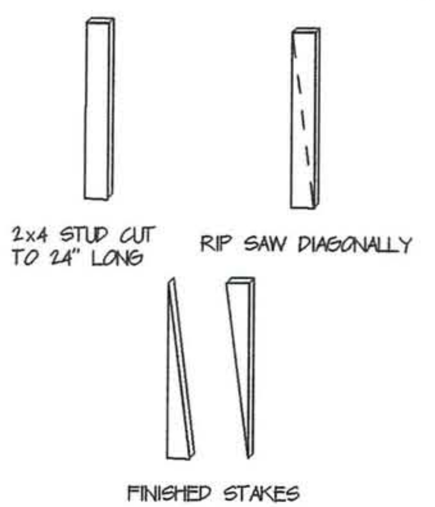
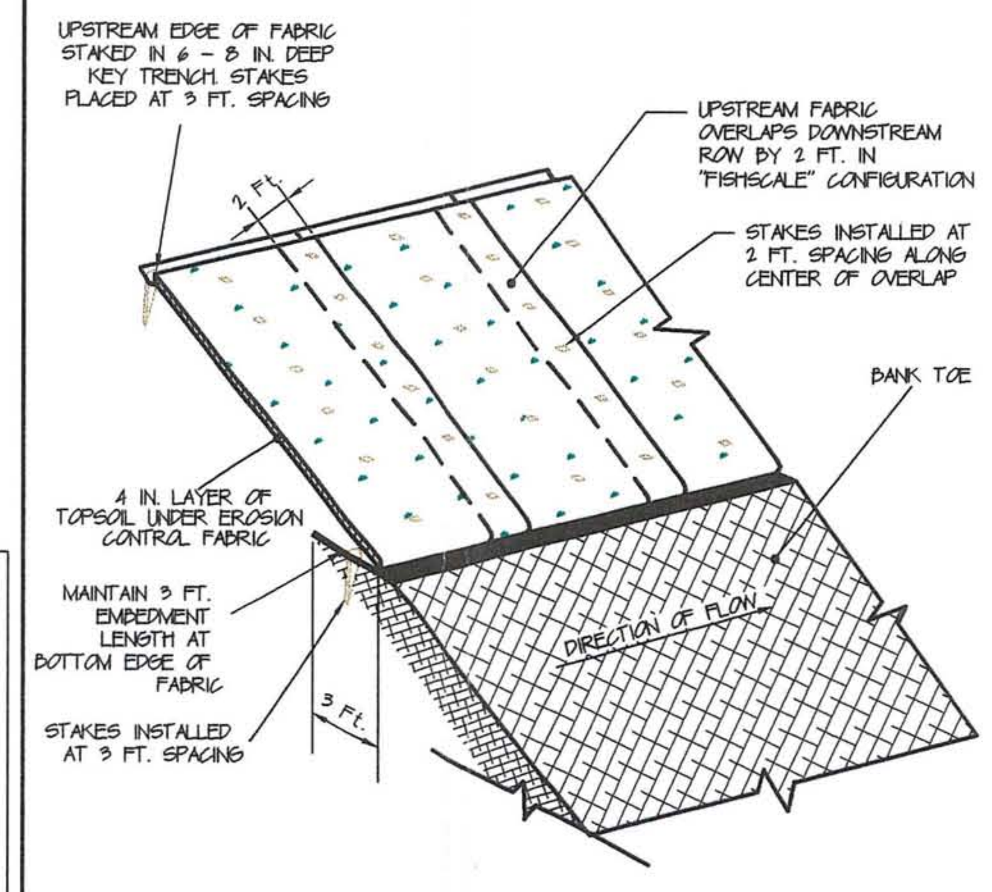



STAKE FABRICATING DETAILS

NOT TO SCALE

GENERAL NOTES ON SECURING FABRIC ON STREAMBANK LIFT

1. FABRICATE THE WOODEN STAKES BY CUTTING 2x4 STUDS INTO 2 FOOT LENGTHS AND THEN RIPPING THE LENGTHS DIAGONALLY TO CREATE A TAPERED END. SEE STAKE FABRICATION DETAIL ON THIS SHEET.
2. WOVEN COIR FABRIC SHALL OVERLAY INNER FABRIC. INNER FABRIC JOINTS SHALL HAVE 1 FT. OVERLAP.
3. FABRIC SHALL BE FOLDED AT EACH BEND AS SHOWN IN PLAN VIEW. NO BEND SHALL EXCEED A 15 DEGREE ANGLE. FOLDS SHALL BE MADE IN AN UPSTREAM TO DOWNSTREAM DIRECTION. STAKE THE FOLDS AS SHOWN IN SECTION B-B'.
4. FABRIC ENDS SHALL BE JOINED BY LAPPING THE UPSTREAM PIECE OF FABRIC OVER THE DOWNSTREAM PIECE AS SHOWN IN PLAN VIEW. OVERLAPS SHALL BE A MINIMUM OF 3 FEET. OVERLAPS SHALL BE STAGGERED FROM ROW TO ROW BY A MINIMUM OF 15 FT.
5. THE HOLES FOR STAKES SHALL NOT BE PRECUT. ALLOW THE STAKE TO BREAK THE MINIMUM NUMBER OF STRANDS AS IT IS BEING DRIVEN. DRIVE STAKES SO THAT A MAXIMUM OF 2" IS LEFT EXPOSED.




FABRIC INSTALLATION OPTION 1

FABRIC INSTALLED PERPINDICULAR TO CHANNEL

NOT TO SCALE

COIR FABRIC INSTALLATION DETAILS

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BIOTECHNICAL BANK PROTECTION SYSTEMS FOR THE MENDENHALL RIVER

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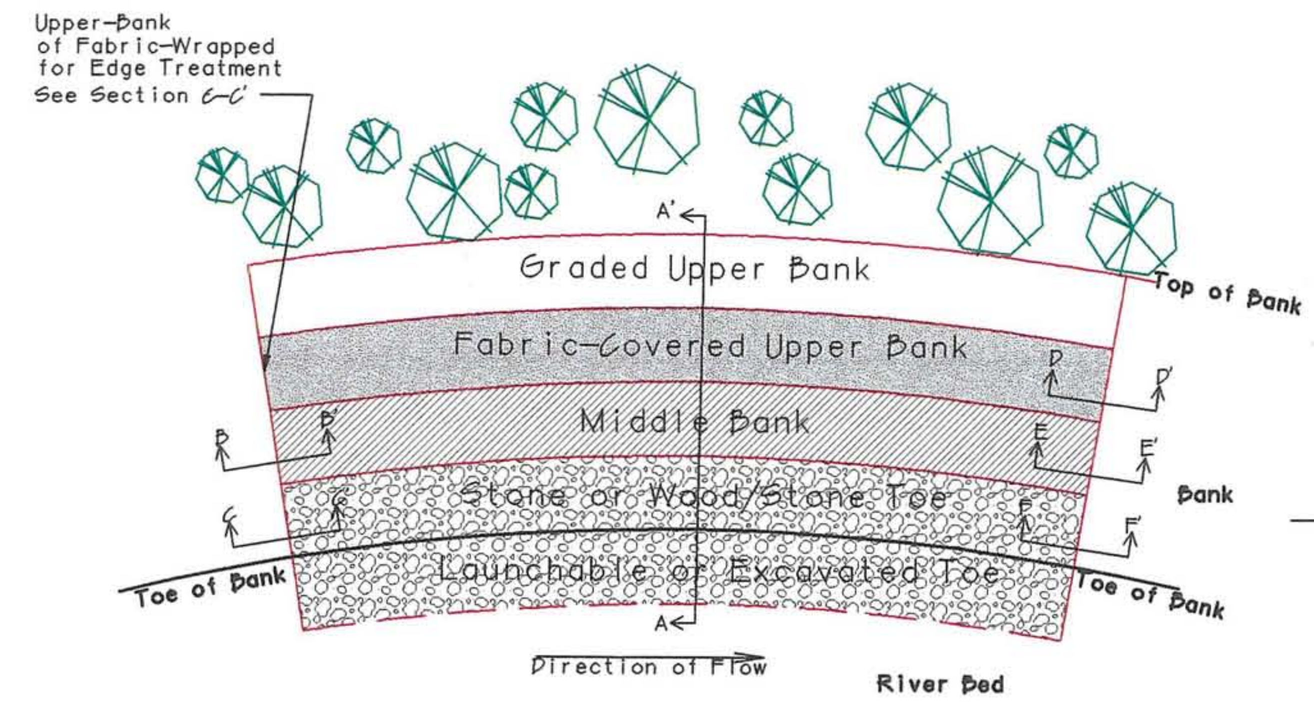
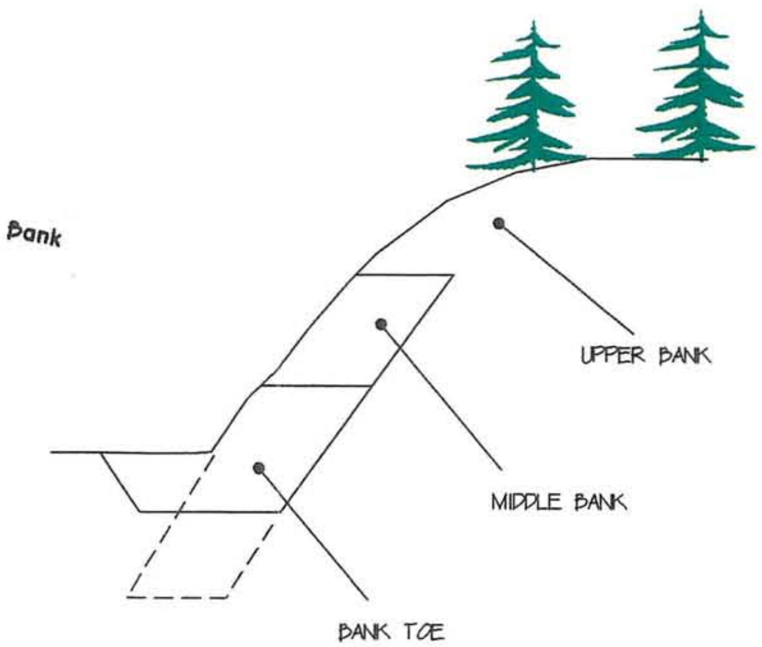
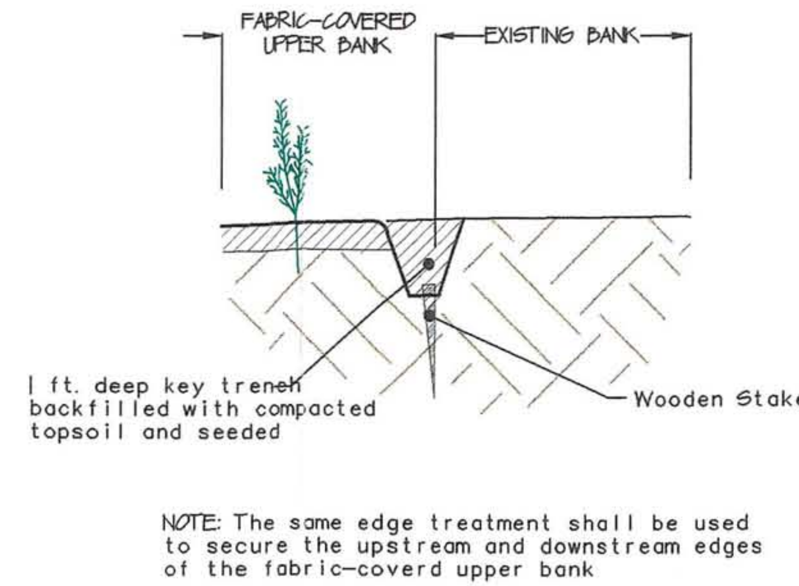


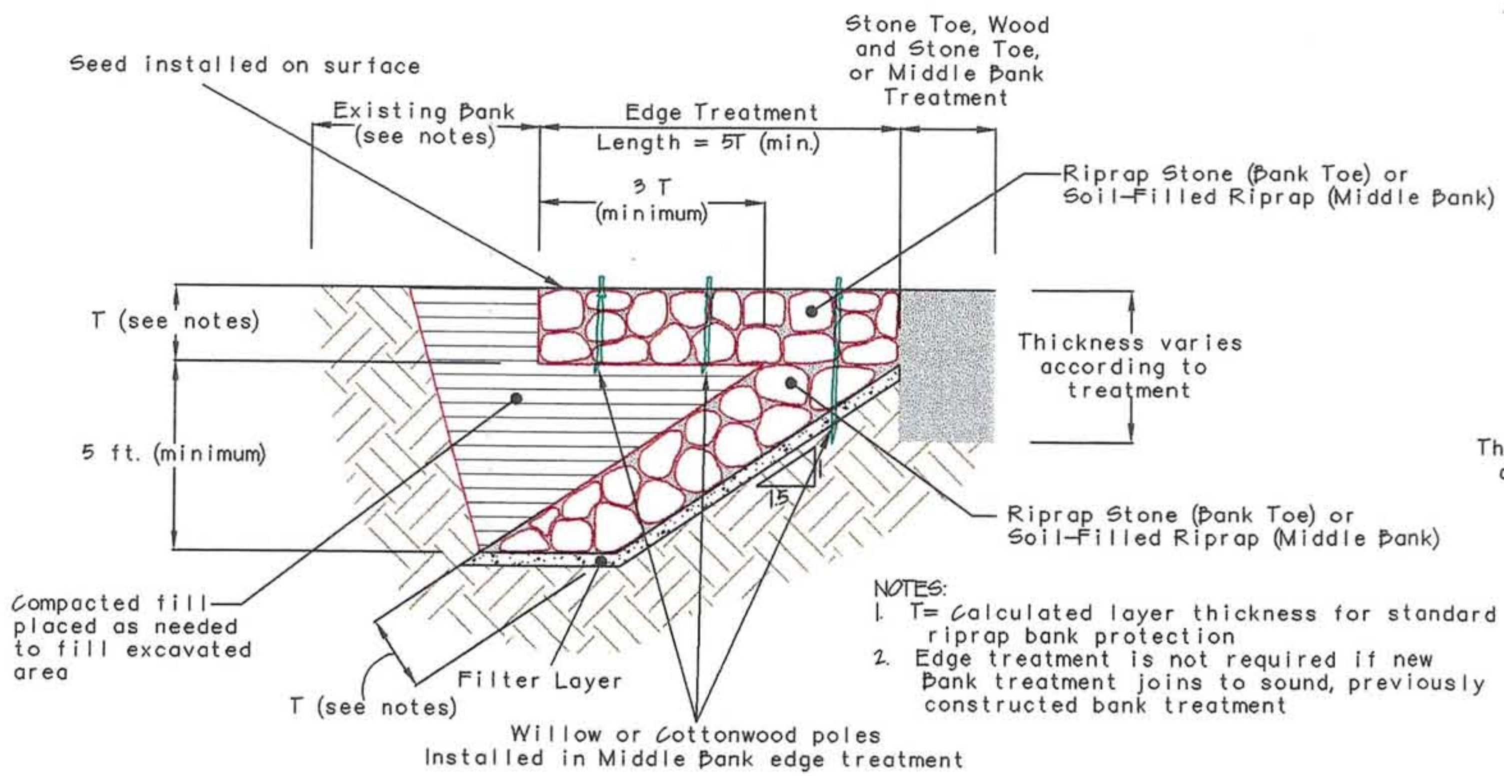

PLAN VIEW OF TYPICAL BANK TREATMENT
Not to Scale



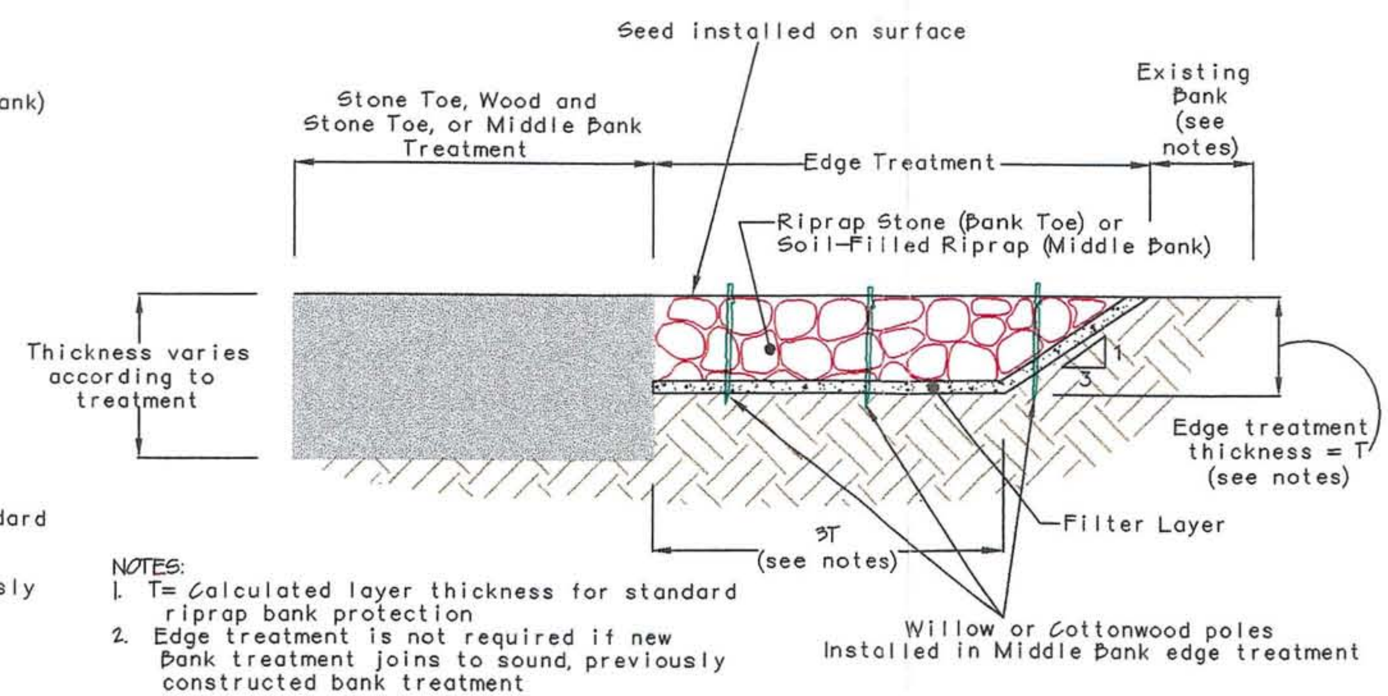

SECTION A-A': TYPICAL TREATMENTS
Not to Scale




SECTION D-D': EDGE TREATMENT FOR FABRIC-COVERED UPPER BANK
Not to Scale




SECTION B-B' AND C-C': UPSTREAM EDGE TREATMENT FOR BANK TOE AND MIDDLE BANK
Not to Scale




SECTION E-E' AND F-F': DOWNSTREAM EDGE TREATMENT FOR BANK TOE AND MIDDLE BANK
Not to Scale

EDGE TREATMENT DETAILS

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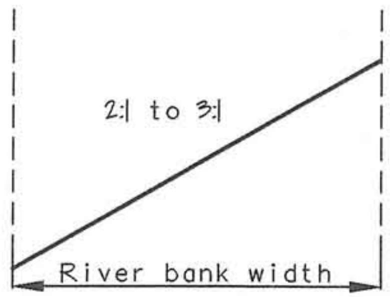
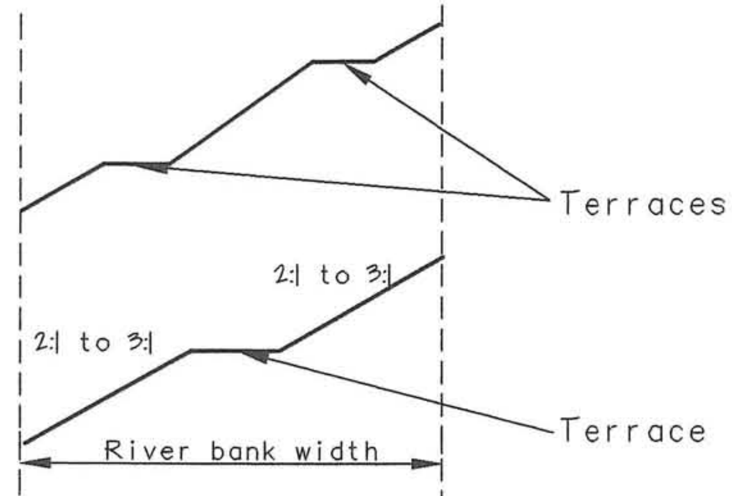
# MIDDLE BANK TREATMENT OPTIONS

## SLOPE CONFIGURATION




SINGLE PITCH SLOPE




TERRACED SLOPE OPTIONS

A terraced slope offers many advantages over a single pitch slope, but requires increased bank width or steeper slopes.

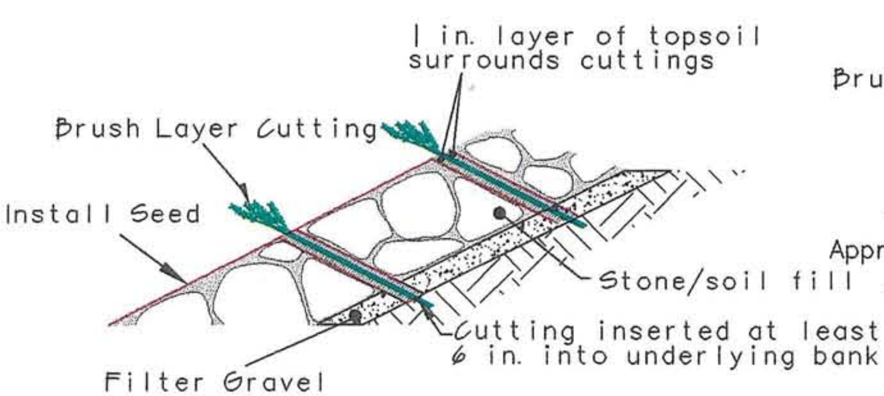
Benefits include:

- Creation of logical transition between treatments or erosional zones
- Creation of excellent planting surface for trees and shrubs
- Creation of mid-bank "floodplains" which reduces river erosional forces
- May allow for walkways or wildlife habitat areas

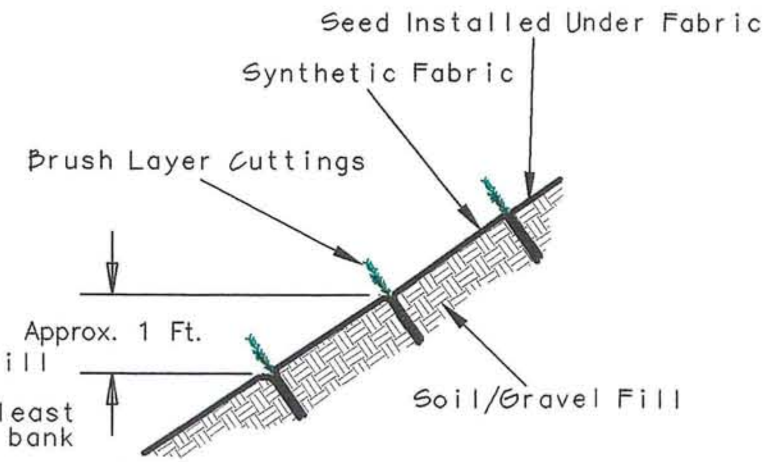
## MIDDLE BANK TREATMENT VARIATIONS

| | ADVANTAGES | DISADVANTAGES |
|---|---|---|
| Recommended Treatment: Brush Layers with Stone/Soil mixture as fill | Good erosion protection<br>Modest material cost | Stone/Soil mixture provides a marginal growing medium |
| Option A: Brush Layers with Synthetic Fabric and Gravel/Soil Mixture as Fill | Good erosion protection<br>Good growing medium for plants | High material cost<br>Requires synthetic material<br>Synthetic material visible until vegetated |
| Option B: GEOCELL (cellular confinement) Terraces fabric wrapped with Soil/Gravel Mixture as backfill | Excellent erosion protection<br>Good growing medium for plants | High material cost<br>Requires synthetic material<br>Synthetic material visible until vegetated |

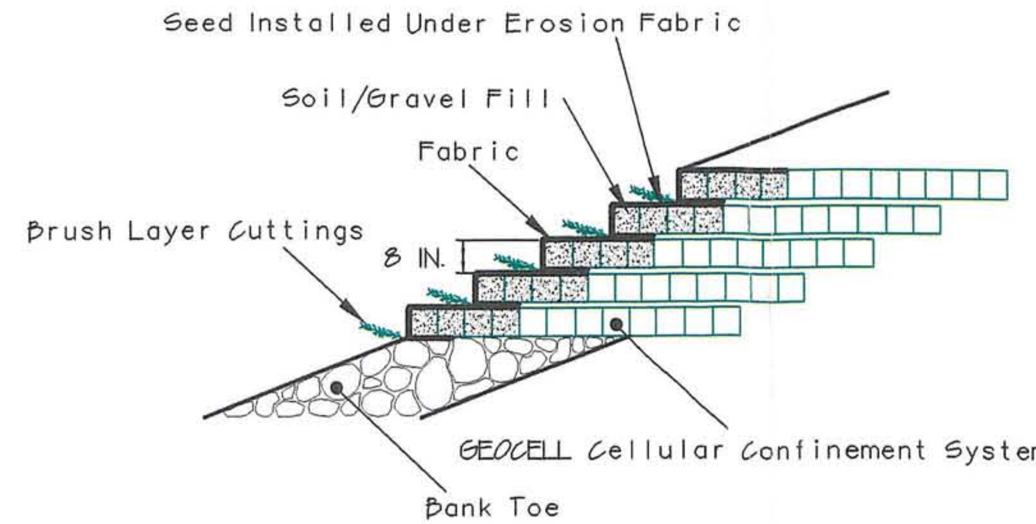
## MIDDLE BANK TREATMENT TYPICALS




RECOMMENDED TREATMENT: BRUSH LAYERS WITH STONE FILL




OPTION A: BRUSH LAYERS WITH SYNTHETIC FABRIC AND GRAVEL/SOIL MIXTURE AS FILL




OPTION B: GEOCELL TERRACES

MIDDDLE BANK TREATMENT OPTIONS

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APPROVED BY: DATE:

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# UPPER-BANK TREATMENT OPTIONS

## SLOPE CONFIGURATION

Upper banks can be terraced as shown for Middle Bank Treatments on sheet 7
Erosion control fabric is recommended below the 5-year flood level on all banks with slopes greater than 3:1.

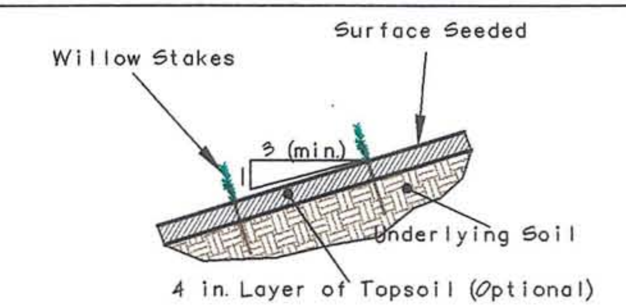
## UPPER BANK PROTECTION VARIATIONS

| UPPER BANK TREATMENT | ADVANTAGES | DISADVANTAGES |
|---|---|---|
| Recommended Treatment: Graded Slope with Erosion Fabric Rows Parallel to Channel. (Seeded and planted with willow stakes and/or containerized plants.) | Immediate Protection Against Surface Erosion<br>Good for Slopes as Steep as 2:1 (H:V) | Requires Experienced Construction Supervision<br>Requires Erosion Fabric and Careful Installation |
| Option I: Graded Slope with Erosion Fabric Rows Perpendicular to Channel. (Seeded and planted with willow stakes and/or containerized plants.) | Immediate Protection Against Surface Erosion<br>Good for Slopes as Steep as 2:1 (H:V) | Requires Erosion Fabric and Careful Installation<br>Not as Durable as "Recommended Treatment" Above |
| Option II: Graded Slope with No Erosion Fabric (Seeded and planted with willow stakes and/or containerized plants.) | Inexpensive | No Immediate Protection against Surface Erosion (prior establishment of vegetation<br>Not Recommended for bank zones below the 2-5 year flood level<br>Not Recommended for Slope Grater than 3:1 (H:V). |
| Option III: Stepped Slope with Willow Fascines (Seeded and planted with willow stakes and/or containerized plants.) | Provides Some Degree of Immediate Protection Against Surface Erosion<br>Less Expensive than Erosion Fabric | Requires Fascine Fabrication and Installation<br>No immediate protection against surface erosion |

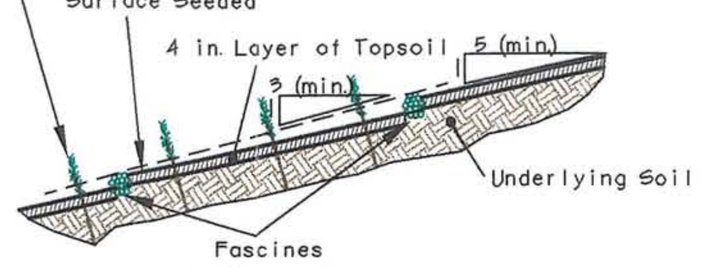
## UPPER BANK TREATMENT TYPICALS

RECOMMENDED TREATMENT: GRADED SLOPE WITH EROSION FABRIC ROWS PARALLEL TO CHANNEL (SEE SHEET 5)

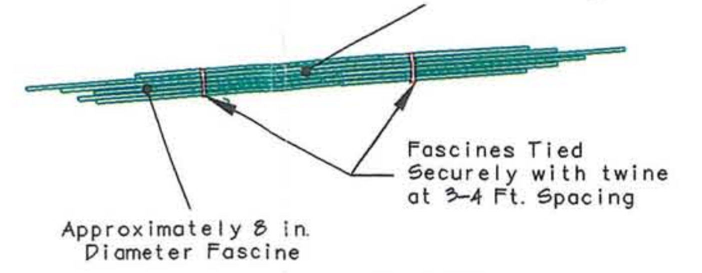
OPTION I: GRADED SLOPE WITH EROSION FABRIC ROWS PERPENDICULAR TO CHANNEL (SEE SHEET 5)




OPTION II: GRADED SLOPE WITH NO EROSION FABRIC




TYPICAL CROSS-SECTION




FASCINE DETAIL

OPTION III: STEPPED SLOPE WITH WILLOW FASCINES

UPPER-BANK TREATMENT OPTIONS

INTER-FLUVE, INC.

BIOTECHNICAL BANK PROTECTION SYSTEMS FOR THE MENDENHALL RIVER

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## SEED

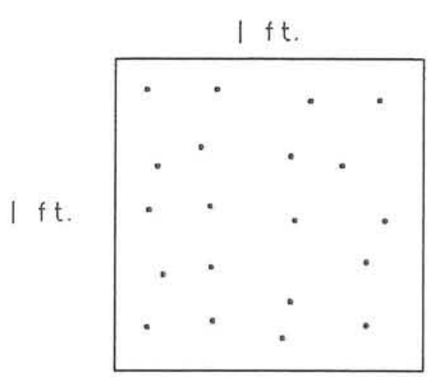
Use approved seed mixes and seeding rates.

Place seed during spring or fall.

Hand broadcast seed on scarified soil surface.
(scarified with hand rake, machine tracks, or excavator bucket)

Hand rake or compact with machine tracks or compactor.

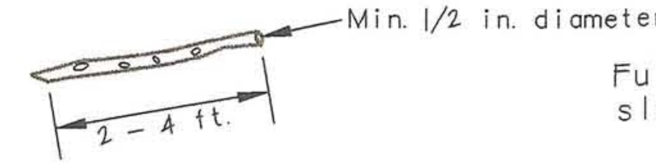
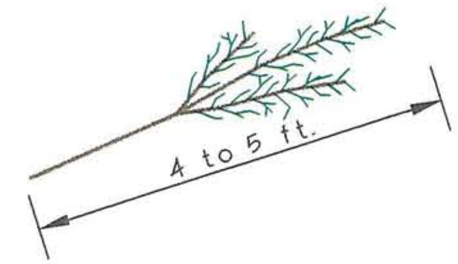
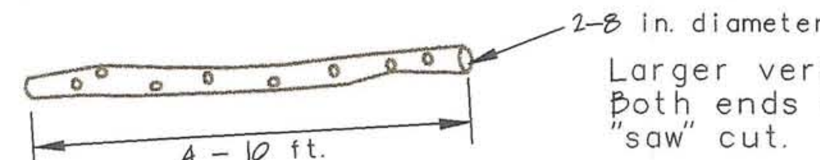
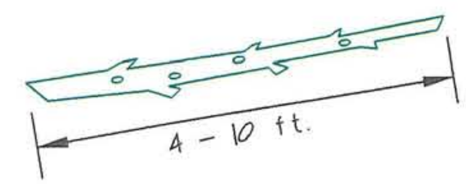
If erosion control fabric is called for on the plans, install fabric after seeding.




After seed placement spot check 1 X 1 ft. plots and ensure a minimum of 20 seeds per square foot.

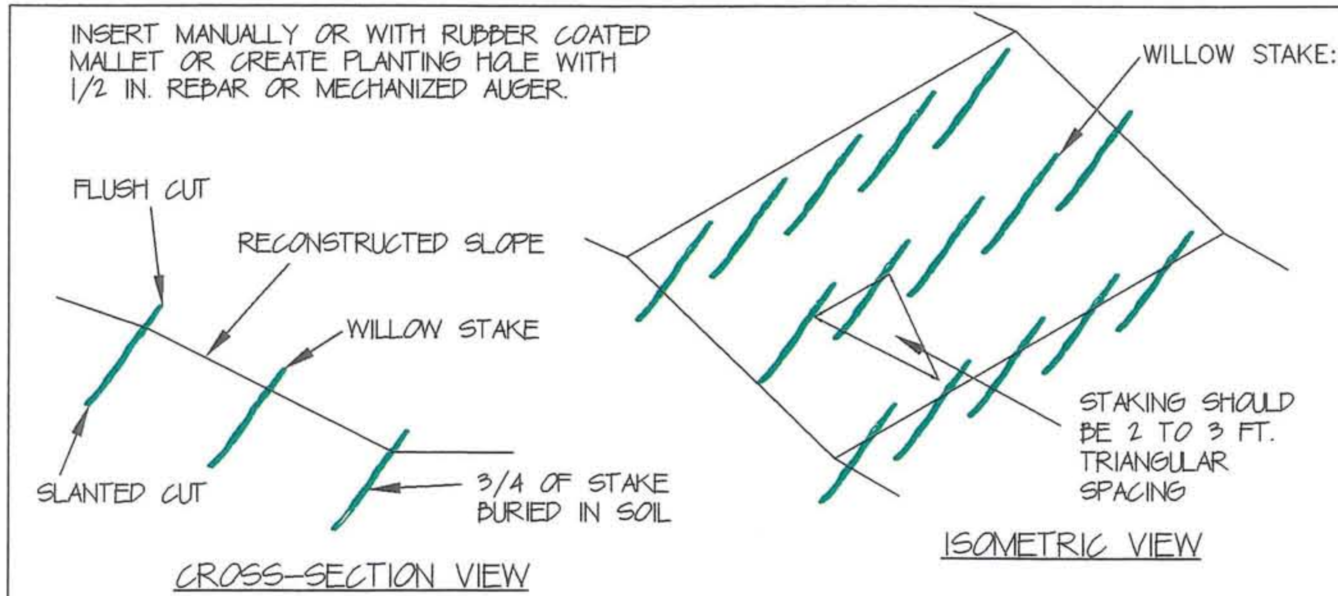
## DORMANT HARDWOOD CUTTINGS

(LOCALLY COLLECTED DORMANT WILLOW AND COTTONWOODS THAT ROOT FROM "CUTTINGS)

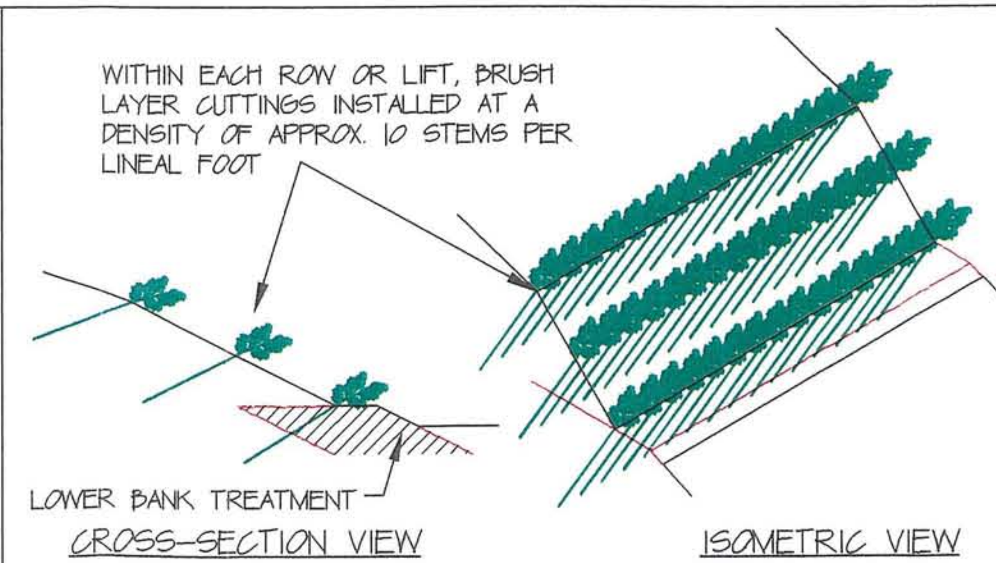
| ITEM | DIMENSIONS | DESCRIPTION |
|---|---|---|
| A. WILLOW STAKES |   | Fully "pruned" cuttings with slanted cut at bottom end. |
| B. BRUSH LAYER CUTTINGS |   | Willow branches with new shoots and stems up to 2 in. diameter. Willow brush layers are essentially a stake without fine branches removed. |
| C. WILLOW OR COTTONWOOD POLES |   | Larger version of stakes. Both ends with typical "saw" cut. |
| D. FASCINE CUTTINGS |   | Willow Stems with branches removed, up to 2 in. in diameter. (See Sheet 8 for Fascine fabrication and installation) |

## INSTALLATION GUIDELINES FOR DORMANT HARD WOOD CUTTINGS

NOTE: (SEE SHEET 8 FOR FASCINE FABRICATION AND INSTALLATION)

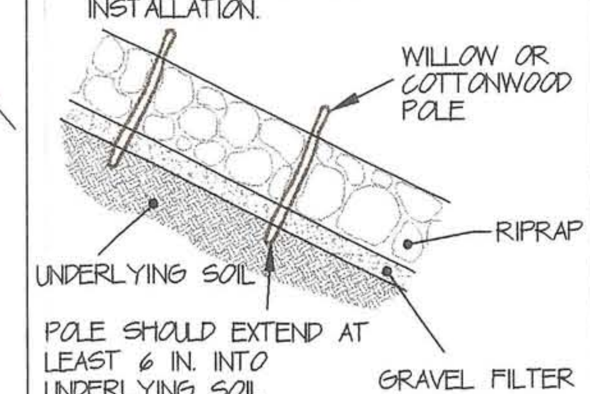



A. WILLOW STAKES




B. WILLOW BRUSH LAYERS

POLES CAN BE DRIVEN THROUGH EXISTING RIPRAP (A BACKHOE & "STINGER" MAY BE REQUIRED TO CREATE HOLE) OR INSTALLED IN PLACE DURING NEW RIPRAP INSTALLATION.




C. WILLOW OR COTTONWOOD POLES

PLANT MATERIALS AND INSTALLATION: SEED AND DORMANT CUTTINGS

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BIOTECHNICAL BANK PROTECTION SYSTEMS FOR THE MENDENHALL RIVER

REVISED BY/DATE: | REASON FOR REVISION:

DRAWN BY: JKT DATE: 10/14/98
APPROVED BY: DATE:
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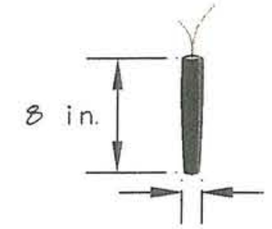
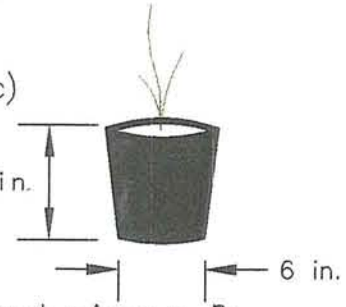
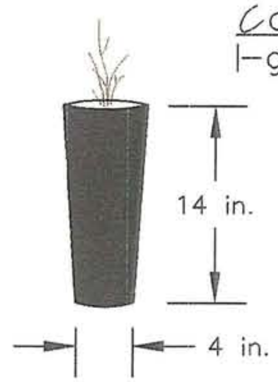
# CONTAINERIZED PLANT MATERIALS AND INSTALLATION



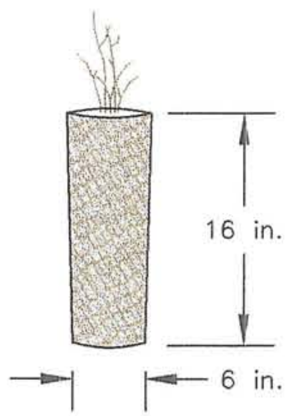

Container A
Tubeling (plastic)



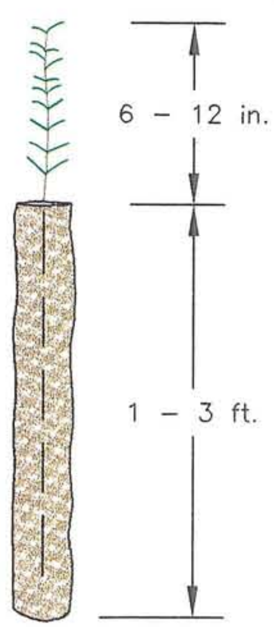

Container B
1-gallon (plastic)




Container C
DEE-Pot
(plastic)




Container D
Fiber Pot
(biodegradable/recycled wood fiber)




Container E
Burlap Sock
(biodegradable burlap)

Container A Remove plant/root mass from container
- Create planting hole with dibble bar
- Insert plant into hole
- Ensure good root-soil contact
- Tamp backfill, leaving no air pockets around roots.

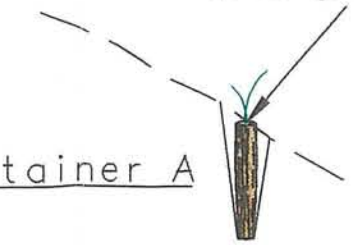
Containers B,C,D Dig planting pit 1 to 2 inches larger than root mass
- Remove plant/root mass from container
- Insert plant into hole
- Backfill soil around root mass, leaving no air pockets around roots.

* If planting through erosion control fabric minimize number of cut fabric strands.

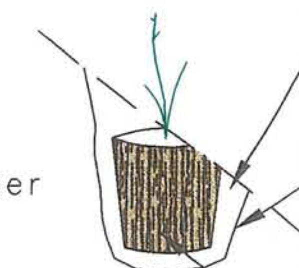
Variation 1 - Containers C, D, or E may be installed horizontally between brush layers

Variation 2 - The fiber pot (Container D) does not need to be removed during planting. This may be useful if planting into new or existing riprap.

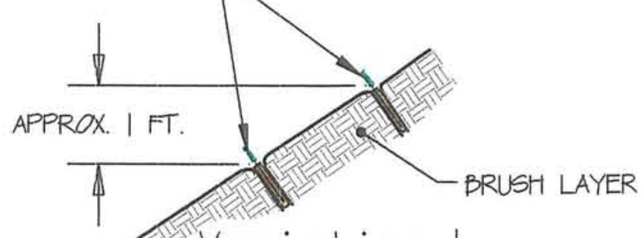
Container E The biodegradable burlap sock container may be used to grow deep narrow rooted cuttings. The container should not be removed and the plant will be installed between soil lifts.



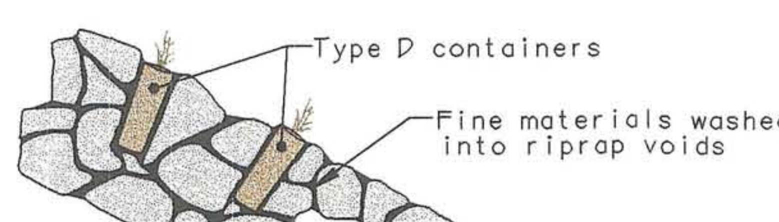

Container A




Container B

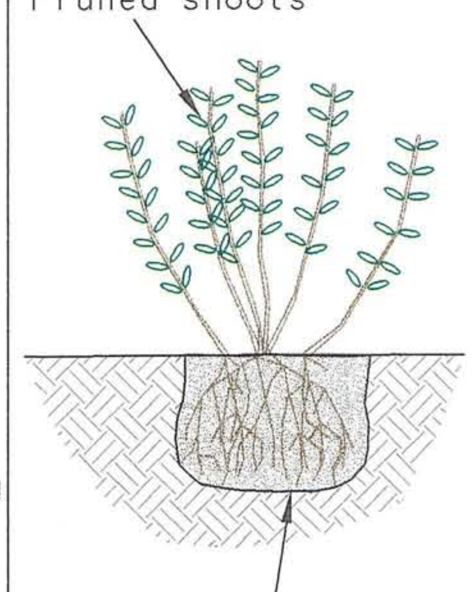



Variation 1
Placement of C, D, or E between soil lifts of brush layer treatment




Variation 2
Planting into new or existing riprap

## SALVAGED SHRUBS




Use mature deciduous shrubs with well developed root systems.

Prune canopy of shrub before excavating root mass.

Excavate planting pit
Salvage root mass/clump with back hoe bucket
Transport and plant salvaged root mass
Backfill as necessary, leaving no air pockets

PLANT MATERIALS AND INSTALLATION: CONTAINERIZED PLANTS

INTER-FLUVE, INC.

BIOTECHNICAL BANK PROTECTION SYSTEMS FOR THE MENDENHALL RIVER

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DRAWN BY: JKT
DATE: 10/14/98
APPROVED BY:
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## 8.3 SPECIFICATIONS

### 8.3.1 Materials



### 8.3.2 Installation



Note: The following "Specifications and Installation Sections" were written solely by Inter-Fluve, Inc. Engineers. These are their professional recommendations for effective bank stabilization project construction. The specifications are not all required by statute, but are written with strict language to insure the proper techniques are used by contractors. Sources for materials listed in the following sections are listed only for scientific completeness. Other sources or suppliers could be used for these materials. The Alaska Department of Fish and Game does not endorse any one supplier over another.

### 8.3.1 Materials

## SECTION 201

## Common Fill

*1.0 Description*

1.01 This item shall consist of furnishing material for backfill as needed, to be placed at locations as shown in the plans or as directed by the Owner. The Contractor shall salvage the Common Fill from on-site sources according to Section 301, Excavation, Backfill, and Compaction, and if there is insufficient Common Fill available on site, the Contractor shall bring suitable material on site.

1.02 The material will be used during construction work in:

Section 302, STONE BANK TOE;
Section 303, WOOD AND STONE BANK TOE;
Section 304, SOIL-FILLED RIPRAP;
Section 305, BRUSH LAYERING;
Section 306, FABRIC-COVERED UPPER BANK;
Section 307, GRADED UPPER BANK; and
Section 308, TRANSITION AREAS.

*2.0 Materials*

2.01 Common Fill (On-Site). The fill material shall originate from within the project site during work described in Section 301, EXCAVATION, BACKFILL, AND COMPACTION and shall consist of earth, sand, gravel, rock, or combinations thereof, and shall contain no muck, peat, frozen material, roots, sod, refuse, or other deleterious matter, and shall be compactable in accordance with the backfill provisions and compaction requirements.

2.02 Common Fill (Off-Site). The fill material shall originate from off-site and shall consist of earth, sand, gravel, rock, or combinations thereof, and shall contain no muck, peat, frozen material, roots, sod, refuse, contamination, or other deleterious matter, and shall be compactable in accordance with the backfill provisions and compaction requirements.

END OF SECTION 201

# SECTION 202

## TOPSOIL

*1.0 Description*

1.01 This section includes all equipment, labor and materials necessary to salvage, furnish, stockpile, and install topsoil in middle and upper banks. Salvage and stockpiling of topsoil shall include removal of all materials which may cause difficulty for the smooth and even spreading of soils.

1.02 The material will be used during construction with work in:

Section 301, EXCAVATION, BACKFILL, AND COMPACTION;
Section 304, SOIL-FILLED RIPRAP;
Section 305, BRUSH LAYERING;
Section 306, FABRIC-COVERED UPPER BANK;
Section 307, GRADED UPPER BANK; and
Section 308, TRANSITION AREAS.

*2.0 Materials*

2.01 Regulation. Quality assurance testing will be performed by the Owner to assure compliance with the Specifications and Drawings. Testing will be performed in accordance with applicable AASHTO and ASTM test methods. If tests indicate materials do not meet specified requirements, the Contractor shall remove all soils not meeting the specified requirements and replace the failing soils with materials meeting the Specifications. Removal and replacement of the affected soils shall be at the Contractor's expense. The frequency and need for testing shall be determined by the Owner.

2.02 References. Applicable AASHTO and ASTM test methodologies, procedures, and standards shall govern for all soil sampling, soil sample preparation, soil classification, field compaction and moisture content testing of soils, and laboratory density and moisture content testing of soils shall be utilized to determine construction compliance to the Drawings and Specifications.

AASHTO T 88 Gradation by Bouyoucos Hydrometer Analysis.
AASHTO T 194 Organic Content of Soils.
ANSI/ASTM D422 Sieve Analysis of Fine and Coarse Aggregates.
ASTM D2216 Natural Moisture Content of Soils.
ASTM D4972-89 pH of Soils.

2.03 Salvaged Topsoil

A. Salvaged Topsoil shall consist of natural friable surface soil obtained from within the project site which is free of admixtures of undesirable subsoil, debris, refuse, and deleterious or objectionable materials.

B. Topsoil shall not incorporate root wads from small brush and grasses. Potential source areas for topsoil are all areas requiring stripping, grubbing, and excavation, or fill placement requiring topsoil removal as shown in the Drawings. If excess topsoil remains at the end of the project, this material shall be disposed of off-site at the Contractors expense.

2.04 Imported Topsoil

A. Submittal. Additional topsoil shall be provided as needed but shall be approved by the Owner at least 2 weeks prior to delivery to the project site. The Contractor shall submit the following information about the proposed topsoil source at least 30 calendar days prior to delivery to the project:

*a.* *Name and phone number of Supplier and a contact person who can show the Owner the source.*

*b.* *Location of proposed source.*

*c.* *The length of time since the topsoil has been removed from its source site, and how it has been stored (e.g., size of stockpiles, and number of times it has been moved since original excavation).*

*d.* *Results of testing of two representative samples of the topsoil taken from the source area. Tests on each of the samples shall include the tests listed under 2.02.*

B. During hauling or placing of Topsoil, the Contractor shall submit test results from tests listed in 2.02, on representative samples of the Topsoil. At least one representative sample of the topsoil shall be tested for each 1,000 cubic yards of Topsoil provided, or more frequently if necessary to control the work.

C. Imported Topsoil shall conform with salvage Topsoil requirements and shall come from a high quality source. Topsoil furnished by the Contractor shall consist of a natural friable surface soul without admixtures of undesirable subsoil, refuse, or foreign materials. It shall be reasonable free from roots, clods, hard clay, noxious weeds, tall grass, brush, sticks, stubble or other litter, and shall be free-draining and non-toxic.

D. Topsoil furnished from sources outside the limits of the Project shall contain not less than 3%, nor more than 20%, organic matter as determined by loss-on-ignition of oven dried samples in accordance with ATM T-6.

E. Topsoil pH shall not be less than 5.5.

F. Topsoil shall meet the following grading requirements:

| Sieve | Percent Passing |
|---|---|
| 2" | 100 |
| No. 4 | 75-100 |
| No. 10 | 60-100 |
| No. 200 | 10-70 |

G. Topsoil shall not have been stored or stockpiled for more than one year.

H. Unsuitable topsoil sources may be used if, prior to delivery to the project, sufficient organic matter in the form of pulverized peat moss or rich organic soil from other sources is thoroughly mixed with the topsoil to provide a product conforming to the above requirements.

I. Material Handling and Storage. The general areas designated on the Drawings are available to the Contractor for stockpiling, staging, processing materials, etc., but the Contractor shall coordinate all details and shall be wholly responsible for all aspects of material processing, delivery, handling and storage.

END OF SECTION 202

## SECTION 203

## Filter Gravel

### *1.0 DESCRIPTION*

This item shall consist of furnishing aggregate for a filter layer (or layers) beneath the Bank Toe and Middle Bank as shown on the plans.

The material will be used during construction with work in:

Section 302, STONE BANK TOE;
Section 303, WOOD AND STONE BANK TOE;
Section 304, SOIL-FILLED RIPRAP;
Section 305, BRUSH LAYERING; and
Section 308, TRANSITION AREAS.

*2.0 MATERIAL*

2.01 References. ANSI/ASTM D422. Sieve Analysis of Fine and Coarse Aggregates.

2.02 Submittal. The Contractor shall submit to the Owner a description of the material, and the results of gradation tests on two representative samples prior to delivery of the material to the site.

2.03 The Filter Gravel shall consist of angular, sound, tough, durable stone or crushed rock. The material shall contain no muck, frozen material, roots, sod or other deleterious matter. The material shall be non-plastic.

2.04 Gradation of filter gravel shall be as shown on the plans

END OF SECTION 203

## SECTION 204

## Riprap Stone

*1.0 Description*

1.01 This work shall consist of furnishing Riprap Stone as specified herein, shown on the plans, or as established by the Owner.

1.02 The material will be used during construction with work in:

Section 302, STONE BANK TOE;
Section 303, WOOD AND STONE BANK TOE;
Section 304, SOIL-FILLED RIPRAP;
Section 305, BRUSH LAYERING; and
Section 308, TRANSITION AREAS.

*2.0 MATERIALS*

2.01 References. ANSI/ASTM D422. Sieve Analysis of Fine and Coarse Aggregates.

2.02 Submittals. The Contractor shall submit the following information at least 2 weeks prior to hauling stone to the project site.

A. Gradation (by size and weight) and specific gravity for stone materials.

B. Samples of the stone to be used.

C. Stone source location, name of supplier, and phone number of contact person.

D. Bulk density of the stone and the method of determination.

2.03 Submittal. The stone shall be washed and free of contaminates prior to being placed into the river or on the slope. If washed on site, the Contractor shall submit a plan for approval to the Owner indicating how the washing is to be controlled to prevent siltation.

2.04 Stone shall be hard, and angular, and have a percentage of wear of not more than 50 at 500 revolutions as determined by AASHTO T 96. The least dimension of any stone shall be not less than 1/4 its greatest dimension. Rounded boulders or cobbles shall not be used on slopes steeper than 2 to 1. The stone shall be resistant to weathering and to water action, and be free from overburden, spoil, shale, structural defects, and organic material.

2.05 Unless otherwise allowed, the density of the stone rock shall be at least 165 pounds per cubic foot, specific gravity of 2.65. The stone shall conform to the gradation(s) shown on the plans.

2.06 Each load of stone shall be well graded from the smallest to the maximum size specified.

2.07 A filter layer (or layers) shall be placed below stone.

END OF SECTION 204

## SECTION 205

## <u>Woody Debris</u>

### 1.0 DESCRIPTION

1.01 This work shall consist of furnishing and placing Woody Debris as shown on the plans or as established by the Owner. Woody Debris shall consist of Root Wads, Logs, and Stems to be installed in the Wood and Stone Bank Toe.

1.02 The material will be used during construction work in:

Section 303, WOOD AND STONE BANK TOE; and
Section 308, TRANSITION AREAS.

### 2.0 MATERIALS

2.01 <u>Woody Debris Type 1.</u> Woody Debris Type 1 shall consist of an even mixture of Root Wads and Stems as described below.

A. Root Wads. Root Wads shall consist of stems with root balls attached. Stem diameter shall range from 12-24 inches, and stem length shall range from 10-15 feet. The root ball shall consist of stout roots, such that roots of minimum 2-inch diameter of shall form a root wad at least 4 ft in diameter. All twigs and branches (except for the roots) shall be removed to stubs no longer than two inches. Logs may consist of western hemlock (*Tsuga heterophylla*) or spruce (*Picea sitchensis*).

B. Stems. Stems consist of branches and shoots ranging in size from 1/4 inch to 2 inches in diameter and 4-6 feet in length. Coniferous species such as western hemlock or Sitka spruce are acceptable as long as live or dead foliage (needles) is not included. In addition, at least 10 percent (by volume) of the stem material must be such as underleaf willow (*Salix commutata*), Sitka willow (*Salix sitchensis*) or black cottonwood (*Populus trichocarpa*).

2.02 Woody Debris Type 2. Woody Debris Type 2 shall consist of an even mixture of Logs and Stems as described below.

A. Logs. Logs shall range from 4-6 inches in diameter, and 5-6 feet in length. Logs with the root wads attached are preferred. All twigs and branches (except for the roots) shall be removed to stubs no longer than two inches. Logs may consist of western hemlock (*Tsuga heterophylla*) or Sitka *spruce (Picea sitchensis*)..

B. Stems. Stems consist of branches and shoots ranging in size from 1/4 inch to 2 inches in diameter and 4-6 feet in length. Coniferous species such as western hemlock or Sitka spruce are acceptable as long as live or dead foliage (needles) is not included. In addition, at least 10 percent (by volume) of the stem material must be willows or cottonwoods native to southeast Alaska such as underleaf willow (*Salix commutata*), Sitka willow (*Salix sitchensis*) or black cottonwood (*Populus trichocarpa*).

END OF SECTION 205

## SECTION 206

## EROSION FABRIC

### 1.0 DESCRIPTION

1.01 This item shall consist of furnishing and storing Inner Fabric and Woven Coir Fabric for installation in Fabric-Covered Upper Bank and adjacent Transition Areas.

1.02 This section also includes specifications for wooden stakes used in erosion fabric installation.

1.03 Erosion fabric shall be used during construction work in:

Section 306, FABRIC-COVERED UPPER BANK; and
Section 308, TRANSITION AREAS.

## 2.0 MATERIALS

2.01 Inner Fabric.

A. This fabric is used to contain fine textured materials as an inner fabric for the fabric wraps in the upper bank treatment. The approved fabric is Landlock Poly-jute, manufactured by Synthetic Industries (1-800-621-0444).

B. Landlock Poly-jute is a flexible, open-weave geosynthetic manufactured from perpendicular rows of photodegradable polypropylene multifilament and tape yarn woven into a matrix.

Minimum Average Roll Values:

| | | |
|---|---|---|
| Mass Per Unit Area | ASTM D-5261 | 1.75 oz.sy |
| Tensile Strength | ASTM D-4632 | 35 x 20 lbs |
| Tensile Strength | ASTM D-5035 | 450 x 250 lb/ft |
| Roll Width | | 12.5 ft x 430 ft |

C. A local supplier is:

Brian Apley
Palmer, AK
phone: (907)745-4292
fax: (907) 746-1554

2.02 Woven Coir Fabric. (900 gram/meter)

A. Coir fabric is a biodegradable erosion control fabric made from coconut fibers.

B. Woven coir fabric (900 gram/meter) is used as the main structural support for the fabric wraps in the upper bank treatment. The woven fabric shall be a high strength, coir (100% coconut fiber), continuously woven mat (i.e., without seams) with the following minimum average roll properties:

| | | |
|---|---|---|
| Thickness | | ASTM D1777 0.30 inches |
| Tensile Strength (wet) | | ASTM D4595 100 lb/sq in x 60 lb/sq in |
| Weight | | ASTM D3776 26 oz/sy (900 gram/m) |
| Open Area | Measured | 65% |
| Roll Width | Measured | 3 or 4 meters |

C. A pre-approved fabric (if without seams) is, and Palm Fiber KoirMat 900 and Rolanka BioDMat 90.

D. A local supplier for coir products includes, but is not limited to:

Polar Supplies
Anchorage, AK
Phone: 907-272-7501

2.03 . Wood stakes for securing coir fabric to ground surface. Wood stakes for installation of all woven and non-woven coir fabric shall be 24 inches long and shall have a top (head) dimension of at least 1.5 inches in one axis (thickness) and 3.0 inches in the second axis (width). Stakes shall be constructed by rip cutting a 24 inch 2"x 4" diagonally from top to bottom across the 4" wide surface such that the top meets the minimum width and thickness specifications.

END OF SECTION 206

## SECTION 207

### WILLOW AND COTTONWOOD POLES

### 1.0 DESCRIPTION

1.01 General. Willow and Cottonwood Poles are large cuttings obtained from trunks or large branches of willow or cottonwood. Poles are 2 to 8 inches in diameter. Required pole length is shown on the plans.

Work shall include procurement, storage, installation, and care of poles.

1.02 Willow and Cottonwood Poles shall be use during construction work in:

Section 304, SOIL FILLED RIPRAP

### 2.0 MATERIALS

2.01 Field Collection.

A. Source. All poles shall be taken from healthy, dormant plants.

B. Size. All poles shall be of the length designated on the plans. The minimum diameter of any pole shall be 2 inches at the narrowest portion of the cutting. The maximum pole diameter shall be 8 inches, measured at the widest portion of the pole.

C. Orientation. The basal end (bottom) of poles shall be indicated by a clean, slanted cut. All lateral stems and branches shall be removed at the juncture with the main pole. Tops of poles (distal ends) shall be indicated by a cut perpendicular to the stem.

D. Collection Dates. Poles shall be collected between October 1 and May 30. Any deviation from this specification requires approval of the Owner. Documentation authenticating the date poles were acquired shall be submitted to the Owner prior to acceptance.

2.02 Storage of poles.

A. Poles must be planted within 2 weeks of collection, and shall not be stored for more than 2 weeks.

B. If stored more than 24 hours, poles must be stored in a moist and fully shaded condition. At no time between collection and installation shall poles be allowed to dry.

2.03 Material Quantities

WILLOW POLES

| COMMON NAME | SCIENTIFIC NAME | QUANTITY |
|---|---|---|
| Sitka willow | *Salix sitchensis* | |
| Underleaf willow | *Salix commutata* | |
| Black cottonwood | *Populus trichocarpa* | |

END OF SECTION 207

**SECTION 208**

**WILLOW STAKES**

## 1.0 DESCRIPTION

1.01 General. Willow Stakes are un-rooted, live plant materials for installation in Fabric-Covered Upper Banks and Graded Upper Banks. Generally uniform in size, live stakes are approximately 0.3 to 1.0 inch in diameter and 3 to 4 feet. Willow Stakes shall consist of willow species native to the Mendenhall Valley.

Work shall include procurement, storage, installation, and care of live stakes.

1.02 Willow Stakes shall be used during construction work in:

Section 306, FABRIC-COVERED UPPER BANK; and

## 2.0 MATERIALS

2.01 Field Collection.

A. Source. All Willow Stakes shall be taken from healthy, dormant, stems of both male and female plants. Willows shall be collected only in areas that have been approved by the Engineer.

B. Size. All Willow Stakes shall be between 3.0 and 4.0 feet long. All live stakes shall be greater than 3/8 inches in diameter at the narrowest portion of the stem.

C. Orientation. The basal end (bottom) of Willow Stakes shall be indicated by a clean, slanted cut. All lateral stems shall be removed at the juncture with the main stem. Tops of Willow Stakes (distal ends) shall be indicated by a cut perpendicular to the stem.

D. Collection Dates. Willow Stakes shall be collected between October 1 and May 30. Any deviation from this specification requires approval of the Owner. Documentation authenticating the date live stakes were acquired shall be submitted to the Owner prior to acceptance.

2.02 Storage of Willow Stakes.

A. Once harvested, Willow Stakes shall be divided into bundles of 100 stems of the same species and oriented with the basal ends all at the same end of the bundle. Bundles of Willow Stakes shall be tied with polypropylene or equivalent, non-degradable string in such a manner as to prevent damage to the stems, bark, or other plant parts. Each bundle shall be labeled with species, collection date, and quantity.

C. Short-term storage. Bundles of Willow Stakes collected more than 2 but no longer than 7 days before installation shall be thoroughly moistened and stored in a cool (34°F to 50°F) environment. Willow Stakes shall be checked to ensure moistness is maintained during the entire short-term storage period.

D. Long-term storage. Bundles of Willow Stakes collected more than 7 days before installation shall be placed in long-term storage to prevent bud break. Long-term storage consists of applying Captan®, a solution to prevent fungal growth, to moistened burlap-wrapped bundles of live stakes. Wrapped and moistened bundles shall then be placed in a refrigeration unit and maintained at 34 to 40°F, without light. Willow Stakes shall be checked to ensure moistness is maintained and that no fungal growth is occurring.

E. On-site storage. Willows may be stored on-site no longer than 36 hours before installation. On-site storage shall consist of placing bundles of willows in a full shade, or in water and ensuring live stakes remain in a moist condition.

2.03. Material Quantities

WILLOW STAKES

| COMMON NAME | SCIENTIFIC NAME | QUANTITY |
|---|---|---|
| Underleaf willow<br>Sitka willow | *Salix commutata*<br>*Salix sitchensis* | |

END OF SECTION 208

## SECTION 209

### BRUSH LAYER CUTTINGS

## 1.0 DESCRIPTION

1.01 General. Brush Layer Cuttings are live cuttings used in the construction of the Brush Layer Middle Bank treatments. The cuttings are clipped at the basal (lower) end the stem, with small diameter first year stems not removed. Brush Layer Cuttings shall consist of willow species native to the Mendenhall Valley.

Work shall include procurement, storage, installation, and care of Brush Layer Cuttings. Brush Layer Cuttings may consist primarily of willows, but may also include alders, and dogwoods and cottonwoods.

1.02 Brush Layer Cuttings shall be used in during construction work in:

Section 305, BRUSH LAYERING.

## 2.0 MATERIALS

2.01 Field Collection.

A. Source. All Brush Layer Cuttings shall be taken from healthy, dormant, stems of both male and female plants. All Cuttings for Surface Planting must be native species found within the Mendenhall Valley.

B. Size. All Brush Layer Cuttings shall be of the length shown on the plans. All Brush Layer Cuttings shall be greater than 0.5 inches in diameter at the basal (bottom) portion of the cutting.

C. Orientation. The basal end of Brush Layer Cuttings shall be indicated by a clean, slanted cut.

D. Collection Dates. Brush Layer Cuttings shall be collected between October 1 and May 30. Any deviation from this specification requires approval of the Owner. Documentation authenticating the date Brush Layer Cuttings were acquired shall be submitted to the Owner prior to acceptance.

2.02 Storage of live branches

A. Once harvested, Brush Layer Cuttings shall be divided into bundles of 50 stems of the same species and oriented with the basal ends all at the same end of the bundle. Bundles of Brush Layer Cuttings shall be tied with polypropylene or equivalent, non-degradable string in such a manner as to prevent damage to the stems, bark, or other plant parts.

B. Labels. All bundles of Brush Layer Cuttings shall placed in bundles of similar species and length. Labels shall identify the collection date, species, and quantity.

C. Short-term storage. Bundles of Brush Layer Cuttings collected more than 2 but no longer than 7 days before installation shall be thoroughly moistened and stored in a cool (34°F to 50°F) environment. Brush Layer Cuttings shall be checked to ensure moistness is maintained during the entire short-term storage period.

D. Long-term storage. Bundles of Brush Layer Cuttings collected more than 7 days before installation shall be placed in long-term storage to prevent bud break. Long-term storage consists of applying Captan®, a solution to prevent fungal growth, to moistened burlap-wrapped bundles of live branches. Wrapped and moistened bundles shall then be placed in a refrigeration unit and maintained at 34 to 40°F, without light. Live branches shall be checked to ensure moistness is maintained and that no fungal growth is occurring.

E. On-site storage. Brush Layer Cuttings may be stored on-site no longer than 36 hours before installation. On-site storage shall consist of placing bundles in full shade, or in water, and ensuring they remain in a moist condition.

2.03 Material Quantities

WILLOW STAKES

| COMMON NAME | SCIENTIFIC NAME | QUANTITY |
|---|---|---|
| Underleaf willow<br>Sitka willow | *Salix commutata*<br>*Salix sitchensis* | |

END OF SECTION 209

## SECTION 210

### SEED

## 1.0 DESCRIPTION

1.01 General. Seed mixes comprised of a mixture of a variety of species suited for the range of conditions expected for the project site shall be used. All seed shall comply with requirements of the Alaska State Law.

1.02 Seed shall be used during construction work in:

Section 304, SOIL-FILLED RIPRAP;
Section 306, FABRIC-COVERED UPPER BANK;
Section 307, GRADED UPPER BANK; and
Section 308, TRANSITION AREAS.

## 2.0 MATERIALS

2.01 Health. Seed mixes shall be healthy and vigorous and free of noxious weed seeds. Seeds that have become wet, moldy, or otherwise damaged, or do not meet the Specifications will be rejected by the Owner at no cost to the Owner.

2.02 Species. Species comprising the seed mix must contain at least one quick establishing species that is either native or does not produce seed sterile, and one perennial species native to Southeast Alaska. Short-lived legume cover crops species such white clover (inoculated) may be used. Before installation any seeded species or seed mixes must be approved.

2.03 Labels. The contents of each bag of seed delivered shall be clearly labeled. and the following information shall be supplied upon delivery of seed:

A) common name genus, species and subspecies (when applicable);
B) amount of Pure Live Seed (PLS) pounds of each species in each seed mix;
C) percent viability of each species in each seed mix;
D) total percentage by weight of other seeds;
E) total delivered weight, in pounds, of each seed mix;
F) state and county of origin of each species of seed used in mixes; and
G) name and address of the seed supplier.

2.04 Delivery. The delivery date for seed mixes shall be arranged with the Contractor, and subject to the approval of the Owner.

2.05 Storage. Seed shall be stored in a cool, dry, and dark environment until application.

## 3.0 SUPPLIER

3.01 Suppliers of grass seed are:

Landscape Alaska, Juneau (907) 780-4916 or Internet: www.landscapealaska.com

Alaska Garden Supply, Anchorage (907) 279-4519

END OF SECTION 210

# SECTION 211
# CONTAINERIZED PLANTS

## 1.0 DESCRIPTION

1.01 General.
The Contractor shall provide all equipment, labor and materials necessary to obtain from a nursery the quantities and species of containerized plant materials.

1.02 Containerized plants shall be used in:

Section 306, FABRIC-COVERED UPPER BANK; and
Section 307, GRADED UPPER BANK.

## 2.0 MATERIALS

2.01 Supply. Containerized plants will be supplied by the Contractor.

2.02 Containerized plant material shall include, but is not limited to, shrub seedlings grown in a tube-shaped container and trees grown in 1-gallon and 2-gallon containers. Plant materials shall be healthy and vigorous with well-developed root systems.

2.03 Containers. Containers shall be sufficiently rigid to hold the root mass during propagation and protect it during shipping. The dimensions of tubeling containers must be pre-approved by the Owner.

2.04 Root Tightness. Tubelings and gallon-sized plants shall be grown in containers for sufficient time to allow roots to grow dense enough so that the root mass will retain its shape and hold together when removed from its container.

2.05 Container Period. No plant shall have been grown in its container for a period of more than two years

2.06 Fertilizer. Fertilizer, including slow release fertilizer, shall be withheld from all nursery-grown plant material for a period of at least three weeks prior to established delivery date. The only exception to this is if fertilizer has been incorporated into the container soil.

2.07 Plant Material Health. All delivered plant materials shall be free of disease, insect pests, and other infestations.

2.08 Certificate of Nursery Inspection. All plant materials shall conform to State and Federal laws relating to inspection for diseases and infestation. A valid certificate of nursery inspection by the appropriate state agency shall accompany each plant delivery.

2.09 Any adjustments or substitutions in plants species, container sizes, container types, or quantities, shall be approved by the Owner

2.10 On-site Plant Storage. Immediately upon delivery and until installation, plant material shall be shaded and watered to ensure that the plants remain alive and healthy.

2.11 Delivery. The delivery date for containerized plant materials shall be arranged with the nursery and the Contractor, and subject to the approval of the Owner.

END OF SECTION 211

## SECTION 212

## Boulders

*1.0 Description*

1.01 This work shall consist of furnishing Boulders as shown on the plans and specified herein or as established by the Owner.

1.02 The material will be used during construction with work in:

Section 303 WOOD AND STONE BANK TOE.

*2.0 Materials*

2.01 Submittals. The Contractor shall submit the following information at least 2 weeks prior to hauling stone to the project site.

A. Size, weight, and specific gravity of Boulders.

B. Boulder source location, name of supplier, and phone number of contact person.

2.02 Submittal. The Boulders shall be washed and free of contaminates prior to being placed. If washed on site, the Contractor shall submit a plan for approval to the Owner indicating how the washing is to be controlled to prevent siltation.

2.03 The Boulders shall be hard, resistant to weathering and to water action, and be free from overburden, spoil, shale, structural defects, and organic material. The least dimension of any Boulder shall be not less than 1/3 its greatest dimension. Rounded Boulders shall not be used on slopes steeper than 2 to 1.

2.04 Unless otherwise allowed, the density of the Boulders shall be at least 165 pounds per cubic foot, specific gravity of 2.65.

2.05 Nominal diameter of the Boulders shall be at least 18 inches.

END OF SECTION 212

## 8.3. 2 INSTALLATION

### SECTION 301

### Excavation, Backfill, and Compaction

*1.0 DESCRIPTION*

1.01 This work shall consist of all excavation, backfill, and compaction required for the construction of all components of the bank protection project as specified and shown on the plans. The work shall be accomplished in accordance with these specifications and in reasonably close conformity with the lines, grades and typical cross sections shown on the plans, or as directed.

1.02 Backfill specified under this section includes all placement of Common Fill materials as specified in Section 201, COMMON FILL.

1.04 Excavation shall include the salvage and stockpile of Topsoil according to Section 202 TOPSOIL.

1.05 Placement of Filter Gravel shall conform to Section 302, STONE BANK TOE and Section 303, WOOD AND STONE BANK TOE.

1.06 Excavation shall include as necessary, sheeting, bracing, bailing, pumping, draining, and the furnishing of all materials, equipment and labor for the placement and removal of any cribbing or cofferdams necessary to perform the excavation. Excavation for structures shall consist of the excavation of whatever character encountered in the work.

1.07 All excavation shall be considered unclassified. Unclassified excavation shall involve all materials of whatever character encountered in the work.

1.08 This work shall be coordinated during construction with work in:

Section 302, STONE BANK TOE
Section 303, WOOD AND STONE BANK TOE
Section 304, SOIL-FILLED RIPRAP
Section 305, BRUSH LAYERING
Section 306, FABRIC-COVERED UPPER BANK
Section 307, GRADED UPPER BANK
Section 308, TRANSITION AREAS

*2.0 MATERIALS*

Conform with appropriate materials specifications given in Sections 201 - 205.

## *3.0 CONSTRUCTION REQUIREMENTS*

### 3.01 EXCAVATION

A. Regulations

1. Excavation procedures shall meet OSHA Regulations found in: Department of Labor, Occupational Safety and Health Administration (OSHA), 29 CFR Part 1926, Occupational Safety and Health Standards - Excavations; Final Rule, The Federal Register, Tuesday, October 31, 1989.

2. Any trenching shall require shoring as specified by OSHA 2207.

3. The Contractor shall be wholly responsible for complying with all applicable regulations relating to excavations, stockpiles, hauling of materials, generation of dust, etc.

B. Preparation. Carry out Clearing and Grubbing as specified in the plans and specifications. Salvage Topsoil and stockpile material, if approved by the Owner, according to Section 202 Topsoil. All Clearing and Grubbing shall be completed before beginning excavation.

C. Limits. The excavation shall be finished to reasonably smooth and uniform surfaces. Excavation operations shall be conducted so that material outside of the limits of slopes shall not be disturbed.

D. Backfill Material. All excavated material shall be utilized as Common Fill material if approved as suitable according to Section 201 COMMON FILL. Soils that cannot be properly compacted in embankment may be designated as unsuitable. Overly wet materials shall either be allowed to dry prior to compacting or shall be disposed of off-site. All unsuitable or surplus excavated material shall be disposed of at approved locations, and in a manner acceptable to the Owner.

E. Waste Material. Disposal areas for unsuitable material or excess useable material may be at locations of the Contractor's choice outside of the project, as approved by the Owner.

F. Scaling. Backslopes in cut areas shall be scaled if necessary during or upon completion of excavation in each lift. Scaling shall consist of the removal of all loose or detached rock and soil masses, including overbreak, that create a potentially dangerous situation to the work area or final constructed facility. Removal shall be by barring, wedging, or use of equipment. The cost of scaling and the disposal of resulting materials shall be considered subsidiary to and included in the payment for Excavation.

G. Equipment Stability. If hauling equipment or equipment operation over the partially constructed stream bank causes loss of stability or other damage, the Contractor shall repair the damaged stream bank at his own expense and adjust his equipment and procedures so as to avoid further damage.

H. Bank Support Materials. Contractor shall install sheeting, bracing or use other means as needed for the temporary support of the stream bank during excavation and construction. All support materials shall be removed by the Contractor following the completion of the work unless abandon-in-place procedures are approved by the Owner.

I. Cofferdams. Suitable cofferdams may be used as necessary by the Contractor. The Contractor shall submit drawings showing his proposed method of cofferdam construction and the details thereof. The details and clearance of cofferdams, insofar as such details affect the character of the finished work shall be subject to approval, but other details of the design shall be left to the Contractor who shall be responsible for the successful construction of the work. The drawings shall be submitted at least three weeks in advance of the time the Contractor begins construction of the cofferdams, unless otherwise permitted.

3.02 BACKFILL AND COMPACTION (COMMON FILL)

A. Backfill in Streams. Streambed channels shall not be altered and excavated materials shall not be placed in natural stream channels except as expressly allowed by all applicable permits.

B. The Contractor shall verify that subgrade of areas to be filled are free of soft spots, debris, or water. The Contractor shall fill soft areas and compact to 95% of maximum dry density.

C. Riverbank embankment materials shall be placed in horizontal layers not exceeding eight inches (uncompacted) for the full width of the embankment and shall be compacted as specified before the next layer is placed. Spreading equipment shall be used on each lift to obtain uniform thickness prior to compacting. As the compaction of each layer progresses, continuous leveling and manipulating will be required to assure uniform density. Water shall be added or removed, if necessary, in order to obtain the required density. Compaction equipment shall be routed uniformly over the entire surface of each layer.

D. When backfilling Geocell units, backfill materials shall be placed as uniformly as possible on all sides of structural units, and care shall be exercised to prevent pressures which would damage the structure.

E. The river bank shall be constructed with approved materials placed and compacted at approximately their optimum moisture content. Optimum moisture shall be determined in accordance with ASTM D698/AASHTO T99. Embankment materials may require drying or uniform moistening prior to compaction in order to bring the moisture in the material to approximately optimum moisture content.

F. Embankment material shall be compacted to not less than 95% of the maximum dry density. Maximum densities shall be determined by ASTM D698/AASHTO T99.

G. Care shall be taken to prevent damage or disturbance when compacting backfill around the Geocell units. The use of compaction equipment shall be limited to walk-behind equipment only for areas within 3 feet of the geocell structure. Contractor shall confirm that the compaction procedure is not laterally displacing the geocell sections.

H. When fine sand or soil consisting of primarily fine or grain size sandy material is encountered, specified density requirements will be waived.

3.03 BACKFILL AND COMPACTION (TOPSOIL)

A. Placement Depth. Topsoil shall be spread to a minimum depth as shown on the plans or as approved by the Owner.

B. Compaction. Topsoil shall be compacted to a dry density of 85% of the Standard Proctor Dry Density.

C. Disposal. All excess topsoil shall be removed from the project site following completion of the project at the expense of the Contractor.

END OF SECTION 301

## SECTION 302

## Stone Bank Toe

*1.0 Description*

1.01 This work shall consist of placing Riprap Stone in Stone Bank Toe as shown on the plans or as established by the Owner. Excavation for the Stone Bank Toe shall conform to Section 301, EXCAVATION, BACKFILL, AND COMPACTION.

*2.0 MATERIALS*

2.01 The following materials will be used in Stone Bank Toe construction:

Section 203, FILTER GRAVEL; and
Section 204, RIPRAP STONE.

*3.0 Construction Requirements*

3.01 Regulations. The Contractor shall be wholly responsible for complying with all applicable regulations relating to stockpiles, hauling of materials, generation of dust, water quality, erosion control, etc.

3.02 Excavation for Stone Bank Toe shall be to lines and grades shown on the plans. Slopes to be protected by stone shall be free of brush, trees, stumps and other objectionable material and shall be dressed to a smooth surface. Soft or spongy material shall be removed to the specified depth and replaced with approved material. Filled areas shall be thoroughly compacted.

3.03 Filter gravel shall be placed as shown on the plans. Each filter gravel layer shall be placed on the prepared surface to the thickness shown on the plans in one operation without segregating the material. Layers shall not be intermixed. Top layer shall be finished to produce an even surface free from mounds or ridges.

3.04 The Riprap Stone shall be handled or dumped into place so as to secure a stone mass of the thickness, height and length shown on the plans, or as staked, with a minimum of voids. Riprap Stone shall be as specified and shown on the plans.

3.05 Undesirable voids shall be filled in with small stones or spalls. The rock shall be manipulated sufficiently by means of a bulldozer, rock tongs, or other suitable equipment to secure a reasonably regular surface and mass stability.

3.06 The Stone Bank Toe shall be placed to its full course thickness at one operation and in such a manner as to avoid displacing the underlying material. Placing of stone protection in layers or by dumping into chutes or by similar methods likely to cause segregation will not be permitted.

3.07 All material going into Stone Bank Toe shall be so placed and distributed that there will be no large accumulation or area composed predominately of either the larger or smaller sizes of stone.

3.08 Voids in the upper 1 ft of the Stone Bank Toe shall be completely filled with Filter Gravel as shown on the plans.

3.09 The Contractor shall provide a level compact area of sufficient size to dump and sort typical loads of stone at Owner approved location(s). The Contractor shall further dump loads specified in this area and assist the Owner as needed to sort and measure the stones in the load for the purpose of determining if the stone is within specifications. Mechanical equipment as needed to assist in this sorting shall be provided by the Contractor at no additional cost.

END OF SECTION 302

## SECTION 303

## Wood and Stone Bank Toe

*1.0 Description*

1.01 This work shall consist of placing Woody Debris and Riprap Stone in the Wood and Stone Bank Toe as shown on the plans or as established by the Owner. Excavation for the Wood and Stone Bank Toe shall conform to Section 301, EXCAVATION, BACKFILL, AND COMPACTION.

*2.0 MATERIALS*

2.1 The following materials will be used in Wood and Stone Bank Toe construction:

Section 203, FILTER GRAVEL;
Section 204, RIPRAP STONE; and
Section 205, WOODY DEBRIS; and
Section 212, BOULDERS.

*3.0 Construction Requirements*

3.01 Regulations. The Contractor shall be wholly responsible for complying with all applicable regulations relating to stockpiles, hauling of materials, generation of dust, water quality, erosion control, etc.

3.02 Excavation for Wood and Stone Bank Toe shall be to lines and grades shown on the plans. Slopes to be overlain by Wood and Stone Bank Toe shall be free of brush, trees, stumps and other objectionable material and shall be dressed to a smooth surface. Soft or spongy material shall be removed to the specified depth and replaced with approved material. Filled areas shall be thoroughly compacted.

3.03 Filter gravel shall be placed as shown on the plans. Each filter gravel layer shall be placed on the prepared surface to the thickness shown on the plans in one operation without segregating the material. Do not intermix the layers. Finish the top layer to produce an even surface free from mounds or ridges.

3.04 The portion of the bank toe lying below the natural stream bed level shall be constructed entirely of Riprap Stone placed in accordance with Section 302, STONE BANK TOE. Riprap Stone shall be as specified and shown on the plans.

3.05 Above the natural stream bed level, the bank toe shall be constructed using approximately 70% (by volume) Riprap Stone and 30% (by volume) Woody Debris. Riprap Stone and Woody Debris Types 1 and 2 shall be as specified and shown on the plans.

3.06 The Riprap Stone and Woody Debris shall be handled or dumped into place so as to secure a stone mass of the thickness, height and length shown on the plans, or as staked, with a minimum of voids.

3.07 Where the plans call for Woody Debris Type 1 to be used in the Wood and Stone Bank Toe, Root Wads (a component of Woody Debris Type 1) shall be installed with their stems at the natural stream bed level or slightly higher. Stems shall be angled such that the rooted end of the Root Wad points upstream. Boulders shall be placed immediately behind the roots to anchor the stem as shown in the plans. Stems (the second component of Woody Debris Type 1) shall be placed in the areas between and above the Root Wads. Stems shall be oriented roughly perpendicular to the river flow, and approximately 20-25% of the length of each stem shall protrude from the Wood and Stone Toe into the river.

3.08 Where the plans call for Woody Debris Type 2 to be used in the Wood and Stone Bank Toe, Woody Debris Type 2 shall be oriented roughly perpendicular to the river flow, and approximately 20-25% of the length of each log and stem shall protrude from the Wood and Stone Bank Toe into the river. To promote stability, at least 75% of the length of each log shall be embedded in the Wood and Stone Bank Toe.

3.09 Undesirable voids shall be filled in with small stones or spalls. The rock shall be manipulated sufficiently by means of rock tongs, or other suitable equipment to secure a reasonably regular surface and mass stability.

3.10 The Wood and Stone Bank Toe shall be placed to its full course thickness at one operation and in such a manner as to avoid displacing the underlying material. Placing of stone in layers or by dumping into chutes or by similar methods likely to cause segregation will not be permitted.

3.11 All material going into Stone Bank Toe shall be so placed and distributed that there will be no large accumulation or area composed predominately of either the larger or smaller sizes of stone, and no large accumulation or area composed predominately of Woody Debris.

3.12 Voids within the upper 1 ft of the Wood and Stone Bank Toe shall be completely filled with Filter Gravel as shown in the plans.

3.13 The Contractor shall provide a level compact area of sufficient size to dump and sort typical loads of stone at Owner approved location(s). The Contractor shall further dump loads specified in this area and assist the Owner as needed to sort and measure the stones in the load for the purpose of determining if the stone is within specifications. Mechanical equipment as needed to assist in this sorting shall be provided by the Contractor at no additional cost.

END OF SECTION 303

## SECTION 304

## Soil-Filled Riprap

*1.0 Description*

1.01 This work shall consist of placing Soil-Filled Riprap as a middle bank treatment as shown on the plans or as established by the Owner. Excavation for the Soil-Filled Riprap shall conform to Section 301, EXCAVATION, BACKFILL, AND COMPACTION.

*2.0 MATERIALS*

2.01 The following materials will be used in Soil-Filled Riprap construction:

Section 202, TOPSOIL;
Section 203, FILTER GRAVEL;
Section 204, RIPRAP STONE; and
Section 207, WLLOW AND COTTONWOOD POLES.

*3.0 Construction Requirements*

3.01 Regulations. The Contractor shall be wholly responsible for complying with all applicable regulations relating to stockpiles, hauling of materials, generation of dust, etc.

3.02 Excavation for Soil-Filled Riprap shall be to lines and grades shown on the plans. Slopes to be protected by stone shall be free of brush, trees, stumps and other objectionable material and shall be dressed to a smooth surface. Soft or spongy material shall be removed to the specified depth and replaced with approved material. Filled areas shall be thoroughly compacted.

3.03 Filter gravel shall be placed as shown on the plans. Each filter gravel layer shall be placed on the prepared surface to the thickness shown on the plans in one operation without segregating the material. Do not intermix the layers. Finish the top layer to produce an even surface free from mounds or ridges.

3.04 The Riprap Stone shall be handled or dumped into place so as to secure a stone mass of the thickness, height and length shown on the plans, or as staked, with a minimum of voids. Riprap Stone Type shall be as specified and shown on the plans.

3.05 Undesirable voids shall be filled in with small stones or spalls. The rock shall be manipulated sufficiently by means of a bulldozer, rock tongs, or other suitable equipment to secure a reasonably regular surface and mass stability.

3.06 The Soil-Filled Riprap shall be placed to its full course thickness at one operation and in such a manner as to avoid displacing the underlying material. Placing of stone protection in layers or by dumping into chutes or by similar methods likely to cause segregation will not be permitted.

3.07 All material going into Soil-Filled Riprap shall be so placed and distributed that there will be no large accumulation or area composed predominately of either the larger or smaller sizes of stone.

3.08 During the installation of the Riprap Stone, the voids between the riprap stones shall be filled with Topsoil. The suggested method of Topsoil installation is by spreading a layer of Topsoil on top of each successive course of Riprap Stone and then washing it into the voids between the stone using water. Care shall be taken not to wash Topsoil out the face of the riprap course. Topsoil shall be installed such that it fills all voids between riprap stones.

3.09 After Topsoil has been installed into a course of Riprap Stone, excess Topsoil shall be removed from the upper surface of the riprap course to allow for the placement of the next course of stone. Topsoil removal shall be sufficient to allow all stone in the newly placed course to directly contact the stone of the proceeding course.

3.10 If the installation of Dormant Hardwood Posts is called for on the plans, Dormant Hardwood Posts shall be installed as part of riprap course as shown on the plans. Interior end of Dormant Hardwood Posts shall be inserted a minimum of 1 ft into the excavated slope or compacted fill underlying the riprap and filter layers.

3.11 After construction of Soil-Filled Riprap is complete, seed and mulch outside face in accordance with Section 309, SEED INSTALLATION.

3.12 The Contractor shall provide a level compact area of sufficient size to dump and sort typical loads of stone at approved location(s). The Contractor shall further dump loads specified in this area and assist the Owner as needed to sort and measure the stones in the load for the purpose of determining if the stone is within specifications. Mechanical equipment as needed to assist in this sorting shall be provided by the Contractor at no additional cost.

END OF SECTION 304

## SECTION 305

## Brush Layering

*1.0 Description*

1.01 This work shall consist of placing Brush Layering and Stone as a middle bank treatment as shown on the plans or as established by the Owner. Excavation for the Brush Layering and Stone shall conform to Section 301, EXCAVATION, BACKFILL, AND COMPACTION.

## *2.0 MATERIALS*

2.01 The following materials will be used in Brush Layering and Stone construction:

Section 202, TOPSOIL;
Section 203, FILTER GRAVEL;
Section 204, RIPRAP STONE; and
Section 209, BRUSH LAYER CUTTINGS.

## *3.0 Construction Requirements*

3.01 Regulations. The Contractor shall be wholly responsible for complying with all applicable regulations relating to stockpiles, hauling of materials, generation of dust, water quality, erosion control, etc.

3.02 Excavation for Brush Layering and Stone shall be to lines and grades shown on the plans. Slopes to be protected by stone shall be free of brush, trees, stumps and other objectionable material and shall be dressed to a smooth surface. Soft or spongy material shall be removed to the specified depth and replaced with approved material. Filled areas shall be thoroughly compacted.

3.03 It shall be verified that the upper surface of the bank toe has been constructed to the proper line and grade according to the plans and specifications. The upper surface of the bank toe shall be prepared by removing any debris which might interfere with middle bank construction.

3.04 Filter gravel shall be placed as shown on the plans. Each filter gravel layer shall be placed on the prepared surface to the thickness shown on the plans in one operation without segregating the material. Do not intermix the layers. Finish the top layer to produce an even surface free from mounds or ridges.

3.05 Constructing the brush layers

A 1-inch thick layer of Topsoil shall be spread to act as bedding for the first brush layer. Voids in underlying Riprap Stone shall be filled with Filter Gravel as necessary to produce bedding for the Topsoil layer.

A layer of Brush Layer Cuttings shall be placed on the Topsoil bedding layer. Cuttings shall be placed perpendicular to the bank, with butt ends inserted throughout the Filter Gravel layer and a minimum of 6 inches into the underlying excavated bank face or compacted fill. A minimum of 12 inches of the distal end of each cutting shall protrude from the finished bank face into the river. Cuttings shall be placed at an average density of 4 cuttings per bank foot. After the layer of cuttings is installed, a 1-inch thick layer of topsoil shall be spread over the cuttings.

All Brush Layer Cuttings installation shall take place during spring (March 1 through

June 1) or fall (September 15 through November 30) and after a streambank construction reach has been approved by the Owner.

3.06 Soil-Filled Riprap lifts between brush layers

Stone and soil lifts shall be constructed to lines and grades shown on the plans. Riprap Stone and Topsoil placement shall conform to Section 304, SOIL-FILLED RIPRAP. Where needed, Common Fill shall be placed behind the Soil-Filled Riprap in accordance with Section 301, EXCAVATION, BACKFILL, AND COMPACTION.

END OF SECTION 305

# **SECTION 306**

## **Fabric-Covered Upper Bank**

### *1.0 Description*

1.01 This work shall consist of constructing and planting the Fabric-Covered Upper Bank treatment as shown on the plans or as established by the Owner. Excavation for the Fabric-Covered Upper Bank shall conform to Section 301, EXCAVATION, BACKFILL, AND COMPACTION.

### *2.0 MATERIALS*

2.01 The following materials will be used in Fabric-Covered Upper Bank construction:

Section 201, COMMON FILL;
Section 202, TOPSOIL;
Section 206, EROSION FABRIC (includes wooden stakes);
Section 209, WILLOW STAKES;
Section 210, SEED; and
Section 211, CONTAINERIZED PLANTS.

### *3.0 Construction Requirements*

3.01 Regulations. The Contractor shall be wholly responsible for complying with all applicable regulations relating to stockpiles, hauling of materials, generation of dust, protection of water quality, erosion control, etc.

3.02 Excavation for Fabric-Covered Upper Bank shall be to lines and grades shown on the plans or as established by the Owner. Slopes shall not be steeper than 2:1 (horizontal:vertical. Slopes to be protected by Fabric-Covered Upper Bank shall be free of brush, trees, stumps and other objectionable material and shall be dressed to a smooth surface. Soft or spongy material shall be removed to the specified depth and replaced with approved material. Any additional areas requiring fill shall be filled in accordance with Section 301, EXCAVATION, BACKFILL, AND COMPACTION. Filled areas shall be thoroughly compacted.

3.03 It shall be verified that the Middle Bank has been constructed to the proper line and grade according to the plans and specifications. The upper surface of the middle bank shall be prepared by removing any debris which might interfere with Fabric-Covered Upper Bank construction.

3.04 Erosion fabric layers shall be installed as shown on the plans, with the Woven Coir Fabric on the outside and the Inner Fabric on the inside (against the soil). Minimum embedment length shall be 3 feet for Woven Coir Fabric and 1 foot for Inner Fabric.

3.05 Topsoil shall be spread to the thickness shown on the plans in accordance with Section 201, EXCAVATION, BACKFILL, AND COMPACTION. Seed application shall conform to Section 310, SEED INSTALLATION.

3.06 Coir Fabric and Wooden Stakes shall conform to Section 207, COIR FABRIC.

3.07 Stakes shall be driven in the locations shown on the plans, such that no more than 2 inches of the stake remain above the surface of the ground. The maximum distance between stakes shall be as indicated on the plans.

3.08 Fabric rolls shall be installed with the long dimension parallel to the bank. Joints between ends of fabric rolls shall include at least 3 feet of overlap and shall be overlapped and staked as shown on the plans. Joints between long edges of fabric rolls shall be constructed and staked as shown on the plans. The upper edge of Fabric-Covered Upper Bank shall be staked in a key trench of dimensions shown on the plans. Key trench shall be backfilled with Topsoil in accordance with Section 201, EXCAVATION, BACKFILL, AND COMPACTION.

3.09 Cuttings for Surface Planting shall be installed in the locations and densities shown on the plans and in accordance with Section 310, WILLOW STAKE INSTALLATION.

END OF SECTION 306

# SECTION 307

## Graded Upper Bank

*1.0 Description*

1.01 This work shall consist of constructing and planting the Graded Upper Bank treatment as shown on the plans or as established by the Owner. Excavation for the Graded Upper Bank shall conform to Section 301, EXCAVATION, BACKFILL, AND COMPACTION.

*2.0 MATERIALS*

2.01 The following materials will be used in Graded Upper Bank construction:

Section 201, COMMON FILL;
Section 202, TOPSOIL;
Section 208, WILLOW STAKES; and
Section 210, SEED.

*3.0 Construction Requirements*

3.01 Regulations. The Contractor shall be wholly responsible for complying with all applicable regulations relating to stockpiles, hauling of materials, generation of dust, preservation of water quality, erosion control, etc.

3.02 Excavation for Graded Upper Bank shall be to lines and grades shown on the plans or as established by the Owner. Slopes shall not be steeper than 3:1 (horizontal:vertical) except by approval of owner. Graded Bank slopes shall be free of brush, trees, stumps and other objectionable material and shall be dressed to a smooth surface. Soft or spongy material shall be removed to the specified depth and replaced with approved material. Any additional areas requiring fill shall be filled in accordance with Section 301, EXCAVATION, BACKFILL, AND COMPACTION. Filled areas shall be thoroughly compacted.

Topsoil shall be spread to the thickness shown on the plans in accordance with Section 301, EXCAVATION, BACKFILL, AND COMPACTION. Seed application shall conform to Section 309, SEED INSTALLATION.

3.09 Cuttings for Surface Planting shall be installed in the locations and densities shown on the plans and in accordance with Section 310, WILLOW STAKE INSTALLATION.

END OF SECTION 307

# SECTION 308

## Transition Areas

*1.0 Description*

1.01 This work shall consist of constructing and planting the Transition Areas as shown on the plans or as established by the Owner. Excavation for the Transition Areas shall conform to Section 301, EXCAVATION, BACKFILL, AND COMPACTION.

*2.0 MATERIALS*

2.01 The following materials will be used in Transition Areas construction:

Section 201, COMMON FILL
Section 202, TOPSOIL
Section 203, FILTER GRAVEL
Section 204, RIPRAP STONE
Section 205, WOODY DEBRIS
Section 208, WILLOW STAKES
Section 210, SEED
Section 211, CONTAINERIZED PLANTS

*3.0 Construction Requirements*

3.01 Regulations. The Contractor shall be wholly responsible for complying with all applicable regulations relating to stockpiles, hauling of materials, generation of dust, etc.

3.02 Excavation for Transition Areas shall be to lines and grades shown on the plans or as established by the Owner.

3.03 Bank Toe Transition Areas shall be constructed as indicated on the plans and in accordance with Section 302, Stone Bank Toe.

3.04 Middle Bank Transition Areas shall be constructed as indicated on the plans and in accordance with Section 304, Soil Filled Riprap.

3.05 Fabric-Covered Upper Bank Transition Areas shall be constructed as indicated on the plans and in accordance with Section 306, Fabric-Covered Upper Bank.

END OF SECTION 308

## SECTION 309

## SEED INSTALLATION

### 1.0 DESCRIPTION

1.01 This work shall consist of installing seed in Soil-Filled Riprap, Fabric-Covered Middle Bank, Graded Upper Bank, and Transition Areas. The plant species and seed rate are specified on the Drawings.

1.02 This work shall be coordinated during construction with

Section 304, SOIL-FILLED RIPRAP;
Section 306, FABRIC-COVERED UPPER BANK;
Section 307, GRADED UPPER BANK; and
Section 308, TRANSITION AREAS.

### 2. 0 MATERIALS

Section 210, SEED

### 3.0 INSTALLATION OF SEED MIXES

3.01 Timing.

Seed mixes shall be installed during stream bank construction as soon as a unit or portion of the project (such as a river bank section) has been completed by the Contractor and approved by the Owner.

3.02 Soil Preparation. All areas to be seeded shall be smoothed to provide a firm but friable seedbed, and shall be constructed to meet the finish grade, and shall be free of any weed or plant growth except for mature trees that are to remain.

3.03 Application of Seed Mixes.

Stream bank seed mix. This seed mix shall be applied to the reconstructed stream banks by broadcast seeding with approved hand operated seeding devices. Broadcast seeding rate is 60 pounds of seed mix per acre (or 1.5 lbs. per 1,000 square feet). Any areas to be seeded shall be seeded in two directions to ensure even application. The first phase shall proceed from the downstream end of a given section of lift, to the upstream end. The second phase shall proceed from upper end to the downstream end. All seed mixes shall be well mixed before and during application.

3.04 Care of Seeded Areas.

All seeded areas shall be protected and maintained throughout the construction of the project and until the work is accepted. No construction traffic will be allowed over a seeded or planted area once the seed and erosion control measures have been completed. Foot traffic shall be minimized and workers shall travel along completed banks only in designated areas. Any damage to seeded areas caused by construction traffic or construction activities shall be repaired and re-seeded at no cost to the Owner.

END OF SECTION 309

# SECTION 310

## WILLOW STAKE INSTALLATION

## 1.0 DESCRIPTION

1.01 This work shall consist of installing dormant hardwood stakes into specified planting areas. Plant species, plant quantities, and plant layout are specified on the Drawings.

1.02 This work shall be coordinated during construction with

Section 307, FABRIC-COVERED UPPER BANK;
Section 308, GRADED UPPER BANK; and
Section 309, TRANSITION AREAS.

## 2.0 MATERIALS

Section 208, WILLOW STAKES

## 3.0 WILLOW STAKE INSTALLATION

3.01 Layout. All live stakes shall be planted above the lower limit of vegetation as specified on Drawings. General planting locations for each type of plant material is specified in the Drawings, however final locations are subject to the approval of the Owner or the on-site plantings supervisor may adjust plant material locations to meet field conditions.

3.02 Planting season. Live stake installation shall take place during spring (March 1 through June 15) or fall (October 1 through November 30) and after river bank construction has been approved by the Owner.

3.04 Live stake placement. Cuttings shall be installed in all bank treatment areas specified on the Drawings. They shall be inserted into moist stream bank soil. In all bank treatments areas, live stakes shall be planted at the rate of 1 plant per face foot of stream bank treatment. Specified live stake species for each treatment can be alternated or clumped at the discretion of the planting supervisor.

3.05 Installation. Once planting location is determined, the basal ends of each live stake shall be placed into moist streambank soils. Live stakes shall be planted to a depth of a minimum of 18 inches into soil by hand or by driving them with shot-filled, rubber coated mallet. Cutting of the woven coir fibers will not be permitted.

3.06 Protruding stems of all live stakes shall be the distal end with a length corresponding to that needed for the presence of four to five healthy bud nodes (approximately 2-4 inches). Mushroomed tops shall be clipped flush. The exposed portion of the stem shall be greater than 2.0 inches and no more than 6.0-inches in length as measured from the finished surface of the erosion control fabric of soils surface.

END OF SECTION 310

## SECTION 311

## CONTAINERIZED PLANT INSTALLATION

### 1.0 DESCRIPTION

1.01 This work shall consist of installing Containerized Plants into specified planting areas.

1.02 This work shall be coordinated during construction with:

Section 307, FABRIC-COVERED UPPER BANK;
Section 308, GRADED UPPER BANK; and
Section 309, TRANSITION AREAS.

### 2. 0 MATERIALS

Section 211, CONTAINERIZED PLANTS

### 3.0 CONTAINERIZED PLANT INSTALLATION

3.01 Shrub Tubelings

A Submittal. To make the desired planting hole for shrub tubelings, a planting tool (i.e., a dibble bar) should be sized so that the tip of the tool closely matches the size of the tubeling root mass. This planting tool must be approved by the Owner one month prior to installation of tubelings.

B Planting Hole. The planting hole shall be approximately the same size (less than 1/4 inch wider and 1 inch deeper) of the tubeling root mass. For each planting hole, up to two strands of the exterior erosion control fabric, if needed, may be cut to make planting through fabric easier.

C. Planting. All planting through erosion fabric should be done when fabric is wet to allow fabric to stretch as planting tool is inserted. The tubeling pit shall be thoroughly watered prior to inserting the soil/root mass. Containers shall be removed immediately prior to planting to prevent desiccation of the roots. All plants shall be set approximately plumb and with the top of the soil/root mass flush with the topsoil surface level. The tubeling pit and the surrounding soil shall then be tamped to remove all air pockets surrounding the soil/root mass.

3.02 Containerized Trees

A. Plant Installation. Planting pits for containerized plant materials shall provide space for not less than 4 inches of topsoil below and around the root-earth mass. If topsoil from the excavation of planting pits is of good quality, it shall be saved and reused.

B. Immediately prior to planting containerized plant material, the root-earth mass shall receive three vertical cuts, each spaced equidistant about the perimeter. Each cut, about 1/2-inch deep, shall begin at the top of the root-earth mass and continue to the bottom.

C. Containers shall be removed immediately prior to planting to prevent desiccation of the roots. All plants shall be set approximately plumb and at the same depth at which they were grown in the nursery. Topsoil shall then be filled in around the root mass to half the depth, tamped to remove all air pockets and thoroughly watered, after which the remainder of the topsoil shall be placed. Earth saucers or water basins shall then be provided and the plant thoroughly watered.

D. Topsoil meeting the requirements of Section 3710 Topsoil (Rich Organic Growth Media) shall be provided in incidental quantities by Contractor and shall not contain stones, lumps roots, or similar objects larger than 2 inches in any dimension.

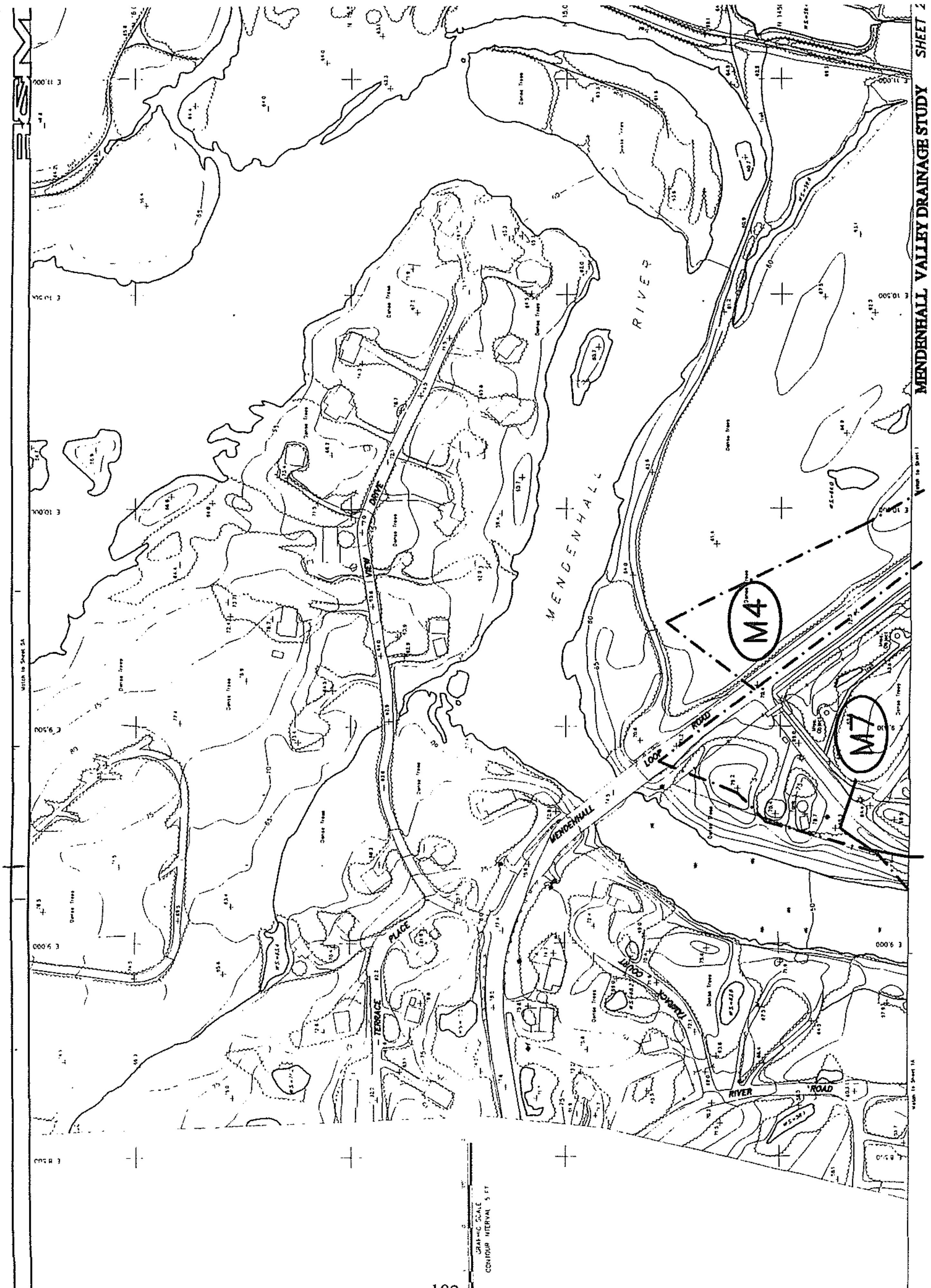
E. Planting Season. Containerized plants shall be installed during spring (April 1 through June 15) or fall (October 1 through November 30) and after river bank construction has been approved by the Owner.

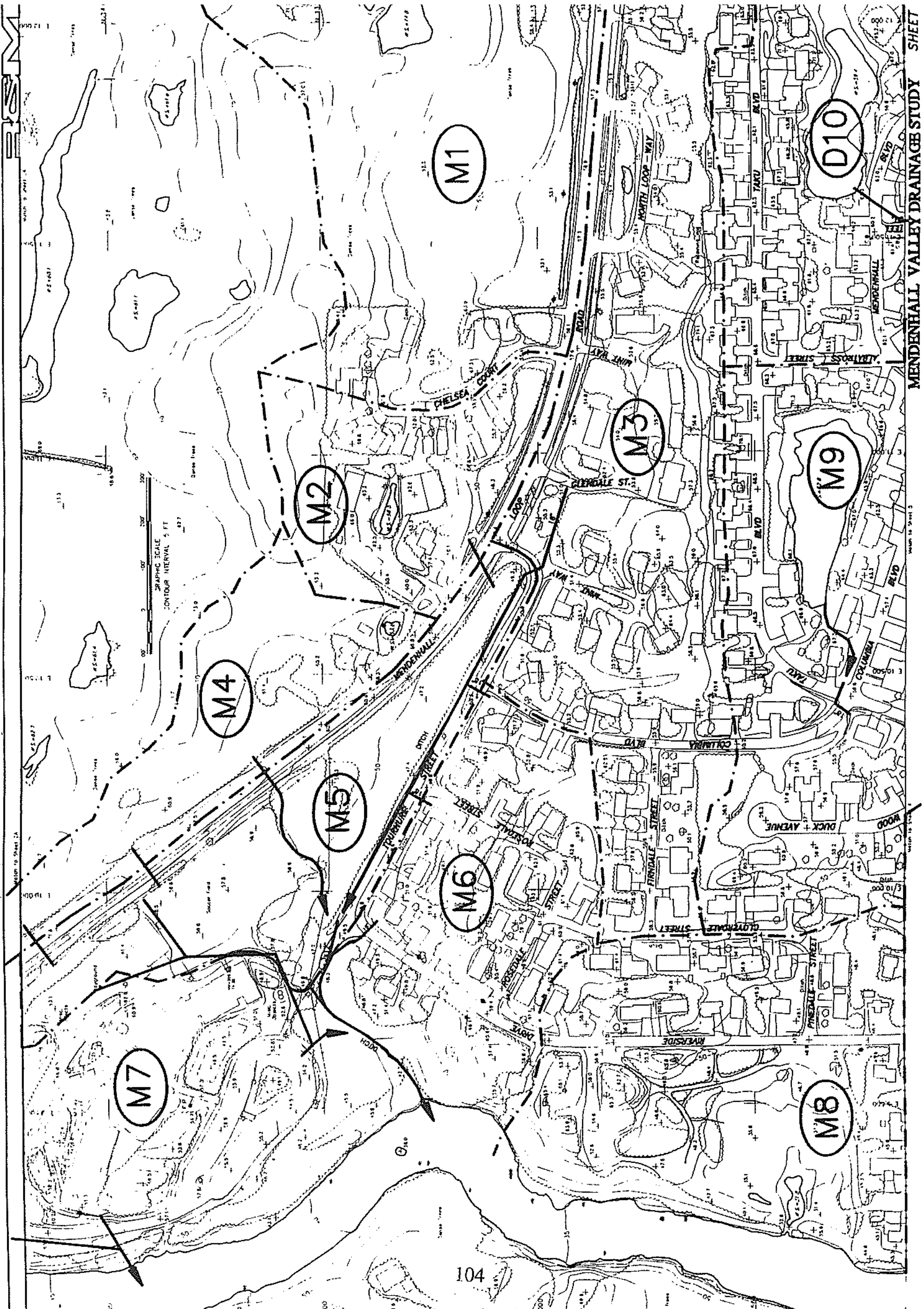
*END OF SECTION 311*

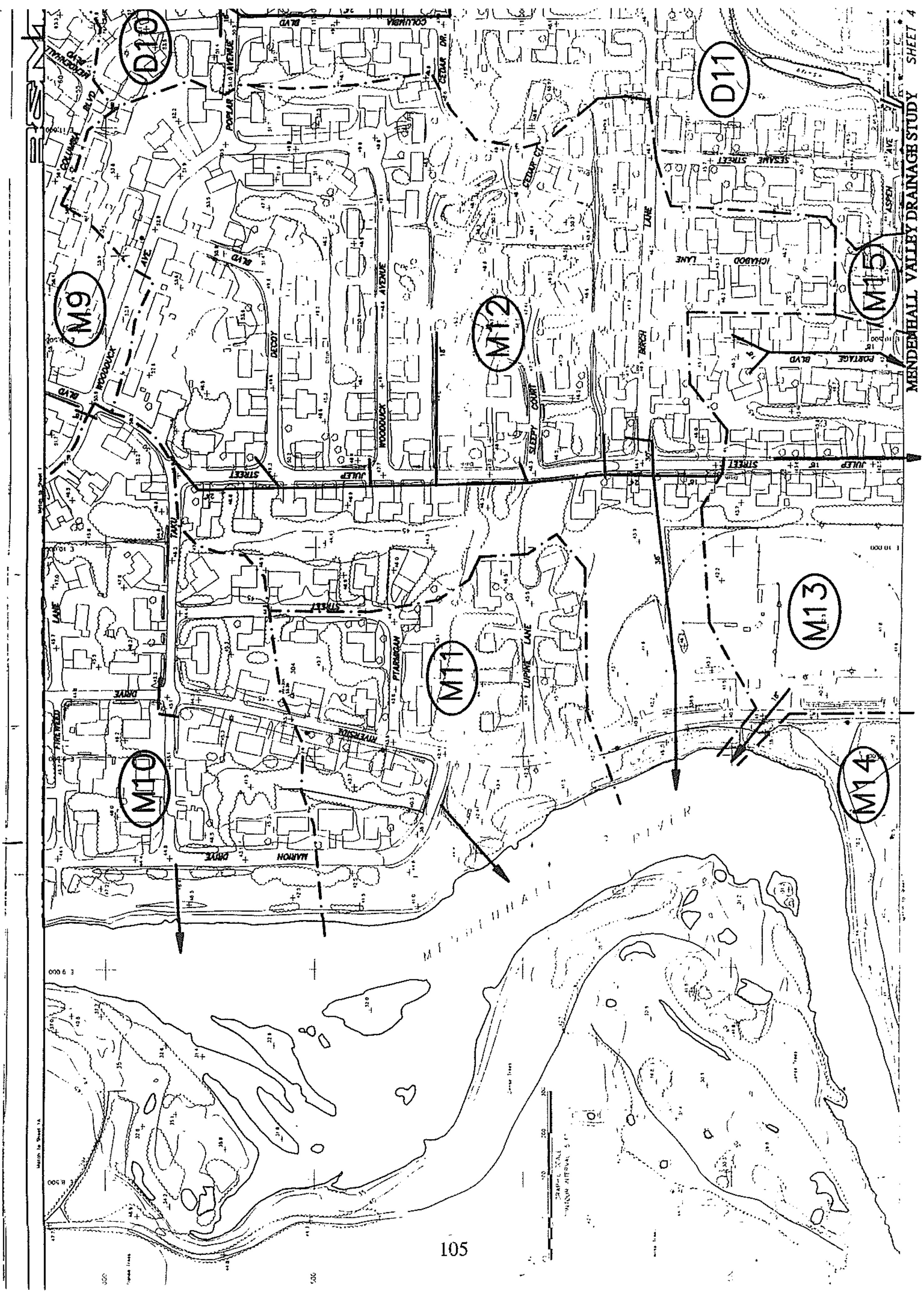
## 8.4 Mendenhall Valley Stormwater Drainage Table and Associated Figures

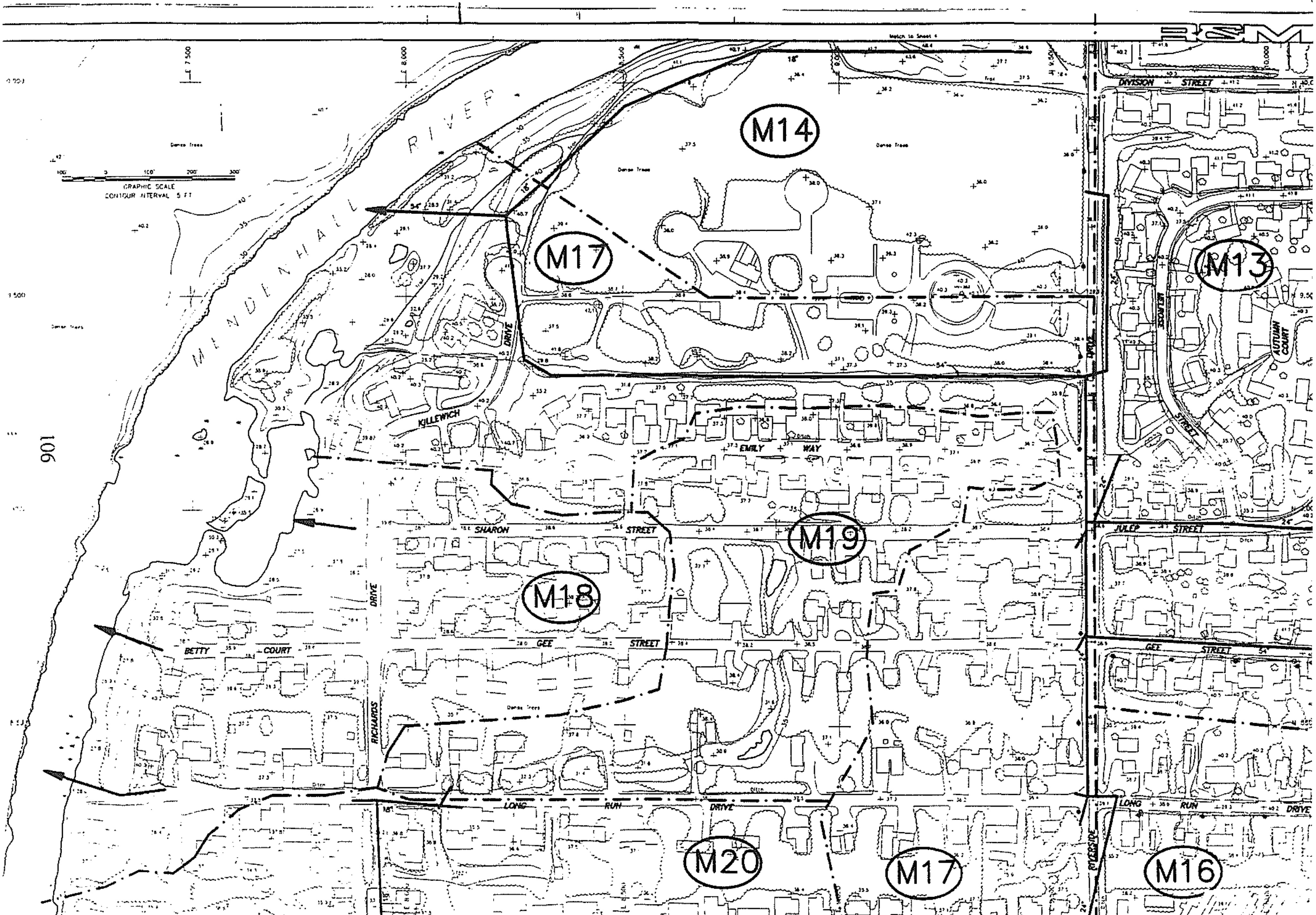
**Table 8.4. Mendenhall Valley Stormwater Drainage.**

| Drainage Area | Location | Filled Area (ac) | Vegetated Area (ac) | Outfall (Size & Location) |
|---|---|---|---|---|
| M1 | Chelsea Ct. | 1.1 | 17.01 | 18" at Back Loop to M2 |
| M2 | Back Loop | 1.99 | 1.14 | 34" at Back Loop to M3 |
| M3 | Tournure | 8.79 | 15.11 | 18" at Tournure to M5 |
| M4 | Back Loop | 1.72 | 10.11 | Back Loop crossing to M5 |
| M5 | M.R.C.S. | 3.05 | 11.84 | 3" X 12" at M.R.C.S. to M7 |
| M6 | Riverside Drive | 2.71 | 4.86 | 18" to M.R.C.S. to M7 |
| M7 | M.R.C.S. | 6.72 | 3.18 | Ditch to Mendenhall River |
| M8 | Riverside Drive | 3.11 | 10.33 | Ditch to Mendenhall River |
| M9 | Taku/Columbia | 6.71 | 7.39 | 18" at Taku to M10 |
| M10 | N. Riverside | 5.05 | 11.09 | Ditch to Mendenhall River |
| M11 | N. Riverside | 3.8 | 7.42 | Ditch to Mendenhall River |
| M12 | Upper Julep | 19.5 | 3.77 | 36" at Melvin Park to Mend. River |
| M13 | Killewich Dr. | 8.72 | 10.5 | 54" to Mendenhall River |
| M14 | Lower Julep | 16.56 | 23.02 | 24" at Riverside to M17 |
| M15 | Portage Blvd. | 4.9 | 7.08 | 54" at Gee St. to M13 |
| M16 | Long Run | 10.71 | 11.16 | 24" at Riverside to M17 |
| M17 | Riverside Dr. | 13.25 | 25.4 | 54" to Mendenhall River |
| M18 | Gee Street | 6.39 | 9.06 | 18" to Mendenhall River |
| M19 | Emily/Sharon | 3.68 | 5.05 | 18" at Long Run Dr. to M20 |
| M20 | Meander Way | 7.69 | 14.45 | 18" to Mendenhall River |
| M21 | Rotary Park | 7.94 | 13.64 | 18" at Riverside to M22 |
| M22 | Meander Way | 7.21 | 12.67 | 18" to Mendenhall River |
| M23 | Rivercourt Way | 5.89 | 8.28 | 18" to Mendenhall River |
| M24 | Mountainwood | 7.91 | 11.49 | 24" at Riverside to M26 |
| M25 | Glacierwood | 14.64 | 10.51 | 18"/24" at Riverside to M26 |
| M26 | Diamond Park | 10.35 | 65.14 | 36" to Mendenhall River |
| M27 | James Blvd. | 1.6 | 7.16 | 24" at Riverside to M29 |
| M28 | Racket Club | 4.82 | 8.4 | 18"/24" at Riverside to M29 |
| M29 | Post Office | 3.45 | 8.79 | Ditch to Mendenhall River |
| M30 | Vintage Park | 22.01 | 23.91 | 24"/48" to Mendenhall River |
| M31 | Glacier Hwy. | 8.73 | 7.77 | Ditch to Mendenhall River |
| M32 | Stikine | 5.24 | 9.57 | 24" to Mendenhall River |
| M33 | Radcliff | 7.01 | 18.75 | 18" to Mendenhall River |
| M34 | Berners Ave. | 9.25 | 22.8 | 30" to Mendenhall River |
| M35 | Antler Way | 5.05 | 12.2 | 18" to Mendenhall River |

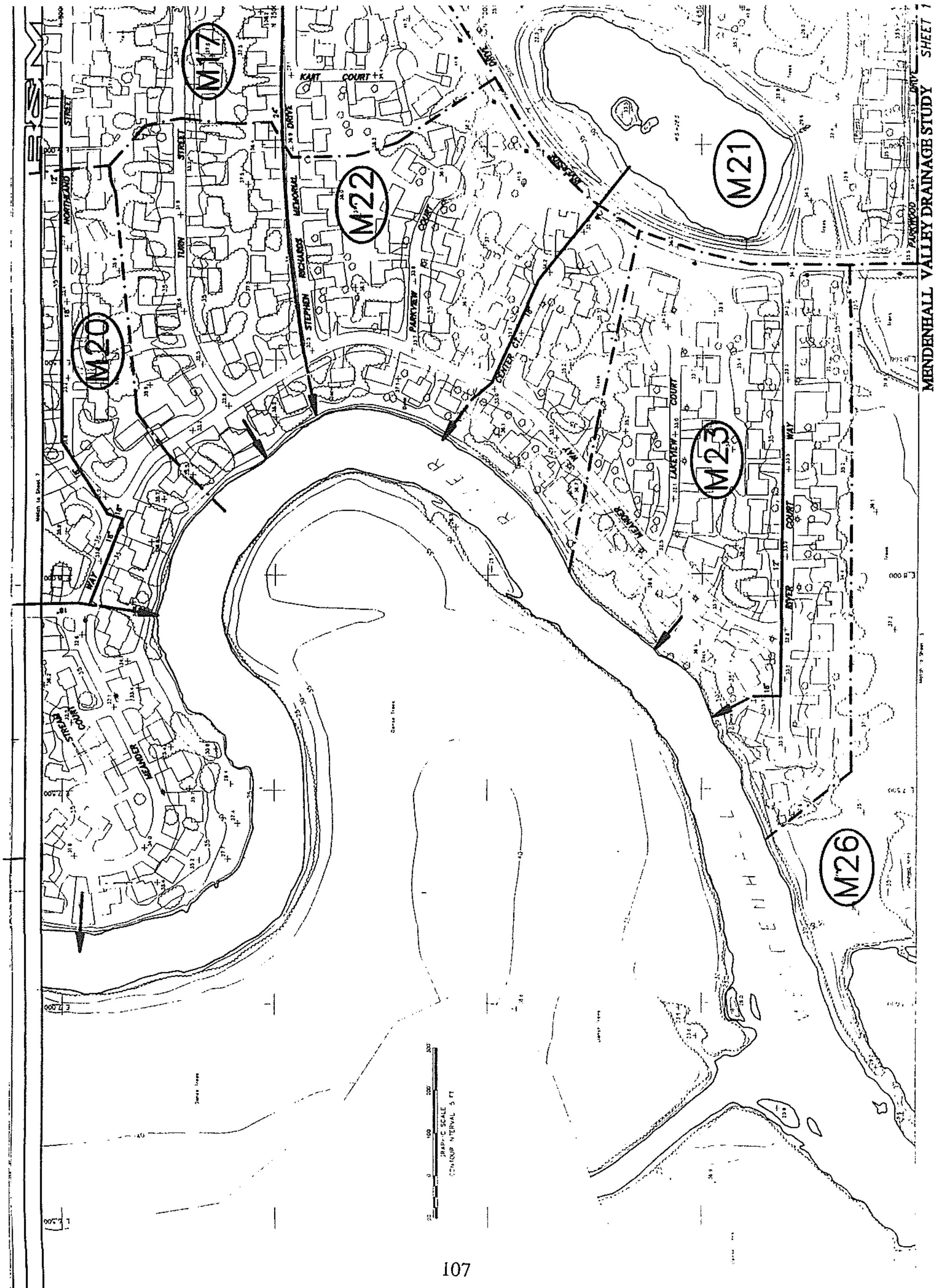

MENDENHALL VALLEY DRAINAGE STUDY
SHEET 2
MENDENHALL RIVER
VIEW DRIVE
TERRACE PLACE
MENDENHALL LOOP ROAD
RIVER ROAD
M4
M7
Dense Trees
GRAPHIC SCALE
CONTOUR INTERVAL 5 FT

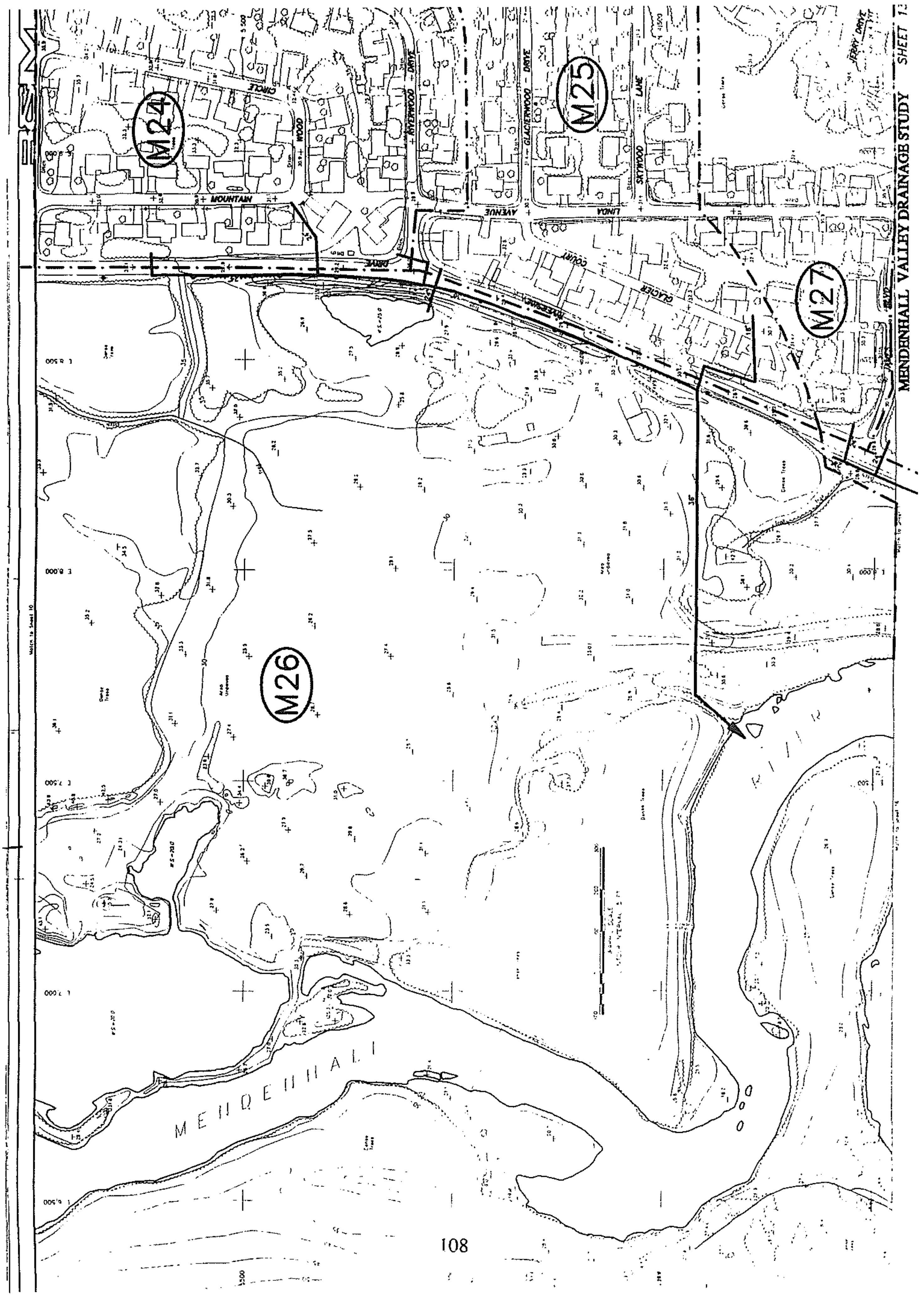

MENDENHALL VALLEY DRAINAGE STUDY
SHEET
M1
M2
M3
M4
M5
M6
M7
M8
M9
D10
MENDENHALL LOOP ROAD
NORTH LOOP WAY
TAKU BLVD
CHELSEA COURT
GLENDALE ST.
ALBATROSS STREET
COLUMBIA BLVD
TOURNURE STREET
DITCH
ROSEDALE STREET
FIRNDALE STREET
CLOVERDALE STREET
PINEDALE STREET
RIVERSIDE DRIVE
DUCK AVENUE
MENDENHALL BLVD
GRAPHIC SCALE
CONTOUR INTERVAL 5 FT

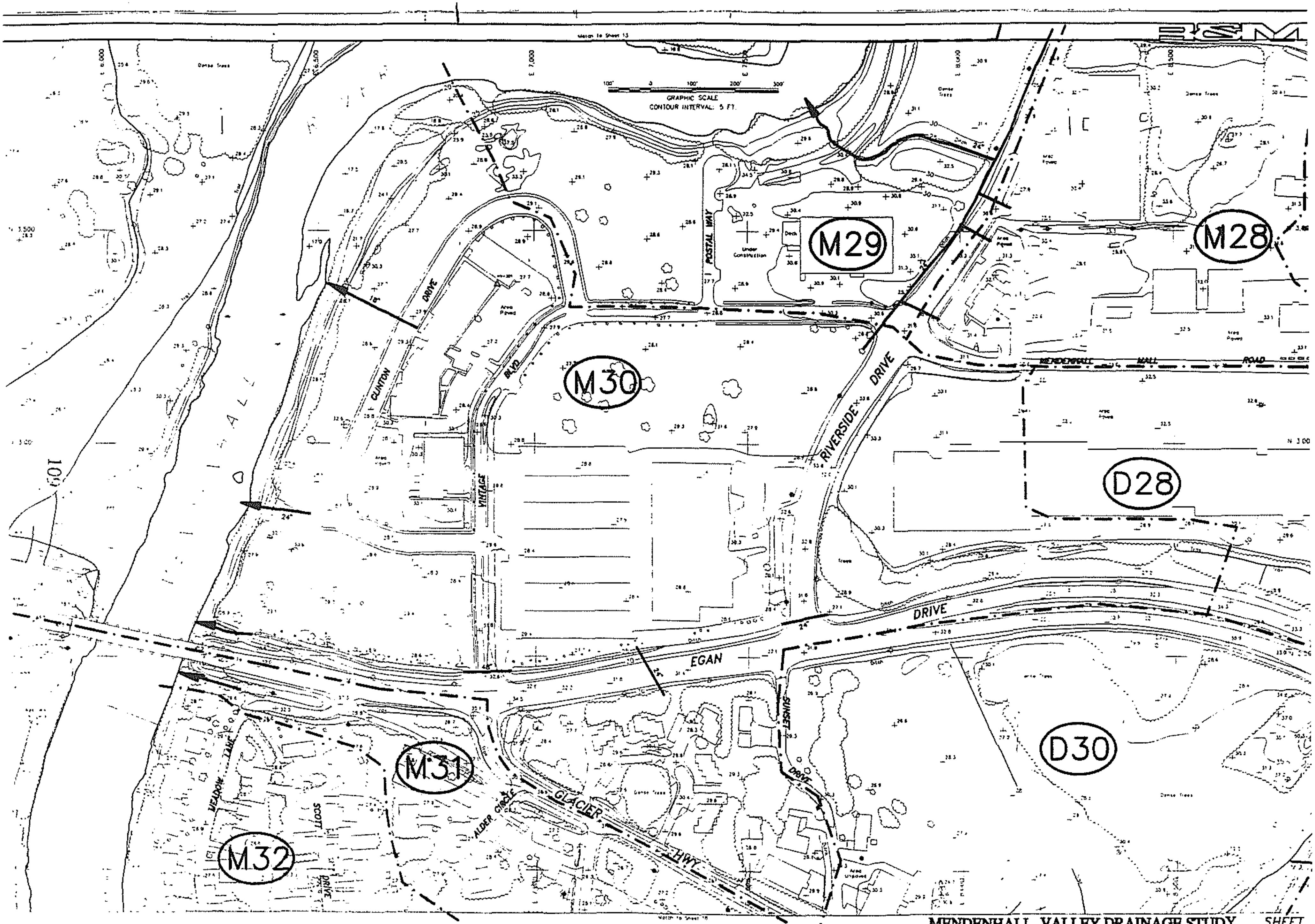

MENDENHALL VALLEY DRAINAGE STUDY
SHEET 4
D10
D11
M9
M10
M11
M12
M13
M14
M15
MENDENHALL RIVER
JULEP STREET
WOODDUCK AVE
WOODDUCK AVENUE
DECOY BLVD
POPLAR AVENUE
COLUMBIA BLVD
CEDAR DR.
CEDAR CT.
SLEEPY COURT
BIRCH LANE
ICHABOD LANE
SESAME STREET
ASPEN AVE
PORTAGE BLVD
TAKU
PTARMIGAN
LUPINE LANE
RIVERSIDE
MARION DRIVE
FIREWEED LANE



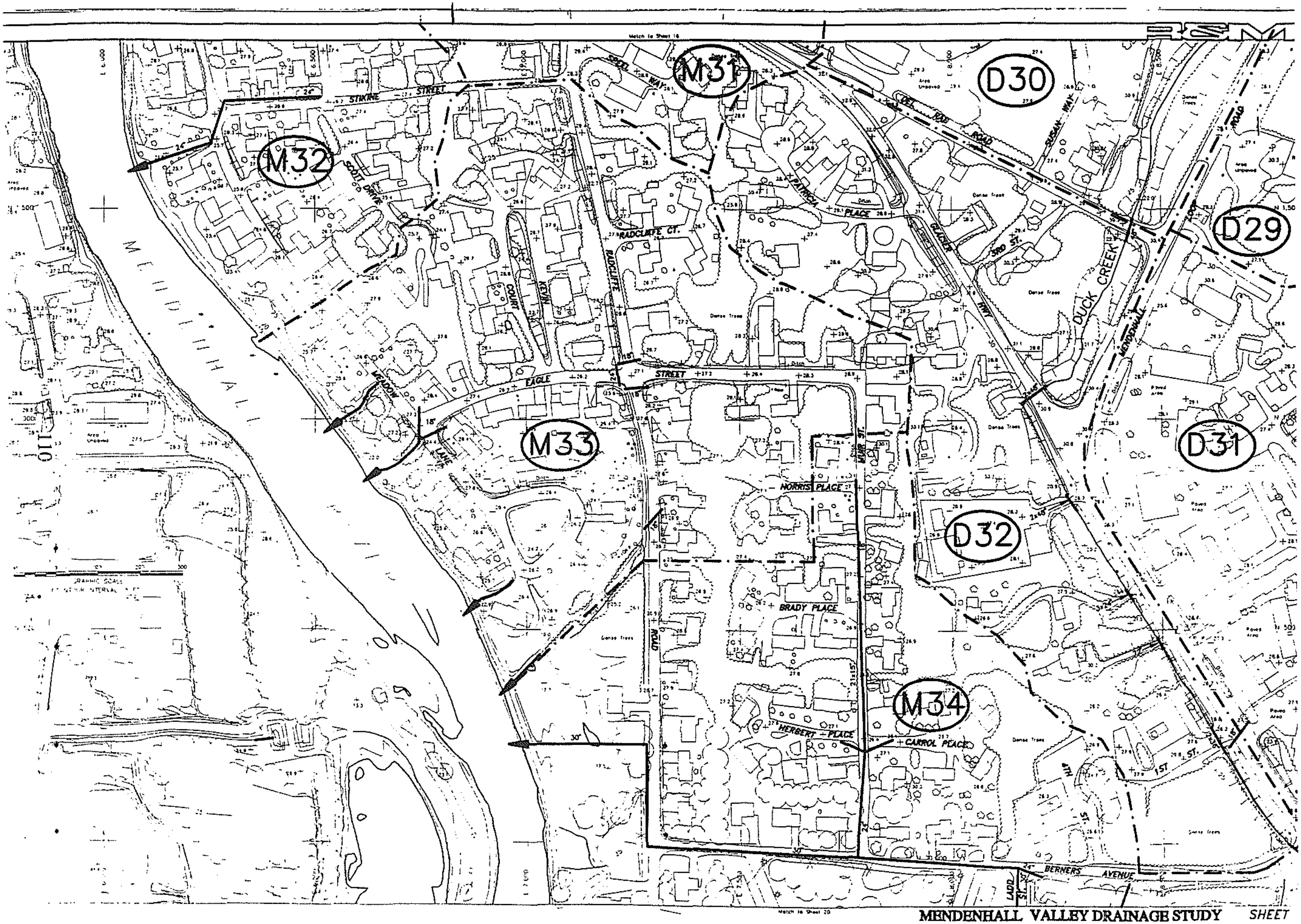

MENDENHALL VALLEY DRAINAGE STUDY SHEET


MENDENHALL VALLEY DRAINAGE STUDY
SHEET 7
M17
M20
M21
M22
M23
M26
NORTHLAND STREET
TURN STREET
STEPHEN RICHARDS MEMORIAL DRIVE
KAIT COURT
PARKVIEW COURT
COTTER CT.
LAKEVIEW COURT
RIVER COURT
MEANDER WAY
PARKWOOD DRIVE
GRAPHIC SCALE
CONTOUR INTERVAL 5 FT

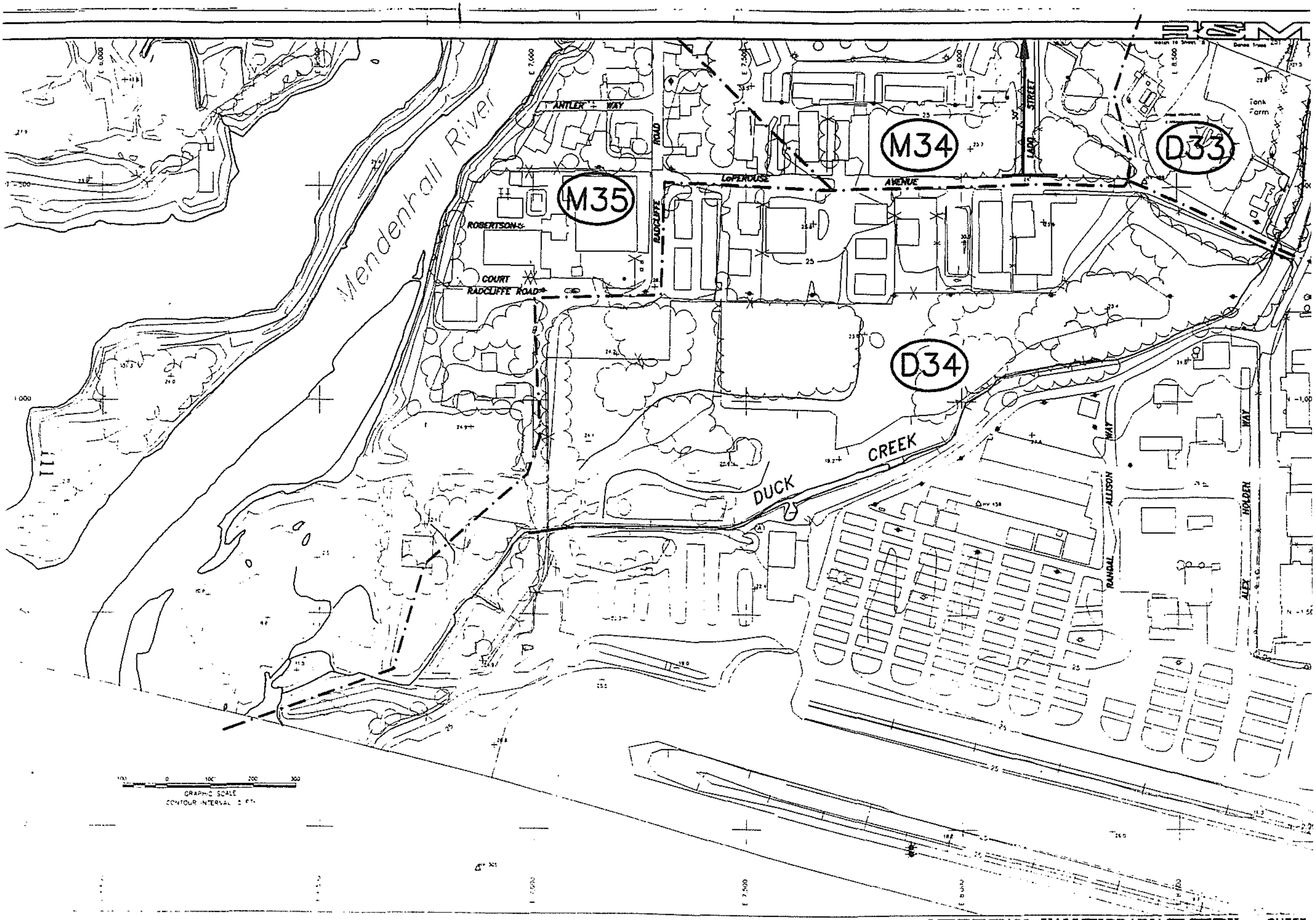

MENDENHALL VALLEY DRAINAGE STUDY
SHEET 13
M24
M25
M26
M27
MOUNTAIN
WOOD
CIRCLE
AVENUE
GLACIERWOOD DRIVE
SKYWOOD LANE
LINDA
RIVERSIDE
DRIVE
GLACIER
COURT
JERRY DRIVE
MENDENHALL
RIVER




MENDENHALL VALLEY DRAINAGE STUDY SHEET



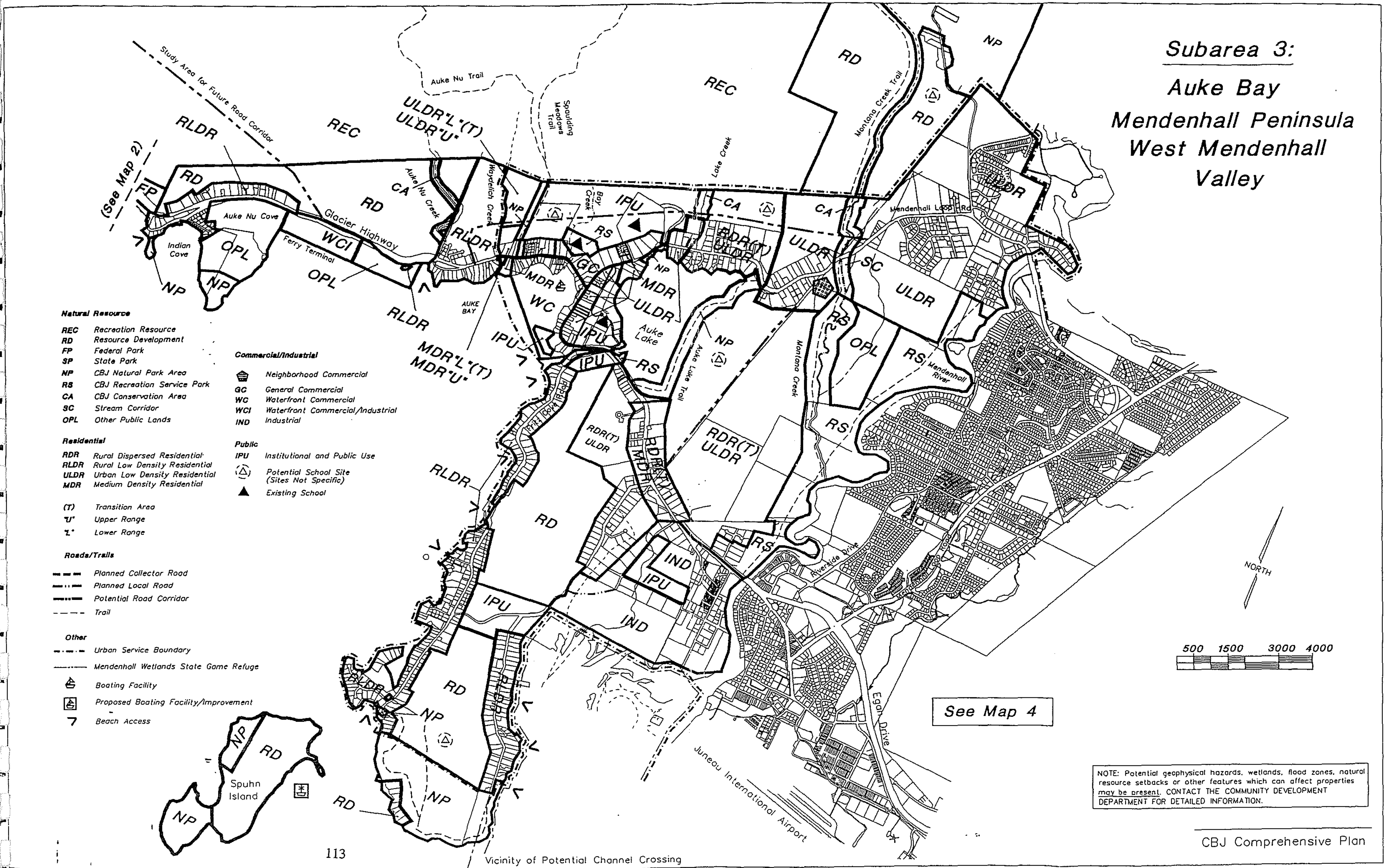

MENDENHALL VALLEY DRAINAGE STUDY SHEET

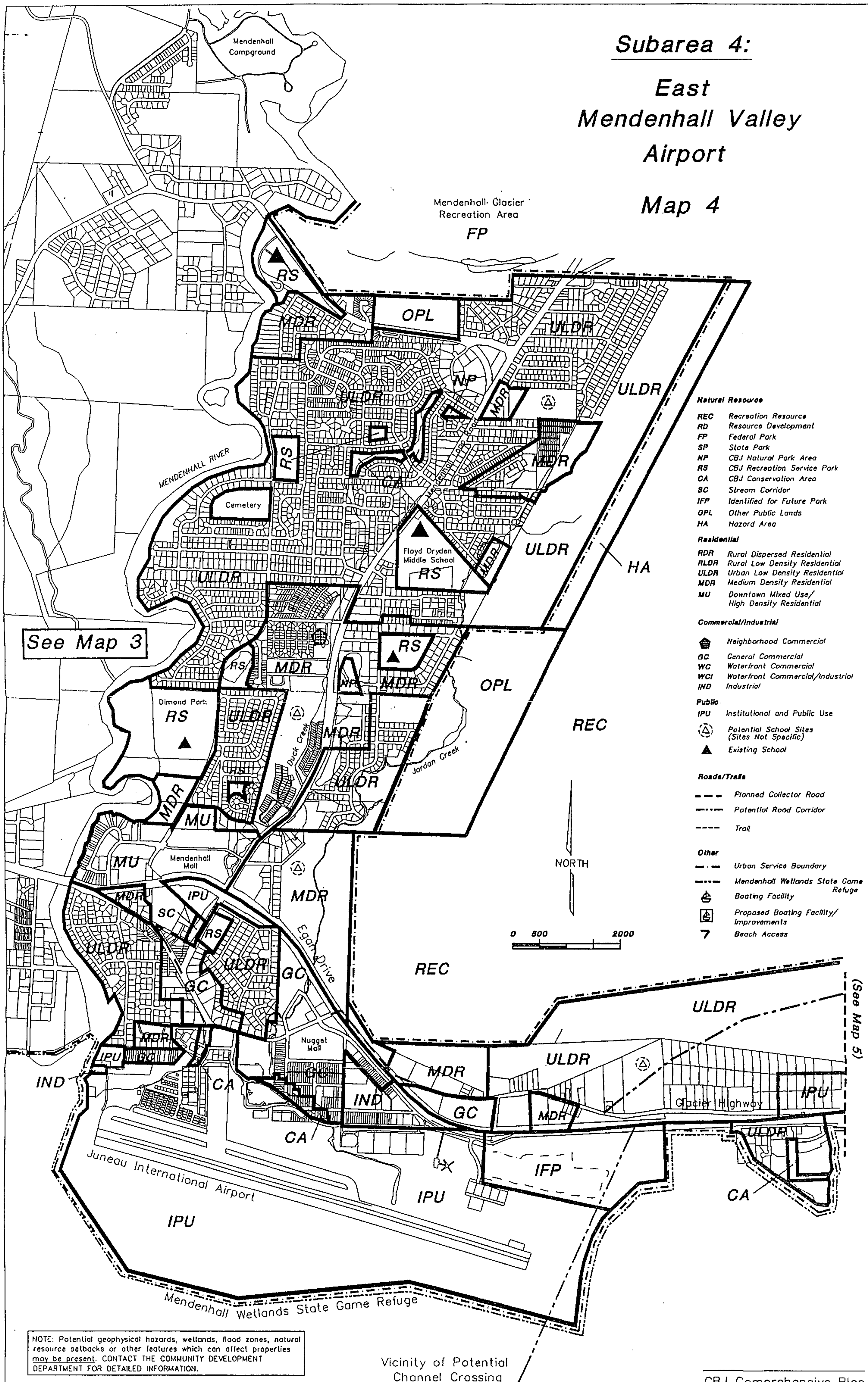




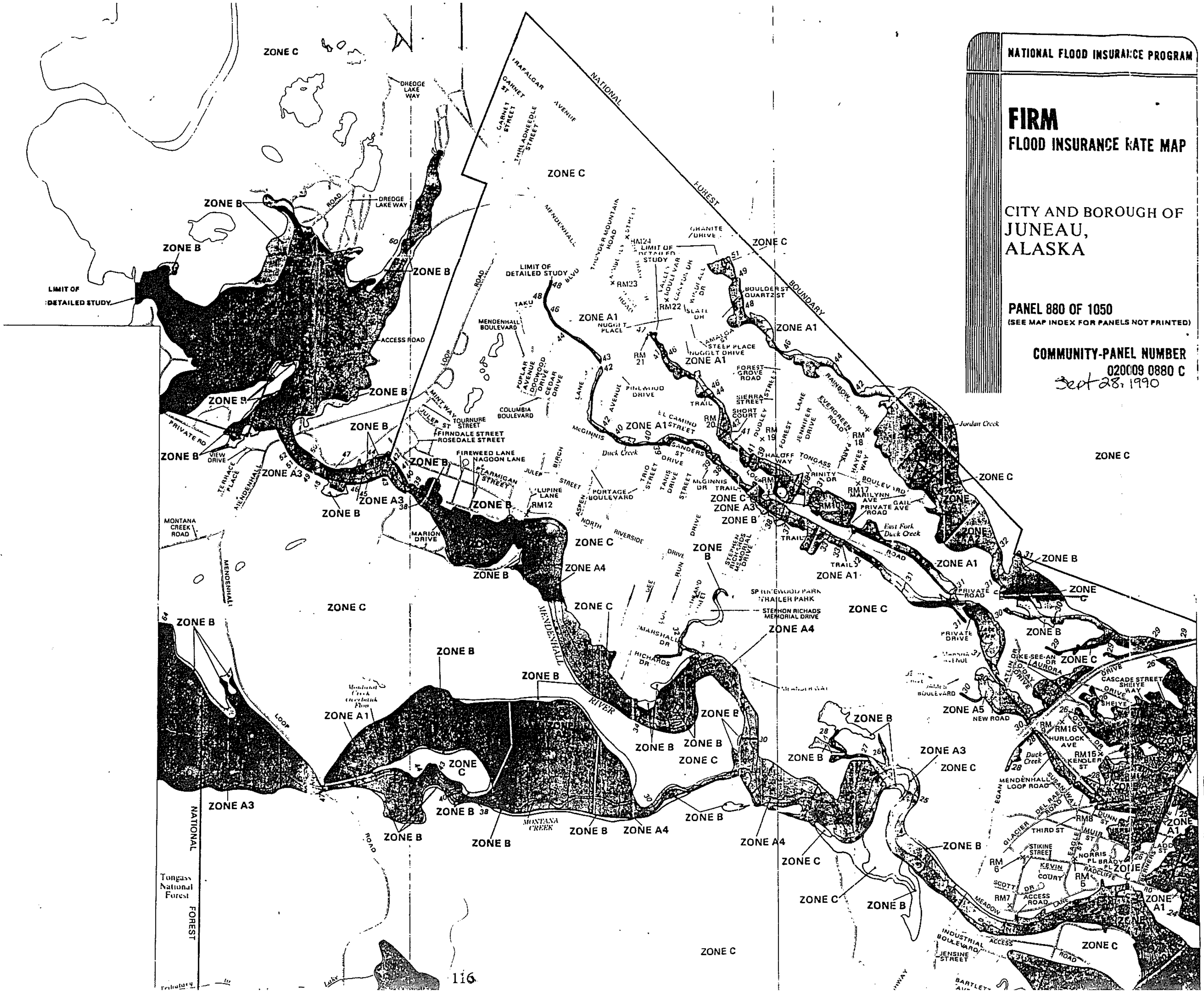

MENDENHALL VALLEY DRAINAGE STUDY SHEET

8.5..Mendenhall Valley City and Borough of Juneau Land Use Maps


Subarea 3:
Auke Bay
Mendenhall Peninsula
West Mendenhall
Valley
Natural Resource
REC Recreation Resource
RD Resource Development
FP Federal Park
SP State Park
NP CBJ Natural Park Area
RS CBJ Recreation Service Park
CA CBJ Conservation Area
SC Stream Corridor
OPL Other Public Lands
Residential
RDR Rural Dispersed Residential
RLDR Rural Low Density Residential
ULDR Urban Low Density Residential
MDR Medium Density Residential
(T) Transition Area
"U" Upper Range
"L" Lower Range
Roads/Trails
Planned Collector Road
Planned Local Road
Potential Road Corridor
Trail
Other
Urban Service Boundary
Mendenhall Wetlands State Game Refuge
Boating Facility
Proposed Boating Facility/Improvement
Beach Access
Commercial/Industrial
Neighborhood Commercial
GC General Commercial
WC Waterfront Commercial
WCI Waterfront Commercial/Industrial
IND Industrial
Public
IPU Institutional and Public Use
Potential School Site (Sites Not Specific)
Existing School
Study Area for Future Road Corridor
(See Map 2)
Auke Nu Trail
Spaulding Meadows Trail
Auke Nu Cove
Indian Cove
Glacier Highway
Ferry Terminal
Auke Nu Creek
Waydelich Creek
Bay Creek
Lake Creek
Montana Creek Trail
Mendenhall Loop Rd
Auke Bay
Auke Lake
Auke Lake Trail
Montana Creek
Mendenhall River
Riverside Drive
Egan Drive
Juneau International Airport
Spuhn Island
Vicinity of Potential Channel Crossing
See Map 4
NORTH
500 1500 3000 4000
NOTE: Potential geophysical hazards, wetlands, flood zones, natural resource setbacks or other features which can affect properties may be present. CONTACT THE COMMUNITY DEVELOPMENT DEPARTMENT FOR DETAILED INFORMATION.


Subarea 4:
East Mendenhall Valley Airport
Map 4
Mendenhall Campground
Mendenhall Glacier Recreation Area
FP
Mendenhall River
Cemetery
Floyd Dryden Middle School
Dimond Park
Duck Creek
Jordan Creek
Mendenhall Mall
Nugget Mall
Egan Drive
Glacier Highway
Juneau International Airport
Mendenhall Wetlands State Game Refuge
Vicinity of Potential Channel Crossing
See Map 3
(See Map 5)
NORTH
0 500 2000
REC
OPL
ULDR
MDR
RS
NP
CA
HA
MU
SC
IPU
GC
IND
IFP
Natural Resource
REC Recreation Resource
RD Resource Development
FP Federal Park
SP State Park
NP CBJ Natural Park Area
RS CBJ Recreation Service Park
CA CBJ Conservation Area
SC Stream Corridor
IFP Identified for Future Park
OPL Other Public Lands
HA Hazard Area
Residential
RDR Rural Dispersed Residential
RLDR Rural Low Density Residential
ULDR Urban Low Density Residential
MDR Medium Density Residential
MU Downtown Mixed Use/ High Density Residential
Commercial/Industrial
Neighborhood Commercial
GC General Commercial
WC Waterfront Commercial
WCI Waterfront Commercial/Industrial
IND Industrial
Public
IPU Institutional and Public Use
Potential School Sites (Sites Not Specific)
Existing School
Roads/Trails
Planned Collector Road
Potential Road Corridor
Trail
Other
Urban Service Boundary
Mendenhall Wetlands State Game Refuge
Boating Facility
Proposed Boating Facility/ Improvements
Beach Access
NOTE: Potential geophysical hazards, wetlands, flood zones, natural resource setbacks or other features which can affect properties may be present. CONTACT THE COMMUNITY DEVELOPMENT DEPARTMENT FOR DETAILED INFORMATION.
CBJ Comprehensive Plan

## 8.6 Mendenhall Valley Flood Hazard Boundary Map




## KEY TO MAP

| | |
|---|---|
| 500-Year Flood Boundary | ZONE B |
| 100-Year Flood Boundary | |
| Zone Designations | |
| 100-Year Flood Boundary | |
| 500-Year Flood Boundary | ZONE B |
| Base Flood Elevation Line With Elevation In Feet** | 513 |
| Base Flood Elevation in Feet Where Uniform Within Zone** | (EL 987) |
| Elevation Reference Mark | RM7× |
| Zone D Boundary | |
| River Mile | •M1.5 |

**Referenced to Mean Lower Low Water

## EXPLANATION OF ZONE DESIGNATIONS

| ZONE | EXPLANATION |
|---|---|
| A | Areas of 100-year flood; base flood elevations and flood hazard factors not determined. |
| A0 | Areas of 100-year shallow flooding where depths are between one (1) and three (3) feet; average depths of inundation are shown, but no flood hazard factors are determined. |
| AH | Areas of 100-year shallow flooding where depths are between one (1) and three (3) feet; base flood elevations are shown, but no flood hazard factors are determined. |
| A1-A30 | Areas of 100-year flood; base flood elevations and flood hazard factors determined. |
| A99 | Areas of 100-year flood to be protected by flood protection system under construction; base flood elevations and flood hazard factors not determined. |
| B | Areas between limits of the 100-year flood and 500-year flood; or certain areas subject to 100-year flooding with average depths less than one (1) foot or where the contributing drainage area is less than one square mile; or areas protected by levees from the base flood. (Medium shading) |
| C | Areas of minimal flooding. (No shading) |
| D | Areas of undetermined, but possible, flood hazards. |
| V | Areas of 100-year coastal flood with velocity (wave action); base flood elevations and flood hazard factors not determined. |
| V1-V30 | Areas of 100-year coastal flood with velocity (wave action); base flood elevations and flood hazard factors determined. |

## NOTES TO USER

This map is for use in administering the National Flood Insurance Program; it does not necessarily identify all areas subject to flooding, particularly from local drainage sources of small size, or all planimetric features outside Special Flood Hazard Areas.

Areas of special flood hazard (100-year flood) include Zones A, A1-30, AE, AH, AO, A99, V, V1-30 AND VE.

Certain areas not in the Special Flood Hazard Areas (zones A and V) may be protected by flood control structures.

Coastal base flood elevations apply only landward of the shoreline shown on this map.

For adjoining map panels, see separately printed Index to Map Panels.

INITIAL IDENTIFICATION:

MAY 9, 1970

FLOOD HAZARD BOUNDARY MAP REVISIONS:

MAY 20, 1977

FLOOD INSURANCE RATE MAP EFFECTIVE:

FEBRUARY 4, 1981

FLOOD INSURANCE RATE MAP REVISIONS:

Map revised SEPTEMBER 28, 1990 to change base flood elevations, to add base flood elevations, to add special flood hazard areas, to change special flood hazard areas, to reflect updated topographic information and to change zone designations.

To determine if flood insurance is available in this community, contact your insurance agent, or call the National Flood Insurance Program, at (800) 638-6620.

APPROXIMATE SCALE IN FEET

## 8.7 Mendenhall Valley Watershed Potential Restoration Projects

Table 8.8 Mendenhall Valley Wateshed Potential Restoration Projects

| Drainage | Restoration Project | Location | Description |
|---|---|---|---|
| Auke Lake | Auke Lake Wayside erosion control | Wayside south of Univ. of Alaska SE | Control erosion at Wayside at outlet to Creek. Relocate wayside and lake access. |
| Auke Lake | Lake Creek culverts | Lake Creek at Back Loop Road | Existing culverts with headwall function fine, but should be redesigned when they need to be replaced. |
| Auke Lake | Storm Water Management Improvements | Lake and Little Lake Creeks | Roadside ditches drain directly into Lake and Little Lake Creeks. Install natural swales to detain water before discharge into creek. |
| Duck Creek | Control of Dissolved Iron | Various sites on creek | Alternative approaches being evaluated. Preferred alternative is to mechanically aerate the water in critical stream reaches. |
| Duck Creek | Streamflow Restoration | Entire creek | Alternative approaches being evaluated. Preferred alternative is to divert flow from Nugget Creek. |
| Duck Creek | Stream Crossings | Remove crossings at: 11 critical sites. | Remove crossings at Glacier View Mobile Home and Kodzoff Acres; Replace culverts at Berners Ave., Mendenhall Mall Road, Valley Paint driveway, FAA Road, Glacier Highway, Del Rae Ave., Egan Expressway, Aspen Drive, and Mendenhall Blvd.at a minimum of 11 critical sites. |
| Duck Creek | Wetland Creation | Nancy Street pond, other ponds on Duck Creek | Fill and revegetate dredge ponds to recreate wetland habitat. |
| Duck Creek | Streambed Lining/Sealing | Key stream reaches, downstream of Egan Expressway | Alternatives include lining the streambed with impervious material or pumping clay into the substrate. |
| Duck Creek | Fine Sediment Removal | Key stream reaches | Dredge and clean stream gravels in 5,000 lineal feet of stream channel. |
| Duck Creek | Riparian Zone Revegetation | Multiple damaged sites along Creek | Revegetate stream bank, thin dense tree stands, construct snow fences to protect vegetation, acquire/establish greenbelts, place woody debris instream. |
| Jordan Creek | Airport General Aviation Tie-down Buffer | GA area north of Jordan Creek at Yandukin Drive | Reestablish adequate width riparian buffer and vegetation. |
| Jordan Creek | Airport Runway Culvert | Juneau Airport | Address problems with fish passage at Airport runway. The existing culvert is not properly bedded, encrusted with barnacles, and too long for fish passage. |
| Jordan Creek | CBJ Water Reservoir Erosion Control | East of Coho Park | Resolve the erosion problem at the CBJ water reservoir access road east of Coho Park. Replace culvert with bridge on lower access road, or close lower access road and retain only the upper road and stream crossing. Revegetate eroded stream banks. Clean sediment from stream reaches below the eroding reservoir site. |
| Jordan Creek | Channel Restoration -- behind Lyles Hardware | Jordan Avenue | Reestablish a sinuous channel, clean out sediment, etc. |

Table 8.8 Mendenhall Valley Wateshed Potential Restoration Projects

| Drainage | Restoration Project | Location | Description |
|---|---|---|---|
| Jordan Creek | Egan Drive Culvert | Egan Drive crossing of Jordan Creek | Investigate whether Egan Drive culvert is adequate, or is a barrier to fish passage, natural hydrology or creek productivity. |
| Jordan Creek | Four-Wheel Use -- Restoration and Management | East of Thunder Mountain Trailer Park, and at Coho Park | Investigate the four-wheeler access sites and consider need for rider education, restrictions on riding in City land, etc. |
| Jordan Creek | Iron Floc Treatment | Glacier Valley Elementary School education trail | Investigate sources of iron from marine sediments in the vicinity of the Glacier Valley school education trail. Develop techniques to reduce this input to the creek and/or treat the discharge. |
| Jordan Creek | MPM Pit Drainage | Valley Blvd. | Investigate the history of the disposal site at the end of Valley Blvd. (i.e., the "MPM Pit"), and determine what effect drainage from pit is having on the Jordan Creek. Solve the discharge problem by either cleaning the site or isolating the or isolate the disposal site, or otherwise address the problem of drainage into creek. |
| Jordan Creek | Spawning Gravel Cleaning | Headwaters to Dudley Street | Improve spawning habitat in the upper reaches of Jordan Creek by cleaning sediment from the gravels. |
| Jordan Creek | Storm Water Management Improvements | Jordan Avenue, Alpine Avenue | Provide better storm water treatment for surface runoff into Jordan Creek from the commercial/industrial area. |
| Jordan Creek | Thunder Mountain Trailer Park "Ditch" restoration | Thunder Mountain Trailer Park | Additional work by the City and Borough of Juneau (CBJ) on "restoring" the Thunder Mountain Trailer Park ditch that drains into Jordan Creek. |
| Jordan Creek | Tlingit Haida Subdivision Drainage | Between Tlingiit Haida subdivision and Thunder Mountain Trailer Court | Improve storm water runoff treatment of water draining from Tlingit Haida subdivision into Jordan Creek. |
| Mendenhall River | Car Body Bend Site | River bank, at Melvin Park, Riverside Drive | Remove car bodies used to stabilize eroding banks in 1950s. Replace with biotechnical bank stabilization, as recommended by Interfluve, Inc. |
| Mendenhall River | Dredge Lake dike rehabilitation | Dredge Lake | Investigate whether Dredge Lake dike, installed in 1970s, should be breached. |
| Mendenhall River | Large Woody Debris | | Investigate whether large woody debris should be reintroduced into overwintering and rearing areas. |
| Montana Creek | Bank stabilization above pedestrian bridge | Upstream of pedestrian bridge | Old vehicle road is eroding into creek. Stabilize with biotechnical bank stabilization methods. Remove old small culverts. Relocate trail away from stream, where needed to control erosion. |
| Montana Creek | Gravel pit restoration. | | Restore old gravel pits, no longer commercially used. |

Table 8.8 Mendenhall Valley Wateshed Potential Restoration Projects

| Drainage | Restoration Project | Location | Description |
|---|---|---|---|
| Montana Creek | Install interpretive signs | Greenbelt trail, and at pedestrian bridge | Install signs to call public attention to Montana Creek values and to urge good stewardship (deter littering). |
| Montana Creek | Investigate "invasion" by Japanese knot weed, an exotic plant species | Along Montana Creek Road | Japanese knot weed is invading native vegetation. Investigate extent of problem and consider impacts. Knot weed dies completely back in winter, so no surface vegetation is left to control surface erosion in winter months (as would native vegetation). |
| Montana Creek | Housing impacts (i.e. sewage and debris) | In the vicinity of the headwaters of Montana Creek | Housing development impacting fish habitat. |
| Montana Creek | Salmon Smolt Release Facility | | Feasibility of excavating a streamside salmon smolt release facility should be determined. |
| Pederson Hill Creek | Fishery enhancement projects | All stream | Excavate pools in stream for rearing and fish refuge during low flows. |
| Pederson Hill Creek | Fishery enhancement projects | Lower stream | Install spawning substrate in stream adjacent to culverts. |
| Pederson Hill Creek | Investigate culverts downstream of Fire Crash station. | Downstream of Fire Crash station on Sherwood Lane | Investigate culverts downstream of Fire Crash station. Possible replacement necessary. |
| All Drainage's | Riparian revegetation on private properties | | |